Airborne Multisensor Pod System (AMPS) Data Management Overview

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Summary

An overview of the Data Management Plan for the Airborne Multisensor Pod System (AMPS) program is provided in this document. The Pacific Northwest Laboratory (PNL) has been assigned responsibility of data management for the program, which includes defining procedures for data management and data quality assessment. Data management is defined as the process of planning, acquiring, organizing, qualifying and disseminating data. Described is the general approach to data management that PNL has developed. Summarized are the overall AMPS data management requirements and the plan for meeting those requirements. Specific requirements will be presented in follow-on documents.

The AMPS program was established by the U.S. Department of Energy (DOE), Office of Arms Control and Non-Proliferation (DOE/AN) and is integrated into the overall DOE AN-10.1 technology development program. Sensors used for collecting the data were developed under the on-site inspection, effluence analysis, and standoff sensor program, the AMPS program interacts with other technology programs of DOE/NN-20. This research will be conducted by both government and private industry. AMPS is a research and development program, and it is not intended for operational deployment, although the sensors and techniques developed could be used in follow-on operational systems.

The primary purpose of the AMPS is to collect high-quality multisensor data to be used in data fusion research on how to reduce interpretation problems associated with data overload and to derive better information than can be derived from any single sensor. Secondary objectives of the AMPS program are sensor development and technology demonstration.

To collect the data for the program, three wing-mounted pods containing instruments with sensors for collecting data will be flight certified on a U.S. Navy RP-3A aircraft. The DOE AMPS program uses a cross section of U.S. DOE national laboratory system to obtain the appropriate technical expertise needed to address the program mission. The following national laboratories are participants in the AMPS development: Sandia National Laboratories, Lawrence Livermore National Laboratories, and the Pacific Northwest Laboratory.

The following organizations are also contributing to the program: Remote Sensing Laboratory at Las Vegas, Nevada, which is responsible for the imaging pod; the Naval Air Warfare Center at Point Mugu, California, which will provide the pilots who will fly the RP-3A aircraft used to test the pods; Consulting Aerospace Engineers, which will certify air worthiness; and the Naval Air Systems Command (NAVAIR), which will review it.

The Savannah River Technical Center is also contributing to the AMPS program. Infotec Development, Inc., provides DOE project management support and liaison with the Navy. PNL is specifically responsible for identifying and analyzing data management requirements across the AMPS program and for providing guidance in implementing data management procedures.

In general, data management for the AMPS project begins with the design of sensors and instruments to be installed in the pods, continues with the collection of data during missions, and concludes with the delivery of the data for use in research. Stages of the AMPS data management process include the following:

- in-flight data collection
- data transfer and backup
- data storage.

Within this process, PNL is to provide the infrastructure required for consistent and orderly planning, acquisition and distribution of AMPS-related information. This infrastructure must allow each participating organization to proceed independently with its research, yet provide a coherent set of data that can be rapidly distributed to the AMPS research community.

Glossary

The following acronyms and terms are used in the AMPS program:

AC-ITMS	Air Concentrator-Ion Trap Mass Spectrometer
ADC	analog-to-digital converter
AMPS	Airborne Multisensor Pod System
AMS	Airborne Multispectral Scanner
amu	atomic mass unit
ANSI	American National Standards Institute
API	application program interface
Ba	barium
BBS	computer bulletin board
BUNO	Bureau Number
CAE	Consulting Aerospace Engineers
CASI	Compact Airborne Spectrographic Imager
CCD	charge coupled device
CD-ROM	Compact Disk - Read Only Memory
CORBA	Common Object Request Broker Architecture
COSE	Common Open Software Endorsement
CVC	color video camera
cm ⁻¹	inversion centimeters
DOE	U.S. Department of Energy
DOE/AN	U.S. Department of Energy/Office of Arms Control and Non-Proliferation
DOP	decision options paper
DP	defense programs
ECMA	European Computer Manufacturers Association
EG&G	EG&G Corporation (formerly, Edgerton, Gernshausen, and Grier)
EGS	Echelle Grating Spectrometer
EMI	electromagnetic interface
ESI	effluent species identification
FAQ	frequently asked/answered questions
FIPS	Federal Information Processing Standards
FTP	file transfer protocol
FLIR	Forward Looking Infrared
GIS	geographic information system
GOSIP	Government Open Systems Interconnection Profile
GPS	global positioning system
IDI	Infotec Development, Inc.
IEEE	Institute of Electrical and Electronic Engineers
IGe	intrinsic germanium
INS	Inertial Navigation System

InSb	indium antimonide
IR	infrared
IS	DOE Office of Intelligence and National Security
ISO	International Standards Organization
IS-20	Office of Research and Development within DOE/IS
ITMS	Trap Mass Spectrometer
Kr	krypton
km	kilometer
LLL	low light level
LLNL	Lawrence Livermore National Laboratory
LSB	least significant byte
m ³	cubic meters
MIL	U.S. Military Standards
min ⁻¹	inverse minutes
MITI	Ministry of International Trade and Industry
MS/MS	mass spectrometry/mass spectrometry (tandem Mass Spectrometry)
MSB	most significant byte
MSI	multisensor imaging
NASA	National Aeronautics and Space Administration
NATOPS	Navel Air Training and Operating Procedures Standardization
NAVAIR	Navel Air Systems Command
NAWC	Navel Air Warfare Center
NIST	National Institute of Standards and Technology
NOAA	National Oceanographic and Atmospheric Administration
NWTR	Naval Western Test Range
OSF	Open Software Foundation
OSI	Open Systems Interconnection
PI	program introduction documentation
PMIS	project management information system
PNL	Pacific Northwest Laboratory
POC	point of contact
POSIX	Portable Operating System Interfaces, IEEE
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
Rb	rubidium
ROMAC	remote optical measurement of airborne chemicals
RSL	Remote Sensing Laboratory
R-TARAC	Real-Time Airborne Radionuclide Analyzer and Vapor Collector
SAR	Synthetic Aperture Radar
SIG	System Integration Group
SMPTE	Society of Motion Picture and Television Engineers
SNL	Sandia National Laboratories

Sr	strontium
SRTC	Savannah River Technology Center
UI	UNIX International
USGC	United States Geological Survey
UV	ultra-violet
VDC	volts direct current
VTR	video tele-recorder
Vis	visible
X3	Accredited Standards Committee for Information Processing
Xopen	user (vendor group for promoting standards)

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1.0 Introduction

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The AMPS program was established by the U.S. Department of Energy (DOE), Office of Arms Control and Non-Proliferation (DOE/AN) and is integrated into the overall DOE AN-10.1 technology development program. Sensors used for collecting the data were developed under the on-site inspection, effluence analysis, and standoff sensor program, the AMPS program interacts with other technology programs of DOE/NN-20. This research will be conducted by both government and private industry. AMPS is a research and development program, and it is not intended for operational deployment, although the sensors and techniques developed could be used in follow-on operational systems.

For a complete description of the AMPS program, see "Airborne Multisensor Pod System (AMPS) Program Plan."^(b)

The primary purpose of the AMPS is to collect high-quality multisensor data to be used in data fusion research to reduce interpretation problems associated with data overload and to derive better information than can be derived from any single sensor. To collect the data for the program, three wing-mounted pods containing instruments with sensors for collecting data will be flight certified on a U.S. Navy RP-3A aircraft.

Secondary objectives of the AMPS program are sensor development and technology demonstration. Pod system integrators and instrument developers will be interested in the performance of their deployed sensors and their supporting data acquisition equipment. A dialogue between the pod integrators and the data researchers is essential to facilitate further sensor/data acquisition enhancements.

Private industry may also become a user of this data, because data collected by the AMPS Program has the potential to be applied to commercial problems, such as pollution detection and control to wetlands and wildlife monitoring and protection. The applications of this type of technological effort are almost without bound. Therefore, in the future, certain AMPS data products and data reduction techniques may be made available to private industry via technology transfer.

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(b) U.S. Department of Energy (DOE). 1993. DOE NN-20, Washington, D.C.

1.1 Organizational Roles

The DOE AMPS program uses a cross section of U.S. DOE national laboratory system to obtain the appropriate technical expertise needed to address the program mission. The following national laboratories are participants in the AMPS development effort: Sandia National Laboratories (SNL), Lawrence Livermore National Laboratories (LLNL), and the Pacific Northwest Laboratory (PNL).

The following organizations are also contributing to the program: Remote Sensing Laboratory (RSL) at Las Vegas, Nevada, which is responsible for the imaging pod; the Naval Air Warfare Center (NAWC) at Point Mugu, California, which will provide the pilots who will fly the RP-3A aircraft used to test the pods; Consulting Aerospace Engineers (CAE), which will certify air worthiness; and the Naval Air Systems Command (NAVAIR), which will review it.

The Savannah River Technical Center (SRTC) is also involved in the development effort. Infotec Development, Inc. (IDI), provides DOE project management support and liaison with the Navy. PNL is specifically responsible for identifying and analyzing data management requirements across the AMPS program and for providing guidance in implementing data management procedures.

1.2 PNL Responsibilities

In general, data management for the AMPS project begins with the design of sensors and instruments to be installed in the pods, continues with the collection of data during missions, and concludes with the delivery of the data for use in research. Stages of the AMPS data management process include the following:

- in-flight data collection
- data transfer and backup
- data storage.

Within this process, PNL is to provide the infrastructure required for consistent and orderly planning, acquisition and distribution of AMPS-related information. This infrastructure must allow each participating organization to proceed independently with its research, yet provide a coherent set of data that can be rapidly distributed to the AMPS research community.

PNL's data management responsibilities include the following:

- formulating plans and procedures for managing sensor data from the AMPS instruments
- ensuring the acquisition and management of accompanying metadata, i.e., data that identifies the circumstances and conditions under which AMPS data is collected
- providing methods to assess the quality of AMPS data.

Specific AMPS program data management procedures will be developed from a requirements analysis. PNL will also investigate techniques for automated assessments of AMPS data quality and will recommend specific techniques to the program. Finally, PNL will investigate alternatives, such as Compact Disk-Read Only Memory (CD-ROM) production for distributing AMPS data sets and make recommendations to the program.

1.3 Document Purpose

The purpose of this document is to describe the general approach to data management that PNL has developed for the AMPS program. The document summarizes the overall AMPS data management requirements and presents the plan for meeting those requirements. Specific requirements will be presented in follow-on documents.

This is a living document that will be revised and updated as necessary over the course of the program. This document, as well as ones containing detailed plans, will be under change control. The official point of contact for requesting changes is Wayne Meitzler, PNL, 509-375-3718 and FAX (509) 375-3641.

Figure 1.1. AMPS Data Management Plan

2.0 Data Management Overview

As stated in the introduction, data management is defined as the process of acquiring, organizing, qualifying and disseminating data. The AMPS Data Management Plan applies to all AMPS data acquired during missions and metadata related to that data. AMPS data is defined as all data acquired through AMPS-designated instruments. These data include raw data, calibration data, and support data, i.e., metadata, which identifies the circumstances and conditions under which all other data is collected.

2.1 Data Users

Potential users of AMPS data include researchers in a myriad of occupations, ranging from agencies of the U.S. government to private industry. The primary users of this data will be data researchers in the DOE community. Many will be both users of AMPS data and producers of AMPS data products. U.S. government agencies include the following:

- the Department of Energy
- the Department of Defense
- the Department of the Interior
- the Department of Agriculture
- the Department of State.

As stated in the introduction, private industry may also become a user of this data. Therefore, in the future, certain AMPS data products and data reduction techniques may be made available to private industry via technology transfer.

For example, combined data from the LANDSAT satellite system, the SPOT observation system, and the United States Geological Survey (USGS) system can reveal stressed vegetation in a geographic area. But that data will not show why the distress has occurred. When that data is combined with specific AMPS data, however, then the sources and effects of effluent releases can be compared and analyzed, and the effect of the releases on the surrounding environment can be determined, i.e., in this case, why the distress has occurred.

2.2 Data Management Process

All AMPS participants will be part of the data management process. PNL is responsible for defining the procedures and infrastructure necessary for each organization to perform quality data management. Those procedures and that infrastructure comprise the AMPS Data Management Plan. Each organization will carry out its data management responsibilities for its aspect of the AMPS program, using the guidance provided by that plan. Each will prepare implementation-specific plans for each mission using the AMPS plan for guidance.

Data management for AMPS must take place at four levels:

- **Pod Level** - Data must be managed on the pod level, i.e., between sensors. It may be possible to use one sensor to "cue" the actions of another. It may also be possible to combine the data collected from multiple sensors to gain a better perspective about the target.
- **Mission Level** - Data must be managed on a mission level, i.e., between pods. As an example, the Synthetic Aperture Radar (SAR) pod can distinguish human artifacts from natural objects with great success. It can only determine the use of the object, however, if the object has a set of unique characteristics. The SAR data may be combined with data from other pods to better determine the use of an observed object. For instance, the combination of SAR data with thermal data from the multisensor imaging (MSI) pod would allow an interpreter to determine which objects were in use when the images were made.
- **Analysis Level** - Data must also be managed at the analysis level, i.e., at the AMPS system level. Data from the AMPS system may be combined with data from other systems used to collect or interpret data relevant to the same or like subjects. For example, AMPS data could be combined with data from the LANDSAT satellite system, the SPOT observation system, or maps from the USGS service.

2.3 Major Data Management Elements

Data management requirements are relevant to many elements of the data being considered and to data handling within AMPS. These elements include the following. A complete description of each will be provided in future documents:

- user data requirements
- data formats from individual AMPS sensor instruments
- metadata from individual instruments, such as instrument calibration and configuration

- administrative data, such as flight information and pod configuration (collective instrument data)
- post-flight data and collected metadata
- implemented data format standards
- storage considerations for raw data and metadata
- production considerations for processed data
- data access, use, and distribution (means as well as form).

2.4 POD Data Management Plan

Data management for the pod instrument systems is critical. The pod data collection systems are a vital link in providing the data for research. Using the general templates provided by the AMPS Data Management Plan, shown in Figure 1.1, detailed Pod Data Management Plans (one for each pod) are used in the mission planning process to generate a Mission Data Management Plan. Each Pod Data Management Plan will be patterned after the templates that contain the following information:

- method of acquiring data to be used
- method of storing data aboard the aircraft
- method of transferring data from the aircraft storage media to the intermediate storage media (if any) and in what form
- method of transferring data to the laboratory computer to be used
- kinds of data quality analyses to be performed
- kinds of post-processing to be performed
- kinds of data products to be produced
- methods of packaging and distributing data products to be used.

These plans are prepared before each mission and convey implementation-specific requirements for both the pods and mission. By using these plans, it will be possible to determine the types of data to be collected before a mission.

Each Pod Data Management Plan will describe for each instrument within a pod the flow of data from acquisition to final data product(s). Data may be transferred to different media between the time they are acquired and the final data product. Also, data may be manipulated, have quality information integrated, and have other value added.

The typical mission planning process will require a mission request, which will include objectives and data requirements and the Instrument Characteristics Document^(a) or instrument "spec sheet". The mission will be planned according to the stated objectives and client requirements, defined within the stated capabilities of the instruments to be used. If conflicts arise between the requirements and the instrument capabilities, a dialogue between the mission planning team and the requester will be opened to resolve the conflict. The conclusion of the mission planning process will be a requester approved "Mission Plan".

The data management plan will also convey the process necessary to establish the data quality designation, which will accompany the data with its distribution. The key element of this aspect of data management is to clearly characterize the data so that researchers will be able to make optimal use of the data.

2.5 Data Collection Instruments

At present, three instrument carrying pods have been specified for use in the AMPS program. Responsibility for developing the pods has been assigned as follows:

- SNL Synthetic Aperture Radar (SAR) Pod - Pod 1
- RSL Multisensor Imaging (MSI) Pod - Pod 2
- LLNL Effluent Species Identification (ESI) Pod - Pod 3

Responsibility for developing pod instruments has been assigned as follows:

- LLNL Echelle Grating Spectrometer (EGS) for the ESI Pod
- PNL AMPS Data Management
- PNL Radionuclide Sampler for the ESI Pod

(a) The Instrument Characteristics Document is a compilation of measured instrument performance and capabilities obtained during shakedown flights.

- PNL Air Concentrator/Ion Trap Mass Spectrometer (AC/ITMS) for the ESI Pod
- SRTC Atmospheric Krypton (Kr-85) Plume Grab Sampler for the ESI Pod.

Each pod and its instruments is described in the following. Briefly, though, Pod 1 (the SAR pod) deploys a synthetic aperture radar. It is particularly useful for imaging targets during all weather conditions, both day and night. Pod 2 contains size imaging instruments and cameras useful for remote target detection and material identification. Pod 3, the effluent species identification pod, has instruments for acquiring air samples, detecting radionuclides, and performing spectroscopy.

Targets for AMPS missions will all possess physical properties that the system's instruments can observe. Some of these properties are as follows:

- size, geometry, construction materials
- movement
- heat
- light (reflected or emitted)
- noise (some form of physical vibration)
- defined chemical properties
- radioactivity.

2.5.1 Characterization of AMPS Instruments

PNL has begun characterizing the various instruments used to collect data with the AMPS. A characterization of the instruments supplied by developers and pod integrators is included in the appendix. The pods and the instruments they are to contain are briefly described in the following paragraphs.

2.5.1.1 Synthetic Aperture Radar Pod (Pod 1)

Pod 1 contains the SAR, which acquires data onto an AMPEX digital tape unit. Data recorded on AMPEX DCRSi tapes consist of phase histories, image data, and positional data from an embedded Global Positioning System/Inertial Navigation System (GPS/INS) system. The phase histories are the raw radar echoes, whereas the imagery data consists of magnitude and phase data. On the ground, magnitude and phase imagery will be downloaded to 8-mm Exabyte tapes and/or CD-ROM.

2.5.1.2 Multisensor Imaging Pod (Pod 2)

Each instrument in Pod 2 is controlled by a switch panel located in the aircraft and operated by a mission specialist. Time and position data are provided by the dual Garmin GPS-100 units on board the aircraft and recorded on tape within the pod. GPS time is manually set on a Society of Motion Picture and Television Engineers (SMPTE) time code generator. From the generator, time is set from a keyboard into the Daedalus/Compact Airborne Spectrographic Imager (CASI) and by switch into the video systems. The following instruments are contained in Pod 2.

2.5.1.2.1 Wild Heerbrugg RC-30 Large Format Camera. The RC-30 uses film widths of 9.5 in. with lengths of 400 ft. A useful image area of 9 x 9 in. per frame results in 420 high-resolution photographs per roll. Photography can be acquired at three-second intervals during flight, permitting overlapping photographic coverage of the ground with aircraft speeds of 250 knots or slower at altitudes of 1,000 ft and above.

2.5.1.2.2 Barr and Stroud IR-18 Thermal Imager. Data acquired with the IR-18 is recorded with a TEAC V-80AB-F. The high-resolution video recorder utilizes a Hi-8-mm format, which captures higher frequencies and bandwidths than conventional VHS video recorders.

2.5.1.2.3 CASI Hyperspectral Imager. The imager can be operated in an imaging or spectrometer mode. In the spectrometer mode, 288 spectra can be recorded for a small subset of scene elements. In the imaging mode, complete spatial coverage is obtained for user-selected sets of spectral bands.

2.5.1.2.4 Intensified Monochrome Charge Coupled Device (CCD) Camera. This high-resolution CCD camera is a highly sensitive COHU 5560 camera designed for low light level conditions. The images formed by this camera are recorded on another TEAC V-80AB-F high-resolution video recorder.

2.5.1.2.5 Sony DXC-750 3-CCD Video Camera. This video camera uses three high-resolution CCDs. Each recorded frame consists of 380,000 pixels. Image data are recorded on a Sony DVR-2 Portable Digital Cassette Video Tele-Recorder (VTR).

2.5.1.2.6 Airborne Multispectral Scanner. The Daedalus 3600 Airborne Multispectral Scanner (AMS) system is a dual optical port multispectral scanner that simultaneously records up to six spectral channels directly onto 8-mm digital tape. A total of 10 spectral bands are available; up to six may be selected for recording by the operator.

2.5.1.3 Effluent Species Identification Pod (Pod 3)

The purpose of this pod is to field sensors that are capable of identifying the chemical species in airborne effluents. The initial sensor complement includes one stand-off optical sensor and three air

samplers/analyzers. Sensor operation will be controlled through a single wire ethernet control network. Position and time data will be provided to the sensors from a GPS receiver in the fuselage of the aircraft. Included in this pod are the following instruments.

2.5.1.3.1 Target Locating and Tracking Platform. A 14-in. Versatron ball turret is externally mounted and equipped with a video camera and a Mitsubishi 3-5 μm imager. A Westinghouse 8-12 μm MicroFLIR (Forward Looking Infrared) can be accommodated in the turret. An autotracking system will be integrated into Pod 3.

2.5.1.3.2 Echelle Grating Spectrometer. The EGS collects the infrared spectrum of a point source by two-dimensionally dispersing the spectrum onto a 256 x 256 (InSb) infrared detector array. The analog signal intensity from each detector element is digitized by a 12-bit analog-to-digital converter (ADC) and is stored on a ruggedized solid-state disk.

2.5.1.3.3 Air Concentrator/Mass Spectrometer. Direct inlet sampling of the air stream permits real-time measurement of a broad range of chemical species below the part-per-billion (ppb) concentrations. Additionally, a sorbent-based concentration system is used to boost detection sensitivity for airborne organic compounds to sub-ppt (parts-per-trillion) concentrations. The discrete sampling throughput of the mass spectrometer system with the air concentrator is reduced to one sample every 30 seconds to 2 minutes, depending on the required concentration factor.

2.5.1.3.4 Airborne Radionuclide Detector. Whole air is sampled at a rate of 10 m^3/min through a filter cartridge placed in front of a high-sensitivity, large-volume intrinsic germanium (IGe) detector. The purpose is to provide near real-time analysis of gamma-emitting radionuclides in the sampled air stream as they are being collected on a filter cartridge. Initially, the system will have a capacity of 10 20-filter cartridges. The in-stream sampling time between cartridge exchanges can range from as short as 10 seconds to as long as several minutes.

2.5.1.3.5 Krypton Sampler. The Aerial Krypton Grab Sampler is a whole-air sampler that selectively concentrates the noble gas fraction from the air stream for subsequent analysis of the ^{85}Kr concentration at a ground-based laboratory. It samples and processes air at the rate of 10 L/min (i.e., 10 minutes to collect and process 100 L of air) and is capable of collecting up to 12 discrete air samples. Post-mission laboratory analysis of the collected Kr-85 samples can be performed by radioactive decay counting or through mass spectrometric (MS) methods.

2.5.1.4 Aircraft Instrumentation

The RP-3A aircraft provides the instrument data sources described in the following paragraphs.

2.5.1.4.1 Outside Air Temperature System. There are no facilities at present to record this information.

2.5.1.4.2 Garmin GPS 100. Each pod will have its own GPS; however, this information is available to and may be recorded by the pods.

2.5.1.4.3 Litton Inertial Navigation System. There are no facilities at present to record navigation data. The capture of data provided by the Inertial Navigation System (INS) is important for proper image rectification. However, Pod 2 will have its own INS for rectifying and registering collected images.

2.5.2 Instrument Developers and Pod Integrators

Instrument developers will be primarily concerned with the data that the developed instrument was designed to collect. Improvements in the performance of these sensor systems will greatly depend on the ability of the developers of these instruments to analyze, interpret, and store the collected data. As instrument developers gain experience in the analysis, interpretation, and internal storage, or forwarding, of the collected data, improvements in the next generation of instruments employed within the AMPS system will follow.

The combination of sensor systems within the pod is another consideration. Construction of the pod, and the physical properties (air drag, optimal use of space, heat generated in flight, etc.) of the pod are other considerations to be dealt with. As the AMPS system becomes operational, the combination of the various data acquisition and dissemination systems will have to be analyzed to obtain optimum performance.

2.5.3 AMPS Instrument Systems Constraints

The following list defines the constraints that pertain to the AMPS pod instrument systems:

- All pods within the AMPS system are self contained. That is, all data are collected, processed, and stored for later retrieval within the pod. No additional systems are required external, or complementary, to the pod for AMPS operations to occur, other than manually kept flight logs and data entered at the operator stations.
- The transfer of data, in real time, outside the AMPS pod is not required.
- A generic as well as integrated data collection system for AMPS pods is not planned and will not be created. This means that all instrument systems will use individual data collection algorithms and mechanisms, provided by instrument developers and pod integrators.

3.0 Requirements

A detailed and comprehensive set of requirements is needed to design and build a hardware/software system such as AMPS. The users' expectations must be set forth in the requirements, and the system is designed after a thorough analysis of the specified requirements. The completed system will be measured against the requirements specifications.

This set of AMPS requirements center around the data management infrastructure--from mission planning to data acquisition to data storage to data dissemination. They include data format standards, data quality assessment, and metadata. The following provides an overview of the areas that the requirements must address.

3.1 Data Management Infrastructure

The AMPS data management requirements are to provide the infrastructure through procedures and plans for guiding AMPS contributors in the design of data acquisition and sensor systems as they relate to the data associated with them. The plan only applies to data intended for distribution as part of the AMPS program.

3.1.1 Mission Planning

Key to the data management planning process is addressing data requirements before missions are conducted so the design of the data to be acquired will meet the needs of the user community. The AMPS Data Management Plan facilitates this process through the pod and mission templates. The pod providers and the mission planners will address the data specifically through the templates during the mission planning process. The AMPS data management plan will provide complete data planning development before AMPS data acquisition.

3.1.2 AMPS Data Acquisition

The AMPS data management plan provides for data management criteria related to the data acquisition process for all AMPS instruments described in Section 2.5, Data Collection Instruments. The purpose of the criteria is to ensure that the acquisition process provides data and supporting metadata that meet the user communities' needs. Builders of the data acquisition capability will apply the criteria to their designs.

3.1.3 Metadata

In addition to the data collected by instruments on targets, metadata (or data about data) will be collected. Sets of data will be collected that relate to the pod in which the instruments are located, the operating environment of the instruments, and the ambient conditions of the flight. In addition, there

will be sets of more static data that describe such things as the instruments themselves, calibration values, flight parameters, and mission goals. All are important to understanding the context of the actual instrument readings.

To fully understand all this metadata, it is necessary to be able to describe and identify all of these various data elements. This type of information on the AMPS program will be collected and maintained in a database called a "data dictionary."

For example, an anemometer that periodically records wind velocity would produce a data set that contains values for Time-of-Day, Wind-Speed, and Wind-Direction. That data collected by the instrument might appear in the data dictionary in the following format:

• • • | year-month-day:hour-minute-second | Wind-Speed | Wind-Direction | . . .

or

• • • | 1999-06-21:12-31-55 | 012.50 | 137.33 | . . .

The metadata about this format would be shown as follows:

Time-of-day	Type: Compound
	Size: 6 Simple elements
	Purpose: Unique identification of instrument reading
	Source: System clock
Year	Type: Integer
	Size: 4 digits
	Value: > 1993
	Purpose: Attribute of Time-of-Day
Month	Type: Integer
	Size: 2 digits
	Value: 0 < > 13
	Purpose: Attribute of Time-of-Day
•	
•	
•	
Wind-Speed	Type: Decimal
	Format: 999.99
	Units: meters per second
	Purpose: Attribute of Wind Velocity
Wind-Direction	Type: Decimal
	Format: 999.99
	Units: Degrees from True North
	Purpose: Attribute of Wind Velocity

In addition to describing the data elements, the data dictionary requires that each element has a unique name. This will ensure that all data elements called, for example **Wind-Speed**, represent the same thing, regardless of the data sets in which they appear. All users would be confident that any discussion or use of **Wind-Speed** would refer to the same thing.

The same type of data dictionary entries would appear about other, more indirect data elements. For instance, a data producer may assign a quality flag to a data set, or even to the individual elements within the set, to give a data user some idea about how "good" the values for a particular set of instrument data might be. In this case, data are being added through a medium other than the instrument itself, but such data are still an integral part of the data set.

In this case, the data dictionary would have to be modified to include the element definition:

Quality-Flag	Type:	Integer
	Size:	1 digit
	Values:	0 means no quality assignment 1 means very poor quality 2 means poor quality, etc.
	Source:	Data Producer
	Purpose:	To provide a subjective evaluation of the data quality

While this discussion has primarily dealt with instrument recorded data sets, the same is true of the other types of data sets; e.g., flight logs, instrument specifications, flight parameters, mission plans, and ambient environmental conditions.

By its very nature, metadata are static in the sense that they do not change. When changes to metadata do take place, they are usually associated with a significant restructuring of the data gathering or utilization functions (such as new instruments or data production methods). Metadata, however, do provide the necessary level of consistency that will allow merging many seemingly disparate data sets into new contexts and associations.

3.1.4 Long-Term Data Storage

The Data Management Plan will address the policy and procedures for archiving data. In general, those organizations responsible for an instrument will maintain the archives of data and corresponding metadata associated with the instrument, according to the established policies and procedures. Responsibilities for the archives are described in the following.

3.1.4.1 Synthetic Aperture Radar Pod (SAR) (Pod 1)

The original AMPEX DCRSi tapes and one copy of the data copied to 8-mm tape and/or CD-ROM will be stored at SNL.

3.1.4.2 Multisensor Imaging Pod (MSI) (Pod 2)

The original video tape cassettes and photographic negatives will be archived at RSL in their Archive for Aerial Film. Selected/required photographs may be digitized by RSL personnel.

3.1.4.3 Effluent Species Identification Pod (ESI) (Pod 3)

Data from Pod 3 will be stored in the following ways:

- **Target Locating and Tracking Platform** - All recordings will be stored at LLNL.
- **Echelle Grating Spectrometer (EGS)** - Data will be archived at LLNL.
- **Air Concentrator/Ion Trap Mass Spectrometer (AC/ITMS) and Airborne Radionuclide Detector** - Data will be archived at SRTC.
- **Aircraft Data** - Data archival has not been addressed at this point, because the data recording method has not yet been decided.

3.1.5 Access

AMPS data are stored at the laboratories responsible for the pod from which any particular data are acquired. Requests for particular data sets must be made to the laboratory at which it resides. PNL will facilitate data access by generating a "data catalog" that will be updated after each AMPS mission. The data catalog will contain references to all AMPS data that has been acquired and will include instruments used, geographic location, date and time, data repository, etc.

3.1.6 AMPS Data Quality

The AMPS program will collect data for use by data researchers who are not directly associated with AMPS. Information on the quality of the data collected is one type of information that users of AMPS data will require. The standards for the quality of the data collected, however, will be established by the researchers. They will specify quality requirements in the Data Management Plan prepared for each mission. Information on the quality of the data collected will also be useful to AMPS investigators in diagnosing instrument performance.

Users of AMPS data will need to choose which data to analyze. In making this decision, they will be interested in knowing which data are "good", i.e., whether the instrument is believed to have been

operating correctly; which data are "suspect", i.e., whether the instrument may have had a problem or whether other factors may have affected the data; and which data are "bad", i.e., whether the instrument was known to have problems. If possible, more quantitative indicators of data quality are desirable. Procedures and guidance for determining data quality are expected to be part of the approved data management plan.

3.1.7 Management

PNL has been assigned responsibility for defining data management procedures for the AMPS program. As such, PNL is currently assessing the requirements for the following:

- managing sensor data from the AMPS instruments
- acquiring and managing accompanying metadata
- assessing the quality of AMPS data.

PNL will develop specific AMPS program data management procedures based on the results of this requirements assessment. As a precursor to this analysis, it has been determined that four areas of consideration have to be addressed in order to complete the assessment, as described above, nominally. These areas are as follows:

- time synchronization
- position determination
- the pointing of the sensor at the time of sighting
- the logging of information as it is received.

These areas will be discussed individually in the following.

3.1.7.1 Time Synchronization

Time synchronization is required for concurrent observations of the same entity by different observers/sensors. Concurrent observations can be used both to validate sensors and for the synergistic use of multiple data sets. Because a generic as well as integrated data collection system for AMPS pods is not planned and will not be created, it is imperative that time and position information be captured and recorded as the observations occur. Because it is also an assumption that the transfer of data, in real time, outside of the AMPS pod is not required, post-flight analysis of the data (i.e., after it is collected from the pod), can combine the observations. This combination will then present a comprehensive image of the target that was being observed.

3.1.7.2 Position Determination

The requirement to accurately determine the positions of targets at the time of the observation is governed by the need to reference the entity for later data acquisition efforts or for some form of progressive action. It should also be noted that all position observation systems really form position estimates, which contain some form of residual error. There are methods to quantify and to minimize this error; however, it is never truly totally removed. Position error tolerances for AMPS user systems will have to be determined.

3.1.7.3 Field of View of the Sensor

An important part of each flight will be to establish sampling backgrounds, both natural and artificial. Those factors that will affect the field of view of the sensor, and hence the validity of the gathered data, are as follows:

- target objective, location, and attitude
- flight altitude
- angles of approach to the target objective during ingress and egress, preferred and actual
- desired and actual time on station
- angle of bank - pitch, roll, or yaw
- aircraft speed over the target area
- controlled variables (search patterns, multiple patterns, operator discretion)
- relevant flight profile characteristics overlap
- field of view restrictions on the subject sensor (internal and external).

3.1.7.4 Information Logging

The ability of an instrument system to collect, process and store information into a retrievable information log is vital to the success of the AMPS effort. All data analysis and fusion depends on this ability. Because the assumption that all pods within the AMPS system are self contained remains valid, the ability to establish an information log is incumbent on the individual instrument developer. Management of the information contained in these logs is heavily dependent on the form of the information as stored and on the elements of data management as cited above. The final plan will specify information logging requirements.

3.1.8 Performance

All systems within the AMPS program need to be analyzed for optimum performance. These include the individual instruments, the pods, the aircraft, and the overall data flow from the instrument to the user community.

3.1.9 Standards

Standards provide the framework for a diverse group of individuals belonging to different organizations to work together nearly autonomously to achieve a mission. In the case of AMPS, the Data Management Plan will provide standards and guidance for information exchange standards. Standards established in the AMPS Data Management Plan will augment existing applicable government standards and consider draft standards currently under development. Other standards, such as for software, will be at the discretion of the controlling organization.

The Data Management Plan will address, at a minimum, the core standard areas described in the following paragraphs.

3.1.9.1 Data Format

The multitude of sensors associated with AMPS provide data in a range of formats and media. The Data Management Plan will address standard formats and media to simplify the process for distributing the data and subsequently optimize the data distribution effort. Data format standards will also reduce the effort and tools necessary for data users to import the data into their analysis systems.

3.1.9.2 Data Dictionary

Standardized data formats do not ensure that codes for data within the format are unique. Therefore, the data dictionary provides a rigorous definition for all data and the attributes that describe them. The data dictionary eliminates duplication and contradiction in data attributes commonly found in data sets whose origins are from diverse sources.

3.1.9.3 Information Catalog

Because the providers of AMPS data will be archiving the data, users will need access to the location of the various data sets as well as information on the data content. The Data Management Plan will provide the framework for data providers to make available catalog information so users can readily and easily determine the location and availability of information.

3.1.9.4 Quality Assurance

The Data Management Plan will describe the process standards for data quality assurance with the goal of enabling data providers to convey clearly (i.e., define) what the corresponding data quality is to users.

3.1.10 Configuration Management

One element of data management is configuration management. The Data Management Plan will convey the configuration management for all AMPS data. Each data provider, before a mission, will prepare a Mission Data Management Plan using the AMPS Data Management Plan Mission Template to fulfill configuration management requirements for data. The AMPS Data Management Plan provides data configuration information before and beyond missions. Thus, the Data Management Plan will provide all guidance specific to data configuration management.

3.2 Data Interchange Architecture

The AMPS data interchange architecture seeks to base itself on accepted national and international standards. For the purpose of AMPS, the most important is a standard file structure. The following is background on these standards and how they apply to AMPS.

3.2.1 Software Standards

The relationship of the various software standards organizations is complex and dynamic. Yet, many well known computer languages, systems, libraries, and applications have been formalized in one or more standards. For example, the UNIX system is specified by FIPS 151-1, POSIX.1, POSIX.2, and others. The popular database query language SQL is standardized in FIPS 127, and equivalent ANSI and ISO documents. The well known graphics standard, CGM, is formalized in standard ANSI X3.122-198X, and also in MIL-D-28003.

User organizations such as UniForum and UNIX International have been established to help users of computer resources understand and acquire electronic information processing standards. The various organizations are loosely related to each other and each uses a different numbering and identification scheme. The user groups can help potential standards users sort this out.

Frequently, methods of computerized information interchange become so well known and widely used that they become known as de facto standards, i.e., a standard in fact. Some de facto standards eventually become formalized by national and international organizations. The ASCII characters may be the best known example of a de facto standard turned formal.

Though the standard efforts described in this report seem to specify UNIX-based tools, most are independent of operating environment, and many include counterparts in environments outside UNIX, such as OS/2, MS-DOS, NT, VMS and MacIntosh OS.

Virtually any library application program interface (API), interface, or application needing to be implemented on multiple platforms is a candidate for software standardization.

In addition to software standards for operating systems, etc., ANSI/IEEE has produced a series of standards for software engineering, project management, software documentation, and quality assurance.

3.2.1.1 National Standards

Standards for data processing exist in several forms and have been published by several national organizations, agencies, and associations. Among these are standards of the following titles:

- ANSI - American National Standards Institute
- IEEE - Institute of Electrical and Electronic Engineers
- NIST - National Institute of Standards and Technology
- FIPS - Federal Information Processing Standards
- GOSIP - Government Open Systems Interconnection Profile
- OSI - Open Systems Interconnection
- MIL - U.S. Military Standards.

3.2.1.2 International Standards

In addition to United States national standards, there are international standards organizations. These include the following:

- ISO - International Standards Organization
- ECMA - European Computer Manufacturers Association
- MITI - Ministry of International Trade and Industry
- X3 - Accredited Standards Committee for Information Processing.

3.2.1.3 Standards User Groups

Many user groups have involved themselves in the business of promoting software standards and distributing information on standards. Distributing information on software standards is one of the biggest endeavors of the 1990s. User groups include the following:

- UniForum - formerly /usr/group
- UI - UNIX International
- X/Open - User, vendor group for promoting standards.

3.2.1.4 Open Standards

Generally, open standards are standards that specify interfaces used or presented by open systems, but do not include the implementation. Open standards usually are made available to the public through public domain releases or nonproprietary licensing. Because only the interfaces are specified in open standards, different vendors can use different technologies in their implementations. Thus, vendors compete based on performance rather than on the merits of the user's interface with the software.

Numerous consortiums have been established for the purpose of building and defining open standards. Some are very well known in the community of users; others are not. For example, the following consortiums promote and develop open standards:

- POSIX - Portable Operating System Interfaces, IEEE
- OSF - Open Software Foundation
- COSE - Common Open Software Endorsement
- CORBA - Common Object Request Broker Architecture.

3.2.1.5 De Facto Standards

Another kind of software standard worth considering in some software projects are de facto standards, sort of pseudo standards, which come about as the result of widely used public domain software packages. Some have become de facto standards, not because of the documentation that goes with them or ballot of an agency's membership, but because of their wide application and acceptance among software users of multiple industries.

Examples of such software are RCS, GNU Make, netCDF, and PERL. All these packages have many users. Each is supported through a formal association or agency. Each has been in use long

enough that they are now considered stable for the current state of the art. Their users have set up teleconferencing style interest groups for helping others with problems, sharing of information, and as a kind of informal support mechanism. Documentation and operating manuals are kept up to date. Many are available for use on different kinds of platforms, e.g., UNIX, VAX/VMS, and MS-DOS.

Not all public domain software packages are worth consideration in programs such as AMPS, as not all are as well maintained and as universal as the four examples above. A careful study of any software, and its support history, should be performed before concluding its applicability to the AMPS program.

3.2.2 Data Management Standards Criteria

Standard methods and policies for storing and distributing AMPS data should be adhered to, to promote ease of access by the AMPS data user community. Components of storage and distribution are file systems, archives, and distribution methods.

3.2.2.1 File Systems

In order that data collected under the AMPS project be available for the widest possible community of users and on different platforms, file systems used to store processed data from AMPS missions should conform to well-known file system standards, e.g., NFS and AFS.

Data sets collected in AMPS can be large, and thus file systems of AMPS data hosts must be capable of storing multiples of gigabyte collections of files.

Within a site's local network, it should be possible to cross mount partitions on the AMPS data hosts to both UNIX and PC platforms. It is not necessary to cross mount site-to-site.

A standard directory structure for data stored at AMPS data hosts shall be established. The (sub)-directory naming convention will be made general enough to meet the needs of any data site. Any anomalies to standard names will be accommodated through symbolic directory links.

Path names will be relative to an unnamed root (sub)directory. In this way, entire missions or sets of missions can be moved from site-to-site or copied to another file system without the need for file systems on different data hosts to have the exact same directory setup.

Path names and (sub)directory names shall be chosen and limited to accommodate all file systems adopted for use in AMPS, e.g., UNIX or PC, plus all possible storage and distribution media, i.e., on-line disk files and CD-ROM.

3.2.2.2 Data Archiving

Data sets should be archived on off-line media, i.e., high-density tape or optical media, at regular intervals. Efficient data compression standards for image data exist and will be studied and recommended.

Archived data set media will remain at the site of the data host. Each site will be responsible for maintaining its own physical archival system and for establishing archival methods. Each AMPS site may choose to utilize its own system administration staff to accomplish archiving and backup, using procedures already proven and working. Archival media should be of a reliable industry standard but need not be uniform at every AMPS site.

Once a data set has been archived, it may (or may not) be deleted from on-line storage. The on-line/archived status should be a switch in the on-line catalog for the data set in question. Catalog entries for archived data sets should remain on-line.

A procedure for calling up archived data sets should be defined. This procedure should be uniform across all AMPS data sites, but the implementation at each site might be different. Data sets, thus restored, can be placed back on-line or written to off-line media, e.g., CD-ROM, for distribution to users.

3.2.2.3 On-Line Distribution

Data sites who elect to make files managed at that site available on-line to the AMPS community shall utilize a standard on-line file access and/or transfer method to be determined.

One possible choice for on-line access is the File Transfer Protocol (FTP) of the Internet, the world's largest and best known computer network. An advantage to this method is the wide knowledge of FTP among potential users. A disadvantage is if any AMPS user site(s) only has electronic mail network access.

Another possibility for file access is electronic mail. This method would be an advantage to any user sites only having e-mail access to computer networks. Several of the standards agencies deal with standards for electronic mail, e.g., X.400, which is based on level 4 of the OSI 7 layer protocol standards.

Finally, it is possible for a data host to offer both file transfer and electronic mail services.

3.2.2.4 Off-Line Distribution

Data sites may elect to make files managed at that site available off-line via high density media. Methods and standards for formatting distributions on high-density tape and on CD-ROM will be selected.

Data sites offering off-line distribution should make U.S. Post, electronic mail, and FAX available as ordering methods.

3.2.2.5 Data Catalog

An on-line catalog for AMPS data is anticipated. The goal here is to make each participating host data site responsible for maintaining its piece of the data catalog and to ensure that the master records of the data catalog can be located on their storage.

The catalog sections set up at each participating data site would then become a part of the overall catalog. Thus, catalog users would actually access a distributed database of catalog entries.

Possible tools to accomplish a distributed catalog on a network are the GOPHER and WAIS programs. Both physical and security issues associated with using and setting up software tools for distributed catalogs will be studied and recommended.

3.2.2.6 Information Services

Distribution of information relating to available data at host sites can be accomplished through the U.S. Post, FAX, electronic mail, or a computer bulletin board (BBS) such as USENET.

If the BBS approach is included, then procedures and protocol for using it need to be adopted. The protocol should be documented in a FAQ (frequently asked/answered questions) document available via electronic mail or FTP from the maintainer's host.

3.2.3 Data File Standards Criteria

Standards for data file storage and format will be evaluated. Criteria for evaluation will include, but not be limited to, the elements listed in this section.

Though there may be differences in the data collected by the instruments in the three pods, a goal of this task is to eventually achieve a uniform file wrapper that all data sites can utilize.

3.2.3.1 Raw Data

Each instrument collects certain elements of raw data. It should be possible to recreate the data formats exactly from processed data files. To accomplish this goal, the processed data file cannot contain any floating point data that was derived from integer data. Rather, integer data plus scale factors should be stored to achieve both the ability to extract scaled floating point data or the original raw data.

Whenever possible, raw floating point data should utilize well-known standards, e.g., IEEE-754.

3.2.3.2 Image Processing and Graphics

The file format standard adopted by this data management plan must be able to store and use image data. The term "image data" means pixel data (monochrome or 3-color) arranged in a 2-d rectangle as a digitized picture. Dimensions of the picture and attributes of pixels must be accommodated in the file.

The file format must also support data of graphical orientation, especially data produced by or compatible with geographic information systems (GIS). This requirement is mainly for off-line integration of AMPS data with other (sub)systems.

3.2.3.3 Attributes and Metadata

The file format standard adopted by this data management plan must be able to store and use meta-data, i.e., pseudo-data which describes the data by its attributes.

Metadata can also be used to describe the nature, structure or layout of the file itself.

3.2.3.4 Instrument Differences

Though the goal of this plan is to accomplish a uniform data wrapping method, differences between the instruments of the various pods must be accommodated.

3.2.3.5 Self-Describing Data File

Merits of self-describing data files shall be evaluated for application to AMPS. Some examples are TIFF, CDF, netCDF, and HDF as well as several FIPS publications.

3.2.4 Selection Process

File standards selection shall be driven by a process of finding potential candidates, evaluating them, comparing attributes of each possible solution with the needs of AMPS, and demonstrating selected candidates when possible. This process will be followed by documentation, adoption and subsequent approval of policy.

A similar multi-step process will be used to specify AMPS data management and information service procedures.

3.2.4.1 Investigation

The investigative process will include a literature search for formal standards dealing with data format, image processing, GIS, graphics, and self-describing data.

Open software and publicly available tools and resources will also be searched via tools of the Internet, e.g., ARCHIE, VERONICA, and GOPHER, and documentation available from ES-Net.

3.2.4.2 Evaluation

After performing a reasonable search, PNL will evaluate each data standard to develop a list of potential standards candidates for AMPS. Results of this search will be presented in a memo to participating AMPS team members.

3.2.4.3 Needs of AMPS

A standard information architecture will be proposed via the investigation and evaluation mentioned in Section 3.2.4.2, Evaluation, of available standards through a dialog between AMPS data researchers, pod integrators, and PNL.

PNL anticipates that no one data standard will be universally accepted by the AMPS community and that some compromise and merging of ideas will be necessary to successfully integrate and facilitate AMPS data interchange.

3.2.4.4 Demonstration

Whenever possible, active demonstrations of potential standards candidates will be set up using systems at PNL and participating AMPS sites. This practice should be especially useful in getting to an acceptable and working data catalog design.

3.2.4.5 Documentation

All procedures, protocols, and decisions of the AMPS data management plan implementation will be documented and made available, both off-line and on-line.

FIPS and ANSI standards for software documentation will be evaluated for applicability to the AMPS data management plan implementation.

On-line documentation shall include both ASCII and postscript files. On-line access will be compatible with methods chosen for on-line data distribution; see Section 3.2.2.3.

The formal AMPS data management plan implementation shall be addressed in the FAQ.

Documentation off-line availability shall be via U.S. post, FAX or CD-ROM.

3.2.4.6 Adoption

All facts considered, PNL's recommendations will be forwarded to AMPS program management for their review and approval.

PNL will create and document an implementation plan to bring about a smooth transition to the approved AMPS data interchange architecture and standards.

Appendix A

AMPS Instrument Data Characteristics

1.0 SAR Pod (Pod 1)

1.1 Synthetic Aperture Radar (SAR)

Instrument Description	
Instrument Name	Synthetic Aperture Radar
Manufacturer	Sandia National Laboratories
Serial Number	N/A
Hardware Version	N/A
Operational Ranges (Temp., Altitude, etc.)	Temperature Controlled in pod to be close to laboratory temperature range Altitude Depends on imaging geometry and desired swath width. Roughly 3-15,000 ft AGL. Max:25,000 ft MSL. Slant Range Depends on imaging geometry. 4.3 to 7.8 km nominal.
Performance Parameters (i.e. range of acquisition freqs.)	Center Frequency 14.85 GHz nominal Bandwidth 1m resolution at 180 MHz 3m resolution at 60 MHz
Normal mode of operation	Side looking strip map
Sampling frequency	66 MHz nominal, independent of resolution
Calibration Procedure	Calibrated for range and signal return against a predetermined corner reflector field during initial checkout flights. Afterward, system is self-calibrating. Calibration can be verified as needed against corner reflectors when convenient.
Error Detection/Correction	Skilled operators
Data Recording Capabilities (how long, how much)	Worst case example: 45 GBytes in 1.2 hours with phase histories and 3m data.

Radar phase histories and complex images are stored in flight on tape using an AMPEX DCRSi recorder system. The AMPEX tape cartridge is considered to be the archive media and as such will be maintained at SNL for future use. Since the AMPEX tapes are not considered to be a deliverable, the format of the data stored on those tapes is not included here.

Image data and associated metadata are downloaded post-flight to the delivery media, which is to be CD-ROM or 8-mm Exabyte tape, depending on the size of the data set. The data will be formatted as shown in the following tables.

SNL assumes that phase histories are not a deliverable item at present. A phase history data product, along with associated documentation on its use, could be developed if needed. It would be delivered on Exabyte tape. Image data are currently delivered in GFF format. This format is described in a separate document maintained by SNL.

Data Record - Processed Form	
(Fill out 1 Instrument Data - Processed Form for each named field)	
Record Length	
Names of data fields	Image Data - GFF Format at present
Record structure	
Recording Media	Disk or Exabyte

Instrument Data - Processed Form	
Name	Image Data - GFF Format at present
Source (detector name)	SAR
How generated (conversion process/algorithm)	SAR
Engineering Units	
Normal Range	
Uncertainty	
Structure (8-, 16-, 32-bit, signed) (Precision for floating point)	
Data that may be correlated with this data to assess quality	

Data Description	
Targeted User(s)	Unknown
How will it be used	Unknown
Useful life of the data	Computer tape shelf-life
Aircraft Data Available/Required	Does not require data from aircraft
Meteorological Data Required	Winds at various altitudes. General weather conditions
Forms in which data may be requested	Image data on 8-mm video tape (Exabyte) Images in GFF format.
How data of interest may be identified by users for extraction	

2.0 Multisensor Imaging Pod (Pod 2)

2.1 Wild Heerbrugg RC-30 Large Format Camera

The RC-30 accepts a 400-foot roll of film allowing approximately 420 exposures. There is a manual clock inside the camera that must be set prior to each flight. A flight log is maintained by an on-board operator. Each frame is numbered in sequence with the time, date, and scale. The time interval between exposures is dependent upon the altitude. Overlapping of frames is adjustable. The lens is calibrated prior to the flight. After a flight, the film is processed, proofed, and cut. The photographs may be scanned into a GIS. The photographs are archived at RSL in their Archive for Aerial Film. They are currently attempting to interface the camera to GPS.

Instrument Description	
Instrument Name	Wild RC-30
Manufacturer	Leica
Serial Number	
Hardware Version	
Operational Ranges	
Operating temperature	-40°C to 50°C
RC30 Camera System	-30°C to 50°C
Head of viewfinder/nav. sight	95%
Maximum relative humidity	ICA0 standard atmospheric pressure, altitude
Maximum ambient vacuum	50,000 ft
Performance Parameters (i.e. range of acquisition freqs.)	
Modes of operation	
SINGLE	Single exposure, without FMC
SPIRAL	Serial exposures, controlled by moving spiral, with FMC external exposure release
INTERVAL	Single exposure, with FMC Serial exposures, controlled by intervalometer, with FMC
Exposure counter identifier 3-digit counter	16 possible codes with reset to 000

Instrument Description (contd)	
Shutter speed	$\frac{1}{100}$ s to $\frac{1}{1000}$ s continuously adjustable
Aperture	f:4 to f:22, continuously adjustable
Data Recording Capabilities Marginal Data internal camera status	automatic recording of aircraft voltage, v/h. shutter setting aperture etc.
external data	from aircraft navigation system or computer
any combination	of internal and external data

2.2 Barr & Stroud IR-18 Thermal Imager

The Barr & Stroud thermal imager is a passive thermal infrared sensor that is especially useful for nighttime reconnaissance of heat-generating targets. Operating much like a video camera, the imager is sensitive only to thermal infrared energy. Its lens is a dual, focal germanium telescope offering 2.5X or 9X power options. The system is cooled by a Joule-Thompson gaseous nitrogen unit. Data acquired with the IR-18 is recorded with a TEAC V-80AB-F. This high-resolution video recorder utilizes a Hi-8-mm format, which captures higher frequencies and bandwidths than those from a conventional VHS video recorder. Although this recorder is small and lightweight, its durable, front-loading design operates on unregulated 28VDC, permitting aircraft or vehicular use.

2.2.1 TEAC V-80AB-F Hi-8-mm Airborne Recorder Specifications

General Specifications	
Capability	Record and Playback, Color and Black & White
Tape Type	Hi-8-mm videocassette
Tape Format	Hi-8-mm
Maximum Recording Time	120 minutes
Power Requirement	28VDC (+4V, -8V) unregulated MIL-STD-704C
Power Consumption	15 watts (nominal) at 28VDC (55 watts with optional heater)

General Specifications (contd)	
Dimensions	5.83 in (W) x 4.73 in (H) x 6.11 in (D), excluding connectors, knobs, and buttons
Operational Position	All directions
Installation	Vertical or horizontal, 4 ways
Weight	Less than 3 kg
Connectors	Power: PT02E-10-6P type Control and Signal: PT02E-18-32P type (Optional MIL-STD-38999, Series 3 connectors available)

Functional Specifications	
Remote Controls (Discrete)	STOP, REC, STDBY, PLAY, FF, REW, EMK REC
Remote Controls (RS-422)	STOP, REC, STDBY, PLAY, FF, REW, SEARCH FWD, SEARCH RVS, STILL, INTERVAL REC, EMK REC, TIMER RESET
Local Controls	CASSETTE REMOVE, REC, STOP, STDBY, EMK REC, REW, FF, PLAY
Remote Indicator Signals (Discrete)	STOP, REC, STDBY, PLAY, EOT, DEW
Remote Indicator Signals (RS-422)	STOP, REC, STDBY, PLAY, FF, REW, SEARCH FWD, SEARCH RVS, STILL, INTERVAL REC, EOT, BOT, DEW, CASSETTE IN, UNTHREAD END, THREAD MOTOR ON, TAPE COUNTER, ERROR, COMMAND ERROR, PARITY/FRAMING ERROR
Interface	Discrete or RS-422 Full Duplex

Video	
Video Signal Standard	EIA RS-170 or NTSC
Bandwidth	4MGz
Horizontal Resolution	400-line nominal
Linearity	10 gray scale or better
Signal-to-Noise Ratio	Better than 43 dB
Input	1.0V p-p 75-ohm negative sync
Level Control	Automatic gain control (AGC)
Output	1.0V p-p 75-ohm negative sync
S-Video Input	1.0V p-p (Y), 0.3V p-p (C), 75 ohm
S-Video Output	1.0V p-p (Y), 0.3V p-p (C), 75-ohm

Audio	
Number of Channels	One
Input Level	0.9 V p-p nominal, (-10 dBV)
Input Impedance	10K-ohm 20%
Level Control	Automatic gain control
Output Level	0.9 V p-p (47K-ohm load)
Bandwidth (Frequency Response)	100 Hz to 10 KHz
Signal-to-Noise Ratio	Better than 40 dB

Environmental Specifications	
Storage Temperature	-20°C to +60°C; MIL-STD-810D 501.2(I) and 502.2(I)
Operating Temperature	-15°C to +55°C; MIL-STD-810D 501.2(II) and 502.2(II) (-40°C to +55°C with optional heater)
Altitude	Sea level to 50,000 feet in an unpressurized, unsealed case; MIL-STD-810D 500.2, operating
Storage Humidity	80% (34°C) to 20% (71°C); MIL-STD-810D 507.1(I)
Operating Humidity	Zero to 95% relative humidity (non-condensing)
Explosive Atmosphere	MIL-STD-810D 511.2(I)
Vibration (operational)	MIL-STD-810D 514.3 (use of proper shock mount is recommended)
Acceleration (operational)	10 G's, MIL-STD-810D 513.3, crash safety (operating)
Radio Frequency Interference/ Electromagnetic Interference	MIL-STD-461C
Heater (optional)	Thermostat-initiated at 0°±5°C

2.3 CASI Hyperspectral Imager

2.3.1 Tape File Format

A CASI raw data tape consists of Files and Filemarks. One Filemark is found after every file. Every File has a File Header at the beginning of the file and may contain numerous Frames.

A File Header contains 1024 bytes (1 sector) and is described below.

A Frame consists of one or more sectors composed of a Frame Header followed by one "scan line" of Spatial Mode or Spectral Mode data and then padded to the end of the last sector with ASCII null characters (i.e., binary zeros). The length of each Frame in bytes and sectors is defined in the File Header, as is the length of the Frame Header. The Frame Data is described below as well.

2.3.2 File Header Format

The CASI file header consists of free-format ASCII fields, each separated by an ASCII null character. Each field, with the exception of the first field, consists of a keyword followed by data in ASCII (printable) format. The locations of the fields after the first field may appear in any order, however, they generally are found in the order shown in the example below.

The file header is 1024 bytes long beginning with the string "CasiFileHeader"; after the last field, the header is filled with ASCII nulls. The length of a file header is 1024 bytes.

Sample CASI File Header	
CasiFile Header	Identifies the file as a CASI data file; Marks the beginning of the file header.
Serial Number NNN	Serial number of the CASI on which the data were recorded (used to relate calibration parameters to the data); Serial number NNN is read as: first digit is the series number and the last two digits are the unit number.
Version 1.52E	CASIIS (instrument software) version number
Frame Header Length 64	The length of the frame headers in the current data file in bytes.
Date 1991 09 06	System clock date when the file was written; ANSI YYYY MM DD format.
Time 13 06 10 390	Time the file was opened (F3 - ARM TAPE pressed); provided by the system clock; format is hh mm ss ppp, where "ppp" is milliseconds.
Mode 1	Mode of instrument operation; Modes are: Spatial (0), Spectral (1) or Calibration (2).
Integration Time 1000	Integration Time in milliseconds from the instrument configuration for this data file.
MaxRows 288	Maximum number of rows (in the spectral dimension).
MaxColumns 612	Maximum number of columns (in the spatial dimension). Note: not all of the columns are available for scene information.
Row1 943	Wavelength in nanometers for the first row of CCD pixels.

Sample CASI File Header (contd)	
Row288 426	Wavelength in nanometers for the 288th row of CCD pixels.
G0 9.432092E+002	G0 through G3 are the constants in a fourth order polynomial used to convert a CCD row number to a wavelength. The general equation is of the form: $\lambda = G0 + R \circ G1 + R^2 \circ G2 + R^3 \circ G3$ where λ represents wavelength (nm) and R represents the (CCD row number - λ); These G-values are determined during the instrument calibration process and are stored on the System Disk provided with each calibration.
G1 -1.9555689675E+000	See G0 above.
G2 &.0466699887E-004	See G0 above.
G3 -5.6624412628E-007	See G0 above.
SpectralConfig 182 9 20 288 6454 7	Regardless of the Mode used in data collection, all configuration information for both Spectral Mode and Spatial Mode are stored in the file header. The Spectral Configuration fields are: Scene recovery channel, Number of Looks less ExtraLooks, Look spacing, Center Look direction, Number of bytes per frame, Number of sectors per frame.
SpatialConfig 9 46 49 97 104 122 124 137 144 145 153 161 167 188 194 215 220 257 263 11080 11	See SpectralConfig above; The Spatial Configuration fields are: Number of Bands N, Start Row for Band 1, End Row for Band 1, ... Start Row for Band N, End Row for Band N, Number of Bytes per frame, Number of Sectors per frame.
Flight ID	Ten lines of Flight Identification information are available for user defined information.
Extra Looks 3	The number of Extra Look directions (currently Electronic Offset, Dark Current and Incident Sensor).
Irradiance Sensor 35	Incident Sensor (formerly termed the "irradiance Sensor") column position varies from instrument to instrument.

2.3.3 Frame Data Format

If a frame ("image scan line") contains X bytes of data, then the first sector (1024 bytes) of the data frame consists of FrameHeaderLength bytes of frame header and the balance is filled with (1024 - FrameHeaderLength bytes of) frame data.

The remaining (X - [1024 - FrameHeaderLength] bytes of) data are stored in successive 1024 byte sectors.

2.3.3.1 Frame Header

The frame header currently consists of a four-byte sequence ID, a four-byte date, and a five-byte time stamp. The remaining bytes in this header are not currently defined.

2.3.3.1.1 Sequence ID Field. The sequence ID is a signed 16-bit integer that identifies the frame within the file. The first frame has sequence ID 0, and subsequent frames have a successively higher sequence ID. A 16-bit integer consists of two bytes in low byte -high byte order.

2.3.3.1.2 Date Field. The date field consists of four bytes; the year since 1980, the month, the date, and the day of the week. (Note that the day of the week may not contain valid data.)

2.3.3.1.3 Time Stamp Field. The time stamp consists of five bytes: hours, minutes, seconds, tens of milliseconds, and tenths of milliseconds.

2.3.4 Spatial Mode Data Format

The Spatial Mode data contains "Number of Bands" spectral bands, each containing "MaxColumns" pixels. These pixels are 16-bit values, in low byte - high byte order. The data is ordered in the file band by band starting at the red end of the spectrum. Within each band there are 612 pixels, which are ordered such that pixels from the right-hand side of the scene (view looking down from the aircraft) come first.

2.3.5 Spectral Mode Data Format

The Spectral Mode data contains both "ExtraLooks" plus the "NumberofLooks" look directions, each containing "MaxRows" pixels, and one single row band (Scene Recovery Channel) of length "MaxColumns" interleaved within the look directions. These pixels are 16-bit values, in low byte - high byte order.

2.3.6 Configuration File Format

All values in the Configuration File are in ASCII printable form encoded as decimal values. All values in the .CCF file are stored on a single line and separated by spaces.

Configuration File Format	
<MODE>	Initial mode: Spectral (0) or Spatial (1)
<DISP_BAND>	Initial band in spatial mode that is to be displayed when the Run Screen is entered.
<MOST_SIG_BIT>	The most significant bit used to display scene data on the Run Screen (11 means that the maximum display value is 4095).
<MODE_IT[0]> <MODE_IT[1]> <MODE_IT[2]>	An array of integration times (in milliseconds) used for Spectral (0), Spatial (1) and Calibration (2) modes.
<MODE_MIT[0]> <MODE_MIT[1]> <MODE_MIT[2]>	An array of MINIMUM allowable integration time (in milliseconds) for Spectral (0), Spatial (1), and Calibration (2) modes.
<IT>	Current integration time in milliseconds.
<MIT>	Current minimum integration time in milliseconds.
<TRACK_RECOV_ROW>	Row number of the Spatial Recovery Channel where a full spatial resolution image of a single spectral row (monochromatic) is obtained during the spectral mode of operation.
<NO_LOOK_DIRS>	Number of programmed Look Directions (excluding ExtraLooks).
<LOOK_SPACING>	The number of spatial columns between each look direction.
<CENTRE_LOOK_DIR>	The column number of the center of the look direction set.
<NUM_OF_BANDS>	Number of spectral bands defined in Spatial Mode.
<START_ROW[1]> <END_ROW[1]>	A pair of values that define the CCD rows corresponding to each spectral band.
<START_ROW[MAX]> <END_ROW[MAX]>	There are MAX number of these bands permitted. MAX is currently defined to be 15. All 15 sets are defined here, but unused bands are defined as pairs <0,0>

2.4 First Generation Intensified Monochrome CCD Camera

The COHU 5560 low light camera is a highly sensitive, high-resolution CCD camera. This camera, designed for low light conditions, uses a first generation image intensifier, which is fiber-optically coupled to the CCD image. A summary of the camera's characteristics follows.

Images are recorded with the TEAC V-80AB-F. This high-resolution video recorder utilizes a Hi-8-mm format, which captures higher frequencies and bandwidths than those from a conventional VHS. This is the same recorder used for the Barr and Stroud thermal imager. Its characteristics are given in Section 2.2.1.

Monochrome 5560 CCD Camera	
Resolution	520 TV lines horizontal > 350 TV lines vertical
Sensitivity Full Video Useable Picture	2854 K faceplate illumination 0.0001 fc (0.001 lux) 0.00025 fc
Auto Black	Maintain set-up level at 7.5 ± 5 IRE units if picture contains at 10% black
Signal-to-Noise Ratio	40 dB unweighted, with AGC low and high voltage low, 0.01 fc faceplate illumination, 45 dB

2.5 SONY DXC-750 3-CCD Video Camera

The DXC-750 3-CCD video camera uses high-resolution CCDs, each frame having 380,000 pixel elements. This low-power consumption camera also has low lag and a high resistance to image burning with no deflection distortion. Electronic shutter options enable the camera to produce clear images in still or slow-motion playback even when the objects are moving at very high speed.

Specifications	
Pick-up Device	Interline Transfer CCD
Picture Elements	768(H) x 493(V)
Sensing Area	8.8-mm x 6.6 mm
Scanning System	525 lines, 60 fields/sec. 2:1 interlace

Specifications (contd)	
Sync System	Internal or external with VBS HD/VD
Horizontal Frequency	15.73 kHz
Vertical Frequency	59.94 kHz
Horizontal Resolution	700 TV lines
Lens Mount	Bayonet
Sensitivity	2,000 lux with F5.6, 89.9 % reflectance
Minimum Illumination	20 lux (F1.4 lens, +18 dB gain)
Gain Selection	0, +9, +18dB selectable
Electronic Shutter	$1/125$, $1/250$, $1/500$, $1/1000$, $1/2000$, $1/4000$, $1/10000$
Detail Level Adjustment	Continuously variable
Linear Matrix	ON/OFF selectable
Gamma	ON/OFF selectable
S/N Ratio	60 dB
Operating Temperature	-5°C to +45°C
Storage Temperature	-20°C to +60°C
Power Consumption	28W
Maximum Cable Length	100m
White Balance, Black Balance	AUTO and MANUAL: R, B (GAIN, PEDESTAL)
Color Temperature	3,200°K / 5,600°K selectable
Color Bar Generator	Full field
Weight	Camera head: 600 g (1.32 lb) (without 2.5m cable) 920 g (2.03 lb) with 2.5m cable Camera Control Unit: 6.5 kg (14.3 lb)

Acquired data is recorded with the SONY DVR-2 Portable Digital Cassette VTR. Utilizing a digital recorder removes dropouts which may occur with an analog system.

General Specifications	
Power Requirements	12 V DC
Power Consumption	Approximately 65W
Operating Temperature	0°C to +40°C
Storage Temperature	-20°C to +60°C
Humidity	Less than 90% (relative humidity)
Weight	Approximately 12kg (without batteries and tape) Approximately 16kg (including batteries and case)
Dimensions	14 in (W), 6 3/8 in (H), 16 5/8 in (D)
Recording Format	SMPTE D-2 format
Tracks/Channels	Digital video and audio (4 channels) 6 tracks/1 field Analog audio (cue) 1 track Time code 1 track CTL 1 track
Tape Speed	131.7 mm/sec
Writing Speed (Relative Speed)	27.387 m/sec
Record Time	Max. 94 minutes with M cassette Max. 32 minutes with S cassette
Cassette type	D-1 cassette (M or S size)
Recommended Tape	Sony metal (1500 Oe) tape or equivalent
Error Correction	Correction and concealment (Reed-Solomon code)
Fast Forward/Rewind Time	Within 150 sec. (with 32 minute tape) Within 360 sec. (with 94 minute tape)
Search Mode	±20 times normal playback
Continuous Operation Time	Approximately 100 minutes (with two BP-90A batteries)

Video	
Sampling Frequency	14.3 MHz
Quantization	8 bits/I, Q axis sampling
Channel coding	M ²
Video Bandwidth	0 to 5.5 MHz ± 0.5 dB, 6 MHz $\pm ?$ dB
Signal-to-Noise Ratio	54 dB
Differential Gain	Less than 2%
Differential Phase	Less than 1°
Moire	0
Y/C Delay	Less than 15 nsec
Tilt (Horizontal & Vertical)	Less than 1%
Low Frequency Linearity	Less than 2% (including quantization noise)
Transient Response "K" Factor (2T Pulse)	Less than 1%
Input Level Adjustable Range	± 3 dB

Digital Audio (DA 1 to 4 Channels)	
Sampling Frequency	48kHz (synchronized to video)
Quantization	16 bits/sample
Frequency Response	20Hz to 20kHz +0.5 db -1.0 dB
Dynamic Range	More than 90dB (at 1kHz, emphasis ON)
Distortion	Less than 0.05% (at 1kHz, emphasis ON, operating level)
Crosstalk	Less than -80 dB (at 1kHz, between any two channels)
Wow & Flutter	Below measurable limit
Headroom	20 dB
Emphasis	T ₁ =50 μ sec/T ₂ =15 μ sec, (ON/OFF selectable)
Input Gain Range	$-\infty$ to +12 dB

Analog Audio	
Frequency Response	100Hz to 12kHz ± 3 dB
Signal to Noise Ratio	Better than 44 dB (at 3 % distortion)
Distortion	Less than 3 % (at 1kHz operating level)
Wow & Flutter	Less than 0.2 % (0.5 to 200Hz, NAB unweighted)
Operating Level	+8. +4.0. -22dBm adjustable (LINE IN/OUT) < Factory set +8 dBm > -60 dBs (MIC INPUT)
Input/Output Level Range	$-\infty$ to +6 dB

Input/Output Signal	
Video Input Analog	1.0 ± 0.3 V p-p 75 ohms
Output Monitor	1V p-p 75 ohms
Audio Input Analog (CH 1,2,3,4)	Line Max. +28dBm (Nominal +8dBm) Mic Max. -44dBs (Nominal -60dBs)
Cue	Line Max. +18dBm (Nominal +8dBm) Mic Max. -44dBs (Nominal -60dBs)
Output Monitor L/R	Max +28dBm (Nominal +8dBm)
Headphones	Variable level control by VR
Time Code Input	2.4V ± 1.4 V p-p, 10k ohms, balanced
Output	2.4Vp-p, low impedance, balanced

2.6 Airborne Multispectral Scanner ABS/AMS

The ABS/AMS system data is recorded onto standard 8-mm video tape cartridges. The data structures on tape are files that are created each time the operator issues a record command from the digitizer. Each file will start with a file header and end with a file mark. A new file is started at the current end-of-data, which is indicated by two file marks; one of these marks is removed whenever a new file is written. The tape between the file header and file mark contains an arbitrary number of lines or frames of scanner data. Each frame starts with a frame header followed by blocks of data, one for each channel. The length of each block of data depends on the detector IFOV. When a full field-of-view and 2.5 mrad detectors are selected, the data from each channel is 720 words long. These 720 words consist of 714 digitized scene pixels, 2 digitized reference source values, and 4 ancillary words. Each data word on tape has a width of 8 bits. If the operator selects 12-bit operation, a third channel is included for each pair of channels and is made up of the least significant 4 bits from the two channels.

2.6.1 General File Structure

Each file starts with a 2048 word header. The first four words are the hexadecimal pattern 55 48 46 AA. The complete format is described below.

Each frame of scanner data, which represents all the data from one rotation of the scan mirror, starts with a 70-word header. Similar to the file header, the first four words are the hexadecimal pattern 56 A5 A6 AF. The remaining words contain information current at the start of the scan line such as time and date, the scan line number (incremented each line), navigation data, external data, and thermal reference settings.

Following the frame header are blocks of channel data, one for each detector channel (8-bit mode). The first four words of each block are the gains and offset settings for that channel. Word five is the detector value for the first reference. The last word is the detector value for the second reference. Between the two reference words are the scene data. The standard size of each channel block is 720 words including the four starting words and the two reference values. The current size options are:

TFOV (degrees)	Detector Size (mrad)	Size (words)
86	5.00	360
86	2.50	720
86	1.25	1440

The size of each channel block is constant within any given file on tape.

For 12-bit operation, the least significant 4 bits from each channel are combined to make up a third channel with the channel 1's LSBs in the most significant 4 bits of channel 3 and the channel 2 LSBs in the least significant 4 bits. The gain and offset words of this combined channel will be zero.

Tape Format (8-Bit Mode, 2.5 mrad)		
File Header		2048 bytes
Scan Line 1	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
Scan Line 2	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
•	•	•
•	•	•
•	•	•
Scan Line n	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
	EOF	--

Tape Format (12-Bit Mode, 2.5 mrad)		
File Header		2048 bytes
Scan Line 1	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
	Channel 3	720 bytes
Scan Line 2	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
	Channel 3	720 bytes
•	•	•
•	•	•
•	•	•
Scan Line n	Frame Header	70 bytes
	Channel 1	720 bytes
	Channel 2	720 bytes
	Channel 3	720 bytes
	EOF	--

2.6.2 Detailed File Structure

2.6.2.1 File Header

The file header is described in the following table.

File Header		
Word	Name	Contents
1-4	Start of File	4-word hexadecimal pattern 55 48 46 AA
5-7	Version Number	ABS/AMS software revision number in ASCII.
8	Header Size	Binary value. Currently 70 decimal.
9	Collection Mode	Scanner collection mode (binary): D7 reserved D6 = 8/12 bits, 1 = 12 bits, 0 = 8 bits. D5 = TFOV, 1=86 deg, 0 = 43 deg. D4,D3 = sample interval 00 = 1.25 mrad, 01 = 2.5 mrad, 10 = 5 mrad. D2,D2,D0 = scan speed, 000 = 100 sps, 001 = 50 sps, 010 = 25 sps, 011 = 12.5 sps, 100 = 6.25 sps.
10, 11	Frame Size	Binary value. Number of words in each fame including the frame header.
12	File Number	Binary value. File number, 0 for first file on tape. Increments for each new file.
13-18	Date and Time	Values taken at start of record. Six words BCD of form ddmmyy and hhmmss.

File Header (contd)		
19-102	Detector Information Words	<p>Twelve 7-byte words for each channel. The standard ABS uses the first 2 only (14 bytes), for channels 1 and 2 respectively. The format for each 7-byte word is:</p> <p>Word 1: D7,D6,D5 = Type: 0 = Si, 1 = MCT, 2 = InSb, 3-7 reserved. D4,D3,D2 = reserved: 0 D1,D0 = IFOV: 0 = 1.25, 1 = 2.5, 2 = 5.0, 3 = fault Word 2,3,4: Upper band edge (ASCII) Word 5,6,7: Lower band edge (ASCII) For MCT and InSb: values between 100 and 200 are tenths of microns; values between 200 and 999 are hundredths of microns. For Si: values between 100 to 200 are 10 nm increments; 200 to 999 are 1 nm increments.</p>
103, 104	Channel	The least significant bit of word 103 indicates Ch 1 is active up to D3 of word 104 for channel 12.
105-256	Reserved	
257-1024	ARINC Format Structure	24 fields of 32 bytes. Each field will define the format of one label of the ARINC Raw Data. This information is used to decode the Nav Data.
1025-2048	Comments	Future upgrade for ASCII text entered by the operator prior to starting the record for the current file.

2.6.2.2 Frame Header

The frame header is repeated at the beginning of each scan line and is currently set to 70 bytes long. Reference to file header word 9 should be made to ensure that the current value is used. The revision number reflects any changes made.

Frame Header		
Word	Name	Contents
1-4	Start of Frame	4-word hexadecimal pattern with 56 in word 1 through 4.
5-7	Scan Line Count	3-word unsigned binary value.
8-13	Date and Time	Repeat of format in file header. Time resolution is to nearest second.
14-22	Standard Nav Data	Three 3-byte words of navigation data from the nav data interface. The six words are: Latitude, $\pm \pi$ radians, 18 bits 2's comp Longitude, $\pm \pi$ radians, 18 bits 2's comp Altitude, 0 to 131,072 feet ASL, 17 bits
23-38	Nav Raw Data	A complete 4-byte representation of all data with ARINC label received by the nav interface, including ARINC label. These words allow for the recovery of any other information not included in the list of Standard Nav Data. The ARINC label indicates the content of the data. Labels may not be in order. No attempt is made to time correlate the information. Each value is the most recently received. This data is completely synchronous with the scan speed and sampling for inclusion in these words.
39-46	Reserved	
47-48	Roll Correction	14-bit representation of the system roll correction. Zero indicates no roll. Each count of the most significant 14 bits represents a roll value of 360 degrees/24000
49-50	Pitch (optional)	15-bit representation of aircraft pitch. Each count represents a value of 360 degrees/65536, using the full 16-bit value.
51-54	External Data	32-bit map of the data present on the digitizer rear panel connector J10.
55-58	Aux Ext Data (optional)	For Aux External Data. 0's unless defined otherwise.

Frame Header (contd)		
59-62	Thermal Reference Settings	Two 16-bit values representing the measured temperatures of the two thermal references. A value of 0 = 0 degrees C. The resolution is 1/16 degree, the least significant 4 bits of each value are always zero.
63	File Number	Current file number.
64	Header Size	Size of the frame header.
65	Collection mode	Scanner collection mode.
66-67	Frame Size	Total number of words in each frame.
68-70	Reserved	

2.6.2.3 Channel Data

The first block (nominally 720 words) is the data for the lowest channel number recorded, followed by the data for other channels in order. If in the 12-bit mode, a third block follows, which is the least significant 4 bits for the preceding pair. The lowest channel number occupies the most significant 4 bits of the confined channel. Each channel block has the following structure.

Channel Data		
Word	Name	Contents
1	Reference Gain	The gain (potentially different than the scene gain) applied while the detectors are viewing the references. The value of this word for any combined channel is always zero.
2	Scene Gain	8-bit binary value representing an operator set gain of 0-MAXGAIN. MAXGAIN varies from channel to channel and from system to system. The value of MAXGAIN is determined during system ATP. This gain is applied while the detectors are viewing the scene. The value of this word for channel 3 is always zero.

Channel Data (contd)		
3	Offset	8-bit binary value representing an offset added after the gain value in words 1 and 2. A decimal value of 128 represents no offset. The values can range between VMAX and -VMAX. VMAX for each channel can be found in the system ATP. Combined channels will show zero; same as above words 1 and 2.
4	Scan Line Number LSB	LSB of the scan line number. This provides a convenient marker in the data when viewing it with the monitor oscilloscope.
5	REF1	The digitized detector value while viewing the first thermal reference source. For non-thermal detectors this represents zero energy.
6-LAST-1	Scene	The digitized detector value measured while viewing the scene.
LAST	REF2	The digitized detector value measured while viewing the second thermal reference source. For non-thermal detectors this represents zero energy.

2.6.2.4 End of File

When recording is terminated, the current frame is completed and an end-of-file mark written. An arbitrary number of zeros will end the file to fill out the current recorder block.

2.6.2.5 File Mark

A file mark will be written at the end of each file. This mark is written on the tape by the recorder when commanded by the Digitizer. This mark is identified by the recorder and will not appear in the data stream. The end of each record operation writes two file marks to signify the end of valid data. Starting a new record operation removes the second file mark and starts a new file. Data past a double file mark should be ignored.

3.0 Effluent Species Pod (Pod 3)

3.1 Echelle Grating Spectrometer

The Echelle Grating Spectrometer data are available at three levels of analysis: pixel, spectrum, and chemical mixture. The data are acquired on a two-dimensional array detector having wavelength as one axis and grating order as the second axis. The analog signal intensity from each pixel is digitized by a 12-bit ADC and stored in a 256 x 256 integer array. Pixels can be read out sequentially from the entire array or individual pixel columns may be randomly addressed and read out. Operating (e.g., exposure time) and calibration (intensity, wavelength) data can be stored along with the spectral data. This defines the lowest level at which the raw data are available. Specialized internal cards in an 80386-based computer running MS-DOS are used to operate the detector and to read out and process the data. Custom software from the detector manufacturer is used to operate the detector and collect the data. Data may be integrated on the detector array or multiple spectra can be read out and co-added in the computer's memory. It is anticipated that a full data set will be collected every 1 to 100 seconds. Data storage will be on an internal ruggedized hard disk or on an external drive such as an Exabyte 2.5 GB 8-mm tape unit.

The wavelength calibration of each pixel in the stored array is used to assemble a linear spectrum of the measured signal intensity (absorption) versus wavelength. This representation is the most scientifically useful form of the data. The data can be further reduced as necessary by performing a search of library spectra to determine the identity and concentration of the chemical compounds found in the measured spectrum.

The image file header format is 256 words (512 bytes) long. A sample C program definition of a header structure for storing data is shown for a revision 1 image header. The image data follow the header, and each pixel value intensity takes 2 bytes = 1 word per pixel (data stored as integers). Typically, the bytes are swapped (ByteSwap=00 00) so that the most significant byte (MSB) follows the least significant byte (LSB). The image header information is stored in the order shown below.

Note that if NumFramesSummed is greater than 1, then the data will be LONG integers and the data won't be byte swapped even though the header may be byte swapped. The only way any of your data may currently have multiple frames summed (rather than averaged) is by using the User Software module and incrementally linking it to the main program.

```
#define Header_Size 256 /* # of WORDs in the ImageHeader - see below */
```

```
struct IMAGE_HEADER {
    int ByteSwap;          /* LSB (MSB) is first if 0x0000 (0xffff) */
    int Xsize;             /* # of pixels in a line */
    int Ysize;             /* # of lines */
    int SampleSize;        /* # of WORDs / pixel */
    int RowColOrder;       /* 0000 (ffff) if column (row) major */
    int Yorigin;           /* 0000 (ffff) if lower (upper) left */
    int Year;
    int Month;
    int Day;
    int Hour;
    int Minute;
    int Second;
    unsigned Intensity0;    /* low temperature calib. intensity */
    float Temperature0;     /* low temperature calib. temperature in C (2 WORDs) */
    unsigned Intensity1;    /* high temperature calib. intensity */
    float Temperature1;     /* high temperature calib. temperature in C (2 WORDs) */
    float TargetGain;       /* (2 WORDs) */
    int Revision;          /* revision # (=0 before 12/20/91
                           =1 after 12/20/91,
                           =2 after 05/20/92) */

    int NumFrames;         /* # of frames stored in file (=1 if no buffer board) */
    int UL_Row;            /* upper row (typically = 0) */
    int UL_Col;            /* left column (typically = 0) */
    int LR_Row;            /* lower row (typically = 127) */
    int LR_Col;            /* right column (typically = 127) */
    int NumFramesSummed;    /* # frames summed in each image */
                           /* The following values added with Revision 2 */
    float FrameRate         /* frame rate in Hz */
    float IntegrationTime;  /* integration time in msec */
    int BuffBrdNumFrames[12]; /* up to 12 buffer board sub-sequence */
                           /* frame values */
    int BuffBrdNumSkip[12]; /* up to 12 sub-sequence values for number of */
                           /* frames skipped between each frame in the */
                           /* subsequences listed above. */

    int EmptyBuffer[HEADER_SIZE-55];
};
```

Instrument Description	
Instrument Name	Echelle Grating Spectrometer
Manufacturer	Lawrence Livermore National Laboratory
Serial Number	0001
Hardware Version	TBD
Operational Ranges (Temp., Altitude, etc.)	Sea level to 30,000 ft. -30° C to 60° C
Performance Parameters (i.e., range of acquisition freqs.)	N/A
Normal mode of operation	Infrared focal plane array (256 x 256) captures a frame of spectral information.
Sampling frequency	1 to 100 seconds
Calibration Procedure	Software driven. Infrared array views several black bodies at different temperatures. The frames are stored and used to correct for pixel non-uniformity.
Error Detection/Correction	None
Data Recording Capabilities (how long, how much)	Internal 20 or 40 MB solid-state disk. An external drive may be added for additional capacity

Data Record - Raw Form (Fill out 1 Instrument Data - Raw Form for each named field)	
Record Length	164352 bytes
Names of data fields	Image_Header, Image
Record structure	512 byte header followed by 163840 bytes of data.
Recording Media	Solid-state disk

Instrument Data - Raw Form	
Name	
Source (detector name)	Infrared focal plane array
Form (analog, digital)	Digital
How generated	Output of each array pixel is digitized by a 12 bit A/D
Units (counts, volts, etc.)	Counts
Normal Range	0 - 4095
Structure (8-, 16-, 32-bit, signed)	16 bit word (pixel)
Internally Processed, e.g. averaged? (If so, how?)	Pixel non-uniformity corrected by applying individual gain and offset based on calibration data, global gain, and offset available.
Recording Media	Hard disk
Data that may be correlated with this data to assess quality	None

Data Record - Processed Form	
(Fill out 1 Instrument Data - Processed Form for each named field)	
Record Length	
Names of data fields	
Record structure	
Recording Media	

Instrument Data - Processed Form	
Name	
Source (detector name)	
How generated (conversion process/algorithm)	Raw spectral traces are pulled from frames captured by the focal plane. Traces are compared with internal library of target chemicals. Alarm tripped if match is found.
Engineering Units	N/A
Normal Range	N/A
Uncertainty	N/A
Structure (8-, 16-, 32-bit, signed) (Precision for floating point)	N/A
Data that may be correlated with this data to assess quality	None

Data Description	
Targeted User(s)	
How it will be used	
Useful life of the data	
Aircraft Data Available/Required	
Meteorological Data Required	
Forms in which data may be requested	
How data of interest may be identified by users for extraction	

3.2 Tracking Subsystem

Instrument Description	
Instrument Name	Tracking Subsystem
Manufacturer	TBD
Serial Number	
Hardware Version	
Operational Ranges (Temp., Altitude, etc.)	0 to 15,000 ft.
Performance Parameters (i.e., range of acquisition freqs.)	Black and white TV or 3-5 μm FLIR with minimum FOV of approximately 2.5°.
Normal mode of operation	1. Operator-aided acquisition 2. Auto track
Sampling frequency	60 fps
Calibration Procedure	TBD
Error Detection/Correction	N/A
Data Recording Capabilities (how long, how much)	SVHS or Hi-8-mm video recorder 1-2 hours

Data Record - Processed Form	
(Fill out 1 Instrument Data - Processed Form for each named field)	
Record structure	Video - TV or FLIR imagery RS170 Annotated with azimuth, elevation, time, and trackgate
Recording Media	SVHS or Hi-8-mm

Instrument Data - Processed Form	
Name	Tracking Subsystem
Source (detector name)	TV / FLIR
How generated (conversion process/algorithm)	CCD - TV or Staring FPA - FLIR
Engineering Units	3 x 4 Aspect ratio

Data Description	
Targeted User(s)	Operator identification of targets, track in fly-by
How it will be used	Flight history, debriefing
Useful life of the data	Life of video tape
Aircraft Data Available/Required	Position and velocity
Meteorological Data Required	Meteorological range (Visibility)
Forms in which data may be requested	Video
How data of interest may be identified by users for extraction	Symbology for azimuth, elevation, and time

3.3 Aerial Krypton Grab Sampler

Instrument Description	
Instrument Name	Aerial Krypton Grab Sampler
Manufacturer	Savannah River Technology Ctr.
Serial Number	
Hardware Version	1
Operational Ranges (Temp., Altitude, etc.)	Storage Temp: -20°C to 70°C Operating Temp: 0°C to 40°C Operating Alt: 0 to 15,000 ft

Instrument Description (contd)	
Performance Parameters (i.e., range of acquisition freqs.)	Air Flow Rate: 10 liters/min $\pm 15\%$ 1 to 12 samples
Normal mode of operation	Collection initiated by operator. Sample sequencing and instrument control after initiation is automatic.
Sampling frequency	1 sample every 10 minutes
Calibration Procedure	Air flow rates calibrated against a primary standard or against a NIST traceable standard.
Error Detection/Correction	Collection parameters and instrument state of health monitoring.
Data Recording Capabilities (how long, how much)	Collection parameters, state of health monitoring for duration of mission.

Data Record - Raw Form (Fill out 1 Instrument Data - Raw Form for each named field)	
Record Length	
Names of data fields	
Record structure	
Recording Media	Solid state memory, battery backed.

Instrument Data - Raw Form	
Name	Sampler Operation Data
Source (detector name)	Aerial Krypton Grab Sampler
Form (analog, digital)	Digital
How generated	From sampler operation
Units (counts, volts, etc.)	N/A
Normal Range	N/A
Structure (8-, 16-, 32-bit, signed)	N/A

Instrument Data - Raw Form (contd)	
Internally Processed, e.g., averaged? (If so, how?)	N/A
Recording Media	Solid state memory
Data that may be correlated with this data to assess quality	N/A

Data Record - Processed Form (Fill out 1 Instrument Data - Processed Form for each named field)	
Record Length	TBD
Names of data fields	TBD
Record structure	TBD
Recording Media	

Instrument Data - Processed Form	
Name	Sampler Operation Data
Source (detector name)	Aerial Krypton Grab Sampler
How generated (conversion process/algorithm)	N/A
Engineering Units	N/A
Normal Range	N/A
Uncertainty	N/A
Structure (8-, 16-, 32-bit, signed) (Precision for floating point)	N/A
Data that may be correlated with this data to assess quality	N/A

Data Description	
Targeted User(s)	DOE AN
How it will be used	Target Analysis
Useful life of the data	Unlimited
Aircraft Data Available/Required	Position location during sample collection.
Meteorological Data Required	Temperature, humidity, barometric pressure, wind direction and speed, elevation of sample collection above sea level. Data to be collected periodically throughout sampling period.
Forms in which data may be requested	Diskette
How data of interest may be identified by users for extraction.	N/A

3.4 Intrinsic Ge Detector

Instrument Description	
Instrument Name	Intrinsic Ge Detector
Manufacturer	EG&G ORTEC
Serial Number	?
Hardware Version	?
Operational Ranges (Temp., Altitude, etc.)	?°F to 90°F 0 to 30,000 ft
Performance Parameters (i.e., range of acquisition freqs.)	Sensitive from 40 KeV to ~4000 KeV
Normal mode of operation	
Sampling frequency	10 seconds
Calibration Procedure	Manual with a mixed standard radioactive source.
Error Detection/Correction	None
Data Recording Capabilities (how long, how much)	120 spectra, 8000 channels each. Approximately 2 hrs. of operation.

Data Record - Raw Form (Fill out 1 Instrument Data - Raw Form for each named field)	
Record Length	16•32 KB
Names of data fields	TBD
Record structure	TBD
Recording Media	RAM with battery backup

Instrument Data - Raw Form	
Name	Intrinsic Ge Detector
Source (detector name)	~ 120% EG&G Ge crystal
Form (analog, digital)	Analog
How generated	Direct result of amplified current pulse generated by gamma interaction with Ge crystal.
Units (counts, volts, etc.)	Volts
Normal Range	.002V to 10V
Structure (8-, 16-, 32-bit, signed)	N/A
Internally Processed, e.g. averaged? (If so, how?)	
Recording Media	MCA
Data that may be correlated with this data to assess quality	Calibration data collected from a mixed radioisotope standard source.

Data Record - Processed Form (Fill out 1 Instrument Data - Processed Form for each named field)	
Record Length	16-32 Kb
Names of data fields	TBD
Record structure	TBD
Recording Media	Battery backed static RAM

Instrument Data - Processed Form	
Name	Gamma Spectrum
Source (detector name)	120% IGe
How generated (conversion process/algorithm)	Result of Gamma radiation
Engineering Units	Counts / Energy chnl Pulse height histogram
Normal Range	0 to 8000 chnls each containing a maximum of 2232 counts.
Uncertainty	± 1.5 Chnls
Structure (8-, 16-, 32-bit, signed) (Precision for floating point)	32 bit unsigned / chnl
Data that may be correlated with this data to assess quality	Calibration spectra from standard source + time of day, airspeed, altitude, temperature, humidity

Data Description	
Targeted User(s)	
How it will be used	
Useful life of the data	
Aircraft Data Available/Required	
Meteorological Data Required	
Forms in which data may be requested	
How data of interest may be identified by users for extraction	Consultation with instrument developers in 1st version. Eventually data of interest will be automatically provided.

4.0 Aircraft Data

4.1 Outside Air Temperature System

Instrument Description	
Instrument Name	Outside Air Temperature Gauge
Manufacturer	Unknown
Serial Number	Unknown
Hardware Version	Unknown
Operational Ranges (Temp., Altitude, etc.)	-50°C to 50°C
Performance Parameters (i.e., range of acquisition freqs.)	
Normal mode of operation	Indicates OAT uncorrected for air compression effects.
Sampling frequency	Continuous
Calibration Procedure	Compared against reported OAT statically on deck.
Error Detection/Correction	None
Data Recording Capabilities (how long, how much)	No automated recording

4.2 Garmin GPS 100

Instrument Description	
Instrument Name	GPS 100
Manufacturer	Garmin
Serial Number	

Instrument Description (contd)	
Hardware Version	
Operational Ranges (Temp., Altitude, etc.)	-15°C to 70°C operating -40°C to 70°C storage Humidity 95% non-condensing
Performance Parameters (i.e., range of acquisition freqs.)	Receiver: tracking up to 8 satellites Acquisition time: 2 minutes 2D 2.5 minutes 3D Update rate: 1 sec. Accuracy: Position: 15m RMS Velocity: 0.1 knots RMS Dynamics: 695 knots velocity 3g dynamics
Normal mode of operation	
Sampling frequency	1 second update rate
Calibration Procedure	
Error Detection/Correction	
Data Recording Capabilities (how long, how much)	

4.2.1 Garmin GPS 100 NMBA 0183 Output Interface

4.2.1.1 Electrical Interface

The output signals conform to NMEA 0183. Data is generated at 4800 baud with each character containing 8 data bits, one stop bit, and no parity. There are approximately 3 milliseconds between character starts.

4.2.1.2 General Output Format

The NMEA 0183 sentences output by the GPS 100 in a single "frame" are:

- RMC
- RMB
- ROO
- WPL - (one for every waypoint identifier in the ROC sentence)
- GLL
- PGRMA
- XTE
- BWC

The GPS 100 NMEA 0183 frame is repeated every two seconds. The format of the sentences contained within each frame are shown below.

RMC Sentence Format (GPS and Transit Specific)

\$GPRMC,HHMMSS,A,DDMM.MM,N,DDDMM,MM,W,XXX.X,XXX.X,DDMMYY,XXX.X,B*XX

1 2 3 4 5 6 7 8 9 10 11 12

1. Time (UTC)
2. Position valid (A=valid, V=invalid)
3. Latitude at UTC time (degrees and minutes)
4. Latitude direction (N=north, S=south)
5. Longitude at UTC time (degrees and minutes)
6. Longitude direction (E=east, W=south)
7. Speed over ground (knots)

8. Course over ground or track (degrees, true)
9. Date (day, month, year)
10. Magnetic variation (degrees)
11. Magnetic variation direction (E= east, W= west)
12. Checksum

RMB Sentence Format (Generic Navigation Information)

\$GPRMB,A,XX.XX,L,CCCC,CCCC,DDMM.MM,N,DDMM.MM,W,XXX.X,XXX.X,XXX.X,A*XX
 1 2 3 4 5 6 7 8 9 10 11 12 13 14

1. Position valid (A=valid, V=invalid)
2. Cross track error (nautical miles)
3. Direction to steer (L=left, R=right)
4. Origin waypoint identifier
5. Destination waypoint identifier
6. Destination latitude (degrees and minutes)
7. Destination latitude direction (N=north, S=south)
8. Destination longitude (degrees and minutes)
9. Destination longitude direction (E= east, W= west)
10. Range from present position to destination waypoint (nautical miles)
11. Bearing from present position to destination waypoint (degrees, true)
12. Closing velocity to destination waypoint (knots)
13. Arrival flag (A=arrival, V=not arrival)
14. Checksum

ROO Sentence Format (Route Number 0)

\$GPRO0,CCCC,CCCC,CCCC,CCCC,CCCC,CCCC,CCCC,CCCC,CCCC, , , , ,*XX
1 2 3 4 5 6 7 8 9 10

1-9. Waypoint identifiers of route in sequence

10. Checksum

WPL Sentence Format (Waypoint Location)

\$GPWFL,DDMM.MM,N,DDDMM.MM,W,CCCC*XX
1 2 3 4 5 6

1. Waypoint latitude (degrees and minutes)
2. Waypoint latitude direction (N=north, S=south)
3. Waypoint longitude (degrees and minutes)
4. Waypoint longitude direction (E=east, W=west)
5. Waypoint identifier
6. Checksum

GLL Sentence Format (Geographical)

\$GPGLL,DDMM.MM,N,DDDMM.MM,W*XX
1 2 3 4 5

1. Present latitude (degrees and minutes)
2. Present latitude direction (N=north, S=south)
3. Present longitude (degrees and minutes)
4. Present longitude direction (E=east, W=west)
5. Checksum

PGRMA Sentence Format (Proprietary GARMIN Altitude)

\$GPGLL,XXXXX,f,X*XX
1 2 3 4

1. Present altitude (feet)
2. Units (f=feet)
3. Position fix dimensions (2=user altitude, 3=GPS altitude)
4. Checksum

XTE Sentence Format (Cross-Track Error, Measured)

\$GPXTE,A,A,XX.XX,L,N*XX
1 2 3 4 5 6

1. Position valid (A=valid, V=invalid)
2. Position valid (A=valid, V=invalid)
3. Cross-track error (nautical miles)
4. Direction to steer (L=left, R=right)
5. Units (nautical miles)
6. Checksum

BWC Sentence Format (Bearing and Distance to Waypoint, Great Circle)

\$GPBWC,HHMMSS,DDMM.MM,N,DDDMM.MM,W,XXX.X,T,XXX.X,M,XXX.X,N,CCC*XX
1 2 3 4 5 6 7 8 9 10 11 12 13

1. Time (UTC)
2. Waypoint latitude (degrees and minutes)
3. Waypoint latitude direction (N=north, S=south)
4. Waypoint longitude (degrees and minutes)
5. Waypoint longitude direction (E=east, W=west)

6. Bearing from present position to waypoint (degrees, true)
7. Units (true degrees)
8. Bearing from present position to waypoint (degrees, magnetic)
9. Units (magnetic degrees)
10. Distance from present position to waypoint (nautical miles)
11. Units (nautical miles)
12. Waypoint identifier
13. Checksum

Data Description	
Targeted User(s)	Pod integrators, data analysts
How will it be used	Position and attitude of aircraft
Useful life of the data	Unlimited
Aircraft Data Available/Required	N/A
Meteorological Data Required	N/A
Forms in which data may be requested	Unknown
How data of interest may be identified by users for extraction	?

4.3 P3 Inertial Navigation System

Instrument Description	
Instrument Name	LTN-72 Inertial
Manufacturer	Litton Aero Products
Serial Number	N/A
Hardware Version	Standard P-3 fleet version

Instrument Description (contd)	
Operational Ranges (Temp., Altitude, etc.)	Warm up to nominal temperature - 15 minutes 0 to 500 knots 0 to 40,000 ft
Performance Parameters (i.e., range of acquisition freqs.)	
Normal mode of operation	Inertial Mode Attitude only as backup if inertial dumps in flight
Sampling frequency	24 Hz
Calibration Procedure	US Navy Maintenance as required Maximum allowable error 1NM/hr
Error Detection/Correction	Post flight and in-flight by navigator
Data Recording Capabilities (how long, how much)	None

Data Record - Raw Form	
(Fill out 1 Instrument Data - Raw Form for each named field)	
Record Length	
Names of data fields	True HDG, N-S Vel, E-W Vel, Pos LAT, Pos LON, WPT LAT, WPT LON, Pitch, Roll, Drift Angle, TAS, MAG HDG
Record structure	
Recording Media	

4.3.1 Litton Inertial Navigation System Data Description

Each aircraft has dual independent systems. The following excerpt describes data generated by the Litton Inertial Navigation System:

In the P-3B only, waypoint words are normally coded "no computed data" unless 1) the operator selects RMT and WPT on the CDD or 2) the operator inserts waypoint latitude or longitude. When the operator selects RMT or WPT, all eighteen waypoint LAT/LON words are output with valid data, in one 64-word cycle. The output then returns to transmission of no computed data in the waypoint words. When the operator inserts a Waypoint Latitude or Longitude, the INS utilizes the next available

64-word cycle to transmit the inserted valid data in the appropriately numbered waypoint words. The output data then returns to transmission of no computed data.

In the data field, bit 32 is odd parity, bits 31 and 30 are the sign matrix, and bit 29 is the MSb. The label field comprises the first 8 bits and is in accordance with ARINC 419.

4.3.1.1 Output Bus 2 (JID-19 through 23)

Output Bus 2 outputs a combination of binary, BCD and packed words that is aircraft-dependent. The relationship is as follows:

- Binary on all aircraft: Velocity north, velocity east, roll, pitch, true airspeed, drift angle, Mag HDG, and waypoint data.
- Binary on all aircraft except SP-3: BCD on SP-3: True heading, latitude, and longitude.
- BCD on all aircraft: distance to go, and ground speed.
- Packed words on all aircraft: distance traveled, waypoint counter, INS status, and AMC out 1, 2, 3, and 4.

4.3.1.2 Binary Data Description

Parameter	Label B	Units	MSB	Significant Bits
True HDG	014	Radians	pi	12
N-S Vel	066	Ft/Sec	540.01664	14
E-W Vel	067	Ft/Sec	540.01664	14
Pos LAT	010	Radians	pi/2	17
Pos LON	011	Radians	pi/2	17
WPT LAT	133	Radians	pi/2	17
WPT LON	133	Radians	pi/2	17
Pitch	135	Radians	pi/2	12
Roll	017	Radians	pi/2	12
Drift Angle	006	Radians	pi/2	12
TAS	033	Knots	500	12
MAG HDG	114	Radians	pi/2	12

Instrument Data - Raw Form	
Name	LTN-72 Inertial
Source (detector name)	Internal
Form (analog, digital)	Binary
How generated	ARINC 419 Format
Units (counts, volts, etc.)	
Normal Range	
Structure (8-, 16-, 32-bit, signed)	
Internally Processed, e.g. averaged? (If so, how?)	
Recording Media	
Data that may be correlated with this data to assess quality	GPS position, groundspeed

Data Record - Processed Form	
(Fill out 1 Instrument Data - Processed Form for each named field)	
Record Length	
Names of data fields	
Record structure	
Recording Media	

Instrument Data - Processed Form	
Name	
Source (detector name)	
How generated (conversion process/algorithm)	
Engineering Units	
Normal Range	

Instrument Data - Processed Form (contd)	
Uncertainty	
Structure (8-, 16-, 32-bit, signed) (Precision for floating point)	
Data that may be correlated with this data to assess quality	

Data Description	
Targeted User(s)	
How will it be used	
Useful life of the data	
Aircraft Data Available/Required	
Meteorological Data Required	
Forms in which data may be requested	
How data of interest may be identified by users for extraction	

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