Final Report

TIC Working Group E
Evolutionary System Architecture

Group Homepage: http://www.seis.utah.edu/anss/wge/

Prepared for

ANSS Technical Integration Committee
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Foreword

TIC Working Group E ("WGE") started its work in July 2004. Our home page on the Web includes, among other things, minutes from two meetings and four conference calls, several subtask reports, and an extensive record of e-mail interactions—all reflecting considerable efforts aimed at addressing our charge and assigned tasks.

Embedded in our charge is the instruction to "[account] for geopolitical realities as well as abstract ideals in designing an ANSS system architecture." We quickly learned that this was to be our paramount challenge. One key question became, How do we reconcile state/local ownership, investment in, and/or ongoing support of significant infrastructure for seismic monitoring with the prescriptions of ANSS decision-makers?

At an early stage we tried to separate technical parts of the problem from "political" ones (that is, institutional, regional, and/or technical special interests). It was evident that the motivation for ongoing state/local support of seismic monitoring should not be undercut. Given a natural tension between any idealized design of an ANSS system and the current configuration and funding of seismic networks in the United States, we recognized the need for a "Road Map for Partnership" between federal and state/local elements of ANSS. The objective would be to persuade network operators (and their varied sponsors) to move ahead toward a better-designed nationwide system that offers a win-win deal for both individual networks and the system. Key points for crafting a Road Map for Partnership are summarized in *Appendix A*.

As a companion to the "Road Map" approach for creating effective partnerships among elements of ANSS, we explored the framework, core values, and concepts of the Baldrige National Quality Program (BNQP). BNQP is a public-private partnership, managed by the National Institute of Standards and Technology (NIST), that aims to help organizations achieve performance excellence through a systems approach based on seven criteria and guided by a set of core values and concepts. More information is provided in *Appendix B*. Although we weren't able to fully implement the BNQP approach during the relatively short time of our working group, we urge that ANSS adopt its guiding principles.

Another task embedded in our charge was the instruction to first clarify key system performance goals relevant to system design and to characterize "where we are now"—both region by region and as a whole—in terms of being able to meet those performance goals. This was done and is summarized in a report presented in *Appendix C*—"Where We Are Now."

The heart of our charge was to define "an evolutionary path for transforming existing elements of ANSS into a functional nationwide system—with emphasis on steps that can be taken in the near term (1–3 years), based on realistic ANSS funding projections."

Ultimately, our working group was unable to reach full consensus on the desirable end state for the system architecture of ANSS—hence, logical difficulty in outlining the next steps. Issues relating to centralized versus distributed system functions seemed to be inextricably intertwined with political and/or benefit-cost issues that have to be resolved in the larger ANSS forum. Nevertheless, the lessons learned from our working group experience valuably pointed the way to some practical next steps that we recommend be taken to advance existing elements of ANSS toward a functional nationwide system. These are summarized in our "Evolutionary Architecture" report, included here as section 5.

— *Walter Arabasz, Chair*

Executive Summary

Working Group E was unable to reach full consensus on the desirable end state for the system architecture of ANSS. Debate relating to centralized versus distributed system functions seemed to be inextricably intertwined with political and/or benefit-cost issues that ultimately have to be resolved in the larger ANSS forum. Nevertheless, even without agreement about the end state, some practical next steps are recommended—notably relating to software development—that will advance existing elements of ANSS toward a functional nationwide system.

A major challenge for building ANSS is the implementation of a processing system (or systems) that produces seismic data reliably and efficiently, from a diverse infrastructure of seismic sensors, and in a way that uses region-specific knowledge to yield highly useful information products. Current processing systems in use in ANSS all require modification to allow for standardized but region-specific data processing.

The *capabilities and requirements* that the ANSS architecture should satisfy fundamentally relate to: rapid parametric information, data exchange, information distribution, quality control, security, public archive, unified earthquake reporting, and reliability. To achieve these capabilities and meet these requirements, three *strategies* were investigated: (1) a distributed decentralized system based on existing regional and national centers; (2) the original TIC plan, which preserves a national center but reorganizes the regional centers into fewer larger units (one per ANSS region) with new software; and (3) a centralized processing but decentralized information delivery system. Pros and cons of each strategy are identified.

There was agreement that the ANSS system must have an NEIC-like capability for assured response to large earthquakes, and there was also agreement that the capabilities and knowledge in the regional seismic networks must be maintained if the ANSS system is to be capable. Regarding the three strategies considered, there was little enthusiasm in the working group for the original TIC plan (the idea of one primary operational center per ANSS region had little support). Shortcomings of the status quo, which the decentralized model closely resembles, lead some to favor a more centralized model, but there is widespread distrust for a centralized system. The concept of an Integrated Processing Service (IPS) was considered which would perform all ANSS processing at a centralized “national” facility (or redundant facilities). The IPS concept is an end member state. A hybrid model of decentralized reporting for capable regions and an IPS for less capable regions could achieve satisfactory results.

The salient outcome of Working Group E for an ANSS evolutionary architecture is a set of recommendations for software development and a project management structure to guide it. The concept of an IPS is “allowed” in the design of software for the ANSS system—viewed not necessarily as an end state but, in effect, an expedient step toward processing capabilities that could greatly advance the performance of ANSS system-wide, even in a decentralized form.

Charge

"This working group is responsible for defining an evolutionary path for transforming existing elements of ANSS into a functional nationwide system—with emphasis on steps that can be taken in the near term (1–3 years), based on realistic ANSS funding projections. The approach should include clarifying key system performance goals, characterizing "where we are now"—both region by region and as a whole—in terms of being able to meet those performance goals, and accounting for geopolitical realities as well as abstract ideals in designing an ANSS system architecture."

Report on Assigned Tasks—Review of What We Were Supposed to Do

(See http://www.anss.org/tic/e/ for the complete description of our charge. The "0" list is keyed to items in the first paragraph of our "Charge"; other numbering is keyed to the "specific tasks" subsequently listed.)

0(a). Clarify key system performance goals relevant to system design

— Completed and documented as part of our *"Where We Are Now"* report (see Appendix C).

0(b). Characterize "where we are now" in terms of being able to meet key system performance goals

— See Appendix C.

0(c). Account for geopolitical realities as well as abstract ideals in designing an ANSS system architecture.

— We spent a great deal of time dealing with the issue of "geopolitical realities." Two outcomes are the "Road Map for Partnership" (see Appendix A) and advocacy of the approach outlined in the Baldrige National Quality Program (see Appendix B).

1. Read and become familiar with the concepts and recommendations made in Chapter 2 and Appendix D of OFR 02-92 for ANSS architecture and interconnection.

— Done.

2(a). Review available ANSS documents (Circular 1188, OFR 02-92, USGS Announcement 04HQPA002, 2002 white paper by Art Lerner-Lam).

— Done. Documents are available online on our working group Web site at <http://www.seis.utah.edu/anss/wge/attachb.shtml>.

2(b). Review the results of Working Groups A, B, and I and other info pertaining to review of seismic networks.
— Done.

3. Make specific written recommendations for either adopting or modifying what was proposed in OFR 02-92 for ANSS architecture and interconnection.

— The recommendations and discussion included in our "Evolutionary Architecture" report address key parts of OFR 02-92. Some other recommendations in OFR 02-92 regarding ANSS architecture and interconnections were discussed and voted upon (see Attachment 5–1, Part III).

4. Define an evolutionary path for transforming existing elements of ANSS into a functional nationwide system, including prioritized steps that can be taken in the next 1–3 years to maximize system performance under realistic ANSS funding projections.

   —Done (see "Evolutionary Architecture" report). "Realistic ANSS funding projections" were estimated in an earlier progress report we made to the TIC and NIC in September 2004 using a standard project-management approach <http://www.seis.utah.edu/anss/wge/progress-rept2NIC_04Sep.pdf>. However, any forecasts of ANSS funding are still highly uncertain.

Introduction

The original ANSS TIC plan (OFR 02-92) presented guidelines for creating a coherent national earthquake monitoring system, building on the existing CNSS concept. Performance, robustness, standardized products, and integrated product delivery were to be supported by a multi-million-dollar software development effort. However, the ANSS is still operating under pilot funding that has been mostly devoted to installing new field equipment, while the CNSS software infrastructure continues with little modification since the inception of ANSS. The TIC Working Group E ("WGE") has been charged with investigating strategies for evolving the existing infrastructure to more fully meet ANSS goals under current funding.

The ANSS architecture needs to explicitly address (1) deployment of seismic sensors, (2) implementation of processing system(s) for the resulting seismic data, and (3) use of the ensemble of scientific knowledge that guides the processing and helps interpret the results in a variety of contexts. This discussion focuses only the latter two components

Current processing systems in use in the ANSS regions and at the NEIC all require modification to allow for standardized but region-specific data processing. Some forms of region-specific scientific knowledge can be parameterized easily for standardized algorithms (such as those used in detection or phase picking). For other functions, such as event location, possibly event magnitude, and more specialized functions like moment-tensor inversion, there may be some differences in the underlying scientific approaches currently used in different regions. In addition, the interpretation of the processing results often depends on region-specific knowledge; for example, "This event resembles the three previous historical events in this county," and so on. In each region, this knowledge currently resides in different places, making its integration into a standardized product one of the system challenges.

This discussion reviews the capabilities and requirements that the ANSS architecture should satisfy. It then describes three different architecture models and the relative merits of each. It concludes with recommendations for a course of action. The discussion is predicated on adoption of performance goals and standards for the ANSS, such as proposed by TIC Working Group A. In order to assess the capabilities of the current system, our working group compared the responses of regional seismic network operators to a March 2004 survey to the proposed performance standards. This comparison, found in Appendix C, forms the basis for the "pro/con" discussions below with respect to the status quo.

Our working group has not performed any benefit-cost analysis. This report indicates system architectural dimensions that in the opinion of WGE should be explored systematically in sufficient detail to develop and document the advantages and trade-offs of major system alternatives. We recommend a documented benefit-cost analysis to inform and guide decision-making. Benefit-cost assessment will require carefully considered guidelines for measuring benefits and costs, including systems requirements analysis and best-practice engineering input.

Architecture Capabilities and Requirements

The Technical Guidelines for the Implementation of The Advanced National Seismic System—Version 1.0 (Open-File Report 02-92) provides an extensive discussion of the capabilities and requirements for the ANSS. We *very* briefly summarize that discussion, and emphasize those areas where we believe the architecture impacts the capabilities.

- **Rapid Parametric Information**. The ANSS must automatically compute earthquake phase arrival times, associate phase information, compute hypocenters (initial and subsequently by enhanced methods like “double difference” and/or 3D locators), magnitudes, mechanisms, ShakeMap, CIIM, finite-fault estimation, and select electronic helicorders and spectrograms. The types of information, while dependent upon magnitude, must be available for the entire system.
- **Data exchange.** To be able to compute accurate and reliable information, seismic networks must have the ability to automatically exchange waveforms and parametric data in near real-time with other seismic networks using the Internet and private circuits using well defined protocols. Waveform data must be available via continuous exchange as well as by requests for specific time intervals. Derived products must also be available for exchange. Mechanisms must exist for automatically notifying networks that exchange data when network information/metadata has changed.
- **Information Distribution**. Immediately after an earthquake the ANSS must be able to quickly and reliably distribute earthquake information to the public via websites, to sophisticated users like emergency responders via the Internet using secure and reliable transport mechanisms, and to users who subscribe to email and short text-message services.
- **Quality Control**. Human review of routine earthquake information is needed to ensure data quality. Confirmation and rapid review of significant earthquakes is needed 7X24 by emergency response agencies and the news media.
- **Security**. Security must be designed into the architecture to prevent unauthorized access or to thwart attempts to interfere with ANSS operations.
- **Public Archive**. Unprocessed waveform data for discrete events, continuous waveforms, and derived parametric and spectral information must be rapidly archived at public data centers for use by the seismological and engineering

research communities. Supporting metadata must be available to facilitate the use of the data.

- **One earthquake, one report**. Conflicting information about earthquakes from different seismic networks confuses our clients. In general, the most authoritative source of information should release information to the public unless it is deemed desirable to release multiple estimates (e.g., HVD CMT, NEIC CMT, CISN CMT). Under normal circumstances, earthquake products should be computed from all available seismic information.
- **Reliability**. The public requires rapid and reliable earthquake information, regardless of the magnitude of the earthquake and impact on the infrastructure. The ability of the ANSS to report information should degrade gracefully as systems capabilities fail. There should be no single-points-of-failure.

Strategies

Two strategies (in addition to the TIC Plan) have been investigated: 1) a distributed system based on existing regional and national centers and 2) a centralized processing, but decentralized information delivery system. These systems can be considered to be end-members of a spectrum that includes the TIC plan system. These systems (and the TIC Plan) can be characterized as follows:

Decentralized:
This end-member of the suite of potential architectures is based on performing much of the processing at the regional centers (Figure 1). In this design, raw data is concentrated and automatically processed in near-real-time at the regional centers. Parameters and products for local and regional events are produced and transmitted from the regional centers to the national center, which then functions as a clearinghouse for results and resolves any overlapping/conflicting results.

[*Figure 1 on next page*]

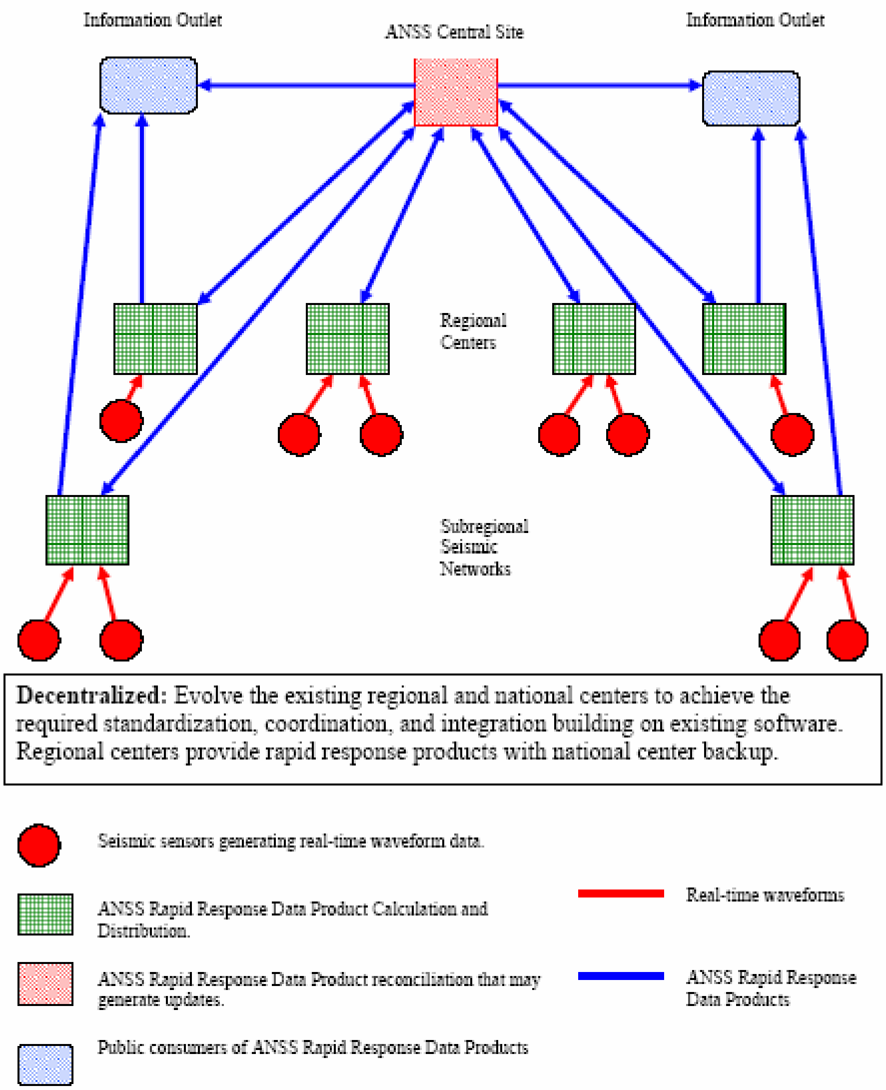

Figure 1. Decentralized Model

Some portion of the raw data would be shared with the national center and between regional centers to facilitate the computation of products for earthquakes outside their regions, and to allow for alternate processing centers in case of individual center failure. Organizationally, it is approximately what is done today.

Pro

- Similar to the current situation and may represent a useful starting point for any evolutionary model for ANSS architecture. ANSS could evolve the existing regional and national centers to achieve the required standardization, coordination, and integration building from existing software.

- Robust, since processing is close to the data sources with the national center acting as a backup.
- Minimal centralized management, and regional centers have the autonomy to work on similar problems. Fosters creative solutions that meet local needs.
- Regional Centers have primary role in computing and releasing products, which provides case for local financial support, incentive to develop new products, and synergy between operations and research staffs.
- Robust system backup by NEIC.
- Takes full advantage of the scientific knowledge that is distributed between the various regional centers. Local seismologists understand their data when processing earthquakes and when discussing it to media and emergency response officials.
- Regional networks can exchange data with neighboring networks to produce comprehensive datasets for local monitoring needs.

Con

- Regional processing facilities are at risk from the earthquakes being monitored.
- Difficult to standardize data exchange across system.
- Rules are required to resolve information conflicts and determine authoritative information.
- Expensive to staff 24x7 in every regional center, particularly where levels of seismicity are low.
- Difficult to integrate global datasets into local archives for significant quakes.
- Duplication of efforts potentially wastes limited resources.

TIC Plan:

The TIC plan is similar in many respects to the Decentralized plan. It preserves a national center, but reorganizes the regional centers into fewer, larger units (one per ANSS region) with new software (Figure 2). Regional centers provide rapid response products with National Center backup.

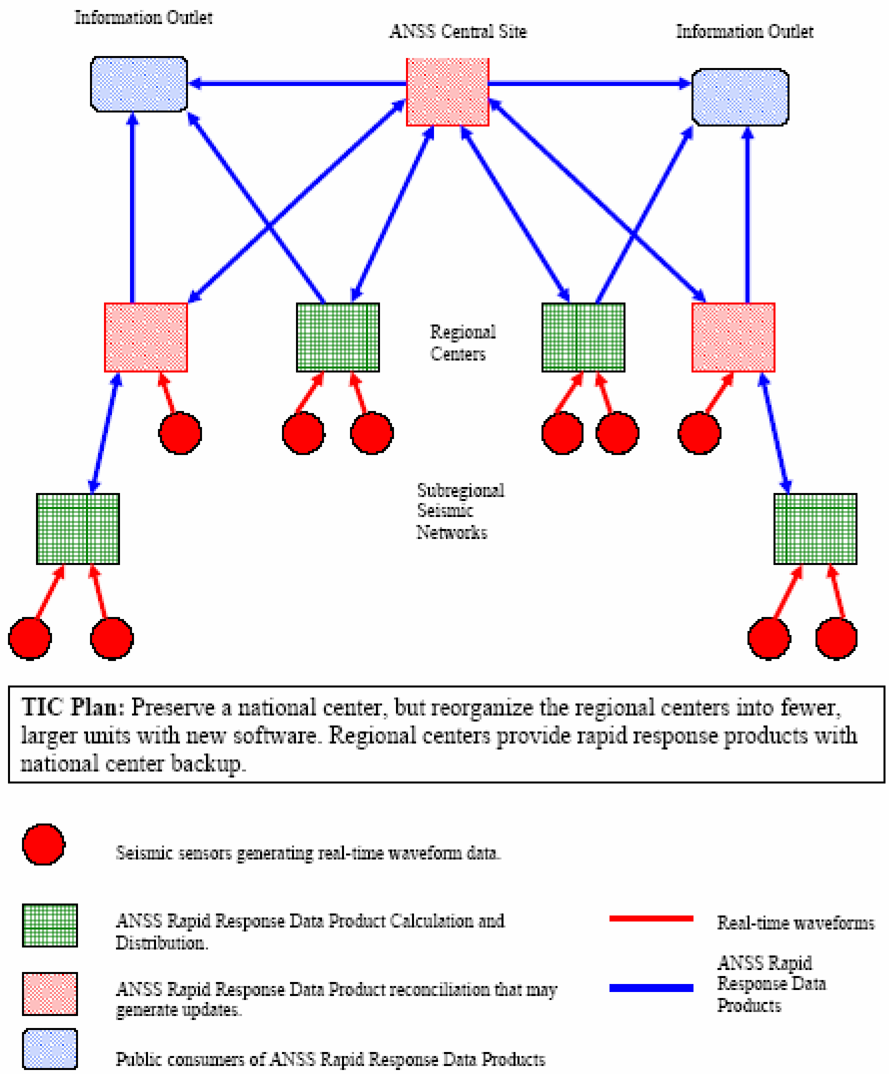

Figure 2. Original TIC Plan

Pro

- Similar to “Decentralized” list.
- Processing could be performed away from faults in areas with reduced seismic hazard.
- Fewer units decreases complexity of system.

Con

- Similar to “Decentralized” list.

- Potentially expensive to establish new regional centers, and given current funding climate is unlikely to receive much support.
- Uneven work loads from region to region.

Centralized:

The other end-member of the suite of potential architectures is based on performing all of the processing at a centralized “national” facility (or redundant facilities) or Integrated Processing Service (IPS) (Figure 3). In this design, raw waveform data is concentrated at the regional centers and continuously forwarded to the IPS(es) where signal and event parameters are produced. Regional centers are closer in this definition to individual networks than TIC-style regional processing centers. The IPS functions as the authoritative source of information for the entire system. Regional centers would have the capability to produce the same products from the data concentrated at their facility in order to back up the national center and to evaluate new methodologies. Some portion of the raw data would also be shared between regional centers to allow calculation of combined results, and to allow for alternate processing centers in case of national center failure. Although products are generated at the national facility, expertise in interpreting the results continues to reside in the regional centers.

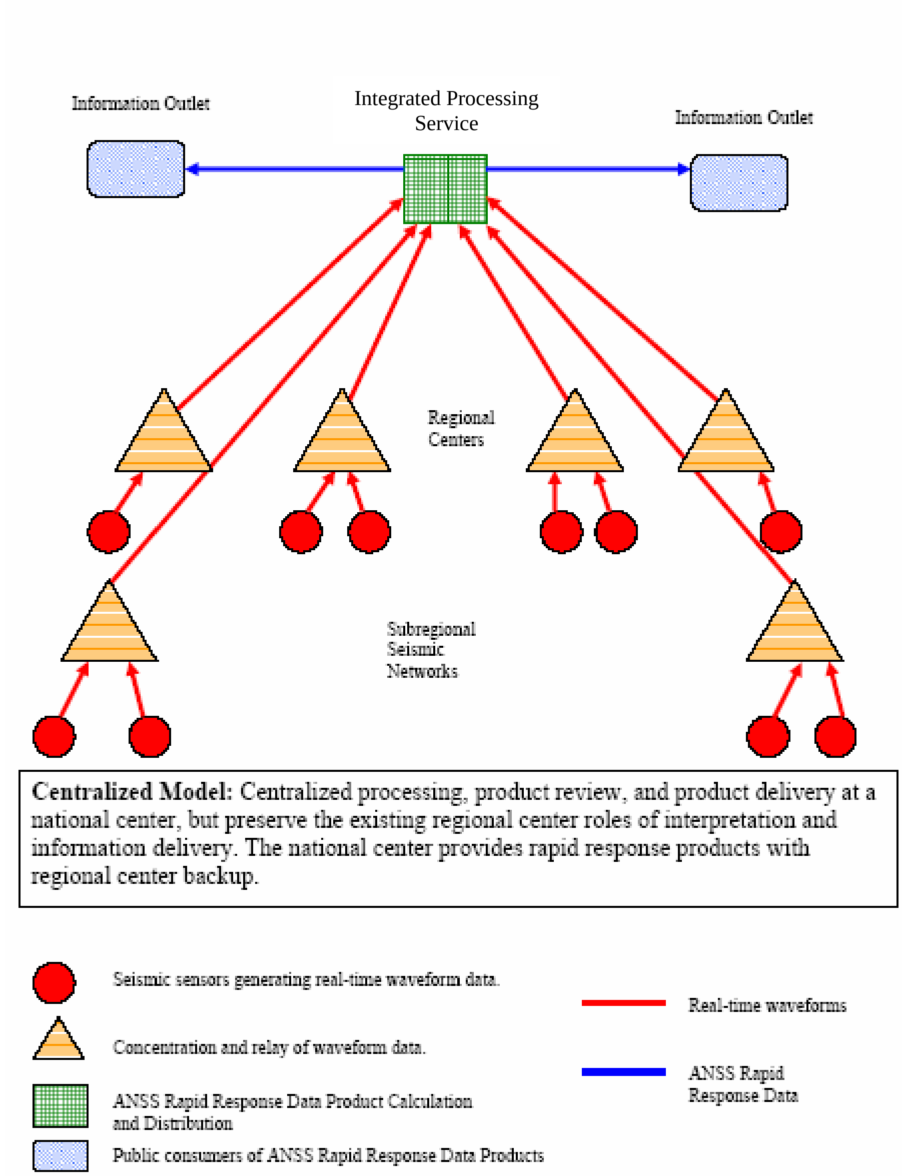

Figure 3. Centralized Model

Pro

- Potentially simplifies standardization and integrated product delivery.
- Robust system backup by regional networks.
- National centers have access to all available data and therefore are most likely to compute the most comprehensive view of an earthquake.
- Provides a common product set for all events regardless of the capabilities and performance of individual components.
- Integrates global seismic data with large regional events.
- Eliminates overlapping/conflicting regional results because the national facility has access to all data.

- Source code likely to be open source.
- Facilitates centralized processing in low-cost areas; also permits continuation of local processing but on a centralized system.
- Minimizes cost of 24x7 response.
- Minimal impact of earthquakes on national center if located in low-hazard seismic area.
- Response to large earthquakes handled by experienced staff. Local information contacts no longer burdened with technical response activities during seismic crises.
- Potentially frees scientific staff from operational duties.

Con

- Data less robust due to long communications paths from sensors through regional centers to the national center and back to regional centers.
- Difficult to preserve experience encapsulated in regional processing algorithms that reflect the unique geologic and seismological conditions in each region.
- Requires methodologies that are appropriate for local, regional, and teleseismic earthquakes.
- Regional identity (and hence support for funding) may be diminished.
- Incentive to develop and implement new methodologies potentially diminished. Sends a tacit message that regional centers are not capable.
- Motivation of analysts in centralized facility may not be as high as those processing data locally.
- Could take years to develop required software.
- Single point of algorithm, hardware, and distribution failure.
- Transfer of standardized code back to regions will be time-consuming, require local training, and could potentially disrupt reporting.
- If full waveform exchange over dedicated circuits is a requirement (as opposed to pick exchange and event waveform retrieval), the costs could be very expensive. Full waveform exchange over the Internet could impact local campus throughput.
- Requires development of procedures to provide feedback on degradation of data quality from centralized facility to local technicians.
- Requires special efforts in order to reconcile the processing of ANSS data and useful non-ANSS data (perhaps non-standard) now being processed at some regional networks (e.g., where support for seismic monitoring relies on multi-source funding and an ability to accommodate special projects).*

**Added in review*

Discussion

The majority in the WGE believes that having the national center as primary and the regions as backup merits serious consideration. However, the centralized model is quite contentious. Many of the “Pro/Con” bullets in the decentralized and centralized model elicit strong response from the Working Group members as well from some members of the CISN Program Management Group. It should be noted that there was little enthusiasm in the Working Group for the TIC plan (Figure 2). In addition to items noted above, there is widespread distrust for a centralized system.

The IPS concept is an end member state. A hybrid model of decentralized reporting for capable regions and an IPS for less capable regions could achieve satisfactory results. The WGE believes that it is important that the ANSS system have an NEIC-like capability for assured response to large earthquakes. Given the time constraints, our committee is only able to recommend, at minimum, that the concept of an IPS be “allowed” in the design of software for the ANSS system. Likewise if capable regional seismic networks want to continue as independent entities, the design of the software should permit that capability through the use of business rules to determine the most reliable information. The latter will be needed in any case to accommodate the situation where the primary center is offline and the backup center is reporting. We all agree that it is important to maintain the capabilities and knowledge in the regional seismic networks if the ANSS system is to be capable.

The review of the present performance of the regional networks and the NEIC against the proposed ANSS performance goals indicates that at present the system is not meeting the proposed standards. It is not surprising, then, that the WGE recommends for improvements in software capability. However, making a decision to centralize operations seems premature. The political issues need to be resolved to most people’s satisfaction before such a decision is made. Likewise, a benefit-cost analysis should be performed to identify if such a change would incur added costs or reduce operational costs and whether any additional costs are justified.

Recommendations for an Evolutionary Architecture

Note: In order to make transparent the degree of consensus among the members of WGE on the following recommendations (and some others), Attachment I summarizes voting results, keyed both to the list of recommendations (1A to 8B) below and to other recommendation statements accompanying Attachment I. Of the ten working group members, nine voted and one abstained, judging that he was inadequately informed to vote in a meaningful way.

— Walter Arabasz

Given the number of unknowns, the WGE suggests the following "evolutionary path" for creating ANSS software that provides advanced monitoring capabilities:

1. Develop project management structure
   - A. A software management group (SMG) of USGS and non-USGS network operators and software engineers should be tasked by the TIC with writing the guidelines for providing oversight on ANSS software efforts. The document should ensure that the process is transparent to the ANSS community.
   - B. The TIC/NIC should review/approve their recommendations.
2. Develop a specifications document
   - A. The SMG should develop specifications for the next generation of ANSS monitoring software. The specifications should follow from the recommendations for ANSS Performance Goals/Standards developed by Working Group A.
   - B. The document should include estimates for cost and milestones delivery dates for each task. Tasks should be prioritized.
   - C. The document should address both regional and global monitoring needs.
   - D. The document should be completed by 10/31/2005.
   - E. WGE realizes that commercial software is used by most monitoring systems (O/S, compilers, and databases) as well as the monitoring software in some instances (Antelope). However, WGE recommends that all software developed for the ANSS be open source and that the software be developed to run on Linux. Open source software reduces future licensing costs and facilitates sharing of the software with other institutions around the world that do not have sufficient financial resources to purchase commercial software.
   - F. WGE recommends that software be evaluated in its full context of development, ownership, and maintenance.
   - G. As discussed above, the WGE recommends a centralized model but believes it is premature to decide if this approach is cost effective or politically feasible. We do recommend, however, that the SMG develop

specifications that call for the creation of a software system that enables the ANSS to operate as a centralized system, but also to operate in a decentralized mode. WGE specifically recommends that the issue of authoritative attribution (i.e., coordination of conflicting information) be included in the system specifications. The WGE also recommends that the issue of remote data review from a central system be included in the specifications.

3. Develop consensus on the specifications document
   A. A period of comment should be allowed. All participants in the ANSS should be invited to comment on the document.
   B. The TIC should be granted the authority to modify the document based on comments received or as the development process proceeds.
   C. The final document should clearly lay out the vision of the ANSS system and have broad political and technical support in the ANSS community.

4. Allocate financial and human resources.
   A. ANSS management should review the document early in FY06 and allocate financial and human resources as available to begin to implement the recommendations.
   B. Universities have considerable expertise in developing software for seismic monitoring. The universities should be invited to participate in the development of ANSS software projects. The ANSS management should effectively utilize this resource because it would retain key staff needed to support local operations and actively involve regional networks in the development of the ANSS system.

5. Perform benefit-cost analysis
   A. ANSS management should perform an analysis in FY06 or FY07 to determine the most effective system architecture for ANSS system performance.

6. Develop clear guidelines for ANSS participation
   A. ANSS management should develop a standard MOA that defines how the partners of the ANSS will participate in the ANSS system. It should define whether the ANSS will expect its partner networks to utilize the proposed ANSS software or whether partners can utilize their own software that computes products with other methods that might yield different results.
   B. The MOA should carefully consider the political issues that relate to centralized and decentralized operation, local ownership, and state/local partnerships.
   C. The MOA should define the performance standards that partners should meet.

7. Implement parallel system

   A. As tasks are completed by the development team, the ANSS software should be distributed to the regions to be run in parallel with existing software for testing, evaluation, and training. Acceptance criteria should be developed before adoption.

8. Develop pilot software, valuable to all future ANSS architectural models, while the (somewhat intimidating) systems specification and benefit-cost work is being done

   A. Software for associator/locators that can use multiple 1-D velocity models or multiple 3-D velocity models should be developed and evaluated.

   B. WGE recommends the implementation and evaluation of a pilot high-data-rate acquisition and earthquake-monitoring system. The goal of this implementation and evaluation is to answer the question, Is it possible to implement a real-time earthquake-monitoring system that can maintain a comprehensive, real-time view of all real-time ANSS data?

ATTACHMENT I. Summary of voting results, keyed to list of recommendations

Number	Description	strongly agree	agree	somewhat agree	somewhat disagree	disagree	strongly disagree
	I. From Evolutionary Architecture Document						
1A	Software management group (SMG) should be tasked to write guidelines for ANSS software oversight	3	5	1			
1B	TIC/NIC should review/approve recommendations of SMG	3	6				
2A	SMG should develop specs for next generation of ANSS software	3	6				
2B	SMG document should include cost estimates and milestones		8		1		
2C	SMG document should address both regional and global monitoring needs	2	2	3	1	1	
2D	SMG document should be completed by 10/31/05	1	5	1	2		
2E	That all software developed for ANSS be open source and that software be developed to run on Linux	2	2	4		1	
2F	Evaluate software in its full context of development, ownership, and maintenance	4	3	1	1		
2G	That specs enable ANSS to operate as centralized system but also to operate in decentralized mode	5	3	1			
3A	Allow/invite comment on software specifications document	6	2	1			

3B	Give TIC authority to modify software specifications doc based on comments and development process	2	6	1			
3D	Have broad political and technical support in ANSS community	1	8				

Number	Description	strongly agree	agree	somewhat agree	somewhat disagree	disagree	strongly disagree
4A	ANSS Mgt should review in early FY06 and allocate dollars/human resources to begin implementation	3	4	1	1		
4B	Invite universities to participate in development of ANSS software projects	3	4	1			1
5A	Benefit-cost analysis in FY06 or FY07	3	3	2	1		
6A	ANSS Mgt should develop standard MOA that defines how partners will participate in ANSS	4	4		1		
6B	MOA should consider political issues (centralized/decentralized options, state/local issues)	4	5				
6C	MOA should define performance standards to be met	5	4				
7A	As ANSS software is developed, should be run in parallel in regions for testing, evaluation, training	5	3			1	
8A	Develop/evaluate pilot software for associator/locators	3	2	3	1		
8B	Implement/evaluate pilot high-data-rate acquisition and EQ monitoring system	2	1	4	1	1	

Number	Description	strongly agree	agree	somewhat agree	somewhat disagree	disagree	strongly disagree
	II. Other Recommendation Statements (see following pages)						
9	Pursue a "Road Map for Partnership" between federal and state/local elements of ANSS	6	3				
10	ANSS should adopt the framework, core values, and concepts of the Baldrige National Quality Program	3	3	3			
11	Instead of "One size fits all," ANSS should adopt a region-by-region approach	3	3	1		1	1
	III. From OFR 02-92 (see following pages)						
	For consistency among WGE voters, the recommendations below were assumed to be for the end goal of an ANSS system						
TIC 01	ANSS should consist of four modular hardware/software building blocks	1	4	4			
TIC 02	Regionalized architecture for ANSS (multiple processing centers and a single national center)	3	1	3	2		
TIC 03	One primary operational center per ANSS region for data processing		1	2	3	2	1
TIC 04	Separation of development and interpretation functions from routine processing	1	6	1		1	

ATTACHMENT 5–1 (continued)

II. Other Recommendation Statements Voted On

9. Pursue a "Road Map for Partnership"

   Given a natural tension between any idealized design of an ANSS system and the current configuration and funding of seismic networks in the United States, WGE recommends the pursuit of a "Road Map for Partnership"—ultimately in the form of well-crafted memoranda of agreement—between federal and state/local elements of ANSS. A primary objective would be to persuade network operators (and their varied sponsors) to move ahead toward a better-designed nationwide system that offers a win-win deal for both individual networks and the system.

10. Adopt the framework, core values, and concepts of the Baldrige National Quality Program

    As a companion to the "Road Map" approach for creating effective partnerships among elements of ANSS, WG-E recommends that ANSS adopt the framework, core values, and concepts of the Baldrige National Quality Program (BNQP). The latter is a public-private partnership, managed by the National Institute of Standards and Technology (NIST), that aims to help organizations achieve performance excellence through a systems approach based on seven criteria and guided by a set of core values and concepts.

11. Instead of a "One size fits all, " ANSS should adopt a region-by-region approach to system building

    Recognizing that that "One size fits all" is not likely to be an effective solution for ANSS system building, and with the example of how the California Integrated Seismic Network (CISN) evolved in the ANSS-California region, WG-E recommends that allowance be made for customizing system architecture in individual ANSS regions. Once ANSS system performance goals have been agreed upon, a systematic region-by-region approach to meeting those goals—under some overarching structure—is likely to be the most productive approach to system building. Because of earthquake geography, some deviation from the boundaries of existing ANSS "regions" may be needed in a few cases to achieve effective seismic monitoring.

III. Some First-order Recommendations from OFR 02-92 Voted On

01. ANSS building blocks

"The Advanced National Seismic System (ANSS) real-time and off-line processing systems should be constructed from four modular hardware/software building blocks. In particular, the heterogeneity and number of the three types of modules (data concentrators, operation centers, and data archiving facilities) that are between the sensors and the users should be kept to a minimum for reliability and cost reasons. However, the fourth module type (outlets, which directly support ANSS participants and end users as well as some production tasks) should be diverse and numerous, involving the whole community and supporting the whole spectrum of ANSS related uses." (Appendix D, p. 86)

02. Overall organization [*Note: In order to distinguish TIC recommendation 02 from 03 for voting purposes, I have substituted in 02 the words (and implicit concept) "multiple processing centers" for "a primary operation/processing center in each ANSS region" —WJA*]

"The TIC recommends a regionalized architecture for the ANSS with [multiple processing centers] and a single national operation/processing center. This model provides multiple processing centers for redundancy, while allowing for customization for regional needs. This model also provides a natural scale for addressing issues of data quality control, scalability of processing systems, redundant reporting, product quality control, and flexibility and responsiveness to local contacts. Besides the [multiple processing centers], there may be multiple operation centers for station and telemetry maintenance and multiple information outlets. Existing local networks likely will be transformed into an operation center or information outlet. The regional model of the ANSS implies consolidation and coordination of effort among the participating networks. The facilities of some local networks may become maintenance and data concentrators with processing activities occurring at the regional center. Local network operators may continue to be involved in station operation and maintenance, but their scientific expertise also will be devoted more to interpretation, research, and development using data from any subset (or all) of the ANSS" (¶ 2.1, p. 11).

03. One primary operational center per ANSS region for data processing

"In general there will be only one primary operational center per ANSS region at which routine data processing for the whole region will be done. The national level operation center will act as backup for all regions as well as coordinate issues between regions. One or more of the regional centers (or a separate facility) will also act as backup for the national center responsibilities in the event of a failure at the national center" (¶ 1.4, p. 7).

04. Separation of development and interpretation functions from routine processing

"[The TIC recommends] "a separation of the development and interpretation functions from routine processing" (¶ 1.3, p. 6). "Production functions (including those performed at outlets) should be logically separate from interpretation functions (also performed at outlets). Separating production and interpretation allows a system design that supports the goals of a highly reliable production environment and a highly diverse interpretation environment. Specialization does have negative aspects including problems in communication and coordination among groups of specialists. However, other large-scale organizations have developed effective strategies for dealing with these issues" (Appendix D, p.86: see also many other arguments presented in Appendix D for separating development and production functions from routine processing).

APPENDIX A. Input for a Road Map for Partnership

Explanation

This is a distillation of key points from five telephone interviews in November 2004 with network operators who are members of TIC Working Group E. (With one exception, the interviewees were non-USGS network operators.) The effort was a first step towards crafting a *Road Map for Partnership* in order to deal with potential "political" hurdles for consensus building to change the status quo in ANSS.

The sampling of opinions and views was intended to be a representative sampling of major issues that individual networks might have, along with potential ways to deal with them. Interviewees were promised that input would not be attributed to any individual and that the intent was to aim for generalized information.

The KEY QUESTION is . . .

"How do we reconcile state/local ownership, investment in, and/or ongoing support of significant infrastructure for seismic monitoring with the prescriptions of ANSS decision makers?"

This dialogue is part of an attempt to find ways to move ahead toward a better-designed nationwide system that offers a win-win deal for both individual networks and the system.

In the following pages, I begin with a list of key points gleaned from the interviews. Because the "bullets" are fairly terse, I've also included a sampling of notes from four interviews that I believe offer some constructive perspectives.

Walter Arabasz

March 1, 2005

Some Key Points for a Road Map (not ranked—and not exhaustive)

- Institutional identity, long-term interests, and avoiding undercutting the motivation for local/state funding are very important . This is stated well in the Memorandum of Agreement for the California Integrated Seismic Network (CISN):

  "This agreement is based on the value the organizations place on their own institutions receiving appropriate credit, and their understanding that the long-term health of an organization depends on the recognition of its value to the community and state."

- The Road Map, in effect, should be a well-crafted Memorandum of Agreement. Will require site visits and a good mutual understanding of what each party can and will do. Not just "send in your proposal."

- There can't be geographic "holes" in a national seismic system. So the system players have to find solutions for performance in all geographic regions—not just criticize or penalize operators where performance is substandard.

- "One size fits all" is not a solution. Using CISN as an example, system architecture may have to be customized in individual ANSS regions. This basically amounts to defining a geographic domain (typically with more than one network within it) and then making a plan to unify seismic monitoring, assure response to significant earthquakes within the domain, and deliver desired earthquake information products and services.

- In the eastern U.S. (as an example of the need for customization), multihazard approaches are essential for gaining partnering with and investment by state and local entities. [The USGS's FY2007 geologic hazards initiative presents a valuable opportunity to exploit ANSS potential to provide infrastructure, management, and a technological template for multihazard monitoring.]

- An effective system will be the fruit of consensus and commitment (buy-in).

- Local expertise and response is important.

- Infrastructure in many networks is multifunded and not focused solely on ANSS objectives.

- Outsourcing of any data processing or centralized function will require confidence building.

- Network operators are sensitive to being told how to manage their network or what software to run. Solutions can be based on agreed-upon interfaces, protocols, performance standards—carrot rather than stick.

- Continual innovation should be encouraged, not stymied by regimentation. In the view of some, regional network operators are likely to be the innovators.

- A sound business case will be needed before any decrease in local capabilities or personnel to outsourcing would be politically acceptable.

- Not all options for system building have yet been explored.

- Pride and sense of ownership in RSNs is important. Network seismologists are dedicated and passionate in giving their time and energy to what they do because of a sense of contributing something to society and a long-term commitment to their network's health and future.

Excerpts from Notes from "Interview A":

The problem is well stated in the question, "How do we reconcile state/local ownership, investment in, and/or ongoing support of significant infrastructure for seismic monitoring with the prescriptions of ANSS decision-makers?"

We all probably share experiences that are general and not one-of-a-kind—especially in states that have significant funding independent from the federal funding.

Part of the reality is that you have to deal with the players. No amount of policy stating has much impact on each of our independent funding—but it could jeopardize state funding. For policies to be made without regard to independent funding is a problem.

From [our] experience, there has to be mutual respect among the parties and a genuine feel of partnership. There's a need for all agencies to reflect their role in public service—especially before the press and appearance to the public . . . visibility . . . uniqueness of the agency. We all need to sell our organizations.

The potential loss of perceived importance to the state is a problem. Don't want to jeopardized contributions that an agency makes to its funder. Credit is important.

Regarding a "Road Map for Partnership": [In our region] the road map is a memorandum of agreement [that] describes how to move ahead, who are the partners, and how they can work together effectively—all under one state jurisdiction. A sense of ownership is a big deal. One of the lessons [from our] experience may be that each ANSS region needs to find its own road map or solution.

Excerpts from Notes from "Interview B":

Need to have an understanding of how new technologies will filter up into network-operations practice—for example, in locating earthquakes, new developments will come not just from the ANSS community.

Need to count on regional seismic networks to innovate. They will continue to do so at whatever funding level. Innovation needs to be recognized and rewarded.

“Multihazard” is better language for partnerships in the eastern U.S. (EUS), rather than just earthquakes. In the EUS, hazards are a high priority, but earthquakes are not. There’s a

potential for leverage in the EUS [that the USGS should recognize and exploit] for a decent multihazard program.

In the EUS, state offices dealing with emergency management are usually small and focused on all hazards. Advocates for earthquake hazards are perceived as gadflies—contrasting with those with holistic agendas.

ANSS could be a springboard for the USGS. Rather than being restricted only to earthquakes, ANSS’s infrastructure component could be leveraged to gain funding for dealing with multihazards. ANSS has the potential to provide infrastructure, management, and a technological template that could be used to meet the USGS’s multihazard objectives.

Looking at urban areas more comprehensively, regional and state emergency managers, as well as elected public officials in towns and cities, want to see risk-based distribution of dollars—not hazard-based. They want to see a risk profile. They’re less interested in fragmented distribution of dollars for individual hazards than a multihazard approach. To understand the rationale for risk-based resource allocation, consider what’s happening in Homeland Security and the concern of large metropolitan areas at risk that are getting insufficient funding.

Real-time monitoring and processing could be expanded to include landslides, tide gauges, and other monitoring technologies . . . generalized environmental hazard monitoring . . . common backbone, institutional network, management structure. None of this exists for landslides, for example. There ought to be economies and interactions between [programs for monitoring] earthquakes and volcanoes..

On the engineering side, need a resilient system for monitoring and response. For example, there could be a ShakeMap counterpart for landslide flow. There ought to be a systems approach for the engineering community—rather than hazard by hazard (e.g., seismically resistant tall buildings that are wind-resistant too).

Regarding volcano monitoring: ANSS has leaped ahead in terms of national integration and leveraging with engineers. This success can be applied to volcano monitoring. Metaknowledge, not just data products, will be relevant. Need to “feed” people who know the “fingerprint” of a particular volcano. The local expert might say, “Hey, I need magnitude 1’s.” There has to be a recognition of needs.

Need periodic or annual technical tests of the regional seismic network (RSN)–NEIC piece of processing. This suggestion was made years ago. This refers to an exercise that would promote technical integration, accountability metrics, and impetus for particular technical developments.

An example test might be waveform cross-correlation. For one month, let's use waveform cross-correlation as a supplement to arrival-time picking. Compare results and see if there's an efficiency to be gained and the level of confidence in the alternative approach.

Approach it like an Navy exercise . . . "Something we have to make work." Implement things that work; go back to the drawing board with others.

Take baby steps toward national integration so we can get some quick results.

Excerpts from Notes from "Interview C":

With RSNs there are always local issues and problems. Infrastructure always goes beyond what the federal government is going to pay for. [For example], Menlo Park and NEIC are the only end-to-end USGS network operations. All other USGS centers are multifunded.

Establishing the endgame is the number one political hurdle. What are the desired objectives?

Top issues include: the need to get buy-in in terms of functional requirements built into the design . . . building an effective system . . . developing consensus and agreement . . . concern that a centralized system removes expertise and resources from an RSN.

With limited funding, if ANSS establishes a processing center, information centers are easier to cut.

A processing center [that is a flexible system element] has some attractions. For example, a customer for a processing/service center [might say], "Here are our spec's." May be the most efficient way of getting [some] processing done—considering budget, standards that have to be met, partial FTEs, multitasking burdens placed on existing staff.

Outsourcing makes sense for "cleaning up" aftershock sequences because of their sheer volume.

[*WJA: Attraction of some outsourcing to relieve three strains on network staff: (1) constant readiness to assure effective response to a big earthquake, (2) 24x7 duty-seismologist roster, when staffing is small, for rapid review of all automatic earthquake locations/magnitudes for shocks above response threshold, and (3) conflict between need for attention to "production" and demands of other multitasking*.]

These strains are real issues. Arguably, these issues do not necessarily demand outsourcing. Important to start out by identifying a system design that's going to be something all can buy into. Has to achieve objectives. What will the system look like? Need the vision and buy-in. A "coalition of the willing" is preferable to enforced compliance.

Politics is the art of compromise; an effective system will be the fruit of consensus and mutual commitment.

For the system to truly succeed, buy-in has to occur at the functional requirements level. It is pointless to develop a path to a place we're not sure we want to go. There are a lot of ways to get to an assured timely response and a uniform catalog; centralizing is only one, and not [necessarily] the best.

Justification for changes should compare in strength to the scale of the changes. The present organizations have come to their present configuration for considered reasons that reflect the thoughts and labors of many people. Yes, some organizational elements are vestigial, but most of what we have was designed and implemented on purpose.

From a political standpoint it will always be preferable to improve key regional capabilities rather than to centralize. Local investment reflects a commitment by ANSS to people and local organizations that make the system work.
Politically, solutions that bring neighbors together will always be preferred to (and more successful than) a vertical organization involving remote centralization.

Instead of exporting all channels, the network would only need to import the smaller number of outside stations potentially relevant to the ANSS specifications. Timeliness could also be specified, perhaps as a function of magnitude. NEIC already imports enough stations to locate M ≥ 3.0 events nation-wide, so assured timely review need not be an issue. There is no safety or engineering requirement for immediate analyst review of small earthquakes. The idea that all channels have to go to the location where the picking occurs skips over the fact that phase arrival times from distant stations cannot be allowed to overrule local stations in the location (due to velocity model uncertainty) or magnitudes (due to uncertainty in attenuation).

It is unlikely that local seismologists will find much pride and sense of ownership in the fruits of their stations if the important earthquakes and the catalog are outsourced.

True partnerships based on respect and engagement will work better than other kinds. Long-term commitments are needed if the networks are to hire and retain qualified staff. Unfunded and underfunded mandates are not good tools for system building.

RSNs also need local capabilities to train seismologists, respond to educational and community queries, and to interact knowledgeably with the data. Successful partnering with ANSS must respect these local, non-ANSS mission requirements.

Excerpts from Notes from “Interview D”:

Top issue: Preserving local identity! The appearance of how earthquake locations from a regional seismic network (RSN) appear to the outside world on a centralized Web site is one example.

[Our state organization] has to go through a sunset review by the state legislature every three years, and it has to present an annual report to the state.

In this part of the country, need to provide information on small earthquakes—including felt shocks as small as magnitude 2. At national level, concern focuses on high-quality broadband stations—but short-period analog stations still have value.

Institutions now doing [routine earthquake analysis] have institutional momentum (e.g., consistency in catalogs) and are reluctant to change. [At a higher system level, there still is] a lack of resolution of issues relating to magnitude determinations.

Success in [our region] is gained by getting consensus. We show [our regional partners] what needs to be done to be part of a national system. Sharing—give and take . . . Helping them do what they need and want to do. Site visits are important. [For example, in one case] a significant breakthrough was gained by having the network technician [from a partner network] come to [our network center]—at [our] expense—for a tech-to-tech visit. He left with a completely different attitude.

Being a PI on a cooperative agreement takes a lot of time. Not enough credit given for effort in managing network operations . . . doesn't generate publications like pure research.

[WJA offered the view that most ANSS cooperative agreements should implicitly be viewed as sustaining state earthquake programs under state-federal partnerships, rather than being for the benefit of an individual institution.]

In [our case], the state legislature appropriates line-item funding to [us] as an organizational entity. Besides [our] mission in seismic monitoring, [we're] required to maintain vigorous educational and outreach components under the umbrella of a "Center of Excellence."

ANSS should take advantage of distributed expertise and avoid duplicating effort. Things that [we] can't easily do include 24x7 response and structural monitoring.

Why regional net operators are so committed . . . Making a business analysis of network operations is lunacy. Without exception, people work here because of a sense of contributing something to society. They like what they're doing. Won't get that in a business model.

APPENDIX B The Baldrige National Quality Program and ANSS

Prepared by Walter Arabasz and Rick Schult
November 16, 2004 (revised March 1, 2005)

What is the Baldrige National Quality Program (BNQP)?

BNQP is a public-private partnership, managed by the National Institute of Standards and Technology (NIST), that aims to help organizations achieve performance excellence through a framework of seven **Criteria***:

1. Leadership
2. Strategic Planning
3. Customer (and Market) Focus
4. Measurement, Analysis, and Knowledge
5. Human Resource Focus
6. Process Management
7. Organizational Performance Results

Note: The Criteria are worded slightly differently in documents customized for the U.S. Business Community, the U.S. Education Community, and the U.S. Health Community, respectively.

The underpinnings of the Criteria are a the following set of **Core Values and Concepts**:

- visionary leadership
- customer-driven excellence
- organizational and personal learning
- valuing employees and partners
- agility
- focus on the future
- managing for innovation
- management by fact
- social responsibility
- focus on results and creating value
- systems perspective

The BNQP was originally created to help U.S. organizations become more competitive globally. The BNQP Criteria are used to judge organizations applying for the prestigious Malcolm Baldrige National Quality Awards (the awards program was established by Congress in 1987)—but they serve more generally as an assessment, self-improvement, and/or planning tool for any organization.

The Web site for the BNQP is at http://www.baldrige.nist.gov
For materials available from the BNQP, see http://www.baldrige.nist.gov/NIST_Materials.htm

Why should ANSS adopt the BNQP approach?

- It's a systems approach to performance excellence

- Because it’s a systems approach, it requires balance—one can’t focus on bottom-line results without also paying due attention to the other six Criteria
- It’s enforced common sense
- It forces discipline on the process and brings the scientific method to bear
- It motivates an important focus on “customers” and stakeholders
- It helps identify and recognize what each “customer” and stakeholder needs
- It makes all tradeoffs explicit if there are limited resources—therefore, it helps make design criteria explicit
- It’s a proven method endorsed by some of the most prestigious companies and organizations in the U.S.
- With NIST now the lead NEHRP agency, it’s an appropriate way for ANSS to strive to meet the expectations of Congress for performance and results—and be able to show our “report card”

Would the (BNQP) tail wag the (ANSS) dog?

Any program like the BNQP can go off track if leaders allow the process to become an end in itself and an exercise in bureaucracy. One of the members of TIC Working Group E offers the following practical advice from first-hand observations of how the U.S. Air Force has used the BNQP for more than five years:

- Consider applying the BNQP in an informal way, avoiding a rigid approach and perhaps judiciously picking and choosing aspects of the BNQP, without unduly compromising the need for balanced overall attention to each of the seven Criteria
- Avoid turning any emphasis on metrics into “no brain” metrics that either are served for their own sake or lead participants to “making the numbers look good”
- Define specific desirable results and measure success in way that makes sense

How the BNQP approach can guide ANSS decision-making

The Baldrige approach enforces addressing all aspects of a problem, which protects against the common flaw of reducing the focus of system analysis solely to a financial bottom-line. All aspects must be addressed explicitly, so key non-financial factors represented as core values can be saved from inadvertent damage.

For example, quality of the ANSS's products must be maintained and improved. Qualities such as the scientific and technical quality of ANSS results, their pertinence to public decision-makers, their timeliness, and their accuracy can be related back to core values such as integrity, excellence, and responsiveness and back to guiding principles, such as incorporating the best of new scientific results and continually improving the system.

Another example could be applying the principle of inspiring excellence in the people involved in ANSS, which ensures that important human resource issues are addressed.
Ideally, BNQP will make such benefits to the system explicit so that their costs can be recognized as necessary.

How the BNQP approach helps value the “people” part of ANSS

The ANSS Technical Integration Committee report OFR 02-92 emphasized that a system is “hardware, software, and people working together to solve a particular problem, or to produce a desired effect." The importance of the "people" part of ANSS is prone to be overlooked. For example, products and services to be delivered by ANSS have been identified, yet there is no available inventory of human resources within ANSS that's being relied on to deliver those products and services.

The Baldrige approach emphasizes the importance of addressing human resource issues explicitly. In fact, these issues are an important part of stakeholder contributions and requirements. People are a vital part of every system and sub-system involved in ANSS, and must be sustained, challenged, and nurtured. Much of the current regional and local seismological knowledge exists in the regional centers and has been developed through scientific studies by their personnel.

Any changes to the system need to explicitly address how this process will continue and evolve. How will ANSS continue to develop the community of seismologists needed to works with ANSS data on an operational basis?   How will ANSS capitalize on the knowledge and expertise of scientific stakeholders to produce new breakthroughs for earthquake risk mitigation?

Another similar challenge is working out functional career progression for a wide range of personnel engaged in professionally operating and managing ANSS. In the case of computer specialists involved in collecting, transmitting and processing ANSS data, their judgment and knowledge need to be recognized by providing them full access and transparency into processing algorithms and processing results.

Performance excellence through customer and market focus

A key part of BNQP performance excellence is customer and market focus. This begins by identifying all stakeholders in the ANSS process, what they contribute to ANSS and what they require from ANSS.

For purely illustrative purposes, a sketchy and incomplete example for current regional network operators might show that they contribute:

- Detailed local knowledge of network seismicity and seismology
- Contacts with local emergency authorities and local public
- Information outlet to these contacts during events
- Rapid warning to local first responders
- Operation and maintenance of stations
- Etc

and they require:

- Political support by state, local government & the public to maintain the regional net
- Full technical insight into national seismic processing
- Rapid availability of national results
- Availability of neighboring data, sometimes national & international data & results
- Backup in case of outage
- etc

A similar analysis for the current NEIC would have another set of contributions and requirements, and so on for all the stakeholders. Emergency responders would require rapid actionable information on the location and severity of damage, and would provide a very important reason for the ANSS to exist.

This process is useful for identifying hidden assumptions and putting all criteria on the table. It is possible to find more potential win-win solutions by explicitly laying all assumptions on the table through this sort of analysis. The process also makes addressing each stake explicit.

Once stakes are identified, goals for the system can be defined to address these stakes. Where possible, quantitative measures of performance against these goals should be defined, to allow for measurement and analysis, and to force progress toward improved performance.

Some of this process has already occurred for ANSS. The challenge for these metrics is keeping them relevant. Many of the stakeholders require political support for continued operations, for which metrics are difficult. Such political support for most government agencies involves strong champions and a general level of constituent support, so counting the loss or displeasure of a strong champion and flagging major dips in public (or legislative) support might be the most useful metric. A metric of more questionable utility might be counting citations of the agency's role in ANSS in the public media: it would be important to differentiate positive and negative citations if possible, and one can think of a number of other potential pitfalls.

Miscellaneous Comments Regarding the BNQP and ANSS (Rick Schult)

"Leaping to a design" — If a complete definition of all stakeholders and the nature of their stakes in ANSS and seismic hazard monitoring are included, the Baldrige approach could help us find ways to work out the goal of partnership. For example, we can identify solutions where all or most parties come out ahead. Yes, the method can be used to justify pre-existing decisions, but getting it all out on the table can help spur creativity. The key is thinking hard about what is the bottom-line for each stakeholder—what does that stakeholder organization need to exist? For example, perhaps a state network needs state legislative support for serving the public's interest in knowing what went bump in the night, and in improving estimates of seismic hazard, and in providing rapid information to emergency responders, and whatever else matters to that network's supporters. Which of these are most important to that network?

Key Definitions (Organizations, Customers, Employees) — Go back to stakeholders. What does each stakeholder bring to the table? What does each stakeholder require for support? Emergency responders require rapid real-time actionable information, no matter what went down during the disaster. They provide/supply a critical purpose/reason for ANSS to exist. Customers, employees and suppliers all provide some things to the system and require some other things from the system.

Customers — The stakeholder approach at least partially addresses the inversion of the customer concept. In business, you can reduce many more things (products and supplies) to money, but in government, life is more complex. You need general political support and, more importantly, strong champions in the governmental decision making processes. You have to treat your government officials and the general public both as suppliers and as customers.

Centralized processing and distributed expertise — The lack of communication between centralized processing and distributed expertise can be addressed in today's distributed processing environment. What it requires is organizational commitment.

You can have distributed knowledge of a centralized system as long as the system is transparent, and as long as there is an institutional commitment to the transparency. In the military, this process can happen from the top down; in other organizations/associations, it requires other/additional ways to institutionalize transparency.

A central ANSS facility may have to have personnel (at least one full-time) dedicated to the transparency process, making sure that distributed experts had visibility into the system, and making sure the expertise is getting incorporated in the system. Regular (annual? monthly?) group meetings of experts to discuss processing improvements would help keep the expert community focused, and keep the transparency issue hot. The Air Force seismic monitoring program has spent a large amount of resources (people) on the equivalent process of getting new scientific results into its centralized processing system. The ANSS effort could be much smaller, but there definitely would need to be resources dedicated to the processing system for the ANSS, and there should be someone looking at making improvements to that system.

Reporting on earthquakes depends on a three-legged stool of sensors, processing and scientific knowledge. Lack of any one of these three regionally-based components can lead to significant failings in the reports. The ANSS architecture needs to explicitly address (1) deployment of seismic sensors, (2) implementation of processing system(s) for the resulting seismic data, and (3) use of the ensemble of scientific knowledge that guides the processing and helps interpret the results in a variety of contexts.

Current processing systems require some degree of modification to allow for standardized but region-specific data processing.

Some forms of region-specific scientific knowledge can be parameterized easily for standardized algorithms (such as those used in detection or phase picking). For other functions, such as event location, possibly event magnitude, and more specialized functions like moment-tensor inversion, there may be some differences in the underlying scientific approaches currently used in different regions. In addition, the interpretation of the processing results often depends on region-specific knowledge: for example, this event resembles the three previous historical events in this county, and so on. In each region, this knowledge currently resides in different places, making its integration into a standardized product one of the system challenges.

APPENDIX C "Where We Are Now" *vis a vis* Draft ANSS Performance Standards:

Subtask Report —TIC Working Group E (Evolutionary System Architecture)

Prepared by Glenn Biasi and David Oppenheimer

November 10, 2004

Background

All of the regional seismic networks provided written responses in March 2004 to a series of "20 questions" distributed to the community. The questions were designed to capture a snapshot of the capabilities of the regional and global seismic networks who are partners of the ANSS. Responses were received from all 7 ANSS regions as well as the NEIC. Some of the regions provided responses for each seismic network in their region, and others summarized the capability of the entire region. The responses, compiled by Mitch Withers of the Center for Earthquake Research and Information, are provided at http://www.ceri.memphis.edu/~withers/TIC/ANSS_Regional_Survey.xls

This report summarizes the responses in a fashion consistent with the Draft ANSS Performance Standards. These standards set specific goals and requirements for the operation of ANSS participating seismic networks. Unfortunately, the "20 Questions" were distributed before the Performance Standards were proposed, so the survey does not address all of the standards, and the Questions address issues not covered in the Standards.

A comparison of the current performance capabilities of the partner networks to the proposed standards inevitably identified opportunities to improve performance. However, this summary was not solicited as a device to criticize individual network performance or capabilities. Partner networks necessarily reflect their varying funding levels, priorities of network stakeholders, and artifacts of development in a heterogeneous computing and instrumentation environment. They also reflect the fact that as of the time of this report there are no standards in the US for the operation of seismic networks. Present network capabilities nevertheless reflect a sustained, system-wide effort and a deep commitment to seismic monitoring for the public good. The funding level of seismic networks at this time is not sufficient to meet the proposed ANSS Performance Standards. If Standards are adopted and funding is provided to improve the performance of partner networks, then future reports such as this one could be used to monitor improvement and provide one important measure the success of the ANSS.

There is no seismic network in the ANSS that meets the Standards as of the date of this report. Moreover, the survey illustrates that there is a disparity of capability across the ANSS which presumably reflects the level of financial support. Some networks like the SCSN are relatively advanced, suggesting that the solutions used in this region could be exported to other networks. Other networks, like the NOAA Tsunami Warning Centers, have missions that do not require them to perform the functions proposed in the ANSS Performance Standards. Of note, there is almost no compliance with the proposed standard for strong motion data processing. While most networks are eager and willing to improve their capabilities, a considerable amount of effort, planning, staffing, time, and funding will be required by the partners of the ANSS to meet the proposed Performance Standards.

Seismic Monitoring

Region	Performance Standard: Completeness level/ % of time reached	Performance Standard: Average location uncertainty	Performance Standard: Magnitude capability	Performance Standard: Waveforms saved	Performance Standard Metadata availability
Densely instrumented regions of the US	M1.5/ 99%	1.0 km hor./2.0 km vert.	1.5<Md<4.5±0.2 3.0<ML<6.0±0.2 4.5<Mw±0.1	95%	Complete instr. resp. 100%
Sparsely instrument regions of the US	M3.0/ 99%	5.0 km hor./10.0 km vert.	3.0<ML<6.0±0.2 4.0<Mb<7.0±0.2 4.5<Mw±0.1	90%	Complete instr. resp. 100%

Completeness level: The magnitude detection threshold varies throughout the US depending on the density of seismic stations and the mission of the network. In densely instrumented regions (some parts of Alaska, Cascadia, and Sierra Nevada volcanic systems, most of western Nevada, portions of the San Andreas fault system, Salt Lake City, and Memphis) the standard of 1.5 is achieved. The NEIC provides uniform detection to M3.0 for the Continental US, M4.0-4.5 for Alaska, and ~M5.3 for the rest of the world. Reported completeness levels for networks in the continental US and on the Big Island of Hawaii are meet or exceed the M3 level, including 1.8 for PNW), 2.2 for CA, and 3.0 (Central US, Utah, and central Nevada).

Average Location Uncertainty: As in Completeness Level, the uncertainly varied with station density. Many networks have regions within which epicentral location uncertainties meet or exceed the 1 km epicentral uncertainty Standard. Regional networks in the western US generally meet or nearly meet the epicentral location criteria in outlying areas. Only HI and Central US report that epicentral location errors could significantly exceed the draft Standard of 5 km. The NEIC reported location uncertainties of ~8km and the WC/ATWC, which observes a small subset of the stations available to the NEIC, reported 30 km. No information on depth uncertainty was requested in the survey.

Magnitude Capability: There is no uniformity of magnitude usage in the ANSS. Regional seismic networks use a variety of magnitudes. Some use ML, others Md, and two Mw. Global networks (NEIC, PTWC, and WC/ATWC) use a variety of magnitudes (ML, Mb, Ms, Mw, etc) depending on the size, location, and depth of the earthquake. Variations in the type of magnitude estimates tend to reflect the type and density of available instrumentation available to the network. Networks relying most heavily on analog channels uniformly use Md, whereas southern California, with its high density of digital instruments, uses ML. Central US and PNW are not reporting ML, likely for lack of enough on-scale, calibrated stations, and the NC use of ML only above M3.5 reflects the low density of broadband station coverage. The Standard of Mw for events M>4.5 is presently met only by California, AEIC, and NEIC.

The geographic descriptions in the questionnaire (“entire region”) and the Performance Standards (“densely instrumented” and “sparsely instrumented”) do not really address the fitness of network performance to the need relative to hazard or population. For example, M3 may be adequate for much the IMW, but in light of the higher population density, may be inadequate for the central and northeast US. In general it appears that a completeness level in high risk regions is generally good. Similarly, location qualities and magnitude estimates improve with station density, but quality relative to at-risk populations was not specifically addressed.

Waveforms Saved: All networks archive at least some waveforms at public datacenters with the exception of networks funded solely by the USGS Volcano Hazards Program and the NOAA Tsunami Warning Centers. All networks, possibly excepting Hawaii, save continuous broadband station data to archives. PNW, Utah, and Nevada also save at least some short-period components to archives as well. The major networks except NEIC and Hawaii save event excerpts to an archive.

Metadata availability: Supporting metadata is available from most of the networks that archive waveforms. Metadata is apparently most available for broadband stations, and less complete for analog channels. There was little depth provided in the responses, and the situation is probably better for current events than historical.

Strong Earthquake Shaking

Region	**Performance Standard:** **Instr. Spacing in urban areas**	**Performance Standard:** **Waveform Data return rate**	**Performance Standard:** **Peak ground motion on scale/ sps/abs timing**	**Performance Standard:** **Data Processing**
Urban regions of the US with-high risk	10 km	90%	2g/ 100sps/yes	**Archive raw data/ Calc. Spectra Correct acc/vel/disp**
Non-urban regions of the US with high hazard	20 km	90%	2 g/ 100sps/yes	**Archive raw data/ Calc. Spectra Correct acc/vel/disp**
Non-urban regions of the US with low hazard	300 km	80%	2 g/ 100sps/yes	**Archive raw data/ Calc. Spectra Correct acc/vel/disp**

Instrument Spacing, Waveform Data Return, and Data Processing: Not addressed in the questionnaire.

Peak Ground Motion On Scale: Although not part of the questionnaire, instruments provided through the USGS ANSS procurement all meet requirements for scale, sample rate, and absolute timing.

Data Processing: In California the California Geological Survey Strong Motion Instrumentation Program and the USGS National Strong Motion Program perform data processing and archiving for events of interest to the engineering community. Outside of California the NSMP performs data processing for significant events recorded by regional seismic networks, but no formal or automated procedures are in place for processing and archiving strong-motion data from the regional networks.

Real-time Automated Product Generation

Region	Performance Standard: Hypocenter Lapse time/ % of time	Performance Standard: Magnitude Lapse time/ % of time	Performance Standard: Moment Tensor Lapse time/ % of time/threshold	Performance Standard: ShakeMaps Lapse time/ % of time/threshold	Performance Standard: Aftershock Probabilities Lapse time/ % of time/threshold
Densely instrumented regions of the US	2 min./99%	3 min./99%	8 min./95%/M4.5	5 min./99%/M3.5	10 min./99%/M5.0
Sparsely instrument regions of the US	3 min./99%	4 min./99%	10 min./90%/M4.5	6 min./99%/M4.0	15 min./99%/M5.0

Hypocenter Lapse time: All networks automatically report earthquake locations into public systems (web, email, pager, etc) with the exception of AVO, PTWC, and NEIC. The speed at which networks report earthquake locations and magnitudes vary from 1-2 minutes to 7 minutes.

Magnitude Lapse time: Information was not requested in the survey. The CISN can meet the standard.

Moment Tensors: Only AEIC, NEIC, and the CISN networks reported routine computation of moment tensors. Magnitude thresholds and time to computation were not requested. The CISN can meet the time-to-computation standard, but does not release the information until it has been reviewed by a qualified seismologist. This often results in delays of hours.

ShakeMaps: ShakeMaps are being produced in real time by PNW, CISN, Utah, and Nevada. CISN and Utah appear to meet the time-to-release Standard of <5 minutes. Comment on the capability to rerun ShakeMap with a finite fault model was not requested.

Aftershock Probabilities: Information not requested.

Post-Processing Product Generation for Major Earthquakes

Region	Performance Standard: Human Review Hypocenter Lapse time/ % of time /Threshold	Performance Standard: Human Review Magnitude Lapse time/ % of time/Threshold	Performance Standard: Human Review Moment Tensor Lapse time/ % of time/Threshold	Performance Standard: Human Review ShakeMaps Lapse time/ % of time/Threshold
Densely instrumented regions of the US	15min./99%/M3.5	15 min./99%/M3.5	30 min./95%/M4.5	15 min./99%/M3.5
Sparsely instrument regions of the US	30 min./99%/M3.5	30 min./99%/M3.5	45 min./90%/M4.5	30 min./99%/M3.5

Human Review: All networks except Hawaii reported the capability to review significant earthquakes promptly. Networks varied in the magnitude point that triggers immediate review, from M3-3.5 in California to M6.0 for NEIC. Only AEIC, Utah, and California reported actually working to the M3.5 threshold for immediate review. Time to review varied from 10 to 30 minutes for most networks, with 15-60 minutes for Utah. Time to review moment tensors varied from 7 to 20 minutes where it could be inferred. Time to review ShakeMaps was not requested.

Data Exchange

Region	Performance Standard: Waveforms: **Timeliness/ Completeness**	Performance Standard: Amplitudes Timeliness/ Completeness	Performance Standard: Phase Picks Timeliness/ Completeness	Performance Standard: Dataless SEED/V0 Availability
Densely instrumented regions of the US	30 sec/95%	30 sec/95%	30 sec/95%	100%
Sparsely instrument regions of the US	30 sec/90%	30 sec/90%	30 sec/90%	100%

Data Exchange: Information was not requested.

Data Archiving

Region	Performance Standard: Import of data to the archive: Timeliness/ completeness	Performance Standard: Availability of Waveforms: Timeliness/ completeness	Performance Standard: Availability of Parametric data Timeliness/ completeness	Performance Standard: User data retrieval Speed/# of users	Performance Standard: Metadata availability
Densely instrumented regions of the U.S.	10 min./95%	30 min/95%	30 min/95%	56KB per sec/30	99%
Sparsely instrumented regions of the U.S.	10 min/95%	30 min/95%	30 min/95%	56KB per sec/30	99%

Data Import: Completeness was not requested in the survey. Most networks archive at least some data locally, with delays of two minutes or less. However, availability at public data centers is far slower. The SCSN makes its data available at the SCECDC almost immediately, the PNW reports a delay of 30 minutes, Utah posts continuous data several times per day, and the NCSN has different time delays depending on whether the data is continuous waveforms, event waveforms, or parametric.

Parametric Data: Phase data are publicly available from NEIC, AEIC, CISN, and Utah. Memphis and Reno archive phase data on site. Time to availability was reported only by NEIC (a few minutes) and CISN (an hour).

The Performance Standards make no distinction between small and large earthquakes on the point of parametric data time to delivery. This will push network partners to report data sooner and in a more preliminary form. Preliminary reporting will require tracking and update capability.

User count: Not addressed in the questionnaire.

Metadata: Addressed above.