NOAA

Unmanned Aircraft System (UAS) Data Management Plan

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NOAA UAS Data Management

Unmanned Aerial Systems (UAS) provide unprecedented data acquisition opportunities:
UAS can expand the range of missions and place observation platforms in previously inaccessible locations.

NOAA and its partners believe UAS and other unmanned systems have the potential to efficiently and safely bridge critical observation gaps in hard-to-reach regions of the Earth, such as the Arctic and remote ocean areas, and to advance the understanding of key processes in Earth systems. Optimizing unmanned capabilities will advance NOAA's mission goals through improved and affordable understanding of oceanic and atmospheric exchanges, hurricanes, wildfires, marine ecosystems, Polar Regions, hazards, and other environmental and ecological processes. Other potential NOAA missions will continue to be evaluated as new technology becomes available and as UAS begin more routine operations in national and international airspace.

The NOAA UAS Program was established to explore the potential of UAS for NOAA applications and to advise whether or not UAS use would be cost and performance effective. An Analysis of Alternatives (AOA), an analytical comparison of the operational effectiveness, cost, and risks of proposed materiel solutions to gaps and shortfalls in operational capability, has been performed to document the rationale for identifying and recommending a preferred solution or solutions to several pressing NOAA needs, such as monitoring in marine sanctuaries and observing marine life. Through numerous intra- and inter-agency operational demonstrations and assessments the AOA has been verified and validated. It is becoming apparent that ***Dull, Dangerous, Dirty and Denied (Remote)*** missions can be accomplished more ***Efficiently, Effectively, Economically, Environmentally –Friendly and Safely*** using unmanned systems technologies.

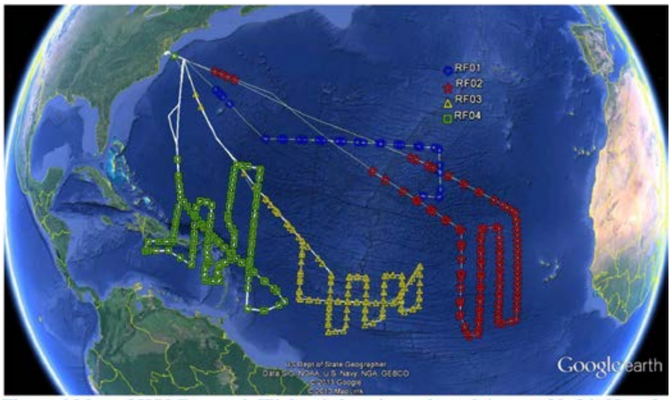


Figure 1 Map of HS3 Research Flights 1 thru 4, conducted August 20, 24, 29 and September 4, 2013.

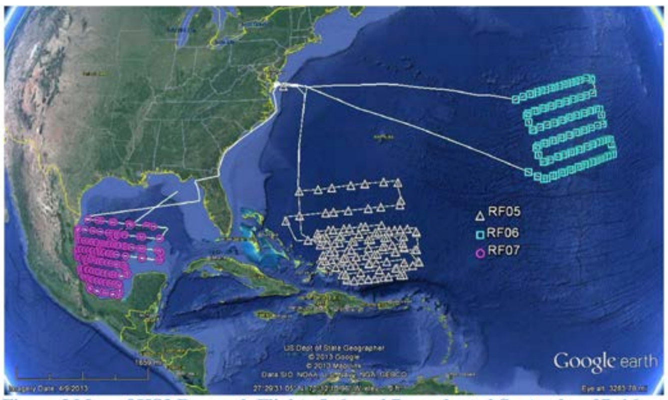


Figure 2 Map of HS3 Research Flights 5, 6, and 7, conducted September 07, 16 and 19, 2013.

The UAS Program Goals, as documented in the UAS Strategic Plan, are the following:

Goal 1: Increase UAS observing capacity
Goal 2: Develop high science-return UAS missions.
Goal 3: Transition cost-effective, operationally feasible UAS solutions into routine operations

Mission Areas:

- High impact weather monitoring
- Polar monitoring
- Marine monitoring

An example of the initial work that has been conducted is through joint partnership – NOAA, NASA, NCAR and Northrop-Grumman exploring the use of the Global Hawk for atmospheric sampling.

The UAS program has developed the Global Hawk in cooperation with NASA; this platform could drop as many as 88 dropsondes in sensitive areas (e.g. over large upstream areas such as the Atlantic), and along with downward looking sounders, significantly improve medium range predictions for dangerous storms. Figures 1 &2 show Global Hawks tracks during 2013 flights.

Maximize Value

By establishing Data Management processes that follow the data from acquisition to archive NOAA UAS can ensure that the potential of the data is fully realized.

NOAA Data Management Planning

I. Document Purpose

This document outlines a plan for managing data and information recorded, collected, or otherwise generated by the NOAA Unmanned Aircraft Systems (UAS) Program for all systems with enclosures for each of the platforms, sensors and applications as required. Enclosure one will focus on the Global Hawk and supporting atmospheric sensors which will be assessed during its SHOUT missions in Fiscal Year 2014-17. This plan is intended to support a comprehensive and standardized approach to identifying, acquiring, displaying, archiving, and publishing UAS mission data and information.

II. Document Authority

NOAA environmental and geospatial data are maintained in accordance with applicable Office of Management and Budget (OMB) regulations, including OMB Circulars A-16 and A-130; Federal Geographic Data Committee (FGDC) approved data standards; the Geospatial Profile of the Federal Enterprise Architecture; federal law related to records management within federal agencies – Sections 3101-3107 of Title 44 of the United States Code (44 U.S.C. 3101-3107); the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.); and the National Archives and Records Administration (NARA) Records Management Regulations – Parts 1220-1238 of Title 36 of the Code of Federal Regulations (36 CFR 1220-1238); NOAA Administrative Issuance NAO 205-17 and NAO 212-15; and the Federal Rules of Civil Procedure (28 U.S.C. § 2072). NOAA Information Access and Dissemination establishes policy for distributing scientific and technical publications and ensuring compliance with NOAA's mission to provide environmental information to its user communities. NOAA Management of Environmental and Geospatial Data and Information provide high-level direction that guides procedures, decisions, and actions regarding environmental data and information management throughout NOAA.

III. Scope of Plan

This plan sets forth a comprehensive and standardized approach to identifying, acquiring, displaying, archiving, and publishing data. The scope of this plan addresses data in its current state and custody arrangement and provides for management throughout the remainder of its lifecycle. It is designed to work in part or in whole to accomplish NOAA's primary data management objectives and may be executed for one data type or the entire universe of data and information.

IV. Data Management Plan Overview

The data collected and/or recorded and products generated as a result of a mission will be managed by the UAS Program Office and Principle Investigator (PI)/Cooperative Institute (CI)

charged with managing UAS data and products for NOAA's Office of Oceanic and Atmospheric Research (OAR). The project team will coordinate actions between OAR, the NOAA Data Centers, and other extramural partners. All data recorded, products generated, and discoveries made during a mission will be made discoverable and accessible to the general public in as close to real-time as possible. Exceptions to this will be noted in the individual mission Data Management Plans (DMP) when data are protected due to submerged cultural resources, in foreign waters, or other valid reason. Public access of these data will be achieved through a variety of discovery and access points, including secure FTP servers, account controlled content management sites, metadata search engines, public access websites, and customized geospatial applications.

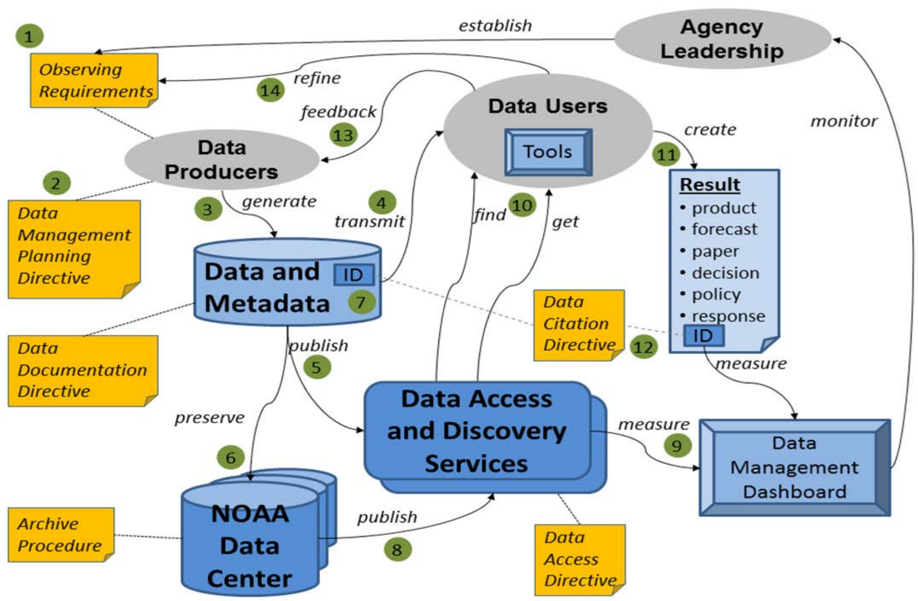


Figure 3. EDMC Process

V. Unmanned Systems, Instrument and Data Type Inventory

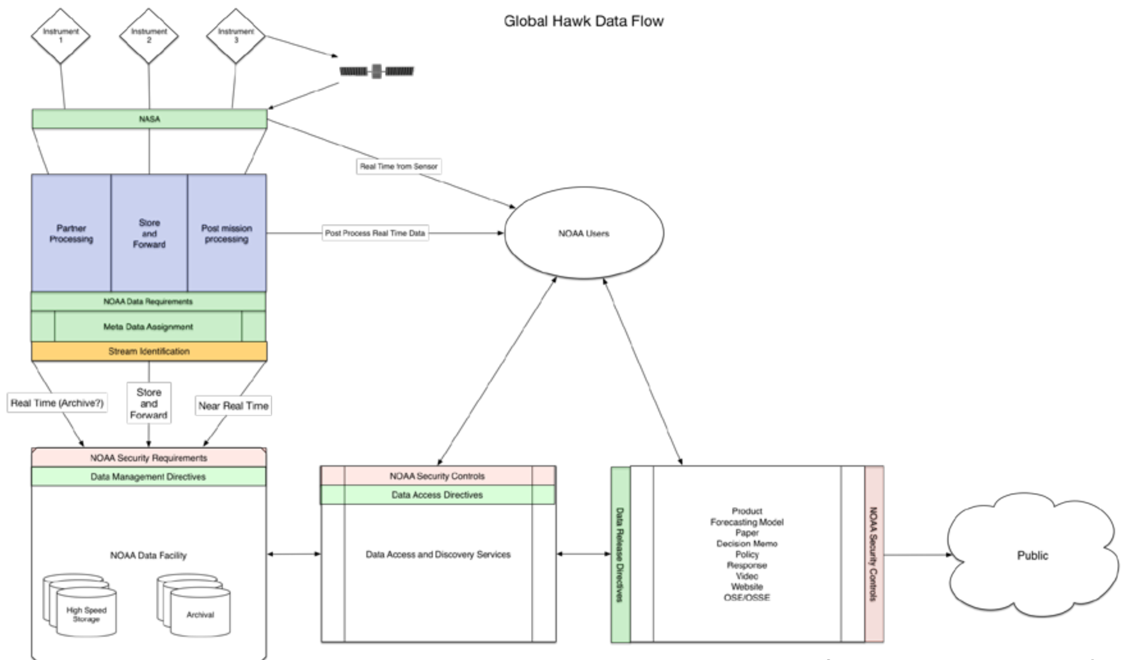
A plan for individual platform/sensor will be provided as enclosures. This plan will include:

- EDMC template completion
- Detail description of data formats during stages of acquisition through archive, metadata, access standards

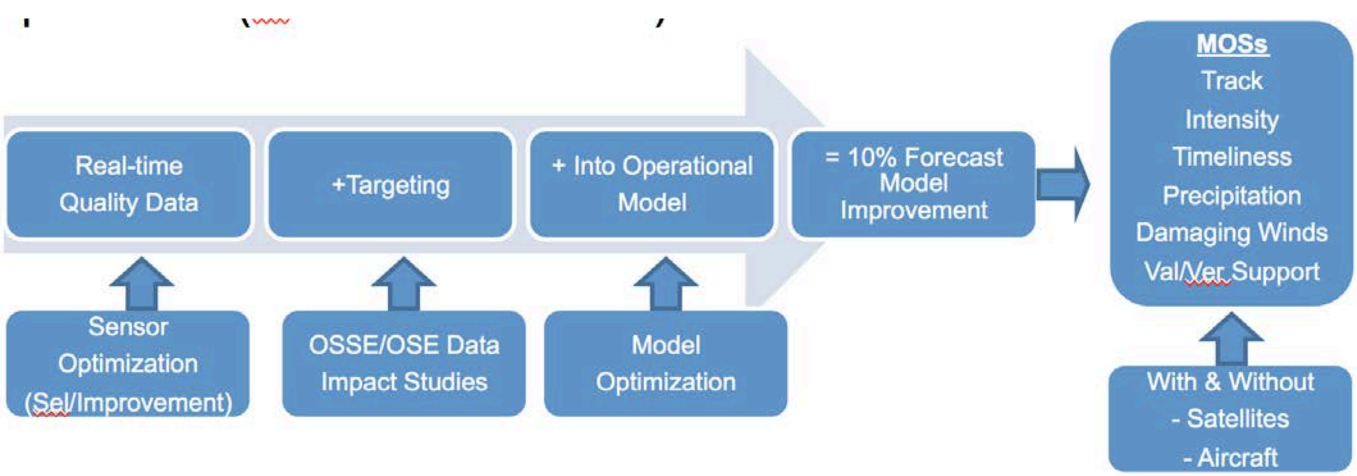
VI. Data Flow Strategies and Procedures

Data recorded and/or products generated as a result of a unmanned system mission will be managed first by the strict enforcement of NOAA (and partner organizations) Standard Operating Procedures (SOPs) followed by specified crew members, mission specific personnel and by the data managers. SOPs for data and metadata flow to the archives, data discovery and accessibility tools will be facilitated by data pipelines from source to server as described for

each platform and sensor. Real-Time, archived, discoverable, visible and accessible data for actionable environmental intelligence and follow-on research will be discussed in the enclosures and will optimized through the projects. The is a general data architecture for data flow for UASs using a Global Hawk as an example:



VII. Data Planning, Metrics and Measures of Success (MOS) : While data flow will vary from sensor to sensor and may vary depending upon UAS platform/sensor capability, the UAS Program is monitoring several data metrics. An example for the Global Hawk is the SHOUT Forecast Improvement Plan's Metrics and Measures of Success (MOS) which will be evaluated against the Total Ownership Cost (TOC) to capture the true scientific, operational and cost benefits as outlined below:



Other unmanned systems metrics and measures of success are being generated and tracked.

VIII. Unmanned Systems Data Management Plan Review and Continuity: The NOAA UAS Program will continue to work with the Environmental Data Management Committee (EDMC) to coordinate the development of NOAA's environmental data management strategy, policy and planning, and promote consistent implementation across NOAA. Environmental data management is an end-to-end process that includes acquisition, quality control, validation, reprocessing, storage, retrieval, dissemination, and long-term preservation activities. The goal of the NOAA UAS Program in supporting the EDMC is to enable NOAA to maximize the value of its environmental data assets through sound and coordinated data management practices providing timely, actionable, reliable unmanned systems data and environmental intelligence to end-users. This plan will be reviewed annually and updated as new applications are introduced into the program. The Lead Systems Engineer will continue to coordinated all data management efforts.

Enclosures

Enclosure 1: High Altitude Long Endurance (HALE)- Global Hawk

- **1a:** Airborne Vertical Atmospheric Profiling System (AVAPS)
- **1b:** High Altitude MMIC Sounding Radiometer (HAMSR)
- **1c:** High-altitude Imaging Wind & Rain Airborne Profiler (HIWRAP)
- **1d:** Lightning Instrument Package (LIP)

Enclosure 2: Medium Altitude Long Endurance (MALE)

- **1a:** Ikhana

Enclosure 3: Low Altitude Short Endurance (LALE)

- **1a:** ScanEagle

Enclosure 4: Low Altitude Short Endurance (LASE)

- **1a:** Altavian
- **1b:** AeroVironment Puma AE
- **1c:** Microdrone MD4-1000
- **1d:** Others

Enclosure 5: Environmental Response Management Application (ERMA)

- **1a:** USCG Ice Breaker Operations

Enclosure 6: Other Unmanned Platforms

Enclosure 1: Global Hawk Data Management Planning - SHOUT

Background

The NOAA UAS Program has designed a project focused on **"Sensing Hazards with Operational Unmanned Technology" (SHOUT)** to quantify the influence of UAS environmental data to high impact weather prediction and assess the operational effectiveness of UAS to help mitigate the risk of satellite observing gaps. The NOAA UAS Program will partner with NASA to conduct missions using advanced UAS for operational prototype data collection. The SHOUT project will begin with a targeted observing effort using NASA Global Hawk platforms and payloads for observing and predicting high impact oceanic weather. As the project matures, other viable unmanned observing technologies may be incorporated into the observing strategies tested as operational prototypes.

Targeted observations from aircraft in oceanic regions can significantly improve how well weather models forecast significant meteorological events such as tropical storms, winter storms and major floods. The long duration and large oceanic areas that can be observed using advanced Unmanned Aircraft. Systems (UAS) such as the Global Hawk make this an important potential observing platform.

National Oceanic and Atmospheric Administration (NOAA) UAS Program will work with the National Aeronautics and Space Administration (NASA) to conduct missions using advanced UAS to determine their utility in prediction of dangerous storms that can affect the United States. This effort to sense hazards with operational unmanned technology will determine the observing strategies and quantify the contribution that advanced UAS can make to mitigate the satellite data gap.

Figure 1. Global Hawk Inflight

1. General Description of Data to be Managed

1.1. Name of the data, datasets or data collection project [→ gmd:title]:

Sensing Hazards with Operational Unmanned Technology (SHOUT)

1.2. Summary description of the data to be generated [→ gmd:abstract]:

1.2.1. There is a well-established scientific finding that adaptive observations can improve weather prediction. This is particularly true for major storms, such as tropical storms, winter storms, and family tornado outbreaks. The operations concept would be that several days before a potential storm, advanced techniques such as “singular vector” calculations are used to determine sensitive areas. The UAS program has developed the Global Hawk in cooperation with NASA; this platform could drop as many as 88 dropsondes in sensitive areas (e.g. over large upstream areas such as the Pacific Ocean), and along with downward looking sounders, significantly improve medium range predictions for dangerous storms. Other sensor packages are also being developed, integrated and assessed, and will be incorporated separately as DMP Enclosures. Summary of the data generated for SHOUT 2015 include:

Instrument	Spectral Bands	Spatial Resolution (FOV) Profile Resolution	Sample/ Profile Frequency	Raw Measurement Precision	Retrieved Parameter Precision	Calibration Requirements
Dropsondes	N/A	N/A, 0.5s	N/A	Pressure +/- 1.0hPa Temp +/- 0.2 C Wind +/- 0.1 m/s Humidity +/-7%	N/A	N/A
HAMSR	50-60 GHz, 113-118 GHz, 166-183 GHz	2 km horiz 1-3km vert	8ms, 320 samples/scan	TB 0.1-0.6 K precision, <1K accuracy	2 K for temp, 15% for water vapor and 25% for liquid water	None, self calibrating
HIWRAP	4,5,6,6.6 GHz	1.6km (6.6 GHz), 2.5 km (4 GHz) @ nadir from 20 km	1.2 s integration	NEDT 0.19K-0.27K Brightness temperature	Wind speed 1-5 m/s	Calm, rain-free Ocean surface
LIP	DC to few kHz, electric field, air conductivity	5-10 km, N/A	0.1 s (data oversampled at 50 Hz) continuous observations	5-10 %	5-10%	GRIP maneuvers

Figure 2. Summary Description of Global Hawk Generated Data

1.3. Actual or planned temporal coverage of the data:

This is an ongoing series of measurements that have taken advantage of multi-agency, multi-platform, multi-mission data sets.

1.4. Actual and planned temporal coverage of the data [→ gmd:EX_TemporalExtent]:

SHOUT temporal coverage will be based on the Atlantic Hurricane Season, but expand to year around missions to cover global regional, seasonal high impact weather.

SHOUT data will include cooperative data gathered with the NASA HS3 projects and others as historical baseline commenced in *January, 2012.* Mission data from 2012 and 2013 will be assimilated within the project for reference with acquisition of new data to begin in 2014. SHOUT is expected to continue through FY2017 with the expectation that data gathered will be retained for use in other projects/operational efforts.

1.5. Actual and planned geographic coverage of the data [→ gmd:EX_Extent]:

Atlantic and Pacific Oceans, Arctic Oceans, National Coverage.

1.6. Data types created or captured (e.g., digital numeric data, photographs, video, acoustic records, database tables, spreadsheets, paper records, physical samples, etc.):

Data types vary by installed sensor on the UAS platform. Some of the data captured is purely numeric (dropsonde) while others combine both numeric and image data following the post processing phase (HAMSR). The sensor data will be further described in the Enclosures. The Global Hawk will have the ability gather still images and video as well.

1.7. Data collection methods (e.g., satellite, airplane, unmanned aerial system, radar, weather station, moored buoy, research vessel, autonomous underwater vehicle, animal tagging, manual surveys, enforcement activities, etc.):

Unmanned systems (aircraft) equipped with a variety of acquisition systems to include radar, telemetry, video, drop sonde, etc. as outlined in Enclosures.

1.8. If data are from a NOAA Observing System of Record indicate name of system:

1.8.1. If data are from another observing system, please specify:

This data compliments the data recorded from the USAF WC-130, NOAA WP-3, NOAA G-IV aircraft, as well as, NASA's NPOESS Preparatory Project (NPP) Satellite with Joint Polar Satellite System (JPSS) follow-on.

1.9. Data archive plan in the NOAA GSD Repository

Locations are being determined at this time working with cooperative institutes and will be linked to the NOAA UAS website.

1.10. Personally Identifiable Information (PII) or any information whose distribution may be restricted by law or national security

Data captured within the SHOUT project should not include PII or restricted data but potential use cases for UAS include data that could be restricted by law or national security.

1.11. Keywords that could be used to characterize the data, and vocabulary from which those keywords were obtained (e.g., GCMD, CF Conventions, etc.) [→ gmd:MD_Keywords]

GCMD: ATMOSPHERE >

ATMOSPHERIC TEMPERATURE > SURFACE AIR TEMPERATURE>

ATMOSPHERIC WATER VAPOR > HUMIDITY>

ATMOSPHERIC RADIATION > SHORTWAVE RADIATION>

ATMOSPHERIC RADIATION > LONGWAVE RADIATION

GCMD: OCEANS >

OCEAN PRESSURE > SEA LEVEL PRESSURE>

OCEAN WINDS > SURFACE WINDS>

OCEAN TEMPERATURE > SEA SURFACE TEMPERATURE>

OCEAN TEMPERATURE > WATER TEMPERATURE>

SALINITY/DENSITY/SALINITY>

SALINITY/DENSITY/DENSITY>

OCEAN CIRCULATION > OCEAN CURRENTS

2. Points of Contact for this Data Management Plan (Author or Maintainer)

2.1. Name: John "J.C." Coffey

2.2. Title: Lead Systems Engineer, NOAA UAS Program

2.3. Affiliation or facility: NOAA OAR Head Quarters, NOAA UAS Program

2.4. E-mail address: john.j.coffey@noaa.gov

2.5. Phone number: 904-923-1709

3. Responsible Party for Data Management

3.1. Representatives present for this data collection project on NOAA's Data Management Integration Team (DMIT). Current members of DMIT are listed at: https://geo-ide.noaa.gov/wiki/index.php?title=DMIT_Membership.

OAR - Darien Davis

3.2. Name: Dr. Gary Wick, PhD.

3.3. Position Title: SHOUT Principle Investigator

3.4. Name of current position holder: Darien Davis

3.5. Responsible for data documentation and metadata activities: Jeb Stewart

3.6. Responsible for the data storage and data disaster recovery activities: Jeb Stewart

SHOUT is working with a cooperative institute to determine best methods/practices for these activities.

3.7. Responsible for ensuring adherence to this data management plan, including ensuring that appropriate resources are available to implement the data management plan:

John "JC" Coffey & Darien Davis following the following components outlined by the DMIT:

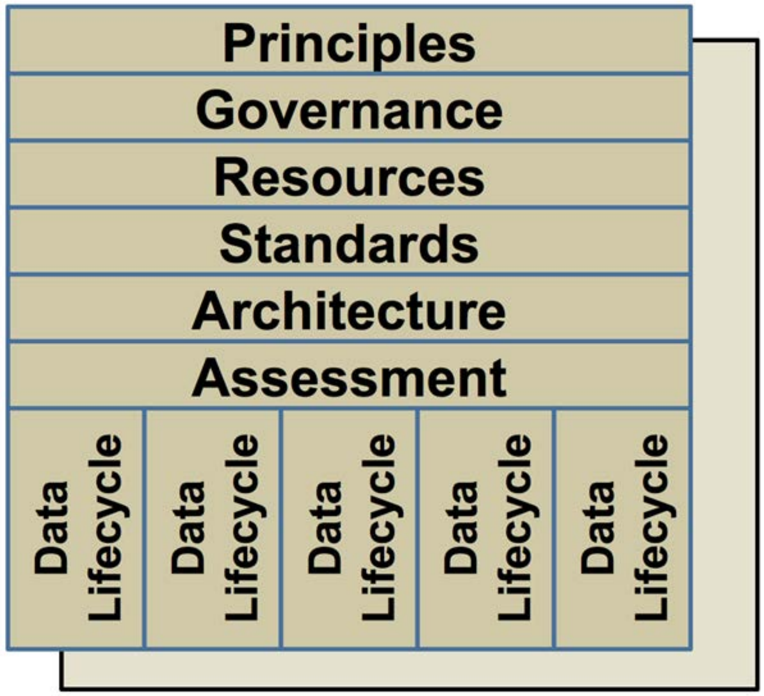


Figure 3. Data Management Overview

4. **Resources**
   Programs must identify resources within their own budget for managing the data they produce.

4.1. Resources for management of these data include: Data management and visualization personnel that have examined the total data lifecyle of this data including final archiving.

4.2. Approximate percentage of the budget for these data devoted to data management (specify percentage or "unknown"): 10% of mission budget.

5. Data Lineage and Quality

5.1. Processing workflow of the data from collection or acquisition to making it publicly accessible (describe or provide URL of description):

Quality Control procedures are being coordinated by the PI and CI using the systems engineering flowchart below as outlined by the EDMC.

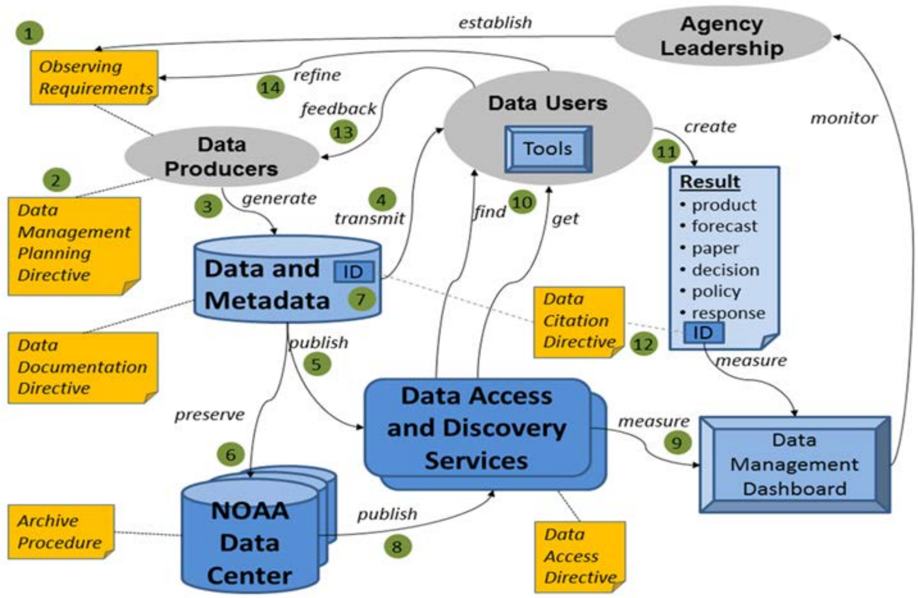


Figure 4. EDMC Process

5.2. Quality control procedures employment: The QA procedures are contained within the EDMC process (Fig. 4) and further outlined for the Global Hawk below.

5.3. Overall lifecycle of the data from collection or acquisition to making it available to customer

Real-time/near real-time data from instruments mounted/delivered from unmanned systems are telemetered via satellite via NASA ground station. NOAA SHOUT monitors, processes and QC's real-time data and places it on a public web page for display and delivery to users. SHOUT also intends to place real-time data onto the Global Telecommunications System (GTS) for distribution to national and international forecast centers.

Delayed-Mode data, higher temporal-resolution, internally recorded data are processed, QC'd, archived and distributed by SHOUT after mission completion.

QC'd real-time and/or delayed-mode data from non-SHOUT systems (NASA, partner organiztions) are collected by SHOUT, integrated with SHOUT data, archived and distributed via the NASA MTS web site and NOAA UAS SHOUT website.

While data flow will vary from sensor to sensor and may vary depending upon UAS platform capability the general flow of the data is captured in this diagram. As more specific versions become available they will be added to this data management plan. The following is the data flow for the dropsondes from the Airborne Vertical Atmospheric Profiling System (AVAPS) which will be further described in Enclosure 1a.

The Global Hawk Data flow follows:

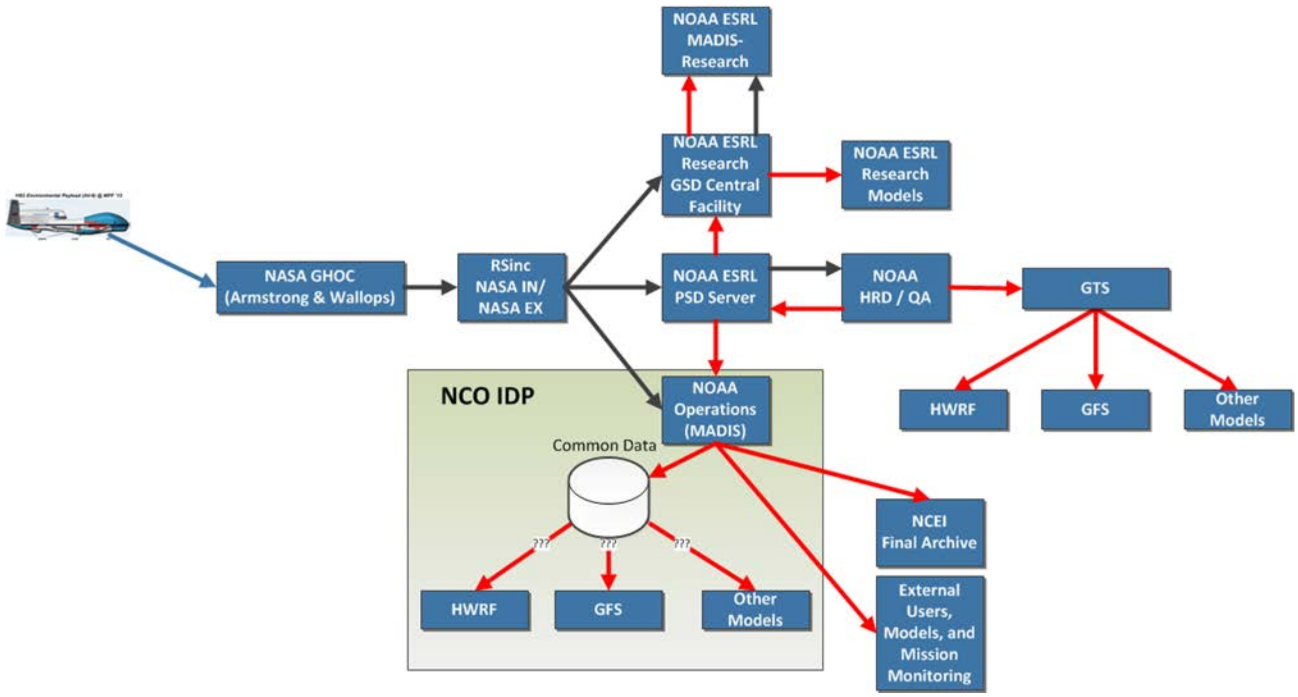


Figure 5. Global Hawk Data Flow, QA and Archiving Architecture

6. Data Documentation

The EDMC Data Documentation Procedural Directive requires that NOAA data be well documented, specifies the use of ISO 19115 and related standards for documentation of new data, and provides links to resources and tools for metadata creation and validation.

6.1. SHOUT Metadata complies with the EDMC Data Documentation Directive

6.2. Metadata repository used to document this data collection:

Complete metadata record storage will be provided to the NOAA's National Center for Environmental Information (NCEI) through coordination with ESRL and supporting cooperative institutes.

6.3. URL of Metadata folder or data catalog: In work.

6.4. Process for producing and maintaining metadata:

The project history has been in cooperation with the NASA HS3 project, the sonde data is very standardized with the data/meta-data is very understood. Continued close cooperation/coordination of metadata/documentation will be maintained throughout the project to insure that historical data remains relevant when combined with ongoing data collections from SHOUT and other project/platforms. Discovery-level metadata is provided with no additional metadata or other documentation is necessary to fully describe the data and ensure its long-term usefulness

7. Data Access

NAO 212-15 states that access to environmental data may only be restricted when distribution is explicitly limited by law, regulation, policy (such as those applicable to

personally identifiable information or protected critical infrastructure information or proprietary trade information) or by security requirements. The EDMC Data Access Procedural Directive contains specific guidance, recommends the use of open-standard, interoperable, non-proprietary web services, provides information about resources and tools to enable data access, and includes a Waiver to be submitted to justify any approach other than full, unrestricted public access.

7.1. Data Access Directive

Real time data sets are made available on NASA MTS website and through SHOUT's website within hours of the observation. Top of the hour meteorological observations are placed onto the GTS within a few hours. Delayed-mode data are placed on SHOUT's web site within 6 to 12 months of mission completion. There is no hold placed on the data. Active data on the current project can be found:

http://espo.nasa.gov/missions/hs3/

http://uas.noaa.gov/shout/

7.2. Name of organization of facility providing data access: ESRL through MODIS with the following URL being: .

7.3. Data access methods or services offered: Web-based data access.

7.4. Approximate delay between data collection and dissemination: Near real-time with only latency only due to the QA process.

7.5. Data subject to any access conditions or restrictions, such as submission of non-disclosure statements, special authorization, or acceptance of a licensing agreement:

None. SHOUT team members/collaborators will have access to SHOUT data. Authors publishing work making use of SHOUT data are asked to acknowledge appropriate NOAA and US Federal data management directives.

7.6. Data access protocols used to enable data sharing"

NOAA UAS Program's SHOUT website will provide data, products and information about the missions and associated data to a wide range of users. These users include: the oceanic, atmospheric and climate research communities; operational weather, climate, and ocean forecasting centers; the satellite community for sensor validation; educators developing classroom and curriculum materials; students in elementary, high school, undergraduate, and graduate education programs; and the general public.

7.7. Catalogs of these services or data will be registered to enable discovery by users and other Catalogs: OAR populates a catalog for these data.

8. Data Preservation and Protection

The NOAA Procedure for Scientific Records Appraisal and Archive Approval14 describes how to identify, appraise and decide what scientific records are to be preserved in a NOAA archive.

8.1. Actual or planned long-term data archive location: NCEI

8.2. Data storage facility prior to being sent to an archive facility (if any): NCEI through MODIS.

8.3. Approximate delay between data collection and submission to an archive facility: Near real-time.

8.4. The data is protected from accidental or malicious modification or deletion be going directly to archiving at NCEI through MODIS. Data back-up, disaster recovery/contingency planning, and off-site data storage relevant to the data collection will be handled through NOAA's NCEI.

9. Additional Line Office or Staff Office Questions and Coordination

9.1. NOAA NWS and NCEI:

Data transformations or procedures will be necessary to prepare data for preservation or sharing (e.g., quality control, format conversion, anonymization of personally-identifiable information, etc.). Related information required to be submitted to the archive to enable future use and understanding of the data [e.g., metadata, references, reports, research papers, algorithms, audio or video codecs, special character sets or fonts, etc.]). Identify the Record Schedule applicable to these data and provide the retention time for these data.

TBD – cooperative institute to determine necessary data transformations. It is the intent of the project to provide all relevant data, metadata, references, reports, papers, algorithms, audio or video codecs, special character sets or fonts, etc. needed to utilize the data within current/future projects.

10. Preliminary SHOUT Data Management Architecture and Plan Of Action and Milestone (POAM)

The following NOAA's Environmental Data Management Framework (EDMF) a data management plan will be developed for handling UAS instrumentation package data covering ingest, integration, visualization, and archival. Recommendations from the plan will be used to prototype and demonstrate all phases of the UAS data life cycle from real-time operations to post analysis and research. The demonstration will build and improve upon NOAA's operational and research data ingest, integration, visualization, and archival strategies in use today.

Proposed Research Tasks/Activities

In summary, the proposed research effort falls under 4 general tasks/activities:

1) UAS data Lifecycle management -- Management and maintenance of data through various stages of the data lifecycle from data creation, real-time delivery for modeling assimilation and visualization, accessible storage for use in other tools and applications, and eventual archival for long-term preservation.

2) Research and investigation of existing visualization tools, providing guidance and recommendations going forward for real-time UAS data visualization within three (3) distinct 'realms': 1- real time field data tracking and collection, 2 – real time field data visualization for operational users, and 3 - scientific visualization for data analysis, comparison and impacts. Each visualization system will allow users to integrate other earth system data synchronized in both time and space. Initial candidates will include

existing NASA Mission Tools Suites, NOAA AWIPS II, and the NOAA Earth Information System (NEIS).

3) Development of real-time data visualization tools resulting from output of task 2.

4) Development and implementation of tools aiding UAS data discovery and accessibility to meet NOAA data management requirements.

Objectives

Year 1:

1. Develop SHOUT data lifecycle management plan. (Coffey)
2. Evaluate existing visualization tools and capabilities for use in three visualization realms described above. (Stewart)
3. Develop recommendations for system architecture and implementation plan for UAS data visualization for three realms described above. (Stewart)
4. Develop recommendations for UAS data visualization for operational NWS forecasters. (Stewart)
5. Develop data discovery and accessibility architecture and implementation plan. (Benjamin & Pratt)
6. Implementation and delivery of initial data lifecycle management for one UAS instrumentation package, making data available for real-time model assimilation and visualization and data archival. (Wick, Benjamin & Pratt)
7. Initial proof of concept visualization development for one UAS instrumentation package. (Wick & Stewart)
8. Implementation and delivery of initial visualization system Real Time Mission Monitoring. (Wick & Stewart)

Year 2:

1. Continue development of data lifecycle management for up to 3 additional UAS instrumentation packages.
2. Implementation and delivery of initial visualization system for Real Time Scientific visualization and analysis.
3. Demonstration of UAS data visualization tools and capabilities.

Year 3:

1. Delivery of final data lifecycle management implementation for UAS data.
2. Delivery of final UAS data visualization system for Real Time Field Data Tracking and collection.
3. Delivery of final UAS data visualization system for Real Time Scientific visualization and analysis.
4. Demonstration of UAS data visualization tools and capabilities.

Task/Task Lead	**Milestone**	**Deliverable**
Develop data lifecycle	02/28/2015	SHOUT Data Lifecycle plan for

management plan. (Coffey)		UAS instrumentation packages.
Evaluate existing visualization tools. (Stewart)	03/31/2015	Recommendations for which tool to use for each visualization 'realm'.
Develop recommendations for system architecture and implementation plan for UAS data visualization for each 'realm'. (Stewart)	06/30/2015	System architecture and implementation plan for visualization of each 'realm'.
Develop recommendations for UAS data visualization for operational NWS forecasters. (Stewart)	06/30/2015	UAS data visualization system architecture and implementation plan for NWS forecasters.
Develop data discovery and accessibility architecture and implementation plan. (Benjamin & Pratt)	06/30/2015	Plan for data discovery and accessibility architecture for UAS instrumentation package data.
Implementation and delivery of initial data lifecycle management for one UAS instrumentation package. (Wick, Benjamin & Pratt)	06/30/2015	One UAS instrumentation package data set ingested, available for integration, available for visualization, discoverable, and archived for all SHOUT flights.
Initial proof of concept visualization development for one UAS instrumentation package. (Wick & Stewart)	06/30/2015	Proof of concept display reading data from UAS data lifecycle implementation.
Implementation and delivery of initial visualization system Real Time Mission Monitoring	06/30/2016	Initial Real Time field data tracking and visualization tools.
Development of data lifecycle management for 3 additional UAS instrumentation packages.	1st add on 06/31/2015 2nd add on 02/29/2016 3rd add on 06/30/2016	Three additional UAS instrumentation package data sets ingested, available for integration, available for visualization, discoverable,

		and archived for all SHOUT flights.
Implementation and delivery of initial visualization system for Real Time Scientific visualization and analysis.	06/30/2016	Real-time scientific displays and analysis of UAS instrumentation package data.
Demonstration of UAS data visualization tools and capabilities	06/30/2016	Demonstrations of real-time scientific display capabilities.
Delivery of final data lifecycle management implementation for UAS data.	06/30/2017	Any additional UAS instrumentation package data sets ingested, available for integration, available for visualization, discoverable, and archived for all SHOUT flights.
Delivery of final UAS data visualization system for Real Time Mission Monitoring.	06/30/2017	Ability to visualize and monitor all SHOUT flights in real-time. Ability to visualize past SHOUT missions.
Delivery of final UAS data visualization system for Real Time Scientific visualization and analysis.	06/30/2017	Ability to visualize and analysis all UAS instrumentation package data for all SHOUT flights.
Demonstration of UAS data visualization tools and capabilities.	06/30/2017	Demonstrations of real-time scientific display capabilities for all SHOUT flights.

Enclosure 1a: Airborne Vertical Atmospheric Profiling System (AVAPS)

A dropsonde is released from one of NASA's Global Hawk aircraft. The paper-towel-sized instrument contains sensors that measure precise location (and therefore wind), temperature, humidity, and pressure. Credit: NASA

A dropsonde is released from one of NASA's Global Hawk aircraft. The paper-towel-sized instrument contains sensors that measure precise location (and therefore wind), temperature, humidity, and pressure. Credit: NASA

The Global Hawk dropsonde system was developed by the National Center for Atmospheric Research (NCAR) with funding support from the Unmanned Aircraft Systems (UAS) program within NOAA. The system, also known as the Airborne Vertical Atmospheric Profiling System (AVAPS), takes advantage of NCAR's extensive experience in the development, operation, and analysis of aircraft dropsonde systems and their data. Integration onto the Global Hawk aircraft was done in collaboration with NASA.

The system can carry up to 88 dropsondes for deployment at altitudes up to 65,000 ft from the unmanned Global Hawk aircraft. The dropsondes collect high vertical resolution measurements of the temperature, pressure, relative humidity, and wind speed and direction in the atmosphere. Coupled with the long 30+ hour endurance of the aircraft, the system provides a revolutionary capability for the monitoring of high-impact weather events.

The Global Hawk dropsonde system was first deployed scientifically during the NOAA-led Winter Storms and Pacific Atmospheric Rivers (WISPAR) experiment in 2011. Currently the system is being employed in the multi-year NASA Hurricane and Severe Storm Sentinel (HS3) experiment and SHOUT.

AVAPS System Characteristics

1. 88-dropsonde capacity
2. Capability to track 8 dropsondes simultaneously
3. Automated telemetry frequency selection
4. Data file (D-file) returned to ground following drop
5. Ground processing enables real-time GTS transmission of data
6. Integrated into the Global Hawk platform

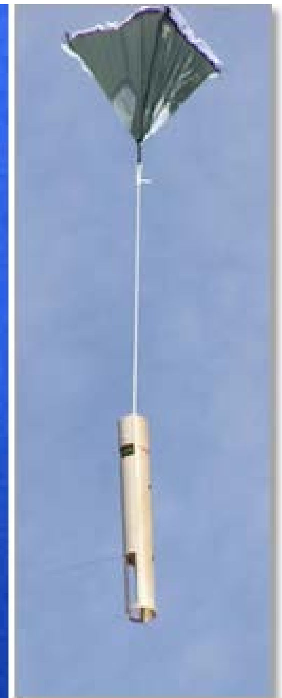
Dropsonde Characteristics

Global Hawk dropsondes utilize the same sensors as the dropsondes used on manned aircraft but are smaller and lighter to facilitate increased capacity

Size: 4.5 cm diameter x 30.5 cm length
Mass: ~167 g
Fall rate: ~11 m/s at surface

Vaisala RS-92 radiosonde sensor characteristics:

Temperature: +60^{o} to -90^{o}, 0.01^{o}C resolution
Humidity: 0 to 100%, 0.1% resolution
Pressure: 1080 to 3 mb, 0.01 mb resolution
Winds based on OEM GPS receiver and position (4 Hz update rate)
Stable cone parachute design
Remote control of power on/off and sonde release
Designed for extreme environmental conditions

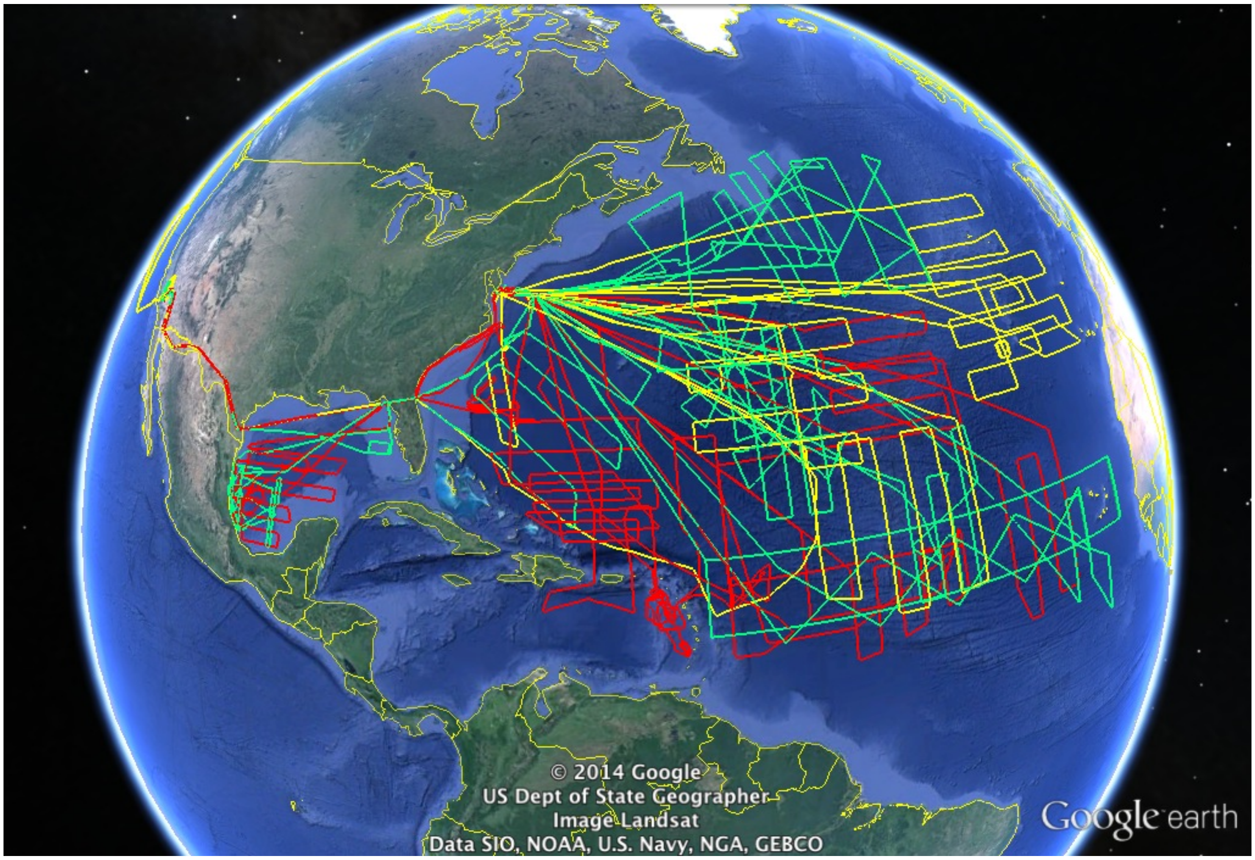


AVAPS Data Flow

- ✓ Individual sensors transmit data back to the AVAPS system integrated into the Global Hawk platform
- ✓ Data from the Global Hawk is transmitted to NASA via satellite
- ✓ Data is moved via USB memory stick to a NOAA computer system
- ✓ Raw data is processed and quality control is applied using the Aspen System (NCAR)
- ✓ Aspen has the capability of outputting data in several formats that should meet the needs of NOAA
- ✓ Data is currently captured/generated in a research mode – Current data flow for research is adequate but for operational use the following changes should be implemented:
- ✓ Data flow from NASA to NOAA has been automated
- ✓ Aspen is supported by managed systems in a NOAA data facility with the appropriate characteristics
- ✓ Data flow has be integrated into NOAA operational systems (MADIS)

Preliminary Report of 2014 SHOUT Data Management for AVAPS

Technical hurdles for the real- time distribution and ingestion of AVAPS dropsonde data into the weather prediction models including Hurricane Weather Research and Forecasting System (HWRF). All technical problems were removed as the Global Hawk (AV-6) and AVAPS deployed for the 2014 HS3/SHOUT season to NASA Wallops. The aircraft and system flew 11 missions covering 250 flight hours while dropping 665 sondes. The events tracks are outlined as follows:



As reported by the Gary Wick (SHOUT PI): It was initially hoped that dropsonde observations from HS3 2014/SHOUT would be assimilated operationally into the HWRF model in 2014. Operational assimilation did not occur, however, because a "do not assimilate" quality flag put in place when testing of real-time GTS transmission of the data was initiated could not be removed in time for the 2014 season. Transmission of Global Hawk dropsonde data through the real time gateway was initiated very early in the testing of the dropsonde system to facilitate access to the data in delayed-mode data denial studies. Real-time assimilation was not desired until that delayed-mode testing could be completed, however, to ensure that the data did not have an inadvertent negative impact on the forecasts. While intercomparisons of the Global Hawk dropsonde data with standard dropsondes deployed from the NOAA G-IV aircraft have shown equivalent quality of the Global Hawk data and the testing of the 2012-2014 Global Hawk data described previously supported its positive impact, the required modifications to the data assimilation system could not be completed in time. Real-time assimilation of Global Hawk data was executed into HWRF during Hurricane Erika in 2015.

Enclosure 1b: High Altitude MMIC Sounding Radiometer (HAMSR)

High Altitude MMIC Sounding Radiometer (HAMSR): HAMSR is an all-weather atmospheric sounder which was designed and built at JPL under IIP funding (Brown, et al, 2007). HAMSR monitors the atmospheric state by retrieving 3-dimensional profiles of temperature, water vapor and cloud liquid water. The measurements can also be used to estimate precipitation rates and provide information on hydrometeor distributions. HAMSR has 8 channels near the 60 GHz oxygen line complex, 10 channels near the 118.75 GHz oxygen line and 7 channels near the 183.31 GHz water vapor line. HAMSR scans cross track below the GH and has a ±45° field of view. HAMSR was first deployed on the ER-2 in the 2001 CAMEX-4 campaign and subsequently participated in the TCSP experiment in 2005. HAMSR also flew on the DC-8 during the 2006 NAMMA campaign. HAMSR was recently upgraded under the AITT program to deploy on the Global Hawk (GH) platform. The effort included a state-of-the-art low noise amplifier for the 183 GHz receiver, an upgraded data system capable of onboard science processing and real-time communication with the GH data network, and a re-designed instrument packaging concept to consolidate the power, data, thermal and receiver sub-systems into one compact housing. These upgrades reduce mass, improve performance and reliability, and reduce field maintenance. The new receiver has an order of magnitude better noise performance than the old receiver. HAMSR was flown on the GH during GRIP and again during WISPAR in Feb-Mar 2011. HAMSR mass is approximately 163 pounds.

Real-time data transmission of the raw HAMSR data during mission flights requires approximately 75 kbps of bandwidth. To account for raw and processed versions of the data (including Level 0, Level 1B, and Level 2), the disk space required for archiving all of this information amount/s to about 1.5 GB per operational flight hour.

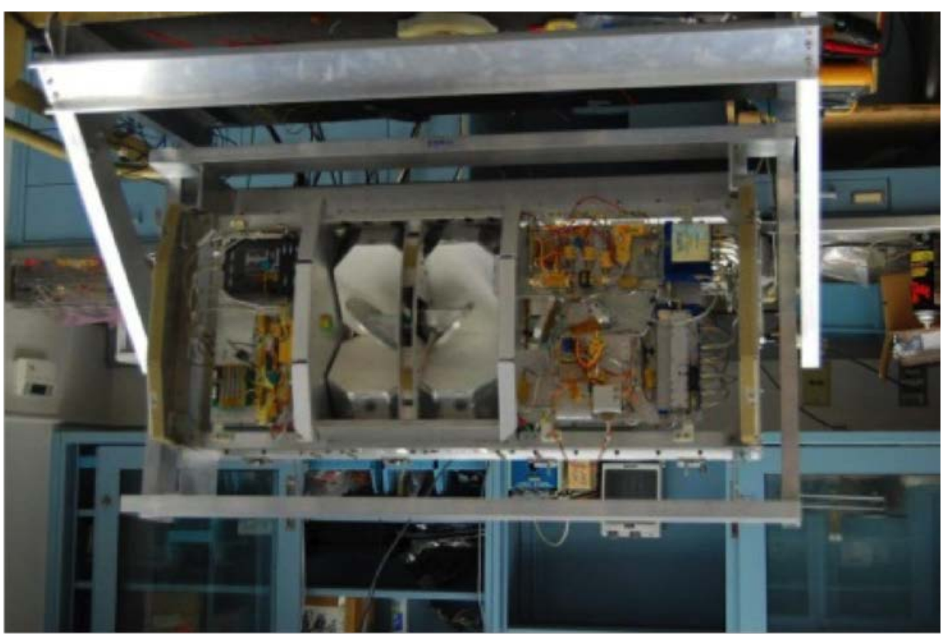


Figure 1B. High Altitude MMIC Sounding Radiometer (HAMSR)

Enclosure 1c: High-altitude Imaging Wind & Rain Airborne Profiler (HIWRAP)

High-altitude Imaging Wind & Rain Airborne Profiler (HIWRAP): HIWRAP is a dual-frequency (Ku- and Ka-band, or ~14 and 35 GHz), dual-beam (30° and 40° incidence angle), conically scanning radar that has been designed for the GH (Heymsfield et al. 2008). HIWRAP uses solid-state transmitters along with a novel pulse compression scheme that results in a system that is considerably more compact and requires less power than typical radars used for precipitation and wind measurements. By conically scanning at 10-20 rpm, its beams will sweep below the GH collecting Doppler velocity/reflectivity profiles, yielding the 3 wind components. The unique HIWRAP sampling and phase correction strategy implemented (frequency diversity Doppler processing technique) will be used to de-alias Doppler measurements. HIWRAP's dual-wavelength operation enables it to map full tropospheric winds from cloud and precipitation volume backscatter measurements, derive information about precipitation drop-size distributions, and estimate the ocean surface winds using scatterometry techniques similar to NASA's QuikScat. Winds will be retrieved using a gridding approach similar to well-established ground-based multi-Doppler radar wind analyses. The mass of HIWRAP is 379 pounds.

With respect to the data management requirements associated with the HIWRAP instrument, 1 Mbps of bandwidth for forward transmission of data is preferred, but as little as 800 kbps can be accommodated. Lastly, for any potential data archival, it is estimated that approximately 50 GB of space will be required to store the Level 1 data that could be obtained from a single flight mission.

Figure 1C. HIWRAP

Enclosure 1d: Lightning Instrument Package (LIP)

The LIP (Lightning Instrument Package) measures lightning, electric fields, electric field changes, air conductivity. LIP provides real time electric field data for science and operations support. The LIP is comprised of a set of optical and electrical sensors with a wide range of temporal, spatial, and spectral resolution to observe lightning and investigate electrical environments within and above thunderstorms. The instruments provide measurements of the air conductivity and vertical electric field above thunderstorms and provide estimates of the storm electric currents. In addition, LIP will detect total storm lightning and differentiate between intracloud and cloud-to-ground discharges.This data is used in studies of lightning/storm structure and lightning precipitation relationships. A total of 8 electrical field mills are part of LIP with a total mass of approximately 80 pounds about 10 pounds for each field mill.

During operations of the LIP instrument package, there are two parallel bandwidths at work, which account for both the on-board acquisition and the real-time transmission of the data. With respect to the on-board data collection bandwidth, the requirement is approximately 16 kbs, covering 3,450 KB of data acquired over a nominal 30 minute period. As for the bandwidth required for the actual transmission of the data in real-time, only about 2.4 kbs will be needed, on average.

In terms of potential short-term or long-term archival requirements, the disk space needed to store raw LIP data obtained for a single flight mission is on the order of 170 MB, assuming a 24-hour mission duration. The equivalent amount of disk space needed to store post-processed data per flight is approximately 1.5 GB.
The four primary instruments may be augmented with additional instruments but for this option only these instruments make up the scientific payload. The total mass for these four instruments is approximately 837 pounds, below the limit for the Global Hawk. It must be noted, however, that while the payload mass is less than the advertised payload for the AV-6 Global Hawk, flight parameters such as altitude, center of gravity, fuel load, ferry time, and proposed time on station impact the maximum instrument payload mass.

Figure 1D - LIP

Enclosure 2: Medium Altitude Long Endurance (MALE)

Enclosure 3: Low Altitude Long Endurance (LALE)

Enclosure 4: Low Altitude Short Endurance (LASE)

Enclosure 5: Environmental Response Management Application (ERMA)

Enclosure 6: Other Unmanned Platforms