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This report documents the features of ShakeCast V3, developed under a three year research effort with the United States Geological Survey (USGS) through the Caltrans Division of Research, Innovation, and System Information (DRISI). ShakeCast is a web-based application that automatically retrieves measured earthquake shaking data and analyzes the data against individual bridge performance characteristics. The system identifies the bridges most likely impacted by the event. By focusing inspection efforts on the most damage-susceptible infrastructure in the most severely shaken areas, ShakeCast drastically reduces Caltrans' response time to assess potentially damaged structures after an earthquake. ShakeCast V2 has been an operational tool at Caltrans since 2008. With the introduction of ShakeCast V3, an expanded set of features brings improved emergency response capability.

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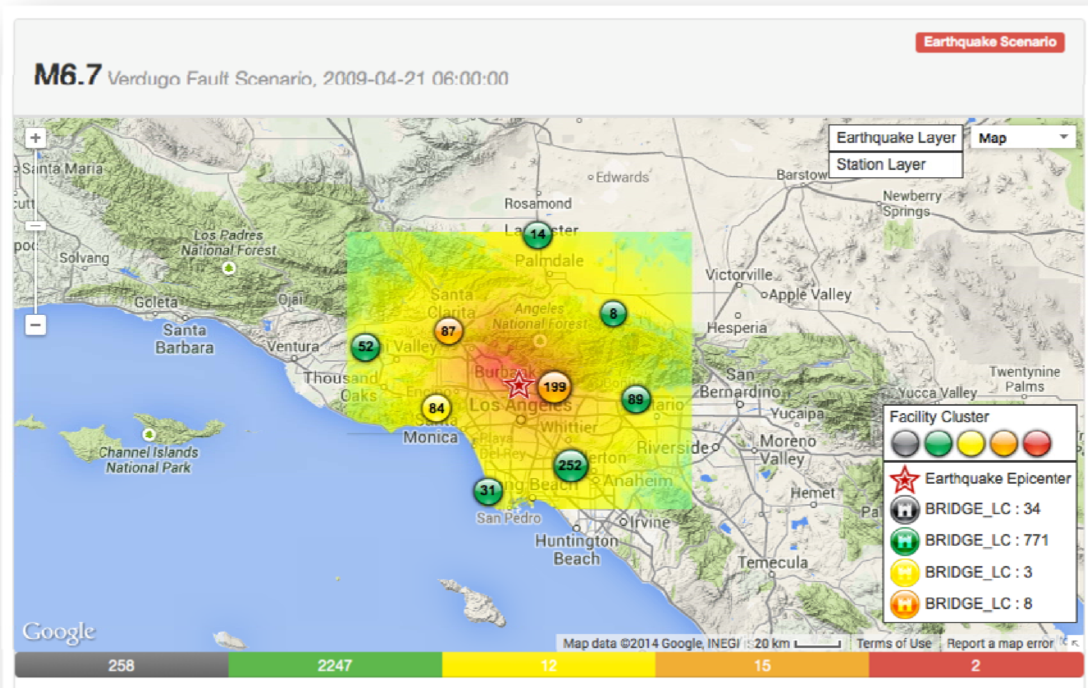
Final Report



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ShakeCast V3 – An Enhanced Tool for Post-Earthquake Response

Caltrans ShakeCast Phase 2 Research Final Report
March 2014

Task 1793
Contract No. 65A0381

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1 EXECUTIVE SUMMARY

This report documents the features of ShakeCast V3, developed under a three year research project with the United States Geological Survey (USGS) through the Caltrans Division of Research, Innovation, and System Information (DRISI). ShakeCast is a web-based application that automatically retrieves measured earthquake shaking data and analyzes the data against individual bridge performance characteristics. The system identifies the bridges most likely impacted by the event. By focusing inspection efforts on the most damage-susceptible infrastructure in the most severely shaken areas, ShakeCast drastically reduces Caltrans' response time to assess potentially damaged structures after an earthquake. ShakeCast V2 has been an operational tool at Caltrans since 2008. With the introduction of ShakeCast V3, an expanded set of features brings improved emergency response capability.

ShakeCast is built on ShakeMap, a USGS product that receives measured ground motion data from the Advanced National Seismic System (ANSS) throughout United States, retrieves macroseismic data from the "Did You Feel It?" (DYFI) application, and combines the information with site-amplification data to create maps that show ground-shaking intensity. The maps provide a level of detail that far surpasses the general information about the earthquake's epicenter and magnitude, which the news media commonly report. ShakeMap provides the input parameters for ShakeCast, which in turn uses the Caltrans facility inventory data to carry out automated analyses and to produce prioritized lists for facility inspection.

Since the release of the Caltrans ShakeCast V2 in 2008, the use of ShakeCast products has been integrated into the emergency response protocols and plans, such as those used by Caltrans Structure Maintenance & Investigations (SMI). The list of Caltrans subscribers of ShakeCast notifications has grown to several hundred and includes a broad range of stakeholders – staff and managers at all levels throughout the department. These stakeholders have different roles in a post-earthquake response situation. For district highway maintenance crews, construction inspectors, and other district field staff that may be first on the scene, ShakeCast serves as an early indicator, focusing limited inspection resources to areas where groups of bridges are more likely to have the critical combination of damaging shaking levels and more vulnerable bridges (i.e. older design-era structures). Managers benefit from having summary information on counts of bridges impacted. This simple aggregation of results allows managers as well as public relations staff to communicate the scope of current inspection efforts to partner agencies, the Governor's office, and the media as warranted. District Traffic Management Centers (TMC) and Emergency Operation Centers (EOC) are better informed so they can more effectively coordinate with the California Highway Patrol (CHP) and local fire, rescue, and law enforcement agencies in assessing the possible condition of emergency lifeline routes.

Improvements in the new Caltrans ShakeCast V3 system are many fold. The redesigned system features a new database schema and process control/dispatch functions to accommodate a broader range of facility types, vulnerability functions, notification messages, and products to satisfy the requirements of a diverse Caltrans user group. The new system tracks and receives earthquake products via multiple sources instead of from ShakeMap producers only. The Caltrans ShakeCast web site now provides direct access to earthquake information (e.g., focal mechanisms and tectonic summaries), and earthquake related products including the "Did You Feel It?" (DYFI) and Prompt Assessment of Global Earthquakes for Response (PAGER) loss estimates. These products are made accessible to ShakeCast users, and can thus be included in email notifications to expand the scope of post-earthquake situational awareness.

ShakeCast V3 incorporates new features to handle different facility types. For events greater than magnitude 4.0 in California and bordering regions, ShakeCast V3 automatically determines the shaking value at the facility locations. (During development and testing, the team tested an inventory comprised of roughly 13,000 state bridges, 12,900 local bridges, 380 maintenance buildings, and numerous landslide prone roadway corridors.) Estimated ground shaking values at facilities are compared with the threshold pre-established for each facility, assessed for component-based probabilistic vulnerability and HAZUS-based building fragility. ShakeCast distributes results of analysis as notification e-mail messages to designated responders within 15 minutes of the event. The e-mails contain general information about the event and a table of facilities sorted by inspection priority.

Each bridge in the system's database has a unique fragility, determined with bridge damage models originally published by Basöz and Mander (Basöz and Mander 1999) and implemented in the Hazards U.S. (HAZUS) software of the Federal Emergency Management Agency (FEMA 2009). The fragility models employ 1-second peak-spectral accelerations and take into account bridge geometry, such as span lengths, number of spans, column heights, and skew; the years of design, construction, and retrofit; and the component material types. As Caltrans begins to capture more information on the various components of individual bridges, such as the project for improved bridge fragility relationships using unique California information, their Generation-2 Fragility (g2F) will be used in ShakeCast V3 in addition to the HAZUS-based method for improved near-real-time damage alerting of bridges in California.

2 PROJECT BACKGROUND

The Caltrans ShakeCast Phase 2 Project continued the work from an earlier 2008 project that began under a partnership between Caltrans and the USGS to develop, deploy, and support an enhanced pilot version of ShakeCast within Caltrans. The phase 2 work consisted of several tasks, and all work elements required extensive Caltrans staff interaction.

2.1 Scope of Work

Work was carried out by the USGS over a three-year period beginning March 2011 and ending March 2014. The specific tasks in the phase 2 project are listed below.

- Task 1- Implement full statistical interpretation of fragility curves in ShakeCast to perform HAZUS like probabilistic fragility analysis.
- Task 2 - Implement a component-based fragility analysis framework in ShakeCast to allow multiple sets of fragility curves to be associated and assessed for one bridge facility.
- Task 3 - Handling of ground failure features (landslides and liquefaction) in ShakeCast by creating a new analysis framework to accommodate secondary ground failure mode and flexible analysis approaches.
- Task 4 - Metric services in ShakeCast to provide supplemental intensity measures and predictive ground shaking.
- Task 5 - Implement polygon/polyline facility location delineation method in ShakeCast for better assessment of ground shaking at facility and to work in conjunction with ground failure analysis.
- Task 6 - Develop and implement method to present results for various facility groupings in ShakeCast to allow users to view the aggregated results of analyses.
- Task 7 - Large scale printable maps in ShakeCast by interacting with Caltrans' ArcGIS program. This task is later removed due to limitations and obstacles in integrating both systems. Instead, the ShakeCast PDF report engine is proposed as a substitute.
- Task 8 - Implement a user-defined HTML facility attribute in the ShakeCast web interface to provide custom facility information and direct links to Caltrans resources.
- Task 9 - Troubleshooting support and implementation of interface enhancements of the ShakeCast program.
- Task 10 – Compile a suite of test and Atlas events for the Caltrans ShakeCast program.
- Task 11 – Automate event maintenance of the Caltrans ShakeCast system.
- Task 12 - Provide a recommendation for IT server deployment at Caltrans.
- Task 13 - User's Manual for the ShakeCast program.
- Task 14 - Final Report.

The “Caltrans ShakeCast Phase 2 SOW Addendum” is included in Appendix B for reference.

2.2 Assessment of User Needs

Two meetings were held early in the project to gather information and assess Caltrans end user needs. A kickoff meeting with key earthquake responders, engineers, and IT personnel was convened on June 3, 2011 at the Caltrans research offices in Sacramento, CA. The focus of this meeting was to discuss roles and the needs of the end users. A requirements specification meeting with the ShakeCast project manager and key Caltrans stakeholders was held on July 28-29, 2011 at the Caltrans TransLab facility in Sacramento, CA. The meetings were intended to identify common and specific needs of earthquake response for different divisions and to clarify expectations regarding the functionality, and user interface of the Caltrans ShakeCast system. The “Caltrans User Needs Assessment” report is included in Appendix A for reference.

Two other meetings were held over the course of the project: Progress meeting in 2012 and Advisory Panel meeting in 2014 (Appendix C).

3 OVERVIEW OF CALTRANS SHAKECAST V3

ShakeCast (http://earthquake.usgs.gov/shakecast), short for *Shake*Map Broad*cast*, is a fully automated, open-source system for delivering specific ShakeMap and related earthquake products to critical users and for triggering established post-earthquake response protocols. ShakeCast allows utilities, transportation agencies, and other large organizations to automatically determine the shaking value at their facilities, set thresholds for notification of damage states (typically green, yellow, and red) for each facility and then automatically notify (via pager, cell phone, or email) specified operators, inspectors, and others within their organizations responsible for those particular facilities in order to prioritize inspection and response.

ShakeCast V3, the system on which the Caltrans ShakeCast V3 is based, has been created and is scheduled to be released in 2014. The Caltrans ShakeCast V3 system is a post-earthquake application and accommodates a broader range of facility, vulnerability function, notification message and product to satisfy the requirements of Caltrans user groups (Figure 3.1).

The Caltrans ShakeCast V3 system automatically retrieves earthquake shaking data from the USGS, compares ground motion intensity measures against the relevant data (e.g., fragility curves) for the facilities in the impacted area, sends notifications of potential impact to responsible parties, and generates facility impact assessment maps and other web-based products for emergency managers and responders. The earthquake shaking data used by the ShakeCast is in the form of a ShakeMap (i.e., a map that displays earthquake shaking parameters spatially), which is obtained by the ShakeCast system which monitors USGS web products. If an earthquake occurs and is above magnitude 4.0 for the State of California and bordering areas, the software retrieves the ShakeMap and begins a series of actions based on protocols and databases previously specified by the user. For example, in Caltrans ShakeCast the system will perform probabilistic fragility analysis for state and local bridges, HAZUS-based building fragility analysis for selected buildings, and assesses shaking estimates along the path of roadway with landslide potentials. After performing the specified actions, the system sends automated notifications containing information needed by key users within the organization operating the ShakeCast system.

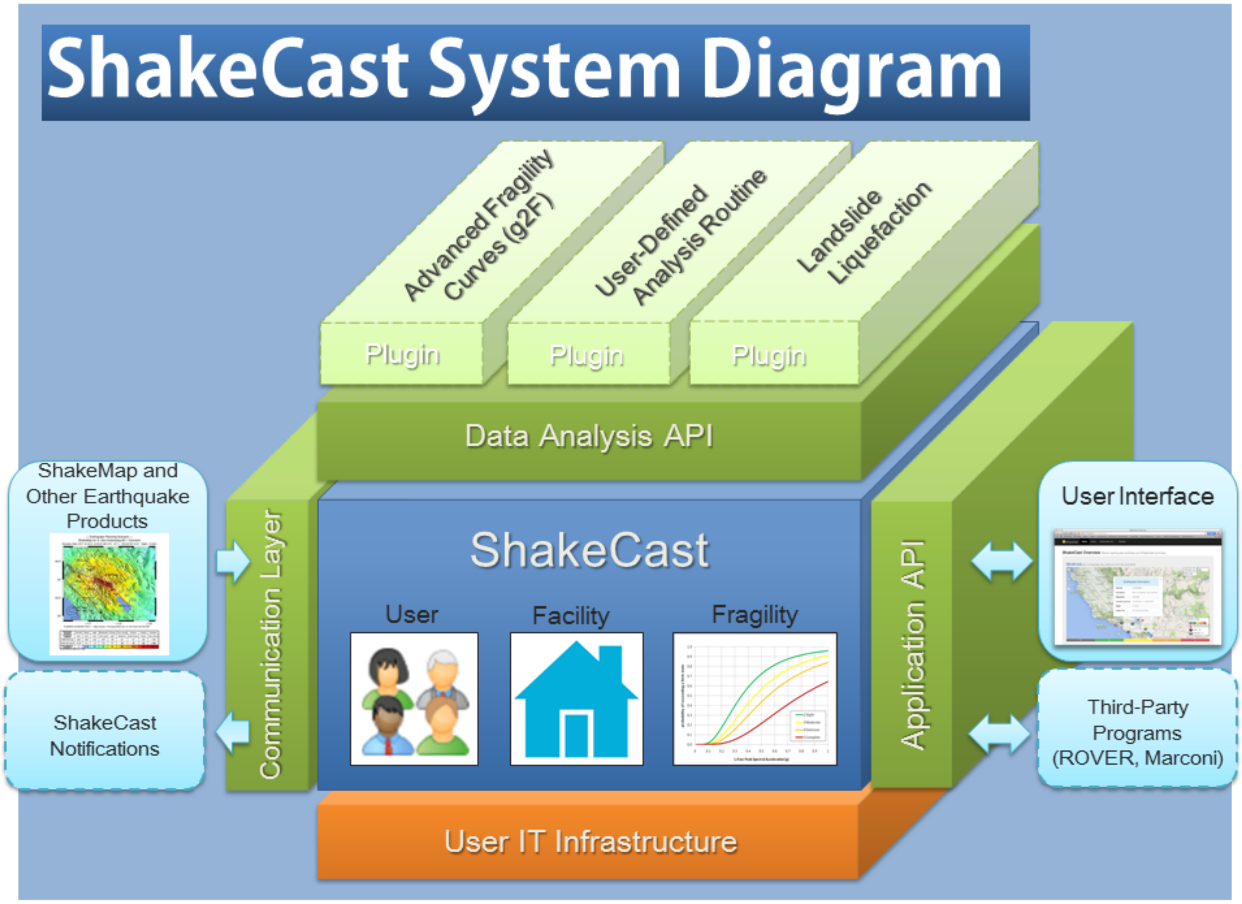


Figure 3.1. Caltrans ShakeCast V3 System Diagram

Since its inception in 2004, ShakeCast utilizes ground shaking information and related products from ShakeMap. The ShakeCast V2 system, initially released in 2008 and subsequently followed with four incremental updates, evolved to work closely with the ShakeMap V3 application regarding available products and semantics. The new Caltrans ShakeCast V3 system continues that same design principle. Specific ShakeMap data related to facility assessment that have been made available to ShakeCast users include: (1) detailed processing parameters about the ShakeMap run; (2) ground shaking estimates at bedrock (before site corrections) and site amplifications at the grid level; and (3) uncertainty estimates for each computed shaking metric at the grid level.

Also implemented into Caltrans ShakeCast V3 is the capability of the new system to track and receive earthquake "products" via multiple sources instead of from ShakeMap producers only. For critical lifeline users, ShakeCast V3 further integrates the new USGS Product Distribution Layer (PDL) as a redundant source to receive earthquake and ShakeMap products, additional earthquake information (e.g., focal mechanisms and tectonic summaries), and earthquake related products including the "Did You Feel It?" (DYFI) and Prompt Assessment of Global Earthquakes for Response (PAGER) loss estimates. All these products are (optionally) stored locally as part of the ShakeCast data repository, accessible by ShakeCast users, and can thus be included to expand the scope of post-earthquake situational awareness.

During the transition from V2 to V3 system, the content of notifications will remain the same and new features will be introduced through subsequent template updates. Detailed results of the analysis will be available through the web interface, which is an entirely new design, to present users different categories of information associated with facilities. Appendix D includes the document for migrating ShakeCast inventory from V2 to V3. Although there is no plan to extract inventory from an existing V2 system, it is an option to ensure smooth conversion of Caltrans inventory.

Regarding ShakeMap scenarios for the purpose of earthquake exercises, the Caltrans ShakeCast V3 system introduces a new workflow to streamline the process. While the ShakeCast V3 system merges scenario and local test events, it is backward compatible and can process both scenario and local test events from the V2 system. Aside from direct access to the USGS ShakeMap archive, a suite of more than 250 scenario packages have been prepared for Caltrans.

4 SHAKECAST FRAGILITY ANALYSIS FRAMEWORK

The ShakeCast V3 system uses information from facility damage functions for both statistical interpretations and rapid notifications.

4.1 Form of Damage Functions

Facility damage functions are in the form of lognormal fragility curves that relates the probability of being in, or exceeding, a damage state for a given intensity measure parameter. The probability that structural damage reaches or exceeds a specific damage state, *ds*, for a given intensity measure, *IM*, is approximated as a cumulative lognormal distribution function:

$$P[ds \mid IM] = \Phi\left(\frac{1}{\beta_{ds}}\ln\left(\frac{IM}{\alpha_{ds}}\right)\right) \qquad (4.1)$$

where

α_{ds} is the median value of input intensity measure, *IM,* at which the structure reaches the threshold of the damage state *ds*,

β_{ds} is the standard deviation of natural logarithm for the damage state *ds*, and

Φ is standard cumulative lognormal distribution function.

4.2 Database Schema for Statistical Fragility Analysis

The ShakeCast V3 system contains an expanded database to store fragility information for each facility. Stored information for each fragility curve includes damage state, intensity measure, median value α_{ds} for the damage state, and standard deviation β_{ds} for the damage state. Fig. 4.1 shows the database schema that correlates facility fragility curves, probability computation, and damage state probability. The lognormal probability table is a pre-computed lookup table (Appendix E) for the lognormal distribution curve. Additional ShakeCast routines have been created to support data import and export, user interface, and output products and notification triggering. An example output plot of fragility analysis is shown in Fig. 4.3.

To accommodate Caltrans' component-based fragility framework, users can define multiple sets of fragility curves by designating the component class and component for each unique set of fragility curves. Specifically, the fragility settings (mean values) of the "SYSEM" component class and component will also be used as the ranged values for the purpose of rapid notification.

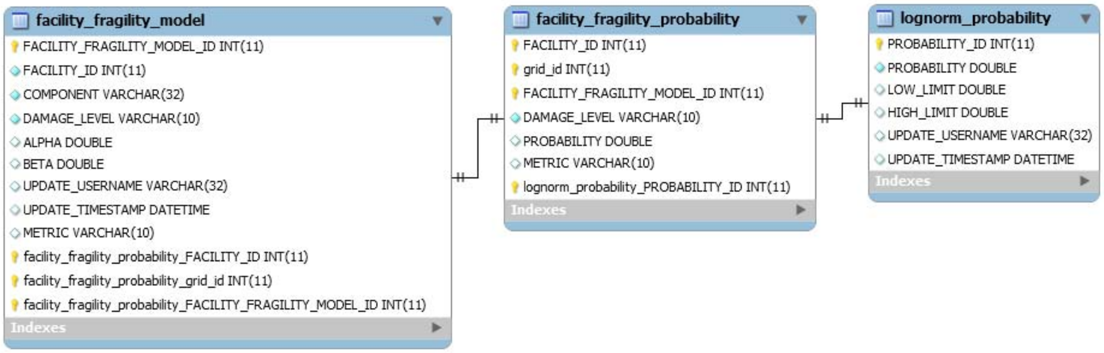


Figure 4.1. Database schema for statistical fragility analysis

4.3 Accounting for Ground-Motion Data Variability

To incorporate uncertainty information associated with ground-motion estimates, Eq. 4.1 can be expanded to Eq. 4.2 (Luco and Karaca, 2007). The resulting equation provides the best estimate of intensity measure *im* based on ShakeMap or a GMPE and its associated uncertainty value:

$$P[DS = ds \mid IM] = \int_{IM} P[DS = ds \mid IM = x]\, f_x(x; im, \sigma)\, dx \tag{4.2}$$

where

$f_{im}(im, \sigma)$ is the probability density function of intensity measure *im* and
σ is the uncertainty for intensity measure *im*.

Fig. 4.2 shows an example of the ShakeMap best estimates of PGA and its associated uncertainty values. The uncertainty map gives the ratio of the estimated uncertainty to the PGA.

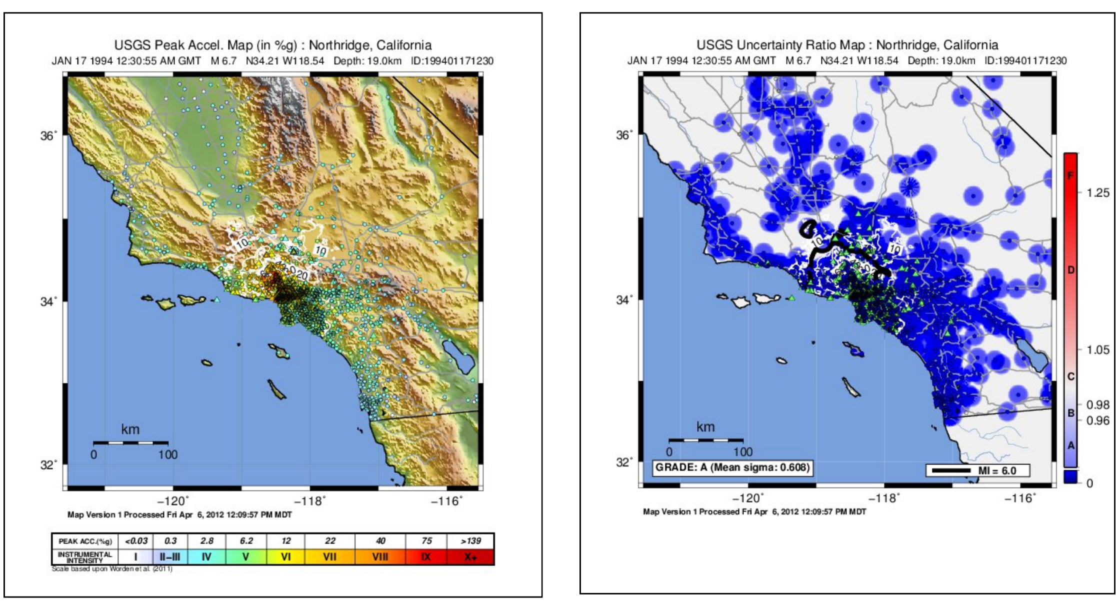


Figure 4.2. PGA and uncertainty estimates for the 1994 M6.7 Northridge ShakeMap.

Currently the function is reserved for research application and is not implemented as part of the standard distribution of the ShakeCast V3 system. A simple five-point approximation of a normal distribution curve (mean +/- two standard deviations) for a given uncertainty value requires as much as five times the computations for a mean-value only computations. Benchmark testing on the Caltrans ShakeCast V3 virtual machine (Windows 2008 server) indicates the system performance of >700 fragility curves/second. With an anticipated inventory of 25,000 bridges and some other structures, assuming 15 components per bridge and 3-5 fragility curves per component, the system will contain a total of more than 1.8 million fragility curves. For earthquake scenarios such as recurrence of the 1994 Northridge or 1989 Loma Prieta earthquake, the system will analyze between 8,000 to 10,000 bridges. With the default setup of a production-ready Caltrans ShakeCast server, it will take ~12 minutes to compute damage probabilities for 600,000-700,000 fragility curves based on the single mean-value without uncertainty information. With added uncertainty information, users should expect a computation time frame of roughly one hour. As such, the treatment of uncertainty in ground motions was not implemented as a default calculation in ShakeCast V3.

4.4 Damage State Probability

As the last stage of the statistical fragility analysis, the probability of each structural damage state for a given facility is expressed as a function of *IM*:

$$P[DS = ds \mid IM] = 1 - P[DS = 0 \mid IM] \qquad ds = 0$$

$$= P[DS = ds \mid IM] - P[DS = ds + 1 \mid IM] \qquad 1 <= ds <= n-1$$

$$= P[DS = n \mid IM] \qquad ds = n \qquad (4.3)$$

where

$P[DS = ds \mid IM]$ is the probability of structural damage state *ds* for a given *IM*.

Fig. 4.3 is an example showing the output plot of full fragility analysis for the SYSTEM component of a Caltrans bridge using a M7.2 San Andreas ShakeMap scenario. In this example there were three fragility curves defined for the bridge that represent inspection priority: low (filled green curve), medium (filled yellow curve), and high (filled red curve). Thus a total of four damage state probability estimates were produced (histogram) as a result; high inspection priority is the state of highest probability.

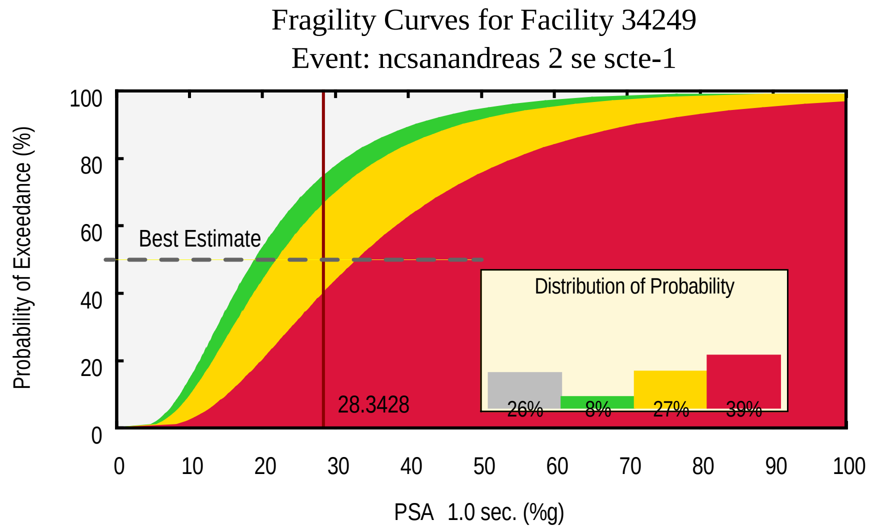


Figure 4.3. ShakeCast V3 damage state (or inspection priority state) probability plot for a Caltrans bridge

The best estimate of damage state in ShakeCast V3 is a separate process for the purpose of rapid notifications. It determines the preliminary damage state by correlating the input intensity measure with the 50th percentile of fragility curves. As an example, shown in Figure 4.3, the facility was determined to be in damage state "yellow" (or "medium inspection priority" as defined by Caltrans).

4.5 Fragility Settings for ShakeCast Notifications

In lieu of storing fragility information for notifications, ShakeCast stores the SYSTEM component parameter corresponding to the mean or *50% probability of exceedance* value as shown in Figure 5.4.

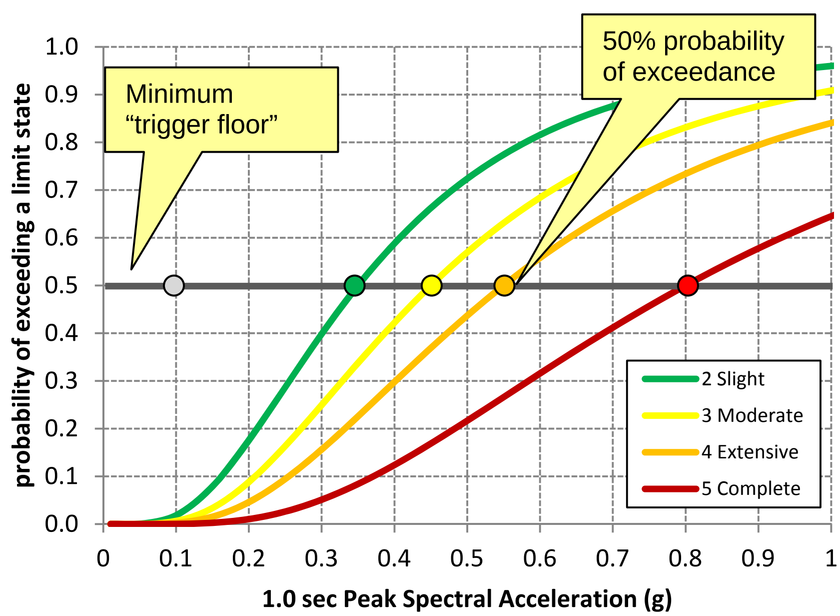


Figure 5.4. Comparison of damage state definition in ShakeCast and the HAZUS-based fragility curve approach.

A trigger "floor" value of 0.1g (1.0 second peak spectral acceleration) is set in ShakeCast as the minimum value required for any facility to be reported in a ShakeCast analysis result.

The curve corresponding to "slight" damage cannot be easily calculated within ShakeCast, and, as such, that value is not stored in the system. Including the trigger floor value, four threshold values are stored in the system and are used to determine four damage states.

4.6 Inspection Prioritization Terminology

Although the HAZUS method results in a prediction of "damage," the ShakeCast system does not use the term "damage" or related phrases anywhere in the system, including in email notifications, on the website, and in other ShakeCast derived products. These terms were intentionally removed from the system so as to avoid any misinterpretation of ShakeCast results as being reports of actual observed damage.

In lieu of damage terms, a series of *inspection priority* terms and standard colors have been adopted. These terms, derived from HAZUS damage state terms, are shown in Figure 5.5. Note that the ShakeCast inspection priority "medium" includes both HAZUS states ds3 and ds2, as documented in Section 4.3. Also, the ShakeCast inspection priority "low" does not directly correspond to a HAZUS damage state.

HAZUS Damage State	Definitions of HAZUS Damage States (FEMA 2009)	ShakeCast Inspection Priority	Definition of ShakeCast Inspection Priority
Complete (ds5)	ds5 is defined by any column collapsing and connection losing all bearing support, which may lead to imminent deck collapse, tilting of substructure due to foundation failure.	**High**	High Priority for full engineering assessment
Extensive (ds4)	ds4 is defined by any column degrading without collapse – shear failure - (column structurally unsafe), significant residual movement at connections, or major settlement approach, vertical offset of the abutment, differential settlement at connections, shear key failure at abutments.	**Medium-High**	Medium-High Priority for full engineering assessment
Moderate (ds3)	ds3 is defined by any column experiencing moderate (shear cracks) cracking and spalling (column structurally still sound), moderate movement of the abutment (<2"), extensive cracking and spalling of shear keys, any connection having cracked shear keys or bent bolts, keeper bar failure without unseating, rocker bearing failure or moderate settlement of the approach.	**Medium**	Medium Priority for full engineering assessment
Slight/Minor (ds2)	ds2 is defined by minor cracking and spalling to the abutment, cracks in shear keys at abutments, minor spalling and cracks at hinges, minor spalling at the column (damage requires no more than cosmetic repair) or minor cracking to the deck		
		Low	Low Priority for full engineering assessment; quick visual inspection likely sufficient. (1.0 second peak spectral acceleration exceeds 0.10g.)
None (ds1)			

Figure 5.5. Inspection priority terminology

4.7 Exceedance Ratio

In order for ShakeCast to compile a single list of bridges in rank ordered inspection priority, bridge inspection priority calculation results must be normalized.

For example, consider the case where two bridges are being analyzed and prioritized for inspection following an earthquake as shown in Figure 5.6. The bridges are located in close proximity to each other and both are exposed to the same ground motion.

Bridge		"A"	"B"
	High	1.34	1.56
Fragility Parameters	Medium-High	1.12	1.33
(1sec PSA)	Medium	0.72	0.87
	Low	0.10	0.10
Measured 1sec PSA during Earthquake		1.06	1.06
Inspection Priority Determined		Medium	Medium
Exceedance Ratio		0.85	0.41

Figure 5.6. Example of calculating exceedance ratios for two bridges

In this example both bridges are determined to have a "medium" priority for inspection. However, the relative prioritization between the two can be difficult to determine since each bridge has unique fragilities. Note that Bridge "A", in this case, is much closer to being categorized as "medium-high" since the 1.0-second peak spectral acceleration value is just below the threshold for medium-high. By contrast, a significantly higher 1.0-second peak spectral acceleration value would be required to push Bridge "B" to a "medium-high" category.

The *exceedance ratio* quantifies the relative priority of different bridges within the same inspection priority state. In the example presented, the exceedance ratio for Bridge "A" can be determined by:

$$exceedance\ ratio_{Bridge\ "A"} = \frac{1.06 - 0.72}{1.12 - 0.72} = 0.85$$

And, for Bridge "B":

$$exceedance\ ratio_{Bridge\ "B"} = \frac{1.06 - 0.87}{1.33 - 0.87} = 0.41$$

In this example, Bridge "A" would be considered a higher priority for inspection since the 1.0-second peak spectral acceleration *exceeds* the threshold by a greater amount than for Bridge "B".

5 CALTRANS FACILITY INVENTORY

5.1 Facility Elements

A facility in ShakeCast V3 consists of four elements (Figure 5.1) of information:

- **Basic Information** is required for all defined facilities and the scope of information is the same as the V2 system.

- **Fragility** element is optional. Although the V3 system accepts the old-style V2 fragility settings, it is highly recommended to take advantage of the probabilistic fragility analysis framework as described in Section 4. V2-like fragility settings will be automatically assigned based on the defined **SYSTEM** component.

- **Attribute** element is optional. It is designed to hold supplemental facility parameters the ShakeCast user needs soon after an earthquake. The Regulatory Method is a user-defined analysis routine against selected facilities. The built-in REG_LEVEL routine for measuring exceedance of regulatory level requirement is specific to the nuclear industry and can be modified to meet the user's needs.

- **Feature** element is optional. The facility feature table holds geometric footprints and custom HTML snippets. The parameters defined here are secondary information and do not affect fragility analysis. The maximum ground shaking values along or within the footprints will be used as representative input shaking values in fragility analysis.

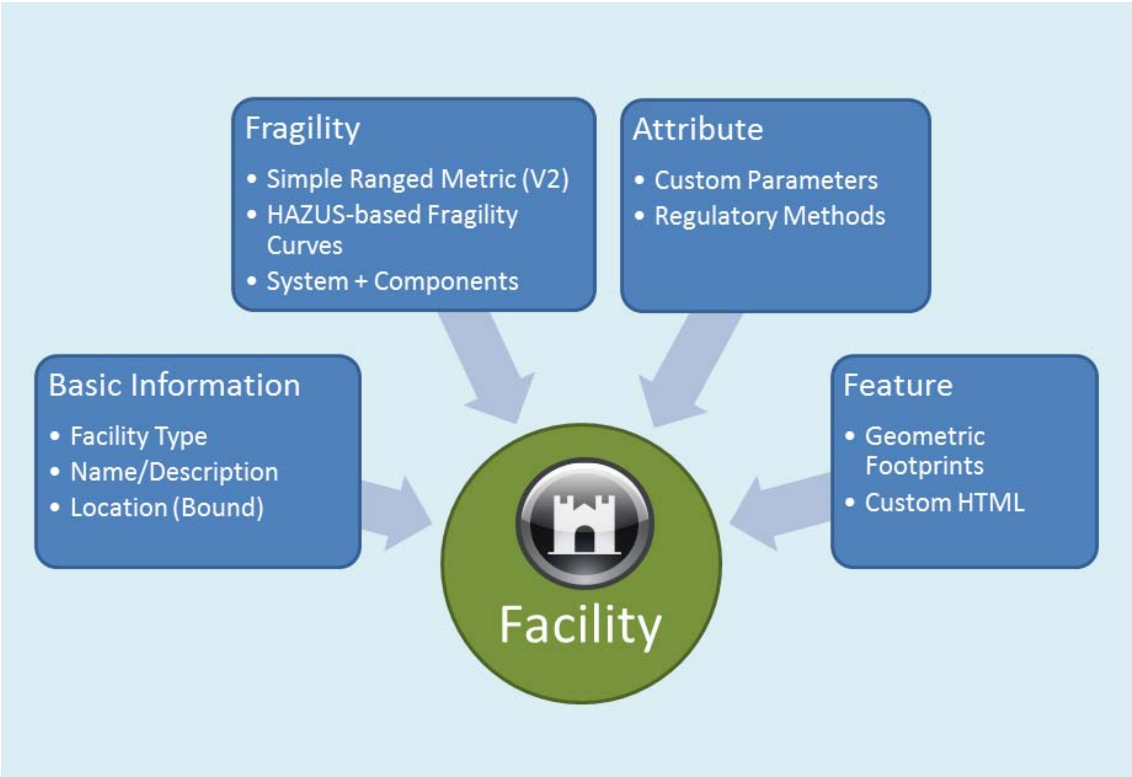


Figure 5.1. Scope of facility related information and fragility settings for ShakeCast V3.

5.2 Bridge Fragility Model

Originally implemented in the Caltrans ShakeCast V2 system, each bridge in the system's database has a unique overall system fragility, determined with bridge damage models originally published by Basöz and Mander (1999) and implemented in the HAZUS software. The fragility models employ 1.0-second PSA and take into account bridge geometry, such as span lengths, number of spans, column heights, and skew; the years of design, construction, and retrofit; and the component material types. The median value α_{ds} for each damage state is used as a threshold for inspection priorities. Unique system fragility parameters are determined for each of the more than 26,000 state and local bridges in the Caltrans inventory.

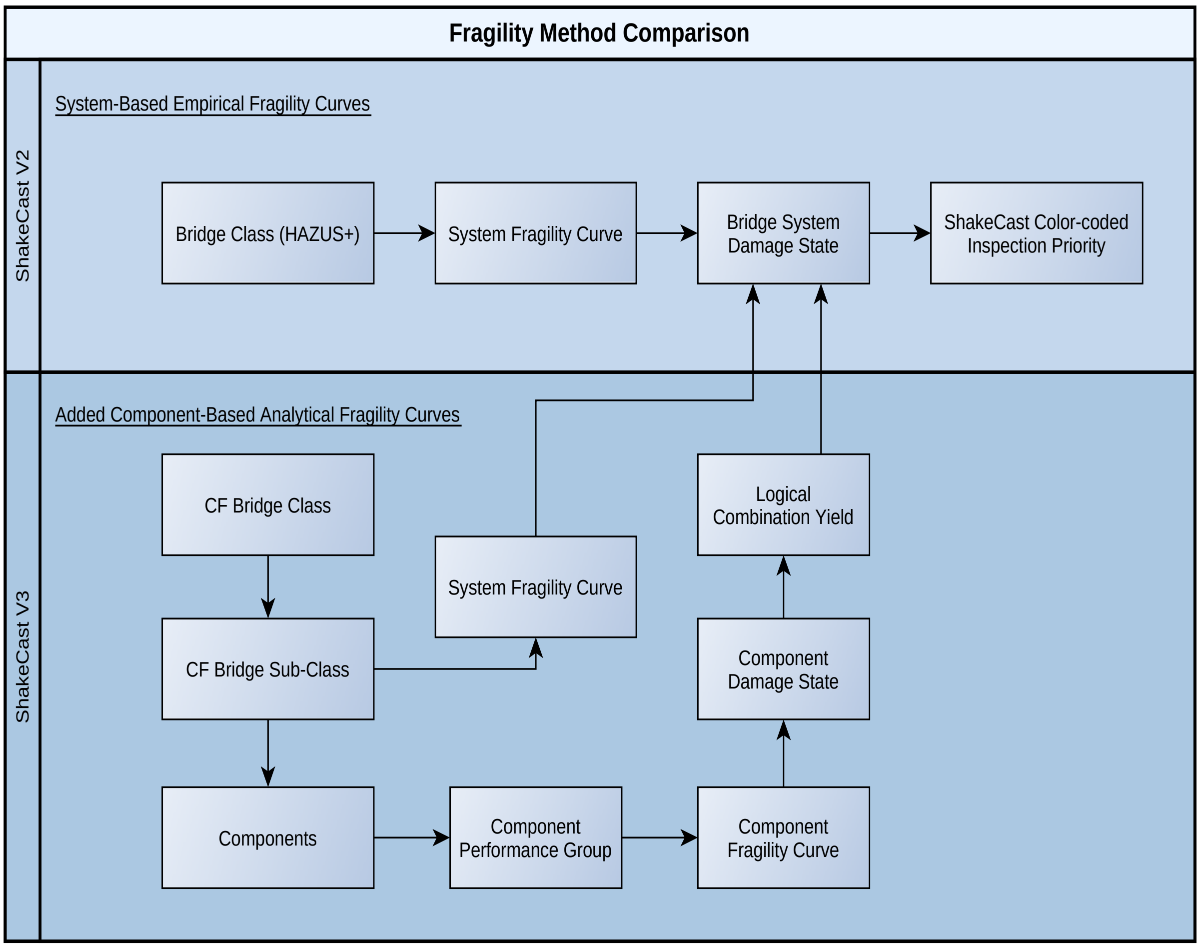


Figure 5.2. Comparison of fragility methods between Caltrans ShakeCast V2 and V3.

Two significant changes were implemented in ShakeCast V3 specific to fragility analysis and presentation of results. First, in addition to using median α_{ds} values as discreet thresholds, the complete spectrum of fragility probabilities are now calculated and presented in the results. That is, the full range of probabilities of a facility being on any one of the predefined damage states is calculated and presented on the ShakeCast V3 website. This more accurate represents the fragility analysis framework, while communicating to users the probabilistic nature of the analysis.

As a secondary enhancement in ShakeCast V3, the full statistical fragility analysis framework was also used to support a more comprehensive component-based bridge fragility methodology being developed through a concurrent effort with Georgia Tech under a research contract with Caltrans (DeRoche 2012). This work extends the HAZUS-based fragility approach by considering fragilities of specific bridge components and the performance of the overall bridge system in the context of its components (Figure 5.2). A first phase feasibility study was completed by Georgia Tech in 2012, and a second phase study is in currently in progress. The anticipated outcome, the “Generation-2 Fragility” (g2F), will be used in ShakeCast V3 in addition to the HAZUS-based method for improved near-real-time post-earthquake inspection prioritization of bridges in California. Converting the HAZUS-based method from V2 to V3 is a straightforward process, since the database only requires the addition of the standard deviation β_{ds} value for each damage state of a bridge. Figure. 5.2 shows the comparison of bridge fragility analysis between Caltrans ShakeCast V2 and V3 systems.

The g2F introduces a new bridge classification taxonomy, building off of bridge classes defined in NBI and extended using Caltrans bridge data sources to identify specific components. Components (e.g. columns, hinges, abutments, etc.) are classified into four generalized categories: primary, secondary, general distress indicators, and ground failure hazards (i.e. landslides and liquefaction). Approximately 20 component categories were identified to test the overall performance of the ShakeCast V3 environment. Although not all bridges will have all component types, dummy values were randomly assigned to all bridges to test the ability of ShakeCast V3 to analyze and process the largest anticipated set of component fragility parameters.

In contrast to the empirical HAZUS-based method, the g2F method considers the overall bridge state as a function of the individual component fragilities. Assessed damage states are presented at both the system and the component levels. For example, a simple bridge might have unique fragilities defined for the columns, abutments, deck, and foundation elements. Each component could be analyzed separately against a ShakeMap intensity measure with probabilities assigned for various component damage states. Those results would then be aggregated into single damage state metric used for summarizing and prioritizing inspections, while providing additional detail to inspectors on specific components that are likely to be the cause of the overall system failure. Fig. 5.3 illustrates the process converting component-based fragility modelling to ShakeCast V3 fragility curves.

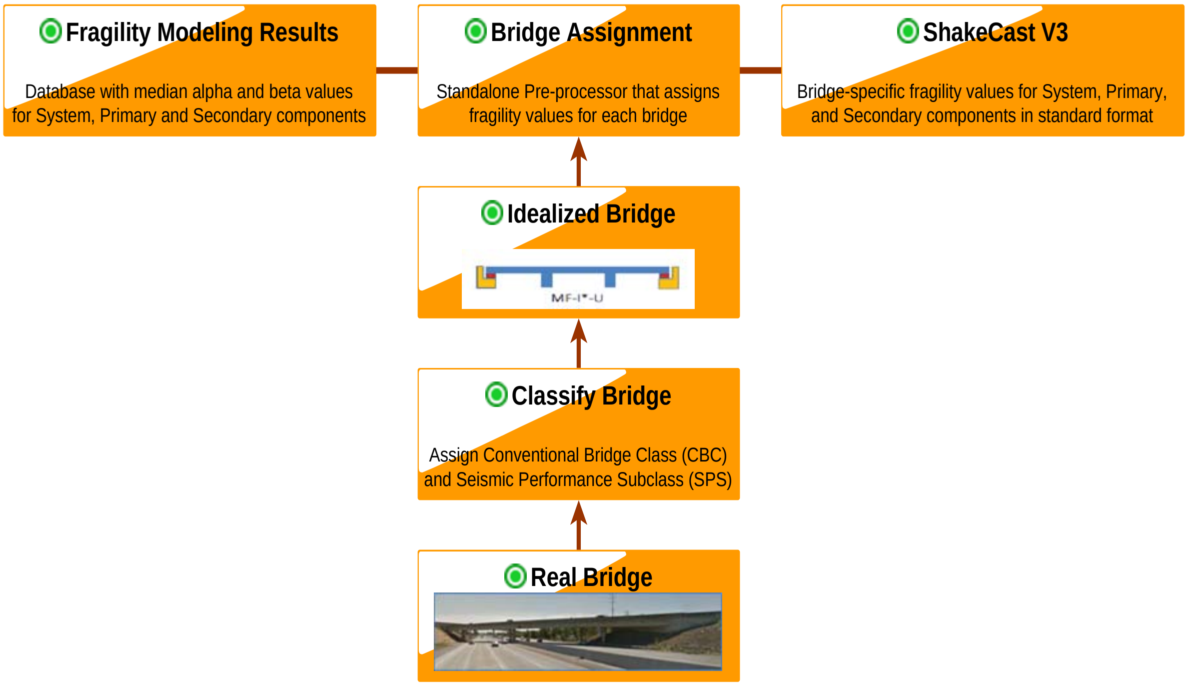


Figure 5.3. Converting g2F component-based fragility modeling to ShakeCast fragility curves.

5.6 Building Fragility Model

A total of 36 HAZUS model building types (Table 5.1 of NIBS and FEMA, 2009) were converted to structural damage levels for ShakeCast V2. "Model building type" refers to the materials of construction (wood, steel, reinforced concrete, etc.), the system used to transmit earthquake forces from the ground through the building (referred to as the lateral force-resisting system), and sometimes height category (low-rise, mid-rise, and high-rise, which generally correspond to 1-3, 4-7, and 8+ stories, respectively). Further included as a modifier to fragility models for each model building type is the building-code era, of which there are 4 (high code, moderate code, low code, and pre-code; Table 5.3 of NIBS and FEMA, 2009). Code eras reflect important changes in design forces or detailing requirements that matter to the seismic performance of a building. Sixteen combinations of model building type and code era do not exist (e.g., high-code unreinforced masonry bearing wall), so in total there are 128 choices of HAZUS model building type and code era.

Implemented into ShakeCast V3 are the equivalent-PGA structural fragility models (Table 5.16a-d of NIBS and FEMA, 2009) in HAZUS-MH for damage analysis. Current ShakeCast V2 users who selected HAZUS-based fragility model for their facilities will automatically receive the new functionality of statistical fragility analysis. Available on ShakeCast wiki are ready-to-use tables (Appendix F) in XML format for users to apply fragility settings on their building inventory.

Each of the four defined damage states (or inspection priorities) in the ShakeCast system remains the same and is color-coded to correspond to the definitions in HAZUS: green corresponds to HAZUS' undamaged or slight structural damage states, yellow corresponds to moderate structural damage, orange to extensive structural damage, and red to complete structural damage. Full descriptions can be found in the HAZUS-MH Technical Manual (NIBS and FEMA, 2009) Section 5.3.1.

For testing and development, an inventory of Caltrans buildings was obtained and used. 380 building facilities were identified statewide, representing 7 general functional types:

- Toll Plaza
- Equipment Shop
- Traffic Management Center
- District Office
- Weigh Station
- Agricultural Inspection Station
- Maintenance Station

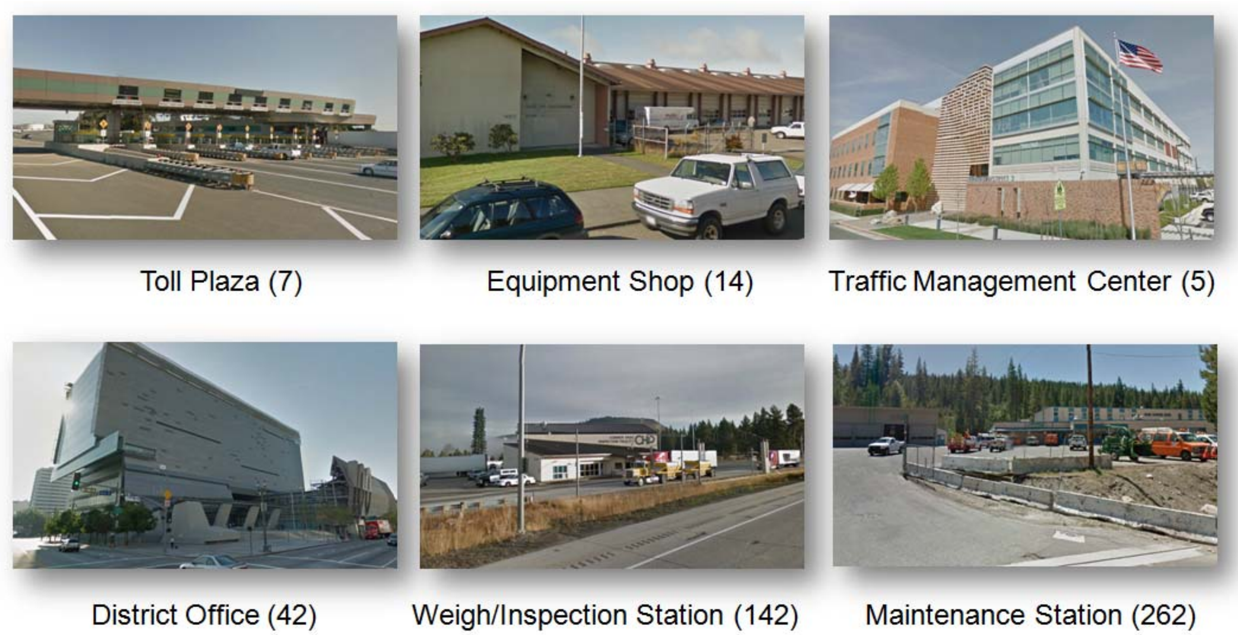


Figure 5.4. Typical Caltrans building facilities and statewide counts.

Assigning relevant HAZUS based fragility parameters to the collection of buildings proved to be challenging due to the limited availability of building data. It was not feasible to gather all of the necessary data to determine the specific building type for each of the 380 Caltrans buildings identified. Furthermore, many of the building locations on the list did not represent a single structure. Rather, they were comprised of a cluster of free-standing structures, each potentially having a different type, geometry, and in some cases design era. Since a rigorous structural assessment of each facility site was not possible and building construction information was not readily available, a more generalized approach was adopted. This approach facilitated testing of the building inventory within the new ShakeCast V3 environment.

For each building in the inventory, an assignment to a HAZUS building class was made. The corresponding PGA-based fragility parameters were then applied. As stated earlier, in many instances a definitive classification was not possible, and a median fragility from a group of building classes was applied. Although this proved to be a reasonable approach for system testing, a more rigorous approach would be needed prior to full operation use.

5.8 Roadway Fragility Model

For testing and development, an inventory of landslide-prone Caltrans highway corridors was obtained and tested. This roadway inventory was comprised of approximately 100 roadway segments. In contrast to the bridge and building inventories, no specific fragility parameters were assigned for the roadway structural section. Rather, the same ground failure hazards applied to the bridge inventory (e.g. landslides and liquefaction) were used. Procedure for identifying roadways is described in Sec. 6.1.

6 SHAKECAST GROUND FAILURE ANALYSIS FRAMEWORK

This project considers two types of earthquake-induced ground failure: landslide and liquefaction. Ground failure features including landslide, liquefaction, lateral spreading, and fault rupture hazards have been identified and mapped along several key highway corridors in California by the California Geological Survey. The goal of this task was to create a pilot analysis framework to accommodate vulnerability functions for handling ground failure features in ShakeCast V3. Results of these analyses are considered supplemental information to the facility fragility analyses and are not envisioned at this time to be used as a primary means for inspection prioritization.

In general, producing real-time estimates of ground failure remains challenging, and well-established procedures on a regional scale are limited in terms of both the models and the necessary geotechnical information required at each site. Further research is needed in identifying proper vulnerability functions for different Caltrans inventory and assigning inspection priorities. Although current methodologies, some described below, are limited in their capabilities, these strategies are commensurate with the expectations of ShakeCast goal: rapid post-event situational awareness of the potential for these secondary hazards.

In Version 2 the ShakeCast default analysis scheme, besides the Metric module, required facility fragility information to be evaluated using existing ShakeMap metrics (intensity measures). Metadata were gathered and parameters are pre-computed into a value range for each defined inspection priority. The lack of standard approach to evaluate vulnerabilities from ground failure makes it difficult to create a single fragility module for this purpose. Even for custom implementation, the existing computational framework is often insufficient due to the varying dimensions and displacements of the landslide and liquefaction hazards needed for the fragility analysis.

In Version 3 of ShakeCast, the system introduces several new functions for facilities with comprehensive fragility information or with special computational requirements. Although not specifically designed for ground failure computations, the new analysis framework can be adopted for the specific need with few modifications. The legacy V2 method remains a valid approach for qualitative analysis or indicative information when no comprehensive ground failure parameters are available for facilities.

In this chapter we describe three new options for handling ground failure analysis: probabilistic method, user-defined, and a new developing USGS ground failure product associated with ShakeMap. The ShakeCast V3 database already includes new table schema for the first two options and generates products to capture the output. The administrator will supply ground failure attribute parameters and methods to activate the process.

Analysis using the new USGS ground failure product is a work in progress. Once the product specifications are finalized, a new process will be added to ShakeCast to permit the systematic use of the new data product. In the mean time, we will introduce the methodology of the USGS ground failure product since it does represent a more general solution for ground failure estimates for ShakeCast users. Any new developments in methodology can be accommodated with future ShakeCast releases.

6.1 Employing Component-Based Analysis for Ground Failure

The ShakeCast probabilistic analysis framework described in Chapter 4 applies to fragility functions that can be presented in the form of lognormal probability distribution function using a ShakeMap intensity measure. It became clear during the course of this project that landslide potential as indicative information can be achieved by combing the statewide landslide susceptibility map (Wills et al., 2011) with expert-opinion triggering thresholds for landslide likelihood. With this approach, there is no need to create a facility category for the purpose of ground failure evaluation. The landslide component can be attached to an existing facility as a secondary component. Other ground failure components can be added to the facility once the forms of probability fragility are defined.

To implement landslide component for Caltrans facilities, the following steps were taken.

1. Obtain statewide landslide susceptibility map from California Geological Survey (Wills et al., 2011). The map shows the variability of landslide susceptibility as a function of rock strength and slope, characterized by a numerical class.

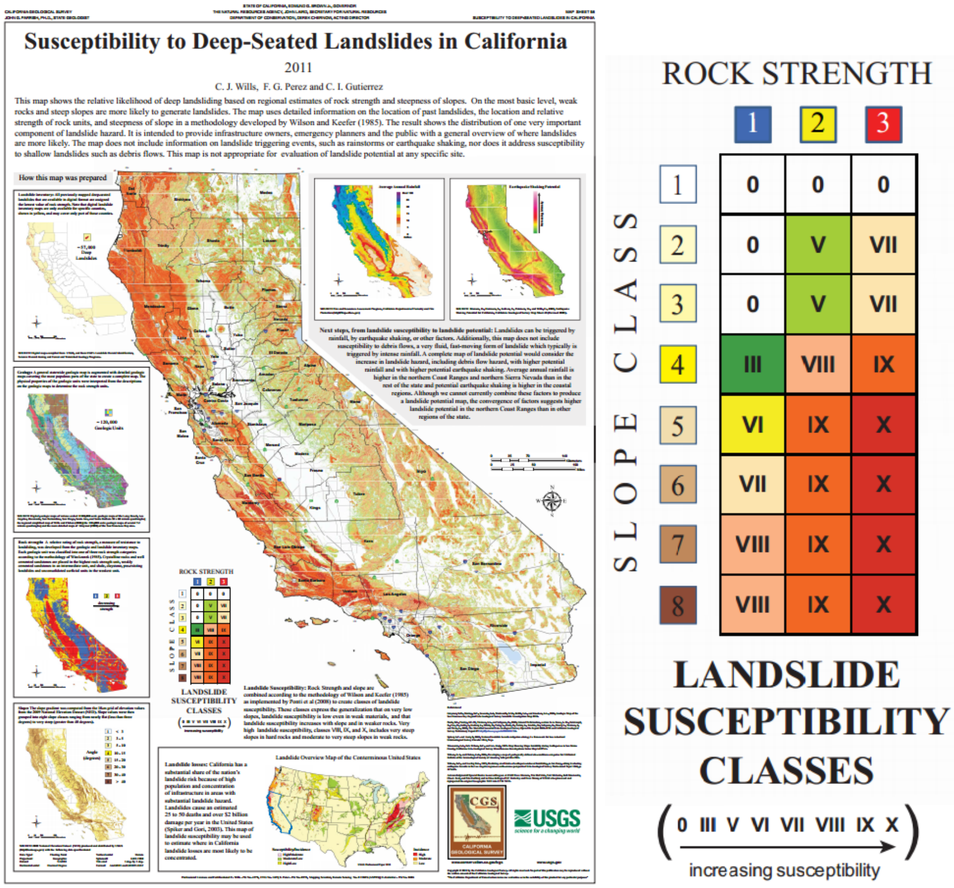


Figure 6.1. Landslide susceptibility in California.

Rock strength and slope are combined according to the methodology of Wilson and Keefer (1985) as implemented by Ponti et al (2008) to create classes of landslide susceptibility. These classes express the generalization that on very low slopes, landslide susceptibility is low even in weak materials, and that landslide susceptibility increases with slope and in weaker rocks. Very high landslide susceptibility, classes VIII, IX, and X, includes very steep slopes in hard rocks and moderate to very steep slopes in weak rocks.

2. Use a GIS application (e.g. ArcGIS) to combine key facility and base layers – landslide susceptibility, state boundaries, highways, bridges, buildings, etc.

3. Create buffer areas around key facilities and determine the maximum susceptibility class within these buffer zones. These zones are intended to represent an area where landslide hazards within the zone could potentially impact the facility. This assumption carries many limitations and results of this analysis should be interpreted with caution.

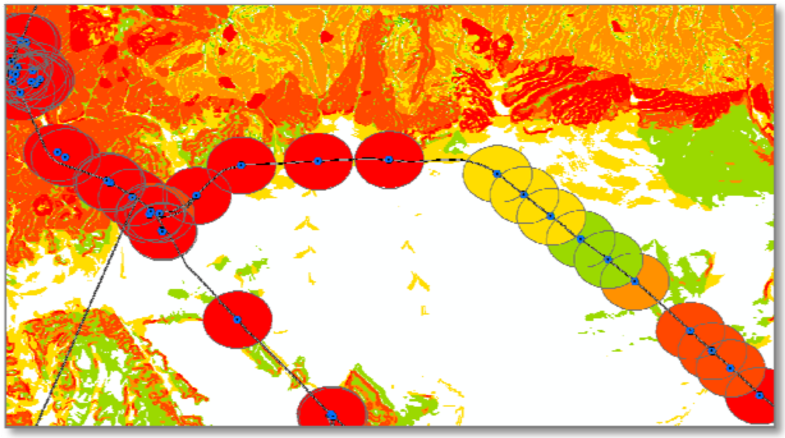
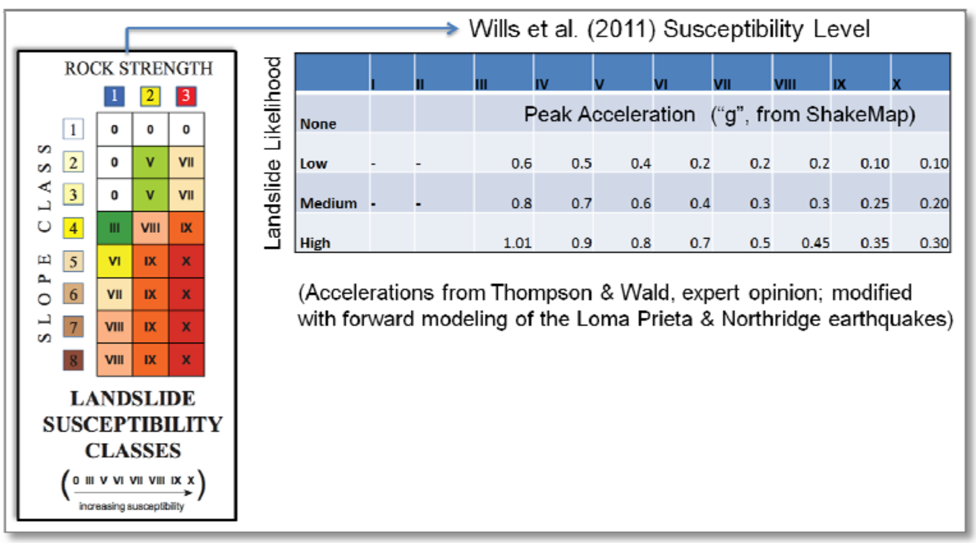


Figure 6.3. Buffer zones around facilities.

4. For each location, assign the landslide likelihood categories (none, low, medium, and high) and PGA ranges, as proposed by E. Thompson and D. Wald based on findings of Nowicki et al (2014).



	I	II	III	IV	V	VI	VII	VIII	IX	X
None			Peak Acceleration ("g", from ShakeMap)							
Low	-	-	0.6	0.5	0.4	0.2	0.2	0.2	0.10	0.10
Medium	-	-	0.8	0.7	0.6	0.4	0.3	0.3	0.25	0.20
High			1.01	0.9	0.8	0.7	0.5	0.45	0.35	0.30

(Accelerations from Thompson & Wald, expert opinion; modified with forward modeling of the Loma Prieta & Northridge earthquakes)

Figure 6.4. Landslide likelihood.

5. Import landslide susceptibility parameters as component fragility in ShakeCast. Landslide values for a facility are evaluated similar to other facility components in the ShakeCast system. Each landslide likelihood state consists of one mean (alpha) value in PGA depending on landslide susceptibility class and a uniform spread (beta) value.

Figure 6.5. Landslide likelihood as presented in ShakeCast results.

6.2 User-Defined Routine

ShakeCast V3 introduces a new user-define routine function to enable user to define and perform custom assessment for selected facilities. The function was originally created for the Nuclear ShakeCast system to evaluate exccedance of regulatory levels for nuclear power plants. The same analysis framework can also be modified to provide ground failure analysis. This approach is suitable if the fragility function does not conform to a simple lognormal probability distribution function. An example is a simple implementation of the HAZUS (FEMA, 2009) liquefaction susceptibility ratings in ShakeCast using the procedure described below:

1. Update the ShakeCast regulatory level exccedance routine with the HAZUS probability of liquefaction relation,

$$P[Liquefaction_{SC}] = \frac{P[Liquefaction_{SC}|PGA = a]}{Km\ Kw} P_{ml}$$

where

$P[Liquefaction_{SC}|PGA = a]$ is the conditional liquefaction probability for a given susceptibility category at a specified level of peak ground acceleration
Km is the moment magnitude (M) correction factor
Kw is the ground water correction factor
Pml proportion of map unit susceptible to liquefaction

2. $P[Liquefaction_{SC}|PGA = a]$ is represented by series of linear relations to be evaluated. The information will be saved in the user routine as program-wide parameters. *Km* is a magnitude depend term and will be computed in real time.

3. The *Kw* correction factor requires a facility-specific parameter for the depth to groundwater table in feet.

4. Assign two facility attributes to facilities that will be subject to liquefaction susceptibility analysis: REG_LEVEL attribute to 1 to enable the process and KW_DEPTH attribute to specifies the depth to groundwater table.

5. Output of the analysis will be saved into the XML file *facility_reg_level.xml* and on the Inventory Details page as supplemental information.

Each user-defined routine needs to register with the system under a unique name. Routines for other ground failures can be added into the system using the same procedure.

6.3 USGS Ground Failure Product

USGS is helping develop global models for assessing seismic-induced landslide and liquefaction potential in near real-time (Nowicki et al., 2014 and Zhu et al., 2014). Both models use logistic regression to predict ground failure potentials against several predicator variables (Figure 6.1) that can be easily determined from remotely-sense datasets. The input predictor variables in the regression include ground motion produced by the earthquake, topographic slope, material strength, and soil wetness. These variables were compared with the spatial distribution of mapped landslides/liquefactions that occurred during past events. From the regressions, for any real-time event, it will be possible to make generalized predictions of the distribution and likelihood of landsliding and liquefaction using a ShakeMap has the shaking hazard (PGA) input. With ShakeCast, these mapped landslide and liquefaction likelihoods can then be employed to determine the potential impact or inspection priority at facility locations.

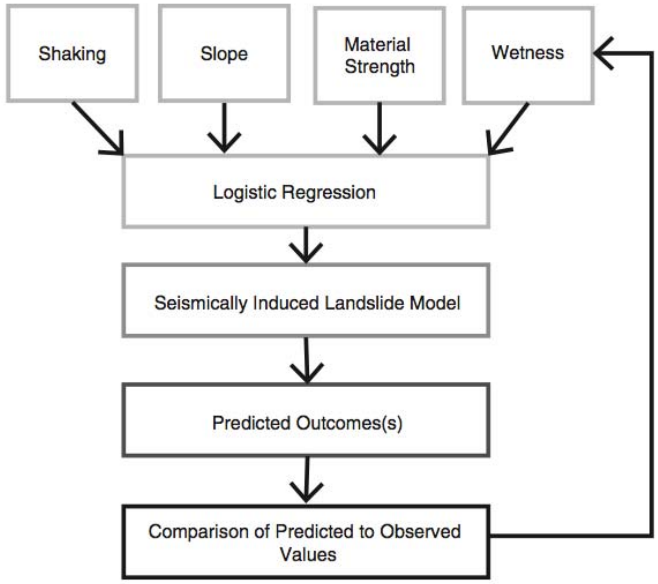


Figure 6.6 Model development for USGS ground failure product. Courtesy of Nowicki et al. (2014). An analogous strategy was conducted by Zhu et al. (2014) for liquefaction likelihood estimates.

While landslide and liquefaction exhibit different forms of regression, both ground failures share some of the same input data layers, such as compound topographic index (CTI), slope, shear wave velocity (*VS30*), magnitude, and peak ground acceleration (PGA).

The USGS Ground Failure product is a derived product to the USGS ShakeMap and generation of the product coincides with the release of ShakeMap and is undergoing evaluation at present. The format of output data is similar to the data grid of ShakeMap ground motion estimates, namely latitude/longitude and in this case probability of liquefaction and landsliding at each grid point. To associate facility fragility with ground failure probability, the ShakeCast user will need to specify inspection priority (susceptibility category) in term of ranged probability values. The footprint of a facility needs to add a buffer zone for this assessment.

The current ShakeCast V3 system does not include any module to process the USGS ground failure product.

7 ADMINISTERING THE SHAKECAST SYSTEM

The ShakeCast V3 system was developed under the CentOS 6 Linux system and ported to other Linux distributions (RedHat ES 6 and SUSE Enterprise Server 10) and the Windows operating system (7/Server 2008) as either a 32- or 64-bit application.

Supporting multiple OS platforms is not possible due to resource limitations, so for general ShakeCast users the strategy going forward is to support Linux Virtual Machine (VM) for local installations and Cloud computing on Amazon Web Services (AWS). The ShakeCast application is bundled with an Open-Source Linux operating system as a standalone system image with the standard installation package.

Considering the challenges with the SUSE Enterprise Linux Server configuration and the benefits of the Windows Server solution, a new strategy was devised by the team to bundle the ShakeCast application under the Microsoft Windows Server operating system (2008 or later) as a standalone system VM image in addition to the standard installation package. The Caltrans ShakeCast system is an example of VM deployment.

This chapter outlines topics regarding system administration for the Linux system and focuses on Windows specific tasks that are applicable to Caltrans operations. Users should refer to the ShakeCast V3 Manual (Appendix G) for comprehensive descriptions of the system.

7.1 Installing the ShakeCast System

7.1.1 ShakeCast on a Virtual Machine

A virtual machine (VM) is a software implementation that executes programs like a physical machine. Virtual machines are separated into two major classifications, system and process virtual machines, based on their use and degree of correspondence to any real machine. ShakeCast VM is a system virtual machine.

ShakeCast V3 on a VM has the benefits of application provisioning, maintenance, high availability and disaster recovery. These also are important factors for consideration when implementing the application at any organization as a VM or physical server.

The host VM described in this document reflects one possible VM option for the purpose of application development. USGS does not endorse any specific VM host for the ShakeCast application. The sections below describe the setup for a generic VM available to the ShakeCast user community. For Caltrans-specific use case and server infrastructure, we detail implementation recommendations in a separate document as part of the Phase 2 project (Appendix H).

7.1.2 ShakeCast System Hardware Requirements

Recommended minimum hardware specifications for the ShakeCast system includes:

- Single Intel Xeon E5-2670 equivalent processor.
- 1GB RAM.
- 30GB hard drive storage
- At least low performance Internet connection (<1MB/s)

The above hardware setup is roughly equivalent to the “micro” instance on the Amazon Elastic Compute Cloud (Amazon EC2) in which the performance was assessed.

Depending on the size of facility and user inventory and the earthquake monitoring areas, more hardware resources will be needed in order to deliver anticipated performance. USGS earthquake products (ShakeMap, ShakeCast, lossPAGER, DYFI?, and others) for each processed earthquake usually consume 30-50 MB of hard drive space. For ShakeCast systems designated for earthquake response purpose, we recommend to at least double the minimum recommended hardware specifications. During the testing phase, the Caltrans ShakeCast V3 system hosting over 26,000 facilities and approximately 400 users in several groups required a VM with the following hardware-equivalent specifications for the primary and backup servers:

- Quad Intel Xeon X5670 2.9GHz processors.
- 8GB RAM.
- 100GB hard drive storage.
- High performance Internet connection.

7.1.3 ShakeCast System Software Requirements

The ShakeCast V3 system is distributed for both Linux and MS-Windows operating systems. The system is built on an open-source stack of supporting applications shared by all platforms, specifically:

- Apache Web server 2.x.
- MySQL 5.x database.
- Perl 5.14+ scripting language.
- Modules: DBI, DBD::mysql, Text::CSV_XS, Config::General, enum, XML::Parser, XML::LibXML, XML::Writer, XML::Twig, XML::Simple, Template-toolkit, PDF::API2, PDF::Table, MIME::Lite, GD, GD::Text, GD::Graph, GD::Graph3d, HTML::TableExtract, Net::SSLeay, Net::SMTP::SSL, Net::SMTP::TLS, Authen::SASL, Archive::Zip, JSON, JSON::XS, File::Path, Image::Size, Mojolicious.
- wkhtmltoimage conversion tool.
- gnuplot image tool.
- HTML5/Google Maps API V3/markerclusterer/jQuery/Bootstrap/dataTables Web tools.
- Optional PHP/phpmyadmin scripting language.
- Optional git version control tool.

Linux implementations:

- Xvfb X virtual framebuffer display server (required for 64-bit systems and optional for 32-bit systems).
- mailx as default mail utility.
- ShakeCast services as background daemon processes.
- Database backup cron job.

Windows implementations:

- SMTP as default mail protocol (supports both SSL/TLS security layers).
- ShakeCast services as Windows system processes.

7.1.4 Security and Firewall

The default setup of ShakeCast allows access via the command line using SSH and the web interface with HTTP or HTTPS. The ShakeCast web server is designed to serve earthquake information to users and to allow administrators to conduct general administration of the system.

Command line access via SSH (Linux) should be granted only to system administrators. ShakeCast tasks not covered by the web interface are considered advanced topics for experienced ShakeCast administrators. For Windows operating systems without installed SSH service, the ShakeCast administrator will need to access the system via the default **Remote Desktop Connection** application (or similar remote access programs) to perform the same tasks.

Normal setup and interaction with a user's ShakeCast web server provides user access to maps, products and services, as well as administrator access. Administrators can modify user profiles and notifications, trigger earthquake scenarios, and access many other configurations functions. However, In the most secure installation of ShakeCast, the administrator can choose to disable modifications from the web and only permit SSH access.

Firewall and system level security configurations are platform specific and not covered by this manual. ShakeCast implements basic authentication, but it is highly recommended to implement system-level firewall policies to limit exposure to/from the Internet. These rules will take precedence over the ShakeCast-defined user authentication. For inbound traffic, firewall policies are effective methods to define domains where users can access the products and information of the ShakeCast server. For outbound traffic, firewall policies should permit the USGS Web server (http://earthquake.usgs.gov), which is the source for all earthquake products processed by ShakeCast. For ShakeCast systems receiving earthquake products via the USGS Product Distribution Layer (PDL) client, the program uses port 39977 to connect to the upstream hub server.

7.1.5 Web Browser Compatibility

The ShakeCast V3 web interface was built using HTML5 standards. Most user and administrator interactions are through using a web browser. Supported web browsers:

	MacOS	MS-Windows
Chrome	25+	25+
Firefox	20+	15+
Opera	12+	12+
Safari	5+	N/A
Internet Explorer	N/A	9+

7.2 ShakeCast MS-Windows Installation

A Windows Installer Package of ShakeCast V3 for Windows had been developed to assist the administrator download, install, and configure the ShakeCast system. The installation process requires administrative privileges on the system and the user performing the installation must be a member of the local **Administration** security group.

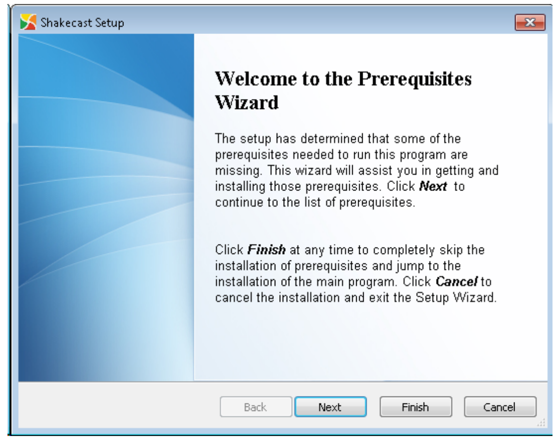
The installation process prompts the users a series of custom setup options and in general default options are the best choices for new users. The size of a new ShakeCast installation is about 2GB including third-party programs that are used by the ShakeCast application.

7.2.1 Prerequisites Wizard

Double-click the ShakeCast installer. If a security warning message appears, click **Run**.

The ShakeCast Prerequisites Wizard window opens.

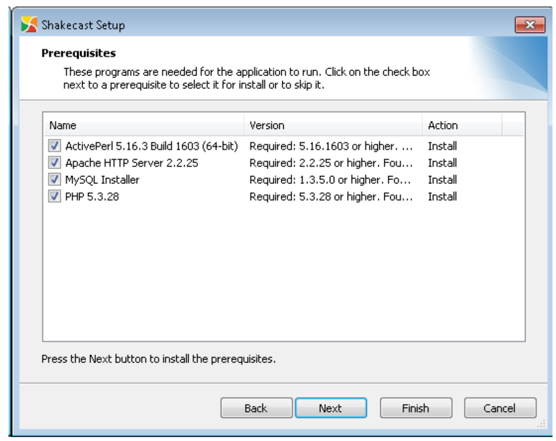
Click **Next**.



The Wizard analyzes pre-installed programs on the operating system. Existing programs that meet the software requirements will be unchecked.

Toggle checkboxes to make optional changes to the planned program list for installation.

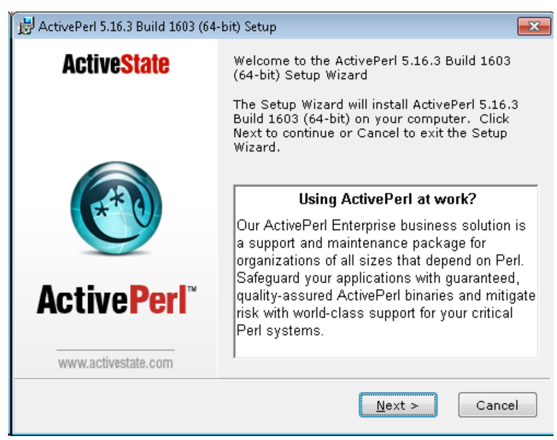
Click **Next**.



7.2.2 Install ActivePerl for Windows

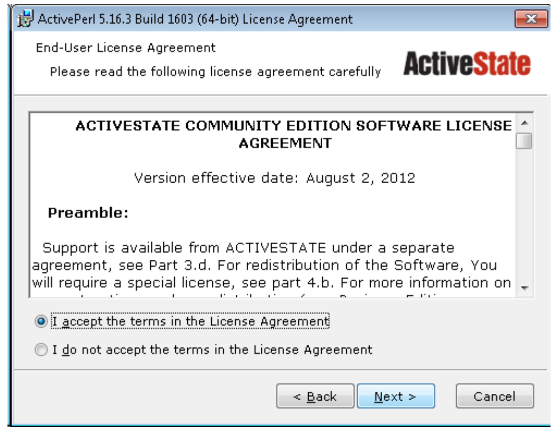
The ActivePerl Setup Window opens.

Click **Next**.



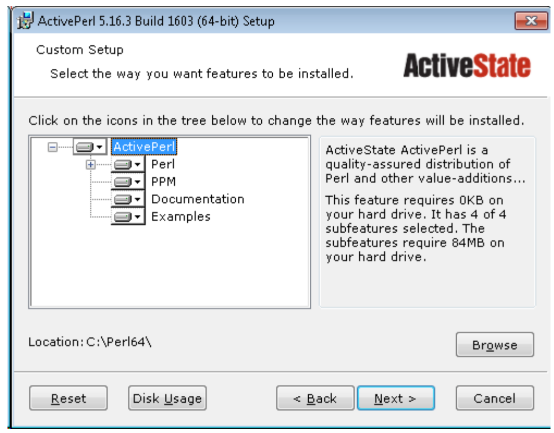
After reading the license, click the option to accept the terms of the license agreement.

Click **Next**.



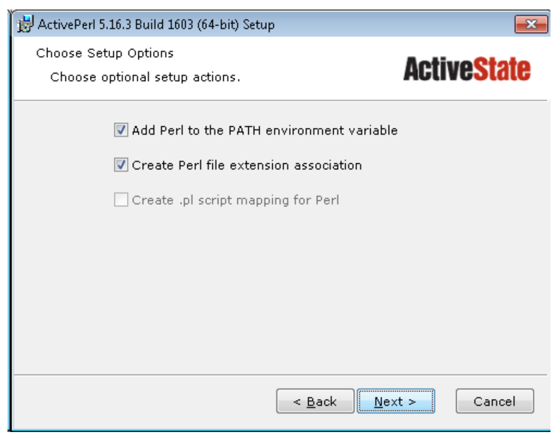
The **Custom Setup** screen appears.

Click **Next**.



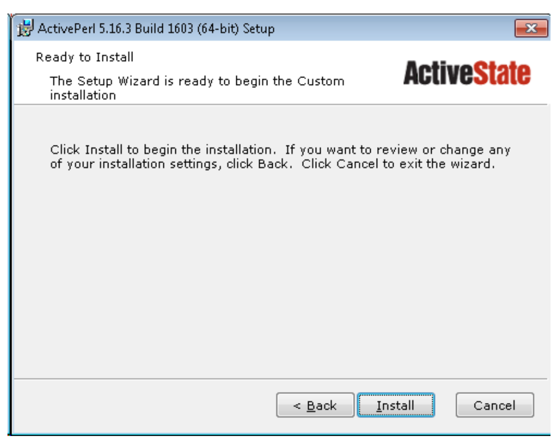
The **Choose Setup Options** screen appears. Do not uncheck the first two checkboxes.

Click **Next**.



The **Ready to Install** screen appears.

Click **Install**.



A window appears, stating the **Setup Wizard** has completed.

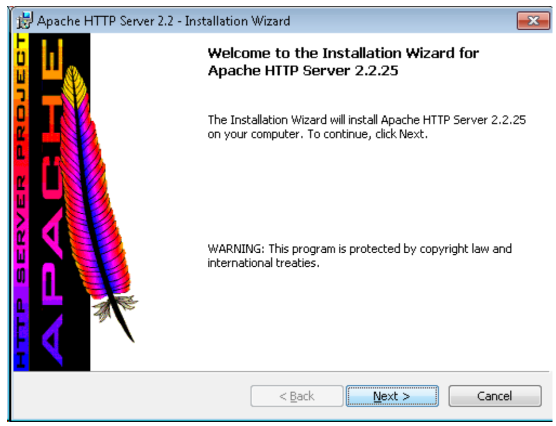
Click **Finish**.

The **ActivePerl Release Notes** appears.

7.2.3 Install Apache for Windows

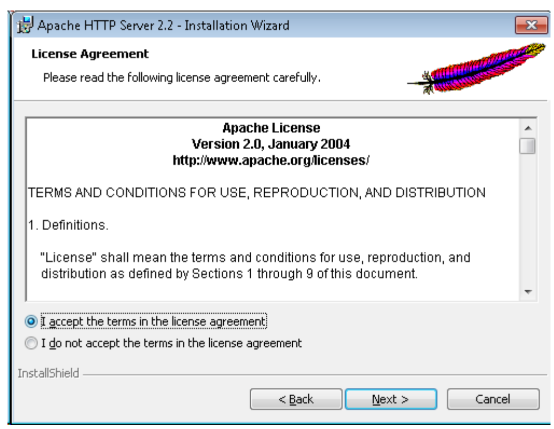
The **Apache HTTP Server Installation Wizard** appears.

Click **Next**.



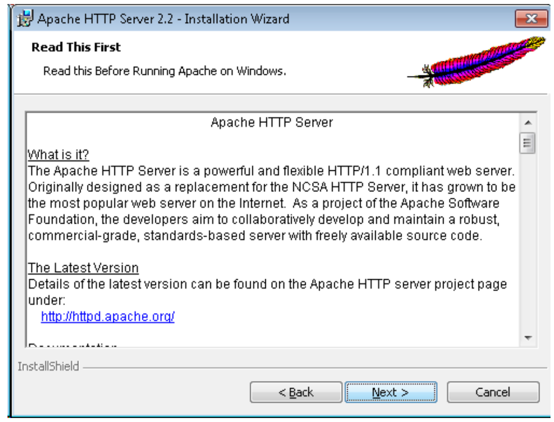
The Apache License Agreement screen appears. Click to accept the terms in the license agreement option to accept the terms.

Click **Next**.



The Apache Readme document screen appears.

Click **Next**.



The Apache Server Information screen appears.

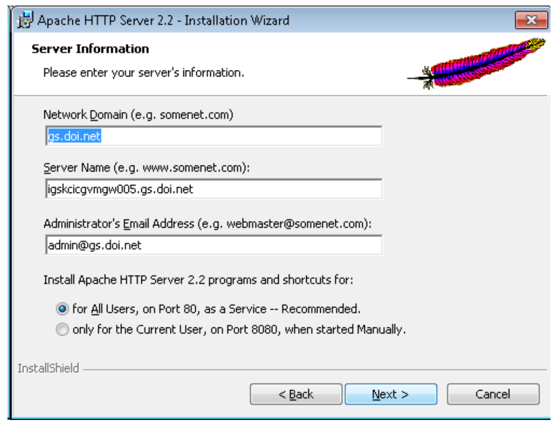
Type your network domain name.

Type your server name.

Type administrator's e-mail address.

Select the for All Users option to install for all users.

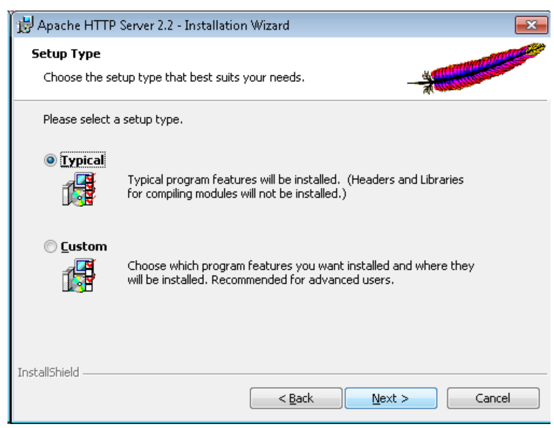
Click **Next**.



The Apache Setup Type screen appears.

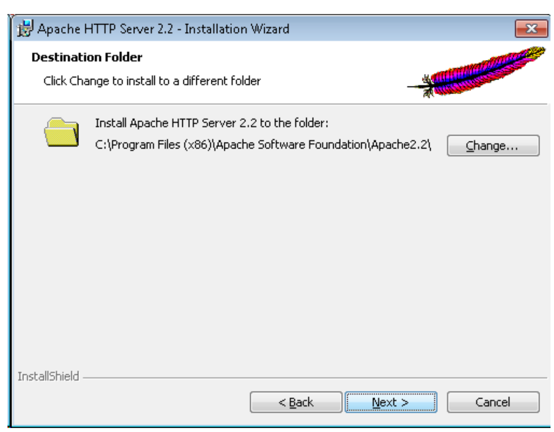
Click to select the Typical option.

Click **Next**.



The Apache Destination Folder screen appears.

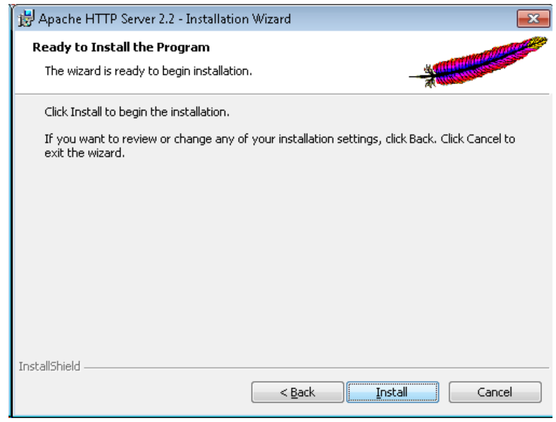
Click **Next**.



The wizard is ready to begin the installation.

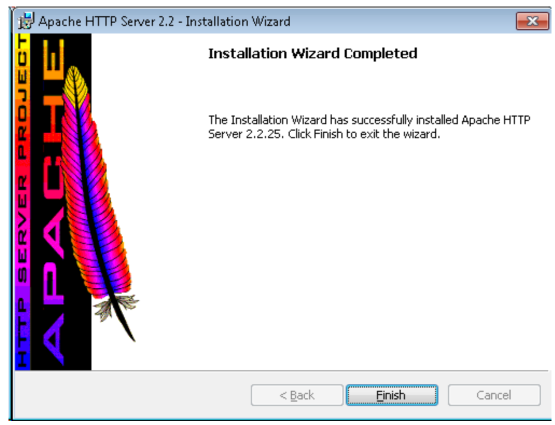
Click **Install**.

Apache for Windows is installed.



The Apache for Windows is installed.

Click **Finish**.



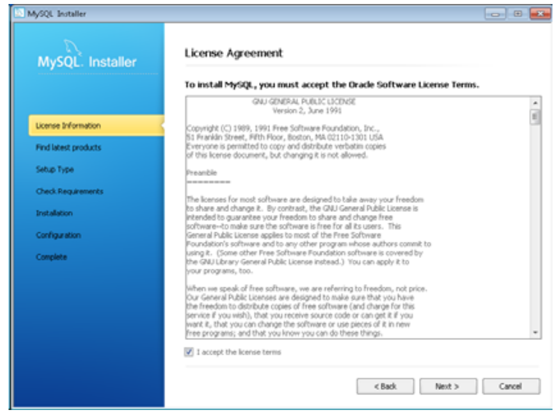
7.2.4 Install MySQL for Windows

The **MySQL Setup Wizard** appears.

Click **Install MySQL Products**.

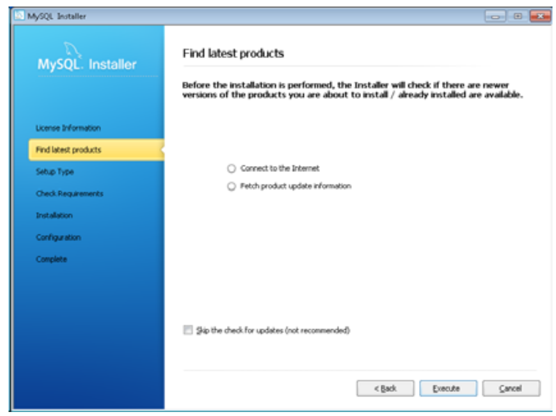
The MySQL License Agreement screen appears. Click to accept the terms in the license agreement option to accept the terms.

Click **Next**.



The MySQL Find latest products screen appears.

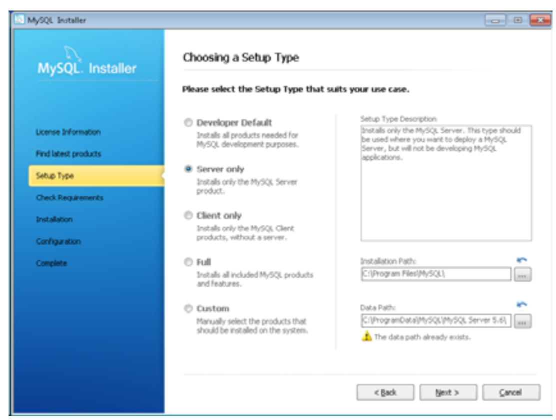
Click **Execute**.



The MySQL Choosing a Setup screen appears.

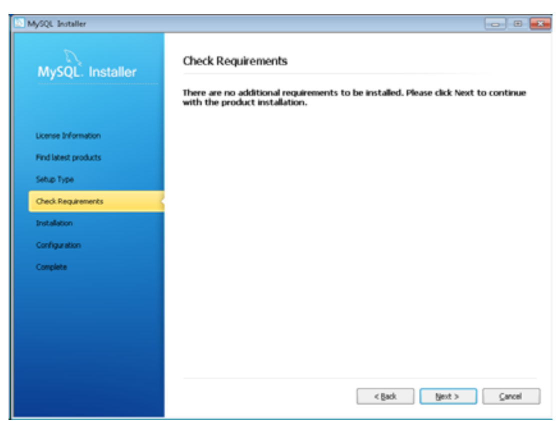
Select the **Server only** option.

Click **Next**.



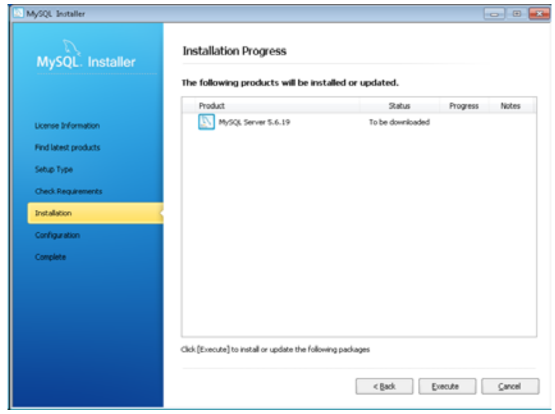
The MySQL Check Requirements screen appears.

Click **Next**.



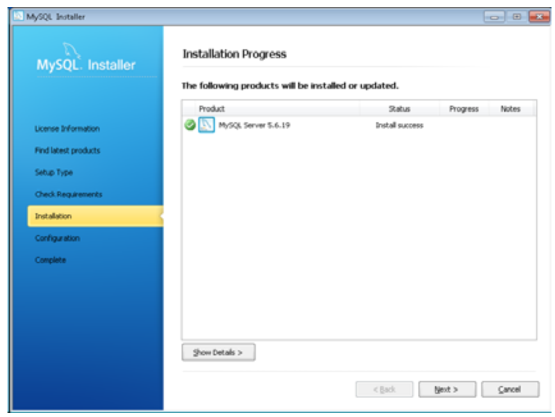
The MySQL Installation screen appears.

Click **Execute**.



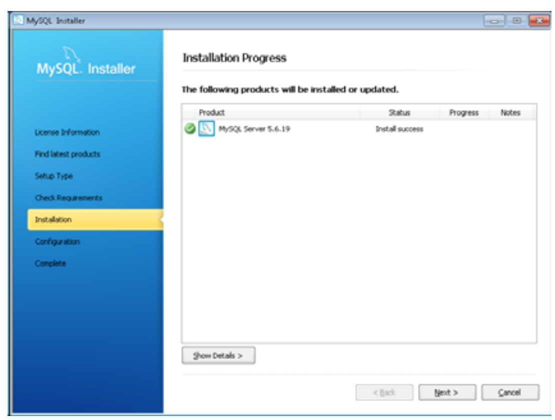
The MySQL Installation Progress is completed.

Click **Next**.



The MySQL Configuration screen appears.

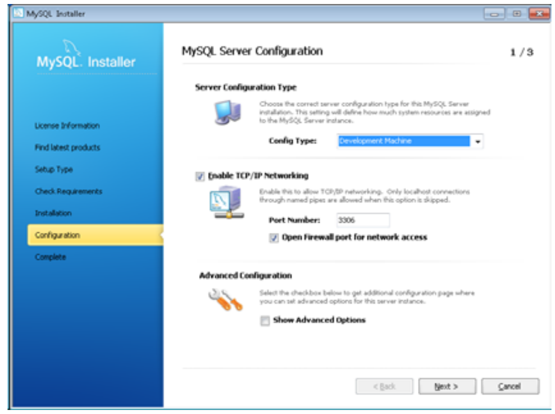
Click **Next**.



The MySQL Server Configuration screen appears.

Select Server Machine as the Config Type.

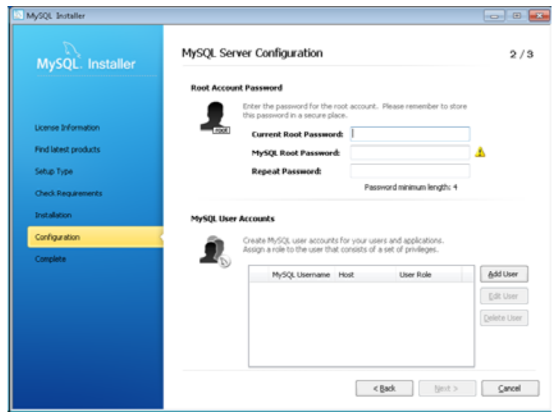
Click **Next**.



Step 2 of the MySQL Server Configuration screen appears.

Type in a root password.

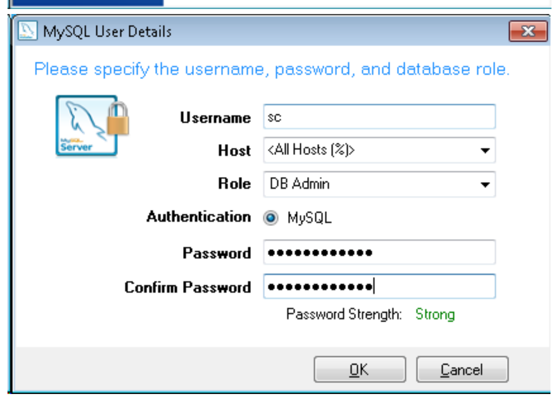
Click **Add User**.



Type in “sc” in Username field.

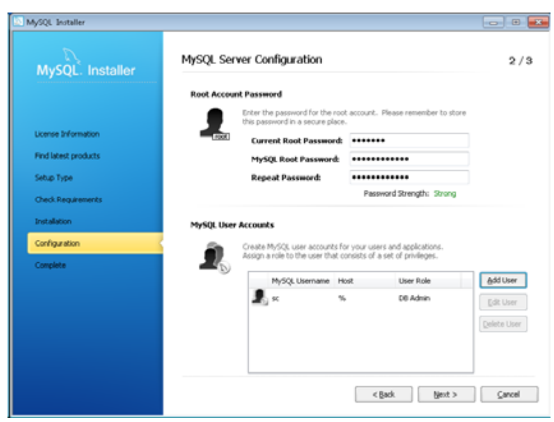
Type in a Password.

Click **OK**.



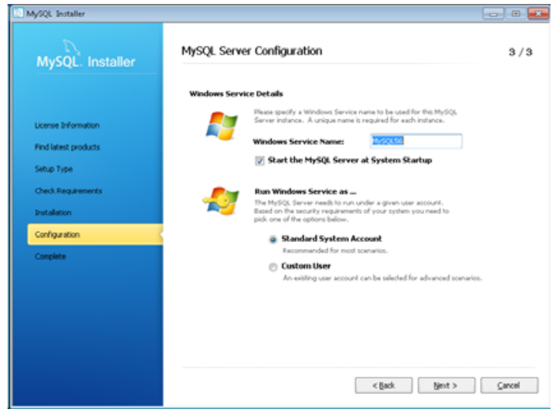
Return to Step 2 of the MySQL Server Configuration screen.

Click **Next**.



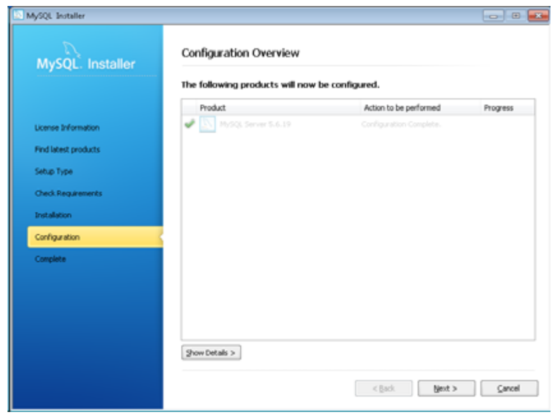
Step 3 of the MySQL Server Configuration screen appears.

Click **Next**.



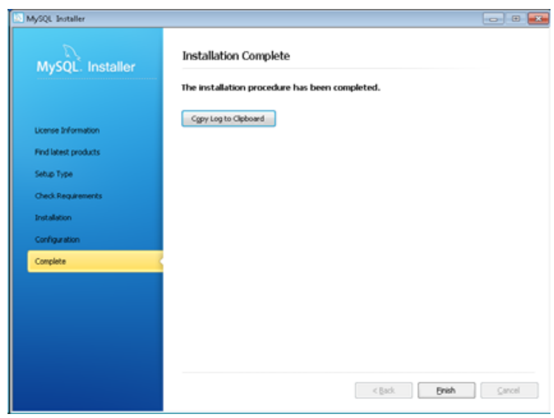
The MySQL Configuration Overview screen appears.

Click **Next**.



The MySQL Installation Complete screen appears.

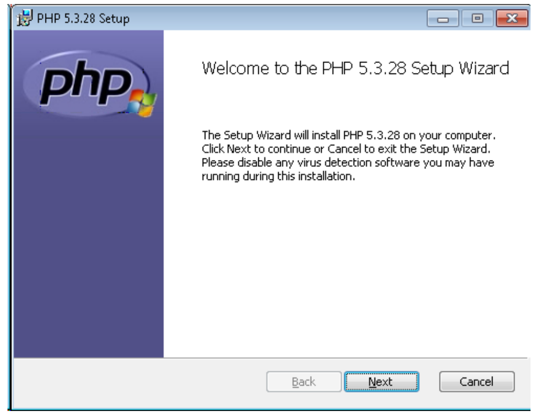
Click **Finish**.



7.2.5 Install PHP for Windows

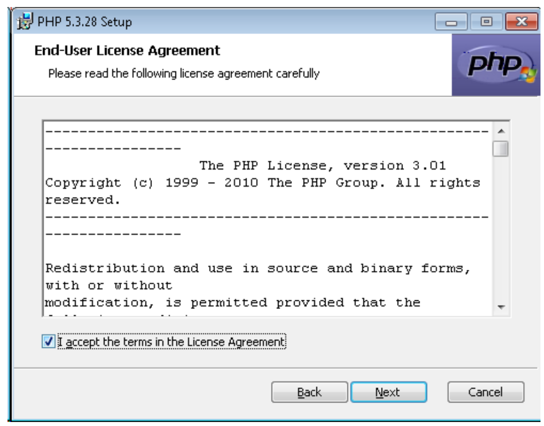
The **PHP Setup Wizard** appears.

Click **Nexts**.



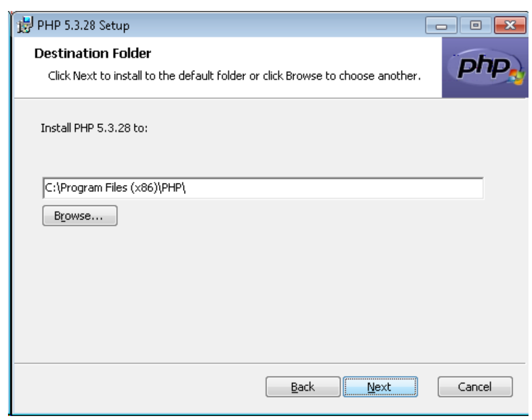
The PHP End-User License Agreement screen appears. Click to accept the terms in the license agreement option to accept the terms.

Click **Next**.



The PHP Destination Folder screen appears.

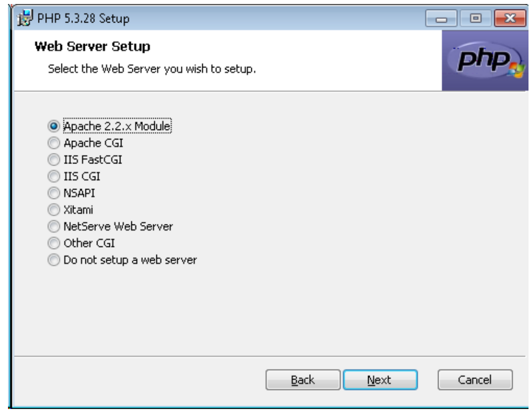
Click **Next**.



The PHP Web Server screen appears.

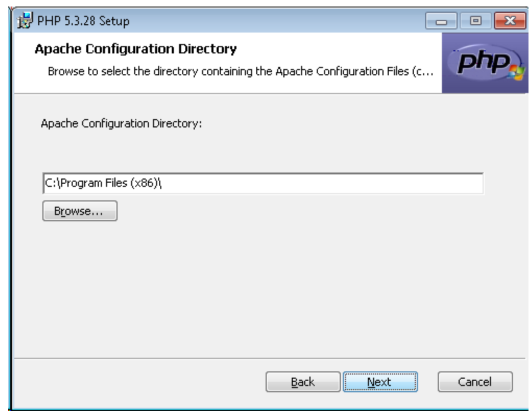
Select the Apache 2.2.x Module.

Click **Next**.



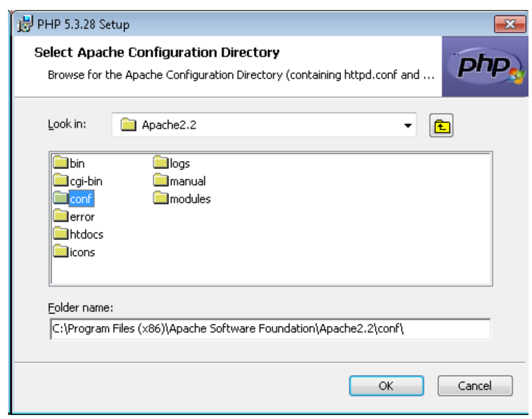
The PHP Apache Configuration Directory screen appears.

Click **Browse** to select the Apache Configuration Directory.



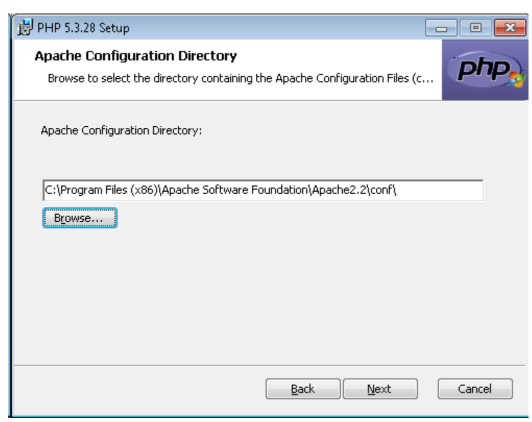
Navigate to the "C:\Program Files (x86)\Apache Software Foundation\Apache2.2\conf" directory.

Click **OK**.



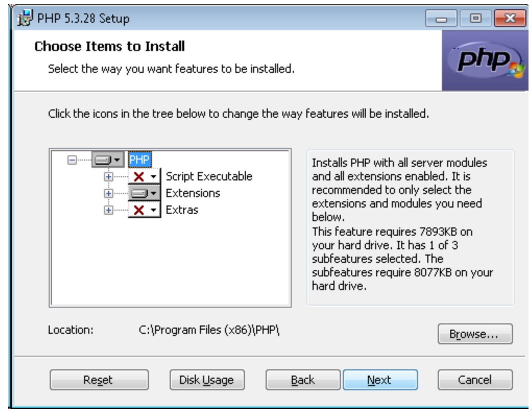
Return to the PHP Apache Configuration Directory screen.

Click **Next**.



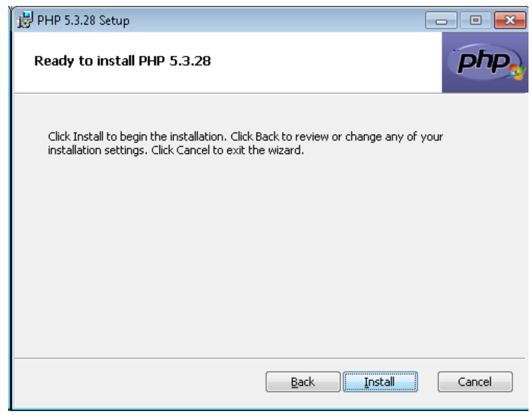
The PHP Choose Items to Install screen appears.

Click **Next**.



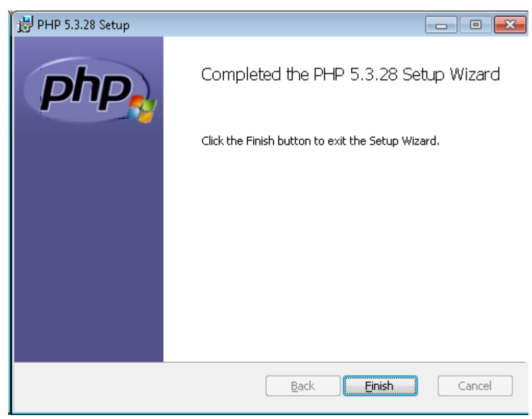
The Ready to Install PHP screen appears.

Click **Install**.



The PHP installation is completed.

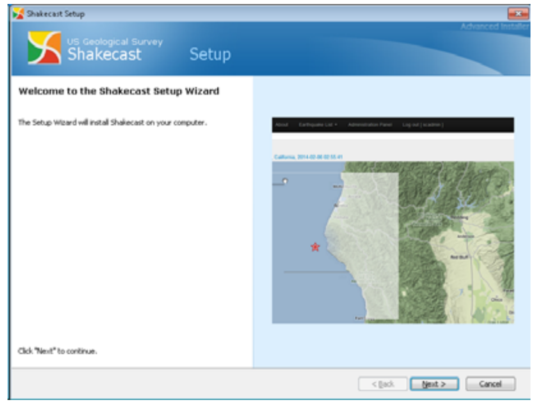
Click **Finishs**.



7.2.6 Install ShakeCast for Windows

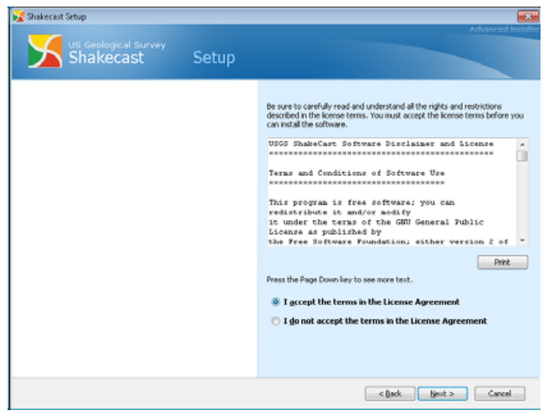
The **ShakeCast Setup Wizard** appears.

Click **Nexts**.



The ShakeCast End-User License Agreement screen appears. Click to accept the terms in the license agreement option to accept the terms.

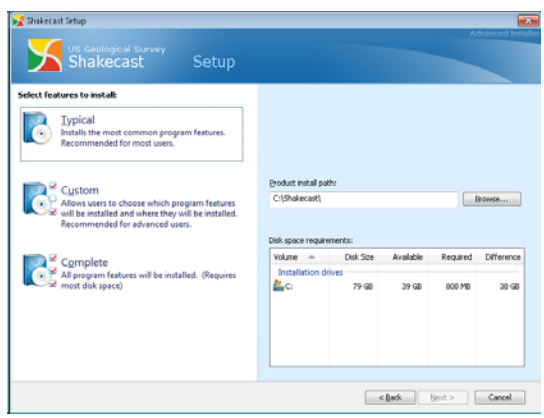
Click **Next**.



The ShakeCast Setup feature screen appears.

Click **Typical** to select the most common program features.

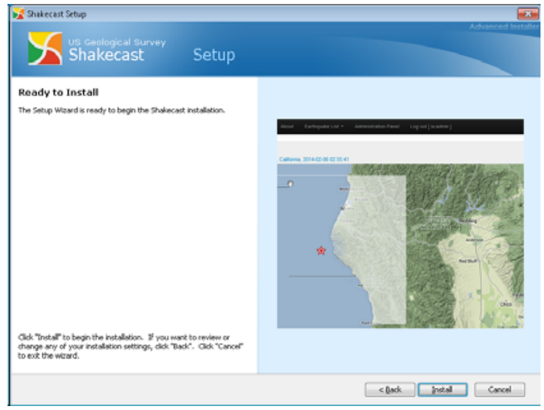
Click **Next**.



The ShakeCast Ready to Install screen appears.

Click **Install**.

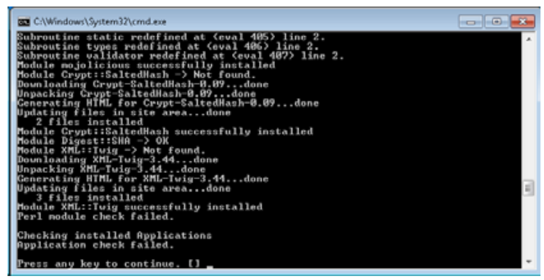
Installation of the base ShakeCast system may take several minutes to finish.



The ShakeCast Perl Post installation screen appears to start the automatic configuration process.

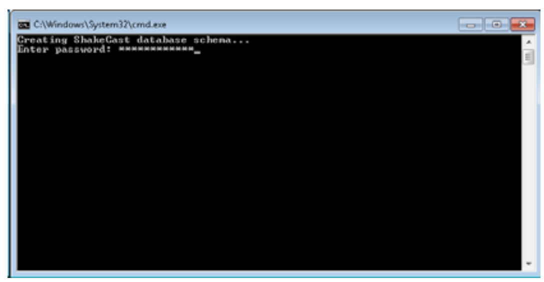
When the process is finished, the message “Press any key to continue. []” at the end of the screen.

Hit any key to Continue.



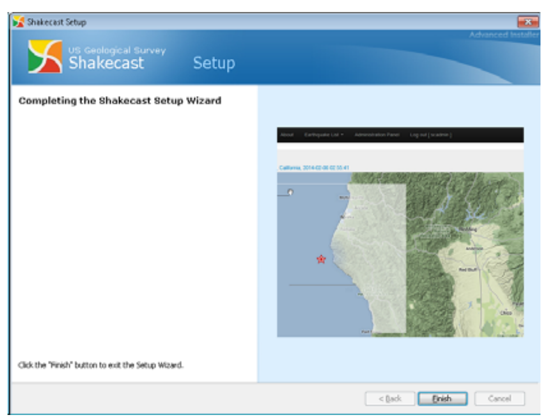
The ShakeCast Database Post installation screen appears.

Enter the root account password for the MySQL database and hit **Enter** to Continue.



The Completing the ShakeCast Setup Wizard screen appears.

Click **Finish**.



7.3 Post-installation Configuration of the ShakeCast System

The ShakeCast AWS VM is a pre-built ShakeCast system comes with a minimal set of configurations with a default email server and worldwide monitoring for earthquake of magnitude 3.0 or greater. Unlike the AWS VM, a fresh installation of ShakeCast does not include information for an email server or a polygon of earthquake monitoring.

Without defining any earthquake monitoring regions, the ShakeCast system continues to download earthquake data, ShakeMaps, and related products but will not attempt to process them. Thus no shaking estimates at facilities, local ShakeCast products, and ShakeCast notifications will be performed as the result.

When customizing the ShakeCast system, the user is highly advised to prepare inventory files outside the ShakeCast system and use the administrative web interface or the equivalent command-line tool to update the database. The ShakeCast V3 system employs a new policy in handling user inventory. In contrast to the legacy V2 system, which allows direct editing of user inventory in the database, the V3 system disables most of the functionality to ensure data consistency. To complement the change, a centralized upload page has been developed to simplify the process of inventory import. The administrator should refer the ShakeCast V3 Guide for further information.

7.3.1 Activate Earthquake Processing

To activate earthquake processing, the administrator simply defines at least one ShakeCast group. The geometric footprints (an enclosed polygon) of the newly defined group become the earthquake monitoring area. When multiple areas are defined, the union of the monitoring regions becomes the new monitoring area.

The example below defines an earthquake monitoring that covers the State of California and bordering regions. Also included is a notification preference for new earthquakes of magnitude 3.0 or greater for the specified region.

```
# Group Configuration file for CA
# $Id: ca.conf 221 2014-07-23 21:04:39Z klin $

<CA>
        POLY    43.000 -126.000       \
                39.000 -126.000       \
                34.000 -123.000       \
                31.000 -118.000       \
                31.000 -113.000       \
                36.000 -113.000       \
                39.000 -118.000       \
                43.000 -118.000       \
                43.000 -126.000

        <NOTIFICATION>
                NOTIFICATION_TYPE             NEW_EVENT
                DELIVERY_METHOD               EMAIL_HTML
                EVENT_TYPE                    ALL
                AGGREGATE                     1
                LIMIT_VALUE                   3
        </NOTIFICATION>
</CA>
```

The format of ShakeCast group definition is the same as the profile definition for the ShakeCast V2 system. Besides syntax, the V3 system has an extended list of options. Although not strictly enforced, it is recommended to postfix ShakeCast group definition file with a *.conf* file extension. Group definition file can be processed by ShakeCast via either the upload tool from the web interface or from the command line with the **manage_group.pl** tool. After the group file has been successfully process, the ShakeCast group is displayed under the **User** tab of the administrative interface as shown in Figure 7.1.

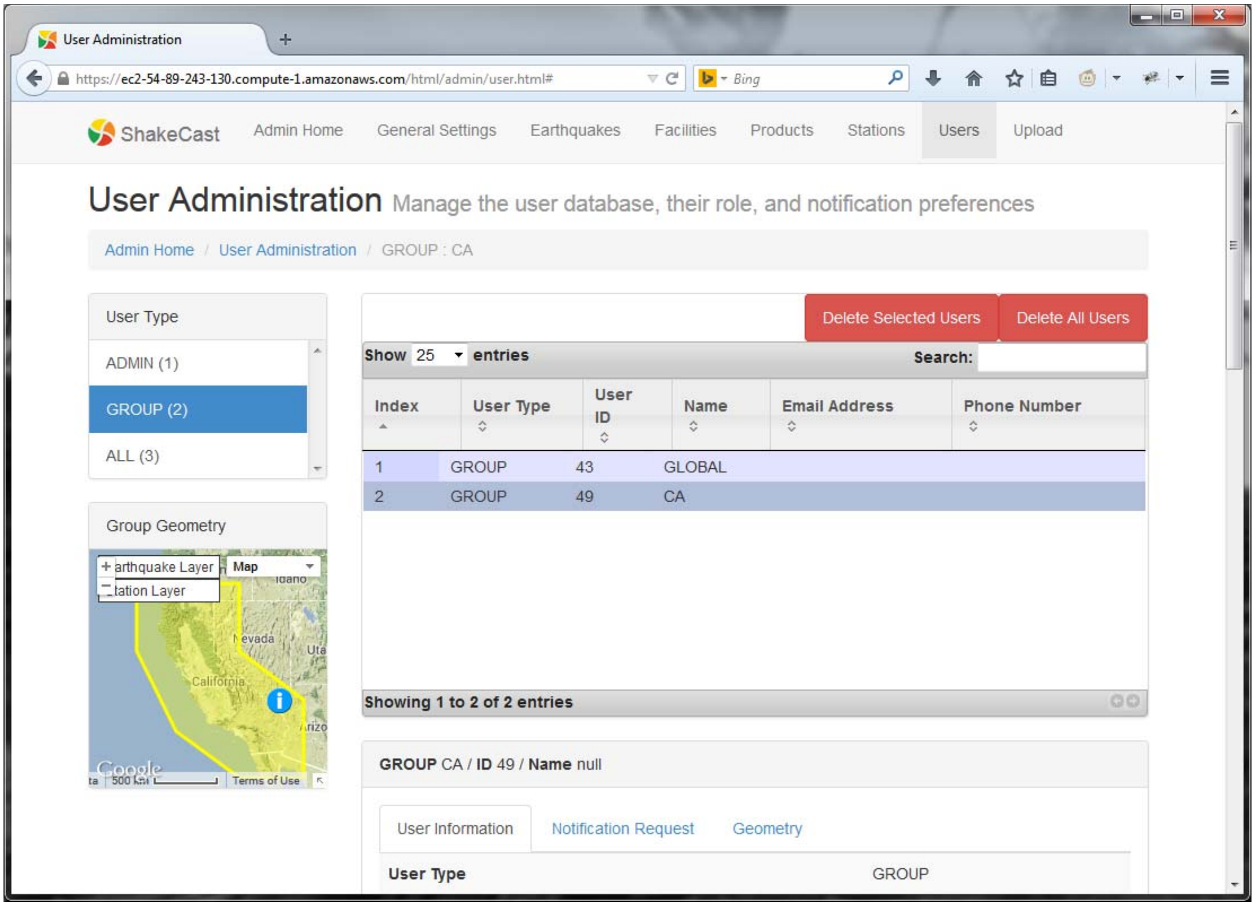


Figure 7.1. ShakeCast CA Group Example.

7.3.2 Configure Email Server for Notification

In comparison with the V2 system, which supports only the Simple Mail Transfer Protocol (SMTP) in plain text, ShakeCast V3 supports the following email protocols,

- Mail Transport Agent (MTA) via mailx
- SMTP with plain text with and without authentication
- SMTP over Secure Sockets Layer (SSL)
- SMTP over Transport Layer Security (TLS)

By default, Linux-based ShakeCast installations (such as the ShakeCast AWS VM) use the built-in mailx utility and require no manual configuration for an email server. The administrator can choose to overwrite the default by specifying an SMTP email server. The Windows system typically lacks MTA support and thus the administrator is advised to enter an SMTP server for delivering ShakeCast notifications.

The administrator can enter the SMTP information from either the web interface under the **General Settings** tab or by editing the ShakeCast system configuration file located at "*<sc_home>/sc/conf/sc.conf*". Required information for an SMTP email server includes:

- DNS hostname of the SMTP server
- Security Layer (none/SSL/TLS)
- Service port (25/465/587)
- Username and Password

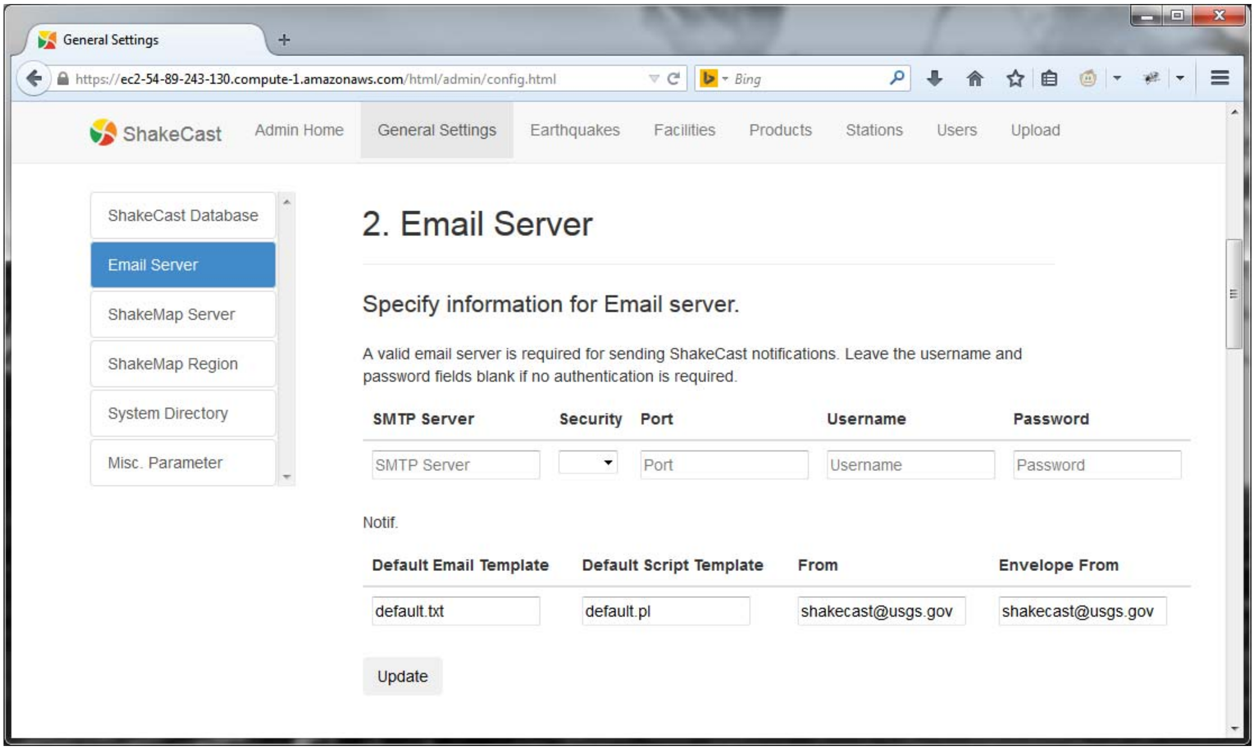


Figure 7.2. SMTP Email server configuration via the web interface.

In addition, the administrator will need to enter a valid email address into the **From** and **Envelope From** fields as the sender email address of the ShakeCast system.

The corresponding section inside the sc.conf file is listed as the Notification block as shown below,

```
<Notification>
    SmtpServer   smtp.gmail.com
    Security   SSL
    Port   465
    DefaultEmailTemplate   default.txt
    DefaultScriptTemplate   default.pl
    Password
    Username
    EnvelopeFrom
    From
</Notification>
```

After saving email server information, the administrator will need to restart the ShakeCast notification service in order to reload the new configuration settings. Restart of ShakeCast services is described in the next section.

7.3.3 Restart ShakeCast System Services

Starting in ShakeCast V3, the administrator no longer controls ShakeCast system services (daemon services on Linux) from the administrative interface. The administrator will require local administration privileges to restart the services.

As a general rule of thumb, restart of system services is needed whenever changes are made to entries under the **General Settings** tab or the system configuration file "*sc.conf*". On the Linux system, two shell scripts are prepared to start/stop daemon services,

- To start services, execute the script “/usr/local/shakecast/sc/rc.d/sc-start-watcher.sh”
- To stop services, execute the script “/usr/local/shakecast/sc/rc.d/sc-stop.sh”

On the Windows system, two batch files are prepared to start/stop system service,

- To start services, execute the batch “<sc_home>/admin/start_sc_services.bat”
- To stop services, execute the batch “<sc_home>/admin/stop_sc_services.bat”

7.4 Inventory Management for ShakeCast

The ShakeCast database is a centralized repository that keeps track of information from several different sources. The scope of information covers sources of the following origins,

- User provided inventory for facilities, user groups, and users.
- Earthquake information and related products including ShakeMap and others from the USGS.
- Local ShakeCast products generated as part of the earthquake processing.
- Notification delivery records and miscellaneous system messages.

Once processed, the above information becomes structured data and may be stored among several interconnected tables inside the database. Figure 7.3 illustrates the database schema for user’s facility inventory on basic information, attributes, features, and fragility. Note how information from a facility entry is distributed across multiple tables. The ShakeCast administrator should not edit records of the ShakeCast database directly with a database viewing/editing tool but via the ShakeCast administrative interface or the command line tool to avoid database corruptions.

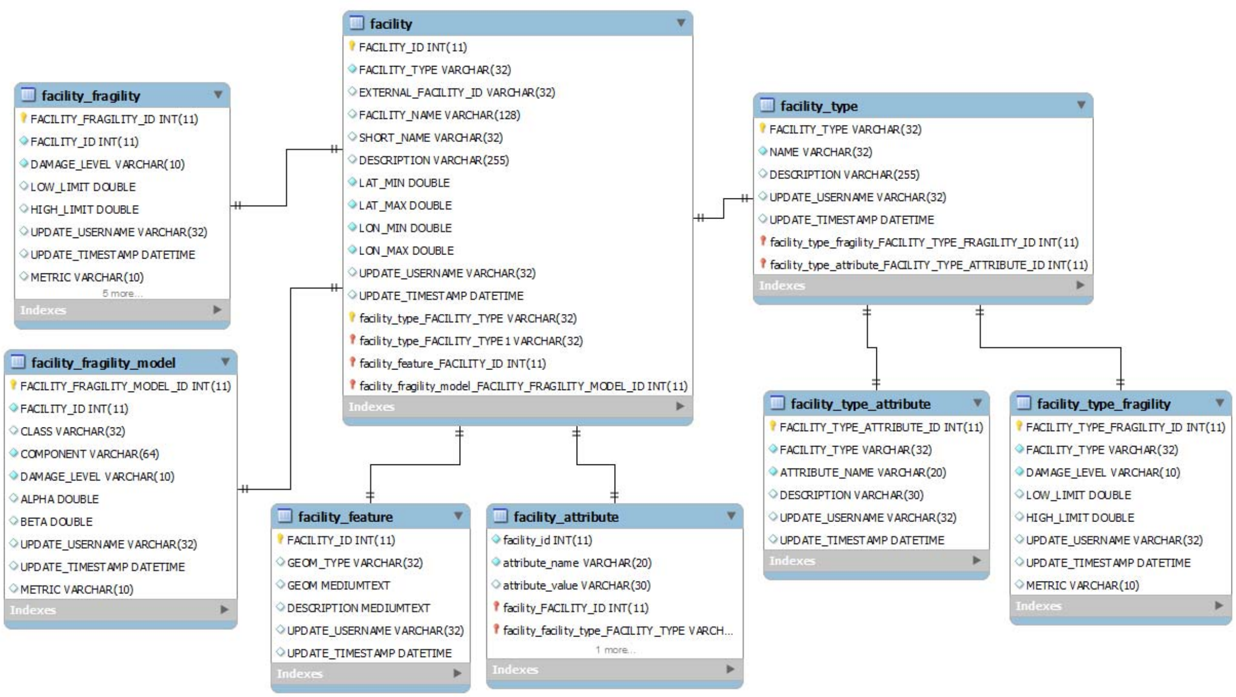


Figure 7.3. Database schema for facility inventory stored in ShakeCast.

7.4.1 System and Database Reset

The size of the database and file system of a ShakeCast system will gradually increase as it processes more earthquakes. Depending on available resources for ShakeCast, users may experience slow performance as the result. Even though the V3 system comes with an automated service that routinely deletes unwanted events from the system, there are occasions when an administrator simply wants to reset the system to its original state.

7.4.1.1 System Reset

To reset a ShakeCast system under Linux-based operation system, the administrator will need to manually purge the database before deleting the installed code base from the file system. Once ShakeCast is removed from the system, the administrator can check out a new copy of ShakeCast from the USGS github repository below to perform manual installation.

https://github.com/klin-usgs/ShakeCast

Manually installation of ShakeCast under Linux is not covered in this report and users should refer to the ShakeCast wiki for latest information.

To reset a ShakeCast system under Windows operating system, the administrator simply use the ShakeCast Installer program to re-install the application as described in Sec. 7.2.6.

7.4.1.2 Database Reset

Database reset is an effective way to deal with out-of-control inventory, critical mis-configuration (such as server information), or crash of a ShakeCast database. The administrator must perform the database reset task from the command line interface.

To reset the ShakeCast database, open a Command Prompt with local Administrator privileges and switch to the ShakeCast administration script directory, default “C:\ShakeCast\admin”. The administrator then performs the following five batch scripts in sequence to reset the database (Figure 7.4).

1. Drop existing “sc” database and create a new one, “create_sc_db.bat”
2. Create ShakeCast database table, “create_sc_tables.bat”
3. Load default data, “load_sc_data.bat”
4. Restart ShakeCast services, “start_sc_services.bat”
5. Activate routine tasks, “inject_init.bat”

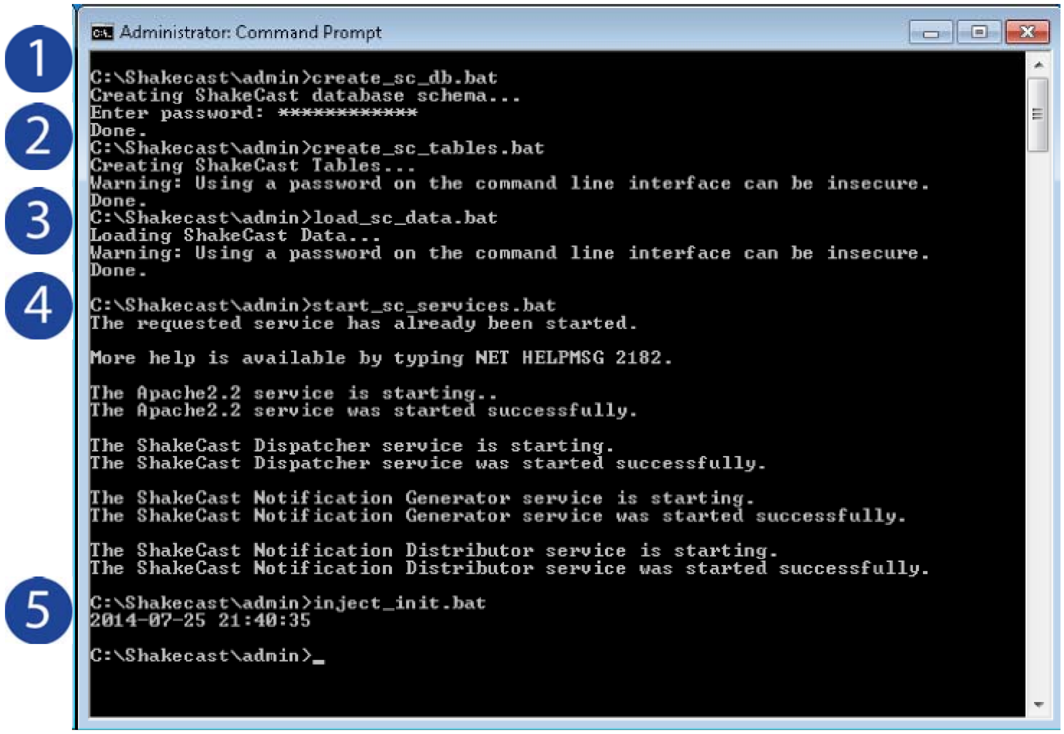


Figure 7.4. Database reset sequence in ShakeCast for Windows.

7.4.2 Caltrans Facility Inventory

For purposes of development at testing, four types of facilities were defined for the Caltrans ShakeCast system – state bridges (BRIDGE_ST), local bridges (BRIDGE_LC), Caltrans buildings (BUILDING), and roadways with landslide potential (ROAD). To support the new component-based fragility assignment and geometric footprints for a facility, a new file format in XML has been defined to accommodate the expanded scope of information.

Figure 7.5 shows an example with information for a typical bridge with 20 components. The uniqueness requirement combining the **FACILITY_TYPE** and **FACILITY_NAME** fields per facility from V2 still applies to the V3 system. Specifically, basic information for the facility is shown in Figure 7.5(a). Figure 7.5(b) shows geometric features and optional custom html snippet (for web presentation). The minimum bounding box of the facility will be used to assess ground motion estimates at the location of facility. Figure 7.5(c) shows fragility settings for each defined component and the fragility settings for **SYSTEM** component will become the representative settings for the purpose of notifications. Fragility settings for each component consist of one chosen metric and one mean and beta pair for every inspection priority.

For building inventory, one component (SYSTEM) is defined per facility. As part of this project, we have ported the fragility settings for HAZUS model building types to the V3 specifications. Building inventory will have fragility settings associated with selected HAZUS model building type once defined.

For roadway inventory, no specific fragility settings are planned for this inventory category. The roadway inventory will include a polyline geometric feature that traces the roadway segment. Shaking along the roadway will be evaluated and summarized in a separate output product “facility_feature_shaking.xml” to be further development in the future project.

In the case when a facility does not come with comprehensive information, the administrator can still use the legacy file format (in CSV) for facility inventory. Details for preparation of facility inventory in the CSV format is described in Appendix D.

(a)

	A	B	C	D	E	F	G
1	EXTERNAL_FACILITY_ID	FACILITY_TYPE	COMPONENT_CLASS	COMPONENT	FACILITY_NAME	SHORT_NAME	DESCRIPTION
2	123456	BRIDGE	1_System	SYSTEM	DEMO BRIDGE	123456	Demonstration bridge
3	123456	BRIDGE	2_Primary_TESTING	ABUT_SEAT			
4	123456	BRIDGE	2_Primary_TESTING	COLUMN			
5	123456	BRIDGE	2_Primary_TESTING	HINGE_SEAT			
6	123456	BRIDGE	2_Primary_TESTING	SUPPORT_SEAT			
7	123456	BRIDGE	3_Secondary_TESTING	ABUT_BEARING			
8	123456	BRIDGE	3_Secondary_TESTING	ABUT_RESTRAINER			
9	123456	BRIDGE	3_Secondary_TESTING	ABUT_SEAL			
10	123456	BRIDGE	3_Secondary_TESTING	HINGE_BEARING			
11	123456	BRIDGE	3_Secondary_TESTING	HINGE_RESTRAINER			
12	123456	BRIDGE	3_Secondary_TESTING	HINGE_SEAL			
13	123456	BRIDGE	3_Secondary_TESTING	SUPPORT_BEARING			
14	123456	BRIDGE	3_Secondary_TESTING	SUPPORT_RESTRAINER			
15	123456	BRIDGE	3_Secondary_TESTING	SUPPORT_SEAL			
16	123456	BRIDGE	4_General_Distress_TESTING	ABUTMENT			
17	123456	BRIDGE	4_General_Distress_TESTING	FOUNDATION			
18	123456	BRIDGE	4_General_Distress_TESTING	SHEAR_KEY			
19	123456	BRIDGE	4_General_Distress_TESTING	RESPONSE			
20	123456	BRIDGE	5_Ground_Failure_TESTING	LANDSLIDE			

(b)

	A	B	I	J
1	EXTERNAL_FACILITY_ID	FACILITY_TYPE	FEATURE:GEOM	FEATURE:DESCRIPTION
2	123456	BRIDGE	-124.055065,41.553771,0	<table border="0" cellpadding="3" cellspacing="3" height="250" width=
3	123456	BRIDGE		
4	123456	BRIDGE		
5	123456	BRIDGE		
6	123456	BRIDGE		
7	123456	BRIDGE		
8	123456	BRIDGE		
9	123456	BRIDGE		
10	123456	BRIDGE		
11	123456	BRIDGE		
12	123456	BRIDGE		
13	123456	BRIDGE		
14	123456	BRIDGE		
15	123456	BRIDGE		
16	123456	BRIDGE		
17	123456	BRIDGE		
18	123456	BRIDGE		
19	123456	BRIDGE		
20	123456	BRIDGE		

(c)

	A	B	K	L	M	N	O	P	Q	R	S	T	U
1	EXTERNAL_FACILITY_ID	FACILITY_TYPE	METRIC	METRIC:ALPHA:GREY	METRIC:BETA:GREY	METRIC:ALPHA:GREEN	METRIC:BETA:GREEN	METRIC:ALPHA:YELLOW	METRIC:BETA:YELLOW	METRIC:ALPHA:ORANGE	METRIC:BETA:ORANGE	METRIC:ALPHA:RED	METRIC:BETA:RED
2	123456	BRIDGE	PSA10	0.001	0.6	10	0.6	96.94	0.6	116.33	0.6	164.79	0.6
3	123456	BRIDGE	PSA10	0.001	0.6	9.15	0.6	83.37	0.6	94.22	0.6	145.02	0.6
4	123456	BRIDGE	PSA10	0.001	0.6	9.86	0.6	89.18	0.6	100.04	0.6	158.20	0.6
5	123456	BRIDGE	PSA10	0.001	0.6	8.6	0.6	86.27	0.6	104.69	0.6	138.43	0.6
6	123456	BRIDGE	PSA10	0.001	0.6	8.41	0.6	95.00	0.6	101.20	0.6	149.96	0.6
7	123456	BRIDGE	PSA10	0.001	0.6	8.92	0.6	91.12	0.6				
8	123456	BRIDGE	PSA10	0.001	0.6	9.07	0.6	86.27	0.6				
9	123456	BRIDGE	PSA10	0.001	0.6	9.58	0.6	90.15	0.6				
10	123456	BRIDGE	PSA10	0.001	0.6	9.25	0.6	89.18	0.6				
11	123456	BRIDGE	PSA10	0.001	0.6	8.02	0.6	95.00	0.6				
12	123456	BRIDGE	PSA10	0.001	0.6	8.02	0.6	77.55	0.6				
13	123456	BRIDGE	PSA10	0.001	0.6	8.74	0.6	84.34	0.6				
14	123456	BRIDGE	PSA10	0.001	0.6	9.94	0.6	90.15	0.6				
15	123456	BRIDGE	PSA10	0.001	0.6	[illegible]	[illegible]	[illegible]	[illegible]				
16	123456	BRIDGE	PSA10	0.001	0.6	[illegible]	[illegible]	[illegible]	[illegible]				
17	123456	BRIDGE	PSA10	0.001	0.6	[illegible]	[illegible]	[illegible]	[illegible]				
18	123456	BRIDGE	PSA10	0.001	0.6	[illegible]	[illegible]	[illegible]	[illegible]				
19	123456	BRIDGE	PSA10	0.001	0.6	8.7	0.6	87.24	0.6				
20	123456	BRIDGE	PGA	0.001	0.6	9.35	0.6	96.94	0.6				

Note: *The fragility parameters shown here were randomly generated for testing and development purposes only.*

Figure 7.5. Sample facility information for one State bridge: (a) Basic bridge information, (b) bridge geometric features, and (c) fragility settings for bridge components.

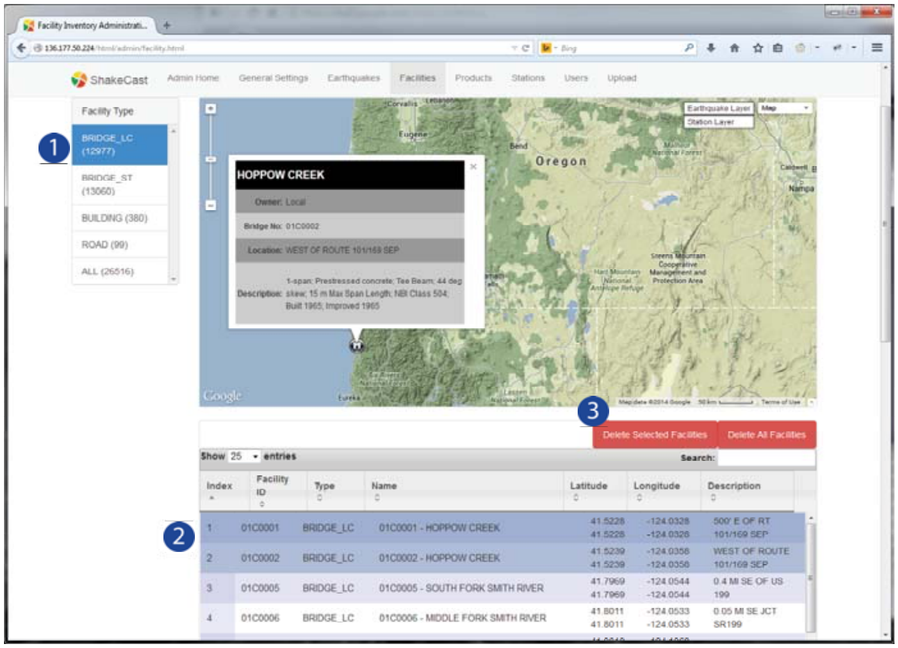
After the facility inventory is saved into a file, e.g. *bridge.xml*, it can be processed by the ShakeCast system via either the **Upload** tab from the administrative interface or the command line script *manage_facility_xml.pl* with the following syntax

```
C:\ShakeCast\sc\bin\manage_facility_xml.pl bridge.xml
```

To delete selected facilities from the ShakeCast database, select the **Facilities** tab from the administrative web interface.

1. Select Facility Type
2. Highlight facilities to be deleted
3. Click the **Delete Selected Facilities** button to delete

To delete all facilities of the selected facility type, click the **Delete All Facilities** button



To revert or delete the facility inventory using the tool under the **Upload** tab, drop-in the same facility inventory file and choose the **Delete** option before submit. With the command line script, *manage_facility_xml.pl,* issue the following syntax

```
C:\ShakeCast\sc\bin\manage_facility_xml.pl –delete bridge.xml
```

7.4.3 Caltrans User Groups

As described in Sec. 7.3.1, a ShakeCast user group registers both the earthquake monitoring region and the notification requests for the user group. For the Caltrans application, we define an area that covers the entire State of California plus one degree buffer for statewide earthquake monitoring. As the result, the contributing networks for earthquake information are not limited to the California Integrated Seismic Network (CISN) and will also include Pacific Northwest network (UW), the Nevada network (NN), and the Global Seismic Network (GSN). Sub-division groups can be derived from the statewide group to provide notifications for specific needs.

Because of the expanded facility inventory stored inside the V3 database, several user groups will be created (one group per facility type). A user can sign up to multiple groups to further customize his notification preference. The criteria of ShakeCast notifications remain similar during the transition from V2 to V3 system. As an example, the Caltrans State Bridge group configuration file shown below contains four directives:

1. **FACILITY_TYPE** directive specifies a filter for state bridges only.
2. **POLY** directive specifies an area for statewide coverage.

3. **NEW_EVENT NOTIFICATION** directive specifies notification requests for new earthquakes (once per event).
4. **Inspection Priority (DAMAGE) NOTIFICATION** directive specifies notifications requests for an aggregated list of state bridges in either GREEN, YELLOW, ORANGE, and RED states. This directive will exclude state bridges tagged as GREY (Below Threshold) and will attach a ShakeCast summary PDF file if it is available at the time of notification.

```
<BRIDGE_ST>
        FACILITY_TYPE  BRIDGE_ST

        POLY    43.000 -126.000        \
                        39.000 -126.000        \
                        34.000 -123.000        \
                        31.000 -118.000        \
                        31.000 -113.000        \
                        36.000 -113.000        \
                        39.000 -118.000        \
                        43.000 -118.000        \
                        43.000 -126.000

        <NOTIFICATION>
                NOTIFICATION_TYPE              NEW_EVENT
                DELIVERY_METHOD                EMAIL_HTML
                EVENT_TYPE                     ACTUAL
                AGGREGATE                      1
                LIMIT_VALUE                    4
        </NOTIFICATION>

        <NOTIFICATION>
                NOTIFICATION_TYPE              DAMAGE
                DELIVERY_METHOD                EMAIL_HTML
                DAMAGE_LEVEL                   GREEN
                EVENT_TYPE                     ACTUAL
                AGGREGATE                      1
                AGGREGATION_GROUP              BRIDGE_ST
                PRODUCT_TYPE                   PDF_BRIST
        </NOTIFICATION>
        <NOTIFICATION>
                NOTIFICATION_TYPE              DAMAGE
                DELIVERY_METHOD                EMAIL_HTML
                DAMAGE_LEVEL                   YELLOW
                EVENT_TYPE                     ACTUAL
                AGGREGATE                      1
                AGGREGATION_GROUP              BRIDGE_ST
                PRODUCT_TYPE                   PDF_BRIST
        </NOTIFICATION>
        <NOTIFICATION>
                NOTIFICATION_TYPE              DAMAGE
                DELIVERY_METHOD                EMAIL_HTML
                DAMAGE_LEVEL                   ORANGE
                EVENT_TYPE                     ACTUAL
                AGGREGATE                      1
                AGGREGATION_GROUP              BRIDGE_ST
                PRODUCT_TYPE                   PDF_BRIST
        </NOTIFICATION>
        <NOTIFICATION>
                NOTIFICATION_TYPE              DAMAGE
                DELIVERY_METHOD                EMAIL_HTML
                DAMAGE_LEVEL                   RED
                EVENT_TYPE                     ACTUAL
                AGGREGATE                      1
                AGGREGATION_GROUP              BRIDGE_ST
                PRODUCT_TYPE                   PDF_BRIST
        </NOTIFICATION>
</BRIDGE_ST>
```

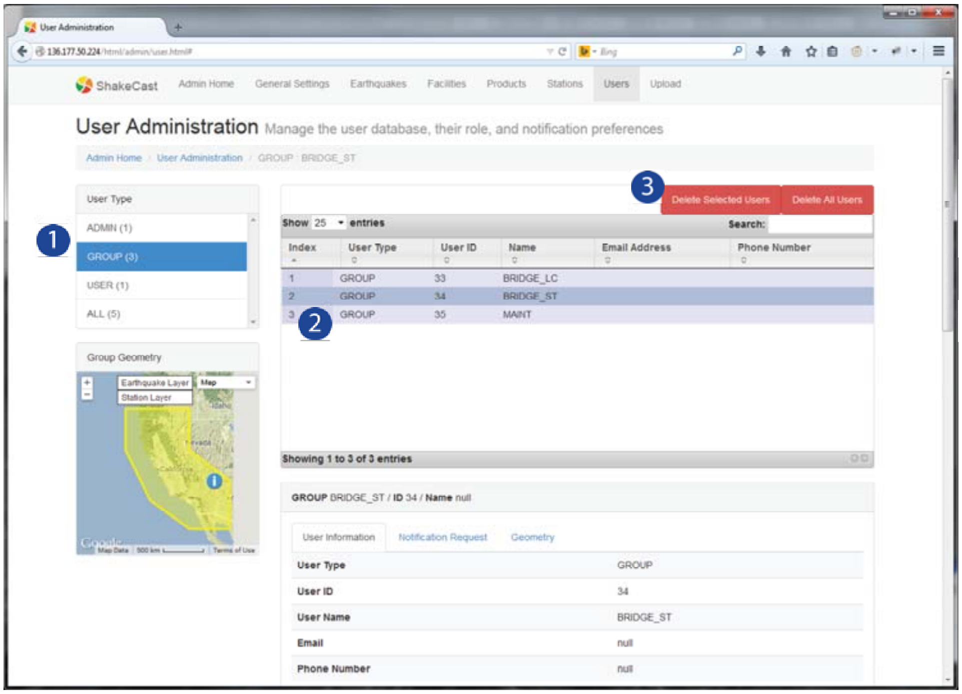
After the group configuration is saved into a file, *bridge_st.conf*, it can be processed by the ShakeCast system via either the **Upload** tab from the administrative interface or the command line script *manage_group.pl* with the following syntax

```
C:\ShakeCast\sc\bin\manage_group.pl –conf bridge_st.conf
```

To delete selected groups from the ShakeCast database, select the **Users** tab from the administrative web interface.

1. Select **GROUP** User Type
2. Highlight groups to be deleted
3. Click the **Delete Selected Users** button to delete

To delete all groups of the selected facility type, click the **Delete All Users** button



To revert or delete the facility inventory using the tool under the **Upload** tab, drop-in the same group inventory file and choose the **Delete** option before submit. With the command line script, *manage_group.pl,* issue the following syntax

```
C:\ShakeCast\sc\bin\manage_group.pl –delete –conf bridge_st.conf
```

7.4.4 Caltrans User Inventory

In the current Caltrans ShakeCast V2 system, the user function is not fully implemented due to performance restrictions. Instead a user mailing list is configured to deliver notification messages and all users of the mailing list receive the same earthquake message. During the development of the V3 system, we redesigned the notification process to address the performance issue.

The V3 system disables user-specific notification preferences and requires a user to sign up for at least one user group in order to receive notifications. When signing up for multiple groups, the group-specific messages will not be aggregated for the user. Thus the user may receive several messages with group-specific contents for an earthquake.

In addition to designating user's group and notification preferences, the user inventory also specifies access privileges via the ShakeCast web interface. The defined username and password is for the web access only and does not create local user accounts on the ShakeCast server.

USER_TYPE	USERNAME	PASSWORD	FULL_NAME	EMAIL_ADDRESS	PHONE_NUMBER	DELIVERY:EMAIL_HTML	GROUP:BRIDGE_ST:BRIDGE_LC
USER	klin	sc4all	John Doe	shake@usgs.gov	(123) 456-7890	shake@usgs.gov	BRIDGE_ST

The full list of Caltrans users and group association still need to be defined. As an example, the above spreadsheet defines the following required information:

1. USER_TYPE is either the **USER** or **ADMIN** type. Users with **ADMIN** type have additional privileges for access and ShakeCast administrative web interface.
2. USERNAME and PASSWORD fields define user access credentials. The combined USER_TYPE and USERNAME field needs to be unique.
3. DELIVERY::EMAIL_HTML field defines the email address for receiving rich content HTML ShakeCast notifications.
4. The GROUP::BRIDGE_ST::BRIDGE_LC header field lists the two allowed group designations (BRIDGE_ST and BRIDGE_LC). The user in the data row has an assigned group for BRIDGE_ST.

After the user inventory is saved into a file in the CSV format, *e.g. caltrans_user.csv*, it can be processed by the ShakeCast system via either the **Upload** tab from the administrative interface or the command line script *manage_user.pl* with the following syntax

```
C:\ShakeCast\sc\bin\manage_user.pl caltrans_user.csv
```

Deleting selected users via the administrative web interface is identical with the steps in Sec. 7.4.3. The administrator selects either the **ADMIN** or **USER** type before highlighting users for deletion. To revert or delete the user inventory using the tool under the **Upload** tab, drop-in the same user inventory file and choose the **Delete** option before submit. With the command line script, *manage_user.pl,* issue the following syntax

```
C:\ShakeCast\sc\bin\manage_user.pl –delete caltrans_user.csv
```

7.4.5 Earthquake and Scenario Inventory

The ShakeCast V3 system maintains a local earthquake database, effectively a subset of the USGS ShakeMap archive. ShakeMaps for actual earthquakes are received and processed by the system as part of the automated process. Scenario ShakeMaps need to be manually triggered by an administrator with a scenario ShakeMap package or download ShakeMaps directly from the USGS web site.

For the automated earthquake processing, management of the ShakeCast earthquake inventory for actual events include two major tasks: (1) defining the earthquake monitoring regions; and (2) configuring the triggering and archiving filters. Refer to Sec. 7.3.1 and 7.4.4 for defining earthquake monitoring regions and user groups.

The filters for earthquake triggering and archiving are optional configurations and are not included under the **General Settings** tab of the administrative interface because of infrequent use. To change the default settings, edit the ShakeCast system configuration file, default at "C:\ShakeCast\sc\conf\sc.conf".

A snippet of the configuration options shown below dictate the behavior for processing and archiving of actual earthquakes. Specifically,

- **MAG_CUTOFF** option specifies the minimum magnitude requirement for triggering the ShakeCast process.
- **ARCHIVE_MAG** option specifies minimum magnitude requirement for the earthquake to be permanently archive after the active time window expires.
- **TIME_WINDOW** option specifies the time window (in days) after the origin for an earthquake to be considered as active.

```
MAG_CUTOFF    3
```

```
ARCHIVE_MAG   5.0

<rss>
    AUTOSTART   1
    TIME_WINDOW   7
    PROMPT   rssd>
    MSGLEVEL   2
    SERVICE_NAME   rssd
    POLL   60
    SPOLL   10
    LOG   C:/Shakecast/sc/logs/sc.log
    REGION   ALL
    SERVICE_TITLE   ShakeCast RSS Daemon
    LOGGING   1
    PORT   53458
</rss>
```

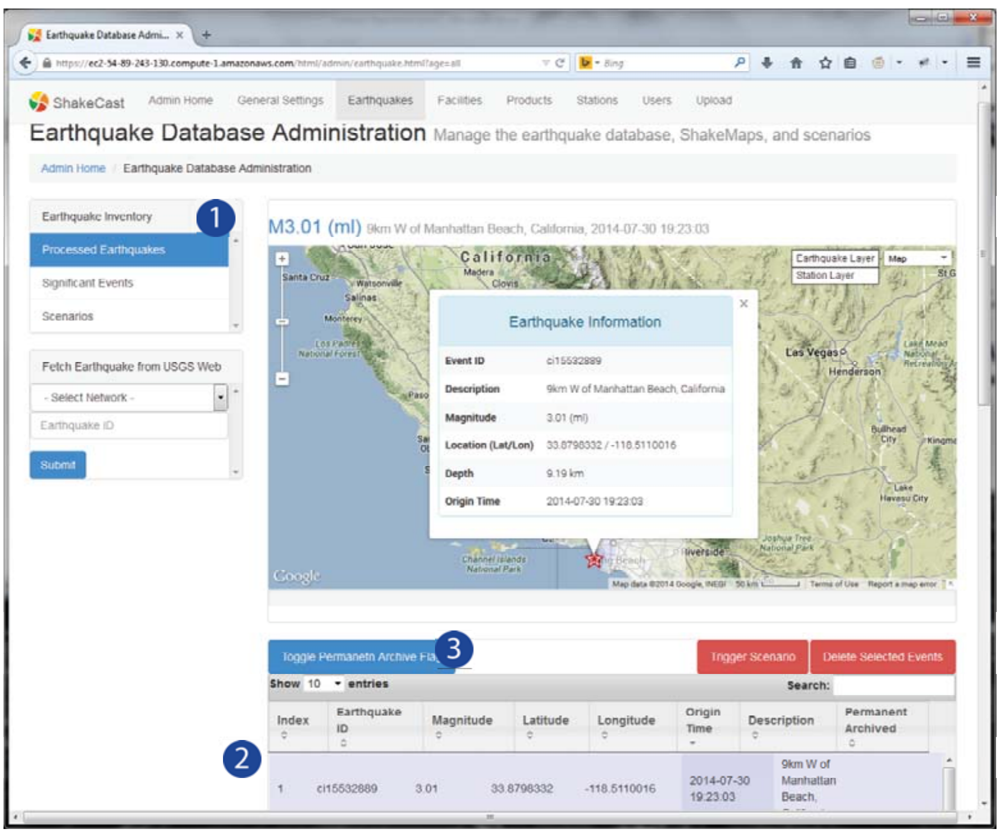
As part of the automated processing, a cron job for earthquake inventory maintenance runs daily to identify and delete unwanted earthquakes from the system. Actual earthquakes with magnitude below the archiving magnitude will be removed from the database automatically. Earthquakes above the archiving magnitude but without any exposed facilities will also be deleted because of their insignificance.

To override the default system behavior, an administrator sets the archiving flag for earthquakes to be excluded from the system archiving policy.

To toggle archive flag for selected earthquakes, select the **Earthquakes** tab from the administrative web interface.

1. Select **Processed Earthquake** list
2. Highlight earthquakes to be archived
3. Click the **Toggle Permanent Archive Flag** button to enable/disable the archive flag

Archived earthquakes are indicated in the **Permanent Archived** column.



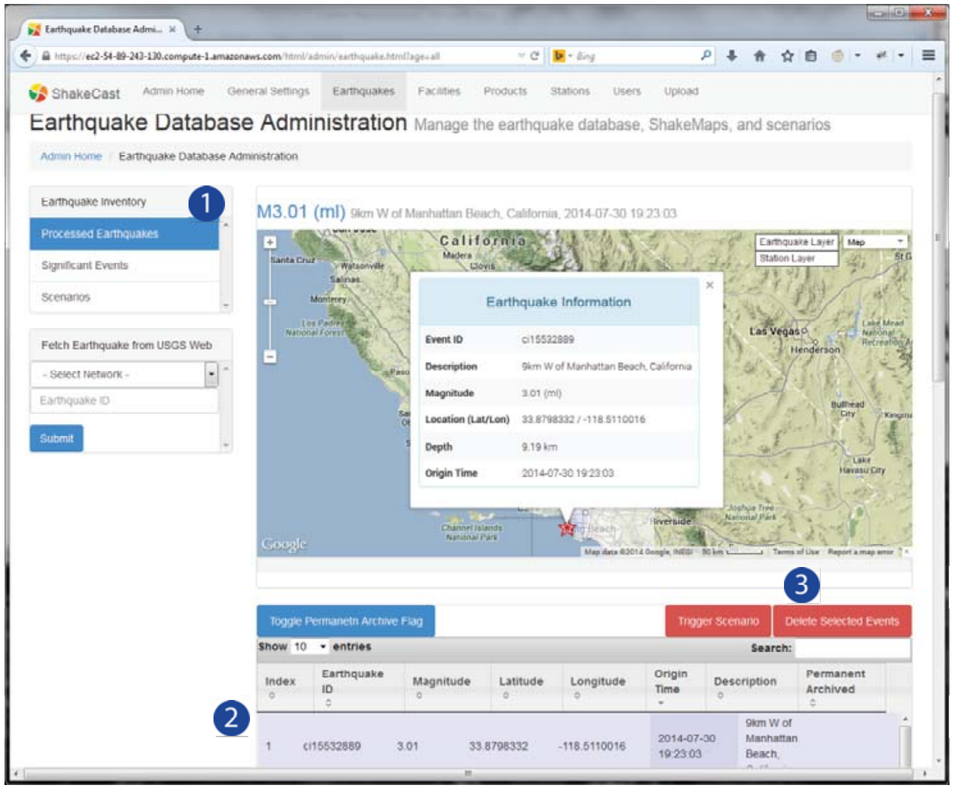
We have prepared ~250 scenario packages for this project for California (80 Northern California and 170 Southern California scenario ShakeMaps). To add scenario ShakeMaps to the ShakeCast system, the administrator either upload a premade scenario package via the **Upload** tab from the administrative interface or download the scenario directly from the USGS web site. The command line script *shake_fetch.pl* performs the same function using the following syntax

```
C:\ShakeCast\sc\bin\shake_fetch.pl –network <netid> -event <eventid> -force_run -scenario
```

Both actual and scenario ShakeMaps can be deleted from the ShakeCast system using the administrative interface. To delete selected earthquakes from the ShakeCast database:

Select the **Earthquakes** tab from the administrative web interface.

1. Select Earthquake Inventory
2. Highlight earthquakes to be deleted
3. Click the **Delete Selected Events** button to delete



To revert or delete the facility inventory using the tool under the **Upload** tab, drop-in the same group inventory file and choose the **Delete** option before submit. With the command line script, *manage_group.pl,* issue the following syntax

```
C:\ShakeCast\sc\bin\manage_event.pl –delete <eventid …>
```

7.4.6 Notification and System Records

ShakeCast tracks system activities related to executed tasks, background processes, notifications, and state-of-health warning and error messages. General activities are logged into separate files

- sc.log file stores general information and results of program execution
- sc_access.log file stores information on access to the system over the web
- sc_error.log file stores information when programs return with non-normal status

More critical information relates to state of notifications and error messages for the system are stored inside the database in two separate tables as a document trail.

To minimize the need for record maintenance, a cron job for log file maintenance runs daily to rotate log files in a ring buffer. The administrator specifies options for the maintenance script inside the system configuration file, “C:\ShakeCast\sc\conf\sc.conf”,

```
<Logrotate>
    LOGSTATDIR   C:/Shakecast/sc/images
    rotate-time   1 week
    compress   Yes
    keep-files   5
    status-file   C:/Shakecast/sc/logs/logrotate.status
    max_size   100 M
    logfile   C:/Shakecast/sc/logs/sc.log
    logfile   C:/Shakecast/sc/logs/sc_access.log
    logfile   C:/Shakecast/sc/logs/sc_error.log
</Logrotate>
```

Key fields of the configuration section **Logrotate** from the system configuration are described below:

- **rotate-time** field specifies the length in time before the log entries to be removed from the log file
- **keep-files** field specifies the number of archived log files to be saved before permanently deleted from the system
- **max_size** field specifies the maximum allowed file size of the log files. Once the file size exceeds the limit, log entries will be removed even before the rotation time is reached
- **logfile** field specifies the list of log files to be maintained and rotated

Maintenance of system records stored inside the ShakeCast database is usually not required and is only needed when the system shows signs of slow performance, such as slow notification. Accumulation of records depends primarily on the number of inventory and notifications configured for a particular system and can vary greatly from one system to another. The administrator should not interact with the database directly and instead uses executes the command below to clean up store messages in the database,

```
C:\ShakeCast\sc\util\clear_notify_table.pl
```

at a suggested frequency of once per quarter.

8 CALTRANS SHAKECAST SYSTEM FOR END-USERS

ShakeCast delivers post-earthquake and inspection prioritization information to users in several different formats, including:

- Email notifications
- ShakeCast Summary Report
- ShakeCast XML, GoogleEarth KML files and Excel spreadsheets (ShakeCast Local Products)

In addition, ShakeCast users can interact with the system to retrieve detailed results of the analysis, including:

- ShakeCast Website
- ShakeCast Application Programming Interface (API)

In this chapter we describe the default templates, products, and the web interface for the ShakeCast. We also show the procedure to customize the above contents to improve user experience. Refer the ShakeCast Technical Guide for detailed description on the ShakeCast local product and API.

8.1 Email Notifications

Initially the Caltrans ShakeCast V3 system will produce and disseminate email notifications using the same email templates from the V2 system. Additional templates will be prepared for individual user groups as ongoing improvements to the system.

Email is the primary method for delivery of ShakeCast notifications following an earthquake. For most users, email notifications provide a sufficient amount of detail about the event and the impacts to state facilities and may be the only ShakeCast product that is used. Email messages are generated by the ShakeCast server and are sent to the Caltrans Outlook email servers for distribution to ShakeCast subscribers. Email messages can be sent to addresses with the Caltrans domain (dot.ca.gov) or sent to non-Caltrans email addresses, such as personal email accounts, cell phone email addresses, etc.

The Caltrans ShakeCast system is pre-configured to send four types of emails to users: NEW EVENT, UPDATED EVENT, CANCELLED EVENT, and FACILITY ASSESSMENT. The type of message is noted in the subject line of email messages.

To address access problems from outside the Caltrans network for earthquake products and images stored on the internal ShakeCast server, the administrator now can choose to include them as attachments to email notifications. This is achieved by simply editing the notification templates. Although any files available on the local ShakeCast server can be included in the notifications, the administrator needs to factor in the overall size of email notifications to meet the performance goal of the organization.

ShakeCast will typically generate email notifications within one or two minutes from the receipt of ShakeMap data from the USGS. The ShakeMap data is typically generated within 5 minutes of the event occurrence. However, there have been a number of events over the course of the project where longer ShakeMap generation times were observed. This has resulted in longer times for users to receive ShakeCast email notifications.

8.1.1 Default Facility Assessment Message

The system is triggered when an earthquake with a magnitude of 4.0 or greater is reported by the USGS. BRIDGE ASSESSMENT emails are sent if the estimated peak spectral acceleration (PSA) at 1.0 second return period is greater than 10%g at any bridge within the mapping area. Both BUILDING and ROADWAY ASSESSMENT are measured based on peak ground acceleration (PGA) and also a triggering threshold of 10%g. This email includes the list of facilities of specified type and their Inspection Priority.

Facility assessment messages contain the following key features:

- A summary of the event with date, time, magnitude, epicenter, and location.
- Key shaking metrics for the ShakeMap.
- A graphic image of the ShakeMap showing the extent of strong shaking.
- The complete list of facilities analyzed and their relative Inspection Priority.
- An optional attachment of ShakeCast Report in PDF (depending on availability at the time of notification) showing detailed information.

These features are shown in an example email in Figure 8.1.

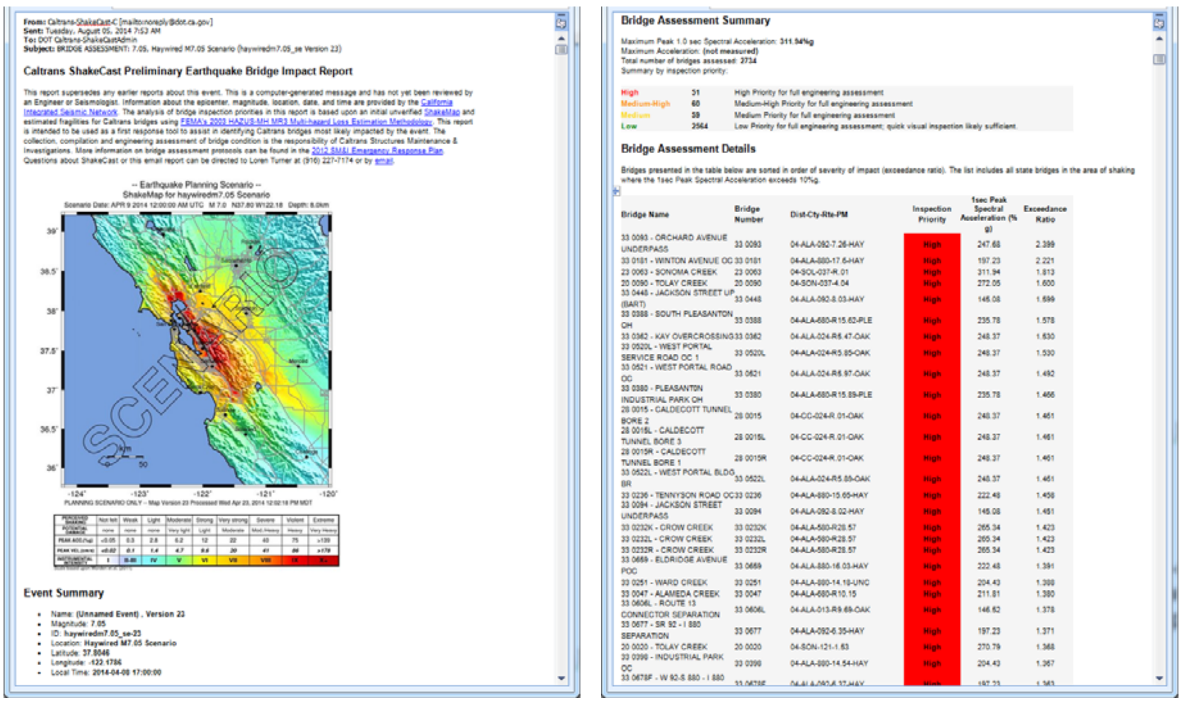


Figure 8.1. ShakeCast Concern Level message and contents.

8.1.2 Notification Template

All ShakeCast notifications and products are template-driven to meet users' specific requirements. The default template for facility assessment message shown in Figure 8.1 is described in details in this section. The administrator can modify the default template and to create new ones for specific user groups.

8.1.2.1 Template Directory

Template directory path is a directive in the system configuration file, *sc.conf*, as

```
TemplateDir    C:/Shakecast/sc/templates
```

Email notification templates are organized by first the notification then the message type under the template directory.

```
TemplateDir → Notification Type Directory → Message Type Directory
```

Valid notification types are

- New Event message type, *new_event*, is trigger when a new earthquake is declared.
- Update Event message type, *upd_event*, is triggered when the source parameters of an earthquake are changed
- Cancel Event message type, *can_event*, is triggered when an earthquake is canceled
- New Product message type, *new_prod*, is triggered when a new registered earthquake product becomes available
- Facility Shaken message type, *shaking*, is triggered when ground shaking estimates are available at one facility
- Facility Assessment message type, *damage*, is triggered when fragility are assessed at a facility given the measured ground motions.
- System message type, *system*, is triggered when the system generates encounters an error during program execution.

8.1.2.2 Template File

One notification template consists of one to several files depending the message aggregation option. If the aggregation flag in the notification request is not set, then a single template file is used. If the aggregate flag is set, then the template file is divided into the header, body, and footer segment files. Among the three files, the body segment aggregates notifications (event, product, shaking, damage, and system) into a table and the table is sorted based on directives in a separate configuration file. Naming of the template needs to match the specified template in the notification request. The filename "*default*" is reserved when no custom notification template is requested.

Therefore, e.g., for a non-aggregated template (damage notification) the content of the default template shown below will be saved into a single template file, *default.txt*. The aggregated template consists of three template segments, *default_header.txt*, *default_body.txt*, and *default_footer.txt*

```
; Default HTML Email Notification -- header
;
From: ShakeCast Win64 <%HEADER_FROM%>
To: %HEADER_TO%
Subject: Inspection Priority M%MAGNITUDE% - %EVENT_LOCATION_DESCRIPTION%
(%EVENT_ID%)
Attach: C:/ShakeCast/sc/data/%SHAKEMAP_ID%-%SHAKEMAP_VERSION%/intensity.jpg
; End -- header

<font size=+2><b>ShakeCast Event: Magnitude %MAGNITUDE%</b></font><br>
ShakeMap %EVENT_NAME:|NULL|;(Unnamed Event)% Version %SHAKEMAP_VERSION%<br>
Event Location: %EVENT_LOCATION_DESCRIPTION%<br>
Event Time: %EVENT_TIMESTAMP%<br>
Generated at %GENERATION_TIMESTAMP%<br>
Reported by: Server ID = %SERVER_ID%, DNS = %DNS_ADDRESS%
<p>
<font size=+2><b>Damage Summary</b></font><br>
Number of Facilities Reported: %_ITEMNO%<br>
Max Value: MMI: %_MAX_METRIC_MMI%;
Acceleration: %_MAX_METRIC_PGA:|NULL|;(not measured)%<br>
Number of Reports of Likely Damage: %_NUM_DAMAGE_LEVEL_RED%<br>
Number of Reports of Possible Damage: %_NUM_DAMAGE_LEVEL_YELLOW%
<p>
```

```
<font size=+2><b>Facility Damage Estimates from ShakeMap</b></font>
<img src="cid:intensity.jpg">
<table border=1 bordercolor=black cellpadding=5 cellspacing=0>
<tr>
  <th>Facility
  <th>Inspection Priority
  <th>Metric
  <th>Value
  <th>Exceedance Ratio
</tr>
;;;;;

; Default HTML Email Notification -- body
;
<tr>
<td>%FACILITY_NAME%
<td
bgcolor=%DAMAGE_LEVEL:RED;RED;YELLOW;YELLOW;ORANGE;ORANGE;GREEN;GREEN%>%DAMAGE_
LEVEL:RED;High;ORANGE;Moderate High;YELLOW;Moderate;GREEN;Low%
<td>%METRIC%
<td>%GRID_VALUE%
<td>%EXCEEDANCE_RATIO%
</tr>

; Default HTML Email Notification -- footer
;
</table>
[END]
```

A separate sorting directive for the body template segment below is saved in the file, *default.conf*.

```
;
;;; config for email html
;
sort severity_rank/d grid_value/d exceedence_ratio/d facility_name/t
;
;;;
```

8.1.2.3 Template Layout and Content

ShakeCast users receive email notifications based on the design of layout and content for the template rendered in real time. Design of an HTML-based template is similar to a web page and usually requires iterations to get the expected user experience. The result may also vary depending on user's email client. Thus we recommend a progressive approach to customize the default template based on users' needs and to thoroughly test the layout on the email clients for receiving notifications.

Keywords enclosed by the "%" symbol in a ShakeCast template are replaced with their corresponding values stored inside the ShakeCast database. Besides the keyword and value substitution, there are several features of the template the administrator needs to consider when customizing the template:

- Attachment to email notification message is a new feature available for the V3 system via a header directive,

  ```
  Attach: C:/ShakeCast/sc/data/%SHAKEMAP_ID%-%SHAKEMAP_VERSION%/intensity.jpg
  ```

  This is a feature most useful when the ShakeCast server is situated behind a firewall. Multiple attachments are allowed and the administrator should balance between the total size of the message and performance.

- The scope of keywords varies for the intended notification type. The general rule of thumb is to follow the database schema of the notification target. Appendix I lists available keywords for all notification types.
- Keywords for derived values (specific to individual notification message) are prepended with an underscore symbol "_", e.g., **`_MAX_METRIC_MMI`**.
- Template-specific value mapping for keywords are separated by the symbol ";", e.g.,

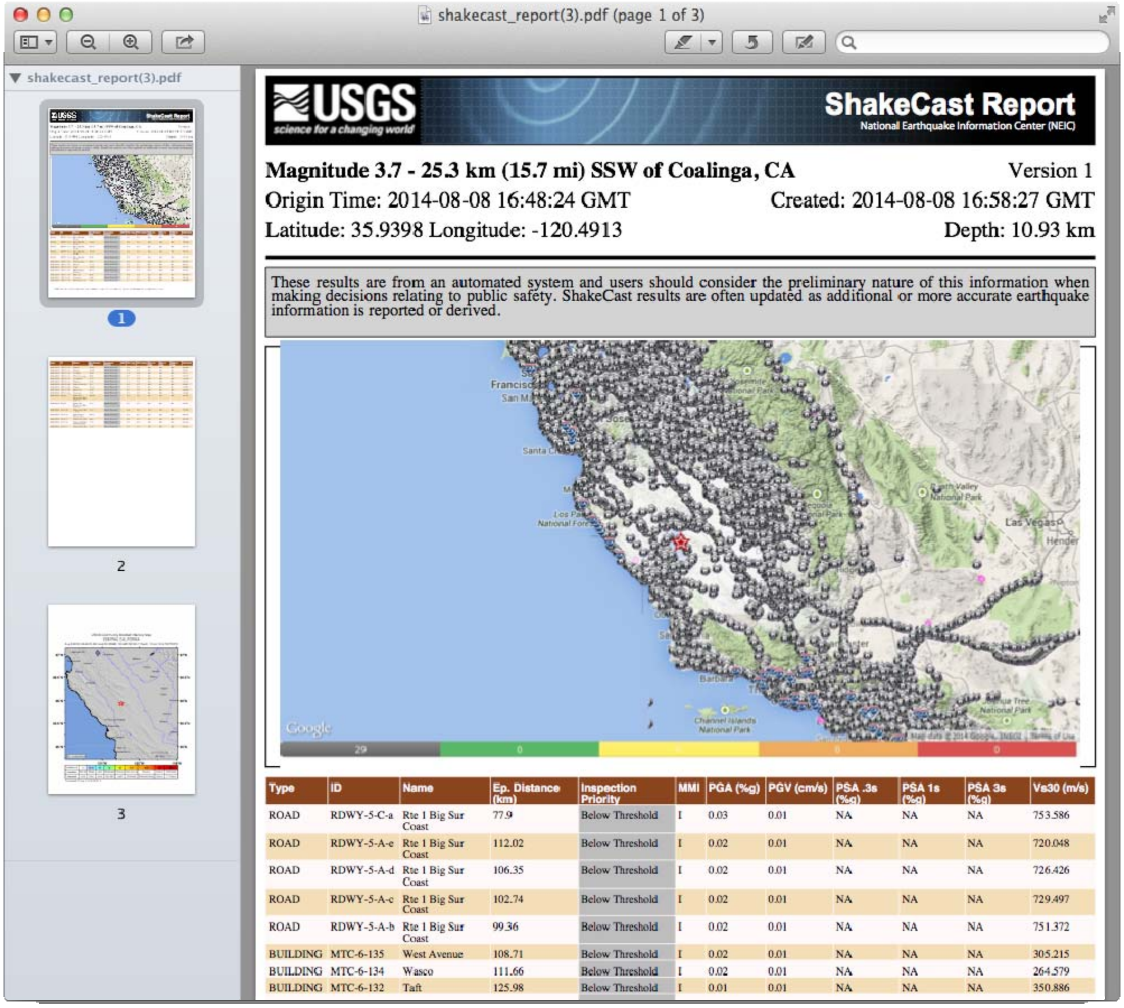
  `%DAMAGE_LEVEL:RED;High;ORANGE;Moderate High;YELLOW;Moderate;GREEN;Low%`

  maps RED to High, ORANGE to Moderate High, YELLOW to Moderate, and GREEN to Low in the facility damage assessment table.

8.1.3 ShakeCast PDF Summary Report

The ShakeCast V3 system includes a PDF engine that generates formatted summary reports as standalone products. The PDF report can be sent directly to users as attachments to the email notification. The default PDF report consists of one ShakeCast summary page, one optional onePAGER summary page, and one optional DYFI map page depending on their availability. The administrator can customize the PDF report similar to customizing email notifications in principle. We will describe the procedure to customize PDF report in this section.

8.1.3.1 ShakeCast Summary Page



Type	ID	Name	Ep. Distance (km)	Inspection Priority	MMI	PGA (%g)	PGV (cm/s)	PSA .3s (%g)	PSA 1s (%g)	PSA 3s (%g)	Vs30 (m/s)
ROAD	RDWY-5-C-a	Rte 1 Big Sur Coast	77.9	Below Threshold	I	0.03	0.01	NA	NA	NA	753.586
ROAD	RDWY-5-A-e	Rte 1 Big Sur Coast	112.02	Below Threshold	I	0.02	0.01	NA	NA	NA	720.048
ROAD	RDWY-5-A-d	Rte 1 Big Sur Coast	106.35	Below Threshold	I	0.02	0.01	NA	NA	NA	726.426
ROAD	RDWY-5-A-c	Rte 1 Big Sur Coast	102.74	Below Threshold	I	0.02	0.01	NA	NA	NA	729.497
ROAD	RDWY-5-A-b	Rte 1 Big Sur Coast	99.36	Below Threshold	I	0.02	0.01	NA	NA	NA	751.372
BUILDING	MTC-6-135	West Avenue	108.71	Below Threshold	I	0.02	0.01	NA	NA	NA	305.215
BUILDING	MTC-6-134	Wasco	111.66	Below Threshold	I	0.02	0.01	NA	NA	NA	264.579
BUILDING	MTC-6-132	Taft	125.98	Below Threshold	I	0.01	0.01	NA	NA	NA	350.886

Figure 8.2. ShakeCast summary page from the PDF summary report.

The ShakeCast summary page provides:

- A summary of basic earthquake parameters, include origin time, magnitude, hypocenter, and the name of the region where the earthquake took place.
- A map with an intensity overlay showing the extent of shaking, plants (enlarged icon for facility with shaking estimates) and recent seismicity in the region.
- A bar at the bottom of the map showing color-coded Inspection Priority and the number of facilities in each level.
- A table showing details parameters for each assessed facility. The template-driven table fields include the name, epicentral distance, Inspection Priority, PGM measures, and estimated Vs30.

Additional metrics can be queried from the web interface described in 8.2 ShakeCast Web.

8.1.3.2 Optional onePAGER Summary Page

The onePAGER summary page (shown in Figure 8.3) will be inserted into the ShakeCast report if the earthquake product is available at the time that the ShakeCast report is generated. The standard operating procedure for the USGS PAGER process requires manual review when the alert level (casualty or economic loss) is in either “orange” or “red”. This means that after a very damaging earthquake, initial versions of the ShakeCast report may not include the onePAGER summary page due to the restriction.

Details of the onePAGER summary page can be found on the USGS PAGER web site,

http://earthquake.usgs.gov/research/pager/onepager.php.

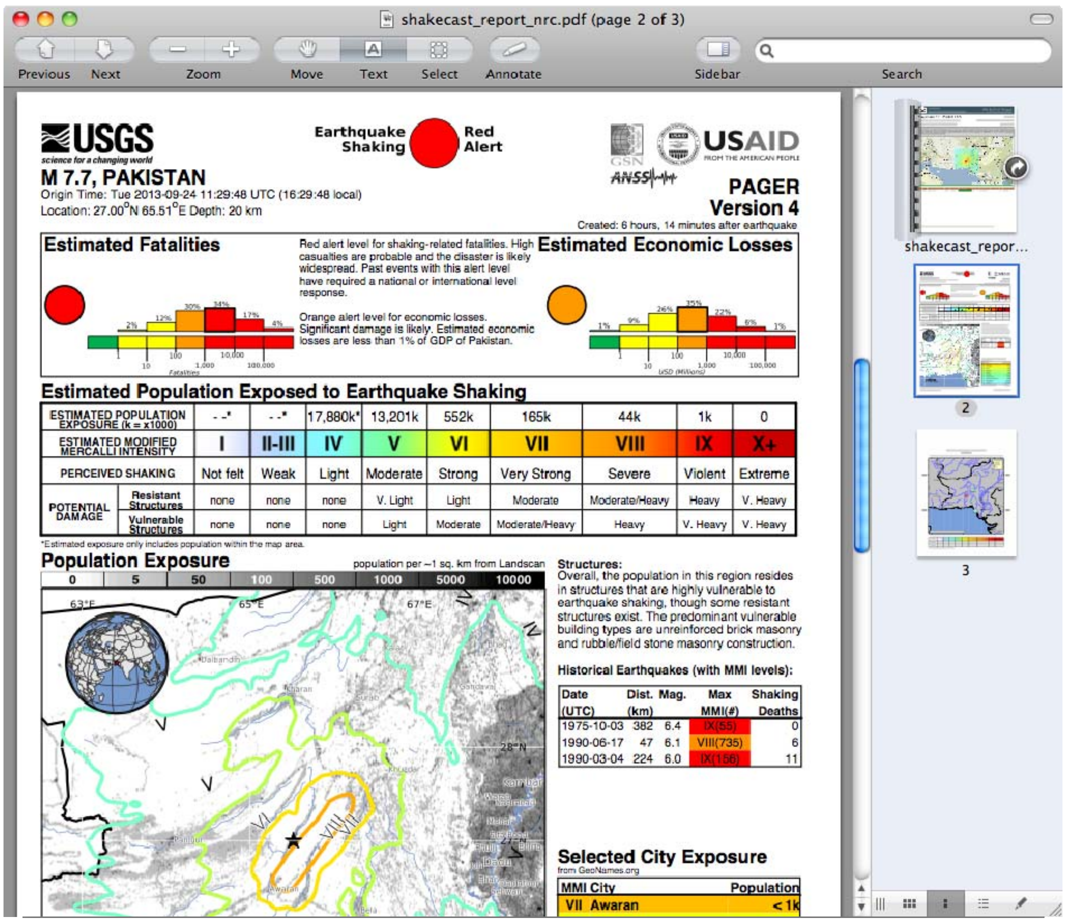


Figure 8.3. Example onePAGER summary page included in the PDF summary report.

8.1.3.3 Optional DYFI? Map Page

The DYFI map (as shown in Figure 8.4) will be inserted into the ShakeCast report if that earthquake product is available when the ShakeCast report is being generated. The DYFI map portraits the same CIIM data that was used as input macroseismic data for ShakeMap in the ShakeCast report. The quality of the DYFI map varies depending on the earthquake location and the number of CIIM entries per location. The Nuclear ShakeCast system typically receives multiple DYFI product updates between each ShakeMap update. Thus, it is likely that the DYFI map included in the ShakeCast report is different from the one shown on the ShakeCast or USGS web page.

Details of the DYFI map page can be found on the USGS DYFI web site, http://earthquake.usgs.gov/dyfi/.

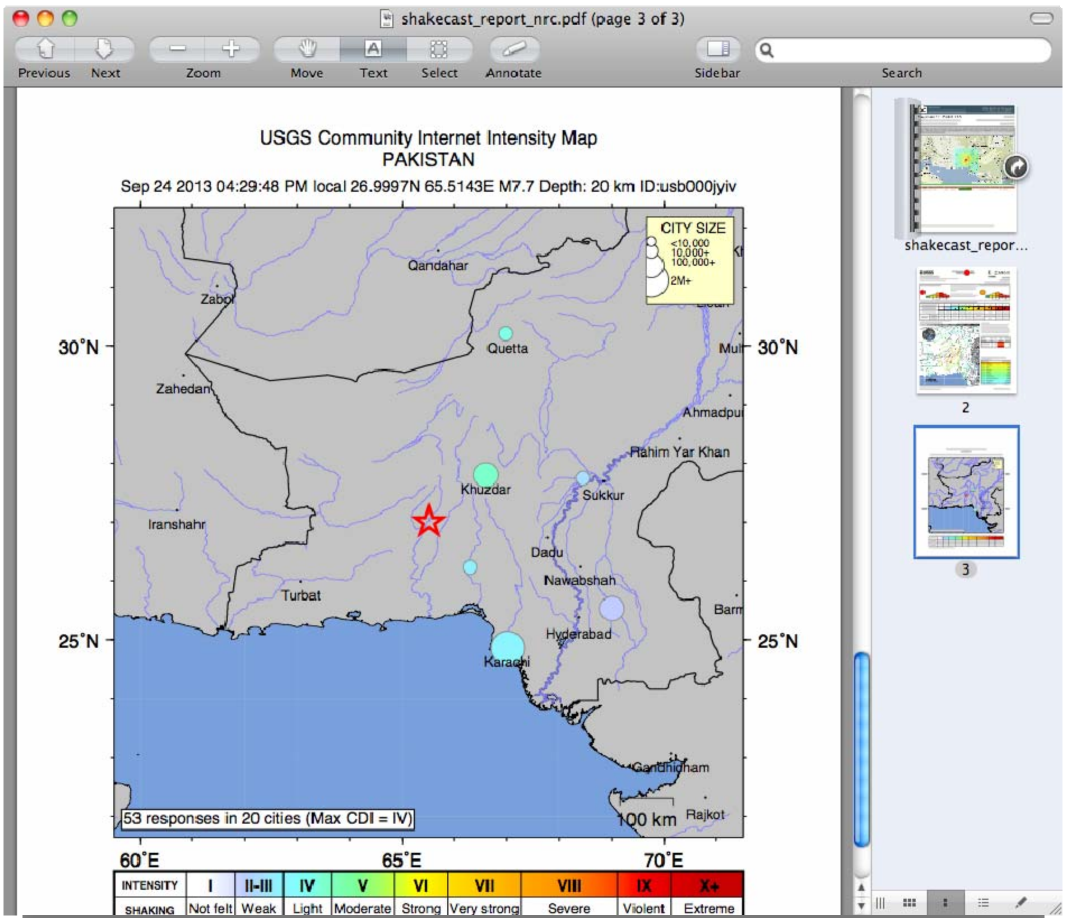


Figure 8.4. Example DYFI? map page included in the PDF summary report.

8.1.4 PDF Summary Report Template

The template-driven ShakeCast PDF report works in the same fashion as email notification. The default template for PDF summary report shown in Figure 8.2 is described in details in this section. The administrator can modify the default template and to create new ones for specific user groups.

8.1.4.1 PDF Template

Template directory (described in 8.1.2.1) is the parent directory of the PDF template directory, named **pdf**,

```
TemplateDir → PDF Directory
```

One PDF template consists of one template file in PDF and one configuration file. The content of the default template, *shakecast_report.pdf*, is shown in Figure 8.5. Templates stored under the PDF template directory will be used to create local ShakeCast products. As part of the initial setup, only the default PDF template is registered as a ShakeCast product that can be triggered via notification requests.

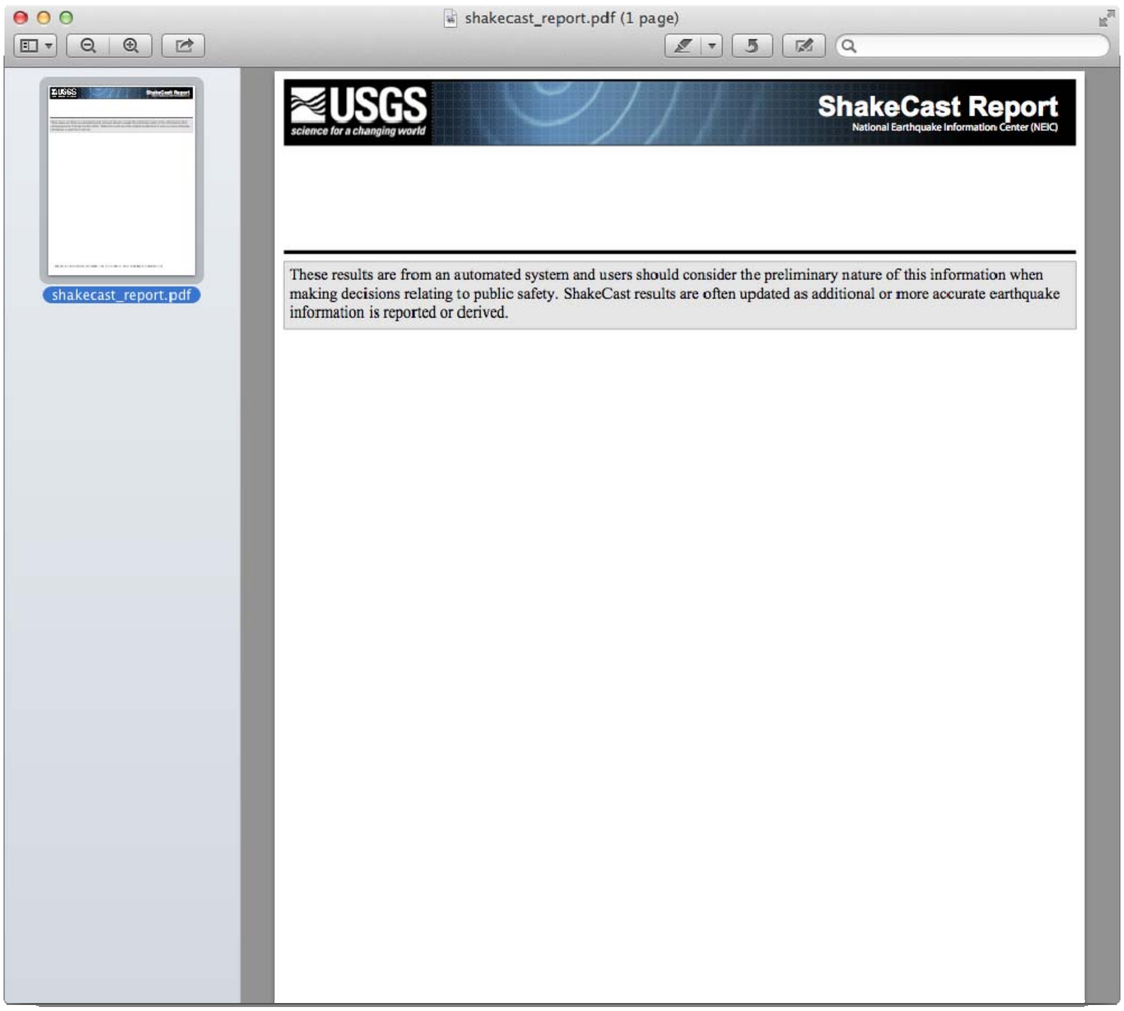


Figure 8.5. The default template in PDF for the summary report.

The default configuration file for the PDF report is in XML format and is named *shakecast_report.conf*, which content is shown below,

```
<?xml version="1.0" encoding="UTF-8"?>
<template>
	<page number="1">
		<block fillcolor="white" strokecolor="black" >
			<action>rect</action>
			<style>fillstroke</style>
			<x>0.1</x>
```

```
                <y>4.0</y>
                <w>8.3</w>
                <h>4.2</h>
                <unit>inch</unit>
                <image>
                        <path>screenshot.jpg</path>
                        <type>jpeg</type>
                        <x>0</x>
                        <y>0</y>
                        <w>8.0</w>
                        <h>4.0</h>
                        <unit>inch</unit>
                        <align>center</align>
                        <valign>center</valign>
                        <pad>0.1</pad>
                </image>
        </block>
        <block fillcolor="lightgrey" strokecolor="black" >
                <action>rect</action>
                <style>fillstroke</style>
                <x>0.1</x>
                <y>8.3</y>
                <w>8.3</w>
                <h>0.7</h>
                <unit>inch</unit>
                <text>
                        <string size="12" >These results are from an
automated system and users should consider the preliminary nature of this
information when making decisions relating to public safety. ShakeCast results
are often updated as additional or more accurate earthquake information is
reported or derived.</string>
                        <x>0.15</x>
                        <y>8.8</y>
                        <w>8.2</w>
                        <h>1.0</h>
                        <lead>10</lead>
                        <align>justify</align>
                        <unit>inch</unit>
                </text>
        </block>
        <table>
                <list>exposure.csv</list>
                <x>0.1</x>
                <w>8.3</w>
                <start_y>3.9</start_y>
                <next_y>10.75</next_y>
                <start_h>3.0</start_h>
                <next_h>10.0</next_h>
                <font_size>8</font_size>
                <padding>2</padding>
                <padding_right>2</padding_right>
                <background_color_even>snow</background_color_even>
                <background_color_odd>wheat</background_color_odd>
                <unit>inch</unit>
                <border>0.25</border>
                <border_color>snow</border_color>

        <field>FACILITY_TYPE,FACILITY_ID,FACILITY_NAME,DIST,DAMAGE_LEVEL,MMI,PGA,
PGV,PSA03,PSA10,PSA30,SDPGA,SVEL</field>
        </table>
        <text>
                <string size="22" type="Times-Bold" >Magnitude [MAG] -
[LOCSTRING]</string>
```

```
            <x>0.1</x>
            <y>9.9</y>
            <w>5.8</w>
            <h>0.5</h>
            <align>justify</align>
            <unit>inch</unit>
        </text>
        <text>
            <string size="16">Version [VERSION]</string>
            <x>7.0</x>
            <y>9.9</y>
            <w>1.4</w>
            <h>0.5</h>
            <align>right</align>
            <unit>inch</unit>
        </text>
        <text>
            <string size="16">Origin Time: [TIMESTAMP]</string>
            <x>0.1</x>
            <y>9.6</y>
            <w>7.0</w>
            <h>0.5</h>
            <align>left</align>
            <unit>inch</unit>
        </text>
        <text>
            <string size="16">[PROCESS_TIME]</string>
            <x>0.1</x>
            <y>9.6</y>
            <w>8.3</w>
            <h>0.5</h>
            <align>right</align>
            <unit>inch</unit>
        </text>
        <text>
            <string size="16">Latitude: [LAT] Longitude: [LON]</string>
            <x>0.1</x>
            <y>9.3</y>
            <w>7.0</w>
            <h>0.5</h>
            <align>left</align>
            <unit>inch</unit>
        </text>
        <text>
            <string size="16" >Depth: [DEPTH] km</string>
            <x>0.1</x>
            <y>9.3</y>
            <w>8.3</w>
            <h>0.5</h>
            <align>right</align>
            <unit>inch</unit>
        </text>
    </page>
    <page>
        <pdf>
            <path>eq_product/[EVID]/onepager.pdf</path>
        </pdf>
    </page>
    <page>
        <pdf>
            <path>eq_product/[EVID]/*_ciim.pdf</path>
        </pdf>
    </page>
```

```
</template>
```

8.1.4.2 Template Layout and Content

The base PDF template (Figure 8.5) contains static content and is in writable PDF format. The included default template was created using the Adobe Illustrator program. The administrator can modify the template to reflect the identity of user's organization using a PDF editing program. As standards of the PDF format is constantly evolving, we recommend saving the PDF template according to the PDF 4.0 specifications to ensure compatibility.

The ShakeCast system interacts with the backend PDF engine (PDF::API2 module) to insert dynamic content into the base PDF template. This is achieved by interpreting configured directives to commands in the PDF::API2 format. Users should refer to the Comprehensive Perl Archive Network (CPAN) below for the full scope of the PDF API.

http://search.cpan.org/~ssimms/PDF-API2-2.022/

To shield users from the complexity, ShakeCast introduces a simple set of XML tags to accommodate common actions in creating PDF files. As a general rule, ShakeCast translates each XML tag in the PDF configuration file and creates one element in the output PDF, in the following hierarchy,

<**template**> → <**page**> → <**block**> / <**text**> / <**image**> / <**table**>

Keywords enclosed by the "[]" bracket within XML tags are replaced with their corresponding values stored inside the ShakeCast database. The element location is in the Cartesian coordinate system with the bottom-left corner of the page as the origin.

- <**template**> tag declares a PDF template directive.
- <**page**> tag inserts a new page in the PDF output file with an optional *number* attribute to specify the page number. The *pdf* attribute imports an external PDF document into the specified page. The page will be skipped if the requested PDF document is not available.
- <**block**> tag is general purpose container. It creates and inserts a vector image at the specified size and location. <**block**> tag can enclose all element types to create a complex element.
- <**text**> tag inserts a string of text into the specified location and bounding box. Line breaks will be inserted and font size will be adjusted automatically to contain the entire string.
- <**image**> tag inserts an external image in either jpeg, gif, or png format to the specified location and dimension. The image may be distorted if the specified dimension is not proportional to the original image.
- <**table**> tag reads an existing table in the csv format on the local system and creates a formatted table with the specified table fields. The table is inserted to the specified location of the page and the height of the table is determined by the number of entries to be included. New pages will be added to the output PDF file to include the entire table. The administrator needs to be aware that the specified table fields can only be a subset of the import table file. The table is sorted by the inspection priority (color-coded) then the epicentral distance.

8.2 Navigating the ShakeCast Website

The ShakeCast website is hosted on the same ShakeCast server that performs the analysis. The types of information on the website are similar to the information communicated in email notifications, but the content is provided in an enriched and interactive web-based environment.

The Caltrans ShakeCast system is currently hosted on Caltrans' intranet. Users who want to access the system via the web interface needs to be on the same intranet and will need to provide their ShakeCast user credentials in order to interact with the system. For the ShakeCast V3 system, a non-ShakeCast user no longer can access the system to request for a user account. The administrator performs all aspects of account management.

8.2.1 Default Home Page

After a successful login, the ShakeCast home page (shown in Figure 8.6) displays:

- An interactive map, centered on the event with the ShakeMap overlay.
- A summary of key earthquake parameters.
- A summary of the number of facilities evaluated and their breakdown by Inspection Priority.
- Links to earthquake-specific USGS event page and additional resources for the ShakeMap and ShakeCast projects.

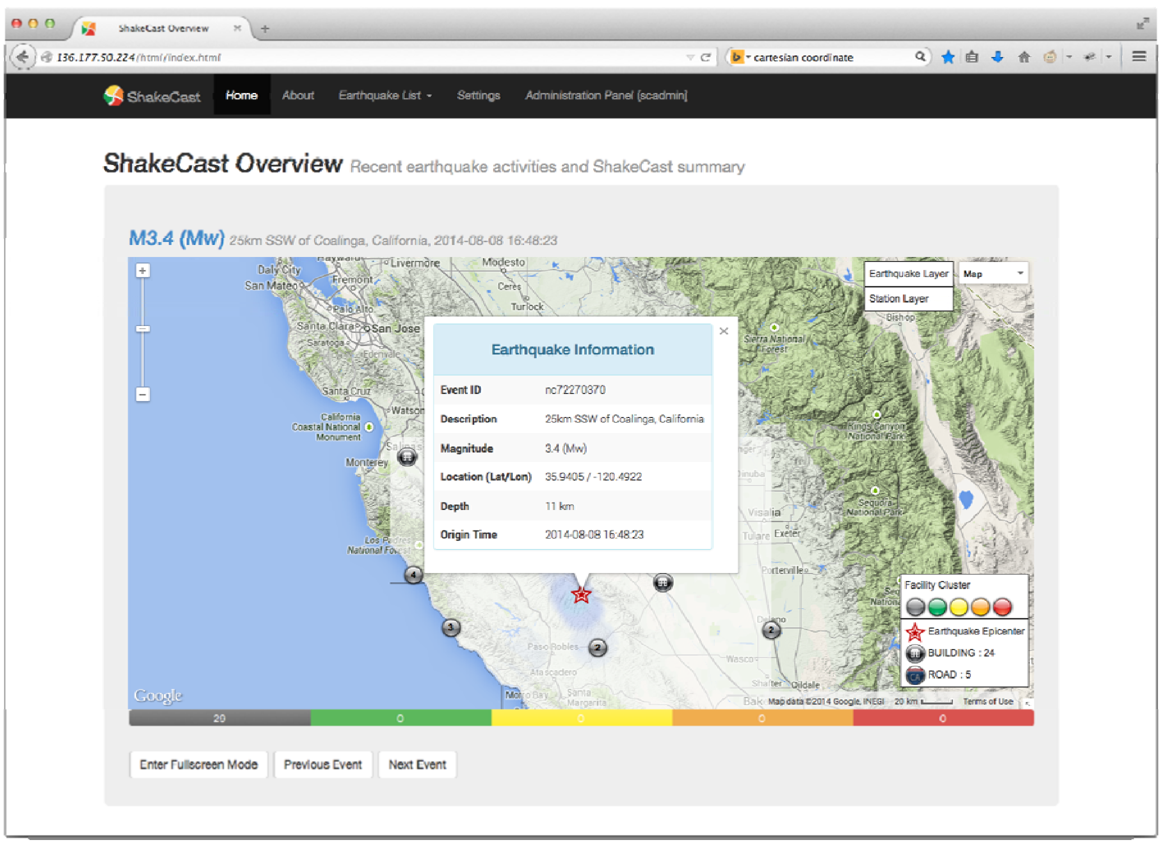


Figure 8.6. ShakeCast home page example.

The interactive map supports standard Google Maps controls. In addition to the ShakeMap intensity overlay, two custom image layers are available including recent earthquakes and seismic stations. The same interactive map is available throughout the web site with some customizations for the target pages.

The analysis results, with assessments for facilities, are presented in a bar chart on the bottom of the map, as shown in Figure 8.6. The detailed breakdown by Inspection Priority is shown in grey, green, yellow, orange, and red bars. Clicking with the left mouse button within the ShakeMap overlay will estimate ground shaking at the location of mouse click, as shown in Figure 8.6. Clicking on facility marker will display facility descriptions in a popup information window.

The default home page will automatically animate recent earthquakes (currently set at seven days) by centering the event roughly every 30 seconds; it refreshes the list after a new earthquake occurs. Users can switch the event by clicking on the **Previous Event** and **Next Event** buttons.

The full screen display (Console mode) is enabled by clicking on the **Enter Fullscreen Mode** button. The console webpage is a single interactive map supporting standard Google Maps controls and scales to match the screen size (Figure 8.7).

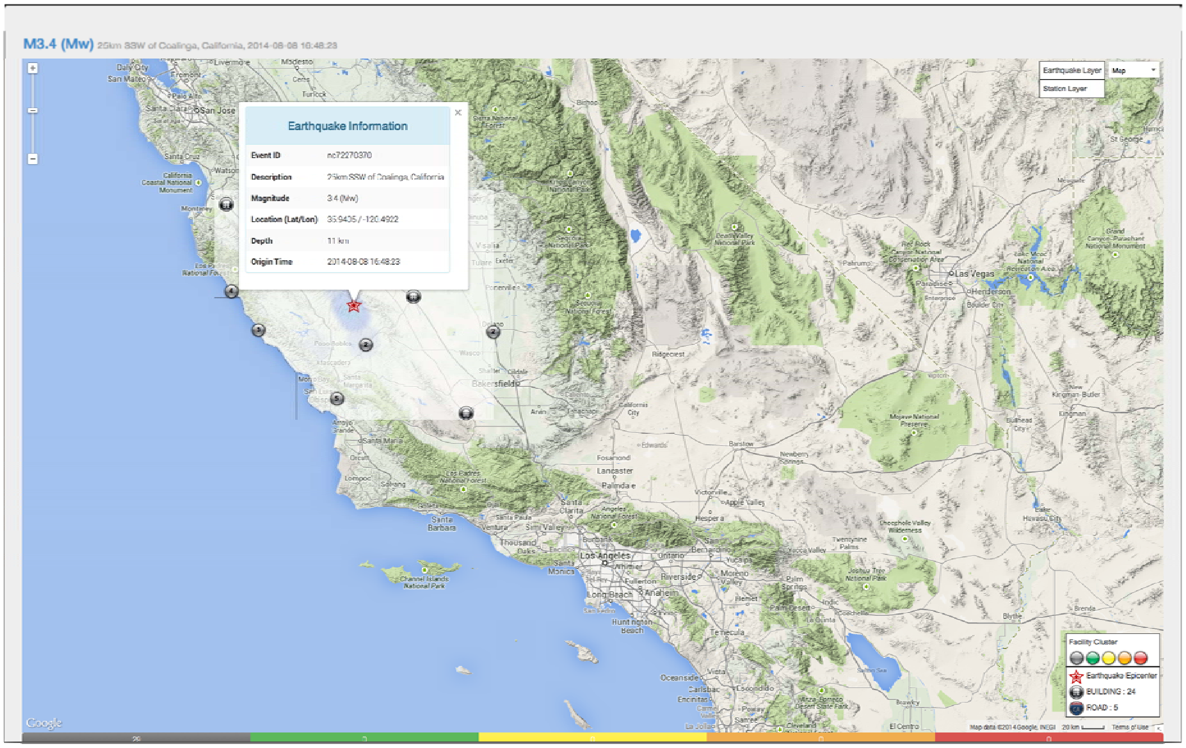


Figure 8.7. ShakeCast home page in full screen mode.

8.2.2 Earthquake Pages

8.2.2.1 Earthquake List Page

The **Earthquake List** page (Figure 8.8) displays a list of links in the left-navigation panel to several earthquake catalogs based on their recency, significance, and purpose. The Caltrans ShakeCast system automatically performs daily maintenance of the earthquake database. Earthquakes without any facility exposure will be removed from the system once they drop out of the active response window. Since the administrator may also manage the earthquake database, users need to be aware of the dynamic nature of the list.

- Recent Events. Display list of earthquakes within the active response window, default is seven days. The event list is the same as the default home page.

- Daily, Weekly, Monthly, Yearly, and All. Display list of earthquakes for the specified time frame.
- Scenarios. Display list of earthquake scenarios downloaded from the USGS ShakeMap web site.
- Test/Exercise Events. Display list of both actual and scenario earthquakes converted for the purpose of local testing or exercises.

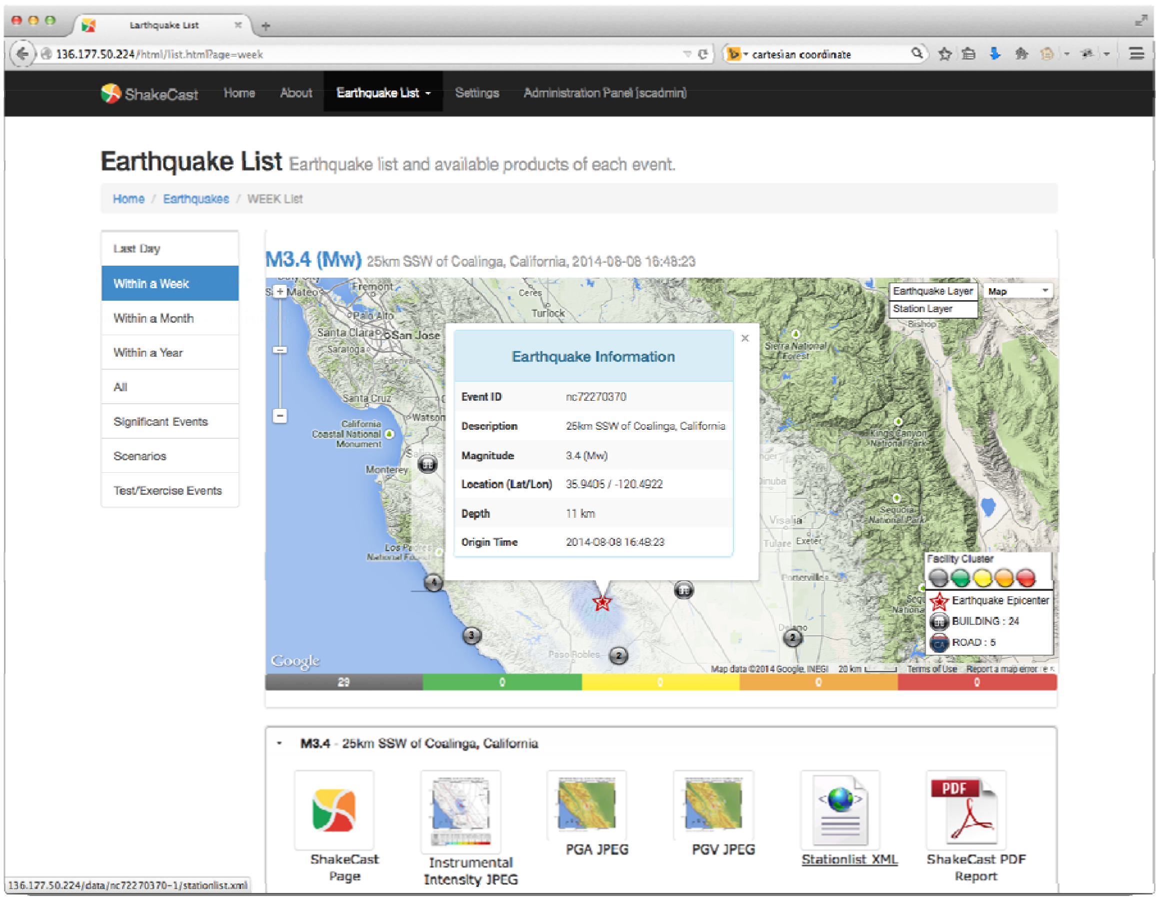


Figure 8.8. ShakeCast Earthquake List page.

Each selected earthquake catalog will be presented in both an interactive map and a paginated list, shown in Figure 8.9, ordered in descending origin time. Click on the earthquake entry to unveil selected products available on the system for direct access.

Currently the system is pre-configured to display the following products (the list can be modified by the administrator):

- ShakeCast Page. Link to ShakeCast Inventory Details page.
- ShakeMap Map Image. Link to ShakeMap ground shaking maps of different metrics, including MMI, PGA, PGV, and optional PSA at 0.3, 1.0, and 3.0 seconds.
- ShakeMap Information. Link to “info.xml” showing detailed information on ShakeMap input data, processing parameters, and output products.

- ShakeCast Products. Link to PDF summary reports and KML for viewing with the Google Earth program.

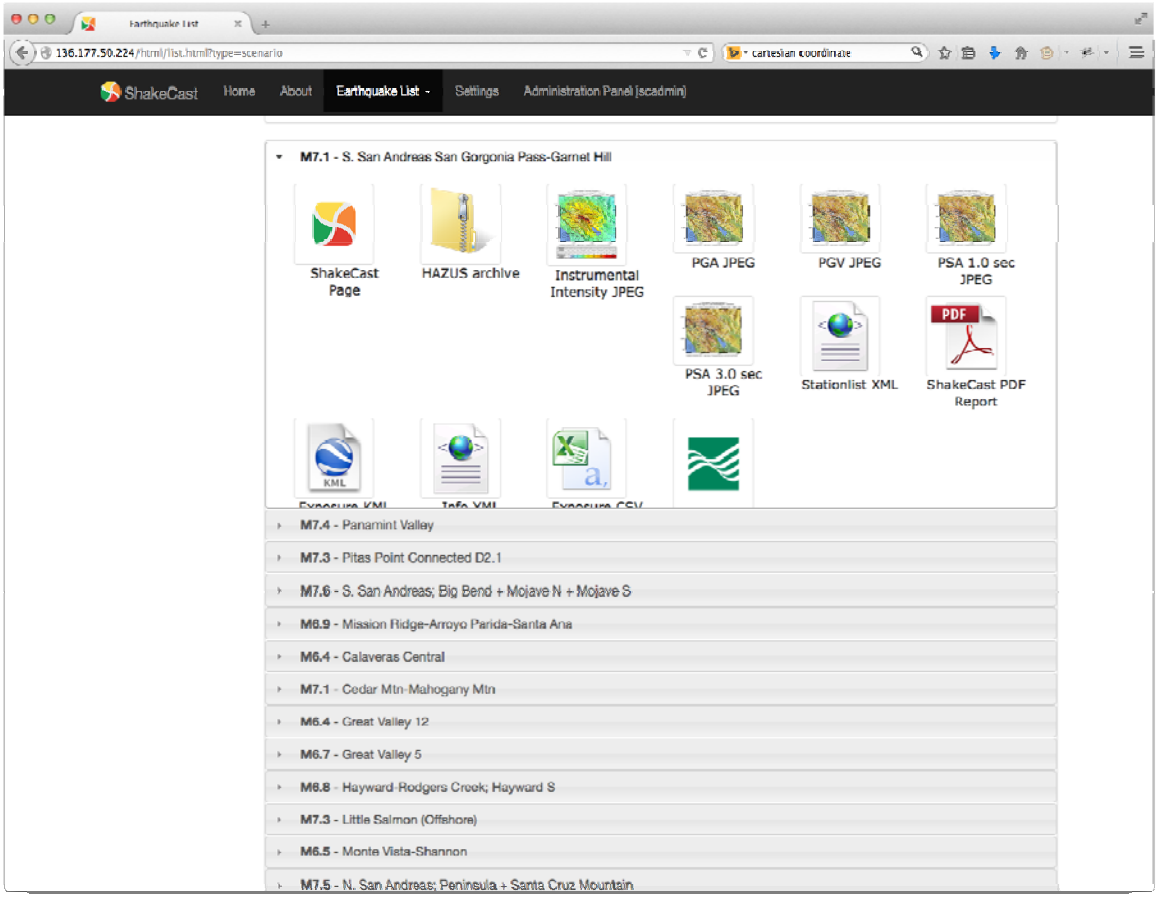


Figure 8.9. Earthquake list for the selected earthquake catalog is shown beneath the interactive map of the earthquake list page.

8.2.2.2 Inventory Details Page

The ShakeCast Inventory Details page displays the complete facility inventory assessment for the selected earthquake. The email notification users received often represents a subset of the entire inventory and depend on the type, geographic coverage, and triggering threshold.

The Inventory Details page consists of two themes to accommodate different use case, the map-centric (Figure 8.10) and table-centric (Figure 8.11) view. As shown in both figures, key components of the page include:

1. **Inventory Type** pane displays a list of inventory types assessed by the system for the earthquake. Click an inventory type will trigger refresh of the map pane in map view or the facility table in table view.

2. **High Priority Facilities** pane displays a list of top (default 10) facilities with high inspection priority for the selected inventory type. The list is synchronized with the selected inventory type in the **Inventory Type** pane.
3. **Earthquake Product** pane displays a list of pre-selected earthquake products by the administrator for direct access to the end users.
4. **Main Map** pane displays all facilities for the selected inventory type. The map is synchronized with the selected inventory type in the **Inventory Type** pane. Behavior of the map pane is the same as the map shown in the home page. While the map legend (in lower right corner) is refreshed for the selected inventory type, the summary bar at the bottom of the map represent the total facility count for each inspection priority.
5. **Facility Assessment** pane displays detailed results of analysis for the selected facility from either the **High Priority Facilities** pane or facility markers in the **Main Map** pane. Three categories of information are presented in tabs: Shaking estimates, fragility probability, and supplemental information. Supplemental information is the results of custom processes triggered by facility-specific attributes.
6. **Fragility Probability** tab (Figure 8.12) summaries assessment for all components for the selected facility. One CDF histogram plot per component is displayed and the represented state is the highest damage state above the 50% percentile. Components are grouped by their designated classes.

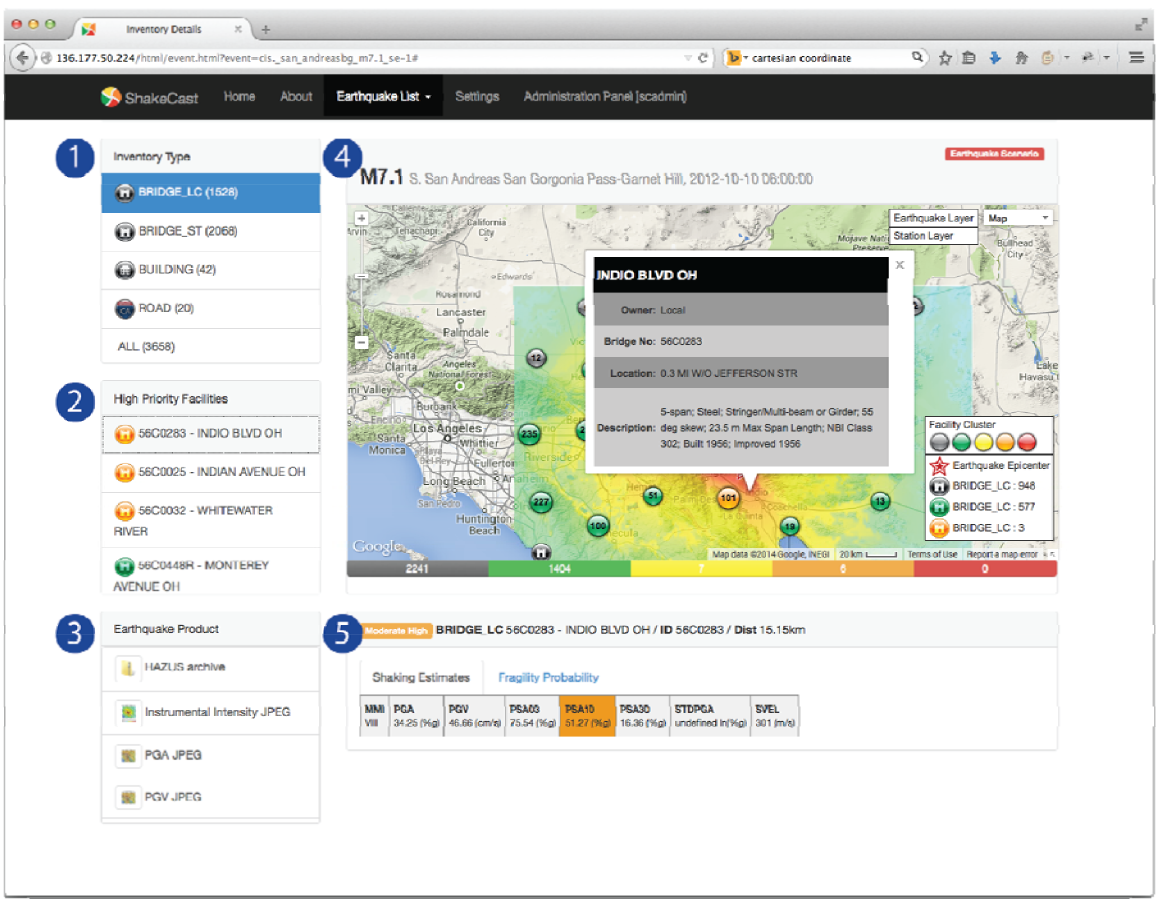


Figure 8.10. ShakeCast Inventory Details page in map view.

7. **Main Table** pane displays all facilities for the selected inventory type. The table is synchronized with the selected inventory type in the **Inventory Type** pane. Select the facility in the table to display detailed information in the **Facility Assessment** pane and the **Mapped Facility** pane.
8. **Mapped Facility** pane is a small map in the **Table View** page that keeps track of facilities examined by the user. Facility-specific information can be displayed by clicking on the facility marker.

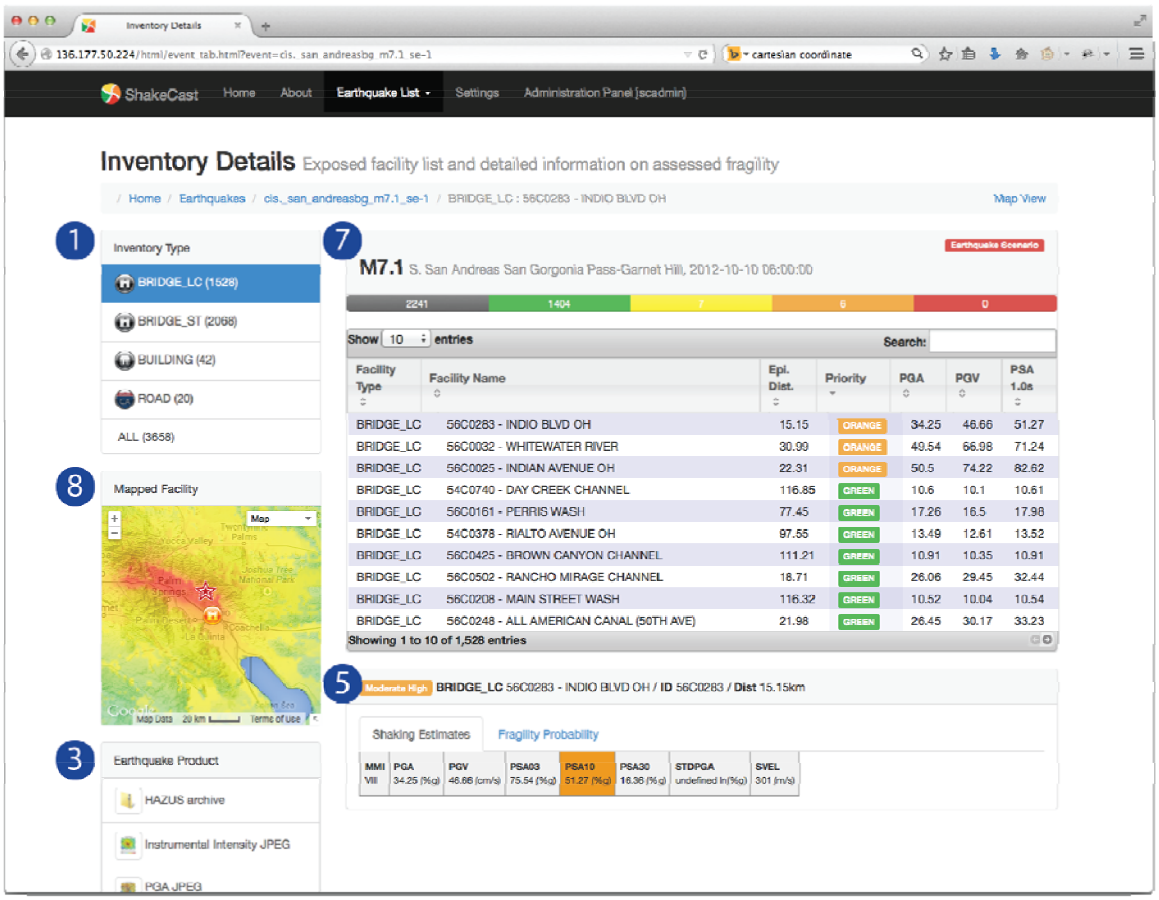


Figure 8.11. ShakeCast Inventory Details page in table view.

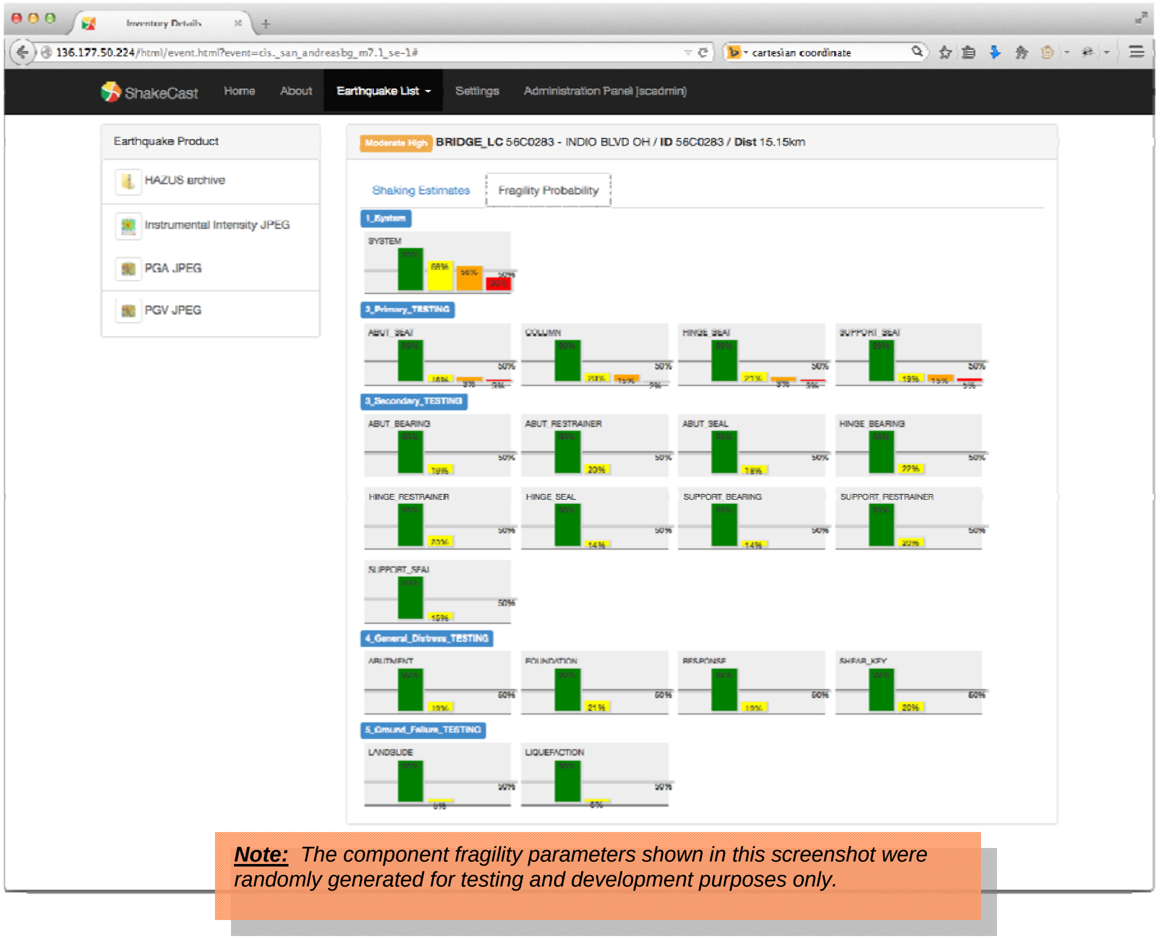


Figure 8.12. Display of component-based fragility probability for a selected bridge in the ShakeCast Inventory Details page.

8.2.3 Full Earthquake Product

ShakeCast archives all versions of ShakeMaps received by the system and products generated locally. This system does exclude archives of other USGS earthquake products and stores only the latest version. As shown in Figure 8.13, the page contains a list of all available ShakeCast files for the specific event and version, including various ShakeMap image files, and the core data files used in the ShakeCast analysis routines, etc. The full list of products and metadata available combining both ShakeMap and ShakeCast processes are usually between 50 and 100 files. Thus access to the full product web page is not recommended except for expert users who are familiar with both applications. Detailed descriptions of ShakeMap and its products are documented in the ShakeMap Manual (Wald et al., 2005). The ShakeCast Guide describes the specifications of data format defined by the Caltrans ShakeCast system.

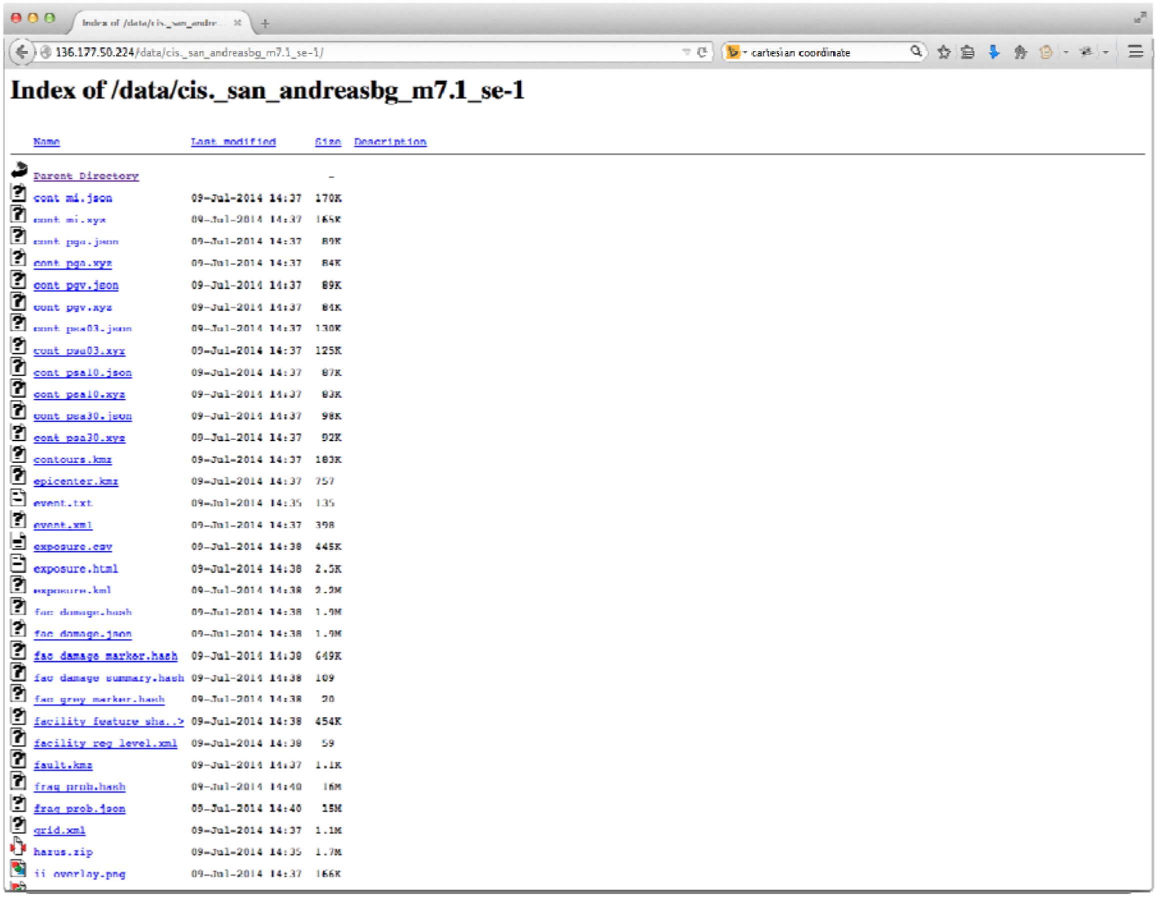


Figure 8.13. Full list of earthquake products available on the ShakeCast web site.

8.2.5 ShakeCast Mobile Page

The ShakeCast Mobile page, shown in Figure 8.14, is an alternative webpage to the default home page and is accessible via the static link at the bottom of the page. The Mobile page is designed to be light and simple that mimics the functions of earthquake pages described in 8.2.2 and only for actual earthquakes. In effect the ShakeCast Mobile page consists of four earthquake web pages in a single HTML document.

- Earthquake List page. Displays list of recent earthquakes (Figure 8.14).
- Earthquake Summary page. Displays ShakeCast summary and Inspection Priorities of facilities (Figure 8.15).
- ShakeMap Summary page. Displays ShakeMap processing parameters and associated shaking maps of different metrics (Figure 8.16).
- Earthquake Product page. Displays list of earthquake products (Figure 8.17).

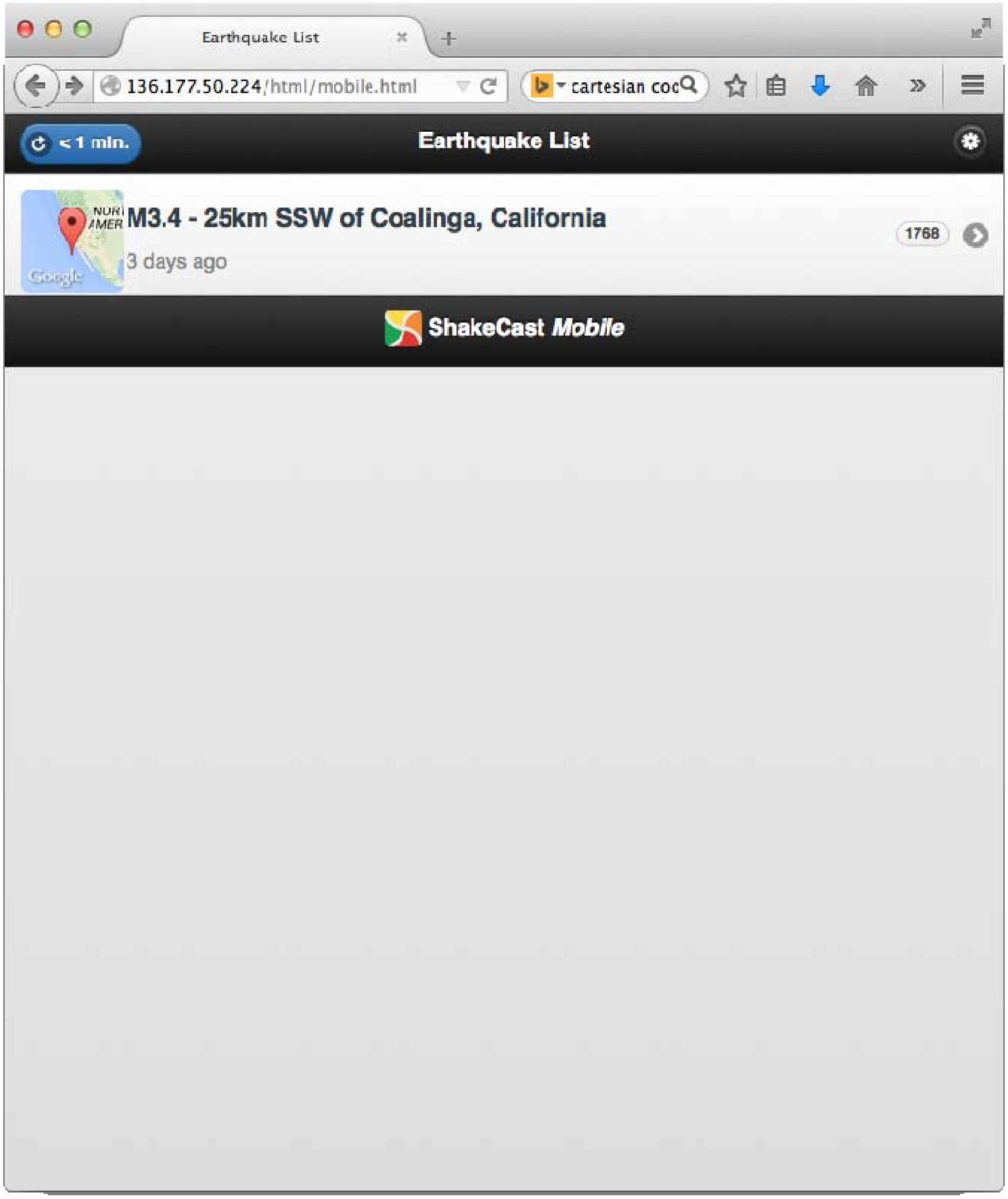


Figure 8.14. Earthquake list of the ShakeCast Mobile web page.

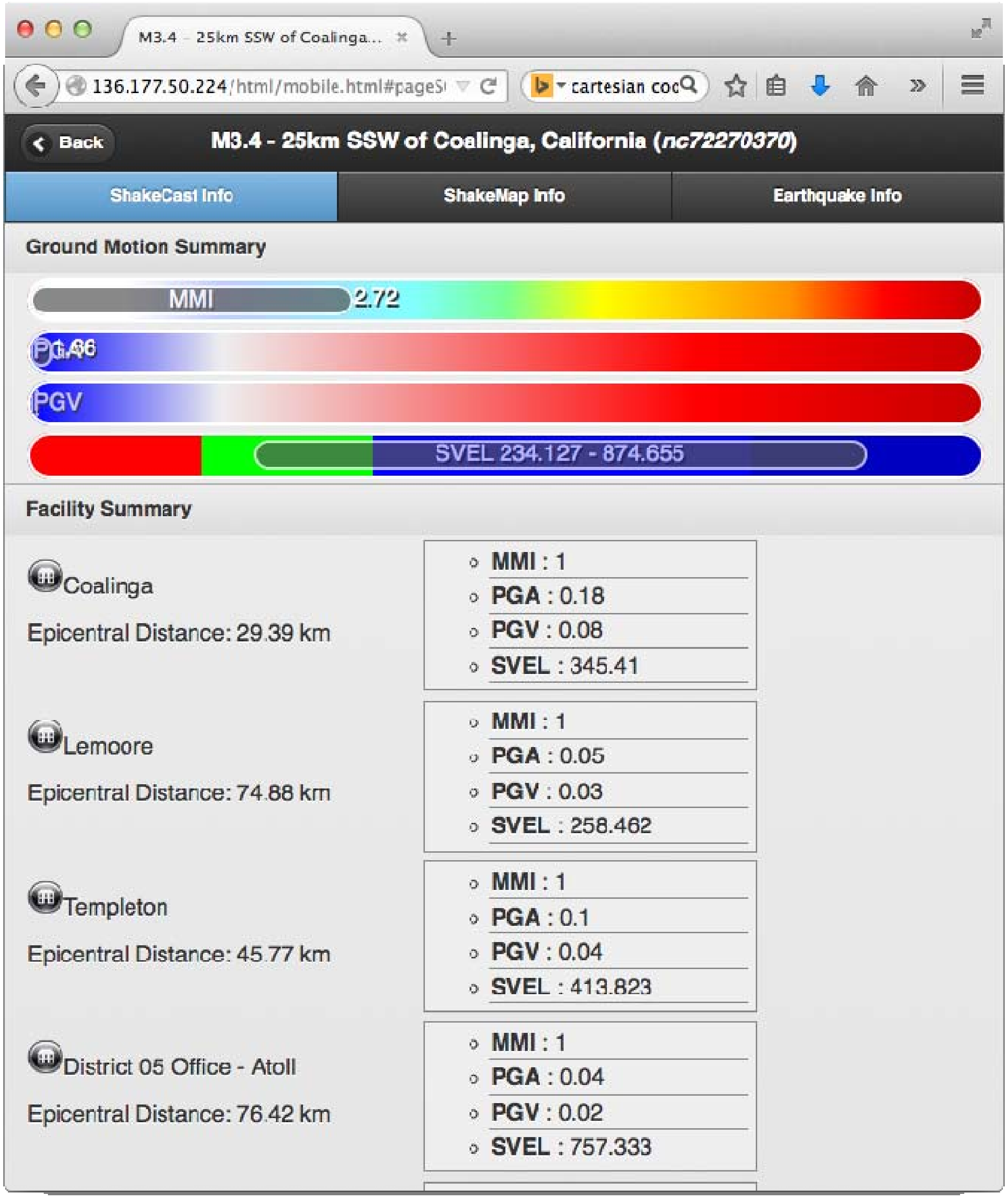


Figure 8.15. Earthquake summary of the ShakeCast Mobile web page.

Figure 8.16. ShakeMap summary of the ShakeCast Mobile web page.

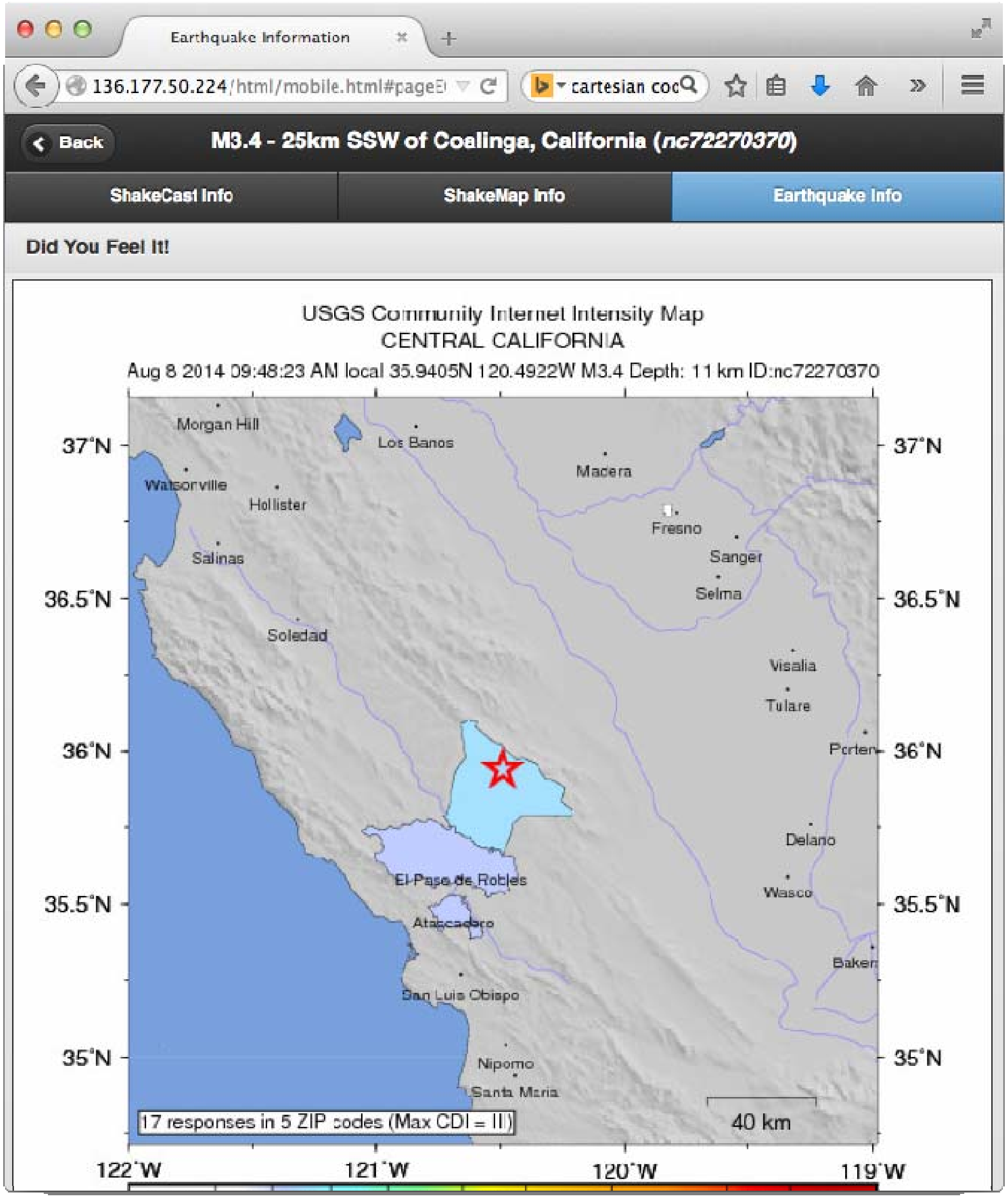


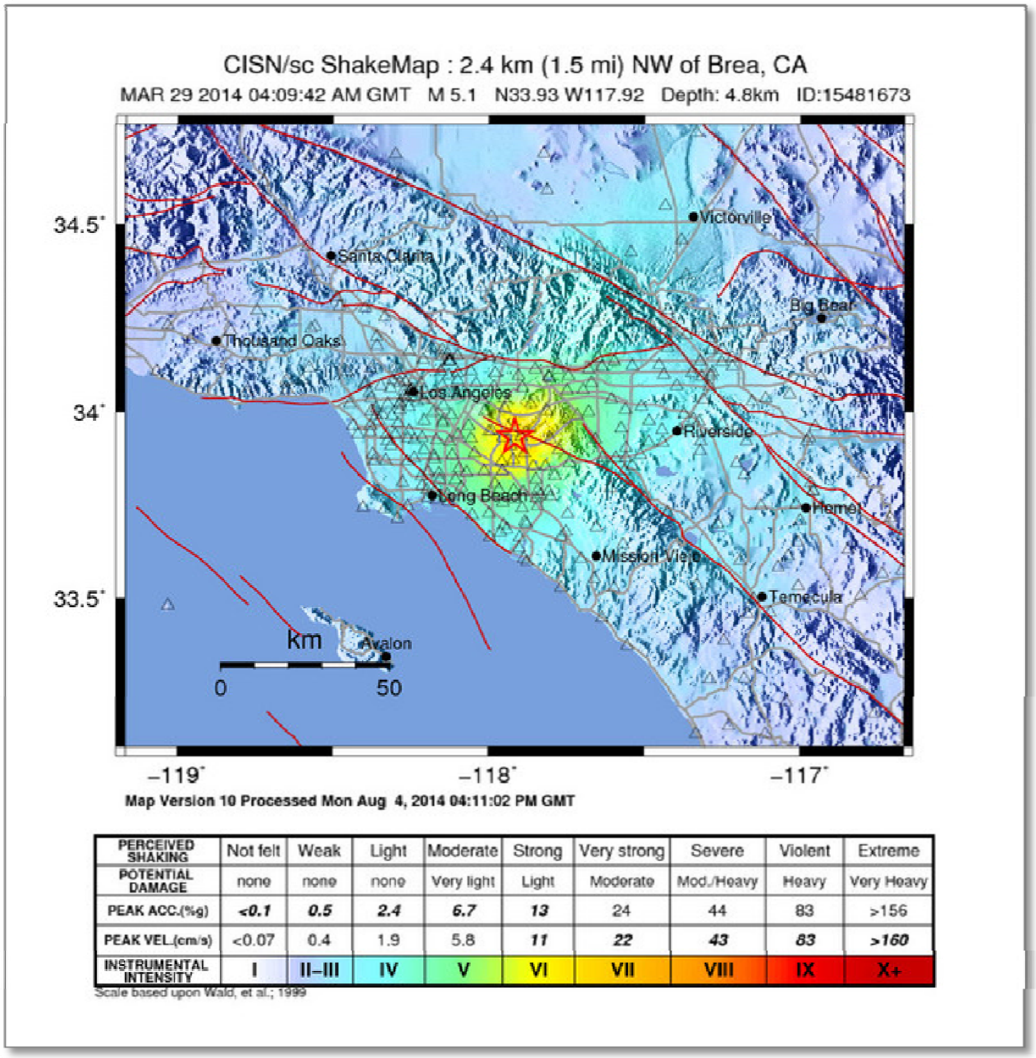
Figure 8.17. Earthquake product of the ShakeCast Mobile web page.

9 CASE STUDIES OF CALTRANS SHAKECAST USAGE

In early 2014 a moderate size earthquake in Southern California occurred, providing a good opportunity for the development team to examine the functionality and performance of the newly configured Caltrans ShakeCast V3 system recently migrated to a Windows 2008 Server VM. At the time of the event, the operational Caltrans-ShakeCast V2 system served as the primary system, analyzing the state bridge inventory and delivering inspection prioritization information to Caltrans responders. However, having both V2 and V3 systems process the event in parallel allowed the development team to compare performance and identify any issues related to the configuration of the V3 system.

9.1 M5.1 Brea Earthquake

At 09:09 PM on Mar 28, 2014, a magnitude 5.1 earthquake occurred near Brea in Southern California as shown in ShakeMap in Figure 9.1. The Caltrans-ShakeCast V3 test system processed the event and generated multiple notifications to the development team, including a “NEW EVENT” message and a corresponding “BRIDGE ASSESSMENT” message.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.1	0.5	2.4	6.7	13	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Figure 9.1. ShakeMap from M5.1 La Habra, Southern California, Earthquake.

9.1.1 ShakeCast V3 Event Processing

A chronology of events for the processing and analysis by the ShakeCast V3 test system is presented in Table 9.1.

Date/Time	Activity
3/28/14 09:09 PM	Brea earthquake occurs.
3/28/14 09:11 PM	ShakeCast V3 receives and sends a “NEW EVENT” message to the development team.
3/28/14 09:21 PM	USGS reports a magnitude 5.1 event and publishes an initial ShakeMap v2.
3/28/14 09:23 PM	ShakeCast V3 analyzes bridge inventory and sends a “BRIDGE ASSESSMENT” message to the development team.
3/28/14 09:30 PM	The USGS issues a v3 ShakeMap. ShakeCast V3 analyzes bridge inventory and sends a revised “BRIDGE ASSESSMENT” message to the development team.
3/28/14 10:16 PM	The USGS issues a v4 ShakeMap. ShakeCast analyzes bridge inventory and does not trigger re-notifications.
3/28/14 10:18 PM	The USGS issues a v5 ShakeMap. ShakeCast analyzes bridge inventory and does not trigger re-notifications. The ShakeMap ground motion estimates stabilize.
3/29/14 09:17 AM	The USGS issues a final v7 ShakeMap. ShakeCast analyzes bridge inventory and does not trigger re-notifications.
3/31/14 04:57 PM	The USGS issues a final v8 ShakeMap. ShakeCast analyzes bridge inventory and does not trigger re-notifications. The active response window subsequently expires and no further automatic triggering of ShakeCast processes for the earthquake.

Table 9.1. Timeline of ShakeCast V3 processes.

An initial “NEW EVENT” ShakeCast message was generated and sent to the development team 2 minutes after the earthquake occurred and before the USGS ShakeMap became available. By contrast, the operational Caltrans ShakeCast V2 system delivered the “NEW EVENT” message approximately 13 minutes following the event. This significant decrease in delivery time is attributed to a new function in V3 that tracks multiple earthquake data feeds in addition to the legacy ShakeMap feed.

The initial ShakeMap became available through the USGS earthquake website approximately 12 minutes after the event. Although this was 7 minutes later than the USGS’s ShakeMap performance goal of 5 minutes, the delivery of the ShakeMap was still within a reasonable time window for responders. The USGS reported that an issue with Internet traffic on the USGS website may have contributed to the delay in making the ShakeMap available to downstream ShakeCast servers.

Within 2 minutes of the ShakeCast V3 system receiving the ShakeMap, facility assessments were completed and three different notifications (i.e. state bridges, local bridges, and buildings) were distributed to the development team.

Text based local ShakeCast products (e.g. CSV, KML) were generated and made available for download on the ShakeCast V3 server at approximately the same time as the notifications. The new PDF summary reports took an additional 2 minutes to complete, and the full analysis results from the probabilistic fragility calculations were available after an additional 7 minutes. These products and analyses are performed in parallel.

The USGS earthquake web server published an updated version 3 of ShakeMap approximately 21 minutes after the earthquake origin time and 9 minutes after a version 2 ShakeMap. The maximum PGA estimate increased from 37%g to 50%g, a 32% increase, and exceeded the predefined retriggering threshold (20%) for a ShakeCast notification update. Another round of facility assessments was performed and notifications were prepared and sent to the development team.

Subsequent ShakeMap updates on the same day (v4 and v5) and up to two days afterwards (v7 and v8) showed stabilized ground motion estimates and did not trigger further ShakeCast processing. The active response window expired after 7 days (a configurable option) and the system no longer processed updates of the earthquake.

To balance between notification performance and content, the notification logic was revised to allow the attachment condition (required or optional) via notification request and template configuration. Products specified in the notification requests are required conditions (must be included as email attachments) before a notification will be sent. Attachments listed in the notification templates are optional and will be attached to the notification if they are available. The computation of probabilistic fragility for all facilities has been rearranged to the last stage of the analysis process by default.

9.2 Earthquake Scenarios

Since the release of ShakeCast V2 in 2008, there has been a steady increase in interest in using ShakeMap scenarios through ShakeCast for the purpose of earthquake planning, exercise, and risk mitigation. However, users have encountered difficulties in adapting to the ShakeMap/ShakeCast methodology due to out-of-date and out-of-sync ShakeMap products, locating and saving desired scenarios, and loading and triggering ShakeMap scenarios.

To address these issues, a new procedure was implemented to facilitate the access and handling of ShakeMap scenarios within ShakeCast V3. The end product is a ready-to-use ShakeMap package per earthquake scenario. Each scenario package is a folder containing all ShakeMap products in a compressed zip format. The scenario has been verified using the latest ShakeMap software and has been tested to run properly with the ShakeCast program.

As part of the Caltrans ShakeCast project, a total of 250 scenario packages were compiled for California. Although this collection of scenario events only represents a small subset of the entire ShakeMap scenario/Atlas archive, the process of converting the catalog of ShakeMap scenarios is ongoing. The non-geospatial tagged scenario packages have been delivered to Caltrans. The geospatial tagged version is queued to be published on the USGS ScienceBase ShakeCast catalog (Figure 9.2), at URL

https://www.sciencebase.gov/catalog/items?q=&filter=tags%3DCalifornia&community=ShakeCast

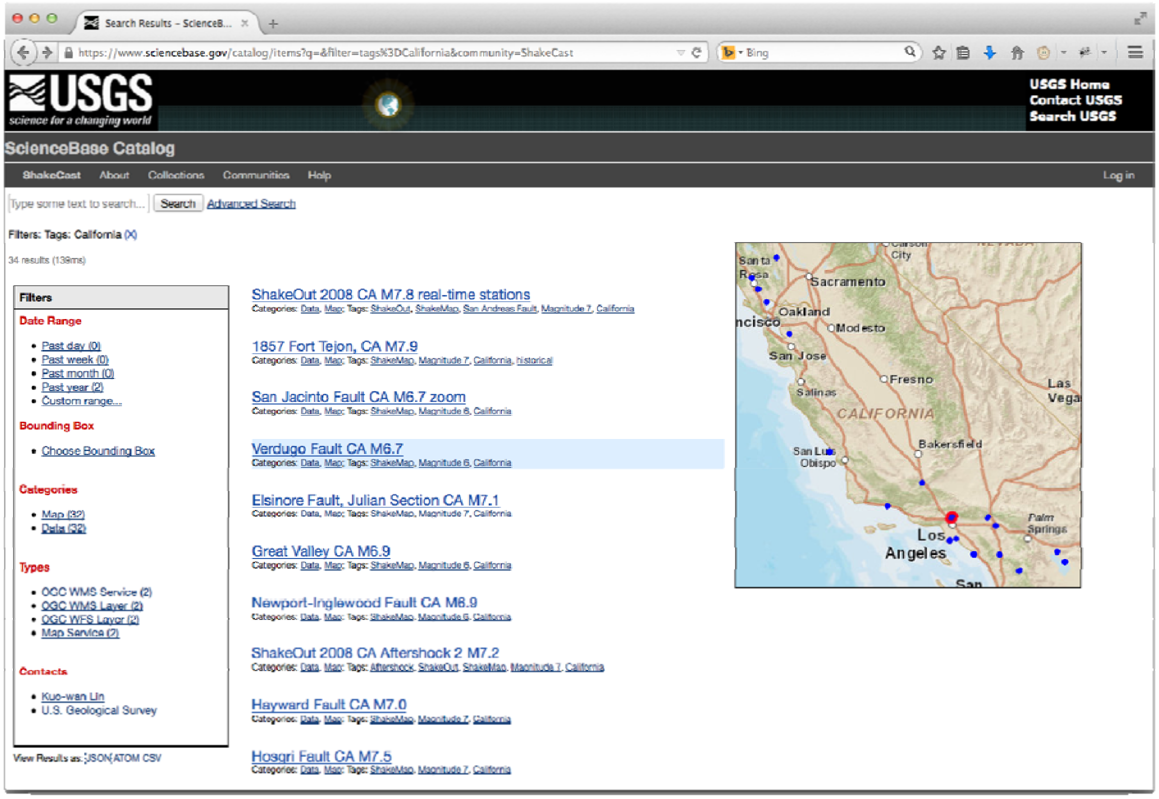
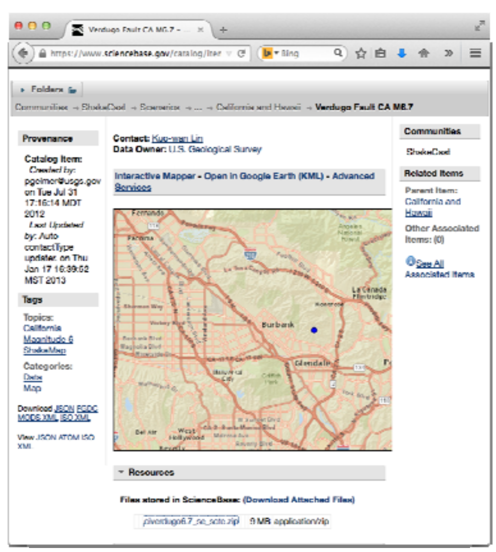
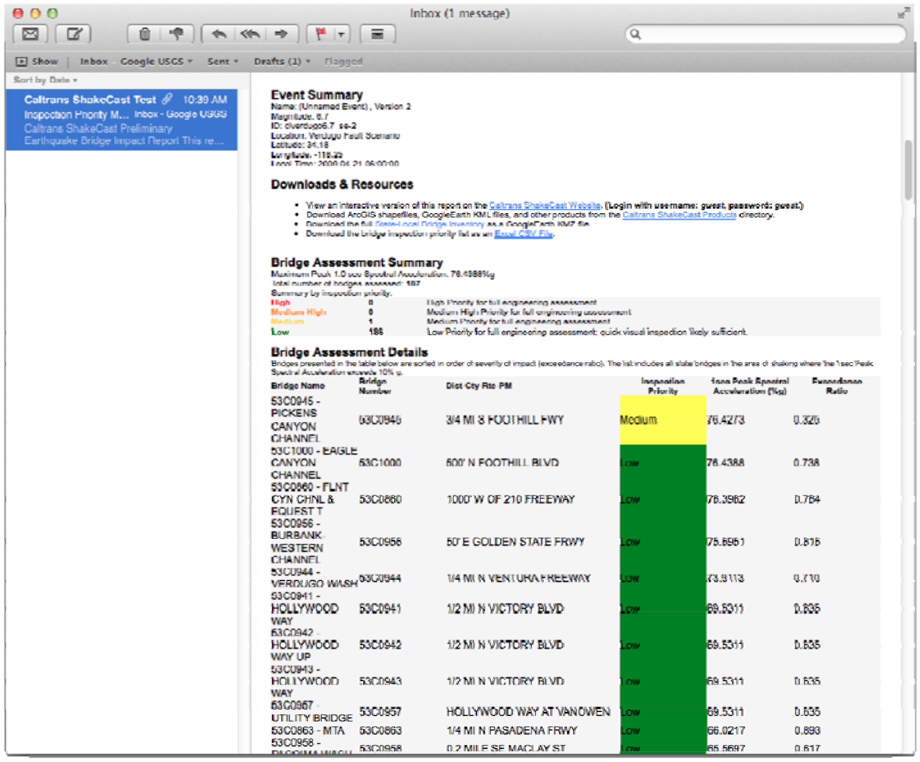


Figure 9.2. Geospatial-tagged ShakeMap scenarios on USGS ScienceBase ShakeCast catalog.

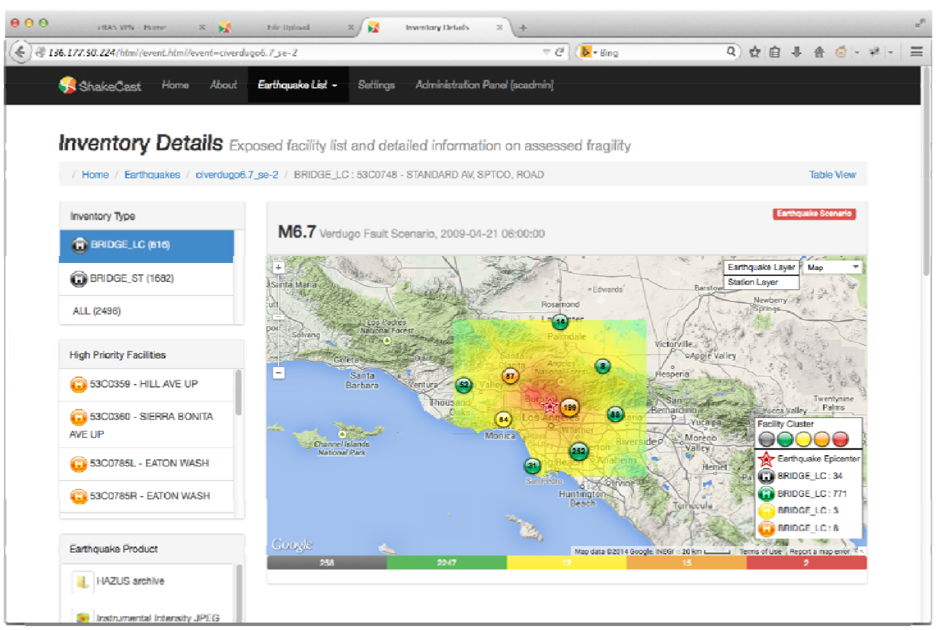
The list of ShakeMap scenarios can be viewed from the web interface or through a third-party program via the data feed in JSON/ATOM/CSV format. At this time we are not aware of any program that utilizes the scenario data feed. To manually launch a ShakeMap scenario, the administrator performs the following steps:

1. Locate the scenario via ScienceBase ShakeCast catalog shown in Figure 9.1.
2. Download the scenario package to local computer (screenshot to the right).
3. As shown in Sec. 7.4.5, verify and delete the scenario if it has already been processed by the system.
4. Use the Inventory Upload tool from the Administrative interface to upload and trigger the ShakeMap scenario.





(a)



(b)

Figure 9.3. ShakeCast (a) notification message and (b) web page for the M6.7 Verdugo Fault ShakeMap scenario.

In ShakeCast V3, the local test "_scte" event type is depreciated but still supported. The system will continue to accept and process packages of local test events as shown in the above example. The event type will be converted to the default scenario type in the process. However, locally generated test events will need to be validated first before packaging as scenario packages.

10 SUMMARY

The main goal of the Caltrans ShakeCast Phase 2 Project was to continue the development, deployment, and support of the ShakeCast V2 system within Caltrans. As a result, the Caltrans ShakeCast V3 system was developed to meet the project requirements to support a broader range of facilities, vulnerability functions, notification messaging, and products.

10.1 State of Deployment

The prototype Caltrans ShakeCast V3 system has been installed within the Caltrans IT infrastructure as a Virtual Machine with the Windows 2008 Server operating system. A duplicate system is set up at USGS in their Golden, Colorado office for performance tuning based on the populated inventory.

Currently the facility inventory and fragility information are not fully populated inside the ShakeCast database. A statewide region for earthquake monitoring has been defined in ShakeCast. User groups, notification message templates, and ShakeCast products will be added to the system as an ongoing effort over the next several months to improve the system.

The existing ShakeCast V2 system will remain operational while introducing the new V3 system to the production environment. Both systems are not conflicting and can function in parallel during the transition to the new system. Once the ShakeCast V3 system is switched to production mode, a secondary V3 system VM will be replicated as a redundant system.

10.2 Benefits of Caltrans ShakeCast V3

The primary benefits of ShakeCast can be summarized as follows:

- **ShakeCast provides a centralized repository for earthquake information and products**. The ShakeCast system tracks and receives earthquake products via multiple sources and the ShakeCast web site provides direct access to earthquake information (e.g., focal mechanisms and tectonic summaries), and earthquake related products including the "Did You Feel It?" (DYFI) and Prompt Assessment of Global Earthquakes for Response (PAGER) loss estimates. All these products are (optionally) stored locally as part of the ShakeCast data repository, accessible by ShakeCast users, and can thus be included to expand the scope of post-earthquake situational awareness.

- **ShakeCast customizes fragility analysis for target facility type.** For events greater than magnitude 4.0 in California and bordering regions, ShakeCast has been successfully demonstrated to automatically determine the shaking value at the locations of a large inventory of Caltrans bridges, buildings, and road segments. Estimated ground shaking values at facilities are compared with the threshold pre-established for each facility, assessed for component-based probabilistic vulnerability and HAZUS-based building fragility. For facilities with complex geometric footprints, comprehensive shaking estimates comprising the facility are stored separately.

- **ShakeCast tailors notifications for user groups.** ShakeCast distributes event notifications as soon as the earthquake source parameters become available and before a ShakeMap is made. Results of facility assessment are distributed as notification e-mail messages to designated responders within 5-10 minutes of the event. The e-mails contain general information about the event and a table of facilities sorted by inspection priority for specific user groups. Reports for the complete inventory are available via the ShakeCast web site.

- **ShakeCast introduces a ground failure analysis framework.** ShakeCast includes functions and features that will accommodate a wide variety of assessment methods, including: shaking estimates for complex facilities, facility-specific attributes and routines, ground failure as a component for probabilistic susceptibility assessment, and potentially the use of USGS Ground Failure product in the future.

- **ShakeCast streamlines management of the system, operations, and inventory.** ShakeCast activates several automated processes during initial setup to handle routine maintenance of the system. Utilities are available to the administrator (via web interface or command line) to fine tune the system for performance purpose. A universal tool has been created to assist the administrator to manage the facility, user, and earthquake inventory. A suite of 250 ShakeMap scenario packages has been made available to Caltrans as part of the scenario planning and evaluation tool. ShakeCast can generate any number of possible earthquake situations and analyze the potential impact on Caltrans facilities.

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APPENDIX A Caltrans User Needs Assessment

See pdf attachment Caltrans ShakeCast User Needs Assessment.

Caltrans ShakeCast Phase 2 Project Requirement Specifications: Draft Report

Prepared by U.S. Geological Survey, August, 2011
Funds for this report are provided under California Department of Transportation Contract No. 65A0381.

1. Introduction

The Caltrans ShakeCast Phase 2 Project continues work that began under a partnership between Caltrans and the USGS to develop, deploy and support an enhanced pilot version of ShakeCast within Caltrans. The enhanced version will add behind-the-scenes capabilities and flexibility to accommodate a broader range of facility (i.e. bridge) and user-group information that will enable dissemination of more information, more accurate, and better tailored messages per requirements of Caltrans user groups.

We summarized the User Needs Assessment from two meetings:

1. A kickoff meeting with key earthquake responders, engineers, and IT personnel to discuss roles and needs of the users.
2. A Requirement specification meeting with the ShakeCast project manager and key engineer.

The kickoff meeting was convened on June 3, 2011 at the Caltrans Division of Research & Innovation in Sacramento. The requirement specification meeting was convened on July 28-29, 2011 at the Caltrans GeoResearch facility in Sacramento. The meetings were intended to identify common and specific needs of earthquake response for different divisions and to clarify expectations regarding the functionality, and user interface of the Caltrans ShakeCast system.

The results of these meetings and follow-up discussions are included in this document.

2. Meeting Participants

ShakeCast Kickoff meeting (June 3, 2011)

Name	Agency
Loren Turner	Caltrans Research
Cliff Roblee	Caltrans Research
Dave Wald	U.S. Geological Survey
Kuo-Wan Lin	U.S. Geological Survey
Steve Sahs	Caltrans Structures Maintenance
Mark Yashinski	Caltrans Earthquake Engineering/PEQIT
Larry Tjoelker	Caltrans Information Technology

Requirement Specification meeting (July 28-29, 2011)

Name	Agency
Loren Turner	Caltrans Research
Cliff Roblee	Caltrans Research
Kuo-Wan Lin	U.S. Geological Survey

3. ShakeCast Deliverable Items

The Caltrans ShakeCast Phase 2 project identifies several key features listed below for the revised version of Caltrans ShakeCast (version3):

- Implement full statistical interpretation of fragility curves.
- Implement a component-based fragility analysis framework.
- Implement landslide hazard analysis function.
- Implement liquefaction hazard analysis function.
- Implement polygon/polyline facility location delineation method.
- Develop and implement method to present results for various facility groupings.
- Automatic generation of large-scale printable map as a standard ShakeCast product.

In addition, the contractor will deliver:

- Troubleshooting support and implementation of interface enhancements.
- A recommendation for IT server deployment at Caltrans.
- User’s Manual.
- Final Report.

The combined expectations of the various Caltrans units are listed below for each category. These items, together with information developed as part of the overall ShakeCast project, provide a foundation for the development of the Caltrans ShakeCast system.

4. Main Issues and Recommendations

The combined expectations of the Caltrans users are listed below for each feature. These items, together with information developed as part of the overall ShakeCast project, provide a foundation for the development of the Caltrans ShakeCast Version 3.0 system.

4.1 Implement Full Statistical Interpretation of Fragility Curves

Fragilities are currently implemented in ShakeCast by defining discrete damage state thresholds from available ShakeMap metrics. For bridges, the damage thresholds are defined using the value corresponding to 50% or greater probability of exceedance of a particular damage state from HAZUS-based fragilities curves (Fig. 1).

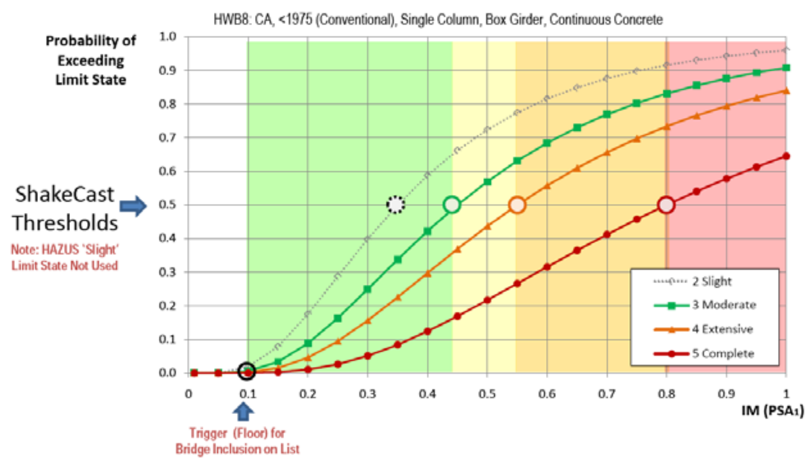


Figure 1. 50% probability of exceedance as implemented in ShakeCast.

These thresholds are calculated from the full fragility curves and are loaded into ShakeCast's database tables. This approach simplifies the analysis of facilities by converting a family of statistical curves into a single "step function" of damage states.

In order to present a more statistically representative picture and convey the degree of uncertainty in the analysis, modify the ShakeCast analysis function to use the family of fragility curves and calculate the probability for each damage state for a given input motion.

Implementation of the curves requires that ShakeCast calculate the various probabilities, rather than perform a comparison against pre-defined thresholds. The HAZUS fragility curves have the following form:

Curve Equation

$$P[ds|IM] = \Phi[1/\beta_{ds} * \ln(IM/\alpha_{ds})]$$

Where:
- ds = damage state associated with curve
- IM = ground motion intensity measure
- Φ = (log?)normal cum. distribution function
- α_{ds} = median IM for damage state curve
- β_{ds} = dispersion for damage state curve

The equation reduces to a three variable calculation taking the ShakeMap intensity measure, an α value, and a β value, and calculating the probability. The ShakeCast system would store, for each damage state for each facility, the α and β values defining the curve to be used in the calculation.

4.1.1 System Processing

The ShakeCast system will store the fragility information for each damage state, the ShakeMap intensity measure, an α value, and a β value that defines the curve. To accomplish the goal, essential changes to the existing ShakeCast system will include database schema, probability computation, damage evaluations and notification triggering, data import/export routines, and the user interface, at the minimum. Fig. 2 demonstrates the three tables created to store the bridge fragility information.

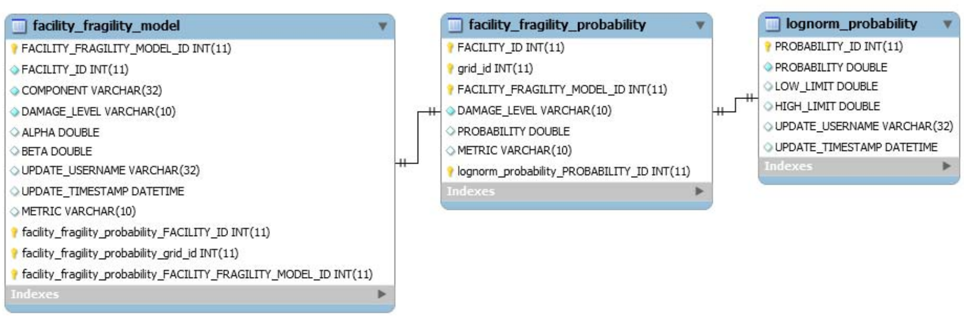


Figure 2. Database schema for bridge fragility.

In the following example (Fig. 3) for the input ground motion (based on the 2008 M7.8 ShakeOut exercise), ShakeCast will compute the probability for each damage state based on individual fragility information and store the results in the database. During the initial stage of ShakeCast implementation these information will be available for engineering review as part of the ShakeCast event page. Notifications based on fragility analysis will become a user configurable option (see **Sec. 4.2 Implement a component-based fragility analysis framework**).

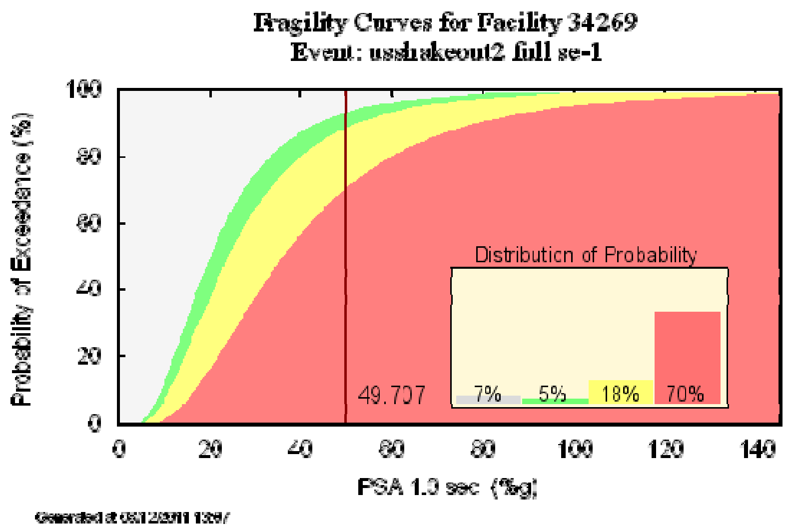


Figure 3. Example ShakeCast bridge fragility plot using the ShakeOut ShakeMap.

4.1.2 Data Handling

The ShakeCast administrator will continue to use the same methods for data import, data spreadsheet (in CSV format), administrative interface, and the database backup file (in SQL format). The existing programs for processing user inventory will be updated to handle optional fragility information user may supply.

Results of the fragility analysis will be stored inside the ShakeCast database. The system will expand the display panel of the current ShakeCast event page to accommodate the fragility information. Conceptual layout of fragility related information is discussed in details in the next section.

4.2 Implement a Component-Based Fragility Analysis Framework

ShakeCast currently stores a single fragility function (as a table of threshold values) for each facility in the system, resulting in a single measure of overall facility vulnerability. As Caltrans begins to capture more information on the various components of individual bridges, there is an opportunity to analyze the overall bridge state as a function of the individual component fragilities. For example, a simple bridge might have unique fragilities defined for the columns, abutments, deck, and foundation elements. Each component could be analyzed separately against a ShakeMap intensity measure with probabilities assigned for various component damage states. Those results would then be aggregated into single damage state metric used for summarizing and prioritizing inspections, while providing additional detail to inspectors on specific components that are likely to be the cause of the overall system failure.

For each bridge in the inventory based on the Component-Based System (CBS), and prior to importing into ShakeCast, Caltrans engineers will perform the following tasks:

- Assign into one of the new model classifications.
- Identify the primary, secondary, and general distress indicators that apply.

Below summaries fragility information for an example bridge based on CBS:

- Primary components:
  - Multispan continuous box girder, seat type abutment, muliframe, single column bent, pre-1971, full height class F retrofit columns. (Type = MCCB-M-S-Cf)
  - Ductile columns (Col-A)
  - Early seismic in-span seat (SIS-B)
  - Early seismic abutment seat (SAb-B)
- Secondary components:
  - Standard joint seal in span (JSI-B)
  - Standard joint seal abutment (JSA-B)
  - Standard elastomeric bearing in span (BrI-B)
  - Standard elastomeric bearing abutment (BrB-B)
  - Pre-SDC key in span (SKI-B)
  - Pre-SDC key abutment (SKA-B)
  - Type 2 short cable restrainer (Res-B)
  - Supported approach slab (ApS-A)
- Generalized distress indicators
  - Bridge deck displacement (GDI-1)
  - Bridge deck residual displacement (GDI-2)
  - Bridge deck strain (GDI-3)
  - Column foundation lateral (GDI-4)
  - Column foundation rotation (GDI-5)
  - Abutment foundation lateral (GDI-6)
  - Abutment wall load active (GDI-7)
  - Abutment wall load passive (GDI-8)
- Summary of bridge fragility:
  - 19 components are assigned to the bridge
  - 44 total fragility curves are in a library

4.2.1 System Processing

The system processing described in Sec. 4.1.1 remains valid for the Component-Based System (CBS). The processing modules are further expanded to handle different categories of fragility parameters: (1) the HAZUS method, (2) the CBS method, and (3) Individual components. Category (1) and (2) are a single set of overall system fragility parameters that corresponds to the list of inspection priorities.

- RED fragility curve (alpha and beta)
- ORANGE fragility curve (alpha and beta)
- YELLOW fragility curve (alpha and beta)
- GREEN fragility curve (alpha and beta)

Inspection priority is calculated based on both the HAZUS and CBS methods whereas CBS governs when available. Email notifications sent to responders will report the 50% probability value and corresponding color code using the HAZUS or CBS method, same as the current practice in ShakeCast V2. Full probability distributions are made available on ShakeCast website (mockup in Sec. 4.2.3).

Components are analyzed in the same manner as system fragilities using ShakeMap metrics, and the 50% probability values and corresponding color code are determined. Full probability distributions are also determined. Both are presented to the user on ShakeCast website.

4.2.2 Data Handling

The method for ShakeCast import file remains the same as described in Sec. 4.1.2. Additional keywords will be created for the list of components.

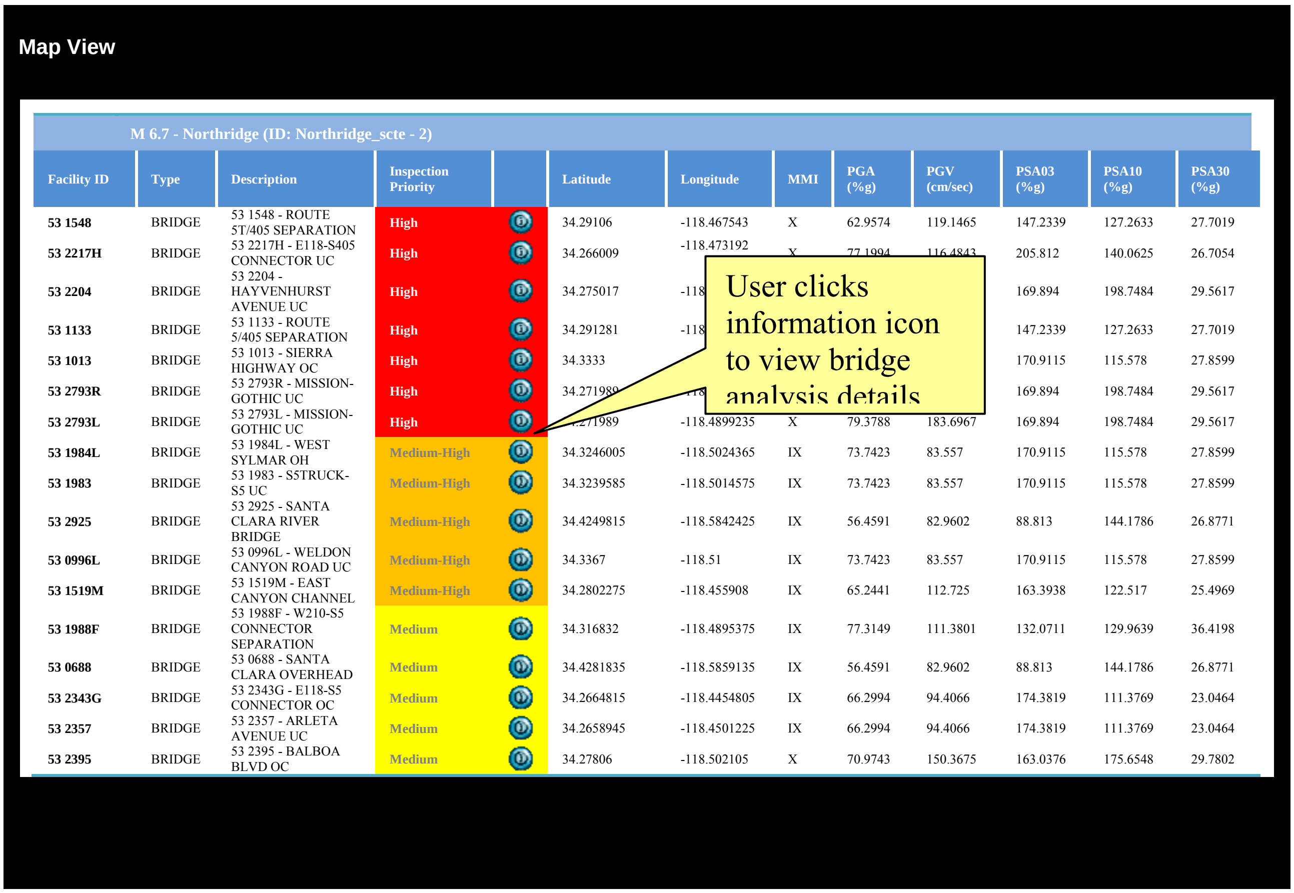
Component attributes for each bridge may include:

- Column RED fragility curve (alpha and beta)
- Column ORANGE fragility curve (alpha and beta)
- Column YELLOW fragility curve (alpha and beta)
- Column GREEN fragility curve (alpha and beta)
- Seat In-Span RED fragility curve (alpha and beta)
- Seat In-Span ORANGE fragility curve (alpha and beta)
- Seat In-Span YELLOW fragility curve (alpha and beta)
- Seat In-Span GREEN fragility curve (alpha and beta)
- Seat Abutment RED fragility curve (alpha and beta)
- Seat Abutment ORANGE fragility curve (alpha and beta)
- Seat Abutment YELLOW fragility curve (alpha and beta)
- Seat Abutment GREEN fragility curve (alpha and beta)
  …. (108 total component based fragility parameters, including all component damage ranges and alpha and beta factors.)

It may be possible to reduce the number of attributes by capturing a single global beta parameter (e.g. 0.60) or by deriving facility-type specific global beta parameter.

4.2.3 ShakeCast Inspection Priority Webpage Mockup

STEP 1 – User goes to ShakeCast website and views bridges for an event. The bridges are presented in same manner as current ShakeCast v2. An informational icon for each bridge, when clicked, opens a gray box overlay with additional information (Fig. 4).



M 6.7 - Northridge (ID: Northridge_scte - 2)												
Facility ID	**Type**	**Description**	**Inspection Priority**		**Latitude**	**Longitude**	**MMI**	**PGA (%g)**	**PGV (cm/sec)**	**PSA03 (%g)**	**PSA10 (%g)**	**PSA30 (%g)**
53 1548	BRIDGE	53 1548 - ROUTE 5T/405 SEPARATION	High		34.29106	-118.467543	X	62.9574	119.1465	147.2339	127.2633	27.7019
53 2217H	BRIDGE	53 2217H - E118-S405 CONNECTOR UC	High		34.266009	-118.473192	X	77.1994	116.4843	205.812	140.0625	26.7054
53 2204	BRIDGE	53 2204 - HAYVENHURST AVENUE UC	High		34.275017	-118	[illegible]	[illegible]	[illegible]	169.894	198.7484	29.5617
53 1133	BRIDGE	53 1133 - ROUTE 5/405 SEPARATION	High		34.291281	-118	[illegible]	[illegible]	[illegible]	147.2339	127.2633	27.7019
53 1013	BRIDGE	53 1013 - SIERRA HIGHWAY OC	High		34.3333	[illegible]	[illegible]	[illegible]	[illegible]	170.9115	115.578	27.8599
53 2793R	BRIDGE	53 2793R - MISSION-GOTHIC UC	High		34.271989	-118	[illegible]	[illegible]	[illegible]	169.894	198.7484	29.5617
53 2793L	BRIDGE	53 2793L - MISSION-GOTHIC UC	High		.271989	-118.4899235	X	79.3788	183.6967	169.894	198.7484	29.5617
53 1984L	BRIDGE	53 1984L - WEST SYLMAR OH	Medium-High		34.3246005	-118.5024365	IX	73.7423	83.557	170.9115	115.578	27.8599
53 1983	BRIDGE	53 1983 - S5TRUCK-S5 UC	Medium-High		34.3239585	-118.5014575	IX	73.7423	83.557	170.9115	115.578	27.8599
53 2925	BRIDGE	53 2925 - SANTA CLARA RIVER BRIDGE	Medium-High		34.4249815	-118.5842425	IX	56.4591	82.9602	88.813	144.1786	26.8771
53 0996L	BRIDGE	53 0996L - WELDON CANYON ROAD UC	Medium-High		34.3367	-118.51	IX	73.7423	83.557	170.9115	115.578	27.8599
53 1519M	BRIDGE	53 1519M - EAST CANYON CHANNEL	Medium-High		34.2802275	-118.455908	IX	65.2441	112.725	163.3938	122.517	25.4969
53 1988F	BRIDGE	53 1988F - W210-S5 CONNECTOR SEPARATION	Medium		34.316832	-118.4895375	IX	77.3149	111.3801	132.0711	129.9639	36.4198
53 0688	BRIDGE	53 0688 - SANTA CLARA OVERHEAD	Medium		34.4281835	-118.5859135	IX	56.4591	82.9602	88.813	144.1786	26.8771
53 2343G	BRIDGE	53 2343G - E118-S5 CONNECTOR OC	Medium		34.2664815	-118.4454805	IX	66.2994	94.4066	174.3819	111.3769	23.0464
53 2357	BRIDGE	53 2357 - ARLETA AVENUE UC	Medium		34.2658945	-118.4501225	IX	66.2994	94.4066	174.3819	111.3769	23.0464
53 2395	BRIDGE	53 2395 - BALBOA BLVD OC	Medium		34.27806	-118.502105	X	70.9743	150.3675	163.0376	175.6548	29.7802

Figure 4. Example ShakeCast event page with icon linking to fragility information.

STEP 2 – The gray box overlay presents more detailed information about a single bridge's inspection priority, including the inspection state of each component (Fig. 5). An area of the right provides a link to expose all the backup statistical data – the probability distributions.

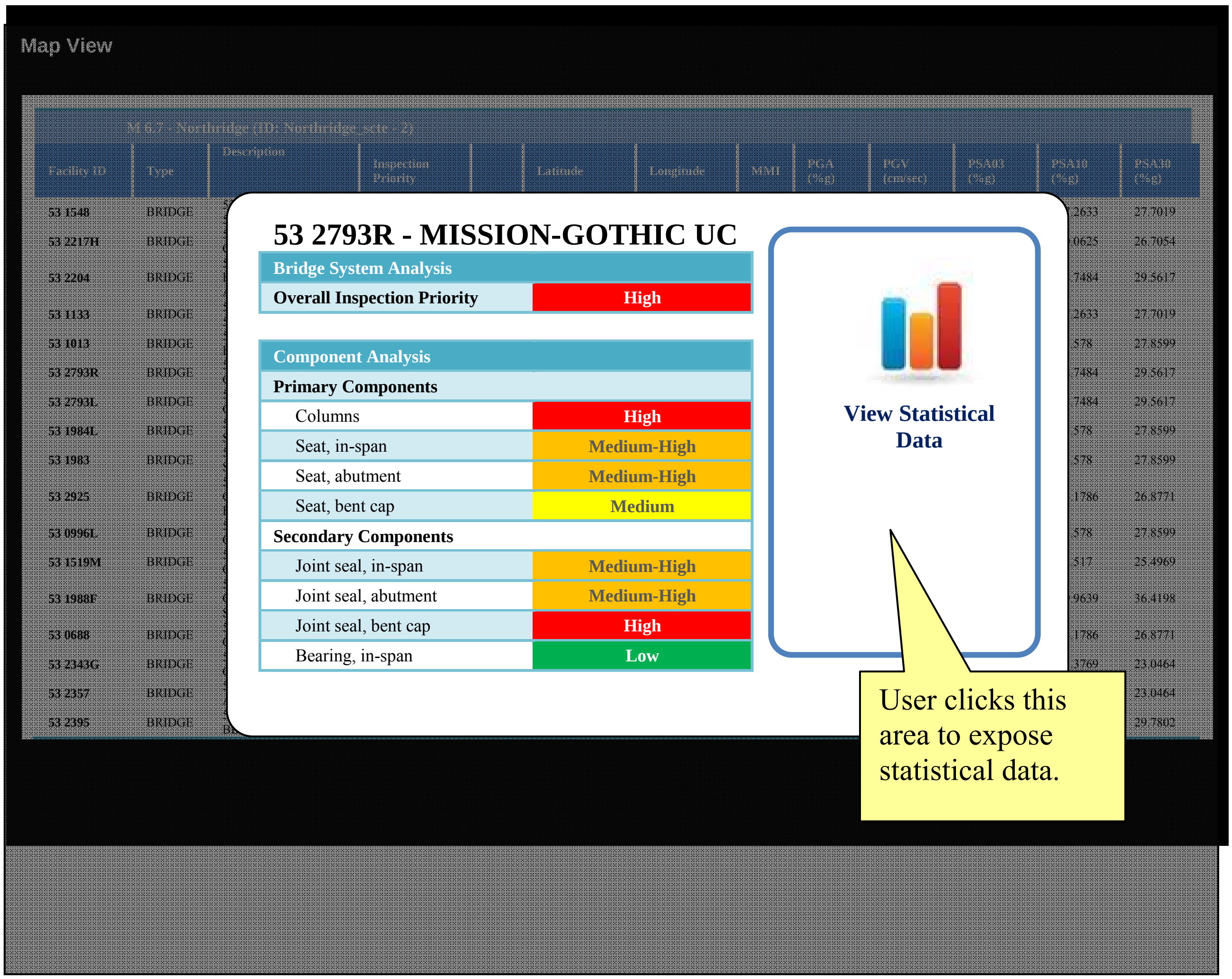


Figure 5. Example overlay with detailed information about a single bridge's inspection priority.

STEP 3 – Clicking the "view statistical data" exposes the probabilistic data for the system and the various components (Fig. 6).

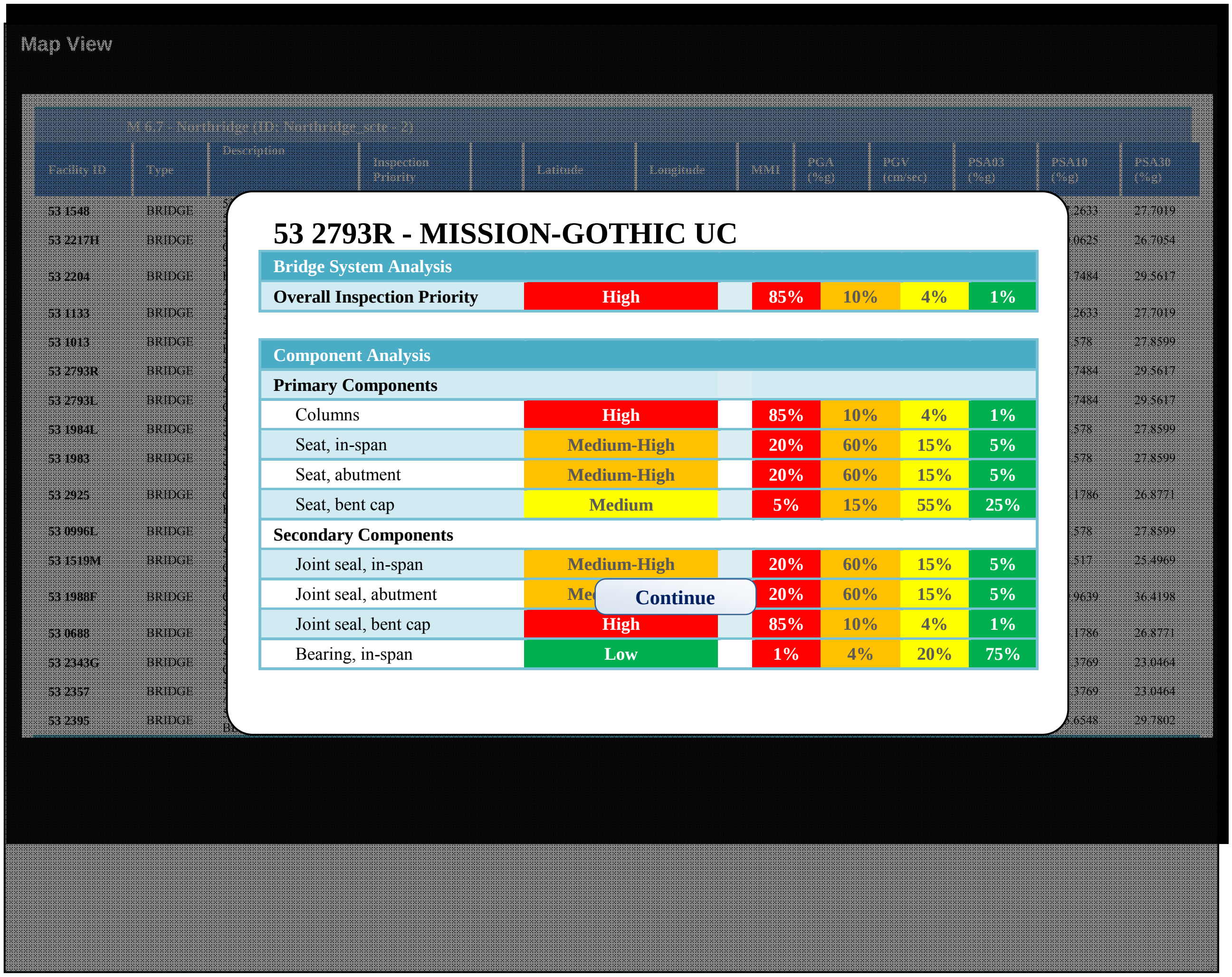


Figure 6. Example overlay showing fragility probability data for the system and components of a bridge.

4.3 Handling of Ground Failure Features (Landslides and Liquefaction)

Ground failure features including landslide, liquefaction, lateral spreading, and fault rupture hazards have been identified and mapped along several key highway corridors in California by the California Geological Survey. This task focuses on identifying vulnerability functions for handling ground failure features and implementing sample inventory, vulnerabilities, and inspection prioritization into ShakeCast.

The ShakeCast built-in analysis function in Version 2 requires facility fragility information to be evaluated using existing ShakeMap metrics. The ground failure problem is further complicated by the varying dimensions of source hazards (Fig. 7) and additional metadata needed for the fragility analysis, such as landslide type, activity, interpreted depth of slide, azimuth of movement, geologic unit, and lithology. The lack of standard approach to evaluate vulnerabilities from ground failure makes it difficult to create a single fragility module for this purpose.

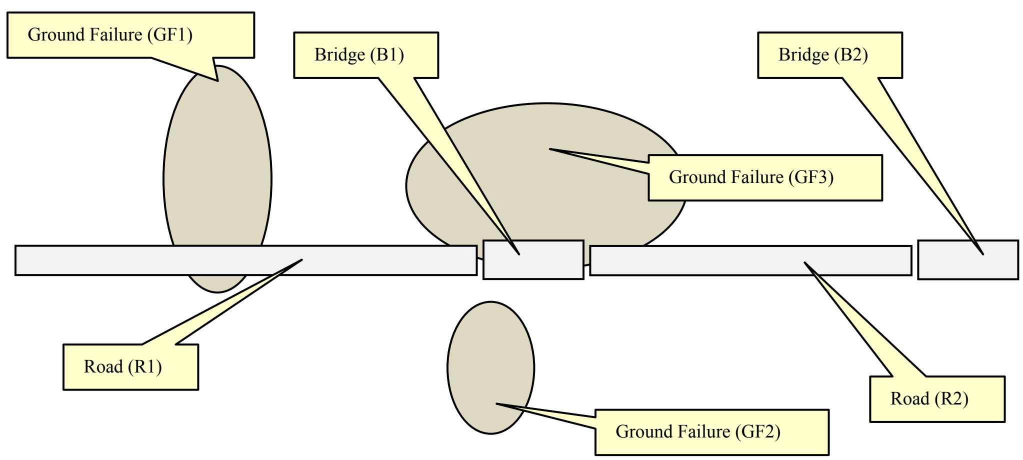


Figure 7. Relations between three ground failure features (landslides, liquefaction, lateral spread, fault rupture) and Caltrans facilities (two bridges and two road segments).

4.3.1 System Processing

Figure 8 shows a conceptual database schema for handling ground failure features. Facilities and ground failure features and their fragility/susceptibility data are captured in different tables. A new table defines which ground failure features impact a facility.

Facilities			
Facility_ID	**Red**	**Yellow**	**…**
B1	0.123	0.456	…
B2	0.123	0.456	…
R1	0.123	0.456	…
R2	0.123	0.456	…

Facility Ground Failure Impact	
Facility_ID	**GFF_ID**
B1	GF2
B1	GF3
R1	GF1
R1	GF2
R1	GF3
R2	GF3

Ground Failure Features			
GFF_ID	**Red**	**Yellow**	**…**
GF1	0.123	0.456	…
GF2	0.123	0.456	…
GF3	0.123	0.456	…

Figure 8. Conceptual ShakeCast database schema for handling ground failure features.

ShakeCast will treat these ground failure features similar to facilities and uses ShakeMap metrics to determine "damage state" or "inspection priority" of the ground failure feature. ShakeCast does not report these as features independently in notifications or on website. They are only reported in the context of impact to a facility (e.g. bridge, roadway, and building).

ShakeCast facilities will need to be associated with ground failure hazards that potentially impact them. This association is captured in a new database table in ShakeCast. Determination of which ground failure feature is linked to facility is done outside of ShakeCast.

In the example above:

- All three ground failures, GF1, GF2, and GF3, can have an impact on road R1.
- Two ground failures, GF2 and GF3, can impact bridge B1.
- Road R2 is only impacted by ground failure GF3.
- Bridge B2 is not impacted by any of the ground failures.

One idea would be to treat all ground failures as being in one of two "damage states" – maybe use green and orange states to present status to responders. Green would indicate little or no likelihood of ground failure occurring. Orange would indicate a chance that ground failure might have occurred and the responder should be aware of it.

The ground failure status may govern the overall inspection priority of the facility. For example, an orange state ground failure turns the inspection priority for a yellow state bridge to an orange status. Ground failure results wouldn't be sent in email notifications as an independent set of data.

4.3.2 Data Handling

The ShakeCast system will provide new routines and database tables to import and store ground failure features, which can be in the format of point, polyline, or polygon. Additional attributes of these features may include:

- ID
- Name
- Description
- Type
- Fragility parameters TBD

On the ShakeCast website, this information could be presented in the detailed view in the gray box overlay as another section, for example:

53 2793R - MISSION-GOTHIC UC

Bridge System Analysis					
Overall Inspection Priority	High	85%	10%	4%	1%
Ground Failure Potential					
Landslide (LS-1234)	Medium-High				
Landslide (LS-5678)	Medium-High				
Fault Crossing (FC-9876)	Low				
Component Analysis					
Primary Components					
Columns	High	85%	10%	4%	1%
Seat, in-span	Medium-High	20%	60%	15%	5%
Seat, abutment	Medium-High	20%	60%	15%	5%
Seat, bent cap	Medium	5%	15%	55%	25%
Secondary Components					
Joint seal, in-span	Medium-High	20%	60%	15%	5%
Joint seal, abutment	Medium-High	20%	60%	15%	5%
Joint seal, bent cap	High	85%	10%	4%	1%
Bearing, in-span	Low	1%	4%	20%	75%

Continue

Figure 9. Example overlay showing ground failure potential in addition to fragility probability data for the system and components of a bridge.

4.4 Metric Services

The ShakeCast Metric system service is a container program for handling user-defined modules. It consists of functions that provide system level support, inter-process communications, database interaction, and data exchange. The Metric service maintains a list of user-defined metrics and fragility modules, performs damage assessments for selected modules and associated facilities, and generates requests for user notifications. The ShakeCast operator populates the module inventory and the list of modules to be evaluated at run-time. A schematic diagram of the ShakeCast Metric system service and its relation with the user-defined module is shown in Figure 10.

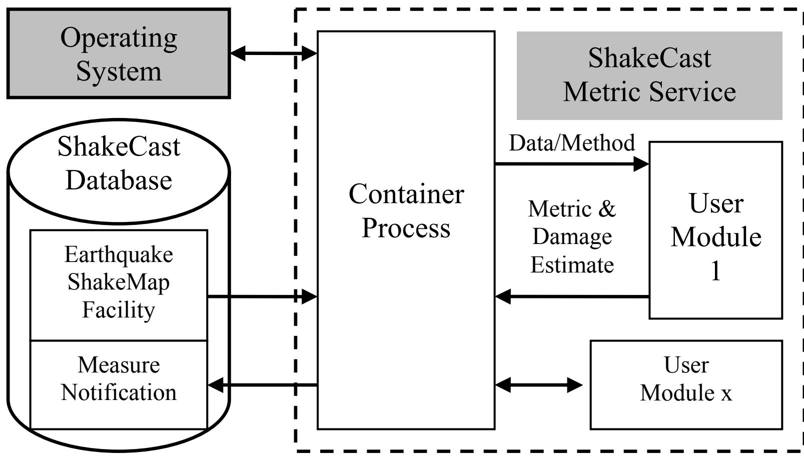


Figure 10. Flowchart depicting the ShakeCast Metric service processing.

4.4.1 System Processing

The ShakeCast Metric service is a new service for the Version 3 release and is an optional service. This feature will be used to define and test two new metrics that are not part of ShakeMap:

- Arias intensity for use in landslide and liquefaction analysis.
- Calculate the "A_2" parameter used in the HAZUS method for determining Damage State 2 for bridge fragility.

4.4.2 Data Handling

The ShakeCast system will treat ShakeMap metrics and user-defined metrics equally. User-defined metrics will be displayed in the ShakeCast web pages (Fig. 11) and can be used as notification criteria.

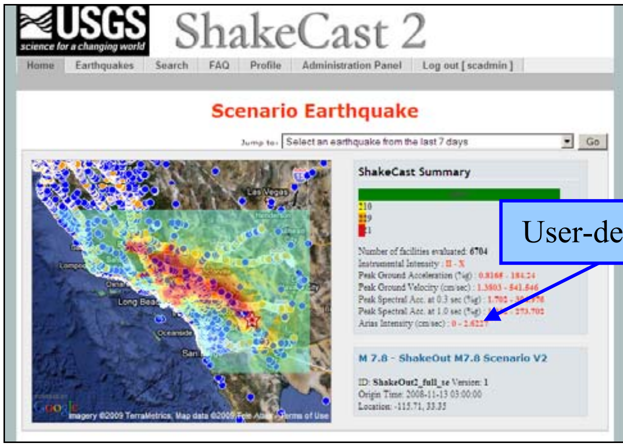


Figure 11. The ShakeCast web page showing the standard ShakeMap and the user-defined Arias Intensity metric.

4.5 Implement Polygon/Polyline Facility Location Delineation Method

Currently, ShakeCast v.2 allows defining the spatial extent of a facility by a rectangle bounded by NE and SW longitude and latitude coordinates. However, this approach limits how the location of a "long" or curved facility can be defined in ShakeCast. For example, the western spans of the San Francisco-Oakland Bay Bridge can be considered a long structure that covers a large area. Currently, the location of the facility can be defined by either a point (Fig. 11a) or a rectangle (Fig. 11b). However, both approaches have limitations. Ideally, the facility would be delineated by a polygon (Fig. 11c) or a polyline.

Figure 11. Bridge representation in (a) point, (b) rectangle, and (c) polygon shape.

4.5.1 System Processing

The ShakeCast system will accept polygon/polyline facility delineation as well as areas of liquefaction and landslide hazards (Sec. 4.3). Geospatial information will be stored as Well-known Text (WKT) or its binary equivalent, well-known binary (WKB) in a separate facility supplemental table.

Since ShakeMap metrics are grid-based, geospatial footprint of a facility is converted to a set of grids that matches the dimensions of ShakeMap grid for shaking and fragility analysis. The ShakeMap grid is typically set with one km spacing so that it is unnecessary to store facility polygons with bounding dimensions smaller than the ShakeMap grid.

Note that one set of facility fragility settings (combination of HAZUS, CBS, and Component) is allowed for one facility polygon.

4.5.2 Data Handling

The ShakeCast system will provide new routines and database tables to import and store geospatial information of facilities, which can be in the format of point, polyline, or polygon. The facility geospatial objects will be displayed in the ShakeCast earthquake web page when the user view point is at the appropriate zoom level.

4.6 Develop and Implement Method to Present Results for Various Facility Groupings

Currently, ShakeCast can be set up to analyze and manage a wide range of facility types with notifications managed through the use of facility aggregation and multiple email notification templates. Although separating various inventories is possible with email notifications, the website interface does not permit this. For example, Caltrans maintains inventories for "state" and "local" bridges. Aggregation lists can be made for both and email sent out based upon analysis results for one, or the other, or both. The website, however, will combine the results of both and present a single combined list of both state and local bridges and their inspection priority. When we consider adding other facility types such as landslides and liquefaction, the problem is compounded. A feature on the ShakeCast website is needed to manage the presentation on facility analysis results. A feature is needed in the email template to facilitate creation of messages that present the results of different groupings of facilities in a logical manner.

In general, the ShakeCast system will implement an add-on module similar to the USGS Earthquake Notification Service (ENS) model. The ShakeCast administrator defines a set of notification polygons and content that will be available to the end users. A ShakeCast user will join pre-defined regions or will define regions of interest. The notification polygon and magnitude threshold will be used as a filter to decide which users will receive the notification.

This development will overhaul the ShakeCast notification subsystem and notification settings will not be compatible between the two versions of ShakeCast. The notification contents, to be defined by the administrator, will be fully integrated with the new ShakeCast template engine for local product generation and notification triggering.

4.6.1 System Processing

The current "Profiles" model will be replaced with "Groups." A group is defined by the content of the products received with the following criteria:

- Minimum event magnitude
- Region
- Facilities included

Caltrans will likely implement a single group with the following properties:

- M4.0+
- California statewide
- All facilities:
    - Bridges, state and local
    - Road segments
    - Buildings (offices, maintenance, toll booths)
    - Other assets

All Caltrans users would receive the same product. Users can set up unique notification profiles (or filters) that control when these standardized messages and products are sent to them. They can control:

- Minimum magnitude (to X.X accuracy)
- Region for which any part of the rectangular ShakeMap footprint overlays.

The tool for setting up the region notification preference will be similar to the ENS tool. The ShakeCast administrator can determine the number of allowed user-defined polygons. There will be predefined standard polygon areas for user to select:

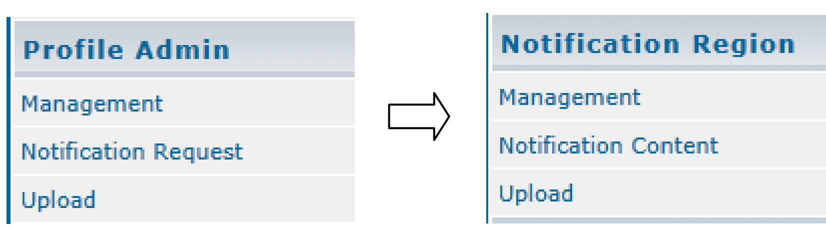
- Northern CA
- Southern CA
- Central CA
- Districts 1-12
- Statewide (default)
- User can define custom polygon

4.6.2 Data Handling

The ShakeCast system will provide new routines and database tables to import and store geospatial information of facilities, which can be in the format of point, polyline, or polygon. The facility geospatial objects will be displayed in the ShakeCast earthquake web page when the viewpoint is at the appropriate zoom level.

There are two main aspects regarding content of notifications configurable by the ShakeCast administrator, message body and attachment. Editing of message body is the same as in v.2. The new attachment function is designed to deliver specific ShakeMap or local ShakeCast products to users who do not have access to the ShakeCast web site. In addition to local ShakeCast products in plain file (CSV, XML, and KML, etc), the product type has been expanded to cover also PDF and common graphic formats. Local products can be used to trigger the notification process just like regular ShakeMap products.

The existing administration section of "Profile Admin" will transform into "Notification Region" for group notifications.



Similarly, the management tool allows the administrator to set up predefined regions. These become the pick list that the user selects from in their notification preferences. The administrator will designate a "default" region that is applied to all new users, until they change it.

The "Upload" function will remain to allow the administrator to upload coordinates of "Notification Region." The relation between "Notification Region" and "Notification Request" will be separated so that the "Notification Region" is used as a filter for triggering notifications and not for the purpose for defining the content of notification. Thus the facility inventory will not be associated with any profile region.

4.7 Large Scale Printable Maps

Caltrans responders have asked that a standard large-scale printable map be made available as a standard ShakeCast product. The map should include typical layers and standard map presentation features – state highways, rivers and lakes, and major cities, map borders, scale, lat/long graticule, north arrow, and legend. ShakeCast specific layers should be presented – ShakeMap overlay and all facilities in the ShakeMap area with analysis results for facilities symbolized with proper color coding.

The ShakeCast system will automatically generate large printable maps (approximately 48" x 36"). The map generation process will avoid creating dependency on external application such as ArcGIS. Maps need to print well at full size, but do not need to conform to publication standards.

4.7.1 System Processing

The ShakeCast system will create a new utility to generate large format printable maps. The proposed approach will use Google Maps images (terrain view) as the base map layer. The utility will retrieve and cache map tiles from Google in order to generate a map that covers the entire ShakeMap footprint, and would print with reasonable pixel density on large format printer. Although the process is similar to the new PDF function, this utility is focused on generating highly customized map products instead of a generalized template-driven system for creating PDF reports.

These map products will consist of multiple maps that covers the entire ShakeMap area as well as detailed maps for specific regions, such as the Los Angels and the Bay area. The maps will follow common GIS standards in the format of scale, legend, feature descriptions, and symbology.

4.8 Implement a User-Defined HTML Facility Attribute

In the "Map View" on the ShakeCast website, the facility name and the ground motion metrics are displayed when the facility icon is clicked by the user. Implement a user-defined attribute for each facility to allow the administrator to store a HTML string. This attribute would then be displayed in the same information balloon when clicked within the Google Maps interface. Types of information that Caltrans would present might include various bridge descriptors and hyperlinks to bridge as-built documents. An example from another Caltrans online application is shown (Fig. 12). Other hyperlinks could be implemented to link to photos or traffic cameras on some bridges.

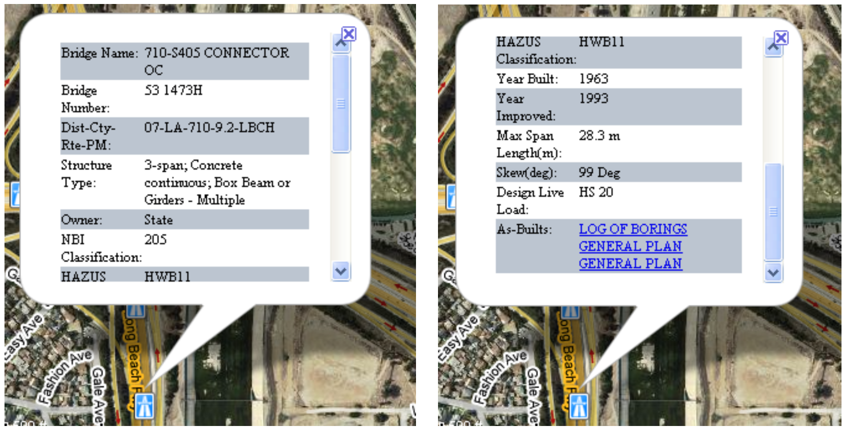


Figure 12. Example of facility attribute display when clicking on the Google Maps

4.8.1 System Processing

The ShakeCast system will include a new facility attribute table to accommodate facility-specific information that is not part of the standard facility table. The user-defined HTML facility attribute is a pre-defined attribute that can be an HTML segment in simple text format or an URL linking the source of attribute information. The new facility supplemental attribute table has been redesigned so that the contents can be included into the ShakeCast notifications. However, we plan to exclude facility HTML attribute from the attribute list due to its unique nature.

4.8.2 Data Handling

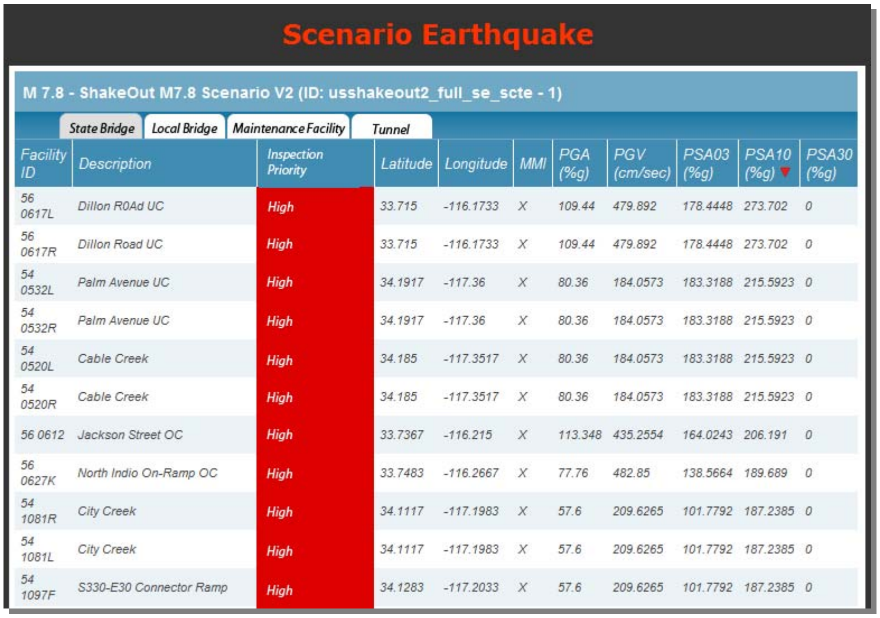
The ShakeCast system will update the facility administration page to provide a text area for entering HTML attribute. The HTML editor for designing notification templates (Sec. 4.9.6) will be shared for editing of HTML facility attributes. The ShakeCast system will also update the facility import routine to volume upload of attribute information via remote URL links only.

4.9 Troubleshooting Support and Implementation of Interface Enhancements

Under this task the contractor will provide technical support via phone, WebEx, or in person for deployment, maintenance, and troubleshooting of Caltrans ShakeCast systems. Implement various minor website and notification interface enhancements, such as a limited-privilege “guest” login account.

4.9.1 Present Multiple Facility Types in Emails and on Website

In the “Table View” on the ShakeCast website and in the email notifications, facilities of different types are combined into a single table. As the number of Caltrans facilities increases to also include local bridges, buildings, toll booths, tunnels, and roadway, etc., it is obvious that there needs to be better method to aggregate multiple facility types. Figure 13 shows an event page which Caltrans facilities are grouped into individual tables based on facility types to assist users navigate through the entire inventory.



Scenario Earthquake

M 7.8 - ShakeOut M7.8 Scenario V2 (ID: usshakeout2_full_se_scte - 1)

State Bridge | Local Bridge | Maintenance Facility | Tunnel

Facility ID	Description	Inspection Priority	Latitude	Longitude	MMI	PGA (%g)	PGV (cm/sec)	PSA03 (%g)	PSA10 (%g)	PSA30 (%g)
56 0617L	Dillon R0Ad UC	High	33.715	-116.1733	X	109.44	479.892	178.4448	273.702	0
56 0617R	Dillon Road UC	High	33.715	-116.1733	X	109.44	479.892	178.4448	273.702	0
54 0532L	Palm Avenue UC	High	34.1917	-117.36	X	80.36	184.0573	183.3188	215.5923	0
54 0532R	Palm Avenue UC	High	34.1917	-117.36	X	80.36	184.0573	183.3188	215.5923	0
54 0520L	Cable Creek	High	34.185	-117.3517	X	80.36	184.0573	183.3188	215.5923	0
54 0520R	Cable Creek	High	34.185	-117.3517	X	80.36	184.0573	183.3188	215.5923	0
56 0612	Jackson Street OC	High	33.7367	-116.215	X	113.348	435.2554	164.0243	206.191	0
56 0627K	North Indio On-Ramp OC	High	33.7483	-116.2667	X	77.76	482.85	138.5664	189.689	0
54 1081R	City Creek	High	34.1117	-117.1983	X	57.6	209.6265	101.7792	187.2385	0
54 1081L	City Creek	High	34.1117	-117.1983	X	57.6	209.6265	101.7792	187.2385	0
54 1097F	S330-E30 Connector Ramp	High	34.1283	-117.2033	X	57.6	209.6265	101.7792	187.2385	0

Figure 13. Example of ShakeCast event summary page with facility type tabs.

The facility grouping (Sec. 4.6) handles primarily geospatial association among facilities, notifications, and users. This task focuses on grouping of facilities based on facility type, damage state, user privileges, and user preferences. The ShakeCast system will create new routines to manage user’s privileges on accessing facility information. The user will be receiving facility assessment summary categorized by facility types and the administrator will be able to decide the list of facilities the user can access. The administrator will implement filters to break out the notification content into a series of tables summarizing the inspection priorities for different facility types as they are shown on the event summary web page and to limit the size of the table. The notification content will also be delivered in the format of attachment such as the ShakeCast summary in PDF (Figure 14).

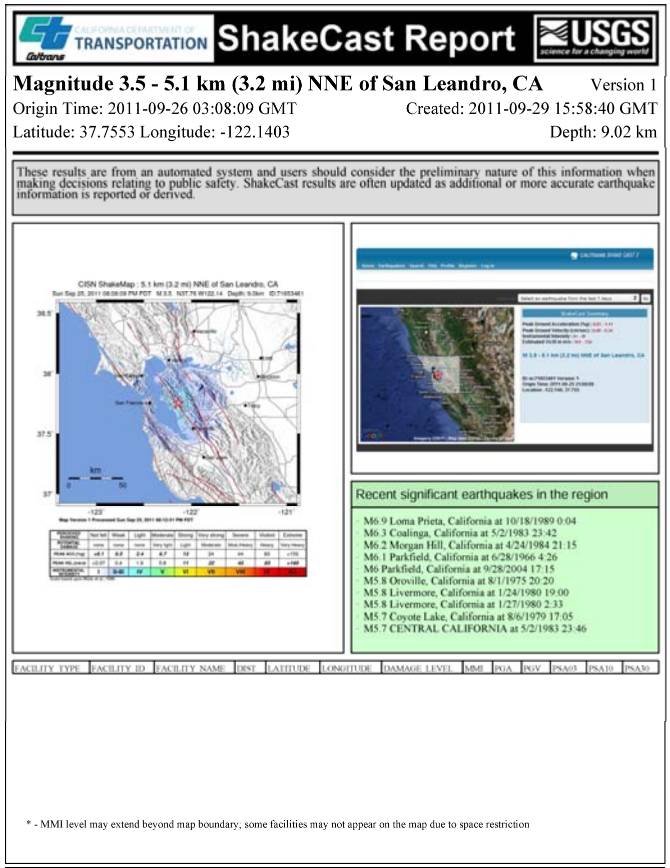


Figure 14. Example of ShakeCast summary report in PDF format.

4.9.2 Handling of Emails

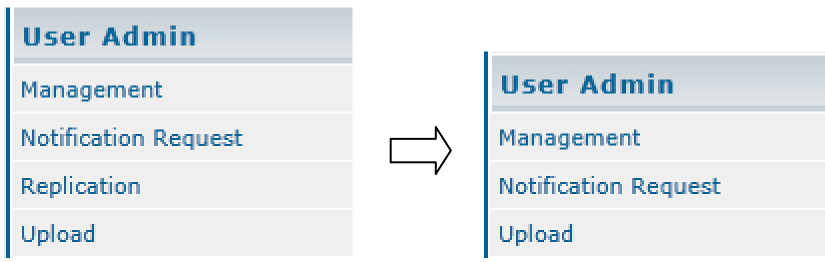
The ShakeCast system will provide new notification delivery routines to expand features of the v.2 system to include Secure Socket Layer (SSL) and Transport Layer Security (TLS) authentication protocols, multiple product attachment, and prioritized delivery. The new notification routines will address a typical notification bottleneck when aggregating multiple user notification requests with a large facility inventory.

Under the new notification scheme, notification content will be disengaged from user notification preferences and will have the following features:

- ShakeCast will send a single email for each grouping of content and products. For Caltrans, this is a single content/product group.
- ShakeCast will assess each user's notification profile to see if they should receive the product.
- ShakeCast will construct a single email with multiple recipients (bcc'd).

4.9.3 User Admin

The ShakeCast system will provide minor functional update to the existing "User Admin" section. Under the new notification design the "Replication" feature of the current ShakeCast system is no longer need.



The ShakeCast system will include the following functionality changes:

- New users will be assigned a default magnitude threshold and a default region. The default magnitude threshold is tied with the new overall system configuration option for setting the magnitude threshold for ShakeMap processing. The default region is tied with the system configuration of ShakeMap regions.
- For "Upload" this would only be used to add groups of new users; it is in effect similar to the current functionality but with limited functions.
- There will be a new checkable column in user table view to allow selection of multiple users for the delete/approve process.
- In the user table, show date that user signed up. The current ShakeCast system does not track user activities on the web site and the user tables in the database will be updated to reflect this request.
- A new "Export Users" function, identical to the one for exporting facilities, in the format that can be uploaded back to the system.

4.9.4 Facility Admin

The ShakeCast system will update "Facility Admin" section to accommodate primarily fragility model information including HAZUS, CBS, and Components and extended facility information. This section is the interface to the new database tables for storing facility-related information.

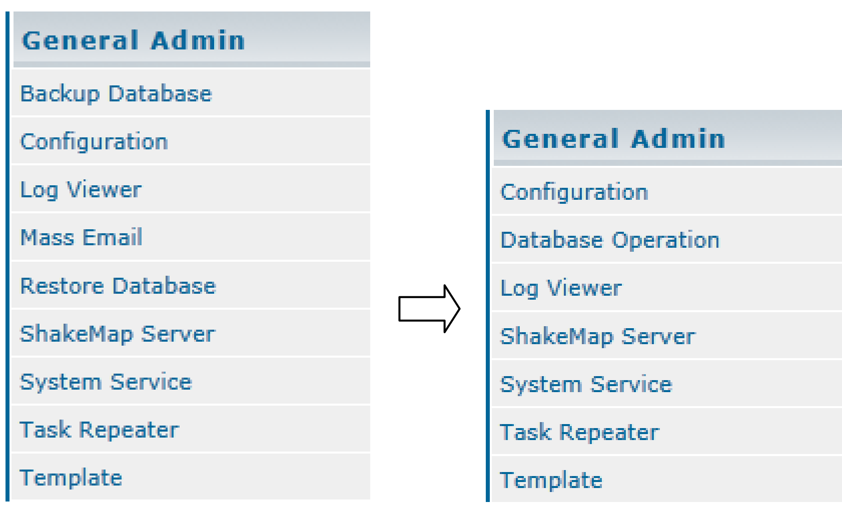
The ShakeCast interface will provide the following functions:

- Adjust interface to accommodate new fragility encoding based on the HAZUS fragility model custom. If the fragility model is defined, the mean (α) value from the CBS (or HAZUS) model will be used as the limit values for the simplified fragility settings for equivalent state for inspection priority.

- Facility supplemental attributes stored inside the database can be included in the output products (e.g. exposure.csv).
- A text field for capture HTML element. Consider implementing a HTML onscreen editor for manual editing. This facility HTML segment will be attached to the “Map View” of the earthquake page.
- A section for defining geospatial boundaries. This information will be used for display the footprint of the facility when inside the Map View” and will be used by the system to determine the ground shaking information at the facility.

4.9.5 General Admin

The ShakeCast system will update “Facility Admin” section to accommodate primarily fragility model information including HAZUS, CBS, and Components and extended facility information. This section is the interface to the new database tables for storing facility-related information.



The USGS Product Distribution Layer (PDL) is a protocol for data exchange of earthquake-related products. This is the method for ShakeMap production servers to publish ShakeMap on the USGS web site. As an end-user, Caltrans will need to use a Java-based client program to receive ShakeMap products directly from the ShakeMap producers. This effectively establishes data redundancy from multiple ShakeMap sources. The ShakeCast system is capable of receiving ShakeMap data from multiple sources.

The ShakeCast interface will provide the following functions:

- Remove "Mass Email." This function was under used and is recommended for removal.
- Combine the Backup and Restore Database on a single page. The ShakeCast system uses a single script to handle both database operations so that this is only a change to the user interface.
- For "ShakeMap Server" where the connections to USGS servers are defined, add a new section that displays the PDL links. Also, for PDL show status of PDL service on the main Admin page and notify Admin if PDL service stops. This function is similar to monitor other ShakeCast services.
- The existing system error messages are not very effective. The ShakeCast system will subdivide the current error messages into error and warning messages. The system functional test routine will expand the current heartbeat function to provide benchmark information of the system. The scope will include the following:
    - Perform system check on active ShakeCast services.
    - Grab screen shot from Admin main page.
    - Include screen shot in Heartbeat message.
    - In subject line of the heartbeat message, provide some indication if problem exists.
- For templates, implement a HTML editor to modify templates similar to the function for editing facility-specific HTML segment.
- For the FAQ section, make it editable by the Admin via a HTML content editor.

4.9.6 Main Page Map Display

The ShakeCast system will update the main page display to allow the administrator with more control of the map behavior. Additionally there are templates targeting mobile devices and exhibition display.

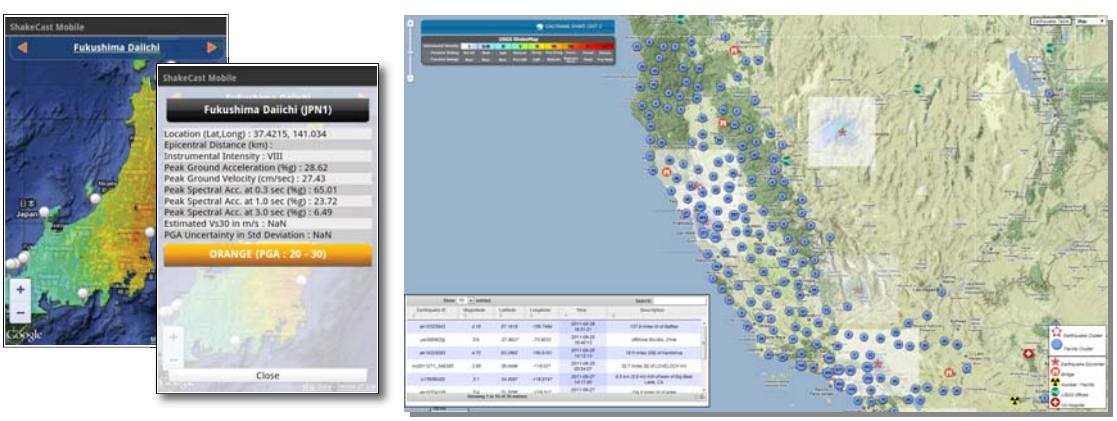


Figure 15. Example of ShakeCast Mobile and Exhibition display.

The ShakeCast system will include the following functional updates:

- Admin definable map scaling for image overlay and facility markers.
- Implement clustering tool to distinguish group of facilities.
- When viewing an event, create tabs to show three different views:
    - Summary view
    - Map view
    - Table view

4.10 Test and Atlas Events

Currently ShakeCast defines ShakeMap events into three major categories: Actual earthquakes, Scenario earthquakes, and Test events. ShakeCast test events are converted ShakeMaps into ShakeCast compatible for the purpose of repeated testing. The ShakeCast system will consolidate the three ShakeMap categories into two: Actual and Scenario. Once a ShakeMap has been processed by the ShakeCast system it becomes part of the local archive that can be used for testing without the need to convert it into a test event. The system will implement a Google Maps interface to help user search and select events in the Event Admin.

Specifically ShakeMaps in the ShakeCast system will be in one of the following status:

- Processed Events
    - These are events that have been processed previously by the ShakeCast system.
    - The permitted function is to re-alert the ShakeCast users. There will be no rerun of the processed event.
- Test Events
    - This event status will be removed.
    - ShakeCast will create a new local archive to handle caching of ShakeMap products downloaded previously.
    - All test events will be launched from the "ShakeCast Repository" events interface.
- Atlas events
    - This event status will be renamed to "ShakeCast Repository".
    - These will be described as "ShakeCast-ready" events.
    - Includes all the scenarios and all major earthquakes worldwide, including CA. Events from the local archive will also be displayed in the "ShakeCast Repository" interface.
    - Injecting these will be treated as a test event in ShakeCast.
    - All of these events will be compatible with ShakeCast.

    - All data will be hosted at the USGS FORT Science Center server.
- USGS ShakeMap
    - This event status remains the same. It accesses the USGS web site to retrieve a list of available ShakeMaps on the USGS web site.
    - Not all events will work in ShakeCast, because this is dependent on the network operators providing all the correct information. There is no way to determine ShakeCast-compatibility prior to downloading.
    - This event status will only include actual events.
    - Injecting these will be treated as a new real event or scenario event if selected.

4.11 Event Maintenance

Event maintenance is the most effective way of performance tuning for a ShakeCast system. The ShakeCast system will implement a proactive approach to event maintenance to ensure the overall system performance. The ShakeCast will allow the administrator to define the minimum magnitude threshold as a process trigger and to define a time window to purge and archive processed earthquakes.

The ShakeCast system will include the following functional updates:

- The "Cutoff Magnitude" option in system configuration to ignore and not process events less than a specified magnitude. This is different from the minimum notification magnitude in v2.0.
- The new feature to purge old events is similar to the existing function for rotating log files:
    - It is run as a scheduled task.
    - The administrator sets up a time window and magnitude as filters.
    - When events are older than 2x the earthquake time window, and no facilities with assessed damage states (no facilities in the shaken area), those events are removed from the database. This also applies to events where facilities are all "Not Evaluated."
    - Need to add this as a new Task Repeater function that can be scheduled through the web interface.
- The new feature to archive old events. This feature applies to events where there is some damage. The archived events are removed from the database and saved locally on the ShakeCast server. These events are available to run as a test event through the new ShakeCast Repository interface.

4.12 Provide a Recommendation for IT Server Deployment at Caltrans

Over the course of the research project, ShakeCast has been running on two servers in Sacramento. Measures were taken to insure a low level of system downtime, including the use of redundant Dell PowerEdge 2850 rack serves, RAID-5 storage, dual power supplies, dual network cards, UPS backup power units, and 24/7 system error monitoring. Although this current deployment has been operating dependably over the course of the phase 1 project, a more comprehensive deployment and operational plan is needed that draws upon the expertise of the USGS in deploying similar systems while maintaining alignment with requirements of Caltrans' Information Technology (IT) Division and the California Department of Finance (DOF). The report would be used by Caltrans as the basis of a Feasibility Study Report for long-term ShakeCast operations and support.

The contractor will assess the current Caltrans IT and DOF requirements and will provide a report with Caltrans IT deployment recommendation.

4.13 User's Manual

The Contractor will prepare a user's manual that describes the system's features.

4.14 Final Report

The Contractor will prepare a Final Report that documents the work completed under the contract.

APPENDIX B Caltrans ShakeCast Phase 2 SOW Addendum

See pdf attachment ShakeCast Phase 2 SOW Addendum 062210.

Work Coordination, Evaluation and Approval of Deliverables

Most of the deliverables (milestones 1 through 8) will result in implementation of a new or enhanced ShakeCast feature, noted in the table below as a “New ShakeCast Feature”. Milestone 9 is a service provided over the course of the contract, noted in the table as a “Service”. Milestones 10 through 12 are documents delivered at the conclusion of the contract, noted in the table as a “Document”.

No.	Milestone/Deliverable	Type of Deliverable
1	Implement polygon/polyline facility location delineation method.	New ShakeCast Feature
2	Implement landslide hazard analysis function.	New ShakeCast Feature
3	Implement liquefaction hazard analysis function.	New ShakeCast Feature
4	Develop and implement method to present results for various facility groupings.	New ShakeCast Feature
5	Implement a user-defined HTML facility attribute.	New ShakeCast Feature
6	Automatic generation of large-scale printable map as a standard ShakeCast product.	New ShakeCast Feature
7	Implement full statistical interpretation of fragility curves.	New ShakeCast Feature
8	Implement a component-based fragility analysis framework.	New ShakeCast Feature
9	Troubleshooting support and implementation of interface enhancements.	Service
10	A recommendation for IT server deployment at Caltrans.	Document
11	User’s Manual.	Document
12	Final Report.	Document

For “New ShakeCast Feature” deliverables the contractor will carry out the work in the following sequence:

- Contractor will participate in teleconference and/or in-person meeting(s) with the Project Manager and the Project Advisory Panel to discuss use cases and end-user requirements for the specific feature.
- Contractor will compile the requirements and specifications into a document and provide an electronic version of the document to the Project Manager.
- The Project Manager will review the document, iterate with the Contractor as needed, and approve when finalized.
- Upon approval, the Contractor will proceed with the development work.
- Over the course of development, the Contractor will demonstrate progress by providing draft code modules and demonstrating code functionality. Demonstrations can be done via WebEx sessions, making development servers accessible to the Project Manager to try in person, or by providing code that can be executed by the Project Manager.
- The Contractor will notify the Project Manager when the deliverable has been finalized. The new feature will be delivered electronically as a package of codes and instructions. The codes shall operate as an extension, replacement, or patch to the latest version of the ShakeCast system.
- The Contractor will supply support as needed for the implementation of the feature on existing Caltrans ShakeCast systems.
- The Project Manager will test the new features to determine that the delivered feature meets the requirements of the contract.
- The Project Manager will notify the Contractor when the deliverable has been approved.
- Once approved, the Contract may submit an invoice for the deliverable.

For deliverable types that result in Documents (i.e. Final Report, User Guide, and Server Deployment), the following work sequence shall be used:

- Prior to preparation of the document, the Contractor shall provide the Project Manager with an outline of the document for review and approval. Electronic version of the document is sufficient.
- The Contractor shall provide the Project Manager with a draft version of the document for review and comment. The Project Manager and the Project Advisory Panel will participate in the review. Electronic version of the document is sufficient.
- The Contractor shall provide the final version of the document to the Project Manager in both electronic and printed hard copy.

Additional work coordination considerations:

- Meetings will be carried out via teleconference and WebEx sessions. WebEx sessions will be arranged by the Project Manager.
- The Project Manager will serve as the single point of contact for Caltrans. The Project Manager will communicate project status and other project related matters to the Project Advisory Panel as appropriate.
- The Contractor will respond to all inquiries from the Project Manager within 48 hours.

Work Location and Personnel

The development work will be carried out by USGS staff at the National Earthquake Information Center (NEIC), located at 1711 Illinois St., Golden, Colorado, 80401. Implementation of new features will be carried out at the Caltrans TransLab facility, located at 5900 Folsom Blvd, Sacramento, California, 95819.

Specific USGS staff performing work on this contract and relevant salary, wage, benefit, overhead, and other costing information are documented in an attachement.

Sub-contractors

There are no sub-contractors for this work.

Resources to be Provided by Caltrans

Caltrans will provide several resources to the Contractor:

- **Facility inventory data sets.** The Project Manager will provide the Contractor with the current inventory of state and local bridges and their corresponding fragility parameters, most of which are published by the FHWA publicly through the National Bridge Inventory (NBI) website. The Project Manager will also provide statewide landslide inventories and relevant metadata obtained from the California Geological Survey (CGS). Liquefaction maps can be obtained by the Contractor directly from CGS.
- **Panel participation for needs assessment.** The Project Manger will organize and arrange meetings of the Project Advisory Panel. This panel will provide input for the Contractor in identifying and synthesizing end-user needs.
- **Dedicated computers for test deployment.** Caltrans currently operates three ShakeCast systems as a result of a prior research project. All three systems currently are located at Caltrans

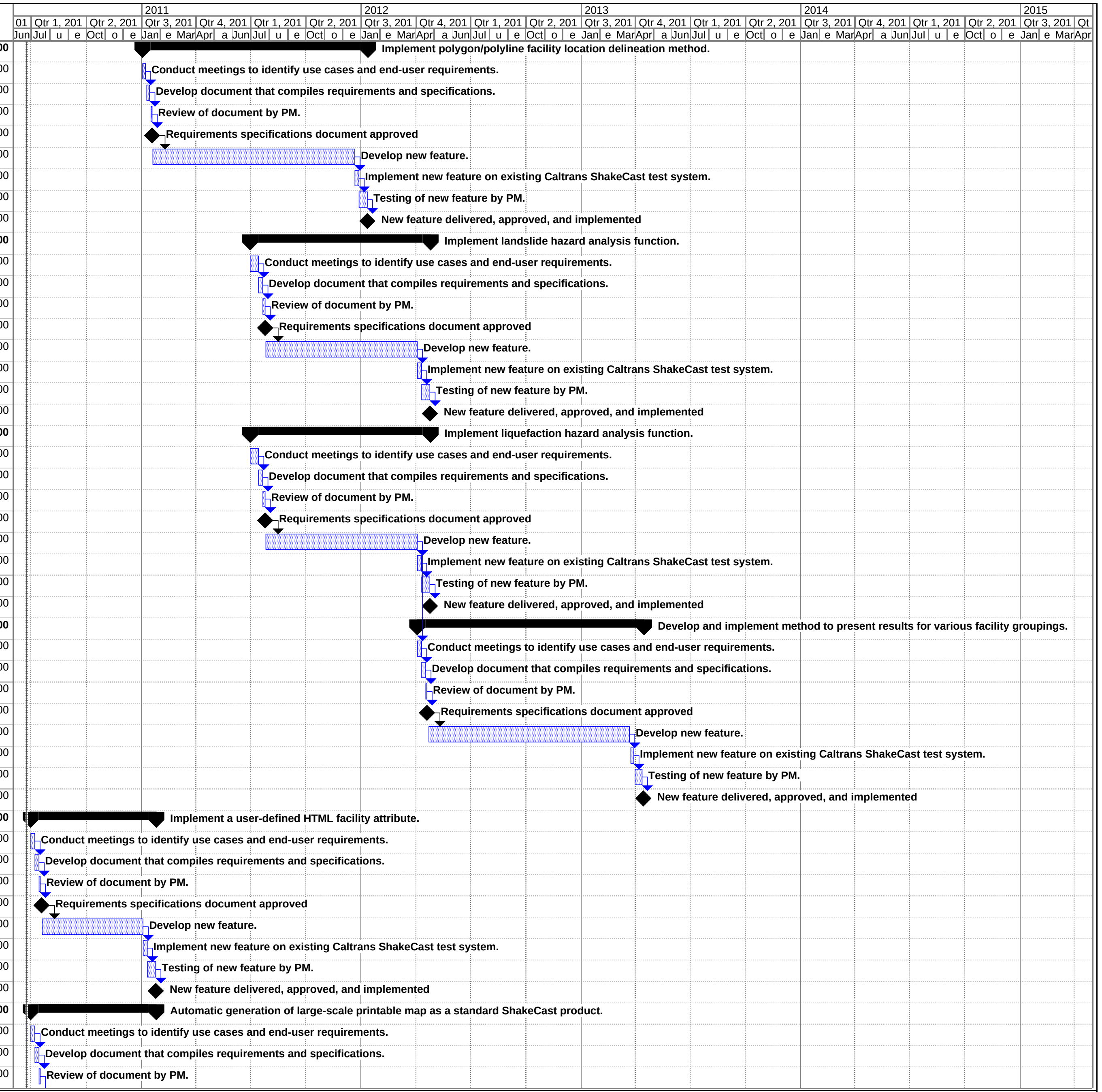
Translab in Sacramento, California. Two of the three instances will be available for installation of new features as they are developed. This will facilitate testing and review of new features. The Project Manager will manage and coordinate the installation of new features on the existing ShakeCast instances and will engage the Contractor for assistance as needed.

- **SMTP email service within Caltrans.** As with the existing ShakeCast system, the ShakeCast system resulting from this project will continue to rely on Lotus Domino servers for delivery of post-earthquake notification emails to Caltrans responders.

Timeline

The timeline of subtasks, milestones, and deliverables is presented in the attached chart.

ID	WBS	Task Name	Duration	Start	Finish	Cost
1	1	**Implement polygon/polyline facility location delineation method.**	**269 days?**	**Mon 1/3/11**	**Thu 1/12/12**	**$20,000.00**
2	1.1	Conduct meetings to identify use cases and end-user requirements.	5 days	Mon 1/3/11	Fri 1/7/11	$0.00
3	1.2	Develop document that compiles requirements and specifications.	5 days	Mon 1/10/11	Fri 1/14/11	$0.00
4	1.3	Review of document by PM.	2 days	Mon 1/17/11	Tue 1/18/11	$0.00
5	1.4	Requirements specifications document approved	1 day?	Wed 1/19/11	Wed 1/19/11	$0.00
6	1.5	Develop new feature.	12 mons	Thu 1/20/11	Wed 12/21/11	$0.00
7	1.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Thu 12/22/11	Wed 12/28/11	$0.00
8	1.7	Testing of new feature by PM.	10 days	Thu 12/29/11	Wed 1/11/12	$0.00
9	1.8	New feature delivered, approved, and implemented	1 day?	Thu 1/12/12	Thu 1/12/12	$0.00
10	2	**Implement landslide hazard analysis function.**	**214 days?**	**Fri 7/1/11**	**Wed 4/25/12**	**$50,000.00**
11	2.1	Conduct meetings to identify use cases and end-user requirements.	10 days	Fri 7/1/11	Thu 7/14/11	$0.00
12	2.2	Develop document that compiles requirements and specifications.	5 days	Fri 7/15/11	Thu 7/21/11	$0.00
13	2.3	Review of document by PM.	2 days	Fri 7/22/11	Mon 7/25/11	$0.00
14	2.4	Requirements specifications document approved	1 day?	Tue 7/26/11	Tue 7/26/11	$0.00
15	2.5	Develop new feature.	9 mons	Wed 7/27/11	Tue 4/3/12	$0.00
16	2.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Wed 4/4/12	Tue 4/10/12	$0.00
17	2.7	Testing of new feature by PM.	10 days	Wed 4/11/12	Tue 4/24/12	$0.00
18	2.8	New feature delivered, approved, and implemented	1 day?	Wed 4/25/12	Wed 4/25/12	$0.00
19	3	**Implement liquefaction hazard analysis function.**	**214 days?**	**Fri 7/1/11**	**Wed 4/25/12**	**$50,000.00**
20	3.1	Conduct meetings to identify use cases and end-user requirements.	10 days	Fri 7/1/11	Thu 7/14/11	$0.00
21	3.2	Develop document that compiles requirements and specifications.	5 days	Fri 7/15/11	Thu 7/21/11	$0.00
22	3.3	Review of document by PM.	2 days	Fri 7/22/11	Mon 7/25/11	$0.00
23	3.4	Requirements specifications document approved	1 day?	Tue 7/26/11	Tue 7/26/11	$0.00
24	3.5	Develop new feature.	9 mons	Wed 7/27/11	Tue 4/3/12	$0.00
25	3.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Wed 4/4/12	Tue 4/10/12	$0.00
26	3.7	Testing of new feature by PM.	10 days	Wed 4/11/12	Tue 4/24/12	$0.00
27	3.8	New feature delivered, approved, and implemented	1 day?	Wed 4/25/12	Wed 4/25/12	$0.00
28	4	**Develop and implement method to present results for various facility groupings.**	**269 days?**	**Wed 4/4/12**	**Mon 4/15/13**	**$20,000.00**
29	4.1	Conduct meetings to identify use cases and end-user requirements.	5 days	Wed 4/4/12	Tue 4/10/12	$0.00
30	4.2	Develop document that compiles requirements and specifications.	5 days	Wed 4/11/12	Tue 4/17/12	$0.00
31	4.3	Review of document by PM.	2 days	Wed 4/18/12	Thu 4/19/12	$0.00
32	4.4	Requirements specifications document approved	1 day?	Fri 4/20/12	Fri 4/20/12	$0.00
33	4.5	Develop new feature.	12 mons	Mon 4/23/12	Fri 3/22/13	$0.00
34	4.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Mon 3/25/13	Fri 3/29/13	$0.00
35	4.7	Testing of new feature by PM.	10 days	Mon 4/1/13	Fri 4/12/13	$0.00
36	4.8	New feature delivered, approved, and implemented	1 day?	Mon 4/15/13	Mon 4/15/13	$0.00
37	5	**Implement a user-defined HTML facility attribute.**	**149 days?**	**Thu 7/1/10**	**Tue 1/25/11**	**$20,000.00**
38	5.1	Conduct meetings to identify use cases and end-user requirements.	5 days	Thu 7/1/10	Wed 7/7/10	$0.00
39	5.2	Develop document that compiles requirements and specifications.	5 days	Thu 7/8/10	Wed 7/14/10	$0.00
40	5.3	Review of document by PM.	2 days	Thu 7/15/10	Fri 7/16/10	$0.00
41	5.4	Requirements specifications document approved	1 day?	Mon 7/19/10	Mon 7/19/10	$0.00
42	5.5	Develop new feature.	6 mons	Tue 7/20/10	Mon 1/3/11	$0.00
43	5.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Tue 1/4/11	Mon 1/10/11	$0.00
44	5.7	Testing of new feature by PM.	10 days	Tue 1/11/11	Mon 1/24/11	$0.00
45	5.8	New feature delivered, approved, and implemented	1 day?	Tue 1/25/11	Tue 1/25/11	$0.00
46	6	**Automatic generation of large-scale printable map as a standard ShakeCast product.**	**149 days?**	**Thu 7/1/10**	**Tue 1/25/11**	**$10,000.00**
47	6.1	Conduct meetings to identify use cases and end-user requirements.	5 days	Thu 7/1/10	Wed 7/7/10	$0.00
48	6.2	Develop document that compiles requirements and specifications.	5 days	Thu 7/8/10	Wed 7/14/10	$0.00
49	6.3	Review of document by PM.	2 days	Thu 7/15/10	Fri 7/16/10	$0.00

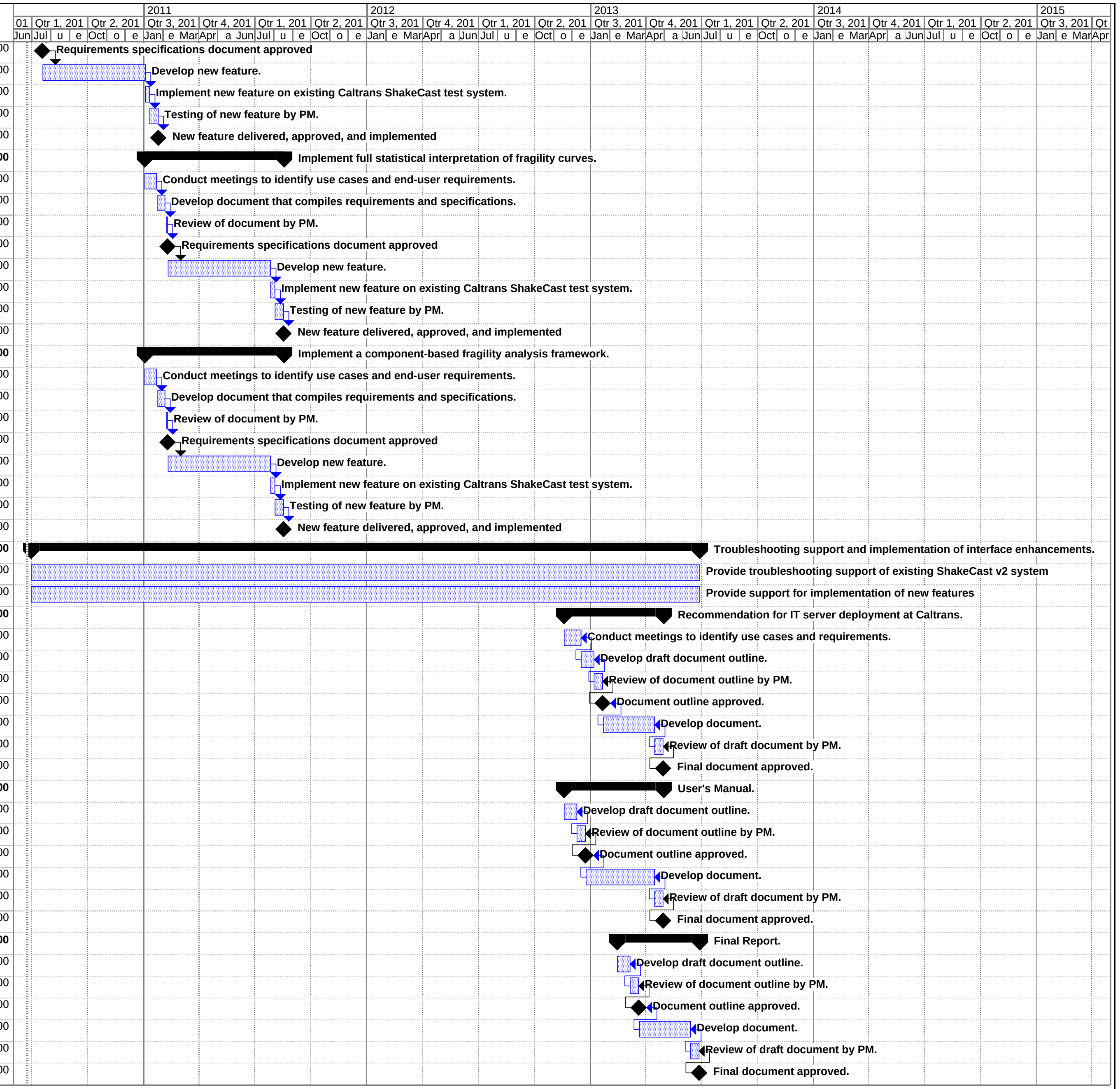


Project: Project Schedule
Date: Wed 6/23/10

Task		Milestone		Rolled Up Task		Rolled Up Progress		External Tasks	
Progress		Summary		Rolled Up Milestone		Split		Project Summary	

Group By Summary; Deadline

ID	WBS	Task Name	Duration	Start	Finish	Cost
50	6.4	Requirements specifications document approved	1 day?	Mon 7/19/10	Mon 7/19/10	$0.00
51	6.5	Develop new feature.	6 mons	Tue 7/20/10	Mon 1/3/11	$0.00
52	6.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Tue 1/4/11	Mon 1/10/11	$0.00
53	6.7	Testing of new feature by PM.	10 days	Tue 1/11/11	Mon 1/24/11	$0.00
54	6.8	New feature delivered, approved, and implemented	1 day?	Tue 1/25/11	Tue 1/25/11	$0.00
55	**7**	**Implement full statistical interpretation of fragility curves.**	**164 days?**	**Mon 1/3/11**	**Thu 8/18/11**	**$50,000.00**
56	7.1	Conduct meetings to identify use cases and end-user requirements.	15 days	Mon 1/3/11	Fri 1/21/11	$0.00
57	7.2	Develop document that compiles requirements and specifications.	10 days	Mon 1/24/11	Fri 2/4/11	$0.00
58	7.3	Review of document by PM.	2 days	Mon 2/7/11	Tue 2/8/11	$0.00
59	7.4	Requirements specifications document approved	1 day?	Wed 2/9/11	Wed 2/9/11	$0.00
60	7.5	Develop new feature.	6 mons	Thu 2/10/11	Wed 7/27/11	$0.00
61	7.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Thu 7/28/11	Wed 8/3/11	$0.00
62	7.7	Testing of new feature by PM.	10 days	Thu 8/4/11	Wed 8/17/11	$0.00
63	7.8	New feature delivered, approved, and implemented	1 day?	Thu 8/18/11	Thu 8/18/11	$0.00
64	**8**	**Implement a component-based fragility analysis framework.**	**164 days?**	**Mon 1/3/11**	**Thu 8/18/11**	**$50,000.00**
65	8.1	Conduct meetings to identify use cases and end-user requirements.	15 days	Mon 1/3/11	Fri 1/21/11	$0.00
66	8.2	Develop document that compiles requirements and specifications.	10 days	Mon 1/24/11	Fri 2/4/11	$0.00
67	8.3	Review of document by PM.	2 days	Mon 2/7/11	Tue 2/8/11	$0.00
68	8.4	Requirements specifications document approved	1 day?	Wed 2/9/11	Wed 2/9/11	$0.00
69	8.5	Develop new feature.	6 mons	Thu 2/10/11	Wed 7/27/11	$0.00
70	8.6	Implement new feature on existing Caltrans ShakeCast test system.	5 days	Thu 7/28/11	Wed 8/3/11	$0.00
71	8.7	Testing of new feature by PM.	10 days	Thu 8/4/11	Wed 8/17/11	$0.00
72	8.8	New feature delivered, approved, and implemented	1 day?	Thu 8/18/11	Thu 8/18/11	$0.00
73	**9**	**Troubleshooting support and implementation of interface enhancements.**	**782 days?**	**Thu 7/1/10**	**Fri 6/28/13**	**$30,000.00**
74	9.1	Provide troubleshooting support of existing ShakeCast v2 system	782 days?	Thu 7/1/10	Fri 6/28/13	$0.00
75	9.2	Provide support for implementation of new features	782 days?	Thu 7/1/10	Fri 6/28/13	$0.00
76	**10**	**Recommendation for IT server deployment at Caltrans.**	**117 days?**	**Mon 11/19/12**	**Tue 4/30/13**	**$10,000.00**
77	10.1	Conduct meetings to identify use cases and requirements.	1 mon	Mon 11/19/12	Mon 12/17/12	$0.00
78	10.2	Develop draft document outline.	15 days	Mon 12/17/12	Mon 1/7/13	$0.00
79	10.3	Review of document outline by PM.	10 days	Mon 1/7/13	Mon 1/21/13	$0.00
80	10.4	Document outline approved.	1 day	Mon 1/21/13	Tue 1/22/13	$0.00
81	10.5	Develop document.	3 mons	Tue 1/22/13	Tue 4/16/13	$0.00
82	10.6	Review of draft document by PM.	10 days	Tue 4/16/13	Tue 4/30/13	$0.00
83	10.7	Final document approved.	1 day?	Tue 4/30/13	Tue 4/30/13	$0.00
84	**11**	**User's Manual.**	**117 days?**	**Mon 11/19/12**	**Tue 4/30/13**	**$10,000.00**
85	11.1	Develop draft document outline.	15 days	Mon 11/19/12	Mon 12/10/12	$0.00
86	11.2	Review of document outline by PM.	10 days	Mon 12/10/12	Mon 12/24/12	$0.00
87	11.3	Document outline approved.	1 day	Mon 12/24/12	Tue 12/25/12	$0.00
88	11.4	Develop document.	4 mons	Tue 12/25/12	Tue 4/16/13	$0.00
89	11.5	Review of draft document by PM.	10 days	Tue 4/16/13	Tue 4/30/13	$0.00
90	11.6	Final document approved.	1 day?	Tue 4/30/13	Tue 4/30/13	$0.00
91	**12**	**Final Report.**	**97 days?**	**Thu 2/14/13**	**Fri 6/28/13**	**$10,000.00**
92	12.1	Develop draft document outline.	15 days	Thu 2/14/13	Thu 3/7/13	$0.00
93	12.2	Review of document outline by PM.	10 days	Thu 3/7/13	Thu 3/21/13	$0.00
94	12.3	Document outline approved.	1 day	Thu 3/21/13	Fri 3/22/13	$0.00
95	12.4	Develop document.	3 mons	Fri 3/22/13	Fri 6/14/13	$0.00
96	12.5	Review of draft document by PM.	10 days	Fri 6/14/13	Fri 6/28/13	$0.00
97	12.6	Final document approved.	1 day?	Fri 6/28/13	Fri 6/28/13	$0.00



Project: Project Schedule
Date: Wed 6/23/10

Task		Milestone		Rolled Up Task	Rolled Up Progress	External Tasks	Group By Summary
Progress		Summary		Rolled Up Milestone	Split	Project Summary	Deadline

APPENDIX C Advisory Panel Meeting

See pptx attachment Advisory Panel Meeting 02-24-14.

ShakeCast v3

Project Advisory Panel Meeting
February 24, 2014

Timeline

Date	Activity
March 30, 2011	Caltrans contract with USGS begins for development of ShakeCast v3.
June 3, 2011	Kickoff meeting held with Advisory Panel.
August 2011	USGS delivers "*Caltrans ShakeCast Phase 2 Project Requirement Specifications*."
February 2014	Advisory Panel Meeting
March 30, 2014	Contract ends.

Agenda for Today

- Update on key activities related to ShakeCast.
- Recap on the original scope of work.
- USGS demonstration of the new features in ShakeCast v3.
- Solicit feedback from panel.
- Next steps.

Updates

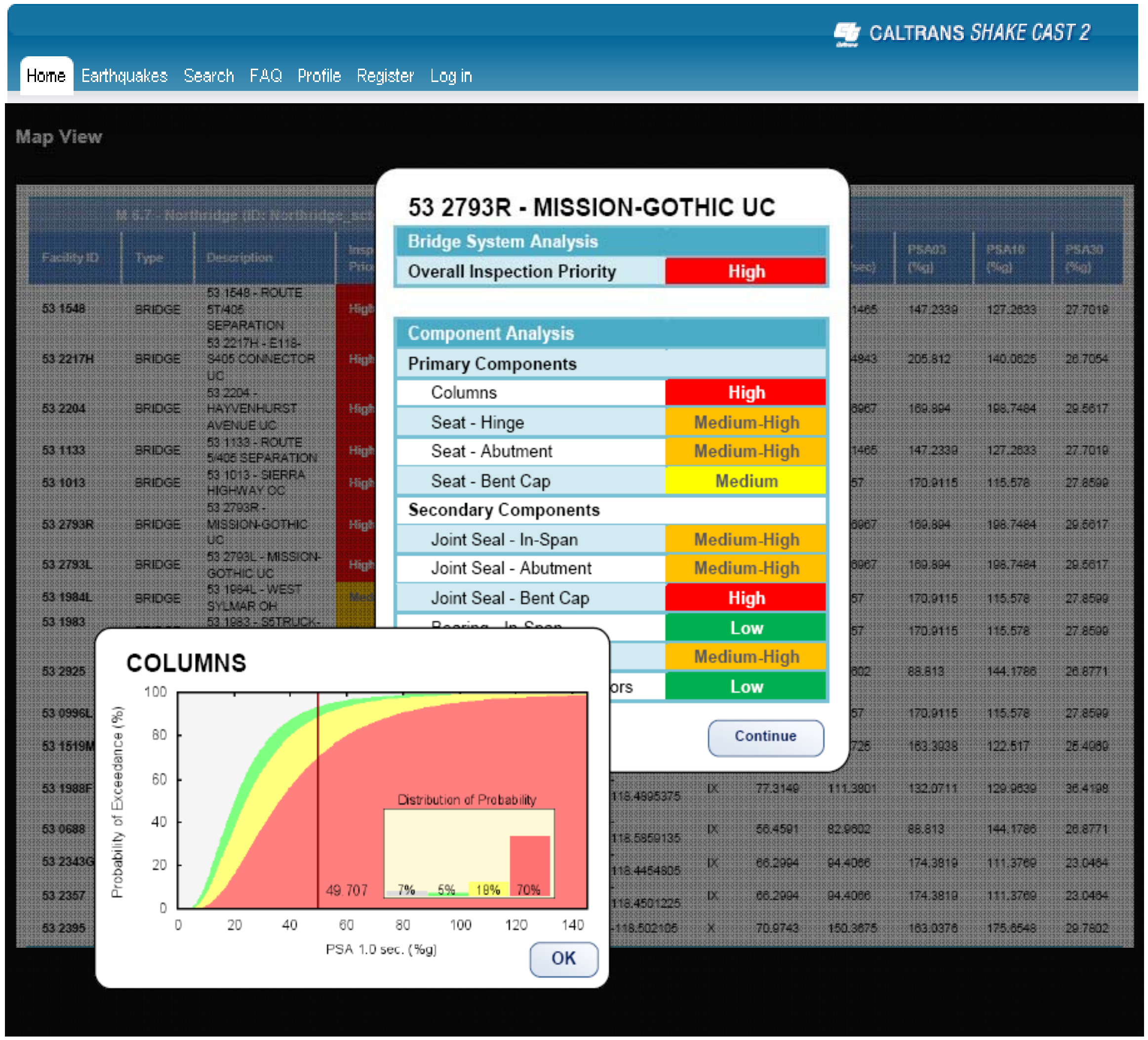
- Development activities
  - Fragility
  - User interface
  - Admin functions
  - Other inventories
- IT aspects
  - Evolving deployment strategy
  - Server OS platform options
  - Setup/migration of ShakeCast v2 and v3 servers
    - http://svgcshakecast.dot.ca.gov/
    - http://svgcshakecastv3.dot.ca.gov/

ShakeCast v3 – Scope of Work

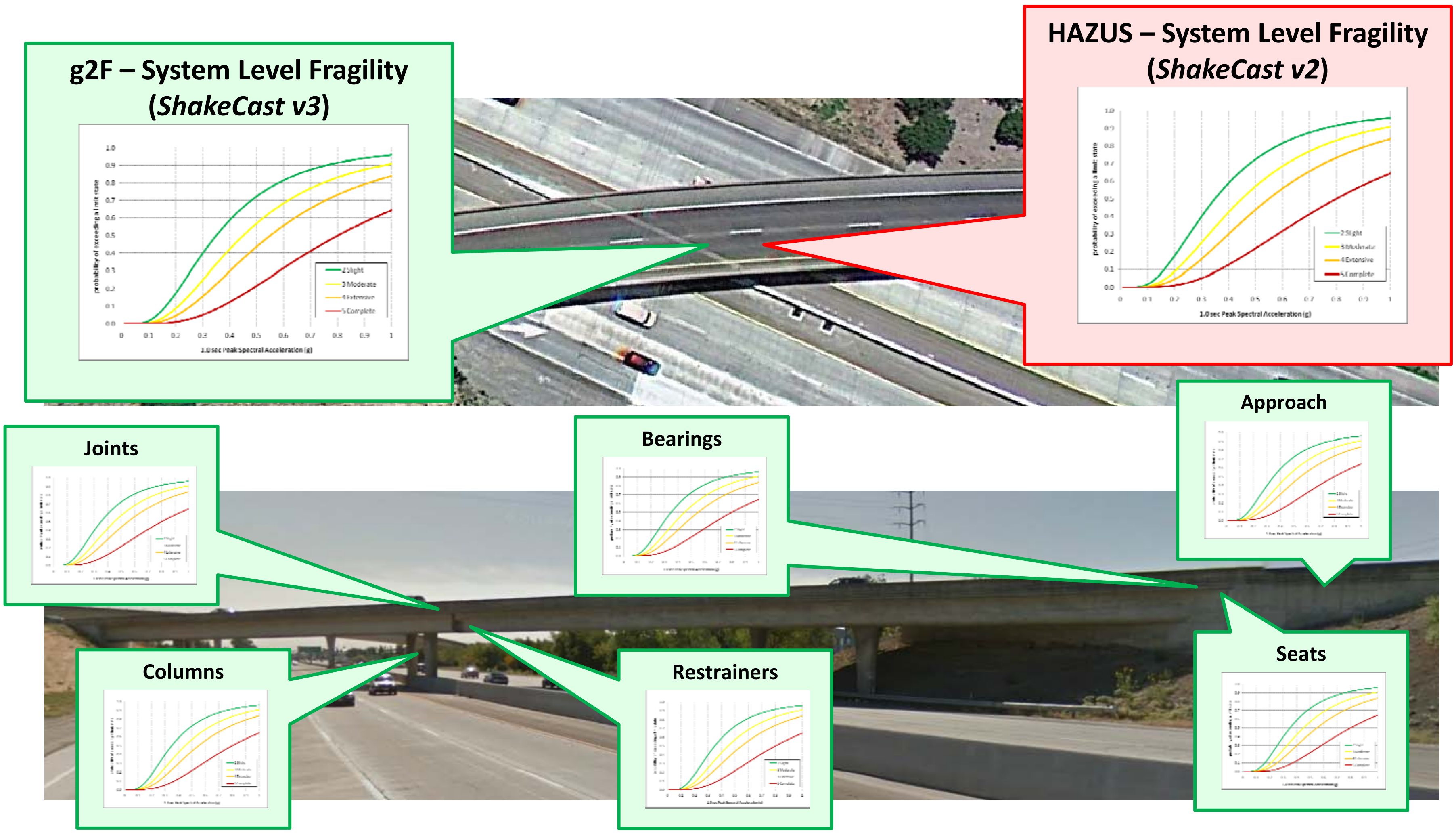
- New ShakeCast Features
  - Bridge Fragility
    - Full statistical interpretation of fragility curves.
    - Component-based fragility analysis framework.
  - Landslides and Liquefaction
  - Interface and Feature Enhancements
    - Polyline/polygon facilities
    - HTML snippets
    - Printable maps
    - Facility grouping presentation
- USGS Support Services
  - Troubleshooting
  - Implementation and deployment
- Reports & Documentation
  - IT Deployment Recommendation
  - User's Manual
  - Final Report

Bridge Fragility

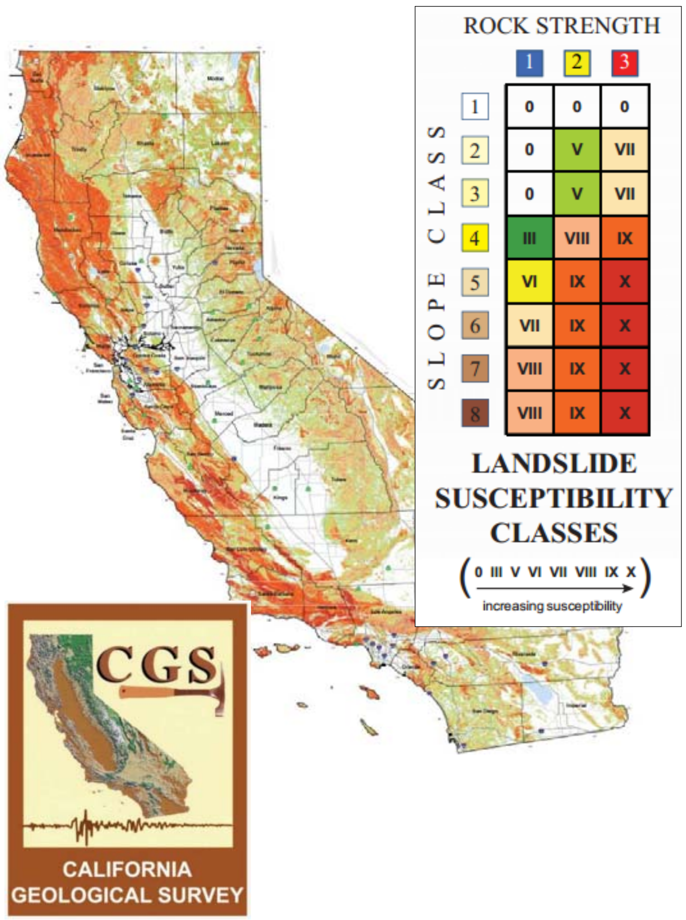
- Implement full statistical interpretation of fragility curves.
- Implement a component-based fragility analysis framework.

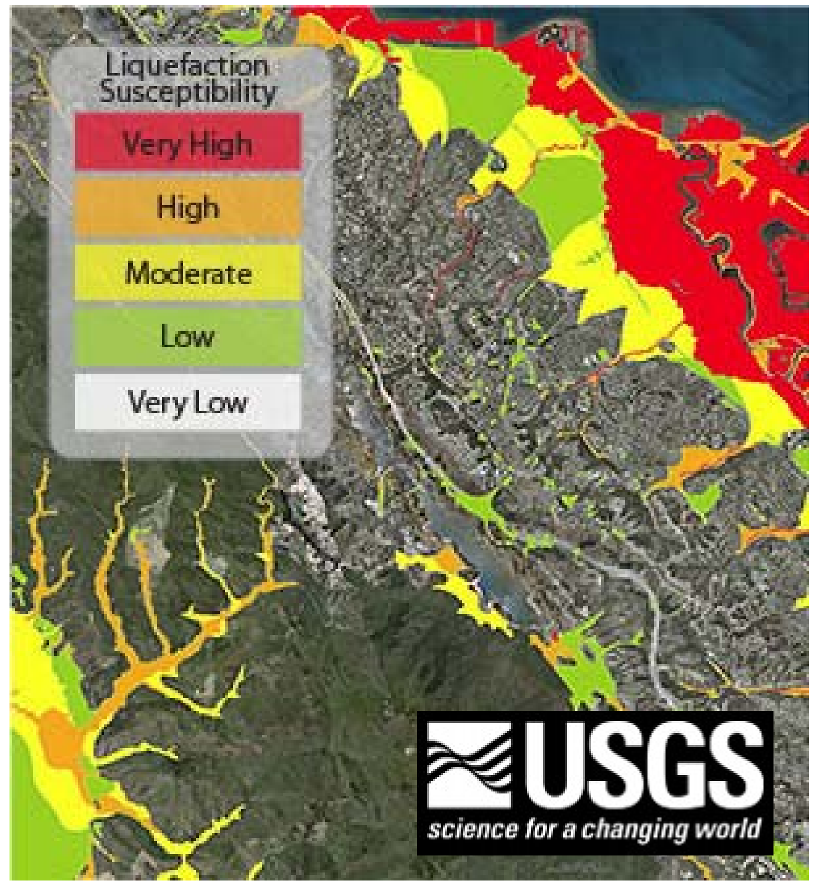


Bridge Fragility



Landslides & Liquefaction





Feature Enhancements

- Implement polygon/polyline facility location delineation method.
  - Better supports long structures.
  - Can capture landslides areas.
  - Suggest using max ShakeMap ground motion metric.

Current:
Facility is a point or a rectangular area

Proposed:
Facility can be a polygon or polyline

Feature Enhancements

- Develop and implement method to present results for various facility groupings.
  - Email and website presentation of different groupings.
  - State vs. Local Bridges

Scenario Earthquake

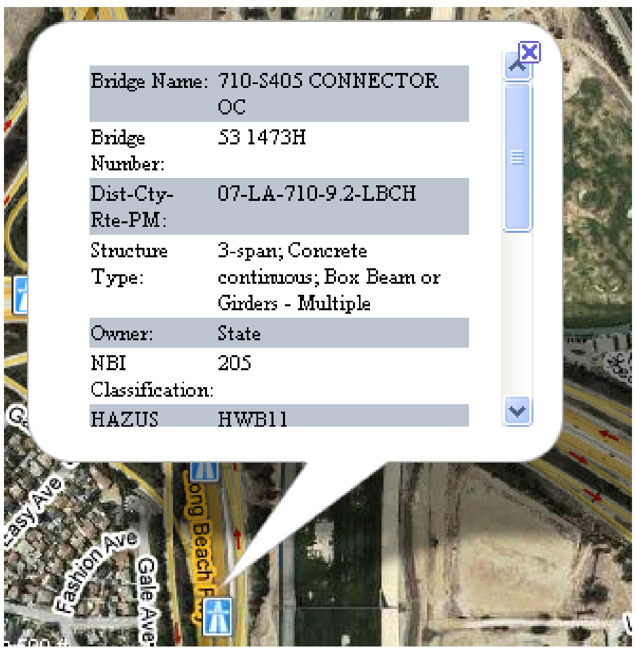
M 7.8 - ShakeOut M7.8 Scenario V2 (ID: usshakeout2_full_se_scte - 1)

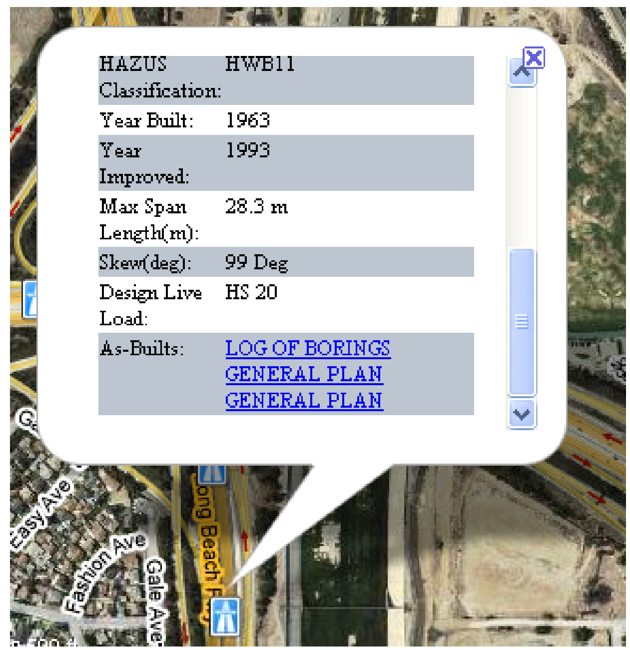
State Bridge | Local Bridge | Maintenance Facility | Tunnel

Facility ID	Description	Inspection Priority	Latitude	Longitude	MMI	PGA (%g)	PGV (cm/sec)	PSA03 (%g)	PSA10 (%g)	PSA30 (%g)
56 0617L	Dillon R0Ad UC	High	33.715	-116.1733	X	109.44	479.892	178.4448	273.702	0
56 0617R	Dillon Road UC	High	33.715	-116.1733	X	109.44	479.892	178.4448	273.702	0
54 0532L	Palm Avenue UC	High	34.1917	-117.36	X	80.36	184.0573	183.3188	215.5923	0
54 0532R	Palm Avenue UC	High	34.1917	-117.36	X	80.36	184.0573	183.3188	215.5923	0
54 0520L	Cable Creek	High	34.185	-117.3517	X	80.36	184.0573	183.3188	215.5923	0
54 0520R	Cable Creek	High	34.185	-117.3517	X	80.36	184.0573	183.3188	215.5923	0
56 0612	Jackson Street OC	High	33.7367	-116.215	X	113.348	435.2554	164.0243	206.191	0
56 0627K	North Indio On-Ramp OC	High	33.7483	-116.2667	X	77.76	482.85	138.5664	189.689	0
54 1081R	City Creek	High	34.1117	-117.1983	X	57.6	209.6265	101.7792	187.2385	0
54 1081L	City Creek	High	34.1117	-117.1983	X	57.6	209.6265	101.7792	187.2385	0
54 1097F	S330-E30 Connector Ramp	High	34.1283	-117.2033	X	57.6	209.6265	101.7792	187.2385	0

Feature Enhancements

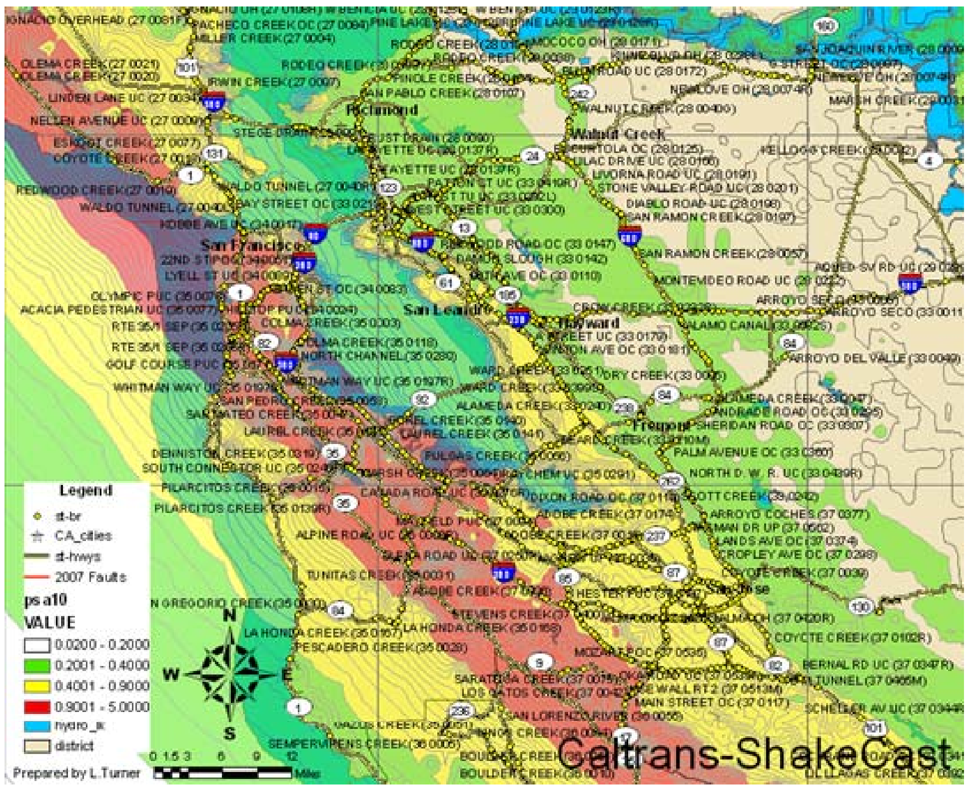
- Implement a user-defined HTML facility attribute.
  - Update ShakeCast GoogleMap interface
  - Include more detailed information on facilities
  - User-definable format and hyperlinks





Feature Enhancements

- Automatic generation of large-scale printable map as a standard ShakeCast product.



ShakeCast v3 Demo

Next Steps

- Final report and documents distributed to panel for review (March 2014).
- ShakeCast v3 made available to panel for evaluation (March-September 2014).
- Migration from v2 to v3 (October 2014).
- Other related activities:
  - Bridge fragility testing
  - Transportation Pooled Fund initiative

APPENDIX D Migrate V2 Inventory to V3

See pdf attachment Migration from V2 to V3 ShakeCast.

Migrating from V2 to V3 ShakeCast

ShakeCast V3 accepts facility inventory in both V2 and V3 format. Even though existing ShakeCast users need to update their inventory to take full advantage of the ShakeCast V3 functions, it is possible to jumpstart the process by loading V2 inventory into the V3 system first.

The new Group function of the ShakeCast V3 system uses the same format as the Profile function of V2. The administrator can use the same profile configuration file for direct upload into the V3 system. It is not possible, nor necessary, to export group configuration using the ShakeCast administration interface.

The User function of the ShakeCast V3 system uses the same format as the V2 system. The administrator can use the same profile configuration file for direct upload into the V3 system. However, with the new Group function it is recommended to compile a new user CSV file with proper group definition and association. It is not possible to export a full user inventory using the ShakeCast V2 administration interface only basic information.

Depending on the complexity of user's inventory, it generally falls into three **categories**, each with increasing complexity, as described in the instructions below.

Category 1. V2 Inventory in ShakeCast CSV Format Without Custom Facility Type

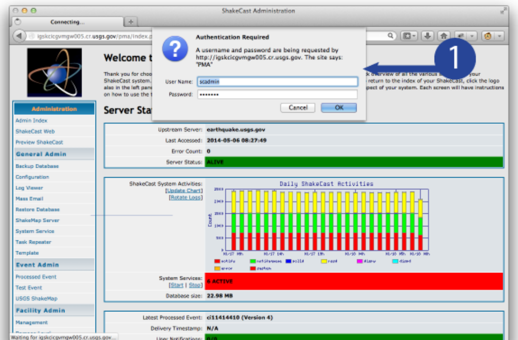
You are in luck. Just use the V3 upload tool as described in the ShakeCast User Guide (Sec. 5.8) to upload individual facility, group, and user inventory.

Category 2. V2 Inventory in ShakeCast CSV Format With Custom Facility Type

You will need to define custom facility types in the V3 system first then use **Category 1** to upload individual facility, group, and user inventory. Finish after **Step 6**.

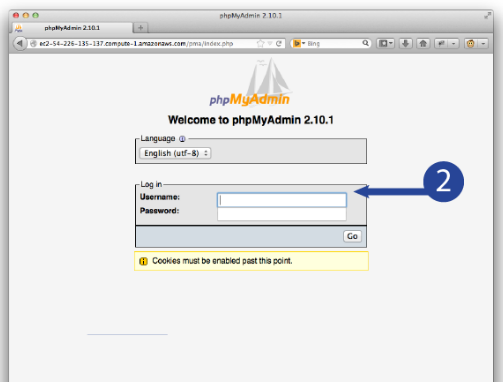
<u>From the ShakeCast V2 administration interface</u>

1 Change the URL from /admin/index.php to /pma/index.php. Use the ShakeCast administrator credentials for authentication to access the phpMyAdmin database interface



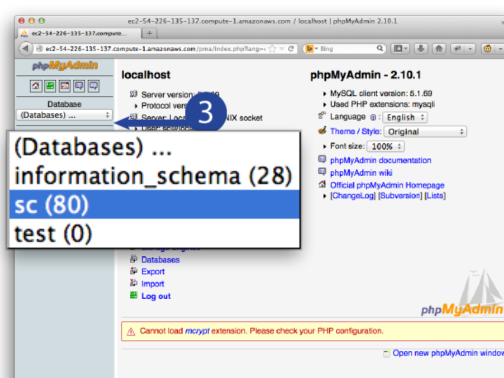
<u>Access the phpMyAdmin database interface</u>

2 Enter the ShakeCast database crendentials, default “sc” for both username and password



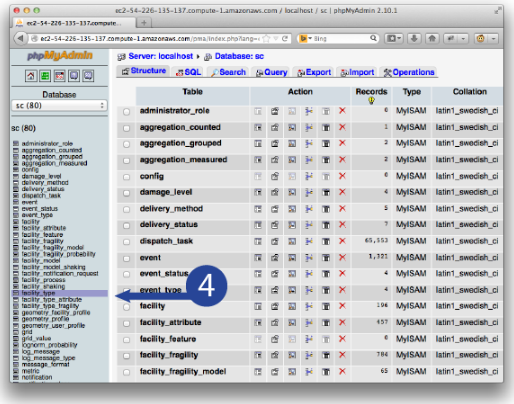
<u>Select the ShakeCast database</u>

3 From the phpMyAdmin interface, select the ShakeCast database **sc** from the pull-down panel in the left navigation panel



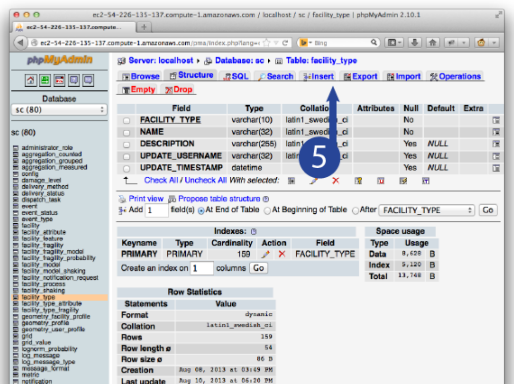
Select the Facility Type Table

4 From the ShakeCast database view, select the table **facility_type** from the left table list panel



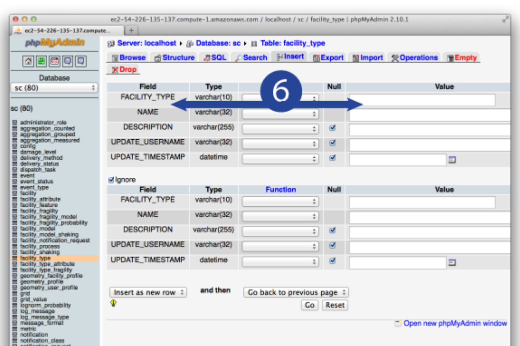
Select Insert New Facility Type Function

5 With the **facility_type** table highlighted, select the **Insert** function near the top of the table schema page



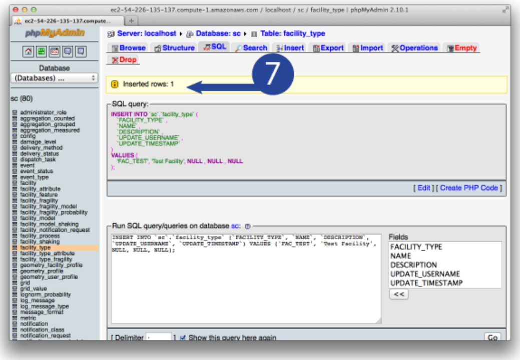
Insert New Facility Type Entries

6 Enter required **FACILITY_TYPE** and **NAME** fields for each custom facility type defined in user's ShakeCast V2 system. The other fields are optional.



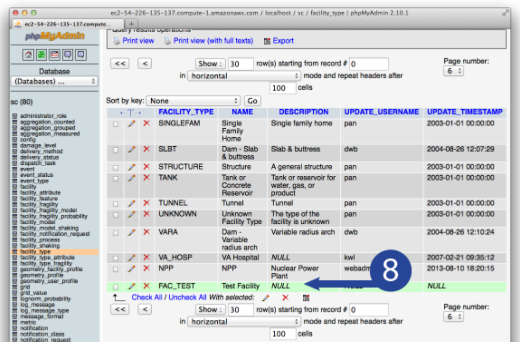
Results of Facility Type Insert

7 Each **FACILITY_TYPE** entry must be unique. Results of database query will be displayed to verify each facility type insert.



Verify Facility Type Entries from the phpMyAdmin interface

8 With the "facility_type" table highlighted, select the **Browse** function near the top of the table schema page and navigate to the end of the table to verify the new entries.



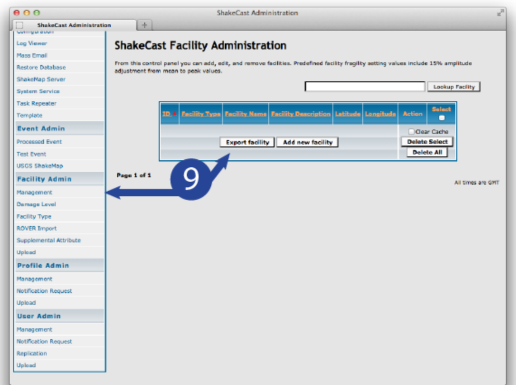
Category 3. V2 Inventory Only in the ShakeCast Database

You will export your inventory from the V2 first then use **Category 1** and **2** to upload individual facility, group, and user inventory.

To export facilities from the ShakeCast:

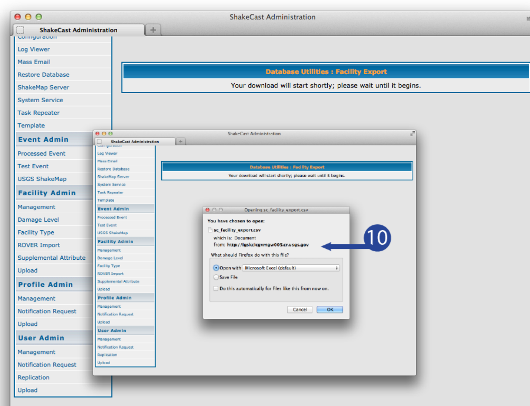
<u>From the ShakeCast V2 administration interface</u>

9 Select Facility Admin **Management** in the left navigation panel and choose the **export facility** function



<u>Save the Facility Export CSV</u>

10 Save the facility export CSV file “sc_facility_export” when prompted for file handling



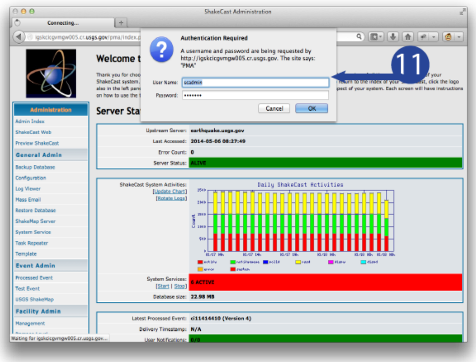
<u>For custom facility types, follow</u> **<u>Category</u>** <u>2 to create custom facility types</u>

<u>Follow</u> **<u>Category</u>** <u>1 to upload facility inventory</u>

Export Basic User Information from the ShakeCast V2 system

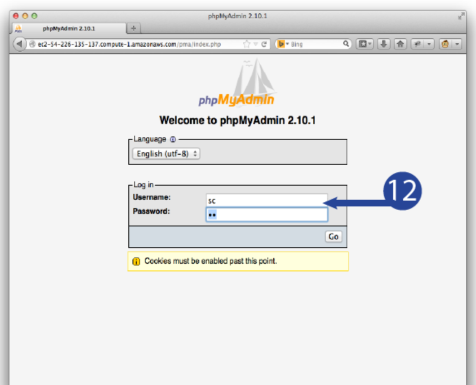
From the ShakeCast V2 administration interface

11 Change the URL from /admin/index.php to /pma/index.php. Use the ShakeCast administrator credentials for authentication to access the phpMyAdmin database interface



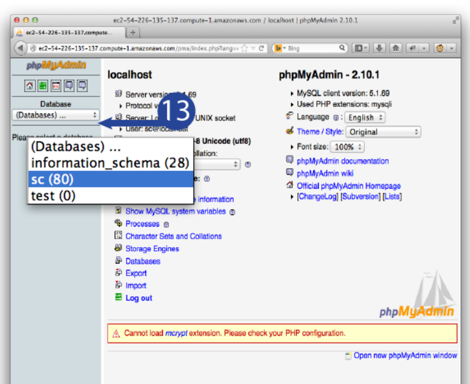
Access the phpMyAdmin database interface

12 Enter the ShakeCast database crendentials, default "sc" for both username and password



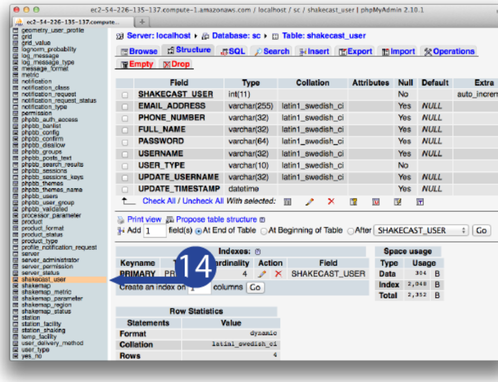
Select the ShakeCast database

13 From the phpMyAdmin interface, select the ShakeCast database **sc** from the pull-down panel in the left navigation panel



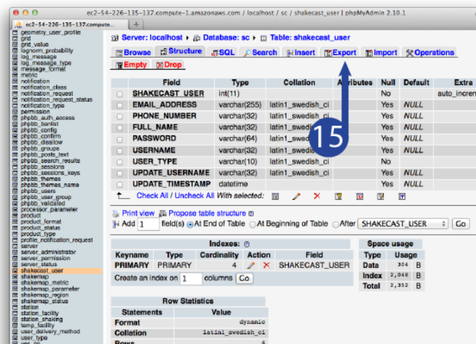
Select the ShakeCast User Table

14 From the ShakeCast database view, select the table **shakecast_user** from the left table list panel



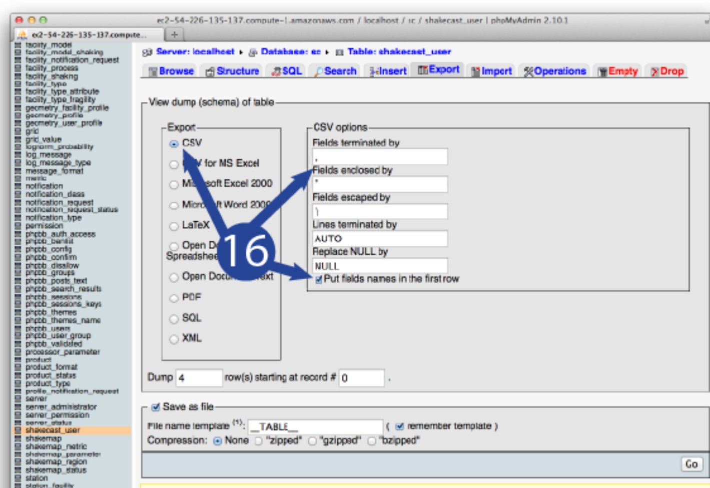
Select Export Function

15 With the **shakecast_user** table highlighted, select the **Export** function near the top of the table schema page



Save User Inventory with Basic Information

16 To save the user file in CSV format, choose the **CSV** option, "," as field termination, check to include the header line, and save the output into a file.



APPENDIX E Lognormal probability distribution lookup table for ShakeCast

Lognormal Probability	Low Limit	High Limit
0	-999	-2.323879311
0.01	-2.323879311	-2.051674006
0.02	-2.051674006	-1.878364261
0.03	-1.878364261	-1.749710825
0.04	-1.749710825	-1.643641126
0.05	-1.643641126	-1.552375223
0.06	-1.552375223	-1.473881252
0.07	-1.473881252	-1.402796841
0.08	-1.402796841	-1.338335772
0.09	-1.338335772	-1.279839028
0.1	-1.279839028	-1.223397176
0.11	-1.223397176	-1.172115941
0.12	-1.172115941	-1.125551427
0.13	-1.125551427	-1.080291158
0.14	-1.080291158	-1.03627128
0.15	-1.03627128	-0.993432012
0.16	-0.993432012	-0.951717157
0.17	-0.951717157	-0.913754885
0.18	-0.913754885	-0.87666349
0.19	-0.87666349	-0.840405269
0.2	-0.840405269	-0.804944335
0.21	-0.804944335	-0.770246471
0.22	-0.770246471	-0.738633298
0.23	-0.738633298	-0.705306648
0.24	-0.705306648	-0.672651894
0.25	-0.672651894	-0.642831243
0.26	-0.642831243	-0.611384309
0.27	-0.611384309	-0.582623623
0.28	-0.582623623	-0.552288419
0.29	-0.552288419	-0.522498278
0.3	-0.522498278	-0.495192274
0.31	-0.495192274	-0.466382917
0.32	-0.466382917	-0.438054686
0.33	-0.438054686	-0.412033497
0.34	-0.412033497	-0.384572049
0.35	-0.384572049	-0.357536199
0.36	-0.357536199	-0.330908666
0.37	-0.330908666	-0.30467304

0.38	-0.30467304	-0.278813752
0.39	-0.278813752	-0.253316043
0.4	-0.253316043	-0.226544379
0.41	-0.226544379	-0.201755439
0.42	-0.201755439	-0.17572017
0.43	-0.17572017	-0.150044833
0.44	-0.150044833	-0.124715051
0.45	-0.124715051	-0.09971733
0.46	-0.09971733	-0.07503901
0.47	-0.07503901	-0.049223539
0.48	-0.049223539	-0.023748044
0.49	-0.023748044	0
0.5	0	0.026235032
0.51	0.026235032	0.050766369
0.52	0.050766369	0.076345929
0.53	0.076345929	0.101605962
0.54	0.101605962	0.126557943
0.55	0.126557943	0.151212457
0.56	0.151212457	0.176847342
0.57	0.176847342	0.202170508
0.58	0.202170508	0.228426213
0.59	0.228426213	0.254357865
0.6	0.254357865	0.279975931
0.61	0.279975931	0.306476039
0.62	0.306476039	0.332651066
0.63	0.332651066	0.358510542
0.64	0.358510542	0.386345516
0.65	0.386345516	0.412698529
0.66	0.412698529	0.44095789
0.67	0.44095789	0.46775429
0.68	0.46775429	0.496389819
0.69	0.496389819	0.524650224
0.7	0.524650224	0.553600245
0.71	0.553600245	0.583207256
0.72	0.583207256	0.613438752
0.73	0.613438752	0.644262297
0.74	0.644262297	0.674646129
0.75	0.674646129	0.706570787
0.76	0.706570787	0.738990335
0.77	0.738990335	0.772828961
0.78	0.772828961	0.807068541
0.79	0.807068541	0.841676527
0.8	0.841676527	0.878444128

0.81	0.878444128	0.91545472
0.82	0.91545472	0.954436487
0.83	0.954436487	0.995260833
0.84	0.995260833	1.03695044
0.85	1.03695044	1.081081462
0.86	1.081081462	1.126655963
0.87	1.126655963	1.17512067
0.88	1.17512067	1.226994046
0.89	1.226994046	1.281956901
0.9	1.281956901	1.341137243
0.91	1.341137243	1.405473973
0.92	1.405473973	1.476375159
0.93	1.476375159	1.554916563
0.94	1.554916563	1.644892204
0.95	1.644892204	1.750785776
0.96	1.750785776	1.880824296
0.97	1.880824296	2.053781047
0.98	2.053781047	2.326661677
0.99	2.326661677	999

APPENDIX F HAZUS Model Building Fragility Table for ShakeCast

Table G.1. High-code fragilities for HAZUS model building types.

FACILITY TYPE	DESCRIPTION	METRIC	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA
W1H	Wood, Light Frame	PGA	26	0.64	55	0.64	128	0.64	201	0.64
W2H	Wood Commercial	PGA	26	0.64	56	0.64	115	0.64	208	0.64
S1LH	Steel Moment Frame, Low Rise	PGA	19	0.64	31	0.64	64	0.64	149	0.64
S1MH	Steel Moment Frame, Mid Rise	PGA	14	0.64	26	0.64	62	0.64	143	0.64
S1HH	Steel Moment Frame, High Rise	PGA	10	0.64	21	0.64	52	0.64	131	0.64
S2LH	Steel Brace Frame, Low Rise	PGA	24	0.64	41	0.64	76	0.64	146	0.64
S2MH	Steel Brace Frame, Mid Rise	PGA	14	0.64	27	0.64	73	0.64	162	0.64
S2HH	Steel Brace Frame, High Rise	PGA	11	0.64	22	0.64	65	0.64	160	0.64
S3H	Steel Light Frame	PGA	15	0.64	26	0.64	54	0.64	100	0.64
S4LH	Steel Frame Shear Wall, Low Rise	PGA	24	0.64	39	0.64	71	0.64	133	0.64
S4MH	Steel Frame Shear Wall, Mid Rise	PGA	16	0.64	28	0.64	73	0.64	156	0.64
S4HH	Steel Frame Shear Wall, High Rise	PGA	13	0.64	25	0.64	69	0.64	163	0.64
C1LH	Concrete Moment Frame, Low Rise	PGA	21	0.64	35	0.64	70	0.64	137	0.64
C1MH	Concrete Moment Frame, Mid Rise	PGA	15	0.64	27	0.64	73	0.64	161	0.64
C1HH	Concrete Moment Frame, High Rise	PGA	11	0.64	22	0.64	62	0.64	135	0.64
C2LH	Concrete Shear Wall, Low Rise	PGA	24	0.64	45	0.64	90	0.64	155	0.64
C2MH	Concrete Shear Wall, Mid Rise	PGA	17	0.64	36	0.64	87	0.64	195	0.64
C2HH	Concrete Shear Wall, High Rise	PGA	12	0.64	29	0.64	82	0.64	187	0.64
PC1H	Precast Concrete Tiltup Wall	PGA	20	0.64	35	0.64	72	0.64	125	0.64
PC2LH	Precast Concrete Frames, Low Rise	PGA	24	0.64	36	0.64	69	0.64	123	0.64
PC2MH	Precast Concrete Frames, Mid Rise	PGA	17	0.64	29	0.64	67	0.64	151	0.64
PC2HH	Precast Concrete Frames, High Rise	PGA	12	0.64	23	0.64	63	0.64	149	0.64
RM1LH	Reinforced Masonry with Wood, Low Rise	PGA	30	0.64	46	0.64	93	0.64	157	0.64
RM1MH	Reinforced Masonry with Wood, Mid Rise	PGA	20	0.64	37	0.64	81	0.64	190	0.64
RM2LH	Reinforced Masonry with Precast Concrete, Low	PGA	26	0.64	42	0.64	87	0.64	149	0.64

	Rise									
RM2MH	Reinforced Masonry with Precast Concrete, Mid Rise	PGA	17	0.64	33	0.64	75	0.64	183	0.64
RM2HH	Reinforced Masonry with Precast Concrete, High Rise	PGA	12	0.64	24	0.64	67	0.64	178	0.64
MHH	Mobile Homes	PGA	11	0.64	18	0.64	31	0.64	60	0.64

Table G.2. Moderate-code fragilities for HAZUS model building types.

FACILITY TYPE	DESCRIPTION	METRIC	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA
W1M	Wood, Light Frame	PGA	24	0.64	43	0.64	91	0.64	134	0.64
W2M	Wood Commercial	PGA	20	0.64	35	0.64	64	0.64	113	0.64
S1LM	Steel Moment Frame, Low Rise	PGA	15	0.64	22	0.64	42	0.64	80	0.64
S1MM	Steel Moment Frame, Mid Rise	PGA	13	0.64	21	0.64	44	0.64	82	0.64
S1HM	Steel Moment Frame, High Rise	PGA	10	0.64	18	0.64	39	0.64	78	0.64
S2LM	Steel Brace Frame, Low Rise	PGA	20	0.64	26	0.64	46	0.64	84	0.64
S2MM	Steel Brace Frame, Mid Rise	PGA	14	0.64	22	0.64	53	0.64	97	0.64
S2HM	Steel Brace Frame, High Rise	PGA	11	0.64	19	0.64	49	0.64	102	0.64
S3M	Steel Light Frame	PGA	13	0.64	19	0.64	33	0.64	60	0.64
S4LM	Steel Frame Shear Wall, Low Rise	PGA	19	0.64	26	0.64	41	0.64	78	0.64
S4MM	Steel Frame Shear Wall, Mid Rise	PGA	14	0.64	22	0.64	51	0.64	92	0.64
S4HM	Steel Frame Shear Wall, High Rise	PGA	12	0.64	21	0.64	51	0.64	97	0.64
C1LM	Concrete Moment Frame, Low Rise	PGA	16	0.64	23	0.64	41	0.64	77	0.64
C1MM	Concrete Moment Frame, Mid Rise	PGA	13	0.64	21	0.64	49	0.64	89	0.64
C1HM	Concrete Moment Frame, High Rise	PGA	11	0.64	18	0.64	41	0.64	74	0.64
C2LM	Concrete Shear Wall, Low Rise	PGA	18	0.64	30	0.64	49	0.64	87	0.64
C2MM	Concrete Shear Wall, Mid Rise	PGA	15	0.64	26	0.64	55	0.64	102	0.64
C2HM	Concrete Shear Wall, High Rise	PGA	12	0.64	23	0.64	57	0.64	107	0.64
PC1M	Precast Concrete Tiltup Wall	PGA	18	0.64	24	0.64	44	0.64	71	0.64
PC2LM	Precast Concrete Frames, Low Rise	PGA	18	0.64	25	0.64	40	0.64	74	0.64
PC2MM	Precast Concrete Frames, Mid Rise	PGA	15	0.64	21	0.64	45	0.64	86	0.64
PC2HM	Precast Concrete Frames, High Rise	PGA	12	0.64	19	0.64	46	0.64	90	0.64
RM1LM	Reinforced Masonry with	PGA	22	0.64	30	0.64	50	0.64	85	0.64

	Wood, Low Rise									
RM1MM	Reinforced Masonry with Wood, Mid Rise	PGA	18	0.64	26	0.64	51	0.64	103	0.64
RM2LM	Reinforced Masonry with Precast Concrete, Low Rise	PGA	20	0.64	28	0.64	47	0.64	81	0.64
RM2MM	Reinforced Masonry with Precast Concrete, Mid Rise	PGA	16	0.64	23	0.64	48	0.64	99	0.64
RM2HM	Reinforced Masonry with Precast Concrete, High Rise	PGA	12	0.64	20	0.64	48	0.64	101	0.64
MHM	Mobile Homes	PGA	11	0.64	18	0.64	31	0.64	60	0.64

Table G.3. Low-code fragilities for HAZUS model building types.

FACILITY TYPE	DESCRIPTION	METRIC	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA
W1L	Wood, Light Frame	PGA	20	0.64	34	0.64	61	0.64	95	0.64
W2L	Wood Commercial	PGA	14	0.64	23	0.64	48	0.64	75	0.64
S1LL	Steel Moment Frame, Low Rise	PGA	12	0.64	17	0.64	30	0.64	48	0.64
S1ML	Steel Moment Frame, Mid Rise	PGA	12	0.64	18	0.64	29	0.64	49	0.64
S1HL	Steel Moment Frame, High Rise	PGA	10	0.64	15	0.64	28	0.64	48	0.64
S2LL	Steel Brace Frame, Low Rise	PGA	13	0.64	17	0.64	30	0.64	50	0.64
S2ML	Steel Brace Frame, Mid Rise	PGA	12	0.64	18	0.64	35	0.64	58	0.64
S2HL	Steel Brace Frame, High Rise	PGA	11	0.64	17	0.64	36	0.64	63	0.64
S3L	Steel Light Frame	PGA	10	0.64	13	0.64	20	0.64	38	0.64
S4LL	Steel Frame Shear Wall, Low Rise	PGA	13	0.64	16	0.64	26	0.64	46	0.64
S4ML	Steel Frame Shear Wall, Mid Rise	PGA	12	0.64	17	0.64	31	0.64	54	0.64
S4HL	Steel Frame Shear Wall, High Rise	PGA	12	0.64	17	0.64	33	0.64	59	0.64
S5LL	Steel Frame Unreinforced Wall, Low Rise	PGA	13	0.64	17	0.64	28	0.64	45	0.64
S5ML	Steel Frame Unreinforced Wall, Mid Rise	PGA	11	0.64	18	0.64	34	0.64	53	0.64
S5HL	Steel Frame Unreinforced Wall, High Rise	PGA	10	0.64	18	0.64	35	0.64	58	0.64
C1LL	Concrete Moment Frame, Low Rise	PGA	12	0.64	15	0.64	27	0.64	45	0.64
C1ML	Concrete Moment Frame, Mid Rise	PGA	12	0.64	17	0.64	32	0.64	54	0.64
C1HL	Concrete Moment Frame, High Rise	PGA	10	0.64	15	0.64	27	0.64	44	0.64
C2LL	Concrete Shear Wall, Low Rise	PGA	14	0.64	19	0.64	30	0.64	52	0.64
C2ML	Concrete Shear Wall, Mid Rise	PGA	12	0.64	19	0.64	38	0.64	63	0.64

C2HL	Concrete Shear Wall, High Rise	PGA	11	0.64	19	0.64	38	0.64	65	0.64
C3LL	Concrete Unreinforced Wall, Low Rise	PGA	12	0.64	17	0.64	26	0.64	44	0.64
C3ML	Concrete Unreinforced Wall, Mid Rise	PGA	11	0.64	17	0.64	32	0.64	51	0.64
C3HL	Concrete Unreinforced Wall, High Rise	PGA	9	0.64	16	0.64	33	0.64	53	0.64
PC1L	Precast Concrete Tiltup Wall	PGA	13	0.64	17	0.64	25	0.64	45	0.64
PC2LL	Precast Concrete Frames, Low Rise	PGA	13	0.64	15	0.64	24	0.64	44	0.64
PC2ML	Precast Concrete Frames, Mid Rise	PGA	11	0.64	16	0.64	31	0.64	52	0.64
PC2HL	Precast Concrete Frames, High Rise	PGA	11	0.64	16	0.64	31	0.64	55	0.64
RM1LL	Reinforced Masonry with Wood, Low Rise	PGA	16	0.64	20	0.64	29	0.64	54	0.64
RM1ML	Reinforced Masonry with Wood, Mid Rise	PGA	14	0.64	19	0.64	35	0.64	63	0.64
RM2LL	Reinforced Masonry with Precast Concrete, Low Rise	PGA	14	0.64	18	0.64	28	0.64	51	0.64
RM2ML	Reinforced Masonry with Precast Concrete, Mid Rise	PGA	12	0.64	17	0.64	34	0.64	60	0.64
RM2HL	Reinforced Masonry with Precast Concrete, High Rise	PGA	11	0.64	17	0.64	35	0.64	62	0.64
URMLL	Unreinforced Masonry, Low Rise	PGA	14	0.64	20	0.64	32	0.64	46	0.64
URMML	Unreinforced Masonry, Mid Rise	PGA	10	0.64	16	0.64	27	0.64	46	0.64
MHL	Mobile Homes	PGA	11	0.64	18	0.64	31	0.64	60	0.64

Table G.4. Pre-code fragilities for HAZUS model building types.

FACILITY TYPE	DESCRIPTION	METRIC	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA	ALPHA	BETA
W1P	Wood, Light Frame	PGA	18	0.64	29	0.64	51	0.64	77	0.64
W2P	Wood Commercial	PGA	12	0.64	19	0.64	37	0.64	60	0.64
S1LP	Steel Moment Frame, Low Rise	PGA	9	0.64	13	0.64	22	0.64	38	0.64
S1MP	Steel Moment Frame, Mid Rise	PGA	9	0.64	14	0.64	23	0.64	39	0.64
S1HP	Steel Moment Frame, High Rise	PGA	8	0.64	12	0.64	22	0.64	38	0.64
S2LP	Steel Brace Frame, Low Rise	PGA	11	0.64	14	0.64	23	0.64	39	0.64
S2MP	Steel Brace Frame, Mid Rise	PGA	10	0.64	14	0.64	28	0.64	47	0.64
S2HP	Steel Brace Frame, High Rise	PGA	9	0.64	13	0.64	29	0.64	50	0.64
S3P	Steel Light Frame	PGA	8	0.64	10	0.64	16	0.64	30	0.64
S4LP	Steel Frame Shear Wall, Low Rise	PGA	10	0.64	13	0.64	20	0.64	36	0.64

S4MP	Steel Frame Shear Wall, Mid Rise	PGA	9	0.64	13	0.64	25	0.64	43	0.64
S4HP	Steel Frame Shear Wall, High Rise	PGA	9	0.64	14	0.64	27	0.64	47	0.64
S5LP	Steel Frame Unreinforced Wall, Low Rise	PGA	11	0.64	14	0.64	22	0.64	37	0.64
S5MP	Steel Frame Unreinforced Wall, Mid Rise	PGA	9	0.64	14	0.64	28	0.64	43	0.64
S5HP	Steel Frame Unreinforced Wall, High Rise	PGA	8	0.64	14	0.64	29	0.64	46	0.64
C1LP	Concrete Moment Frame, Low Rise	PGA	10	0.64	12	0.64	21	0.64	36	0.64
C1MP	Concrete Moment Frame, Mid Rise	PGA	9	0.64	13	0.64	26	0.64	43	0.64
C1HP	Concrete Moment Frame, High Rise	PGA	8	0.64	12	0.64	21	0.64	35	0.64
C2LP	Concrete Shear Wall, Low Rise	PGA	11	0.64	15	0.64	24	0.64	42	0.64
C2MP	Concrete Shear Wall, Mid Rise	PGA	10	0.64	15	0.64	30	0.64	50	0.64
C2HP	Concrete Shear Wall, High Rise	PGA	9	0.64	15	0.64	31	0.64	52	0.64
C3LP	Concrete Unreinforced Wall, Low Rise	PGA	10	0.64	14	0.64	21	0.64	35	0.64
C3MP	Concrete Unreinforced Wall, Mid Rise	PGA	9	0.64	14	0.64	25	0.64	41	0.64
C3HP	Concrete Unreinforced Wall, High Rise	PGA	8	0.64	13	0.64	27	0.64	43	0.64
PC1P	Precast Concrete Tiltup Wall	PGA	11	0.64	14	0.64	21	0.64	35	0.64
PC2LP	Precast Concrete Frames, Low Rise	PGA	10	0.64	13	0.64	19	0.64	35	0.64
PC2MP	Precast Concrete Frames, Mid Rise	PGA	9	0.64	13	0.64	24	0.64	42	0.64
PC2HP	Precast Concrete Frames, High Rise	PGA	9	0.64	13	0.64	25	0.64	43	0.64
RM1LP	Reinforced Masonry with Wood, Low Rise	PGA	13	0.64	16	0.64	24	0.64	43	0.64
RM1MP	Reinforced Masonry with Wood, Mid Rise	PGA	11	0.64	15	0.64	28	0.64	50	0.64
RM2LP	Reinforced Masonry with Precast Concrete, Low Rise	PGA	12	0.64	15	0.64	22	0.64	41	0.64
RM2MP	Reinforced Masonry with Precast Concrete, Mid Rise	PGA	10	0.64	14	0.64	26	0.64	47	0.64
RM2HP	Reinforced Masonry with Precast Concrete, High Rise	PGA	9	0.64	13	0.64	27	0.64	50	0.64
URMLP	Unreinforced Masonry, Low Rise	PGA	13	0.64	17	0.64	26	0.64	37	0.64
URMMP	Unreinforced Masonry, Mid Rise	PGA	9	0.64	13	0.64	21	0.64	38	0.64
MHP	Mobile Homes	PGA	8	0.64	11	0.64	18	0.64	34	0.64

APPENDIX G ShakeCast V3 Manual

See pdf attachment ShakeCast V3 Manual.

ShakeCast V3 Manual

by

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Sally Jewel, Secretary

U.S. Geological Survey
Suzette Kimbal, Director

U.S. Geological Survey, Reston, Virginia 2014

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

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Table of Contents

1 OVERVIEW OF SHAKECAST V3

ShakeCast® (http://earthquake.usgs.gov/shakecast), short for *Shake*Map Broad*cast*, is a fully automated, open-source system for delivering specific ShakeMap products to critical users and for triggering established post-earthquake response protocols. ShakeCast allows utilities, transportation agencies, and other large organizations to automatically determine the shaking value at their facilities, set thresholds for notification of alert levels (typically green, yellow, and red) for each facility and then automatically notify (via pager, cell phone, or email) specified operators, inspectors, and others within their organizations responsible for those particular facilities in order to prioritize inspection and response.

We specifically use the term “alert level” rather than “damage level” because the sensitivity of the latter term, and to the reality that estimated damage is an uncertainty statistical estimate, not an actual site-specific evaluation. Users can and have labeled the alert levels with such terms as “inspection priority”, “concern level”, and “damage likelihood”; the specific choice can be redefined by any user.

When an earthquake occurs, the U.S. Geological Survey (USGS) ShakeMap portrays the extent of potentially damaging shaking. In turn, the ShakeCast system automatically retrieves earthquake shaking data from ShakeMap, compares intensity measures against users’ facilities, sends notifications of facility alert levels to responsible parties, and generates facility assessment maps and other web-based products for emergency managers and responders. ShakeCast is particularly suitable for earthquake planning and response purposes by transportation departments, critical facility and lifeline utilities, large businesses, engineering and financial services, and loss modelers.

The newly-released Version 3 of the ShakeCast system includes a full statistical fragility analysis framework for assessment of the overall structural system as well as structural components, significant improvements in the graphical user interface, including a console view for operations centers, management of multiple facility inventories, and custom, user-defined hazard and loss modules. The ShakeCast upgrade also simplifies user database uploading and upkeep through drag-and-drop file loading.

Since its inception in 2004, ShakeCast utilizes ground shaking information and related products from ShakeMap. The ShakeCast V2 system, released in 2008, and subsequently followed by four incremental updates, evolved to work closely with the ShakeMap application regarding available products and semantics.

The new ShakeCast V3 system continues that same design principle. Specific ShakeMap data related to damage assessment that have been made available to ShakeCast users include: (1) detailed processing parameters about the ShakeMap run; (2) ground shaking estimates at bedrock (before site corrections) and site amplifications at the grid level; and (3) uncertainty estimates for each computed shaking metric at the grid level.

Also implemented into ShakeCast V3 is the capability of the new system to track and receive earthquake “products” via multiple sources instead of from ShakeMap producers only. For critical lifeline users, ShakeCast V3 further integrates the new USGS Product Distribution Layer (PDL) as a redundant source to receive earthquake and ShakeMap products, additional earthquake information (e.g., focal mechanisms and tectonic summaries), and earthquake related products including the “Did You Feel It?” (DYFI) and Prompt Assessment of Global Earthquakes for Response (PAGER) loss estimates. All of these products are (optionally) stored locally as part of the ShakeCast data repository, accessible by ShakeCast users, and can thus be included to customize and expand each ShakeCast user’s vision and scope of post-earthquake situational awareness.

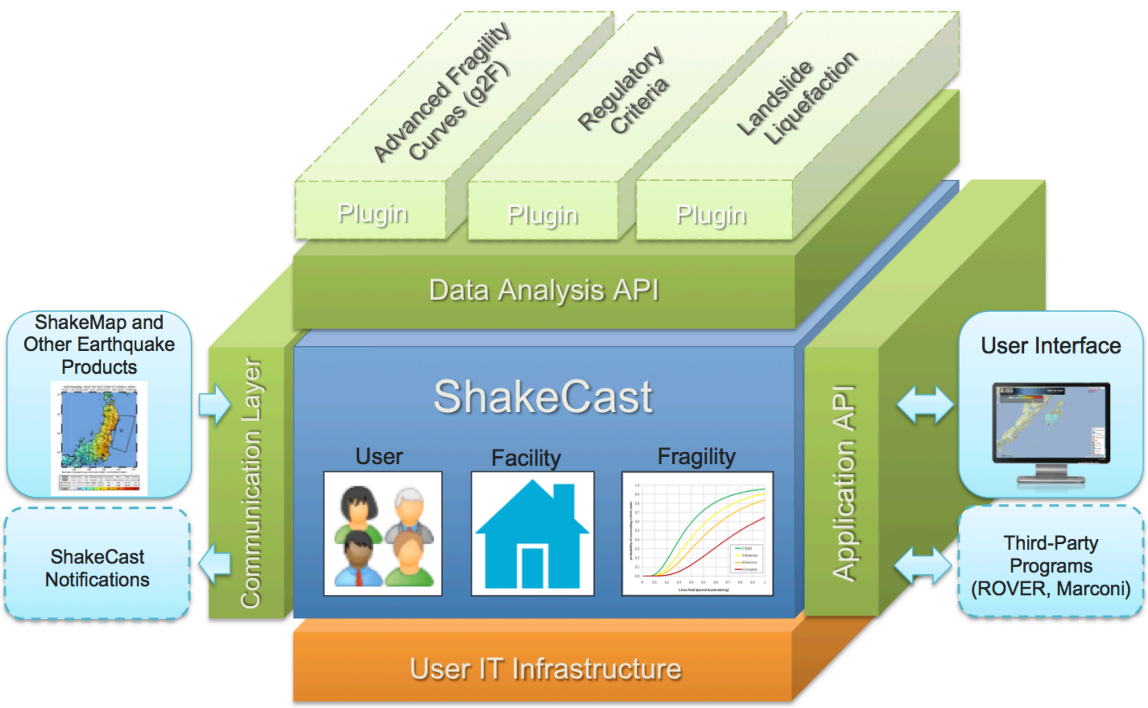


Figure 1.1. ShakeCast V3 System Diagram

2 SHAKEMAP AND RELATED EARTHQUAKE PRODUCTS

2.1 The Advanced National Seismic System (ANSS)

The ANSS includes a national backbone seismic network, the National Earthquake Information Center (NEIC), the National Strong Motion Project, and 15 regional seismic networks operated by USGS and its partners. ANSS provides an advanced infrastructure for seismic monitoring throughout the United States (Figure 2.1) for the ShakeMap system, which in turn feeds the ShakeCast system. When an earthquake strikes, ANSS delivers real-time information, providing situational awareness for emergency-response personnel. That information includes–within minutes–a ShakeMap, quantifying and showing the distribution of potentially damaging ground shaking. The ShakeCast system automatically retrieves the aggregated ShakeMap and related earthquake products from contributing networks at the NEIC to estimate shaking at the locations of a user's facilities.

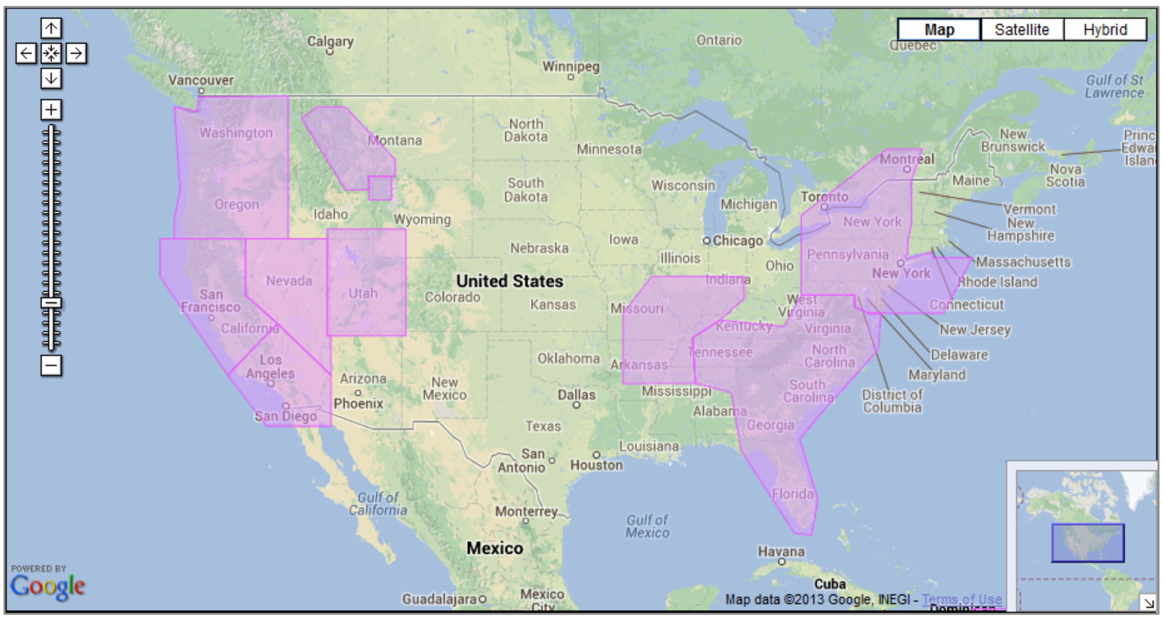


Figure 2.1. ANSS regions contribute to seismic monitoring inside the U.S.

Outside the U.S., the Global Seismographic Network (GSN) provides worldwide monitoring, with over 150 modern seismic stations distributed globally used primarily for determining earthquake magnitude and location. These global earthquake source parameters are immediately used at the NEIC as the primary input for the generation of Global ShakeMap (GSM) and related earthquake products.

2.2 ShakeMap

ShakeMap is a system for rapidly characterizing the extent and distribution of strong ground shaking following significant earthquakes worldwide (e.g., Wald et al., 2006). Current ShakeMap systems are deployed and operating at several regional networks within the U.S., in various national and local networks worldwide, and at the USGS NEIC in Golden, Colorado, for the production of ShakeMaps for significant earthquakes around the world (GSM) (Figure 2.2).

Starting in 2012, the NEIC Global ShakeMap system and most regional networks have upgraded their ShakeMap application to the latest Version 3.5. ShakeMap V3.5 represents a major change in the way ShakeMaps are computed and has improved in both data handling and precision over prior implementations (Worden et al., 2010). However, existing ShakeMap users may not be able to interpret the data products based on V3.5 appropriately without understanding the inner workings of the new application. For example, macroseismic observations are now a valid input data type, and converted observations are a new class of data in ShakeMap. With the introduction of the Intensity Prediction Equation (IPE) in addition to the more commonly used Ground Motion Prediction equations (GMPEs), the ground-motion estimate at a grid point is a weighted sum of the different types of contributing information among observations, converted observations, and GMPE/IPE estimates, weighted inversely by their uncertainties. The underlying, spatially varying, uncertainty grid is preserved for use in loss-estimation algorithms, including ShakeCast. Another ShakeMap upgrade is the bias correction scheme (for removing inter-event variability), which is now a magnitude adjustment rather than an amplitude multiplier. To a great extent, ShakeCast V3 will help the end user seamlessly migrate to ShakeMap V3.5 and to take advantage of the new data and uncertainty products.

Triggering of ShakeMap depends on both the magnitude and location of the earthquake. Although the criteria differ slightly among ShakeMap producers, one can expect a ShakeMap for an earthquake of magnitude 3.5 or higher inside the U.S. and magnitude 5.5 elsewhere.

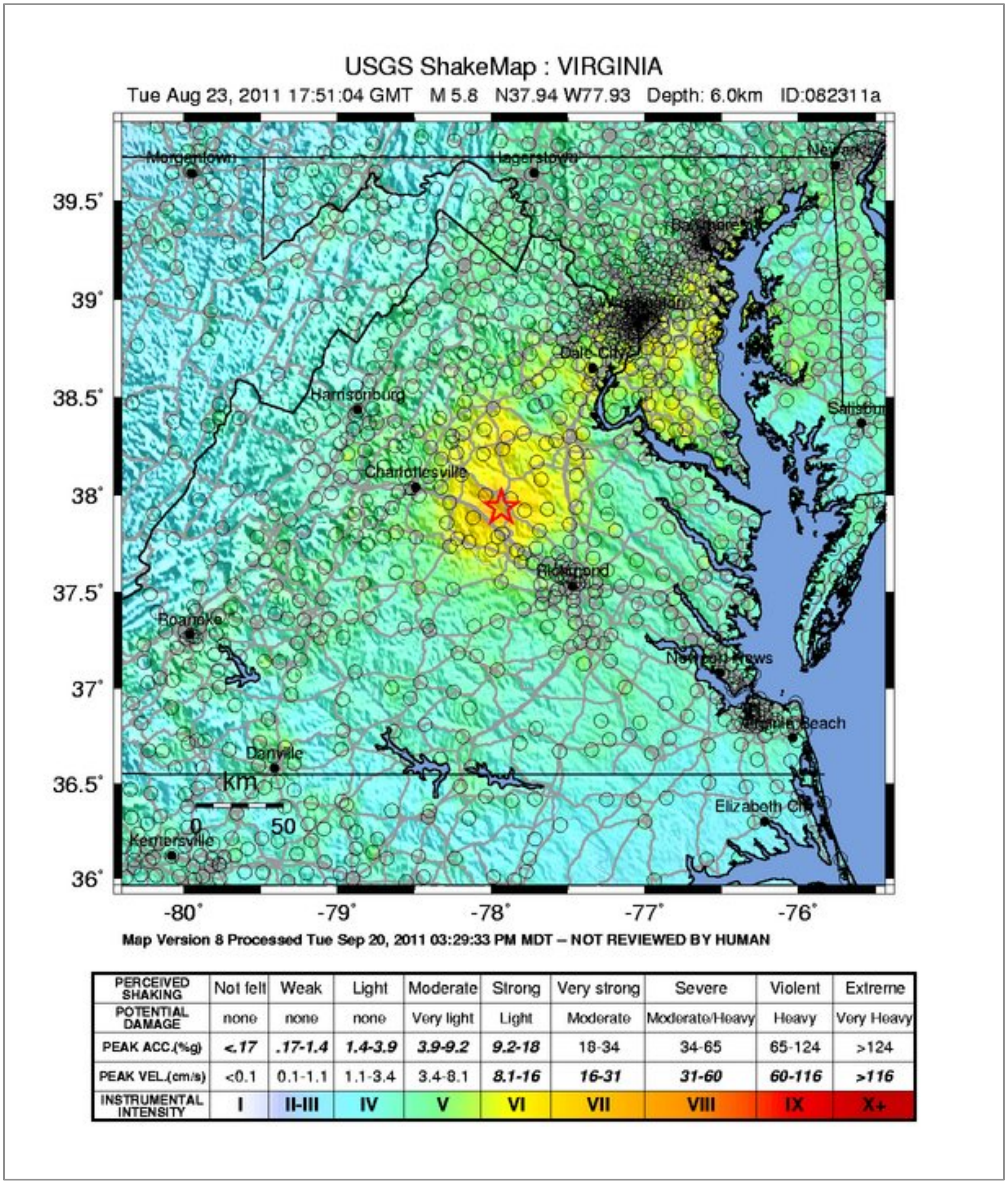


Figure 2.2. The ShakeMap Intensity Map for the 2011 M5.8 Mineral, Virginia earthquake.

Table 2.1. ShakeMap region code and description

Region Code	Description
SC	**Southern California**
CI	**Southern California**
NC	**Northern California**
NN	**Nevada**
UT	**Utah**
PN	**Pacific Northwest**
HV	**Hawaii**
AK	**Alaska**
GLOBAL	**Global and U.S. regions not covered by the above networks (NEIC ShakeMap)**
ALL	**All the above**

2.3 Did You Feel It? (DYFI)

The USGS "Did You Feel It?" web (DYFI, http://earthquake.usgs.gov/dyfi/) is a portal compiling internet-based user reports of shaking intensity into a Community Internet Intensity Map (CIIM) in the immediate aftermath of an earthquake. CIIM shows where and how strongly the earthquake had been felt and where damage occurred.

A CIIM is automatically made after each widely-felt earthquake in the U.S. summarizes the users' responses to standardized macroseismic intensity questionnaires. An intensity value is assigned to each ZIP Code for which one or more DYFI questionnaires are completed. The intensity values in each ZIP-Code area are averaged, and the map is updated as additional data are received. Zip-Code areas for which data have been received are color-coded according to the intensity scale shown below the map on the DYFI web page; other areas are gray (see Figure 2.3). When larger numbers of entries are received for an earthquake, the users' locations are also geocoded and more precise locations are used to refine the macroseismic intensity values.

DYFI macroseismic data is incorporated as part of the input for both the Global ShakeMap system and the Pacific Northwest (PNW) region. Thus often ShakeMap intensity estimates at the site of users' facilities in the U.S. match closely with felt intensities reported via DYFI unless sufficient strong ground motion observations are available in the vicinity.

In the new ShakeCast V3, DYFI CIIM products are locally cached and are made available to reponders directly through the local ShakeCast website and provides additional context when evaluating ShakeCast analysis results.

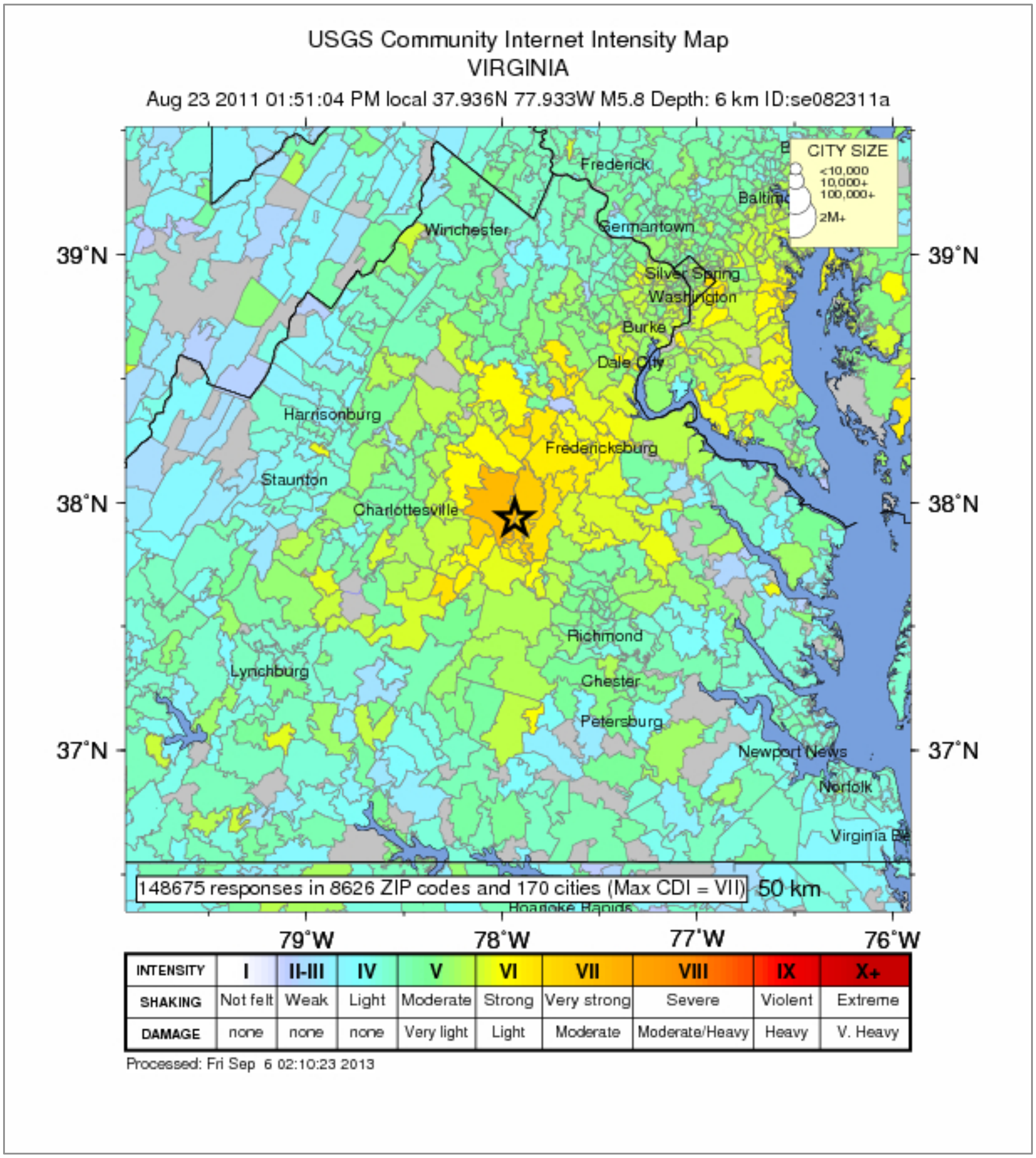


Figure 2.3. The DYFI Community Internet Intensity Map (CIIM) for the 2011 M5.8 Mineral, Virginia earthquake.

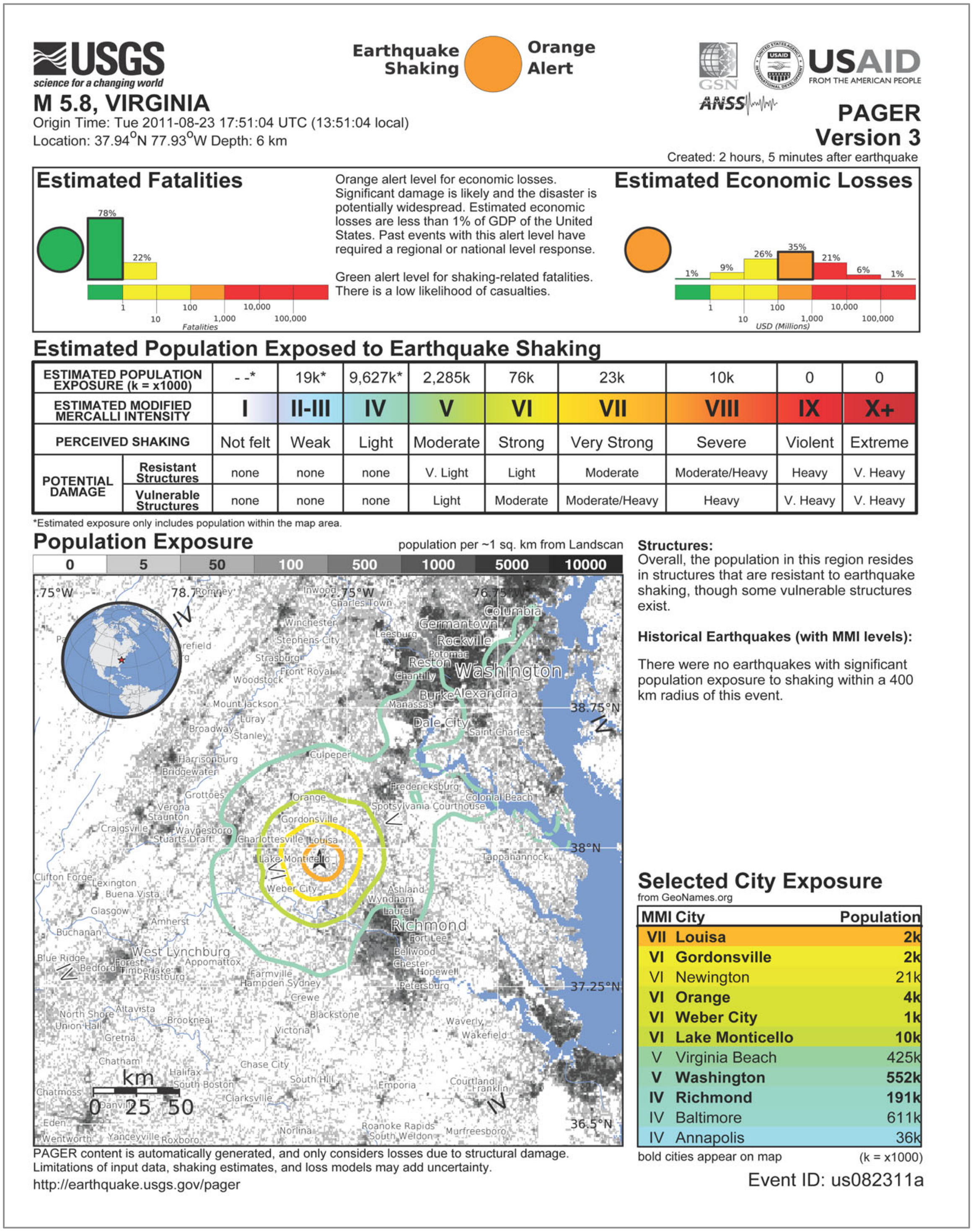
2.4 Prompt Assessment of Global Earthquakes for Response (PAGER)

PAGER (for Prompt Assessment of Global Earthquakes for Response) is an automated system that produces content concerning the estimated impact of significant earthquakes around the world, informing emergency responders, government and aid agencies, and the media of the scope of the potential disaster. PAGER rapidly assesses earthquake impacts by comparing the population exposed to each level of shaking intensity with models of economic and fatality losses based on past earthquakes in each country or region of the world. Earthquake alerts – which were formerly sent based only on event magnitude and location, or population exposure to shaking – are now generated based on the estimated range of fatalities and economic losses (see Figure 2.4).

PAGER uses ShakeMap ground shaking estimates as input data. Thus the generation of PAGER occurs immediately following the release of ShakeMap. Currently the triggering threshold is for earthquakes of magnitude of 3.5 or higher in the U.S. and magnitude 5.5 for the rest of the world.

PAGER results are generally available within 20-30 minutes of a significant earthquake, shortly after the determination of its location and magnitude and the generation of the subsequent ShakeMap. However, information on the extent of shaking will be uncertain in the minutes and first few hours following an earthquake and but it typically improves as additional sensor data and reported intensities are acquired and incorporated into models of the earthquake's source. The uncertainty of the ShakeMap shaking model and subsequent PAGER (as well as ShakeCast) loss estimates are a function of the number of observations (fault location, intensity observations and ground motion observations), which vary greatly from region to region and earthquake to earthquake. Users of PAGER exposure estimates —or any other ShakeMap-derived analyses—should account for the fact that ShakeMaps are uncertain shaking estimates and should always seek the most current PAGER release for any earthquake.

In the new ShakeCast V3, PAGER products are locally cached and are made available to reponders directly through the local ShakeCast website and provides additional context when evaluating ShakeCast analysis results.



USGS science for a changing world

Earthquake Shaking — Orange Alert

USAID FROM THE AMERICAN PEOPLE

GSN ANSS

M 5.8, VIRGINIA

Origin Time: Tue 2011-08-23 17:51:04 UTC (13:51:04 local)
Location: 37.94°N 77.93°W Depth: 6 km

PAGER
Version 3

Created: 2 hours, 5 minutes after earthquake

Estimated Fatalities

Orange alert level for economic losses. Significant damage is likely and the disaster is potentially widespread. Estimated economic losses are less than 1% of GDP of the United States. Past events with this alert level have required a regional or national level response.

Green alert level for shaking-related fatalities. There is a low likelihood of casualties.

Estimated Economic Losses

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	19k*	9,627k*	2,285k	76k	23k	10k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan

0	5	50	100	500	1000	5000	10000

Structures:
Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist.

Historical Earthquakes (with MMI levels):

There were no earthquakes with significant population exposure to shaking within a 400 km radius of this event.

Selected City Exposure
from GeoNames.org

MMI	City	Population
VII	**Louisa**	2k
VI	**Gordonsville**	2k
VI	Newington	21k
VI	**Orange**	4k
VI	**Weber City**	1k
VI	**Lake Monticello**	10k
V	Virginia Beach	425k
V	**Washington**	552k
IV	**Richmond**	191k
IV	Baltimore	611k
IV	Annapolis	36k

bold cities appear on map (k = x1000)

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.
http://earthquake.usgs.gov/pager

Event ID: us082311a

Figure 2.4. The PAGER summary report for the 2011 M5.8 Mineral, Virginia earthquake.

2.5 Supplemental Earthquake Products

By default, ShakeCast retrieves ShakeMap, DYFI and PAGER products from the USGS web site as part of the specification requirements. The system also downloads additional earthquake products outputs to assist situational awareness. These supplemental earthquake products include:

- Origin - detailed earthquake source parameters, including magnitude and hypocenter
- Historic seismicity map,
- Historic moment-tensor map, and
- Tectonic summary.

Although the ShakeCast system does not digest the contents of supplemental earthquake products, they are available on the local system and can be integrated into new products, for example, in the customized ShakeCast PDF product that is automatically distributed to users.

3 USGS SHAKEMAP ATLAS AND ITS USE IN SHAKECAST

The USGS ShakeMap Atlas, available at

http://earthquake.usgs.gov/earthquakes/shakemap/atlas.php,

is a major resource for investigating strong ground-motions near the source, as well as for seismic hazard, risk, and loss-modeling analyses. Version 1 of the Atlas was released in 2007 with a compilation of near 5,000 ShakeMaps of the most significant global earthquakes between 1973 and 2007.

The new version (2.0) of the ShakeMap Atlas represents a significant improvement over the previous release that includes relevant changes in almost all aspects of the catalogue. These changes are related with four main areas: (1) a new version of the ShakeMap software; (2) an updated and extended source catalog (through 2012); (3) a refined way to select prediction and conversion equations for a given earthquake; and (4) additional macroseismic intensity and ground-motion data.

The revised Version 2 Atlas events are available through the new searchable Comprehensive Catalog utility at USGS ("ComCat") at

http://earthquake.usgs.gov/earthquakes/search/.

Select the contributor "ShakeMap Atlas" and use search parameters to find events within chosen space, time, and magnitude ranges.

3.1 ShakeMap Upgrade V3.2 to V3.5

The ShakeMap software combines ground-truth observations, wherever available, and prediction equations, where no data are present, to compute maps for two layers: macroseismic intensity and ground motion. V3.5 of ShakeMap, publicly released in 2009, represents a major change to the algorithms used to compute ShakeMaps (see Worden et al., 2010, for details on composite ShakeMap). One key addition in this software version is the distinction in the nature of the available data depending on the map layer considered. In ground-motion maps (PGA, PGV, and PSA) we call *native* observations to any ground motion data obtained from seismic stations, while we define *converted* observations as those derived from macroseismic intensity (i.e. Modified Mercalli Intensity (MMI)) data transformed into ground-motion parameters through the use of intensity-to-ground-motion conversion equations (IGMCE). Conversely, in the intensity layer MMI assignments constitute the native data, while ground-motion parameters converted into MMI values via a ground-motion-to-intensity conversion equation (GMICE) are the converted data. Due to the added uncertainty related with the use of conversion equations, converted data always carry additional uncertainties, which are incorporated through a weighted-average approach in the computations.

Specifically, in ShakeMap V3.5:

- ShakeMaps now include a new class of data, converted observations. A converted observation would be, for example, MMI converted to PGA, PGV, or PSA, or one of those ground motion observations converted to MMI. On a map of PGA, for example, PGA data are considered *native* observations, and MMI converted to PGA are considered *converted* observations.
- ShakeMap produces a weighted combination of native observations, converted observations, and estimated data at every location within the mapping area. Previously in V3.2, it combined observations (data) with GMPE-derived estimates computed on a coarse grid, then interpolated (i.e., filled gaps) to a finely spaced grid. Estimates near observations were rejected in favor of the observation. Weighting is now determined by the formal uncertainty of each datum.
- Macroseismic intensity (DYFI data) is treated as any other ground motion parameter. MMI (or Intensity) was formerly computed only from PGA and/or PGV. For intensity maps, intensity observations are now native, Peak Ground Motion (PGM) is converted to intensity for converted observations, and estimates are made directly from an Intensity Prediction Equation (IPE).
- The conversion from PGM to Intensity (and Intensity to PGM) is now a configurable option. The operator may select (or develop) the conversion function most appropriate for his or her region.
- Bias is now a magnitude adjustment, rather than an amplitude multiplier. (I.e., the magnitude given to the GMPE is adjusted to give the best fit to the observed and converted data (with converted observations being down weighted relative to native observations.)
- Computation of site amplification is a configurable option between the GMPE's native site amplification term and the default NEHRP-style site corrections.

3.2 Earthquake Inventory for the Atlas

The earthquake inventory for the first version of the Atlas is a composite earthquake catalog that has been developed entirely from published or online databases and reports. These global earthquake catalogs are openly available in digital format and include the USGS Preliminary Determination of Epicentres Bulletin (PDE), the Centennial, and the Global Centroid Moment Tensor (GCMT) catalogs. Although no new information has been derived in its compilation, for the first time it brings together information from a range of sources in a comprehensive, easy to use digital format.

The Atlas 2.0 source information is based on the PAGER-CAT catalog (Allen *et al.*, 2009), which includes information not only from the above mentioned databases, but from the Global Earthquake Model (GEM) Global Instrumental Earthquake Catalogue, the Utsu Catalogue of Damaging Earthquakes in the World, the NOAA Significant Earthquakes Database, regional catalogues provided by national and local agencies, and a vast amount of published studies on individual earthquakes. Whenever the reliability of regional and local sources was confirmed, we have substituted global hypocenters by regional ones. This is particularly important for depth estimations, since global catalogs tend to suffer from considerable depth errors, sometimes as large as 30-50 km depending on the region, which can cause substantial under or overestimation of the ground shaking depicted in the maps.

For most relevant earthquakes a thorough search on the literature had been conducted to add finite fault models (FF), resulting in the inclusion of FFs for more than 60% of M >= 8 events and 20% of M >= 7 events, plus many others in the M 5.5-7.0 range. Currently there are more than 240 FFs incorporated into the Atlas, covering the majority of the most destructive earthquakes in the 1973-2012 period, and the list is continuously being updated.

The initial version of the Atlas spanned a period through mid-2007 however excluded some potentially relevant events based on simplistic magnitude and depth criteria. These criteria have now been refined to consider more accurately the potential impact of a given earthquake, and the Atlas span has been extended through June 30th, 2012, resulting in a broader catalogue containing nearly 8,000 events. Most of the important earthquakes that occurred in the past several years, such as Darfield and Christchurch (New Zealand), Chile, Tohoku (Japan), Lorca (Spain), and Virginia (USA), are also available in this version.

3.3 Ground Motion Prediction Equation

Prediction equations (GMPEs and IPEs) are fundamental in ShakeMap for any point where no data are available. In addition, conversion equations (IGMCEs and GMICEs) are used wherever observations have to be transformed into other parameters. Therefore, the choice of the appropriate equations for a given event plays a crucial role in the shaking estimates shown in the resulting maps.

Compared with Atlas 2.0, the Atlas 1.0 (using ShakeMap 3.2) implemented a relatively simple GMPE-selector based on the geographic location, depth, and magnitude for any given earthquake. The Atlas 2.0 makes use of a wealth of global and regional seismotectonic information, including plate boundaries, hotspots, digital elevation data, stable continental regions, slab models, global seismicity catalogues, and additional studies for some complex areas (García *et al.*, 2012). Based on all of this information the region where each earthquake in the Atlas took place has been classified according to the tectonic regimes and seismotectonic domains listed in Table 3.1. Next, each event in the Atlas has been automatically assigned to one of the earthquake types of Table 5.1 according to its location, depth, and focal mechanism, as well as the subduction zone geometry (if pertinent). In this process, the use of regional and local hypocenters helps discriminate among the different types of earthquakes that may occur in tectonically complex areas, such as subduction zones. For each type a set of predefined prediction and conversion equations is used to compute the ShakeMap.

With the new GMPE selection approach, a substantial number of improvements to the choice of GMPE assignments for earthquakes contained in the Atlas 1.0 have been made. The new scheme allows us, from now on, to be more consistent in how equations are automatically selected, given that the process is reproducible and can be updated at any time by incorporating more detailed catalogues and regional models into the process or by swapping in new or updated prediction equations.

Table 3.1. Regionalization scheme for equation selection in the ShakeMap Atlas

Tectonic Regime	Seismotectonic Domain		Possible Earthquake Types
Stable Continental Region	Generic		Stable Continental
	Above a Slab		Stable Continental
			Intraslab
Stable Oceanic Region	Generic		Stable Oceanic
	Above a Slab		Stable Oceanic
			Intraslab
Active Non-Subduction Region	Shallow Continental		Active Continental (shallow)
	Deep Continental		Active Continental (shallow)
			Active Continental (deep)
	Oceanic Boundary		Oceanic Boundary
	Above a Slab	Shallow Continental	Active Continental (shallow)
			Intraslab
		Deep Continental	Active Continental (shallow)
			Active Continental (deep)
			Intraslab
		Oceanic Boundary	Oceanic Boundary
			Intraslab
	Hotspot		Hotspot
Subduction Zone	Generic		Outer-trench
			Active Continental (shallow)
			Active Continental (deep)
			Interface
			Intraslab
	Outer-trench		Outer-trench
			Intraslab
	Onshore		Active Continental (shallow)

	Active Continental (deep) Interface Intraslab
Inland/Backarc	Active Continental (shallow) Active Continental (deep) Intraslab

3.4 Input Data of ShakeMap

The first version of the Atlas included most of the macroseismic intensity and ground-motion observations easily available online, which were also amendable to incorporation via automatic processing. This included global and regional repositories, such as the Consortium of Organizations for Strong Motion Observation Systems (COSMOS) database, the Next Generation Attenuation project, the European Strong-Motion Database, the Regional Centre for Seismology in South America (CERESIS) macroseismic intensity database, as well as some national datasets from Australia, Iran, Japan, New Zealand, and the USA.

In this second version of the Atlas we have first carried out a thorough review of the available data, in order to remove redundancies, inconsistencies, incorrect intensity assignments (such as those related to the X, XI, and XII intensity levels of the MMI scale, which are no longer in use), and other problems not detected during the automatic processing of the previous data. Following Musson et al. (2010), we have also assumed that the intensity levels of all macroseismic intensity scales currently in use are roughly equivalent, except for the Mercalli-Cancani-Sieberg (MCS) scale. The MCS scale is used systematically in Italy and thus for events in this country we keep a separate set of prediction and conversion equations specifically developed there.

In a second step we have requested additional macroseismic and ground-motion data mostly from national and local agencies. This is a time-consuming and less-efficient effort than the one made for the Atlas 1.0, since it requires personal contact with each institution, often long waiting times, and in most cases numerous data format changes. As results, it has significantly increased the number of available ground motions, exceeding 20,000 PGA values and 18,000 PGV and PSA values (42% more data than in the Atlas 1.0), and especially of macroseismic intensity assignments, which have been almost doubled (more than 61,000 data). This vast amount of new data makes the Atlas 2.0 one of the most comprehensive openly-accessible global repositories on near-source ground shaking observations available to date.

Intensity data are especially valuable, since they usually provide wider coverage of near-source areas than ground-motion data. This is especially true for CEUS and corresponding stable continent regions. Moreover, MMI values often represent the only available observations for many significant earthquakes included in the Atlas that took place in countries with a lack of dense seismic networks at the time of the event.

3.5 Benefits of Altas 2.0 for ShakeCast

The Atlas of ShakeMaps provides a consistent and quantitative description of the distribution and intensity of shaking for recent global earthquakes as well as selected historic events. As for calibrating the PAGER project, the Atlas provides ShakeCast users estimated ground shaking data via a centralized source for modeling facility fragility, assessing facility performance, and siting purposes.

ShakeCast automatically archives site-specific ground shaking and input data and assesses facility impact as it processes each ShakeMap. The dual function of the application as a research tool can be easily achieved by injecting selected ShakeMaps (both Atlas and Comcat) in the same areas as user's facilities to extract the history of estimated ground shaking at the facility site. The shaking history and associated information including Vs30, GMPE, station data, and uncertainty data can be used to validate facility performace.

Results of such analyses are critical for pre-earthquake planning to evaluate facility vunlerbility. As the Atlas effort progresses, improvements to ground shaking estimates will be carried over to ShakeCast and directly benefits the facility fragility modeling process.

4 INSTALLING THE SHAKECAST SYSTEM

First, a note on the logic behind the choice of software operating systems used for porting the ShakeCast system. The ShakeCast V3 system was originally developed under the CentOS 6 Linux system and, due to varying client requirements, was ported to several Linux distributions (RedHat ES 6 and SUSE Enterprise Server 10) as well as Windows operating systems (7/Server 2008) as either a 32- or 64-bit application. Over the course of ShakeCast V3 development, supporting multiple OS platforms proved to be challenging due to technical and organizational policy hurdles as well as more complex user support requirements. A new strategy was devised to bundle the ShakeCast application with an Open-Source Linux operating system as a standalone system image, referred to as a “Virtual Machine (VM),” in addition to the standard installation package. The Nuclear Regulatory Commission’s (NRC) Nuclear ShakeCast system is an example of a VM deployment. The ShakeCast user can decide the method and location of the deployment of a standard ShakeCast VM and to modify the configurations regarding security and access controls to meet user-specific needs.

4.1 Virtual Machine (VM)

A virtual machine (VM) is a software implementation of a machine (e.g., a computer) that executes programs like a physical machine. Virtual machines are separated into two major classifications, system and process virtual machines, based on their use and degree of correspondence to any real machine. ShakeCast VM refers to a system virtual machine.

A VM provides a complete system platform which supports the execution of a complete operating system (OS). It usually emulates an existing architecture, and is built with the purpose of either providing a platform to run programs where the real hardware is not available for use (for example, executing on otherwise obsolete platforms), or of having multiple instances of virtual machines leading to more efficient use of computing resources, both in terms of energy consumption and cost effectiveness (known as hardware virtualization, the key to a cloud computing environment), or both.

ShakeCast is essentially a database application. The dynamic nature regarding the scope of input ShakeMap data (earthquake monitoring regions), user’s inventory and performance requirements make it difficult to anticipate the appropriate hardware setup for individual users. The growth rate of the database and constant evolutions of computer hardware futher complicates the decision process.

Starting in ShakeCast V3 we recommend the VM option primarily for the benefits of application provisioning, maintenance, high availability and disaster recovery. These also are important factors of considerations when implementing the application at any organizations as a VM or physical server.

The host VM mentioned in this document simply reflects the available VM options for the purpose of application development. We do not endose any specific VM host or cloud provider for the ShakeCast application. To reduce requests for ShakeCast support, the sections below describe the setup for a generic VM which we make it available to the ShakeCast user community. We will expand the supported VM image format depending on future user demends.

4.1 System Hardware

Recommended minimum hardware specifications for the ShakeCast system includes:

- Single Intel Xeon E5-2670 equivalent processor.
- 1GB RAM.
- 30GB hard drive storage.
- At least low performance Internet connection (<1MB/s).

The above hardware setup is roughly equivalent to the "micro" instance on the Amazon Elastic Compute Cloud (Amazon EC2) in which the performance was assessed. A system with these minimum requirements should only be used for non-production purpose and was found to be adequate to support a ShakeCast instance with <100 facilities and <10 users for each processed ShakeMap.

Depending on the size of facility and user inventory and the earthquake monitoring areas, more hardware resources will be needed in order to deliver anticipated performance (e.g., near instantaneous facility evaluation and user notifications). Products (ShakeMap, ShakeCast, lossPAGER, DYFI?, and others) for each processed earthquake usually consume 30-50 MB of hard drive space. For ShakeCast systems designated for earthquake response purpose, we recommend to at least double the minimum recommended hardware specifications. As a case example, the Caltrans ShakeCast system consists of ~26,000 bridge facilities, ~500,000 bridge components, ~300 users in several groups and uses the following hardware specifications for all primary and backup servers,

- Two Intel Xeon E5530 equivalent processors.
- 8GB RAM.
- 120GB hard drive storage.
- High performance Internet connection.

4.2 System Software

The ShakeCast V3 system is distributed for both Linux and MS-Windows operating systems. The system is built on an open-source stack of supporting applications shared by all platforms, specifically:

- Apache Web server 2.x.
- MySQL 5.x database.
- Perl 5.14+ scripting language.
    - Modules: DBI, DBD::mysql, Text::CSV_XS, Config::General, enum, XML::Parser, XML::LibXML, XML::Writer, XML::Twig, XML::Simple, Template-toolkit, PDF::API2, PDF::Table, MIME::Lite, GD, GD::Text, GD::Graph, GD::Graph3d, HTML::TableExtract, Net::SSLeay, Net::SMTP::SSL, Net::SMTP::TLS, Authen::SASL, Archive::Zip, JSON, JSON::XS, File::Path, Image::Size, Mojolicious.
- wkhtmltoimage conversion tool.
- gnuplot image tool.
- HTML5/Google Maps API V3/markerclusterer/jQuery/Bootstrap/dataTables Web tools.
- Optional PHP/phpmyadmin scripting language.
- Optional git version control tool.

Linux-specific implementations:

- Xvfb X virtual framebuffer display server (required for 64-bit systems and optional for 32-bit systems).
- mailx as default mail utility.
- ShakeCast services as background daemon processes.
- Database backup cron job.

Windows-specific implementations:

- SMTP as default mail protocol (supports both SSL/TLS security layers).
- ShakeCast services as Windows system processes.

4.3 Firewall and Security Setup

The default setup of a ShakeCast system allows access via both the command line using SSH and the web interface with HTTP or HTTPS. The ShakeCast web server is designed both to serve earthquake information to users and to allow administrators to conduct general administration of the system. Command line access via SSH (Linux) should be limited to only administrators. ShakeCast tasks not covered by the web interface are considered as advanced topics for experienced ShakeCast administrators. Normal setup and interaction with a user’s ShakeCast web server provides both user access to maps, products, and services, as well as administrator access. As discussed in more detail below, administrators can for example, modify configurations user profiles and notifications, trigger earthquake scenarios, and access many other functions. However, in the most secured setup of ShakeCast, the administrator can choose to disable access from the web and only permits SSH access.

Firewall and system level security setup are platform specific issues not covered by this manual. Even though ShakeCast implements a basic authentication scheme, it is highly recommended to implement system-level firewall policies to limit exposure to the Internet. These rules will take precedence over the ShakeCast-defined user authentication scheme. For inbound traffic, firewall policies are effective methods to define domains where users can access the products and information of the ShakeCast server. For outbound traffic, firewall policies should permit the USGS Web server http://earthquake.usgs.gov, the source for all earthquake products processed by ShakeCast. For ShakeCast systems receiving earthquake products via the USGS Product Distribution Layer (PDL) client, the program uses port 39977 to connect to the upstream hub server.

4.2 Web Browser Compatibility

The ShakeCast V3 web interface was built using the HTML5 standards. Most User and Administrator interactions with the ShakeCast V3 system is carried out using a web browser. The following web browsers and versions are supported for typical users:

	MacOS	MS-Windows
Chrome	25+	25+
Firefox	20+	15+
Opera	12+	12+
Safari	5+	
Internet Explorer		9+

5 SHAKECAST SYSTEM ADMINISTRATION

The ShakeCast administrative interface is platform independent and is designed for an administrator to perform common tasks ranging from management of both facility and user inventory to system-wide maintenance and configuration. Access to the administrative page is restricted to ShakeCast users with administrative privileges. The range of tasks that can be performed from the interface includes: (1) general system configuration; (2) earthquake/ShakeMap management; (3) facility management; (4) station management; (5) group/user account and notification management; and (5) inventory uploading.

The ShakeCast administrative interface does not cover management for system level services and supporting software. These services include three ShakeCast daemon services (dispatch, notify queue, notify processes), the Apache Web server and MySQL database applications. An administrator will need to log on to the server system where the ShakeCast system resides to make changes to the configuration files of applications and to start and stop ShakeCast system processes and supporting software.

5.1 Scope of System Management

The majority of administrative functions for the ShakeCast system can be accessed via the web interface. The new system continues to adopt the template driven approach in creating the administrative web interface as was defined in the original V2 system. In an effort to ensure smooth transition from V2 to V3, the web interface retains most of the V2 features while introducing V3 specific functions. In general, the interface allows the system administrator to:

- Manage general settings for the ShakeCast server and the database.
- Manage archives of actual and scenario earthquakes processed by the system.
- Manage facility inventories and associated fragilities.
- Manage ShakeCast specific products and accessibility.
- Manage station inventory of which ground motions are used in ShakeMap.
- Manage group, users, user-group associations, and user-notification preferences.
- Manage utility for uploading inventory, configuration, and earthquake scenarios.

Contrary to the V2 system, ShakeCast V3 prohibits direct editing (except delete) of inventory stored inside the database. A universal file drop page is created in V3 to receive updated inventory data. Section 5.8 describes details of the function.

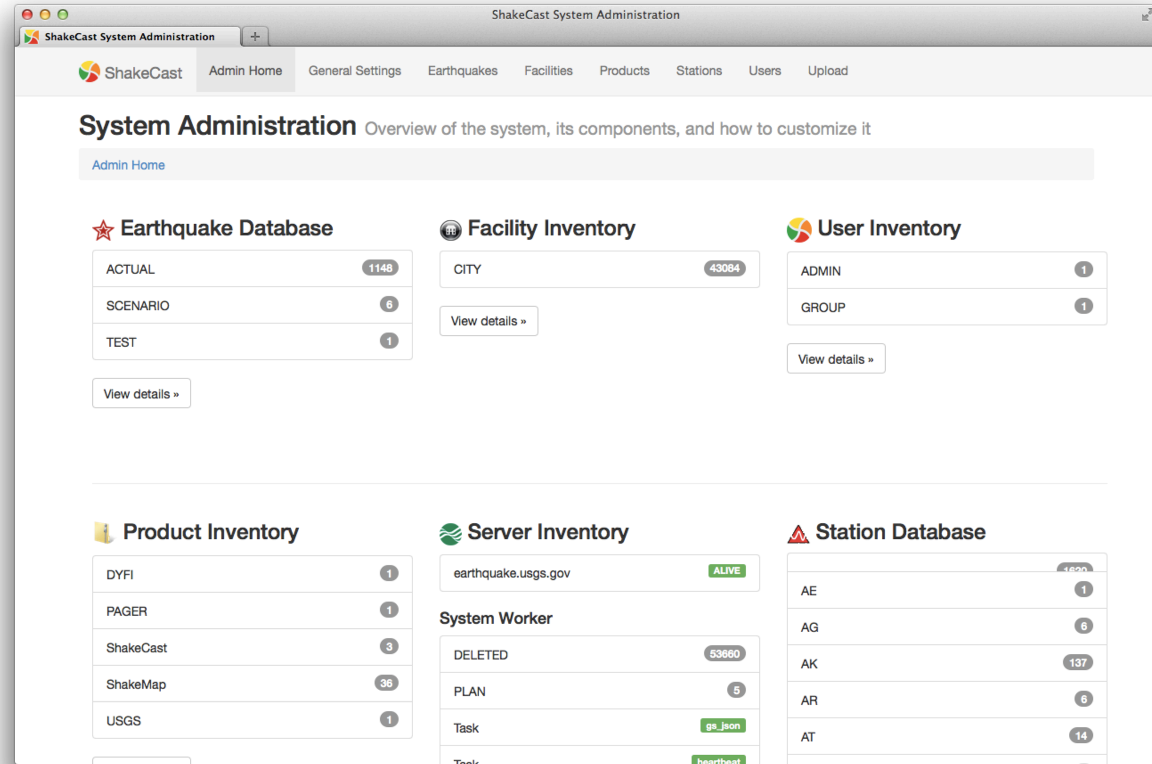


Figure 5.1. ShakeCast administrative web interface. The default page displays summary of the system inventory stored inside the database and active processes.

The Task Repeater function of ShakeCast V2 is replaced by a new generic Cron function in ShakeCast V3. Unlike Task Repeater, which is tied to the Windows operating system, Cron Job simulates the generic cron function of a UNIX system and is platform independent. Cron jobs (crons) are saved inside the ShakeCast database and are managed by the ShakeCast dispatcher. This means that the administrator does not need a separate system account with elevated credentials to create a cron job.

The scope of executable crons has also been expanded to cover all aspects of the system and secondary computation processes to expand the core functions of the system (System Worker in Figure 5.1). Details of these executable crons are described in Appendix C (task_inject), and provide the following functions:

- Compute theoretical ground motions for facilities of the specified earthquake.
- Rotate the ShakeCast log files.
- Generate log statistics plots.
- Trigger a ShakeCast heartbeat message.
- Refresh the USGS earthquake JSON feed and process new earthquakes.
- Trigger maintenance of the ShakeCast database.

- Trigger the process to compute probabilistic facility fragilities.
- Trigger the process to compute exceedance of regulatory levels.
- Take a screen shot for the selected earthquake and save the output image.
- Generate image tile overlay to be displayed on the web interface.

By default there are five pre-installed cron jobs for a ShakeCast system that receive earthquake products and perform maintenance of the system. Custom configuration of cron jobs should only be performed by an experienced ShakeCast administrator.

5.2 General Settings

The General Settings page allows the ShakeCast administrator to manage system-wide configurable information in six different categories: (1) ShakeCast Database; (2) Email Server; (3) ShakeMap Server; (4) ShakeMap Region; (5) System Directory; and (6) Misc. Parameter.

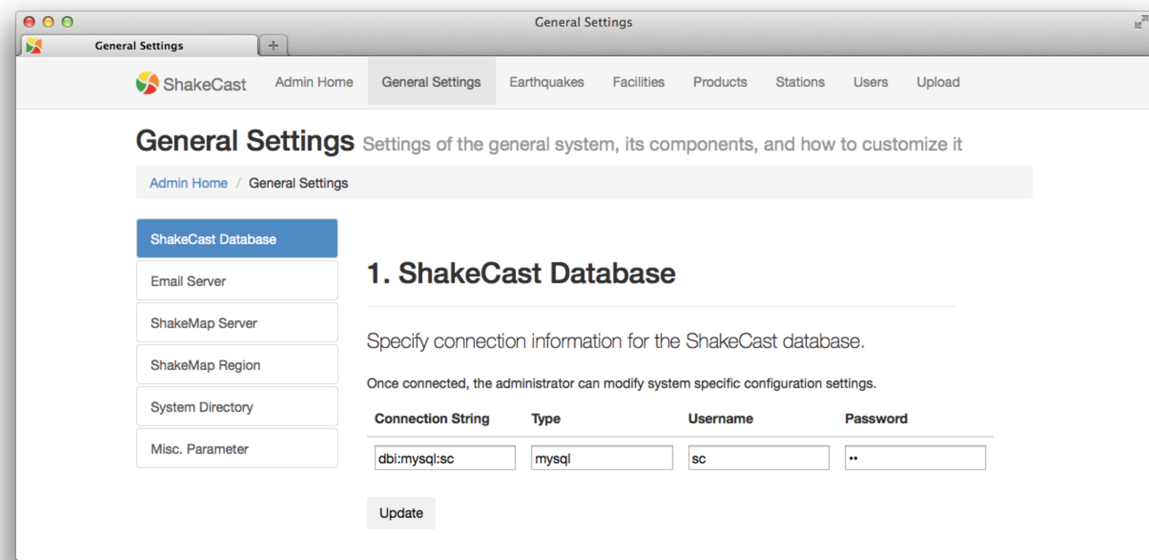


Figure 5.2. ShakeCast administrative web interface for general system settings.

5.2.1 ShakeCast Database

The ShakeCast Database form specifies the database connection information (Figure 5.2). The ShakeCast database account has full privileges to the ShakeCast database only. Changes to the database account require database administration privileges. Users should consult with the system administrator and the MySQL documentation for information on modifying the database and access privileges.

A summary of the form fields and a description of their content is provided in Table 5.1.

Table 5.1. ShakeCast database server information.

Field	Description	Example
Connection String	ShakeCast dtatabase name	db:mysql:sc
Type	Database engine	mysql
Username	Username	sc
Password	Password	xx

5.2.2 Email Server

The Email Server form specifies information of the email server, sender, and default template of ShakeCast notifications (Figure 5.3). The SMTP server information is required for MS-Windows based installations. On Linux servers ShakeCast uses built-in mail agent (mailx) as the default mail program and the SMTP server information is optional. Users deploying ShakeCast cloud hosting can take advantage of built-in emailing capabilities of their cloud services provided.

Email notification-related issues are the most encountered problems for ShakeCast operations, particularly for in-house (as opposed to cloud-hosted) installations. They are also difficult to troubleshoot as the cause of the problems range from server setup and server message filter to notification request and template setup. It is a good practice to perform routine testing to ensure connectivity between ShakeCast and email servers and to involve administrators of email servers to set up proper protocol and authentication information. One of the default ShakeCast Cron Jobs is a heartbeat cron, which triggers a heartbeat notification for users/administrators who are configured to receive it.

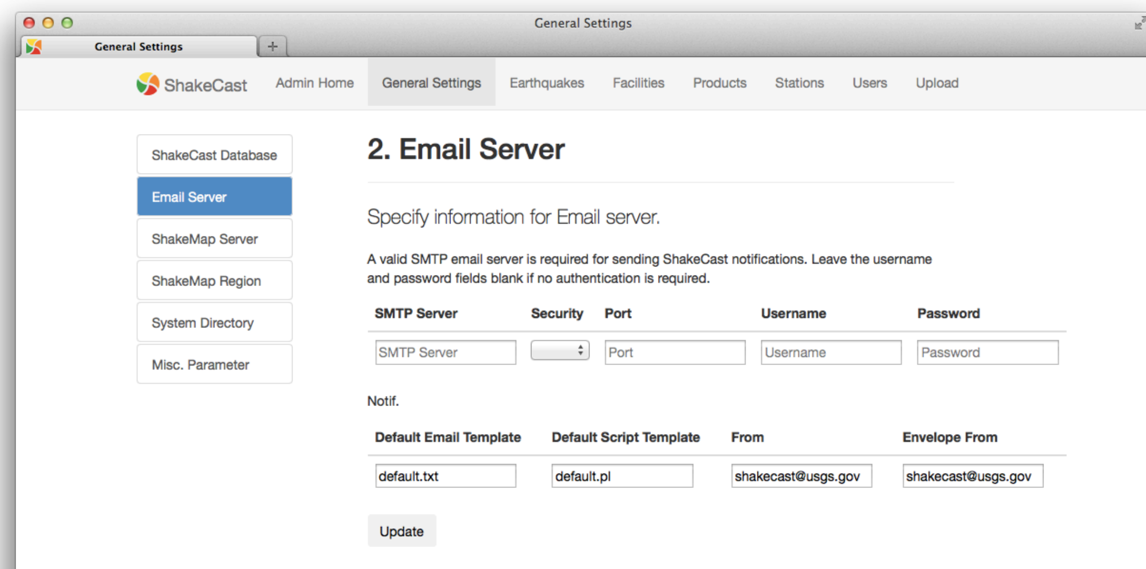


Figure 5.3. ShakeCast administrative web interface for Email Server configuration.

A summary of the form fields and a description of their content is provided in Table 5.2.

Table 5.2. SMTP Email server information.

Field	Description	Example
SMTP Server	SMTP Email server name	smtp.gmail.com
Security	Security option	SSL
Port	Connection port	465
Username	Username	sc
Password	Password	xx
Default Email Template	Default Email template	default.txt
Default Script Template	Default Script template	default.pl
From	Sender email	shakecast@usgs.gov
Envelope From	Reply email	shakecast@usgs.gov

5.2.3 ShakeMap Server

The ShakeMap Server form specifies information of the ShakeMap server (Figure 5.4). The ShakeMap server is also the source of other USGS earthquake products. Currently all ShakeMap products and maps, and the DYFI, PAGER, tectonic summary, and historical seismicity plot products are retrieved automatically. The administrator can enable/disable selected servers by toggling the Query flag if multiple servers have been configured.

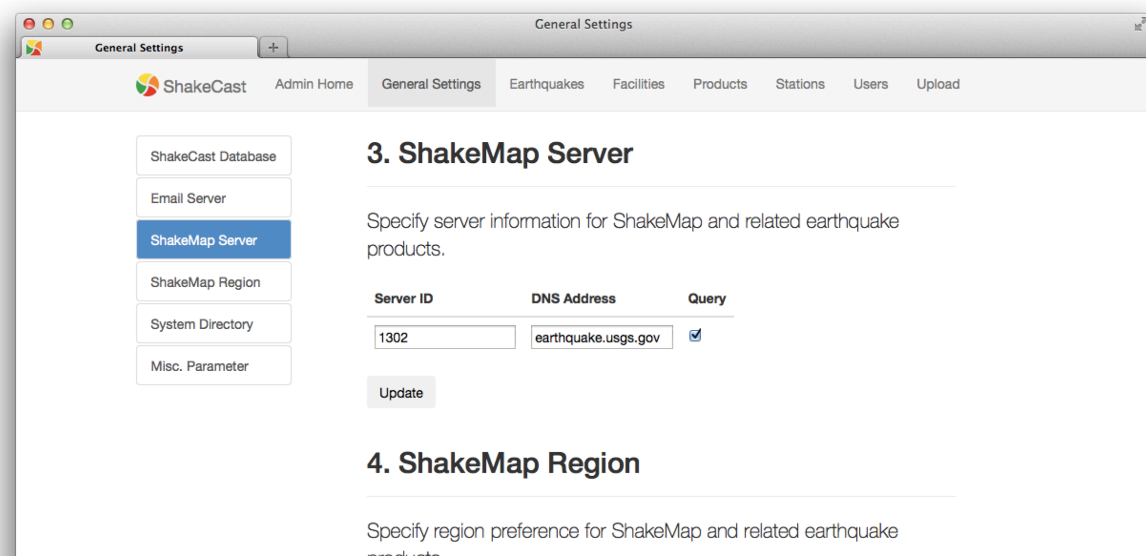


Figure 5.4. ShakeCast administrative web interface for ShakeMap Server configuration.

A summary of the form fields and a description of their content is provided in Table 5.3.

Table 5.3. Upstream server information.

Field	Description	Example
Server ID	Unique server ID	1302
DNS Address	Server hostname	Earthquake.usgs.gov
Query	Active server flag	checked

5.2.4 ShakeMap Region

The ShakeMap Region form specifies information of the ShakeMap regions (Figure 5.5) to be processed by the system. The ShakeMap Region directive functions as a spatial filter based on the predefined boundaries of seismic networks (Figure 2.1). With the new user-defined monitoring region (via group definition) for the V3 system, users should combine notification requests with user-defined regions to improve performance of the system without unnecessary processing. For example, users interested in receiving notifications for California might consider entering “NC CI SC NN” corresponding to the Northern California, Southern California, and Nevada networks. The only exception is when there is no group defined in the database and the monitoring regions coincide with the seismic networks.

A table of all regions and their corresponding region codes are provided in Table 2.1.

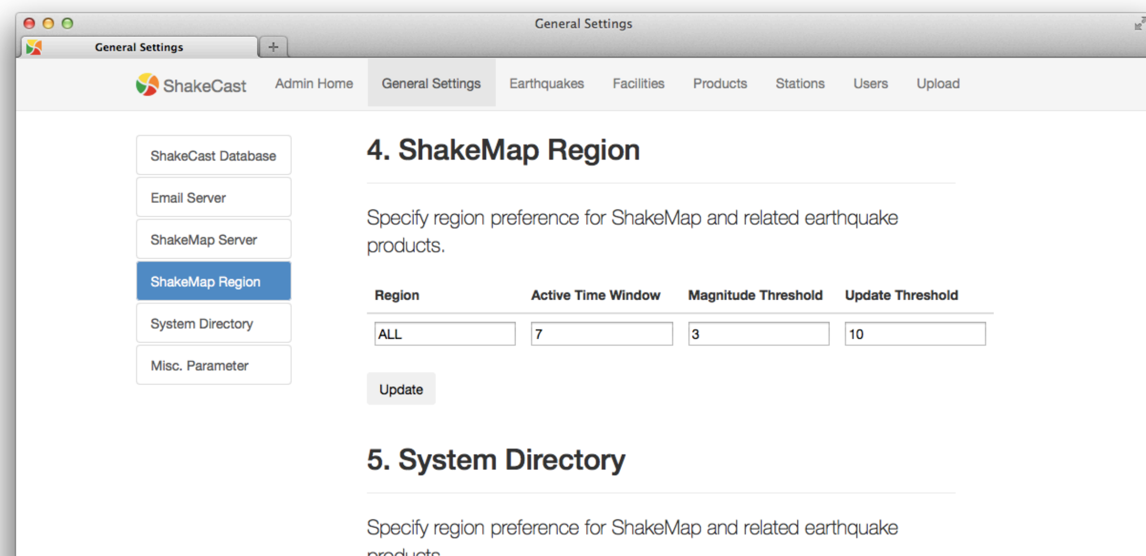


Figure 5.5. ShakeCast administrative web interface for ShakeMap Region configuration.

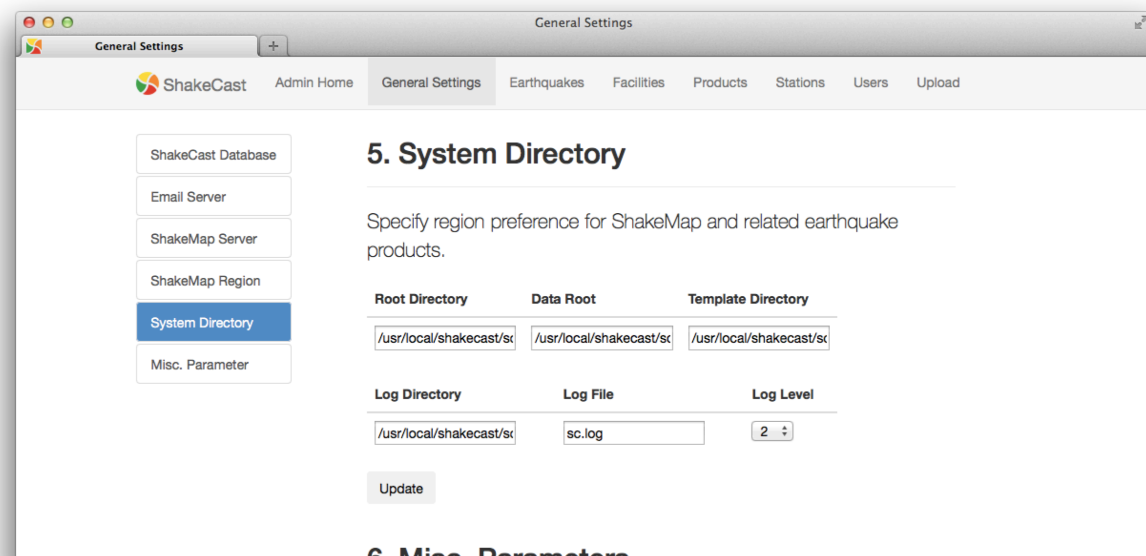
A summary of the form fields and a description of their content is provided in Table 5.4.

Table 5.4. ShakeMap region configuration information.

Field	Description	Example
Region	ANSS network region code (see Table 2.1). Multiple values are sparated with comma or white space.	NC,SC,UT,NV
Active Time Window	The number of days from origin to trigger ShakeCast process	7
Magnitude Threshold	The minimum magnitude to trigger ShakeCast process.	3.5
Update Threshold	The percent change in PGM to trigger ShakeCast process.	10

5.2.5 System Directory and Miscellaneous Parameters

The System Directory and Miscellaneous Parameters forms specify information of main directories of ShakeCast and its supporting application (Figure 5.6). Users usually do not need to change the default settings and will need verify access permissions (data directory needs to be readable from the Internet) when specifying a new location in the file system.



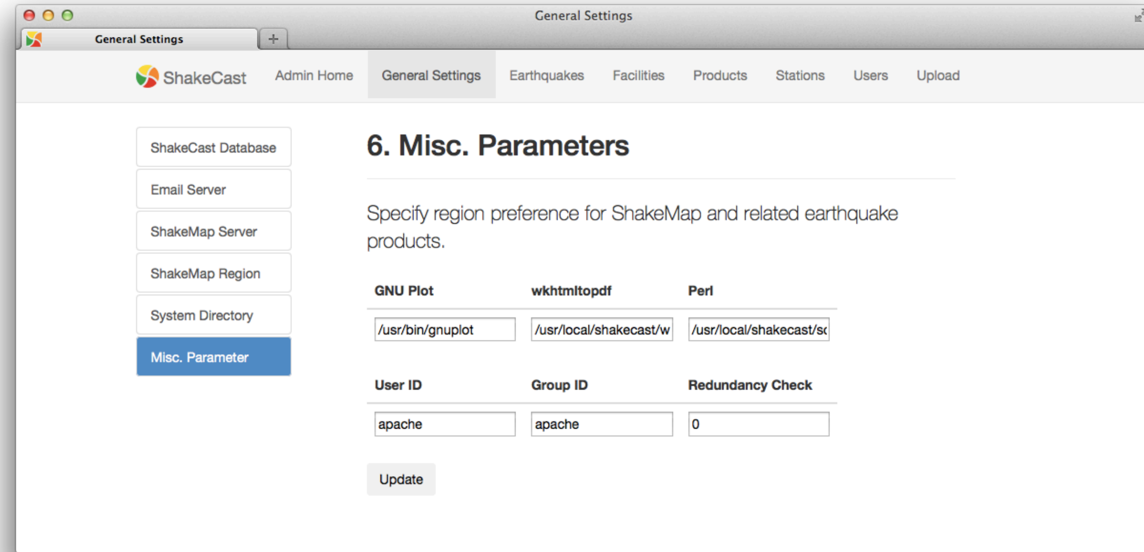


Figure 5.6. ShakeCast administrative web interface for System Directory (top) and Misc. Parameters configuration (bottom).

A summary of the form fields and a description of their content is provided in Table 5.5.

Table 5.5. Directory and Miscellenous Parameters.

Field	Description	Example
Root Directory	ShakeCast install directory	/usr/local/shakecast/sc
Data Root	ShakeCast data directory	/usr/local/shakecast/sc/data
Template Directory	ShakeCast template directory	/usr/local/shakecast/sc/template
Log Directory	ShakeCast log directory	/usr/local/shakecast/sc/logs
Log File	ShakeCast log file	sc.log
Log Level	ShakeCast log level	2
GNU plot	Path to gnuplot	/usr/bin/gnuplot
wkhtmltopdf	Path to wkhtmltopdf	/usr/bin/wkhtmltoimage
Perl	Path to perl	/usr/bin/perl
User ID	User ID for ShakeCast process (Linux only)	www
Group ID	Group ID for ShakeCast process (Linux only)	www
Redundancy Check	Best effort to detect event under different ID	0

5.3 Earthquake Database Management

The Earthquake Database Management section (Figure 5.7) allows a ShakeCast administrator to manage earthquake inventory in three different categories: (1)

processed ShakeMap events, (2) significant earthquakes list, and (3) ShakeMap scenarios. Processed ShakeMap events are those automatically downloaded and processed by the user's system based on the ShakeMap Region configuration; those that constitute "significant" as defined by the user can be more readily accessed. Scenarios are hypothetical event ShakeMaps produced and stored on the USGS web pages, for example, at

http://earthquake.usgs.gov/earthquakes/shakemap/list.php?x=1&s=1

ShakeCast users can choose to "inject" (import) any such scenarios for they own for ShakeCast testing or for earthquake planning exercises using ShakeMap/ShakeCast.

The web form inside the page is used to retrieve additional ShakeMap inventory from the USGS Web site. The ShakeCast local test event type "*_scte" is merged with the scenario type "*_se" in V3. The scenario is supported but users are encouraged to switch to using the standard scenario type.

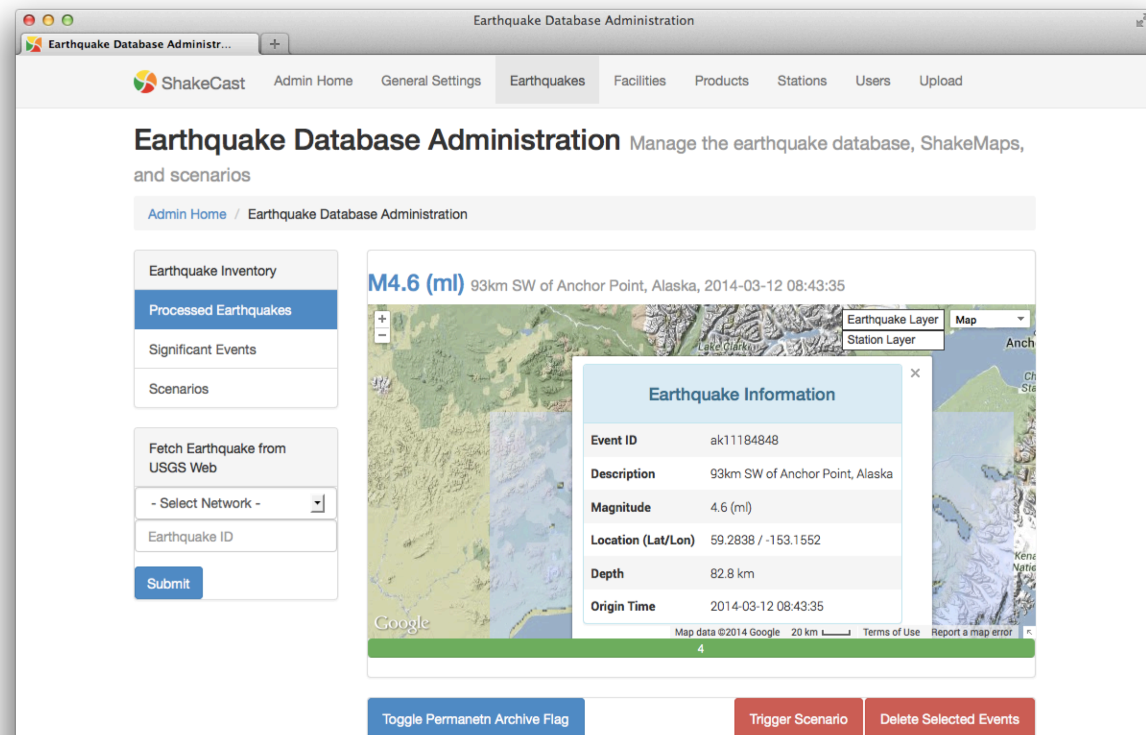


Figure 5.7. ShakeCast administrative web interface for earthquake database administration.

Besides ShakeMap scenarios, the list of earthquakes processed and stored inside the ShakeCast database is determined by both the geospatial and magnitude filter. The geospatial filter is based on either seismic network or user-defined polygon boundaries as a pre-processor for ShakeCast. The magnitude threshold filter is also a pre-processor filter for triggering ShakeCast process, default 3.0, and can be changed from the web interface. The archiving magnitude filter, default 5.0, is used by the earthquake maintenance cron job for archiving purpose and can only be changed inside the ShakeCast configuration file from the file system. For users within seismically active regions, these filters and archiving thresholds become key for balancing the immediate access to and the volume of ShakeMap products stored.

The ShakeCast V3 earthquake maintenance cron job runs daily and automatically maintains the earthquake inventory. Earthquakes without any facility exposure and with magnitudes below the archiving magnitude will be removed from the system once they fall outside twice the active response time window (defined by the user) from the earthquake origin time.

The three main operations on an earthquake and its associated products via the GUI (Figure 5.8) are to (1) toggle an archive flag, (2) trigger a scenario run, and (3) delete an event. The new archival flag is used to manually override of the default system behavior. An earthquake will be permanently archived if the archive flag is set. Also, all events retrieved and triggered via the web interface are treated as scenario events. To trigger a ShakeMap as an actual event, the administrator needs to perform the action from the command line to avoid accidental triggering. If the triggered ShakeMap falls outside the active response window, a "-force_run" option is required to execute the command. See Appendix C for details on triggering ShakeMaps ("shake_fetch.pl" and "scfeed_local.pl") from the command line.

- Processed Earthquakes. The **Processed Earthquakes** link displays a table showing all processed actual earthquakes within twice the active response window and all archived events. Available actions are shown as clickable buttons at the top of the table. To apply the action, select the earthquake rows (multiple selections are allowed using CTRL-click or SHIFT-click) then click on the corresponding action button.
- Significant Events. The **Significant Events** link displays a table showing all processed actual earthquakes with a set archive flag. Available actions are the same as processed earthquakes.
- Scenarios. The **Scenarios** link displays a table showing both scenarios and actual earthquakes converted for use as scenarios. Scenario earthquakes are not subject to the archiving rules.
- USGS ShakeMap Archive. The **USGS ShakeMap Web** form reads one network ID and one event ID. It triggers the "shake_fetch" program to retrieve and process the specified event as a scenario. If the event has already been processed by the system then the request will fail. The user should use the **Trigger Scenario** function instead. The collection of ShakeMaps for real events includes the thousands of ShakeMap Atlas historic events around the globe as described in Section 3.
- Custom ShakeMap scenarios. ShakeMaps that are not available from the USGS web site can be uploaded into ShakeCast via the upload utility page. These ShakeMaps are usually custom-made based on user request or for earthquake

exercise.   Most of the pre-compiled ShakeMap scenarios can be found on the ShakeCast Wiki site.

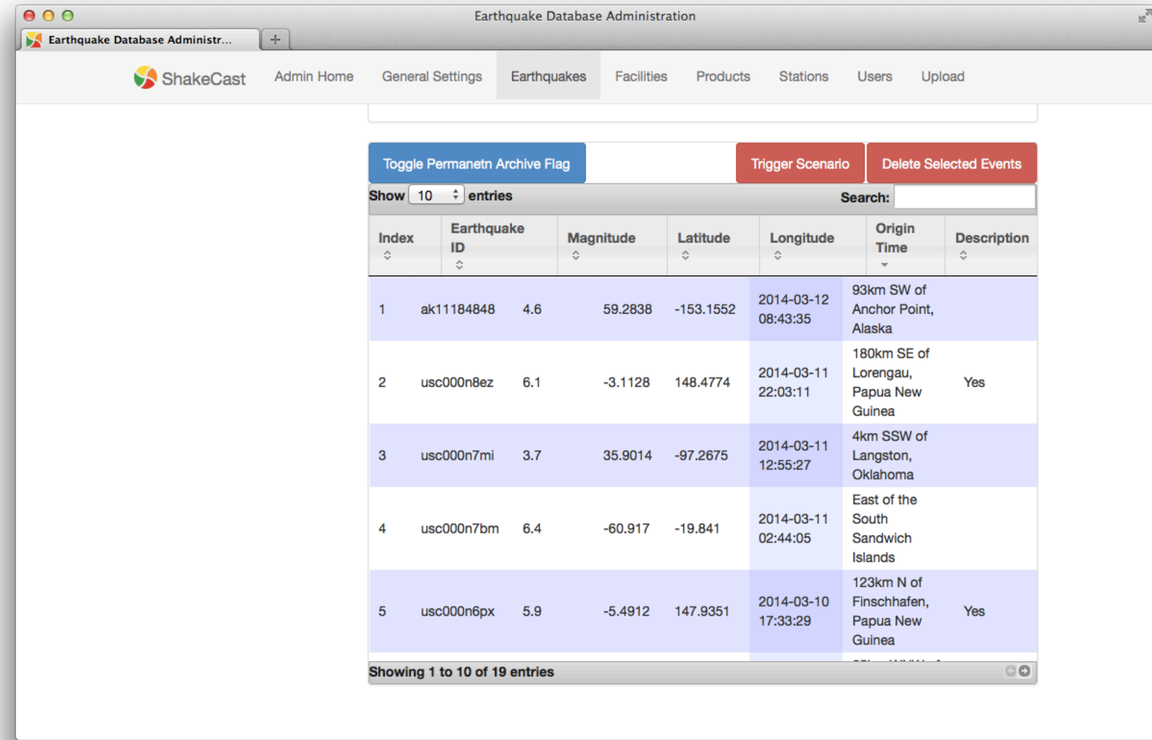


Figure 5.8. ShakeCast administrative web interface for earthquake database management.

5.4 Facility Database Management

The Facility Database Management section allows the administrator to inspect facility information and to perform simple maintenance tasks (Figure 5.9). ShakeCast V3 has greatly expanded facility-related information and processing capabilities and includes:

- Basic facility and fragility information.
- Probabilistic fragility curve information.
- Supplemental attributes and facility-specific assessment methods.
- Supplemental geometric features and detailed facility information.
- Prototype facility-station association.
- Prototype predictive ground motion estimates.

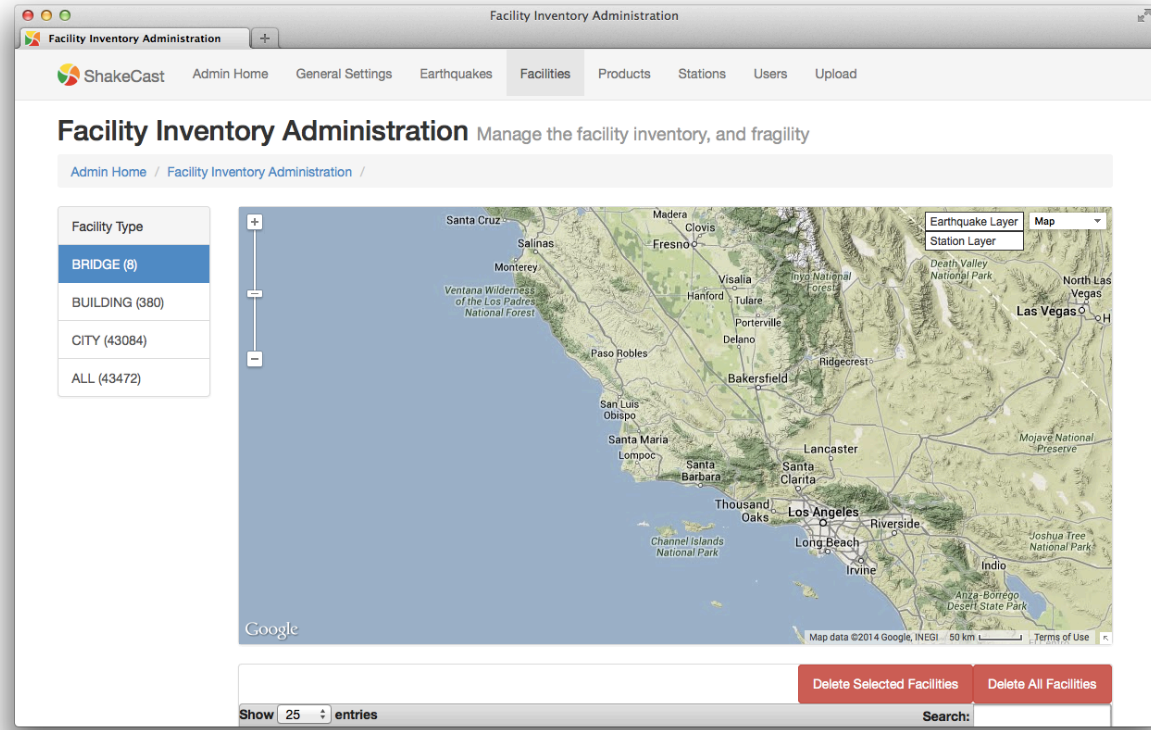


Figure 5.9. ShakeCast administrative web interface for facility inventory management.

The two main actions for an earthquake via the GUI (Figure 5.10) are to either (1) delete selected facilities or (2) purge facilities for the selected facility type. Due to the increasing complexity of facility-related information, direct editing of facility information stored inside the ShakeCast database is disabled via the web interface. ShakeCast operators will be required to maintain their facility inventory in external data systems and produce ShakeCast compatible XML or CSV formatted files as their facility inventory and data changes over time. The XML/CSV files are then used to periodically update the facility inventory in the ShakeCast system using an upload utility page. The general approach, then, for ShakeCast database management is that a ShakeCast operator will maintain facility data (as well as user, notification, and other ShakeCast input) offline locally to avoid editing the operational system's database, and update the operational system with pre-compiled, separately maintained data.

To view information for a single a facility, select the facility in the facility table (Figure 5.10) to display detailed facility information (Figure 5.11).

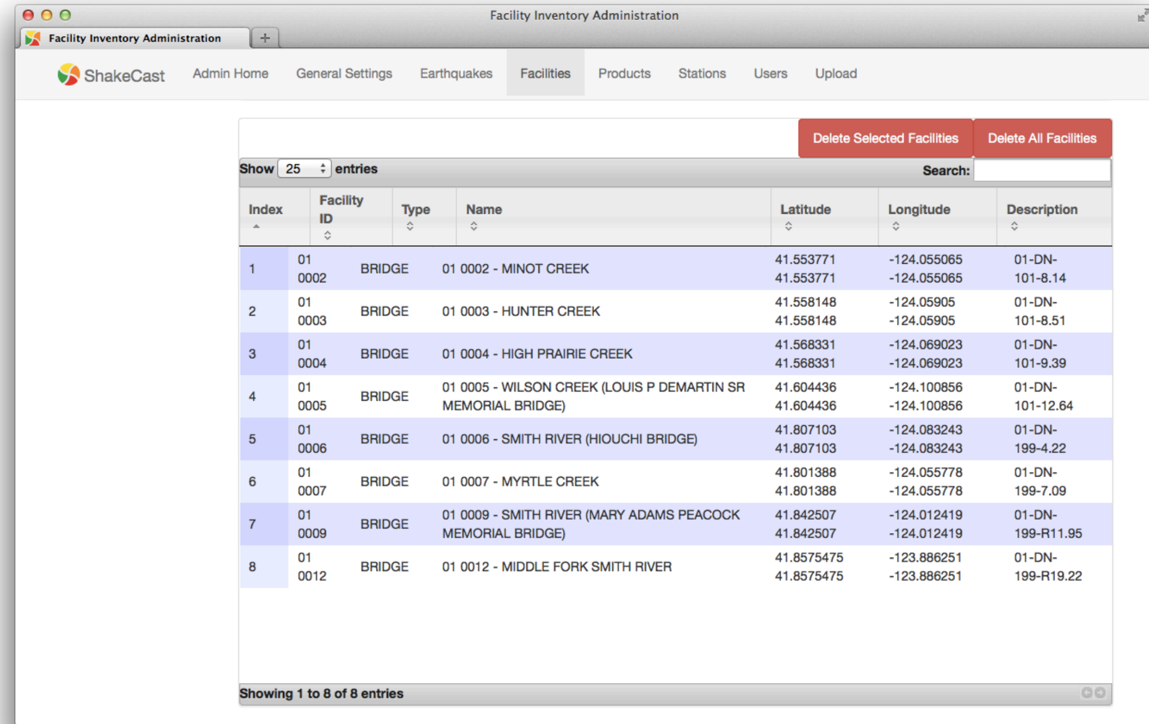
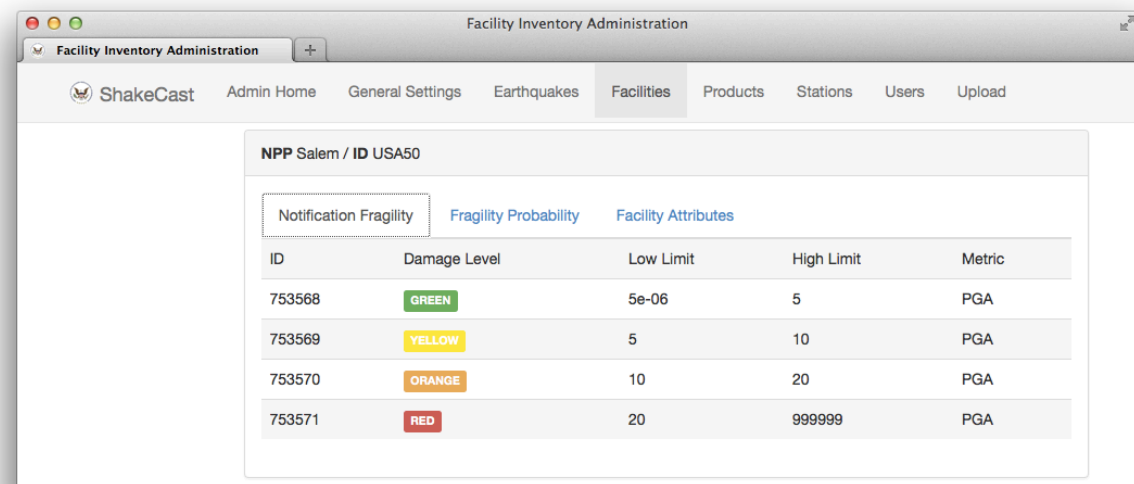
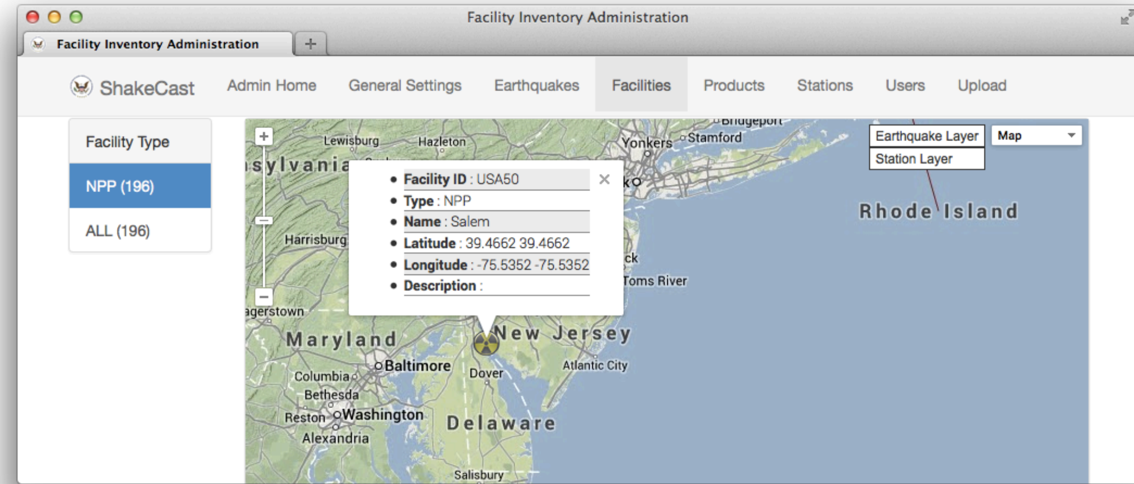


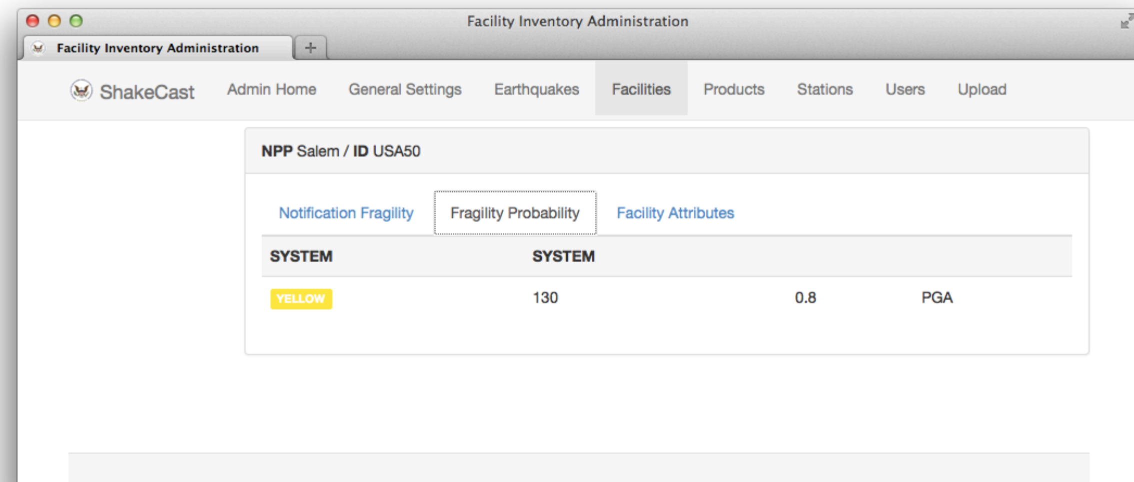
Figure 5.10. ShakeCast administrative web interface for facility inventory management.



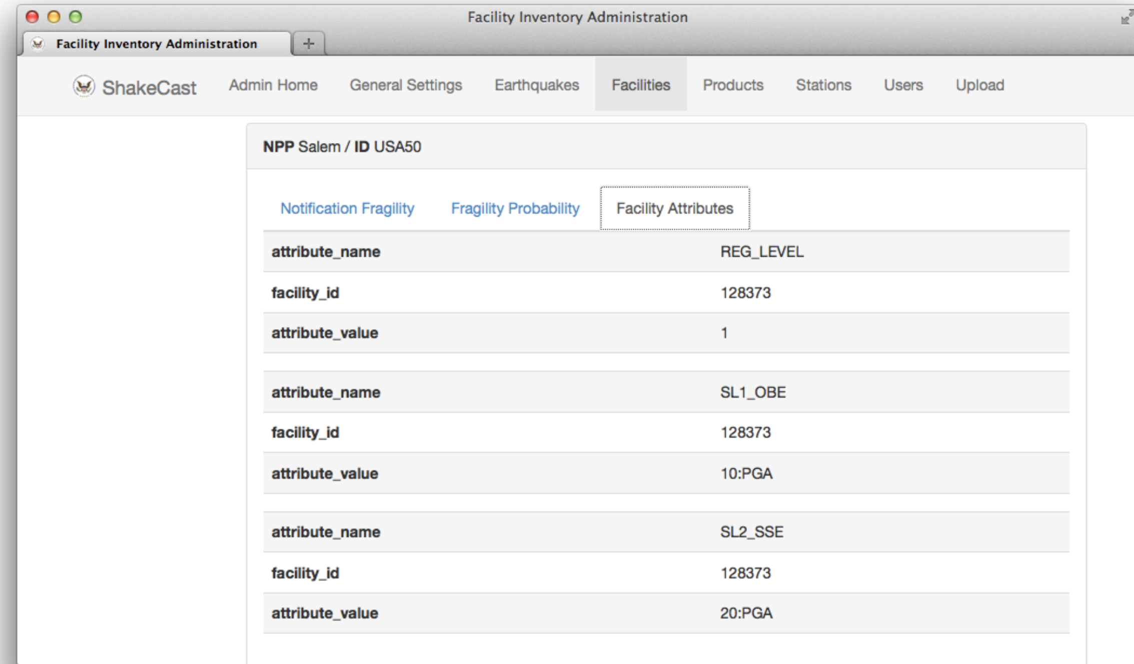
(a)


Facility Inventory Administration
ShakeCast
Admin Home
General Settings
Earthquakes
Facilities
Products
Stations
Users
Upload
Facility Type
NPP (196)
ALL (196)
Earthquake Layer
Station Layer
Map
Facility ID : USA50
Type : NPP
Name : Salem
Latitude : 39.4662 39.4662
Longitude : -75.5352 -75.5352
Description :

(b)


Facility Inventory Administration
ShakeCast
Admin Home
General Settings
Earthquakes
Facilities
Products
Stations
Users
Upload
NPP Salem / ID USA50
Notification Fragility
Fragility Probability
Facility Attributes
SYSTEM
SYSTEM
YELLOW
130
0.8
PGA

(c)



(d)

Figure 5.11. (a) Basic facility fragility for notification, (b) facility features, (c) fragility probability information and (d) facility attributes for a selected facility.

5.5 Earthquake Product Management

The Earthquake Product Management section allows the administrator to control and customize the products listed in the earthquake page that are presented to users, as shown in Figure 5.12.

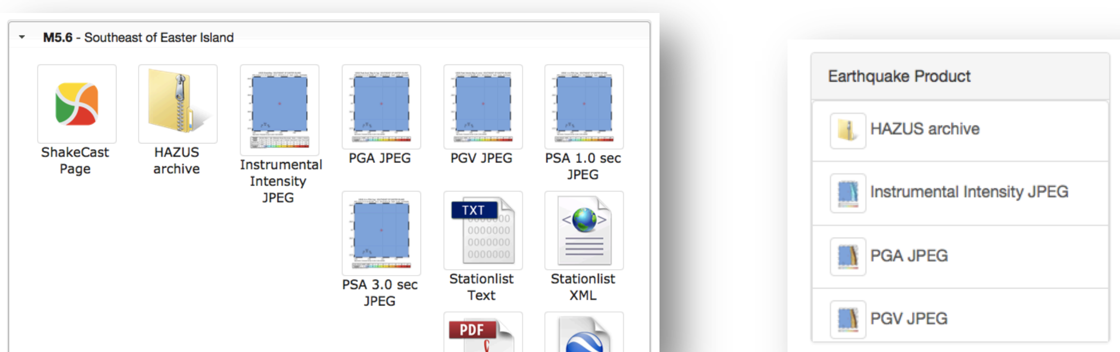


Figure 5.12. Earthquake product list in both the ShakeCast earthquake list and detailed page.

In ShakeCast V3 the scope of earthquake products covers not only the ShakeMap products required by ShakeCast, but also other ShakeMap products and products available from the USGS web site. Depending on the system setup, earthquake products are received via either the earthquake JSON data feed or via the PDL client. The system is pre-configured to recognize selected USGS earthquake product types including DYFI?, PAGER, ShakeMap, tectonic summary, and some local ShakeCast products. Products besides ShakeMap and ShakeCast are saved into the "eq_product" data directory. Products not registered in the ShakeCast database, such as additional DYFI? and PAGER products, geoserve, nearby_cities, and seismicity plots, are reserved for user customization in the future. Note that a product (either from USGS or locally generated) needs to be registered in ShakeCast before it can be included in the ShakeCast processing. These processes include both notification attachment and custom assessment procedure calls.

From the administrative interface shown in Figure 5.13, a product can be enabled to disabled for direct access by the end-user.

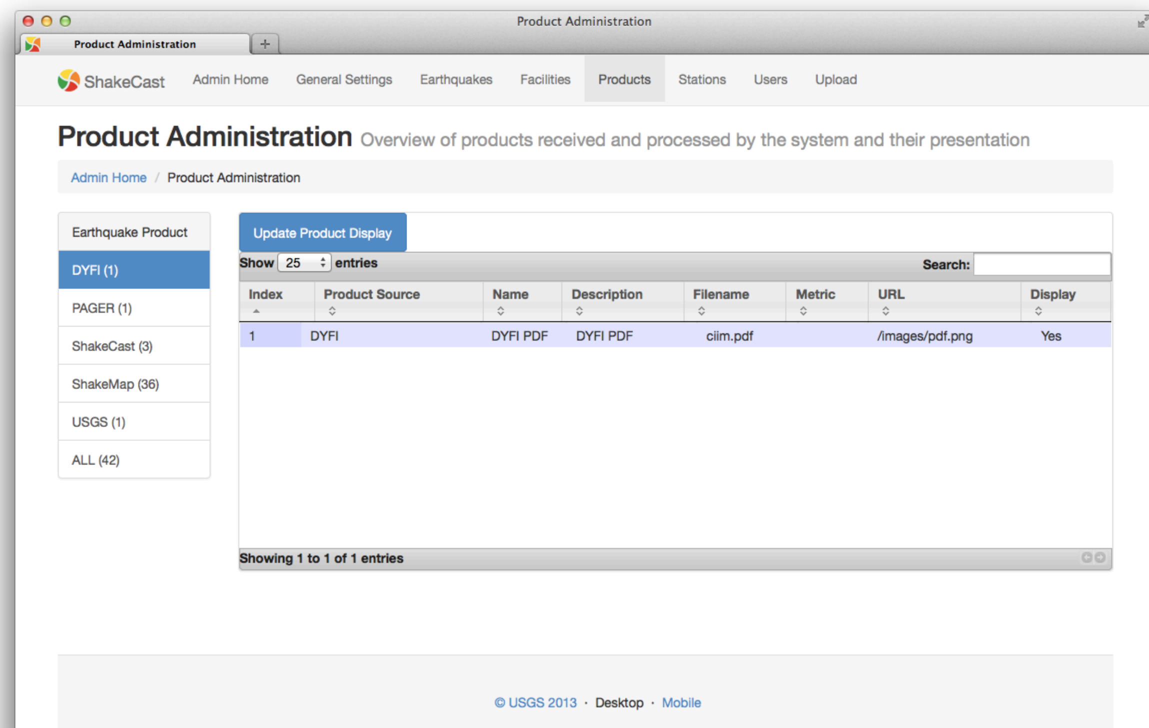


Figure 5.13. ShakeCast administrative web interface for earthquake product management.

5.6 Station Database Management

Internally, ShakeCast has been archiving strong motion data used by ShakeMap as input data since V2. As a result of the ShakeMap Atlas effort, ShakeCast V3 comes pre-configured with a station database containing information of ~10,000 stations globally. The system will continue to add new stations to its database as it processes new station data from ShakeMap.

ShakeCast V3 includes a prototype feature that permits users to create station-facility associations to preselect actual station recordings nearby a facility to estimate from ShakeMap. The source of ground shaking data is normally based on ShakeMap input station files, but can also be provided by the user via an import program. After an earthquake, the ground shaking estimates at the site of facilities will be based on observations at station-associated facilitys, or with ShakeMap estimates initially and then replaced with actual station recordings if they then become available via subsequent ShakeMap revisions or user import.

Users who are interested in adapting the function should be aware of potential issues pertaining to availability and quality control of strong motion data. The ShakeMap process combines predictive, actual, and converted ground motions to produce the best and stable estimates. Relying solely on a single source of data may result in unreasonable facility shaking assessment if the associated station is not properly maintained or if the recorded data is not processed correctly (e.g., clipped and non-seismic data). Also ShakeMap does not enforce the naming convention of input station data, thus it is possible that the ShakeCast station database contains duplicate entries of the same station. The baseline station information will be refreshed as part of the ShakeCast update to reflect the changes to station location and instrumentation.

From the administrative interface shown in Figure 5.14, users can inspect the station information, but the only permitted action is to remove the selected stations from the ShakeCast database.

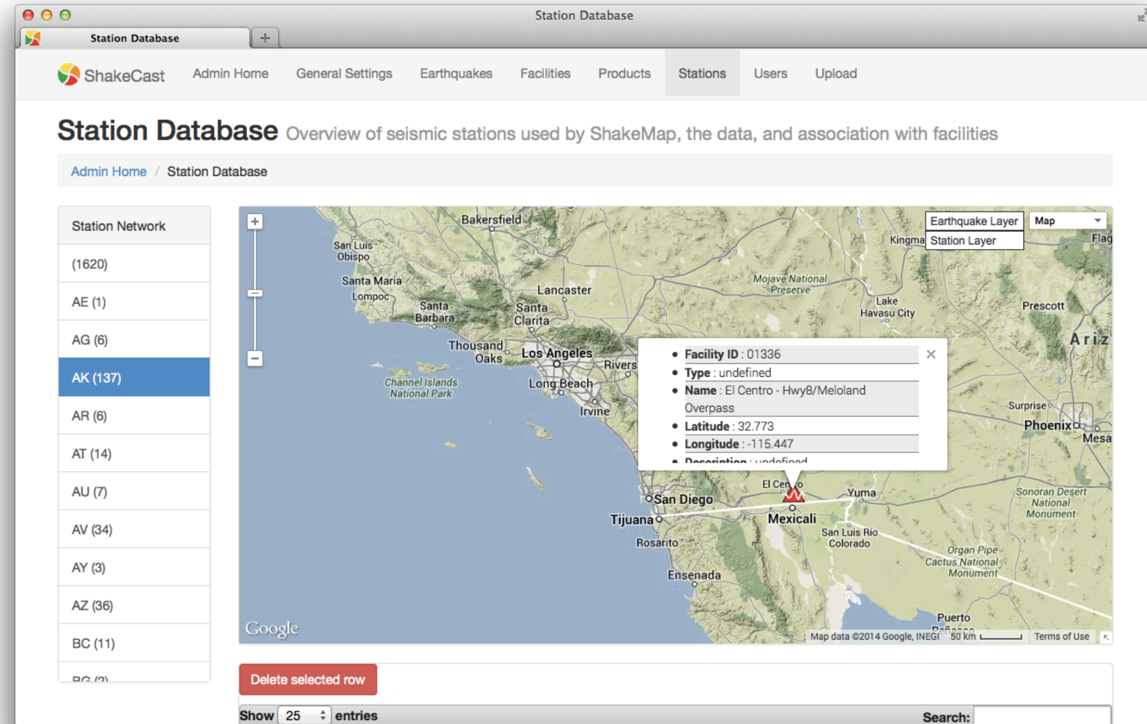


Figure 5.14. ShakeCast administrative web interface for station database management.

5.7 User Database Management

ShakeCast V3 defines three different user types: **ADMIN**, **USER**, and **GROUP**. The system comes pre-configured with a default administrator account "scadmin" and user should change its password or remove the account before bringing the server into production.

Figure 5.15 shows the administrative interface for user database management. The user group (**GROUP**) category is a new function introduced in ShakeCast V3 to replace the original User Profile function of the ShakeCast V2 system. The User Profile function in V2 operates, in principle, like a universal filter for notification requests prior to earthquakes. In ShakeCast V3, **GROUP** is a valid user type that comes with the User Profile functions. Detailed information for the scope of User Group is documented in Appendix A.

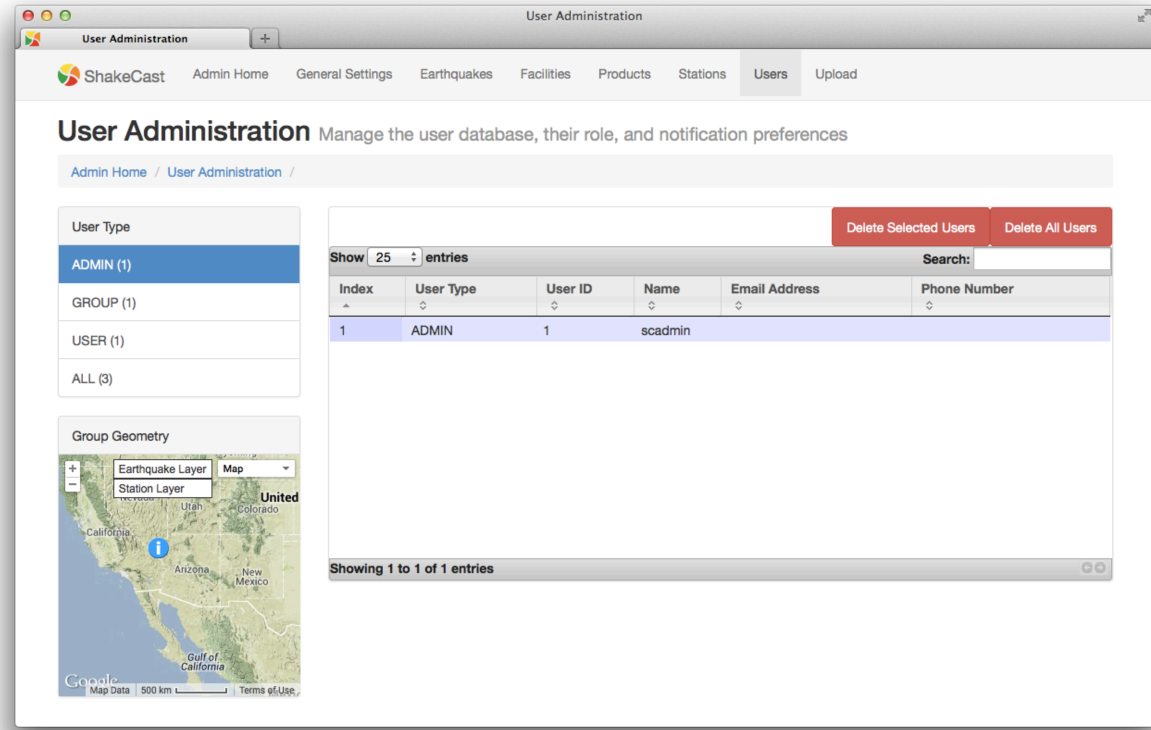


Figure 5.15. ShakeCast administrative web interface for user database management.

The most distinct feature of User Group is the dual purposes of the geometric polygon definition. Before an earthquake occurs, the user-defined polygon is used to compile a list of facilities within the footprint of the polygon for notification requests. After an earthquake occurs, the same custom polygon is used as a filter to determine whether or not it should be processed by the ShakeCast system.

As a result, a user group geometry polygon is equivalent to an earthquake response region defined by the administrator. Thus the user is no longer bound to existing earthquake or ShakeMap regions defined by the seismic networks. When multiple polygons are defined, the union of the polygon footprints is the effective response region. As the default, the ShakeCast V3 system currently has one user group defined in the database with global coverage for the 40,000+ city inventory.

ShakeCast V3 only permits the **GROUP** user type to register notification requests in the ShakeCast database (Figure 5.16), both the **ADMIN** and **USER** type users need to be associated with at least one group in order to receive ShakeCast notifications (Figure 5.17). A user can be affiliated with multiple groups to receive multiple group-specific notifications. Note that notifications from multiple groups will not be aggregated into a single message for the user. Thus users may receive duplicate notifications if the same request is configured in separate group-specific notification requests.

Appendix A contains detailed information regarding specifications of user data, notification requests, and monitoring regions. There are two corresponding programs described in Appendix C that handle **GROUP** ("mange_group.pl") and **ADMIN**/**USER** ("manage_user.pl") data.

As a general rule, user and profile data files from the V2 system can be imported directly into the V3 system, even though the data are interpreted differently. The V3 system does allow more keywords in the group definition file to refine notification requests and to provide new features, such as group-specific triggering threshold, processing regions, and file attachment to notifications.

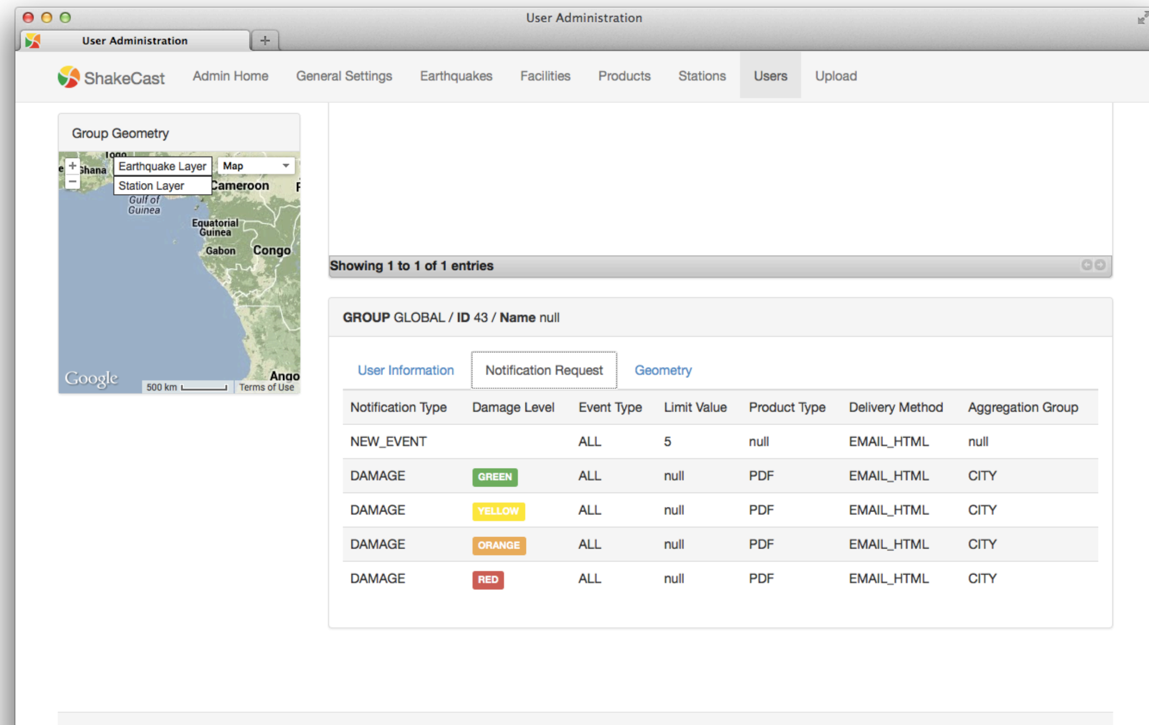


Figure 5.16. Notification requests for the GLOBAL group defined in the ShakeCast user database.

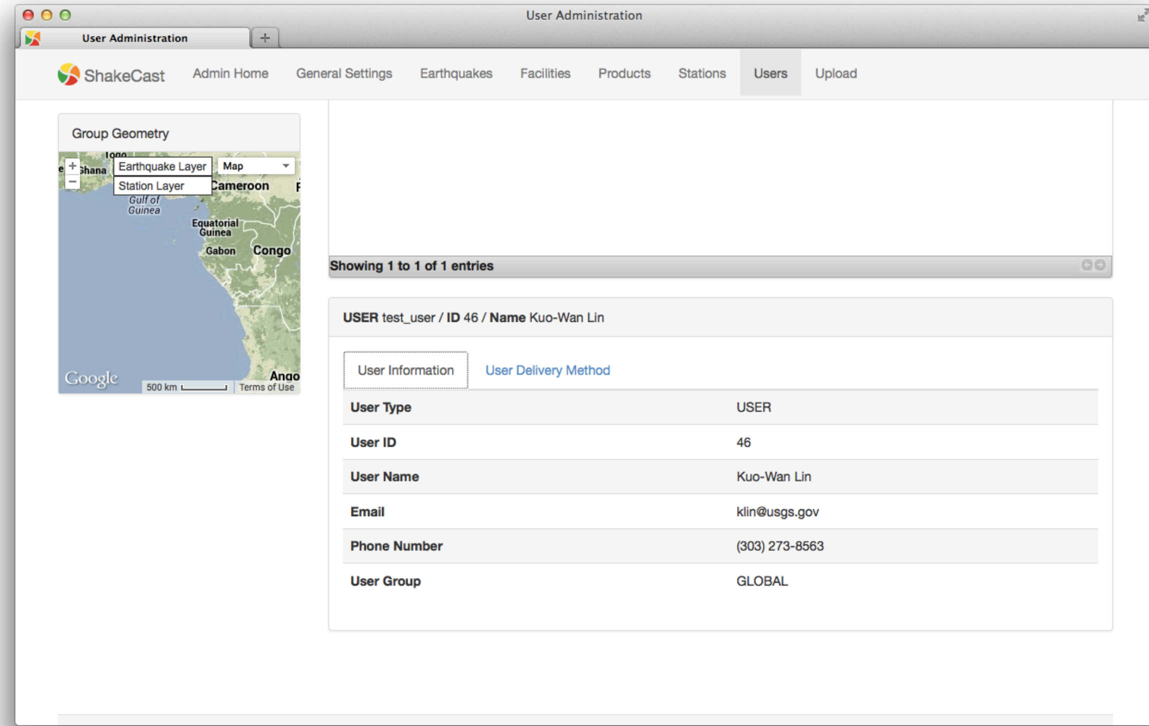


Figure 5.17. An example of user information and group association defined in the ShakeCast user database.

5.8 Inventory Upload Utility

ShakeCast V3 introduces a new centralized inventory upload utility page for transferring user inventory files to the ShakeCast file system (Figure 5.18). The upload page implements a drag-and-drop technique to provide a unified interface for all inventory types. The system is pre-configured to allow up to five files to be uploaded simultaneously with a maximum file size of ~500MB.

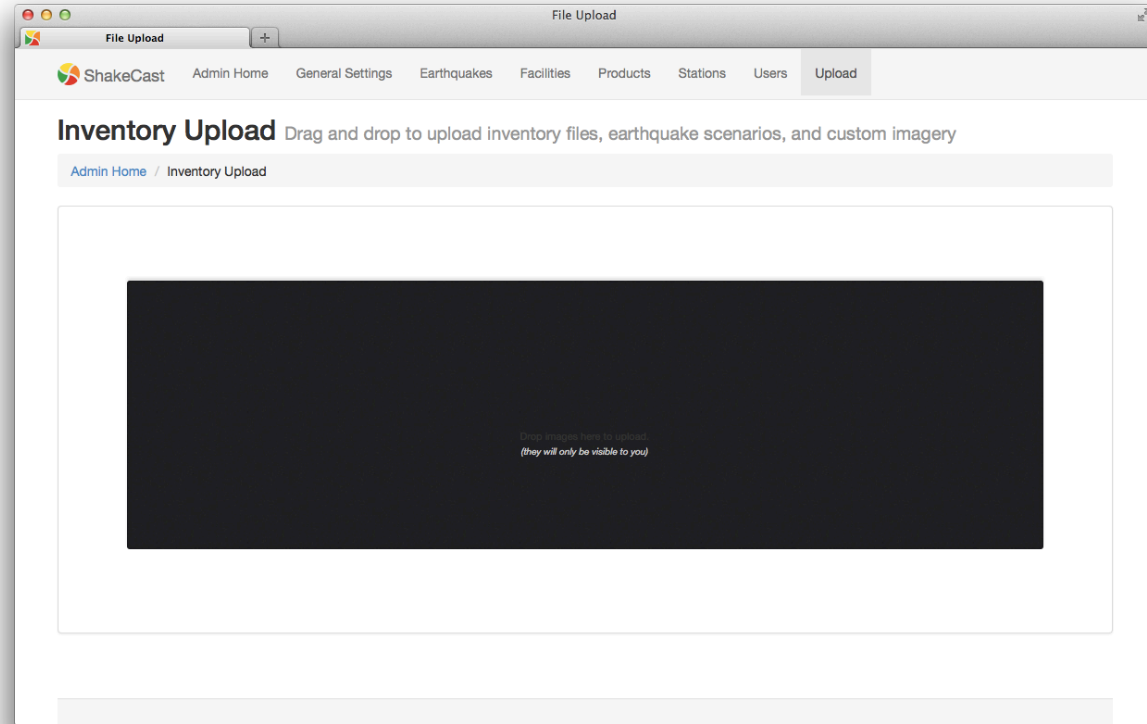


Figure 5.18. ShakeCast administrative interface for drag-and-drop inventory upload.

As shown in Figure 5.19 the inventory upload page will display both status and result of individual upload attempts. All uploaded files are collected in the “tmp” directory under the ShakeCast system directory. After a successful upload, the file will be examined and the software will prompt the user with applicable choices given the nature of the file uploaded, if applicable.

The recognized file types include:

- Compressed (zip) archive. Only the zip file type is accepted. The uploaded zip file will be uncompressed to inspect the content. Both ShakeMap scenario and ShakeCast test event will trigger an event processing action.
- Configuration (conf) file. The content of an uploaded configuration file will be examined to determine if it is a valid group configuration file. A user group processing action will be triggered if the file passes the validity checks.
- CSV file. The content of an uploaded CSV file will be examined to determine if it is a valid facility or user file. A user processing action will be triggered if the file is a valid user file. A CSV facility processing action will be triggered if the file is a valid facility file.
- Image file. gif, jpg, and png are acceptable file types. No actions will be applied. Uploaded image files will be saved as read only files into the ShakeCast image directory. This is used to upload user-specific images to overwrite the system logo and facility icons.

- XML file. The content of an uploaded XML file will be examined to determine if it is a valid facility XML. An XML facility processing action will be triggered if the file passes the test.
- All other files. No actions will be taken if the content of an uploaded file cannot be verified. Examples of uploaded files in this category include ShakeCast patch update and notification templates.

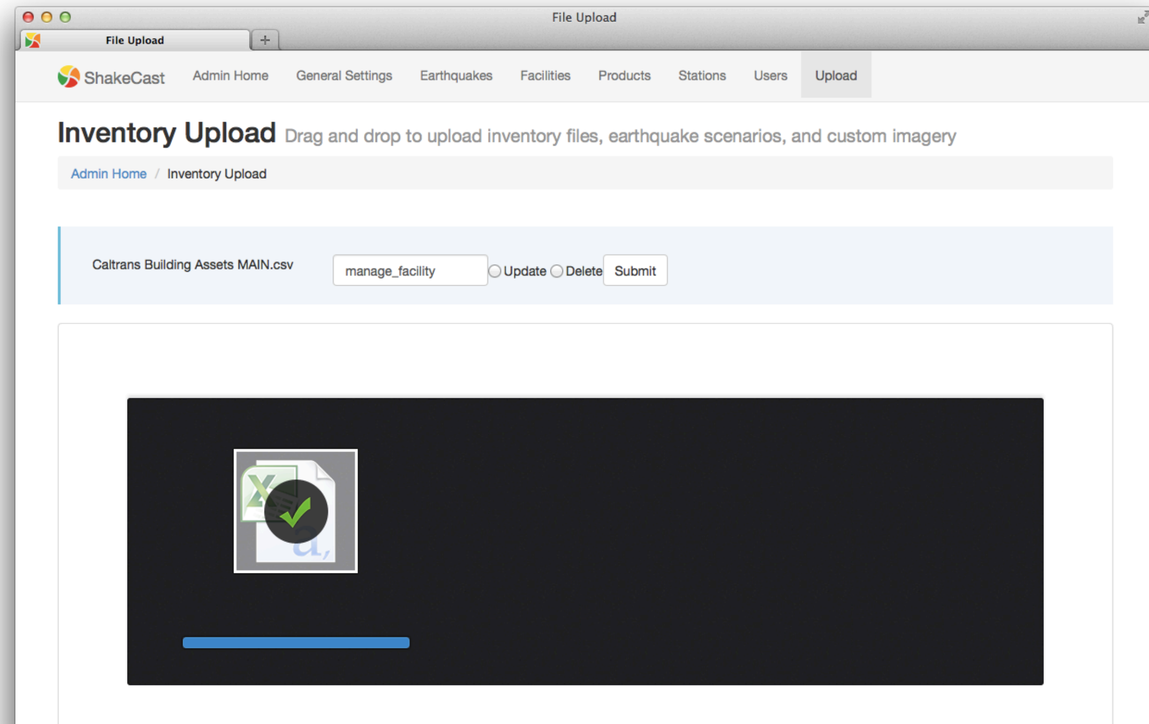


Figure 5.19. ShakeCast administrative interface for inventory upload showing the result of upload and the recommended user options to further process the uploaded file.

If a subsequent process is applicable to the uploaded file, a dialog form will be displayed above the drag-and-drop section. The allowed actions, insert, update, and delete, will complement the inventory management described in previous sections. Results of a submitted action will be prompted as shown in Figure 5.20. It is advised that the ShakeCast administrator should take advantage of the upload utility to perform common inventory maintenance tasks.

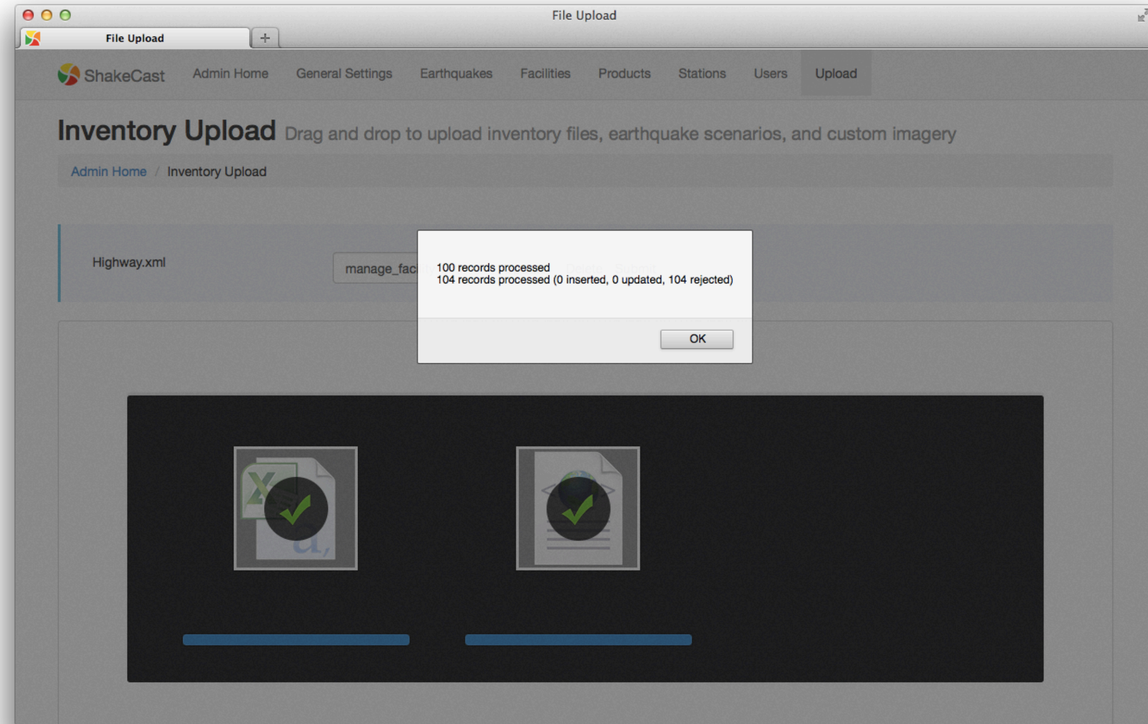


Figure 5.20. ShakeCast administrative interface for inventory upload showing output messages from the processing program for the uploaded file.

6 SHAKECAST SYSTEM FOR END-USERS

ShakeCast delivers post-earthquake and inspection prioritization information to users in several different formats. The system is pre-configured to provide users with notifications, products, and an information portal, which include:

- Email notifications
- ShakeCast Summary Reports
- User's ShakeCast Website
- GoogleEarth KML files
- Excel spreadsheets

Depending on the needs of individual users, the system can be configured to produce custom notifications and products.

6.1 Email Notifications

Email notifications are the primary method for delivery of ShakeCast analysis results following an earthquake. For most users, email notifications provide a sufficient amount of detail about the earthquake and estimated shaking alert levels at facilities and may be the main or only ShakeCast product that they require. Email messages are generated by the ShakeCast server and are only sent to ShakeCast subscribers defined by the local ShakeCast system Administrator.

ShakeCast will typically generate email notifications within one or two minutes of receipt of ShakeMap data from the USGS. Depending on the location of earthquake, ShakeMap is usually available on the USGS web site within 5-10 minutes of the event occurrence in the U.S. and within 15-20 minutes for the rest of the world. Figure 6.1 summarizes the typical timing of ShakeCast operations following an event. There have been a number of events over the course of the project where longer ShakeMap generation times were observed. This has resulted in longer delay for users to receive ShakeCast email notifications. To date, sources of delays have been 1) delayed triggering or generation of a ShakeMap for an event, and 2) post earthquake USGS web traffic, or server or Internet slowdown. These known sources of delays are being constantly revisited, but they cannot be eliminated entirely, and new issues may arise.

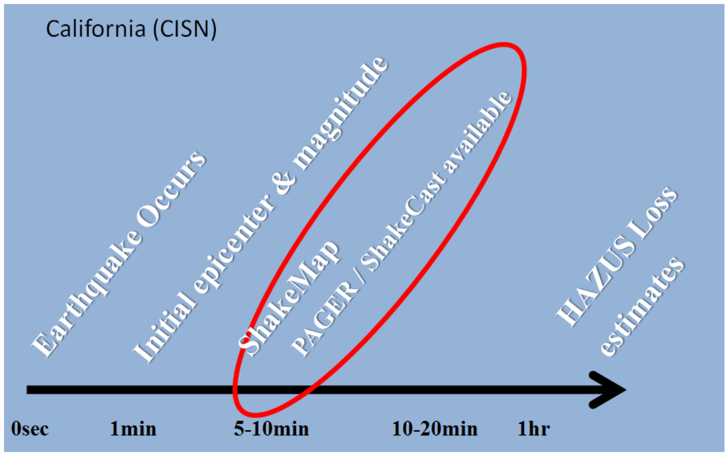


Figure 6.1. Timeline of products for earthquakes in California.

The ShakeCast system is pre-configured to send long and short message email formats targeting different user groups. The default inventory file and group configuration of the ShakeCast system produces a notification for a summary of impacted cities with a PDF summary report, a long message, for ShakeCast users. However, it is expected that each user customize their own messages with user-specific content using the PDF generation templates provided (details below).

6.1.1 Facility Shaken Messages

By default, the system is triggered when an earthquake with a magnitude of 3.0 or greater is reported by the USGS. Facility-shaken email messages are sent if the earthquake generates shaking at any facility location within the shaking zone above preselected shaking values. This email includes the list of facilities (by default, global cities), the shaking level at those facilities, and their assessed alert level or inspection priority.

Facility shaken messages contain the following key features:

- A summary of the event with date, time, magnitude, epicenter, and location.
- Key shaking metrics for the ShakeMap.
- The complete list of facilities analyzed and their alert level.
- An attachment of ShakeCast Report in PDF showing detailed information.

These features are shown in an example email in Figure 6.2.

ShakeCast Event: Magnitude 5.1

ShakeMap (Unnamed Event) Version 2
Event Location: 2km E of La Habra, California
Event Time: 2014-03-29 04:09:41
Generated at 2014-03-29 04:16:05
Reported by: Server ID = 1000, DNS = i386_NEIC2

Damage Summary

Number of Facilities Reported: 3
Max Value: MMI: 4.56; Acceleration: (not measured)
Number of Reports of Likely Damage: |NULL|
Number of Reports of Possible Damage: |NULL|

Facility Damage Estimates from ShakeMap

Facility	Damage Level	Metric	Value	Exceedance Ratio
Ontario, CA (pop. 158K)	Unlikely	MMI	4.56	0.890
Santa Ana, CA (pop. 337K)	Unlikely	MMI	4.46	0.865
Corona, CA (pop. 124K)	Unlikely	MMI	4.08	0.770

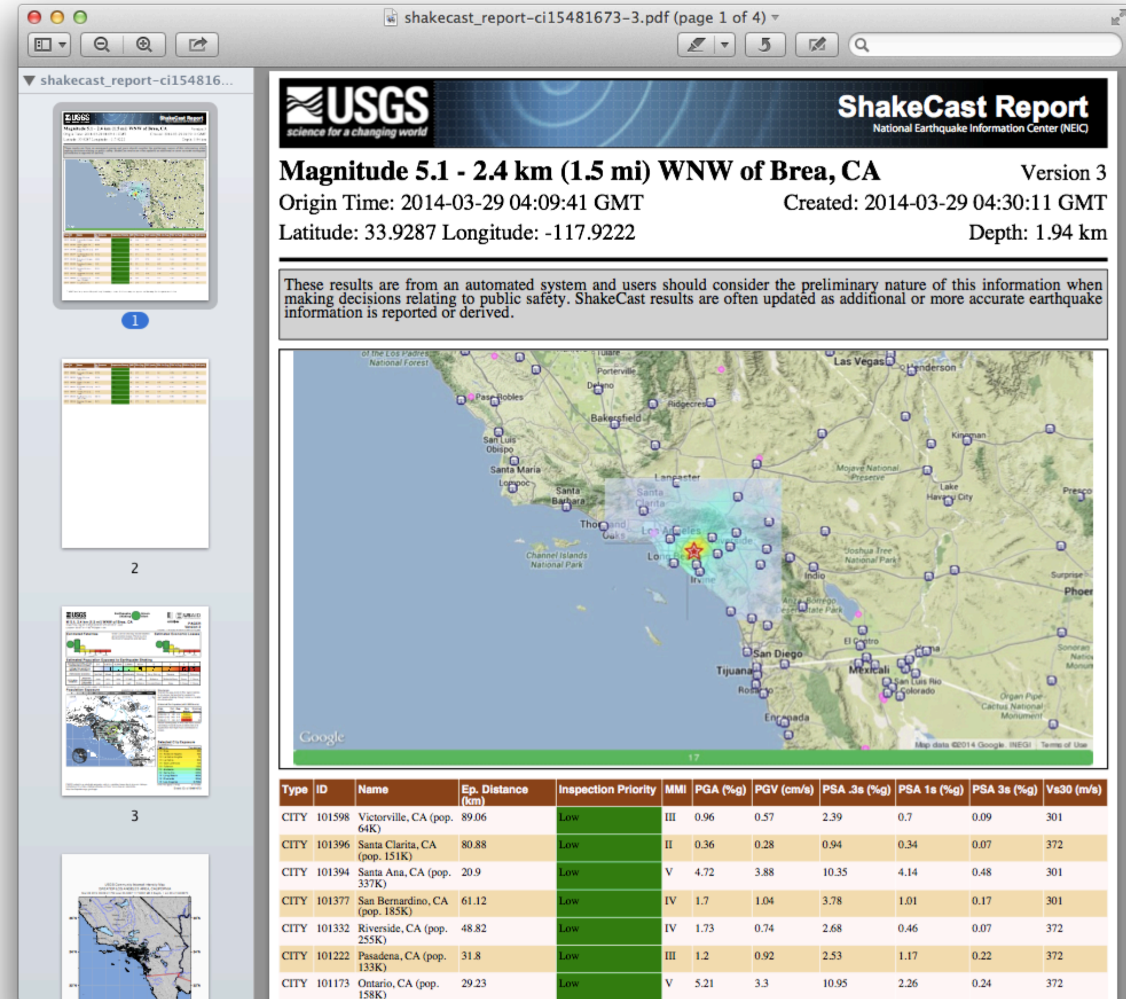
[END]

Figure 6.2. Default ShakeCast Email notification message and contents.

6.1.2 ShakeCast PDF Summary Report

The system generates a default summary report as part of the email sent to users. The default PDF report (Figure 6.3) consists of one ShakeCast summary page, one optional onePAGER summary page, and one optional DYFI map page depending on their availability.

6.1.2.1 ShakeCast Summary Page



Type	ID	Name	Ep. Distance (km)	Inspection Priority	MMI	PGA (%g)	PGV (cm/s)	PSA .3s (%g)	PSA 1s (%g)	PSA 3s (%g)	Vs30 (m/s)
CITY	101598	Victorville, CA (pop. 64K)	89.06	Low	III	0.96	0.57	2.39	0.7	0.09	301
CITY	101396	Santa Clarita, CA (pop. 151K)	80.88	Low	II	0.36	0.28	0.94	0.34	0.07	372
CITY	101394	Santa Ana, CA (pop. 337K)	20.9	Low	V	4.72	3.88	10.35	4.14	0.48	301
CITY	101377	San Bernardino, CA (pop. 185K)	61.12	Low	IV	1.7	1.04	3.78	1.01	0.17	301
CITY	101332	Riverside, CA (pop. 255K)	48.82	Low	IV	1.73	0.74	2.68	0.46	0.07	372
CITY	101222	Pasadena, CA (pop. 133K)	31.8	Low	III	1.2	0.92	2.53	1.17	0.22	372
CITY	101173	Ontario, CA (pop. 158K)	29.23	Low	V	5.21	3.3	10.95	2.26	0.24	372

Figure 6.3. ShakeCast summary page from the PDF report.

The ShakeCast summary PDF page provides:

- A summary of basic earthquake parameters, including origin time, magnitude, hypocenter, and the name of the region where the earthquake took place.
- A map with an intensity overlay showing the regional extent of shaking, and the facilities and recent seismicity within the shaking region.
- A bar at the bottom of the map showing color-coded impact/inspection priority levels and the number of facilities in each level.
- A table showing details parameters for each assessed facility. The template-driven table fields include the name, epicentral distance, location, Impact Level, ShakeMap intensity measures, and estimated Vs30.

6.1.2.2 onePAGER Summary Page

The onePAGER summary page (shown in Figure 6.4) is inserted into the ShakeCast report if the earthquake product is available at the time that the ShakeCast report is generated. The standard operating procedure for the USGS PAGER process requires manual review when the alert level (casualty or economic loss) is in either “orange” or “red”. This means that after a very damaging earthquake, initial versions of the ShakeCast report may not include the onePAGER summary page due to the restriction or due to latency in the PAGER process and product generation and delivery.

Details describing the content of the onePAGER summary page can be found on the USGS PAGER web site, http://earthquake.usgs.gov/research/pager/onepager.php.

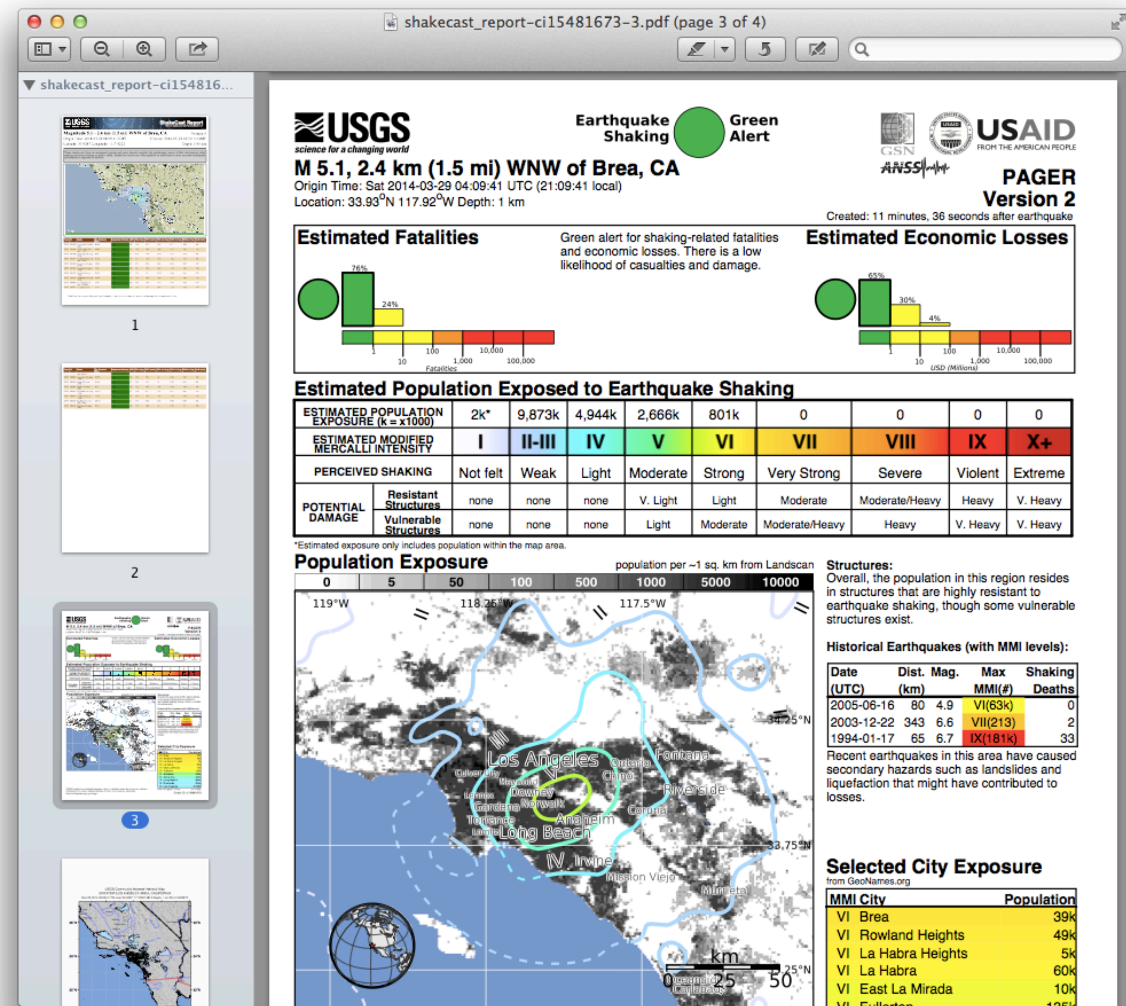


Figure 6.4. Example onePAGER summary page included in the ShakeCast PDF report.

6.1.2.3 DYFI Map Page

The DYFI map (as shown in Figure 6.5) will be inserted into the ShakeCast report if that earthquake product is available when the ShakeCast report is generated. The DYFI map portraits the same intensity data that were used as input macroseismic data for ShakeMap in the ShakeCast report. The quality of the DYFI map varies depending on the earthquake location and the number of intensity observations per location. The ShakeCast system typically receives multiple DYFI product updates between each ShakeMap update. Thus, it is likely that the DYFI map included in the ShakeCast report is different from the one shown on the ShakeCast or USGS web page.

Details of the DYFI map page can be found on the USGS DYFI web site, http://earthquake.usgs.gov/dyfi/.

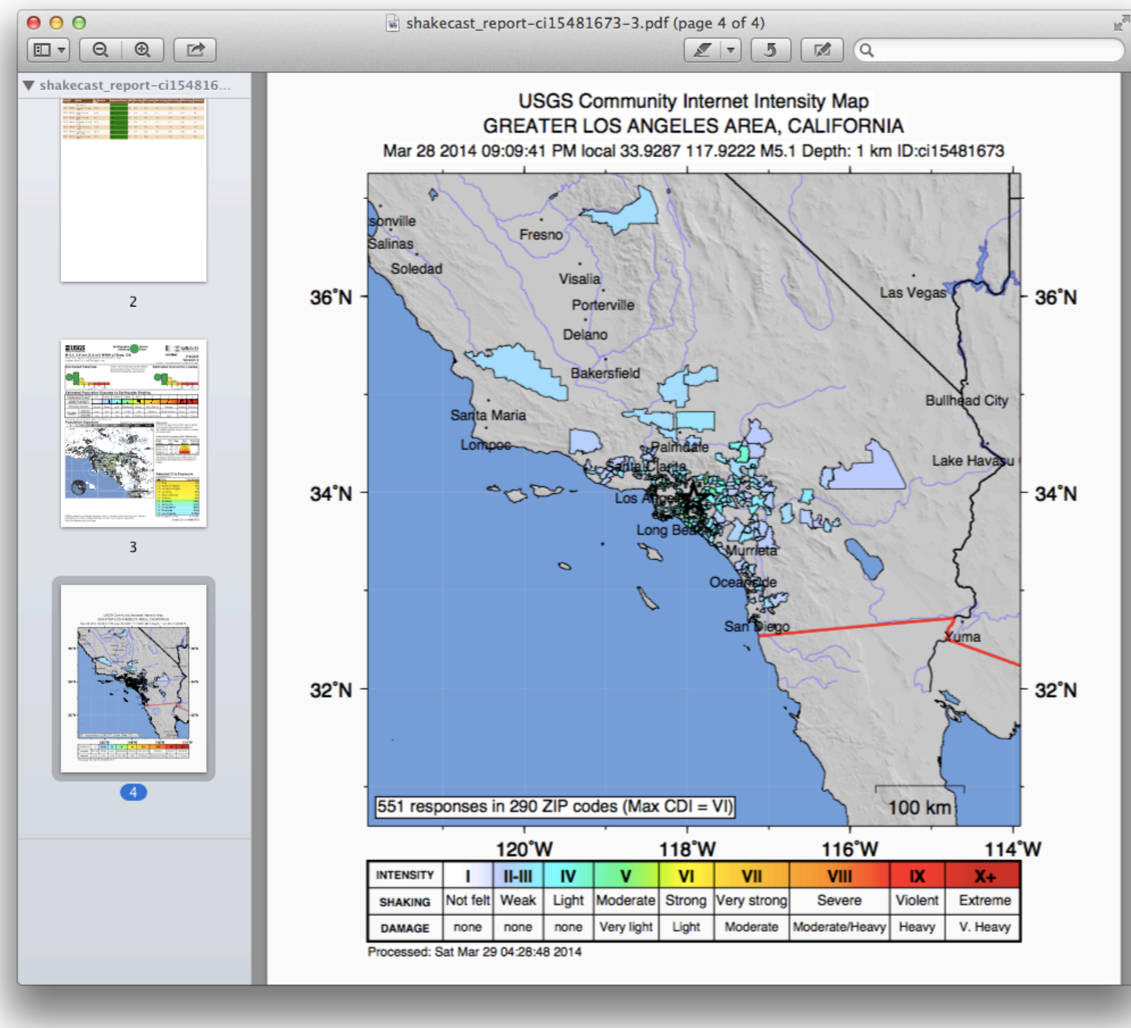


Figure 6.5. Example DYFI map page included in the ShakeCast PDF report.

6.2 Navigating the ShakeCast Website

The ShakeCast website is hosted on the same ShakeCast server that performs the analysis. The types of information on the website are similar to the information communicated in email notifications, but the content is provided in an enriched and interactive, responsive web-based environment.

6.2.1 Default Home Page

After a successful login, the ShakeCast home page (shown in Figure 6.6) displays:

- An interactive map, centered on the event with the ShakeMap overlay.
- A summary of key earthquake parameters.
- A summary of the number of facilities evaluated and their breakdown by alert level.
- Links to earthquake-specific USGS event page and additional resources for the ShakeMap and ShakeCast projects.

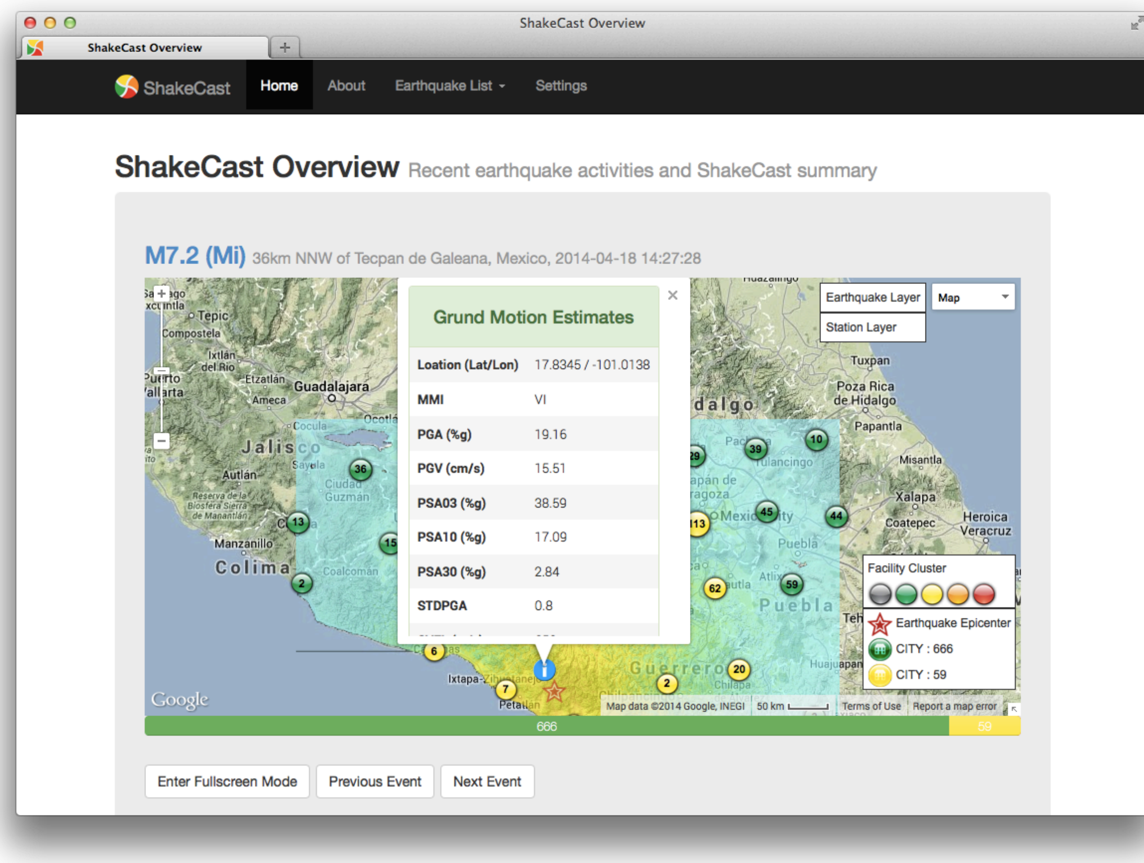


Figure 6.6. Example ShakeCast home page.

The interactive map supports standard Google Maps controls. In addition to the ShakeMap intensity overlay, three custom image layers are available including recent earthquakes, facility inventory, and seismic stations. The same interactive map is available throughout the web site with some customizations for the target pages. The default home page will automatically refresh the list of earthquakes.

The analysis results with the global city inventory (the ShakeCast default facility inventory are presented in a bar chart on the bottom of the map shown in Figure 6.6. The detailed breakdown by alert level is shown by green, yellow, orange, and red bars. Clicking with the left mouse button within the ShakeMap overlay will provide a pop-up window indicating the estimated ground shaking levels at the location of mouse click, as shown in Figure 6.6

To enter the display mode, click the “Enter Fullscreen Mode” button. This mode works in conjunction with the user-define settings to animate recent earthquakes and to display supplemental back seismicity, facility, and station information. Fullscreen mode is also useful for large displays in operations centers.

6.2.2 Earthquake Pages

6.2.2.1 Earthquake List

The “earthquake list” left-navigation panel shown in Figure 6.7 links to several earthquake catalogs based on their recency, significance, and purpose. The ShakeCast system automatically performs daily maintenance of the earthquake database. Earthquakes without any facility exposure will be removed from the system once they drop out of the active response window. Since the administrator may also manage the earthquake database, users need to be aware of the dynamic nature of the list.

- Daily, Weekly, Monthly, Yearly, and All. Display list of earthquakes for the specified time frame.
- Significant Events. Display list of significant earthquake processed by the ShakeCast system. Significant earthquakes are events above the archive magnitude and with facility exposure.
- Scenarios. Display list of earthquake scenarios downloaded from the USGS ShakeMap web site or converted from processed actual events.
- Test/Exercise Events. Display list of both actual and scenario earthquakes converted for the purpose of local testing or exercises.

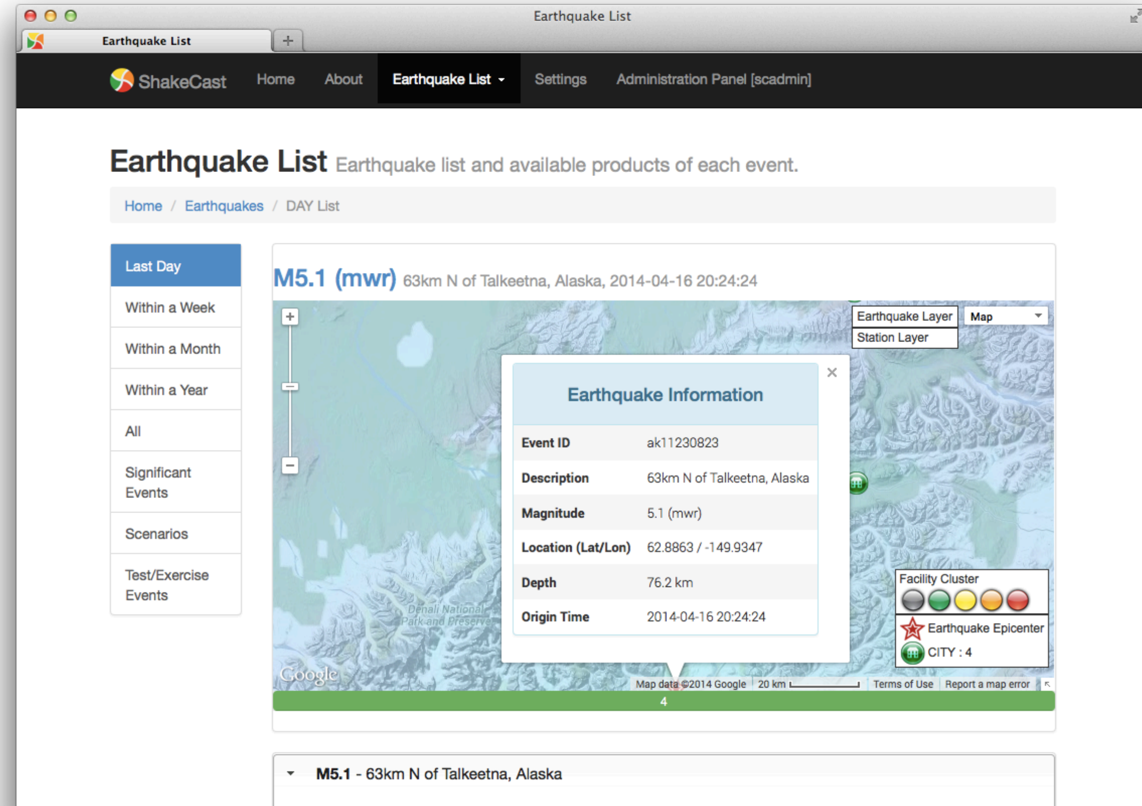


Figure 6.7. ShakeCast Earthquake List page.

6.2.2.2 Earthquake List Table

Each selected earthquake catalog will be presented in both an interactive map and an interactive tabbed list, as shown in Figure 6.8. Click on the earthquake tab to unveil selected products available on the system for direct access.

Currently the system is pre-configured to display the following products (the list can be modified by the administrator):

- ShakeCast Page. Link to ShakeCast detailed earthquake page.
- ShakeMap Map Image. Link to ShakeMap ground shaking maps of different metrics, including MMI, PGA, PGV, and optional PSA at 0.3, 1.0, and 3.0 seconds.
- ShakeMap Information. Link to “info.xml” showing detailed information on ShakeMap input data, processing parameters, and output products.
- ShakeCast Products. Link to PDF summary reports and KML for viewing with the Google Earth program.

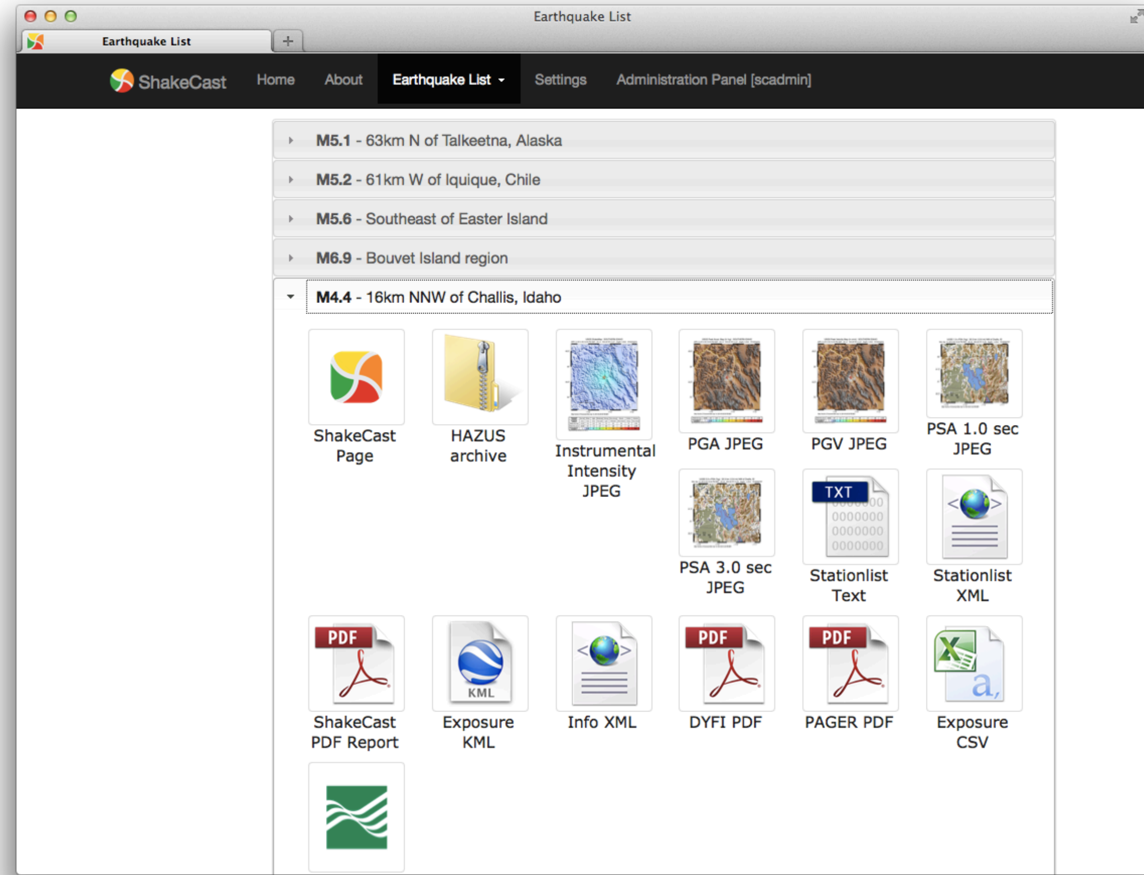


Figure 6.8. ShakeCast Earthquake List page.

6.2.2.3 Inventory Details Page

The ShakeCast event page displays the complete facility inventory assessed for the selected earthquake. The notification email message users received often represents a subset of the entire inventory depending on their type, geographic coverage, and triggering threshold.

Users can navigate to the Inventory Details page by clicking either the "ShakeCast Page" icon or the hyperlinked event name above the map in the Earthquake List page.

The event page aggregates facilities with different types in order to provide a comprehensive view of all facilities shaken by the earthquake (Figure 6.9). The left-navigation panel is consisted of three displays, facility type list, high priority facility list, and earthquake product list. The facility type list filters the master facility list based on the selected facility type and updates the high priority list accordingly. Select the facility in the facility list or via the interactive map to display detailed ground shaking estimates, potential damage state probabilities, and facility-specific attributes and assessment results. The interactive map interface also facilitates a simple inspection tool (right-mouse click) to inquire shaking estimates at the point location or to select a facility for detailed interrogation (see below).

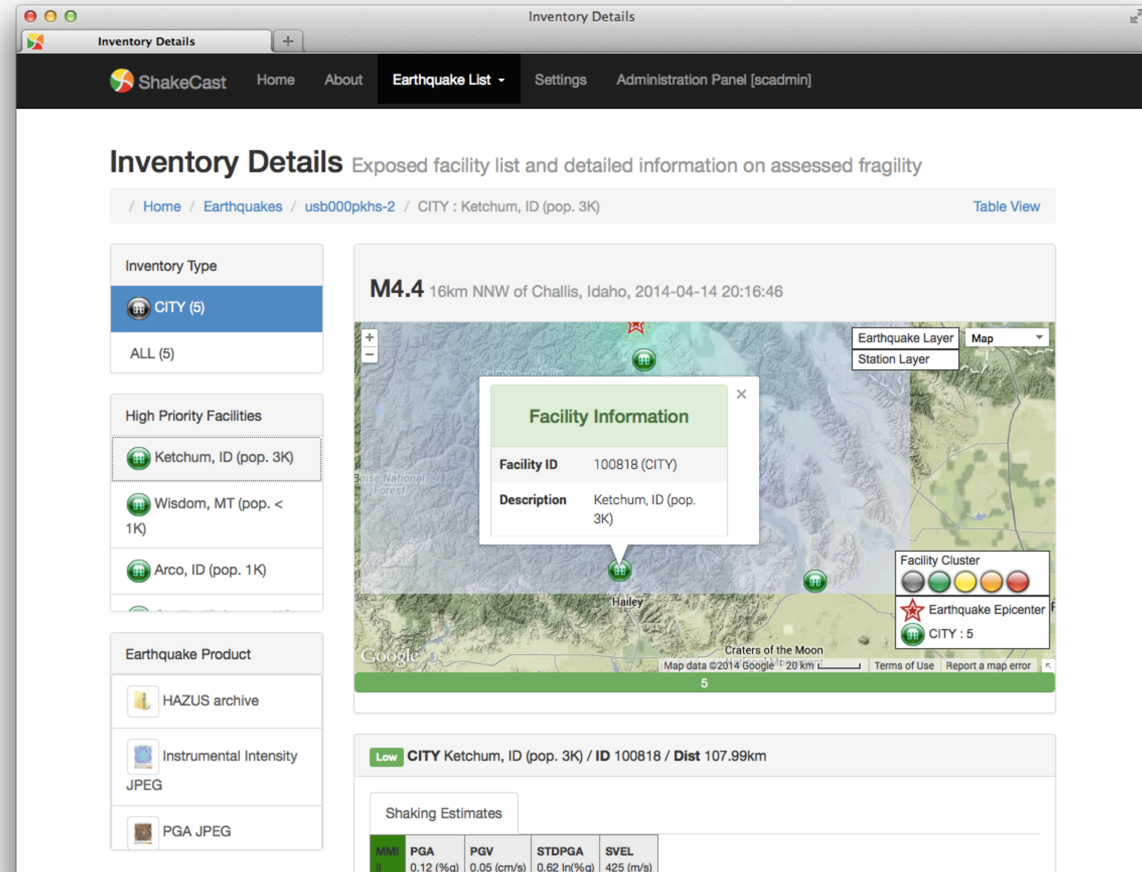


Figure 6.9. ShakeCast Inventory Details page for the selected earthquake.

The inventory details page in table view is shown in Figure 6.10. In this page each selected facility type will be presented in an interactive paginated table. The facility table can be sorted by individual parameters and can be searched to refine the catalog. Select the facility in the facility list to display the same detailed ground shaking estimates, potential damage state probabilities, and facility-specific attributes and assessment results as shown in the inventory details page.

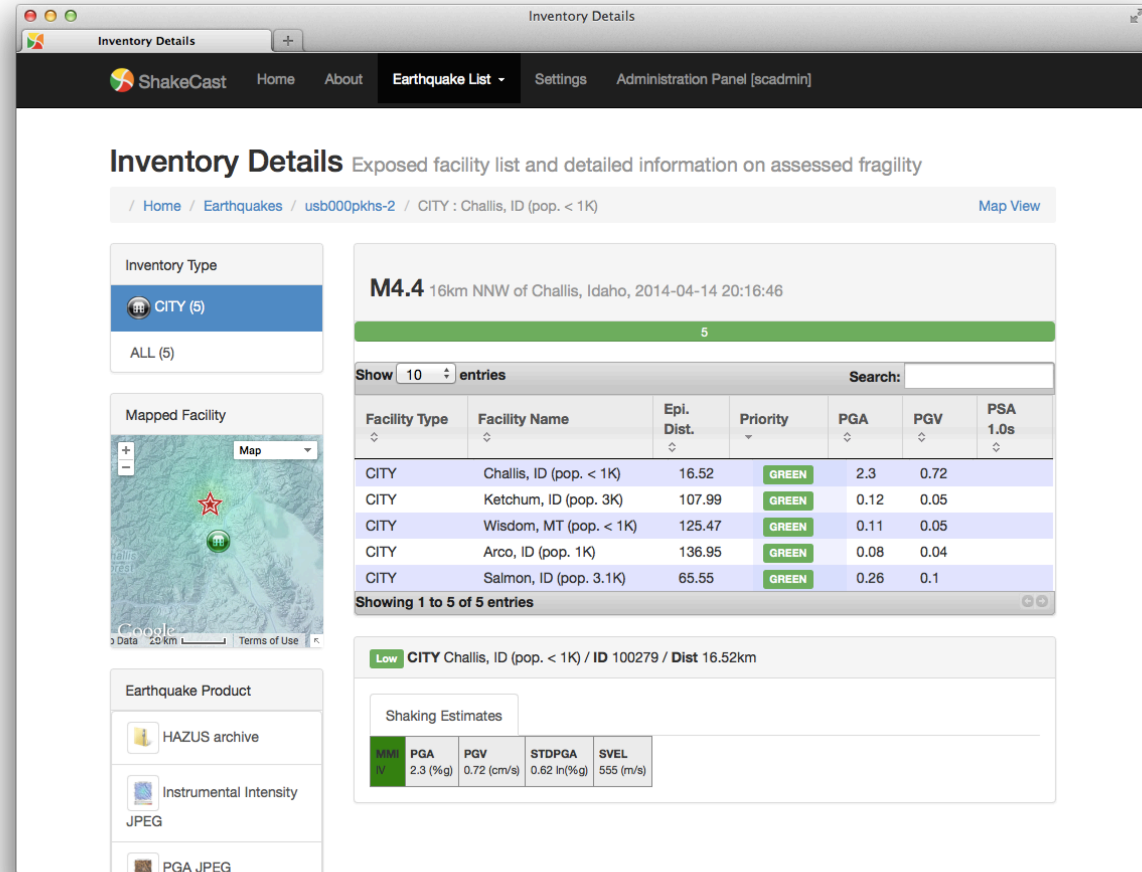
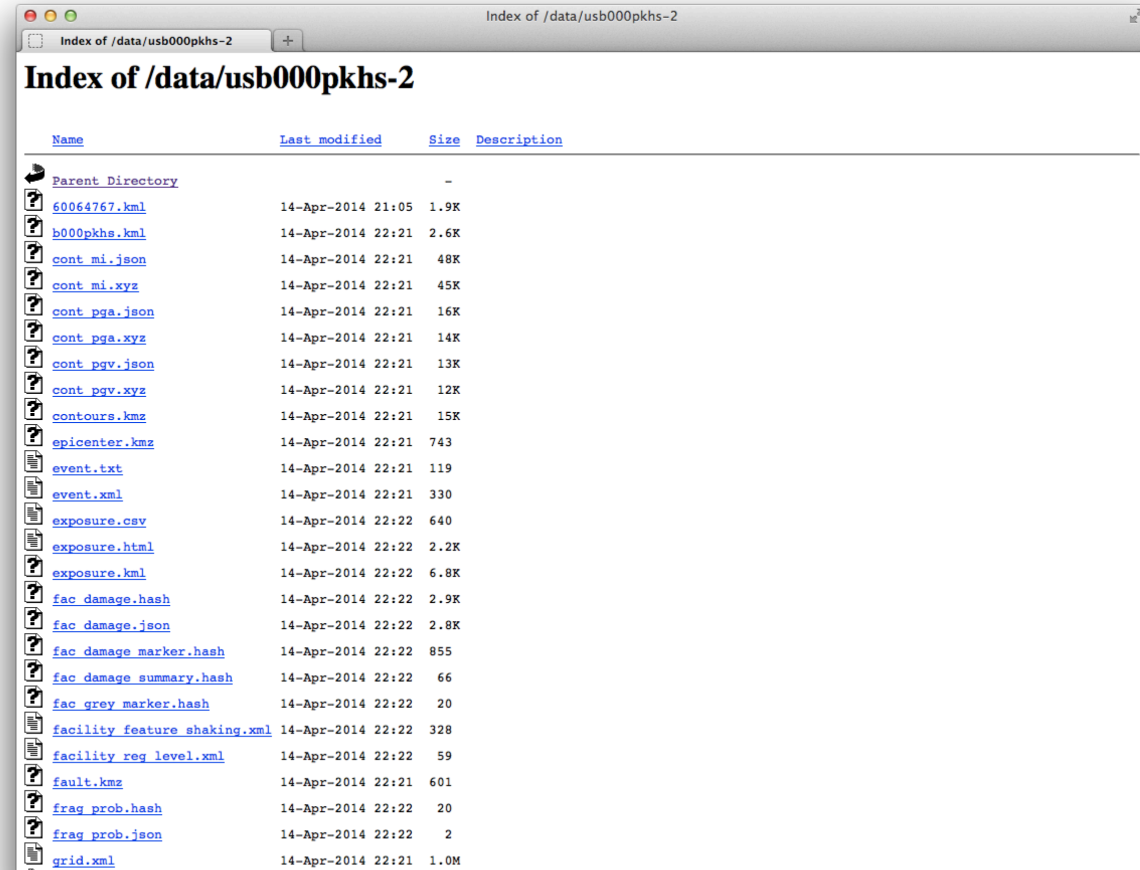


Figure 6.10. ShakeCast Inventory Details page in table view.

6.2.3 Full Earthquake Product

ShakeCast archives all versions of ShakeMaps received by the system and products generated locally. This system, however, does notinclude archives of other USGS (non-ShakeMap) earthquake products. As shown in Figure 6.11, the page contains a list of all available ShakeCast files for the specific event and version, including various ShakeMap image files, and the core data files used in the ShakeCast analysis routines. The full list products and metadata available combining both ShakeMap and ShakeCast processes often add up to between 50 and 100 files. Thus access to the full product web page is not recommended except for expert users who are familiar with both applications. Detailed descriptions of ShakeMap and its products are documented in the ShakeMap Manual (Wald et al., 2005) or under the “downloads” tab any earthquake’s ShakeMap web page. Appendix A of this report describes the specifications of data format defined by the ShakeCast system.


Index of /data/usb000pkhs-2

Index of /data/usb000pkhs-2

Name	Last modified	Size	Description
Parent Directory		-	
60064767.kml	14-Apr-2014 21:05	1.9K	
b000pkhs.kml	14-Apr-2014 22:21	2.6K	
cont_mi.json	14-Apr-2014 22:21	48K	
cont_mi.xyz	14-Apr-2014 22:21	45K	
cont_pga.json	14-Apr-2014 22:21	16K	
cont_pga.xyz	14-Apr-2014 22:21	14K	
cont_pgv.json	14-Apr-2014 22:21	13K	
cont_pgv.xyz	14-Apr-2014 22:21	12K	
contours.kmz	14-Apr-2014 22:21	15K	
epicenter.kmz	14-Apr-2014 22:21	743	
event.txt	14-Apr-2014 22:21	119	
event.xml	14-Apr-2014 22:21	330	
exposure.csv	14-Apr-2014 22:22	640	
exposure.html	14-Apr-2014 22:22	2.2K	
exposure.kml	14-Apr-2014 22:22	6.8K	
fac_damage.hash	14-Apr-2014 22:22	2.9K	
fac_damage.json	14-Apr-2014 22:22	2.8K	
fac_damage_marker.hash	14-Apr-2014 22:22	855	
fac_damage_summary.hash	14-Apr-2014 22:22	66	
fac_grey_marker.hash	14-Apr-2014 22:22	20	
facility_feature_shaking.xml	14-Apr-2014 22:22	328	
facility_reg_level.xml	14-Apr-2014 22:22	59	
fault.kmz	14-Apr-2014 22:21	601	
frag_prob.hash	14-Apr-2014 22:22	20	
frag_prob.json	14-Apr-2014 22:22	2	
grid.xml	14-Apr-2014 22:21	1.0M	

Figure 6.11. Full list of earthquake products available on the ShakeCast web site.

6.2.4 User Settings

The ShakeCast user interface allows end-users to customize settings of presented earthquake information to improve their experience (Figure 6.12). User settings are saved locally by the user's web browser, not on the ShakeCast server, and will override the default values. The scope of the settings include:

- User credentials. User credential information is used to dynamic retrieve information from the ShakeCast web server. Users should only save credential information on their private computers.
- Map layers. Specify displayed layers of maps, location, and controls.
- ShakeMap list. Specify how the earthquake list is refreshed and displayed. This setting is mainly used for the default homepage.
- Facility list. Specify the list and behavior of facilities displayed in the interactive map.

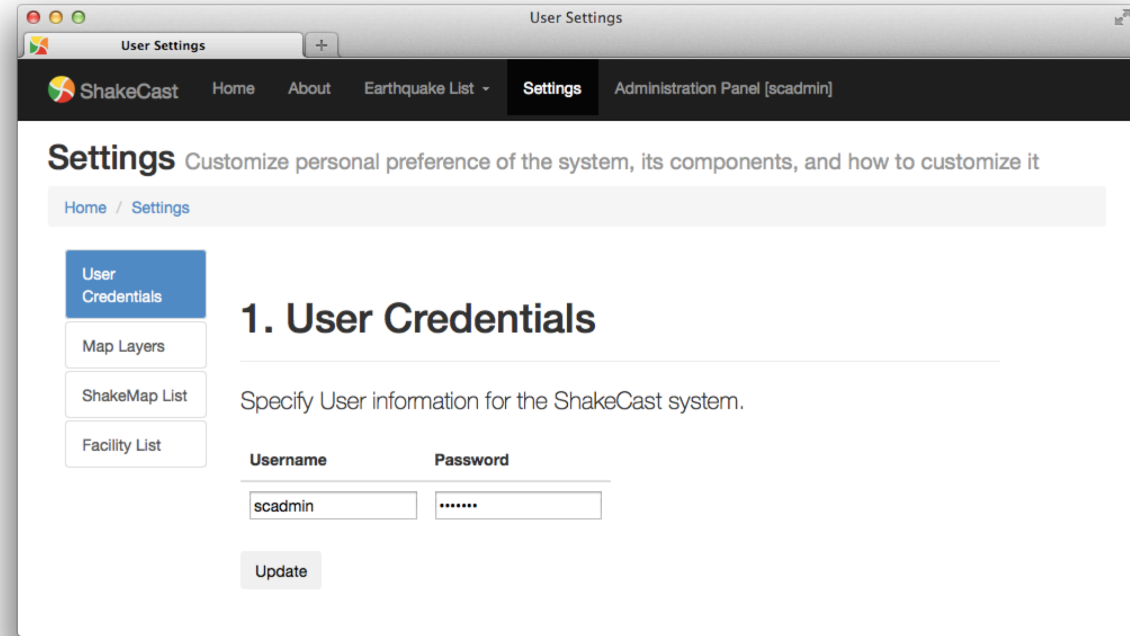


Figure 6.12. The user settings page of the ShakeCast web.

6.2.5 ShakeCast Mobile Page

The ShakeCast Mobile page, shown in Figure 6.13, is another alternative webpage to the default home page. The Mobile page is designed to be light and simple that mimics the functions of earthquake pages described in 6.2.2. In effect the ShakeCast Mobile page consists of four earthquake web pages in a single HTML document.

- Earthquake List page. Displays list of recent earthquakes (Figure 6.13).
- Earthquake Summary page. Displays ShakeCast summary and alert level of facilities (Figure 6.14).
- ShakeMap Summary page. Displays ShakeMap processing parameters and associated shaking maps of different metrics (Figure 6.15).
- Earthquake Product page. Displays list of earthquake products (Figure 6.16).

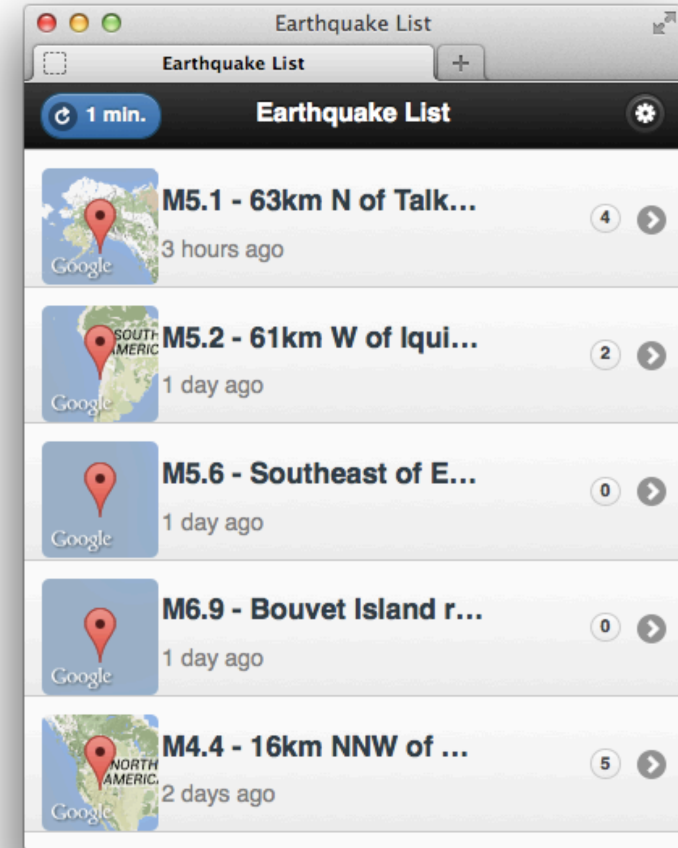


Figure 6.13. Earthquake list on the ShakeCast Mobile web page.

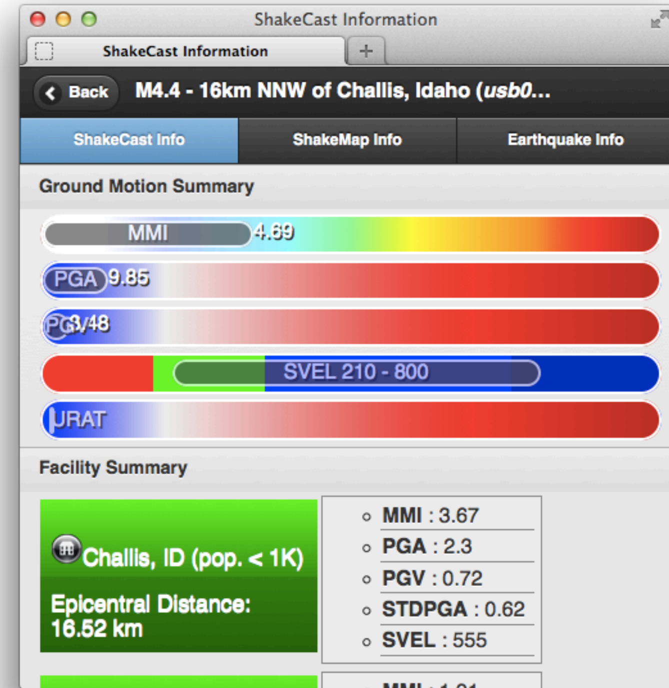


Figure 6.14. Earthquake summary on the ShakeCast Mobile web page.

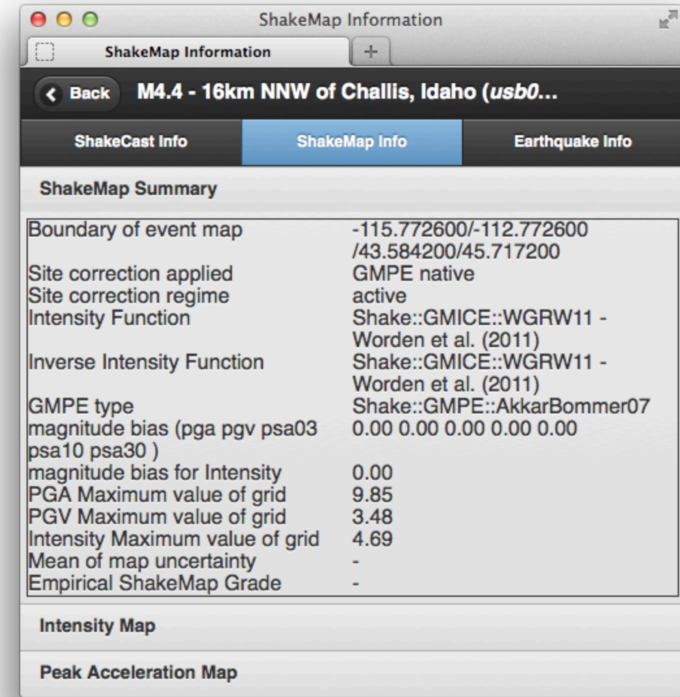


Figure 6.15. ShakeMap summary information on the ShakeCast Mobile web page.

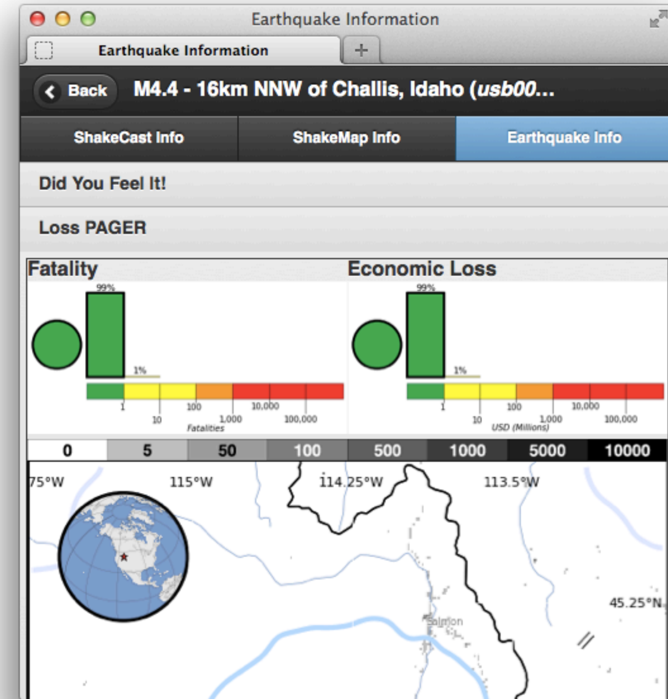


Figure 6.16. Earthquake product on the ShakeCast Mobile web page.

7 CASE STUDIES OF SHAKECAST USAGE

In the beginning of the project in 2011, there were several events for which ShakeCast notifications proved to be an effective response tool. Additionally, these events provided a good opportunity to identify and improve several issues with the configuration of the ShakeCast system.

7.1 M5.8 Virginia Earthquake

At 17:51 UTC on Aug 23, 2011, a magnitude 5.8 earthquake occurred near Mineral in Central Virginia as shown in Figure 7.1. The prototype ShakeCast V3 system for the nuclear industry processed the event and distributed multiple notifications to subscribers, including several ShakeCast messages.

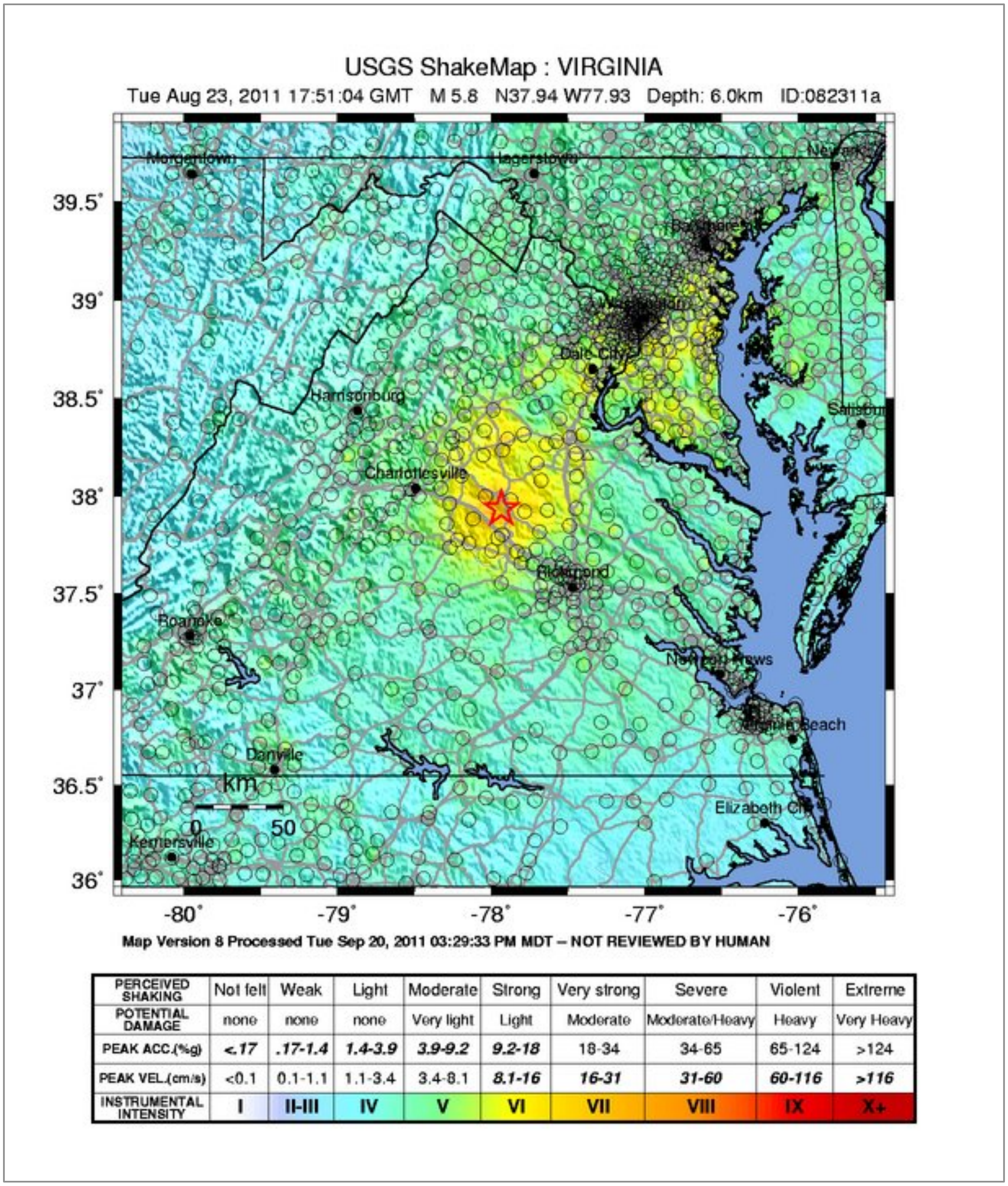


Figure 7.1. ShakeMap for the M5.8 Virginia Earthquake in 2011.

7.1.1 Timeline of Events

A chronology of ShakeCast actions is shown in the table below.

Date/Time	**Activity**

8/23/11 17:51 UTC	Virginia earthquake occurs.
8/23/11 18:06 UTC	USGS reports a magnitude 5.9 event and publishes an initial ShakeMap v1.
8/23/11 18:16 UTC	ShakeCast at IAEA retrieves the v1 ShakeMap data from USGS and sends a ShakeCast message to IAEA subscribers.
8/23/11 18:42 UTC	ShakeCast at NEIC retrieves the v1 ShakeMap data from USGS and sends a ShakeCast message to NRC subscribers.
8/23/11 15:11 UTC	ShakeCast retrieves the v4 ShakeMap data from USGS and sends a notification update to subscribers.
8/24/11 20:55 UTC	ShakeCast retrieves the v6 ShakeMap data from USGS and sends a notification update to subscribers.
8/26/11 14:50 UTC	The USGS issues a final v7 ShakeMap. ShakeCast retrieves the v6 ShakeMap data from USGS and sends a notification update to subscribers.

There were a number of factors that impacted the delivery of ShakeCast notifications for this event, including a slight delay in the distribution of the ShakeMap data and the repeated processing of subsequent ShakeMap versions.

The first version of ShakeMap was made 15 min after the earthquake, more than the typical 5-10 min stated as the USGS's ShakeMap performance goal, but the event occurred outside of any of the densely-instrumented ANSS Regional Seismic Networks (RSNs). The initial Nuclear Regulatory Commission (NRC) ShakeCast message (Figure 7.2) was sent 51 minutes after the event occurred. Meanwhile, the similar International Atomic Energy Agency (IAEA) ShakeCast message was sent 24 minutes after the earthquake, 10 min after the release of the USGS ShakeMap. For more details on the "Nuclear ShakeCast" system, see Kammerer et al. (2011).

The Mineral, Virginia, earthquakes were felt by more Americans than any earthquake in the history of the country. The USGS reported that an issue with spiked Internet traffic at USGS web servers and network connectivity at NEIC were the causes of the delay in making the ShakeMap and subsequent processing at the downstream ShakeCast servers. In the end, however, the overall impact to response was negligible.

Two ShakeCast notifications (Figure 7.3) were sent to users in the first two hours following the event, as the ShakeMap was updated multiple times. It is typical for an event of this magnitude to be updated in the hours and days following the earthquake, as scientists review and update the ShakeMap to reflect additional seismological data obtained after the initial ShakeMap was created.

The ShakeCast server was set up to process and send out notifications only if the peak values changes more than 20% between ShakeMap updates. The threshold was created to minimize repeated messages for the same event that may cause too much confusion with recipients.

U.S.NRC **ShakeCast Report** USGS science for a changing world

Magnitude 5.9 - VIRGINIA

Version 1

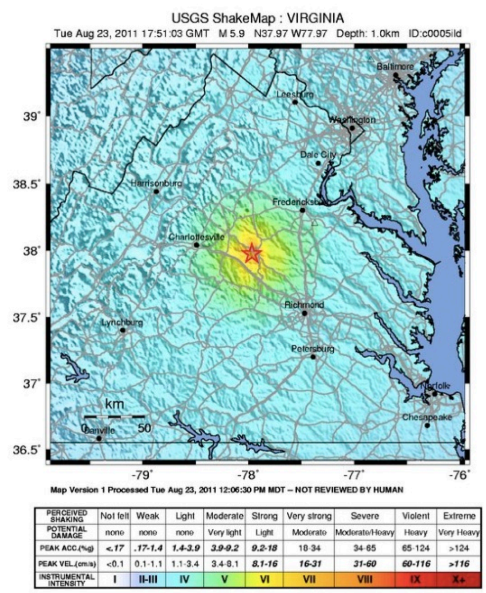
Origin Time: 2011-08-23 17:51:03 GMT

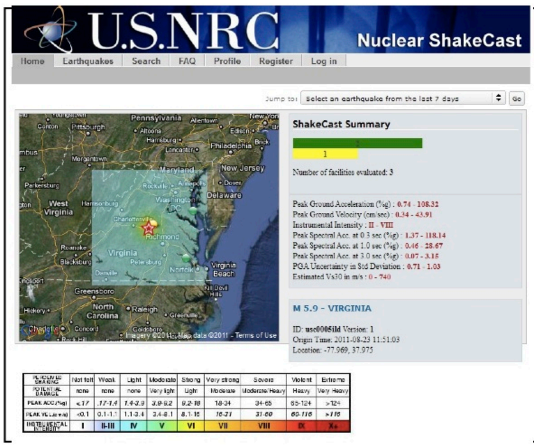
Created: 2011-08-23 18:42:51 GMT

Latitude: 37.9746 Longitude: -77.9689

Depth: 1.0 km

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as additional or more accurate earthquake information is reported or derived.





Recent significant earthquakes in the region

- M4.5 VIRGINIA at 12/9/2003 20:59

FACILITY_TYPE	FACILITY_ID	FACILITY_NAME	DIST	LATITUDE	LONGITUDE	DAMAGE_LEVEL	MMI	PGA	PGV	PSA03	PSA10	PSA30
NUCLEAR	USA37	North Anna	17.77	38.0573	-77.7956	YELLOW	VI	16.6639	6.5376	21.4418	5.1476	0.5304
NUCLEAR	USA8	Calvert Cliffs	143.02	38.4319	-76.4424	GREEN	IV	1.6502	0.8533	2.9634	0.8883	0.0974
NUCLEAR	USA56	Surry	144.19	37.1633	-76.6942	GREEN	IV	1.6397	0.8496	2.9455	0.885	0.0971

* - MMI level may extend beyond map boundary; some facilities may not appear on the map due to space restriction

Figure 7.2. Initial version of ShakeCast summary PDF for the Virginia Earthquake.

International Seismic Safety Centre

ShakeCast Report

IAEA.org International Atomic Energy Agency | USGS science for a changing world

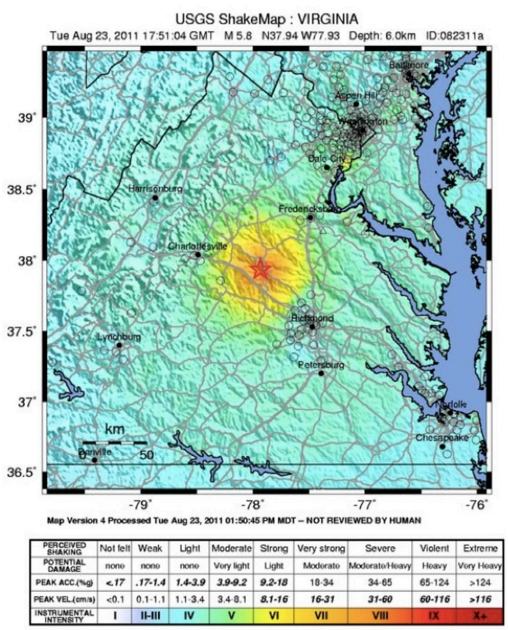
Magnitude 5.8 - VIRGINIA

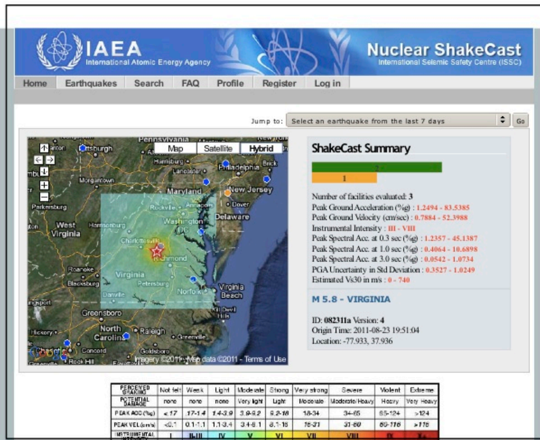
Version 4

Time: 2011-08-23 17:51:04 GMT
Location: 37.94 N/ -77.93 W
Depth: 6.0 km

Created: 2011-08-23 20:55:24 GMT
For more information and latest version see
http://nuclearshakecast.iaea.org

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as addtional or more accurate earthquake information is reported or derived.





Recent significant earthquakes in the region

- M4.5 VIRGINIA at 12/9/2003 20:59
- M3.4 POTOMAC-SHENANDOAH REGION at 7/16/2010 9:04

FACILITY_TYPE	FACILITY_ID	FACILITY_NAME	LATITUDE	LONGITUDE	DAMAGE_LEVEL	MMI	PGA	PGV	PSA03	PSA10	PSA30
NPP	USA8	Calvert Cliffs	38.4319	-76.4424	GREEN	4.46	3.8332	4.2936	3.6402	1.4434	0.1515
NPP	USA37	North Anna	38.0573	-77.7956	ORANGE	7.17	37.7344	24.5409	22.2016	5.4092	0.536
NPP	USA56	Surry	37.1633	-76.6942	GREEN	4.52	4.1069	4.6754	3.6715	1.4528	0.1525

* - MMI level extends beyond map boundary, actual population exposure may be much larger
** - Some facilities may not appear on the map due to space restriction

http://nuclearshakecast.iaea.org

Figure 7.3. Version 4 of ShakeCast summary PDF for the Virginia Earthquake.

7.1.2 PGA Estimates of Facilities

Of the three facilities assessed by ShakeCast, the North Anna NPP, with an epicentral distance of 18 km, was reported to have exceeded the generic setup for concern level. The PGA ground motion estimate at the site varies from 18% to 38% g between ShakeMap updates; the analog strong motion record recovered onsite indicates 0.28 g.

Other than within the North Anna NPP, for which the data were not available for ShakeMap, there were few strong motion stations in the region at the time of the earthquake. The majority of them are >300km from the epicenter, only four are within 200 km, and the nearest station is ~54km from the epicenter. This sparse station coverage is insufficient to compute bias adjustment for estimated ground motions. Thus CIIM data from the DYFI application and its converted ground motion measures were the primary source of input data.

Specifically, the first version of ShakeMap was a pure predictive map with little input data to constrain the ground shaking estimates. ShakeCast identified three plants that were subjected to noticeable PGA and the North Anna plant 18% g, identified as YELLOW level for concern.

Version 2 and 3 of ShakeMap reflected update to the earthquake source parameters, which magnitude was lowered to 5.8, and strong motion data. The changes in ground shaking estimates with added input data did not trigger ShakeCast update.

When volume CIIM data was added to the input data in Version 4 nearly two hours after the earthquake, ShakeMap computed bias to be ~+0.3, approximately less than two times the predictive value. The PGA estimate at North Anna NPP was raised accordingly to 38%. With more than one million CIIM entries of which new entries near the epicenter and refined earthquake parameters, the ground shaking estimate stabilized within two days as shown in Figure 9.4 and 9.5. The final estimate of shaking from ShakeMap at the North Anna NPP was 27% g, very close to the value ultimately recovered from the analog strong motion instrument onsite (Figure 9.5).

U.S.NRC ShakeCast Report USGS science for a changing world

Magnitude 5.8 - VIRGINIA

Version 6

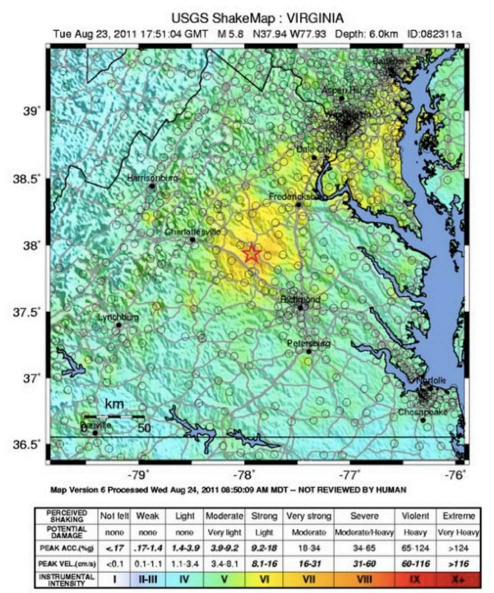
Origin Time: 2011-08-23 17:51:04 GMT

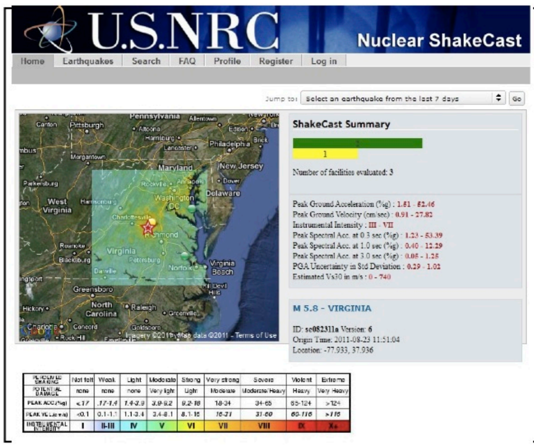
Created: 2011-08-24 15:11:29 GMT

Latitude: 37.9360 Longitude: -77.9330

Depth: 6.0 km

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as additional or more accurate earthquake information is reported or derived.





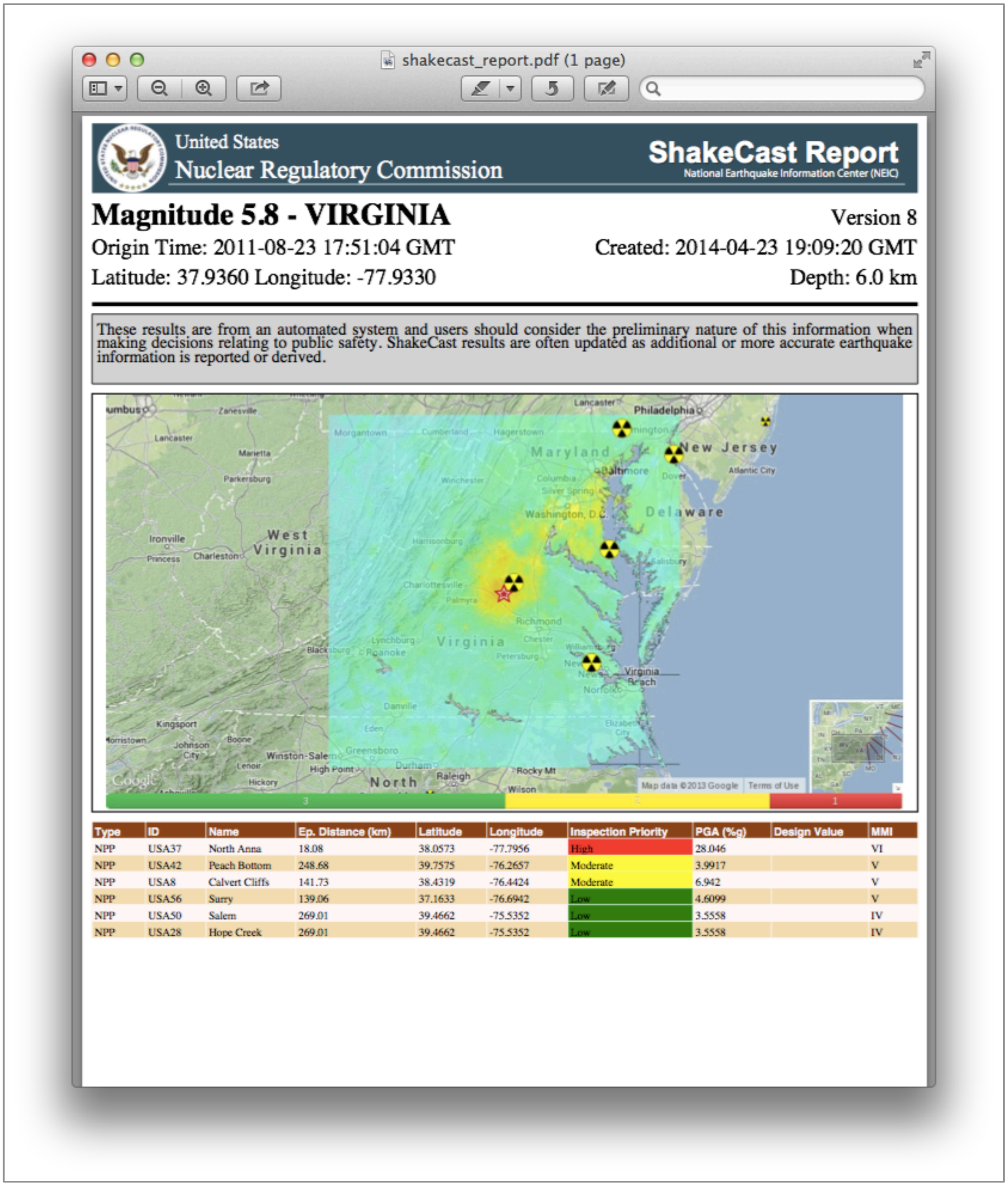
Recent significant earthquakes in the region

- M4.5 VIRGINIA at 12/9/2003 20:59

FACILITY_TYPE	FACILITY_ID	FACILITY_NAME	DIST	LATITUDE	LONGITUDE	DAMAGE_LEVEL	MMI	PGA	PGV	PSA03	PSA10	PSA30
NUCLEAR	USA37	North Anna	18.08	38.0573	-77.7956	YELLOW	VI	19.9918	12.2568	26.0078	5.9443	0.5989
NUCLEAR	USA8	Calvert Cliffs	141.73	38.4319	-76.4424	GREEN	V	6.8436	6.7083	3.5967	1.4285	0.1501
NUCLEAR	USA56	Surry	139.06	37.1633	-76.6942	GREEN	V	6.1296	6.5473	3.5591	1.4118	0.1482

* - MMI level may extend beyond map boundary; some facilities may not appear on the map due to space restriction

Figure 7.4. Version 6 of ShakeCast summary PDF for the Virginia Earthquake.



shakecast_report.pdf (1 page)

United States
Nuclear Regulatory Commission

ShakeCast Report
National Earthquake Information Center (NEIC)

Magnitude 5.8 - VIRGINIA

Version 8

Origin Time: 2011-08-23 17:51:04 GMT

Created: 2014-04-23 19:09:20 GMT

Latitude: 37.9360 Longitude: -77.9330

Depth: 6.0 km

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as additional or more accurate earthquake information is reported or derived.

Type	ID	Name	Ep. Distance (km)	Latitude	Longitude	Inspection Priority	PGA (%g)	Design Value	MMI
NPP	USA37	North Anna	18.08	38.0573	-77.7956	High	28.046		VI
NPP	USA42	Peach Bottom	248.68	39.7575	-76.2657	Moderate	3.9917		V
NPP	USA8	Calvert Cliffs	141.73	38.4319	-76.4424	Moderate	6.942		V
NPP	USA56	Surry	139.06	37.1633	-76.6942	Low	4.6099		V
NPP	USA50	Salem	269.01	39.4662	-75.5352	Low	3.5558		IV
NPP	USA28	Hope Creek	269.01	39.4662	-75.5352	Low	3.5558		IV

Figure 7.5. Final version of ShakeCast summary PDF (V3 system) for the M5.8 Mineral, Virginia Earthquake.

7.2 M9.0 Tohoku, Japan Earthquake

At 05:46 UTC on Mar 11, 2011, a magnitude 9.0 earthquake occurred near the East Coast of Honshu in Japan as shown in Figure 7.6. This event represents a likely timeline after a major earthquake, though magnitude determination for such events has improved significantly at the NEIC in recent years. Under normal operation situation the user can expect a ShakeCast message 2-5 minutes after a ShakeMap update is posted on the USGS web site.

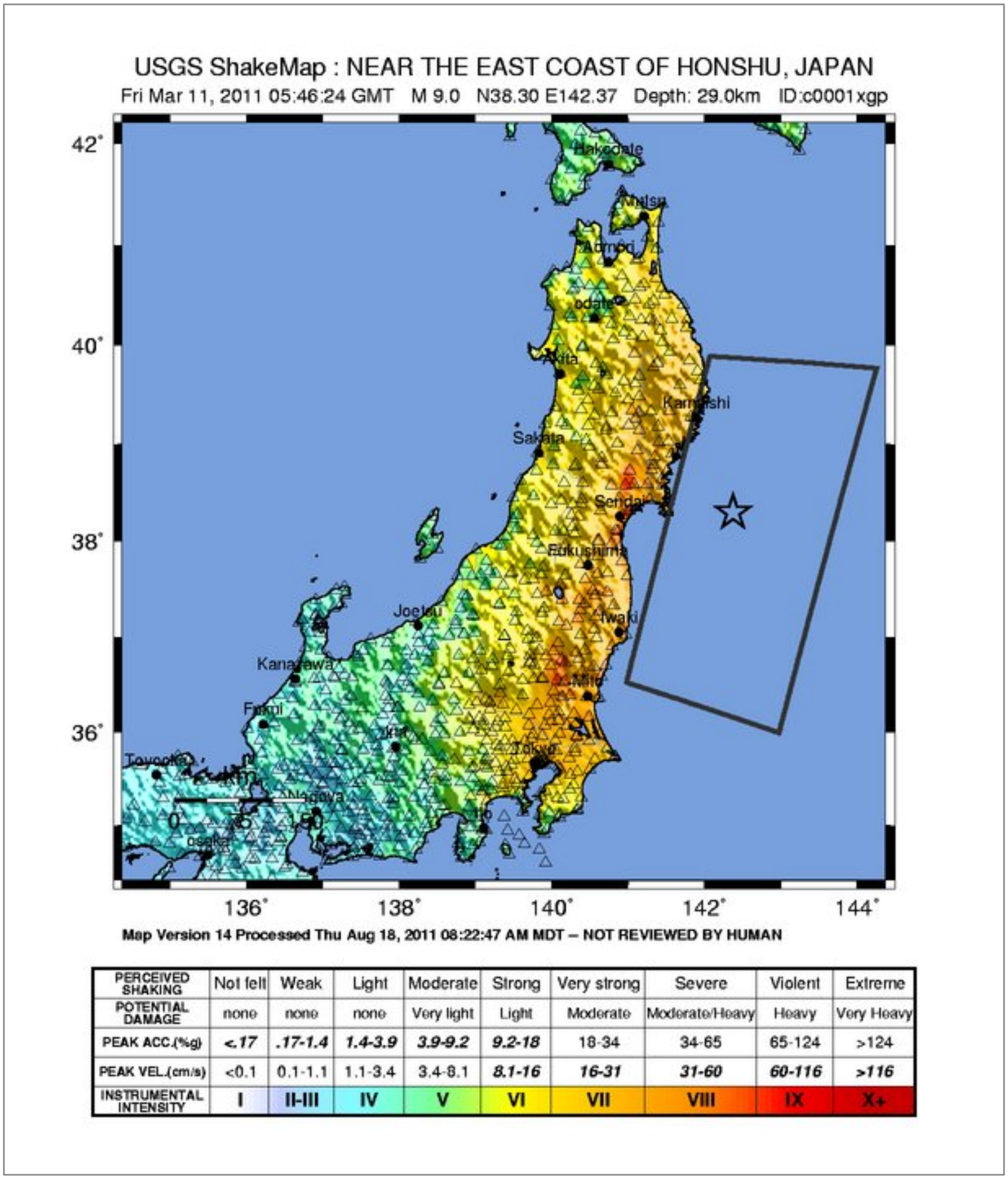


Figure 7.6. ShakeMap from 2011, M9.0 Tohoku earthquake

7.2.1 Timeline of Events

A chronology of ShakeCast actions is shown in the table below.

Date/Time	Activity
3/11/11 05:46 UTC	Japan earthquake occurs.
3/11/11 06:07 UTC	USGS reports a magnitude 7.9 event and publishes an initial ShakeMap v1, 22 minutes after the origin time.
3/11/11 06:26 UTC	USGS updates the earthquake location, magnitude to 8.8, and publishes ShakeMap v2, 40 minutes after the origin time.
3/11/11 06:55 UTC	USGS updates the earthquake magnitude to 8.9 and publishes ShakeMap v3, 1.1 hours after the origin time.
3/11/11 08:28 UTC	USGS adds the finite fault model, DYFI CIIM data, and publishes ShakeMap v4, 2.7 hours after the origin time.
3/14/11 21:47 UTC	USGS adds selected NIED station data (12) and publishes ShakeMap v5, 3 days after the origin time.
3/15/11 15:02 UTC	USGS adds K-Net station data (273) and publishes ShakeMap v6 with bias correction, 4 days after the origin time.
3/19/11 21:26 UTC	USGS adds KiK-Net station data (108) and publishes ShakeMap v6 with bias correction, 8 days after the origin time.
3/23/11 15:38 UTC	USGS adds full K-Net station data (683) and publishes ShakeMap v10, 12 days after the origin time.
3/26/11 13:09 UTC	USGS adds full KiK-Net station data (501) and publishes ShakeMap v11, 15 days after the origin time.

There were a number of factors that impacted the analysis of ShakeCast assessment for this event, mainly a delay in the availability of the Japan strong motion data and the finiteness (dimensions) of fault rupture.

For the Japan area with dense coverage of seismic stations, the Global ShakeMap uses both K-Net and KiK-Net data as the primary source of input to improve quality of ground motion estimates. Also since this is a non-U.S. earthquake, the precision of the DYFI intensity data is at the city level instead of the zip-code level and will not have as much influence as for U.S. events.

The first version of ShakeMap was made 22 minutes after the earthquake, in line with the typical 15-30 minutes of the USGS's ShakeMap performance goal. Since this is a major event, the initial Mwp magnitude was raised significantly at later time when robost magnitudes (MwW) and surface wave based moment tensor solutions became available. This contributed mainly to the ShakeMap update in version 2 and 3, roughly one hour after the earthquake and raised the magnitude from the initial 7.9 to 8.9 and later to M9.0.

The second major ShakeMap update occurred in version 4 when the finite-fault model was added 2.7 hours after the origin time. The shift from the point source to a planar rupture model significantly increased the shaking estimates along the east coast and at the facility locations (Figure 7.7).

The USGS noted an issue with retrieving strong motion data from the NIED data repository. Strong motion data usually available within hours of earthquakes at NIED were not accessible due to an earthquake-related power outage of their facility. A subset of the data was finally available four days after the earthquake. It was promptly processed and was added to ShakeMap as shown in version 6 through 11. USGS released the final version (11) of ShakeMap update when the last batch of KiK-Net data was added two weeks after the earthquake when the Japanese released a much more complete data set.

7.2.2 PGA Estimates of Facilities

The number of facilities assessed by ShakeCast changes from four in version 1 to six in version 4, and eventually 12 after version 7. One operational goal of the Global ShakeMap system is to include areas with potential shaking of MMI V or greater. Thus update of the earthquake magnitude (7.9 to 8.8) and adding the finite-fault model resulted in changing the bounding coordinates of ShakeMap. Figure 7.7 shows the facilities assessed for each ShakeMap version and their corresponding PGA estimates.

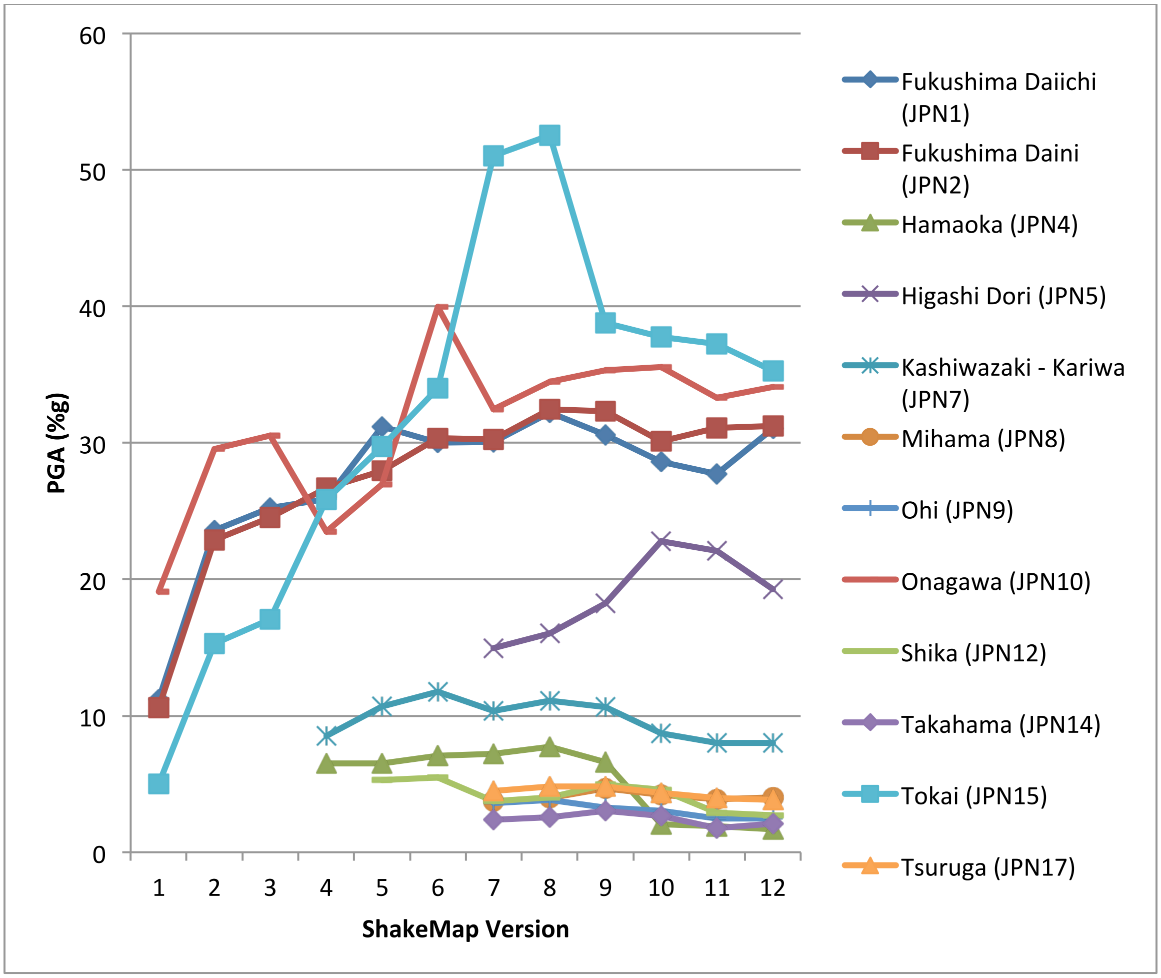


Figure 7.7. ShakeCast PGA estimates from ShakeMap updates for the Japan Earthquake

Variations in PGA estimates are attributed to the magnitude change (7.9 to 9.0), the addition of a finite-fault model, and the addition of strong motion data. The standard bias adjustment in ShakeMap is turned off for earthquakes with magnitude of 7.0 or greater and is not a factor for this major event.

As results, PGA estimates for the three nuclear power plants (NPPs) close to the earthquake source are show large variations, though the range of values among the plants was much larger (Figure 7.7):

- Onagawa NPP. Final PGA estimate of 33% g (19% - 33%).
- Fukushima Daiichi. Final PGA estimate of 28% g (11% - 28%).
- Fukushima Daini. Final PGA estimate of 32% g (11% - 32%).

8 SUMMARY

The USGS ShakeCast system is an open-source application for post-earthquake response utilizing the ShakeMap system for estimating shaking at users' facilities. ShakeCast Version 3, released in 2014 represents a major upgrade in functionality and ease of use from the previous release in 2008.

The primary benefits of ShakeCast can be summarized as follows:

- ShakeCast allows for any organization to have a rapid, automated and more focused post-earthquake response. The ShakeCast products provide responders a heightened level of situational awareness (e.g., damage assessment, inspection priority, or level of concern) in the minutes and hours following an earthquake, with content previously unavailable. This information can influence critical decisions made in the aftermath of a significant earthquakes and provides reassurance when shaking levels are confirmed to be low at sites of interest for other events.

- ShakeCast users are better informed and can communicate the post-earthquake facility assessment situation. ShakeCast quantifies the number of facilities in the affected area and provides a breakdown of estimated impact or inspection-priority levels (e.g., GREEN, YELLOW, ORANGE or RED) based upon distribution of ground motions and pre-assigned facility fragilities tied to these estimated shaking levels. This simple aggregation of results will allow users to easily communicate the scope of current assessment efforts.

- The ShakeMap Atlas and online ShakeMap scenarios provide a suite of historical and hypothetical events for use with ShakeCast to help test the ShakeCast system and to prepare their user communities. As a scenario planning and evaluation tool, ShakeCast can generate any number of possible earthquake situations and analyze the potential level of concern at all facilities.

This release coincided with our porting ShakeCast software to the cloud and to package it as a virtual machine image using both Linux and MS-Windows operating systems. It is anticipated that this virtualizing effort will reduce the need for USGS support of the software as well as adoption by the ShakeCast user community. Users now have a low-cost alternative to local hosting, by fully offloading hardware, software, and communication obligations to the host server of virtual machines, either via the user's organization or by a cloud-hosting provider.

In order to accommodate the growing needs of the ShakeCast user community, the USGS is providing tiered technical support to ShakeCast users. Support and information is also available from the ShakeCast webpages, which include FAQ, a Wiki, manuals, and installation guides. Application update and announcements are disseminated via the ShakeCast users listserv. Further information on ShakeCast can be found online including a ShakeCast Wiki and support at shakecast-help@usgs.gov.

8 ACKNOWLEDGMENTS

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APPENDIX A SHAKECAST USER DATA FORMAT SPECIFICATIONS

Appendix A provides provide specifications and user guidance on the format of the data files that must be supplied to customize the system to a user's inventory (facilities), their fragilities and their user and notification information. An example of each file is provided with the V3 ShakeCast distribution in a folder found in the ShakeCast database directory, default at “/usr/local/shakecast/sc/db” A text editor is sufficient for customizing these files, though users with substantial inventories may consider keeping a database or spreadsheet for this purpose. The suggested strategy is to maintain or export CSV files for each of the required input files described below, and then use the drag-and-drop functionality within the ShakeCast web interface to upload (or update) any of the files.

Facility Data

The scope of facility data for ShakeCast V3 covers three main categories: 1) basic facility and associated simple fragility information; 2) probabilistic fragility information; and 3) supplemental feature information. Facility data can be prepared in the format of either Comma-Separated Values (CSV) or Extensible Markup Language (2003 Excel XML export format) to be imported into the ShakeCast database. Currently there are several import scripts for processing facility data of each category and to ensure backward compatibility with V2 facility data. Specifically, the format and requirement for basic facility and associated fragility information are identical for both V2 and V3 systems. Users can migrate from a V2 system to V3 using the same facility data file.

By default CSV fields are separated by commas; field values that include commas are protected by enclosing them in quotes, but these defaults can be modified if necessary. The first record in the input file must contain column headers allowing processing scripts to interpret the rest of the records. Each header field must specify a facility field, a facility metric field, or a group field. The header fields are case-insensitive; `facility_name` and `FACILITY_NAME` are equivalent. Fields can appear in any order.

Facility Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

external_facility_id (Text(32), required always)
This field identifies the facility. It must be unique for a facility type but the same external_facility_id may be used for different types of facilities.

facility_type (Text(10), required always)
This field identifies the type of facility. It must match one of the types in the `facility_type` table. Currently defined types are: BRIDGE, CAMPUS, CITY, COUNTY, DAM, DISTRICT, ENGINEERED, INDUSTRIAL, MULTIFAM, ROAD, SINGLEFAM, STRUCTURE, TANK, TUNNEL, UNKNOWN, and HAZUS building types. Refer the HAZUS Damage Level document for the 128 HAZUS building types and code era.

facility_name (Text(128), required for insert/replace)
The value of this field is what the user sees.

short_name (Text(10), optional)
The value of this field is used by ShakeCast when a shorter version of the name is needed due to space limitations in the output.

description (Text(255), optional)
You can use this field to include a short description of the facility.

lat (Float, required for insert/replace)
Specifies the latitude of the facility in degrees and fractional degrees.

lon (Float, required for insert/replace)
Specifies the longitude of the facility in degrees and fractional degrees.

Fragility Fields

Each field beginning with `METRIC:` is taken to be a facility fragility specifier. The format of a fragility specifier is:

METRIC:*metric-name***:***damage-level*

where *metric-name* is a valid ShakeMap metric (MMI, PGV, PGA, PSA03, PSA10, or PSA30) and *alert-level* is a valid damage level (GREEN, YELLOW, ORANGE, or RED). Examples of Facility Fragility column labels are `METRIC:MMI:RED` and `metric:pga:yellow`.

The metric-name values are defined by the ShakeMap system, and are generally not changed. The above values are current as of summer 2013. The damage-level values shown above are the default values shipped with ShakeCast. These values are defined in your local ShakeCast database, and you may use the administration web interface to change those values and the color-names that refer to them.

Attribute Fields

A facility can have attributes associated with it. These attributes can be used to group and filter facilities.

Each field beginning with `ATTR:` is taken to be a facility attribute specifier. The format of a facility attribute specifier is:

ATTR:*attribute-name***:***attribute-value*

where *attribute-name* is a string not more than 20 characters in length.

Examples of Facility Attribute column labels are `ATTR:COUNTY` and `ATTR:Construction`. Attribute values can be any string up to 30 characters long.

Example Facilities

Example 1 -- Point Facilities

Assume we have a file named *ca_cities.csv* containing California cities that we want to load into the ShakeCast database. The file is in CSV format and includes the name of each city and the latitude/longitude of its city center or city hall. Records in the file are of the form

```
Rancho Cucamonga,34.1233,-117.5794
Pasadena,34.1561,-118.1318
```

The file is missing two required fields, `external_facility_id` and `facility_type`. Since the city name is unique we can add a new column that is a copy of the name column and use that as the external_facility_id. Another column containing the value `CITY` for each row is added for the facility_type. You can either make these changes using a spreadsheet program or with a simple script written in a text processing language like Perl.

After making these modifications the records look like

```
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794
CITY,Pasadena,Pasadena,34.1561,-118.1318
```

The input file also needs a header record; after adding one the input file looks like

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,FACILITY_NAME,LAT,LON
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794
CITY,Pasadena,Pasadena,34.1561,-118.1318
 ...
```

The facilities in this file can now be loaded into ShakeCast using the command

```
manage_facility.pl ca_cities.csv
```

Example 2 -- Fragility Parameters

Building on the previous example, assume a simple model where Instrumental Intensity (MMI) above 7 corresponds to a high-level alert (RED), MMI between 5 and 7 corresponds to a medium-level alert (YELLOW), and MMI below 5 corresponds to a low alert level (GREEN). The lower threshold of each range (1, 5, 7) is appended to every record in the input file and the header record is changed to reflect the added fields:

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,FACILITY_NAME,LAT,LON, \
      METRIC:MMI:GREEN,METRIC:MMI:YELLOW,METRIC:MMI:RED
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794,1,5,7
CITY,Pasadena,Pasadena,34.1561,-118.1318,1,5,7
 ...
```

Example 3 -- Multiple Attributes and Multiple Metrics

You can include multiple attributes, multiple metrics, or multiple attributes and multiple metrics for each row of an import file. For example,

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,ATTR:COUNTY, ATTR:SIZE,\
      METRIC:MMI:GREEN, METRIC:MMI:YELLOW, METRIC:MMI:RED
CITY,Rancho Cucamonga,San Bernardino,Small,1,2,6
CITY,Pasadena,os Angeles,Medium,1,2,6
```

This file would be loaded using the command

```
manage_facility.pl --update city_county.csv
```

The above example updates the existing city locations to associate them with a county attribute and a size attribute, and defines the green, yellow, and red shaking alert thresholds.

Probabilistic Facility Fragility Data

ShakeCast V3 includes a generic processer for evaluating probabilities of exceedance of individual damage states and their likelihood as a combined set. The probability density function is modeled as log-normal distribution. To enable this optional function, users need to provide the mean (ALPHA) and the spread (BETA) value of a fragility curve for each potential damage state to be evaluated.

When preparing probability fragility data for ShakeCast import, the format requirements for facility data are applied to fragility data. Specifically, the **external_facility_id** and **facility_type** fields of the fragility data file must match the entry in the facility data file if they are imported separately. It is permitted to define more than one set of fragility curves targeting different aspects of facility performance. This function is implemented with an additional facility attribute field called "**component**." It is a user-defined field for describing facility-specific components to be modeled and evaluated for a given ground motion input. The user needs to specify the designated component of the facility for each fragility curve set. It is not required to define fragility curves for all potential damage states for a component. This usually applies to modeling secondary components or general stress indicators.

The user should be aware that the assessment of probabilistic analysis is considered as a secondary analysis. Results of the analysis will be stored on the ShakeCast system for inquiry by expert users but will not be sent out as the primary method for notification. Among defined components, the ALPHA value of the "SYSTEM" component will be translated as simple fragility information to be used as part of the basic facility information. This fragility information will be used for triggering notifications.

Facility Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

external_facility_id (Text(32), required always)
This field identifies the facility. It must match the one specified in the basic facility data file if the information is entered separately.

facility_type (Text(10), required always)
This field identifies the type of facility. It must match one of the types in the `facility_type` table. It must match the one specified in the basic facility data file if the information is entered separately.

class (Text(32), optional)
The value of this field is used by ShakeCast to categorize components.

component (Text(255), required always)
The value of this field is used by ShakeCast to specify the target component of the defined fragility curve.

Fragility Fields

Each field beginning with `METRIC:` is taken to be a facility fragility specifier. The format of a fragility specifier is:

METRIC:*metric-name***:[ALPHA,BETA]:***alert-level*

where *metric-name* is a valid Shakemap metric (MMI, PGV, PGA, PSA03, PSA10, or PSA30) and *alert-level* is a valid alert level (GREEN, YELLOW, ORANGE, or RED). Examples of Facility Fragility column labels are `METRIC:MMI:ALPHA:RED` and `metric:pga:alpha:yellow`.

The metric-name values are defined by the ShakeMap system, and are generally not changed. The above values are current as of summer 2013. The alert-level values shown above are the default values shipped with ShakeCast. These values are defined in your local ShakeCast database, and you may use the administration web interface to change those values and the color-names that refer to them.

Example Probabilistic Fragility Parameters

Assume a simple probability model where Instrumental Intensity (MMI) with ALPHA of 8 and BETA of 0.6 corresponds to a high-level alert (RED), MMI with ALPHA of 7 and BETA of 0.6 corresponds to a medium-level alert (YELLOW), and MMI with ALPHA of 5 and BETA of 0.6 corresponds to a low-level alert (GREEN). The input file and the header record is changed to reflect the added fields:

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID, \
      METRIC:MMI:ALPHA:GREEN,METRIC:MMI:BETA:GREEN, \
      METRIC:MMI:ALPHA:YELLOW,METRIC:MMI:BETA:YELLOW, \
      METRIC:MMI:ALPHA:RED,METRIC:MMI:BETA:RED
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794,5,0.6,7,0.6,8,0.6
CITY,Pasadena,Pasadena,34.1561,-118.1318,5,0.6,7,0.6,8,0.6
 ...
```

Facility Feature Data

ShakeCast facility feature data is an extension to basic facility data defined in the legacy V2 system. It allows users to define geometric footprints and rich content descriptions of a facility. The optional description field is specifically designed to store custom HTML snippet to be displayed in the ShakeCast web interface. Content of this field will mask the data from the description field of basic facility information. The optional facility geometry field is designed to allow ShakeCast to take in account the extent of facility footprints when assessing ground shaking and damage state. The ShakeMap data grid is usually produced at a resolution of ~2x2 km^2 depending on the producer. Therefore this feature is directly applicable to facilities with linear feature such as roadway or aqueduct, etc. For facilities with small footprints there is no added benefits to define complex geometry other than either point or rectangular type.

When preparing feature data for ShakeCast import, the format requirements for facility data are applied to fragility data. Specifically, the **external_facility_id** and **facility_type** fields of the feature data file must match the entry in the facility data file if they are imported separately. The user needs to specify the geometry type of the facility for the defined geometry coordinate set. The user should be aware that the assessment of probabilistic analysis is considered as a secondary analysis. In order to accommodate the unique nature HTML snippet for the facility description, the facility feature data needs to be in the format of XML with the CSV field definition translated to tagged format.

Facility Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

external_facility_id (Text(32), required always)

This field identifies the facility. It must match the one specified in the basic facility data file if the information is entered separately.

facility_type (Text(10), required always)

This field identifies the type of facility. It must match one of the types in the `facility_type` table. It must match the one specified in the basic facility data file if the information is entered separately.

geom_type (Text(32), required always)

The value of this field is used by ShakeCast to handle the geometry coordinates from the **geom** field. Currently defined types are: POINT, POLYLINE, POLYGON, RECTANGLE, and CIRCLE.

geom (Text(mediumtext), required always)

The value of this field is used by ShakeCast to specify the coordinates of the facility. The format of this field is in (longitude,latitude) pairs separating by a white space. The size limit of data is ~16MB.

description (Text(mediumtext), required always)

You can use this field to include a description of the facility. The size limit of data is ~16MB.

Example Probabilistic Fragility Parameters

Assume a simple probability model where Instrumental Intensity (MMI) with ALPHA of 8 and BETA of 0.6 corresponds to a high-level alert (RED), MMI with ALPHA of 7 and BETA of 0.6 corresponds to a medium-level alert (YELLOW), and MMI with ALPHA of 5 and BETA of 0.6 corresponds to low-level alert (GREEN). The input file and the header record is changed to reflect the added fields:

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID, \
      METRIC:MMI:ALPHA:GREEN,METRIC:MMI:BETA:GREEN, \
      METRIC:MMI:ALPHA:YELLOW,METRIC:MMI:BETA:YELLOW, \
```

```
      METRIC:MMI:ALPHA:RED,METRIC:MMI:BETA:RED
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794,5,0.6,7,0.6,8,0.6
CITY,Pasadena,Pasadena,34.1561,-118.1318,5,0.6,7,0.6,8,0.6
 ...
```

User Group Data

ShakeCast group is a new user classification introduced in Version 3. It is designed to replace the user profile of Version 2 and to provide area-specific processing and notifications for geographic regions defined by the users. Regarding user notifications, the user group is a primary channel of notifications for users with the same need of earthquake information. Both ShakeCast V2 user and profile functionality remain in V3 but is discouraged and is recommended to use group definition for filtering earthquakes and ShakeMaps for the regions of interest and for delivering user notifications.

To ease the transition from user profile to user group, format and requirements for defining a user group is the same as for defining a user profile. However, the same data may be interprets different in ShakeCast V3. For example, the polygon information in V2 was used to filter facilities for the purpose of notifications. In V3, the same polygon data is primarily used as a geospatial filter for incoming earthquakes and ShakeMaps. This function enables ShakeCast users to define their own monitoring regions beyond the existing ShakeMap region boundaries. Thus users may need to review the spatial coverage of their user profiles to make sure that they include all regions of their interest.

User group data is given in Apache config format. Lines begin with '#' and empty lines will be ignored. Spaces at the beginning and the end of a line will also be ignored as well as tabulators. If you need spaces at the end or the beginning of a value you can use apostrophe **"**. An option line starts with its name followed by a value. An '=' sign is optional. Some possible examples:

```
user    max
user  = max
user            max
```

If there is more than one statement with the same name, it will create an array instead of a scalar.

Each group is defined as a **block** of options. A **block** looks much like a block in the apache config format. It starts with <**blockname**> and ends with </**blockname**>. An example:

```
<CI>
   POLY       35.8000 -116.4000      \
              34.0815 -114.4717      \
              32.0000 -114.3333      \
              32.0000 -120.5000      \
              34.5000 -121.2500      \
              37.2167 -118.0167      \
              36.6847 -117.7930      \
              35.8000 -116.4000
   <NOTIFICATION>
              NOTIFICATION_TYPE      NEW_EVENT
              DELIVERY_METHOD        EMAIL_HTML
              EVENT_TYPE             ALL
   </NOTIFICATION>
   <NOTIFICATION>
              NOTIFICATION_TYPE      NEW_PROD
              DELIVERY_METHOD        EMAIL_HTML
```

```
                PRODUCT_TYPE            GRID_XML
                EVENT_TYPE              ALL
    </NOTIFICATION>
</CI>
```

Each group is defined as a **block** of options. A **block** looks much like a block in the well known apache config format. It starts with <**blockname**> and ends with </**blockname**>. The above example defines the user group **CI**.

Group Tag Names

The following group tag names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

poly (float pairs, required always)

This field identifies the boundaries of the group geometry. It must contain at least three anchor points in order to define a polygon. The total number of anchor points should limit to less than 100, otherwise the administration interface may not be able to display the entire polygon during editing. The manage_profile.pl will however process the polygon definition.

notification (Text(32), optional)

One notification block represents one notification request associated with the group and applies to all facilities within the group polygon. Multiple notification blocks for a group are permitted.

facility_type (Text, optional)

One notification block represents facility types to be associated with the group and applies to all facilities of the specified types within the group polygon. Multiple type specifications must be separated by white spaces.

description (Text(255), optional)

One description block includes a simple description of the group.

Notification Tag Names

Each notification block defines one notification request. Tag names are corresponding to the field names of the table "notification_request." Required tags for a notification block include `NOTIFICATION_TYPE`, `DELIVERY_METHOD`, and `EVENT_TYPE`. Valid notification types are `CAN_EVENT, NEW_EVENT, UPD_EVENT, SHAKING, NEW_PROD, and DAMAGE`.

can_event

This notification request is triggered when an event is cancelled by the seismic network in which the event was located and removed from the USGS web site. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

new_event

This notification request is triggered when an event is located by a seismic network. A ShakeMap may or may not be produced for the earthquake depending on triggering criteria defined by the ShakeMap producers. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

upd_event

This notification request is triggered when the source parameters of an event is updated with a new version by the seismic network. New versions of ShakeMaps for the event may or may not coincide with an updated event. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

new_prod

This notification request is triggered when a specified ShakeMap product of an event is available on the USGS web site. Require `EVENT_TYPE, DELIVERY_METHOD,` and `PRODUCT` tags.

shaking

This notification request is triggered when the ground shaking parameter at the location of the facility exceeds the preset value. Require `EVENT_TYPE, DELIVERY_METHOD, METRIC,` and `LIMIT_VALUE` tags.

alert-level

This notification request is triggered when the ground shaking parameter at the location of the facility falls between the high and low values of facility fragility settings. Require `EVENT_TYPE`, `DELIVERY_METHOD`, and `ALERT_LEVEL` tags.

User Data

The scope of user data for ShakeCast V3 covers three user categories: 1) regular user; 2) group user; and 3) administrative user. Besides the additional group user type, there is little change to the requirements of user data and they can be prepared in the CSV format to be imported into the ShakeCast database.

Similar to facility CSV data, the first record of user data file must contain column headers. These headers tell `manage_user.pl` how to interpret the rest of the records. Each header field must specify a user name field and a user type field. The header fields are case-insensitive; `username` and `USERNAME` are equivalent. Fields can appear in any order.

User Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

username (Text(32), required always)
This field identifies the user. It must be unique for a user type.

user_type (Text(10), required always)
This field identifies the type of use. It must match one of the types in the `user_type` table. Currently defined types are: ADMIN, USER, and SYSTEM.

full_name (Text(32), optional)
The value of this field is the user's full name.

email_address (Text(255), optional)
The value of this field is the user's email address for receiving communication from the ShakeCast system.

password (Text(64), optional)
The value of this field is used by ShakeCast to generate password for accessing the ShakeCast interface and the web site if password protected. Internally the password is saved inside the database using a cryptographic hash function SHA-256.

phone_number (Text(32), optional)
You can use this field to include a user's phone number.

Delivery Method Fields

Each field beginning with `DELIVERY:` is taken to be a delivery method specifier. The format of a delivery method specifier is:

DELIVERY:*delivery-method*

where *delivery-method* is a valid message format (PAGER, EMAIL_HTML, or EMAIL_TEXT). Examples of Delivery Method column labels are `DELIVERY:EMAIL_HTML` and `delivery:email_html`.

The message format values are defined by the ShakeCast system, and are generally not changed. The alert-level values shown above are the default values shipped with ShakeCast. These values are defined in your local ShakeCast database, and you may use the administration web interface to change those values and the color-names that refer to them.

Group Fields

A user can have notification requests replicated from an existing group. Each field beginning with `GROUP:` is taken to be a group specifier. The format of a profile specifier is:

GROUP:*group-name[:goup-name…]*

where *group-name* is a valid group name.

User Fields

A user can have notification requests replicated from an existing user. Each field beginning with `USER:` is taken to be a user specifier. The format of a user specifier is:

USER: *shakecast-user*

where *shakecast-user* is a valid user id. In V3, use of this option is discouraged.

Example Users File

Assume we have a file named *test_user.csv* containing users that we want to load into the ShakeCast database. The file is in CSV format and includes the name of each user, user delivery method and group association. The input file with the header record looks like

```
USER_TYPE,USERNAME,PASSWORD,FULL_NAME,EMAIL_ADDRESS,PHONE_NUMBER,DELIVERY:
PAGER,DELIVERY:EMAIL_HTML,GROUP:GLOBAL
USER,test_user,sc4all,Test User,testuser@usgs.gov,(123)456-7890,
testuser@usgs.gov, testuser@usgs.gov,GLOBAL
...
```

Plain-Text Product Template

ShakeCast V3 uses the same template engine (the Perl Template Toolkit) as V2 to generate plain-text products, such as csv, xml, and kml, etc. only available on the local ShakeCast system. A template also defined as a ShakeCast product can be included as an attachment in the ShakeCast notification to be delivered to the users directly. Please see the Template Manual manpage for the complete reference which goes into much greater details about the features and use of the Template Toolkit.

This section covers a brief summary of the template directives. ShakeCast specific identifiers include `exposure`, `item`, and `type`. Facility specific identifiers include `name`, `latitude`, `longitude`, `alert_level`, `MMI`, `PGA`, `PGV`, `PSA03`, `PSA10`, and `PSA30`.

GET

Evaluate and print a variable or value.

```
[%   GET variable %]
[%       variable %]
[%       hash.key %]
[%         list.n %]
[%     code(args) %]
[% obj.meth(args) %]
[%  "value: $var" %]
```

CALL

As per GET but without printing result (e.g. call code)

```
[%  CALL variable %]
```

SET

Assign a values to variables.

```
[% SET variable = value %]    # 'SET' also optional
[%     variable = other_variable
       variable = 'literal text @ $100'
       variable = "interpolated text: $var"
       list     = [ val, val, val, val, ... ]
       list     = [ val..val ]
       hash     = { var => val, var => val, ... }
%]
```

DEFAULT

Like SET above, but variables are only set if currently unset (i.e. have no true value).

```
[% DEFAULT variable = value %]
```

INSERT

Insert a file without any processing performed on the contents.

```
[% INSERT legalese.txt %]
```

INCLUDE

Process another template file or block and include the output. Variables are localised.

```
[% INCLUDE template %]
[% INCLUDE template  var = val, ... %]
```

PROCESS

As INCLUDE above, but without localising variables.

```
[% PROCESS template %]
[% PROCESS template  var = val, ... %]
```

WRAPPER

Process the enclosed block WRAPPER ... END block then INCLUDE the named template, passing the block output in the 'content' variable.

```
[% WRAPPER template %]
   content...
[% END %]
```

BLOCK

Define a named template block for subsequent INCLUDE, PROCESS, etc.,

```
[% BLOCK template %]
   content
[% END %]
```

FOREACH

Repeat the enclosed FOREACH ... END block for each value in the list.

```
[% FOREACH variable = [ val, val, val ] %]    # either
[% FOREACH variable = list %]                 # or
[% FOREACH list %]                            # or
   content...
   [% variable %]
[% END %]
```

WHILE

Enclosed WHILE ... END block is processed while condition is true.

```
[% WHILE condition %]
   content
[% END %]
```

IF / UNLESS / ELSIF / ELSE

Enclosed block is processed if the condition is true / false.

```
[% IF condition %]
   content
[% ELSIF condition %]
     content
[% ELSE %]
     content
[% END %]
[% UNLESS condition %]
   content
[% # ELSIF/ELSE as per IF, above %]
   content
[% END %]
```

SWITCH / CASE

Multi-way switch/case statement.

```
[% SWITCH variable %]
[% CASE val1 %]
   content
[% CASE [ val2, val3 ] %]
   content
[% CASE %]          # or [% CASE DEFAULT %]
   content
[% END %]
```

MACRO

Define a named macro.

```
[% MACRO name <directive> %]
[% MACRO name(arg1, arg2) <directive> %]
...
[% name %]
[% name(val1, val2) %]
```

FILTER

Process enclosed FILTER ... END block then pipe through a filter.

```
[% FILTER name %]                       # either
```

```
[% FILTER name( params ) %]             # or
[% FILTER alias = name( params ) %]     # or
   content
[% END %]
```

USE

Load a "plugin" module, or any regular Perl module if LOAD_PERL option is set.

```
[% USE name %]                          # either
[% USE name( params ) %]                # or
[% USE var = name( params ) %]          # or
...
[% name.method %]
[% var.method %]
```

PERL / RAWPERL

Evaluate enclosed blocks as Perl code (requires EVAL_PERL option to be set).

```
[% PERL %]
     # perl code goes here
     $stash->set('foo', 10);
     print "set 'foo' to ", $stash->get('foo'), "\n";
     print $context->include('footer', { var => $val });
[% END %]
[% RAWPERL %]
   # raw perl code goes here, no magic but fast.
   $output .= 'some output';
[% END %]
```

TRY / THROW / CATCH / FINAL

Exception handling.

```
[% TRY %]
     content
   [% THROW type info %]
[% CATCH type %]
     catch content
   [% error.type %] [% error.info %]
[% CATCH %] # or [% CATCH DEFAULT %]
     content
[% FINAL %]
   this block is always processed
[% END %]
```

NEXT

Jump straight to the next item in a FOREACH/WHILE loop.

```
[% NEXT %]
```

LAST

Break out of FOREACH/WHILE loop.

```
[% LAST %]
```

RETURN

Stop processing current template and return to including templates.

```
[% RETURN %]
```

STOP

Stop processing all templates and return to caller.

```
[% STOP %]
```

TAGS

Define new tag style or characters (default: [% %]).

```
[% TAGS html %]
[% TAGS <!-- --> %]
```

COMMENTS

Ignored and deleted.

```
[% # this is a comment to the end of line
   foo = 'bar'
%]
[%# placing the '#' immediately inside the directive
    tag comments out the entire directive
%]
```

Example Exposure Template

Assume we have a file named *exposure_csv.tt* containing template directives that we want to generate a local ShakeCast product "*exposure.csv*." The template file first includes a static header is in CSV format. The main body of the template file contains a directive that loops through exposure facilities and outputs selected fields, including basic facility information, shaking estimates and damage estimate. The template file with the header record looks like

```
FACILITY_TYPE,FACILITY_ID,FACILITY_NAME,DIST,LATITUDE,LONGITUDE,\
DAMAGE_LEVEL,MMI,PGA,PGV,PSA03,PSA10,PSA30,STDPGA,SVEL
[% FOREACH exposure = shakecast.exposure %]
[%- FOREACH item = exposure.item -%]
[% exposure.type %],"[% item.external_facility_id %]",\
"[% item.facility_name %]",[% item.DIST %],[% item.latitude %],\
[% item.longitude %],[% item.damage_level %],[% item.MMI %],\
[% item.PGA %],[% item.PGV %],[% item.PSA03 %],[% item.PSA10 %],\
[% item.PSA30 %],[% item.STDPGA %],[% item.SVEL %]

[%- END -%]
[% END %]
```

and the output exposure.csv looks like

```
FACILITY_TYPE,FACILITY_ID,FACILITY_NAME,DIST,LATITUDE,LONGITUDE,DAMAGE_LEV
EL,MMI,PGA,PGV,PSA03,PSA10,PSA30,STDPGA,SVEL
CITY,"101614","Warm Springs, NV (pop. 1K)",111.15,38.2,-
116.4,GREEN,1,0.02,0.01,0.01,0,0,,784
CITY,"100241","Caliente, NV (pop. 1.1K)",86.76,37.615,-
114.511,GREEN,1.08,0.02,0.01,0.02,0,0,,483.25
CITY,"100019","Alamo, NV (pop. < 1K)",32.61,37.365,-
115.164,GREEN,3.08,0.15,0.04,0.15,0.02,0,,460.5
...
```

Portable Document Format (PDF) Product Template

ShakeCast V3 introduces a new template engine to generate reports with flexible layouts in PDF format. Each PDF product template consists of one base PDF template and one configuration (or directive) file. Earthquake-specific PDF output will be saved into the earthquake-specific data directory under the same name as the PDF template. A template also defined as a ShakeCast product can be included as an attachment in the ShakeCast notification to be delivered to the users directly.

PDF directive file must be prepared in XML format. The PDF template engine runs as a middleware to translate directives to PDF layout commands. Thus although there are no ShakeCast-specific requirements, users need to refer to the Adobe PDF specifications regarding text, fonts, graphics, and other information needed to display it.

Each styled-content is defined as a **block** of options. A **block** looks much like a block in the well-known XML tag. It starts with <**blockname**> and ends with </**blockname**>. An example:

```
<image>
        <path>screenshot.jpg</path>
        <type>jpeg</type>
        <x>0</x>
        <y>0</y>
        <w>8.0</w>
        <h>4.0</h>
        <unit>inch</unit>
        <align>center</align>
        <valign>center</valign>
        <pad>0.1</pad>
</image>
```

defines the content and layout of an image.

The following PDF tag names are recognized. These fields correspond to specific PDF format specification.

page

Insert a new page in the PDF document. The example below inserts a new page in the PDF document and import a DYFI pdf into the page.

```
<page>
      <pdf>
            <path>eq_product/[EVID]/*_ciim.pdf</path>
      </pdf>
</page>
```

block

Insert a block of content inside a page at the specified location. The example below paints a gray rectangle with black borders and inserts a paragraph of text inside the block.

```
<block fillcolor="lightgrey" strokecolor="black" >
      <action>rect</action>
```

```
                <style>fillstroke</style>
                <x>0.1</x>
                <y>8.3</y>
                <w>8.3</w>
                <h>0.7</h>
                <unit>inch</unit>
                <text>
                      <string size="12" >These results are from an
automated system and users should consider the preliminary nature of
this information when making decisions relating to public safety.
ShakeCast results are often updated as additional or more accurate
earthquake information is reported or derived.</string>
                      <x>0.15</x>
                      <y>8.8</y>
                      <w>8.2</w>
                      <h>1.0</h>
                      <lead>10</lead>
                      <align>justify</align>
                      <unit>inch</unit>
                </text>
          </block>
```

text

Insert a text block at the specified location.

```
  <text>
          <string size="22" type="Times-Bold" >Magnitude [MAG] -
[LOCSTRING]</string>
          <x>0.1</x>
          <y>9.9</y>
          <w>7.0</w>
          <h>0.5</h>
          <align>justify</align>
          <unit>inch</unit>
  </text>
```

image

Insert an image from an external file at the specified location with respect to the event directory. If width (w) and height (h) are specified, the image will be resized to the specified dimensions. Acceptable image types are jpeg, tiff, png, gif, and gd.

```
  <image>
          <path>screenshot.jpg</path>
          <type>jpeg</type>
          <x>0</x>
          <y>0</y>
          <w>8.0</w>
          <h>4.0</h>
          <unit>inch</unit>
          <align>center</align>
          <valign>center</valign>
          <pad>0.1</pad>
  </image>
```

table

Insert a table from an external CSV file to the current page. The example below inserts a table to the specified location of the current page. New pages will be inserted if the length of the table exceeds the page height.

```
<table>
        <list>exposure.csv</list>
        <type>CITY USGS</type>
        <x>0.1</x>
        <w>8.3</w>
        <start_y>3.9</start_y>
        <next_y>10.75</next_y>
        <start_h>3.0</start_h>
        <next_h>10.0</next_h>
        <font_size>8</font_size>
        <padding>2</padding>
        <padding_right>2</padding_right>
        <background_color_even>snow</background_color_even>
        <background_color_odd>wheat</background_color_odd>
        <unit>inch</unit>
        <border>0.25</border>
        <border_color>snow</border_color>
<field>FACILITY_TYPE,FACILITY_ID,FACILITY_NAME,DIST,DAMAGE_LEVEL,MMI,P
GA,PGV,PSA03,PSA10,PSA30,SDPGA,SVEL</field>
</table>
```

APPENDIX B SHAKECAST XML/JSON METADATA FORMAT SPECIFICATIONS

Extensible Markup Language (known by the acronym XML) is a widely used and easily implemented method of exchanging data between disparate computer systems. The ShakeCast System receives ShakeMap information in XML from the USGS web server and uses XML to communicate all kinds of information between ShakeCast servers:

- Data about ShakeCast Servers and the ShakeCast software itself
- Data about events (earthquakes) and products (data files) available on the network
- Status information that helps the administrators of ShakeCast servers tell if their network is running smoothly

JavaScript Object Notation (JSON) is a text-based open standard designed for human-readable data. ShakeCast V3 adopts JSON as an alternative to the XML data for exchange of earthquake information. Specifically, the V3 system receives the USGS earthquake feed in the format of geographic data structures (GeoJSON) in order to retrieve selected earthquake products beyond ShakeMaps. The ShakeCast system also provides its own JSON data, primarily for the purpose of web presentations and for persistent data storage.

All locally generated XML and JSON files are stored in earthquake specific directory as cached content to be used primarily by the ShakeCast web server. This Section documents the ShakeCast XML and JSON file formats.

ShakeMap RSS Feed XML

RSS, which stands for "Really Simple Syndication" (sometimes called Rich Site Summary), has been adopted by news services, weblogs, and other online information services to send content to subscribers. After subscribing to an RSS feed, you will be notified when new content is available without having to visit the web site. The USGS ShakeMap RSS data feed contains


```
<?xml version="1.0"?>
<?xml-stylesheet href="shake_feed.xsl" type="text/xsl" media="screen"?>
<rss  xmlns:geo="http://www.w3.org/2003/01/geo/wgs84_pos#"
xmlns:dc="http://purl.org/dc/elements/1.1/"
xmlns:eq="http://earthquake.usgs.gov/rss/1.0/"  version="2.0">
<channel>
   <title>USGS Earthquake ShakeMaps</title>
   <description>List of ShakeMaps for events in the last 30
   days</description>
   <link>http://earthquake.usgs.gov/</link>
   <dc:publisher>U.S. Geological Survey</dc:publisher>
   <pubDate>Mon, 16 Jul 2007 20:23:29 +0000</pubDate>
   <item>
      <title>6.7 - NEAR THE WEST COAST OF HONSHU, JAPAN</title>
      <description><![CDATA[<img
      src="http://earthquake.usgs.gov/eqcenter/images/thumbs/shakemap_global_
      2007ewac.jpg" width="100" style="float:left;" />Date: Mon, 16 Jul 2007
```

```
      01:13:27 GMT<br />Lat/Lon: 37.574/138.44<br />Depth: 49<br
      />]]></description>
      <link>http://earthquake.usgs.gov/eqcenter/shakemap/global/shake/2007ewa
      c/</link>
      <pubDate>Mon, 16 Jul 2007 01:13:27 GMT</pubDate>
      <geo:lat>37.574</geo:lat>
      <geo:long>138.44</geo:long>
      <dc:subject>6</dc:subject>
      <eq:seconds>1184598989</eq:seconds>
      <eq:depth>49</eq:depth>
      <eq:region>global</eq:region>
      <eq:shakethumb>http://earthquake.usgs.gov/eqcenter/images/thumbs/shakem
      ap_global_2007ewac.jpg</eq:shakethumb>
   </item>
</channel>
</rss>
```


Event XML

A ShakeCast Event is described by Event XML. A sample Event XML is shown in the following figure:


```
<event event_id="SAF_south7.8_se" event_version="1" event_status="RELEASED"
event_type="SCENARIO" event_name="" event_location_description="SAF-southern
M7.8 Scenario" event_timestamp="2006-08-03 12:00:00"
external_event_id="SAF_south7.8_se" magnitude="7.8" lat="33.922270" lon="-
116.469670" />
```


Product XML

A ShakeCast Product is described by Product XML. A sample Product XML is shown in the following figure:


```
<product shakemap_id="SAF_south7.8_se" shakemap_version="1"
product_type="HAZUS" product_status="RELEASED" generating_server="1"
generation_timestamp="2007-02-08 16:07:03" lat_min="32.405603"
lat_max="35.455603" lon_min="-114.769670" lon_max="-119.353003" />
```


ShakeMap XML

A ShakeCast ShakeMap is described by ShakeMap XML. A sample ShakeMap XML is shown in the following figure:


```
<shakemap shakemap_id="SAF_south7.8_se" shakemap_version="1"
event_id="SAF_south7.8_se" event_version="1" shakemap_status="RELEASED"
```

```
generating_server="1" shakemap_region="ci" generation_timestamp="2007-02-08
16:07:03" begin_timestamp="2007-02-08 16:07:03" end_timestamp="2007-02-08
16:07:03" lat_min="32.405603" lat_max="35.455603" lon_min="-119.353003"
lon_max="-114.769670">
   <metric metric_name="MMI" min_value="10.0000" max_value="9.4900" />
   <metric metric_name="PGA" min_value="10.0002" max_value="9.9989" />
   <metric metric_name="PGV" min_value="10.0000" max_value="99.9109" />
   <metric metric_name="PSA03" min_value="10.0005" max_value="99.9687" />
   <metric metric_name="PSA10" min_value="10.0007" max_value="99.9747" />
   <metric metric_name="PSA30" min_value="1.7880" max_value="9.9989" />
</shakemap>
```

Exposure XML

A ShakeCast Exposure is described by Exposure XML. A sample Exposure XML is shown in the following figure;

```
<?xml version="1.0" encoding="UTF-8"?>
<exposure>
   xmlns:xlink="http://www.w3.org/1999/xlink"

   code_version="Pager 0.2.0"
   event_id="usneb6_06"
   version="1"
   timestamp="2006-10-11T16:07:03Z"
   source="us"
   status="RELEASED">

   <event
      type="ACTUAL"
      id="urn:earthquake.usgs.gov:origin:usneb6_06:1"
      magnitude="6.3"
      depth="17.1"
      latitude="-7.955000"
      longitude="110.430000"
      timestamp="2006-05-26T22:54:01GMT"
      description="JAVA, INDONESIA" />

   <shakemap
      code_version="3.1.1 GSM"
      id="urn:earthquake.usgs.gov:shakemap:usneb6_06:6"
      version="6"
      timestamp="2006-10-11T16:07:03Z"
      source="us"
      status="RELEASED" />

   <summary type="MMI" units="mmi">
      <bin label="I" value="1" range="[.5,1.5)" keywords="incomplete">
         <measure type="population" value="0" units="people"
source="landscan2005" />
      </bin>
      <bin label="II" value="2" range="[1.5,2.5)" keywords="incomplete">
         <measure type="population" value="0" units="people" />
```

```
      </bin>
      <bin label="III" value="3" range="[2.5,3.5)" keywords="incomplete">
         <measure type="population" value="963142" units="people" />
      </bin>
   </summary>
</exposure>
```

Facility Import XML

Facility data combining basic facility information, probabilistic fragility and feature data can be exported directly from Microsoft Excel using the XML Spreadsheet 2003 format to be imported into ShakeCast. A sample facility import XML is shown in the following figure:

```
<?xml version="1.0"?>
<?mso-application progid="Excel.Sheet"?>
<Workbook xmlns="urn:schemas-microsoft-com:office:spreadsheet"
 xmlns:o="urn:schemas-microsoft-com:office:office"
 xmlns:x="urn:schemas-microsoft-com:office:excel"
 xmlns:ss="urn:schemas-microsoft-com:office:spreadsheet"
 xmlns:html="http://www.w3.org/TR/REC-html40">
 <DocumentProperties xmlns="urn:schemas-microsoft-com:office:office">
  <Author>Lin, Kuo-wan</Author>
  <LastAuthor>Lin, Kuo-wan</LastAuthor>
  <Created>2013-08-30T19:13:27Z</Created>
  <Version>14.00</Version>
 </DocumentProperties>
 <OfficeDocumentSettings xmlns="urn:schemas-microsoft-com:office:office">
  <AllowPNG/>
 </OfficeDocumentSettings>
 <ExcelWorkbook xmlns="urn:schemas-microsoft-com:office:excel">
  <WindowHeight>7740</WindowHeight>
  <WindowWidth>19155</WindowWidth>
  <WindowTopX>120</WindowTopX>
  <WindowTopY>90</WindowTopY>
  <ProtectStructure>False</ProtectStructure>
  <ProtectWindows>False</ProtectWindows>
 </ExcelWorkbook>
 <Styles>
  <Style ss:ID="Default" ss:Name="Normal">
   <Alignment ss:Vertical="Bottom"/>
   <Borders/>
   <Font ss:FontName="Calibri" x:Family="Swiss" ss:Size="11"
ss:Color="#000000"/>
   <Interior/>
   <NumberFormat/>
   <Protection/>
  </Style>
  <Style ss:ID="s62">
   <Alignment ss:Vertical="Bottom" ss:WrapText="1"/>
   <Font ss:FontName="Calibri" x:Family="Swiss" ss:Size="11"
ss:Color="#000000"
    ss:Bold="1"/>
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
  </Style>
```

```
  <Style ss:ID="s63">
   <Alignment ss:Horizontal="Center" ss:Vertical="Bottom" ss:WrapText="1"/>
   <Font ss:FontName="Calibri" x:Family="Swiss" ss:Size="11"
ss:Color="#000000"
    ss:Bold="1"/>
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
  </Style>
  <Style ss:ID="s64">
   <Alignment ss:Horizontal="Center" ss:Vertical="Bottom" ss:WrapText="1"/>
   <Font ss:FontName="Calibri" x:Family="Swiss" ss:Size="11"
ss:Color="#000000"
    ss:Bold="1"/>
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
   <NumberFormat ss:Format="Fixed"/>
  </Style>
  <Style ss:ID="s65">
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
  </Style>
  <Style ss:ID="s66">
   <Alignment ss:Horizontal="Center" ss:Vertical="Bottom"/>
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
  </Style>
  <Style ss:ID="s67">
   <Alignment ss:Horizontal="Center" ss:Vertical="Bottom"/>
   <Interior ss:Color="#FFFFFF" ss:Pattern="Solid"/>
   <NumberFormat ss:Format="Fixed"/>
  </Style>
 </Styles>
 <Worksheet ss:Name="Sheet1">
  <Table ss:ExpandedColumnCount="19" ss:ExpandedRowCount="31921"
x:FullColumns="1"
   x:FullRows="1" ss:DefaultRowHeight="15">
   <Row ss:AutoFitHeight="0" ss:Height="47.25" ss:StyleID="s62">
    <Cell><Data ss:Type="String">EXTERNAL_FACILITY_ID</Data></Cell>
    <Cell><Data ss:Type="String">FACILITY_TYPE</Data></Cell>
    <Cell><Data ss:Type="String">COMPONENT_CLASS</Data></Cell>
    <Cell><Data ss:Type="String">COMPONENT</Data></Cell>
    <Cell><Data ss:Type="String">FACILITY_NAME</Data></Cell>
    <Cell><Data ss:Type="String">SHORT_NAME</Data></Cell>
    <Cell><Data ss:Type="String">DESCRIPTION</Data></Cell>
    <Cell><Data ss:Type="String">FEATURE:GEOM_TYPE</Data></Cell>
    <Cell><Data ss:Type="String">FEATURE:GEOM</Data></Cell>
    <Cell><Data ss:Type="String">FEATURE:DESCRIPTION</Data></Cell>
    <Cell ss:StyleID="s63"><Data ss:Type="String">METRIC</Data></Cell>
    <Cell ss:StyleID="s63"><Data
ss:Type="String">METRIC:ALPHA:GREEN</Data></Cell>
    <Cell ss:StyleID="s63"><Data
ss:Type="String">METRIC:BETA:GREEN</Data></Cell>
    <Cell ss:StyleID="s64"><Data
ss:Type="String">METRIC:ALPHA:YELLOW</Data></Cell>
    <Cell ss:StyleID="s63"><Data
ss:Type="String">METRIC:BETA:YELLOW</Data></Cell>
    <Cell ss:StyleID="s64"><Data
ss:Type="String">METRIC:ALPHA:ORANGE</Data></Cell>
    <Cell ss:StyleID="s63"><Data
ss:Type="String">METRIC:BETA:ORANGE</Data></Cell>
```

```
    <Cell ss:StyleID="s64"><Data
ss:Type="String">METRIC:ALPHA:RED</Data></Cell>
    <Cell ss:StyleID="s63"><Data
ss:Type="String">METRIC:BETA:RED</Data></Cell>
   </Row>
   <Row ss:StyleID="s65">
    <Cell><Data ss:Type="String">57C0705</Data></Cell>
    <Cell><Data ss:Type="String">BRIDGE_LC</Data></Cell>
    <Cell><Data ss:Type="String">SYSTEM</Data></Cell>
    <Cell><Data ss:Type="String">SYSTEM</Data></Cell>
    <Cell><Data ss:Type="String">57C0705 - SANTA MARIA CREEK S/E
FORK</Data></Cell>
    <Cell><Data ss:Type="String">57C0705</Data></Cell>
    <Cell><Data ss:Type="String">0.08M N/O HANSON LANE</Data></Cell>
    <Cell><Data ss:Type="String">POINT</Data></Cell>
    <Cell><Data ss:Type="String">-116.8664,33.0275,0</Data></Cell>
    <Cell><Data ss:Type="String">         &lt;table border=&quot;0&quot;
cellpadding=&quot;3&quot; cellspacing=&quot;3&quot; height=&quot;250&quot;
width=&quot;350&quot;&gt;                  &lt;tbody&gt;
      &lt;tr&gt;                           &lt;td colspan=&quot;2&quot;
style=&quot;background-color: rgb(0, 0, 0);&quot;&gt;
            &lt;span style=&quot;color:#ffffff;&quot;&gt;&lt;span
style=&quot;font-size: 16px;&quot;&gt;&lt;strong&gt;&lt;span
style=&quot;font-family: arial,helvetica,sans-serif;&quot;&gt;SANTA MARIA
CREEK S/E
FORK&lt;/span&gt;&lt;/strong&gt;&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
            &lt;/tr&gt;                           &lt;tr&gt;
      &lt;td style=&quot;text-align: right; background-color: rgb(153, 153,
153);&quot;&gt;                                 &lt;strong&gt;&lt;span
style=&quot;font-size:12px;&quot;&gt;&lt;span style=&quot;font-family:
arial,helvetica,sans-
serif;&quot;&gt;Owner:&lt;/span&gt;&lt;/span&gt;&lt;/strong&gt;&lt;/td&gt;
                        &lt;td style=&quot;background-color: rgb(153, 153,
153);&quot;&gt;                                 &lt;span style=&quot;font-
size:12px;&quot;&gt;&lt;span style=&quot;font-family: arial,helvetica,sans-
serif;&quot;&gt;Local&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
      &lt;/tr&gt;                           &lt;tr&gt;
      &lt;td style=&quot;text-align: right; background-color: rgb(204, 204,
204);&quot;&gt;                                 &lt;span style=&quot;font-
size:12px;&quot;&gt;&lt;span style=&quot;font-family: arial,helvetica,sans-
serif;&quot;&gt;&lt;strong&gt;Bridge
No:&lt;/strong&gt;&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
      &lt;td style=&quot;background-color: rgb(204, 204, 204);&quot;&gt;
                              &lt;span style=&quot;font-
size:12px;&quot;&gt;&lt;span style=&quot;font-family: arial,helvetica,sans-
serif;&quot;&gt;57C0705&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
      &lt;/tr&gt;                           &lt;tr&gt;
      &lt;td style=&quot;text-align: right; background-color: rgb(153, 153,
153);&quot;&gt;                                 &lt;span style=&quot;font-
size:12px;&quot;&gt;&lt;span style=&quot;font-family: arial,helvetica,sans-
serif;&quot;&gt;&lt;strong&gt;Location:&lt;/strong&gt;&lt;/span&gt;&lt;/span&
gt;&lt;/td&gt;                           &lt;td style=&quot;background-
color: rgb(153, 153, 153);&quot;&gt;
      &lt;span style=&quot;font-size:12px;&quot;&gt;&lt;span
style=&quot;font-family: arial,helvetica,sans-serif;&quot;&gt;0.08M N/O
HANSON LANE&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
      &lt;/tr&gt;                           &lt;tr&gt;
```

```
      &lt;td style=&quot;text-align: right; background-color: rgb(204, 204,
204);&quot;&gt;                                &lt;span style=&quot;font-
size:12px;&quot;&gt;&lt;span style=&quot;font-family: arial,helvetica,sans-
serif;&quot;&gt;&lt;strong&gt;Description:&lt;/strong&gt;&lt;/span&gt;&lt;/sp
an&gt;&lt;/td&gt;                                &lt;td
style=&quot;background-color: rgb(204, 204, 204);&quot;&gt;
                  &lt;span style=&quot;font-size:12px;&quot;&gt;&lt;span
style=&quot;font-family: arial,helvetica,sans-serif;&quot;&gt;1-span;
Prestressed concrete; Slab; 12 deg skew; 13 m Max Span Length; NBI Class 501;
Built 2001; Improved 2001&lt;/span&gt;&lt;/span&gt;&lt;/td&gt;
      &lt;/tr&gt;                  &lt;/tbody&gt;          &lt;/table&gt;
</Data></Cell>
    <Cell ss:StyleID="s66"><Data ss:Type="String">PSA10</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">10</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
    <Cell ss:StyleID="s67"><Data
ss:Type="Number">98.901344820675007</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
    <Cell ss:StyleID="s67"><Data
ss:Type="Number">118.68161378481</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
    <Cell ss:StyleID="s67"><Data
ss:Type="Number">168.13228619514749</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
   </Row>
   <Row ss:StyleID="s65">
    <Cell><Data ss:Type="String">57C0705</Data></Cell>
    <Cell><Data ss:Type="String">BRIDGE_LC</Data></Cell>
    <Cell><Data ss:Type="String">GENERAL_DISTRESS</Data></Cell>
    <Cell><Data ss:Type="String">ABUTMENT</Data></Cell>
    <Cell ss:Index="11" ss:StyleID="s66"><Data
ss:Type="String">PSA10</Data></Cell>
    <Cell ss:StyleID="s67"><Data
ss:Type="Number">8.2100000000000009</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
    <Cell ss:StyleID="s67"><Data
ss:Type="Number">90.152101901050102</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="Number">0.6</Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="String"></Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="String"></Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="String"></Data></Cell>
    <Cell ss:StyleID="s67"><Data ss:Type="String"></Data></Cell>
   </Row>
  </Table>
  <WorksheetOptions xmlns="urn:schemas-microsoft-com:office:excel">
   <PageSetup>
    <Header x:Margin="0.3"/>
    <Footer x:Margin="0.3"/>
    <PageMargins x:Bottom="0.75" x:Left="0.7" x:Right="0.7" x:Top="0.75"/>
   </PageSetup>
   <Selected/>
   <Panes>
    <Pane>
     <Number>3</Number>
     <ActiveRow>1</ActiveRow>
     <RangeSelection>R2:R31921</RangeSelection>
    </Pane>
```

```
    </Panes>
    <ProtectObjects>False</ProtectObjects>
    <ProtectScenarios>False</ProtectScenarios>
   </WorksheetOptions>
  </Worksheet>
  <Worksheet ss:Name="Sheet2">
   <Table ss:ExpandedColumnCount="1" ss:ExpandedRowCount="1" x:FullColumns="1"
    x:FullRows="1" ss:DefaultRowHeight="15">
   </Table>
   <WorksheetOptions xmlns="urn:schemas-microsoft-com:office:excel">
    <PageSetup>
     <Header x:Margin="0.3"/>
     <Footer x:Margin="0.3"/>
     <PageMargins x:Bottom="0.75" x:Left="0.7" x:Right="0.7" x:Top="0.75"/>
    </PageSetup>
    <ProtectObjects>False</ProtectObjects>
    <ProtectScenarios>False</ProtectScenarios>
   </WorksheetOptions>
  </Worksheet>
  <Worksheet ss:Name="Sheet3">
   <Table ss:ExpandedColumnCount="1" ss:ExpandedRowCount="1" x:FullColumns="1"
    x:FullRows="1" ss:DefaultRowHeight="15">
   </Table>
   <WorksheetOptions xmlns="urn:schemas-microsoft-com:office:excel">
    <PageSetup>
     <Header x:Margin="0.3"/>
     <Footer x:Margin="0.3"/>
     <PageMargins x:Bottom="0.75" x:Left="0.7" x:Right="0.7" x:Top="0.75"/>
    </PageSetup>
    <ProtectObjects>False</ProtectObjects>
    <ProtectScenarios>False</ProtectScenarios>
   </WorksheetOptions>
  </Worksheet>
</Workbook>
```

Facility Feature Shaking XML

Facility feature shaking XML describes ground-shaking estimates within or along the footprints of facilities for the specified ShakeMap. It contains shaking estimates only for facilities with defined geometry feature. A sample facility feature shaking XML is shown in the following figure:

```
<?xml version="1.0" encoding="utf-8"?>
<kml>
<grid_field index="1" name="LON"/>
<grid_field index="2" name="LAT"/>
<grid_field index="3" name="PGA"/>
<grid_field index="4" name="SVEL"/>
<grid_field index="5" name="PSA03"/>
<grid_field index="6" name="MMI"/>
<grid_field index="7" name="PGV"/>
<grid_field index="8" name="PSA30"/>
<grid_field index="9" name="PSA10"/>
```

```
<facility id="27-A-a">
<geom_shaking>-
117.676512368421,33.5527855263158,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.677138857258,33.5540927826784,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.678030566667,33.5552422,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.679133671875,33.55618890625,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.680390588235,33.5569211764706,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.681761858527,33.5574195542636,13.64,330,24.41,6.04,13.19,3.16,12.95
-117.683193220238,33.5576959464286,13.64,330,24.41,6.04,13.19,3.16,12.95
</geom_shaking>
<geom_type>POLYLINE</geom_type>
</facility>
</kml>
```


USGS Earthquake JSON Feed

USGS earthquake JSON feed provides information of earthquakes and related products available on the USGS web site. A sample earthquake JSON feed is shown in the following figure:


```
{
	type: "FeatureCollection",
	metadata: {
		generated: 1379445250000,
		url:
		"http://earthquake.usgs.gov/earthquakes/feed/v1.0/summary/1.0_day
		.geojson",
		title: "USGS Magnitude 1.0+ Earthquakes, Past Day",
		status: 200,
		api: "1.0.11",
		count: 101
	},
features: [
	{
	type: "Feature",
	properties: {
		mag: 1.1,
		place: "41km SSW of North Pole, Alaska",
		time: 1379439188000,
		updated: 1379439776911,
		tz: -480,
		url:
		"http://earthquake.usgs.gov/earthquakes/eventpage/ak10807381",
		detail:
		"http://earthquake.usgs.gov/earthquakes/feed/v1.0/detail/ak108073
		81.geojson",
		felt: null,
		cdi: null,
		mmi: null,
		alert: null,
		status: "AUTOMATIC",
		tsunami: null,
		sig: 19,
		net: "ak",
```

```
        code: "10807381",
        ids: ",ak10807381,",
        sources: ",ak,",
        types: ",general-link,geoserve,nearby-cities,origin,",
        nst: null,
        dmin: null,
        rms: 0.27,
        gap: null,
        magType: "Ml",
        type: "earthquake",
        title: "M 1.1 - 41km SSW of North Pole, Alaska"
    },
    geometry: {
        type: "Point",
        coordinates: [
        -147.7486,
        64.4188,
        9.7
        ]
    },
    id: "ak10807381"
    },
```

Facility Fragility Probability JSON

Facility fragility probability JSON describes ground shaking estimates within or along the footprints of facilities for the specified ShakeMap. It contains shaking estimates only for facilities with defined geometry feature. A sample facility feature shaking XML is shown in the following figure:

```
{
"26074":
    [
        {
            "damage_level":"GREEN,YELLOW",
            "facility_id":"26074",
            "metric":"PGA",
            "prob_damage_level":"NA",
            "component":"LANDSLIDE",
            "class":"GROUND_FAILURE_HAZARD",
            "cdf":"0,0",
            "prob_distribution":"1,0,0"
        },
        {
            "damage_level":"GREEN,YELLOW",
            "facility_id":"26074",
            "metric":"PGA",
            "prob_damage_level":"NA",
            "component":"LIQUEFACTION",
            "class":"GROUND_FAILURE_HAZARD",
            "cdf":"0,0",
            "prob_distribution":"1,0,0"
        }
```

```
        ],
"25957":
        [
                {
                        "damage_level":"GREEN,YELLOW",
                        "facility_id":"25957",
                        "metric":"PGA",
                        "prob_damage_level":"NA",
                        "component":"LANDSLIDE",
                        "class":"GROUND_FAILURE_HAZARD",
                        "cdf":"0,0",
                        "prob_distribution":"1,0,0"
                },
                {
                        "damage_level":"GREEN,YELLOW",
                        "facility_id":"25957",
                        "metric":"PGA",
                        "prob_damage_level":"NA",
                        "component":"LIQUEFACTION",
                        "class":"GROUND_FAILURE_HAZARD",
                        "cdf":"0,0",
                        "prob_distribution":"1,0,0"
                }
        ]
}
```

Event JSON

JSON equivalent of ShakeCast Event XML. A sample Event JSON is shown in the following figure:

```
{
    "shakemap_version": "1",
    "magnitude": "3.66",
    "event_id": "nn00423851",
    "lat": "37.5105",
    "superceded_timestamp": null,
    "shakemap_id": "nn00423851",
    "event_source_type": "",
    "seq": "33443",
    "mag_type": "Mwr",
    "event_name": "",
    "event_status": "NORMAL",
    "event_type": "ACTUAL",
    "event_version": "7",
    "initial_version": "0",
    "depth": "5.5",
    "external_event_id": "",
    "grid_id": "3746",
    "event_location_description": "32km WNW of Alamo, Nevada",
    "event_region": "nn",
    "event_timestamp": "2013-09-16 14:12:31",
```

```
    "lon": "-115.4841",
    "major_event": null,
    "receive_timestamp": "2013-09-16 15:43:25"
}
```

ShakeMap JSON

JSON equivalent of ShakeCast ShakeMap XML. A sample Event JSON is shown in the following figure:

```
{
    "magnitude": "3.51",
    "shakemap_version": "3",
    "event_id": "nn00423851",
    "lat": "37.5135",
    "superceded_timestamp": "2013-09-16 14:20:42",
    "metric": [
        {
            "shakemap_version": "3",
            "min_value": "1",
            "metric_name": "MMI",
            "shakemap_id": "nn00423851",
            "max_value": "5.33",
            "value_column_number": "3"
        },
        {
            "shakemap_version": "3",
            "min_value": "0.01",
            "metric_name": "PGA",
            "shakemap_id": "nn00423851",
            "max_value": "3.11",
            "value_column_number": "1"
        },
        {
            "shakemap_version": "3",
            "min_value": "0",
            "metric_name": "PGV",
            "shakemap_id": "nn00423851",
            "max_value": "0.38",
            "value_column_number": "2"
        },
        {
            "shakemap_version": "3",
            "min_value": "0.01",
            "metric_name": "PSA03",
            "shakemap_id": "nn00423851",
            "max_value": "3.5",
            "value_column_number": "4"
        },
        {
            "shakemap_version": "3",
            "min_value": "0",
            "metric_name": "PSA10",
            "shakemap_id": "nn00423851",
```

```
            "max_value": "0.13",
            "value_column_number": "5"
        },
        {
            "shakemap_version": "3",
            "min_value": "0",
            "metric_name": "PSA30",
            "shakemap_id": "nn00423851",
            "max_value": "0",
            "value_column_number": "6"
        },
        {
            "shakemap_version": "3",
            "min_value": "301.25",
            "metric_name": "SVEL",
            "shakemap_id": "nn00423851",
            "max_value": "1061",
            "value_column_number": "8"
        }
    ],
    "end_timestamp": "2013-09-16 15:26:55",
    "shakemap_id": "nn00423851",
    "lon_max": "-114.4841",
    "shakemap_region": "nn",
    "begin_timestamp": "2013-09-16 15:26:55",
    "seq": "33435",
    "lat_min": "36.7105",
    "mag_type": "ml",
    "event_type": "ACTUAL",
    "shakemap_status": "RELEASED",
    "lon_min": "-116.4841",
    "depth": "5.57",
    "event_version": "1",
    "generation_timestamp": "2013-09-16 15:26:55",
    "event_location_description": "32km WNW of Alamo, Nevada",
    "lat_max": "38.3105",
    "lon": "-115.4817",
    "event_timestamp": "2013-09-16 14:12:31",
    "generating_server": "1",
    "receive_timestamp": "2013-09-16 14:19:29"
}
```


Shaking JSON

Shaking JSON describes ground shaking estimates at facility sites for the selected earthquake. A sample Shaking JSON is shown in the following figure:


```
{
    "facility_probability": {},
    "grid": {
        "shakemap_version": "3",
        "shakemap_id": "nn00423851",
        "lon_max": "-114.4841",
```

```
        "lon_min": "-116.4841",
        "origin_lon": "-115.4841",
        "grid_id": "3749",
        "latitude_cell_count": "97",
        "origin_lat": "37.5105",
        "lat_max": "38.3105",
        "longitude_cell_count": "121",
        "lat_min": "36.7105",
        "receive_timestamp": "2013-09-17 19:34:32"
    },
    "facility_shaking": {
        "171187": {
            "pgv": "0.01",
            "psa10": "0",
            "facility_id": "171187",
            "svel": "784",
            "mmi": "1",
            "psa03": "0.01",
            "psa30": "0",
            "dist": "111.15",
            "pga": "0.02",
            "grid_id": "3749"
        },
        "169854": {
            "pgv": "0.01",
            "psa10": "0",
            "facility_id": "169854",
            "svel": "483.25",
            "mmi": "1.08",
            "psa03": "0.02",
            "psa30": "0",
            "dist": "86.76",
            "pga": "0.02",
            "grid_id": "3749"
        },
        "169641": {
            "pgv": "0.04",
            "psa10": "0.02",
            "facility_id": "169641",
            "svel": "460.5",
            "mmi": "3.08",
            "psa03": "0.15",
            "psa30": "0",
            "dist": "32.61",
            "pga": "0.15",
            "grid_id": "3749"
        }
    }
}
```


Damage JSON

Damage JSON describes fragility settings and damage state estimates at facility sites for the selected earthquake. A sample Damage JSON is shown in the following figure:

```
{
    "facility_probability": {},
    "grid": {
        "shakemap_version": "3",
        "lon_max": "-114.4841",
        "shakemap_id": "nn00423851",
        "lon_min": "-116.4841",
        "grid_id": "3749",
        "origin_lon": "-115.4841",
        "latitude_cell_count": "97",
        "origin_lat": "37.5105",
        "lat_max": "38.3105",
        "longitude_cell_count": "121",
        "lat_min": "36.7105",
        "receive_timestamp": "2013-09-16 15:29:51"
    },
    "damage_summary": {
        "GREEN": 2
    },
    "count": 2,
    "facility_attribute": null,
    "facility_damage": {
        "169854": {
            "psa10": "0",
            "pgv": "0.01",
            "facility_id": "169854",
            "low_limit": "1",
            "svel": "483.25",
            "lon_max": "-114.511",
            "metric": "MMI",
            "psa03": "0.02",
            "psa30": "0",
            "lat_min": "37.615",
            "damage_level": "GREEN",
            "facility_fragility_id": "877837",
            "mmi": "1.08",
            "dist": "86.76",
            "high_limit": "5",
            "lon_min": "-114.511",
            "facility_type": "CITY",
            "facility_name": "Caliente, NV (pop. 1.1K)",
            "pga": "0.02",
            "grid_id": "3749",
            "update_timestamp": null,
            "lat_max": "37.615",
            "update_username": null
        },
        "169641": {
            "psa10": "0.02",
            "pgv": "0.04",
            "facility_id": "169641",
            "low_limit": "1",
            "svel": "460.5",
            "lon_max": "-115.164",
            "metric": "MMI",
            "psa03": "0.15",
            "psa30": "0",
```

```
            "lat_min": "37.365",
            "damage_level": "GREEN",
            "facility_fragility_id": "877198",
            "mmi": "3.08",
            "dist": "32.61",
            "high_limit": "5",
            "lon_min": "-115.164",
            "facility_type": "CITY",
            "facility_name": "Alamo, NV (pop. < 1K)",
            "pga": "0.15",
            "grid_id": "3749",
            "update_timestamp": null,
            "lat_max": "37.365",
            "update_username": null
        }
    },
    "type": null
}
```


Station JSON

Station JSON describes stations used to generate ShakeMap. A sample Station JSON is shown in the following figure:


```
[
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-117.43391",
        "station_id": "7",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.55046",
        "station_network": "CI",
        "station_name": "Adelanto Receiving Station",
        "external_station_id": "ADO",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-118.76699",
        "station_id": "8",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.14647",
        "station_network": "CI",
        "station_name": "Agoura",
        "external_station_id": "AGO",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-118.29946",
```

```
        "station_id": "9",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.68708",
        "station_network": "CI",
        "station_name": "Antelope",
        "external_station_id": "ALP",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
]
```

Station JSON

Station JSON describes stations used to generate ShakeMap. A sample Station JSON is shown in the following figure:

```
[
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-117.43391",
        "station_id": "7",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.55046",
        "station_network": "CI",
        "station_name": "Adelanto Receiving Station",
        "external_station_id": "ADO",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-118.76699",
        "station_id": "8",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.14647",
        "station_network": "CI",
        "station_name": "Agoura",
        "external_station_id": "AGO",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
    {
        "source": "Southern California Seismic Network",
        "commtype": "DIG",
        "longitude": "-118.29946",
        "station_id": "9",
        "update_timestamp": "2011-01-11 10:07:08",
        "latitude": "34.68708",
        "station_network": "CI",
        "station_name": "Antelope",
        "external_station_id": "ALP",
        "receive_timestamp": "2013-09-17 19:41:16"
    },
]
```

Product JSON

JSON equivalent of ShakeCast Product XML. A sample Product JSON is shown in the following figure:


```
{
    "shakemap_version": "3",
    "shakemap_id": "nn00423851",
    "lon_max": "-114.4841",
    "lon_min": "-116.4841",
    "update_timestamp": "2013-09-16 15:29:48",
    "product_status": "RELEASED",
    "generation_timestamp": "2013-09-16 15:26:55",
    "lat_max": "38.3105",
    "product": [
        {
            "product_file_exists": "1",
            "metric": "MMI",
            "name": "Instrumental Intensity JPEG",
            "max_value": null,
            "description": null,
            "product_type": "INTEN_JPG",
            "product_id": "111052",
            "min_value": null,
            "filename": "intensity.jpg",
            "url": null
        },
        {
            "product_file_exists": "1",
            "metric": "PGA",
            "name": "PGA JPEG",
            "max_value": null,
            "description": null,
            "product_type": "PGA_JPG",
            "product_id": "111059",
            "min_value": null,
            "filename": "pga.jpg",
            "url": null
        }
]
```


Facility JSON

Facility JSON describes facilities currently populated inside the ShakeCast database. A sample Facility JSON is shown in the following figure:


```
{
    "facility_id": "171293",
    "short_name": "01 0002",
```

```
"model": [
    [
        {
            "damage_level": "YELLOW",
            "facility_id": "171293",
            "metric": "PSA10",
            "beta": "0.6",
            "facility_fragility_model_id": "1248",
            "update_timestamp": "2013-09-02 18:21:24",
            "component": "SUPPORT_RESTRAINER",
            "alpha": "90.1521019010501",
            "class": "SECONDARY",
            "update_username": "admin"
        },
        {
            "damage_level": "GREEN",
            "facility_id": "171293",
            "metric": "PSA10",
            "beta": "0.6",
            "facility_fragility_model_id": "1247",
            "update_timestamp": "2013-09-02 18:21:24",
            "component": "SUPPORT_RESTRAINER",
            "alpha": "9.94",
            "class": "SECONDARY",
            "update_username": "admin"
        }
    ]
],
"lon_max": "-124.055065",
"external_facility_id": "01 0002",
"feature": [
    {
        "update_timestamp": "2013-09-02 18:21:24",
        "geom": "41.553771,-124.055065",
        "geom_type": "POINT",
        "facility_id": "171293",
        "update_username": "admin",
        "description": "    "
    }
],
"attribute": [],
"lat_min": "41.553771",
"fragility_model": [
    {
        "abut_bearing": null,
        "system": null,
        "key": null,
        "landslide": null,
        "abutment": null,
        "support_seal": null,
        "hinge_restrainer": null,
        "abut_seal": null,
        "support_bearing": null,
        "column": null,
        "abut_restrainer": null,
        "hinge_seal": null,
        "response": null,
```

```
            "liquefaction": null,
            "hinge_bearing": null,
            "support_seat": null,
            "abut_seat": null,
            "hinge_seat": null,
            "foundation": null,
            "support_restrainer": null
        }
    ],
    "lon_min": "-124.055065",
    "description": "01-DN-101-8.14",
    "facility_name": "BRIDGE-123456",
    "facility_type": "BRIDGE",
    "update_timestamp": null,
    "lat_max": "41.553771",
    "fragility": [
        {
            "damage_level": "RED",
            "low_limit": "164.79416476536",
            "facility_id": "171293",
            "facility_fragility_id": "882593",
            "metric": "PSA10",
            "high_limit": "999999",
            "update_timestamp": null,
            "update_username": null
        },
        {
            "damage_level": "GREEN",
            "low_limit": "10",
            "facility_id": "171293",
            "facility_fragility_id": "882590",
            "metric": "PSA10",
            "high_limit": "96.9377439796238",
            "update_timestamp": null,
            "update_username": null
        },
        {
            "damage_level": "YELLOW",
            "low_limit": "96.9377439796238",
            "facility_id": "171293",
            "facility_fragility_id": "882591",
            "metric": "PSA10",
            "high_limit": "116.325292775549",
            "update_timestamp": null,
            "update_username": null
        },
        {
            "damage_level": "ORANGE",
            "low_limit": "116.325292775549",
            "facility_id": "171293",
            "facility_fragility_id": "882592",
            "metric": "PSA10",
            "high_limit": "164.79416476536",
            "update_timestamp": null,
            "update_username": null
        }
    ],
```

    "update_username": null,
    "receive_timestamp": "2013-09-17 19:53:36"
}

APPENDIX C SHAKECAST SCRIPT UTILITY REFERENCE MANUAL

A number of valuable Perl scripts are distributed with ShakeCast. This Appendix documents these utilities. For the most part, these scripts are internal to the system and normally users many need only a few of them, but users with complicated databases and needs may benefit at least an awareness of their functionality.

NAME

facility_feature_shaking.pl – Ground Shaking Estimation Tool for Facilities with Complex Geometry

SYNOPSIS

```
facility_feature_shaking.pl <operation> [ option ... ]
```

DESCRIPTION

The **facility_feature_shaking.pl** utility is used to generate ground-shaking estimates for facilities with complex geometry. It reads one event id and one version from the command line. Output of the script is saved in facility_feature_shaking.xml under the directory of the specified event.

The default grid processing routine of ShakeCast handles facilities with either point or rectangle shapes. Recognized complex shapes include circle, polyline, and polygon. The shaking information is considered as secondary and cannot be used as notification thresholds.

This script is usually invoked by ShakeCast as part of the automated process. It can be run manually or by the system workers through dispatcher tasks.

OPERATIONS

event
Specify ID of the event to process.
version
Specify Version of the event to process.

OPTIONS

--verbose
Display more detailed information about the progress of the analysis. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

facility_fragility_stat.pl – Probabilistic Fragility Estimation Tool for Facilities with Probability Fragility Curves

SYNOPSIS

```
facility_fragility_stat.pl <operation> [ option ... ]
```

DESCRIPTION

The **facility_fragility_stat.pl** utility is used to evaluate both CDF and distribution of likelihood of damage states for each identified components of the facility. It reads one event id and one version from the command line. Full fragility curve interpretation is one of the most time consuming processes of ShakeCast. The utility saves results of the analysis in both binary form “frag_prob.hash” and in text form “frag_prob.json”. The binary data is a fully structured data storage that captures a snapshot of the final data output that can be used by subsequent processes without repeating the same computation. The text-based JSON output is designed for presentations through the web interface.

The shaking information is considered as secondary and cannot be used as notification thresholds. The probability fragility tool provides detailed evaluations to complement the basic fragility and notification processes.

This script is usually invoked by ShakeCast as part of the automated process. It can be run manually or by the system workers through dispatcher tasks.

OPERATIONS

event
Specify ID of the event to process.
version
Specify Version of the event to process.

OPTIONS

--verbose
Display more detailed information about the progress of the analysis. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

facility_regulatory_level.pl – Tool for Evaluating Exceedance of Regulatory Levels for Nuclear Power Plants

SYNOPSIS

```
facility_regulatory_level.pl <operation> [ option ... ]
```

DESCRIPTION

The **facility_regulatory_level.pl** utility is used to evaluate exceedance of regulatory levels for nuclear power plants. Regulatory levels include SL1/OBE, SL2/SSE, and Reg. 1.166 Appendix A. It reads one event id and one version from the command line. Results of evaluations are saved in the output file "facility_regulatory_level.xml" to be used in preparing the PDF reports and to be displayed through the web interface.

The shaking information is considered as secondary and cannot be used as notification thresholds. Although the script is created for the nuclear industry as part of the project requirement, it can be modified to provide user-specific criteria as a rule-based analysis tool. The regulatory level tool provides detailed evaluations to complement the basic fragility and notification processes.

This script is usually invoked by ShakeCast as part of the automated process. It can be run manually or by the system workers through dispatcher tasks.

OPERATIONS

event
Specify ID of the event to process.
version
Specify Version of the event to process.

OPTIONS

--verbose
Display more detailed information about the progress of the analysis. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

gs_json.pl – USGS Earthquake JSON Feed Parser Tool

SYNOPSIS

```
gs_json.pl
```

DESCRIPTION

The **gs_json.pl** utility is used to parse the USGS earthquake JSON feed and selected products from the web server. Currently accepted earthquake product types include ShakeMap, DYFI?, LossPAGER, Earthquake Location Map, Historical Moment Tensor Map, Historical Seismicity Map, Tectonic Summary, Origin. The parser follows the JSON feed of individual earthquake products to download the selected products for use by the local ShakeCast system. Origin, ShakeMap, DYFI? and LossPAGER will invoke a Dispatcher task to handle the downloaded products.

This script is usually invoked by ShakeCast as part of the automated process. It can be run manually or queued to be handled by the system workers.

NAME

heartbeat.pl - ShakeCast Heartbeat Generator

SYNOPSIS

```
heartbeat.pl
```

DESCRIPTION

The **heartbeat.pl** utility is used to generate a ShakeCast event XML with event type as "`HEARTBEAT`." The output is injected into the ShakeCast system via **sm_inject.pl** and a copy stored in the ShakeMap data directory. This will trigger an event notification to users whom are subscribed to receiving heartbeat events.

The script reads no options from the command line. To create a customized heartbeat event, edit the script located inside the ShakeCast bin directory.

NAME

logrotate.pl - ShakeCast Log File Rotation Tool

SYNOPSIS

`logrotate.pl [ -conf config file ]`

DESCRIPTION

The **logrotate.pl** utility is used to generate rotating backup files of ShakeCast log files (`sc.log`, `sc_access.log`, and `sc_error.log`). Configurable parameters include `rotate-time`, `max_size`, `keep-files`, `compress`, and `status-file`. The administrator can schedule a routine run of this script for maintenance of ShakeCast log files.

The script reads one optional configuration file from the command line. The default configuration file is "sc.conf".

rotate-time
Specify the time windows for keeping log entries.
max_size
Specify the size limit of log files.
keep-files
Specify the number of backup log files to retain.
compress
Specify the compression option of backup log files.
status-file
Specify the filename of process status.

OPTIONS

--conf
Specify the filename of a custom configuration file to read process parameters for `logstats.pl`.

NAME

logstats.pl - ShakeCast Chart Generator for System Statistics

SYNOPSIS

```
logstats.pl [ -conf config file ]
```

DESCRIPTION

The **logstats.pl** utility is used to process ShakeCast log files (`sc.log`, `sc_access.log`, and `sc_error.log`) specified in the system configuration file and generate a set of image files in both histogram and pie charts. The daily activity chart is the default chart displayed in the default page of the Administration Web Interface. The administrator can schedule a routine run of this script to generate new statistics charts.

The script reads one optional configuration file from the command line. The default configuration file is "sc.conf".

OPTIONS

--conf
Specify the filename of a custom configuration file to read process parameters for `logstats.pl`.

NAME

manage_event.pl - ShakeCast Event Management Tool

SYNOPSIS

```
manage_event.pl [ mode ] [ option ... ] event_id [event_id2 ... ]
```

DESCRIPTION

The **manage_event.pl** utility is used to re-alert, or delete processed ShakeMap events in the ShakeCast database. It reads one or more event ids from the command line. Mode is one of –`resend` or --delete. `manage_event.pl` will return an error message if you do not specify a mode.

--resend
Reprocess notifications for the ShakeMaps and resend notifications to users who are on the recipient list.
--delete
Delete existing events. All information for the processed ShakeMaps will be removed from the ShakeCast database but not downloaded products in the file system.

OPTIONS

--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

manage_facility.pl - ShakeCast Facility Management Tool

SYNOPSIS

`manage_facility.pl [ mode ] [ option ... ] file.csv [ file2.csv ... ]`

DESCRIPTION

The **manage_facility.pl** utility is used to insert, update, or delete facility data in the ShakeCast database. It reads data from one or more CSV format files. One or more files must be given on the command line. Multiple files can have different formats. Mode is one of `--insert`, `--replace`, --delete, `--update`, or `--skip`. `manage_facility.pl` will operate in `replace` mode if you do not specify a mode.

--insert
New facility records are inserted. It is an error for the facility to already exist; if it does the input record is skipped.
--replace
New records are inserted. If there is an existing facility it is first deleted, along with any associated attributes and fragility levels. All required facility fields must be supplied.
--delete
Delete existing facilities. All required facility fields must be supplied.
--skip
New facility records are inserted. Records for existing facilities are skipped without generating an error. The summary report will indicate how many records were skipped.
--update
Update existing facilities. If the facility does not already exist an error is issued and the record is skipped.

In this mode the only required fields are `EXTERNAL_FACILITY_ID` and `FACILITY_TYPE`. Any group values are simply added to the existing set of attributes for the facility, unless the new value matches an existing value, in which case the group value is skipped. For metrics, any metric that appears in the input will be completely replaced.

OPTIONS

--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options
--limit=*n*
Terminate the import after ***n*** errors in input records. Set to 0 to allow an unlimited number of errors.

This limit only applies to errors encountered when processing a data record from the input file. More serious errors, such as omitting a required field, will always cause the entire input file to be skipped.

--quote=*x*

Use *x* as the quote character in the input file. The default quote character is a quote `(")`. This character is also used as the escape character within a quoted string.

--separator=*x*

Use *x* as the field separator character in the input file. The default separator character is a comma `(,)`.

FILE FORMAT

manage_facility.pl reads from one or more CSV-formatted files. By default fields are separated by commas and field values that include commas are protected by enclosing them in quotes, but these defaults can be modified; see the **--quote** and **--separator** options below.

The first record in the input file must contain column headers. These headers tell `manage_facility.pl` how to interpret the rest of the records. Each header field must specify a facility field, a facility metric field, or a group field. The header fields are case-insensitive; `facility_name` and `FACILITY_NAME` are equivalent. Fields can appear in any order.

Facility Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

external_facility_id (Text(32), required always)

This field identifies the facility. It must be unique for a facility type but the same external_facility_id may be used for different types of facilities.

facility_type (Text(10), required always)

This field identifies the type of facility. It must match one of the types in the `facility_type` table. Currently defined types are: BRIDGE, CAMPUS, CITY, COUNTY, DAM, DISTRICT, ENGINEERED, INDUSTRIAL, MULTIFAM, ROAD, SINGLEFAM, STRUCTURE, TANK, TUNNEL, UNKNOWN, and HAZUS building types. Refer the HAZUS Damage Level document for the 128 HAZUS building types and code era.

facility_name (Text(128), required for insert/replace)

The value of this field is what the user sees.

short_name (Text(10), optional)

The value of this field is used by ShakeCast when a shorter version of the name is needed due to space limitations in the output.

description (Text(255), optional)

You can use this field to include a short description of the facility.

lat (Float, required for insert/replace)

Specifies the latitude of the facility in degrees and fractional degrees.

lon (Float, required for insert/replace)

Specifies the longitude of the facility in degrees and fractional degrees.

Fragility Fields
Each field beginning with `METRIC:` is taken to be a facility fragility specifier. The format of a fragility specifier is:

METRIC:*metric-name***:***damage-level*

where *metric-name* is a valid Shakemap metric (MMI, PGV, PGA, PSA03, PSA10, or PSA30) and *damage-level* is a valid damage level (GREEN, YELLOW, ORANGE, or RED). Examples of Facility Fragility column labels are `METRIC:MMI:RED` and `metric:pga:yellow`.

The metric-name values are defined by the ShakeMap system, and are generally not changed. The above values are current as of summer 2007. The damage-level values shown above are the default values shipped with ShakeCast. These values are defined in your local ShakeCast database, and you may use the administration web interface to change those values and the color-names that refer to them.

Attribute Fields
A facility can have attributes associated with it. These attributes can be used to group and filter facilities.

Each field beginning with `ATTR:` is taken to be a facility attribute specifier. The format of a facility attribute specifier is:

ATTR:*attribute-name***:***attribute-value*

where *attribute-name* is a string not more than 20 characters in length.

Examples of Facility Attribute column labels are `ATTR:COUNTY` and `ATTR:Construction`. Attribute values can be any string up to 30 characters long.

EXAMPLES

Example 1 -- Point Facilities

Assume we have a file named *ca_cities.csv* containing California cities that we want to load into the ShakeCast database. The file is in CSV format and includes the name of each city and the latitude/longitude of its city center or city hall. Records in the file are of the form

```
Rancho Cucamonga,34.1233,-117.5794
Pasadena,34.1561,-118.1318
```

The file is missing two required fields, `external_facility_id` and `facility_type`. Since the city name is unique we can add a new column that is a copy of the name column and use that as the external_facility_id. Another column containing the value `CITY` for each row is added for the facility_type. You can either make these changes using a spreadsheet program or with a simple script written in a text processing language like Perl.

After making these modifications the records look like

```
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794
CITY,Pasadena,Pasadena,34.1561,-118.1318
```

The input file also needs a header record; after adding one the input file looks like

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,FACILITY_NAME,LAT,LON
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794
CITY,Pasadena,Pasadena,34.1561,-118.1318
 ...
```

The facilities in this file can now be loaded into ShakeCast using the command

```
manage_facility.pl ca_cities.csv
```

Example 2 -- Fragility Parameters

It is easy to load fragility parameters for your facilities using **manage_facility.pl**. Building on the previous example, assume a simple model where Instrumental Intensity (MMI) above 7 corresponds to high-level alert (RED), MMI between 5 and 7 corresponds to medium-level alert (YELLOW), and MMI below 5 corresponds to little a low-level (GREEN). The lower threshold of each range (1, 5, 7) is appended to every record in the input file and the header record is changed to reflect the added fields:

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,FACILITY_NAME,LAT,LON, \
      METRIC:MMI:GREEN,METRIC:MMI:YELLOW,METRIC:MMI:RED
CITY,Rancho Cucamonga,Rancho Cucamonga,34.1233,-117.5794,1,5,7
CITY,Pasadena,Pasadena,34.1561,-118.1318,1,5,7
 ...
```

Import this file as before. New facility data will replace existing ones.

Example 3 -- Multiple Attributes and Multiple Metrics

You can include multiple attributes, multiple metrics, or multiple attributes and multiple metrics for each row of an import file. For example,

```
FACILITY_TYPE,EXTERNAL_FACILITY_ID,ATTR:COUNTY, ATTR:SIZE,\
      METRIC:MMI:GREEN, METRIC:MMI:YELLOW, METRIC:MMI:RED
CITY,Rancho Cucamonga,San Bernardino,Small,1,2,6
CITY,Pasadena,os Angeles,Medium,1,2,6
```

This file would be loaded using the command

```
manage_facility.pl --update city_county.csv
```

The above example updates the existing city locations to associate them with a county attribute and a size attribute, and defines the green, yellow, and red alert level shaking thresholds.

NAME

manage_group.pl - ShakeCast Group Management Tool

SYNOPSIS

`manage_group.pl [ mode ] [ option ... ] [ profile.conf ] [ lat,lon … ]`

DESCRIPTION

The **manage_group.pl** utility is used to insert, update, or delete groups in the ShakeCast database and to associate facilities within the profile boundaries with the geometric profile. It reads data from a group configuration file or lat/lon pairs of a polygon from the command line. Mode is one of `--insert`, --delete, `--update`, or `--poly`. `manage_group.pl` will operate in `replace` mode if you do not specify a mode.

--insert
New groups are inserted. It is an error if the group already exists; if it does the input record is skipped.
--delete
Delete existing groups. All required group fields must be supplied.
--poly
Read polygon data from the command line and output facility data within the polygon boundaries.

OPTIONS

--conf
Specify the optional profile configuration file.
--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

FILE FORMAT

manage_group.pl reads data from a file in Apache config format. Lines begin with '#' and empty lines will be ignored. Spaces at the beginning and the end of a line will also be ignored as well as tabulators. If you need spaces at the end or the beginning of a value you can use apostrophe **"**. An option line starts with its name followed by a value. An '=' sign is optional. Some possible examples:

```
user    max
user  = max
user            max
```

If there is more than one statement with the same name, it will create an array instead of a scalar.

Each group is defined as a **block** of options. A **block** looks much like a block in the apache config format. It starts with <**blockname**> and ends with </**blockname**>. An example:

```
<CI>
    POLY        35.8000 -116.4000      \
                34.0815 -114.4717      \
                32.0000 -114.3333      \
                32.0000 -120.5000      \
                34.5000 -121.2500      \
                37.2167 -118.0167      \
                36.6847 -117.7930      \
                35.8000 -116.4000
    <NOTIFICATION>
                NOTIFICATION_TYPE      NEW_EVENT
                DELIVERY_METHOD        EMAIL_HTML
                EVENT_TYPE             ALL
    </NOTIFICATION>
    <NOTIFICATION>
                NOTIFICATION_TYPE      NEW_PROD
                DELIVERY_METHOD        EMAIL_HTML
                PRODUCT_TYPE           GRID_XML
                EVENT_TYPE             ALL
    </NOTIFICATION>
</CI>
```

Group Tag Names
The following profile tag names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.
poly (float pairs, required always)
This field identifies the boundaries of the profile geometry. It must contain at least three anchor points in order to define a polygon. The total number of anchor points should limit to less than 100, otherwise the administration interface may not be able to display the entire polygon during editing. The manage_profile.pl will however process the polygon definition.
notification (Text(32), optional)
One notification block represents one notification request associated with the profile and applies to all facilities within the profile polygon. Multiple notification blocks for a profile are permitted.

Notification Tag Names

Each notification block defines one notification request. Tag names are corresponding to the field names of the table "profile_notification_request." Required tags for a notification block include `NOTIFICATION_TYPE`, `DELIVERY_METHOD`, and `EVENT_TYPE`. Valid notification types are `CAN_EVENT, NEW_EVENT, UPD_EVENT, SHAKING, NEW_PROD, and DAMAGE`.

can_event

This notification request is triggered when an event is cancelled by the seismic network region in which the event was located and the ShakeMap removed from the USGS web site. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

new_event

This notification request is triggered when an event is located by a seismic network region and a ShakeMap becomes available on the USGS web site. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

upd_event

This notification request is triggered when the source parameters of an event is updated with a new version by the seismic network. New versions of ShakeMaps for the event may or may not coincide with an updated event. Require `EVENT_TYPE` and `DELIVERY_METHOD` tags.

new_prod

This notification request is triggered when a specified ShakeMap product of an event is available on the USGS web site. Require `EVENT_TYPE`, `DELIVERY_METHOD`, and `PRODUCT` tags.

shaking

This notification request is triggered when the ground shaking parameter at the location of the facility exceeds the preset value. Require `EVENT_TYPE`, `DELIVERY_METHOD`, `METRIC`, and `LIMIT_VALUE` tags.

damage

This notification request is triggered when the ground shaking parameter at the location of the facility falls between the high and low values of facility fragility settings. Require `EVENT_TYPE`, `DELIVERY_METHOD`, and `DAMAGE_LEVEL` tags.

NAME

manage_user.pl - ShakeCast User Management Tool

SYNOPSIS

`manage_user.pl [ mode ] [ option ... ] file.csv [ file2.csv ... ]`

DESCRIPTION

The **manage_user.pl** utility is used to insert, update, or delete user data in the ShakeCast database. It reads data from one or more CSV format files. One or more files must be given on the command line. Multiple files can have different formats. Mode is one of `--insert`, `--replace`, --delete, `--update`, or `--skip`. `manage_user.pl` will operate in `replace` mode if you do not specify a mode.

--insert
New user records are inserted. It is an error for the user to already exist; if it does the input record is skipped.
--replace
New records are inserted. If there is an existing user it is first deleted, along with any associated delivery addresses, notification requests and profiles. All required user fields must be supplied.
--delete
Delete existing users. All required user fields must be supplied.
--skip
New user records are inserted. Records for existing users are skipped without generating an error. The summary report will indicate how many records were skipped.
--update
Update existing users. If the user does not already exist an error is issued and the record is skipped.

In this mode the only required fields are `USERNAME` and `USER_TYPE`. Any delivery methods, profiles and users for cloning that appears in the input will be completely replaced.

OPTIONS

--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options
--limit=*n*
Terminate the import after ***n*** errors in input records. Set to 0 to allow an unlimited number of errors.

This limit only applies to errors encountered when processing a data record from the input file. More serious errors, such as omitting a required field, will always cause the entire input file to be skipped.

--quote=*x*

Use *x* as the quote character in the input file. The default quote character is a quote `(")`. This character is also used as the escape character within a quoted string.

--separator=*x*

Use *x* as the field separator character in the input file. The default separator character is a comma `(,)`.

FILE FORMAT

manage_ user.pl reads from one or more CSV-formatted files. By default fields are separated by commas and field values that include commas are protected by enclosing them in quotes, but these defaults can be modified; see the **--quote** and **--separator** options below.

The first record in the input file must contain column headers. These headers tell `manage_user.pl` how to interpret the rest of the records. Each header field must specify a user name field and a user type field. The header fields are case-insensitive; `username` and `USERNAME` are equivalent. Fields can appear in any order.

User Fields

The following facility names are recognized. These fields correspond to tables and columns in the ShakeCast database. Please refer to the ShakeCast Database Description for a more detailed description of the structure of the ShakeCast Database.

username (Text(32), required always)

This field identifies the user. It must be unique for a user type.

user_type (Text(10), required always)

This field identifies the type of use. It must match one of the types in the `user_type` table. Currently defined types are: ADMIN, USER, and SYSTEM.

full_name (Text(32), optional)

The value of this field is the user's full name.

email_address (Text(10), optional)

The value of this field is the user's email address for receiving communication from the ShakeCast system.

password (Text(10), optional)

The value of this field is used by ShakeCast to generate password for accessing the ShakeCast interface and the web site if password protected.

phone_number (Text(255), optional)

You can use this field to include a user's phone number.

Delivery Method Fields

Each field beginning with `DELIVERY:` is taken to be a delivery method specifier. The format of a delivery method specifier is:

DELIVERY:*delivery-method*

where *delivery-method* is a valid message format (PAGER, EMAIL_HTML, or EMAIL_TEXT). Examples of Delivery Method column labels are `DELIVERY:EMAIL_HTML` and `delivery:email_html`.

The message format values are defined by the ShakeCast system, and are generally not changed. The damage-level values shown above are the default values shipped with ShakeCast. These values are defined in your local ShakeCast database, and you may use the administration web interface to change those values and the color-names that refer to them.

Profile Fields
A user can have notification requests replicated from an existing profile. Each field beginning with `PROFILE:` is taken to be a profile specifier. The format of a profile specifier is:

PROFILE:*profile-name*

where *profile-name* is a valid profile name.

User Fields
A user can have notification requests replicated from an existing user. Each field beginning with `USER:` is taken to be a user specifier. The format of a user specifier is:

USER: *shakecast-user*

where *shakecast-user* is a valid user id.

NAME

map_tile.pl – ShakeCast Image Tile Generation Tool

SYNOPSIS

```
map_tile.pl -type map_type [ option ... ]
```

DESCRIPTION

The **map_tile.pl** utility is used to generate images tiles to be used by the mapping engine of the web interface. Initially, the generated map tiles are used by the Google Maps API and can also be used by other mapping engines, such as the OpenLayers or OpenStreetMap. It reads one map_type from the command line. The map type includes earthquake, facility, and station.

Earthquake tiles are dynamically updated as soon as a new event is processed by the ShakeCast system. Both facility and station tiles are considered semi-static. Update of these tiles can be done manually or by creating a cron job in the database to schedule generation of tiles.

OPTIONS

--map_type
Specify type of map tile to process. The type must be either "event_tile", "facility_tile", or "station_tile".
--min_zoom
Specify the minimum zoom level to process. The zoom level must be between 1 and 18.
--max_zoom
Specify the maximum zoom level to process. The zoom level must be between 1 and 18.
--rebuild
Delete all existing map tiles of the specified type before generating new map tiles.
--id
Create map tiles only for facility of the selected ID.
--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

sc_pdf.pl – ShakeCast PDF Report Generation Tool

SYNOPSIS

```
sc_pdf.pl -event event_id –version [ option ... ]
```

DESCRIPTION

The **sc_pdf.pl** utility is used to generate PDF reports for the selected earthquake. It reads one event id and one version from the command line. It will loop through all defined PDF templates in the PDF template directory. If a PDF report is successfully created, it will be registered as a local product and saved into the earthquake-specific data directory.

This script is usually invoked by ShakeCast as part of the automated process. It can be run manually or queued to be handled by the system workers.

OPTIONS

--event
Specify ID of the event to process.
--version
Specify Version of the event to process.
--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

scfeed_local.pl – ShakeMap Grid/Product Injection Tool

SYNOPSIS

```
scfeed_local.pl [ -event event_id ] [ option ... ]
```

DESCRIPTION

The **scfeed_local.pl** utility is used to process downloaded ShakeMap products located in the ShakeCast data directory. It reads one event id from the command line and creates XML messages before feeding them to ShakeCast. The injection process triggers the ShakeCast process in the same manner as for a real earthquake with respect to facility damage assessment and user notifications.

The name of an unprocessed ShakeMap must match the name of the event ID. ShakeMaps can be downloaded via the USGS ShakeMap link from the ShakeCast Administration Panel or manually from other sources. It will be renamed with the version number appended to the end of the directory name after **scfeed_local.pl** processed the ShakeMap. Outputs of ShakeCast XML files will also be stored in the same directory.

The script will quit gracefully if the ShakeMap has been processed earlier by the ShakeCast system and as a result no notifications will be delivered. To reprocess a ShakeMap that already exists in the ShakeCast system, the administrator will need to either convert the ShakeMap into a test event or delete the event first. In addition to the Administration Interface, an administrator can use the **tester.pl** utility to convert a ShakeMap to a test event and the **manage_event.pl** utility to delete a ShakeMap. The ShakeCast data directory for the deleted ShakeMap also needs to be removed from the file system before starting the reprocess procedure described earlier.

OPTIONS

--event
Specify ID of the event to process.
--scenario
Treat the ShakeMap as a scenario.
--force_run
Force ShakeCast to process the ShakeMap for events that do not meet the process criteria.
--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

shake_fetch.pl – ShakeMap Retrieval/Injection Tool

SYNOPSIS

```
shake_fetch.pl -network net_id -event event_id [ option ... ]
```

DESCRIPTION

The **shake_fetch.pl** utility is used to download and process ShakeMap located on the USGS web site. It reads one network id and one event id from the command line. ShakeMap products on the USGS web site are first downloaded before invoking the scfeed_local process to inject the ShakeMap into ShakeCast. The injection process is exactly the same as the scfeed_local script.

OPTIONS

--network
Specify ID of the network to process.
--event
Specify ID of the event to process.
--scenario
Treat the ShakeMap as a scenario.
--force_run
Force ShakeCast to process the ShakeMap for events that do not meet the process criteria.
--verbose
Display more detailed information about the progress of the import. This option may be repeated to increase detail further.
--help
Print a synopsis of program usage and invocation options

NAME

template.pl – ShakeCast General Templating Tool

SYNOPSIS

```
template.pl [ option ... ] –event event_id –template template
```

DESCRIPTION

The **template.pl** utility is used to generate ShakeCast facility summary for the specified event. The script reads at least one event ID and one template file from the command line. The output file is stored in the ShakeCast data directory for the specified event.

--event=s
Specify ID of the event to process.
--template=s
Specify filename of the template used to generate ShakeCast summary. The template files are located under the ShakeCast "template/xml" directory. The system comes with two default templates. "shakecast.tt" is the template for generating "exposure.xml' and the "kml.tt" for generating Google Earth kml format XML files.

OPTIONS

--version=n
Specify version number of the event to process.
--output=s
Specify filename of the output of ShakeCast summary. The output directory is the ShakeCast data directory for the specified event.
--help
Print a synopsis of program usage and invocation options

FILE FORMAT

template.pl is based on the Perl Template Toolkit. Please see the Template Manual manpage for the complete reference which goes into much greater details about the features and use of the Template Toolkit.

This section covers a brief summary of the template directives. ShakeCast specific identifiers include `exposure`, `item`, and `type`. Facility specific identifiers include `name`, `latitude`, `longitude`, `damage_level`, `MMI`, `PGA`, `PGV`, `PSA03`, `PSA10`, and `PSA30`.

GET
Evaluate and print a variable or value.

```
[%   GET variable %]
[%       variable %]
```

```
[%       hash.key %]
[%         list.n %]
[%     code(args) %]
[% obj.meth(args) %]
[%  "value: $var" %]
```

CALL

As per GET but without printing result (e.g. call code)

```
[%  CALL variable %]
```

SET

Assign a values to variables.

```
[% SET variable = value %]    # 'SET' also optional
[%     variable = other_variable
       variable = 'literal text @ $100'
       variable = "interpolated text: $var"
       list     = [ val, val, val, val, ... ]
       list     = [ val..val ]
       hash     = { var => val, var => val, ... }
%]
```

DEFAULT

Like SET above, but variables are only set if currently unset (i.e. have no true value).

```
[% DEFAULT variable = value %]
```

INSERT

Insert a file without any processing performed on the contents.

```
[% INSERT legalese.txt %]
```

INCLUDE

Process another template file or block and include the output. Variables are localised.

```
[% INCLUDE template %]
[% INCLUDE template  var = val, ... %]
```

PROCESS

As INCLUDE above, but without localising variables.

```
[% PROCESS template %]
[% PROCESS template  var = val, ... %]
```

WRAPPER

Process the enclosed block WRAPPER ... END block then INCLUDE the named template, passing the block output in the 'content' variable.

```
[% WRAPPER template %]
   content...
[% END %]
```

BLOCK

Define a named template block for subsequent INCLUDE, PROCESS, etc.,

```
[% BLOCK template %]
   content
[% END %]
```

FOREACH

Repeat the enclosed FOREACH ... END block for each value in the list.

```
[% FOREACH variable = [ val, val, val ] %]    # either
[% FOREACH variable = list %]                 # or
[% FOREACH list %]                            # or
   content...
   [% variable %]
[% END %]
```

WHILE

Enclosed WHILE ... END block is processed while condition is true.

```
[% WHILE condition %]
   content
[% END %]
```

IF / UNLESS / ELSIF / ELSE

Enclosed block is processed if the condition is true / false.

```
[% IF condition %]
   content
[% ELSIF condition %]
     content
[% ELSE %]
     content
[% END %]
[% UNLESS condition %]
   content
[% # ELSIF/ELSE as per IF, above %]
   content
[% END %]
```

SWITCH / CASE

Multi-way switch/case statement.

```
[% SWITCH variable %]
[% CASE val1 %]
   content
[% CASE [ val2, val3 ] %]
   content
[% CASE %]         # or [% CASE DEFAULT %]
   content
[% END %]
```

MACRO

Define a named macro.

```
[% MACRO name <directive> %]
[% MACRO name(arg1, arg2) <directive> %]
...
[% name %]
[% name(val1, val2) %]
```

FILTER

Process enclosed FILTER ... END block then pipe through a filter.

```
[% FILTER name %]                       # either
[% FILTER name( params ) %]             # or
[% FILTER alias = name( params ) %]     # or
   content
[% END %]
```

USE

Load a "plugin" module, or any regular Perl module if LOAD_PERL option is set.

```
[% USE name %]                          # either
[% USE name( params ) %]                # or
[% USE var = name( params ) %]          # or
...
[% name.method %]
[% var.method %]
```

PERL / RAWPERL

Evaluate enclosed blocks as Perl code (requires EVAL_PERL option to be set).

```
[% PERL %]
     # perl code goes here
```

```
        $stash->set('foo', 10);
        print "set 'foo' to ", $stash->get('foo'), "\n";
        print $context->include('footer', { var => $val });
    [% END %]
    [% RAWPERL %]
       # raw perl code goes here, no magic but fast.
       $output .= 'some output';
    [% END %]
```

TRY / THROW / CATCH / FINAL

Exception handling.

```
    [% TRY %]
         content
       [% THROW type info %]
    [% CATCH type %]
         catch content
       [% error.type %] [% error.info %]
    [% CATCH %] # or [% CATCH DEFAULT %]
         content
    [% FINAL %]
       this block is always processed
    [% END %]
```

NEXT

Jump straight to the next item in a FOREACH/WHILE loop.

```
    [% NEXT %]
```

LAST

Break out of FOREACH/WHILE loop.

```
    [% LAST %]
```

RETURN

Stop processing current template and return to including templates.

```
    [% RETURN %]
```

STOP

Stop processing all templates and return to caller.

```
    [% STOP %]
```

TAGS

Define new tag style or characters (default: [% %]).

```
    [% TAGS html %]
    [% TAGS <!-- --> %]
```

COMMENTS

Ignored and deleted.

```
    [% # this is a comment to the end of line
       foo = 'bar'
    %]
    [%# placing the '#' immediately inside the directive
        tag comments out the entire directive
    %]
```

NAME

task_inject.pl – ShakeCast Task Schedule Tool

SYNOPSIS

```
task_inject.pl task [ option ... ]
```

DESCRIPTION

The **task_inject.pl** utility is used to manually queue a task into the ShakeCast database. The queued task needs to be recognized by the ShakeCast Dispatcher or it will return a FAILED status.

The script is usually invoked from the administration interface but also can be executed directly. Depending on the task type, additional parameters are read from the command line.

OPTIONS

--task
Specify the type of task to process. Default task type includes '`comp_gmpe`', '`logrotate`', '`logstats`', '`heartbeat`', 'gs_json', 'maintain_event', 'facility_fragility_stat', 'facility_regulatory_level', 'facility_feature_shaking', 'screen_shot', or '`map_tile`'.
comp_gmpe
Compute theoretical ground motions for facilities of the specified earthquake. Additional event ID is read from the command line.
logrotate
Rotate the ShakeCast log files. No additional parameters are required.
logstat
Generate log statistics plots. No additional parameters are required.
heartbeat
Trigger a ShakeCast heartbeat message. No additional parameters are required.
gs_json
Refresh the USGS earthquake JSON feed and process new earthquakes. No additional parameters are required.
maintain_event
Trigger to maintain the ShakeCast database. Old ShakeMaps without exposure will be purged from the system. No additional parameters are required.
facility_fragility_stat
Trigger the process to compute probabilistic facility fragility. Additional one event ID and one Version parameters are read from the command line.
facility_regulatory_level
Trigger the process to compute exceedance of regulatory levels. This function is specifically design for nuclear power plants. Additional one event ID and one Version parameters are read from the command line. **facility_feature_shaking**

Trigger the process to compute facility feature shaking for the selected earthquake. Additional one event ID and one Version parameters are read from the command line.
screen_shot
Take a screen shot for the selected earthquake and save the output image. Additional one event ID and one Version parameters are read from the command line.
map_tile
Generate image tile overlay to be displayed on the web interface. Additional tile type parameter is read from the command line.

--event
Specify ID and Version of the event to process.

NAME

tester.pl – ShakeCast Test Event Tool

SYNOPSIS

`tester.pl [ option ... ]`

DESCRIPTION

The **tester.pl** utility is used to handle ShakeCast test events and includes conversion, listing, and triggering of test events. The script is usually invoked from the administration interface but also can be executed directly. It reads one process type from the command line.

OPTIONS

--type
Specify the type of action to process. Process type is one of '`event_menu`', '`new_test`', '`create_test`', '`inject_next`', or '`inject_first`'.
event_menu
Output a list of test events available on the system.
new_test
Output a list of actual events on the system that have not been converted into test events.
create_test
Convert the specified event into a test event that can be triggered locally. Require an additional `-key` option. A new data directory for the event will be created under the "test_data" directory with the name of event ID and "_scte" postfix.
inject_first
Trigger a ShakeCast process for the specified test event as a new event. Require an additional `-key` option.
inject_next
Trigger a ShakeCast process for the specified test event as an updated event. Require an additional `-key` option.

--key
Specify ID of the event to process. All information for the processed ShakeMaps will be removed from the ShakeCast database but not downloaded products in the file system.

APPENDIX D Converting HAZUS Structure Type to Potential Structural Damage Level

D.1 Selecting Model Building Type and Code Era

ShakeCast offers structural damage estimation capability adapted from the HAZUS-MH earthquake module (NIBS and FEMA, 2003). For any site of interest, the user begins by selecting from the available HAZUS model building types, of which there are 36 (table D.1). “Model building type” refers to the materials of construction (wood, steel, reinforced concrete, etc.), the system used to transmit earthquake forces from the ground through the building (referred to as the lateral force-resisting system), and sometimes height category (low-rise, mid-rise, and high-rise, which generally correspond to 1-3, 4-7, and 8+ stories, respectively).

The user must also select for each facility its building code era, of which there are four (high code, moderate code, low code, and pre-code; table D.2 and fig. D.1). Code eras reflect important changes in design forces or detailing requirements that matter to the seismic performance of a building. Sixteen combinations of model building type and code era do not exist (for example, high-code unreinforced masonry bearing wall), so in total there are 128 choices for HAZUS model building type and code era. Note that code era is largely a function of location and year built, so in principal ShakeCast could simplify the user’s job of selecting a code era by asking for era of construction (pre-1941, 1941-1975, or post-1975) instead and then looking up the code era via internal GIS database.

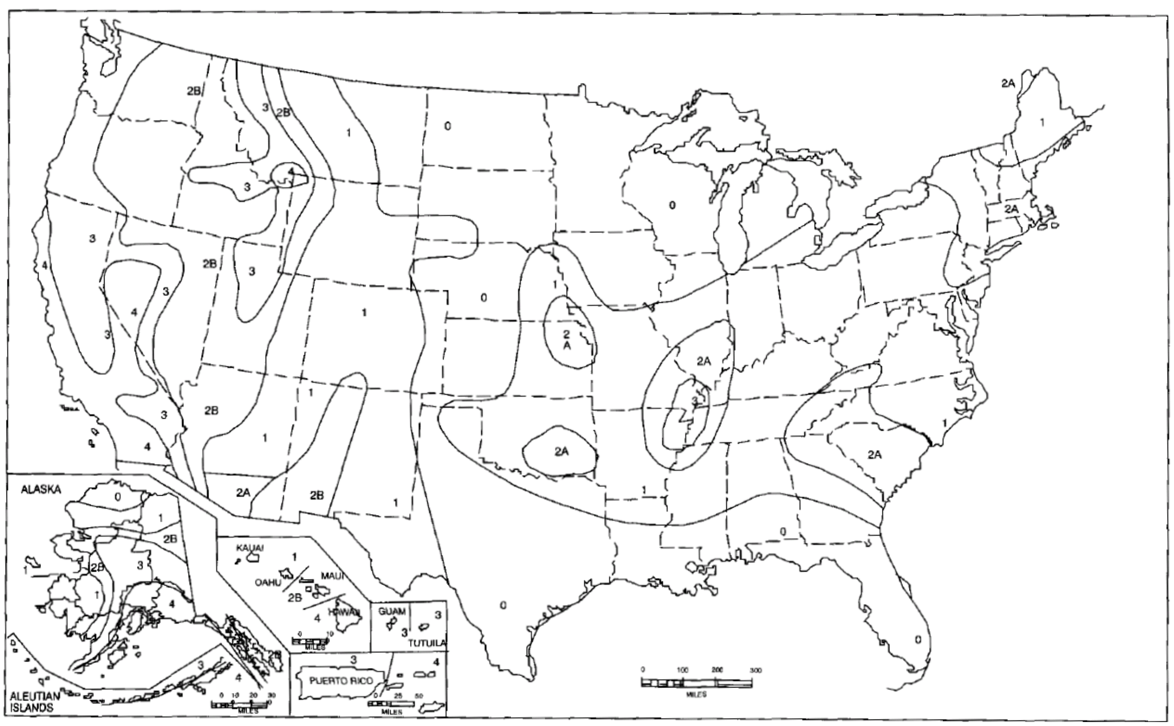

Figure D.1 Seismic zone map of the United States (fig. 16-2, ICBO, 1997).

D.2 Describing Potential Damage

The user selects between 3 and 4 alert levels, meaning that any facility affected by an earthquake is noted either green, yellow, or red (3 levels), or green, yellow, orange, or red (4 levels). These colors index the likely structural damage state of the facility in HAZUS terms: green corresponds to HAZUS' undamaged or slight structural damage states, yellow corresponds to moderate structural damage, orange to extensive structural damage, and red to complete structural damage. These terms (slight, moderate, etc.) are described via likely effects of the earthquake on the structural system. For example, for a small wood-frame building (W1, regardless of code era), "green" corresponds to "Undamaged or small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer." These descriptions can be found in the HAZUS-MH technical manual (NIBS and FEMA, 2003) Section 5.3.1.

The code level ("L" for "low") is appended to the structure's Label (e.g., "W1") in order to represent the internal ShakeCast facility type ("W1L") from which a look-up is used to retrieve the corresponding building-specific HAZUS-MH Technical Manual Table 5.16a-d median (alpha) and variability (beta) fragility values.

D.3 Relating Seismic Excitation to Structural Damage

When an earthquake occurs, its shaking intensity at each facility location is estimated in terms of peak horizontal ground acceleration (PGA). Buildings and ground motions are highly variable, even given a model building type and PGA level, so it is uncertain the exact level of PGA that will cause a given facility to experience structural damage of any particular level. The relationship between PGA and damage state is therefore probabilistic, meaning that one can estimate the probability of a given building experiencing a given structural damage state when the building experiences a certain level of PGA. It is more convenient here to estimate the PGA at which there is a given probability of damage exceeding a given structural damage state. In ShakeCast, a facility is indicated as damage level x (that is, green, yellow, orange, or red) when the PGA is such that there is at least a 50% probability of the corresponding HAZUS structural damage state and less than a 50% probability of the next-higher HAZUS structural damage state. These PGA values are taken from the HAZUS-MH Technical Manual Table 5.16a-d.

D.4 Tabular Lookup Data

Two lookup files in CSV format are provided with this manual, one for a three-level damage scheme; the other is for a four-level damage scheme. Each has seven columns or fields, listed in table D.3. The fields correspond to data appearing in the ShakeCast Facility Administration screen (see Section 4.3).

Table D.1. HAZUS-MH earthquake model building types (NIBS and FEMA, 2003, Table 3.1)

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1 2	W1 W2	**Wood, Light Frame (≤ 5,000 sq. ft.)** **Wood, Commercial and Industrial (>5,000 sq. ft.)**		1 - 2 All	1 2	14 24
3 4 5	S1L S1M S1H	**Steel Moment Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
6 7 8	S2L S2M S2H	**Steel Braced Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
9	S3	**Steel Light Frame**		All	1	15
10 11 12	S4L S4M S4H	**Steel Frame with Cast-in-Place Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
13 14 15	S5L S5M S5H	**Steel Frame with Unreinforced Masonry Infill Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 13	24 60 156
16 17 18	C1L C1M C1H	**Concrete Moment Frame**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
19 20 21	C2L C2M C2H	**Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
22 23 24	C3L C3M C3H	**Concrete Frame with Unreinforced Masonry Infill Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
25	PC1	**Precast Concrete Tilt-Up Walls**		All	1	15
26 27 28	PC2L PC2M PC2H	**Precast Concrete Frames with Concrete Shear Walls**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
29 30	RM1L RM2M	**Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms**	Low-Rise Mid-Rise	1-3 4+	2 5	20 50
31 32 33	RM2L RM2M RM2H	**Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms**	Low-Rise Mid-Rise High-Rise	1 - 3 4 - 7 8+	2 5 12	20 50 120
34 35	URML URMM	**Unreinforced Masonry Bearing Walls**	Low-Rise Mid-Rise	1 – 2 3+	1 3	15 35
36	MH	**Mobile Homes**		All	1	10

Table D.2. HAZUS-MH guidelines for selection of damage functions for typical buildings based on UBC seismic zone and building age (NIBS and FEMA, 2003, Table 5.20).

UBC Seismic Zone (NEHRP Map Area)	**Post-1975**	**1941 - 1975**	**Pre-1941**
Zone 4 (Map Area 7)	High-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 3 (Map Area 6)	Moderate-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 2B (Map Area 5)	Moderate-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 2A (Map Area 4)	Low-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 1 (Map Area 2/3)	Low-Code	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)
Zone 0 (Map Area 1)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)

Table D.3. Layout of damage lookup tables.

Field name	**Type**	**Description**
ID	Integer	A unique index
Facility Type	String	HAZUS model building type and seismic design level
Color	String	Green, Yellow, Orange, or Red
Damage Level	String	Equivalent HAZUS structural damage level(s)
Low Limit	Integer	Intensity with 50% probability of this damage level occurring
High Limit	Integer	Intensity with 50% probability of next damage level occurring
Metric	String	Intensity metric

APPENDIX H Caltrans ShakeCast V3 Implementation Recommendation

See pdf attachment Caltrans ShakeCast V3 Implementation Recommendation.

Caltrans ShakeCast V3

IMPLEMENTATION RECOMMENDATION

Version <*1.0*>

<*04/22/2014*>

1 Introduction

1.1 Purpose

This document presents recommendations for the technology infrastructure and setup requirements for deploying the ShakeCast V3 system at Caltrans. The contents of this report are intended for use by information technology (IT) professionals to serve as a technical reference during the deployment process.

The recommendations contained in this document draw from the extensive experience of scientists and IT professionals at the United States Geological Survey (USGS) National Earthquake Information Center (NEIC), having operated robust 24/7 earthquake notification and reporting systems for the past 40 years for worldwide earthquakes. The Caltrans ShakeCast V3 system will be required to operate continuously under similar requirements, delivering critical post-earthquake information to Caltrans responders.

1.2 System Overview

ShakeCast, short for ShakeMap Broadcast, is a fully automated system for delivering specific ShakeMap products to critical users and for triggering established post-earthquake response protocols (Figure 1.1). ShakeMap is a well-established tool used to portray the extent of potentially damaging shaking following an earthquake. It is available and can be found on the Internet at http://earthquake.usgs.gov/shakemap. It was developed for and is used primarily for emergency response, loss estimation, and public information. However, for an informed response to a serious earthquake, critical users must go beyond just looking at ShakeMap, and understand the likely extent and severity of impact on the facilities for which they are responsible. To this end the USGS has developed ShakeCast.

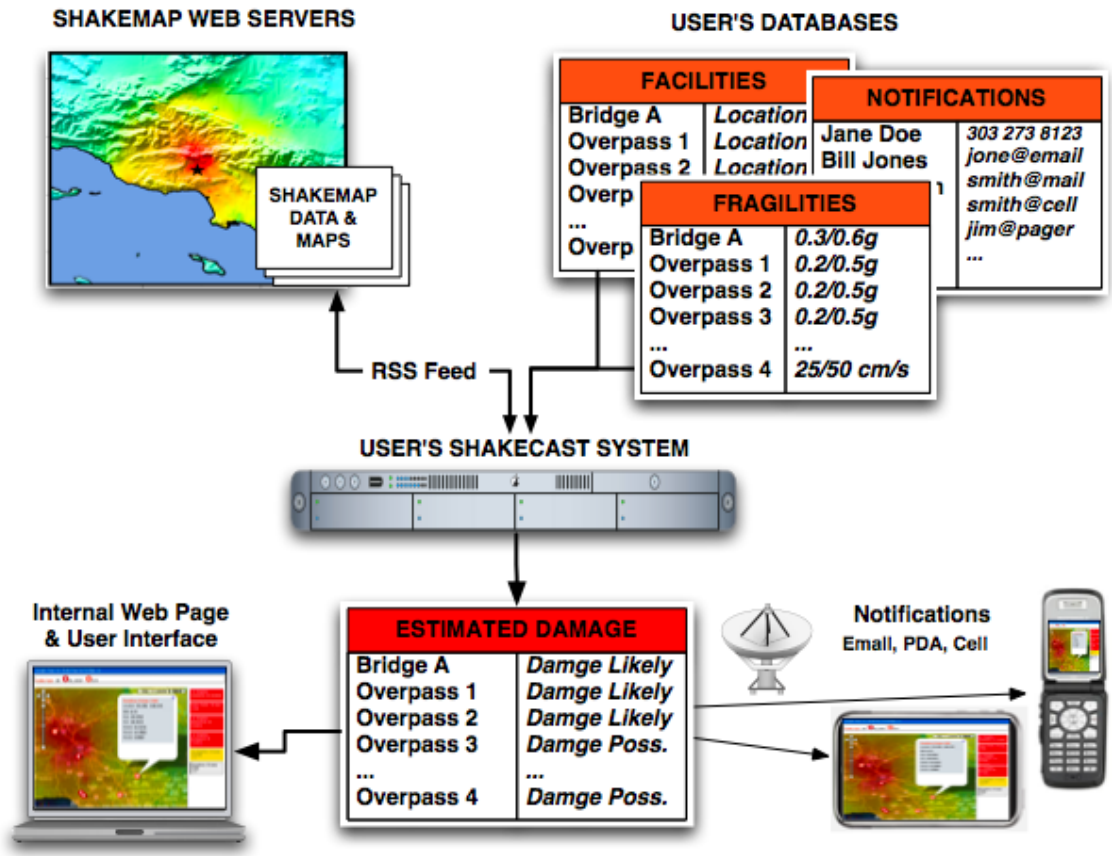

Figure 1.1 ShakeCast flow chart indicating flow of USGS ShakeMap data, users' ShakeCast inventory and user databases, and notifications.

1.2.1 Background

The Caltrans ShakeCast V3 system was developed through a research project in the Division of Research, Innovation, and System Information (DRISI) and continues work that began under a partnership between Caltrans and the USGS to develop, deploy and support an enhanced pilot version of ShakeCast within Caltrans. This new version adds behind-the-scenes capabilities and flexibility to accommodate a broader range of facility types (e.g., bridges, buildings, roads) and user-group information that enable more effective dissemination of information, and more accurate and better tailored messages per requirements of Caltrans user groups.

Up until late 2013, ShakeCast V2 had been running on two physical servers at the Transportation Laboratory in Sacramento. Measures were taken to insure a low level of system downtime, including the use of redundant serves, data storage, power supplies, and 24/7 system error monitoring. Although this deployment had been operating dependably over the course of the phase 1 project and much of the phase 2 project, a more comprehensive deployment and operational plan was needed that draws upon the expertise of the USGS in deploying similar systems, while maintaining alignment with Caltrans' Information Technology (IT) standards and requirements set forth by the California Department of Finance (DOF). An interim solution was adopted in late 2013, where the physical ShakeCast V2 servers were decommissioned, and the ShakeCast systems were migrated to virtual machines on Caltrans intranet servers. A similar VM deployment approach was also adopted for the rollout of the new ShakeCast V3 system.

1.2.2 System Description

To support development and testing work over the course of the research project, the Caltrans ShakeCast V3 system was set up to operate on several development platforms. The primary development server was established by the USGS at the NEIC in Golden, Colorado. Two additional servers were set up on the Amazon Web Services (AWS) in northern Virginia to facilitate testing and review between USGS and Caltrans project team members. The system at NEIC is a prototype system and an exact replica is installed on a Caltrans intranet server as a system Virtual Machine (VM). Once the Caltrans ShakeCast system is fully tested and ready for operations, the Caltrans system will become the primary system and will serve earthquake products and notifications to Caltrans users. A redundant backup Caltrans VM is also being set up.

1.3 System Environment

The project initially called for implementation of the ShakeCast V3 system running under a Linux environment. At the beginning of the phase 2 project, Caltrans IT was in the process of migrating all internet and intranet servers from older Sun Solaris systems to newer Linux-based servers. The team, at that time, envisioned deploying ShakeCast on the same Linux platform, coexisting with other department web applications, sharing the standard suite of base web technologies (e.g., Apache, MySQL, and PHP).

After numerous discussions between Caltrans and USGS IT staff and deliberation of technical aspects, it became clear that deployment of ShakeCast alongside other Caltrans web applications was not only going to be technically challenging, the overall performance and reliability of ShakeCast services would likely be compromised. The strategy was then shifted towards the deployment of ShakeCast under an independent VM instance that could be more easily configured and tuned to maximize system reliability.

Up to that point in the project, the application had been successfully installed on Red Hat Enterprise Linux Server 6, CentOS Linux 6, and SUSE Linux Enterprise 12 for both 32 and 64-bit systems. Specifically, the system on AWS is a ShakeCast VM in CentOS Linux. Caltrans IT, however, requested that VM instances be built upon either SUSE Enterprise Linux Server or Windows 2008 Server. Caltrans IT indicated that both platforms were supported and no strong preference given to one platform or the other. Deploying on the SUSE Enterprise Linux Server was going to require some additional work by the USGS team due to differences between SUSE Enterprise and CentOS Linux Server in the handling of packages and system administrative functions. Windows Server had been used to date for the current ShakeCast system and the system administrator was already familiar with configuring and maintaining a Windows based system.

Considering the challenges with the SUSE Enterprise Linux Server configuration and the benefits of the Windows Server solution, a new strategy was devised by the team to bundle the ShakeCast application under the Microsoft Windows Server operating system (2008 or later) as a standalone system VM image in addition to the standard installation package. The Caltrans ShakeCast system is an example of VM deployment.

The ShakeCast administrator can decide the method and location of the deployment of a standard ShakeCast VM and to modify the configurations regarding security and access controls to meet specific needs.

1.3.1 Assumptions and Constraints

Our design goal for the ShakeCast reference implementation is that a modestly knowledgeable personal computer user can install the entire system and begin receiving useful, reliable, authenticated, location-specific reports of earthquake shaking with about an hour of effort. A further goal is to continue enhancement and extension of ShakeCast so that ShakeMap information can be made more readily usable by their organizations. These goals will require significant ongoing efforts from both civil engineers and software developers to improve the quality of input inventory and to define and produce custom products and information that benefit the entire ShakeCast community.

Specifically, the list of items to consider prior to a ShakeCast system implementation include:

- Schedule for at least 1-2 hours for ShakeCast implementation after creation of the reference operating system (VM).
- Budget for personnel cost, license fee of the VM operating system, and host VM for system installation. The ShakeCast application is free to use and modify. Consulting resources may be needed to prepare engineered facility inventory.
- Access to support for administration of the operating system (user account and application), firewall policy configuration (inbound and outbound traffic), and SMTP server configuration.
- Knowledge of Apache web server configuration, MySQL database configuration, system deamon process, and system/shell/Perl script languages in order to customize the installed system.

1.3.2 System Organization

Figure 1.2 shows main components of a typical ShakeCast installation. These components are universal to all operating systems and vary depending on platform specific implementation requirements. Detailed specifications for both hardware and software are described in Section 3.1. The reference implementation consists of several major components applicable to every operating system, including:

- One database server with earthquake and ShakeMap data, user's inventory data, and results of shaking and vulnerability analysis for earthquake-impacted facilities
- One web server with USGS earthquake products (for example, ShakeMap, ShakeCast, PAGER, etc.), user and administrative interface, and full RESTful API services
- One directory server with a base ShakeCast system of executable scripts and utility programs, configurations, and product and notification templates

- Between four and up to seven daemon services to automatically retrieve earthquake information and products from USGS, perform shaking and vulnerability analysis, and send out notifications to ShakeCast users.

This report assumes all ShakeCast components are installed on the same system. It is possible to separate the database server and the web server from the main ShakeCast system. The directory server and the daemon services must reside on the same system. Before separating database and web components from the main ShakeCast system, the system administrator needs to make sure proper policies are in place for accessing these servers over the network.

It is recommended to plan for a dedicated server for a ShakeCast installation. Utilization of system resources by the application varies greatly and depends on both the number of facilities being evaluated which is known ahead of time, but also on the number of significant events in any earthquake sequence, which is not predictable. When implemented as a standalone system, the administrator can determine the allowed number of generic workers to run simultaneously based on the available resources. When ShakeCast is installed in an operating system sharing resources with other applications, the administrator will need to prorate resources in advance by reducing the maximum number of generic workers.

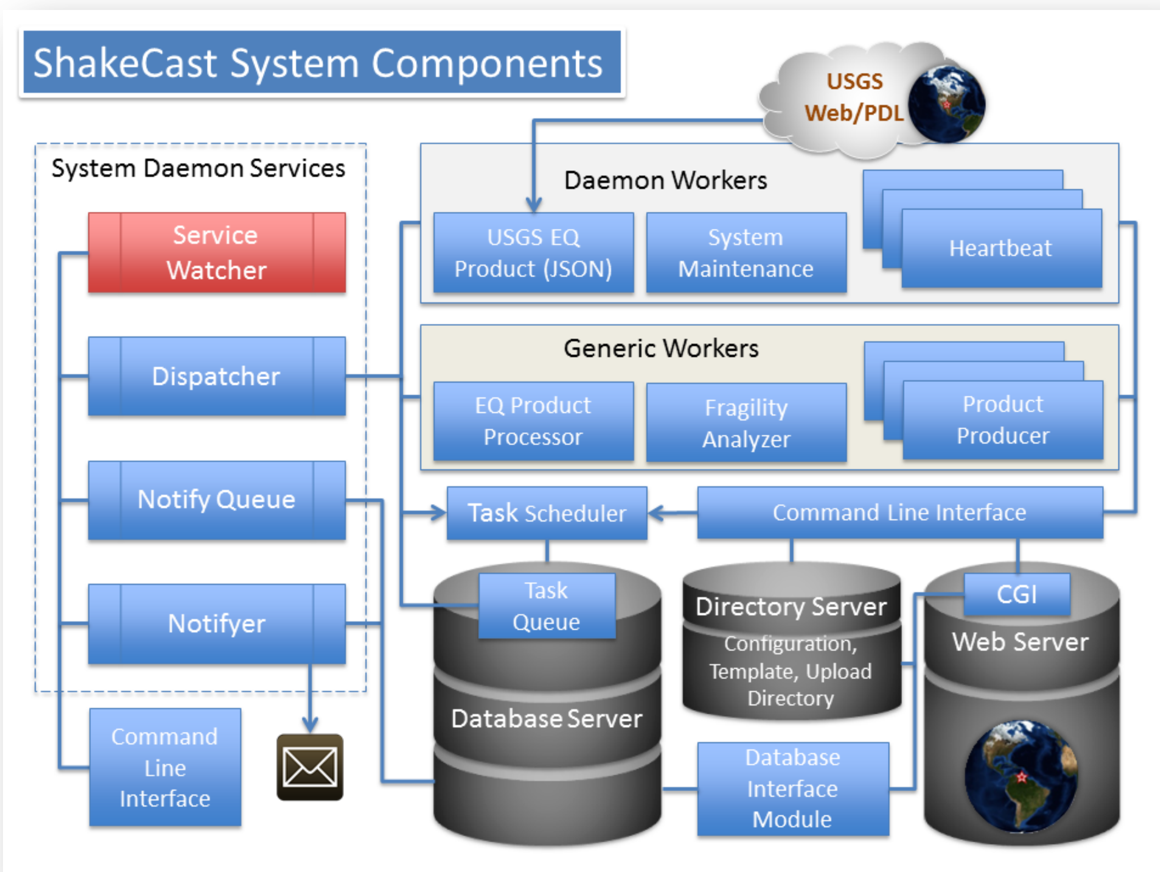

Figure 1.2 ShakeCast system component chart describing main components of a ShakeCast system. The number of daemon workers is configurable and only a subset of both daemon and generic workers are shown.

2 Management Overview

2.1 Description of Implementation

The procedure described in this section applies to a standalone installation of the ShakeCast system. Unlike the ShakeCast V2 system, which carries a server-specific identity, the V3 system is designed to be generic internally. Thus, once a base system is created, such as virtual machine, it can be used to replicate additional systems as needed without repeating the implementation.

A typical ShakeCast system implementation takes place in several phases in sequence, including host operating system preparation, application installation, activation, application configuration, inventory loading, and testing. The administrator needs to validate each main component of the system shown in Figure 1.2 during the implementation and to involve persons with appropriate expertise. An end-to-end functional test can only be performed after all main components are functioning properly.

2.2 Points-of-Contact

Key Person	Role
Caltrans Project/Program Manager	Oversee the ShakeCast project and coordinate activities regarding research, implementation, and operation of the ShakeCast system at Caltrans
Virtual Machine Administrator	Administer the host server for ShakeCast VMs and configure system components for the virtual machine
Security/Firewall Policy Administrator	Administer user account, account privileges, firewall settings, and network interconnectivity (USGS web server and Caltrans SMTP server)
ShakeCast System Administrator	Install ShakeCast software; administer ShakeCast database inventory on facilities, earthquakes, groups, and users; maintain the ShakeCast system
USGS ShakeCast Team	Provide training and technical support on the ShakeCast system

Table 2.2 Points-of-Contact

2.3 Major Tasks

This section lists major tasks of a typical ShakeCast implementation. Activation of the system is marked when ShakeCast daemon services are successfully launched. Each major task should be conducted in incremental phases, including:

- Preparation of host operating system with specified hardware and software specifications
- Configuration of firewall wall policies with permitted inbound traffic (TCP/UDP) for HTTP, HTTPS, SSH, and RDP protocols for authorized domains
- Configuration of firewall wall policies with permitted outbound traffic for EMAIL server on SMTP protocol, optional SSL/TLS protocols, the USGS domain (usgs.gov) on HTTP protocol, and optional PDL (39977) protocol
- Creation of user account with administrative privileges for the ShakeCast installation (MS-Windows)
- Installation of database engine (MySQL) with only local access and updated root password
- Installation of web server (Apache) with secure layer option (openssl)
- Installation of Perl with required modules listed in Sec. 3.1.2
- Installation of supporting utilities for gnuplot, wkhtmltopdf, and git
- Installation of optional web-based database management support (PHP/phpMyAdmin)
- Installation of ShakeCast base system (default folder “C:\ShakeCast” for Windows and “/usr/local/shakecast” for UNIX)
- Initialization of ShakeCast database with database account, schema, and default data inventory
- Initialization of ShakeCast web server domain with ShakeCast web in both HTTP and HTTPS protocols and access control
- Loading of facility inventory
- Loading of user group inventory with defined earthquake monitoring regions
- Loading of user inventory with at least one more ShakeCast administrator account and updated credentials for the default administrator account “scadmin”
- Activation of the ShakeCast application
- Functional test of the system with ShakeCast heartbeat (notification) and ShakeMap scenario (damage assessment)

2.4 System Security

The default setup of a ShakeCast system allows access via both the command line using SSH and the web with HTTP or HTTPS. The ShakeCast web server is designed to serve earthquake information to users and to allow administrators to conduct general administration of the system (Lin *et al*., 2014). Command line access via SSH (Linux) should be limited to only administrators. ShakeCast tasks not covered by the web interface are considered as advanced topics for experienced ShakeCast administrators. In the most secured setup of ShakeCast, the administrator can choose to disable access from the web and only permits SSH access.

Firewall and system level security setup are platform specific issues not covered by this manual. Even though ShakeCast implements a basic authentication scheme, it is highly recommended to implement system-level firewall policies to limit exposure to the Internet. These rules will take precedence over the ShakeCast-defined user authentication scheme. For inbound traffic, firewall policies are effective methods to define domains where users can access the products and information of the ShakeCast server. For outbound traffic, firewall policies should permit the USGS Web server http://earthquake.usgs.gov, the source for all earthquake products processed by ShakeCast. For ShakeCast systems receiving earthquake products via the USGS Product Distribution Layer (PDL) client, the program uses port 39977 to connect to the upstream hub server.

3 Implementation Support

3.1 Hardware, Software, Facilities, and Materials

3.1.1 Hardware

Recommended minimum hardware specifications for the ShakeCast system includes:

- Single Intel Xeon E5-2670 equivalent processor.
- 1GB RAM.
- 30GB hard drive storage.
- Low performance Internet connection (<1MB/s).

The above hardware setup is roughly equivalent to the “micro” instance on the Amazon Elastic Compute Cloud (Amazon EC2) in which the performance was assessed.

Depending on the size of facility and user inventory and the earthquake monitoring areas, more hardware resources will be needed in order to deliver anticipated performance. USGS earthquake products (ShakeMap, ShakeCast, lossPAGER, DYFI?, and others) for each processed earthquake usually consume 30-50 MB of hard drive space. For ShakeCast systems designated for earthquake response purpose, we recommend to at least double the minimum recommended hardware specifications. During the testing phase, the Caltrans ShakeCast V3 system hosting over 26,000 facilities and approximately 400 users in several groups required a VM with the following hardware-equivalent specifications for the primary and backup servers:

- Quad Intel Xeon X5670 2.9GHz processors.
- 8GB RAM.
- 100GB hard drive storage.
- High performance Internet connection.

3.1.2 Software

The ShakeCast V3 system is distributed for both Linux and MS-Windows operating systems. The system is built on an open-source stack of supporting applications shared by all platforms,

- Apache Web server 2.x.
- MySQL database 5.x.
- Perl 5.14+ scripting language.
- Modules: DBI, DBD::mysql, Text::CSV_XS, Config::General, enum, XML::Parser, XML::LibXML, XML::Writer, XML::Twig, XML::Simple, Template-toolkit, PDF::API2, PDF::Table, MIME::Lite, GD, GD::Text, GD::Graph, GD::Graph3d, HTML::TableExtract, Net::SSLeay, Net::SMTP::SSL, Net::SMTP::TLS, Authen::SASL, Archive::Zip, JSON, JSON::XS, File::Path, Image::Size, Mojolicious.

- wkhtmltoimage conversion tool.
- gnuplot image tool.
- HTML5/Google Maps/markerclusterer/jQuery/Bootstrap/dataTables Web tools.
- Optional PHP/phpmyadmin scripting language.
- Optional git version control tool.

Linux-specific implementations:

- Xvfb X virtual framebuffer display server (required for 64-bit systems and optional for 32-bit systems).
- mailx as default mail utility.
- ShakeCast services as background daemon processes.
- Database backup cron job.

Windows-specific implementations:

- SMTP as default mail protocol (supports both SSL/TLS security layers).
- ShakeCast services as Windows system processes.

3.1.3 Facilities

For purpose of post-earthquake response, the ShakeCast system host needs to be installed on a high availability server. Depending on the IT infrastructure of the user's organization, it is desirable to have features of a typical network operation center, including:

- 24x7 production environment with service monitoring and technical support
- High level of data security and operational reliability
- Switchover between primary and secondary ShakeCast server
- Rapid backup and recovery of system.

3.1.4 Materials

For a standalone installation, the ShakeCast application and its supporting open-stack programs are freely available on the Internet, include:

- ShakeCast application (V2 and V3) at http://earthquake.usgs.gov/shakecast
- MySQL database server (5.x) Community Edition at http://www.mysql.com
- Apache HTTP server (2.x) at http://www.apache.org

- Perl scripting language (5.14+) at http://www.activeperl.com
- wkhtmltopdf screen capture utility at http://wkhtmltopdf.org
- PHP scripting language (5.3+) at http://php.net
- phpMyAdmin PHP application for database management (2.x) at http://phpmyadmin.net
- git version control system at http://www.git-scm.com
- gnuplot graphing utility at http://gnuplot.info

User-specific materials related to ShakeCast implementation is applicable to post-installation configuration and database population, include:

- Administrator credentials for the operating system, database, and web server
- SMTP server access information and optional proxy server access information
- Facility (bridge/building/roadway) inventory for the ShakeCast database
- Group/user inventory for the earthquake monitoring regions and notifications
- ShakeCast notification and product templates.

3.2 Documentation

This document provides background information on the best practice for the ShakeCast implementation. Additional information regarding installation, presentation and training can be found on the ShakeCast wiki site at

https://my.usgs.gov/confluence/display/ShakeCast/Home

Specific documents related to ShakeCast implementation include:

- *ShakeCast User Guide*
- *Install ShakeCast V3 on AWS*

Additionally the USGS maintains a ShakeCast listsrv mailing list and email support shakecast-help@usgs.gov to complement the static documentation. Users are advised to consult with the documentation before requesting for technical support.

3.3 Implementation Impact

After a successful launch of the ShakeCast system, it will begin to receive and process real-time earthquake information from the USGS. The system will interact with both users and administrators of the ShakeCast system and to deliver notifications based on established criteria. As results the ShakeCast administrator needs to anticipate demand from system-related activities as part the implementation, include:

- Storage growth rate of the system (~50MB per earthquake per version) for incoming and processed earthquake products, typically on the order of 3GB/month for California events greater than M4.0.
- Performance requirements and availability of the system during active processing period
- Security requirements of ShakeCast and host operating system with appropriate user accounts and settings
- System backup of ShakeCast and host operating system for recovery after system disasters
- Help desk support of the system for end-users on ShakeCast web interface, processed products, and notifications.

3.4 Performance Monitoring

As part of the high availability requirements, the ShakeCast system needs to be monitored at both the system and the application levels.

System level monitoring includes:

- Internet connectivity and associated security settings
- User accounts and access privileges
- CPU utilizations and storage

Application level monitoring includes:

- ShakeCast system services
- MySQL database
- Apache web server

3.5 Configuration Management Interface

The ShakeCast administrative web interface is not available in the early stages of the installation process. The administrator should expect to use OS-specific tools for installing individual applications and for configuring access control. After the ShakeCast system is installed, the administrator can choose among several options to manage the application, including:

- ShakeCast Administration Web Interface for general configuration, inventory management, user accounts and access control
- Command line console and/or Microsoft Remote Desktop Connection for full access to all ShakeCast functions, worker management, daemon services, etc.

- Command line console and/or Microsoft Remote Desktop Connection for system level administrative tasks.

REFERENCES

Lin, K., D. J. Wald, and L. Turner (2014). ShakeCast User Guide, *U.S. Geol. Survey Open File Rep.* xxx, 154 pp.

APPENDIX KEY TERMS

ShakeCast Terms and Terminology

The terminology used in ShakeCast may differ slightly from that used in other information systems.

ShakeCast Server

A ShakeCast Server is a computer that is running the ShakeCast Server Software. The server may or may not be acting as a server in the traditional sense: sending data downstream to another ShakeCast Server. Instead, a server may be only receiving data from another ShakeCast Server and making that data available on the web.

Upstream and Downstream

ShakeCast machines are more easily defined in terms of being upstream or downstream. An upstream machine sends ShakeMap data to a downstream machine. The request to send the data may originate on either machine.

Event

An event is a seismic event – an earthquake (either real or simulated). All events have a globally unique and permanent identifying number, called an event ID. The event ID is assigned by the seismic monitoring systems, not by ShakeCast or ShakeMap. Once created, events may not be deleted, although they may be marked as “canceled” to indicate that an event message was anomalous and should no longer be considered.

ShakeMap and ShakeMaps

ShakeMap is a software system for computing maps of shaking intensity. It uses data from networks of seismometers and other sources to estimate shaking intensity as measured by a variety of physical or instrumental metrics such as peak acceleration, velocity, spectral response, instrumental intensity, and so on. There are very few ShakeMap systems, all of them operated by teams of seismologists and their professional support staffs.

ShakeMap is also the name for the maps produced by the ShakeMap system.

Product

A ShakeMap Product (or just Product) is a result of ShakeMap processing. When ShakeMap processes a seismic event, it produces files and maps for many different metrics (i.e., peak acceleration, velocity, etc.). Each of these maps may be produced in many different data formats (i.e., as a grid of scalar values, as a GIS shapefile, as an image in JPEG format, as an image in PostScript format, etc.).

Each combination of event, metric, and format is a different product.

Facility

A facility is a location that is to be monitored by ShakeCast. A facility is typically a building, bridge, highway, or similar man-made structure. The location of the facility must be known so that ShakeCast can attribute various levels of shaking at that location, and the facility may have associated fragility measures in one or more of the shaking metrics.

Fragility

Fragility is the measure of likely damage at a particular facility when a certain level of shaking is exceeded, as measured in a particular metric (e.g., “peak acceleration at the period of one second”).

Damage (Alert) Level

There are classes of fragility associated with each facility in each metric. The damage level is the class or category of shaking intensity experienced at a particular location. Damage levels are typically assigned as “No damage expected”, “Some damage expected”, and “Damage likely”, or “green”, “yellow”, and “red”. Damage levels are locally defined on each ShakeCast Server, and different organizations may use different categories or a different number of categories.

Notification

Notification is the process of electronically notifying a ShakeCast end user that a particular damage level is estimated at a particular facility from a certain event. Notifications can be delivered in a variety of electronic forms, including as an email message or an electronic pager message. The following figure shows one possible notification format. The format and content of notification messages may be altered by the local ShakeCast system administration.

APPENDIX I Keywords for Notification Templates

I.1 EVENT Notification Keywords

Constant	Description
EVENT_ID	Earthquake identifier e.g., nn00423851
EVENT_VERSION	Integer indicating event version
EVENT_STATUS	ShakeMap status NORMAL: RELEASED REVIEWED CANCELLED:
EVENT_NAME	String name describing event; defined by local network
MAGNITUDE	Event magnitude
EVENT_LOCATION_DESCRIPTION	String name describing event location with geographic reference; defined by local network e.g., "32km WNW of Alamo, Nevada"
EVENT_TIMESTAMP	Event timestamp e.g., yyyy-mm-ddThh:mm:ssZ
LAT	Event latitude (decimal degrees, north)
LON	Event longitude (decimal degrees, east)
EXTERNAL_EVENT_ID	Same as EVENT_ID in V3
NOTIFICATION_ID	Sequence ID in ShakeCast notification table
TRIES	Number of notification attempts.
DELIVERY_STATUS	Result of notification attempt.
SHAKECAST_USER	ShakeCast User ID
DELIVERY_ADDRESS	Email address for delivery
DELIVERY_METHOD	Product delivery type for the given notification EMAIL_HTML: email with html formatting EMAIL_TEXT: plain text email PAGER: simple text message for SMS delivery
EVENT_TYPE	Types of events that will trigger notifications to be sent: ALL: includes all event types (inclusive) ACTUAL: real earthquake SCENARIO: a scenario or converted actual event TEST: system test HEARTBEAT: a heartbeat system test message
NOTIFICATION_TYPE	Types of events that will trigger a notification to be sent Valid notification types: **NEW_EVENT**: an earthquake exceeding a user-set threshold value. Requires EVENT_TYPE and DELIVERY_METHOD tags. **DAMAGE:** Triggered when the ground shaking parameter at a facility (or facilities) is between the high and low values of the user-set facility parameters. Requires

	EVENT_TYPE, DELIVERY_METHOD, and DAMAGE_LEVEL tags. **SHAKING**: Triggered when the ground shaking parameter at the facility location of the facility exceeds the preset value. Requires EVENT_TYPE, DELIVERY_METHOD, METRIC, and LIMIT_VALUE tags. **CAN_EVENT**: cancelled event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **UPD_EVENT**: updated event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **NEW_PROD**: triggered when a specific ShakeMap product becomes available. Require EVENT_TYPE, DELIVERY_METHOD, and PRODUCT tags.
MESSAGE_FORMAT	Name of notification template (default)
LIMIT_VALUE	Minimum magnitude for a notification to be sent
PRODUCT_TYPE	Type of product to be delivered. If omitted, product is plain text. PDF: PDF from templates
FILENAME	External files to be attached to message
AGGREGATION_GROUP	Notification to be sent based on GROUP type defined by membership in a GROUP. ShakeCast has a predefined CITY group of global cities.
MAX_TRIES	Maximum number of notification attempts.
FACILITY_ID	Unique facility identifier. Text(32)
FACILITY_TYPE	Type of facility. Current defined types are: BRIDGE, CAMPUS, CITY, COUNTY, DAM, DISTRICT, ENGINEERED, INDUSTRIAL, MULTIFAM, ROAD, SINGLEFAM, STRUCTURE, TANK, TUNNEL, UNKNOWN, and HAZUS building types.
EXTERNAL_FACILITY_ID	Organization's unique facility identifier. Text (32) This field must be unique for a facility type but the same external_facility_id may be used for different types of facilities.
FACILITY_NAME	Facility name. Text(128). The value of this field is displayed to the user.
SHORT_NAME	Shortened version of facility name. Text(128). ShakeCast uses the value in this field when a shorter version of the name is needed due to output space limitations.
DESCRIPTION	Facility description. Text(255).
FACILITY_LAT	Facility latitude (decimal degrees, north)
FACILITY_LON	Facility longitude (decimal degrees, east)
GEOM_TYPE	The value of this field is used by ShakeCast to handle the geometry coordinates from the geom field. Text(32) Currently defined types are: POINT, POLYLINE, POLYGON, RECTANGLE, and CIRCLE.

GEOM	Geometry of a facility. The value of this field is used specify the coordinates of the facility. Text(32) Format of this field is in (longitude latitude) pairs separated by a white space. The size limit of data is ~16MB.
AGGREGATE	Flag to indicate whether notifications should be combined into a single message Integer value e.g., 1
SERVER_ID	Identifier of this ShakeCast server
DNS_ADDRESS	Domain name of this ShakeCast server

I.2 PRODUCT Notification Keywords

Constant	Description
PRODUCT_ID	Product sequence ID in ShakeCast database
PRODUCT_TYPE	Type of product to be delivered. If omitted, product is plain text. PDF: PDF from templates
NAME	Short product type description
DESCRIPTION	Long product type description
FILENAME	Filename for the product on local system
GENERATION_TIMESTAMP	Timestamp showing when the product was created on remote or local server
PRODUCT_STATUS	Status of product as RELEASED, REVIEWED, or CANCELLED
EVENT_ID	Earthquake identifier e.g., nn00423851
EVENT_VERSION	Integer indicating event version
EVENT_NAME	String name describing event; defined by local network
MAGNITUDE	Event magnitude
EVENT_LOCATION_DESCRIPTION	String name describing event location with geographic reference; defined by local network e.g., "32km WNW of Alamo, Nevada"
EVENT_TIMESTAMP	Event timestamp e.g., yyyy-mm-ddThh:mm:ssZ
LAT	Event latitude (decimal degrees, north)
LON	Event longitude (decimal degrees, east)
SHAKEMAP_ID	Same as the event id
SHAKEMAP_VERSION	Integer indicating map revision
NOTIFICATION_ID	Sequence ID in ShakeCast notification table
TRIES	Number of notification attempts.
DELIVERY_STATUS	Result of notification attempt.
SHAKECAST_USER	ShakeCast User ID
DELIVERY_ADDRESS	Email address for delivery
DELIVERY_METHOD	Product delivery type for the given notification

	EMAIL_HTML: email with html formatting EMAIL_TEXT: plain text email PAGER: simple text message for SMS delivery
NOTIFICATION_TYPE	Types of events that will trigger a notification to be sent Valid notification types: **NEW_EVENT**: an earthquake exceeding a user-set threshold value. Requires EVENT_TYPE and DELIVERY_METHOD tags. **DAMAGE:** Triggered when the ground shaking parameter at a facility (or facilities) is between the high and low values of the user-set facility parameters. Requires EVENT_TYPE, DELIVERY_METHOD, and DAMAGE_LEVEL tags. **SHAKING**: Triggered when the ground shaking parameter at the facility location of the facility exceeds the preset value. Requires EVENT_TYPE, DELIVERY_METHOD, METRIC, and LIMIT_VALUE tags. **CAN_EVENT**: cancelled event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **UPD_EVENT**: updated event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **NEW_PROD**: triggered when a specific ShakeMap product becomes available. Require EVENT_TYPE, DELIVERY_METHOD, and PRODUCT tags.
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EXTERNAL_FACILITY_ID	Organization’s unique facility identifier. Text (32) This field must be unique for a facility type but the same external_facility_id may be used for different types of facilities.
FACILITY_NAME	Facility name. Text(128). The value of this field is displayed to the user.
SHORT_NAME	Shortened version of facility name. Text(128). ShakeCast uses the value in this field when a shorter version of the name is needed due to output space limitations.

DESCRIPTION	Facility description. Text(255).
FACILITY_LAT	Facility latitude (decimal degrees, north)
FACILITY_LON	Facility longitude (decimal degrees, east)
GEOM_TYPE	The value of this field is used by ShakeCast to handle the geometry coordinates from the geom field. Text(32) Currently defined types are: POINT, POLYLINE, POLYGON, RECTANGLE, and CIRCLE.
GEOM	Geometry of a facility. The value of this field is used specify the coordinates of the facility. Text(32) Format of this field is in (longitude latitude) pairs separated by a white space. The size limit of data is ~16MB.
AGGREGATE	Flag to indicate whether notifications should be combined into a single message Integer value e.g., 1
SERVER_ID	Identifier of this ShakeCast server
DNS_ADDRESS	Domain name of this ShakeCast server

I.3 SHAKING Notification Keywords

Constant	Description
SHAKEMAP_ID	Same as the event id
SHAKEMAP_VERSION	Integer indicating map revision
SHAKEMAP_REGION	ShakeMap Network Code
GENERATION_TIMESTAMP	ShakeCast processing timestamp e.g., yyyy-mm-ddThh:mm:ssZ
EVENT_ID	Earthquake identifier e.g., nn00423851
EVENT_VERSION	Integer indicating event version Integer indicating event version
EVENT_NAME	String name describing event; defined by local network
MAGNITUDE	Event magnitude
EVENT_LOCATION_DESCRIPTION	String name describing event location with geographic reference; defined by local network e.g., "32km WNW of Alamo, Nevada"
EVENT_TIMESTAMP	Event timestamp e.g., yyyy-mm-ddThh:mm:ssZ
LAT	Event latitude (decimal degrees, north)
LON	Event longitude (decimal degrees, east)
NOTIFICATION_ID	Sequence ID in ShakeCast notification table
TRIES	Number of notification attempts.
DELIVERY_STATUS	Result of notification attempt.
DELIVERY_ADDRESS	Email address for delivery
METRIC	ShakeMap metric for the shaking value
GRID_VALUE	ShakeMap shaking value

DELIVERY_METHOD	Product delivery type for the given notification EMAIL_HTML: email with html formatting EMAIL_TEXT: plain text email PAGER: simple text message for SMS delivery
NOTIFICATION_TYPE	Types of events that will trigger a notification to be sent Valid notification types: **NEW_EVENT**: an earthquake exceeding a user-set threshold value. Requires EVENT_TYPE and DELIVERY_METHOD tags. **DAMAGE:** Triggered when the ground shaking parameter at a facility (or facilities) is between the high and low values of the user-set facility parameters. Requires EVENT_TYPE, DELIVERY_METHOD, and DAMAGE_LEVEL tags. **SHAKING**: Triggered when the ground shaking parameter at the facility location of the facility exceeds the preset value. Requires EVENT_TYPE, DELIVERY_METHOD, METRIC, and LIMIT_VALUE tags. **CAN_EVENT**: cancelled event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **UPD_EVENT**: updated event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **NEW_PROD**: triggered when a specific ShakeMap product becomes available. Require EVENT_TYPE, DELIVERY_METHOD, and PRODUCT tags.
MESSAGE_FORMAT	Name of notification template (default)
LIMIT_VALUE	Minimum magnitude for a notification to be sent
PRODUCT_TYPE	Type of product to be delivered by the specified DELIVERY_METHOD. Products include PDF: GRID_XML PGA_JPG INTEN_JPG
FILENAME	External file to be attached to message
AGGREGATION_GROUP	Notification to be sent based on GROUP type defined by membership in a GROUP. ShakeCast has a predefined CITY group of global cities.
MAX_TRIES	Maximum number of notification attempts.
FACILITY_ID	Unique facility identifier. Text(32)
FACILITY_TYPE	Type of facility. Current defined types are: BRIDGE, CAMPUS, CITY, COUNTY, DAM, DISTRICT, ENGINEERED, INDUSTRIAL, MULTIFAM, ROAD, SINGLEFAM, STRUCTURE, TANK, TUNNEL, UNKNOWN, and HAZUS building types.
EXTERNAL_FACILITY_ID	Organization’s unique facility identifier. Text (32) This field must be unique for a facility type but the same

	external_facility_id may be used for different types of facilities.
FACILITY_NAME	Facility name. Text(128). The value of this field is displayed to the user.
SHORT_NAME	Shortened version of facility name. Text(128). ShakeCast uses the value in this field when a shorter version of the name is needed due to output space limitations.
DESCRIPTION	Facility description. Text(255).
FACILITY_LAT	Facility latitude (decimal degrees, north)
FACILITY_LON	Facility longitude (decimal degrees, east)
GEOM_TYPE	The value of this field is used by ShakeCast to handle the geometry coordinates from the geom field. Text(32) Currently defined types are: POINT, POLYLINE, POLYGON, RECTANGLE, and CIRCLE.
GEOM	Geometry of a facility. The value of this field is used specify the coordinates of the facility. Text(32) Format of this field is in (longitude latitude) pairs separated by a white space. The size limit of data is ~16MB.
BOUND_SOUTH	ShakeMap boundary to south
BOUND_NORTH	ShakeMap boundary to north
BOUND_WEST	ShakeMap boundary to west
BOUND_EAST	ShakeMap boundary to east
AGGREGATE	Flag to indicate whether notifications should be combined into a single message Integer value e.g., 1
SERVER_ID	Identifier of this ShakeCast server
DNS_ADDRESS	Domain name of this ShakeCast server

I.4 DAMAGE Notification Keywords

Constant	Description
SHAKEMAP_ID	Same as the event id
SHAKEMAP_VERSION	Integer indicating map revision
SHAKEMAP_REGION	ShakeMap network code
GENERATION_TIMESTAMP	ShakeCast processing timestamp e.g., yyyy-mm-ddThh:mm:ssZ
EVENT_ID	Earthquake identifier e.g., nn00423851
EVENT_VERSION	Integer indicating event version
EVENT_NAME	String name describing event; defined by local network
MAGNITUDE	Event magnitude
EVENT_LOCATION_DESCRIPTION	String name describing event location with geographic reference; defined by local network e.g., "32km WNW of Alamo, Nevada"

EVENT_TIMESTAMP	Event timestamp e.g., yyyy-mm-ddThh:mm:ssZ
LAT	Event latitude (decimal degrees, north)
LON	Event longitude (decimal degrees, north)
NOTIFICATION_ID	Sequence ID in ShakeCast notification table
TRIES	Number of notification attempts.
DELIVERY_STATUS	Result of notification attempt.
SHAKECAST_USER	ShakeCast User ID
DELIVERY_ADDRESS	Email address for delivery
METRIC	ShakeMap metric used for damage assessment
GRID_VALUE	ShakeMap value used for damage assessment
DAMAGE_LEVEL	String parameter for notification to be sent within the damage threshold e.g., GREEN, ORANGE, YELLOW, RED
DAMAGE_LEVEL_NAME	Damage level description
IS_MAX_SEVERITY	Flag showing whether this is the most severe damage state
SEVERITY_RANK	Rank of damage state
LOW_LIMIT	Minimum shaking value of the damage state
HIGH_LIMIT	Maximum shaking value of the damage state
DELIVERY_METHOD	Product delivery type for the given notification EMAIL_HTML: email with html formatting EMAIL_TEXT: plain text email PAGER: simple text message for SMS delivery
NOTIFICATION_TYPE	Types of events that will trigger a notification to be sent Valid notification types: **NEW_EVENT**: an earthquake exceeding a user-set threshold value. Requires EVENT_TYPE and DELIVERY_METHOD tags. **DAMAGE:** Triggered when the ground shaking parameter at a facility (or facilities) is between the high and low values of the user-set facility parameters. Requires EVENT_TYPE, DELIVERY_METHOD, and DAMAGE_LEVEL tags. **SHAKING**: Triggered when the ground shaking parameter at the facility location of the facility exceeds the preset value. Requires EVENT_TYPE, DELIVERY_METHOD, METRIC, and LIMIT_VALUE tags. **CAN_EVENT**: cancelled event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **UPD_EVENT**: updated event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **NEW_PROD**: triggered when a specific ShakeMap product becomes available. Require EVENT_TYPE, DELIVERY_METHOD, and PRODUCT tags.

MESSAGE_FORMAT	Name of notification template (default)
LIMIT_VALUE	Minimum magnitude for a notification to be sent
PRODUCT_TYPE	Type of product to be delivered. If omitted, product is plain text. PDF: PDF from templates
FILENAME	External file to be attached to message
AGGREGATION_GROUP	Notification to be sent based on GROUP type defined by membership in a GROUP. ShakeCast has a predefined CITY group of global cities.
MAX_TRIES	Maximum number of notification attempts.
FACILITY_ID	Unique facility identifier. Text(32)
FACILITY_TYPE	Type of facility. Current defined types are: BRIDGE, CAMPUS, CITY, COUNTY, DAM, DISTRICT, ENGINEERED, INDUSTRIAL, MULTIFAM, ROAD, SINGLEFAM, STRUCTURE, TANK, TUNNEL, UNKNOWN, and HAZUS building types.
EXTERNAL_FACILITY_ID	Organization's unique facility identifier. Text (32) This field must be unique for a facility type but the same external_facility_id may be used for different types of facilities.
FACILITY_NAME	Facility name. Text(128). The value of this field is displayed to the user.
SHORT_NAME	Shortened version of facility name. Text(128). ShakeCast uses the value in this field when a shorter version of the name is needed due to output space limitations.
DESCRIPTION	Facility description. Text(255).
FACILITY_LAT	Facility latitude (decimal degrees, north)
FACILITY_LON	Facility longitude (decimal degrees, east)
GEOM_TYPE	The value of this field is used by ShakeCast to handle the geometry coordinates from the geom field. Text(32) Currently defined types are: POINT, POLYLINE, POLYGON, RECTANGLE, and CIRCLE.
GEOM	Geometry of a facility. The value of this field is used specify the coordinates of the facility. Text(32) Format of this field is in (longitude latitude) pairs separated by a white space. The size limit of data is ~16MB.
BOUND_SOUTH	ShakeMap boundary to south
BOUND_NORTH	ShakeMap boundary to north
BOUND_WEST	ShakeMap boundary to west
BOUND_EAST	ShakeMap boundary to east
AGGREGATE	Flag to indicate whether notifications should be combined into a single message Integer value e.g., 1
SERVER_ID	Identifier of this ShakeCast server
DNS_ADDRESS	Domain name of this ShakeCast server

I.5 SYSTEM Notification Keywords

Constant	Description
LOG_MESSAGE_ID	Log sequence ID in ShakeCast database
LOG_MESSAGE_TYPE	Message type in WARNING or ERROR
SERVER_ID	Local ID for this ShakeCast server
DESCRIPTION	Server description
RECEIVE_TIMESTAMP	Timestamp when this notification was requested e.g., yyyy-mm-ddThh:mm:ssZ
NOTIFICATION_ID	Sequence ID in ShakeCast notification table
TRIES	Number of notification attempts.
DELIVERY_STATUS	Result of notification attempt.
SHAKECAST_USER	ShakeCast User ID
DELIVERY_ADDRESS	Email address for delivery
DELIVERY_METHOD	Product delivery type for the given notification EMAIL_HTML: email with html formatting EMAIL_TEXT: plain text email PAGER: simple text message for SMS delivery
NOTIFICATION_TYPE	Types of events that will trigger a notification to be sent Valid notification types: **NEW_EVENT**: an earthquake exceeding a user-set threshold value. Requires EVENT_TYPE and DELIVERY_METHOD tags. **DAMAGE:** Triggered when the ground shaking parameter at a facility (or facilities) is between the high and low values of the user-set facility parameters. Requires EVENT_TYPE, DELIVERY_METHOD, and DAMAGE_LEVEL tags. **SHAKING**: Triggered when the ground shaking parameter at the facility location of the facility exceeds the preset value. Requires EVENT_TYPE, DELIVERY_METHOD, METRIC, and LIMIT_VALUE tags. **CAN_EVENT**: cancelled event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **UPD_EVENT**: updated event. Requires EVENT_TYPE and DELIVERY_METHOD tags. **NEW_PROD**: triggered when a specific ShakeMap product becomes available. Require EVENT_TYPE, DELIVERY_METHOD, and PRODUCT tags.
MESSAGE_FORMAT	Filename of notification template (default)
LIMIT_VALUE	Minimum magnitude for a notification to be sent
AGGREGATE	Flag to indicate whether notifications should be combined

	into a single message Integer value e.g., 1
AGGREGATION_GROUP	Notification to be sent based on GROUP type defined by membership in a GROUP. ShakeCast has a predefined CITY group of global cities.
MAX_TRIES	Maximum number of notification attempts.
SERVER_ID	Identifier of this ShakeCast server
DNS_ADDRESS	Domain name of this ShakeCast server

I.6 Derived Value Keywords

Facility Attributes As ATTR_[ATTRIBUTE_NAME]	Description
_ITEMNO	Total number of entries in this notification
NUM[METRIC] (SHAKING/DAMAGE only)	Total number of entries for the specified ShakeMap metric
MIN[METRIC] (SHAKING/DAMAGE only)	The minimum reported value for the specified ShakeMap metric
MAX[METRIC] (SHAKING/DAMAGE only)	The maximum reported value for the specified ShakeMap metric
MEAN[METRIC] (SHAKING/DAMAGE only)	The averaged value for the specified ShakeMap metric
EXCEEDANCE_RATIO (DAMAGE only)	The relative position between the LOW_LIMIT and HIGH_LIMIT values, normalized to between 0 and 1.