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The Integration Process Design for Incorporating Information Products 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 high-quality *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* 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 *data sets* will be systematically tracked through the integration portion of their life cycle. Moore *et al*. [2000] provides a summary of the integration process as it was implemented through the year 2000. Updates to that integration process based on lessons learned during its initial implementations are presented in this report.

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[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 4.1, Participant *Roles* and Responsibilities, or Section 8.0, Glossary.

Acknowledgements

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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, *NNSA* must develop, track, and integrate products as they move from the research level to operations, and must ensure that these products are reliable and technically *correct*.

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 generally include pertinent *data sets* and analytical tools.   In addition, each *Information Product* also includes critical supporting information (*metadata*) about the *data sets* and tools.

If any process is to retain its effectiveness, it must be continuously assessed and improved whenever possible.   During the initial implementation of the *Knowledge Base* Integration Process, a rigorous evaluation was conducted.   Through this evaluation, improvements have been proposed.   Specifically, two improvements were identified and have been added:
- 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.

Moore *et al.* [2000] provides a summary of the integration process as it was implemented through the year 2000.   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.

As most of the process has not changed, many portions of this document reiterate those found in Moore *et al.* [2000].

2.0   Scopes and Audience

This document summarizes the *NNSA Knowledge Base* integration process. 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. This document does not provide details of responsibilities of the *Knowledge Base Integrator* (see Moore *et al*. [2000] for these details).

For those responsible for the hands-on *Knowledge Base* integration, this document serves as a description of the process and procedures of *Knowledge Base* integration at the *NNSA* laboratories (*LANL*, *LLNL*, *SNL*). 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.

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 *data set*; 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 *data sets.* A *data set* is a collection of data and associated tools, usually all of the same kind (e.g., event data, contextual data, parametric grid data). *Metadata* accompany each *data set* and describe the content, source, quality and condition of the *data set*. At the next level up, a combined grouping of *data sets* makes up an *Information Product*, which is organized around a defined logical theme. An *Information Product* comprises:

- One or more conceptually related *data sets* and/or tools
- *Metadata* corresponding to each *data set*
- 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.*
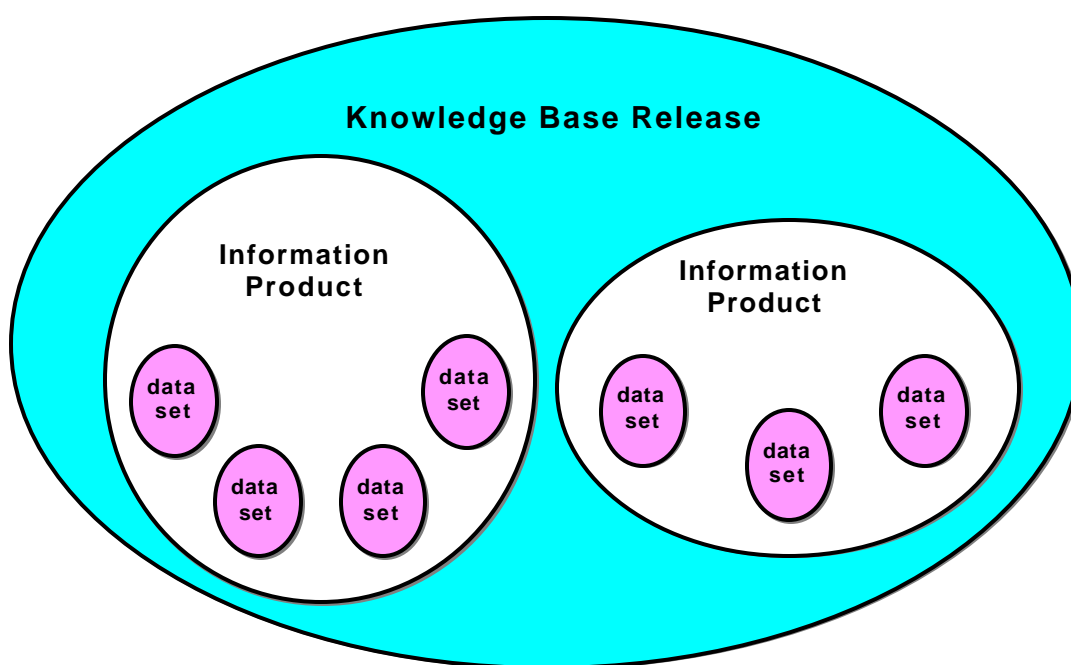
Figure 1 - *Knowledge Base* **components**

The term *data sets* in this document includes software in addition to or instead of basic data. 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 discrimtool 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 included as part of a *data set* is evaluated similarly to the other components of a *data set* 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 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 Kriging software 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* technical *reviewer*s, the *Content Developers*, 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 libCGI 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, *Data sets* and *Information Products* evolve into a *KB* through the coordination and integration efforts of the *Scientific Integ*rators and the *KB Integrator*.

4.0   Integration Process Participants

The participants in the *Knowledge Base* integration process are shown in Figure 2. The *KB* integration process participants include *Contributors* (i.e., *Content Developers*, *Principal Investigators*), integrators, 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. A *NNSA Product Integrator* is assigned by contacting: Leslie Casey, *National Nuclear Security Administration* (NA-22), at (202) 586-2151, leslie.casey@hq.doe.gov.   The flow of information from *Contributors* to *Scientific Integrators* to *KB Integrator* corresponds to integration of products shown in Figure 1. That is, *Principal Investigators* develop products at the level of the *data sets* depicted in Figure 1. *Principal Investigators* then contribute these *data sets* to a *Product Integrator*.   The *Product Integrator* provides these data sets to an *Information Product Coordinator* who sees that they are compiled or integrated into an *Information Product*. The *KB Coordinator* then works with the *Information Product Coordinators* and the *KB Integrator* to combine the *Information Products* together 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 *data sets* 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.

A general overview of the responsibilities of the integration process participants is provided here. Details are provided in the section that follows (Participant *Roles* and Responsibilities).   The *Product Integrator* delivers the *data sets* received from *Contributors* to an *Information Product Coordinator*, who is responsible for ensuring that the *Information Product* is integrated into a complete and cohesive package. In addition, the *Information Product Coordinator* is responsible for ensuring that all issues are resolved prior to delivery of their assigned *Information Product* to the *Knowledge Base Integrator*. A *Knowledge Base Coordinator* acts as the single point of contact for an *NNSA* laboratory to the *Knowledge Base Integrator*; as such, the *Knowledge Base Coordinator* typically has oversight of several *Information Products* and works to ensure consistency across *Information Products*, working closely with the *Information Product Coordinators*. The *Knowledge Base Coordinator* also works with the *KB Working Groups* to complete technical *validation* and *verification* of *Information Products* prior to their evaluation by the *KB Integration Board* and integration into the *Knowledge Base*. Finally, the integrated *Knowledge Base* is evaluated and validated by the *KB Integration Board* prior to being delivered to the *Operational Users*.
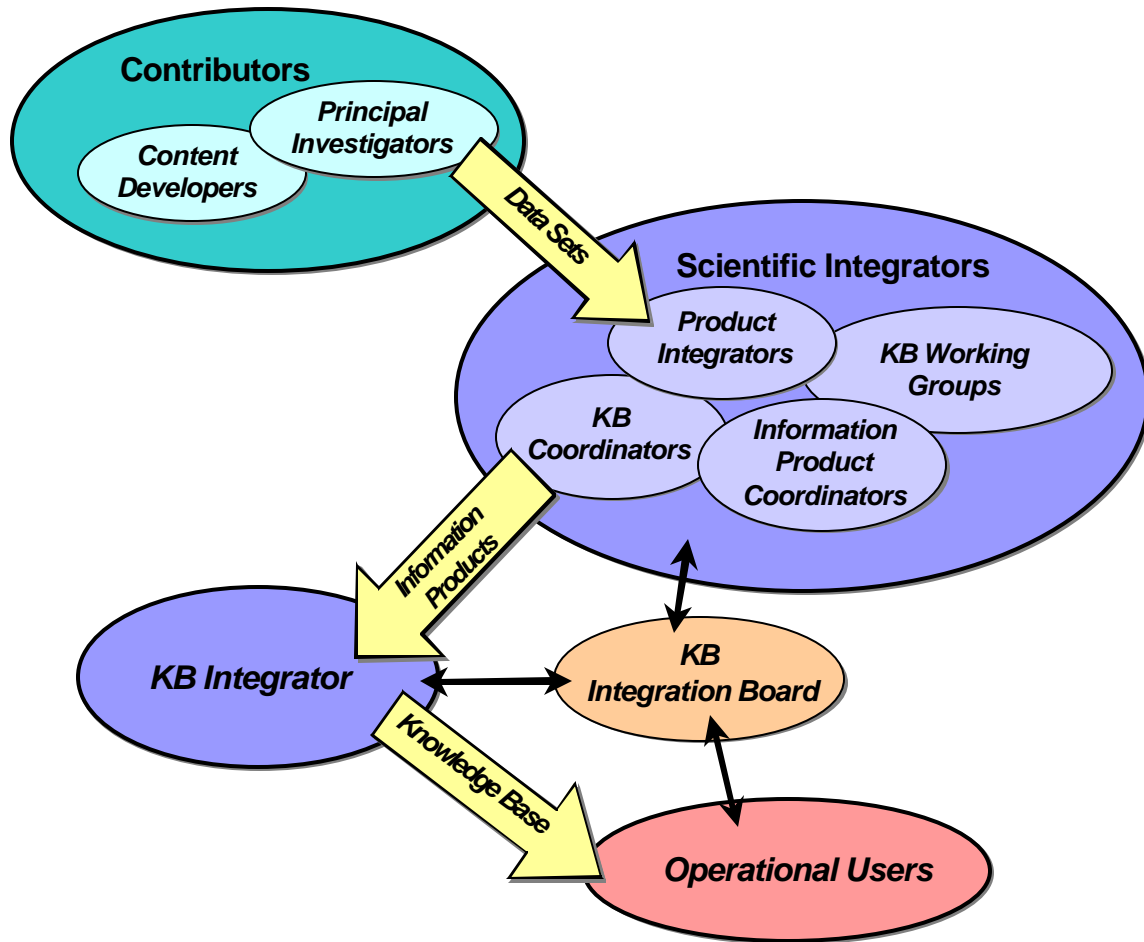
Figure 2 - *KB* **integration process participants and flow of information**

Participant *Role*s & Responsibilities

The list below provides definitions for the *role*s and responsibilities for each of the integration process participants shown in Figure 2.

Content Developer
> One who creates or collects raw or unprocessed data and processes it for research and development purposes. The *Content Developer* passes this work on to a *Principal Investigator* or *Product Integrator*. A *Content Developer* is a *Contributor*.

Contributor
> A group of individuals gathering *data sets* and incorporating them into *Information Products* for *delivery* to a *Product Integrator*. A *Contributor* may be from a *NNSA* laboratory, a university or from the private sector. *Contributors* include *Content Developers* and *Principal Investigators*.

Information Product Coordinator (IP Coordinator)

An individual responsible for the oversight and development of a specific *Information Product* proposed for inclusion in a *KB release*. The *IP Coordinator* works closely with the *KB Coordinators* to assemble the *Information Products*. Entities that fill this role include *Scientific Integrators* at the *NNSA* laboratories (*LANL, LLNL, PNNL* and *SNL*). The *IP Coordinator*:

- has a comprehensive understanding of the *Information Product* concept and the *Knowledge Base* concept,
- manages the development of a given *Information Product*,
- acts as the single point of contact and final editor for a given *IP document*,
- works with the *KB Coordinator* to identify the *KB Working Groups* that will contribute to and *validate* the *Information Product*,
- oversees the incorporation of *data sets* into an *Information Product*,
- resolves *KB Working Group* comments on draft *IP documents* prior to delivery to the *KB Integrator*,
- ensures that all issues associated with a draft *IP document* are resolved prior to the *IP Document's* submittal to the *KB Integration Board* for evaluation,

The *IP Coordinator* is a *Scientific Integrator*. The *IP Coordinator* interfaces with *Product Integrators*, *KB Working Groups*, and a *KB Coordinator*.

KB Coordinator

An individual or group responsible for the oversight and integration of *data sets* into *Information Product deliveries* for potential *KB* population. The *KB Coordinator* works closely with and provides *Information Products* to the *KB Integrator*. Entities that fill this role include *Scientific Integrators* at the *NNSA* laboratories (*LANL*, *LLNL*, *PNNL* and *SNL*). The *KB Coordinator*:

- has a comprehensive understanding of the overall *Knowledge Base* concept,
- creates a concept for an *Information Product* in cooperation with *KB Working Groups*,
- manages the review of the *Information Product* concept,
- oversees the development and integration of several *Information Products* (including documentation), working closely with the *IP Coordinators*,
- acts as the single point of contact for a suite of *Information Products*,
- oversees the integration of *data sets* into *Information Products*,
- reviews *Information Product* summaries and draft *IP documents*,
- submits draft *IP documents* to the appropriate *KB Working Groups* for evaluation,
- delivers final *IP documents* to the *KB Integrator*,
- provides feedback to the *KB Integrator* during and after each integration cycle,
- prepares *Information Product deliveries* (*data sets* and *IP documents*) according to *IP delivery* instructions,
- includes test cases that were used for *validation*,
- solicits input from the *KB Working Groups* to provide advice to the *KB Integration Board* regarding acceptance of *Information Products*, and,
- may remove the *Information Product* or any of its components from the development

process at any time due to technical considerations.

The *KB Coordinator* is a *Scientific Integrator*. The *KB Coordinator* interfaces with *IP Coordinators*, *KB Working Groups*, *KB Integrator*, and the *KB Integration Board*.

KB Integration Board (IB)
The *IB* will review a collection of *Information Products* being proposed for inclusion in a *KB release* based on *summary* reports provided by the *KB Coordinators* and the *KB Integrator*. The *IB* is permanently composed of a program leader from each contributing laboratory, the *NNSA* sponsor, and a technical representative from the *Operational User's* site (can be a rotating position). 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* status reports
- is advised by the *KB Coordinators* regarding *Information Product* readiness,
- is advised by the *KB Integrator's KB Release document*, and
- provides assessment of release readiness to the *KB Integrator*.

The *IB* acts as a *reviewer*, as defined in Section 8.0, Glossary. The *KB Integration Board* interfaces with the *KB Coordinators* and the *KB Integrator*.

KB Integrator
Individuals who combine the *Information Products* into the *KB* product. *SNL* acts as the *KB Integrator*. The *KB Integrator*:
- receives draft *IP documents*,
- verifies the draft *IP document* to prepare for review,
- receives *IP deliveries*,
- verifies *IP deliveries*,
- integrates *KB release*s,
- organizes review of *KB release*s by the *IB*,
- prepares the *KB release document* for review by the *IB*,
- tests *KB release*s as a system, and
- delivers *KB release*s to the *operational user*.

The *KB Integrator* interfaces with the *KB Coordinators,* 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 *data set* and *Information Product* coordination, integration, and *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 to the *KB Coordinators* on *Information Product* definition through requirements analysis
- Validate the use of a specific methodology for developing a given *Information Product*
- Coordinate schedule, formats, and *Information Product* structure (including *metadata*)
- Develop and follow a schedule of critical meetings
- Assist in the requirements definition for tools and *data sets*
- *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*, as requested by a *KB Coordinator*
- Work with the *KB Coordinators* to 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 8.0, Glossary). The *KB Working Groups* interface with *Product Integrators*, *IP Coordinators*, and *KB Coordinators*.

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*.

Principal Investigator

An individual responsible for building *data sets* and handing them off to a *Product Integrator*, if appropriate, to become part of an *Information Product*. A *Principal Investigator* is a *Contributor* and may also be a *Content Developer*.

Product Integrator

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

The *Product Integrator*:
- has a good overall understanding of the *KB* - its structure, content, and use,
- works within the scope of the contract as negotiated by the *Principal Investigator* and the funding agency,
- obtains published reports from the contract and talks to the *Principal Investigator* 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 from a *Principal Investigator*, verifies and validates it,
- if appropriate, works with the *Principal Investigator* to create *metadata* for eventual use in the *KB*, [2]
- works with the appropriate *IP Coordinator* to supply data and metadata for an *Information Product*,
- maintains current summary information about the contract on the *NNSA* Coordination web page (http://www.nemre.nn.doe.gov/coordination/index.html), and
- works with the *KB Coordinators* at Los Alamos, Lawrence Livermore, and Sandia National Laboratories to ensure that the contract's results are properly integrated into the *KB*, and
- provides notification of upcoming product integration meetings to GNEM R&E management and follows up with documentation of the results of those meetings.

Product Integrators are *Scientific Integrators*. *Product Integrators* interface with *Principal Investigators*, *IP Coordinators*, and *KB Coordinators*.

Scientific Integrator

Integrates the results of individual *Contributors* from inside and outside *NNSA* through the efforts of a *KB Coordinator*. Develops 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. The *NNSA* laboratories (*LLNL*, *LANL*, *PNNL* and *SNL*) are *Scientific Integrators*. A *Scientific Integrator* is a *Product Integrator*, *KB Coordinator*, or *KB Working Group* member.

The integration and evaluation process is discussed in greater detail in Section 5.0 and is derived from Moore *et al*. [2000]. The most significant change to the integration process since the initial implementation has been the addition of technical *KB Working Groups*. The next section will use the *role*s defined here as actors in the process flow.

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[2] Lineage of integrated products to their original source is important, and that information is carried in the *metadata*.

5.0 *Knowledge Base* Evaluation and Integration Process

This document delineates a clearly defined integration process and procedures to manage *Information Products* as they migrate from the applied development world toward a *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 con-textual 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 informa-tion 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 evaluation and integration process, shown in Figure 3, illustrates a simplified flow of potential *KB* data and software tools as they migrate step-by-step into a *KB delivery* for *release* to the *Operational Users*. User evaluation is ongoing in some form at all steps of the integration process. This evaluation process is generally described below.
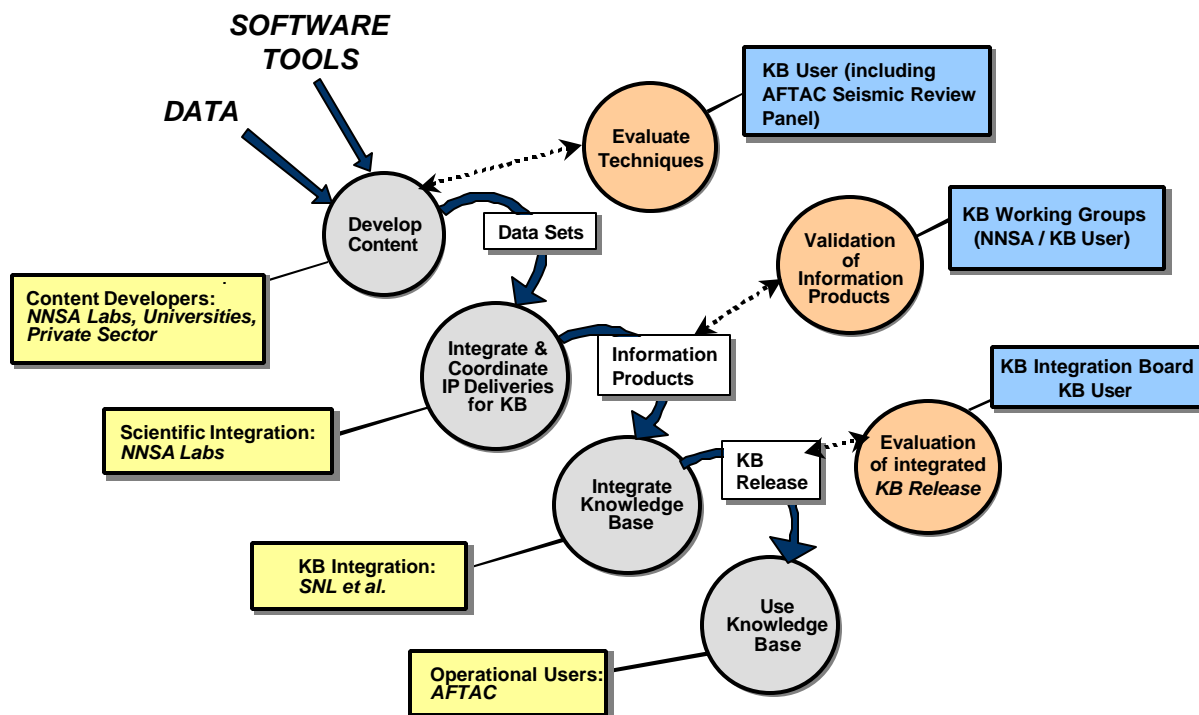
Figure 3 - *Knowledge Base* **evaluation and integration process**

In Figure 3, the center series of elements, beginning with "DATA" and "SOFTWARE TOOLS," depicts how data and algorithms are integrated into *data sets*, then into *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 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 end 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 *data set* or *Information Product*, as well as evaluation of technical accuracy. Another key characteristic of this process is that products (i.e., *data sets, Information Products, Knowledge Base*) are verified and validated at each step in the process.

The addition of technical *KB Working Groups* 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* 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 *KB Coordinators* and *IP Coordinators* to verify that the *Information Products* are technically accurate, 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, and finally, implementation.

Information Product Tracking

Once *research products* (*data sets*, software products) are integrated so that they reach the point at which they are referred to as *Information Products*, they are systematically tracked by the *Knowledge Base Integrator*. This is discussed in detail in Moore *et al.* [2000]. An example tracking report showing a collection of *Information Products,* displayed in a table-based format, is shown in Table 1 below.

Table 1. Example *Information Product* Status Report

Information Product	Draft *IP* Document Received by SNL	Draft *IP* Document *Verified* by SNL	Draft *IP* Document *Validated* by *KB Working Groups*	*IP* Delivery Received by SNL	*IP* Delivery *Verified* by SNL	Integrated *KB Release Verified* by SNL	Integrated *KB Release* Approved by *IB*	*IP* Withdrawn	*IP* Rejected
IP 1	04-14-2000	04-18-2000	04-20-2000	05-16-2000	06-10-2000	06-12-2000	06-13-2000		
IP 2	03-29-2000	04-03-2000	04-05-2000	05-15-2000	06-10-2000	06-12-2000	06-13-2000		
IP 3	03-17-2000	03-20-2000	04-06-2000	05-15-2000	06-01-2000	06-12-2000	06-13-2000		

As an *Information Product* proceeds through each of the tracking steps (moving left to right in Table 1), it is recorded and it is then deemed ready for the next step. The tracking proceeds through the integration, *verification*, and *validation* (i.e., *KB Integration Board* approval for *release*) of a *Knowledge Base release*.

6.0   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*.
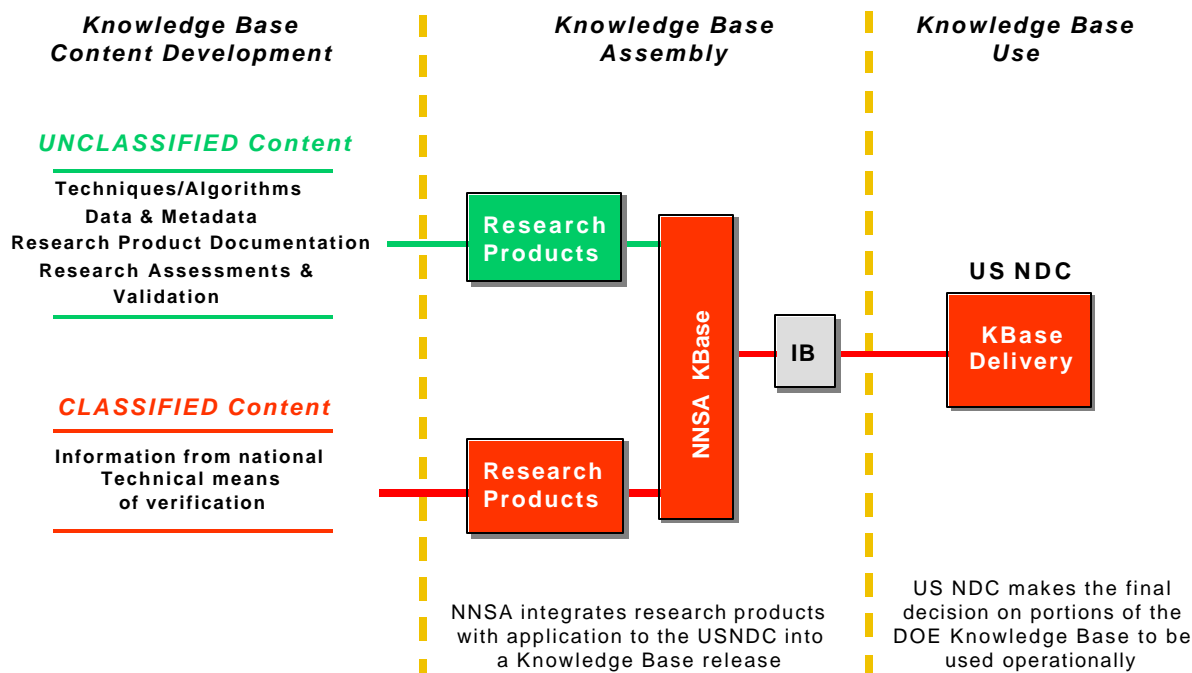
Figure 4 - Classification Guide interpretation

The *Information Products* are composed of one or more *research product*s[3] (collections of *data sets*) and are 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 *NNSA KB*. The tracking of unclassified and classified 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*.

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[3] The term *research product* (Section 8.0, Glossary) is used by the research community to describe a product tied to a contracted research output. This sometimes corresponds one-to-one with *Information Product* and sometimes corresponds to a subset of *data sets* which may become part of an *Information Product*. The notion of *research product* is not required to understand the integration process design presented here.

7.0   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 data delivered are useful for the *USNDC* and are of high quality. 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 *Information 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 *data sets* and *Information Product deliveries*.

8.0   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 4.0). 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 data. A collection of *data sets* makes up an *Information Product*. *Data sets* typically have corresponding *metadata.*

delivery
    A transfer of an *Information Product* or *KB.*

DOE
    United States Department of Energy.

domain expert
    Individual with extensive knowledge about a particular *data set* 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 *data sets.*

Information Product (IP)
    One or more *data sets* with corresponding *metadata* and documentation. May also include software and models, if appropriate. An *Information Product* may be, for example, all data collected which are associated with New Zealand.

IP
    See *Information Product*.

IP document
    A document generated by the *IP Coordinator* under the oversight of a *KB Coordinator* containing product identification, list of *data sets*, goals and purpose, specifications, analysis results, and a *delivery* schedule. The contents of the draft *IP document* are defined in the *KB* Contributor's Guide [Carr *et al*., 2000].

Knowledge Base (KB)

An organized collection of data used for automated regionalization and analyst efforts at the *USNDC* and sponsored by the *NNSA*.

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 user at a given time. Each *KB release* subsumes the previous release as well as incorporates modification in response to operational feedback on the previous releases.

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. *Metadata* contained in the *Information Products' release documents* will not be duplicated in the *KB release document*, but will be accessible via the *KB* Catalog.

LANL

Los Alamos National Laboratory.

LLNL

Lawrence Livermore National Laboratory.

metadata

Data which describe the content, quality, condition, and other characteristics of data, particularly geospatial data. [Carr *et al*., 2000]

NNSA

National Nuclear Security Administration

PNNL

Pacific Northwest National 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 *data sets*, *research product*s, or *Information Products*.

research product

A product of contracted research. A *research product* may consist of one or more *data sets.* This may correspond one-to-one with an *Information Product* and sometimes corresponds to a subset of *data sets* which may become part of an information product.

reviewer

An individual or group of individuals with knowledge of the domain. The *reviewer* thoroughly examines the technical content of a draft *IP document* or *delivery* to aid in determining its *correctness* and validity. A *reviewer* is a peer. See also, *verifier*, Document *Verifier*, Data *Verifier*, and the *KB Integration Board* (Section 6.0, Selected *Role*s and Responsibilities).

role

A set of actions or functions performed by an individual or a group. An individual may have several *role*s. *Role*s include *KB Coordinator*, *Product Integrator*, IB, *KB Integrator*, etc. *Role*s which are part of the formalized integration process are described in Section 4.0. Others are found here in the Glossary.

SNL

Sandia National Laboratories.

summary

The *summary* is generated by the *KB Coordinator* and contains product identification, lists containing *research product*s, *data sets*, goals and purpose. The *summary* becomes part of the *release document*.

United States National Data Center (USNDC)

The *United States National Data Center* 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 an *Information Product* for inclusion in the *KB*. *Validation* of an *Information Product* includes assuring relevance to the *USNDC* goals, as well as, scientific quality. The *KB Integration Board* and *Operational User* make high-level acceptance or rejection. Supporting *validation* may be done by the *KB Working Groups*, the *KB Integrator*, and the *Scientific Integrator* or *Contributor*. *Information Product validation* requires a *release document* including purpose and specification. *Verification* testing results may be required for *validation*. If possible, predefined metrics will be used to streamline the *validation* process.

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.*

verifier

An individual or group of individuals, typically at *SNL*, who verify a draft *IP document*, data or *metadata.* A *verifier* is a *reviewer*.

9.0   References

Carr, D., S. Moore, H. Armstrong, L. Wilkening, M. Chown, E. Shepherd, T. Edwards, R. Keyser, C. Young, A. Cogbill, J. Aguilar-Chang, A. Velasco, and S. Ruppert (2000), *Knowledge Base* Contributor's Guide, Sandia National Laboratories, Report No. SAND2000-0442, Albuquerque, NM.
(also available from http://www.nemre.nn.doe.gov/nemre/kbase_info.html)

Moore, S., H. Armstrong, D. Carr, R. Keyser, E. Shepherd, L. Wilkening, C. Young, M. McCornack, J. Aguilar-Chang, A. Velasco, S. Ruppert, T. Hauk, and C. Schultz (2000), The Integration Process Design for Incorporating *Information Products* into the Department of Energy *Knowledge Base*, Sandia National Laboratories, Report No. SAND2000-0597, Albuquerque, NM.
(also available from http://www.nemre.nn.doe.gov/nemre/kbase_info.html).

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 May 9, 2001.

MEMORANDUM OF UNDERSTANDING
AMONGST
AIR FORCE TECHNICAL APPLICATIONS CENTER (AFTAC)
AND
UNITED STATES GEOLOGICAL SURVEY (USGS)
AND
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)

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"). Its purpose is to support nuclear explosion monitoring and the development and operation of the US National Data Center (NDC) based on the long-standing, cooperative, working relationships amongst these Parties.

2. Authority: This MOU complements the following MOUs that address other aspects of nuclear explosion monitoring:

    a. US Nuclear Detonation System (USNDS) – US Air Force (USAF)/DOE MOU, dated January 8, 1997

    b. Cooperation on Matters Pertaining to the Comprehensive Nuclear-Test-Ban Treaty (CTBT) – Department of Defense (DoD)/USGS MOU, dated September 16, 1997

    c. Automated Radioxenon Sampler Analyzer (ARSA) Acquisition – AFTAC/DOE MOU, dated February 26, 1998

    d. DoDI 4000.19, Interservice and Intragovernmental Support, Aug 9, 95

    e. AFI 25-201, Support Agreement Procedures, Dec 1, 96

3. General:

    a. Background. The United States Air Force has long held missions to monitor arms control treaty compliance and maintain nuclear threat warning, attack assessment, and nuclear force management capabilities. 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 weapons of mass destruction, AFTAC has undertaken an aggressive program to enhance the USAEDS capabilities. AFTAC will utilize the full resources of the USAEDS to meet the requirements of the US

national policy community for nuclear explosion monitoring and in support of the purpose of this MOU.

The USGS is responsible for the applied earth science elements of the National Earthquake Hazards Reduction Program and for the Global Seismograph Network Program. This requires monitoring national and worldwide seismicity and reporting to national and international emergency response agencies and to other interests including the media and the general public. To the extent possible 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 A1A, Patrick AFB FL 32925-3002, phone 321-494-2356, fax 321-494-2274, dave@rayleigh.tt.aftac.gov, http://www.tt.aftac.gov.

USGS
Dr. John R. Filson, Coordinator of Earthquake Hazards Program, United States Geological Survey / MS 905, 12201 Sunrise Valley Drive, Reston, VA 20192, phone 703-648-6785, fax 703-648-6592, jfilson@usgs.gov, http://www.usgs.gov.

NNSA
Ms. Leslie A. Casey, Manager of Nuclear Explosion Monitoring Research and Engineering Program, National Nuclear Security Administration /NN-20, 1000 Independence Avenue, SW, Washington, DC 20585-0420, phone 202-586-2151, fax 202-586-0485, leslie.casey@hq.doe.gov, http://www.nemre.nn.doe.gov.

4. Responsibilities: This MOU is not a basis for obligation, commitment or transfer of funds. Specific funding and tasking will be implemented through separate agreement. This MOU expresses the intention of the Parties to apply the unique resources of AFTAC, USGS and NNSA to a shared goal of improved national security through nuclear explosion 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 National Data Center (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 US Government policy with respect to nuclear testing treaties, moratoria and agreements.

(3) Operate and maintain the USAEDS to meet US national requirements.

(4) Operate and maintain the US NDC headquartered at Patrick AFB, in Florida, the Alternate National Data Center at Goodfellow AFB, in Texas, and AFTAC's National Capitol Region Operating Location (NCR OL), in Reston, Virginia.

(5) Provide test beds for evaluating research products and facilitating their transition to the operational USAEDS and US NDC.

(6) Provide the research community with monitoring data in a manner consistent with US public law on redistribution of data.

(7) Provide USGS with connectivity to AFTAC computer resources, including access to the NNSA-developed integrated knowledge base.

(8) Provide connectivity for data and analysis results between the US NDC operations and the US interagency policy community.

b. USGS will:

(1) Host the US NDC portion of AFTAC's NCR OL in Reston, Virginia.

(2) Provide to interested parties data and information, collected within its normal mission, on seismic events occurring within the US and worldwide.

(3) Expand its domestic reporting mission to include seismic events not related to earthquake hazards, such as mining explosions, with external support.

(4) Cooperate with AFTAC and NNSA in the advancement of techniques to improve seismic monitoring and notification, including support to the US NDC.

(5) Contribute geological expertise and appropriate products to the development of the NNSA knowledge base, with external support.

(6) Provide research, data and analysis products supporting nuclear explosion monitoring, with external support.

    c. NNSA will:

    (1) 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.

    (2) Integrate validated research products into the operational test beds at AFTAC.
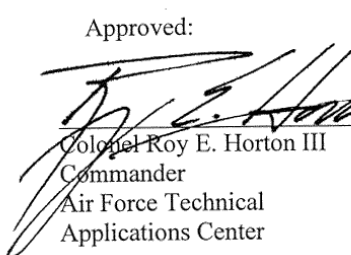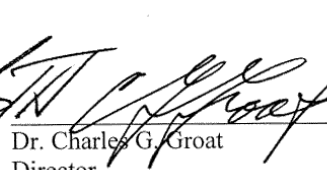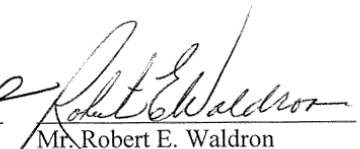
    (3) Maintain a comprehensive research, development and engineering program (i.e., the Nuclear Explosion Monitoring Research and Engineering program) to continuously improve US monitoring capabilities to meet US national requirements.

    (4) Provide the USGS information about seismic events at NNSA facilities, particularly those at the Nevada Test Site, to aid nuclear treaty verification and compliance.

5. 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:

Colonel Roy E. Horton III
Commander
Air Force Technical
Applications Center

Dr. Charles G. Groat
Director
United States Geological
Survey

Mr. Robert E. Waldron
Assistant Deputy Administrator
Nonproliferation Research &
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