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The Integration Process for Incorporating Nuclear Explosion Monitoring Research Results into the National Nuclear Security Administration Knowledge Base

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The Integration Process for Incorporating Nuclear Explosion Monitoring Research Results into the National Nuclear Security Administration *Knowledge Base*

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Abstract *follows*

Abstract

The process of developing the National Nuclear Security Administration (*NNSA*) *Knowledge Base*[1] *(KB)* must result in high-quality *Information Products* in order to support activities for monitoring nuclear explosions consistent with United States treaty and testing moratoria monitoring missions. The *validation*, *verification*, and management of the *Information Products* is critical to successful scientific integration, and hence, will enable reliable *deliveries* to be made to the *United States National Data Center* (*USNDC*) at the *Air Force Technical Applications Center (AFTAC)*. As an *Information Product* passes through the steps necessary to become part of a *delivery* to *AFTAC*, *domain experts* (including technical *KB Working Groups* that comprise *NNSA* and *DOE* laboratory staff and the customer) will provide coordination and *validation*, where *validation* is the determination of relevance and scientific quality. *Verification* is the check for completeness and *correctness*, and will be performed by both the *Knowledge Base Integrator* and the *Scientific Integrator* with support from the *Contributor* providing two levels of testing to assure content integrity and performance. The *Information Products* and their contained *research products* will be systematically tracked through the integration portion of their life cycle. The integration process, based on lessons learned during its initial implementations, is presented in this report.

[1] For the reader's convenience, specialized terms used in this document are displayed in italics at each occurrence in the main body of the text. These italicized terms are defined in Section 4.2, Participant *Roles* and Responsibilities, or Section 7.0, Glossary.

Acknowledgements

This document summarizes the integration process developed by many researchers with diverse backgrounds from seismology and computer science to geographic information systems and configuration management. The integration organizations represented are four Department of Energy (*DOE*) National Laboratories: Sandia (*SNL*), Los Alamos (*LANL*), Lawrence Livermore (*LLNL*), and Pacific Northwest (*PNNL*). These organizations are part of the Nuclear Explosion Monitoring Research & Engineering (*NEM R&E*) Program (http://www.nemre.nn.doe.gov/) of the National Nuclear Security Administration's Office of Nonproliferation Research & Engineering (NA-22). The wide array of disciplines represented increases the probability of success for use of these processes and procedures.

Special appreciation goes to the *NEM R&E* participants who developed the previous versions of this document and who participated in numerous process definition meetings and reviews, providing experiences, insight, and suggestions fundamental to building a meaningful process to serve the collective integration needs.

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1.0 Introduction

The National Nuclear Security Administration (*NNSA*) Ground-Based Nuclear Explosion Monitoring Research & Engineering (*GNEM R&E*) program provides research and development in support of United States monitoring missions. Specifically, the *GNEM R&E* program provides products that will be utilized by the *Air Force Technical Applications Center (AFTAC)* in operation of the *United States National Data Center* (*USNDC*), consistent with the responsibilities set forth in the Memorandum of Understanding enacted in May 2001 [see Appendix]. To serve this role, the *GNEM R&E* program tracks and integrates products as they move from the research level to operations and ensures that these products are reliable and technically correct. In doing this the *GNEM R&E* program draws research results from *NNSA* sponsored research as well as research sponsored by others.

To summarize, *NNSA*'s responsibilities include:

- Development of operationally useful products (scientific data and the tools to manipulate them) that support the United States' nuclear explosion monitoring mission at *AFTAC*,
- Integration of technical products developed by *NNSA* and others into a comprehensive and cohesive package (*Knowledge Base*) that can be readily utilized by *AFTAC*,
- Technical assessment, *validation*, and *verification* of all products prior to *delivery* to *AFTAC*, and
- *Delivery* and integration support of the operational *Knowledge Base* to *AFTAC*.

The practical implementation of the development, integration, assessment and *delivery* of operational products occurs through the process of creating periodic *Knowledge Base* (*KB*) releases. Specifically, the *Knowledge Base* is composed of a set of *Information Products (IP)*, which include pertinent *research products* (i.e., data sets and analytical tools). In addition, each *Information Product* also includes critical supporting information (*metadata*) about the *research products*.

During the initial implementations of the *Knowledge Base* Integration Process, a rigorous evaluation was conducted. Through this evaluation, improvements have been proposed. Specifically, improvements identified and added include:

- The use of *Knowledge Base Working Groups* to better address *validation* of *data sets* and *Information Products* and
- More explicit descriptions of how the integration process works for software products and algorithms, and
- A broader definition of *research products* and how they go from the *Contributor* to the *Product Integrator* in their *Scientific Integration* role.

This document provides an update to the integration process based on lessons learned during its initial implementations. In general, this document describes the improved implementation of the *Knowledge Base* development, evaluation, and integration process.

2.0 Scope and Audience

This document summarizes the *NNSA Knowledge Base* integration process for the results of research, regardless of sponsor. It is intended that any interested party will find this document helpful in providing transparency to the integration process and an aid to effective participation in the process.

For those responsible for the hands-on *Knowledge Base* integration, this document serves as a general description of the process and procedures of *Knowledge Base* integration at the *NNSA* and *DOE* laboratories (*LANL*, *LLNL*, *SNL*, and *PNNL)*. In particular, those individuals playing the role of *Knowledge Base Integrator* and for those who interact directly with the *Knowledge Base Integrator* should find this document useful in describing generally, the integration process from beginning to end.

The *Contributor's* role is more fully addressed in the companion document, The National Nuclear Security Administration Knowledge Base Contributor's Guide [Carr, 2003a]. In addition, the *Product Integrator's* role is addressed in another companion document, The National Nuclear Security Administration Knowledge Base Product Integrator's Guide [Carr, 2003b].

From a managerial perspective, this document seeks to provide an overview of the *Knowledge Base* integration process to assist in effective tracking and management of research and development activities. Participants include *Contributors* at *LANL*, *LLNL*, *PNNL*, and *SNL*, universities and private organizations, *Scientific Integrators*, *Knowledge Base Integrators*, decision-making entities such as the *Knowledge Base Integration Board*, and the *Operational Users* (see Section 4.0). Contractual research obligations and their relationship to data products are not addressed here. However, for the *verification* and *validation* of the integrated products, as well as the operational use of the *Knowledge Base*, a mapping from a contract to a data product can be found in the *metadata* provided with each *research product*; hence, a mapping from a contract to an *Information Product* can also be defined. This lineage or ability to trace information to its source is an important attribute of both the integration process and the *Knowledge Base* as an end product.

3.0 *Knowledge Base* Composition

The organizational structure of the *Knowledge Base* is shown as a simplified schematic in Figure 1. The fundamental building blocks of the *Knowledge Base* are referred to as *research products*. A *research product* is a collection of data (e.g., event data, parametric grid data, contextual data, supporting information) and/or associated software tools. Typically, one or more similar or related *research products* are grouped together as an *integrated research product*. *Metadata* accompany each *integrated research product* and describe the content, source, quality and condition of the included *research products*. At the next level up, a combined grouping of *integrated research products* makes up an *Information Product*, which is organized around an *AFTAC* requirement or defined logical theme. As shown in Figure 1, not all *research products* included in a given *integrated research product* necessarily end up in an *Information Product*. An *Information Product* comprises:

- One or more conceptually related *integrated research products*,
- *Metadata* corresponding to each *integrated research product* included, and
- An *Information Product document*, which provides a detailed description of the *Information Product.*

Usually, an *Information Product* is not initially associated with the *KB* or any *KB* successors. Finally, the *Knowledge Base* is composed of several *Information Products*.

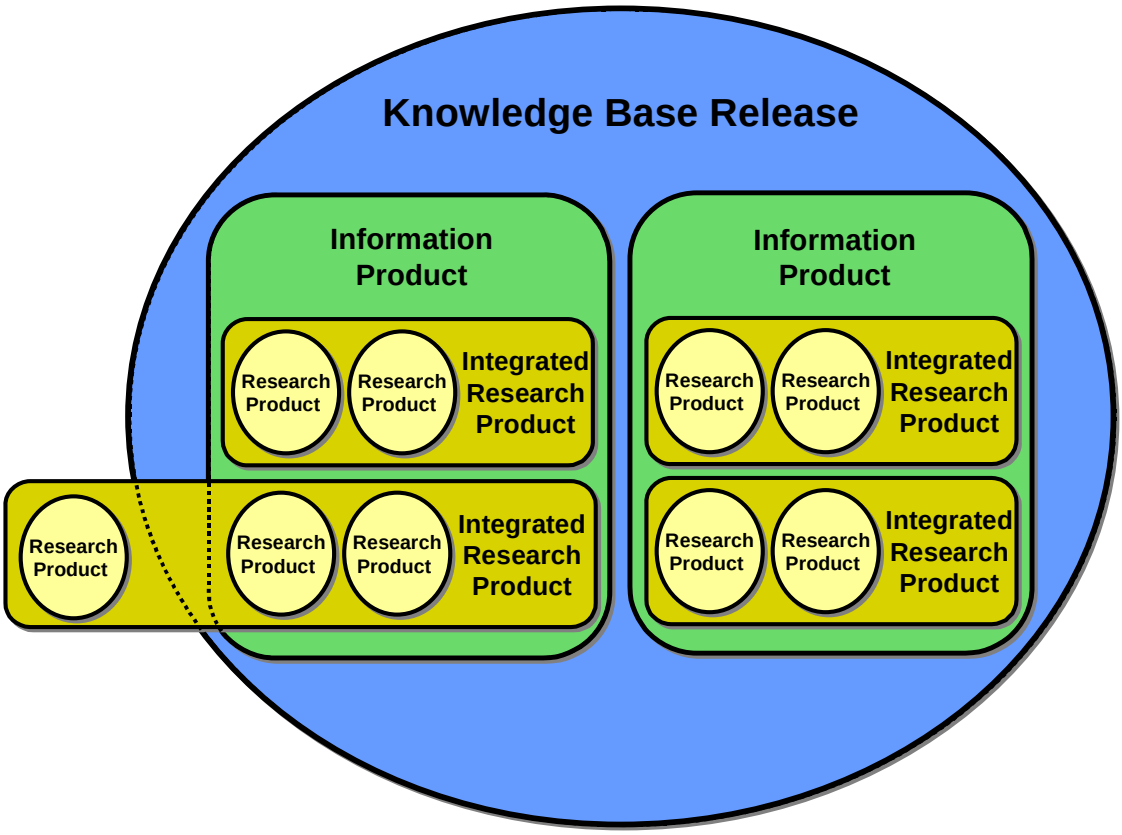

Figure 1 - *Knowledge Base* components

The term *research product* in this document includes basic *data sets* in addition to software research tools. This software is usually designed to provide a method of displaying or applying the information within a *data set*. Such software permits users to examine, validate, and apply the data to solving problems. One example is the geographic information system applications that allow users to view contextual data, event origins, error ellipses, and other geospatial information in a georeferenced (i.e. map) format. Another example would be the MatSeis-based event discrimination tool that allows users to evaluate the relative utility of different discriminant ratios for a *data set* within a given region. This category of software is typically developed by a *Contributor* and is provided with the *data set(s)*. The software is evaluated similarly to the *data sets* and follows the process laid out in this document.

Two other categories of software related to the *KB* also exist: content creation software and operational interface software. These types of software are vital to the function of the *KB*, but the evaluation processes for these categories of software are generally part of their development and are outside the scope of this document. However, their *verification* and *validation* paths are briefly described below.

Content creation software is used by *Contributors* to manage and process initial or raw data into *data sets* for inclusion in an *Information Product*. An example would be the geostatistics software package used to create travel time correction surfaces from the measured event data. Content creation software receives its *verification* and *validation* in an iterative process that includes *AFTAC*'s Seismic Review Panel, *NNSA* and *DOE* technical *reviewer*s, the *Contributors* who develop content, and the software developers.

Operational interface software provides the linkages between the *KB* components and the software components of the *USNDC* system. An example would be the software that allows the locator software in the *USNDC* system to get travel time corrections from the *KB*. Operational interface software is generally developed by the *KB Integrator* and is closely coordinated with the *USNDC* development contractor. The *verification* and *validation* procedures used in the development of the *USNDC* system provide the required evaluation for this software.

As will be described in the following section, *research products*, *integrated research products*, and *Information Products* evolve into a *KB* through the coordination and integration efforts of the *Scientific Integ*rators and the *KB Integrator*.

4.0 Knowledge Base Integration and Evaluation Process

This document delineates a clearly defined integration process and procedures to manage *Information Products* as they migrate from the applied development world toward an *NNSA Knowledge Base* for use by the *Air Force Technical Applications Center (AFTAC)* in their *United States National Data Center* (*USNDC)* operations. The integration process is for both *NNSA* and non-*NNSA* funded contributions. The process will guide the integration of diverse research contributions through a well-defined set of procedures. The *NNSA* is sponsoring the development of the *Knowledge Base (KB),* which will be delivered to the *USNDC* for use in monitoring nuclear explosions consistent with United States nuclear explosion monitoring missions.

To successfully monitor explosive nuclear testing, access to large quantities of detailed technical and contextual information is needed. The smaller, regional distance events expected in the emerging monitoring environment require a significant increase in the amount, type, and detail of information provided to both automated systems and human analysts. The *NNSA*'s *KB* aims to provide this mass of information in a form that is ordered, consistent, easily accessed, well documented, reproducible, accurate and relevant. *Verification* will ensure that it is complete, in the *correct* form, and properly documented. *Validation* will provide assurance that the *Information Products* are appropriate for the *USNDC* mission. *Validation* will also ensure as much accuracy as current scientific information allows. The management and documentation of the *validation* and *verification* of the integrated components of *KB releases* will provide the level of quality required by the *USNDC* mission.

Integration of any kind requires planning. However, even when integration is planned, there can be unforeseen difficulties. The interdependencies among contributions to the *KB* offer a challenge. Facilitating the smooth integration of the research work of many organizations into a *NNSA KB*, while maintaining technical substance in the contributions, is the primary driver for this document. Integration of specific *Information Products* into a *KB release* does not guarantee acceptance by the *USNDC,* which exercises its own review process after receipt of a *NNSA delivery*. However, significant coordination with the *USNDC* is an integral part of the *NNSA* integration process. *KB* integration is the product of the coordination of many organizations.

The integration and evaluation process, shown in Figure 2, illustrates an overview of the flow of potential *KB datasets* and software tools as they migrate step-by-step into a *KB delivery* for *release* to the *Operational Users*. Evaluation by the *Operational User* is ongoing in some form at all steps of the integration process.

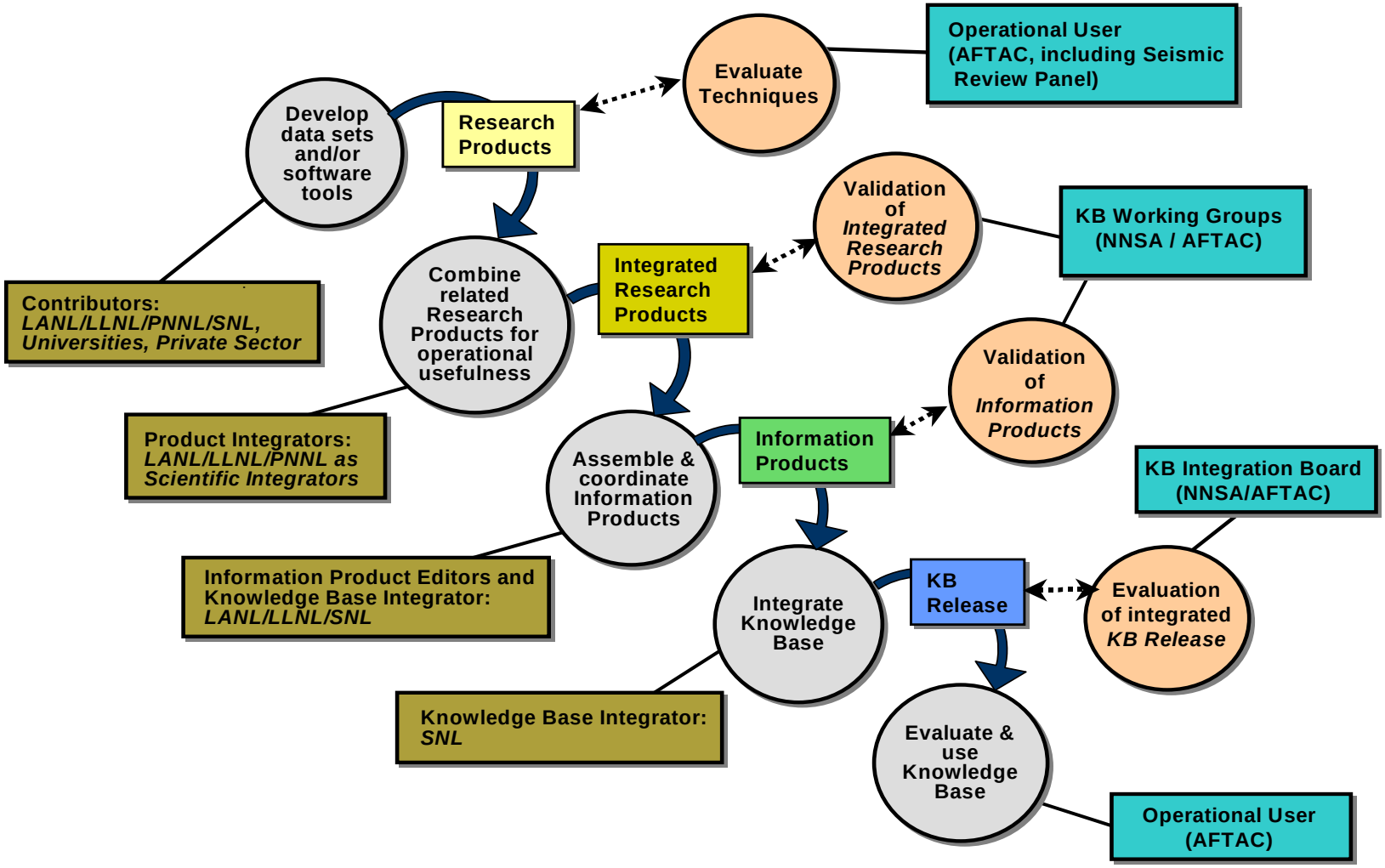

Figure 2 - *Knowledge Base* evaluation and integration process

In Figure 2, the center series of elements, beginning with "Develop data sets and/or software tools," depicts how data, algorithms, and software applications are integrated into *research products*, *integrated research products*, *Information Products*, and finally, into a complete *Knowledge Base Release*. The boxes to the left of this integration series are the specific players who conduct each of the integration steps. The circular elements to the right of the integration series represent the technical evaluation and subsequent *validation* that occurs at each step in the process. The boxes to the far right are the specific players that conduct these evaluations. A key characteristic of this process is that the *operational user* (*AFTAC*/*USNDC*) is involved throughout the integration and evaluation process, from the *validation* of techniques for content development through the evaluation of the integrated *Knowledge Base* release. This is important because the end user is critical in the early-on determination of relevancy and usefulness of any given *research product* or *Information Product*, as well as evaluation of technical accuracy. Another key characteristic of this process is that products (i.e., *research products*, *integrated research products*, *Information Products*, *Knowledge Base*) are verified and validated at each step in the process.

The addition of technical *KB Working Groups* to the integration process has provided not only coordination early on and throughout the process, but has provided an additional component of technical assessment throughout the process. The *KB Working Groups* comprise *NNSA* and *DOE* technical personnel and representatives from *AFTAC*. For a given *Knowledge Base* Release, these *KB Working Groups* will serve the primary functions of *verification*, *validation*, and coordination associated with a specific *Information Product*, which may become part of a *Knowledge Base release*. Generally, the *KB Working Groups* would interact with researchers to provide technical guidance and feedback for the *research product*s that form the basis for *Information Products*.

The *validation* and coordination support, which is provided by the *KB Working Groups*, positions each resulting *Information Product* for review by the *KB Integration Board*. The *KB Working Groups* work with the *IP Editors* and *KB integrator* to verify that the *Information Products* are technically accurate, functionally validated, cohesive and complete.

Following review of the individual *Information Products* by the *KB Working Groups*, the aggregate set of *Information Products* is integrated into a proposed *Knowledge Base* Release and submitted to *KB Integration Board* for review and approval. Once approved, the *Knowledge Base* is delivered to the end user (*AFTAC*) for evaluation, comment, acceptance in whole or part, and finally, implementation. Specific steps along the integration process are described below.

4.1 Summary of Integration Process

There is a specific process through which *research products*, *integrated research products*, and *Information Products* are defined, verified, functionally validated and integrated into the *Knowledge Base*. The steps below provide a brief overview of the process.

4.1.1 Develop Research Product Content

Contributors perform monitoring research and development and create *research products* that

have potential operational use at *AFTAC*. A *Product Integrator* receives a *research product* from a *Contributor*.

4.1.2 Integrated Research Product Proposal and Approval

The *Product Integrator* brings the *research product* from a *Contributor* to the appropriate *KB Working Group*. The *KB Working Group* determines if it should be part of an *integrated research product* and recommends to the *KB Integration Board* that the *integrated research product* be included in the *Knowledge Base*. The objective of the *KB Integration Board* is to ensure that *AFTAC's* needs are addressed, and as such they may reject an *integrated research product* if it does not address an *AFTAC* need.

4.1.3 Integrated Research Product Assembly

Once an *integrated research product* has been approved, the *Product Integrator* executes the plan to build it. The *Product Integrator* may solicit *data sets* or algorithms from the original *Contributor* as part of the plan or may refer the *Contributor* to the NNSA Knowledge Base Contributor's Guide [Carr, 2003a], which guides the *Contributor* through the process of preparing data sets for transfer. For certain types of *data sets*, specific formats are required [see Carr, 2003b], and often the formatting is done by the *Product Integrator* after receiving the *research product* from a *Contributor*.

As part of product assembly, the *Product Integrator* will reformat data or recode algorithms to be compatible with *AFTAC* software. Extensive testing of the finished product follows to ensure proper operational use. The *Product Integrator* creates *integrated research product* documentation, which includes any *metadata*, product installation procedures and tests following *NNSA* templates [see Carr, 2003b].

4.1.4 Information Product Integration and Validation

By a specific deadline, all of the *integrated research products* (content and documentation) must be presented to the *Knowledge Base Integrator* for integration into *Information Products*. The *KB Integrator* checks product contents against documentation and attempt to run installation tests. The *KB Integrator* iterates with *Product Integrators* to resolve any problems encountered.

In parallel with the integration and testing of the content of the *Information Product* at the *KB Integrator*, an *Information Product document* is created by the *Information Product Editor* from component *integrated research product* documents sent to the *KB Integrator* by *Product Integrators*.

4.1.5 Knowledge Base Integration and Testing

Once the *integrated research product* components of the *Information Product* have been put in place and unit-level tested, the proposed *Knowledge* Base is assembled. A graphical interface to the proposed *Knowledge Base* is built using a new NNSA tool known as the *Knowledge Base* Navigator. The Navigator provides a simple “point-and-click” style interface that allows users easy access to the vast holdings of the *Knowledge Base*. *Product Integrators* work with the *KB Integrator* to determine how best to represent their *integrated research product* in the Navigator.

4.1.6 Knowledge Base Integration Board Review/Approval

The *KB Integration Board* reviews individual *integrated research products* and assesses the quality of the proposed *Knowledge Base* as a whole, typically using the Navigator. Problematic products are deferred to a subsequent release or eliminated. The *Integration Board* ensures that products pass all integration cross-checks, that all content has been delivered, and that *validation* testing has been passed. The *Integration Board* also verifies proper integration of product documentation.

4.1.7 Knowledge Base Delivery and Demonstration

The approved *Knowledge Base* is delivered to *AFTAC*. Some re-configuration must be done on-site to account for any system differences between the *NNSA Knowledge Base* test bed at *SNL* and the *AFTAC* target system. Products are re-tested on site at *AFTAC* to ensure that nothing has been broken during delivery. The fully tested system is demonstrated to *AFTAC* by *Product Integrators* who travel to *AFTAC*, lecture on the use of the products and provide hands-on training

4.1.8 AFTAC Evaluation of the Knowledge Base

AFTAC personnel critically evaluate the *Knowledge Base*. Generally *Knowledge Base* calibration products and tools are evaluated on *AFTAC* data to test effectiveness for various monitoring tasks. Performance is the most important criterion, but organization, ease of use, and completeness of *metadata* are factors. Detailed feedback for each *integrated research product*, provided to the *Product Integrators* through a written report to the *KB Integration Board* coupled with discussions at *KB Working Group* meetings, then guides product updates and new product development. Following evaluation, *AFTAC* chooses suitable parts of the *Knowledge Base* for implementation in their *USNDC* processing pipeline.

4.2 Integration Process Participants - Roles & Responsibilities

The *Knowledge Base* integration process participants include *Contributors*, integrators, evaluators and assessors, and coordination personnel. Both *NNSA*-funded and non-*NNSA*-funded *Contributors* begin the integration process with assignment of a *NNSA* lab contact, or *Product Integrator*, who will perform process coordination functions and acts as the interface between the *Contributor* and the rest of the *Knowledge Base* participants (see Carr [2003b]). An *NNSA Product Integrator* is assigned when contracts are awarded and assignments are shown on the Coordination web site (https://www.nemre.nnsa.doe.gov/cgi-bin/prod/coord/index.cgi) on the list of contracts. The flow of information from *Contributors* to *Scientific Integrators* to *KB Integrator* corresponds to integration of products shown in Figures 1 and 2. That is, *Contributors* develop products at the level of the *research products* depicted in Figure 1. *Contributors* then provide these *research products* to a *Product Integrator*, who combines several into an *integrated research product*. The *Product Integrator* provides these *integrated research products* to an *Information Product Editor* who sees that they are compiled or integrated into an *Information Product*. Finally, the *IP Editors* provide the *Information Products* to the *KB Integrator* who combines them into a single *Knowledge Base*.

Before the integration begins, the theme or concept of a given *Information Product* is defined, based on requirements, to ensure that the appropriate *research products* go to the correct *Product Integrator*. It is the *Operational User* who is responsible for providing the general requirements definition, and it is the *KB Working Groups* who conduct requirements analysis and product recommendation. In addition, the *KB Working Groups* provide coordination during *Information Product* development, implementation of specific approaches to address the requirements, technical validation of *Information Products*, and technical issue resolution.

The list of roles below provides definitions of the responsibilities for each of the integration process participants shown in Figure 2.

Contributor

An individual or group of individual creating *research products* for delivery to a *Product Integrator*. A *Contributor* may be from a *NNSA* or DOE laboratory, a university or from the private sector.

Information Product Editor

An individual or group of individuals who edit and compile the *integrated research product* documents from a *KB Working Group* into the *Information Product document* from that *KB Working Group*. The *IP Editor*:

- has a comprehensive understanding of the *Information Product* concept and the *Knowledge Base* concept,
- acts as the single point of contact and final editor for a given *IP document*,
- works with the *KB Integrator* to identify the *KB Working Groups* that will contribute to and *validate* the *Information Product*,
- oversees the incorporation of *integrated research products* into an *Information Product*,
- resolves *KB Working Group* comments on draft *IP documents* prior to delivery to the *KB Integrator*.

KB Integration Board (IB)

The *KB Integration Board (IB)* is permanently composed of a program leader from each contributing laboratory, the *NNSA* sponsor, and a technical representative from the *KB operational user*. The *IB* will review a collection of *Information Products* being proposed for inclusion in a *KB release* based on the *Information Product documents*. The program leaders may choose other technical representatives to aid in evaluating the *Information Products*. This group will be as small as possible in order to remain focused and functional. The *Scientific Integrator* being the most knowledgeable of the domain will present *validation* information to the *IB*, if needed. The *KB Integrator* may present *verification* information or status reports to the *IB*, if needed. The *IB*:

- reviews the contents of a *KB release*,
- is advised by the *KB Working Groups'* reports,
- is informed by the *Information Product documents*,
- is advised by the *KB Integrator* regarding *Information Product* readiness,
- is advised by the *KB Integrator's KB release* document,

- provides assessment of release readiness to the *KB Integrator*.

The *IB* acts as a *reviewer*, as defined in Section 7.0, Glossary. The *KB Integration Board* interfaces with the *Scientific Integrators* and the *KB Integrator*.

KB Integrator

Individuals who combine the integrated research products into the *KB release*. *SNL* acts as the *KB Integrator*. The *KB Integrator*:

- reviews the Files and Installation Testing Procedure sections from the *integrated research product document*,
- receives the *integrated research product deliveries*,
- *verifies* that the *integrated research product* was successfully transferred to the *KB Integrator* by comparing what was received to the Files section of the *integrated product research documentation*,
- *validates* the stand-alone *integrated research product* by following the Installation Testing Procedures from the *integrated research product document*,
- integrates the *integrated research products* into the KB,
- re-*validates* the *integrated research products* once they have been integrated into the *KB* using the same Installation Testing Procedures as before,
- oversees the *IP Editor* in compiling the *Information Product documents*,
- organizes review of *KB releases* by the *IB*,
- prepares the *KB release document* for review by the *IB*,
- test *KB releases* as a system using the KB Navigator, and
- delivers *KB releases* to the *operational user*.

The *KB Integrator* interfaces with the *IP Editors*, the *KB Integration Board*, and the *Operational User*.

KB Working Group

A group of topically-related technical experts (i.e., domain experts), developers, and users, who provide coordination for *research products*, *integrated research products* and an *Information Product*. The *KB Working Group* provides integration, and technical *validation* prior to *KB Integration Board* review. *KB Working Groups* are *Scientific Integrators*.

The *KB Working Groups* specifically have the following tasks:

- identify outstanding technical issues, assign some level of priority to those issues, and develop strategies and technically sound methodologies for addressing these issues
- provide guidance on *Information Product* definition through requirements analysis
- validate the use of a specific methodologies for developing *research products* within a given *Information Product*
- assist in the requirements definition for *research products*
- *validate* site-specific models and the data created through implementation of those models
- assess and report on the quality of any empirical data to be delivered or used
- assess and report on the operational usefulness of tools and *data sets*, which may

include some *validation* of analytical and content creation software products
- provide technical feedback and recommendations to researchers
- conduct technical *validation* of completed *Information Products* for a given *KB Release*,
- provide advice to the *KB Integration Board* regarding readiness of *Information Products*, and
- assist with *metadata* preparation, including lineage-to-source information.

The *KB Working Groups* can act as a *Contributor*, *Scientific Integrator*, and a *reviewer* (as defined in Section 7.0, Glossary). Members of the *KB Working Groups* interface with *Product Integrators*, *IP Editors*, and *KB Integration Board*.

Operational User

Customers/users who employ the *Knowledge Base* in an operational setting. The *Operational User* to whom the Knowledge Base is delivered is the *Air Force Technical Applications Center (AFTAC)*. As the KB user, *AFTAC* brings considerable expertise to the interpretation process; for example, operational experience and the expert advice of the *AFTAC* Seismic Review Panel. Specifically, the Operational User:

- provides general requirements for *Knowledge Base* development and use
- participates in the *KB Working Group* activities
- participates in *KB Integration Board* assessments and determinations, and
- independently assess *Knowledge Base* deliveries and provides comments and recommendations to the *KB Integrator*.

Product Integrator

A scientist assigned by the *NNSA* to be responsible for coordinating with specific research and development contractors, particularly those not funded by *NNSA*. The *Product Integrator's* responsibility is to determine whether the contractor's results and products could or should be considered for incorporation into the *Knowledge Base* and to facilitate transfer of the information through the *KB Working Group* to the *KB Integrator*. A Product Integrator is a *Scientific Integrator*.

The *Product Integrator*:

- has a good overall understanding of the *Knowledge Base* - its structure, content and use,
- works within the scope of the contract as negotiated by the *Contributor* and the funding agency,
- obtains published reports from the contract and talks to the *Contributor* informally, for example, at scientific meetings
- has a clear understanding of what part of the results of the contract, if any, should be integrated into the *KB*,
- receives raw data (as a data set or research product) from a *Contributor*, *verifies* and *validates* it,
- if appropriate, works with the *Contributor* to create *metadata* for eventual use in the *KB*,
- takes research products from *Contributors* and creates an *integrated research product* with its associated *integrated research product document*,

- maintains current summary information about the contract on the *NNSA* Coordination web page (https://www.nemre.nnsa.doe.gov/cgi-bin/prod/coord/index.cgi),
- ensures that the contract's results are properly integrated into the *KB*,
- provides notification of upcoming product integration meetings to GNEM R&E management and follows up with documentation of the results of those meetings, and
- is a member of a *KB Working Group*.

Product Integrators are *Scientific Integrators*. *Product Integrators* interface with *Contributors*, other members of the *KB Working Groups* and *IP Editors*.

Scientific Integrator

The scientists at the *NNSA* and *DOE* laboratories engaged in GNEM R&E (*LLNL*, *LANL*, *SNL*, and *PNNL*) are *Scientific Integrators*. *Scientific Integrators* integrate the results of individual *Contributors* from inside and outside *NNSA*, and develop individual science contributions as appropriate to fill gaps and enhance other efforts. Furthermore, the *Scientific Integrator* performs enabling research to allow the customer to meet operational requirements. *Scientific Integrators* act as *Product Integrators*, *KB Coordinator*, and are *KB Working Group* members.

5.0 Classification Guide Interpretation

Classification guides relevant to the U.S. ground-based nuclear explosion monitoring program were interpreted by several experts, and the following working-level diagram resulted. The diagram addresses the integration of unclassified information with information from National Technical Means of verification.

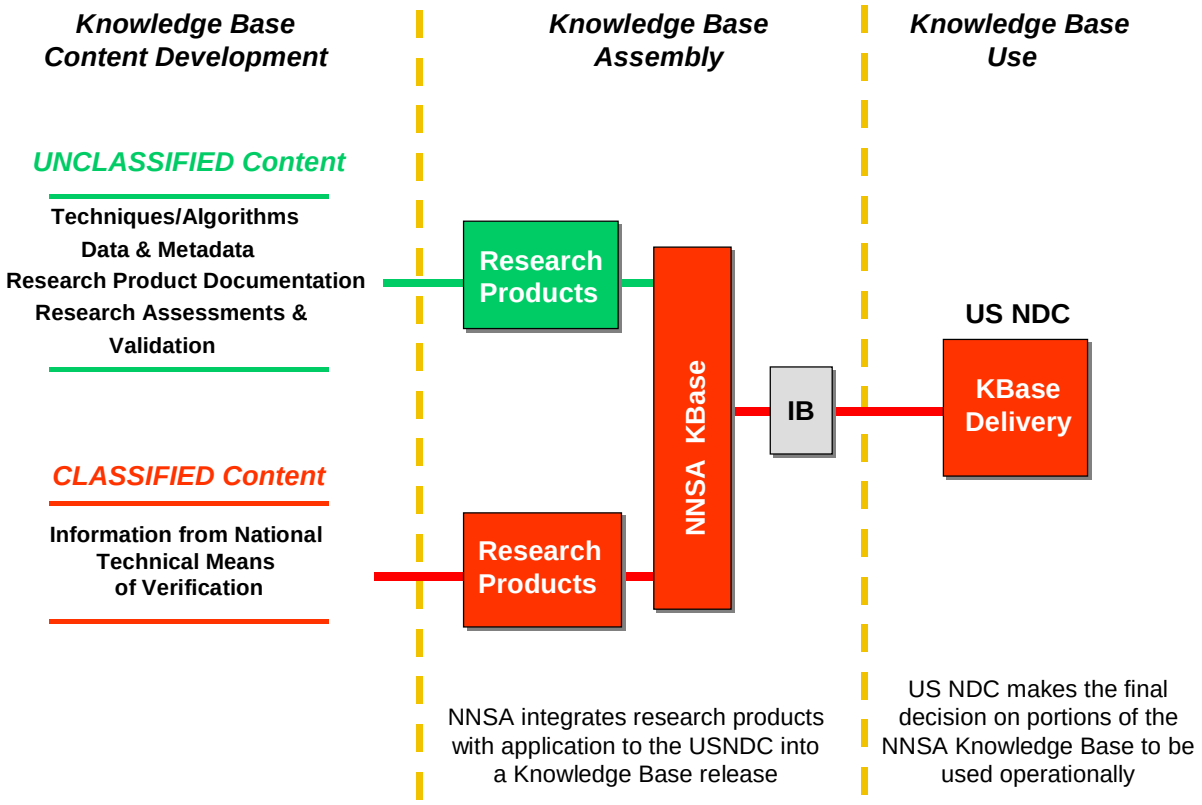

Figure 3 - Classification Guide interpretation

As discussed in Section 4, several *research product*s will be integrated into a preliminary *KB release*, for *KB Integration Board* approval. The unclassified products and classified products are tracked independently before being integrated into a final *NNSA Knowledge Base*. The tracking of unclassified and classified *research products* is done on a restricted network and a secure classified local area network, respectively. *Information Products* are integrated into a *KB* on the secure classified local area network. All or part of a *KB* may become operational after final selection by the *NNSA KB Integration Board* and subsequent selection by the *USNDC.*

6.0 Summary

This report outlines a process to facilitate the formation of reliable and useable *KB releases*. Both *validation* and *verification* are performed in the context of this process to ensure that the *research products* delivered to the *USNDC* and are useable, accurate, relevant, and reliable. A protocol is established to assure that all parts of the process are completed. This process forms a shell within which *verification* and *validation* are performed.

The process of integrating *research products* into a *KB* may be complicated more by the number of entities and organizations involved than by the actual tasks being performed. Either way, the intent of this document is to define a common process and a common interface for the participants in *KB* development. It is also intended to allow flexibility to suit changing needs.

This process will continue to be refined through practical application and insightful suggestions in order to meet certain objectives and to more efficiently perform our work. These objectives include providing ordered, consistent, easily accessed, well documented, and relevant *KB* development through *verification*, *validation* and management of *research products*, *integrated research products* and *Information Products*.

7.0 Glossary

AFTAC
Air Force Technical Applications Center.

Air Force Technical Applications Center (AFTAC)
The *Operational User* of the *Knowledge Base* and operator of the *USNDC*.

correct
An *IP* is considered *correct* when it has been tested successfully against specifications included in the *IP document* and with any test software submitted by the *KB Coordinator* (Section 4.2). The quality of test software delivered is not assessed, nor is any aspect of the data which have not been specified in a testable manner in the *release document* or *metadata*.

data set
A *data set* is a collection of data usually all of the same kind. The four broad categories of *data sets* are event data, parametric grid data, contextual data, and supporting information. A *data set* is a *research product*.

delivery
A transfer of a *research product*, an *Information Product* or *KB*.

DOE
United States Department of Energy.

domain expert
Individual with extensive knowledge about a particular *research product* or *Information Product* and its applications. A *domain expert* is a *Contributor*. See also, *Principal Investigator* (Section 4.0). The *domain expert* provides expert opinion about *research products*.

Information Product (IP)
One or more *integrated research products* with corresponding *metadata* and documentation, which is organized around *AFTAC* requirements or a defined logical theme. There is a one-to-one correspondence between *Information Products* and *KB Working Groups*.

Information Product document
A document generated by the *IP Editor* under the oversight of the *KB Integrator*. This document contains three sections. The first section is an overview that defines the purpose of the *IP*, lists the integrated research products in the IP and states what is new in the version of the *IP*. The second section contains the *integrated research product* documentation for all the integrated research products in the *IP*. The contents of the draft *IP document* are defined in the KB Contributor's Guide [Carr, 2000a].

integrated research product
A collection of one or more related *research product*s put together by a *Product Integrator*.

Each *integrated research product* must have corresponding *metadata*. Several *integrated research products* go into a single *Information Product*.

IP

See *Information Product*.

Knowledge Base (KB)

An *NNSA*-sponsored integrated, organized collection of *integrated research products* and *Information Products* used for automated regionalization and analyst efforts delivered to the *USNDC*.

KB

See *Knowledge Base*.

KB release

A product consisting of a group of *Information Products* that has been *verified* and *validated* as an integrated *delivery* to the *operational user* at a given time.

KB release document

A document generated by the *KB Integrator* (Section 4.0) containing product identification, list of *Information Products*, goals and purpose, specifications, analysis results, and a *delivery* schedule.

LANL

Los Alamos National Laboratory, a *NNSA* laboratory.

LLNL

Lawrence Livermore National Laboratory, a *NNSA* laboratory.

metadata

Information that describe the content, quality, condition, and other characteristics of data, especially geospatial data. The standards for *metadata* for the *Knowledge Base* are based on the "Content Standard for Digital Geospatial Metadata," (http://www.fgdc.gov/metadata/contstan.html)

NEM R&E

Nuclear Explosion Monitoring Research and Engineering

NNSA

National Nuclear Security Administration (http://www.nnsa.doe.gov), a semi-autonomous part of DOE.

PNNL

Pacific Northwest National Laboratory, a DOE laboratory.

release

A release is a product with corresponding data, software, *metadata*, documentation, and supporting information that is delivered from one entity to another. A release is reproducible. A release in the context of this document refers *KB* products as delivered from the *KB Integrator* to the *USNDC*.

release document

A document accompanying delivery of each *Knowledge Base release* containing product identification, product changes from prior versions, a list of elements, a *delivery* schedule and installation instructions. Also included are specific descriptions for each element. Elements specified may be *research products*, *integrated research product*s, or *Information Products*.

research product

A product of contracted research. A *research product* consists of one or more *data sets* and/or associated software. Typically, several *research products* go into a single *integrated research product.*

reviewer

An individual or group of individuals with knowledge of the domain, who provide evaluation and assessment of a particular product.

SNL

Sandia National Laboratories, a *NNSA* laboratory.

United States National Data Center (USNDC)

The *United States National Data Center* (http://www.tt.aftac.gov) operated by the *Air Force Technical Applications Center* at Patrick Air Force Base in Florida receives *NNSA KB deliveries*. Technical representatives of the *USNDC* provide *validation* of the *Information Products* and their *KB release*s. The *USNDC* makes independent decisions about adoption of all or part of *NNSA KB release*s.

USNDC

See *United States National Data Center*.

validation

Evaluation of the appropriateness of a product (*research product, integrated research product, or Information Product*) for inclusion in the *KB*. *Validation* of a product includes assuring relevance to the *USNDC* goals, as well as, scientific quality.

verification

The process of checking that the data delivered are installable, formatted properly, *correct*, complete, and concise. (A product which is concise includes only the relevant parts; no extraneous files.) *Verification* includes verifying that the data values meet the specifications provided in the *metadata*.

8.0 References

Carr, D. (2003a), National Nuclear Security Administration Knowledge Base Contributor's Guide, Sandia National Laboratories, Report No. SAND2002-2771, Albuquerque, NM. (also available from https://www.nemre.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Knowledge+Base)

Carr, D. (2003b), National Nuclear Security Administration Knowledge Base Product Integrator's Guide, Sandia National Laboratories, Report No. SAND2004-0809P, Albuquerque, NM. (also available from https://www.nemre.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Knowledge+Base)

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Appendix

Memorandum of Understanding (MOU) amongst Air Force Technical Applications Center (AFTAC) and United States Geological Survey (USGS) and National Nuclear Security Agency (NNSA), signed August 16, 2005.

MEMORANDUM OF UNDERSTANDING
AMONGST
AIR FORCE TECHNICAL APPLICATIONS CENTER (AFTAC)
AND THE
UNITED STATES GEOLOGICAL SURVEY (USGS)
AND THE
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)
REGARDING NUCLEAR EXPLOSION MONITORING
AND RELATED MATTERS

1. Purpose: This Memorandum of Understanding (MOU) formalizes the functions and responsibilities of the Air Force Technical Applications Center (AFTAC), the United States Geological Survey (USGS) and the National Nuclear Security Administration (NNSA), herein sometimes collectively referred to as "Parties" in regard to support for nuclear explosion monitoring and the operation of the U.S. National Data Center (US NDC). This understanding is founded on long-standing, cooperative, working relationships amongst these Parties.

2. Authority: This MOU supersedes the version of 9 May 2001, and complements the following documents that address other aspects of nuclear explosion monitoring:

a. U.S. Nuclear Detonation System (USNDS)–U.S. Air Force (USAF)/DOE MOU, dated January 8, 1997
b. Concerning Cooperation on Matters Pertaining to the Comprehensive Nuclear- Test-Ban Treaty (CTBT)-Department of Defense (DoD)/USGS MOU, dated September 16, 1997
c. DoDI 4000.19, Interservice and Intragovernmental Support, August 9, 1995
d. AFI 25-201, Support Agreement Procedures, May 1, 1996

3. General:

a. Background.

The United States Air Force has long held missions to monitor arms control treaty compliance. AFTAC is responsible for operating and maintaining the United States Atomic Energy Detection System (USAEDS), which provides monitoring for the Limited Test Ban Treaty (LTBT) and the Threshold Test Ban Treaty (TTBT). In an effort to curtail the proliferation of nuclear weapons, AFTAC has undertaken an aggressive program to enhance the capabilities of USAEDS. AFTAC will utilize the full resources of the USAEDS to meet the requirements of the U.S. national policy community for nuclear explosion monitoring and in support of the purpose of this MOU.

The USGS is responsible under the Stafford Act (P.L. 93-288) for reporting earthquakes through the National Earthquake Hazards Reduction Program and for the Global Seismograph Network Program for the monitoring of national and worldwide seismicity and reporting to state, national and international emergency response agencies, and to other interests including the media and the general public. To the extent possible and within its primary responsibilities, the USGS is prepared to employ its national and worldwide seismic monitoring activities to cooperate with other national interests involved in nuclear explosion monitoring, and to apply its other capabilities in related efforts in support of the purpose of this MOU.

The NNSA, through its nuclear weapons laboratories and other Department of Energy laboratories, has broad capabilities and in-depth technical expertise in nuclear phenomenology, nuclear monitoring technologies, and systems engineering and integration. The NNSA's Nuclear Explosion Monitoring Research and Engineering program has a proven record of delivery of integrated state-of-the-art engineered systems to Air Force users for nuclear explosion monitoring. These capabilities are offered to support the purpose of this MOU.

b. Points of Contact

AFTAC/US NDC

Dr. David R. Russell, Director for Nuclear Treaty Monitoring, Air Force Technical Applications Center/TT, 1030 S. Highway AlA, Patrick AFB FL 32925-3002, phone 321-494-2356, fax 321-494-2274, dave@aftac.gov, http://www.tt.aftac.gov.

USGS

Dr. David Applegate, Senior Science Advisor for Earthquake and Geologic Hazards, U.S Geological Survey M/S 905, 12201 Sunrise Valley Dr., Reston VA 20192, phone 703-648-6714, fax 703-648-6717, email applegate@usgs.gov, http://earthquake.usgs.gov.

NNSA

Ms. Leslie A. Casey, Manager of Ground-Based Systems, Nuclear Explosion Monitoring Research and Engineering Program, National Nuclear Security Administration /NA-22, 1000 Independence Avenue, SW, Washington, DC 20585, phone 202-586-2151, fax 202-586-0485, leslie.casey@nnsa.doe.gov , https://www.nemre.nnsa.doe.gov .

4. Responsibilities: This MOU expresses the intention of the Parties to apply their unique resources to a shared goal of improved national security through global monitoring and to collaborate to maximize the effectiveness of existing budgets. The following lists outline the main functions of each organization supporting national security goals related to nuclear explosion monitoring, as well as the development and operation of the US NDC.

a. AFTAC will:

(1) Implement monitoring of current nuclear test limitation treaties (e.g., LTBT, TTBT), moratoria, and agreements.
(2) Support the development and execution of U.S. Government policy with respect to nuclear testing treaties, moratoria and agreements.
(3) Operate and maintain the USAEDS to meet U.S. national requirements.
(4) Operate and maintain the US NDC headquartered at Patrick AFB, in Florida, and the Alternate National Data Center at Goodfellow AFB, in Texas.
(5) Coordinate with USGS in the operation of the Extended National Data Center at USGS' National Earthquake Information Center (NEIC) in Golden, Colorado.
(6) Provide all International Monitoring System (IMS) data and AFTAC non-sensitive unclassified data of interest to USGS to support its mission. Release of AFTAC non-sensitive unclassified data, except IMS Data, requires approval of host country.

(7) Cooperate with USGS and NNSA in the advancement of techniques to improve seismic monitoring and notification, including support to the US NDC.
(8) Provide test beds for evaluating research products and facilitating their transition to the operational USAEDS and US NDC.

b. USGS will:
(1) Host and operate the Extended National Data Center at the USGS' NEIC in Golden, Colorado.
(2) Provide communications connectivity between the US NDC and NEIC.
(3) Adhere to policy provisions provided by AFTAC for distribution of IMS and AFTAC data to other government and research organizations, relying on AFTAC and the CTBT Organization's International Data Center for archival and distribution of USAEDS and IMS data, respectively.
(4) Provide IMS data of interest to the National Oceanic and Atmospheric Administration's Pacific and West Coast & Alaska Tsunami Warning Centers, with external support, and as appropriate given (b.3) above.
(5) Provide to interested parties information collected within its normal mission, on seismic events occurring within the U.S. and worldwide.
(6) Continue reporting on seismic events not related to earthquake hazards, such as mining explosions, with external support.
(7) Cooperate with AFTAC and NNSA in the advancement of techniques to improve seismic monitoring and notification, including support to the US NDC.
(8) Contribute geological expertise and appropriate products to the development of the NNSA knowledge base, with external support.
(9) Provide research, data and analysis products supporting nuclear explosion monitoring, with external support.

c. NNSA will:
(1) Maintain a comprehensive research, development and engineering program (i.e., the Nuclear Explosion Monitoring Research and Engineering Program) to continuously improve U.S. monitoring capabilities to meet U.S. national requirements.
(2) Deliver focused, applied research and engineering products, including an integrated knowledge base, to AFTAC, with appropriate testing, demonstration and technical support, for the US NDC and USAEDS operational systems.
(3) Integrate validated research products into the operational test beds at AFTAC.
(4) Provide the USGS information about seismic events at NNSA facilities, in advance when possible and particularly for those at the Nevada Test Site, to aid nuclear treaty verification and compliance and to assist USGS in providing accurate and timely information to its customers.
(5) Cooperate with AFTAC and USGS in the advancement of techniques to improve seismic monitoring and notification, including support to the US NDC.

5. Funding

This MOU is not a basis for the commitment, obligation or transfer of funds. Specific funding and tasking will be implemented through separate agreements or other documents.

6. Agreement and Administration

This MOU shall become effective upon the latest date of signature of the Parties, and shall remain effective for an initial period of 5 years unless modified or extended before then by written agreement of the Parties. This MOU will be reviewed every 5 years to determine if updating is desired. The Parties may jointly terminate this MOU at any time by mutual agreement or any Party may unilaterally terminate its participation in this MOU upon 6-months' written notice to the other parties.

Approved:

Dr. David R. Russell Director, Nuclear Treaty Monitoring Air Force Technical Applications Center	Dr. Linda Gundersen Acting Assoc. Director for Geology United States Geological Survey	Dr. T. Jan Cerveny Assistant Deputy Administrator Nonproliferation Research & Engineering, National Nuclear Security Administration
(date) 25 JULY 2005	(date) 16 August 2005	(date) 8 Aug 2005

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