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Version 1
8/26/02

Performance-Based Assessment for the ANSS
Summary and Suggested Implementation

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August 2002

I. Introduction and Rationalization

This note arises from discussions at the meeting of the ANSS National Implementation Committee in Salt Lake City on July 17 and 18, 2002, where there was debate on the need to assess the performance of components of the ANSS with respect to the objectives stated in USGS Circular 1188 (Requirements of an Advanced National Seismic System) and the technical specifications detailed in OFR 02-92 (Technical Guidelines for the Implementation of the ANSS Version 1.0, or the "TIC Report"). I was asked to develop some thoughts on the need for such assessments, what they might be, and how they might be met.

Performance-based assessments of a system involve the evaluation of system characteristics in the context of desired system outcomes. The assessment is fed by performance-based criteria, which are recommended or required properties of the integrated system assets and recommended or required utilities of the products. The need for such assessments stems from work in operations research showing how performance-based engineering design can be used to develop and understand complex integrated systems constrained by desired outcomes. This basic concept differs from acceptance tests, which measure adherence to technical specifications, in that the integrated outcome of the system, rather than the performance of individual components, is assessed. A system-wide performance assessment benefits systems with large and diverse stakeholder communities. This mindset ("seeing the forest instead of the trees") drives discussions with stakeholders in more productive ways.

The specific properties and utilities involved can be derived from technical specifications of individual components of the system, and stakeholder-defined needs for information products. Once these so-called performance criteria are defined, it becomes possible to establish a quantitative baseline against which improvements or deficiencies in the system can be measured. In the context of the projected utility of the information products and the needs of various stakeholder groups, performance baselining and performance measurement assure stakeholders that their needs are being met, and help to communicate the nature of technical constraints. Such metrics could provide additional justification for further investments and could contribute to operational decisions in both the short- and long-term. If implemented, performance assessments could provide operations and management teams with the knowledge base required to take corrective

action, or to prioritize needed improvements. Thus performance assessments are a component of performance-based system management.

The ANSS as envisaged qualifies as a complex system whose integrated output must meet the needs of a diverse stakeholder base. Thus the relevance to ANSS implementation and management is nearly axiomatic. There is no question that this is recognized by USGS management, by the operators of the regional networks, and by the seismological and earthquake engineering communities at large. It is also recognized by those at the intersection of science and policy who must communicate the efficacy of the system to federal and state budget authorities. It is worth noting that among other related efforts, emergency management communities use performance testing and assessment as a management and training tool.

As was apparent at the July meeting of the NIC, the individual components of the ANSS, including the separate regional networks and the USGS components, are meeting their implementation obligations as technology and resources allow. However, there is one missing element that provides justification for the National Implementation Committee to pursue performance-based assessment, that is, a level of programmatic coordination among the individual components of the system necessary to effect national and regional operational integration. To be sure, there are many successful individual examples of such coordination, including success stories from Nisqually. These examples are exemplary, but in some cases ad hoc. They do not necessarily develop into program or project plans that would effectively direct individual operators of ANSS components. The examples are driven by events, rather than by planning. The examples are also dominantly regional, testifying to the dedication and regional stakeholder networking that some regional networks have been able to muster.

Further, it is important to avoid “mission creep” while developing performance assessment strategies. The mission of the ANSS is clear, and is clearly stated and understood by all involved. Rather, this exercise should be viewed as one leading to the development of new organized activities that reaffirm the mission, implement it, and communicate it to existing and new stakeholders, as well as funding partners. In other words, can we plan programs and projects that develop confidence and capabilities in the integrated aspects of the ANSS mission?

II. Existing Technical Framework

The development of a performance assessment framework should build upon the existing technical guidelines, as detailed in the TIC report, Circular 1188, and other documents. Performance assessment criteria and the programmatic and management strategies for implementing them are intrinsically related to these documents, and therefore should be derived from them. In this section, I summarize these documents with the goal of trying to establish a framework for a system performance assessment.

Briefly, Circular 1188 and OFR 02-92 envisage an ANSS with the following components:

1. National earthquake monitoring

2. Regional earthquake monitoring
3. Urban ground motion and structure monitoring
 - a. Free-field and reference sites
 - b. Building and infrastructure sites
4. Regional and national network operation centers
5. Data management and distribution centers
6. Portable seismograph arrays and networks

Technical guidelines for each of these components have been developed by the TIC and are detailed thoroughly in the TIC report. These guidelines provide a standards-based approach to equipment acquisition, deployment and installation of seismograph or structural-monitoring systems, operations and maintenance at regional and national levels, and the content and quality of information products.

In addition to the technical guidelines, technical performance goals also have been detailed in Circular 1188 and the TIC report. Those that might form the basis of a performance assessment framework are:

1. Uniform coverage of areas not covered by regional networks;
2. Improved space-time resolution of seismicity in areas covered by regional networks;
3. Comprehensive characterization of seismic sources and active tectonic processes in regions of moderate to high seismic hazard and risk (including potentially active volcanoes);
4. Rapid and authoritative notification for emergency response and recovery;
5. Rapid and authoritative notification for other purposes, including media, forensic engineering, national security, and real-time public awareness, stakeholder notification, and educational programs;
6. Collection of free field strong motion data and critical facility observations for resolution of outstanding issues in engineering design practice;
7. Archiving and maintaining availability of data for in-depth studies, and for the needs and requirements of science and engineering research communities;
8. Aftershock survey response capabilities;
9. Capabilities for problem-based “strategic recording” or opportunistic studies.

For the purpose of this discussion, these goals can be characterized as those pertaining to seismograph or other instrument deployments, and those pertaining to the development of data management systems. Specifically, those goals relating to hypocenter determination and source characterization are grouped with the instrument deployments under the assumption that they pertain to functions of a network operations center. This includes the triage processing schemes that refine initial information as more post-event data analysis is completed. With this simplification, the relevance of specific ANSS components to these goals can be summarized in the following tables:

Instrument Deployment and Operating Goals

Goal	National	Regional	Urban free field	Urban structure	Portable
Uniform	Yes	Contributing	No	No	Supporting

coverage	Lead				
Improved resolution	No	Yes Lead	No	No	Contributing
Source characterization	Yes	Yes Lead	Yes	No	Contributing
Rapid notification	Yes	Yes Lead	Yes	Yes	No
Aftershock studies	No	Contributing	Contributing	Contributing	Yes Lead*
Strategic Recording	No	Contributing	Contributing	Contributing	Yes Lead*

*assumes facility deploying portable instruments takes the lead in processing.

Data Management Goals:

Goal	National	Regional	Urban free field	Urban structure	Portable
Providing Engineering data	No	Yes supporting	Yes Shared lead	Yes Shared lead	Yes supporting
Providing Research data	Yes Shared lead	Yes Shared lead	Yes	Yes	Yes

In addition, both 1188 and the TIC Report elucidate goals for information products and services. These include:

1. Immediate availability of information needed for public safety and emergency response;
2. Quantitative support for mitigation and loss reduction research and implementation, including policy discussion;
3. Public education and awareness, and raising awareness within the professional communities concerned with policymaking, planning and design, disaster preparedness, risk management;
4. Education to ensure the long-term availability of seismological expertise for the Nation.

Goal	National	Regional	Urban free field	Urban structure	Portable
Emergency Response	Supporting	Lead	Supporting	Supporting	Supporting
Mitigation	Shared lead	Shared lead	Supporting	Supporting	Supporting
Outreach	Shared lead	Shared lead	Supporting	Supporting	Supporting
Training	Supporting	Lead	Supporting	Supporting	Supporting

These information products and services are further divided into real-time/immediate components and those having greater latency. All components of the ANSS have both near-real-time and latent processing responsibilities, which require coordination.

1. Time-critical information and service:
 - a. Early warning
 - b. Distribution of strong shaking
 - c. Authoritative earthquake information products
 - d. Interactions with state and local emergency service agencies
 - e. Media interactions and public notification
 - f. Private sector notification and interactions
2. Non-time-critical information and service:
 - a. Comprehensive national seismicity catalog
 - b. Improvements in earthquake knowledge
 - i. Characterization of earthquake source zones
 - ii. Contributions to understanding physics of earthquakes, active faults, space-time patterns, rupture processes
 - iii. Source and propagation effects
 - c. Validation and calibration of earthquake loss reduction tools
 - i. Microzonation
 - ii. Liquefaction potential
 - iii. HAZUS calibration
 - d. Training and public education
 - e. FEMA interaction as part of emergency management training
 - f. Improvements in engineering practice
 - i. Site response and site-specific ground motion
 - ii. Structural response and SSI
 - iii. Ancillary measurements of selected structures
 - iv. Time-history of strong motion (strong motion data sets and meta data)

The ANSS management structure, the leadership role of the NEIC, and need for integration with the regional network operators, are described explicitly in Circular 1188. In particular, the management structure posits operational and information-exchange partnerships between NEIC and the regional networks, and between the regional networks and regional stakeholders. The various committees of the ANSS have the responsibility of performing oversight and integrating functions. In particular the National Implementation Committee assumes the responsibility for providing a formal communications structure through which operators of the ANSS components can exchange information and keep each other up-to-date. Thus the NIC is the appropriate body to implement system-wide performance assessments and discuss their use.

In this context, the development of performance assessment criteria, system-wide performance assessments, and the consequent improvements to the ANSS, should become an operational, budgeted element of the NIC charge. Such performance-based management should include the following four components, in an iterative loop:

1. Baseline current ANSS system capabilities through technical tests, scenario studies, and practice exercises, performed by NIC members;
2. Compare baseline performance against goals with input from NIC membership, and representatives of stakeholders, end-users, and USGS management;
3. Develop and prioritize actions to improve or enhance performance baseline;
4. Develop funding for and implement technical programs and projects in response to priorities.

...and loop.

Thus, we have:

Recommendation 1: The charge of the NIC should be expanded to include (1) development of system-wide performance criteria; (2) implementation of performance assessments, and (3) administration of technical tests or technical programs needed to implement performance improvements or enhancements. The NIC should advise ANSS management structure on matters of system performance.

The tables above show that lead/supporting relationships among the ANSS components can be constructed. These relationships can be static or dynamically adaptive, but should govern the design of performance assessment activities by the NIC. Thus:

Recommendation 2: The NIC should develop and implement specific lead/support relationships among the components of the ANSS, for various performance goals.

III. Developing Performance-based assessments

The tables above give a summary of the degree of component interaction and lead/support responsibilities in the ANSS. This discussion requires more detailed input and refinement.

Given this explicit enumeration of goals and standards in the TIC Report and 1188, a performance assessment framework might be developed around the following sets of questions, some of them quite obvious:

1. What is the detection threshold of the ANSS as a function of source location and noise?
2. What is the marginal improvement in detection threshold as a function of regional network or opportunistic deployments?
3. How do variations in the detection threshold affect the development of a comprehensive, homogeneous national seismicity catalog and estimates of its completeness?
4. What is the accuracy of hypocentral determinations?
 - a. Unreviewed
 - b. Reviewed
 - c. Include estimates of depth
5. What is the marginal improvement in accuracy afforded by regional network and opportunistic deployments?

6. How can modern multiple-event location techniques contribute to the accuracy of the catalog?
7. Is there enough ancillary information to assign each event to a known fault? When is it logical or effective to acknowledge occurrence on previously unknown faults?
8. Is the accuracy and completeness of source characterization uniform across the system?
9. Where is source characterization most needed? Where are complete catalogs most needed? Where are strong-motion measurements most needed? Is this a function of risk or seismicity or both?
10. What is the regional variation in data latency?
11. What is the regional variation in processing latency?
12. Is there systematic improvement in information accuracy as a function of time-after-event?
13. Is the information-release triage effectively calibrated by improvements in accuracy?
14. What resolution is provided by existing free-field and reference site strong-motion observations? What improvements in resolution will occur after the new deployments come on-line? How does this compare with needed resolution? (Shakemap study)
15. Are emergency manager prepared to receive information? Do they understand the uncertainties and information triage?
16. Engineering questions tbd.

These questions are a subset of those that arise naturally from the stated goals and objectives. Finding a way to answer these questions will improve the ANSS and lead to a management style that can focus on needed improvements within resource constraints. Thus:

Recommendation 3: The NIC should develop a prioritized list of performance-assessment criteria (related to the questions above), with stakeholder input.

IV. Implementing performance-based assessment.

In section II we noted that performance-based assessment should include four components: (1) Baselineing, (2) Comparison, (3) Prioritizing, and (4) Implementation programs. In this section, I propose a confidence-building exercise and a workshop in order to build performance-assessment skills within the network operations and management communities.

A first step in adopting this approach should include technical exercises to build confidence among and within the NIC while quantifying some useful indicators of system performance. Arguably a good example would be an assessment of earthquake detection threshold within the US. This problem is well understood within the test-ban verification community, which has developed a substantial technical base for assessing network performance on global and regional scales. Thus the fourth recommendation:

Recommendation 4: The NIC should propose to ANSS management that each regional network perform an assessment of detection threshold. Once these are established, the NEIC should collaborate with all of the regional networks to establish a national map of detection threshold.

This can be done with existing software. Doing this exercise would have two results:

1. it would provide a baseline estimate of an essential capability of any earthquake monitoring system;
2. it would provide a mechanism for establishing and exercising inter-network communication and NEIC-network collaboration.

The fourth recommendation is simply an attempt to define a well-constrained project having useful results, that could promote operational integration among the networks and between the networks and the NEIC. More broadly, the actions of the NIC should re-center on developing similar exercises and the resources to implement them:

Recommendation 5: The NIC should hold a performance assessment workshop that would define baseline assessment goals and the exercises needed to quantify them.

V. Developing performance-based management

A desired outcome of these recommendations is the development of a performance-based management system that effectively aids the individual component managers and operators in integrating their efforts. This should be a USGS management function with support from the NIC. This is already occurring in California, and to a certain extent in other active components, but the pathways for the remaining components to follow need to be clarified. I suggest that adopting some form of these recommendations may assist this process.

Acknowledgements: This short note benefited from discussions with and directions from Harley Benz, John Filson, Steve Malone, and Paul Richards. However, the views are my own, and I take responsibility for any misrepresentations.