# NGA-East Final Project Plan

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## VERSION CONTROL INFORMATION

This project plan is a living document that will be used to communicate the project goals and activities to project participants and to the public. The following information is provided for tracking released versions.

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CENA | Central and Eastern North America |
| CEUS | Central and Eastern United States |
| CEUS SSC | Central and Eastern U.S. Seismic Source Characterization for Nuclear Facilities Project |
| DNFSB | Defense Nuclear Facilities Safety Board |
| DOE | United States Department of Energy |
| EPRI | Electric Power Research Institute |
| GM | Ground Motion |
| GMC | Ground Motion Characterization |
| GMPE | Ground motion prediction equation (AKA attenuation relationship) |
| HFA | Hazard Feedback Analysis or Hazard Feedback Analyst |
| JMC | Joint Management Committee |
| MIA | NGA-East/CEUS SSC Model Interface Advisor |
| NGA | Next Generation Attenuation Relationship |
| NGA-East | Next Generation Attenuation Relationship for the Central and Eastern North American Region |
| NGA-West | Next Generation Attenuation Relationship for shallow crustal earthquakes in active tectonic regions (original project) |
| NGA-West2 | Next Generation Attenuation Relationship for shallow crustal earthquakes in active tectonic regions (phase 2 of NGA-West project) |
| NRC | United States Nuclear Regulatory Commission |
| NUREG | Regulatory guides, reports and brochures from the U.S. Nuclear Regulatory Commission |
| NUREG/CR | Regulatory guides, reports and brochures from the U.S. Nuclear Regulatory Commission prepared by NRC Contractors |
| PEER | Pacific Earthquake Engineering Research Center |
| PGA | Peak Ground Acceleration |
| PGV | Peak Ground Velocity |
| PM | Project Manager |
| PPRP | Participatory Peer Review Panel |
| PSHA | Probabilistic Seismic Hazard Analysis |
| Q | Quality factor |
| RFP | Request For Proposal |
| Sa | Spectral acceleration |
| SCR | Stable Continental Region |
| SGPM | SSHAC Guidelines Process Manager |
| SSC | Seismic Source Characterization |
| SSHAC | Senior Seismic Hazard Assessment Committee |
| T | Spectral period (in seconds) |
| TI | Technical Integrator |
| U.S. | United States |
| USGS | United States Geological Survey |
| V/H | Vertical to horizontal ground motion ratio |
| WG | Working Group |
| WUS | Western United States |

# 1. INTRODUCTION

This document outlines the Next Generation Attenuation for Central and Eastern North-America project (NGA-East). The objective of NGA-East is to develop a new ground motion characterization (GMC) model for the Central and Eastern North-American (CENA) region. The GMC model consists in a set of new ground motion prediction equations (GMPEs) for median and standard deviation of ground motions (GMs) and their associated weights in the logic-trees for use in probabilistic seismic hazard analyses (PSHA).

NGA-East is a multi-disciplinary research project coordinated by the Pacific Earthquake Engineering Research center (PEER), with headquarters at the University of California, Berkeley. The project involves a large number of participating researchers from various organizations in academia, industry and government. The project is jointly sponsored by the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI) and the U.S. Geological Survey (USGS).

A major component of NGA-East is treated as a SSHAC Level 3 project (SSHAC, 1997). The current project plan sent to the Participatory Peer Review Panel (PPRP) for review was developed for the SSHAC Level 3 tasks only. Additional "non-SSHAC" tasks are managed by the Project Manager (PM) and the Joint Management Committee (JMC) outside of the SSHAC framework. This document presents the SSHAC project objectives and the technical work plan devised to meet these objectives, along with intermediate deliverables with their associated schedule. The technical work plan was developed over a period of time with input from the NGA-East project teams and the JMC. The NGA-East Technical Integration team (TI team) and Project Manager then refined the plan to its current form. The project plan is consistent with the budget and scope revisions approved by the JMC in a conference call on March 9, 2011.

The project is funded by U.S. agencies, and their interest is to develop the ground motion model for the Central and Eastern U.S. (CEUS). Nonetheless, because the tectonic region of interest reaches across into Canada, the ground motion model developed in NGA-East will be applicable to the larger CENA region. A large number of earthquake records used in this project were provided with support from the Geological Survey of Canada.

## 2. OBJECTIVES

The goals of the NGA-East project, listed below, are based on input from the sponsors and other stakeholders. This section focuses on principal objectives; task-specific objectives are presented in Section 5.

The general objective of NGA-East is to develop a new ground motion model for the CENA region. The products of the project are a set of new candidate GMPEs, commonly known as attenuation relationships, and a set of associated logic-trees for use in PSHA. Additional products include earthquake ground motion databases as well as models for site response and for vertical component ground motion.

A large portion of the NGA-East project is treated as a SSHAC Level 3 project (SSHAC, 1997). More details on the SSHAC level specification are presented in Section 3. The project objectives associated with the SSHAC Level 3 portion of the project are referred to as "SSHAC objectives". There are additional project objectives that are not covered by the SSHAC Level 3 umbrella and those are referred to as "non-SSHAC objectives". The non-SSHAC objectives are not discussed further in this project plan, but are listed below for completeness.

**Principal SSHAC Objective**

*To provide the best estimate of the distribution (median and standard deviation) of average horizontal ground motions (PGA, PGV and 5%-damped Sa for T=0.01-10s) on hard-rock sites located up to 1,000 km from future earthquakes in CENA with moment magnitudes in the 4.0 to 8.0 range, and to provide the epistemic uncertainty associated with this estimate.*

This objective must be achieved in the context of a SSHAC Level 3 study. More specifically, the SSHAC objectives are associated with the development of new databases, the full assessment and incorporation of variability and uncertainty, the inclusion of the center, body and range of technically defensible interpretations of the available data, models and methods, the development of exhaustive documentation, and a thorough peer review.

*Interaction with the CEUS SSC Project*

Input to PSHA computations require both seismic source and ground motion characterization. The NGA-East project is a ground motion characterization project. The complementary Central and Eastern United States Seismic Source Characterization for Nuclear Facilities project (CEUS SSC) is nearing completion. The CEUS SSC is also conducted as a SSHAC Level 3 study (Coppersmith and Salomone, 2008). Because the NGA-East and CEUS SSC products will be used together in PSHA assessments, there needs to be a strong interaction between the two projects. A timely dialogue between key participants of both projects is necessary to ensure compatibility of the source characterization and ground motion characterization and to make sure that the final PSHA estimates reflect the intent of the CEUS SSC and NGA-East products. Therefore, the GMPEs developed in this project and the implementation guidance developed by the NGA-East TI team, should be compatible with the logic tree-based model that will result from the CEUS SSC Project.

**Principal Non-SSHAC Objectives**

*To develop site amplification models to account for site response effects on geo-materials not defined as hard rock.*

*To develop models to quantify the ground motions in the vertical direction of shaking.*

In addition, other non-SSHAC objectives include the collaboration and integration with other projects:

*Collaboration with NGA-West2*

The NGA-West2 project is currently updating the NGA-West models within PEER. There are issues that are addressed in NGA-West2 that are of interest to NGA-East and some results from the NGA-West2 effort will be transferable to NGA-East. This applies mainly to the tasks from the Sigma and Vertical Ground Motion Working Groups. These working groups have the same teams of researchers.

*Integration with the USGS National Hazard Mapping Program*

The project plan was designed to have at least some products, including draft GMPEs if possible, completed in a timeline that allows the USGS to incorporate them in the development of the next iteration of the U.S. National Seismic Hazard Maps.

# 3. PROJECT EVOLUTION AND SSHAC STUDY LEVEL

NGA-East was originally developed as a science-based research project (Bozorgnia, 2008). The project was to be a follow-up to the previous NGA project (referred to as NGA-West for clarity) that focused on the development of GMPEs for shallow crustal earthquakes in active tectonic regions (Power et al., 2008). NGA-East evolved to a SSHAC Level 3 in early 2010 so that it would be consistent with the CEUS SSC project and to allow the products of these projects to be combined for use in Level 3 site-specific studies. As a result, the scope of work and the level of complexity of the project have increased considerably.

SSHAC stands for the "Senior Seismic Hazard Analysis Committee", which is the entity that developed the SSHAC Guidelines detailed in the NUREG/CR-6372 document (SSHAC, 1997). The SSHAC assessment process can be used in the development of PSHA input models or in PSHA studies. The fundamental goal of a SSHAC assessment process is to carry-out properly and document completely the activities of evaluation and integration, defined as:

- **Evaluation:** The consideration of all the data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.
- **Integration:** Representing the center, body, and range of technically defensible interpretations in light of the evaluation process.

The SSHAC guidelines define four study levels, each higher level corresponding to an increase in complexity. Higher study levels are associated with a higher confidence that the center, body and range of technically defensible interpretations of the available data, models and methods have been captured in the final products. The SSHAC Level 3 was selected as appropriate to ensure the stability and transparency of the NGA-East products given the complexity, importance and regulatory concerns associated with the study. More details on the level of study and the SSHAC process are presented in SSHAC (1997), Hanks et al. (2009) and in U.S. NRC (2011, in prep.), which is currently under preparation.

The SSHAC Level 3 assessment process requires a level of documentation and review that is much more demanding than what was carried out in other comparable research projects, such as NGA-West for example. This implies larger resources in both time and capital investment. In an effort to optimize the needs of the different agencies with the available resources, the SSHAC Level 3 study was assigned to tasks associated to NRC and DOE objectives only. The remaining “non-SSHAC” tasks and objectives will be addressed as typical research tasks coordinated by PEER.

# 4. ORGANIZATION

As a result of the project evolution, the NGA-East organization features all the components of a SSHAC Level 3 project, but it also features groups from the original project model (Figure 1). An important feature of NGA-East is the inclusion of Working Groups (WGs) that support the TI Team and focus on specific technical areas. Some NGA-East WGs and technical tasks are not formally part of the SSHAC Level 3 process, but they are nonetheless important to the overall project. These are the Geotechnical and Vertical WGs shown in Figure 1. The role of the different groups and participants in Figure 1 are briefly summarized below and more details on roles in SSHAC studies are available in SSHAC (1997) and U.S. NRC (2011, in prep.). Note in Figure 1 that the Geotechnical WG and sub-award researchers and contractors provide support to SSHAC and non-SSHAC tasks. In the context of the SSHAC process, the WGs essentially play the role of Resource Experts and the sub-award researchers and contractors play the role of Specialty Contractors. Some individuals from these two groups will also play a Proponent Expert role at specific times during the project. Refer to SSHAC (1997) and U.S. NRC (2011, in prep.) for the key attributes and requirements associated to the SSHAC roles.

## 4.1 General Organization

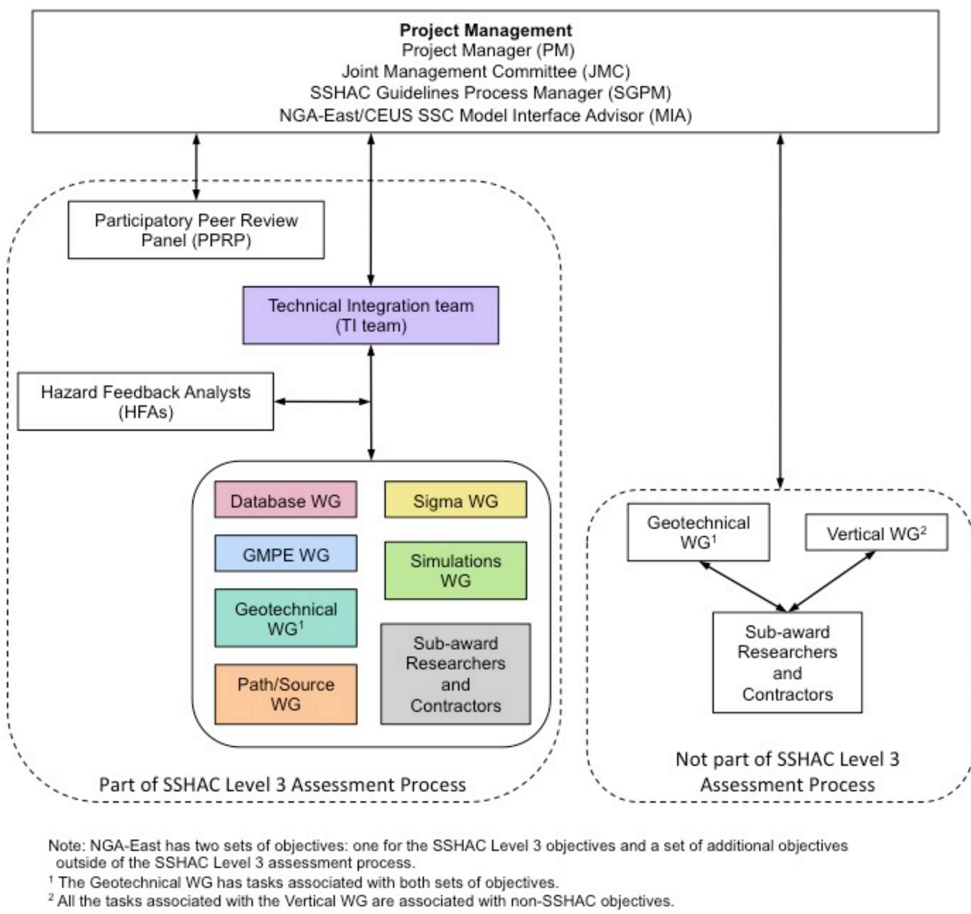


**Figure 1. NGA-East organization flowchart and lines of communications.**

**Project Management: Project Manager, Joint Management Committee and SSHAC Guidelines Process Manager**

The project is managed by the PM and the JMC which is composed of representatives of the key sponsoring organizations. These organizations are the NRC, EPRI, DOE and USGS. The PM and JMC authorize the use of project resources on various tasks and are responsible for the overall direction of the project. The PM and JMC oversee that there is adequate funding and cash flow for the project.

The SSHAC Guidelines Process Manager (SGPM) provides further guidance on the implementation of the SSHAC Level 3 assessment process. The SGPM is also responsible to maintain discussion and communication with the NRC and Defense Nuclear Facilities Safety Board (DNFSB) staff to assure the ongoing regulatory acceptability of the NGA-East SSHAC Level 3 approach.

**Participatory Peer Review Panel (PPRP)**

The PPRP provides the overall process and technical review as required by the SSHAC Level 3 process. The PPRP reports directly to the Project Manager, as shown in Figure 1. The role of the PPRP is by definition participatory and continual from project inception to project completion. The PPRP will be responsible for assuring that the overall process is consistent with the objectives of the SSHAC guidelines. The PPRP is not responsible for the review of NGA-East tasks that are not defined in the SSHAC Level 3 process.

**Technical Integration Team (TI team)**

The TI team takes ownership of the results from the SSHAC Level 3 assessment process. The TI team is ultimately responsible for all GMC technical products, technical assessments and for defending their bases, as well as for the associated documentation. The TI team also oversees and coordinates the technical work performed by the WGs, sub-award researchers, and contractors and supports the PM when ensuring that the project scope and schedule are maintained. The TI team will participate regularly in WG meetings to monitor the progress on technical tasks. The TI team, in collaboration with the PM, is responsible for the development of the project plan and for the organization of the workshops. Note: the two TI co-chairs (Section 4.2) are also referred to as TI Leads in the current document.

**Epistemic Uncertainty Consultant (EUC)**

The Epistemic Uncertainty Consultant (EUC) works directly with the TI team. The EUC will provide the TI team with a new tool to support their assessment and quantification of the epistemic uncertainty captured by the logic trees.

**Hazard Feedback Analysts**

The Hazard Feedback Analysts (HFAs) provide hazard feedback estimates. The goal of these analyses is to facilitate the systematic quantification of impact related to decisions made on parameters, models or specific logic tree weights. Two teams will contribute to hazard analyses results. A team composed of a USGS researcher, and a member of the TI team will be selected by the TI team to run the analyses and develop analysis tools for use by the TI team. The USGS will help with this task and provide the necessary software to conduct the analyses. Because it is anticipated that the USGS software may only include a simplified implementation of the CEUS SSC model, another team of external HFAs was selected to conduct additional analyses (Table 1) with the complete source model. This dual process will allow the TI team the flexibility to easily run regular analyses while the second set of analyses will ensure that the TI team conclusions are also consistent with the complete source model implementation.

### Working Groups (WGs)

The NGA-East project includes seven WGs, each of which is focused on a specific technical area. The WGs were originally created to address the key technical issues identified in Bozorgnia (2008). The WGs are an essential part of NGA-East. They support the TI team by providing guidance on research needs and/or research products. Some research tasks are performed directly by the WG members while other tasks are performed by other researchers outside the WG. The WGs work closely with the TI team. Below is a short overview of the main tasks associated with each WG.

*Database WG*: develop an exhaustive database of recorded motions in CENA and other Stable Continental Regions (SCRs), with the associated metadata. The database will be used by most WGs and by the TI team.

*Path/Source WG*: develop regionalized models for correlated sets of source (stress-drop) and path parameters (attenuation and quality factor, Q).

*Simulations WG*: coordinate the validation and forward modeling of ground motion simulation, considering different methods for finite fault and point source simulations. Because simulations are important to achieving the project goals, the TI team assumes a very active role in the tasks related to the Simulations WG. The Simulations WG relies on input from the Database, Path/Source, and Geotechnical WGs.

*Geotechnical WG*: develop a simplified model to remove site effects at the recording stations, define the reference rock shear wave velocity and kappa values, and the range of conditions to which they apply. The Geotechnical WG is also tasked to develop a site effects model for NGA-East, but this task is not formally part of the SSHAC Level 3 process and is not discussed further.

*Sigma WG*: develop a suite of candidate standard deviation models for the project. This WG uses both recorded data and numerical simulations from CENA and Western U.S. (WUS) to develop the models. The Sigma WG tasks are integrated through both the NGA-East and the NGA-West2 projects.

*Vertical Motions WG*: develop models for V/H ratios to be applied to the horizontal ground motion models. This task is not part of the SSHAC Level 3 process, and is coordinated by PEER in conjunction with the NGA-West2 project.

*GMPE Developers WG:* develop candidate GMPEs for CENA. The members for this WG will be selected by an open request for proposals (RFP). This WG will work in close collaboration with the TI team who will evaluate the candidate GMPEs developed by the group and incorporate the selected models into the ground motion logic tree.

### Sub-award Researchers and Contractors

This category represents researchers that will contribute data, models or methods outside of the working groups. Some of the contractors will be coordinated by WGs while others will be directly coordinated by the TI team. In the context of Figure 1, this category also represents the different Resource Experts that provide data, models or methods and the Proponent Experts as defined in the SSHAC assessment process documentation (SSHAC, 1997).

### The NGA-East/CEUS SSC Model Interface Advisor (MIA)

The NGA-East/CEUS SSC MIA will ensure compatibility and consistency between the SSC and GMC models in terms of parameter definitions and ranges that link the seismic sources to the GMPEs.

## 4.2 Project Team, Lines of Communications and Points of Contacts

Efficient communication and timely transfer of information is critical to the success of NGA-East. The flow of information in the project is shown on Figure 1, and the list of core participants is provided in Table 1. The points of contact for the different groups and entities are highlighted in yellow in Table 1. The PM is to be copied on all correspondence and work products. The PM is the point of contact for the JMC and the main point of contact between the PPRP, the TI team and the JMC. To streamline the flow of information between groups, communications should be done primarily through the points of contact highlighted in Table 1. In instances where two chairpersons or points of contact are listed for a group, both should be included in the correspondence.

The PM, with the assistance of the TI team, is to inform the JMC and the PPRP of process and technical developments. The TI Team Leads (e.g., co-chairs) are responsible to make sure that all the technical participants (TI team, HFAs, MIA, WGs, sub-award researchers and contractors) have the required information to support the project. The TI team, with input from the whole project team, is responsible for identifying and providing invitations to the resource and proponent experts proposed for the workshops Project-wide e-mail distributions are to be coordinated by the PM and the TI Leads to be channeled through the PEER staff.

**Table 1. NGA-East project team and points of contact (group chairs are the points of contact for each group and are highlighted in yellow).**

| Committee or Group | Members | | | |
|---|---|---|---|---|
| | Name | Last Name | Organization | e-mail |
| Project Manager (PM) | Yousef | Bozorgnia | PEER, UC Berkeley | yousef@berkeley.edu |
| Joint Management Committee (JMC) | Annie | Kammerer | NRC | annie.kammerer@nrc.gov |
| | Mark | Petersen | USGS, Denver | mpetersen@usgs.gov |
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| | Steve | McDuffie | DOE | Stephen.McDuffie@RL.Doe.Gov |
| SSHAC Guidelines Process Manager (SGPM) | Annie | Kammerer | NRC | annie.kammerer@nrc.gov |
| NGA-East/CEU SSC Model Interface Advisor (MIA) | Kevin | Coppersmith | Coppersmith Consulting, Inc. | kcoppersmith@earthlink.net |
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| | Jonathan | Stewart | Univ. of California - Los Angeles | jstewart@seas.ucla.edu |
| GMPE Working Group | Members to be defined by RFP | | | |
| Path/Source Working Group | Martin | Chapman | Virginia Tech. | mcc@vt.edu |
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| | Walt | Silva | Pacific Engineering, Inc. | pacificengineering@juno.com |

## 5. TECHNICAL WORK PLAN

NGA-East is focused on development of the next generation GMPEs, as opposed to producing the next incremental GMC model update. The project plan was designed to allow a reassessment of all key issues that form the technical basis for GMPE development, without being tied to past decisions.

The SSHAC Level 3 objectives are addressed by 12 groups of tasks, labeled from A to M (Figures 2 and 3). The groups of tasks are divided into main numbered tasks as shown on Figure 3. Section 5.1 focuses on a global presentation of the groups of tasks (Figure 2) while Section 5.2 goes into more details on the key numbered tasks and their relationships (Figure 3). Many of the numbered tasks are composed of intermediate subtasks that the WG chairs and/or the TI team use to monitor the progress of the main tasks and to manage the project. For brevity, these detailed subtasks are not presented here.

The workflow converges to the final products being developed by the TI team: the GMPE logic trees for the median and standard deviation (sigma) models. The planned approach is described below. The proposed approach may need to be revised based on the results or budget constraints.

### 5.1 Summary of General TI Team Approach

The TI team plans to use point-source stochastic simulations (Figure 2, box G) as the primary tool for developing median rock GMPEs (H). This will require the development of new general point-source models (F) for this task (the source spectrum is expected to be a double-corner model). Recorded data (A) will be corrected to rock conditions (B) for their use in most tasks shown on Figures 2 and 3. Recorded data from CENA (A) will be used to evaluate the regional characteristics of ground motion attenuation (C) and to define source and path parameters (D). Results from these two tasks will allow the definition of CENA-specific input parameters for the point-source models (G). The plan is to constrain the lower and higher frequency range ordinates of the point-source spectra using finite-fault simulation results (E) and recorded data (A) in conjunction with source information (D) respectively. Because finite-fault simulations are resource intensive, the plan is to use them for low frequencies only (less than 1 Hz), for which they are the most reliable. The suite of GMPEs developed by the TI team will be complemented by a second set developed by the GMPE WG (H).

The plan is to develop the standard deviation (sigma) models (J) independently from the median models. The primary approach consists in using well-constrained sigma models for WUS and adjusting them as needed to be applicable to CENA. Standard deviations from both recorded data and numerical simulations will be used to evaluate the applicability of WUS standard deviation models to CENA.

The TI team will assemble the median GMPEs and standard deviation models into logic trees (L), which constitute the final products of the project. The ground motion models (logic tree branches) will also be tested (I) against available intensity and paleoliquefaction data from large earthquakes in CENA and by a set of key records from CENA and other SCRs to check that the candidate GMPE models are not inconsistent with the range of ground motions implied by these data sets. Epistemic uncertainty of the GMPEs will also be formally evaluated (K). A useful tool in this evaluation is the new methodology being developed by Prof. Frank Scherbaum, which is based on a visualization technique involving Self-Organizing Maps (SOMs).

The Hazard Feedback Analysis (task M) is performed throughout the project, at points when critical decisions need to be made, and is coordinated by the TI team. Task M helps in defining what parameter or model is important to the ground motion hazard and where resources should be spent in model refinement. A separate box is shown in Figures 2 and 3, but for readability reasons, no arrows are shown pointing to this box. Hazard feedback analyses are to be presented at each SSHAC workshop (Section 6) to keep the discussion focused on hazard-relevant issues.

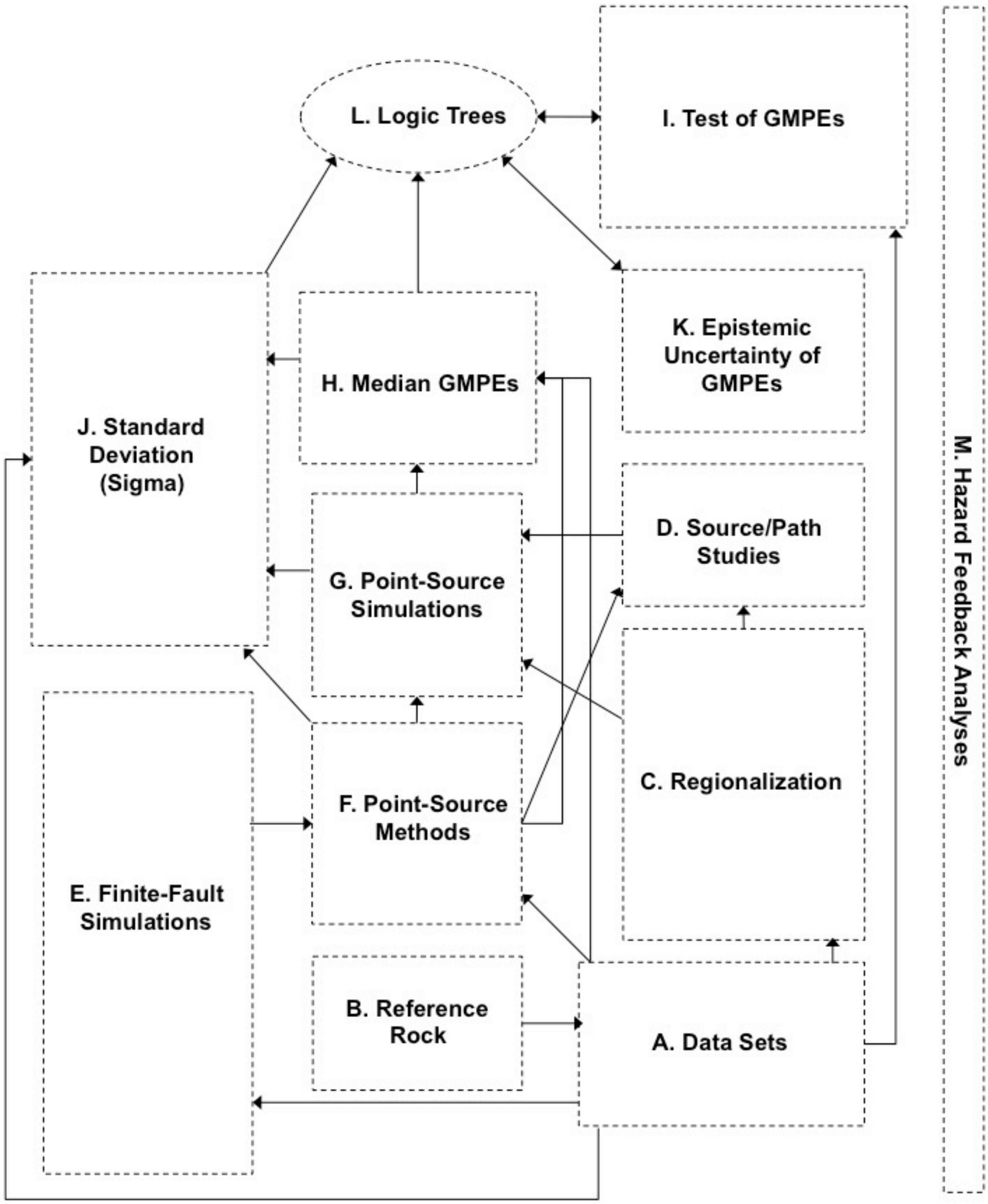


**Figure 2. NGA-East tasks, simplified flowchart showing task groups.**

## 5.2 Description of Tasks

The main tasks shown in Figure 3 are described below and the appropriate task identifier is shown in parenthesis in the text (e.g. A.1 refers to the CENA Database). The key objectives related to each group of tasks are also listed below. The tasks use a combination of open RFPs and directed work by the WGs or to sub-awards researchers and contractors.

Tasks in groups C through H are essentially part of the median GMPE development while task J is the only group for the development of standard deviation models. This representation should not impress on the reader that the standard deviation models are less important in the NGA-East scope. The tasks in group J are more self-contained and were combined to allow the global project representation shown in Figure 3.

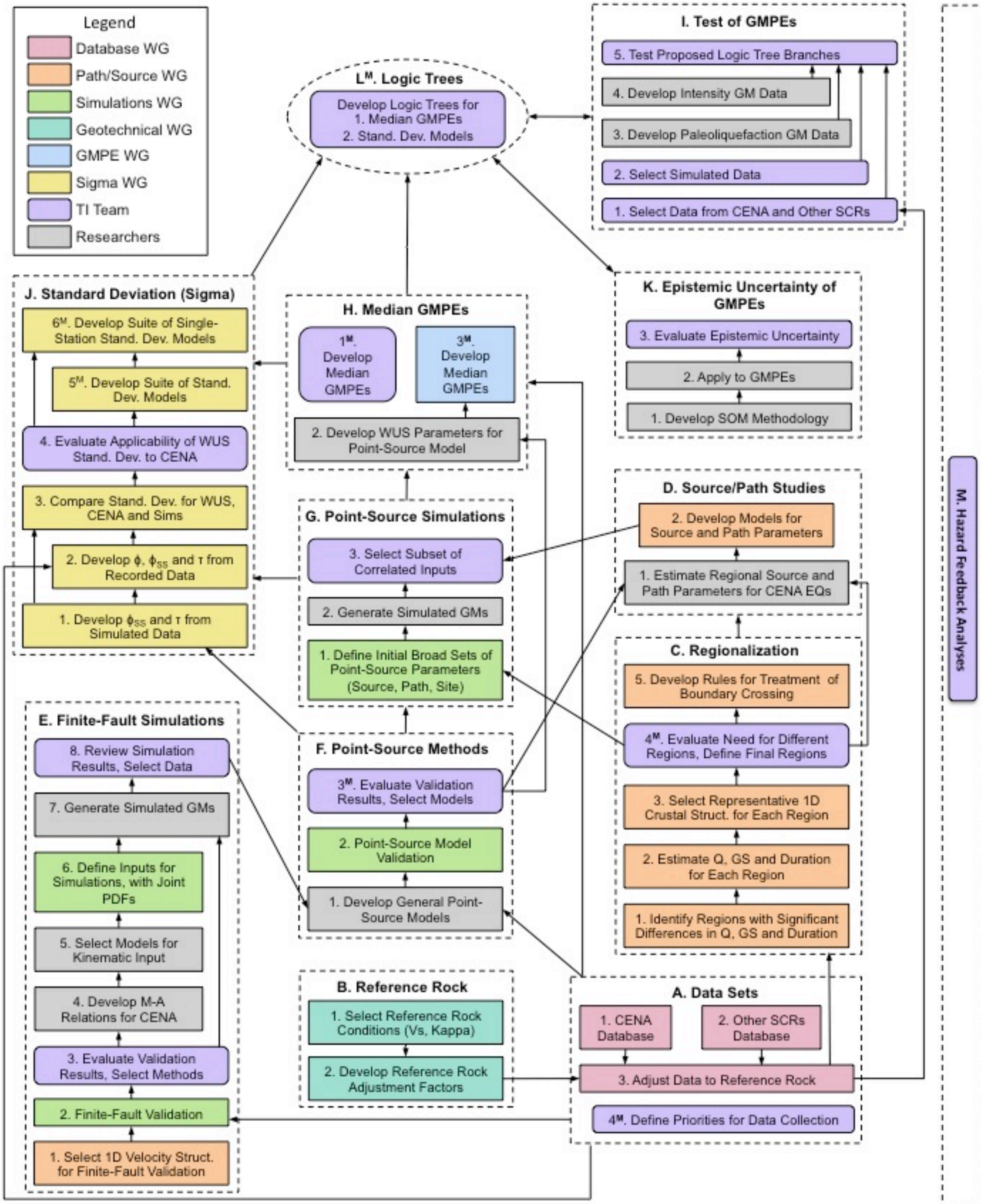


**Figure 3. NGA-East tasks flowchart. "M" superscripts refer to tasks associated with HFAs.**

## A. Data Sets

*Objective:*

- *To develop earthquake databases (with metadata) for CENA and other SCRs.*

As part of NGA-East, two new earthquake record databases will be developed (for CENA and other SCRs). Data collection includes the reviewing and processing of earthquake recordings from stations on various site conditions (rock and soil) and also includes the compilation of available metadata into a flatfile (magnitude, distance, site conditions, etc.). The Database WG is responsible for developing the CENA ground motion database (Task A.1). The ground motions will be adjusted to the reference rock conditions using the scale factors provided by the Geotechnical WG (B.2 and A.3). The site-corrected data are provided to the Path/Source WG for evaluation of the need for regionalizing the ground motion attenuation (C.1).

An interface issue between the CEUS SSC and NGA-East project is the earthquake magnitudes. The GMPEs will be based on moment magnitude. If magnitude conversions to moment magnitude are required for the older earthquakes, then the conversions need to be consistent between the CEUS SSC and NGA-East data sets.

The Database WG will also compile additional key ground motion data from other SCRs (A.2) to the extent that there are sufficient metadata available to make these data useful. A subset of the other SCRs' data will be used as checks on the GMPEs in task I.1. Database development for active tectonic regions (also referred to as the WUS database) is outside the scope of NGA-East.

The Simulations WG will select subsets of recorded data to be used for the simulation method validations (E.2 for finite-fault and F.2 for point-source models). The recorded data sets will be used by the GMPE developers in Task H and by the Sigma WG for Task J.2.

The TI team is responsible for defining priorities for further collection of data (A.4), based on the project needs.

## B. Reference Rock

*Objectives:*

- *To select the reference rock conditions to be used for simulations and GMPE development.*
- *To develop amplification factors or models to be used to remove site effects at recording stations.*

The Geotechnical WG is responsible for selecting the center, body and range of the shear-wave velocity and kappa of the reference rock to be used for the GMPEs and simulations (B.1). This task involves the analysis of recorded data for CENA, coming both from the A task and from additional gathering of data. The Geotechnical WG will also develop a simple method for adjusting the recordings in the CENA database to the reference rock conditions (B.2). Task B.2 involves a preliminary and a final model. The site-corrected data are provided to the Path/Source WG for evaluation of the need for regionalizing the ground motion attenuation (C.1). Given the tight schedule, task C.1 will use the preliminary version of the site correction factors developed in collaboration with the TI team. Task I.1 will use the site-corrected records (final site correction for CENA records and using a simplified correction for other SCRs).

**C. Regionalization**

*Objectives:*

- *To define a small number of discrete crustal regions (with associated attenuation parameter values) to capture essential differences in distance attenuation that affect ground motions.*
- *To develop rules for computing ground motions when paths cross regions.*

The Path/Source WG will evaluate the CENA data to identify regions that have significant differences in the ground motion attenuation (e.g., regions that require different GMPEs) in task C.1. As mentioned above, task C.1 will use site-corrected records from tasks A.3 and B.2. Tasks C.2, C.3 and C.5 will also be completed by the Path/Source WG. Task C.2 will focus on defining the appropriate values of Q, geometrical spreading and duration for each of the regions defined in C.1. Task C.3 involves the selection of representative 1D crustal velocity structure for each of the regions defined in C.1

The TI team will make the final decision on the number of separate regions considering the trade-off between simplicity (fewer regions) and the accuracy of GMPEs that most affect the hazard at CENA sites (task C.4, which requires HFA).

Task C.5 involves the development of a set of rules for the treatment of region boundary crossings (source in one region and ground motion estimates in another).

**D. Path/Source Studies**

*Objective:*

- *To develop regional models for source and path parameters that include the correlation between parameters.*

Source/Path Studies tasks (D.1 and D.2) are needed to define the subset of point-source simulations that will be used in the GMPE development (G.3). Task D.1 draws from task C.4 and from the Point Source Model Validation results (F.2) to estimate the regional source and path parameters for CENA earthquakes. This task will be performed by targeted researchers and involves the estimation of parameter values and their distribution, but also the evaluation of the correlation between the parameters. The researchers developing the double-corner models will participate actively in the development of parameter correlation models so that they are consistent with the software/code they use in task F.1. The Path/Source WG will then develop models for the source and path parameters developed in D.1.

**E. Finite-Fault Simulations**

*Objective:*

- *To develop a database of low frequency simulated ground motions to supplement the recorded data for CENA using finite-fault models.*

The main use of the finite-fault simulations is to guide the development of the general double-corner model and to constrain the scaling of the low frequency behavior for earthquake events not represented in the database (e.g. large magnitudes). The Simulations WG is responsible for selecting the methods for validation (task E.2, selection through RFP) and for developing the validation requirements, in collaboration with the TI team. Additional selected methods developed by USGS researchers will be validated as well and considered for use in forward simulations. As part of E.2, the WG will also evaluate the finite-fault methods based on the validations (pass/fail). The TI team will review the WG recommendations and make the final decision as to which model(s) will be applied in the forward simulations (E.3).

The Simulations WG will coordinate the definition of the inputs for the selected finite-fault simulations. This includes the development of area-magnitude scaling relations for CENA (task E.4 to be completed by a researcher selected through RFP) and the selection of models for kinematic input (E.5 to be completed by a pre-identified researcher).

As part of task E.6, the Simulations WG will also define the cases for forward simulations (earthquake scenarios and station locations). The simulations will be completed in task E.7 by the researchers selected in task E.3. The Simulations WG will conduct initial reviews of the simulation results to compare the results from the different finite-fault modelers, identify areas with significant differences in the ground motions, and identify the causes of the differences in the ground motions. The results of that initial review phase will be presented for discussion at a workshop. The final review of the simulations results including recommendations on which results to use will be presented following the workshop. Although not formally shown in the figure, the TI team will work closely with the Simulations WG on tasks E.6 and E.8.

The suites of finite-fault simulations will be provided to the Point-Source Simulation Method tasks (F) for use in constraining the low frequency end of the source spectrum.

The finite-fault simulation results will also be compared to the GMPEs as a consistency check that the finite-fault effects were captured in the implemented general point-source model and carried through the GMPE development (I.2).

### F. Point-Source Simulation Methods

*Objective:*

- *To develop new alternative generalized (double-corner) point-source simulation models using CENA data and the finite-fault simulation results to constrain the source spectrum.*

A pair of general (most likely double-corner) suites of models will be developed, one via a targeted proposal to pre-identified researchers and a second via RFP (task F.1). It will be important to ensure consistency in implementation of the models with derivation of various input parameters that feed them. For example, the specification of the source/path parameters is closely linked with how those parameters were determined in the Path/source WG studies. The models should be consistent with large magnitude data (from finite-fault simulations and WUS data). Single-corner point source models will be a special case of the general models. The Simulations WG will lead the effort for the validation (tasks F.2) in collaboration with the TI team. The TI team will review the simulation results and select the model to be used in the forward computations (F.3). This important task will use HFA results, as shown by the M superscript in Figure 3. Results from F.3 will be used in tasks D.1, H.1 and H. 3.

## G. Point-Source Simulations

*Objectives:*

- *To develop a database of simulated ground motions to be used in GMPE development.*

The point-source simulations will be the main method for generating ground motion data for GMPE development. The first task (G.1) consists in the Simulations WG selecting broad sets of point source parameters. The goal of this task is to cast a net wide enough that it will include all the plausible combinations of input parameters in the generation of simulated ground motions (task G.2). This will create a large database of simulated ground motions and will prevent the need to go back and conduct additional simulations following the TI team evaluations. Task G.2 represents the actual simulations, to be completed by a contracted researcher. In task G.3, the TI team will select the subsets of input parameters that correspond to realistic combinations properly representing the correlation between the parameters. Only the ground motions from simulations using these combinations of parameters will be used in the GMPE development (H.1 and H.3). Task G.3 is dependent on the completion of task D.2.

## H. Median GMPEs

*Objectives:*

- *To develop a set of median GMPEs using the simulated data set.*
- *To develop additional median candidate GMPEs using all the data available (recorded and simulated data).*

In task H.1, the TI team will develop a set of median GMPEs using the point source simulation results and conduct HFAs. To help capture the epistemic uncertainty associated with GMPE development, additional models will be developed outside of the TI team. An open RFP will be issued for the development of up to three alternative GMPEs based on different approaches (simulation-based and at least one hybrid model). The hybrid model consists of the revision of an existing GMPE developed for another region (WUS) that will be adjusted for CENA. For the hybrid model, the funded team(s) will need to identify the point source model parameters for WUS (task H.2) and CENA, to run the required simulations and to develop adjustment factors that account for source and path differences in the two tectonic regions. The selected researchers (also referred to as GMPE developers) will form the GMPE WG and will have access to all of the recorded data and numerical simulations and they will have the flexibility to select subsets of the available data. The GMPE development itself is done in task H.3. The median GMPEs from tasks H.1 and H.3 will be incorporated in the median logic tree (L.1) and tested in task I.

## I. Test of GMPEs

*Objectives:*

- *To develop simple relationships to relate paleoliquefaction and intensity data to ground motion intensity measures.*
- *To evaluate the GMPEs developed in tasks H.1 and H.3 and J.5-6 against finite-fault simulations results, CENA and other SCRs data and the intensity measures associated with paleoliquefaction and intensity data.*

Four main sets of data will be used to evaluate the GMPEs developed in tasks H.1 and H.3 and J.5-6 against: 1) ground motion data from CENA and other SCRs (for large magnitudes not represented in the CENA database), 2) finite-fault simulation results and 3) liquefaction and 4) intensity data from past large CENA earthquakes. Given that some of the data has large inherent uncertainty, and that some data come from simulations and not observations, the goal of these tests is not to calibrate the GMPEs, but rather to check if the different data sets are consistent with the GMPEs. The ground motion data from CENA and other SCRs come directly from Data Sets tasks A.1 and A.2 (task I.1); the other SCRs data will mostly be used for large magnitude events not represented in the CENA database. The TI team will also use finite-fault simulation ground motions (I.2) to ensure that their properties have been carried through the GMPE development process. The paleoliquefaction data are expected to come directly from the CEUS SSC project, but will need to be associated with ground motion intensity measures (task I.3). A simple database of earthquake intensity will be developed by a contracted researcher, possibly from the USGS, who will also need to associate the intensity with ground motion intensity measures (task I.4). Finally, a member of the TI team will conduct the test of the GMPEs against these data to identify any inconsistency (I.5). The tests will be conducted at the logic tree level, but on single branches that combine the median and standard deviation models. The TI team will adjust the weights for the GMPEs as needed based on the test results (task L).

## J. Sigma

*Objective:*

- *To develop suites of standard deviation models applicable to CENA for:*
  - *ergodic within-event standard deviation (Phi, $\phi$)*
  - *single-station within-event standard deviation (Phi$_{SS}$, $\phi_{SS}$)*
  - *between-event standard deviation (Tau, $\tau$)*

The standard deviation (sigma) of GMPEs has a strong influence on the results of PSHA. The present state-of-the-practice of seismic hazard studies applies the standard deviations from ground-motion models developed using a broad range of earthquakes, sites, and regions to analyze the hazard at a single site from a single small source region. This is referred to as the ergodic assumption. The most promising approach to reducing the aleatory sigma is identifying the components of ground motion variability at a single site that are repeatable and removing them from the aleatory variability. These repeatable components are then transferred to the quantification of the epistemic uncertainty. A standard deviation term for which the site effects are systematically removed from the variability is referred to as single-station sigma.

The main objectives of the Sigma WG are to evaluate the ergodic within-event standard deviation (Phi), the single-station within-event standard deviation (Phi$_{SS}$) and the between-event standard deviation (Tau) for CENA. These values will be compared to Phi, Phi$_{SS}$ and Tau evaluated for WUS and other regions around the world (Mexico, Japan, Turkey, Taiwan, Switzerland, China and Australia). The final product of the Sigma WG is a suite of parametric ergodic and single-station sigma models. These variability models will be adopted by the NGA-East TI team and assigned weights in the standard deviation logic tree (task L).

The sigma models will be developed using simulated data and the WUS data, which are much more complete than for CENA (tasks J.1 and J.2 respectively). The WG will compare the ergodic sigma and single-station sigma from small magnitude earthquakes from CENA and WUS to determine the applicability of the models to CENA (J.3). The TI team will then formally evaluate the applicability of the models to CENA (J.4). If needed, adjustments will be made to the within-event and between-event standard deviation terms. Final models for ergodic (J.5) and single-station (J.6) standard deviations will be developed and incorporated in the sigma logic tree (task L.2).

### K. Epistemic Uncertainty of GMPEs

*Objective:*

- *To evaluate the body of the distribution and making sure that the individual GMPEs collectively sample the epistemic uncertainty space.*

The TI team will systematically assess and quantify the epistemic uncertainty captured by the logic trees. The definition of the range of epistemic uncertainty to capture in the logic tree models will be defined by expert judgment of the TI team, with insight from the larger project team. A useful tool in the epistemic uncertainty evaluation is to use the new methodology introduced in Scherbaum et al. (2010). This tool will be further developed by the EUC for the project. The methodology is based on a visualization technique involving Self-Organizing Maps (SOMs). The SOM figures show the distribution and separation of the models in ground-motion space, and will aid the TI team in assessing the similarities or differences between models. This new method, as one possible tool, will be used applied to all the GMPEs developed in the project. The TI team will use these results to evaluate if the suite of GMPEs and weights in the logic tree are adequate. If needed, the logic tree will be modified and/or additional GMPEs will be proposed to better capture the epistemic uncertainty. If modifications are made, the evaluation of the epistemic uncertainty will be repeated.

### L. Logic Trees

*Objective:*

- *To develop weights that capture the center, body and range of the technically defensible interpretations, as informed by the various tasks and by the hazard feedback analyses.*

The TI team is responsible for developing the GMPE logic trees. This final task combines all the products from the other NGA-East tasks and addresses the principal project objective. As mentioned above (task I), the branches of the logic trees will be tested against recorded and simulated data.

### M. Hazard Feedback Analyses

*Objective:*

- *To conduct hazard sensitivity studies to assess the importance of factors, models and parameters that affect the ground motion hazard.*

HFAs represent a critical task that will ensure that the project team stays focused on issues that affect the ground motion hazard. The analyses essentially consist of a series of sensitivity studies on models and/or parameters used to develop the models. HFAs will be conducted throughout the project and key results will be presented at each workshop to help the project keep the focus on the key factors that control the hazard. As mentioned earlier, the TI team plans to use a dual approach for the HFAs. The TI team will coordinate with the USGS to use their implementation of the CEUS SSC model and run their own analyses. However, it is anticipated that the USGS software may only include a simplified implementation of the CEUS SSC model, and a second team of external HFAs was selected to conduct additional analyses (Table 1) with the complete source model. This dual process will allow the TI team the flexibility to easily run regular analyses while the second set of analyses will ensure that the TI team conclusions are also consistent with the complete source model implementation.

The hazard feedback for GMPEs needs to consider the magnitude and distance contributions from the different tectonic environments in CENA. The plan is to coordinate with the CEUS SSC project and possibly include the seven test sites that were used for the CEUS SSC hazard feedback. The seven sites were previously selected by the CEUS SSC to capture the range of tectonic environments and are appropriate for use in the ground motion hazard feedback. The goal is to use the sites to illustrate the relative importance of various components of the GMC model to seismic hazard. The final site selection will also depend on the regionalization models selected.

As mentioned above, the HFAs will be conducted regularly and presented at the workshops. An "M" superscript is shown next to the key tasks where HFAs are anticipated (Figure 3). This list of tasks is not exhaustive and the need for HFAs will be regularly re-assessed by the TI team throughout the project.

## 5.3 Documentation

A critical task is the project documentation, which is vital to the successful completion of any project. The need for comprehensive documentation is especially important for studies conducted within the regulatory arena. The SSHAC guidelines document devotes a full chapter on the type and required level of documentation (SSHAC, 1997).

In a SSHAC Level 3 assessment project, the TI team is responsible for the documentation of the technical bases for accepting, rejecting and assigning weights to models. Because of the project complexity and breadth of topics, the WG Chairs will support the TI team by developing the documentation of intermediate products and by performing the integration in the project timeframe. Therefore, each WG Chair will ensure the documentation related to their group's specific activities is complete. A researcher assigned by the TI team will help the WG Chairs and individual sub-award researchers and contractors for the documentation tasks. As stated earlier, the TI team is responsible to ensure that the documentation is complete and will work closely with the WG Chairs and the SGPM to ensure that the level and type of documentation is consistent with that of a SSHAC Level 3 assessment project. It is anticipated that the documentation of the CEUS SSC project (also a SSHAC Level 3 assessment project) will serve as an example and template for the NGA-East documentation. The PPRP, through their review of intermediate documents produced by the project team, will also play an instrumental role in achieving the proper level of documentation. The approval of the final report by the PPRP will signify that the documentation goal was achieved.

The project documentation is expected to include the following items (also shown is the entity supporting the TI Team in the documentation development):

- Project plan - TI team and PM
- Summary table (as appropriate) for NGA-East data for CENA and other SCRs - Database WG
- Evaluation table (as appropriate) for NGA-East data for CENA and other SCRs - All users of data
- Project parameter and acronym glossary, including definitions of terminology used for the various components of uncertainty - SGPM
- Project final report that includes full project information from the final version of the project plan and (all by TI team unless stated otherwise)
  - SSHAC Workshop summaries, including slides and videos
  - Other workshops and working meeting summaries (including WG meetings)
  - Description of the complete technical bases for the GMPEs developed - GMPE WG and TI team
  - PPRP letters and final report - PPRP
  - Hazard Input Document providing the final logic tree and application recommendations for critical facilities
  - NGA-East database of earthquake recordings, including waveforms, flat file and metadata, and report on how the database was developed.

The documentation should achieve the following:

- Allow the reader to fully understand the project objectives, technical approaches and activities, data sets, participants, and results.
- Provide a clear and complete description of the technical basis for all GMPEs, their associated uncertainties, and their ultimate weights provided in the final project model and guidance.
- Document that all relevant data/information/models that were reviewed and incorporated or not into the assessment and the reasons for inclusion or exclusion.
- Lead to transparency, openness, and communication with the public and other stakeholders.

# 6. WORKSHOPS

## 6.1 SSHAC Workshops

This section focuses on the "SSHAC workshops", which are different from other working meetings or public workshops already held during the project (Section 6.2). Workshops play a vital role in the SSHAC Level 3 assessment process. The SSHAC workshops provide opportunities for key interactions to occur; for models and interpretations to be presented, debated, and defended; and for sponsors and reviewers to observe and comment on the progress being made on the study. For a SSHAC Level 3 assessment process, there are three mandatory SSHAC workshops or workshop themes, each serving a specific purpose. The objectives and goals of each SSHAC workshop are briefly described below for convenience. Refer to the SSHAC (1997) original document and to U.S. NRC (2011, in prep.) for more details.

The TI Leads with input from the PM and PPRP are responsible for preparing the workshop agendas, for inviting the relevant resource and proponent experts and for leading the workshops. Each workshop should begin with a clear definition of the goals of the workshop, an explanation for the process that will be followed, and a definition of the roles of those who attend.

The text below refers to the project key technical issues. As mentioned above, these key technical issues were first highlighted in the "Roadmap" document (Bozorgnia, 2008) that was prepared in the development of the NGA-East project (before the SSHAC Level 3 designation). These issues were organized into the seven categories that led to the formation of the WGs. The key remaining issues are identified by the WGs and the TI team in the course of the project and summarized at the SSHAC Workshops by the TI team. The list of technical issues is to be circulated in the form of a draft agenda three months before each workshop along with the list of identified participants (Resource and Proponent Experts) for each topic.

First and foremost, the workshops are held to provide information to assist the TI team and the project team in their technical assessments. Workshop attendees presenting and/or involved in discussions with the TI team include members of the WGs and additional invited Resource Experts or Proponent Experts, as per SSHAC (1997). Other technical attendees, such as the PM or members of the PPRP and JMC may pose questions if doing so will clarify the discussions. The PPRP will provide preliminary observations to the TI Team, PM and JMC after each day of each workshop. All other workshop attendees are "observers". The workshops will be open to the public and videos of the presentations and discussions will be posted on the PEER website following each workshop.

**SSHAC Workshop Themes**

The required SSHAC workshops are organized into three themes that are summarized here for convenience. The term "theme" is used because the NGA-East SSHAC workshops may cover more than a single SSHAC workshop element.

*Workshop Theme 1 - Significant Issues and Data Needs*

The goals of this workshop are: 1) to identify the technical issues of highest significance to the hazard analysis, and 2) to identify the available data and information that will be needed to address those issues. The discussions of the available data should be made by a series of presentations by resource experts who have developed specific data sets.

From the standpoint of the SSHAC assessment process, the evaluation of the data for use in the hazard analyses is led by the TI team. In the case of the NGA-East project, a significant amount of technical development work is required and is being lead by the WGs. As a result, the WGs will support the TI team by performing a number of critical evaluations and proposing a variety of technical choices.

*Workshop Theme 2 - Proponent Discussions of Alternative Interpretations*

The goals of Workshop 2 are: 1) to present, discuss, and debate alternative viewpoints regarding key technical issues; 2) to identify the technical bases for the alternative hypotheses and to discuss the associated uncertainties; and 3) to provide a basis for the subsequent development of preliminary hazard models that consider these alternative viewpoints. The workshop also provides an opportunity to review the progress being made on the database development and to elicit additional input, as needed, regarding this activity.

A key attribute of this workshop is the discussion and debate of the merits of alternative viewpoints regarding key technical issues. Proponents and Resource Experts (see role definitions in SSHAC, 1997) will present their interpretations and the data supporting them. Alternative viewpoints will be juxtaposed and facilitated discussions will be focused on implications to the inputs to the hazard analysis (not just on scientific viability) and on uncertainties (e.g., what conceptual models would capture the range of interpretations and what weights should be applied). The Proponent Experts need to be prepared to discuss the uncertainties in their interpretations, the strengths and weaknesses in their arguments, and their view of where their interpretations lie with regard to the larger technical community. When organizing the proponent workshops, the TI Leads will circulate the proposed list of participants to ensure that the agenda incorporates all viable views and hypotheses. Individuals who may not be present at the workshops will be identified so that their interpretations are presented and considered.

*Workshop Theme 3 – Presentation and Feedback on Proposed Models*

Typically following the workshop (or workshops) focused on proponent discussions of alternative interpretations, the TI team members develop their preliminary models, and preliminary calculations and sensitivity analyses are conducted. The goal of Workshop 3 is to present and discuss the preliminary models and calculations in a forum that provides the opportunity for feedback to the TI team. Feedback can be given in the form of input by technical specialists or in the form of hazard results and sensitivity analyses to shed light on the most important technical issues. The feedback gained at this workshop will ensure that no significant issues have been overlooked and will allow the TI team to understand the relative importance of their models, uncertainties, and assessments of weights. At this time, the PPRP will be invited to interrogate the TI team on the models and weights they are proposing. This information will provide a basis for the finalization of the models following the workshop.

The workshop typically consists principally of the TI team presenting their preliminary models, with particular emphasis on the manner in which alternative viewpoints and uncertainties have been captured. The technical bases for the assessments and weights will be described to allow for a reasoned discussion of the constraints provided by the available data. The invited experts will be responsible to question and probe aspects of the preliminary model to understand the manner in which the range of technically defensible interpretations has been captured.

**Planned SSHAC Workshops**

A total of five workshops are planned. A preliminary list of topics for each workshop is presented below (the associate task identifiers are shown in parentheses when applicable). Additionally, at each workshop, the TI team plans to:

- Review the scope of the workshop, clearly explain the participants' roles and workshop rules and include a warning regarding the dangers of cognitive biases
- Present and overview of the project objectives and tasks (e.g. Figure 3) and give an update on progress
- Address relevant remaining critical issues and data needs
- Present relevant hazard feedback analyses results

*Workshop 1 – Critical Issues and Data Needs (November 15-18 2010)*

***SSHAC Workshop theme 1***

Presentation of known critical issues and data needs and working group proposals to address needs:

- Overview of critical issues and interface issues identified by the TI team
- Review of the preliminary recorded ground motion databases for CENA and other SCRs, discussion of additional available data and discussion on prioritizing further data needs (A.1-2)
- Presentation of available site profile data for CENA (B.1-2)
- Presentation of reference rock definition (shear wave velocity and kappa) and available data sources (B.1)
- Presentation of issues with point-source models (single Vs double corner(s), large magnitude, frequency related issues) and past validation results (F)
- Presentation of available and considered models for finite fault simulations (E)
- Presentation of current knowledge on regionalization of 1D crustal structures and Q and discussion of critical issues for use as input in finite fault simulations (C, E.1)
- Presentation on alternative regionalization of geometrical spreading and Q for point source simulations (C)
- Discussion of range of input stress drops and correlation of input parameters for point source simulation (C, E)
- Overview of alternative methods of generating finite source inputs (E)
- Presentation of the Sigma WG plan (J)
- Identification of other critical issues and data needs

*<u>Workshop 2 – Proponent Discussions (October 11-13 2011)</u>*

***SSHAC Workshop themes 1 and 2, with focus on theme 2***

- Review of action items and progress from Workshop 1
- Overview of remaining critical issues and interface issues identified by the TI team
- Presentation of selection and discussion of proposed sites for hazard feedback analyses (M)
- Presentation of hazard feedback analyses results using existing GMPEs with the CEUS SSC model
- Review of the final recorded ground motion databases for CENA and other SCRs, discussion of additional available data and discussion on prioritizing further data needs (A.1-2)
- Presentation of final reference rock definition (shear wave velocity and kappa) (B.1)
- Presentation of simplified (prelim.) and final site amplification factor models applied to CENA and other SCRs records (B.2)
- Presentation of final simulation validation results for finite fault simulations (E.2), including validation protocol
- Presentation of plan for development of alternative point-source simulation methods and review of critical issues (F.1)
- Overview and proponent discussions on regionalization issues (C and E.1):
    - regionalization model for Q, geometrical spreading and duration (C.1)
    - estimation of Q, geometrical spreading and duration for identified regions (C.2)
    - 1D velocity structure for finite fault simulations (E.1)
    - preliminary selection of 1D velocity structure for each region (C.3)
- Overview and proponent discussions on finite fault simulations (E):
    - magnitude-area relationships for CENA (E.4)
    - models for kinematic input (E.5)
    - community distribution (center, body and range) for input to finite fault simulations (E.6)
    - finite fault models to generate simulated data (E.7)
- Proponent discussions on community distribution (center, body and range) for point source model parameters based on technical basis and input developed by working groups (G.1)
- Proponent discussions on range of GMPE approaches to appropriately capture uncertainty (H)
- Proponent discussions on GMPE approaches (hybrid and empirical) and their development (H.2-3)
- Presentation of Sigma WG plan and proponent discussion on alternative approaches (J)

- Presentation of TI team plan to select final regionalization model (C.4)
- Presentation and proponent discussion for regional source and path parameters (D.1)
- Presentation of preliminary results for cross-boundary rules (D.2)
- Presentation of preliminary plan for point source simulation validations (F.2)
- Review of plan and critical issues for testing of GMPEs (I.1-5)

*Workshop 3 – Proponent Discussions and Feedback Analyses (October 2012, exact dates to be determined later)*

***SSHAC Workshop themes 1, 2 and 3, with focus on theme 2***

- Review of action items and progress from Workshop 2
- Overview of remaining critical issues and interface issues identified by the TI team
- Presentation of hazard feedback analyses results using existing GMPEs with the CEUS SSC model for issues and parameters identified by the TI team and the WGs
- Presentation of preliminary hazard feedback analyses for GMPEs under development by TI team (H.1)
- Presentation and proponent discussions of final finite fault simulations results (E.8)
- Presentation of plan and approach for developing cross-boundary rules (D.2)
- Presentation and proponent discussion of
    - point source simulation methods (F.1, F.3)
    - point source validation protocol (F.2)
- Proponent discussions on GMPE approaches (H.1 and H.3)
- Presentation and proponent discussion on the testing of GMPEs (I.1-5), focusing on the development of ground motion intensity parameters for paleoliquefaction and intensity data
- Presentation on the development (K.1) and planned use (K.2-3) of the SOM tool
- Presentation of draft of initial logic tree structure (L) by the TI team

*Workshop 4 – Presentation of Median and Standard Deviation GMPE Models, Preliminary Logic Trees and Feedback Analyses (September 2013, exact dates to be determined later)*

***SSHAC Workshop themes 2 and 3***

- Review of action items and progress from Workshop 3
- Presentation of hazard feedback analyses results using existing GMPEs with the CEUS SSC model for issues and parameters identified by the TI team and the WGs
- Presentation and proponent discussion of final point source simulation results and final finite source simulation results (E.7, G.2-3), with focus on G.3 (appropriate subset of correlated input parameters)
- Comparison and discussion of point source and finite fault source results, including development of technical approach to explain differences, if necessary

- Proponent discussion of modeling uncertainties and sensitivity to parametric uncertainties in point source simulations (G)
- Proponent discussion
  - of technical basis for alternate GMPEs (medians) by the GMPE development teams (H)
  - alternate sigma models by Sigma WG (J)
- Presentation of draft weighted logic tree structure (L) by the TI team, discussion of logic tree branches
- Presentation of Hazard feedback using CEUS SSC source characterization model at selected sites

*Workshop 5 – Presentation and Discussion of Weighted Logic Tree Models (April 2014, exact dates to be determined)*

***SSHAC Workshop theme 3***

- Presentation and discussion of revised weighted model by TI team
- Presentation of updated hazard feedback results

## 6.2 Other Workshops and Working Meetings

In the NGA-East project, several working meetings will be held by the different WGs. The objective of these meetings is to assure that the project has sufficient opportunities to capture the full range of viewpoints in the technical community. Unlike the SSHAC Workshops, the purpose and scope of these working meetings is not described in the SSHAC guidelines. In these less formal meetings, a wider group of researchers and experts will openly discuss data and technical issues. It is expected that these meetings will significantly contribute to the technical advancement of the project. The WG members will summarize and present the key points from these meetings and discussions at the SSHAC workshops.

# 7. SCHEDULE

The deadlines for the main tasks are shown graphically on Figure 4, which completely parallels Figure 3 for quick reference. Figure 5 presents the same information in a different format with the addition of the SSHAC Workshop dates (e.g. WS 1 refers to the November 2010 workshop, as identified in Section 6.1).

The deadlines represent the time at which the products are handed off to the TI team for review and/or to be distributed to other groups. Ideally, most tasks should be performed sequentially, but the tight schedule requires that in some instances, a preliminary version of the work be used as the hand-off to another task (e.g. for task B.2, the preliminary version of the site factors are used in tasks A.3 and C.1). Some tasks require a review from either the WG or the TI team (e.g. task E.8). For these tasks, two deadlines are shown on Figure 5: one for the preliminary version and one for the final version of the product (identified by P and F). The shown deliverable dates correspond to the end of month (for example, the preliminary model from task B.1 was delivered as planned by the end of January 2011). The planned schedule is directly linked to, and influenced by, available long-term and short-term funding from sponsoring agencies.

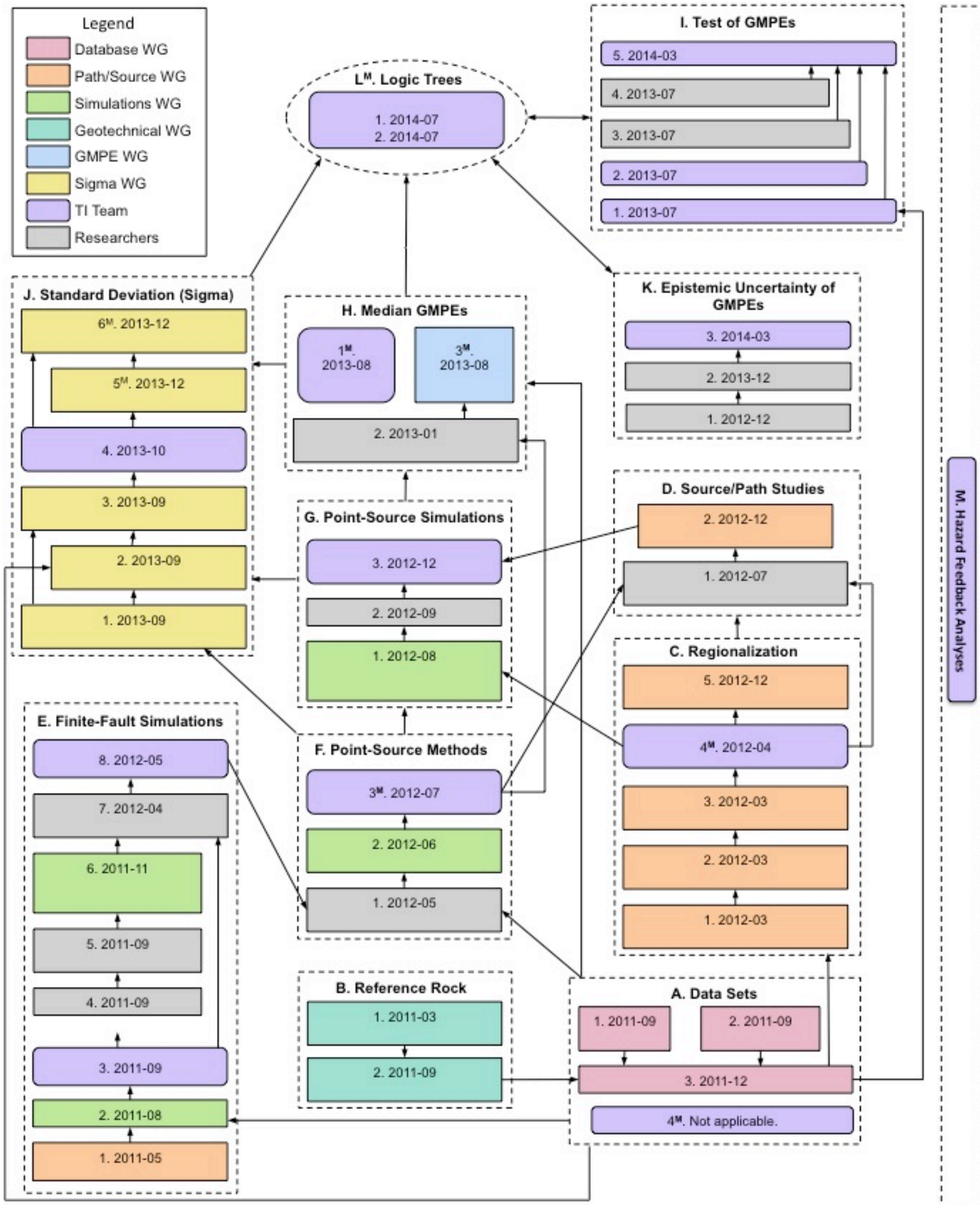


**Figure 4. NGA-East schematic schedule (see Figure 3 for task definitions). Dates shown correspond to final product deliverables.**

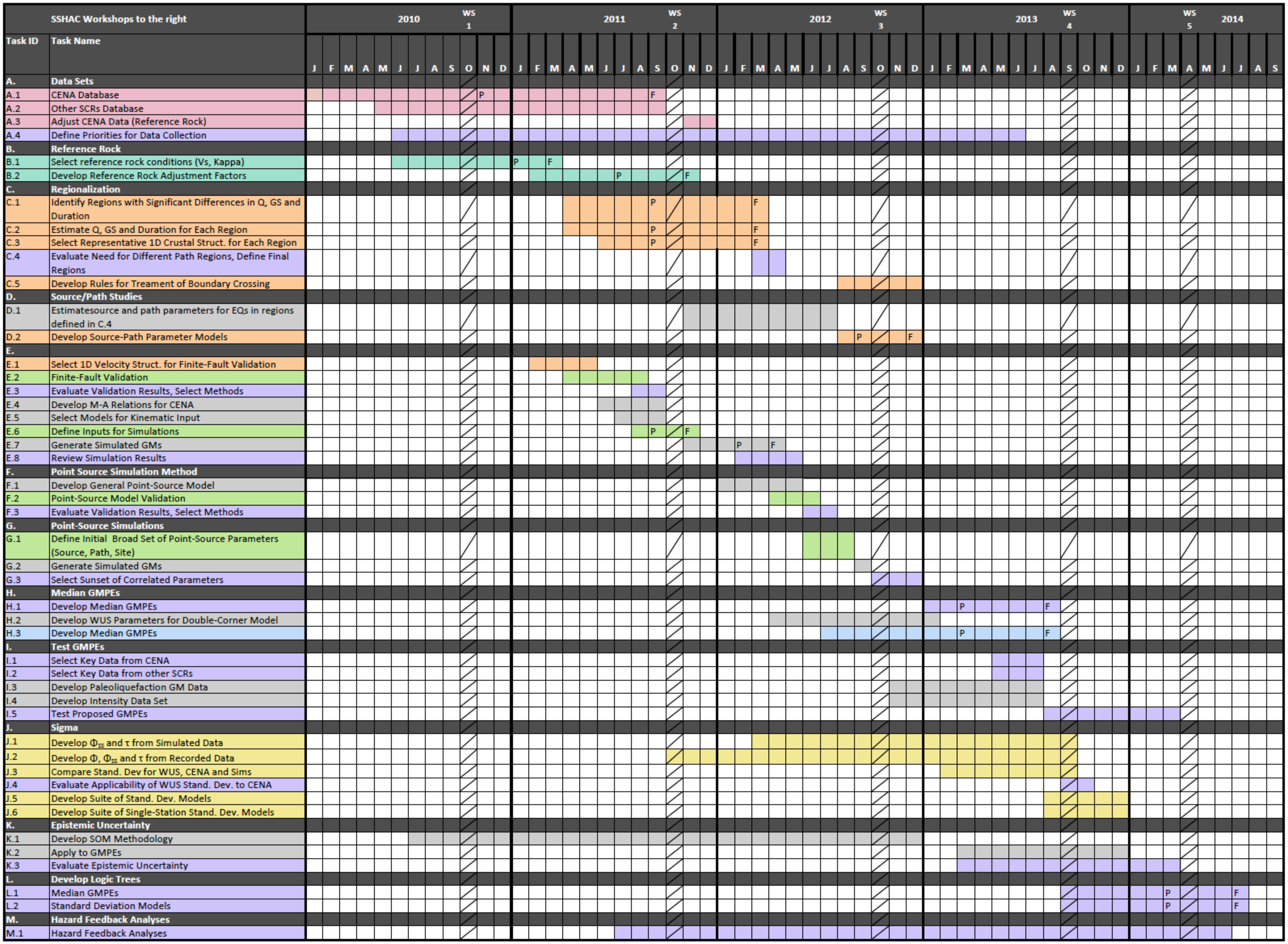


**Figure 5. NGA-East tasks schedule. P and F refer to Preliminary and Final results respectively.**

# 8. REFERENCES

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