COVER SHEET
Access 5 Project Deliverable

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Title: Weather Requirements and Procedures

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Abstract:
This cover sheet is for version 2 of the weather requirements document along with Appendix A. The purpose of the requirements document was to identify and to list the weather functional requirements needed to achieve the Access 5 vision of “operating High Altitude, Long Endurance (HALE) Unmanned Aircraft Systems (UAS) routinely, safely, and reliably in the National Airspace System (NAS) for Step 1.” A discussion of the Federal Aviation Administration (FAA) references and related policies, procedures, and standards is provided as basis for the recommendations supported within this document. Additional procedures and reference documentation related to weather functional requirements is also provided for background. The functional requirements and related information are to be proposed to the FAA and various standards organizations for consideration and approval. The appendix was designed to show that sources of flight weather information are readily available to UAS pilots conducting missions in the NAS. All weather information for this presentation was obtained from the public internet.

Status:

SEIT-Approved

Limitations on use:
This document represents thoughts and ideas of the Weather Awareness work package team. It has not been reviewed or approved as an Access 5 project position on this subject. In addition to SEIT review and comment, the information also needs substantiation through simulation/flight demonstrations. Furthermore, this document is an interim deliverable. It represents the project position on Weather Awareness functions and performance requirements limited to enroute operations above FL430. Operations below FL430 and terminal operations have not been addressed in this document.
Weather Requirements and Procedures

(Update for FY05)

For

STEP 1
High Altitude Long Endurance (HALE)
Unmanned Aircraft System (UAS)
Flight Operations in the National Air Space (NAS)

By

WP09 Weather Work Package
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EXECUTIVE SUMMARY

The purpose of this document is to identify and to list the weather functional requirements needed to achieve the Access 5 vision of “operating High Altitude, Long Endurance (HALE) Unmanned Aircraft Systems (UAS) routinely, safely, and reliably in the National Airspace System (NAS) for Step 1.” A discussion of the Federal Aviation Administration (FAA) references and related policies, procedures, and standards is also included. Additional procedures and reference documentation related to weather functional requirements is also provided for background. The functional requirements and related information are to be proposed to the FAA and various standards organizations for consideration and approval.

Additional information contained in this document relates to the availability and the limitations of weather data and products required for support to Step 1 operations. The need for routine weather information, both current and forecast, at Step 1 altitudes which are above FL430 is not new. Since the highest current use of the NAS occurs at altitudes below FL430, the availability of forecast weather data and products is limited above that flight level. Few forecast weather data and products are currently produced by the National Weather Service (NWS) National Meteorological Center (NMC) at or above FL450. This document identifies some of the limitations with obtaining weather information for the Step 1 mission profile.
1. **General.** The Access 5 HALE UAS requires weather awareness requirements and procedures to perform Access 5 STEP 1 flight operations. All Access 5 STEP 1 flight operations begin when the UAS enters the airspace at altitudes at or above FL430. The Access 5 weather work package is responsible for producing requirements and procedures involving weather for STEP 1 UAS flight operations. This document provides weather requirements and procedures to be considered for application for Access 5 STEP 1 flight operations.

2. **Background.** The need for routine weather information, both current and forecast, at altitudes above FL430 is not new. However, based on the research completed for this requirements investigation, commercially available weather information for operating altitudes of FL450 and higher is limited. The limitations discovered during the investigation detailing the weather limiting factors for Access 5 HALE UAS STEP 1 operations are provided below.

   a. **Limitations on forecast weather data and products at or above FL450.** Since the highest current use of the NAS occurs at altitudes below FL430, the use of forecast weather data and products is limited above that flight level. In addition, based on the investigation results at this time the National Weather Service (NWS) National Meteorological Center (NMC) has no requirement to produce forecast weather data and products above FL550, or atmospheric pressure levels above 100 millibars (mb) or hectopascals (hPa). Based on this investigation the limitations listed below exist for forecast weather data and products.

      i. Forecast wind and temperature data are not normally available for FL450 and FL530, but are available on request/reply to users via AFSS/FSS.

      ii. **NOTE:** There are specific flight level winds which NOAA, NWS, and NMC produce products for on a normal schedule. Data for FL420 through FL480 must be specially requested and are normally derived from the flight level closest to actual standard NWS forecast level.

      iii. Forecast data and products for wind, temperature, and flight hazard (turbulence, and icing) information and products at operating altitudes at or above FL530. Based on the investigation completed this year, it is unclear whether or not the NWS produces flight hazard forecasts at or above FL530. The references reviewed do not list any data or products above FL530.

      iv. **NOTE:** A high-level significant weather prognostic chart is produced for the entire layer from FL240 to FL600. However, these products provide average weather conditions for the entire FL240-to-FL600 layer, but do not provide information at specific altitudes in this layer.

   b. **Observed weather data and products at or above FL430.** The NWS produces observational data for altitudes below, at, and above FL430. These observations are
primarily taken from the NWS rawinsonde network. Rawinsonde observations include temperature, wind, humidity, and several other meteorological parameters. The rawinsonde observations are taken at specified levels from station ground level up to approximately 100,000 feet. These data are available via the internet and specify data for designated rawinsonde sites located across the U.S.

3. **STEP 1 Limitations.** Since the Access 5 HALE UAS program is phased into 4 steps there are specific weather work package objectives to be addressed for each of these steps. The STEP 1 objectives are limited to weather support requirements for flight operations at or above FL430. This implies weather issues will be limited to addressing the following operational areas:

   a. Safety of flight and Step 1 weather awareness at or above FL430
   b. Maneuvering and routing at or above FL430
   c. Mission planning at or above FL430
   d. Solar Environmental Events affecting flight at or above FL430
   e. Contingency Management for Solar Environmental Events affecting flight at or above FL430.
   f. Weather requirements below FL430 are not part of, nor the responsibility of, the Access 5 STEP 1 program effort.

4. **STEP 1 Assumptions.** The requirements listed in this document provide a starting point for the evaluation of STEP 1 weather support and procedures. These requirements were produced using the following set of assumptions:

   a. Unless specifically addressed under limiting factors (para. 5), weather data and products required for initial STEP 1 flight operations are available via the highest possible direct or internet communications connection speed from existing public or private Qualified Internet Commercial Provider (QICP) sources.
   b. UAS pilot organizations supporting Access 5 flight operations have access to weather sources required for initial STEP 1 flight operations.
   c. UAS pilots are required to satisfy the same FAA en route wind weather briefing information requirements levied on other non-UAS pilots.
   d. The Access 5 Policy IPT will address with the appropriate agencies any limiting factors identified by this work package in the area of STEP 1 weather data and products.
   e. The UAS pilot has as good or better access to flight weather information than pilots of manned aircraft.

5. **Step 1 Weather Functional Requirements.** The following weather functional requirements apply to Access 5 HALE UAS Step 1 operations. These requirements are extracted from the Functional Requirements Document for HALE UAS Operations in the NAS, Step 1, Version 2, dated September 2005.

5.4.3 **AVOID HAZARDOUS WEATHER**

*The UAS shall be able to avoid hazardous weather while flying in the NAS.* Hazardous weather is defined as any atmospheric or space environment phenomena that could be
detrimental to the UAS mission. Hazardous aviation weather for the purposes of Step 1 typically includes thunderstorms, icing conditions, turbulence, or massive solar ejections. However, this may vary based on the structural characteristics of the UA being flown. It is important to note that the primary need for the UAS avoiding hazardous weather is to prevent the UA from harming people or property, not for self preservation of the UA.

5.4.3.1 Maintain Weather Awareness

*The UAS Weather Awareness System shall maintain awareness of hazardous weather along the entire route of flight.* The UAS should be able to routinely access pertinent aviation weather information to include atmospheric and space weather data. This requirement ensures the UAS pilot has access to the necessary weather information resources such as ATC and/or packaged weather products, throughout the entire route of the flight.

5.4.3.1.1 Gather Weather Information

*The UAS Weather Awareness System shall gather all necessary weather information for the entire route of flight.* This information should be gathered for the altitude at which the UAS will be operating as well as the area below the UAS in case descent through the lower airspace is required. It is assumed that the UAS pilot is part of the UAS Weather Awareness System.

5.4.3.1.1.1 Request weather information (HSI F8b)

*The UAS Human System Interface shall enable the pilot to request weather specific to a current or future flight plan.*

5.4.3.1.1.2 Convey weather information to the UAS Pilot (HSI F8a)

*The UAS Human System Interface shall convey weather information to the pilot.*

5.4.3.1.2 Evaluate Potential for Weather Conflicts

*The UAS Weather Awareness System shall evaluate the potential for flying into hazardous weather situations.* This requirement enables the UAS pilot to plan for hazardous weather along the route of flight utilizing all available weather resources.

5.4.3.2 Coordinate Weather Avoidance Maneuver

The UAS Weather Awareness System shall coordinate with ATC the appropriate avoidance maneuver that prevents the UA from flying through the hazardous weather. The UA will always be flying under Instrument Flight Rules and, therefore must coordinate any deviation of the current flight path with ATC.

5.4.3.3 Command Weather Avoidance Maneuver

*The UAS Weather Awareness System shall be capable of commanding an appropriate
maneuver to avoid the hazardous weather. It is assumed that the UAS pilot, as part of the UAS Weather Awareness System, will initiate the maneuver since autonomous maneuvers are outside the scope of Step 1. The commanded maneuver can include initiating a new maneuver, continuing an ongoing maneuver, or terminating an avoidance maneuver if hazardous weather no longer exists.

5.4.3.1 Control the Weather Awareness System (HSI F8c)
The UAS Human System Interface shall enable the pilot to control the Weather Awareness System. The pilot must have the ability to configure the Weather Awareness System settings as well as initiate, modify, or discontinue and avoid maneuver.

6. Detailed weather requirements discussion. The following information provides background detail on the Step 1 Weather Functional Requirements. In addition, a separate section is included to highlight key procedural considerations related to the functional requirements.

   a. **STEP 1 Requirements.** The process of identifying weather requirements for Access 5 HALE UAS flight operations will evolve over the life of the Access 5 program. This document provides an initial set of support requirements for areas expected to be part of STEP 1 flight operations. As the initial and follow-on simulation and flight test events take place and weather impacts are better known, this list of requirements will be refined and updated. These updates and refinements will lead to a set of requirements that reflect a more broad operational scope of weather support required for STEP 1 flight operations. The initial requirements are listed below.

      i. UAS pilots are required to have the appropriate pilot knowledge accessible to them with regard to Air Traffic order 7110.10R, Flight Services, with specific reference to Chapter 9, FAA Weather Services.

         NOTE: FAA document, Advisory Circular (AC) 00-45E, December 1999 (revised), Aviation Weather Services, is the Air Traffic publication weather services reference in publication 7110.10R for detailed information weather services provided to FAA certified aircraft.

      ii. UAS pilots are required to have the appropriate pilot knowledge accessible to them with regard to Air Traffic Order 7210.3T, Facility Operation and Administration, with specific reference to Part 4, Chapter 14, Aviation Meteorological Services and Equipment.

      iii. UAS aircraft pilots can access the information on ATC Service A circuits, which may include but is not limited to, the Hazardous In-flight Weather Advisory Service (HIWAS), to receive updated weather information while operating UAS aircraft.

      iv. UAS aircraft pilots require the following atmospheric flight weather briefing information for weather awareness, mission planning, safety of flight,
contingency management and scheduled operations at or above FL430 for the entire route and duration of flight:

1. Pilot weather briefing information on current and forecast en route winds at the expected operating altitude at or above FL430
2. Pilot weather briefing information on current and forecast en route temperatures along the route at the expected operating altitude
3. Pilot weather briefing information on forecast flight hazards (turbulence or icing) of any intensity en route at the expected operating altitude at or above FL430
4. Pilot weather briefing information on forecast areas of en route thunderstorms.
5. Pilot considers all weather awareness information as appropriate to the mission, and proceeds per approval of the FAA during flight
6. Pilot has access to all QICP websites depicting appropriate tropospheric weather data useful to flight.
7. Pilot shall gather hazardous atmospheric weather information and take the appropriate actions to complete UAS mission planning preparations prior to flight.
8. Pilot shall access and update mission planning information as necessary from all QICP sources to ensure appropriate route changes are completed to avoid new or developing hazardous tropospheric weather conditions.
9. When a contingency occurs, the pilot shall access and update contingency management information as necessary from all QICP sources to ensure appropriate route changes are completed to avoid new or developing hazardous weather conditions.
10. During conditions requiring emergency landing at a planned or unplanned divert location, the pilot shall access weather information required to make the appropriate landing preparations.
11. The UAS shall be able to avoid hazardous weather in the troposphere by maneuvering the UA in accordance with weather information provided by the HSI interface or ATC advisories. This requirement ensures the UAS is equipped with the capability for routine access to real time aviation weather information while airborne.

NOTE: Forecast information at altitudes FL450 and FL530 is available via special request (Reference: AT publication 7110.10R, paragraph 9-4-2).

v. UAS aircraft pilots require the following radio communication and navigation flight weather briefing information for weather awareness, mission planning, safety of flight, contingency management and scheduled operations at or above FL430:

1. Pilot weather briefing on flight communications and navigation impacts due to solar environmental events/activity recent, present and
forecast including radio bursts, coronal mass ejections, solar flares, sudden ionospheric disturbances, or any other flight hazard affecting radio communications and navigation frequencies during flight.

2. Pilot considers all communication frequency and navigation information as appropriate to the mission, and proceeds per approval of the FAA during flight.

3. Pilot has access to all QICP websites identifying communication and navigation data useful to flight.

4. Prior to flight, pilot shall gather hazardous communication and navigation weather information and take the appropriate actions to complete UAS mission planning preparations.

5. The UAS shall be able to mitigate communication and navigation impacts due to hazardous solar environmental and/or space weather conditions. This requirement ensures the UAS is able to communicate and navigate effectively while airborne.

NOTE: Forecast information at altitudes FL450 and FL530 is available via special request (Reference: AT publication 7110.10R, paragraph 9-4-2).

b. **STEP 1 Procedures.** The process of developing weather support procedures for Access 5 HALE UAS flight operations will evolve over the life of the Access 5 program. This document provides an initial, set of support procedures for STEP 1 flight operations. These procedures are intended to provide a starting point for the STEP 1 scope of the Access 5 flight weather support process. As the initial and follow-on HALE UAS simulation and flight test events take place and weather impacts are better known, these procedures will evolve over time and will be expanded, refined, and updated accordingly. For the FY04 deliverable, an investigation was completed on key flight operations documents and resulted in outlining the Access 5 STEP 1 procedures listed below.

i. Access 5 (A5) UAS pilots access, monitor, and review AFSS/FSS flight weather briefing information and take the appropriate actions based on the following:

1. Forecast and actual winds along the planned route and altitude.
2. Forecast and actual air temperatures along the planned route and altitude.
3. Forecast and observed areas of flight hazards along the planned route and altitude.
4. Forecast and observed solar/space weather events and the affected communication and navigation of the flight.
5. Updates to communication and navigation information affecting the planned route, altitude, and duration of the flight.
ii. A5 UAS pilots review any applicable sections of Air Traffic order 7110.10R, Flight Services, with specific reference to Chapter 9, FAA Weather Services relating to the mission objectives for STEP 1 flight operations.

NOTE: FAA document, Advisory Circular (AC) 00-45E, December 1999 (revised), Aviation Weather Services, is the Air Traffic publication weather services reference in publication 7110.10R for detailed information on weather services provided to FAA certified aircraft.

iii. A5 UAS pilots make any necessary arrangements for compliance regarding weather knowledge requirements relating to Air Traffic order 7210.3T, Facility Operation and Administration, with specific reference to Part 4, Chapter 14, Aviation Meteorological Services and Equipment.

iv. A5 UAS pilots make the necessary arrangements to have the highest speed access to ATC Service A circuits to receive updated weather information.

v. While operating aircraft at STEP 1 altitudes, A5 UAS pilots have access to and monitor AIRMETs/SIGMETs and other available hazard information such as HIWAS or on-board visual monitoring devices.

vi. A5 UAS pilots monitor weather sources for updates and take the appropriate routine and contingency actions regarding route adjustments based on the following weather criteria for STEP 1 flight information at or above FL430:

1. Forecast winds at the expected operating altitude at or above FL430
2. Forecast temperatures at the expected operating altitude
3. Forecast areas of flight hazards (turbulence or icing) of any intensity at the expected operating altitude at or above FL430
4. Forecast areas of thunderstorms along or near the route of flight.
5. Recent, current and forecast solar environmental events/activity that could affect radio communications and navigation of flight at or above FL430.
6. Updated weather information affecting contingency management and emergency divert weather for flight missions at or above FL430.

vii. A5 UAS pilots conduct the necessary contingency management planning for contingencies affecting flight at FL430 or above.

NOTE: Forecast information at altitudes FL450 and FL530 is available via special request (Reference: AT publication 7110.10R, paragraph 9-4-2).

7. Step 1 Flight Scenario. To test the validity of gathering and employing weather information for a Step 1 mission profile, a flight scenario was created for a two-day mission. This scenario is presented as a separate Microsoft PowerPoint attachment (WX_001 Appendix A). The information included in the PowerPoint presentation includes sample data and products
related to the each mission segment. In addition, this scenario was used as an initial verification and validation of the Step 1 Weather Functional Requirements.

8. **References.** The references used to develop the requirements are listed below. Where possible the most current web-available references were used to discern the specific weather support requirements for Access 5 HALE UAS STEP 1 operations.

   a. Air Traffic publication 7110.10R, Flight Services, August 5, 2004
   b. Air Traffic Order 7210.3T, Facility Operation and Administration, August 5, 2004
   c. Air Traffic Aeronautical Information Manual, August 5, 2004
   d. FAA Advisory Circular, AC 00-45E, Aviation Weather Services, Revised December 1999
   e. FAA Advisory Circular, AC 90-99, High Altitude Airspace Redesign Phase 1, September 22, 2003
   f. FAA Advisory Circular, AC 00-62, Internet Communications of Aviation Weather and NOTAMs
   k. Functional Requirements Document for HALE UAS Operations in the NAS, Step 1, Version 2, September 2005
## Verification Matrix

<table>
<thead>
<tr>
<th>FRD #/ Description</th>
<th>Verification Method</th>
<th>Additional Verification Required</th>
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<tbody>
<tr>
<td>5.4.3 Avoid Hazardous Weather</td>
<td>Flight scenario created to determine open internet access to weather data</td>
<td>Flight Simulation and Flight Demonstration</td>
</tr>
<tr>
<td>5.4.3.1 Maintain Weather Awareness</td>
<td>Flight scenario weather awareness data and information accessed via open internet at ADDS</td>
<td>Flight Simulation and Flight Demonstration</td>
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<tr>
<td>5.4.3.1.1 Gather Weather Information</td>
<td>Flight scenario weather awareness data and information accessed via open internet at ADDS</td>
<td>Flight Simulation and Flight Demonstration</td>
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<td>5.4.3.1.1.1 Request Weather Information (HSI F8b)</td>
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<td>5.4.3.2 Coordinate Weather Avoidance Maneuver</td>
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<td>Flight Simulation and Flight Demonstration</td>
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<tr>
<td>5.4.3.3 Command Weather Avoidance Maneuver</td>
<td>Flight scenario weather awareness data and information accessed via open internet at ADDS</td>
<td>Flight Simulation and Flight Demonstration</td>
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<td>5.4.3.3.1 Control the Weather Awareness System (HSI F8c)</td>
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<td>5.4.3.4 Execute the Weather Avoidance Maneuver</td>
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The following document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.
Flight Scenario

A High Altitude Long Endurance (HALE) Unmanned Air System (UAS) flight was conducted between 8 September 2005 and 10 September 2005 to collect chemical data from upper air (FL480) systems i.e. ozone concentration, NOx levels, etc.

This flight began on 8 September 2005 from Edwards Air Force Base in southern California and ended on 10 September 2005 at Andrews Air Force Base in the Washington D.C. area.

During the mission there were two orbiting/data collection sessions which took place enroute to Andrews from Edwards. Each orbiting/data collection session lasted approximately 12 hours. The orbiting sessions were conducted between Denver, CO and Kansas City, MO and between Indianapolis, IN and Detroit, MI.

This presentation is designed to show that sources of flight weather information are readily available to UAS pilots to conduct successful UAS missions in the NAS. All weather information for this presentation was obtained from the public internet. Weather information closest to the mission times is presented.

Assumptions:
- UAS cruises at 200 kts
- Climb to and descent from altitude FL480 takes 1.5 hours
Our Mission Objectives

The objectives of this mission are as follows:

• To depict the necessary weather data that must be accessible via a QICP weather provider to UAV pilots in order to conduct safe and successful missions.

• To explain the knowledge that must be extrapolated from the weather data sources to show the complexity of forecasting weather for HALE missions.

• To show potential contingency scenarios that may result from emergency situations.

• To show the importance of weather to the overall success of the mission.
**Schedule of Flight**

**Begin:** Edwards AFB 1700 UTC (10:00 am PDT) 8 September 2005  
Collected the following weather information:  
- Turbulence data, Convective Wx Sigmet/Airmet, Winds/Temps, Icing,  
- METAR, Satellite

*Arrive Denver, CO 2330 UTC 8 September 2005
Initiate data collection mission

*Arrive Kansas City, MO 0230 UTC 9 September 2005
Enter orbit area for data collection mission

*Orbit between Kansas City and Denver for approximately 12 hours from  
0230 UTC to 1430 UTC on 9 September 2005.
Schedule of Flight (cont.)

*Arrive Indianapolis, IN 1900 UTC 9 September 2005.
Initiate data collection mission

*Arrive Detroit, MI 2230 UTC 9 September 2005
Enter orbit area for data collection mission

*Orbit between Indianapolis and Detroit for approximately 12 hours from 2230 UTC 9 September 2005 to 1030 UTC 10 September 2005.

Proceed to Andrews AFB to complete flight

**Finish:** Arrive and descend at Andrews AFB at approximately 1600 UTC on 10 September 2005.
Access 5 Step One Flight Scenario Route

Key:
- ★ Start/Finish Destination
- ★★ Divert Location
- ★★★ Target Location for Data Collection
- Flight Path
- Data Collection Path
Weather Data Gathered for Takeoff from Edwards Air Force Base

16Z Takeoff weather for Edwards:

Observations for EDWARDS, CA (EDW)

<table>
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<th>STN</th>
<th>TIME</th>
<th>PWSL</th>
<th>ALTN</th>
<th>TMP</th>
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</tr>
</tbody>
</table>

Few clouds at 100, no ceiling. Winds variable at 2kts.

Local area weather chart at takeoff time

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[Weather data table and chart]
Flight Scenario First Leg

Start/Finish Destination: Edwards AF Base, Arizona
Divert Location: Phoenix (PHX)
Target Location for Data Collection: Edwards AF Base, Arizona
Weather Data Gathered for Takeoff from Edwards AFB and Climb to FL480

Turbulence:

Pilot Reports (PIREPs) valid 1500 UTC indicate favorable weather for takeoff and during climb to altitude of FL480:

No turbulence forecast is expected to affect takeoff and climb to FL480.
Wind Speed:

Wind Speed Analysis for FL480 over the Contiguous United States at 1500 UTC:

Temperature:

Temperature Forecast for FL480 over the Contiguous United States at 1500 UTC:

The temperature is approximately -60 degrees Celsius at FL480.

FL480 enroute winds from Edwards AFB to Denver orbit area average 40 knots from the southwest
Visible Satellite Imagery
for Edwards AFB and surrounding Area:

Infrared satellite imagery at 1615Z indicates showers and possible isolated thunderstorms later in the day over N Arizona and E Utah/central Colorado. These could affect the entry into the Denver orbit area.

Visible satellite imagery at 1615Z indicates some clouds located over the N Arizona and E Utah/central Colorado area.

Infrared Radar Imagery from Edwards AFB and surrounding Area:
METAR Outlook for the Denver Area:

Broken clouds with ceiling at 200. Winds from the west at 10 knots. Thunderstorms beginning at 2224 UTC were present with occasional cloud to ground lightening to the northeast with additional distant thunderstorms to the northeast-east moving toward the northeast.
Convective SIGMET for the Contiguous U.S.:

There is the potential for isolated convective weather for this portion of flight.

All active AIRMETs and SIGMETs
chart created at 1455 UTC Thu 08 Sep 2005
AIRMETs valid until 2000z/8th, SIGMETs expire at or before 1800z/8th

All active AIRMETs and SIGMETs
chart created at 1655 UTC Thu 08 Sep 2005
SIGMETs valid until 1800z/8th, Outlooks valid from 1800z/8th to 2200z/8th
High-Level Weather Fixed Time Forecast Chart for FL250-FL630:

No significant weather for our mission profile.
Divert Weather:

PIREPs Turbulence for the Continental U.S. on 8 September 2005:

There is light to moderate turbulence in the Denver area at this time.
Flight Scenario First Orbit Area

Key:
- Star: Start/Finish Destination
- Red Star: Divert Location
- Blue Star: Target Location for Data Collection
- Dotted Line: Flight Path
- Dotted Orange Line: Data Collection Path

Start/Finish Destination: Denver, CO (DEN)
Divert Location: TUL
Target Location for Data Collection: Kansas City, MO (MCI)
Orbit for 12 Hours: Nebraska
3.0 Hours: Kansas

Flight Path:
- Denver, CO (DEN)
- Nebraska
- Kansas City, MO (MCI)

Data Collection Path:
- TUL Divert
- Kansas City, MO (MCI)
Current mission time: approximately 2330 UTC on 8 September 2005

Flight status: entering mission orbit area 1, and heading to Kansas City, MO for 0230 UTC on 9 September 2005.
Turbulence Forecast at FL450 for 0000 UTC on 9 September 2005:

Heading from Denver, CO to Kansas City, MO and orbiting for 12 hours in between the two locations beginning data collection.

Turbulence of light intensity or less is expected along the flight path.

Turbulence Forecast at FL450 for 0600 UTC on 9 September 2005:
Turbulence forecast at FL450 valid 1200 UTC on 9 September 2005.

Currently orbiting and collecting data between Denver, CO and Kansas City, MO.

There is light to moderate turbulence for FL450 in the western orbit area during this portion of flight.
Turbulence AIRMETs and SIGMETs as of 1355 UTC on 9 September 2005:

Turbulence is expected from surface to FL080 between Denver and Kansas City.

This would affect any divert to Kansas City.
Wind Speed at FL480 at 0000 UTC 9 September 2005:

The winds for this portion of flight decrease from 40 to 30 kts from the northwest as the flight moves toward Kansas City.

Wind Speed at FL480 at 0600 UTC 9 September 2005:
Wind Speed Chart at FL480 for 18UTC on 9 September 2005:

Winds from Denver to Kansas City are from the West-Southwest at approximately 15-45 knots.
All active AIRMETs and SIGMETs for the continental U.S. as of 1255 UTC on 9 September 2005:

There is a mountain obscuration AIRMET for the Denver area.
METAR for the Denver area at approximately 1300 UTC on 9 September 2005:

**Observations for DENVER, CO (DEN)**

DEN 0912332 24007KT I020 FEW008 SCT120 10/09 A2808 RMK AOC SLPH81 T0170080
DEN 0910331 18007KT I050 FEW008 SCT120 16/08 A2807 RMK AOC SLPH81 T0170080
DEN 0909331 21008KT I050 FEW008 SCT120 23/09 A2807 RMK AOC SLPH81 T0246080
DEN 0908331 31010KT I050 FEW008 BKN020 22/09 A2808 RMK AOC SLPH81 T0220089 88018
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DEN 0902331 00007KT I050 SCT090 BKN100 24/09 01007 RMK AOC SLPH81 OCNL LTCCG DSNT NE VISGA VC E-I
DEN 0901331 00007KT I050 FEW008 SCT110 BKN100 24/09 01007 RBX AOC SLP081 OCNL LTCCG DSNT NE VISGA
DEN 0900331 25007KT I050 FEW008 SCT110 BKN100 28/09 01006 RBX AOC T82356834 OCNL LTCCG DSNT NE VISGA
DEN 0900331 30007KT I050 FEW008 SCT110 BKN100 28/09 01006 RBX AOC T82356834 DSFT VISGA DSNT NE VISGA
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DEN 0807171 28010KG14KT I050 FEW008 SCT110 SCT120 BKN100 31/09 03006 RBX AOC TSE11 OCNL LTCCG DSNT NE TS MV
DEN 0806232 28010KT I050 FEW008 SCT090 SCT120 BKN100 02/09 03006 RBX AOC T82356834 SLPH81 OCNL LTCCG VC MV TS
DEN 0805232 15010KT I050 FEW008 SCT090 SCT120 BKN100 03/09 03006 RBX AOC T82356834 OCNL LTCCG VC MV TS
DEN 0804232 09010KT I050 FEW008 SCT110 BKN100 04/09 03006 RBX AOC T82356834 OCNL LTCCG VC MV TS
DEN 0803033 32007KT I050 FEW008 SCT110 SCT120 BKN100 05/09 03006 RBX AOC TSE11 OCNL LTCCG DSNT VS VISGA DNT M V
DEN 0802232 28007KT I050 FEW008 SCT110 BKN100 06/09 03006 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
DEN 0801333 32007KT I050 FEW008 SCT110 BKN100 07/09 03006 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
DEN 0800333 19007KT I050 FEW008 SCT110 BKN100 08/09 03006 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
DEN 0700333 27007KT I050 FEW008 SCT110 BKN100 09/09 03006 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
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DEN 0500333 29007KT I050 FEW008 SCT110 BKN100 11/09 03007 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
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DEN 9900333 31007KT I050 FEW008 SCT110 BKN100 17/09 03007 RBX AOC SLP100 OCNL LTCCG DSNT VS VISGA DNT M V
METAR for the Kansas City area as of 1313 UTC on 9 September 2005:

Observations for KANSAS, MO (MCI)

1151Z 8 Sep 2005 to 1251Z 9 Sep 2005

<table>
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<th>STN</th>
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<th>PXSL</th>
<th>ALTE</th>
<th>TNP</th>
<th>DSR</th>
<th>RH</th>
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<th>SPD</th>
<th>VIS</th>
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</table>
Temperatures for the continental U.S. at FL480 for 1200 UTC on 9 September 2005:

Temperatures at FL480 over the Denver/Kansas City flight area are approximately -60 degrees Celsius.
Visible Satellite Image over Denver, CO at 1415 UTC on 9 September 2005:

There are thunderstorms along the western border of Colorado. There are also thunderstorms in western Nebraska.

Infrared Satellite Imagery over Denver, CO at 1415 UTC on 9 September 2005:
Visible Satellite Imagery over Kansas City, MO at 1415 UTC on 9 September 2005:

The skies are clear over this area.

Clear skies are depicted from this image as well as the visible.

Infrared Satellite Imagery over Kansas City, MO at 1410 UTC on 9 September 2005:
PIREP of turbulence for 1430 UTC on 9 September 2005 across the continental U.S.:

Ending data collection from Denver, CO to Kansas City, MO.

Heading from Kansas City to Indianapolis, IN, arriving in Indianapolis at 1900 UTC on 9 September 2005.
PIREP of Weather and Sky condition for 1430 UTC 9 September 2005:

Pilot Reports (PIREPs) of Weather and Sky Conditions

1258z – 1426z 09/09/05

PIREP Key:

- Temperature (°C)
- Visibility (SM)
- Wind Barb

Sky Coverage Key:

- CLR
- FOG
- SCT
- BKN
- OVC
- IMC
Surface Analysis Chart for potential diverts/contingency management valid 1200 UTC on 9 September 2005:
High-level fixed time forecast chart of North America and the U.S. valid 0000 UTC 10 September 2005:
Current Time approximately 1451 UTC.

Flight status: en route from Kansas City, MO to Indianapolis, IN orbit point.

Estimated time of arrival: 1900 UTC

Turbulence of light intensity or less is expected along the flight path.

Turbulence AIRMETs and SIGMETs reported for 1400 UTC on 9 September 2005 valid until 2000 UTC on 9 September 2005.
Winds associated with a jet stream are over the Indianapolis area. The winds in this area are 45-55 knots from the northwest.
Temperature forecast for FL480 valid at 1700 UTC on 9 September 2005:

Temperature (°C) at 48,000 ft MSL (125 mb)

03-hour forecast valid 1700 UTC Fri 09 Sep 2005

Flight level temperature forecast of -60°C or less for the entire mission.
Visible Satellite Imagery of the Indianapolis Area:

There is no significant weather in the area at this time.

Infrared Satellite Imagery of the Indianapolis area:
METAR of the Indianapolis Area valid 1507 UTC on 9 September 2005:

<table>
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<tr>
<th>Station</th>
<th>Time</th>
<th>Temp</th>
<th>Dew Point</th>
<th>Humidity</th>
<th>Pressure</th>
<th>Wind Direction</th>
<th>Wind Speed</th>
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- **OBSERVATIONS FOR INDIANAPOLIS, IN (IND)**

<table>
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<tr>
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<th>Wind Direction</th>
<th>Wind Speed</th>
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<th>Clouds</th>
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</thead>
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All active AIRMETs and SIGMETs valid at 1500 UTC and until UTC on 9 September 2005:

There are no valid AIRMETs and SIGMETs for this leg of the flight.
Flight Scenario Second Orbit Area

Indianapolis, IN (IND)

Flight Path

Key:
- Start/Finish Destination
- Divert Location
- Target Location for Data Collection
- Flight Path
- Data Collection Path
Arrived at Indianapolis, IN headed to Detroit, MI:

Estimated time of arrival in Detroit, MI is 2230 UTC on 9 September 2005

Turbulence forecast at FL450
09 hr forecast valid 0300 UTC Sat 10 Sep 2005

Turbulence of light intensity or less is expected along the flight path.
METAR for the Detroit, MI area:

Observations for DETROIT, MI (DET)

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</table>
PIREPs summarizing weather and sky conditions over the contiguous United States:
Wind speed forecasts for the Indianapolis/Detroit leg of flight:

Begin data collection when arrive in Detroit, MI Orbit for 12 hours from 2230 UTC on 9 September 2005 to 1030 UTC on 10 September 2005.

Winds for this portion of flight are approximately 30-40 knots from the northwest.
Temperature forecast for FL480 valid 1200 UTC on 10 September 2005.

Data collection in progress for Detroit/Indianapolis leg of flight.

All active AIRMETs and SIGMETs valid 1456 UTC on 9 September 2005.

AIRMETs are valid until 2000 UTC on 9 September 2005.

SIGMETs expire at 1655 UTC on 9 September 2005.
Visible and IR imagery for the Detroit/Indianapolis area:

No significant weather for this area.
Surface map and high-level fixed time forecast for the continental U.S. during the IND/DET leg of flight:
12 hour and 24 hour surface level forecasts valid until 0600 UTC and 1800 UTC respectively on 10 September 2005.
Flight Scenario Final Leg

Indianapolis, IN (IND)

Andrews AF Base

BNA Divert

Detroit, MI (DTW)

5.5 Hours

Key:

☆ Start/Finish Destination

☆ Divert Location

☆ Target Location for Data Collection

Flight Path

Data Collection Path
Current Time: approximately 1500 UTC on 10 September 2005

On Final approach from Detroit, MI to Andrew’s AFB.

For this area there is an Instrument Flight Rules AIRMET valid during descent and landing/planned arrival time.

There is also a turbulence AIRMET in effect near the Andrews AFB area. The turbulence AIRMET is effecting flight between 27,000 to 39,000 feet. The pilot should be aware of both notifications for descent into Andrews.
Turbulence forecast at FL450 valid 1200 UTC on 10 September 2005:

Map shows light turbulence or less enroute from Detroit to Andrews AFB with some areas of moderate turbulence just south of Andrews AFB.
Wind speeds at 1300 UTC on 10 September 2005 for FL480.

The plane will be flying in the jet stream from Detroit to Andrews AFB with winds around 30-40 knots.

Temperatures at FL480 valid 1500 UTC on 10 September 2005.

Temperatures at this time are approximately -60 degrees Celsius.
METAR for the Andrew’s AFB and surrounding area at approximately 1313 UTC on 10 September 2005.

Broken clouds with ceiling at 030 for Andrews AFB. Winds from the east (080) at 6 kts.
Visible Satellite Imagery of the route of flight from Detroit to Andrews AFB at 1315 UTC on 10 September 2005

Both images show a disturbance in the area off of the Carolina coast. The pilot should be aware of this disturbance caused by Tropical Storm Ophelia in the Atlantic. Visible imagery indicates low clouds or fog in the area around Andrews AFB.

Infrared Imagery of the route of flight valid 1315 on 10 September 2005
PIREPs of Turbulence and Weather and Sky conditions valid until 1330 on 10 September 2005:

The Pilot should be aware there is light to moderate turbulence in the Andrews AFB area.
Surface analysis valid 1200 UTC on 10 September 2005.

Map shows important divert/contingency management information for this leg of flight.

Map also shows the current location of Tropical Storm Ophelia.
High-level fixed time forecast
weather data valid until 0000 UTC
on 11 September 2005.
Reminder: Our Mission Objectives

The objectives of this mission are as follows:

- To depict the necessary weather data that must be accessible via a QICP weather provider to UAV pilots in order to conduct safe and successful missions
- To explain the knowledge that must be extrapolated from the weather data sources
- To show the complexity of forecasting weather for HALE missions
- To show potential contingency scenarios that may result from emergency situations
- To show the importance of weather to the overall success of the mission.
End of Flight Scenario

Any Questions??
Contingency Scenario
Solar Weather Causes Loss of Link during Orbit One

• On September 7\textsuperscript{th}, sunspot # 798/808 exploded, producing an X-17 solar flare. Explosions are expected to continue for the next few days.

• Each X-flare causes a shortwave radio blackout on Earth and pumped new energy into a radiation storm around our planet.

• Magnetic clouds are scheduled to hit the Earth on September 10\textsuperscript{th} causing aurora’s that are being seen as far south as Arizona.

• This solar activity has cause a loss of link on our UAV mid-orbit. The pilot should be aware of this activity and the plane is recommended to divert to the nearest divert point—in this section of flight the divert location is Tulsa, OK.

• In addition to solar activity, the METAR shows thunderstorms evolving in the Denver area accompanied with lightning.
Access 5 Step One Flight Scenario Route

**Emergency Divert to Tulsa:** Due to loss of link

- **Start/Finish Destination:** Edwards AF Base, Arizona
- **Divert Location:** PHX Divert
- **Target Location for Data Collection:** TUL Divert, Arkansas
- **Flight Path:** Orbit for 12 Hours
- **Data Collection Path:** 5.0 Hours Denver, CO (DEN)
- **Data Collection Path:** 3.0 Hours Kansas City, MO (MCI)

**Key:**
- ✨ Start/Finish Destination
- ⚠️ Divert Location
- 🌟 Target Location for Data Collection
- — — — Flight Path
- — — — Data Collection Path
Surface Analysis and UA Charts for divert to Tulsa, OK valid 1200 UTC on 9 September 2005:
Divert to Tulsa, OK:

Observations for TULSA, OK (TUL)

2353Z 7 Sep 2005 to 0035Z 9 Sep 2005

University of Wyoming
TAF for Tulsa, Oklahoma

NOTE: Specific TAFs related to the contingency scenario were not included in the original presentation. TAFs were included here to verify availability over the public internet Aviation Digital Data Service (ADDS) site.

TAF for Denver, Colorado

TAF for Andrews Air Force Base