ShakeCast User Guide
(Draft)

by

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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.

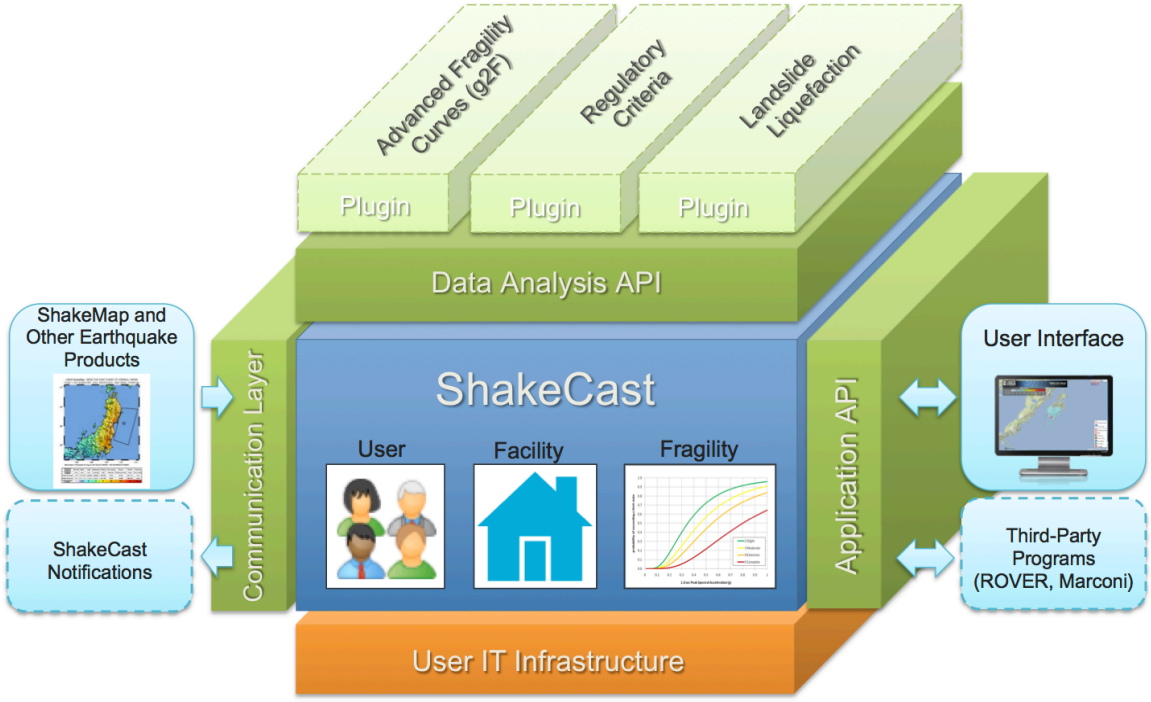


Figure 1.1. ShakeCast V3 System Diagram

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.

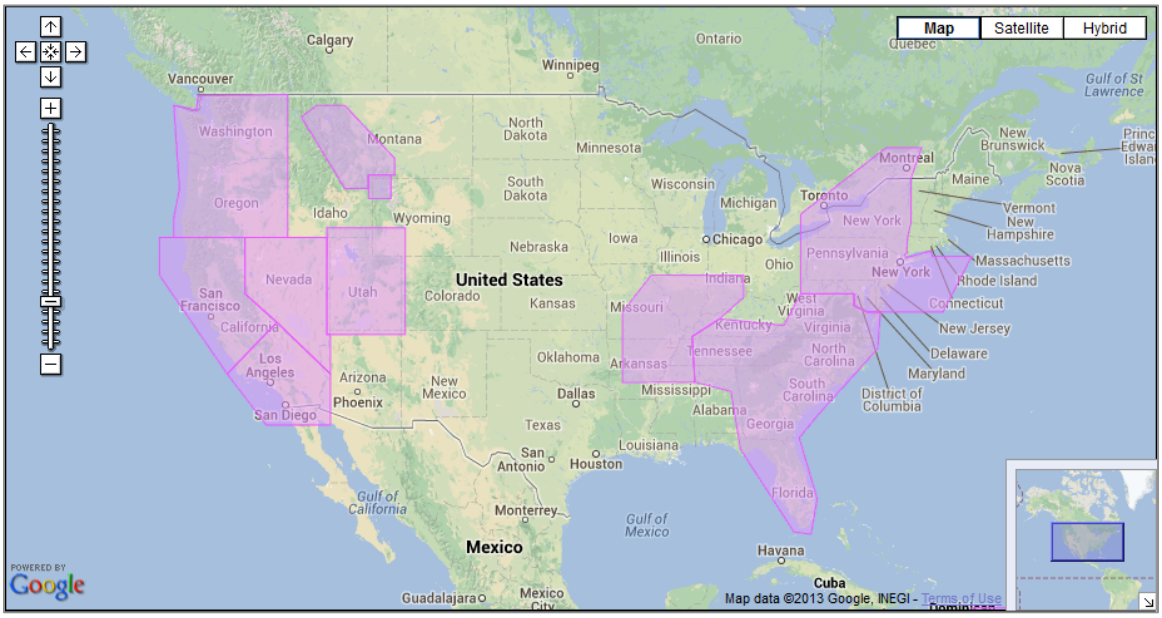


Figure 2.1. ANSS regions contribute to seismic monitoring inside the U.S.

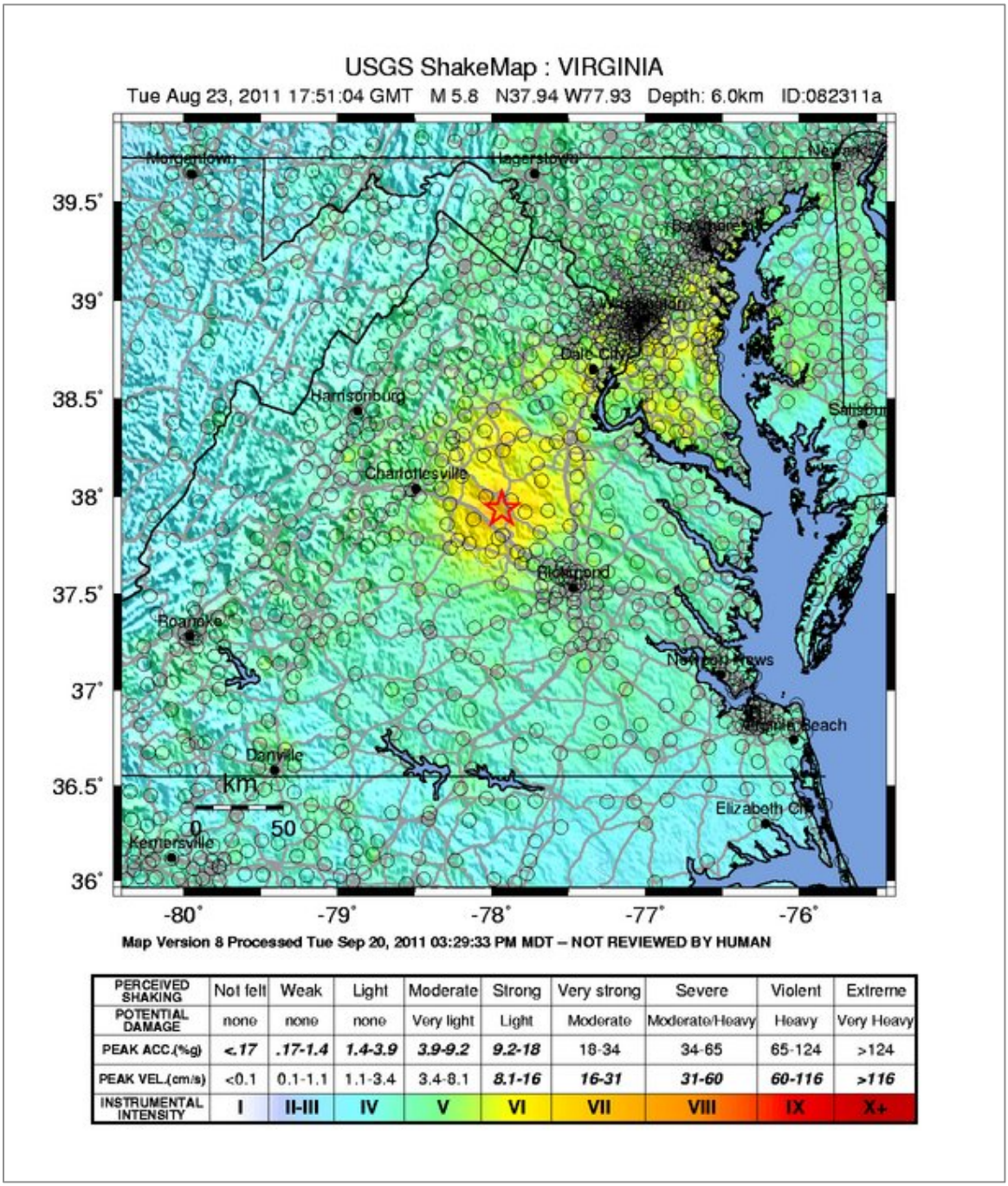
Outside the U.S., the Global Seismographic Network (GSN) provides worldwide monitoring, with over 150 modern seismic stations distributed globally used primarily for determining earthquake magnitude and location. These global earthquake source parameters are immediately used at the NEIC as the primary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



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

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.

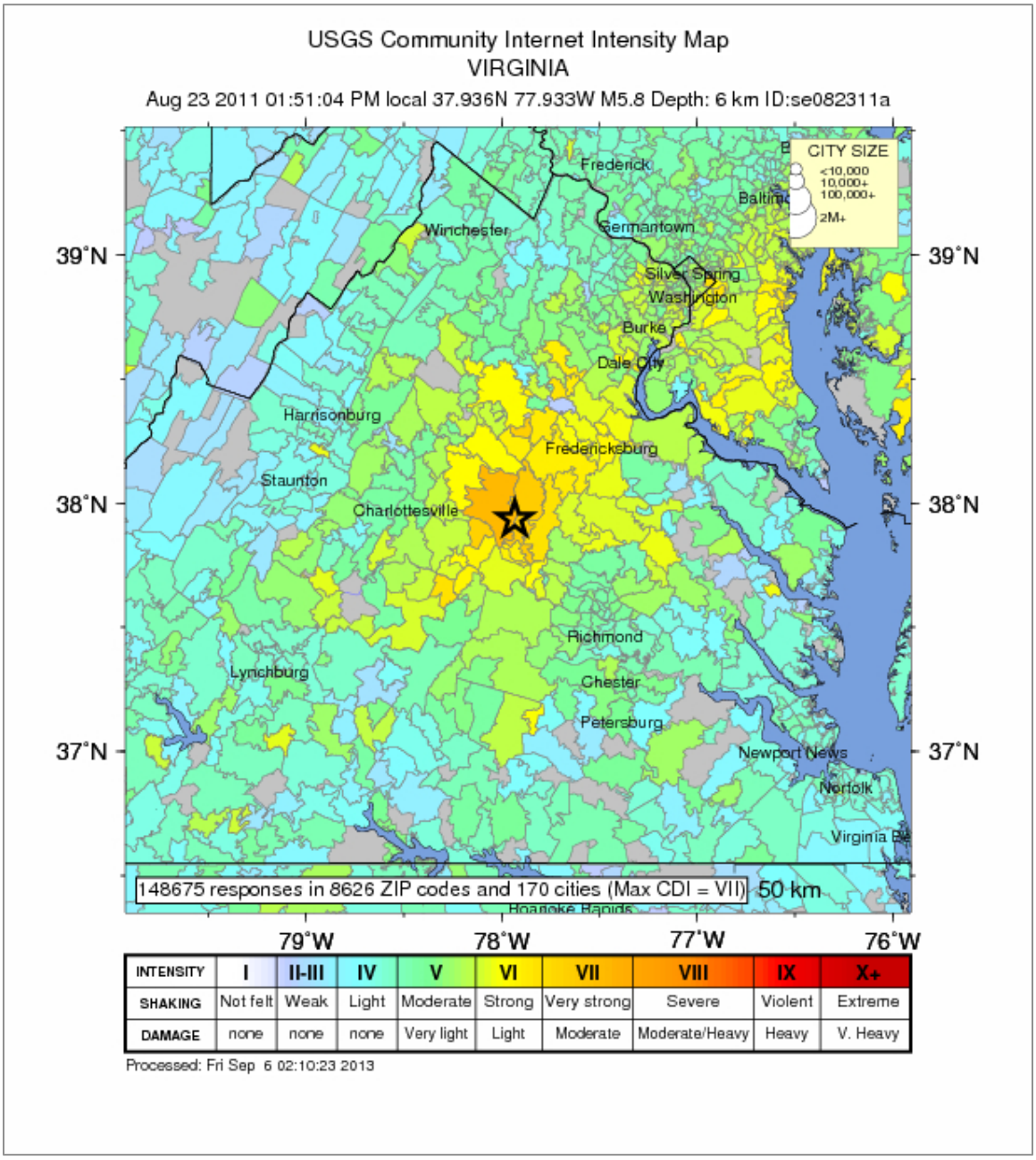


Figure 2.3. The DYFI Community Internet Intensity Map (CIIM) for the 2011 M5.8 Mineral, Virginia earthquake.

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.

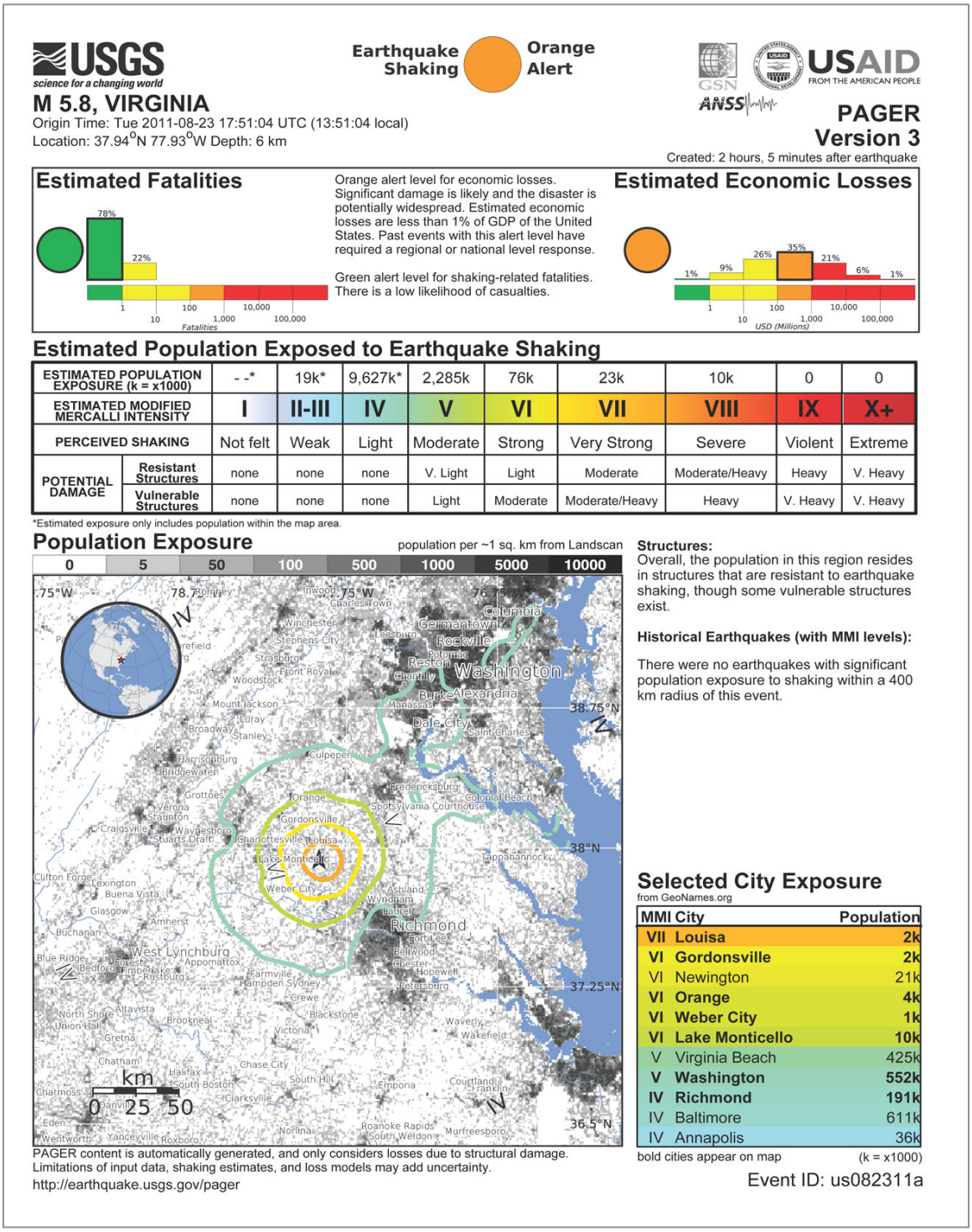


Figure 2.4. The PAGER summary report for the 2011 M5.8 Mineral, Virginia earthquake.

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 that 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 that 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 HTML5 standards. Most User and Administrator interactions with the ShakeCast V3 system are 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.

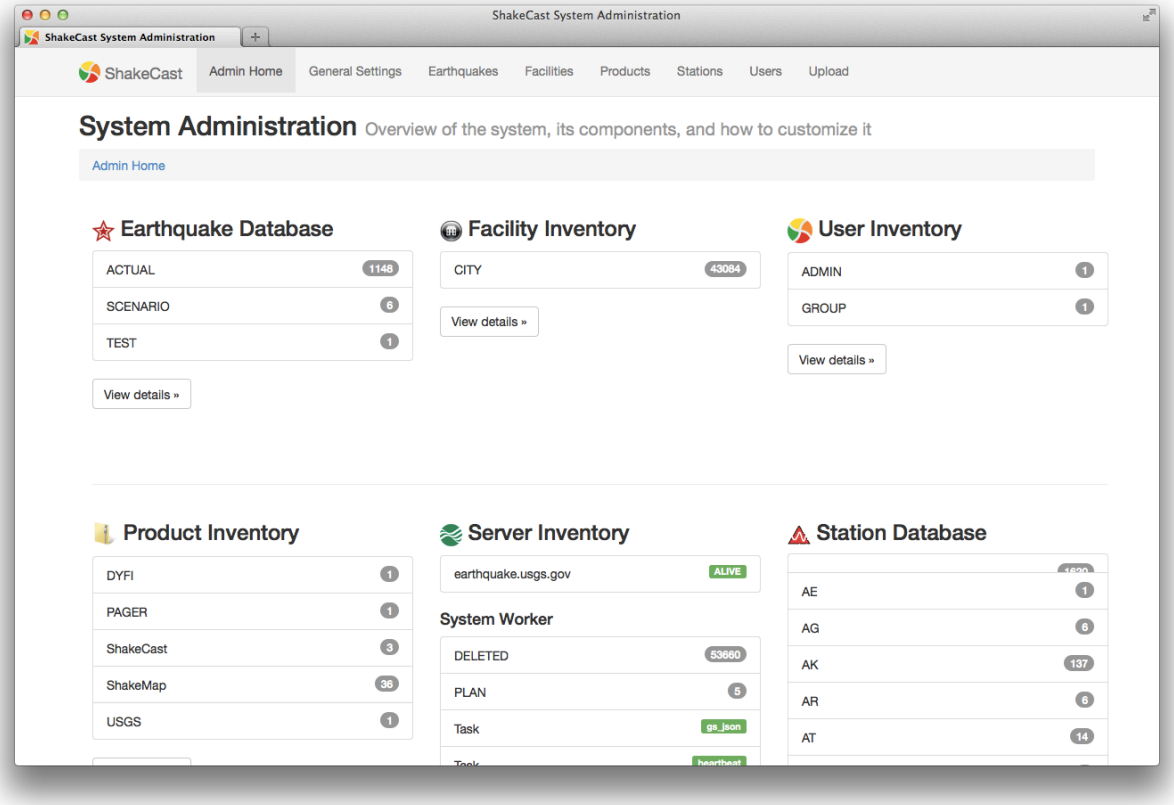


Figure 5.1. ShakeCast administrative web interface. The default page displays summary of the system inventory stored inside the database and active processes.

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.

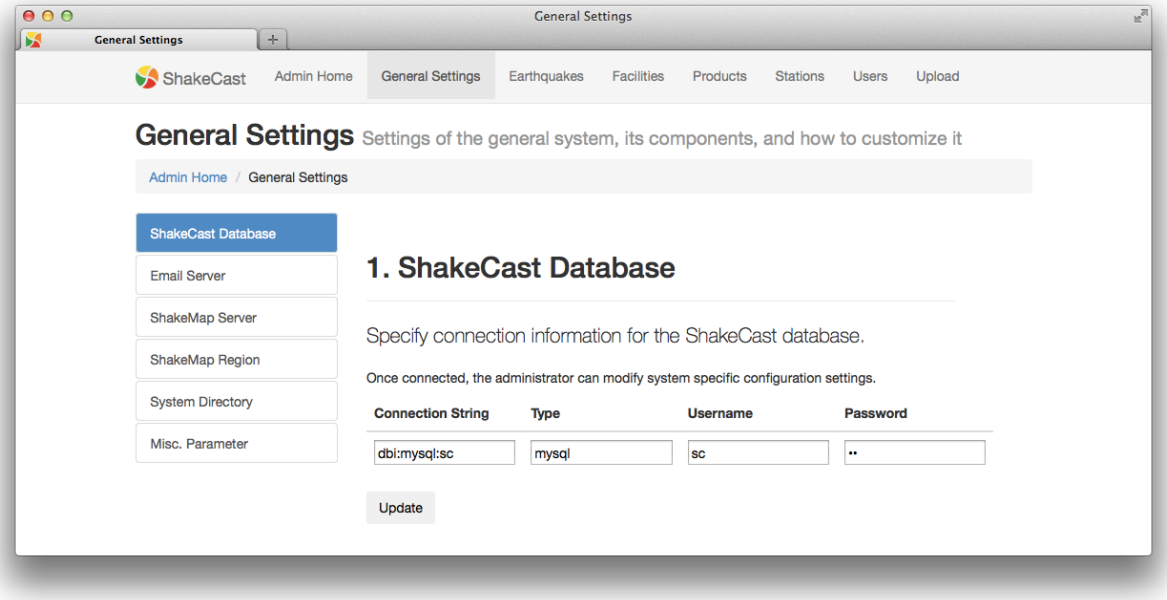


Figure 5.2. ShakeCast administrative web interface for general system settings.

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.

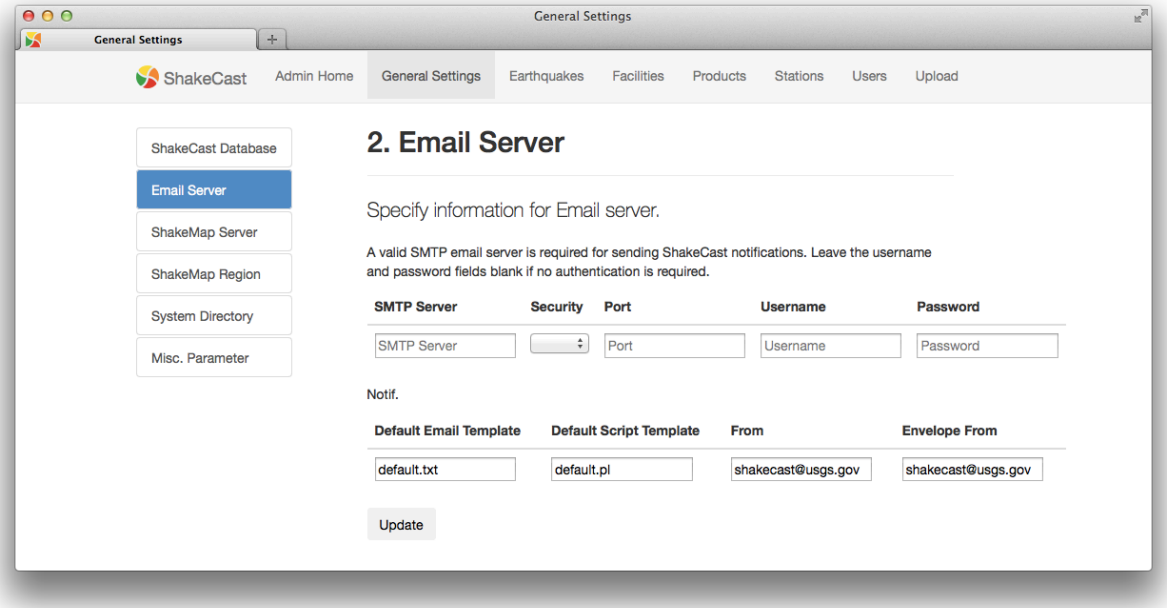


Figure 5.3. ShakeCast administrative web interface for Email Server configuration.

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.

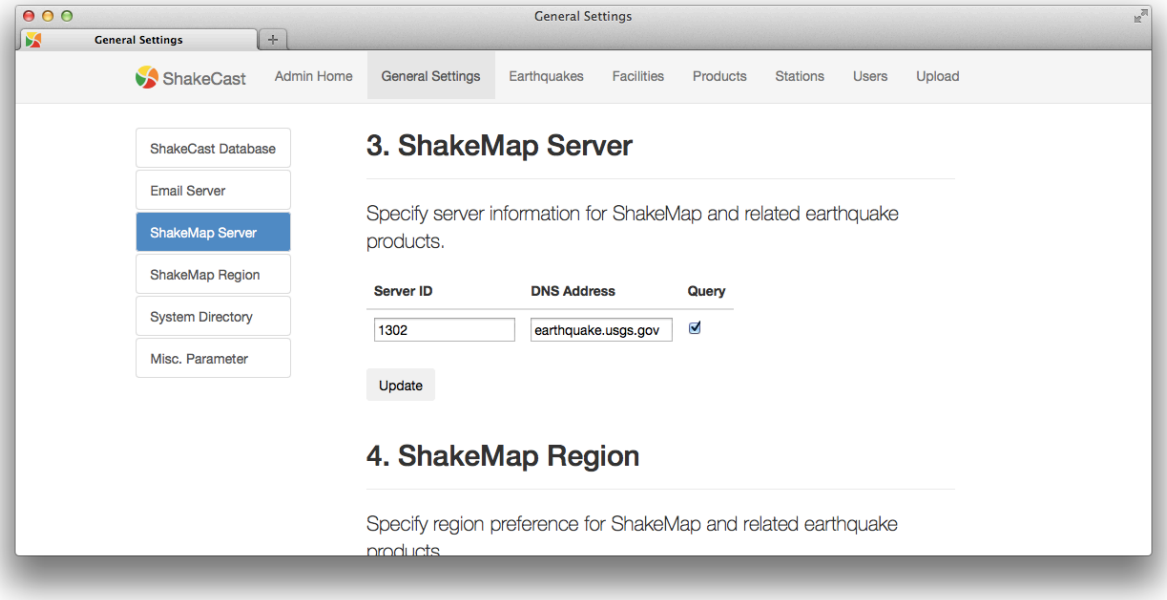


Figure 5.4. ShakeCast administrative web interface for ShakeMap Server configuration.

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.

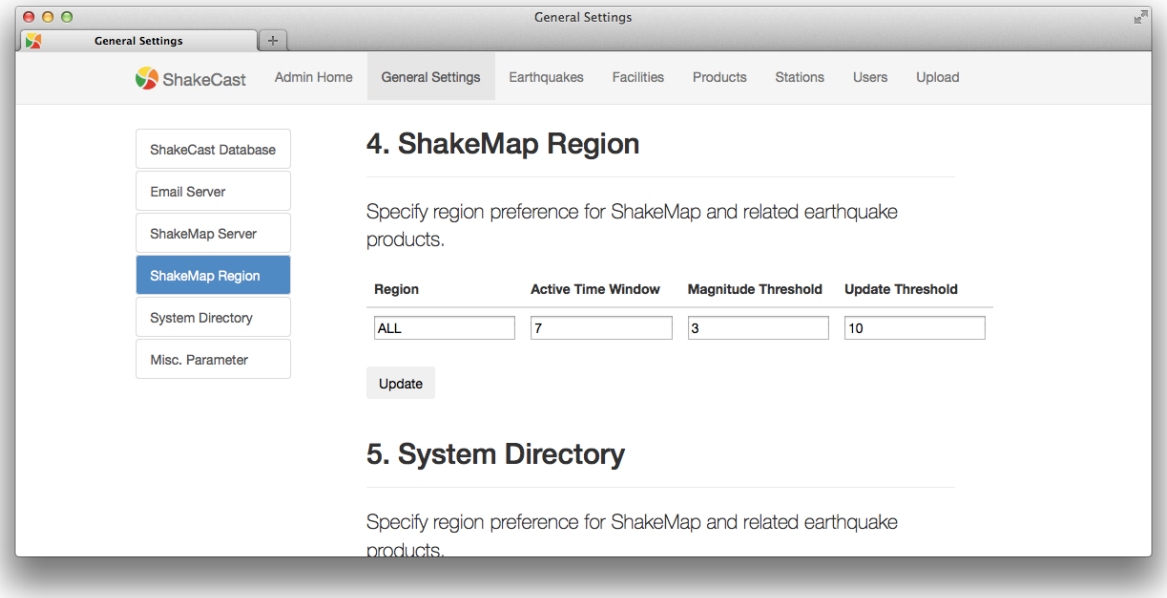


Figure 5.5. ShakeCast administrative web interface for ShakeMap Region configuration.

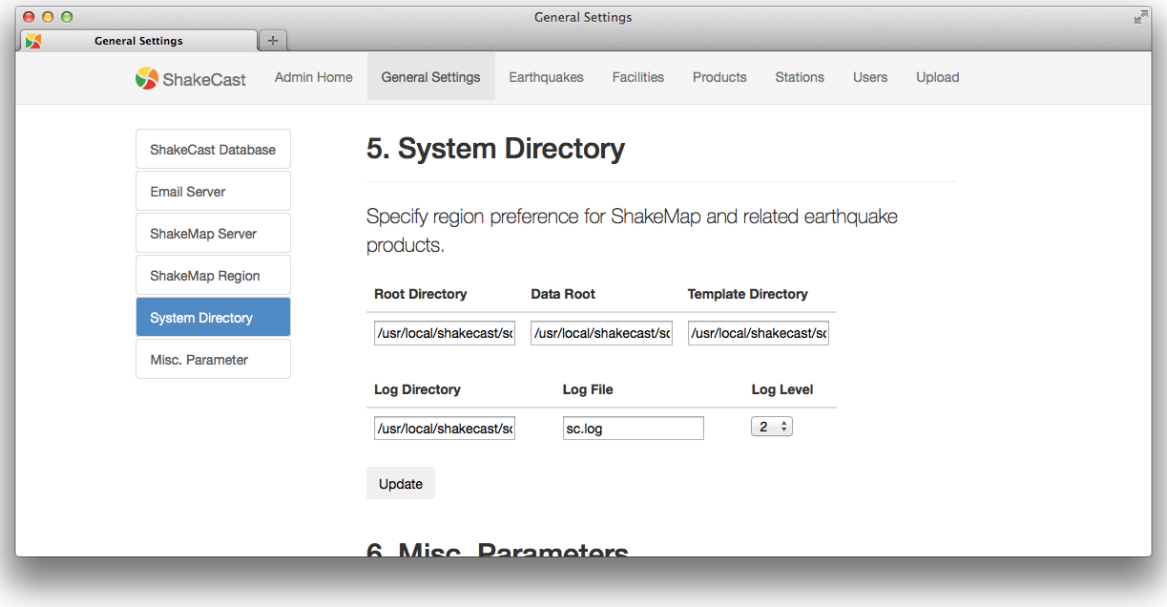
A summary of the form fields and a description of their content is provided in Table 5.4.

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.



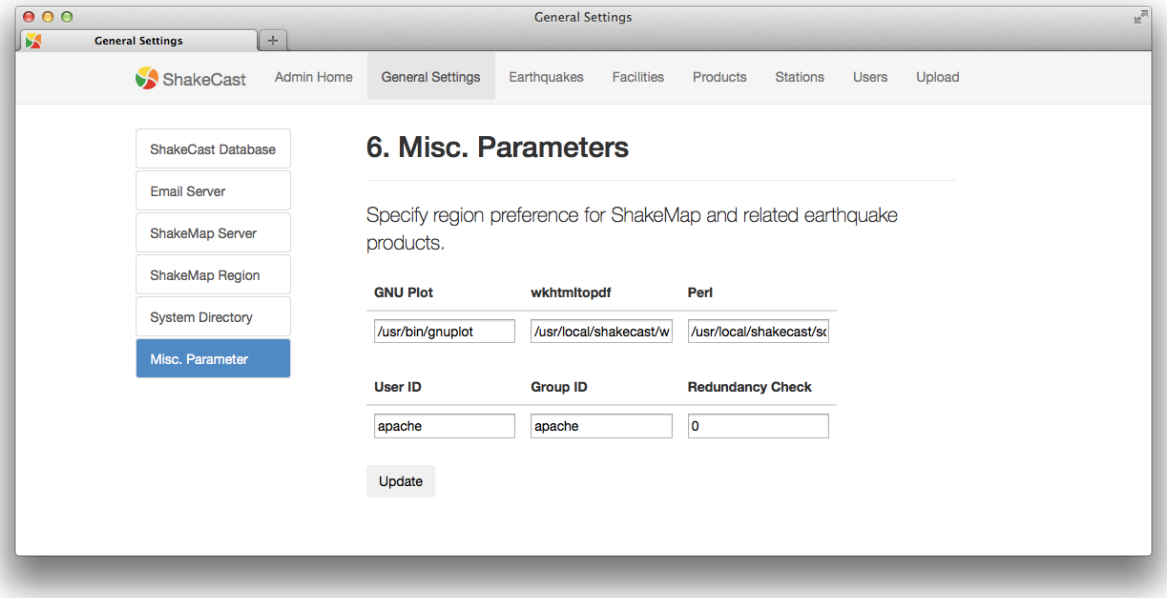


Figure 5.6. ShakeCast administrative web interface for System Directory (top) and Misc. Parameters configuration (bottom).

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.

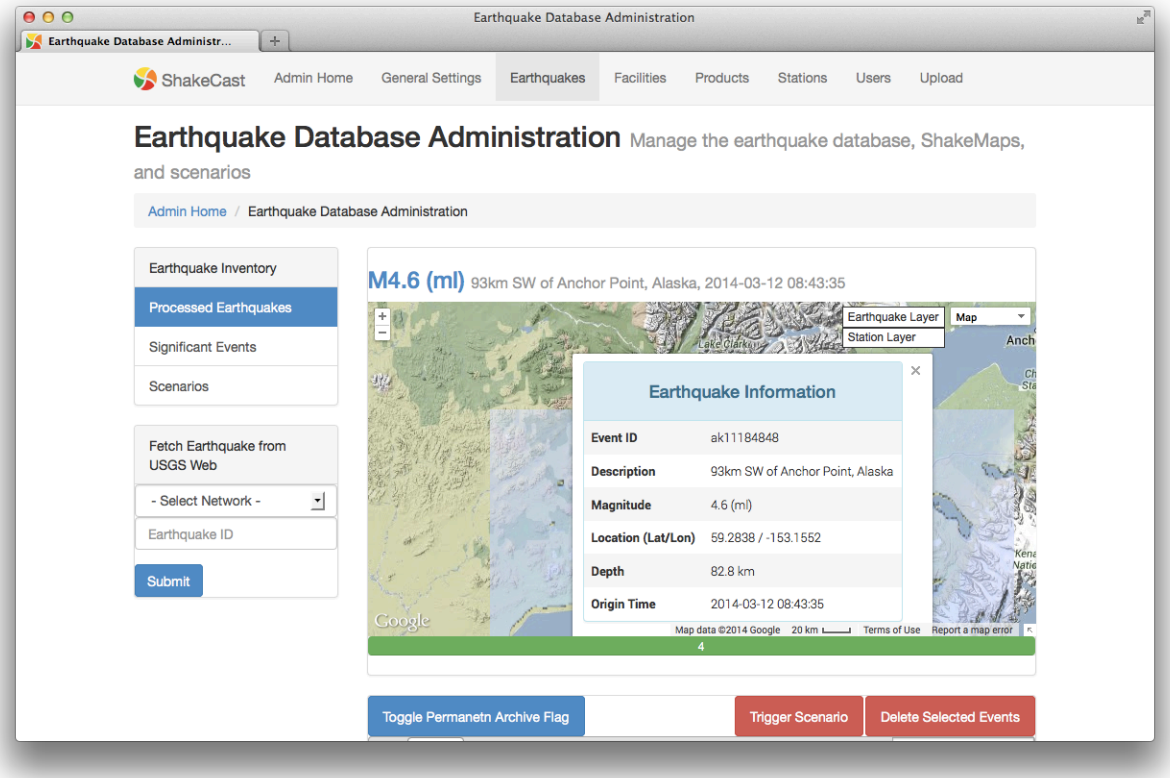


Figure 5.7. ShakeCast administrative web interface for earthquake database administration.

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.

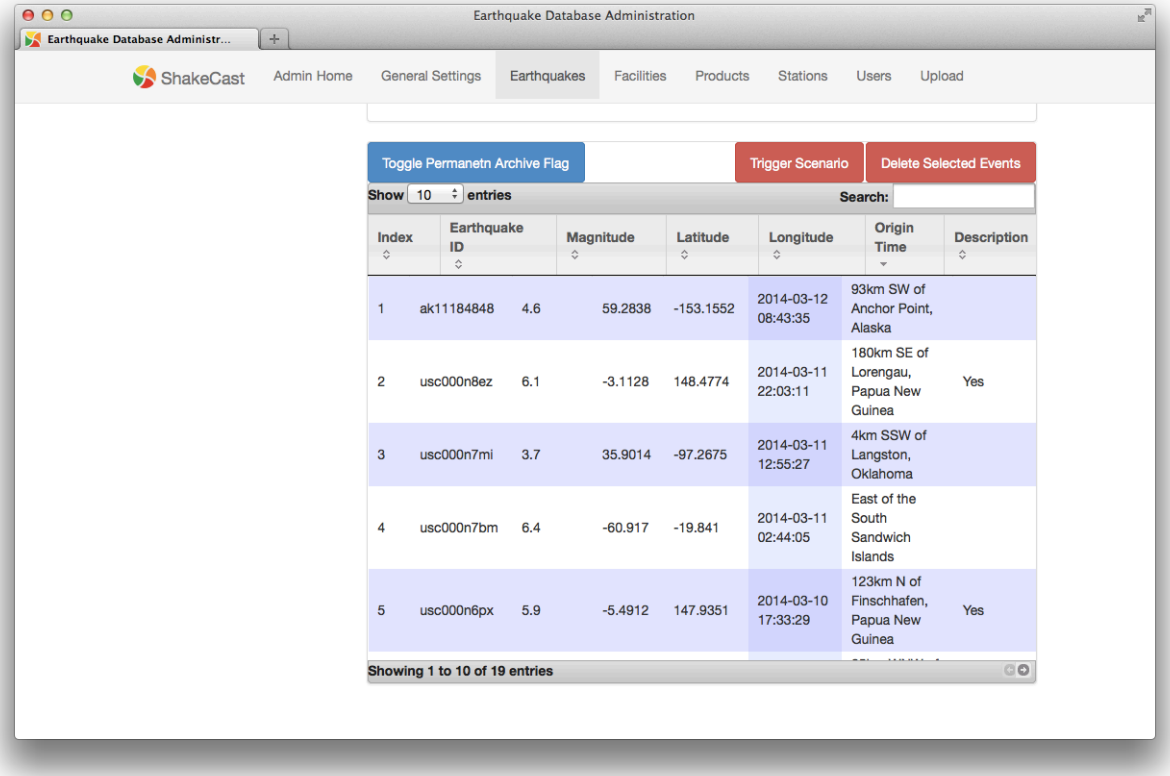


Figure 5.8. ShakeCast administrative web interface for earthquake database management.

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.

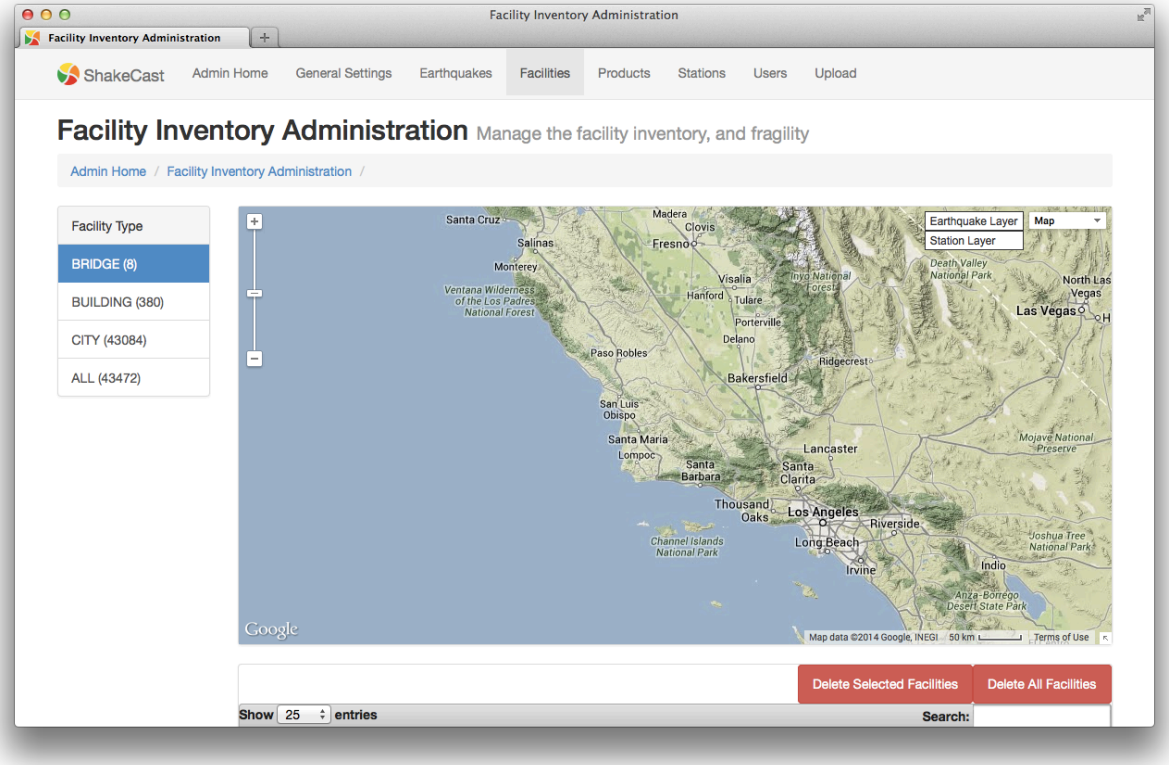


Figure 5.9. ShakeCast administrative web interface for facility inventory management.

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).

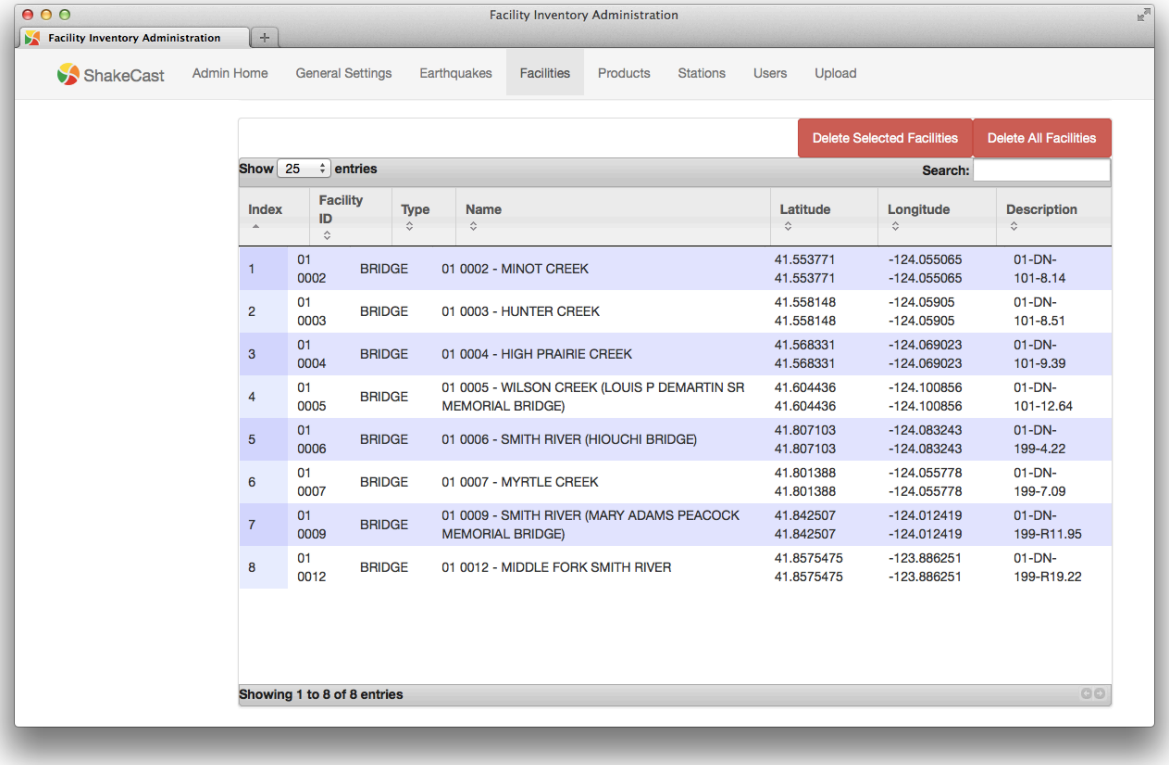
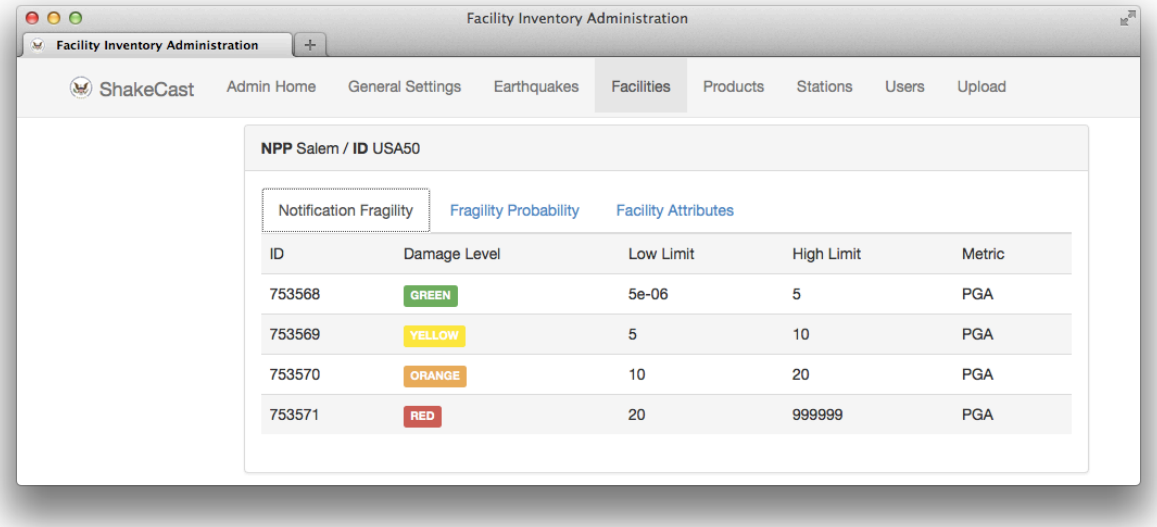
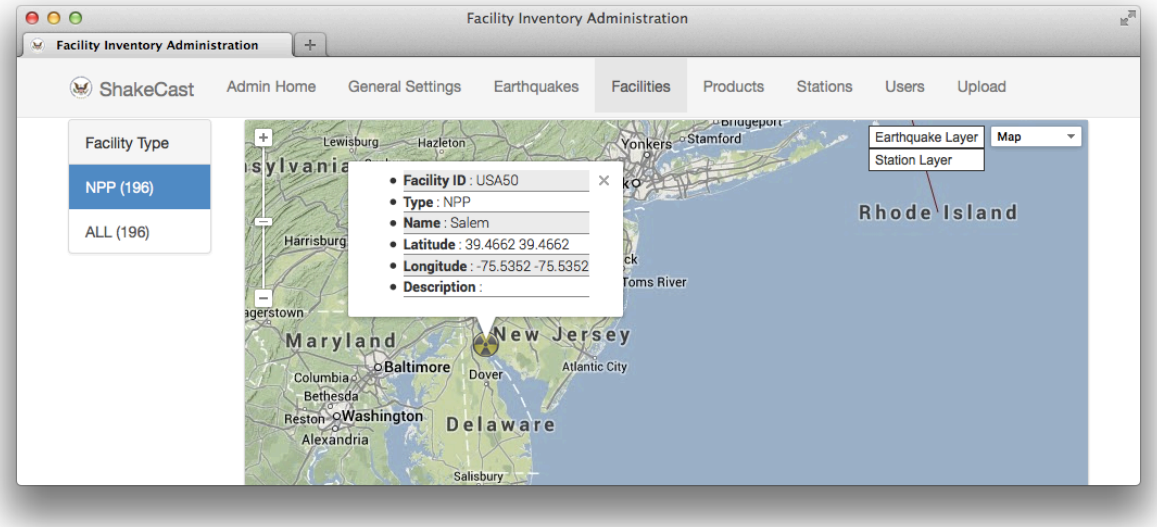


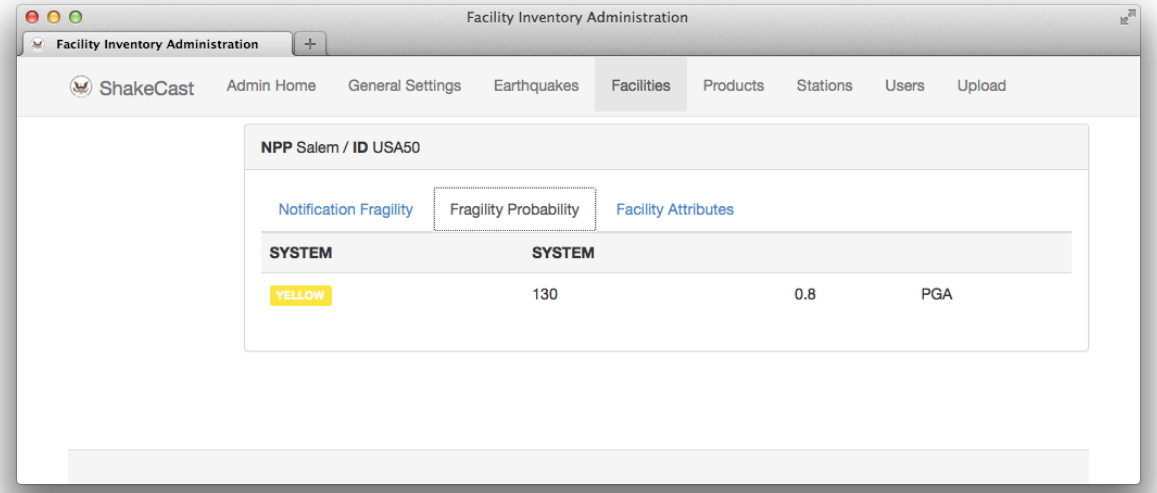
Figure 5.10. ShakeCast administrative web interface for facility inventory management.



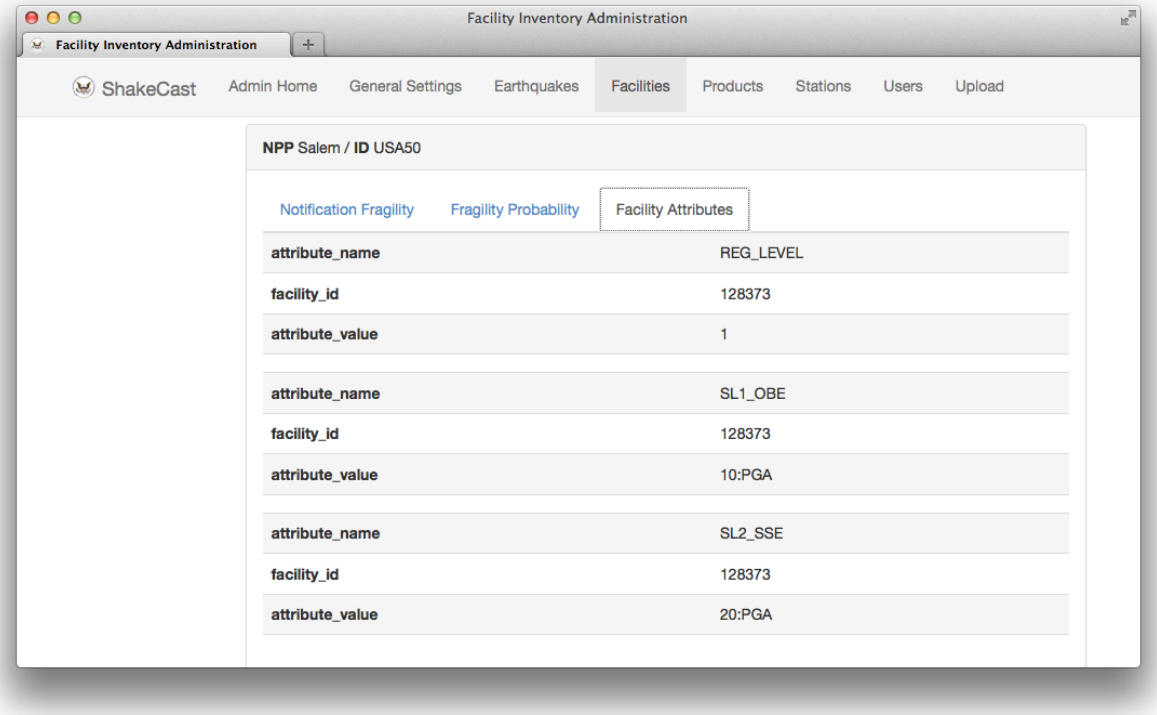
(a)


Facility Inventory Administration
Facility Inventory Administration
ShakeCast
Admin Home
General Settings
Earthquakes
Facilities
Products
Stations
Users
Upload
Facility Type
NPP (196)
ALL (196)
Facility ID : USA50
Type : NPP
Name : Salem
Latitude : 39.4662 39.4662
Longitude : -75.5352 -75.5352
Description :
Earthquake Layer
Station Layer
Map
Rhode Island
Maryland
New Jersey
Delaware
Baltimore
Washington
Dover
Atlantic City
Yonkers
Stamford
Lewisburg
Hazleton
Harrisburg
Toms River
Columbia
Bethesda
Reston
Alexandria
Salisbury

(b)


Facility Inventory Administration
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.

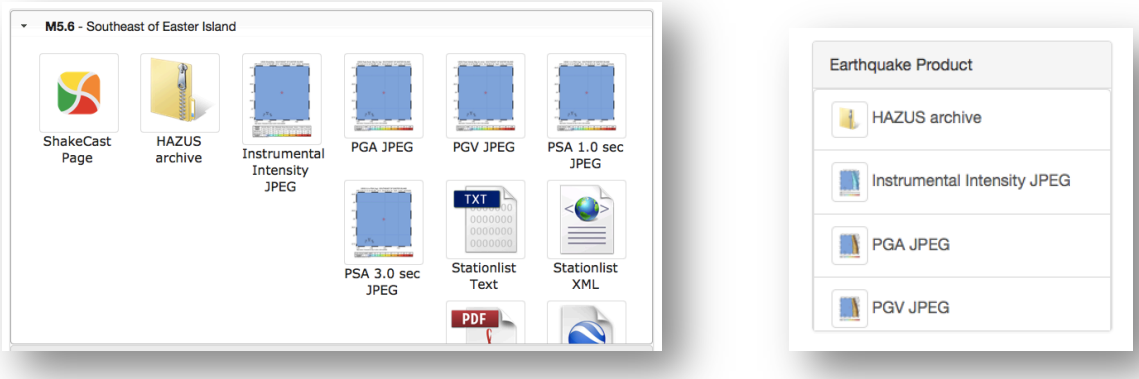


Figure 5.12. Earthquake product list in both the ShakeCast earthquake list and detailed page.

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.

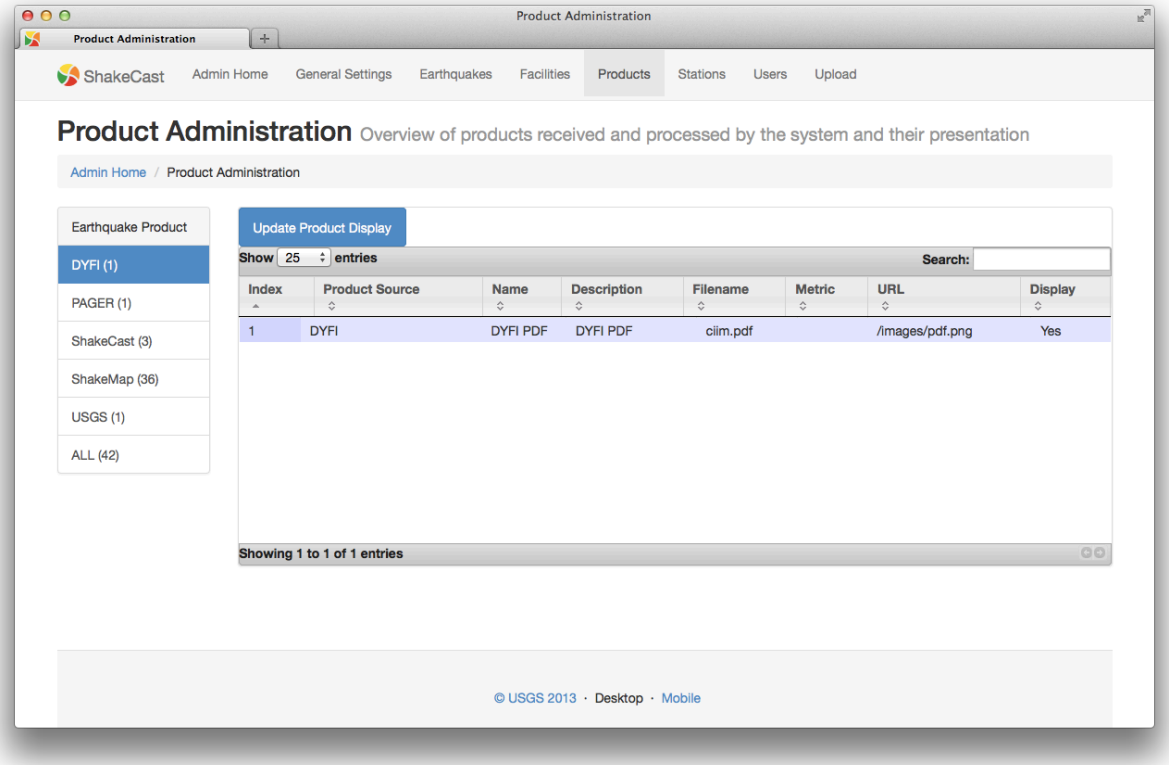


Figure 5.13. ShakeCast administrative web interface for earthquake product management.

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.

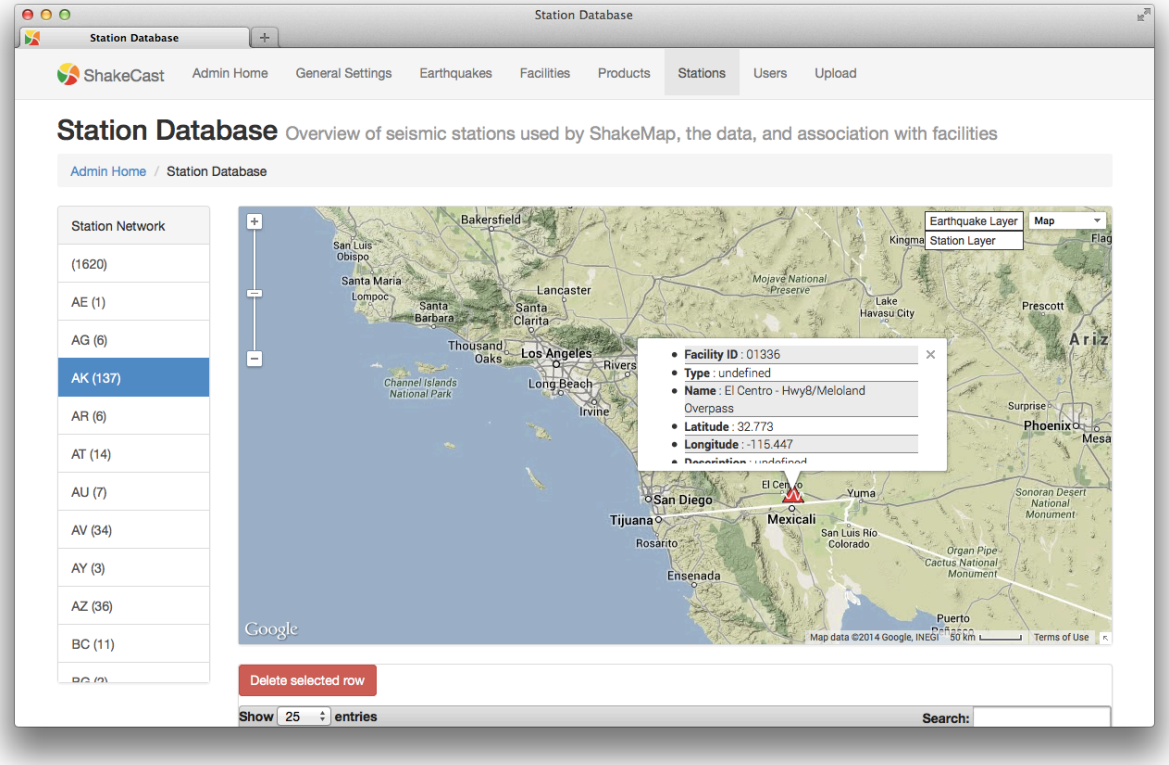


Figure 5.14. ShakeCast administrative web interface for station database management.

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.

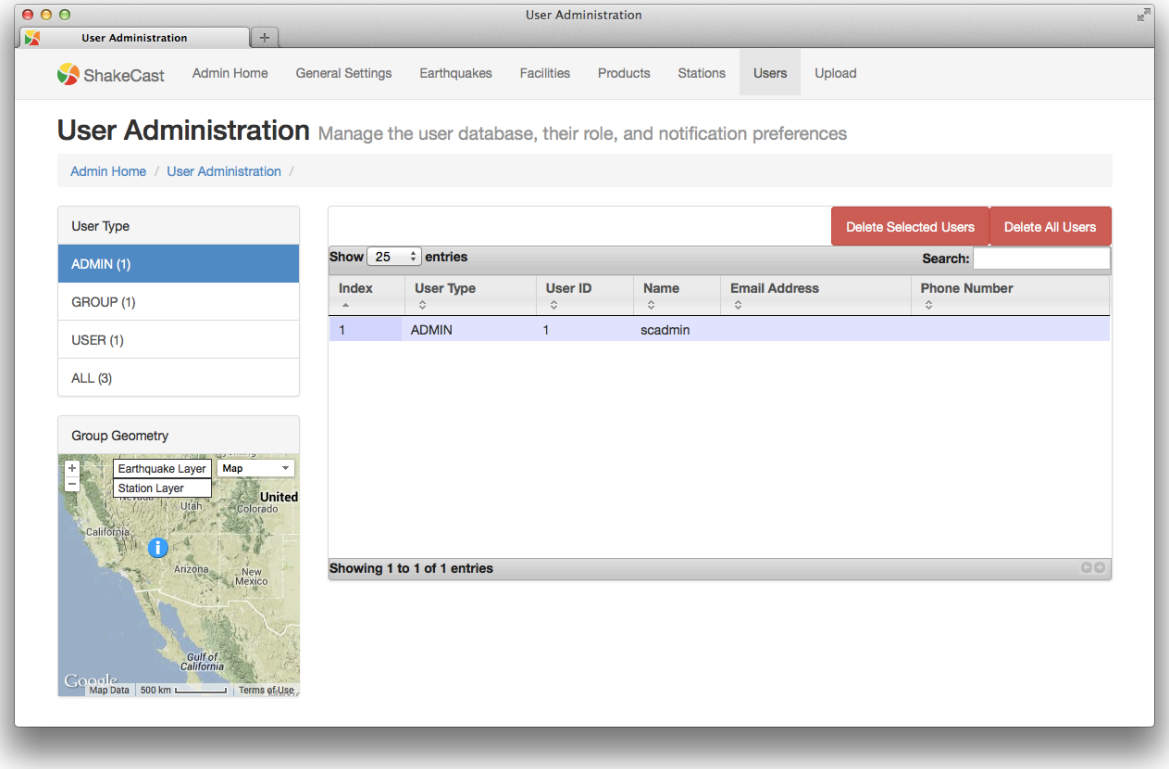


Figure 5.15. ShakeCast administrative web interface for user database management.

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.

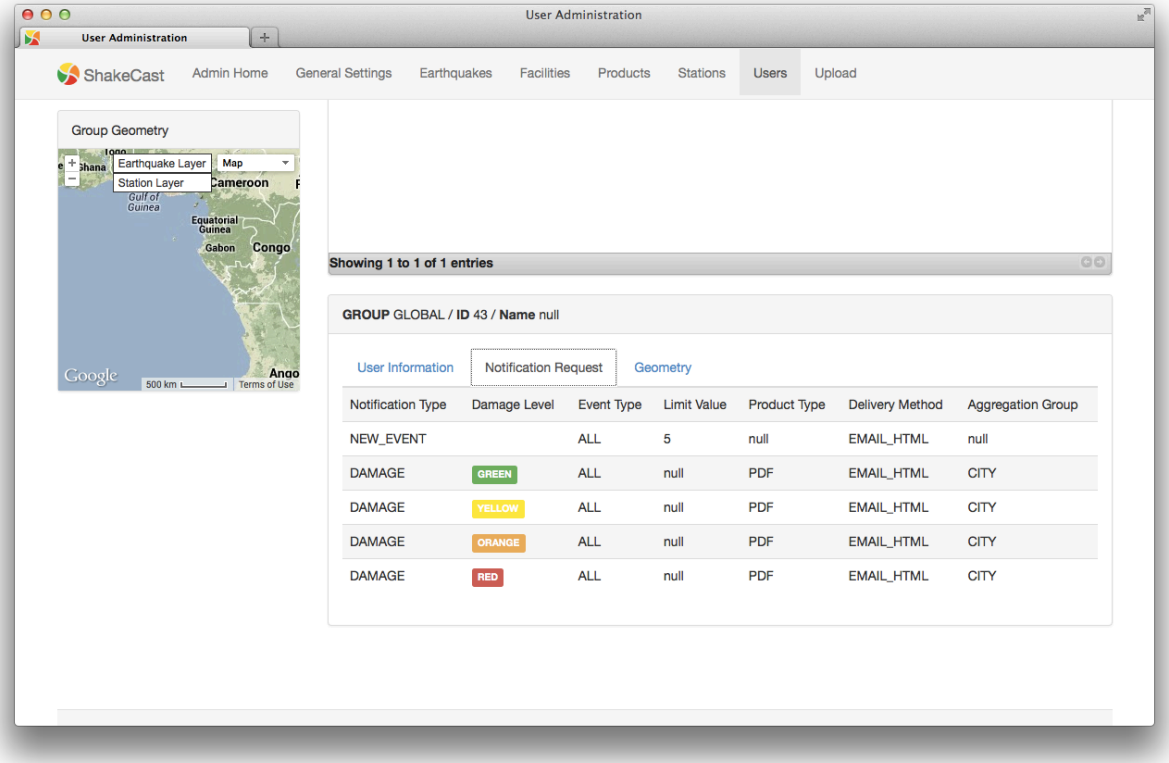


Figure 5.16. Notification requests for the GLOBAL group defined in the ShakeCast user database.

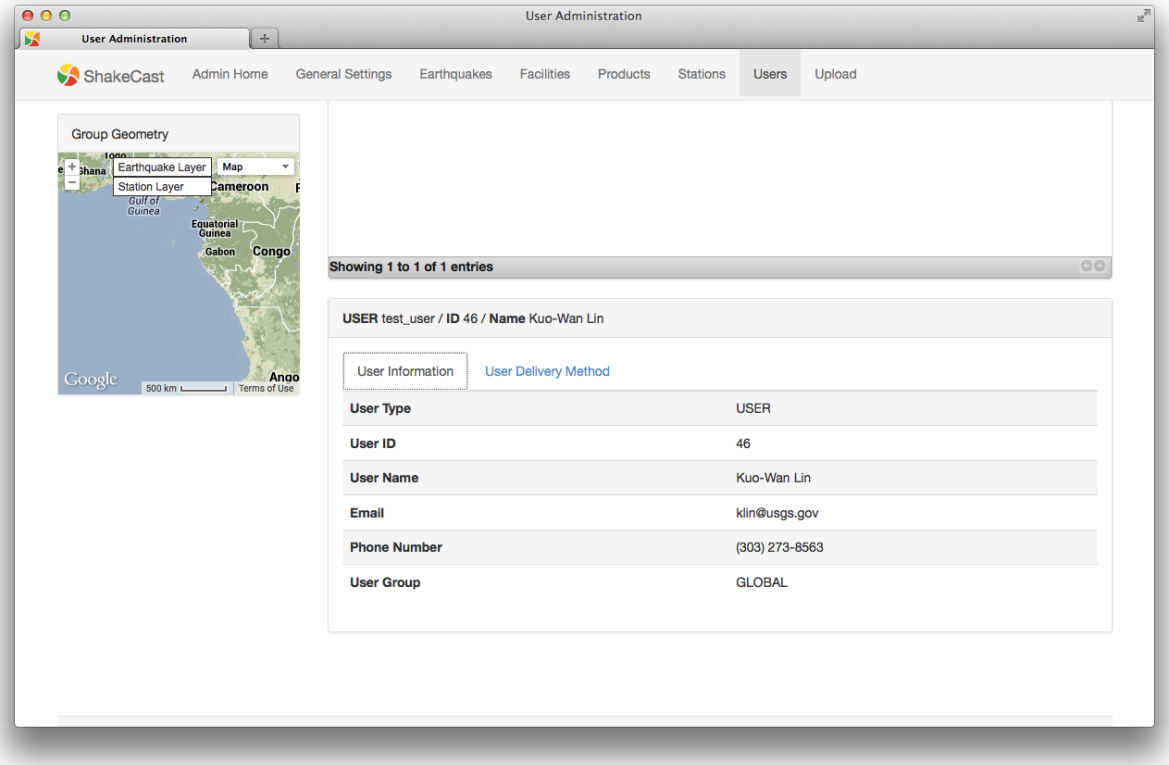


Figure 5.17. An example of user information and group association defined in the ShakeCast user database.

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.

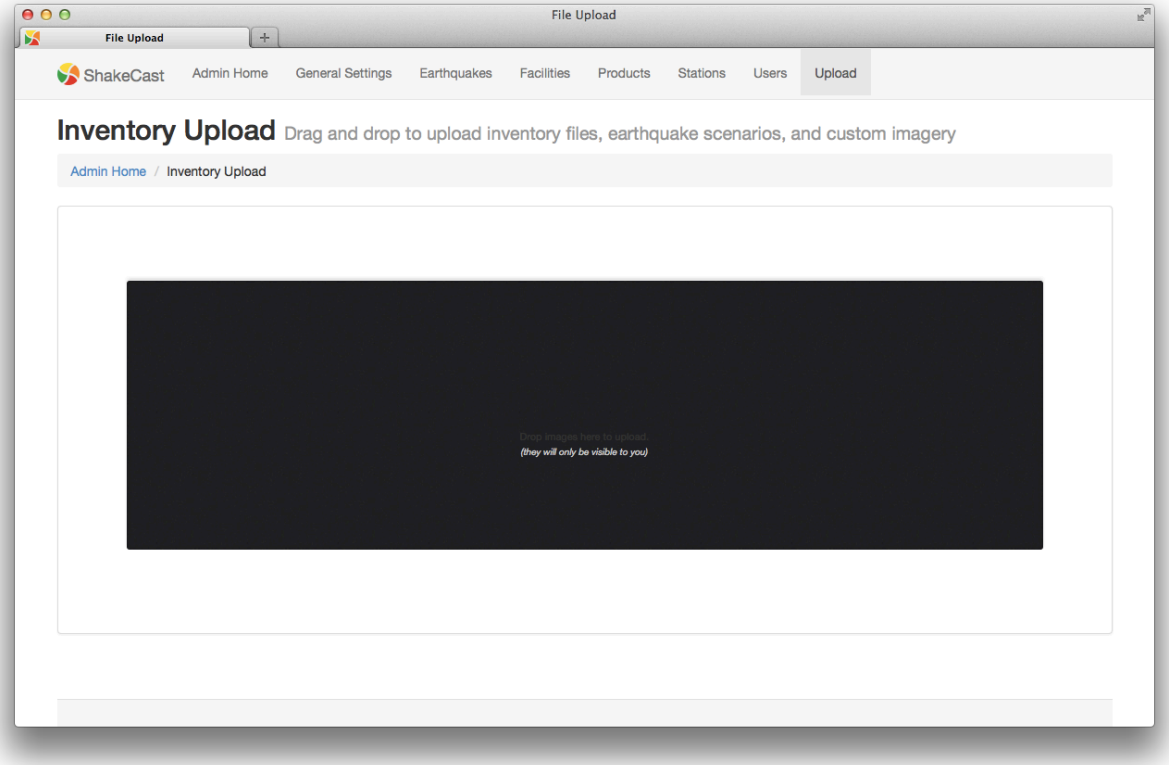


Figure 5.18. ShakeCast administrative interface for drag-and-drop inventory upload.

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.

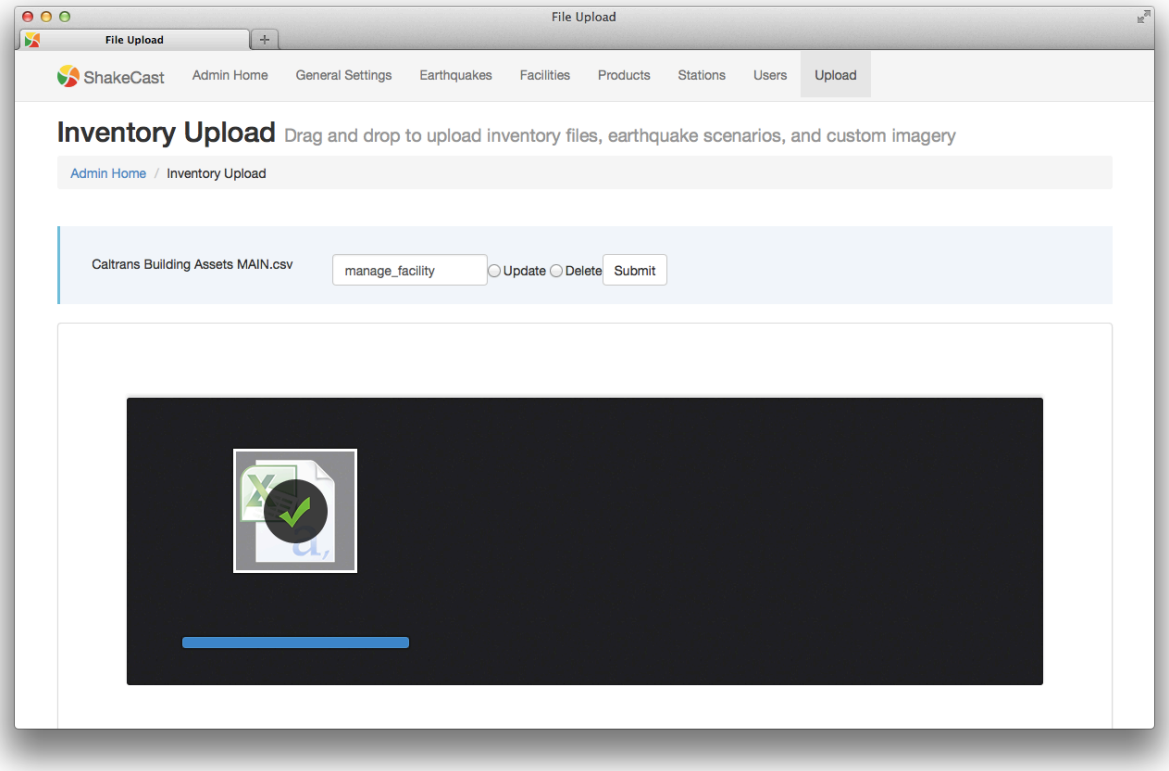


Figure 5.19. ShakeCast administrative interface for inventory upload showing the result of upload and the recommended user options to further process the uploaded file.

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.

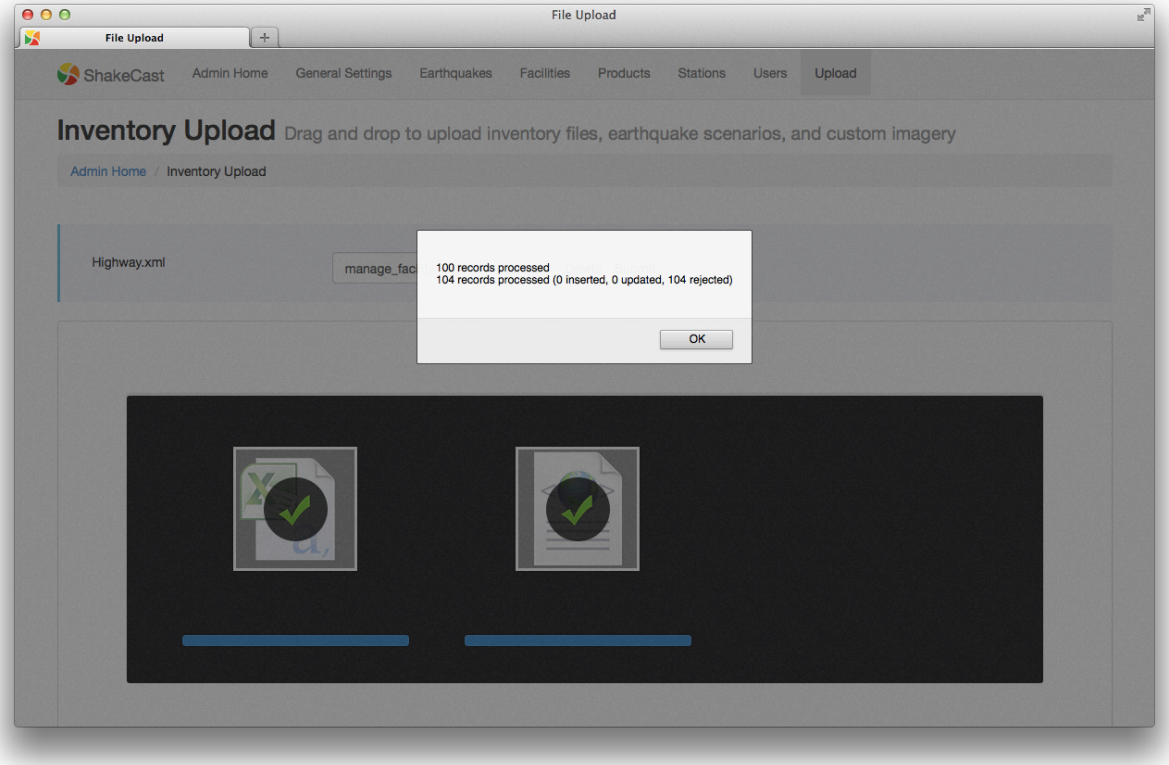


Figure 5.20. ShakeCast administrative interface for inventory upload showing output messages from the processing program for the uploaded file.

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.

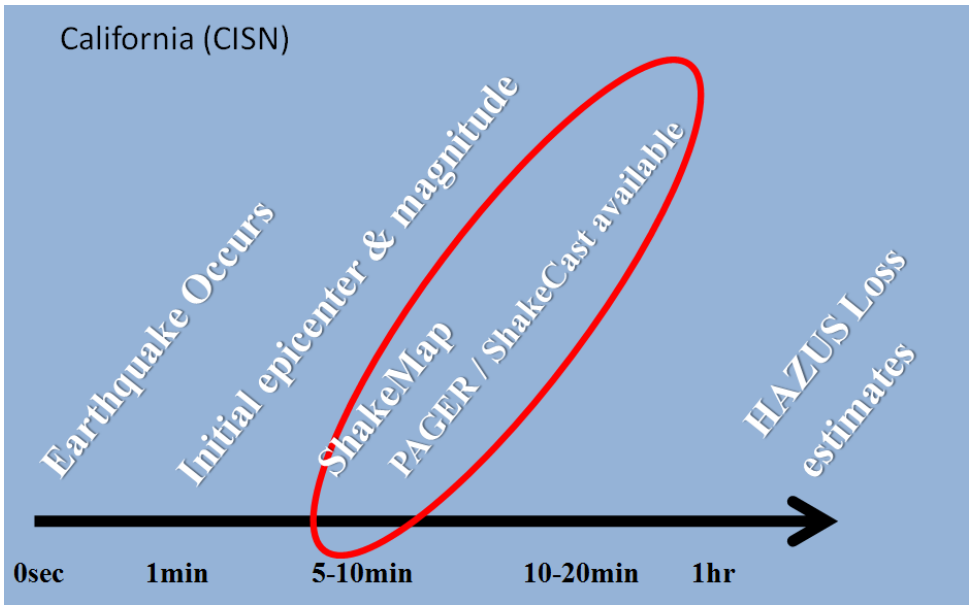


Figure 6.1. Approximate timeline of products for earthquakes in California.

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).

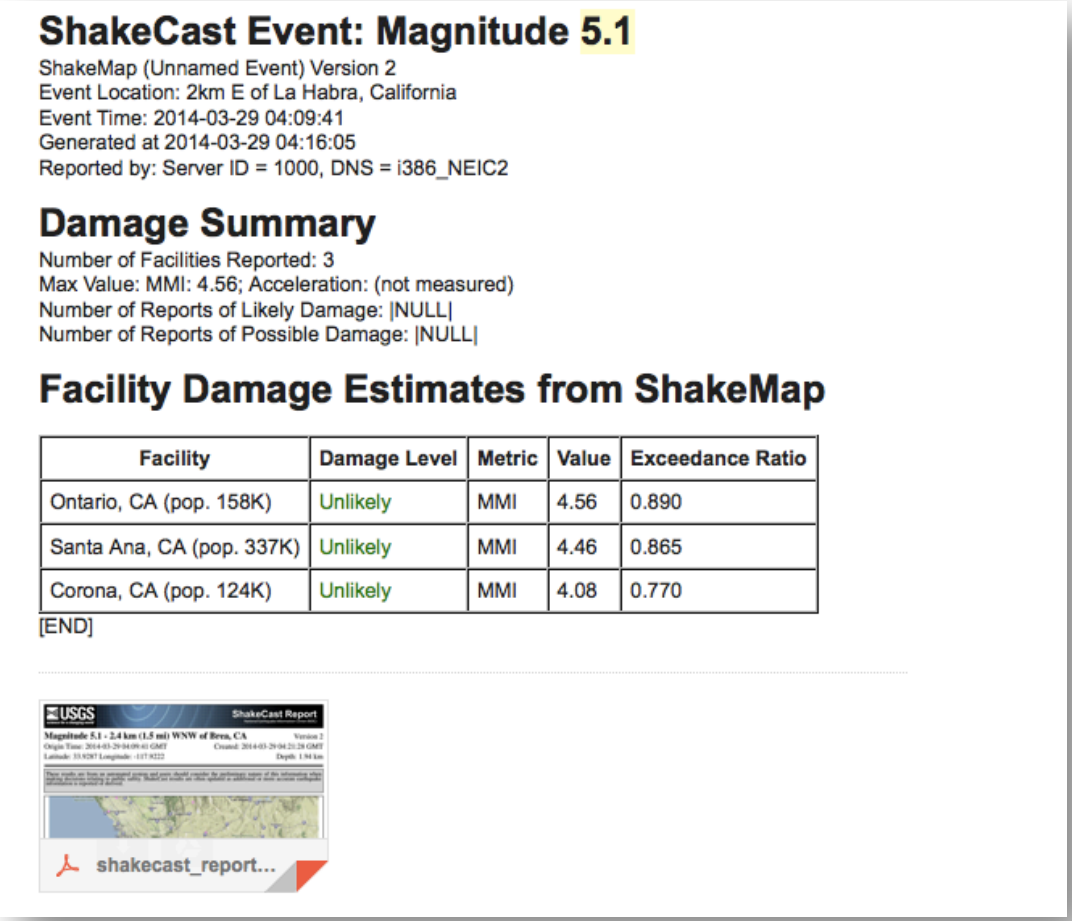
6.1.1 Facility Shaken Messages

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

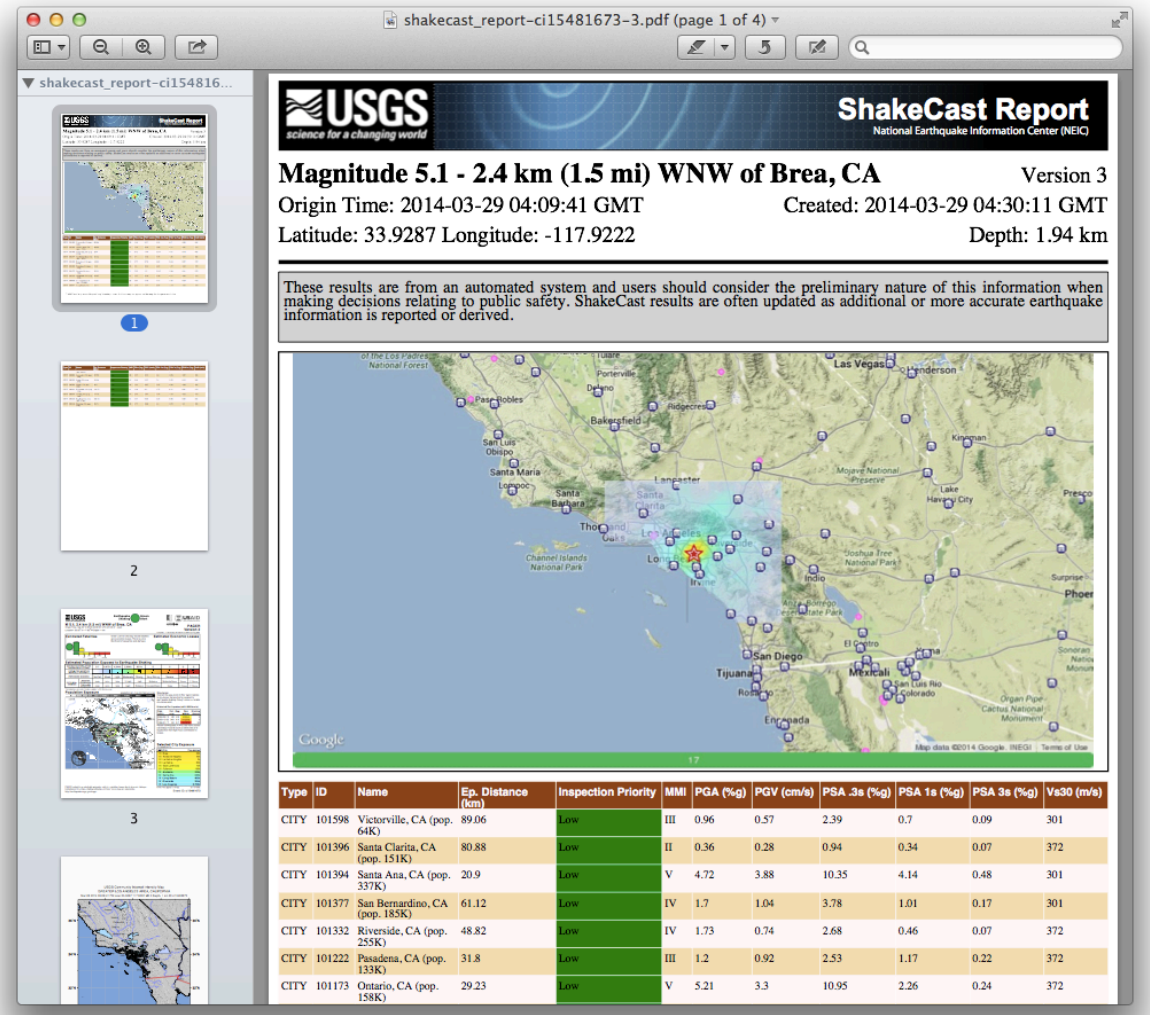
[END]

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.

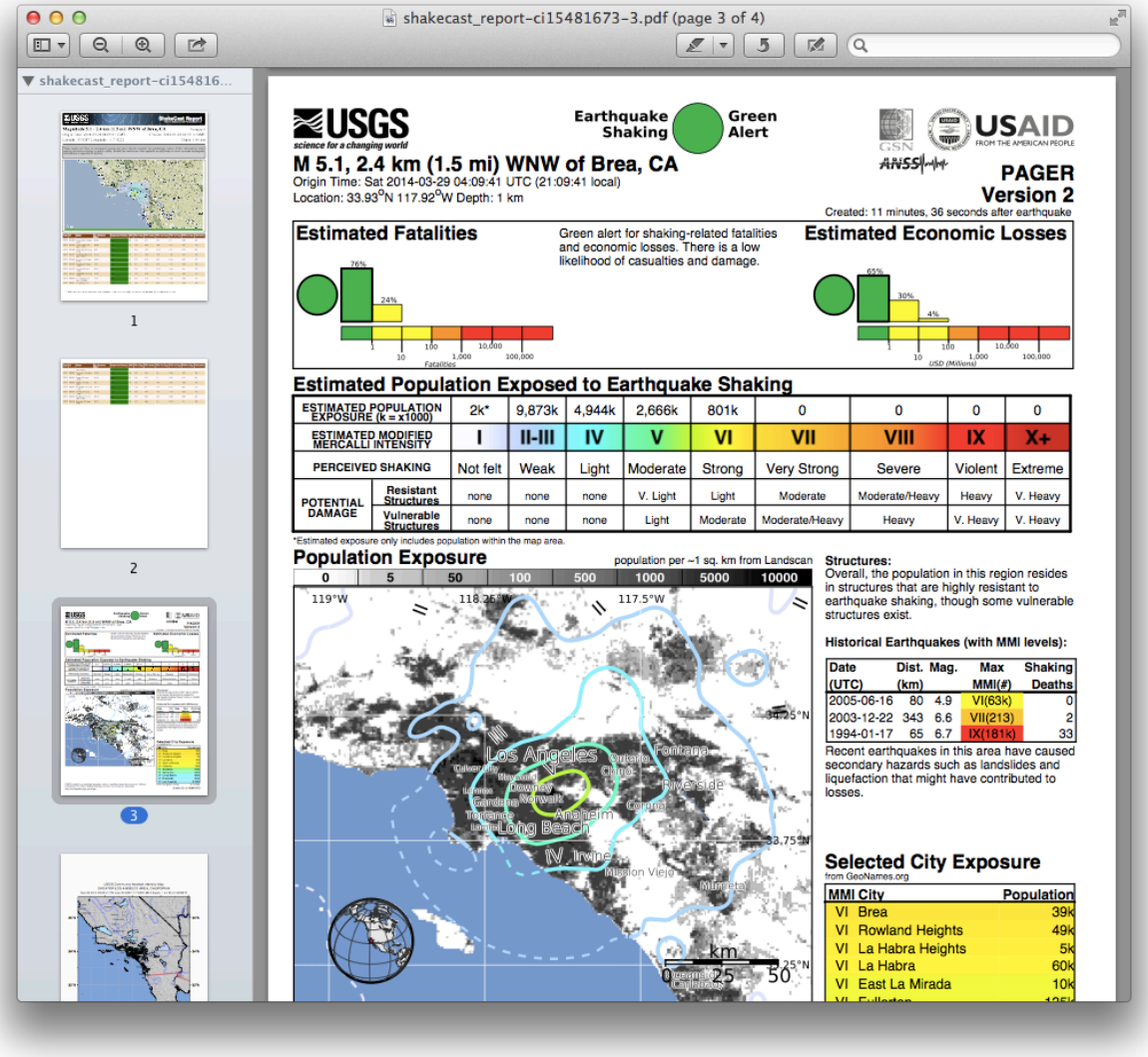


Figure 6.4. Example onePAGER summary page included in the ShakeCast PDF report.

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/.

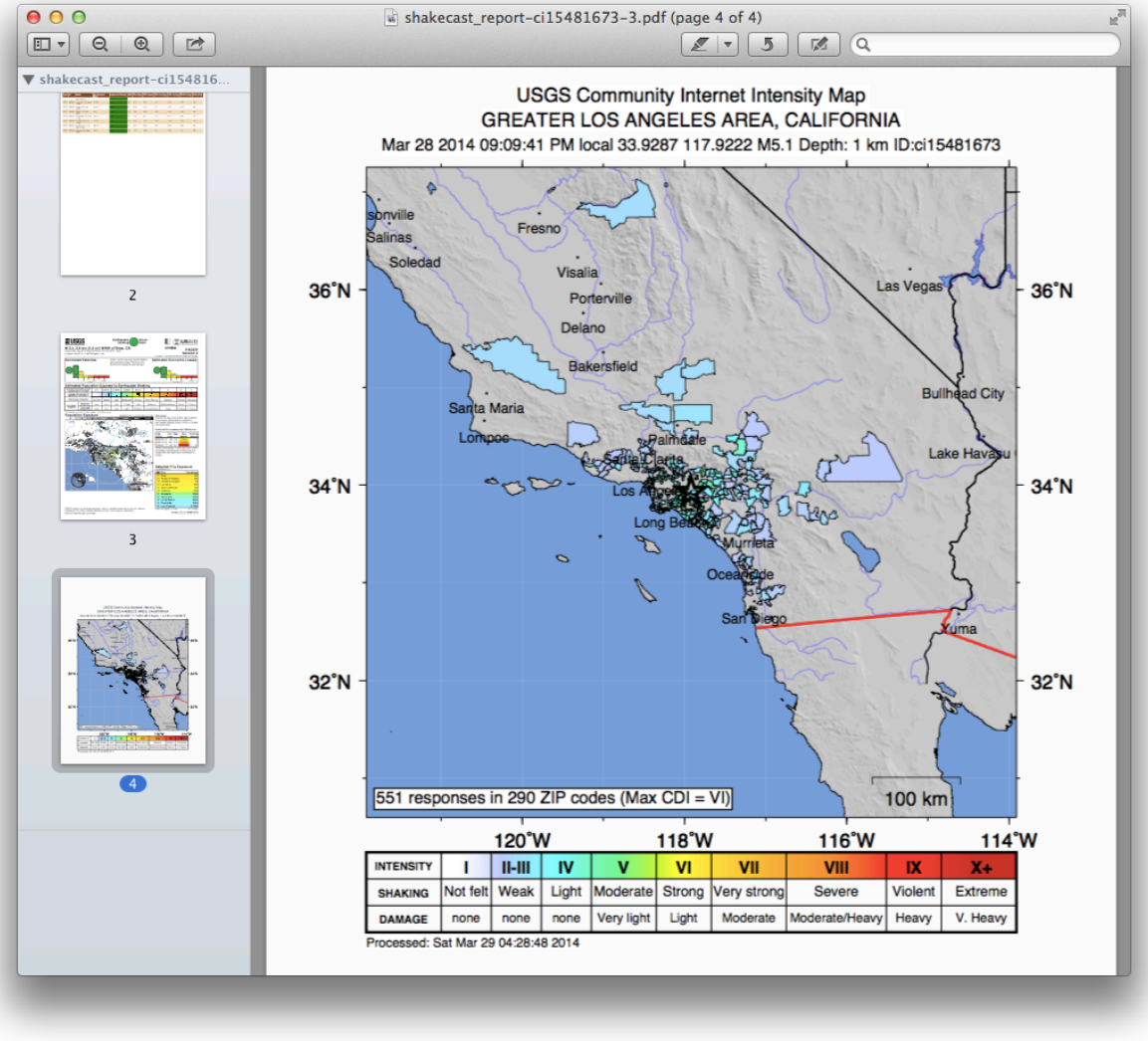


Figure 6.5. Example DYFI map page included in the ShakeCast PDF report.

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.

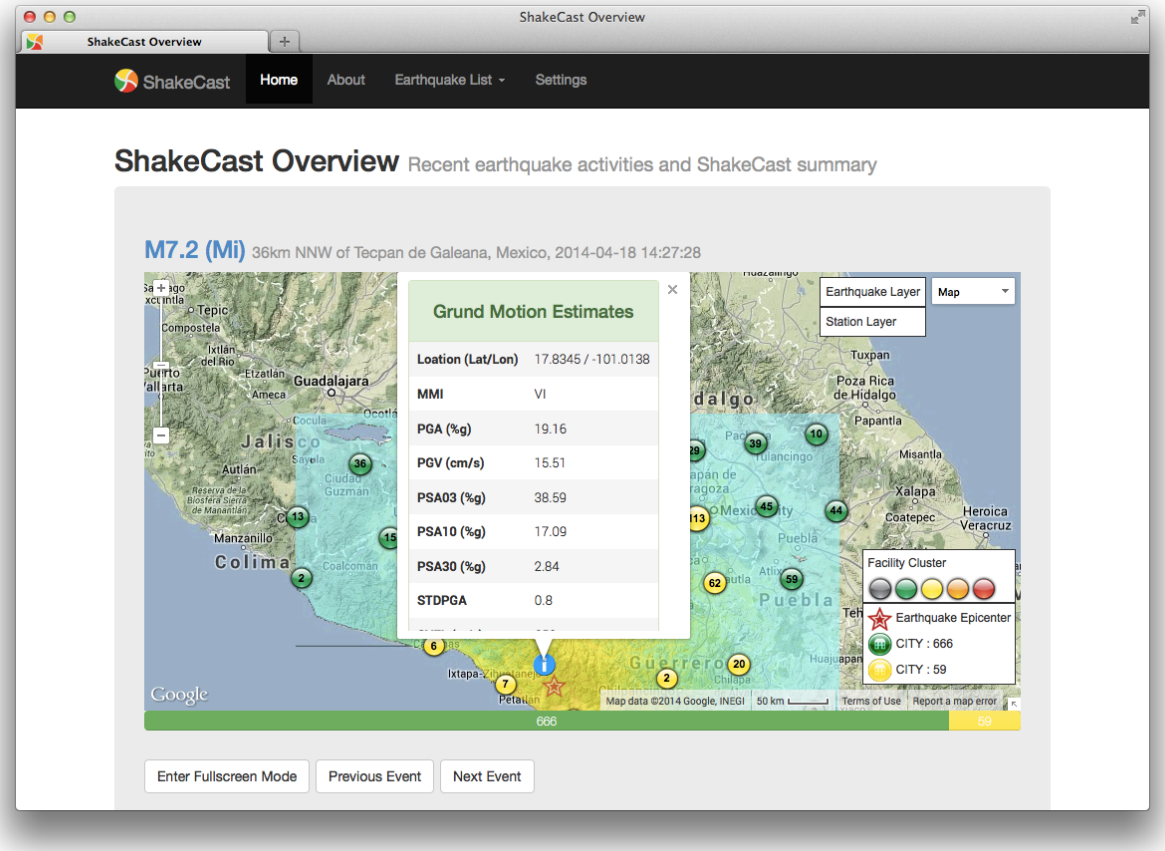


Figure 6.6. Example ShakeCast home page.

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.

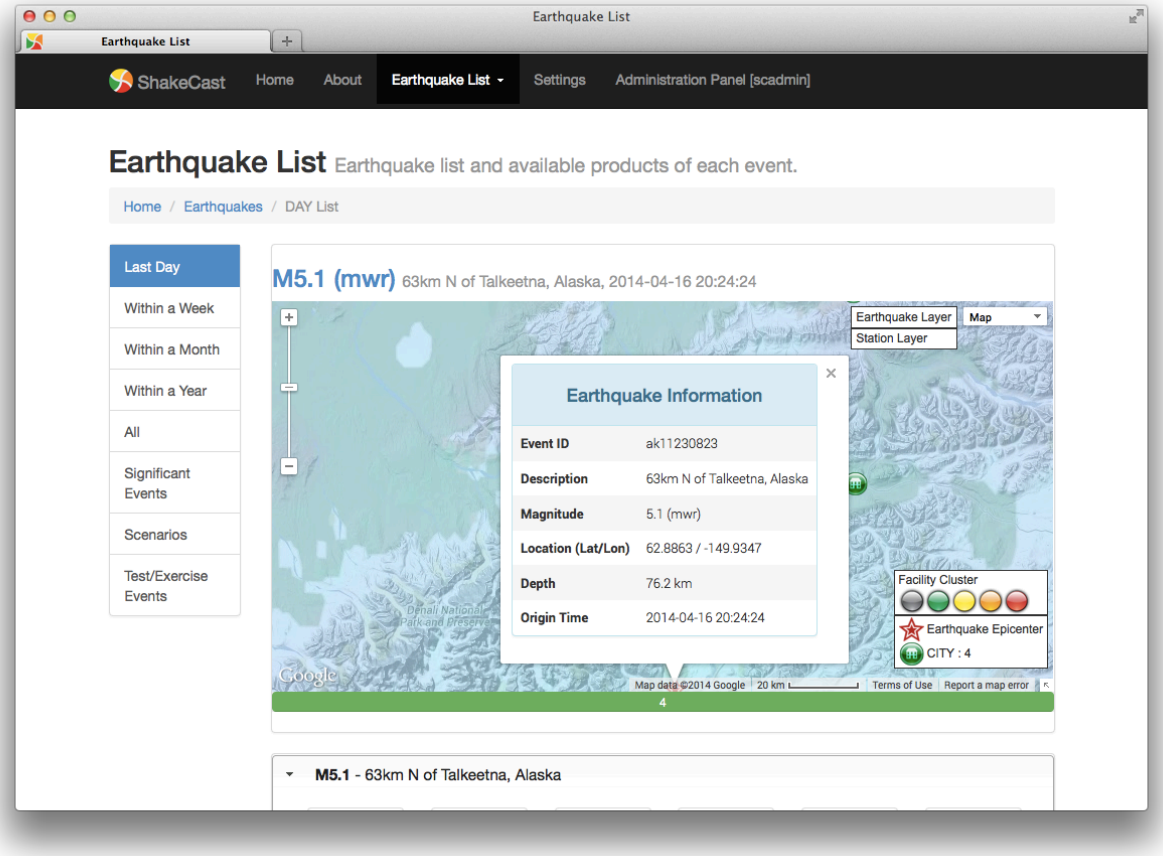


Figure 6.7. ShakeCast Earthquake List page.

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.

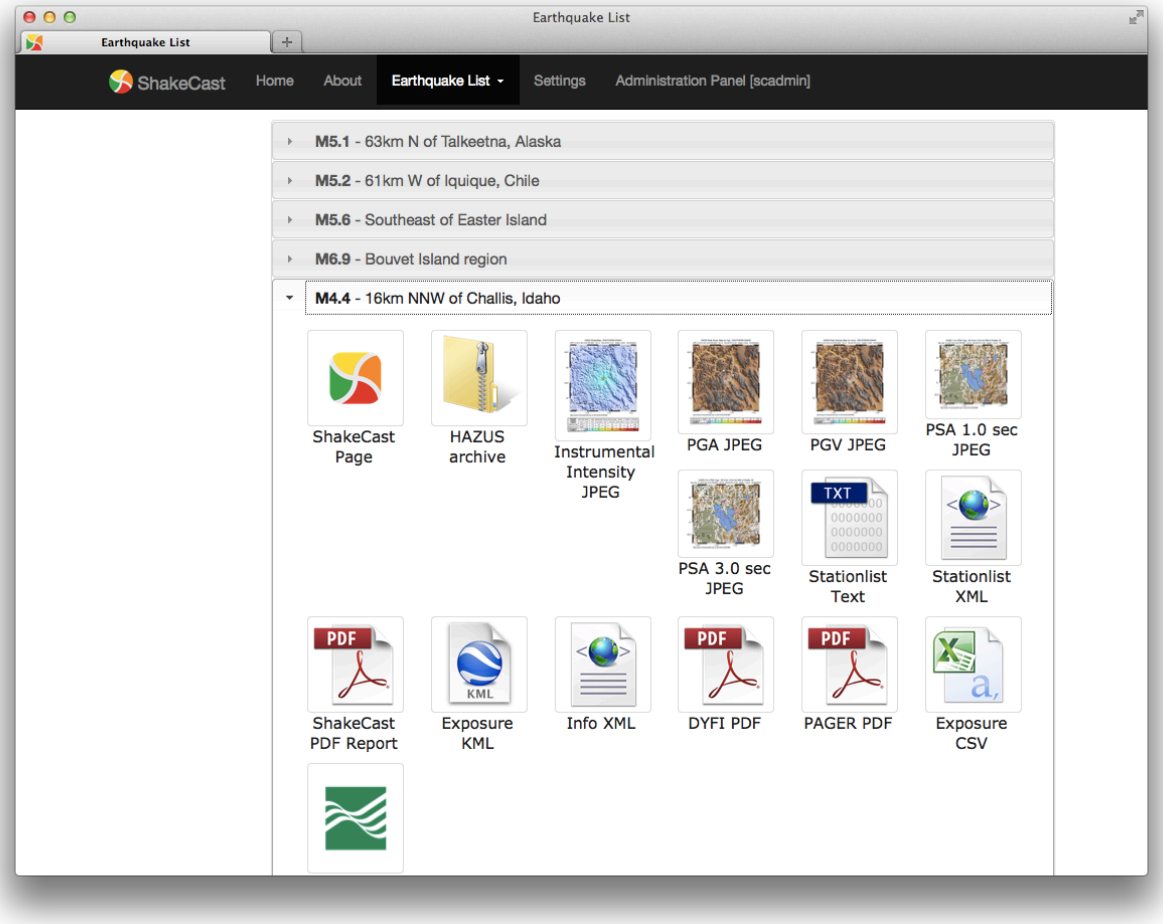


Figure 6.8. ShakeCast Earthquake List page.

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).

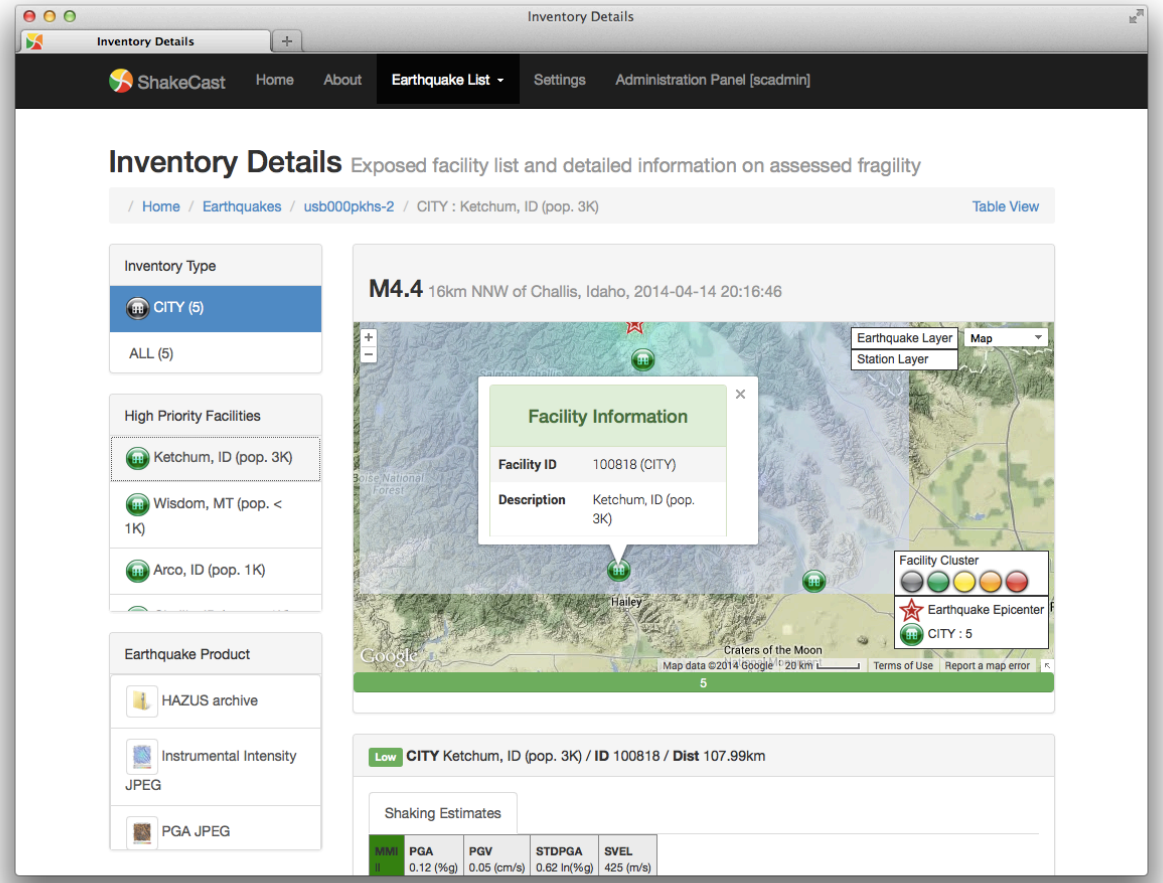


Figure 6.9. ShakeCast Inventory Details page for the selected earthquake.

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.

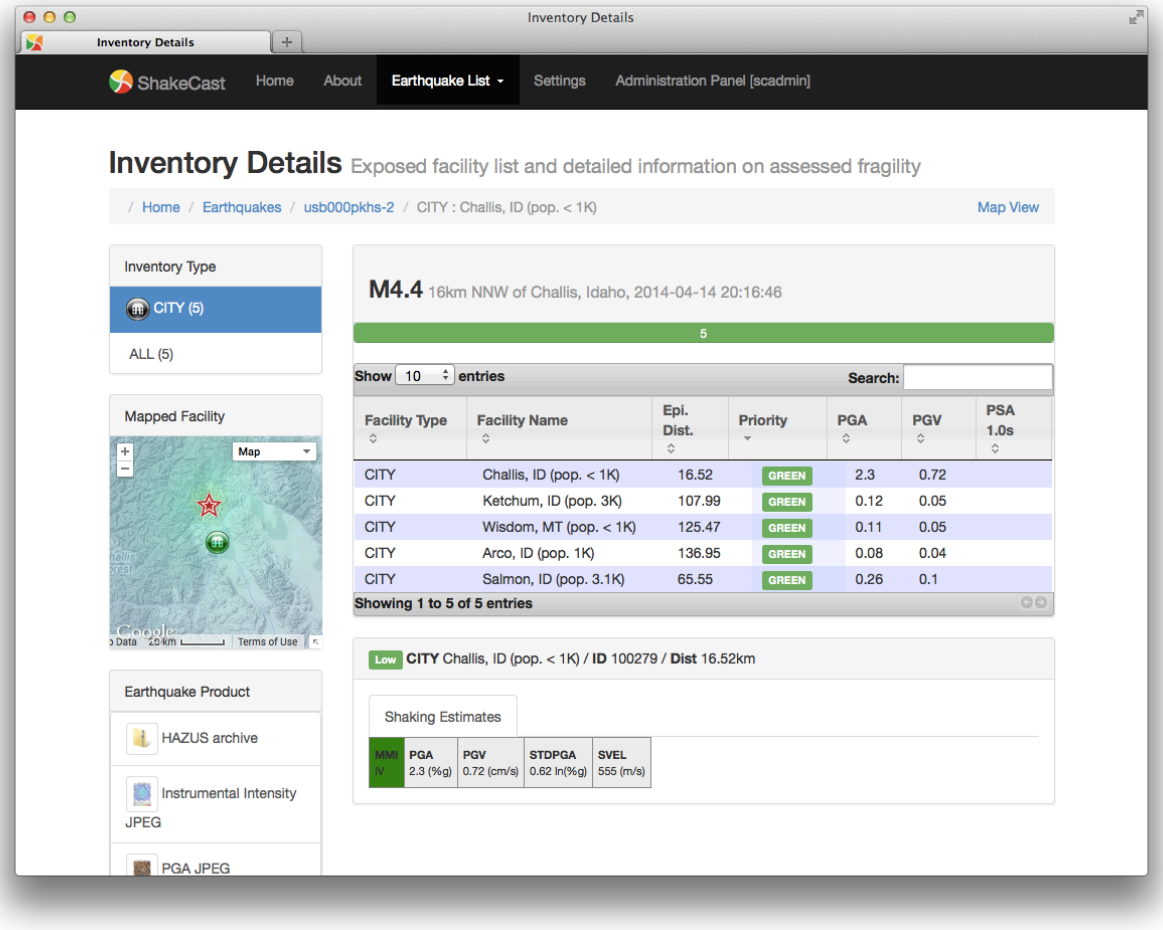


Figure 6.10. ShakeCast Inventory Details page in table view.

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.

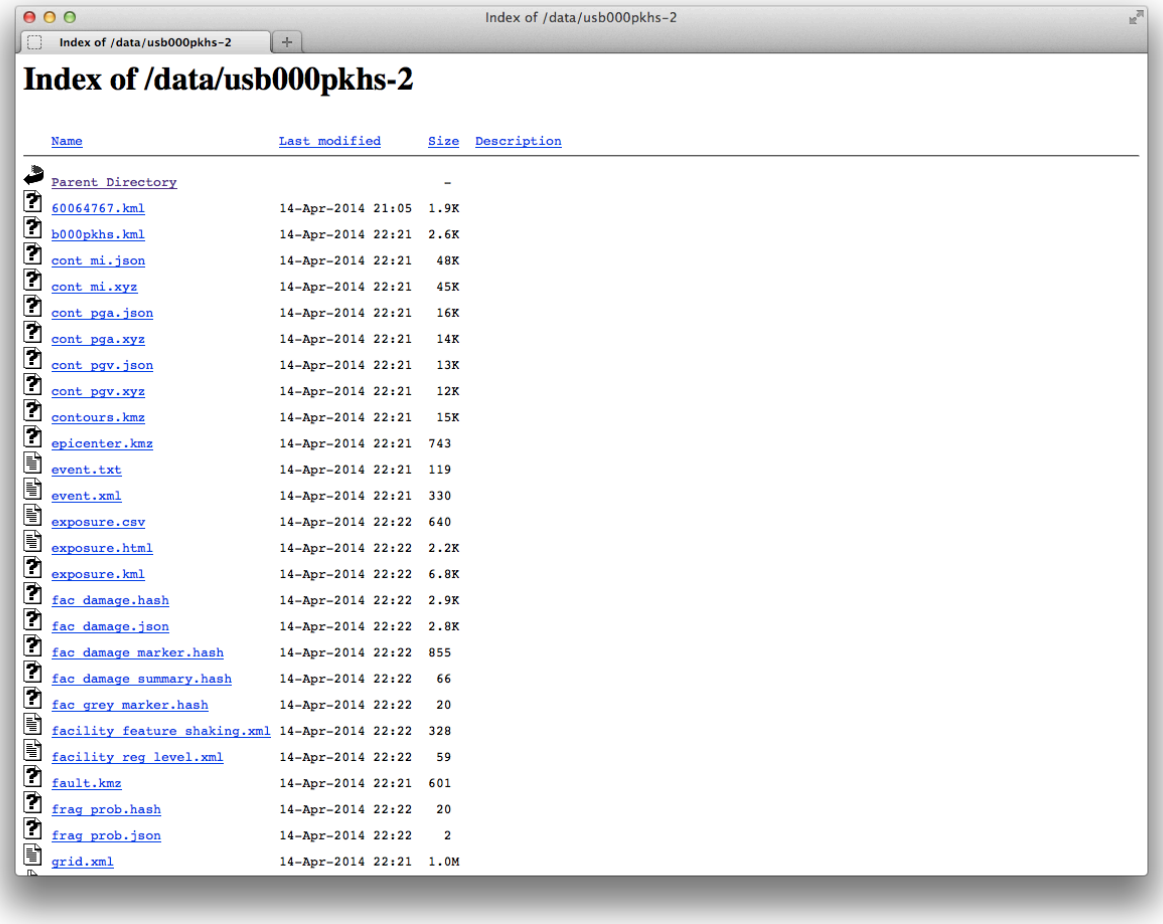


Figure 6.11. Full list of earthquake products available on the ShakeCast web site.

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.

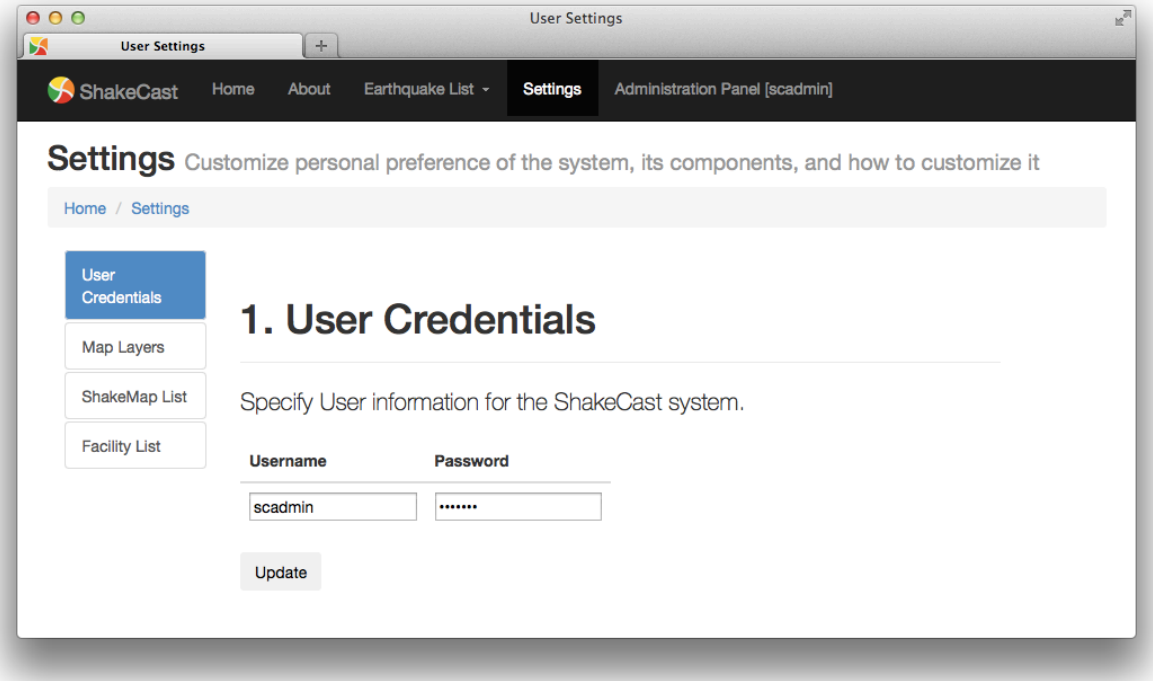


Figure 6.12. The user settings page of the ShakeCast web.

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).

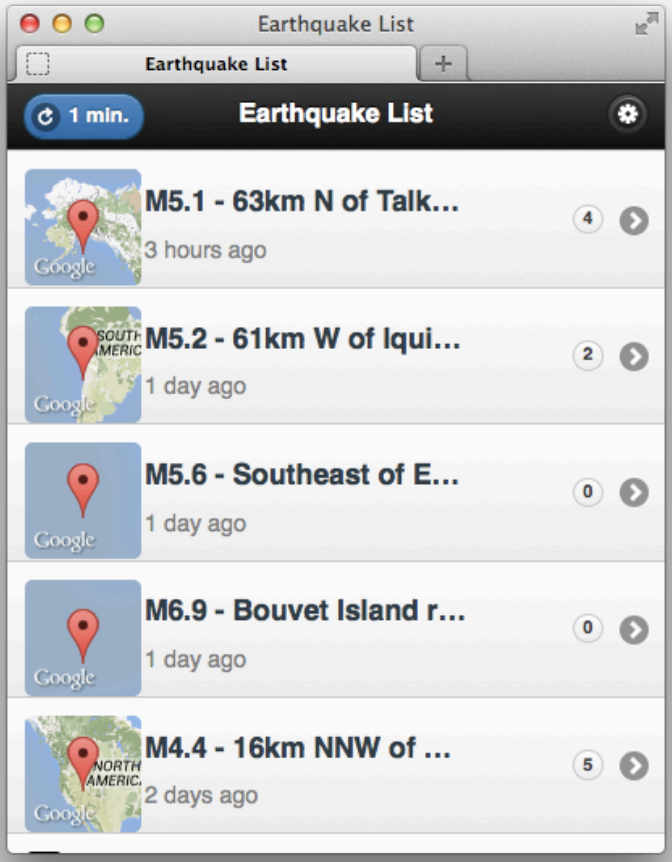


Figure 6.13. Earthquake list on the ShakeCast Mobile web page.

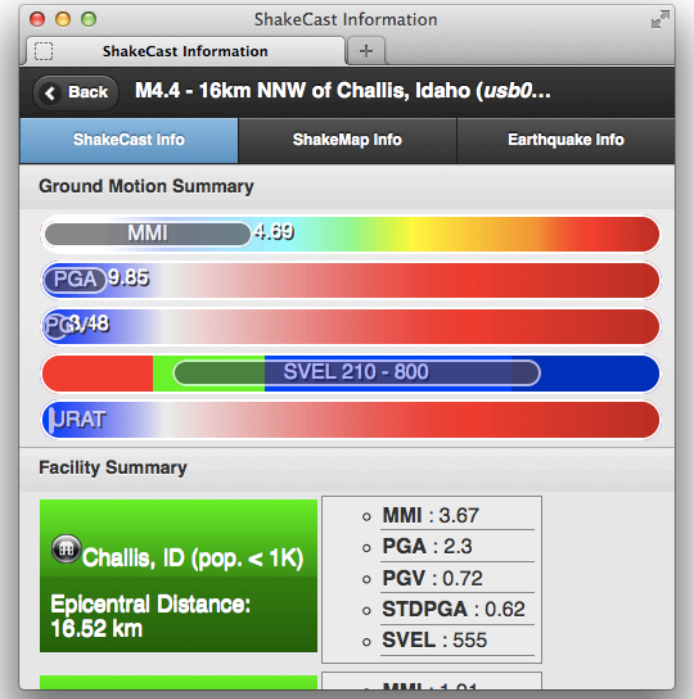


Figure 6.14. Earthquake summary on the ShakeCast Mobile web page.

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

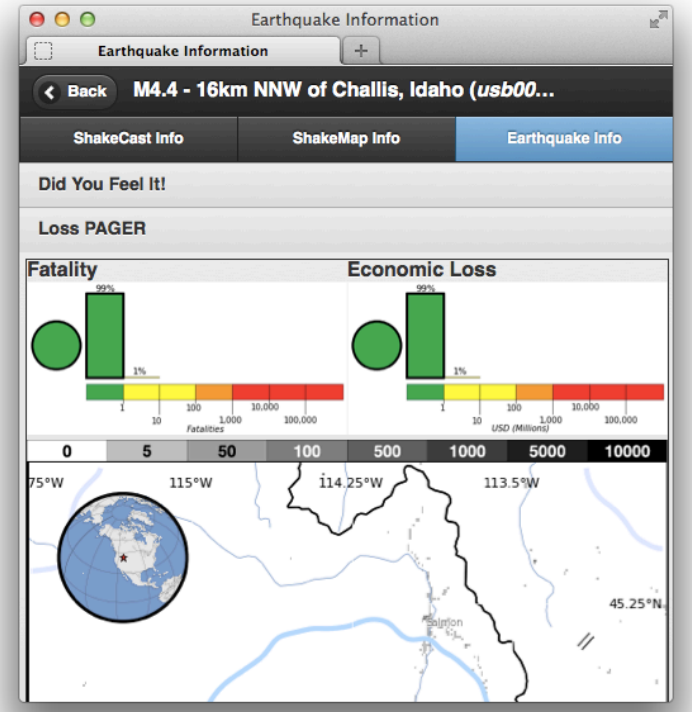


Figure 6.16. Earthquake product on the ShakeCast Mobile web page.

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.

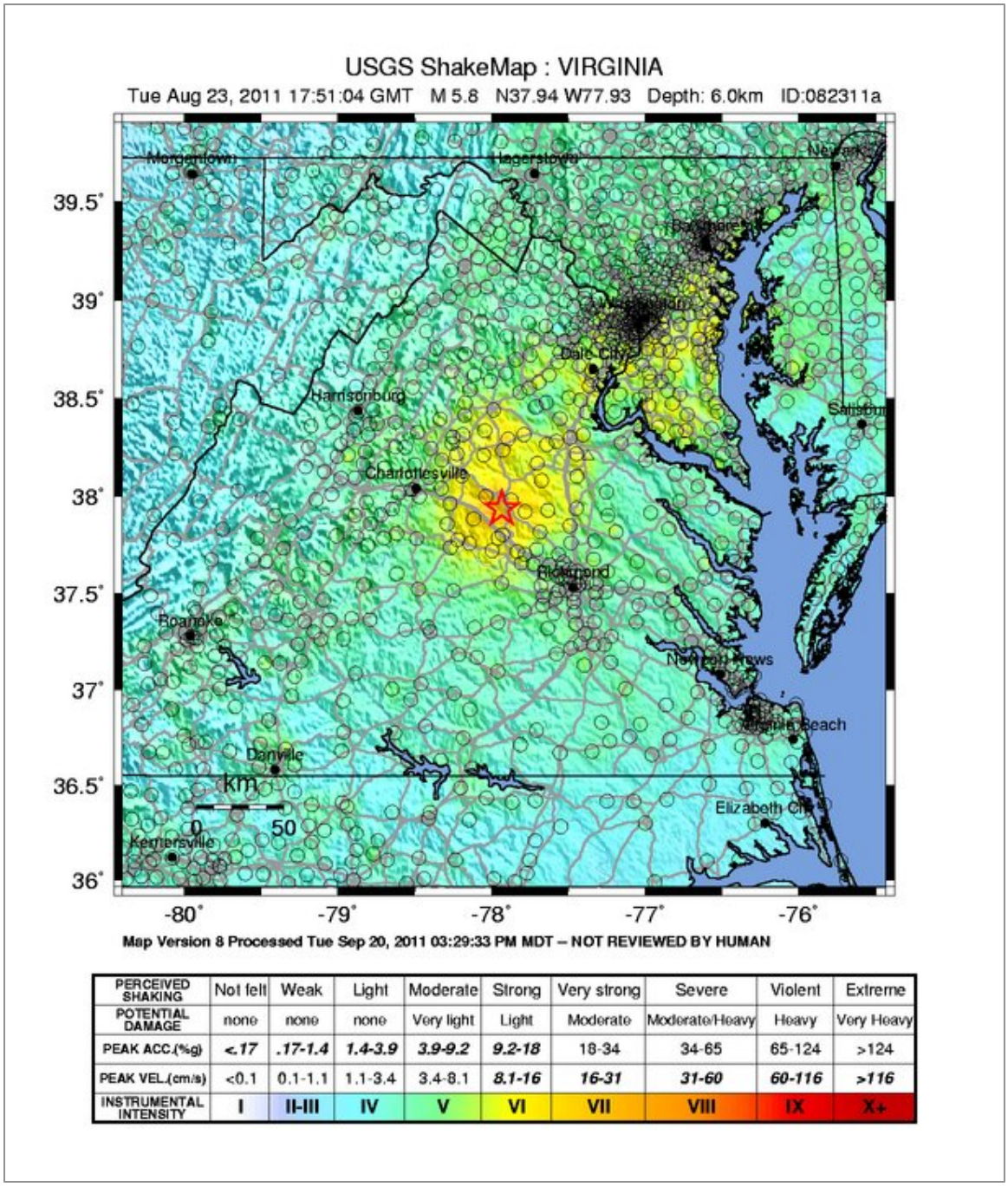


Figure 7.1. ShakeMap for the M5.8 Virginia Earthquake in 2011.

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

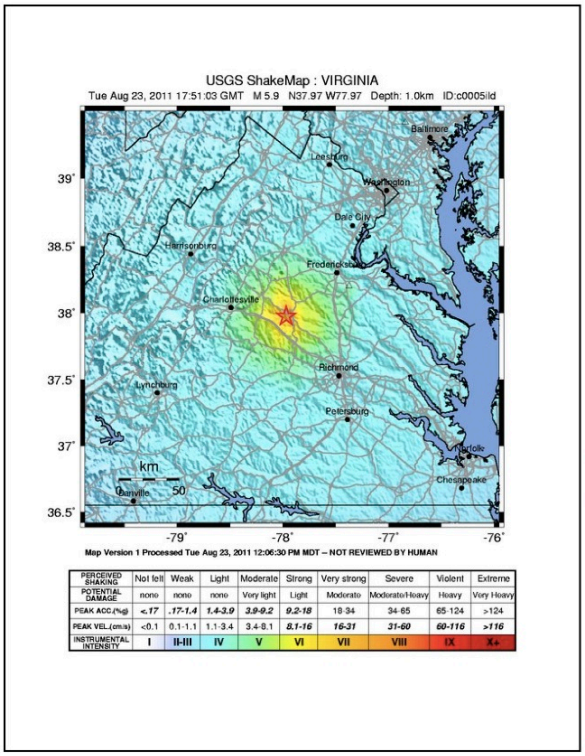
Origin Time: 2011-08-23 17:51:03 GMT

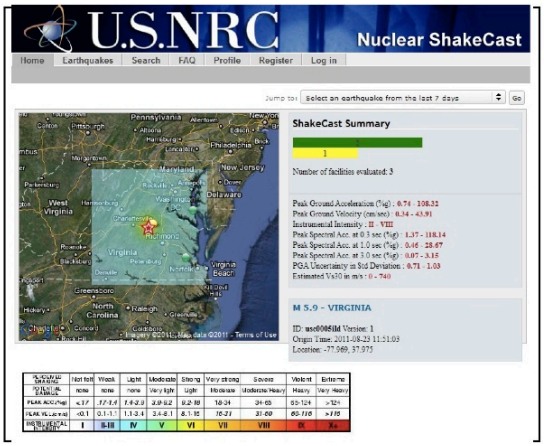
Created: 2011-08-23 18:42:51 GMT

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

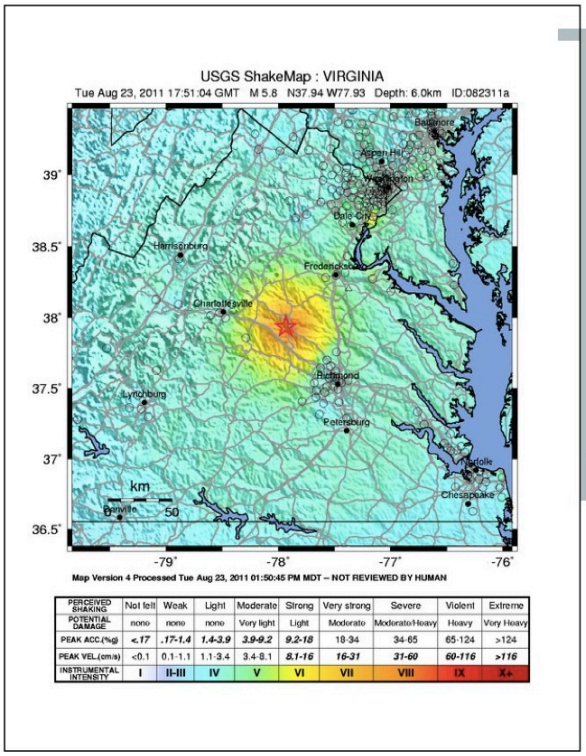
Magnitude 5.8 - VIRGINIA

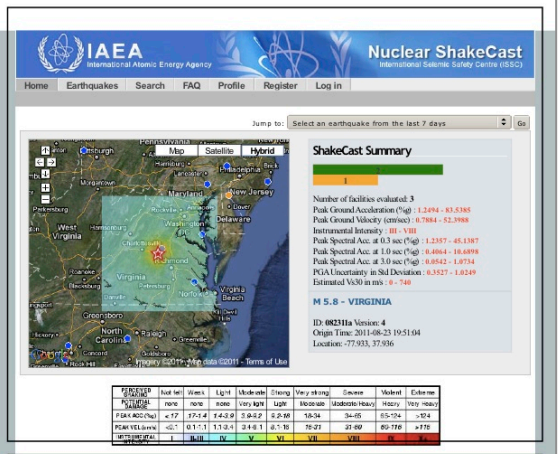
Time: 2011-08-23 17:51:04 GMT
Location: 37.94 N/ -77.93 W
Depth: 6.0 km

Version 4

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

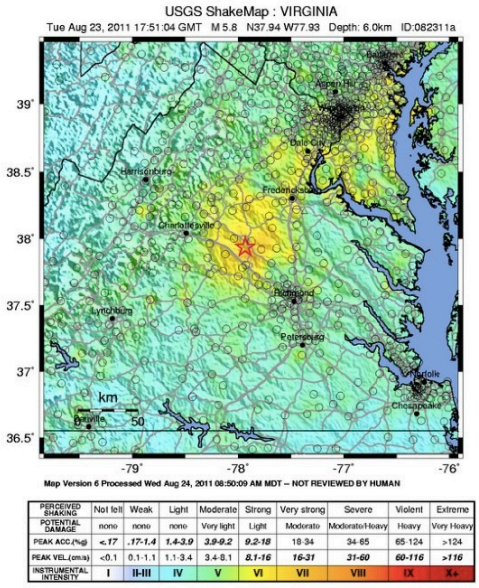
Origin Time: 2011-08-23 17:51:04 GMT

Created: 2011-08-24 15:11:29 GMT

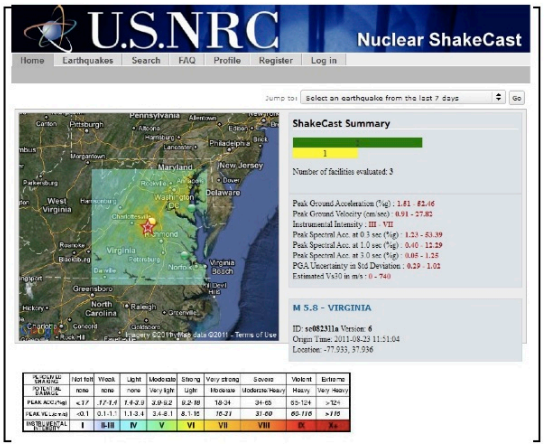
Latitude: 37.9360 Longitude: -77.9330

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.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



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.

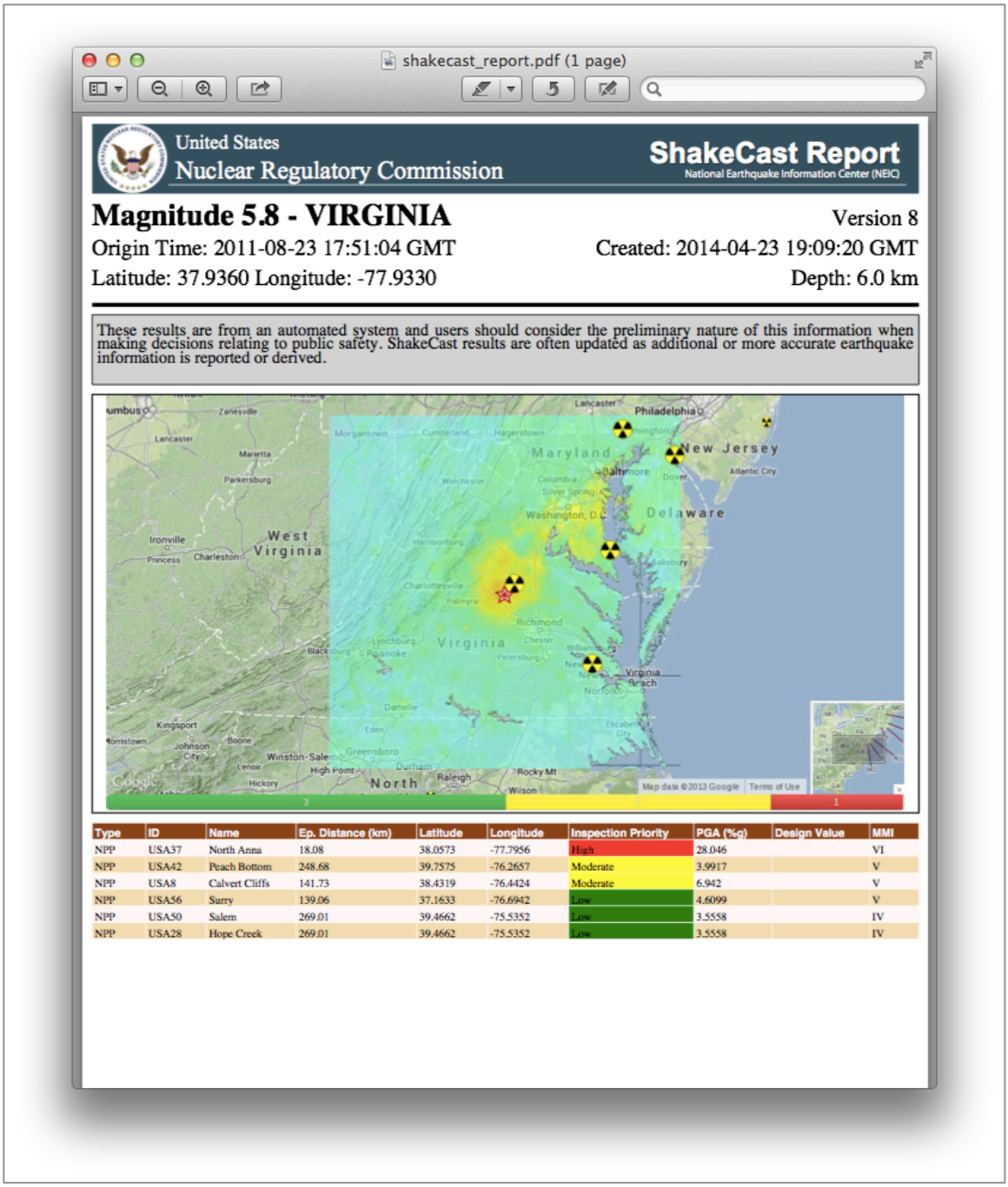


Figure 7.5. Final version of ShakeCast summary PDF (V3 system) for the M5.8 Mineral, Virginia Earthquake.

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.

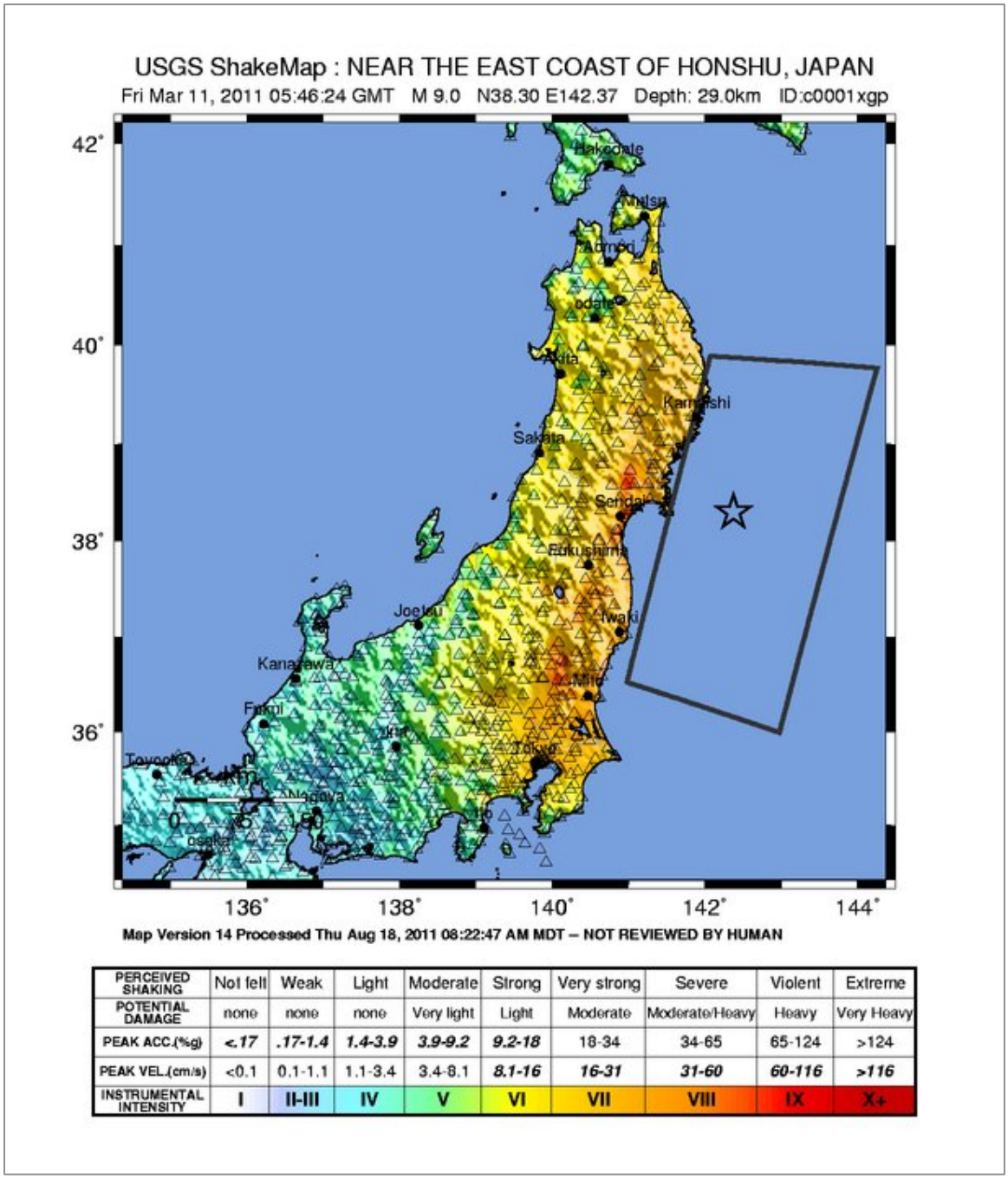


Figure 7.6. ShakeMap from 2011, M9.0 Tohoku earthquake

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.

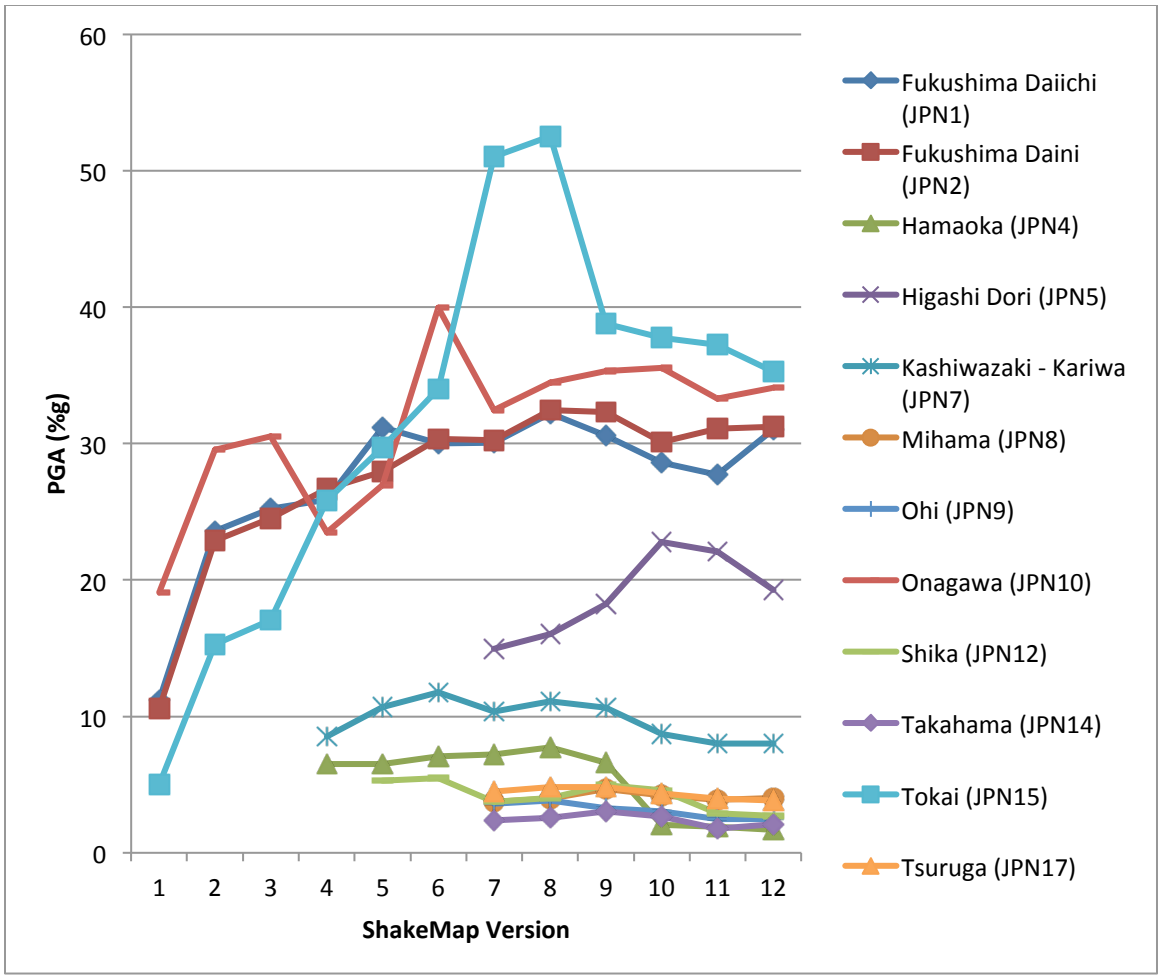


Figure 7.7. ShakeCast PGA estimates from ShakeMap updates for the Japan Earthquake

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

We thank Caltrans, the IAEA and the VA for continued support for ShakeCast operations, user support, and continued development. We also thank A. Kammerer and S. Stoval for their efforts as part of the U.S. Nuclear Regulatory Commission (USNRC) and N. Bekiri of the (IAEA) for helping guide the development of “Nuclear ShakeCast”, in particular, the regulatory framework developed for ShakeCast use therein. Any mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

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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.

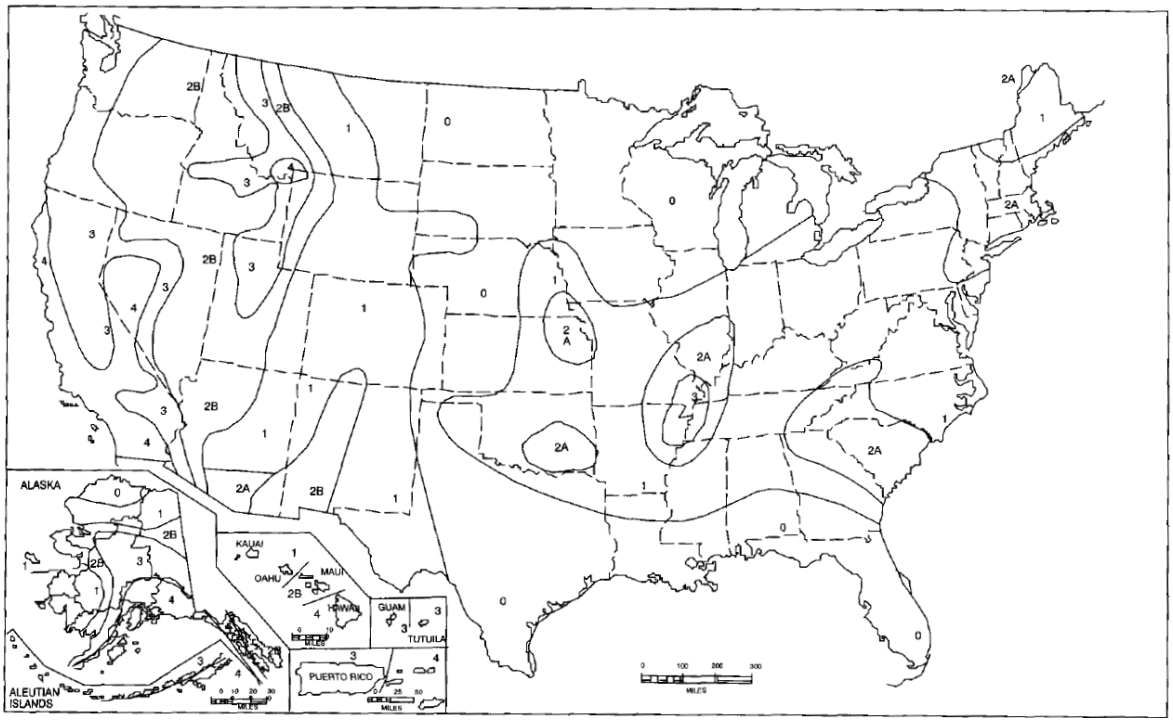

Figure D.1 Seismic zone map of the United States (fig. 16-2, ICBO, 1997).

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	W1	**Wood, Light Frame (≤ 5,000 sq. ft.)**		1 - 2	1	14
2	W2	**Wood, Commercial and Industrial (>5,000 sq. ft.)**		All	2	24
3	S1L	**Steel Moment Frame**	Low-Rise	1 - 3	2	24
4	S1M		Mid-Rise	4 - 7	5	60
5	S1H		High-Rise	8+	13	156
6	S2L	**Steel Braced Frame**	Low-Rise	1 - 3	2	24
7	S2M		Mid-Rise	4 - 7	5	60
8	S2H		High-Rise	8+	13	156
9	S3	**Steel Light Frame**		All	1	15
10	S4L	**Steel Frame with Cast-in-Place Concrete Shear Walls**	Low-Rise	1 - 3	2	24
11	S4M		Mid-Rise	4 - 7	5	60
12	S4H		High-Rise	8+	13	156
13	S5L	**Steel Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	24
14	S5M		Mid-Rise	4 - 7	5	60
15	S5H		High-Rise	8+	13	156
16	C1L	**Concrete Moment Frame**	Low-Rise	1 - 3	2	20
17	C1M		Mid-Rise	4 - 7	5	50
18	C1H		High-Rise	8+	12	120
19	C2L	**Concrete Shear Walls**	Low-Rise	1 - 3	2	20
20	C2M		Mid-Rise	4 - 7	5	50
21	C2H		High-Rise	8+	12	120
22	C3L	**Concrete Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	20
23	C3M		Mid-Rise	4 - 7	5	50
24	C3H		High-Rise	8+	12	120
25	PC1	**Precast Concrete Tilt-Up Walls**		All	1	15
26	PC2L	**Precast Concrete Frames with Concrete Shear Walls**	Low-Rise	1 - 3	2	20
27	PC2M		Mid-Rise	4 - 7	5	50
28	PC2H		High-Rise	8+	12	120
29	RM1L	**Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms**	Low-Rise	1-3	2	20
30	RM2M		Mid-Rise	4+	5	50
31	RM2L	**Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms**	Low-Rise	1 - 3	2	20
32	RM2M		Mid-Rise	4 - 7	5	50
33	RM2H		High-Rise	8+	12	120
34	URML	**Unreinforced Masonry Bearing Walls**	Low-Rise	1 – 2	1	15
35	URMM		Mid-Rise	3+	3	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