



ICAO/WMO APAC MET/ATM Seminar 2015  
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# DAPs Potential and an Analysis on Weather Uncertainty for TBO

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# Outline

## ENRI's ATM Research Activities Concerning Aviation Weather & TBO\*

\* Trajectory-Based Operation

### Topics

- Wind Estimation by Airborne Information
- Analysis Result : Weather Uncertainty Effect on Flight Time
- Study Plan : Arrival Manager



# Introduction of ENRI

- A National Institute for ATM/CNS Research
- About 50 Researchers
- Research Areas :  
TBO, AeroMACS, GNSS, WAM ...



Experimental Aircraft



ENRI's International Workshop

# Wind Estimation by Airborne Information

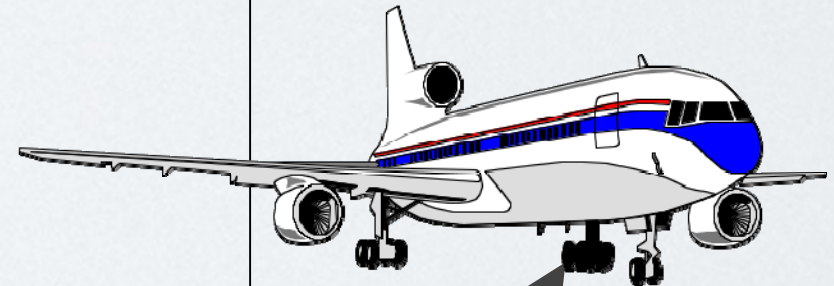
# DAPs on SSR Mode-S

## SSR Mode-S : ATC Surveillance Radar

- Data Communication Function : DAPs\*

\* Downlink Aircraft Parameters

- Interrogation to Each Aircraft
- Airborne Information Downlinked
  - ◀ Wx Information Items Included



Possibility Offered

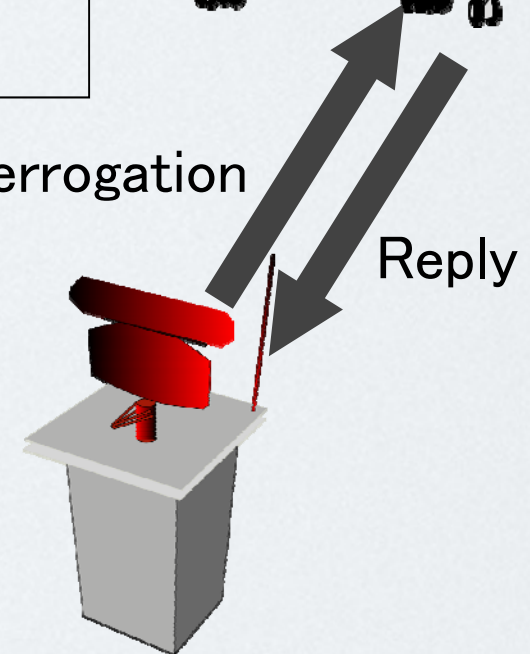


New Means for Wx Observation

- Higher Frequency in Broader Areas

Interrogation

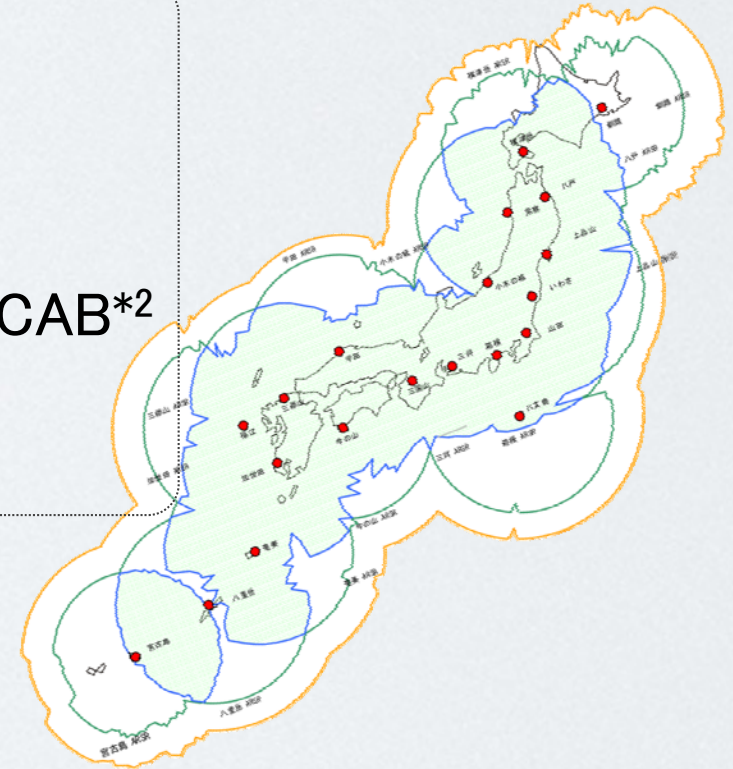
Reply





# ARSR/ORSR\*<sup>1</sup> in Japan

- 21 Radar Stations Installed for Area Control
  - 12 Stations : Mode-S Ready
- Future Plan to Put DAPs into Operation by JCAB\*<sup>2</sup>
  - Some Flights in Operation : DAPs Ready



2 Experimental Mode-S Radar Stations in ENRI



Information Downlinked

Wind Data Items Focused on

\*<sup>1</sup> Air/Oceanic Route Surveillance Radar

\*<sup>2</sup> Japan Civil Aviation Bureau

# Downlinked Items

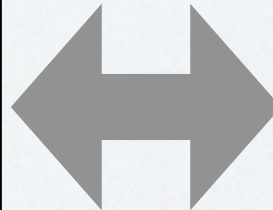
Around 80% of the  
Registered Airframes

## Monitoring Results

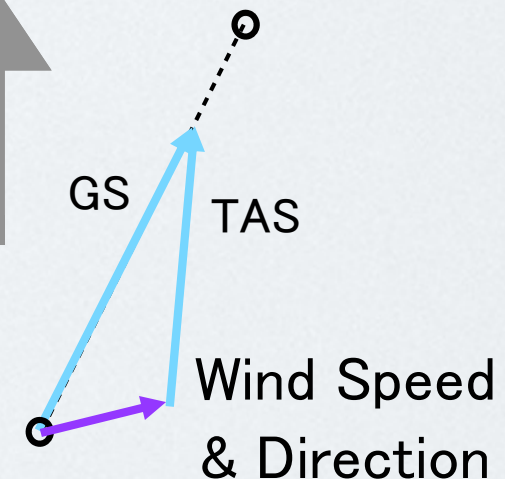
Less than 1% of the  
Registered Airframes

- True Track Angle
- Ground Speed
- Magnetic Heading
- True Air Speed
- Mach

- Wind Speed
- Wind Direction
- Static Air Temperature



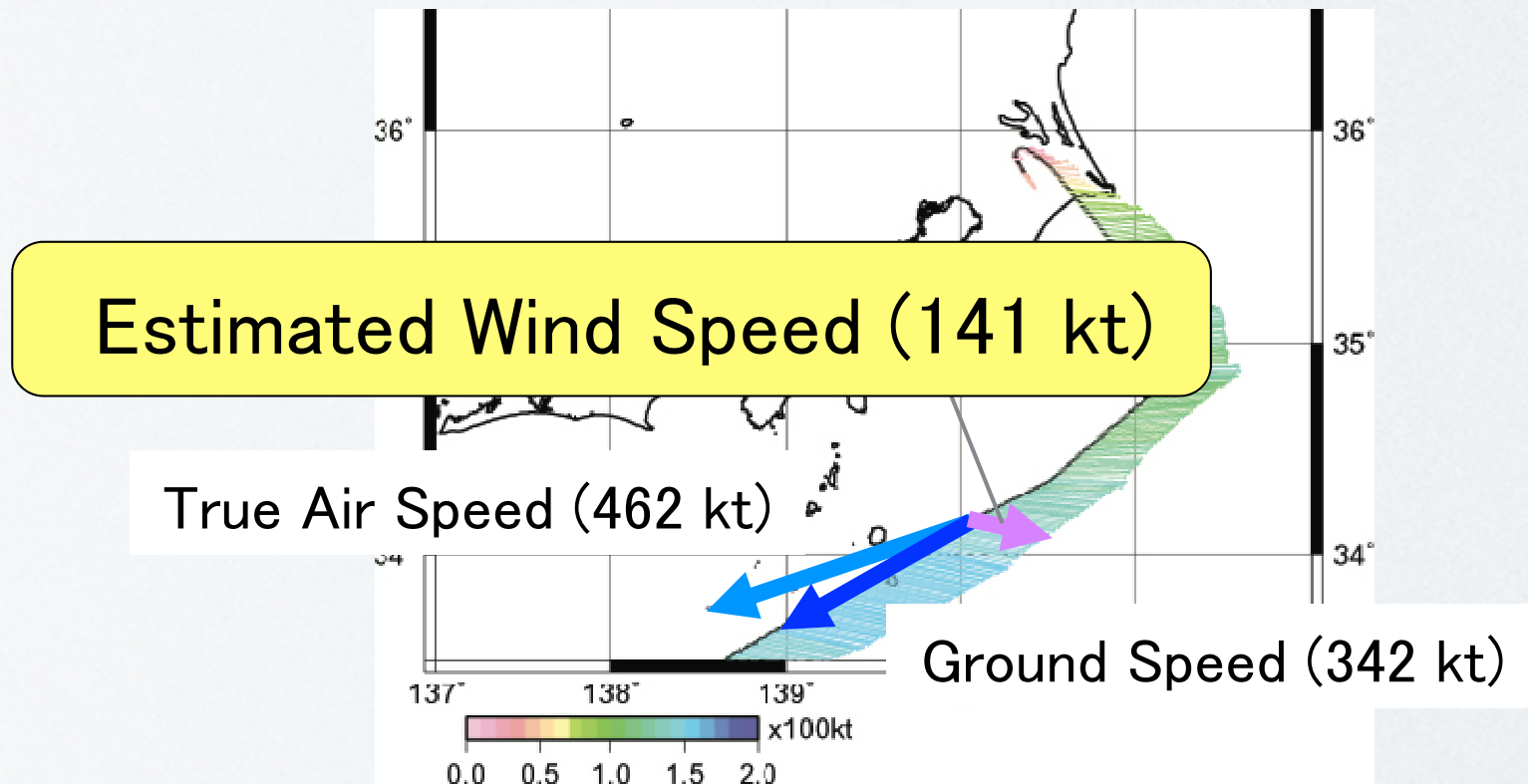
Estimation





# Wind Estimation Example

- Information from a Flight Exploited
- Estimated Every 10 Seconds (= Position Update Rate)



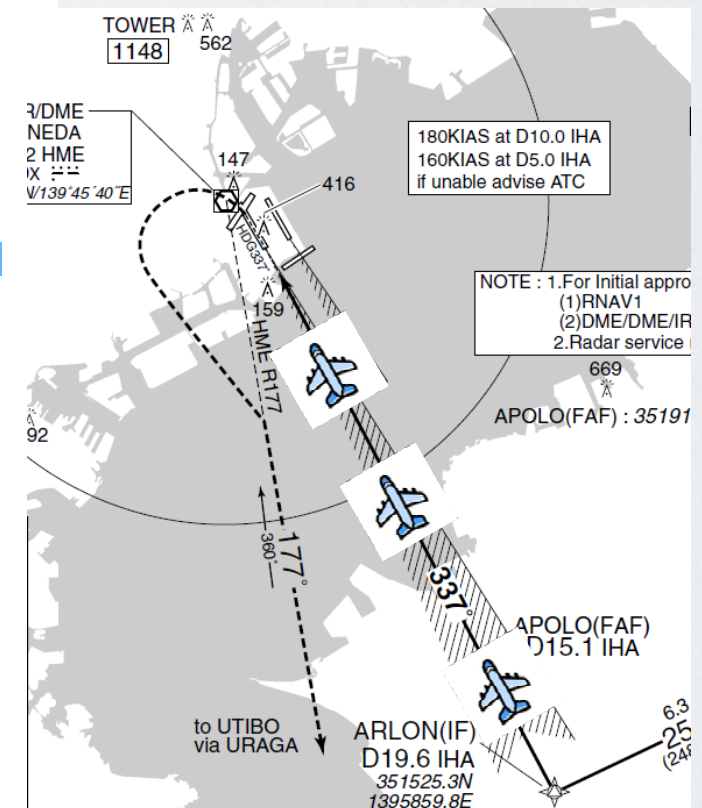
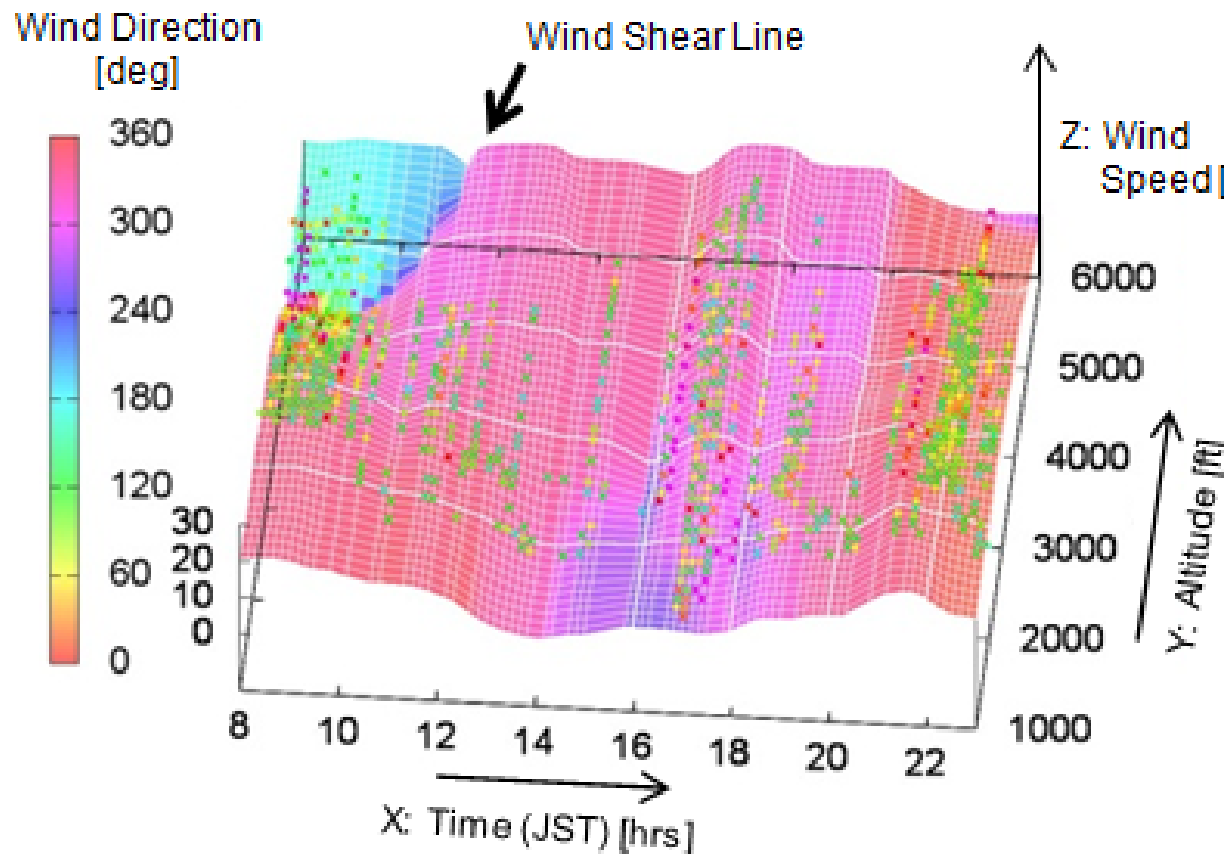
Estimation Results Compared with JMA\* Products: Validated

\* Japan Meteorological Agency



# An Application Example

## Visualization of Estimated Wind Shear (near Haneda Airport)



Haneda RWY34 Approach  
(North Wind Condition)

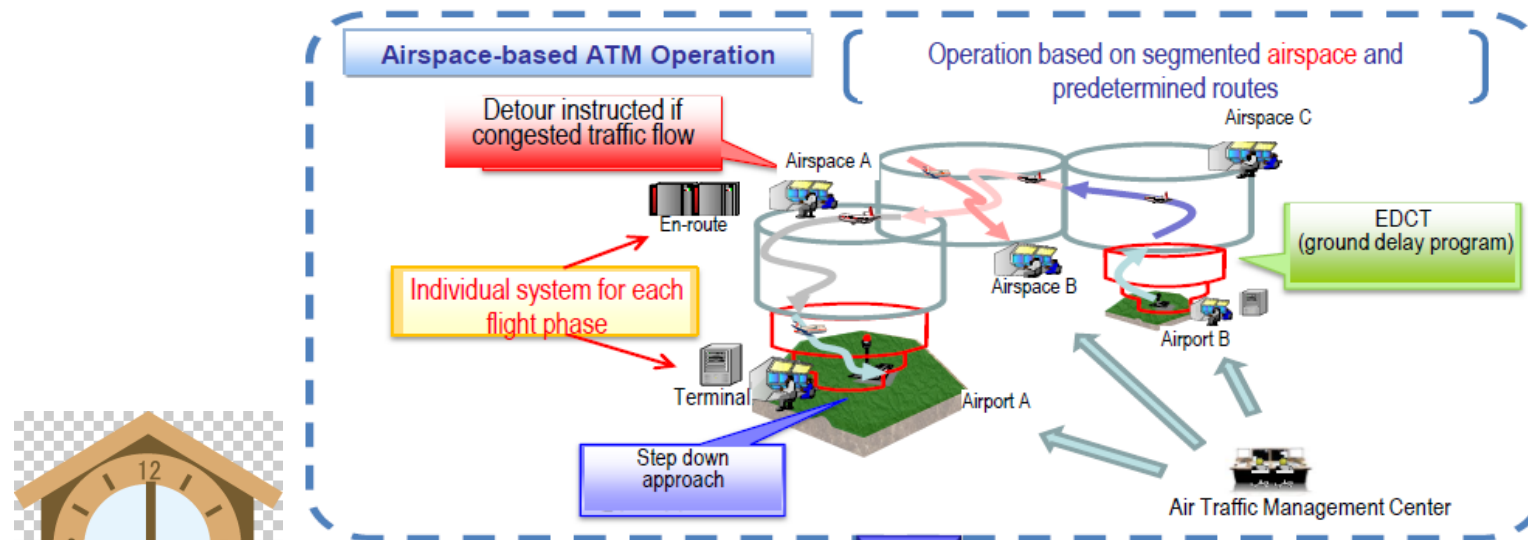
*Provided by the Joint Research with A. Tezuka (Waseda University)*

# Analysis Results : Weather Uncertainty Effect on Flight Time

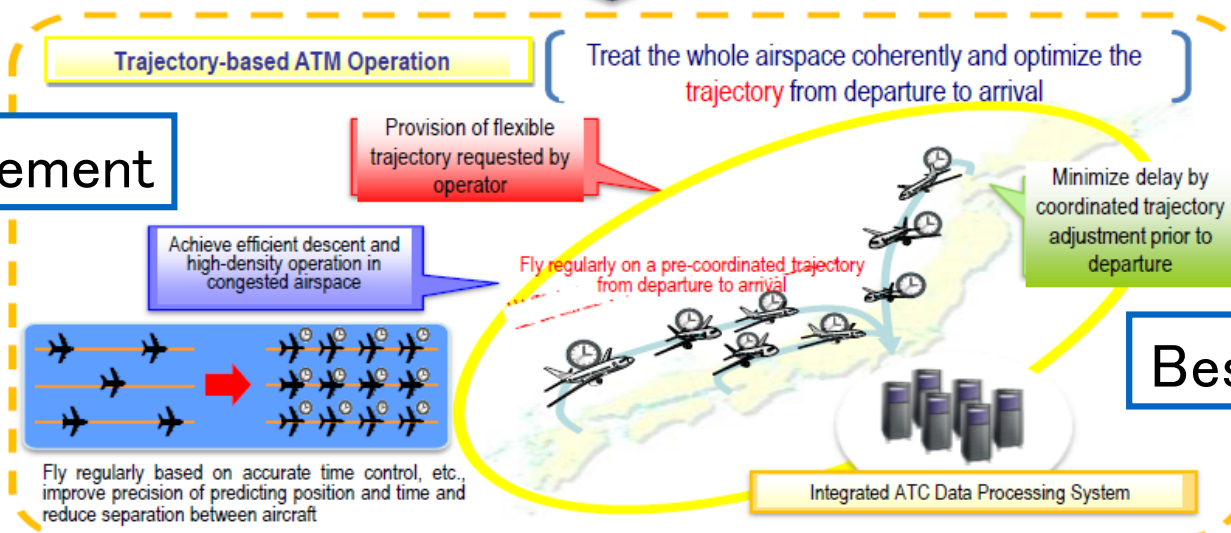
# Trajectory-Based Operation

## Transition to Trajectory-Based Operation

P17



### Time Management



### Best Coordination



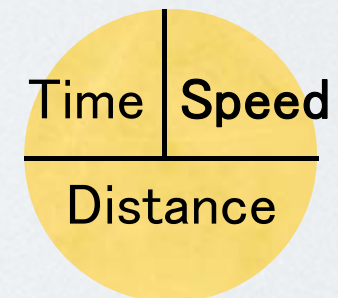
# Trajectory Prediction

- TBO : Coordinated Route & Time Kept in Flight

← Supported by High-Accurate Trajectory Prediction

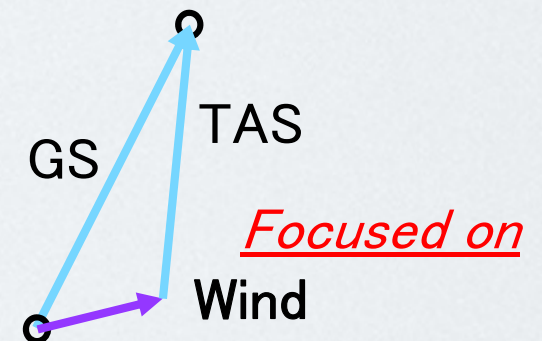
- Major Factors of Estimated Flight Time Error :

- Operational Intent : Aircraft Performance Model
- Weather Uncertainty : Wx Forecast Data



Given by  
Automatically (FMS)  
Manually (Pilot/ATCo)

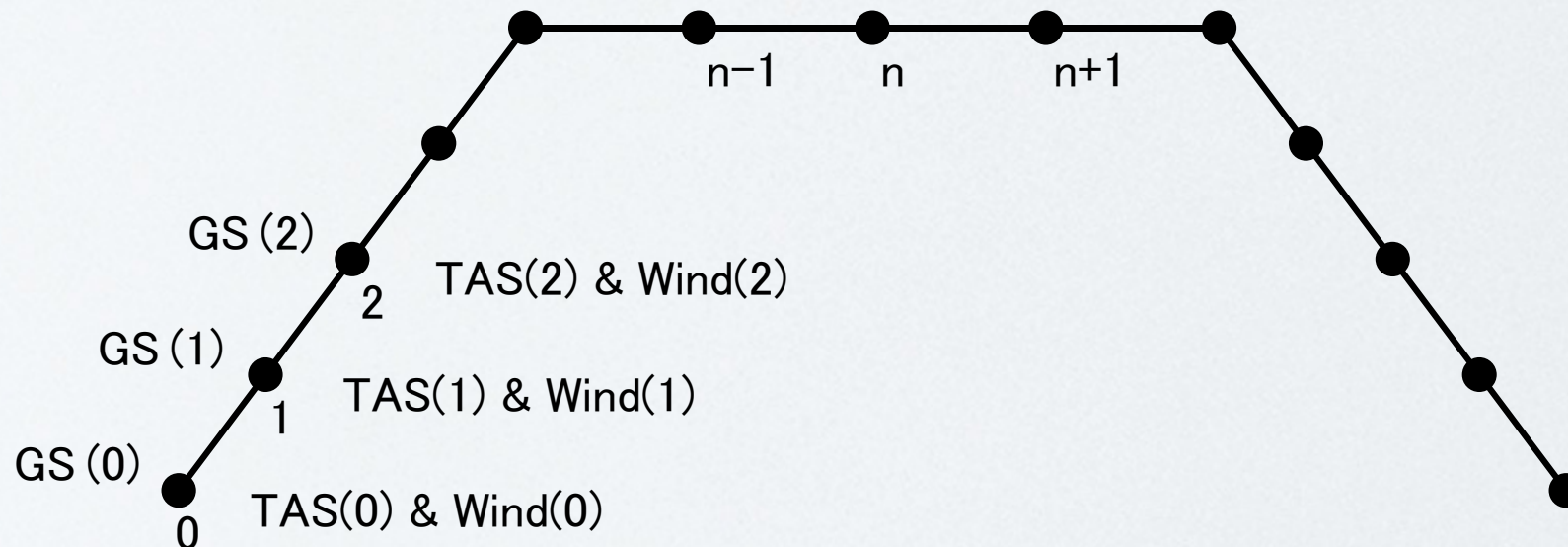
Air Density  
& Pressure  
(Temperature  
& Altitude)



# Analysis Method

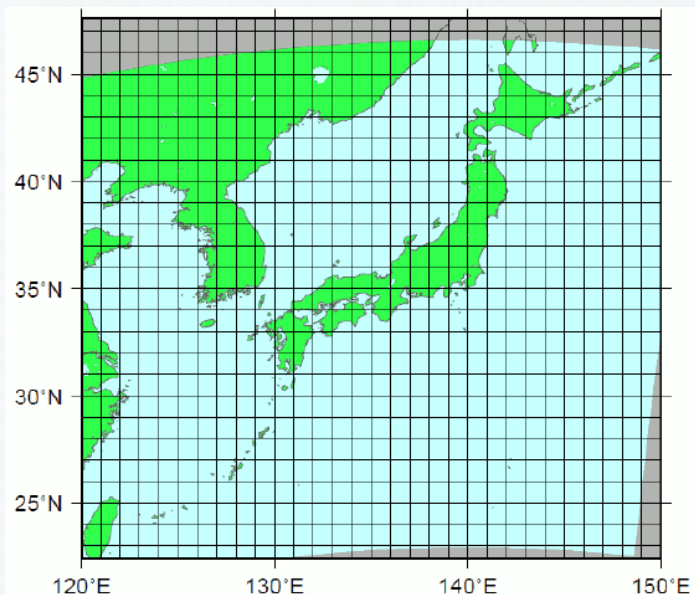
- Information Sources :
  - GS & TAS : DAPs Values
  - Wind : Interpolation Values of JMA Products
- Ratio of Predicted & Actual Flight Time Calculated

$$\frac{FT_{pre}}{FT_{act}} = \frac{GS_{act}}{GS_{pre}} = Average\left(\frac{GS(n)}{TAS(n) + Wind(n)}\right)$$



# Wind Data in Analysis

- 2 JMA Products Utilized & Compared
  - MSM : Standard in Trajectory Prediction
  - LFM : New for Smaller-Scale Wx Phenomena Expression
- Wind Values at Any 4-Dimensional Points
  - ← Calculated by Linear Interpolation of MSM/LFM Grid Point Values

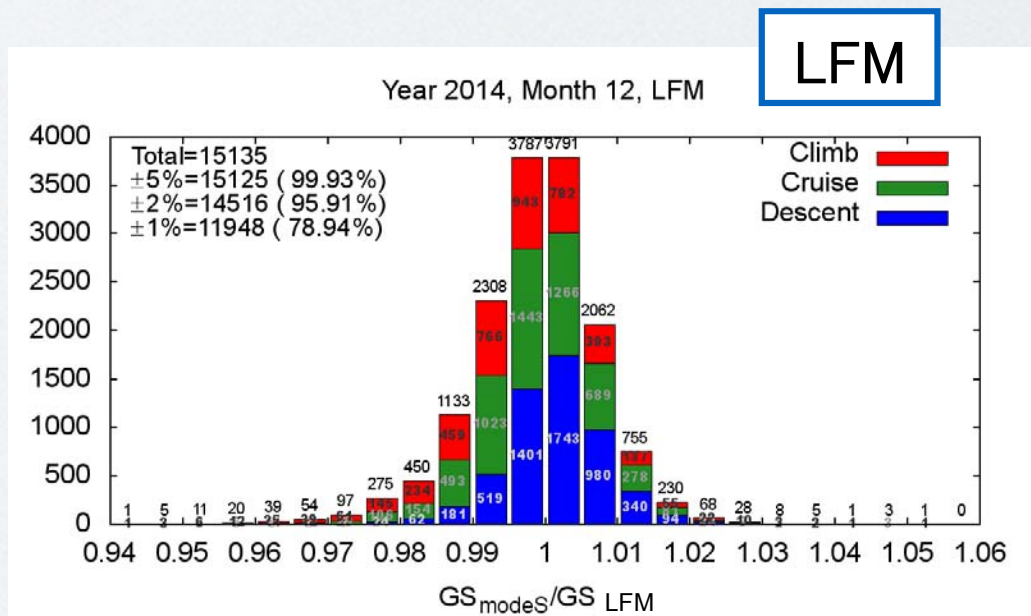
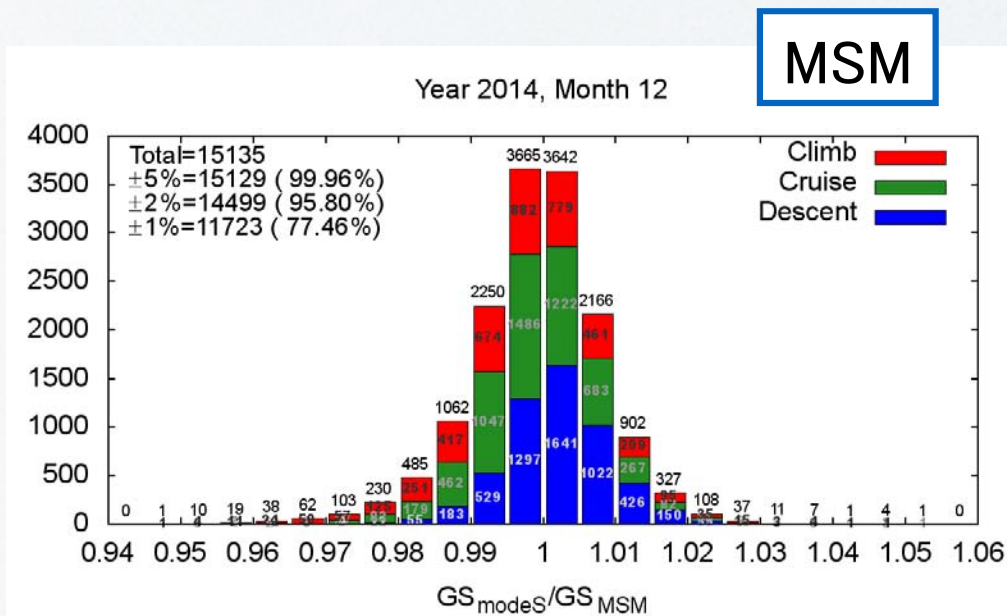


	MSM (Meso Scale Model)	LFM (Local Forecast Model)
Initial Time	00, 03, 06, ..., 21 (8 times/day)	00, 01, 02, ..., 23 (24 times/day)
Forecast Range	Up to 39 hrs (3hr-interval)	Up to 9 hrs (1hr-interval)
Grid Size	0.1 * 0.125 deg (5km-mesh)	0.04 * 0.05 deg (2km-mesh)
Data Volume	About 2.24 GB/day	About 22 GB/day
Num. of Vertical Layer	16 layers (1,000 to 100 hPa)	
Delivery Delay	+2 hrs & 10 or 30 min	+1 hr 30 min
Parameters	Altitude, Wind (u & v), Temperature, Vertical Velocity, Relative Humidity	



# An Analysis Result

- Data Volume : 10 Days in December, 2014
- Wind Uncertainty Effect on Flight Time :
  - Less than 2 % per Flight Time (95 % of the Analyzed Flights)
  - No Differences between MSM & LFM Results, but ...

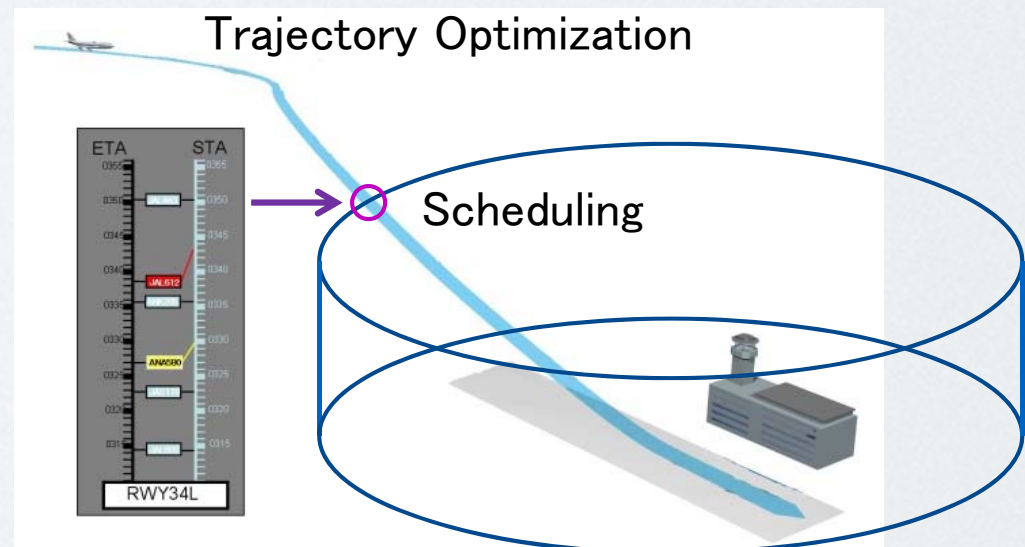


*Provided by the Joint Research with A. Tezuka (Waseda University)*

# Study Plan : Arrival Manager

# Arrival Manager

- Current Status : Flight Distance Extensions Often Occur
  - ← Due to Traffic Concentration & Bad Wx around Haneda Airport
- An ATC Support Tool for Arrival Management Studied
  - Scheduling & Trajectory Optimization
  - How to Apply Wx Data to Minimizing Wx Uncertainty Effect





# An Expectation

- Possibilities of Reducing Bad Wx Impacts on ATC
  - LFM (in Prediction) & DAPs Wind (in Real-time)
    - ← To Catch Wx Position & Movement More Accurately
  - New Forecast Products
    - ← How to use **Probability** Info



Normal Condition  
(Aug. 21, 2010)



Cb Occurs  
(Aug. 17, 2010)

# Summary

- Wind Estimation by DAPs
- An Analysis of Wind Uncertainty Effect on Flight Time
  - Less than 2 % per Flight Time (95 % of the Analyzed Flights)
  - No Differences between MSM & LFM Results
- Study Plan : Arrival Manager





# Workshop Announcement

## ENRI International Workshop on ATM/CNS (EIWAC) 2015

- Date : Nov. 17–19, 2015
- Place : Ryogoku, Tokyo, Japan
- Covered : Aviation Weather & ATM/CNS Related Areas



For More Information



<http://comm.stage.ac/eiwac2015/index.html>





Thank you for your attention.



The “Manga” about ENRI’s  
ATM Research Activities