DOCUMENT 175-11

DATA SCIENCES GROUP

TEST AND EVALUATION (T&E) METADATA BEST PRACTICES

WHITE SANDS MISSILE RANGE
REAGAN TEST SITE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ABERDEEN TEST CENTER
ELECTRONIC PROVING GROUND

NAVAL AIR WARFARE CENTER WEAPONS DIVISION, PT. MUGU
NAVAL AIR WARFARE CENTER WEAPONS DIVISION, CHINA LAKE
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION, PATUXENT RIVER
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT

30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
ARNOLD ENGINEERING DEVELOPMENT CENTER
BARRY M. GOLDWATER RANGE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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TEST AND EVALUATION (T&E) METADATA BEST PRACTICES

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Prepared by

DATA SCIENCES GROUP (DSG)

Data Management Committee (DMC)

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PREFACE

This document was prepared by the Data Management Committee (DMC), Data Sciences Group (DSG), of the Range Commanders Council (RCC) under Task DS-03. The DMC performed research and analysis of the commonalities in the test and evaluation (T&E) processes across RCC member ranges and developed this document of best practices and lessons learned on metadata usage in range applications. The document provides the best practices based on success stories and lessons learned at various ranges and identifies what to avoid when initiating a metadata effort. The foundation is laid for a metadata standard at all ranges which will assist in achieving commonality and for facilitation of real-time and post-test common access methodology for local and distributed test events.

The RCC would like to thank the Data Management Committee for the hard work in developing this document.

Task Lead: Annette Weisenseel AFFTC
Air Force Flight Test Center (AFFTC)
812 TSS/CM
307 E. Popson Ave
Edwards Air Force Base (AFB) CA 93524-6680
Phone: (661) 277-1240 DSN 527-1240
Fax: (661) 277-0249 DSN 527-0249
Email: annette.weisenseel@edwards.af.mil

Data Management Committee Members:

Jason Kaza - Yuma Proving Ground (YPG)
Dave Quick - Naval Undersea Warfare Center Division Keyport NUWCDIVKPT
Dave Salas - White Sands Missile Range (WSMR)
Steve Powell - Arnold Engineering Development Center (AEDC)
Tracy Mullendore - Dugway Proving Ground (DPG)
John Hamilton - Knowledge Based Systems, Inc. (KBSI)

Please direct any questions to:

Secretariat, Range Commanders Council
ATTN: CSTE-DTC-WS-RCC
100 Headquarters Avenue
White Sands Missile Range, NM 88002-5110
Phone: (575) 678-1107 DSN 258-1107
Fax: (575) 678-7519 DSN 258-7519
Email: mailto:wsmrrcc@conus.army.mil

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ACRONYMS

AEDC	Arnold Engineering Development Center
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
APG	Aberdeen Proving Ground
ATEC	Army T&E Command
CTEIP	Central T&E Investment Program
DoD	Department of Defense
DPG	Dugway Proving Ground
DSG	Data Sciences Group (DSG)
I&M	Instrumentation and Modernization
IEEE	Institute of Electrical and Electronics Engineers
IEEE	Institute of Electrical and Electronics Engineers
IHAL	Instrumentation Hardware Abstraction Language
iNET	integrated Network Enhanced Telemetry
IRIG	Inter-range Instrumentation Group
ITC	International Telemetering Conference
JMETC	Joint Mission Environment Test Capability
KBSI	Knowledge Based Systems, Inc.
MDL	Metadata Description Language
MISG	Motion Imagery Standards Group
NUWCDIVKPT	Naval Undersea Warfare Center Division Keyport
RCC	Range Commanders Council
SBIR	Small Business Innovative Research
SBIR	Small Business Innovative Research
T&E	test and evaluation
TEML	T&E Markup Language
TEMPL	T&E Metadata Plaza
TEMRL	Test & Evaluation Metadata Reference Model
TENA	Test and Training Enabling Architecture
TG	Telemetry Group
TMATS	Telemetry Attributes Transfer Standard
WSMR	White Sands Missile Range
XML	eXtensible Markup Language
YPG	Yuma Proving Ground

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CHAPTER 1

BACKGROUND

1.1 Purpose

Modern test and evaluation (T&E) efforts produce large amounts of information that is external to the actual measurements being acquired, such as test requirements, descriptions of the test article, data format descriptions, and much more. Maintaining access to and understanding this metadata is crucial to understanding the data itself. This understanding becomes especially critical when test data must be revisited months, or even years, after a test is completed. The value of the original data is diminished without the metadata. The ability to review all of the metadata associated with a previously performed test provides a complete picture of the circumstances in which the data was gathered. Therefore, the analysis of the older data will be easier and more effective.

The purpose of this document is to describe "best practices" gathered from the T&E community regarding the creation, utilization, and storage of T&E metadata. The information contained herein does not completely define a general T&E process, nor does it serve as a mandate on test organizations to implement the identified practices. Instead, this document merely suggests means by which individual organizations, and the T&E community as a whole, can improve the way T&E metadata is handled.

Note: A very useful companion document is the Range Commanders Council (RCC) Document 176-11, *T&E Metadata Reference Model* document (Reference a).

1.2 Scope

The scope of this document is "T&E Metadata". The most general definition of metadata is "data about data." For this effort, we define "T&E data" to be the actual acquired measurements from a test. In Reference b, T&E Metadata is defined as follows:

> *"T&E metadata is any information that provides additional description or context to the T&E data. This covers a broad spectrum of information, ranging from the initial requirements and motivation for the test, to the test article and instrumentation modifications required to perform the test, to the description of the packet format in which the data is transported."*

This definition includes requirements, test plans, safety reports, instrumentation hardware descriptions, measurement lists, TMATS files, and other relevant data. The breadth of this effort is the complete set of T&E metadata as described above. In comparison, the depth is relatively small. The best practices described herein are meant to be abstract enough to be relevant for all T&E organizations, regardless of the type of article being tested, the systems being used, or the geographical location of the test.

1.3 Methodology

The research for and documentation of these metadata best practices was assisted by a Phase II Small Business Innovative Research (SBIR) Project funded by Edwards AFB and carried out by Knowledge Based Systems, Inc (KBSI). The project, named "T&E Metadata Plaza" (TEMPL), seeks to develop a methodology and a suite of tools to improve management of diverse types of T&E metadata (Reference c).

1.3.1 Actions Taken in Developing this Document. The following major activities taken included information gathering, coordination with the committee, and creation of the document.

a. Information Gathering. In order to gather the information necessary to develop this document, we visited a diverse set of T&E organizations across the country and discussed current metadata artifacts, practices, and issues with the various metadata developers and users at each site. The purpose of each visit was to gather information not only for this document, but also for the T&E Metadata Reference Model described in Reference a.

Over the course of 4 months, members of the KBSI project team visited seven different test organizations. Table 1-1 lists the facilities visited, the date of each visit, and the key points of contact.

TABLE 1-1. T&E ORGANIZATION VISITS

Service	Facility	POC	Trip Date	KBSI Attendees
Air Force	Edwards AFB	Charles Jones	4/15/2010	John Hamilton Tim Darr
NASA	NASA Dryden	Robert Harvey	4/16/2010	John Hamilton Tim Darr
Army	Yuma Proving Ground	Jason Kaza	6/7/2010	John Hamilton Byon Williams
Commercial	Boeing	Lee Eccles	6/15/2010	John Hamilton Byon Williams
Army	Aberdeen Proving Ground	George Bartlett	6/29/2010	Byon Williams
Navy	Keyport	David Quick	7/13/2010	John Hamilton Byon Williams
Navy	Patuxent River	Eric Harvey	7/26/2010	John Hamilton Byon Williams
Army	White Sands Missile Range	Dave Salas	8/3/2010	John Hamilton Byon Williams

During each visit, the KBSI members met with several different groups within the organization. These groups were coordinated by the primary point of contact for each facility, but were typically grouped according to their role in the test process.

Each group was asked to describe their typical test process. During each of these process descriptions, the specific metadata artifacts that were created, modified, or used at each step were documented, along with how they are used, where they are stored, and how they are accessed. Members were also asked to share any specific difficulties they have encountered in dealing with metadata or any specific activities they perform that make management of T&E metadata easier.

In preparation for each visit, the group participants were sent a list of questions to consider in advance of each visit. This list contained the following questions:

(1) What metadata/document management systems do you use, and how well do they work?
(2) What metadata-related issues have you solved/improved, and how? What hasn't worked and why?
(3) Are there any metadata-related issues that you would like solved?
(4) What is missing from the current T&E Metadata Reference Model?
(5) Do you have suggestions for improving the Reference Model terminology?
(6) What metadata standards do you use today? Examples include the Institute of Electrical and Electronics Engineers, IEEE 1484.12.1-2002 Standard; the integrated Network Enhanced Telemetry (iNET); the Motion Imagery Standards Group; the IRIG/RCC Telemetry Standards 106 Chapter 9 and Chapter 10; and the Joint Mission Environment Test Capability (JMETC) user groups.
(7) Are you aware of any other efforts that could augment this effort? Examples are Small Business Innovative Research (SBIR) programs, Instrumentation and Modernization (I&M) programs, working groups, and so forth.

b. Coordination Between KBSI and the Committee. Throughout this effort, KBSI conducted monthly teleconferences with members of the RCC-DSG Data Management committee to review the information gathered from each trip and to solicit feedback. Additionally, a collaboration website by KBSI was set up where committee members could weigh in on the progress of tasks between meetings. The collaboration site includes the following major components:
(1) A document repository for storage of current documents, minutes, and records from all meetings.
(2) A discussion forum for posting of questions and feedback regarding the tasks and deliverables.

c. Development of the Document. During the information-gathering phase, a running list of metadata best practices was maintained, along with the organization(s) who suggested each one. At each monthly telecon with the Data Management Committee, this list was reviewed, discussed, and modified.

Following the completion of the various site visits, the list of best practices was again reviewed by the committee, at which time the various practices were grouped into categories and edited to ensure applicability to the T&E community as a whole. These categories and practices are documented in the next section.

CHAPTER 2

BEST PRACTICES

2.1 Utilization of Standards

One of the biggest challenges facing T&E organizations with respect to metadata management is the wide range of proprietary metadata formats and differing terminologies used by the various organizations. This lack of standardization makes it difficult for one organization to share metadata (and thus, data) with another organization. This issue exists not only between test organizations but also within individual organizations.

If the metadata associated with a specific aspect of a test is stored in a proprietary format, then any organization needing access to that metadata is required to have systems capable of interpreting that format. Without standards, the number of formats (and hence the complexity and/or number of systems) dramatically increases.

Additionally, confusion can occur when metadata is shared between organizations lacking a common terminology. Without specifically defined terminology, the meanings of many terms used to describe tests can be ambiguous. For example, one organization may typically use the term "transmission" to refer to vehicle transmissions, while another organization may use the same term to refer to the sending of information via radio waves. Even if metadata is not shared outside of a particular organization, lack of standardization can cause problems. Proprietary formats are often tied to a particular commercial entity or product, and may not be well documented. This makes it difficult, if not impossible, for an organization to migrate to a new system that uses a different format. In addition, products become obsolete over time, and companies go out of business. When a proprietary format is used for the archiving of metadata, there is a risk that the information will no longer be accessible beyond the lifetime of the company or product.

These problems are eliminated by using widely accepted, well-documented standards. Given the broad scope of T&E Metadata, no single standard can be all encompassing. However, a number of standards exist or are being developed that cover specific sub-scopes of T&E metadata. Some of these standards are identified below.

a. Telemetry Attributes Transfer Standard (TMATS). A well-known text-based format maintained by the RCC Telemetry Group (TG) for describing the attributes required to process telemetered data (Reference d).

b. Instrumentation Hardware Abstraction Language (IHAL). An XML-based language for describing the capabilities and configuration of data acquisition instrumentation (Reference e). The IHAL is currently under review by the RCC Telemetry Group (TG) for inclusion as one of their published standards.

c. Metadata Description Language (MDL). An XML-based language for describing measurements, including their conversions, data formats, and transmission. The MDL language was developed as part of the Central T&E Investment Program (CTEIP) iNet program (Reference f).

d. T&E Markup Language (TEML). An XML-based language developed at Aberdeen Proving Ground (APG) for configuring the instrumentation systems used in their tests. They have approached several vendors about adding native support for TEML.

e. Test and Training Enabling Architecture (TENA). An object model, software architecture, and toolset to enable the exchange of test information between organizations (Reference g). While TENA is not a standard metadata language or format, it does define a standard terminology to use when exchanging test data, and provides standard definitions for common concepts such as time.

f. Data Dictionary. A data dictionary of common T&E terms maintained by the Army T&E Command (ATEC). The purpose of this data dictionary is to serve as a controlled vocabulary for Army T&E operations. This dictionary of terms and their definitions helps to disambiguate overloaded terms and ensure shared understanding of T&E terminology.

g. T&E Metadata Reference Model. A high-level T&E Metadata Reference Model published by the RCC Data Sciences Group (Reference a). The purpose of this model is to:
   (1) Capture, at a global level, the types of metadata required to completely describe a test.
   (2) Provide a common terminology that can be used when sharing data and metadata among organizations.
   (3) Serve as a guideline for test organizations to ensure a more comprehensive capture of metadata.
   (4) Enable and guide the development of T&E metadata management systems by providing a common high-level information model.

2.2 Metadata Creation

The complete recommended list of types of metadata that should be captured is documented in the Test & Evaluation Metadata Reference Model (Reference a). Most of the items in this model are already commonly captured by most test organizations. However, during our studies at the various test organizations, we identified several types of metadata that were being captured by only a few test organizations, but that proved to be highly useful and thus worthy of a special mention:

a. Test Event Log. During playback, the start and end times for each test point or other important event (expected or unexpected) are recorded electronically. This creates a single log that identifies each of the important periods for which the data should be studied. Capturing this log in one place during playback eliminates the need to go back after-the-fact and cross-reference multiple logs.

b. Test Asset Versions. Test metadata should include a description of the versions of all test assets used during the test, including versions of all software and firmware used during the test. Capturing this information is critical if at any time in the future some aspect of the test needs to be recreated. Additionally, it enables the quick identification of all tests that may be affected if a software defect is identified.

c. Policy Conformance. It is important to document the information necessary to demonstrate that relevant test organization policies are being followed during a test. This enables the test organization to respond adequately to audits from federal or other regulatory agencies. This is especially relevant to environmental policies, as there is growing concern over environmental impacts.

2.3 Metadata Storage and Access

Among the test organizations visited for this task, it was almost universally acknowledged that some form of central metadata catalog system (as described in Reference h) should be put in place to handle the storage of test metadata. The metadata loaded into such a system may not necessarily conform to any single format. However, the structure imposed by a central catalog allows (and in some cases, forces) engineers to associate metadata with the information accessible through the catalog. For example, storing reports in a document management system, rather than a simple file system, enables additional pieces of information such as the author, revision, and test date to be easily associated with the report in a standard way.

A metadata catalog should be logically centralized but could be physically distributed. That is, the catalog does not necessarily require that all metadata be stored in a single physical location. There are cases where different systems and storage strategies work better for different types of metadata. It is best to allow users to create metadata with the most appropriate system for the job, and provide a central catalog that can access metadata regardless of its location.

Furthermore, a metadata catalog should present the information to the user according to that user's role. Because different users may require access in different orders or generation of metadata in different orders, custom views make their jobs more efficient.

That said, it is important that the catalog not be overly constrained to the ideal process flow. Specifically, it should not require that one piece of information be added before another. Creating such constraints can render the system unusable if metadata documentation is frequently presented in an inconsistent order.

2.4 Data and Metadata Archiving

This document thus far has dealt mostly with current test data and metadata. Equally important is that test organizations develop, document, and conform to data and metadata retention, archival, and backup policies. Generally, archived test information is stored differently than current test information. A well-documented policy should describe:

a. Which information should be kept.
b. How long to keep the information.
c. Which formats are to be used.
d. The format and media refresh policies; that is, how often the data should be transferred to a new medium or a new format.
e. The security restrictions and classification of the data.

Since policies may change over time, a snapshot of the current archival policy should be stored with the archived information, so that users will know under which policy it was archived. In this sense, the archival policy itself becomes a source of metadata associated with the test.

CHAPTER 3

CONCLUSIONS

Following a study of representative test organizations, the DSG has documented a number of best practices on how RCC member ranges can best deal with T&E metadata. The practices presented in this document are meant to encourage member ranges to consider the types of metadata they document, the formats and terminology used for describing metadata, the systems used for storage and retrieval of metadata, and the policies used for archival of metadata. This document provides guidance to test organizations in development of their T&E metadata management strategies, while potentially avoiding problems others have faced.

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