# Space Weather in the Next Generation Air Transportation System

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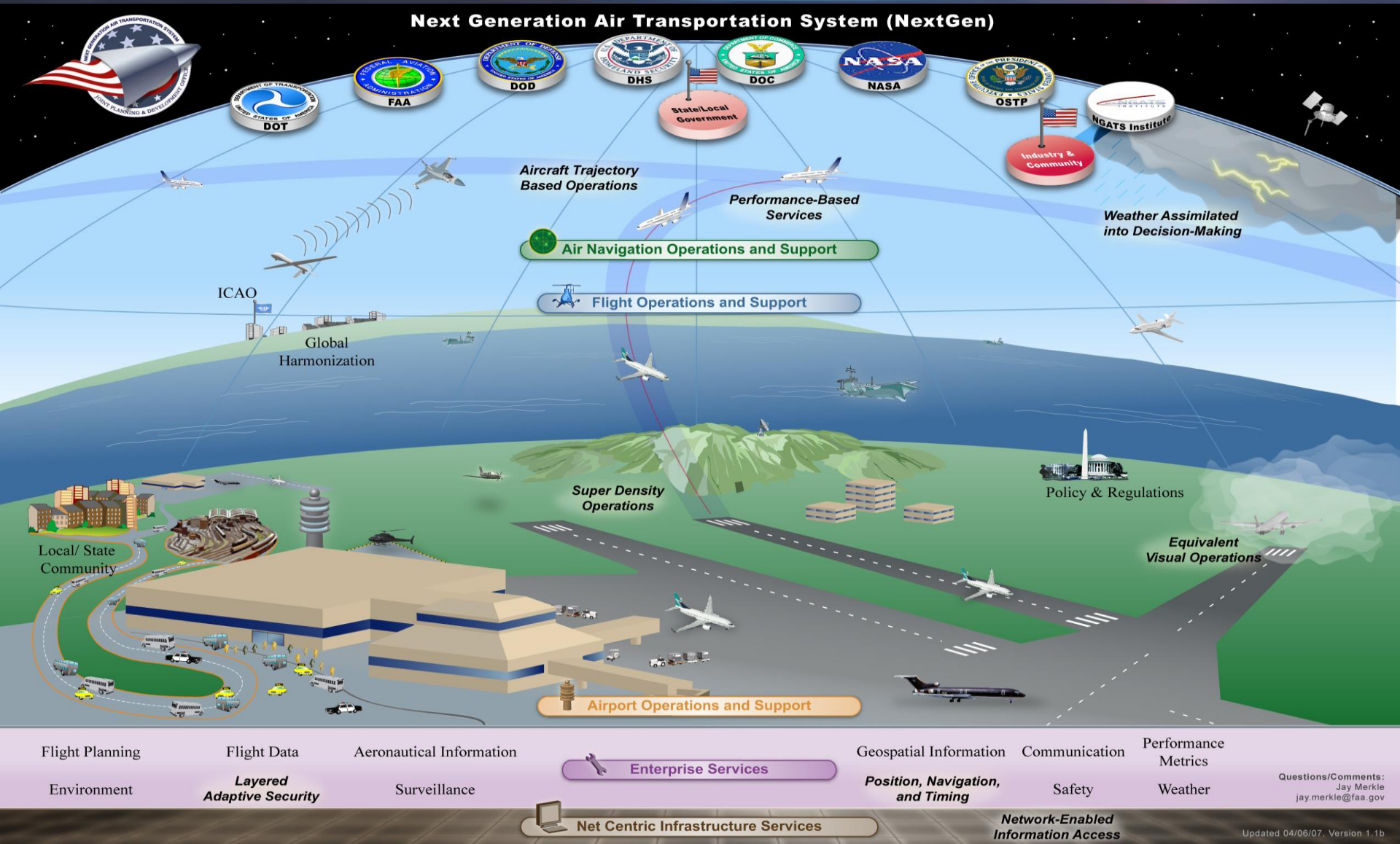
Cecilia Miner

*NOAA/NWS/Aviation Services Branch*

# Overview

- NextGen 101
- NextGen Key Themes
- What are the 4-D Cube and the Single Authoritative Source
- Requirements
- The Roadmap Ahead

# NextGen 101

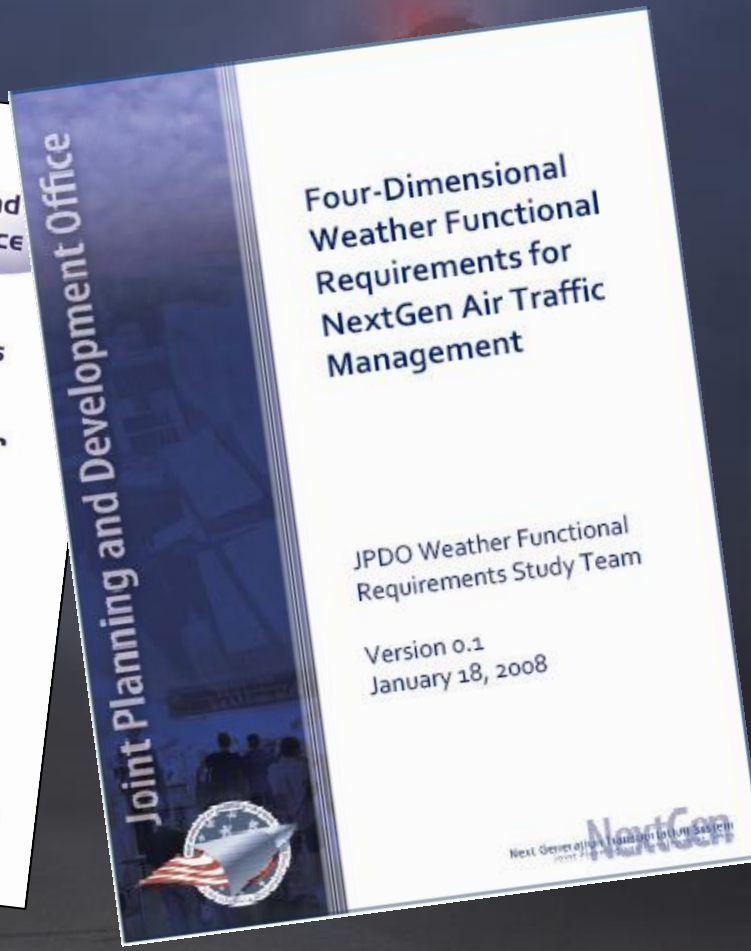



Questions/Comments:
Jay Merkle
jay.merkle@faa.gov

Updated 04/06/07, Version 1.1b

# NextGen 101 Documents






**http://www.jpdo.gov**
**>Knowledge Center >Collateral Library >Technical Documents**

NextGen
Joint Planning and Development Office

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# Conference Examines the Future of TBO

**Mar 27, 2009**

Collaboration is a key element of any successful organization, and is a driving force of the Joint Planning and Development Office (JPDO). With that said, the Working Group Co-Chairs and their designated team members convened for the first JPDO conference focused on Trajectory-Based Operations (TBO).

TBO represents a critical NextGen capability that uses specific technologies to optimize an individual flight, as well as the overall operations of the national airspace system (NAS).

Held March 24 at the Department of Transportation Headquarters in Washington DC, the TBO Conference—which the JPDO also streamed live via the WebEx platform—offered a unique opportunity to accomplish two goals: 1) develop a common understanding of the TBO vision for the far-term, and 2) identify how the JPDO Working Groups can contribute to that vision.

More>>

## Other News

Full House for JPDO "All Hands" Meeting

A New Paradigm for the 21st Century: Collaboration, Transparency, and Change


JPDO "All Hands" Meeting May 21, 2009


Integrated Work Plan Version 1.0

The NextGen INSTITUTE | Joint Planning Environment | JPDO SnapShots

1500 K Street, NW, Suite 500, Washington, DC 20005 TEL: 202-220-3487

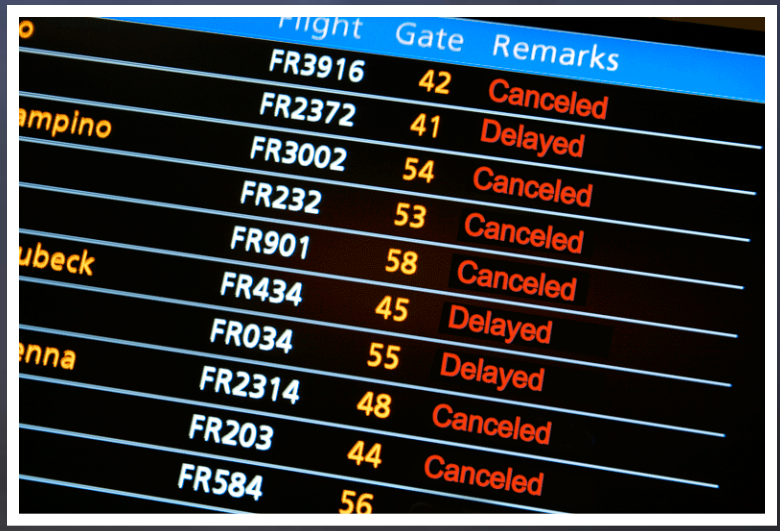
# NextGen 101

- **Weather contributes to 70% of all air traffic delays within the U.S. National Airspace System (NAS)**

- **"A key finding, based on an analysis of several 2005-2006 convective events, is that as much as two-thirds of the weather related delay is potentially avoidable."**
  *-Research, Engineering and Development Advisory Committee; Report of the Weather-ATM Integration Working Group; Oct 3, 2007*

# NextGen 101

- **"The total cost of domestic air traffic delays to the U.S. economy was as much as $41 billion for 2007."**
  - *Air-traffic delays raised airlines' operating costs by $19 billion.*
  - *Delays cost passengers time worth up to $12 billion.*
  - *Indirect costs of delay to other industries added roughly $10 billion to the total burden.*



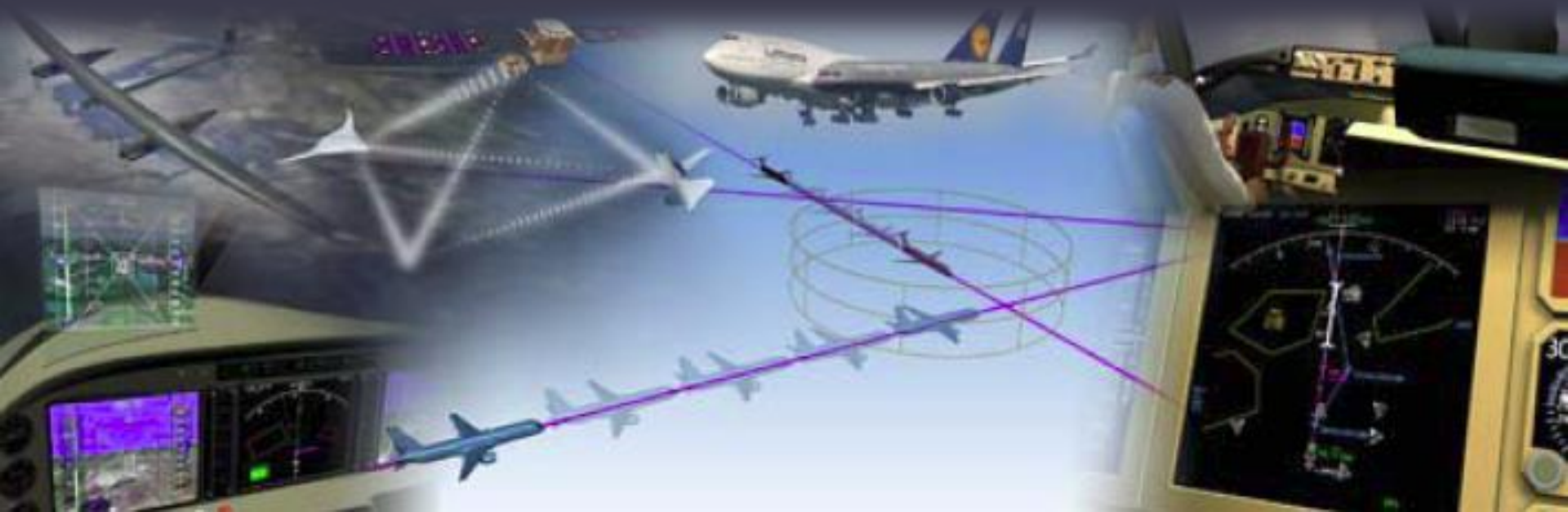

- *Your Flight Has Been Delayed Again; Congressional Joint Economic Committee; May 2008*

# NextGen 101

| | | | |
|---|---|---|---|
| **Airlines (Communications)**<br><br>**(Loss of flight HF radio communications)** | **United, Continental, Northwest, American, Lufthansa, Qantas Virgin, British Airways, FedEx, Air New Zealand, ExecuJet, etc.** | **Divert polar flights, change flight plans**<br><br>**Change altitude** | **Cost ~ $100k per diverted flight**<br><br>**$10-50k for re-routes** |
| **Airlines (Radiation)**<br><br>**(Radiation dose on crew and passengers)** | **United, Continental, Northwest, American, Lufthansa, Qantas Virgin, British Airways, FedEx, Air New Zealand, ExecuJet etc.** | **Divert polar flights, change flight plans**<br><br>**Change altitude (even at mid-latitudes)** | **Cost ~ $100k per diverted flight**<br><br>**Health risks** |

# NextGen Key Themes

- An integrated and nationally consistent common weather picture for observation, analysis, and forecast data available to all system users



# NextGen Key Themes

- **A Net-centric (net-enabled) capability is envisioned:**
  - ***"Network Enabled"…***
    - An information network that makes information available, securable, and usable in real time
    - Information may be pushed to known users and is available to be pulled by others
    - Weather information sharing is two-way
  - ***"Virtual" repository with no single physical database or computer***
    - Conceptually unified source distributed among multiple physical locations and suppliers

# NextGen Key Themes

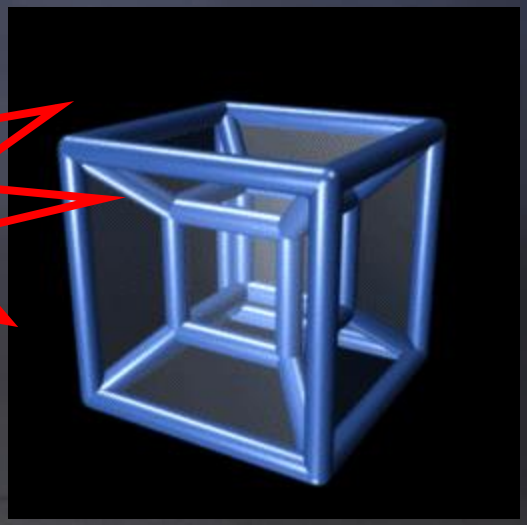
- Direct integration of weather information into operational decision making processes

# NextGen Now and Future

| Today | NextGen (new requirements) |
| --- | --- |
| Not integrated into aviation decision support systems (DSS) | Totally integrated into DSS |
| Inconsistent/conflicting on a national scale | Nationally consistent |
| Low temporal resolution (for aviation decision making purposes) | High temporal resolution |
| Disseminated in minutes | Disseminated in seconds |
| Updated by schedule | Updated by events |
| Fixed product formats (graphic or text) | Flexible formats |

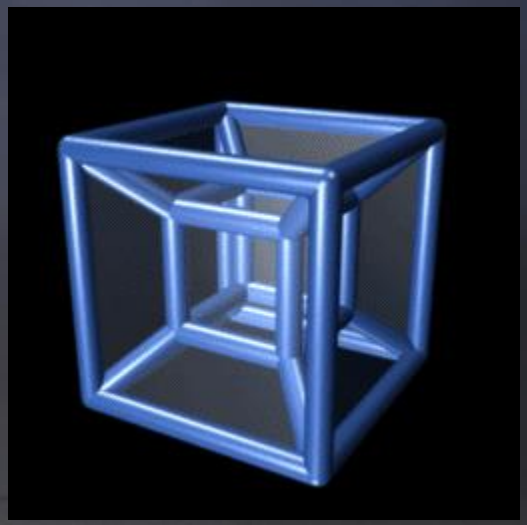
# What is the 4-D Weather Cube?

- **The 4-Dimensional (4-D) Weather (Wx) Cube (3 dimensions plus time) will contain:**
  - ***Continuously updated weather observations (surface to low earth orbit, including space weather and ocean parameters)***
  - ***High resolution (space and time) analysis and forecast information (conventional weather parameters from numerical models)***
  - ***Aviation impact parameters***
    - Turbulence
    - Icing
    - Convection
    - Ceiling and visibility
    - Wake vortex
  - ***The 4-D Wx Cube of the future will contain "all" weather data, not just aviation parameters.***

# What is the 4-D Weather Single Authoritative Source?

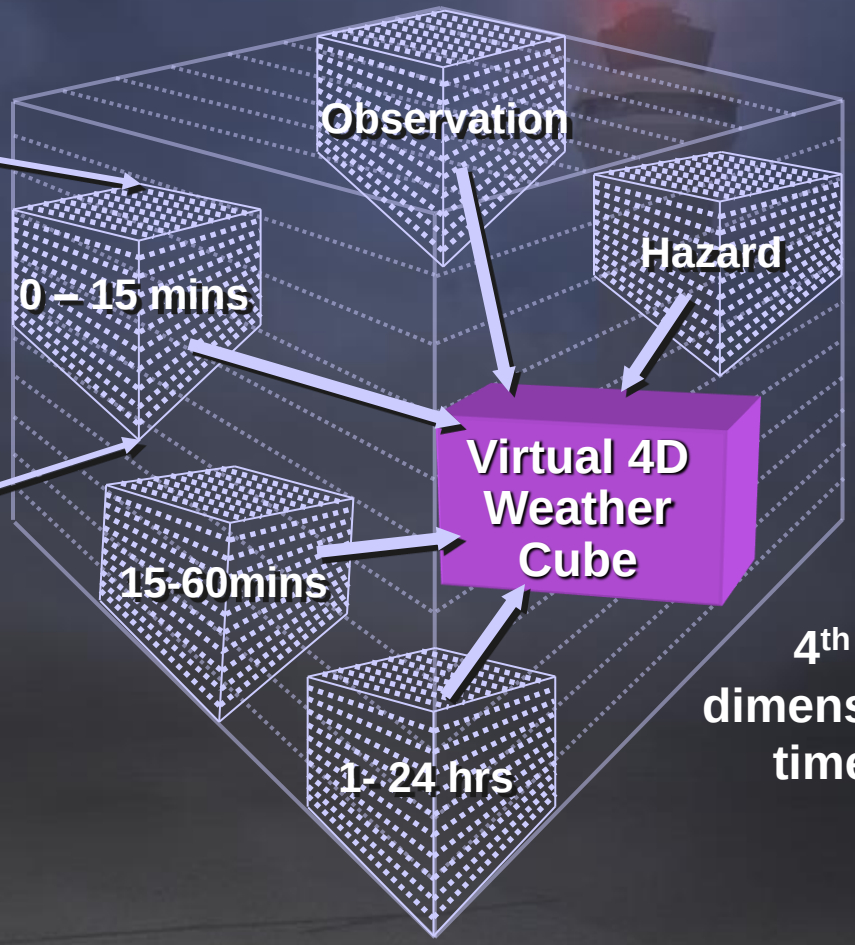
- **The 4-D Wx Single Authoritative Source (SAS):**
  - *Is only a portion of the 4-D Wx Cube*
  - *Provides a common weather picture for National Air Space (NAS) participants (Airlines, DoD, FAA, etc.)*
  - *Is the basis for all aviation decisions by Air Traffic Management (ATM) in the FAA*
  - *Is formed by merger of model data, automated gridded algorithms, climatology and observational data, and meteorologist input/data manipulation to ensure consistency and accuracy*



# Virtual 4D Weather Cube

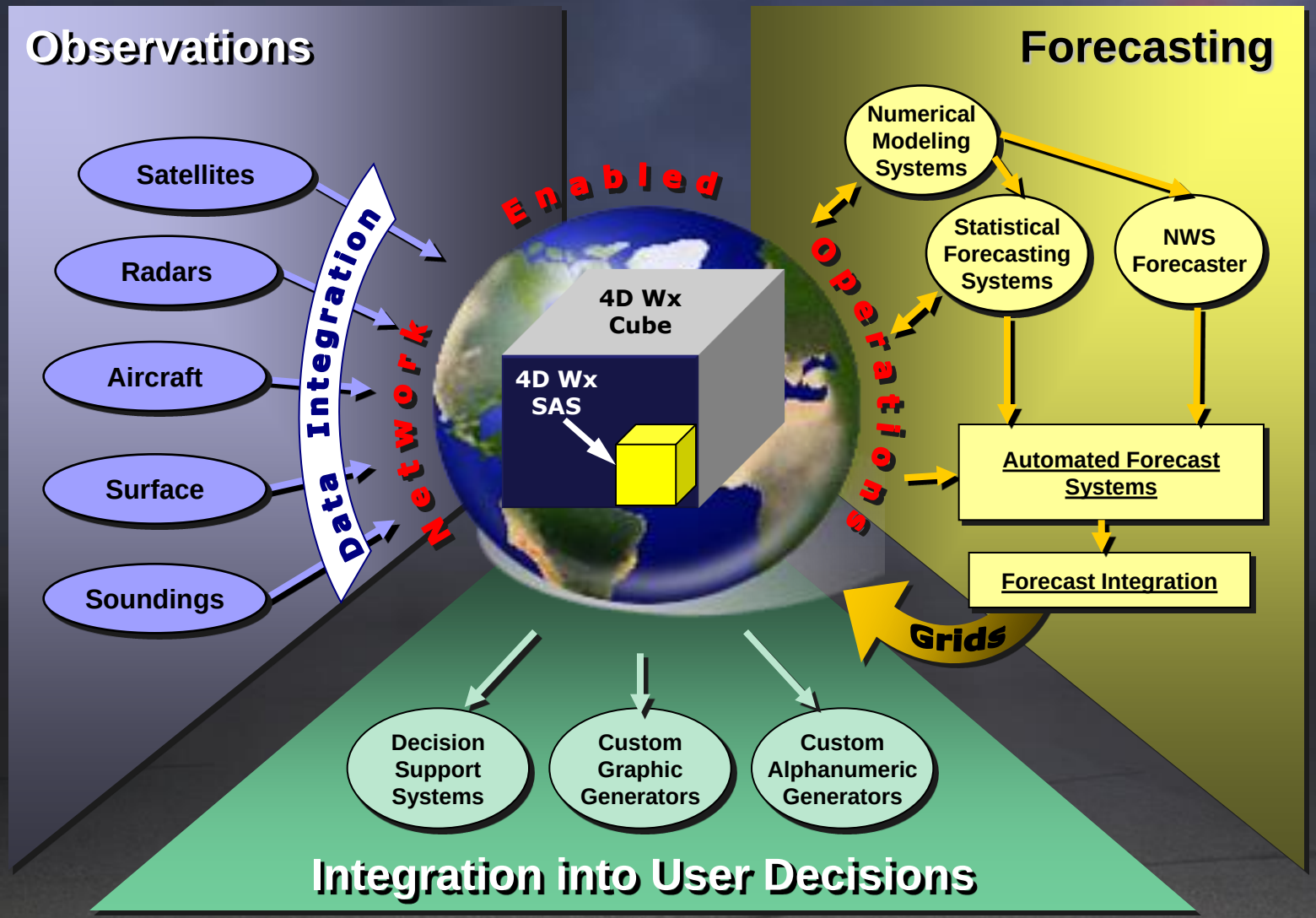


Aviation weather information
in 3 dimensions
( latitude/longitude/height)




4th
dimension
time

# The 4-D Cube: A Conceptual Model



# Requirements: Observation

## Space Weather Parameters

**498** The NextGen shall determine the magnitude of solar radiation affecting aviation with an accuracy of plus or minus 0.5x10-8 Watts $m^{-2}$.

**499** The NextGen shall determine **onset of solar radiation affecting aviation** with an **accuracy of plus or minus 5 minutes.**

**500** The NextGen shall calculate the **duration of solar radiation affecting aviation** with an accuracy of plus or minus 5 minutes.

**501** The NextGen shall measure those **regions of the globe exposed to high levels (> 10 MeV) of solar radiation with a horizontal accuracy of plus or minus 500 miles.**

**502** The NextGen shall determine **latitudinal areas subject to high levels of (> 100 MeV) solar radiation with a horizontal accuracy of 300 miles.**

### Geomagnetic Storm activity

**503** The NextGen shall determine **regions of the globe affected by geomagnetic storm activity with a horizontal accuracy of plus or minus 80 km.**

**504** The NextGen shall determine the **onset of geomagnetic storm activity with an accuracy of plus or minus 5 minutes.**

**505** The NextGen shall determine end of geomagnetic storm activity with an accuracy of plus or minus 5 minutes.

**506** The NextGen shall determine end of geomagnetic storm activity affecting aviation with an accuracy of plus or minus 5 minutes.

**507** The NextGen shall determine **duration of geomagnetic storm activity with an accuracy of plus or minus 5 minutes.**

# Requirements: Forecast

## Space Weather

201 The NextGen shall forecast the **arrival time** at the top of the NAS of adverse space weather conditions (e.g., solar flares, coronal mass ejections) with an accuracy of plus or minus 10 minutes out through 12 hours, with an accuracy of plus or minus 20 minutes from 12 hours to 24 hours, and with an accuracy of plus or minus 60 minutes from 24 hours to 48 hours.

202 The NextGen shall forecast the **ending time** at the top of the NAS of adverse space weather conditions (e.g., solar flares, coronal mass ejections) with an accuracy of plus or minus 10 minutes out through 12 hours, with an accuracy of plus or minus 20 minutes from 12 hours to 48 hours, and with an accuracy of plus or minus 30 minutes from 24 hours to 48 hours.

203 The NextGen shall forecast the **duration** of adverse space weather conditions (e.g., solar flares, coronal mass ejections) with an accuracy of plus or minus 10 minutes out through 12 hours, with an accuracy of plus or minus 30 minutes from 12 hours to 24 hours and with an accuracy of plus or minus 1 hour from 24 hours to 48 hours.

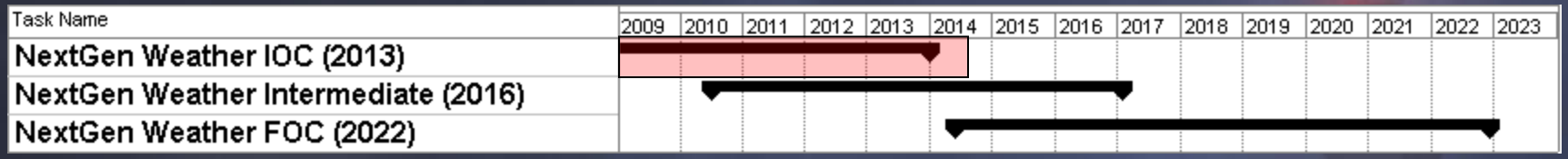
204 The NextGen shall forecast solar radiation activity affecting aviation with an accuracy of plus or minus 1 X $10^{-7}$ watts $m^{-2}$ through 12 hours, with an accuracy of plus or minus 5 X $10^{-7}$ watts $m^{-2}$ from 12 to 24 hours and with an accuracy of plus or minus 1 X $10^{-6}$ watts $m^{-2}$ from 24 hours to 48 hours.

205 The NextGen shall forecast the **regions of high energy (> 10 MeV)** solar radiation with a **horizontal accuracy of plus or minus 300 miles**.

206 The NextGen shall forecast the **regions of high energy (> 10 MeV)** solar radiation with a vertical accuracy of **plus or minus 4,000 feet**.

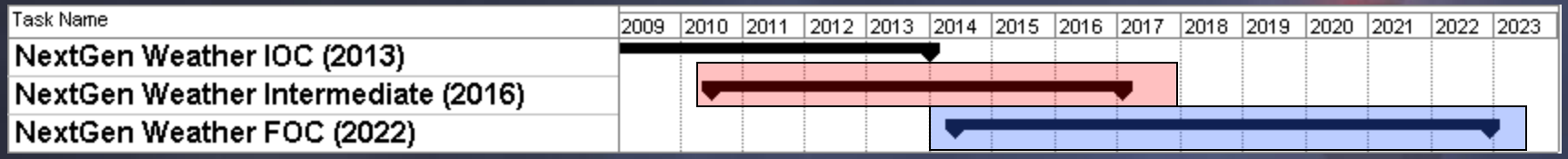
207 The NextGen shall forecast regions of the globe subject to high energy levels **(> 100 MeV)** of solar radiation with a horizontal accuracy of **plus or minus 1000 miles.**

# The JPDO Weather Roadmap




- **Initial Operational Capability (2013)**
  - *Integrated environmental information sources*
  - *Common data standards and protocols*
  - *Initial integration of diverse weather elements into decision support tools*
  - *IT infrastructure allows access to 4D Cube data by the FAA's System Wide Information Management (SWIM) network*
  - *Implement NWS forecast processes required to generate, arbitrate and consolidate 4D weather forecast information to populate the 4D Cube with all required weather elements for IOC, including meteorologist oversight of gridded data*
  - *Adapt existing NOAA/NWS observation systems to provide information to the 4D Cube*

# The JPDO Weather Roadmap




- **Intermediate Capability (2016)**
  - *Improved modeling and science enables higher resolution more accurate information*
  - *Full Network compatibility of environmental information*
  - *Direct integration of weather into Air Traffic Management Systems*
- **Full Operational Capability (2022)**
  - *All NextGen requirements met and benefits achieved*
  - *High resolution, nested scale forecasts available for all elements*
  - *Full network connectivity ensures consistent information use across service areas and user groups*

# Backup

# The Roadmap Ahead

- Aviation Digital Data Service (ADDS)
  - *Extremely popular aviation weather web service*
  - *Not just a display capability*
  - *Already has many NextGen data service capabilities*
  - *Data service easily capable of supporting JMBL*
    - Has existing capability to support 4D data cube
    - Slices, dices, and returns a subset of data (flight paths or subset cubes)

**http://adds.aviationweather.gov/**