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Common Sensor Integration Requirements for NASA Research Aircraft: Preliminary Assessment and Roadmap

29 December 2009

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[2]NASA Ames Research Center

Prepared for:

Andrew C. Roberts
Airborne Science Program
NASA Headquarters
Washington, DC 20546-0001

Contract No. FA8802-09-C-0001

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1. Introduction

NASA operates a large number of different aircraft that serve as platforms for scientific research and engineering development in support of national objectives. These aircraft cover a very wide range of altitudes, mission durations, crews, and capabilities. They carry a large variety of important instruments from a spectrum of government agencies, universities, industry, and international sources. Finally, they are operated by different NASA centers. In this report we use the words "aircraft" and "platform" interchangeably.

At the present time these platforms all have independent and unique processes, paths, and documentation to integrate scientific instruments and other sensors for missions. In addition, each platform has unique technical requirements. This system can be cumbersome for instrument Principal Investigators (PIs), making migration of instruments from one NASA aircraft to another time-consuming and expensive.

In order to investigate how to increase cross-platform interoperability, NASA formed the Joint Airborne Science Sensor Integration Working Group (JASSIWG). The WG has the responsibility to make sure a plan is designed and implemented to enhance cross-platform interoperability within the constraints of costs, benefits, and schedules.

Attendees of the first JASSIWG meeting in early FY08 agreed that NASA should be able to provide the science community with a more consistent and standardized set of information, design requirements, and processes so that instruments can be designed and operated in a more cross-platform manner[1]. Such commonality and transportability will increase opportunities for the community of investigators, the airborne science platforms, and NASA management to meet airborne science goals. The structure and implementation of cross-platform interoperability should not impact safety of flight or mission assurance, the procedures for which are well-established and managed at each of the centers. The overall goal is to promote portability of aircraft-based instruments, in the design phase where possible (e.g., new or in modification), in order to increase the utility of NASA research aircraft as national assets supporting PIs from the full spectrum of research agencies and organizations. Increasing portability and aircraft utility will also lower costs and increase the timeliness and value of scientific data.

The JASSIWG recognizes that the process of increasing sensor interoperability could impact a number of organizations and existing processes. The WG identified the major stakeholders as:

- Scientific community
- NASA Airborne Science Program
- Aircraft Engineering (AE) support organizations for each platform
- Intercenter Aircraft Operations Panel
- NASA Earth Science Project Office (ESPO)

While the general concept of implementation of common requirements across different platforms leading to increased operations and mission flexibility is a good one, implementation of common requirements across a variety of payloads and carriers is, in general, difficult and the benefits so derived carry offsetting costs. These may include uncertainty in the interpretation of data obtained from different aircraft, time spent conforming to the new common and integrated system, and initial perceptions that the previous system, while arbitrary, was at least understood on its own terms. While we acknowledge the costs as well as the benefits of common requirements, it is not the purpose of this study to perform a detailed cost and benefit analysis of common integration requirements. Rather we begin with the assumption that a system of common integration requirements will provide more science data, at lower cost, and in a timelier manner than would be possible were the current system carried forward.

It is important to note that the concepts proposed at the JASSIWG meeting do not involve changing or revising requirements on the instruments carried by the aircraft, or adding new requirements. Rather, the concept in this early stage is to create a union of information and documentation that can serve the needs of all aircraft.

1.1 Purpose

The purpose of this document is to present:

- The rationale and goal of developing a set of common documentation requirements to serve across NASA airborne platforms.
- Recommendation of a three-phase (Phases A, B, and C) approach to meet this goal.
- Details of the first phase (A) activities and implementation plan
- A general outline of the second phase (B) of the plan in order to complete the overall goal.
- A definition of Phase C, including the effort end state and final products.
- The Phase A deliverable report.

1.2 Phase A Study Products

The JASSIWG identified three areas for initial focus that, while only the first steps toward the ultimate goal of common instrument requirements, would lay the foundation for success. The three focus areas and associated analysis products were to be completed by the end of FY 08.

Two interacting sets of requirements form the basis for definition of the study products. First, there are requirements that an instrument or sensor levies on the aircraft that naturally divide into science-based flight regime requirements and engineering-based aircraft system requirements. These requirements levied on the platform must be met for successful data collection and to determine which of the NASA research aircraft could be requested to carry a particular instrument. This is determined by the PI. Second, there are requirements levied on the instrument by the aircraft for safety, operations, interference, and certification purposes that naturally divide into engineering and operational requirements.

The first study product focuses on the ability of the PI to effectively determine which platforms meet the science requirements. The second focuses on both the science and engineering requirements, and the third focuses on the engineering requirements with respect to the information required by AE. At this juncture, all of the products are proposed as guidelines for use by the Airborne Science community, and should be tailored to each unique situation.

1.2.1 Unified Aircraft Performance and Instrument Design Criteria

This product is a matrix compilation of performance characteristics and design requirements for airborne science platforms in a common format. Coverage is limited to the eleven airborne platforms selected by the working group: DC-8, ER-2, G-3, Ikhana, Global Hawk, WB-57, P-3, B-200, S-3, Twin Otter, and Learjet 25 (see Table 1 in Section 2). The performance data should be sufficient to allow PIs to identify which aircraft meets the flight requirements of the instrument and associated science. That is to say, a PI new to the NASA research aircraft fleet should be able to determine which aircraft can successfully fly the PI's instrument to the required atmospheric regions, for the required period of time, and perform the particular flight maneuvers required. The design criteria data are sufficient to allow first-order analysis of instrument demands on aircraft systems and integration constraints to improve multiplatform interchangeability of instruments. The common matrix format allows for efficient comparison across the aircraft. However, this information should be primarily used for reference and comparison purposes. Detailed or specific aircraft performance and accommodation issues should be directed to the appropriate aircraft management organization.

1.2.2 Common Experimenter Handbook (CEH) Format

This product is a common format for the Experimenter Handbook (EH) that is issued by each platform in order to guide PIs in experiment design, fabrication, integration, test, and mission planning. A proposed CEH is provided in Appendix 2; it serves as a table of contents for all EHs to follow as part of regular rewrites, construction of new EHs for aircraft that do not yet issue one, or anytime one of the covered aircraft will issue a new (version) of the EH. The content is general enough to encompass all of the aircraft and present EH data in a consistent scope and format.

1.2.3 Common Payload Data Package (CPDP) Format

This product is a format and questionnaire to guide PIs on how to produce a document to transmit information regarding instrument characteristics. The CPDP questionnaire is to be constructed in a way to be sufficient to serve the needs of aircraft engineering organizations for all the covered platforms. The CPDP is to be used initially for instruments in the phases of design, re-design, or migration to a new platform. The purpose of the CPDP is to present in a normalized format the following aspects of information flows from the PI to AE: design, flight requirements, operations, hazards, and rationale for platform selection. The questionnaire presented in Appendix 3 serves as the template for a form-based application that would automatically generate the CPDP from the PI responses prompted by the questionnaire.

2. Problem Description and Study Approach

2.1 Current Instrument Integration Process

A documented process must be followed in order to successfully integrate and fly hardware (hereafter, "instrument") on one of NASA's airborne platforms. Figure 1 shows a generalized process flow of the actions between the instrument Principal Investigator (PI) and the Aircraft Engineering (AE) organization, which has responsibility for integration of the instrument onto the aircraft. Each platform currently has separate and unique versions of this flow and Figure 1 is meant only for general discussions. Note that the external information inputs to the aircraft selection and PDP steps are many-valued and possibly conflicting.

The first step in the process is for a PI to determine and select which aircraft meets the flight requirements associated with the measurement. The PI then prepares and submits a Payload Data Package (PDP) to platform AE. AE then conducts a suitable technical review of the information in the PDP to determine if the instrument meets the platform-specific technical requirements (materials, safety, strength, etc.) and confirms that the platform can support the technical needs of the instrument (inlets, space, power, control, etc.). The PDP is critical for this process. In almost all circumstances a feedback loop—including both the PI and AE—takes place to ensure that the PDP contains all of the information required by AE to successfully evaluate the suitability of the PI's proposed hardware, software, and operations and identify shortfalls in the instrument design, construction, or operations or the interface between the two. Modifications are often the outcome of this process. After AE review (which varies from platform to platform) requirements are met by the PI, the instrument can be integrated onto the platform for test and flight. In this model the main communication between the PI and AE during the PDP preparation phase and before the determination that the instrument meets the aircraft requirements.

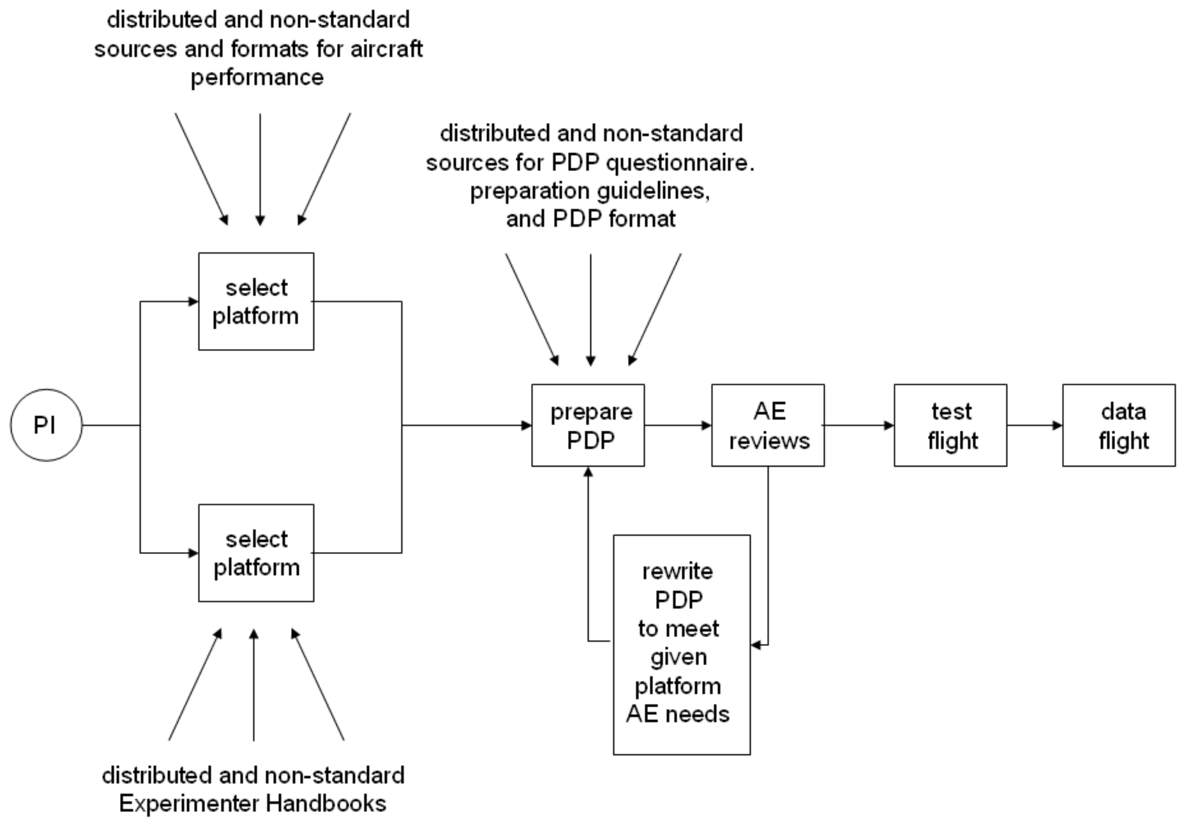

Figure 1. Representation of integration process required to fly an instrument on one of the NASA aircraft platforms. The process details are different for each platform. The AE reviews could include Preliminary Design, Critical Design, Operational Readiness, Flight Readiness, Safety, or Pressure Systems.

This process suffers from a number of serious weaknesses and inefficiencies that increase cost, schedule, and the "hassle factor" for a PI and AE. First, platform selection, which should be done by the PI to meet science driven requirements, is often done in part by AE since clear and consistent aircraft performance information has not historically been readily available. PIs are often unsure of where to find flight performance data and encounter conflicting information. Indeed, the internet has led to a proliferation of aircraft information of uncertain accuracy and sophistication. Often the information assumed by a PI is determined by AE to be incorrect or misleading.

Second, there is no standardization or quality control over PDP generation and so PIs (particularly PIs moving from one platform to another) often do not know, or are unaware of, how to meet the information needs of AE as represented by the PDP. Here again the proliferation of non-standard information can cause inefficiencies. For example, a PI will often use a colleague's previously prepared PDP for one aircraft as a model for interacting with a different aircraft, which exacerbates the feedback loop in Figure 1. Most platform AE organizations do not have PDP templates or formats and those that do are all unique, having been developed informally over a long period of time. Often a PI carries over documentation (oftentimes outdated) from one platform to another in a way that does not meet the information needs of the new platform, so the PDPs are generated on an aircraft-by-aircraft basis. Thus the PDP becomes part of the feedback process in a way that is time-consuming, inefficient, and inflexible. Often a new PI approaches AE completely "cold" and has little direction on how to generate a PDP or is not familiar with aircraft performance and so is unsure of the ability of a given platform to meet flight requirements.

It should be noted that integration and approval processes can be quite different for the various aircraft platforms and between the various centers. For some platforms, such as the DC-8, much of the payload data package is produced by the National Suborbital Education and Research Center (NSERC) in cooperation with the instrument PI, while for other platforms, it is often the sole responsibility of the instrument PI to produce the payload package. Also, the data package can be frequently updated based on interaction between the PIs and aircraft organizations during the integration process.

Table 1 shows some of the documentation status for the aircraft selected for this study. A formal Experimenter Handbook has been issued for six of eleven aircraft, while a PDP formal preparation document (often referred to as a questionnaire) has been issued for three of eleven. Of these documents, there is no uniformity in scope, coverage, or organization, and thuse corresponds to the variable external information flows in Figure 1. This means that for a PI wishing to integrate a new (or newly modified) instrument on one aircraft or plan to integrate a single instrument (new or existing) on more than one aircraft, there is no single source for determination of performance and design requirements. The variation in (or lack of) documents is the cause of lost time, added cost, missed new flight opportunities on different aircraft or missions, and leads to a pattern of inefficiency with regard to the sue of NASA aircraft. Table 1 and Figure 1 make clear the need and motivation for developing common information flows, documents, and requirements.

Table 1. Aircraft Documentation Status.

Platform	Experimenter Handbook	Payload Data Package	Web Site
DC-8	June 2002 - Update currently in work.	Draft Science Investigator questionnaire in work.	archive.nserc.und.edu/filedump
ER-2	Last update August 2002.	Experimenter worksheet (4-02).	http://www.nasa.gov/centers/dryden/aircraft/ER-2
Ikhana	User's guide completed - contains proprietary information.		http://www.nasa.gov/centers/dryden/aircraft/Ikhana
G-III	Exp handbook approved 4-07.		http://www.nasa.gov/centers/dryden/aircraft/G-III
Global Hawk	User's guide updated (8-07). Revised experimenter handbook in mgmt review.		http://www.nasa.gov/centers/dryden/aircraft/GlobalHawk
WB-57	User guide last updated 2-02. Subsequent A/C on web site.	Sample PDP on web site.	http://jsc-aircraft-ops.jsc.nasa.gov/wb57
B-200	No handbook.	None to date.	
P-3	Draft completed & under review - release expected 11-08.	Experimenter Questionnaire updated 9-07.	http://wacop.wff.nasa.gov/LAAPBDesc.cfm
Learjet 25	Completed and issued - 5-08. Manual # GLM-7900.7		http://www.grc.nasa.gov/WWW/AircraftOps/Learjet.html
S-3	No handbook.		http://www.grc.nasa.gov/WWW/AircraftOps/S3BViking.html
Twin Otter (DHC-6)	No handbook.		http://www.grc.nasa.gov/WWW/AircraftOps/TwinOtter.html

Recognition and discussion of inefficiencies and problems with the current uncoordinated approach to instrument integration were the basis for the 2008 JASSIWG meeting. The mitigation of these shortcomings were determined to be in the area of commonality and standardization of instrument integration information requirements and process flows. The WG accepted the notion that the long-term goal of this effort—that is, a set of common integration requirements—must be realized in steps. The first step is to identify common information needs and is the subject of the analysis products discussed above. The second step is to analyze the engineering requirements placed on the instruments by the aircraft and place them on a comparative basis, possibly including modification of some existing requirements, in order to increase the range of potential aircraft deployment options for a given instrument.

2.2 Benefit of Common Integration Requirements

The goal of the JASSIWG charter is the design and implementation of a process that is unified and common to the greatest degree possible, while still retaining flexibility. In the revised process, the PI can quickly and effectively determine if an instrument meets the requirements for a particular platform, where the shortfalls are, and implement suitable modification *before* submitting information to AE. The PI and AE would be confident that an instrument meets (or a plan is in place to meet) aircraft requirements and that the platform can meet the instrument requirements prior to detailed work with engineering. In addition, the new process would allow a PI to design or modify an instrument to easily migrate from platform to platform with a clear understanding on both sides of the integration interface (i.e.), PI and AE that requirements and constraints are met. Figure 2 shows the proposed process in which there are single-valued external information inputs regarding aircraft performance, EHs, and format and data content of PDPs. Theoretically, since the AE organizations know that the PDP so prepared will contain the information required to proceed to the review process, the PDP preparation feedback loop is no longer needed.

This improved process shown in Figure 2 would serve a number of purposes. First, it would streamline the process for a PI to fly an instrument on more than one platform (for different field campaigns, for example.) Second, it would assist a new PI in the design process. Lastly, it would allow platform AE to more effectively consider new instruments, serve a greater variety of PI users, and better manage integration of a large number of instruments for field campaigns. This will result in greater efficiency on everyone's part.

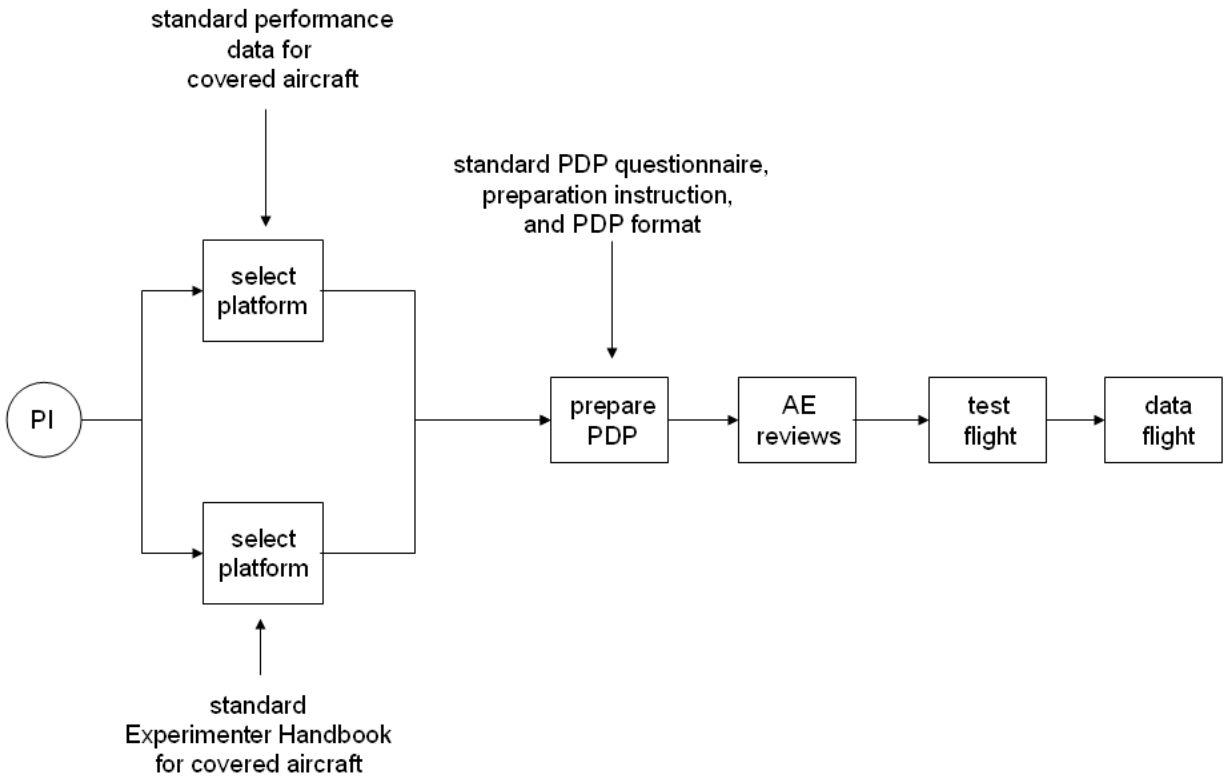

Figure 2. Proposed improved process under the JASSIWG goals.

There are logical limits to commonality, however, and an appropriate degree of feedback and interaction between a PI and individual platform engineering is both necessary and desirable. Still, the approach presented here provides a useful first step toward unification across NASA aircraft.

A pragmatic view of the information required by a PI to determine (1) which aircraft are likely to meets the science requirements of an instrument, (2) which of these aircraft are likely to meet the engineering requirements of the instrument, and (3) whether the PI's instrument (or design) meets the hardware and operational requirements imposed on the instrument by the aircraft.

The problem can be considered as a three-dimensional space of flight performance, instrument accommodation, and instrument design requirements where each dimension can take on up to eleven values corresponding to the eleven aircraft. Thus an arbitrarily new (that is, perfectly unfamiliar NASA Airborne Science aircraft) PI sees more than a thousand possible ways to fill the requirements, a daunting task. The piecemeal and informal way that PIs have used to narrow the possible ways to fly an instrument is (1) wasteful and inefficient, and (2) leads to the focus on only a single aircraft, usually the first one that seems to meet the PI requirements.

A better way would be to formalize the process with common information, common processes, and common documentation. This way a new PI could quickly determine all of the cases (that is to say, platforms) in the requirements three-space (of eleven coordinates per dimension) all of the science and engineering requirements are or could be met.

2.3 Aircraft Covered

The JASSIWG determined that, in order to be most effective at this time, a suitable subset of all NASA aircraft should be at first covered by the common requirements work. These were determined based on (1) scientific utility, (2) general payload characteristics, (3) known, existing common aspects, and (4) to constrain the scope of work to what could be reasonably accomplished with the available resources. Table 2 presents the determination of the JASSIWG as to the list of NASA aircraft to be covered by the proposed process and documentation. Note that the list includes manned and autonomous aircraft across five NASA centers and facilities. The eleven aircraft to be covered marks the present effort as ambitious, without overreaching to the point of increasing the risk of failure. Further, since the included aircraft are managed by five NASA centers and facilities, and since much of the integration process (Figures 1 and 2) is determined by center practices, the selected aircraft are a good choice for the initial phases of the work. The long-term goal will be to include as many additional NASA airborne science aircraft as appropriate. These initial phases will serve, to some degree, as a guide for the process of constructing a common set of integration requirements.

Table 2. Aircraft Covered by Proposed Process.

Platform	Lead Center	POC	Phone
DC-8	DFRC	A. Webster	701-330-7090
ER-2	DFRC	M. Kapitzke	661-276-2575
Ikhana	DFRC	K. Howell	661-276-3654
G-III	DFRC	M. Holtz	661-276-3934
Global Hawk	DFRC	M. Graham	661-276-3202
WB-57	JSC	S. Baccus	281-244-9807
B-200	LaRC	R. Yasky	757-864-2251
P-3	WFF	M. Cropper	757-824-2140
Learjet 25	GRC	E. Emery	216-433-5694
S-3	GRC	E. Emery	“
Twin Otter (DHC-6)	GRC	E. Emery	“

3. Path to Common Integration Requirements

3.1 Overall Plan

In order to move toward the JASSIWG goal we propose a three-phase effort. Such a stepped approach is suggested by the need to collect input and gain concurrence from a large number of stakeholders and organizations that have not historically had significant interaction, even informally.

The first step, Phase A, is limited to creating uniform formats to accommodate the top level information flows between investigators and aircraft engineering. This includes formalization of the main documents passed between NASA and scientists prior to flight on NASA aircraft. This commonality of information flows also has the effect of formalizing and streamlining the communication process. Synthesis of common documentation does not directly affect local (i.e., NASA center) procedures and processes. Phase A streamlines the communication but does not affect the data in the communication stream.

The second step, Phase B, is more ambitious. Initially Phase B will assess the potential for making the requirements of the aircraft on instrument design and fabrication more uniform and, in some cases, common. In this case the potential exists to change some requirements in a way that both increases sensor transportability and does not materially affect local procedures and processes.

After NASA determined a need for improved sensor integration across its aircraft, the JASSIWG issued initial goals to guide the first phase of the analysis. This report is the result of that analysis. Proposed new documents will be distributed for review and comment to the WG and to all stakeholders in the process. A second JASSIWG meeting will be held to review the revised documents and issue concurrence on the revised documents and proposed plans. A final technical report will be issued, and upon the direction of the Airborne Science Director, the Phase A plan will be implemented and the Phase B study started.

The final phase, Phase C, will focus on the final product of this process: a single common design requirements document that covers all aircraft and minimizes to the extent feasible differences between aircraft requirements.

3.2 Phase A

3.2.1 Phase A Objectives

The objectives of Phase A are twofold. First, Phase A will serve as a way to develop the contacts and discussions needed to make progress in the future. Second, Phase A will result in a common information interface between PIs and AE.

The latter objective in turn has three parts. First is to make common the description of aircraft capabilities so that PIs can review and select the appropriate platform that meets the science and top-level requirements of the instrument. This decreases the time required for AE to make what are *de facto* science decisions regarding the suitability of a given aircraft for data collection.

Second, a common format is needed for aircraft Experimenter Handbooks. Some platform AE organizations issue such a handbook to guide the PI in basic design and planning; some do not. The construction (if new) and reconstruction (if existing) of EHs into the common version should only be done once, so agreement and consensus on the concept and format must be widespread before actual rewriting of legacy EHs begins. Accordingly, Phase A would only include the proposed common format for the Common Experimenter Handbook

Third is the notion of a common payload data package, the CPDP. A CPDP, owned by PIs with a "guarantee" of a kind that the document will be accepted by any of the AE organizations (at least as an initial version) in order to begin the integration process, will decrease the paperwork required by PIs, increase the cross-platform science support of NASA aircraft, and decrease the workload on NASA AE.

Figure 3 shows the simplification that will result from the adoption of a CPDP. The left panel shows the current situation: each platform has information requirements that have only small commonality with the requirements of other platforms. This lack of commonality comes about because the requirements are informal, variable with aircraft, variable with center, and often based on heritage processes. The right panel shows the goal of the Phase A CPDP: the information requirement has been made common across all platforms. The CPDP is the union of information requirements of all platforms. We acknowledge that each aircraft has unique requirements. We emphasize that the commonality here is the sum of all requirements with redundancy removed so that nothing will be lost.

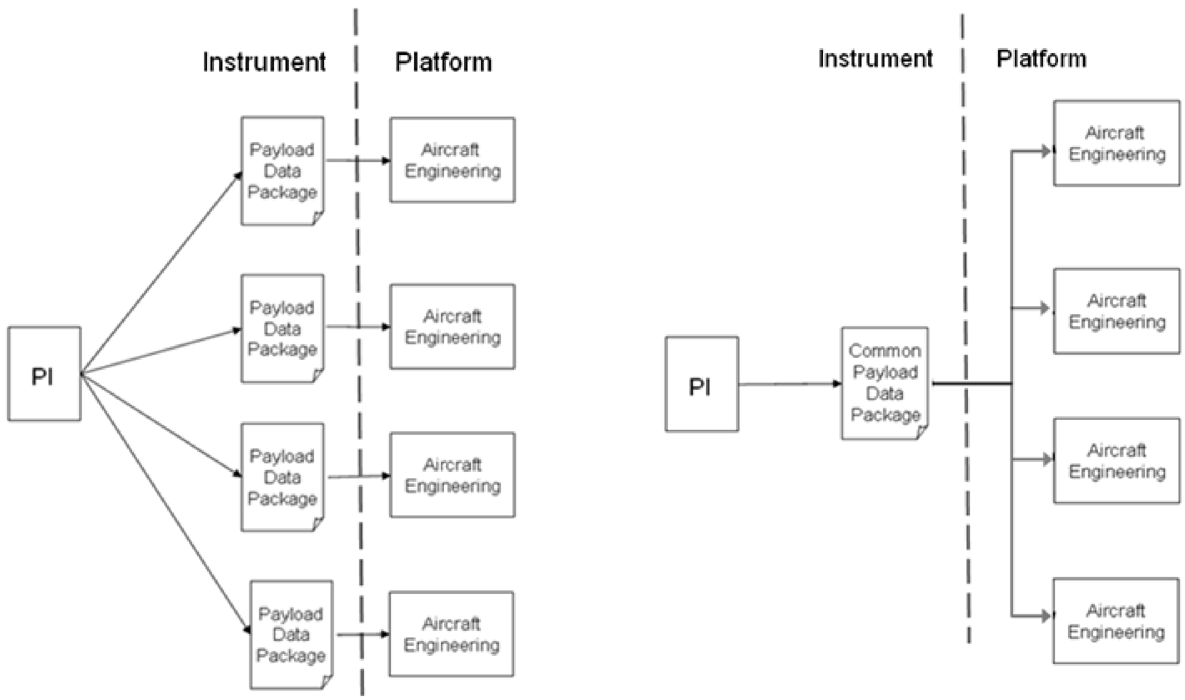

Figure 3. Schematic of documentation flow between PI and AE to meet AE information requirements. The left panel shows the current situation where a PI has as many interface documents as desired platforms. The right panel shows the situation following implantation of Phase A where there is a single interface between a PI and AE, the CPDP.

In addition to the CPDP, two other areas of common information flows were identified by the JASSIWG. These are related to the quality of information that a new PI needs in order to best make use of NASA aircraft for planning purposes.

First, PIs require an agreed-upon set of performance specifications and descriptions for the covered aircraft, focused on top-level information that allows a PI to quickly determine which aircraft can place a sensor in the right place for the right period of time. Second, they require quidelines for instrument design and preparation for missions.

3.2.2 Phase A Implementation Process

The management of the Phase A plan is shown in Figure 4. The analysis of work to determine the scope of the problem and propose a roadmap to implementation of a solution (the results of which are presented in this document, involved the (1) collection, validation, and organization of existing information from the platforms, (2) identification of the problem, and (3) notional development of a path forward.

We are proposing that the Phase A documents be reviewed by all stakeholders, that the JASSIWG concurs on the adoption and deployment of the revised documents, and that the Airborne Science management approves the implementation of the Phase A documents. It is important to note that the two main players, the PI community and platform AE, do not have directly approval of the documents or processes. As critical stakeholders, the PIs have a review and concurrence role. Most importantly, each AE has approval, through the WG.

Key factors that determine the implementation plane are (1) ensuring all stakeholders have an opportunity for input, (2) obtaining concurrence from the WG, and (3) ensuring that the original goals of the JASSIWG are incorporated into the plan. This Technical Report serves as the "Draft Report" document for distribution to the WG and other stakeholders for review and comment.

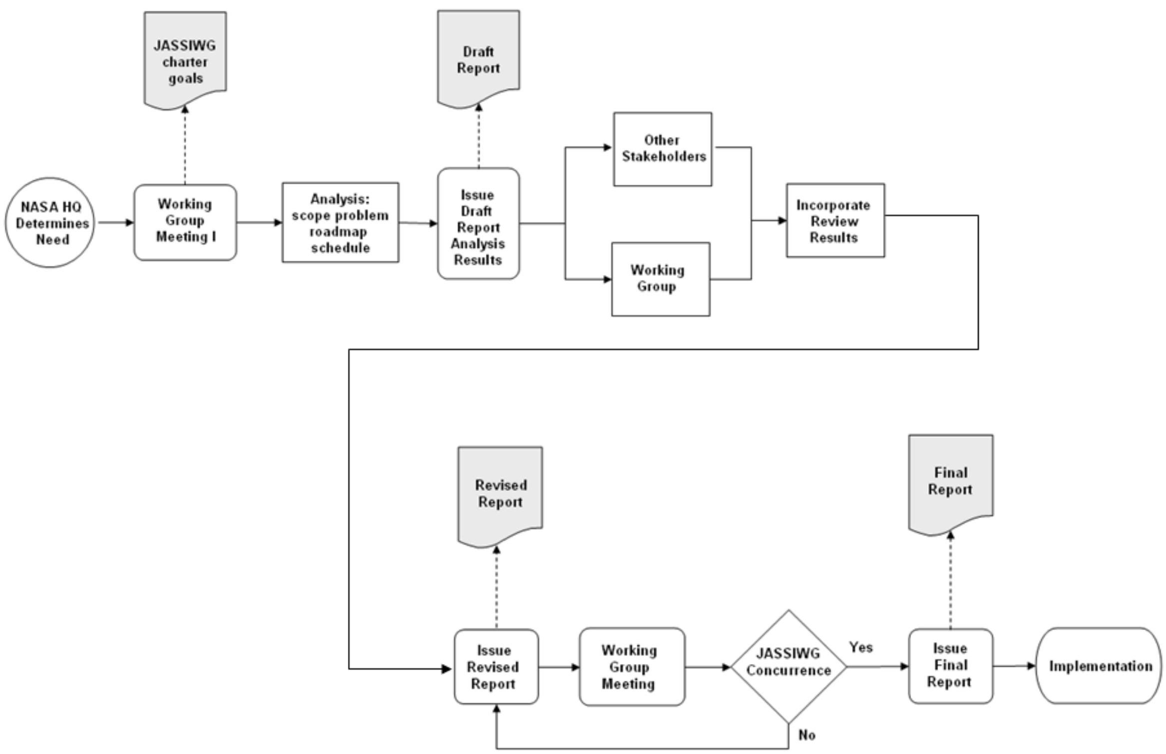

Figure 4. Phase A implementation plan. The plan includes review and comment from all stakeholders and requires concurrence from JASSIWG members prior to final implementation and deployment.

3.3 Phase A Study Products

Figure 5 shows the Phase A products and how they serve the proposed process that will be used in the future for the primary information interface between a PI and the organization of a particular aircraft. Three products are aligned with the outcome of the first JASSIWG meeting:

- Unified Aircraft Performance and Characteristics Matrix
- Common Experimenter Handbook Format
- Common Payload Data Package

The versions of the products in this document (see Appendices 1, 2, and 3) are draft proposals coming out of the Phase A analysis that have been reviewed by the JASSIWG. These draft proposals are being distributed to all other stakeholders for review, comment, and concurrence via this report.

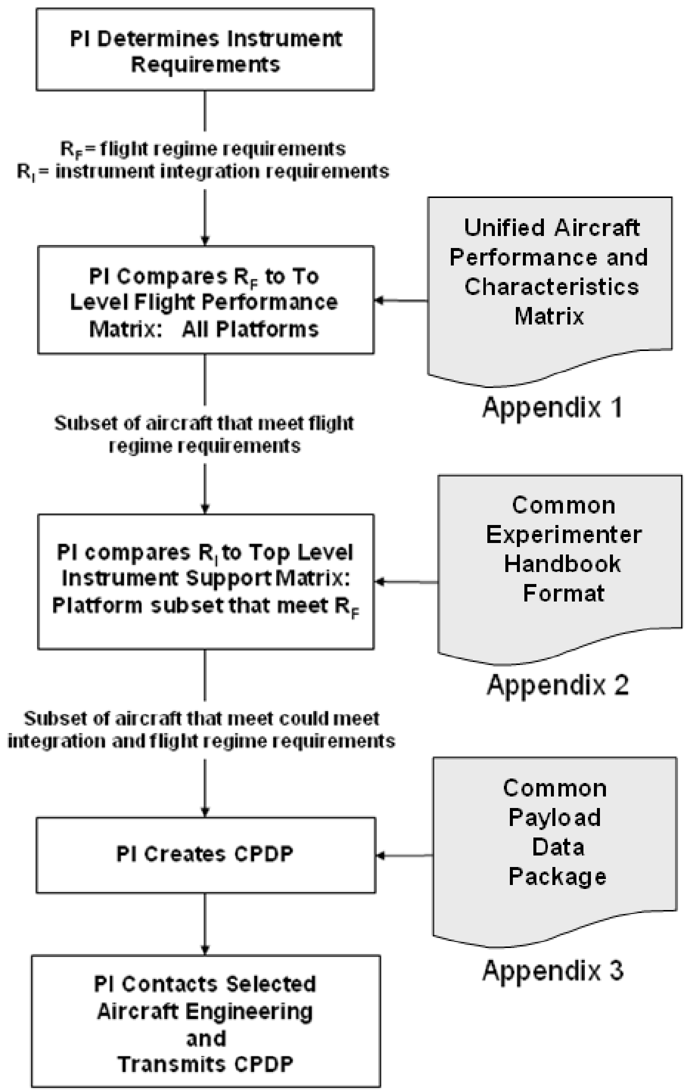

Figure 5. Schematic of the process flow for PIs to meet information needs of AE organizations during the integration process. The shaded boxes show the documentation to be deployed during the Phase A.

Finally, a web page should be established on the NASA Airborne Science website to explain the effort and serve to distribute approved documentation. A web-based application for CPDP generation using web forms, image uploads, and automatic document formatting and construction was identified in the initial JASSIWG meeting notes as a "potential product." We propose that this should be elevated to a required product for Phase A completion. The web page could be initially very simple (single page with links to this and other reports) and would explain the goals of the effort, POCs, and would form the basis for implementation of the common documentation.

3.3.1 Phase A Schedule

The following milestones will allow Phase A should be completely implemented by the end of FY09.

Phase A Milestone	Completion Date
Distribution of preliminary analysis products to the JASSIWG for review	30 September 2008
Publication of Technical Report (with preliminary analysis products)	30 October 2008
Distribution of revised documents	15 November 2008
JASSIWG meeting for discussion and concurrence of final documents and plan	30 January 2009
Post documents and instructions on AS website	15 February 2009

3.4 Phase B

While Phase A addressed the subject of bringing commonality to information requirements, Phase B presents a more difficult task: that of suitably combining requirements levied on instruments by the aircraft. While the goals of increased efficiency can be met in Phase A by a simple union of information requirements, increased efficiency in Phase B requires detailed analysis of the aircraft requirements levied on the instruments. The processes developed during Phase B would apply to both the aircraft shown in Table 2 and to additional aircraft as they are brought under the common requirements.

The outcome of the Phase B analysis may be to suggest minor changes to the requirements, standards, or operating procedures of some aircraft engineering organizations or NASA centers. This could be a contentious process, so the Phase B analysis must be deliberate and careful.

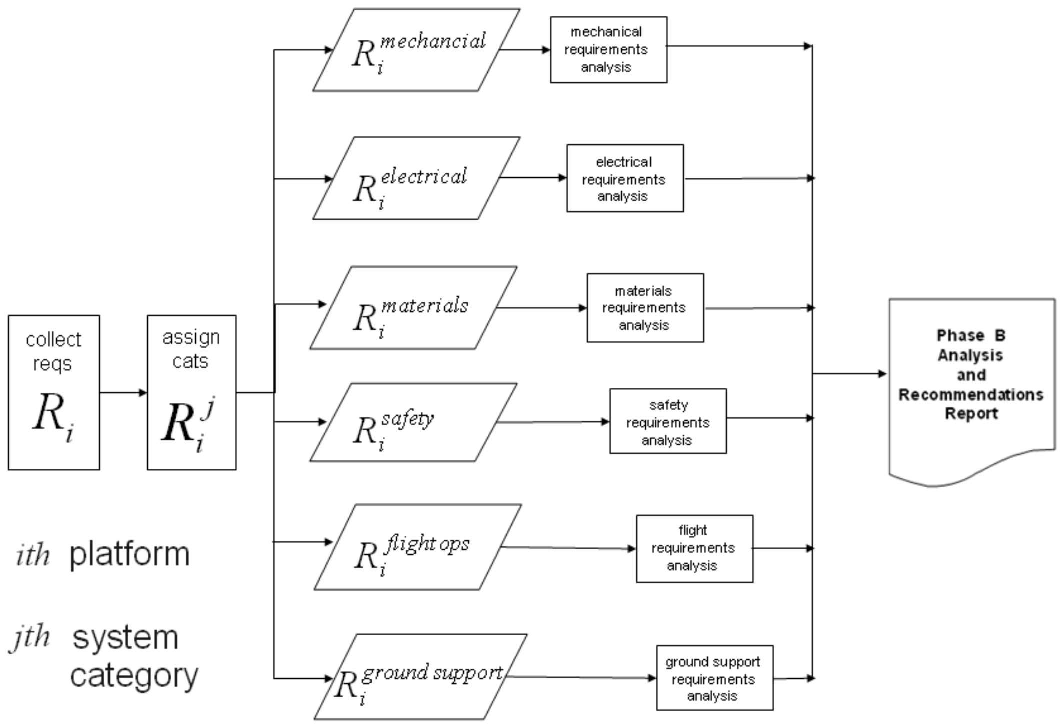

Figure 6. Schematic of notional Phase B analysis.

The systems analysis for Phase B would involve a compilation of all the requirements for each platform into a common format that would allow a determination of the degree of commonality with each other. The analysis would be performed according the sequence shown in Figure 6.

Analysis would be done by system type for all aircraft (the particular sequence in Figure 6 is notional). For each system, the associated requirements would be retrieved from existing documentation for each aircraft. Analysis would be done to determine the degree of commonality; that is, the intersection, union, and complement of the requirements in the space of all aircraft requirements. We anticipate that requirements will fall into one of three categories: (1) common requirements that already exist via external standards or specifications, (2) common requirements that can be determined based on the original rationale for a requirement or expansion of requirements domain, and (3) requirements that cannot be made common due to the uniqueness of a platform in comparison to the others (manned vs. autonomous, for example).

The scope of the work and potential near term (FY09) progress will be clear only after some of the aircraft requirements are "opened up" for analysis. Integration requirements for existing systems are often of heritage origin, and in some cases the original rationale for a requirement has been lost, or the requirement analysis is no longer relevant. In that case, the capability to change (however small) a requirement in order to bring it into commonality with the rest of the platforms is restricted.

3.4.1 Phase B Objectives

The primary objective of Phase B is to assess and analyze platform design requirements. A follow-on phase, Phase C, would result in a unified aircraft requirements document, the Common Platform Integration Requirements (CPIR).

The primary outcome of the Phase B analysis would be a determination, across the domain of aircraft under consideration, of:

- Integration requirements that are already common (e.g., the requirement is an existing NASA or MIL spec)
- Integration requirements that are not common but could be made common across the domain with relatively minor changes to a minority of the aircraft requirements
- Integration requirements that are not common, and not likely to made common, because of the unique nature of each aircraft, or the amount of resources required to align the requirements

Like the Phase A products, the Phase B products will need to be reviewed not only by the JASSIWG, but also internally at each center, including their operational and engineering organizations, as well as their management and oversight boards.

3.4.2 Phase B Schedule

Phase B Milestone	Completion Date
Completion of Onsite Discussions (DFRC, LaRC, GRC, JSC, WFF)	Mar 2009
Distribution of draft Requirements Analysis to AE organizations for review	June 2009
Publication of revised Requirements Analysis	Sept 2009
Distribution of Phase B report	Oct 2009

3.5 Overall Schedule and Milestones

Figure 7 presents the overall schedule and milestones for this effort. Phases A, B, and C are indicated with durations of 14 months, 12 months, and 10 months, respectively. The reviewed, revised, and operational versions of the Unified Aircraft Information, Common Experimenter Handbook Format, and Common Payload Data Package will be deployed in early 2009.

	Task Name	Start	Finish
1	Start	Mon 10/1/07	Mon 10/1/07
2	WG Meeting	Thu 11/15/07	Thu 11/15/07
3	Phase A	Mon 12/3/07	Wed 12/31/08
4	Phase A Data Collection	Mon 12/24/07	Fri 6/27/08
5	Analysis	Mon 4/21/08	Fri 9/5/08
6	Draft Report to WG	Fri 9/19/08	Fri 9/19/08
7	WG Initial Reviews	Mon 9/22/08	Fri 9/26/08
8	Publish Report	Wed 10/15/08	Wed 10/15/08
9	Stakeholder Reviews	Wed 10/1/08	Fri 10/24/08
10	Phase B	Thu 1/1/09	Thu 12/31/09
11	Synthesis of Stakeholder Reviews	Mon 10/13/08	Fri 11/14/08
12	Phase B Data Collection	Mon 11/3/08	Fri 5/22/09
13	Revised Documents to WG	Mon 11/24/08	Mon 11/24/08
14	JASSIWG Webpage Dev	Mon 12/1/08	Fri 1/30/09
15	WG Concurrence Meeting	Fri 1/30/09	Fri 1/30/09
16	JASSIWG Webpage Deploy	Mon 2/23/09	Mon 2/23/09
17	New Documentation Adopt	Mon 3/2/09	Mon 3/2/09
18	Phase B Analysis	Mon 2/16/09	Fri 8/28/09
19	Phase A Monitor and Maintenance	Mon 3/2/09	Wed 9/30/09
20	Center Visits	Mon 1/19/09	Fri 4/10/09
21	Draft Report: Phase A Implementation Status and Preliminary Phase B	Fri 8/28/09	Fri 8/28/09
22	Phase C	Mon 11/2/09	Thu 9/30/10
23	Issue Draft Common Design Requirements	Mon 5/3/10	Mon 5/3/10
24	Common Design Requirements	Mon 5/3/10	Fri 8/27/10
25	Issue Final Documentation	Mon 9/6/10	Mon 9/6/10

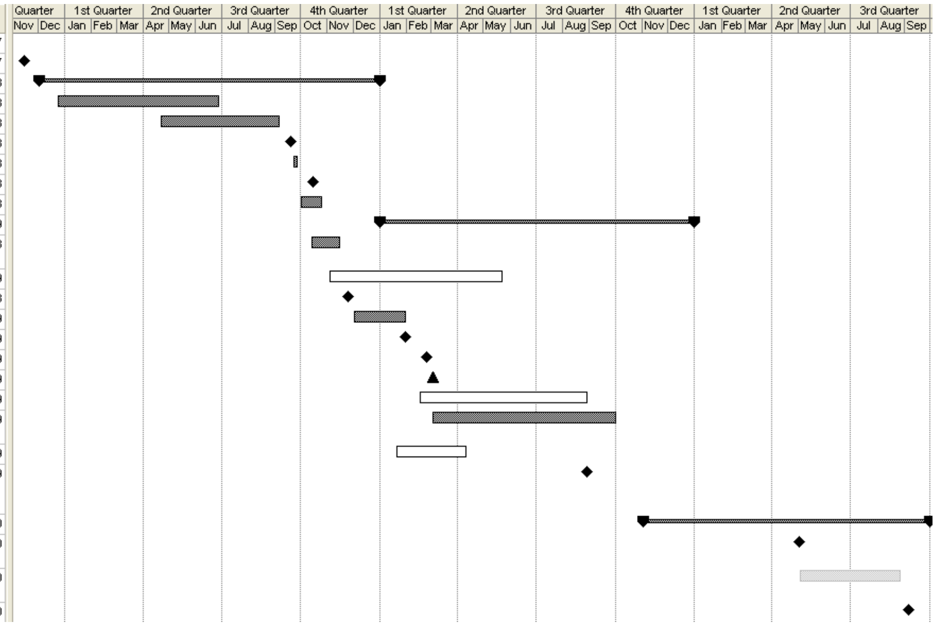

Figure 7. Overall Schedule and Milestones

3.6 Outstanding Concerns and Uncertainties

3.6.1 Resources

The goals and objectives presented by the JASSIWG are very ambitious. This study has presented a preliminary analysis of those goals and shown how they might be approached. It is clear that to make substantial progress beyond this analysis will require more resources in FY 09 compared to FY 08. In order to make substantial progress on Phase B, as outlined here, the level of effort would roughly need to double. This includes dedicated supporting aircraft engineering work at NASA centers.

3.6.2 Document Management

The Phase A plan involves documentation products that will be approved by the JASSIWG, implemented by Airborne Science management, and so adopted by the PI and AE communities. These documents and related information will then need to be managed. Deployment, revision control, and update schedules are all to be determined.

3.6.3 Organization

While the goals and objectives that came out of the JASSIWG meeting are good, they are difficult to achieve. We have proposed that the JASSIWG concur on the Phase A products and their deployment, and that all other stakeholders have a “review and comment” role. It is our intent that the Phase A objectives and implementation would not conflict with local NASA center organizational requirements and authority.

3.6.4 Treatment of Existing Instruments

A large number of instruments already fly on various NASA aircraft; many have flown on more than one aircraft, and so have already provided information to the relevant AE. It remains to be determined how (or if) existing instruments will be required to prepare a CPDP for re-flight on previously flown aircraft.

4. Completed Products from Phase A Study

4.1 Common Aircraft Technical Information

To compare and contrast airborne platform options and their respective capabilities, it is useful to identify a number of important top-level performance parameters and payload accommodations for the PI and list approximate values. The goal of this activity is to allow a PI to identify which platform is able to carry the sensor to the required atmospheric region, for right amount of time, and perform any required maneuvers.

Review of current information (as reflected in Appendices 1 and 4) shows differing levels of technical information and little information on specifications that include accuracy and precision. This provides further motivation for common documentation and specs for all aircraft.

Appendix 1 provides aircraft characteristics; Appendix 2 presents the proposed experimenter handbook.

4.1.1 Aircraft Performance Characteristics and Sensor Design Constraints

Appendix 1 represents a compilation of top-level aircraft flight characteristics and the most important constraints on instrument design, fabrication, and operations on board each aircraft. Note that Appendix 1 does not present a comprehensive view of aircraft flight performance and operational requirements for instruments. Aircraft flight performance is determined by a mix of a number of highly-coupled variables such as total payload weight, inlet or instrument pod drag, altitude profile, and meteorological conditions. Similarly, instrument requirements must often take into account flight and operational constraints unique to a given payload or flight conditions. In all cases, a PI should contact the appropriate aircraft organization regarding specific details, requirements, and accommodations to meet their requirements.

Certain characteristics are not addressed. These include aircraft orientation ranges, ground clearances, cross-winds, other aircraft loads (such as aerodynamic forces), restrictions on flight operations due to crew duty limitations, and ground support systems. Also, little information was discovered regarding electromagnetic and electrostatic environments. If appropriate, additional technical information can be added to this summary database at a later time.

Also note that, in general, we have not included aircraft performance limits, as these typically are not realistic flight scenarios for airborne science data acquisition.

Appendix 1 does present what would be considered a summary view of the information required by PIs to determine (1) which aircraft are likely to meet the science requirements of an instrument, (2) which of these aircraft are likely to meet the engineering requirements of the instrument, and (3) what are the top-level constraints on instrument design and operation for the aircraft selected.

The problem can be considered as a three-dimensional space of flight performance, instrument accommodation, and instrument design requirements, where each dimension can take on up to eleven values corresponding to the eleven aircraft. Thus, an arbitrarily new PI sees over 1300 different combinations of flight performance, instrument accommodation, and instrument design requirements. Our goal in compiling Appendix 1 is to collect all this information in a consistent format across all platforms in way that allows easy determination of which aircraft meets the flight performance requirements within the constraints of the engineering requirements.

4.1.2 Flight Performance Summary

A summary of top-level aircraft performance specifications is provided in Table 3. The PI can apply these specifications against the instrument data collection requirements as the first gate of platform selection and performance familiarization. The idea is to identify all aircraft that can meet the sensor science requirements. These are to be vetted by the relevant organization before release.

Table 3. Top-level Aircraft Performance

Platform	Cruise Altitude (ft)	Max Altitude (ft)	Operational Altitudes (ft)	Cruise Speed (knots)	Rate of climb (ft/sec)	Duration (hrs)	Range (nm)	Turn Radius (nm)	Bank Angle of Radius (deg)	Max Duty Day (hrs)	Min Runway (ft)
DC-8	35,000	41,000	1000-41,000	450		10	5400	8.1	20	14	8000
ER-2	65,000	70,000	20,000-70,000	410	30	10	6000	12.0	22	14	6000
G-3	42,000	45,000	500-45,000	485	33	7	3600	5.8		8	5000
Ikhana		45,000	40,000	170		30	3500			-	5000
Global Hawk	55,000	65,000	42,000-65,000	335	50	31	11,000	6.5	15	-	8000
WB-57	58,000	64,000	500-65,000	410	60	6	2500	3-6	26-28	12	7000
P-3	28,000	35,000	200-35,000	330	25	12	3800	1.0	30	14	6000
B-200	28,000	35,000	200-28,000	260	15	6	1250	3.5	30	12	5000
S-3	28,000	40,000	200-40,000	360	33-67	6	2300	0.5	60	14	6000
Twin Otter	10,000	25,000	200-20,000	140	16-25	3	400	0.5	45	14	2000
Learjet 25	42,000	45,000	500-45,000	450	67-100	3	1200	2.5	45	14	6000

Notes:
KIAS vs KTAS not specified
Rate of climb altitude-dependent
Min runway at sea level.
Twin Otter is unpressurized, supplemental oxygen required above 10,000 ft.

4.2 Common Experimenter Handbook Format

4.2.1 Rationale

The purpose of a standard Experimenter Handbook for NASA Airborne Science platforms is to support the scientific user community by:

- Providing a common information format and document that allows ready comparison of technical requirements across aircraft options
- Providing a commensurate level of technical detail and information for Airborne Science platforms.

The proposed standard outline was developed based on review and comparison of experiment handbooks for the DC-8, ER-2, Global Hawk, WB-57, Learjet, and G-III. All platform handbooks had differing formats, levels of detail, and ordering and presentation of technical information. The most detailed handbooks were those DC-8 and ER-2. Some handbooks, for example, for the Learjet, were very much focused on potential researchers and what information they would need for payload development and integration.

The proposed common organization for Airborne Science Experimenter Handbooks (EH) is presented in Appendix 2. The standard is meant as a guideline, since each Experiment Handbook will need to be tailored to the specific characteristics and requirements of each individual airborne platform.

Currently, Experimenter Handbooks are developed, managed, and controlled by the NASA field centers, which have the management responsibilities for their respective aircraft. Some considerations for development of new and updated handbooks are:

- Existing handbooks are currently updated on an infrequent basis. Based on evolution and the modifications schedule of the platforms, a proposed review and update timeframe for Airborne Science Experimenter Handbooks is 3-5 years.

- Specific design requirements a platform would levy on a payload need to be written with appropriate form and terminology (for example, distinction of "shall" versus "should" or "may" statements), and should have means for verification. A compendium of requirements could be developed as appendices to each handbook, with means for compliance and verification, or could be specifically delineated in the body of the document.

4.3 Common Payload Data Package

The proposed CPDP is presented in Appendix 3. The appendix is presented as instructions and format guidelines for the PI to prepare a PDP. The CPDP would be owned and maintained by the PI and accepted as sufficient information to begin the integration process by any of the AE organizations associated with the covered aircraft.

The questionnaire required to generate the CPDP was determined by reviewing the existing documents (where available) and merging them together in a way that includes all of the information required by each platform. The CPDP questionnaire therefore represents the union of all available questionnaires and contains all of the information required by a particular platform AE in order to perform the first review for integration. Note that the CPDP will then contain some information that is not required by a particular AE. It might also be desirable to format the main body of the CPDP as the intersection of requirements (i.e., information needs common to all platforms) with supplemental addenda for specific aircraft.

At this time the CPDP format presented in Section 2 is for review and comment purposes only. The Phase A completion goal is to issue the operational CPDP as an electronic form that may be based on HTML or another database format. In this way the CPDP author would enter text and supporting images and documentation and the CPDP would be generated as a PDF document. There will need to be review and acceptance of the format by the PI community, and to then ensure it is used by them, so that the most up-to-date instrument description and configuration information is available.

4.4 Common Format Document Maintenance

Once the three documents have been reviewed and vetted by the stakeholder community and a consensus has been reached on content, the Common Aircraft Technical Information, Common Experimenter Handbook Format, and Common Payload Package would be posted on a website for public access and use.

It is proposed that the Earth Science Division at Ames Research Center have primary responsibility for hosting and maintenance of the consensus documentation formats (and eventual web application) for this effort. ESPO already serves as the interface between PIs and NASA Airborne Science for the aircraft flight request process and so could play a similar role for the common requirements. The Airborne Science Program will have sole authority to modify the documentation (once consensus is reached by the WG) and will document changes as required and issue new versions as required.

5. Next Steps

5.1 Completion of Phase A and Implementation

The JASSIWG concept requires a phased transition from the current way of doing business to the proposed, more efficient, way of doing business. This will require full participation and buy-in of stakeholders. Review, approval, and implementation of Phase A data products will be assumed by the JASSIWG.

5.2 Phase B Start

Once Phase A documentation has been accepted and implemented, the more difficult Phase B task will begin. Phase B analysis will begin and proceed in parallel with implementation of Phase A. The first task will be the discovery and collection of relevant requirements.

5.3 Challenges

Design and implementation of a set of common integration requirements, across a range of platforms, presents a variety of technical, institutional, and operational challenges. In this study we have assumed that the benefits of such an effort (for a selection of NASA research aircraft) outweigh the costs, and this was the position taken by the JASSIWG. While most of the stakeholders would no doubt agree, we acknowledge that a formal cost/benefit analysis does not exist to prove the point.

We see no readily apparent technical or safety risks associated with this effort, at least no more than would be assumed for the integration of any particular new instrument, though we do see schedule risks. Specific challenges include:

- Ensuring that sufficient resources (manpower) are applied, including at the AE level, across the different centers and facilities. Maintaining the schedule depends on the cooperation and supporting work from several different NASA organizations.
- Managing expectations with respect to achievable progress in Phase B, since evaluation and potential modification of requirements crosses many NASA organizations, each with their established management processes.
- Understanding the organizational requirements for approving any requirement changes that are typically under local control. This is sometimes not apparent until an attempt is made to change a requirement.

6. Summary and Study Recommendations

We have considered the desired goal of the NASA Airborne Science Program to implement a degree of commonality in the sensor integration process for NASA research aircraft. The following recommendations are based on the results of our study within the framework of the JASSIWG conclusions:

R1. The *implementation should be done in multiple phases*. The first phase (A) should be limited to information flows between PIs and AE organizations alone. The second phase (B) should begin analysis of the quantitative details of aircraft requirements and their potential for commonality.

R2. It is critical that *all stakeholders be identified and provided with the opportunity to review and comment* on the new documentation associated with Phase A. We assume that approval by the Joint Airborne Science Sensor Integration WG is sufficient for implementation under the direction of NASA HQ.

R3. NASA should have a *single document that defines top-level aircraft flight performance and sensor design requirements in a unified format and level of detail* with the purpose of allowing a PI (who may be unfamiliar with any of the NASA aircraft) to quickly determine which aircraft meets the science and engineering needs of the sensor and what modifications are required, if any, to move a sensor from one aircraft to another.

R.4 *The Experimenter Handbook for all aircraft should follow a common organization* in order to facilitate the design of sensors that can fly on the maximum number of aircraft. The specific information in each EH will be unique to each platform but the overall organization should follow a common format.

R.5 The Payload Data Package required by all aircraft *should follow a common organization* so that a PI can quickly and efficiently transmit sensor data to any AE organization for any aircraft. This Common Payload Data Package can be prepared once and serve the needs of all AE.

R.6 A *web page should be deployed to explain the Joint Airborne Science Sensor Integration goals and implementation plan*. The web page would then serve as the host for the unified and common documentation.

R.7 The JASSIWG should meet within four months of the issue of this report with the goal of approval of the three documents related to R.3, R.4, and R.5.

R.8 *Sufficient resources* should be made available in FY09 to implement Phase A and begin Phase B.

Acronyms

AE	Aircraft Engineering
AS	Airborne Science
CPDP	Common Payload Data Package
CPIR	Common Platform Integration Requirements
DFRC	Dryden Flight Research Center
EH	Experimenter Handbook
ESPO	Earth Science Project Office
GRC	Glenn Research Center
GSE	Ground Support Equipment
JSC.	Johnson Space Center
LaRC	Langley Research Center
JASSIWG	Joint Airborne Science Sensor Integration Working Group
NSERC	National Suborbital Education and Research Center
PDP	Payload Data Package
PI	Principal Investigator
POC	Point of Contact
WFF.	Wallops Flight Facility
WG	Working Group

Appendix 1: Aircraft Design Characteristics

Platform: DC-8				
Technical Contact: Ron Wilcox, ronald.m.wilcox@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	41,000	ft	Max	
	33,000 - 41,000	ft	Cruise	
	1000-41,000	ft	Operational range	Can go as low as 500 ft over very flat terrain or 300 ft over large expanses of water.
Cruise Speed	450	kts	TAS	Range from 220-500.
Rate of Climb		ft/sec		
Duration	10	h		12 h max
Range	5400	nm		R/T
Turn Radius	8.1	nm	20 deg bank, 450 KTAS	Range from 2-34 nm.
Loiter Time	-	h		
Minimum Runway Length	8000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	30,000	lbs		40000 maximum, 35,000 with max fuel load.
Payload Volume		ft3		
Payload Dimensions		in	Max length, width, height	
Compartment Max Payload/Description				
Main Cabin		lbs		Multiple payload racks. (List max wt. per rack?)
Cargo Compartment		lbs		
Wing Pylons	200	lbs	2 at 100 lbs ea	
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz, 1 or 3-phase		Total of 30 pwr stations available. 28 VDC and 220 VAC available on request. 400 Hz recommended for experiment use.
	115	V, 60 Hz, 1 phase		
Max Sensor Power	20	Amps	115 VAC, 60 Hz.	
	20	Amps	per phase, 115 VAC, 400 Hz.	
Total Aircraft Power	80	kVA	40 for 400 Hz and 40 for 60 Hz.	
Payload Environmental Characteristics				
Pressure	11	psia	Estimated, at max alt.	
Temperature	74	°F	Max	
	65	°F	Min	
Relative Humidity	10	%	At cruise alt.	Low level flying can significantly increase the cabin humidity level
Stability	+/- 1.0	deg		3-axis, smooth air, controlled by autopilot, recorded during flights.
Qmax	4	psi		
Vibration	-	Hz		Combination of frequencies and magnitudes, varies significantly with fuselage station. Vibration levels are relatively low compared to smaller aircraft.
Crash Loads				
Forward	9.0	g's (ultimate)	(3.0 for cargo compartment)	Emergency landing ultimate loads.
Aft	1.5	g's (ultimate)		
Up	4.3	g's (ultimate)		
Down	7.2	g's (ultimate)		
Lateral	3.0	g's (ultimate)	(1.5 for cargo compartment)	

Shock		g's		3-axis
Radiofrequency Interference	2-5400	MHz		10 kHz to 10 GHz
Electromagnetic Interference/Pulse		(??)		A/C pwr is contaminated withbroadband RF.
Electrostatic Discharge				
Payload Accommodations				Still some work required to format/define this section.
A/C Time Code	IRIG-B and NTP			
Payload Support Equipment				21 various viewports (up to 16 in), incl 1 zenith and 2 nadir ports, plus angles zenith and nadir ports. Some with shutters. Various optical quality windows available. Wing pylons available.
Standard (19") dual-bay equipment racks	Numerous		Various sizes (low, medium, high)	Also have various other equipment support structures that have been built over the years
Standard Passenger Window Ports (14" x 1	>40			
Modified Passenger Viewports (16" x 18")	10			
Directly Zenith Ports (16" x 18")	1			
Directly Nadir Ports (37" x 30")	2			
62° Off-Centerline Zenith Ports (16" x 21")	4			
Off-Centerline Nadir Ports (16" x 21")	2			
PMS Canister Probe Accomodations	4			
Optical Windows	Numerous		Various materials including fused silica/quartz, borosilicate crown glass, pyrex, and soda lime	
Inlet Probes and Venturi Exhausts				
Supplemental Cooling for the Cargo Pits				
Data Channels				
Rate (Hz)				Most parameters are recorded at 1Hz, but selected ones can be sampled much faster.
Format				IWG1 and heritage ASCII format
Data Recorder	REVEAL			
Payload Control				
Aircraft State Parameters (which, units)	Extensive			Position, direction, atmospheric, sun/moon positions.
GPS/INS latitude, longitude, altitude, 3D velocity, 3D acceleration, pitch, roll, heading, pitch rate, roll rate, yaw rate				
Radar Altitude				
NMS/FMS distance to next waypoint, time to next waypoint, cross track distance, drift angle, latitude, longitude, ground speed, track angle, true heading, wind speed, wind direction, pitch, roll, pressure altitude				
ADC pressure altitude, barometric altitude, static air temperature, mach number, vertical speed, total air temperature, indicated airspeed, true airspeed				
GPS time, latitude, longitude, altitude, vertical velocity, track angle				
Dew/frost point				
Infrared surface temperature				
Static air temperature				
Atmospheric pressure				
Various solar angle parameters				
Various lunar angle parameters				
Potential temperature				
Cabin altitude				
Total air temperature				
Aircraft Facility Instruments (measurement, units)				C-band weather radar, INS, GPS, total air temp, frostpoint hygrometer, surf temp radiometer, radar altimeter, cabin altimeter, high data rate position and attitude system, air data computer. Forward and nadir video cameras available. Dropsonde launch tube available.

Communications				
Voice			Iridium Satellite Phone, UHF VHF, HF Radio	
Data			4-Channel Iridium satellite modem system	Commonly used to provide chat communication between the aircraft and ground and/or other aircraft, ships, etc.
Science crew complement	up to 45			up to 8 flight crew
Payload Design Characteristics				
Factor of Safety	2.25			For operational limit loads. No FOS for ultimate loads.
Cable and Connector Types - Cabin Power				Additional connector types for wingtip pylon pwr & data.
	MS24266R14B4PN		115VAC, 60Hz Mating Connector	
	M83723-76A1808N		115VAC, 400Hz Mating Connector	
Gases	Various			Basic gases (typically dry nitrogen and compressed air) are provided, specialty gases must be provided by the experimenter
Cryogens	LN2, LHe			3 35 L LN2 dewars can be located in cabin, plus some small amounts at/near experimenter stations. Some LHe transport capability (60L dewar).
Web Site:				www.nasa.gov/centers/dryden/aircraft/DC-8/index.html www.nserc.und.edu

Platform: ER-2				
Technical Contact: Mike Kapitzke, Mike.S.Kapitzke@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Altitude	70,000	ft	Max	
	65,000	ft	Cruise	
	20,000-70,000	ft	Operational range	
Cruise Speed	410	kts	fixed	
Rate of Climb	30	ft/sec		
Duration	10+	h		
Range	6000	nm		R/T
Turn Radius	12	nm		22 deg bank angle
Loiter Time		h		
Minimum Runway Length	6000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	2,550	lbs		Subject to CG constraints.
Payload Volume	295	ft3		
Payload Dimensions		in	Max length, width, height	
Compartment Max Payload/Description				
Wing Pods	1300	lbs, max		Environmental control - fwd 2/3s.
Nose Area	605	lbs, max		Environmental control.
Q-bay	1300	lbs, max		Environmental control. P/Ls must withstand pressure at altitude.
Centerline Pod	350	lbs, max		No environmental control.
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz, 3-phase		Standard electrical interface
	28	VDC		
Max Sensor Power	100	A (400 Hz AC)		
	4	KW (28 VDC)		
Total Aircraft Power	?			
Payload Environmental Characteristics				
Pressure	4.5	psia, min	at max altitude	Variable pressures based on altitude ranges.
Temperature				
Q-bay	10-50	°F	Min	
	120	°F	Max	
Nose	-40	°F	Min	heaters/blowers available.
	68	°F	Max	
Wing Pods	-40	°F	Min	at cruise
	20	°F	Max	at cruise
Relative Humidity		%		
Stability				FCS provides stabilty control augmentation.
Roll	0.25	deg/min	??	
Pitch	0.4/5	deg/min	??	
Vibration	80-110	Hz		
Crash Loads - Fuselage				Static ultimate load factors
Forward	2.5	g's (ultimate)	(8.0 for Q-bay)	
Aft	2.5	g's (ultimate)		
Up	3.3	g's (ultimate)		
Down	6.3	g's (ultimate)		
Lateral	1.5	g's (ultimate)		
Crash Loads - Wing pods				Static ultimate load factors
Forward	3	g's (ultimate)		
Aft	3	g's (ultimate)		
Up	6	g's (ultimate)		Higher for wing tips.
Down	9	g's (ultimate)		Higher for wing tips.
Lateral	4.5	g's (ultimate)		

Shock		g's		3-axis
Radiofrequency Interference	2-1090	MHz		Radios & ATC transponder.
Electromagnetic Interference/Pulse		(??)		
Electrostatic Discharge				
Payload Accommodations				Still some work required to format/define this section.
A/C Time Code	IRIG-B			
Payload Support Equipment				5 16 in window ports: Nadir: 2 Q-bay, 1 nose, and on wingpod fore-bodies. Zenith: 1 Q-bay, 1 wingpod fore-body, and wingpod aft-tail cones.
Data Channels				
Rate	1	Hz		
Format				
Data Recorder				
Payload Control	None			Power on/off switch only.
Aircraft State Parameters				INS & GPS parameters, plus total press and temp.
Aircraft Facility Instruments				
Communications				
Voice				UHF, VHF, HF
Data				
Science crew complement	0			1 pilot
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases				Inert, non-toxic gasses in up to 200 psi bottles.
Cryogens				Add 2 hours to flight time for dewar capacity/access.
Web Site:				http://www.nasa.gov/centers/dryden/aircraft/ER-2

Platform: G-III (C-20A)				
Technical Contact: Mike Holtz, Michael.D.Holtz@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	45,000	ft	Max	
	42,000	ft	Cruise	Varies due to gross weight and OAT
	500-45,000	ft	Operational range	
Cruise Speed	485	kts	KTAS, M=0.85 (clean)	At 45Kft.
	470	kts	KTAS, M=0.82 (w/pod)	
Rate of Climb	>33	ft/sec		Varies greatly with gross weight
Duration	7	h		
Range	3600	nm		R/T
Turn Radius	0.33 - 5.8	nm		Min, function of bank angle and TAS (which is dependant on altitude)
Loiter Time	-	h		
Minimum Runway Length	5000	ft	at sea level	
Duty Day	8	h		Normal, may extend to 12 while at Dryden, and up to 14 while on deployment if the aircraft flies for more than 5 hrs. Minimum of 10 hrs rest.
Payload Physical Characteristics				
Payload Weight (total)	2000?	lbs		Need to verify. Payload weight will vary greatly based on mission requirements. Rack located, mounted on floor, in a pod, how many experimenters, how much fuel, etc.
Payload Volume	825	ft3	Usable cabin volume	
Payload Dimensions	235 x 60	in		14 seat/rack locations, pressurized cabin compartment
Compartment Max Payload/Description				
Racks	300	lbs		6 rcaks currently available.
Wing Pods	N/A	lbs		
Centerline Pod	1200	lbs		
Nose	N/A	lbs		
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz, 1 or 3-phase		Standard electrical interface?
	115	V, 60 Hz, 1 phase		
	28	VDC		
Max Sensor Power	TBC		Peak	
Total Aircraft Power	TBC		Average	

Payload Environmental Characteristics				
Pressure		psig		
Temperature		°F	Max	
		°F	Min	
Relative Humidity		%		
Stability		deg/sec		3-axis
Vibration		Hz		3-axis
Crash Loads				Instrumentation not required to withstand loads.
Forward	9	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	2	g's (ultimate)		
Down	4.5	g's (ultimate)		
Lateral	3	g's (ultimate)		
Shock		g's		3-axis
Radiofrequency Interference		Hz		
Electromagnetic Interference/Pulse		(??)		
Electrostatic Discharge				
Payload Accommodations				Still some work required to format/define this section.
A/C Time Code (IRIG, SMPTE)				
Payload Support Equipment				Internal racks. No window ports or inlets.
Data Channels				
Rate				
Format				
Data Recorder				
Payload Control				
Aircraft State Parameters	Multiple			Data Collection and Processing System (DCAPS)
Aircraft Facility Instruments				
Communications				four com stations (2 users each)
Voice			SAT, UHF, VHF, HF	
Data				
Science crew complement	8			3 flight crew
Payload Design Characteristics				
Factor of Safety	2.25		Metallic structure, verification by analysis	
	3		Composite structure, verification by analysis	
	1.875		Metallic or composite structure, verification by proof test to 125% of flight loads.	
Cable and Connector Types				
Gases				
Cryogens				
Web Site:				

Platform: Ikhana				
Technical Contact: Tom Rigney, thomas.k.rigney@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	45,000	ft	Max	
		ft	Cruise	
		ft	Operational range	
Cruise Speed	170	kts		
Rate of Climb		ft/sec		
Duration	30	h		
Range	3500	nm		R/T
Turn Radius		nm		Min, function of bank angle
Loiter Time		h		
Minimum Runway Length	5000	ft	at sea level	
Duty Day	-	h		
Payload Physical Characteristics				
Payload Weight (total)		lbs		
Payload Volume		ft3 or in3?		
Payload Dimensions		in	Max length, width, height	
Compartment Max Payload/Description				
Pallets		lbs		
Wing Pods		lbs		
Nose		lbs		
Aft Fuselage		lbs		
Hatches		lbs		
Payload Electrical Characteristics				
Available Power Types/Forms/Options		V, Hz, A		Standard electrical interface
Max Sensor Power			Peak	
Total Aircraft Power			Average	
Payload Environmental Characteristics				
Pressure		psig		
Temperature		°F	Max	
		°F	Min	
Relative Humidity		%		
Stability		deg/sec		3-axis
Vibration		Hz		3-axis
Crash Loads				
Forward		g's (ultimate)		
Aft		g's (ultimate)		
Up		g's (ultimate)		
Down		g's (ultimate)		
Lateral		g's (ultimate)		
Shock		g's		3-axis
Radiofrequency Interference		Hz		
Electromagnetic Interference/Pulse		(??)		
Electrostatic Discharge				
Payload Accommodations				
A/C Time Code (IRIG, SMPTE)				
Payload Support Equipment				

Data Channels				
Rate				
Format				
Data Recorder				
Payload Control				
Aircraft State Parameters				
Aircraft Facility Instruments				
Communications				
Voice				
Data				
Science crew complement	0			
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases				
Cryogens				
Web Site:				

Platform: Global Hawk				
Technical Contact: Matt Graham, matt.s.graham@nasa.gov				
U.S. Government Use Only				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	65,000	ft	Max	
	55,000	ft	Begin Cruise Climb	Begins climb due to fuel burn gross weight decrease
	42,000-65,000	ft	Operational range	Vertical profile limit based on NAS restrictions.
Cruise Speed	335	kts	TAS @ 55 kft	
Rate of Climb	50-55	ft/sec	Estimated.	Up to 55 kft altitude. Much lower above 55kft.
Duration	31	h	Nominal	Demonstrated maximum duration is 31 hours.
Range	11000	nm		Round trip
Turn Radius	6.5	nm	15 deg bank angle, 55 kft	function of altitude
Loiter Time	15	h	at 2500 nm	
Minimum Runway Length	8000	ft	at sea level	
Duty Day	-	h		
Payload Physical Characteristics				
Payload Weight (total)	1,500	lbs		Estimated, subject to CG constraints.
Payload Volume	335	ft3		Total
Payload Dimensions	105x56x36	in	Largest compartment □(Max length, width, ht)	
Compartment Max Payload/Description			14 payload zones of□various d	7 of the payload zones have environmental conditioning (30% of total vol).
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz, 3-phase		Standard electrical interface is new "EIP".
	28	VDC		24 AC & DC payload connections available.
Max Sensor Power	8.2	kVA @ 115 VAC, 3-phase		Total payload AC Bus power avail. at each "EIP".
	1.2	kW @ 28 VDC		Provided by TRU converted DC power from AC Bus.
Total Aircraft Power	8.2	kVA @ 115 VAC, 3-phase		
	7.2	kW @ 28 VDC		
Payload Environmental Characteristics				
Pressure				
Environmentally Controlled Zone	14.7 to 5	psia	Estimated.	
Non-Controlled Zone	14.7 to 0.8	psia	Estimated.	
Temperature				
Environmentally Controlled Zone	32-130	°F	Min-Max	
Non-Controlled Zone	-120 - 140	°F	Min-Max	
Relative Humidity	99-100	%		Environmentally conditioned zones non-condensing
Stability		deg/sec		3-axis
Vibration	N/A	Hz		Refer to GH Project Office.
Crash Loads	N/A			There are no "Crash" Loads specified
Forward		g's (ultimate)		Acceleration environment specified.
Aft		g's (ultimate)		
Up		g's (ultimate)		
Down		g's (ultimate)		
Lateral		g's (ultimate)		
Shock	None			

Radiofrequency Interference		Hz		
Electromagnetic Interference/Pulse		(??)		
Electrostatic Discharge				
Payload Accommodations				Still some work required to format/define this section.
A/C Time Code	IRIG-B□GPS			
Payload Support Equipment				Six distributed Experiment Interface Panels with Ethernet switches (8 RJ-45 ports each, 100 Mbps).
				Direct payload bay mounting points or pallets.
Data Channels				All communication is TCP/IP Ethernet
Rate				All communication is TCP/IP Ethernet
Format				All communication is TCP/IP Ethernet
Data Recorder				High capacity data storage unit in work.
Payload Control				Ethernet-based Command & Control - payload to provide health/status info to operations center.
Aircraft State Parameters				
Aircraft Facility Instruments				
Communications				
Vehicle	UHF		Redundant Links	Line-of-sight flight
	Iridium Satcom		Redundant Links	Iridium for global flight capability, including over the Polar Regions
Payloads	Iridium Satcom	9.6 kbps	4 Bonded Links	Baseline global capability including Polar Regions
	Inmarsat Satcom	64-480 Kbps	Swift-64 System	64-128 kbps - expanding to 480kbps with expansion to Swift Broadband Service in 4QFY09
	Ku Satcom	40 Mbps		Planned expansion to GH Ku payload-dedicated system by FY10
Science crew complement	0			Payload Operations Room in GH Operations Center has 14 Science workstations, another 15 stations in overflow area.
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				16 pin, RJ-45
Gases				
Cryogens				
Web Site:				http://www.nasa.gov/centers/dryden/aircraft/GlobalHawk

Platform: WB-57				
Technical Contact: Shelley Baccus, Shelley.Baccus-1@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	64,000	ft	Max	
	58,000	ft	Cruise	
	500-65,000	ft	Operational range	
Cruise Speed	410	kts		TAS @ 60kft
Rate of Climb	60	ft/sec		
Duration	6	h		
Range	2500	nm		R/T
Turn Radius	3-6	nm		26-28 deg bank angle
Loiter Time	5	h		Function of weight, drag.
Minimum Runway Length	7000	ft	at sea level	
Duty Day	12	h		Flight crew only.
Payload Physical Characteristics				
Payload Weight (total)	6,000	lbs		
Payload Volume	TBC	ft3 or in3?		Payload bay + wing pods + nose. This does not include aft fuselage or hatches.
Payload Dimensions	18' x 5' x 3'	in		Max length, width, height
Compartment Max Payload/Description				
Pallets	4000	lbs		Including pallets. 3 or 6 ft pallets, 12 ft pallet bay. Pressurized or unpressurized.
Wing Pods	560	lbs		2; Unpressurized. Weight does not include pod.
Nose	600	lbs		Pressurized or unpressurized.
Aft Fuselage	TBC	lbs		Unpressurized. Talk to the program office with a specific proposal.
Hatches	65	lbs		65 pounds each including panel. 12 total, 6 per wing; Unpressurized.
Payload Electrical Characteristics				
Available Power Types/Forms/Options	110	V, 400 Hz, 3-phase		Standard electrical interface
	110	V, 60 Hz, 1 phase		
	28	VDC		
Max Sensor Power	115	VAC, 400 Hz 3-phase @ 100 amps per phase		
	110	VAC, 60 Hz 1-phase @ 70 amps		
	28	VDC on 2-200 amp lines		
Total Aircraft Power	115	VAC, 400 Hz 3-phase @ 135 amps per phase		
	110	VAC, 60 Hz 1-phase @ 70 amps		
	28	VDC @ 600 amp		
Payload Environmental Characteristics				
Pressure	5	psig		To nose and pallet compartment
Temperature	100	°F	Max	Cooling & heating are customer provided.
	-80	°F	Min	
Relative Humidity	99	%		
Stability	-	deg/sec		3-axis
Vibration	-	Hz		See WB-57 website for vibration data.
Crash Loads				
Forward	3.0	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	2.0	g's (ultimate)	(3.0 for wing pods)	
Down	4.5	g's (ultimate)	(6.0 for wing pods)	
Lateral	1.5	g's (ultimate)		
Shock	TBC	g's		3-axis

Radiofrequency Interference	TBC	Hz		
Electromagnetic Interference/Pulse	TBC	(??)		
Electrostatic Discharge	TBC			
Payload Accommodations				
A/C Time Code	IRIG-B			
Payload Support Equipment				Pressurized cannisters, windows, community exhaust, wing hatches.
Data Channels	4			
Rate	1	Hz		
Format	ASCII			
Data Recorder	Nav data recorder			Old-syle nav data recorder.
Payload Control	Payload determined			Power on/off switch only. Pointing & Tracking system available for optical palyoads.
Aircraft State Parameters	32			State and environment parameters.
Aircraft Facility Instruments				None.
Communications				
Voice				SAT, UHF, VHF, HF
Data				Payload specified.
Science crew complement	1			1 pilot, 1 instrument operator
Payload Design Characteristics				
Factor of Safety	1.5			
Cable and Connector Types				Aircraft qualified.
Gases	Yes			
Cryogens	Yes			
Web Site:				http://jsc-aircraft-ops.jsc.nasa.gov/wb57

Platform: P-3				
Technical Contact: Mike Cropper, Michael.C.Cropper@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	35,000	ft	Max	Non-RVSM
	28,000	ft	Cruise	
	200-35,000	ft	Operational range	
Cruise Speed	330	kts		
Rate of Climb	25	ft/sec		Max Gross Wt @ Sea Level.
Duration	12	h		
Range	3800	nm		R/T
Turn Radius	1	nm		Min, bank angle (30 deg)
Loiter Time	-	h		
Minimum Runway Length	6000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	15,000	lbs		
Payload Volume	-	ft3 or in3?		
Payload Dimensions		in	Max length, width, height	
Compartment Max Payload/Description				
Zenith port	280	lbs		with CG 10" below port opening
DC-8 passenger windows (3)	100	lbs		CG 18" from viewport mounting surface combined with a drag area of 1 sq. ft.
Wing Mounts		lbs		
Nose radome		lbs		
Aft radome		lbs		
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz, 3-phase		16-18 experimenter stations. Standard electrical interface.
	115	V, 60 Hz, single phase		
	28	VDC		
Max Sensor Power	15	Amps		per station
Total Aircraft Power	60	KVA (115 VAC)		60 kVA available on ground, 90 kVA available in flight.
	200	Amps (28 VDC)		Max power
Payload Environmental Characteristics				
Pressure	14.7 - 11.1	psi		internal cabin and below cabin floor
	14.7 - ambient	psi		bomb bay, nose and aft radome
Temperature	100	°F	Max	internal cabin and below cabin floor
	20	°F	Min	internal cabin and below cabin floor
	150	°F	Max	bomb bay, nose and aft radome (hot sea level day)
	-50	°F	Min	bomb bay, nose and aft radome (@ altitiude over arctic)
Relative Humidity	10.0	%		internal cabin above cabin floor, at altitude.
Stability	1.0	deg		3-axis with autopilot engaged
Vibration	68	Hz		natural frequency
Crash Loads - Cabin				Vary from cabin to cockpit, etc. Gust loads may exceed crash loads. See Exp Handbook.
Forward	9	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	2	g's (ultimate)		
Down	6	g's (ultimate)		
Lateral	3	g's (ultimate)		

Shock		g's		3-axis
Radiofrequency Interference	2MHz to 4.37GHz			
Electromagnetic Interference/Pulse		(??)		
Electrostatic Discharge				
Payload Accommodations				Still some work required to format/define this section.
A/C Time Code	IRIG			
Payload Support Equipment				Various viewports (up to 19 in), incl 1 zenith and 3 nadir ports, plus 2 bomb bay ports and mutiple window types(4 bubble, 3 DC-8 size). Wing mounts available.
Data Channels				
Rate				
Format				
Data Recorder				
Payload Control				
Aircraft State Parameters	Extensive			
Aircraft Facility Instruments				weather radar, fwd/nadir video, GPS, total temp. probe, hygrometer, surface temp. radiometer, radar altimeter, cabin altimeter, automatic identification system, time code display.
Communications				
Voice	SAT, UHF, VHF, HF			
Data	hannel Iridium sat com			(total bandwidth - 1200 baud approx)
Science crew complement	24			max including aircrew (4-6 nom)
Payload Design Characteristics				
Factor of Safety	2			
Cable and Connector Types				
Gases				Aluminum bottles only
Cryogens				1 35L LN2 Dewar
Web Site:				

Platform: B-200				
Technical Contact: Rick Yasky, richard.j.yasky@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	35,000	ft	Max	Non RVSM certified. Altitudes above 28,000 only in Special Use Airspace.
	28,000	ft	Cruise	
	200-28,000	ft	Operational range	
Cruise Speed	260	kts		True Airspeed at 28,000 feet MSL. Range 180-260.
Rate of Climb	15	ft/sec		25 ft/sec at sea level, 8 ft/sec at 28,000 feet
Duration	6	h		
Range	1250	nm		R/T
Turn Radius	3.5	nm		Nominal, function of bank angle and speed.
Loiter Time	3	h		
Minimum Runway Length	5000	ft	at sea level	
Duty Day	12	h		
Payload Physical Characteristics				
Payload Weight (total)	4,100	lbs		Max, incl crew & support equip. Weight distribution and density may be factors.
Payload Volume	90	ft3	Approx	Usable. Total cabin vol - 270 cu ft.
Payload Dimensions	158 x 24 x 36	in	Max length, width, height	Maximum dimensions determined by cabin/cargo door size and egress paths.
Compartment Max Payload/Description				Pressurized cabin compartment, several aircraft compatible 19 in. racks available with defined wt/cg envelopes. Cabin Internal Pressure dome 31 x 24 x 24 in (L, W, H). Common, certified fwd and aft rack configuration.
Payload Electrical Characteristics				
Available Power Types/Forms/Options	28	VDC (3 x 50A)		Aircraft power fed to research power thru 3 - 1200W inverters to a power distribution panel to split the AC/DC requirements. Cockpit mounted research power switch.
	115	V/60 Hz (3 x 10A)		
Max Sensor Power	4200	W		
Total Aircraft Power (Research)	4200	W		
Payload Environmental Characteristics				
Pressure	Altitude dependent	psig		Controllable within limits; nominal Sea Level Pressure to 13,000, and 5.8 psid up to 28,000 feet. 10,000 feet max cabin altitude.
Temperature	90	°F	Max	Cabin uses freon A/C during ground ops, and conditioned air in flight. Temps depend on ambient conditions and heat generated by instrument(s).
	60	°F	Min	

Relative Humidity	-	%		Not controlled.
Stability	UNK	deg/sec		
Vibration	UNK	Hz		
Crash Loads				Design goals: lower values may be acceptable for limited exposure tests.
Forward	18	g's (ultimate)		
Aft	-	g's (ultimate)		
Up	3	g's (ultimate)		
Down	6	g's (ultimate)		
Lateral	4.5	g's (ultimate)		
Shock		g's		3-axis
Radiofrequency Interference	None	Hz		None noted to date.
Electromagnetic Interference/Pulse	-	(??)		Ground EMI verification and Instrument Check Flight required.
Electrostatic Discharge	-			
Payload Accommodations				
A/C Time Code				Access to GPS time synch.
Payload Support Equipment				2 nadir apertures, 19 in. racks available pressure dome available. No current inlets (UC-12 has in situ probes). Contact Langley Research Services Directorate for specific component specifications.
Data Channels				
Rate				
Format				
Data Recorder				
Payload Control				
Aircraft State Parameters				Athena & Crossbow IMUs. Total air temp, hygrometer, and air sampler measurements available.
Aircraft Facility Instruments				Applanix Model 501, Applanix POSTrack real-time guidance, Common Airborne Instrumentation System, Differential GPS and GPS signal feeds. UC-12 has in situ probes and pitot & static pressure taps.
Communications				
Voice			Sat Phone, VHF (2), HF (1)	UC-12 also has 1 UHF.
Data			Iridium	
Science crew complement	3 to 4			1-2 flight crew
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases	Yes			DOT cylinders and volumes dependent on type of gas
Cryogens	Yes			0.75 liter LN2 in cabin and 7 liters LN2 under pressure dome previously approved.
Web Site:				http://airbornescience.nasa.gov/platforms/platforms.html
Other:				Langley has additional, similar variant, UC-12B, with same nadir aperatures, power systems, large cargo door, and fixtures for external probes.

Platform: S-3				
Technical Contact: Ed Emery, Edward.F.Emery@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	40,000	ft	Max	
	28,000	ft	Cruise	TAS
	200-40,000	ft	Operational range	
Cruise Speed	360	kts		
Rate of Climb	33 - 67	ft/sec		
Duration	6	h		A/C equipped with in-flight refueling.
Range	2300	nm		R/T
Turn Radius	0.5	nm		60 deg bank angle
Loiter Time	-	h		
Minimum Runway Length	6000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	4,000	lbs		Potential to 10,000+
Payload Volume	68	ft3		CNU-246/A Cargo Pod only
	152 x 26	in	?	
Compartment Max Payload/Description				
Wing Pods	2000	lbs		CNU-246/A Cargo Pod, unpressurized.
Fuselage	3000	lbs		
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz		Standard electrical interface?
	115	V, 60 Hz		
	28	VDC		
Max Sensor Power	45	kVA		
Total Aircraft Power	190	kVA		
Payload Environmental Characteristics				
Pressure	N/A	psig		Unpressurized.
Temperature	N/A	°F	Max	Partial heating available.
	N/A	°F	Min	
Relative Humidity	N/A	%		
Stability		deg/sec		3-axis
Vibration		Hz		3-axis
Crash Loads				
Forward	9	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	3	g's (ultimate)		
Down	6	g's (ultimate)		
Lateral	3	g's (ultimate)		
Shock	N/A	g's		3-axis
Radiofrequency Interference	N/A	Hz		
Electromagnetic Interference/Pulse	N/A	(??)		
Electrostatic Discharge	N/A			

Payload Accommodations				Still some work required to format/define this section.
A/C Time Code	IRIG			
Payload Support Equipment				
Data Channels				
Rate				
Format				
Data Recorder				
Payload Control				
Aircraft State Parameters				
Aircraft Facility Instruments				
Communications				
Voice	SAT, UHF, VHF			
Data				
Science crew complement	2			2 flight crew
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases				
Cryogens				
Web Site:				

Platform: Twin Otter				
Technical Contact: Ed Emery, Edward.F.Emery@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	25,000	ft	Max	
	10,000	ft	Cruise	
	200-20,000	ft	Operational range	
Cruise Speed	140	kts		
Rate of Climb	16 - 25	ft/sec		
Duration	3	h		
Range	400	nm		R/T
Turn Radius	0.5	nm		45 deg bank angle
Loiter Time	2	h		
Minimum Runway Length	2000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	500	lbs		
Payload Volume	27	ft3		
Payload Dimensions	36 x 36 x 36	in		limited by cargo door opening.
Compartment Max Payload/Description				
Fuselage (cabin)	500	lbs		Unpressurized.
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz		Standard electrical interface?
	115	V, 60 Hz		
	28	VDC		
Max Sensor Power	5.6	kVA		
Total Aircraft Power	11.2	kVA		
Payload Environmental Characteristics				
Pressure	Ambient	psig		Unpressurized.
Temperature		°F	Max	Partial heating available.
		°F	Min	
Relative Humidity		%		
Stability		deg/sec		
Vibration		Hz		
Crash Loads				
Forward	9	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	3	g's (ultimate)		
Down	6	g's (ultimate)		
Lateral	3	g's (ultimate)		
Shock	N/A	g's		
Radiofrequency Interference	N/A	Hz		
Electromagnetic Interference/Pulse	N/A			
Electrostatic Discharge	N/A			
Payload Accommodations				Still some work required to format/define this section.

A/C Time Code	IRIG			Available on request.
Payload Support Equipment				4 research racks.
Data Channels				
Rate				
Format				Analog / Digital
Data Recorder				SEA M300 Data System
Payload Control	N/A			
Aircraft State Parameters				Altitude, Airpseed, Outside Temperature, GPS standard navigation parameters - ARINC 429 & RS 232; Control Surface Position.
Aircraft Facility Instruments				Relative Humidity , Cloud Physic Probes (FSSP, 2DG, 2DGP, CIP, CDP, 2DS,CPI, AIMMS20), Liquid Water (King, SEA, Nevzorov, Dmt-CSI, Licquor).
Communications				
Voice	SAT, UHF, VHF			
Data				
Science crew complement	3			2 pilots.
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases				
Cryogens				
Web Site:				

Platform: Learjet 25				
Technical Contact: Ed Emery, Edward.F.Emery@nasa.gov				
Parameter	***Value***	***Units***	***Notes***	***Comments***
Aircraft Performance				
Altitude	45,000	ft	Max	A/C equipped with RVSM.
	42,000	ft	Cruise	
	500 - 45,000	ft	Operational range	
Cruise Speed	450	kts		
Rate of Climb	67-100	ft/sec		200 with light load.
Duration	3	h		
Range	1200	nm		R/T
Turn Radius	2.5	nm		22 deg bank angle
Loiter Time	-	h		
Minimum Runway Length	6000	ft	at sea level	
Duty Day	14	h		
Payload Physical Characteristics				
Payload Weight (total)	1,150	lbs	nominal (1600 max)	
Payload Volume		ft3 or in3?		
Payload Dimensions		in	Max length, width, height	
Compartment Max Payload/Description				Pressurized cabin compartment
Payload Electrical Characteristics				
Available Power Types/Forms/Options	115	V, 400 Hz		Standard electrical interface?
	115	V, 60 Hz		
	28	VDC		
Max Sensor Power	7	kVA		
Total Aircraft Power	22.4	kVA		
Payload Environmental Characteristics				
Pressure	8.77	psig	Max	
Temperature	80	°F	Max	70 °F avg
	60	°F	Min	
Relative Humidity		%		
Stability	-	deg/sec		
Vibration	-	Hz		
Crash Loads				
Forward	9	g's (ultimate)		
Aft	1.5	g's (ultimate)		
Up	2	g's (ultimate)		
Down	7	g's (ultimate)		
Lateral	1.5	g's (ultimate)		
Shock	N/A	g's		
Radiofrequency Interference	N/A	Hz		
Electromagnetic Interference/Pulse	N/A			
Electrostatic Discharge	N/A			
Payload Accommodations				

A/C Time Code				Available on request.
Payload Support Equipment				Two 22x19 in nadir optical windows Two 12 in dia centerline zenith ports One 13.5x10.5 in left window with sliding door One 9.75x10.5 in right window with infrared quartz window.
Data Channels				Various A/C parmeters available, incl alt, airspeed, OAT, and Mach #.
Rate	1	Hz		
Format				ARINC 429
Data Recorder				UEI Data Logger
Payload Control				N/A
Aircraft State Parameters				Airspeed, Mach #, Altitude, Temp (Total/Static), Standard GPS information.
Aircraft Facility Instruments				
Communications				
Voice	SAT, UHF, VHF			
Data				
Science crew complement	3			2 flight crew.
Payload Design Characteristics				
Factor of Safety				
Cable and Connector Types				
Gases				
Cryogens				
Web Site:				

Appendix 2: NASA Airborne Science Program
Platform Experimenter Handbook
September 2008

Proposed Standard Document

1.0 Introduction

- 1.1 Overview
- 1.2 Purpose & Scope of Document

2.0 Aircraft Description

- 2.1 General
- 2.2 Performance
  - 2.2.1 Altitude
  - 2.2.2 Speed
  - 2.2.3 Range
  - 2.2.4 Endurance
- 2.3 Payload Weight Limits

3.0 Payload Accommodations

- 3.1 Physical
  - 3.1.1 Locations & Dimensions
  - 3.1.2 Mass & Center of Gravity Constraints (moment?)
- 3.2 Electrical Power
- 3.3 Payload Control
- 3.4 Payload Data Access
- 3.5 Viewports
  - 3.5.1 Windows
- 3.6 Inlets & Protrusions
- 3.7 Cameras/Video
- 3.8 Facility Instruments
- 3.9 Science Crew Complement

4.0 Environment

- 4.1 Pressure
- 4.2 Temperature
- 4.3 Load & Acceleration
- 4.4 Airflow and Boundary Layer
- 4.5 Stability
- 4.6 Vibration & Shock
- 4.7 Radiofrequency and Electromagnetic Interference
- 4.8 Radiation

5.0 Communications, Navigation, and Data Acquisition

- 5.1 Voice & Data Communications
- 5.2 Navigations Systems
- 5.3 Navigation Data Recorder
- 5.4 Data Acquisition
- 5.5 Timing

6.0 Payload Design Planning, Engineering, and Integration Processes

- 6.1 Experiment Development & Planning
  - 6.1.1 Airborne Science Flight Requests
  - 6.1.2 Payload Data Package
  - 6.1.3 Drawing and Other Technical Data
  - 6.1.4 Hazard Analysis
  - 6.1.5 Aircraft Personnel (Mission Manager, Operations Engineer)
- 6.2 Certifications, Reviews, & Approvals
  - 6.2.1 Management Reviews (AFSRB, TRR, FRR)
- 6.3 Aircraft Integration

7.0 Payload Design and Construction Requirements

- 7.1 Mechanical Systems
  - 7.1.1 Loads & Structures
  - 7.1.2 Inlet Systems
  - 7.1.3 Fasteners
  - 7.1.4 Welding
- 7.2 Electrical Systems
  - 7.2.1 Wiring
  - 7.2.2 Cabling
  - 7.2.3 Connectors
- 7.3 Materials
  - 7.3.1 Metallic
  - 7.3.2 Non-Metallic
  - 7.3.3 Hazardous Materials
- 7.4 Pressure & Hydraulic Systems
  - 7.4.1 Pressure/Vacuum Systems
  - 7.4.2 Purge/Vent Systems
- 7.5 Thermal
- 7.6 Access & Physical Integration
- 7.7 Flight Safety
- 7.8 Other (Gases & Cryogens, Lasers)

8.0 Aircraft – Payload Interfaces

- 8.1 Structural Attachments
- 8.2 Racks
- 8.3 Experiment Control Panel
- 8.4 Electrical Interface Panel

9.0 Flight Operations

- 9.1 Operational Scenarios (flight hours & duty days)
- 9.2 Testing (TRRs)
- 9.3 Flight Safety
  - 9.3.1 Access/Egress
  - 9.3.2 Specialized Safety Equipment
  - 9.3.3 Personnel Training & Certification
- 9.4 Field Deployments

10.0 Ground Operations

10.1 Facilities
10.2 Ground Support Equipment
10.3 Access (including local badge requirements)
10.4 Safety

Appendices

- Payload Data Package Requirements
    - Hazard Checklist
- Detailed Design Requirements
- Rack/Mounting Locations
- Data/Navigation Parameters
- Detailed Safety & Emergency Procedures

Appendix 3. Common Payload Data Package

Table of Contents

Part 1. Purpose and Instructions to Authors

1.1 Purpose

The purpose of this document is to provide guidance to a Principal Investigator (PI) in the preparation of a Common Payload Data Package (CPDP) which will be submitted to the relevant Aircraft Engineering (AE) POC for any of the NASA research aircraft.

The CPDP generated by the application of this will have the following characteristics:

- It will be a single document, generated once, and acceptable by any of the platform AE organizations as he first step towards integration and flight.

- The PI is responsible for CPDP authorship, ownership, and maintenance of document version control.

- The document is subject to modification based on new information, instrument design changes, or the further information requested by AE.

- It will follow the format and conventions contained herein.

1.2 Instructions

The PI shall conform to the following instructions while constructing the CPDP:

- Provide commentary and responses to the information prompts, requests, and queries in the questionnaire.

- Express umerical data in Standard English engineering units.

- Express measurements or other numerical values with associated uncertainties and tolerances.

- Indicate as appropriate if a requested value or design detail is unknown, not yet designed, to be determined, or not applicable.

- Insert images, drawings, plots, or other graphic material in the text as jpg files. If more detail is required (e. g. a particular CAD file) by AE, such can be sent as needed.

1.3 Document Structure and Control

The document will be structured according to the format below, including the section and subsection sequence and numbering. The cover page shall be one page and the remaining sections shall be as many pages as required. Page numbering shall begin with the first page of Section 1.

The PI is responsible for updating and editing the document as required. The PI is responsible for maintaining a record of document changes and version issuance as per Section 6.

Part 2. CPDP Format

Cover sheet (1 page)

Section 1. Basic Information

Section 2. Platform Requirements Overview

Section 3. Detailed Instrument Description

Section 4. Hazards and Risks Evaluation

Section 5. Proposed Operation

Section 6. Document Control

Part 3. CPDP Questionnaire

Cover Sheet

The cover sheet should contain the following information:

- Name of Instrument
- Acronym
- Principal Investigator name and contact information
- Logo or image
- Date, author, and CPDP version number

Section 1. Basic Information

1.1 Instrument Principal Investigator and Principal Engineer contact information

List contact information of the responsible parties for the instrument, including:

- Principal Investigator
- Principal Engineer
- Other team members

1.2 Instrument Overview

Provide a short overview description:

- The science objectives and measurement details
- Instrument hardware description
- General operating principals

1.3 Instrument Development History and Flight Heritage

Provide a short description of the heritage of the instrument, including technical development, previous missions, previous platforms, and significant changes from previous flights.

Section 2. Platform Requirements Overview

2.1 Required and Desired Platform Characteristics

Provide a brief description of the flight characteristics levied on the platform by the instrument in order to (1) collect useful science data in the atmospheric regions of interest and (2) have high probability of successfully being integrated, tested, and flown on science missions. The first (details to be provided in Section 2.2) includes atmospheric regions of interest, seasonal influences, deployment locations, flow or line of sight concerns. The second (details to be provided in Section 2.3) include fundamental mechanical, electrical, and operational concerns. The characteristics should be categorized as required or desired.

2.2 Overview of Flight Requirements (minimum, desired, maximum)

- Altitude
- Duration
- Airspeed
- Climb or descent rates
- Turn radius or bank angle
- Total number of flights, flight hours, and flight sequence
- Time of year

2.3 Overview of Interface Requirements

- Weight (total and per component)
- Power (start-up, standby, operation, surge)
- Dimensions and volume (each component)
- Pressure and temperature environment (minimums and maximums)
- Sample probe, sample inlet, window, or antennae required including airflow quality and viewing geometry
- Instrument control within the context of tended cabin operation, simple on-off control from the cockpit switches, automatic control based on flight data, or completely autonomous operation
- Data uplink and downlink
- Access to aircraft systems such a pitot static pressure line, navigation data, time code

2.4 Analysis of Proposed Platforms

2.4.1 Proposed Aircraft

List the aircraft that are proposed to carry the instrument. This should be based on the comparison of the characteristics in Sections 2.2 and 2.3 against aircraft characteristics in the associated documentation. Note if specific mounting locations or payload bays in specific aircraft are required or desired.

2.4.2 Potential Concerns

List and discuss any potential concerns regarding the ability of the proposed aircraft to meet the flight and interface needs of the instrument. This is meant to include situations where the margin between instrument requirements and aircraft performance is less than 10% or the instrument needs are not completely understood due to design immaturity.

Section 3. Detailed Instrument Description

3.1 Methods and Data Products

Provide a description of the method and technique used by the instrument, including primary measurements, inferred measurements, and data recorded each flight.

3.2 Hardware components

Provide a component level list of all hardware to be installed on the aircraft, their weight, and function. This should include an overview block diagram of all components and their interfaces with each other and the aircraft.

3.3 Schematic of Proposed Installation

Provide a system-level description of the proposed installation of the instrument on the aircraft including photographs, drawings, or schematics. This includes inlets, exhaust, ports, rack mounting points, etc.

3.4 Power Block Diagram

Provide a subsystem-level schematic of the instrument power control and conditioning, electromechanical devices, associated thermal control, circuit breakers or fuses, and the proposed electrical interface with the aircraft.

3.5 Software and Control Block Diagram

Provide a subsystem-level schematic of instrument computation, data flows, control, and data recording.

3.6 Pressure System Block Diagram

Provide a subsystem-level schematic of instrument gas and fluid flows, valves, bottles, and inlet and exhaust flows.

3.7 Structural Analysis

Provide an analysis of the ability of the instrument to meet aircraft load and structural design characteristics, including internal components, welds, aircraft interface, and associated safety factors.

Section 4. Hazards and Risks Evaluation

4.1 Identification of Hazards and Risks

Identify any of the following potential safety, performance, or operational risks or limitations that the instrument (components, inlets, or mounting structure) could potentially present to the platform or to other instruments carried by the platform.

4.1.1 Flammable, combustible, or explosive materials

4.1.2 Toxic, corrosive, reactive, frangible, or radioactive materials

4.1.3 Components or subsystems supporting a pressure differential from ambient values (cabin, equipment bay, or atmosphere)

4.1.4 Moving parts or machinery such as pumps, filter wheels, acoustic devices, covers, motors, springs, or deployable devices

4.1.5 Active electromagnetic emissions such as lasers, microwave, RF noise, internal wireless links, or radar

4.1.6 Control of large thermal capacitance by heaters, coolers, air flow, or radiators

4.1.7 High voltage power supplies, batteries or capacitors, or other spark sources

4.1.8 Cryogenic materials such has liquefied or solidified gases

4.1.9 Potentially hazardous failure mode in the event of loss of thermal, power, computer, or pressure control

4.2 Detailed Analysis and Proposed Mitigation of Hazards and Risks

Provide an evaluation of any of the potential hazards identified in the previous section. The information should be sufficiently detailed so a platform engineer or technical representative of another instrument may determine (1) impact to safety, performance, cost, schedule, or overall mission objectives, (2) the probability of occurrence, and (3) potential mitigation. In some cases further information or other action could be required.

The evaluation should reference all supporting documents, data sheets, certifications, analysis, and testing to support the platform engineer.

The evaluation for each potential hazard should be in a Section 4.2.1-9 corresponding to the organization of Section 4.1.1-9 and include, but not be limited to, the following information as required:

- Hazardous material (name, composition, purpose, ref. HMDP reference, amount carried by instrument, amount consumed during flight)
- Hazardous material container (volume, pressure, type of vessel, ref. certifications)
- Pressure devices (purpose, volume, design operating pressure, certifications, manufacturer data, failure modes)
- Moving machinery (purpose, frequency, manufacturer data, failure modes)
- Electrical hazards (purpose, voltage, current, frequencies, manufacturer data)
- Electromagnetic emitters (external or internal, power, frequency, band, duty cycle, control)
- Thermal control (source and sink temperatures, power, method of heat transfer, coolant, failure modes)

Section 5. Proposed Operation

5.1 Flight Operations

5.1.1 Science Flights

Provide a description of instrument control and operation during routine flight operations, including number of persons required (for tended cabin instruments), power on and off sequences, failure modes.

5.1.2 Pre- and Post-flight Support

Provide a description of planned routine pre- and post-flight instrument support, including time required prior to takeoff, fluid or cryogenic material replenishment, hardware change-outs, and the frequency that the instrument or inlet must be downloaded after each flight.

5.1.3 Integration and Test

Provide a description of the sequence of test flights that is desired for the instrument to be made ready for routine science flights.

5.2 Ground Operations

Provide a description of ground support equipment (GSE) required during integration and flight test, routine flight operations, and the minimum GSE set required for remote deployment.

Section 6. Document Control

Provide a cumulative record of the issue date, author, changes from previous version, and version number as the CPDP is modified, completed, or improved. This information should be entered under this section as follows.

Date	Version	Author	Sections Modified	Issued To	Reason For Modification

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