WWRP CAS/CAeM AvRDP Workshop

MET ATM under CARATS

Collaborative Actions for Renovation of Air Traffic Systems

October 2018

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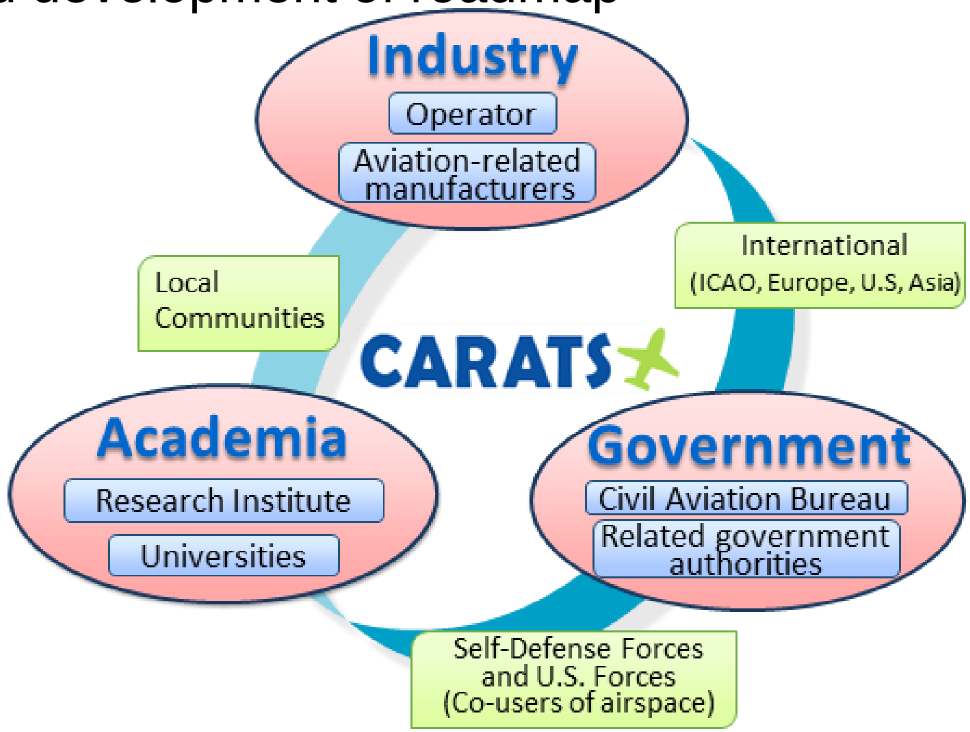
Japan Meteorological Agency (JMA)

Consideration of long-term vision

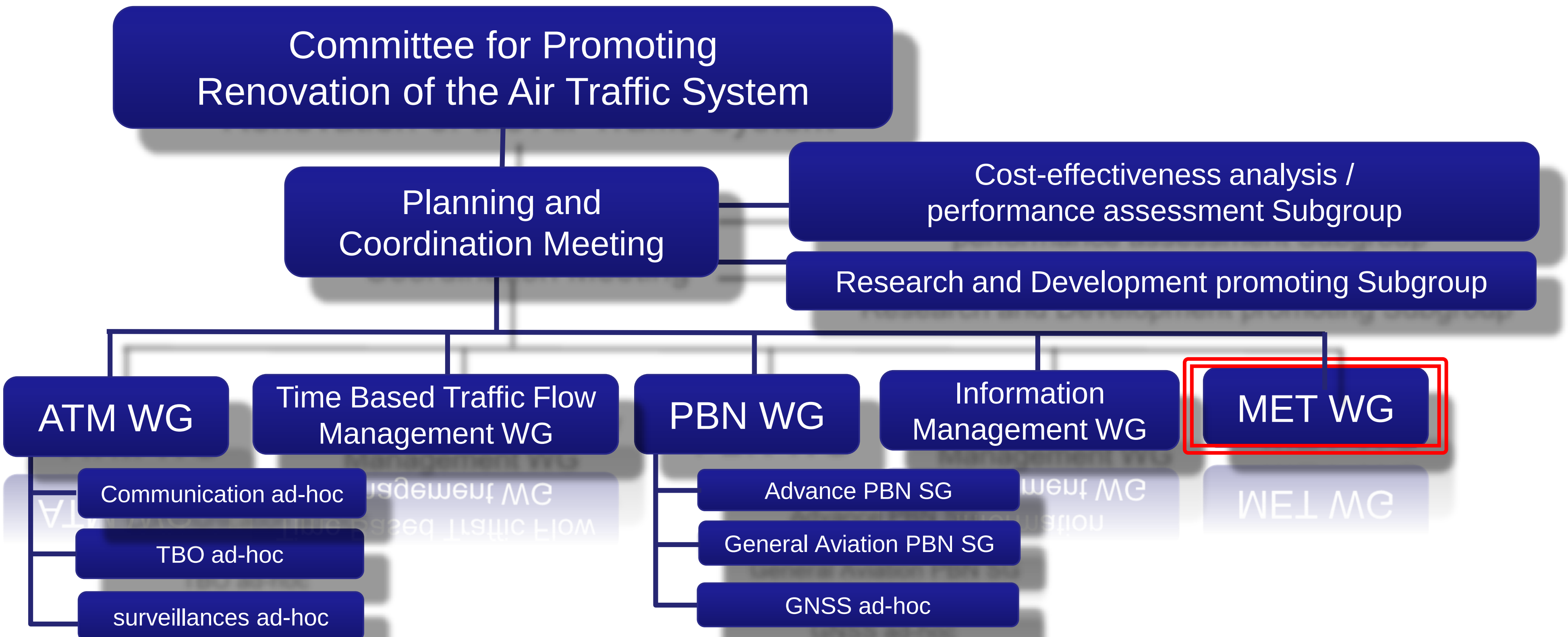
- <u>2009～2010</u>　<u>Development of long-term vision</u>
  - Establishment of "Study group for Promoting Renovation of the Air Traffic System"
  - Development and promulgation of "Collaborative Actions for Renovation of Air Traffic Systems" (CARATS)

- <u>2010～2011</u>　<u>Development of roadmap for each measures</u>
  - Establishment of "Committee for Promoting Renovation of the Air Traffic System"
  - Consideration of concrete measures and development of roadmap

- <u>2011 ～</u>　<u>Implementation Phase</u>



Working Framework in 2018



PBN: Performance Based Navigation

- There are five working groups and relevant ad-hoc groups and sub groups.
- All of the groups carry out collaborative activities between airlines, research institutes, manufactures, JCAB, JMA and other government organizations.
- Assessments with cost-benefit analysis are required before implementation of each measure.

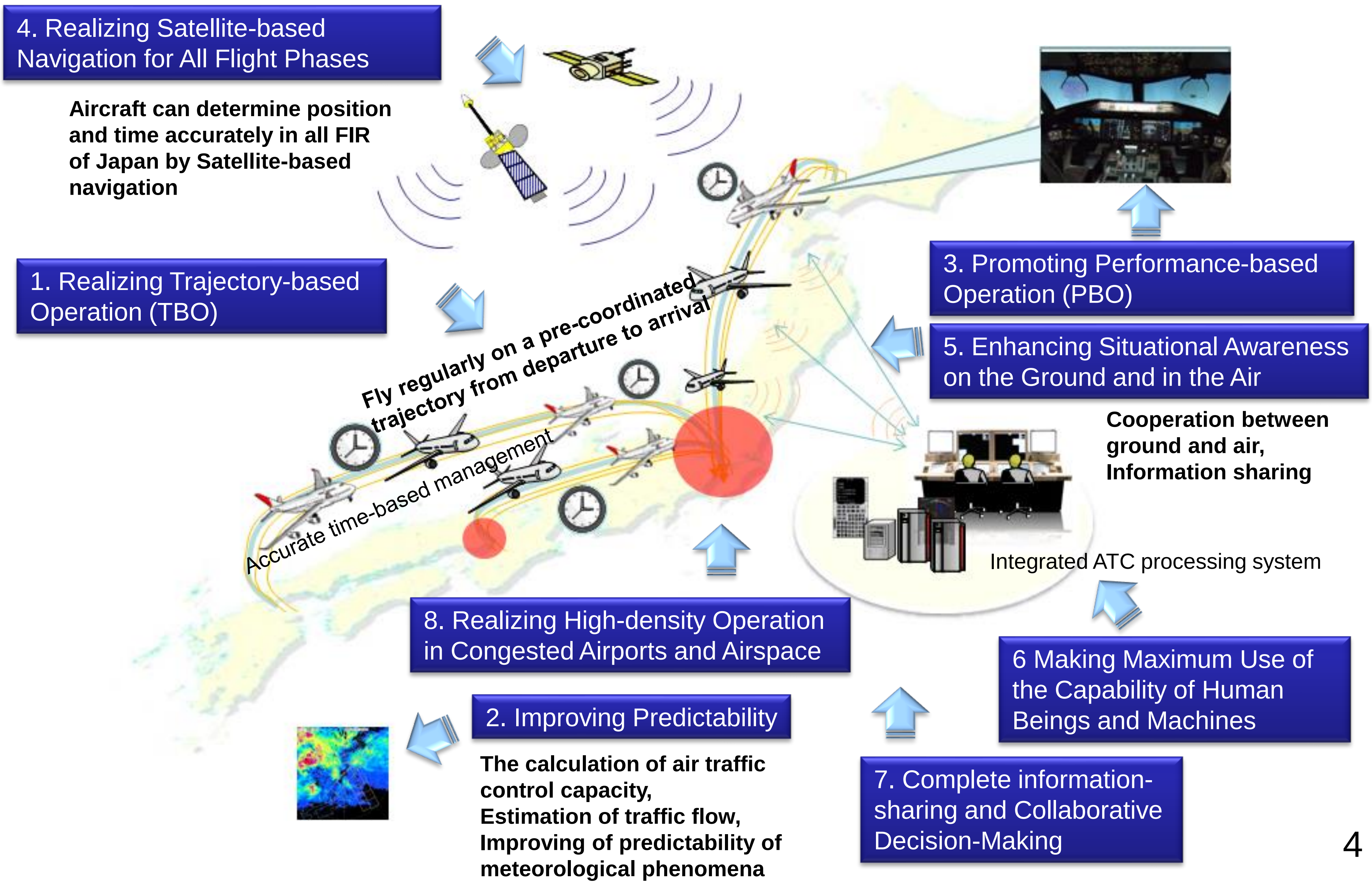
Objectives of CARATS and Development of performance indicators

Development of indicators for checking the status of implementation of the CARATS measures
Progressing CARATS measures steadily and monitoring and analyzing them continuously

Objective and Numerical target	Outline of indicator
1 Enhancing safety (Increase safety level by 5 times)	The number of aircraft accident and important incident resulting from ATC (the average number for the past five years)
2 Responding to the increase in air traffic volume (Double the air traffic control capacity in congested airspace)	(Under consideration)
3 Improving user conveniences (Improve services level by 10%)	Punctuality : The rate of the arrival delay flights exceeding 15 minutes
	Actual operation rate : The flight cancellation rate by the influence of the whether (the average rate for the past three years)
	Rapidness: Flight time of Gate-to-Gate of main routes.
4 Improving operational efficiency (Reduce fuel consumption per flight by 10%)	The amount of the fuel consumption per flight in main routes
5 Improving productivity of air traffics services (Improve productivity of air traffic services by 50% or more)	The flight plan operation number of each air traffic controller
	The flight plan operation number to the maintenance expense (the average number for the past three years)
6 Responding to environmental issues (Reduce CO_2 emissions per flight by 10%)	The amount of the CO_2 emissions per flight in main routes
7 Enhancing the international presence of Japan in the aviation field	(Qualitative objective)

Objectives to be achieved by 2025 (clarifying numerical targets)

Direction of renovation in CARATS



Measures of aviation weather in CARATS

CARATS Roadmap

operational improvements：OI
(improve operation)

enablers：EN
（technology for enabling OI）

Measures of aviation weather

ALL Measures of **aviation weather** are enablers (EN)

Improved weather observation capabilities

・Integration of observation data around aerodrome and air spaces

Improved weather forecast capabilities

・Development of NWP model with high frequency and resolution
・Expansion of forecast elements

Quantification of the impact of severe weather on capacity and other aircraft operations

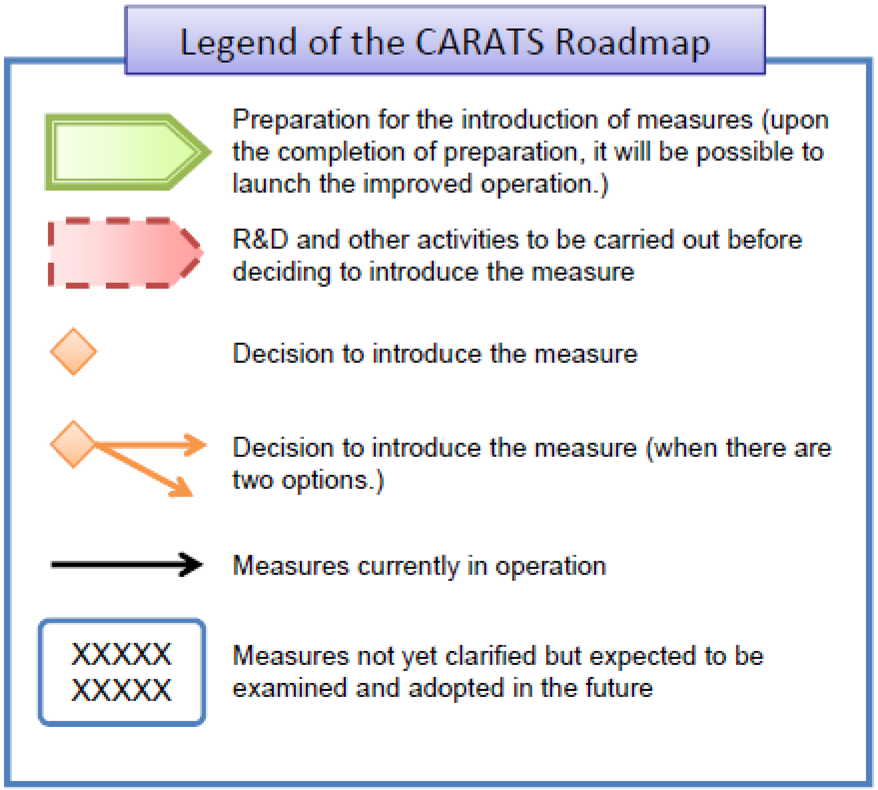
・Estimation of impact on ATM using MET information
・Translation from MET data to airport/airspace capacity

MET information sharing infrastructure

・Sharing of weather information with standardized format on SWIM environment

CARATS Roadmap

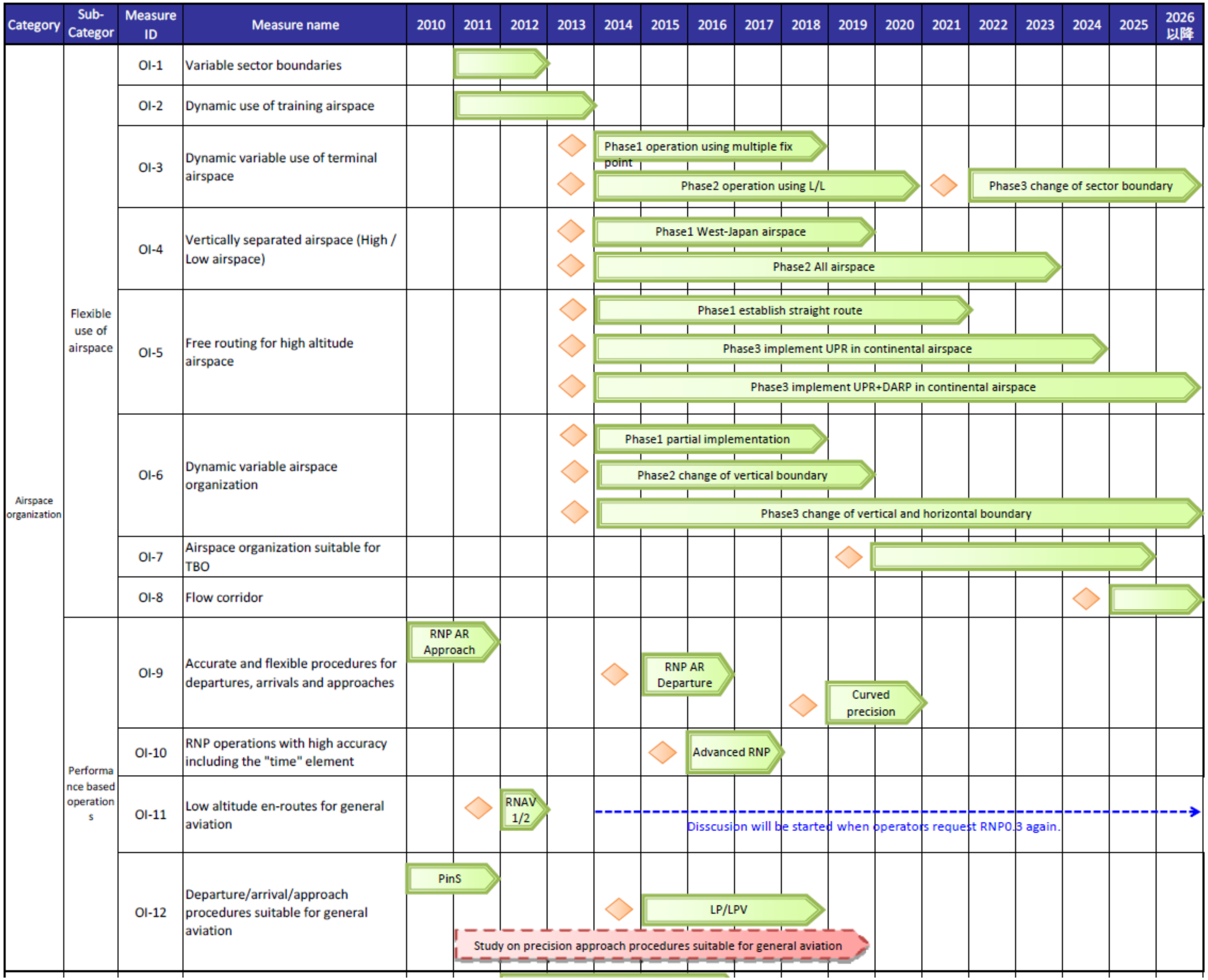
The roadmap specifies 64 measure that needs to be taken in order to achieve the CARATS, and categorizes them into measures intended to improve operation (operational improvements (OI)) and measures relating to technology necessary for enabling such improvement (enablers (EN)).



Please note that following table may different from current version.

Roadmap OI (1)

OI (operational improvements): measures intended to improve operation.



Roadmap OI (2)

Category	Sub-Categor	Measure ID	Measure name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 以降
Pre-flight	Collaborative trajectory generations	OI-13	CDO and CCO			Phase1 CDO using datalink (inbound from		Phase2 CDO using datalink (from continental en-route		CCO							Phase3 Enhancement (ATN-B2, etc.)			
		OI-14	Shared trajectories, weather information and constraints for aircraft operations														Enhancement (ATN-B2, etc.)			
		OI-15	Collaborative coordination of trajectories prior to the flight																	
		OI-16	Enhanced traffic management using CFDTs for multiple points based on the trajectory data																	
		OI-17	Conflict-free trajectories from gate to gate																	
In-flight	Real-time trajectory updates	OI-18	Time-based management using CFDTs at single points (Initial CFDT operations)																	
		OI-19	Time-based metering at merging points					Phase1 Fixed metering fix Phase2 dynamic metering fix									Phase3 Enhancement (ATN-B2, etc.)			
		OI-20	Conflict detection using the trajectory information																	
		OI-21	Shared trajectory data via datalink / FLIPCY、FLIPINT、4DTRAD				Development and evaluation of Software applications for Trajectory based operations			FLIPCY		FLPINT		4DTRAD						
		OI-22	Real time trajectory revision supported by automation systems														Enhancement (ATN-B2, etc.)			
	High density	OI-23	Improved efficiency of aerodrome operations		Optimization of off-block time (Introducing				DMAN, AMAN, SMAN					Efficient overall aerodrome						
		OI-24	Improved airport facilities to enhance throughput of airports																	
		OI-25	Improved throughput for closely separated parallel runways																	

Roadmap OI (3)

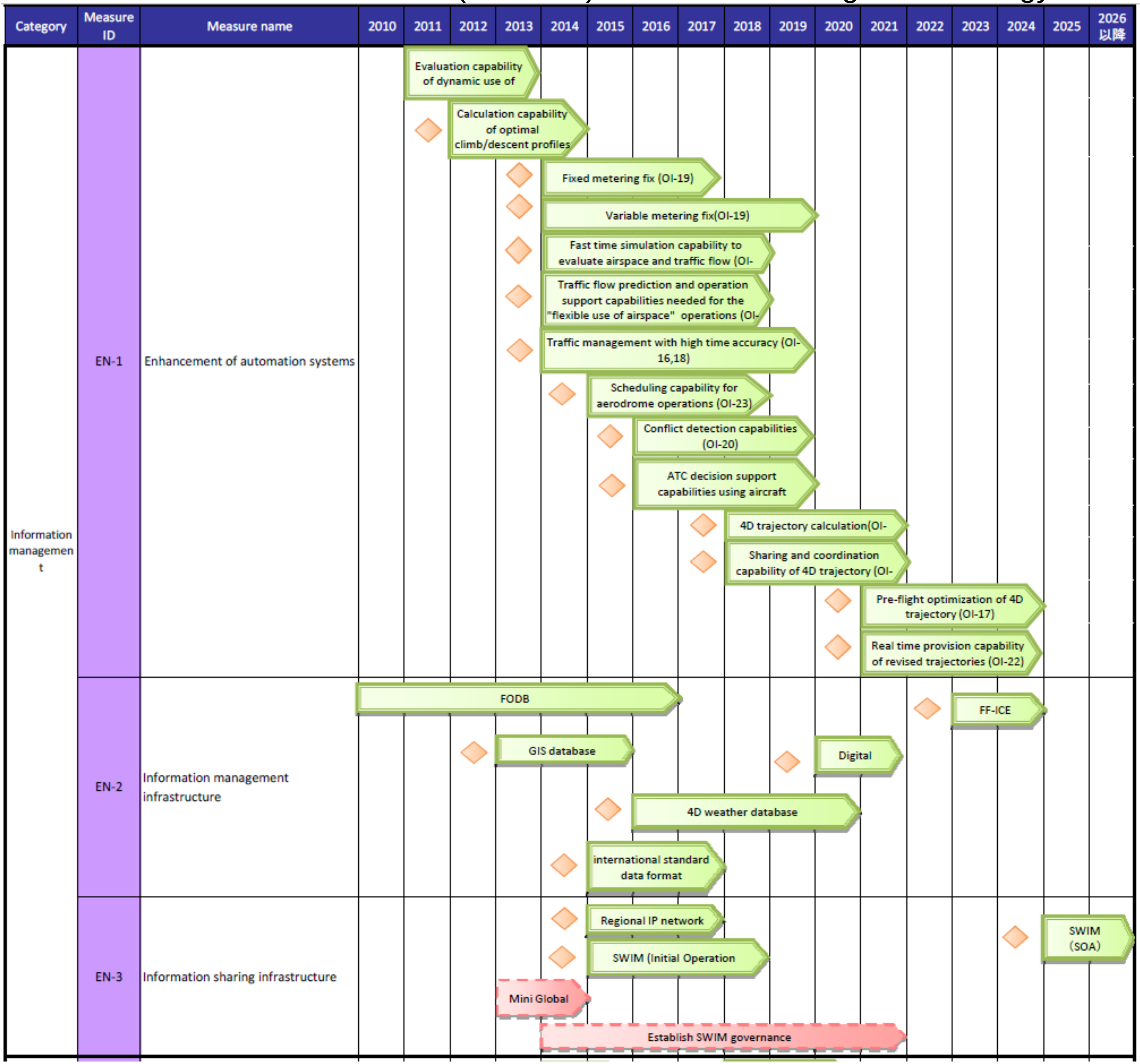
Category	Sub-Categor	Measure ID	Measure name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 以降
	operations	OI-26	Reduced wake turbulence separation minima		R&Ds and evaluations on the techniques to mitigate the impact of wake			Phase1, 2					Phase3 Reflected wind data to			Detection/prediction of				
		OI-27	Reduced separation minima for high density airspace (3NM for enroute)																	
		OI-28	Reduced separation minima for oceanic airspace																	
In-flight	High density operations	OI-29-1	Improved capacity of ATC using datalink for routine communications / ATC clearance (airport) - DCL, D-TAXI		DCL Trial Monitoring the International standardization status/R&Ds					DCL (Revised) D-TAXI (FANS-1/A+(POA/M2))							Enhancement (ATN-B2, etc.)			
		OI-29-2	Improved capacity of ATC using datalink for routine communications / ATC clearance (enroute) - continental CPDLC					Continental CPDLC (FANS-1/A+(POA/M2))									Enhancement (ATN-B2, etc.)			
		OI-29-3	Improved capacity of ATC using datalink for routine communications / Flight information services - D-ATIS, D-OTIS, D-RVR, D-HZWX	D-ATIS Trial			Monitoring the International standardization status/R&Ds			D-ATIS (FANS-1/A+(POA/M2))		D-OTIS D-RVR/HZWX					Enhancement (ATN-B2, etc.)			
		OI-30-1	Air-to-air surveillance (ASAS) / ATSA-ITP operations			R&Ds and evaluations on			ATSA-ITP											
		OI-30-2	Air-to-air surveillance (ASAS) / ATSA-AIRB operations (1090ES)			R&Ds and evaluations			ATSA-AIRB											
		OI-30-3	Air-to-air surveillance (ASAS) / ATSA-AIRB Operations (UAT/TIS-B)			R&Ds and evaluations on ATSA-AIRB(UAT)					ATSA-AIRB(UAT)									
		OI-30-4	Air-to-air surveillance (ASAS) / ATSA-VSA operations			R&Ds and evaluations on			ATSA-VSA											
		OI-30-5	Air-to-air surveillance (ASAS) / ASPA-IM operations			R&Ds and evaluations on ASPA-IM												ASPA-IM		

Roadmap OI (4)

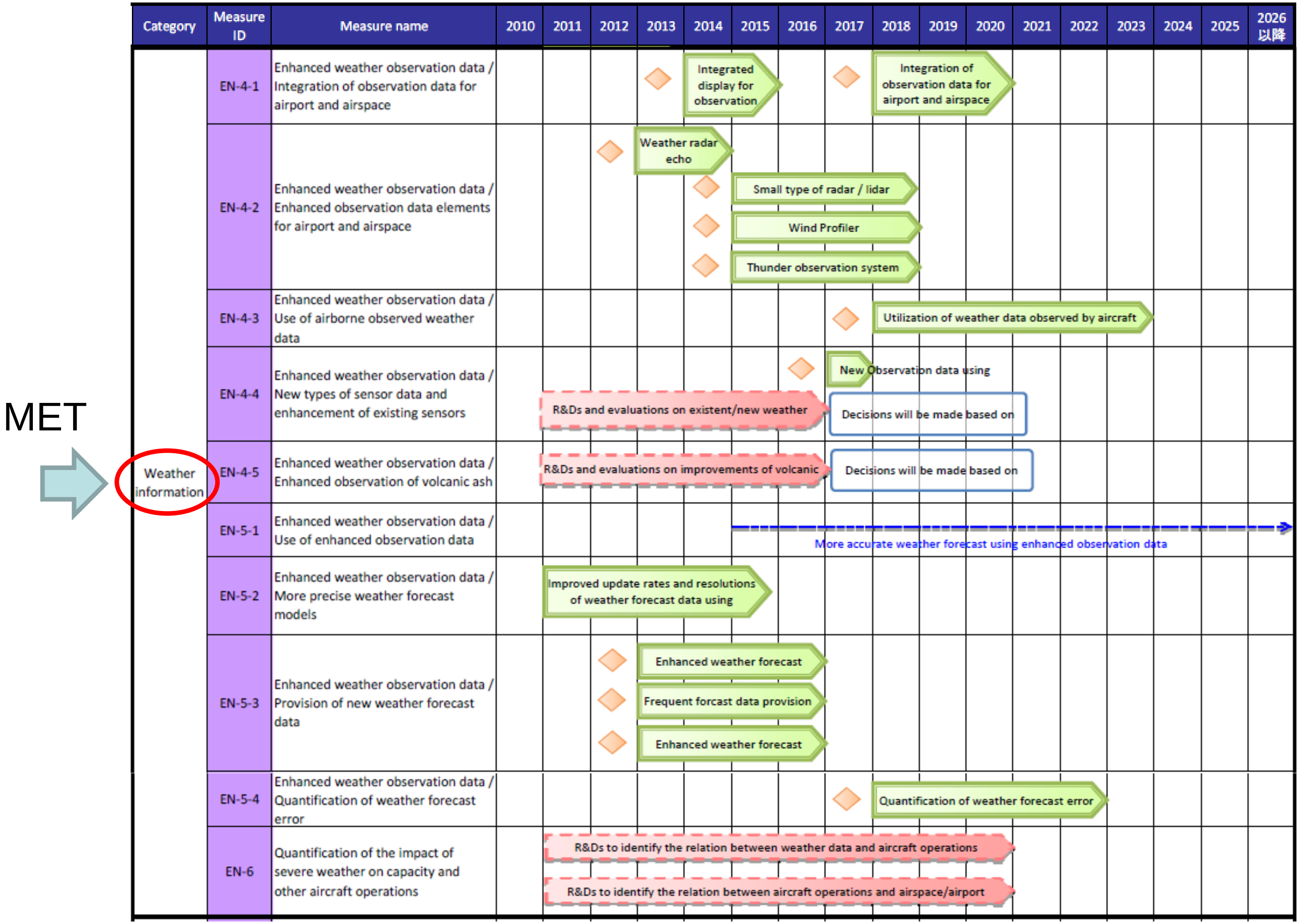
Category	Sub-Categor	Measure ID	Measure name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 以降
In-flight	Improved information services	OI-31	Enhanced information in the cockpit		Monitoring the International standardization status	◇	Terrain / obstacle	◇ ◇	Weather information Traffic information					◇	Aeronautical information					
		OI-32	Improved information services for aircraft operators		Monitoring the International standardization status /							◇	Provided effective information to operators							
Post-flight	Sharing and utilizing safety related information	OI-33	Sharing and utilizing safety related information	Implement SSP		◇	accumulation/analysis/evaluation of acquired safety information								Study on real time risk management		◇	Real time risk management		

Roadmap EN (1)

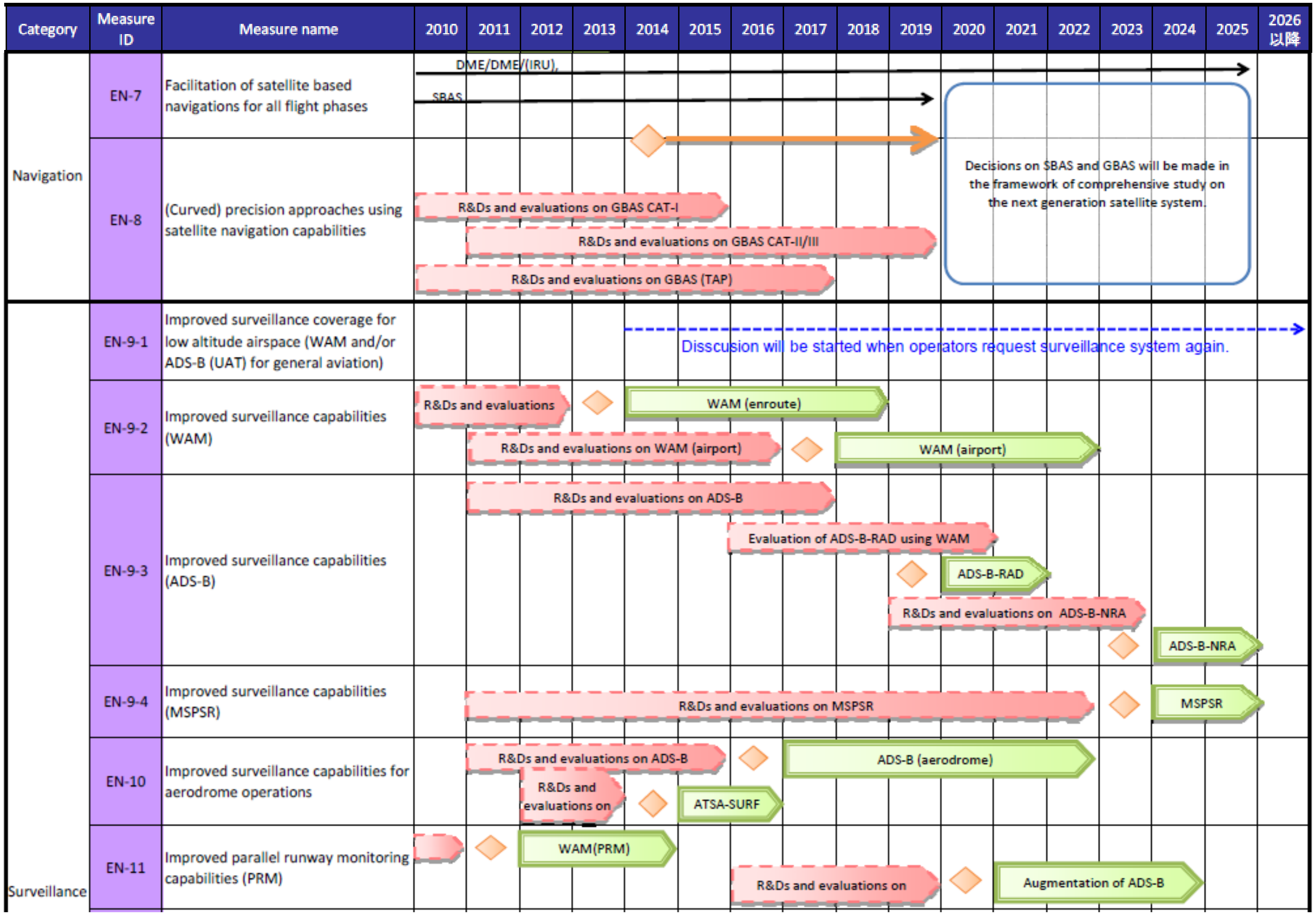
EN (enablers): measures relating to technology necessary for enabling OI.



Roadmap EN (2)

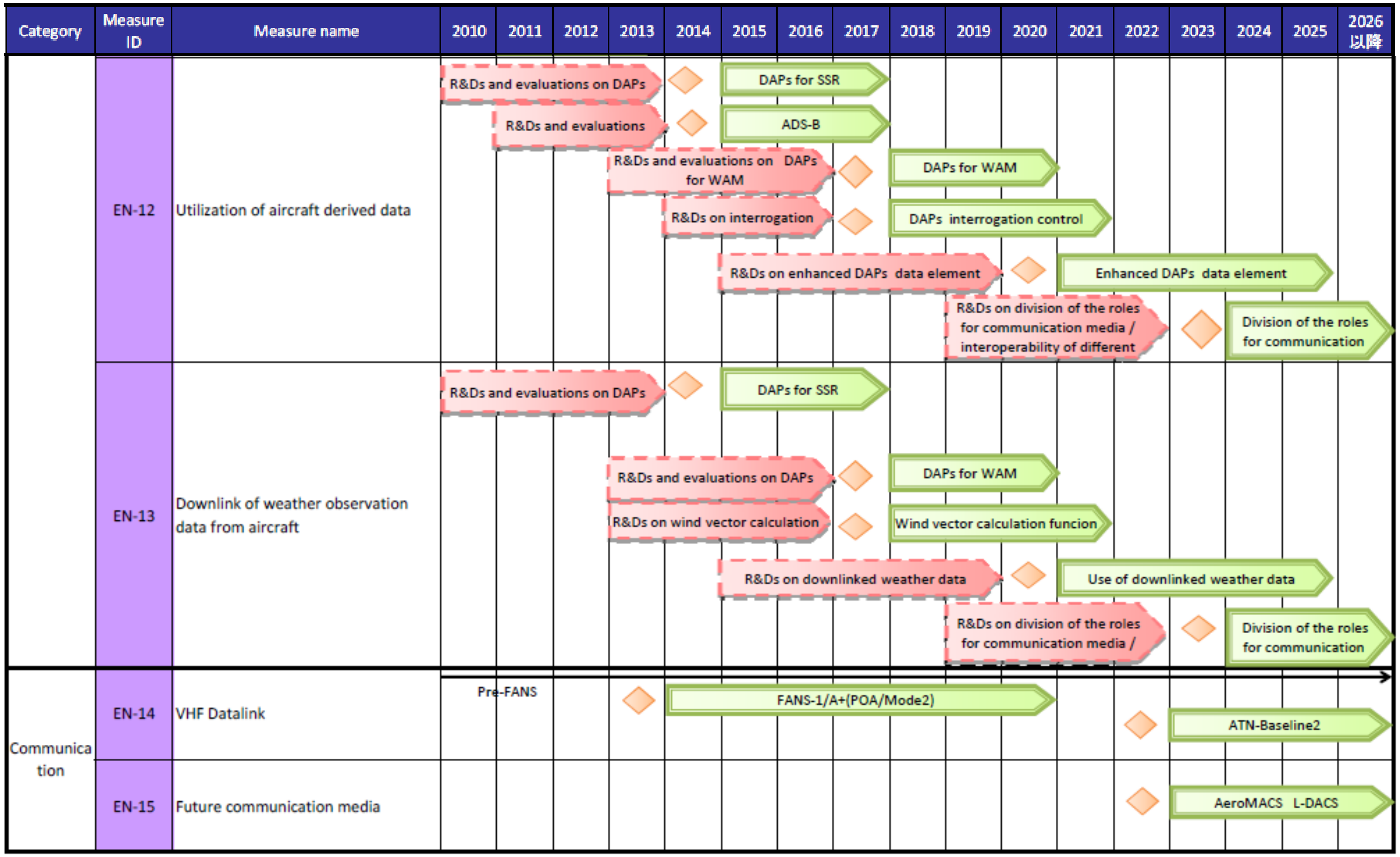

MET
Category
Measure ID
Measure name
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026 以降
Weather information
EN-4-1
Enhanced weather observation data / Integration of observation data for airport and airspace
Integrated display for observation
Integration of observation data for airport and airspace
EN-4-2
Enhanced weather observation data / Enhanced observation data elements for airport and airspace
Weather radar echo
Small type of radar / lidar
Wind Profiler
Thunder observation system
EN-4-3
Enhanced weather observation data / Use of airborne observed weather data
Utilization of weather data observed by aircraft
EN-4-4
Enhanced weather observation data / New types of sensor data and enhancement of existing sensors
New Observation data using
R&Ds and evaluations on existent/new weather
Decisions will be made based on
EN-4-5
Enhanced weather observation data / Enhanced observation of volcanic ash
R&Ds and evaluations on improvements of volcanic
Decisions will be made based on
EN-5-1
Enhanced weather observation data / Use of enhanced observation data
More accurate weather forecast using enhanced observation data
EN-5-2
Enhanced weather observation data / More precise weather forecast models
Improved update rates and resolutions of weather forecast data using
EN-5-3
Enhanced weather observation data / Provision of new weather forecast data
Enhanced weather forecast
Frequent forcast data provision
Enhanced weather forecast
EN-5-4
Enhanced weather observation data / Quantification of weather forecast error
Quantification of weather forecast error
EN-6
Quantification of the impact of severe weather on capacity and other aircraft operations
R&Ds to identify the relation between weather data and aircraft operations
R&Ds to identify the relation between aircraft operations and airspace/airport

Roadmap EN (3)



Category
Measure ID
Measure name
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026 以降
Navigation
EN-7
Facilitation of satellite based navigations for all flight phases
DME/DME/(IRU),
SBAS
EN-8
(Curved) precision approaches using satellite navigation capabilities
R&Ds and evaluations on GBAS CAT-I
R&Ds and evaluations on GBAS CAT-II/III
R&Ds and evaluations on GBAS (TAP)
Decisions on SBAS and GBAS will be made in the framework of comprehensive study on the next generation satellite system.
Surveillance
EN-9-1
Improved surveillance coverage for low altitude airspace (WAM and/or ADS-B (UAT) for general aviation)
Disscussion will be started when operators request surveillance system again.
EN-9-2
Improved surveillance capabilities (WAM)
R&Ds and evaluations
WAM (enroute)
R&Ds and evaluations on WAM (airport)
WAM (airport)
EN-9-3
Improved surveillance capabilities (ADS-B)
R&Ds and evaluations on ADS-B
Evaluation of ADS-B-RAD using WAM
ADS-B-RAD
R&Ds and evaluations on ADS-B-NRA
ADS-B-NRA
EN-9-4
Improved surveillance capabilities (MSPSR)
R&Ds and evaluations on MSPSR
MSPSR
EN-10
Improved surveillance capabilities for aerodrome operations
R&Ds and evaluations on ADS-B
ADS-B (aerodrome)
R&Ds and evaluations on
ATSA-SURF
EN-11
Improved parallel runway monitoring capabilities (PRM)
WAM(PRM)
R&Ds and evaluations on
Augmentation of ADS-B

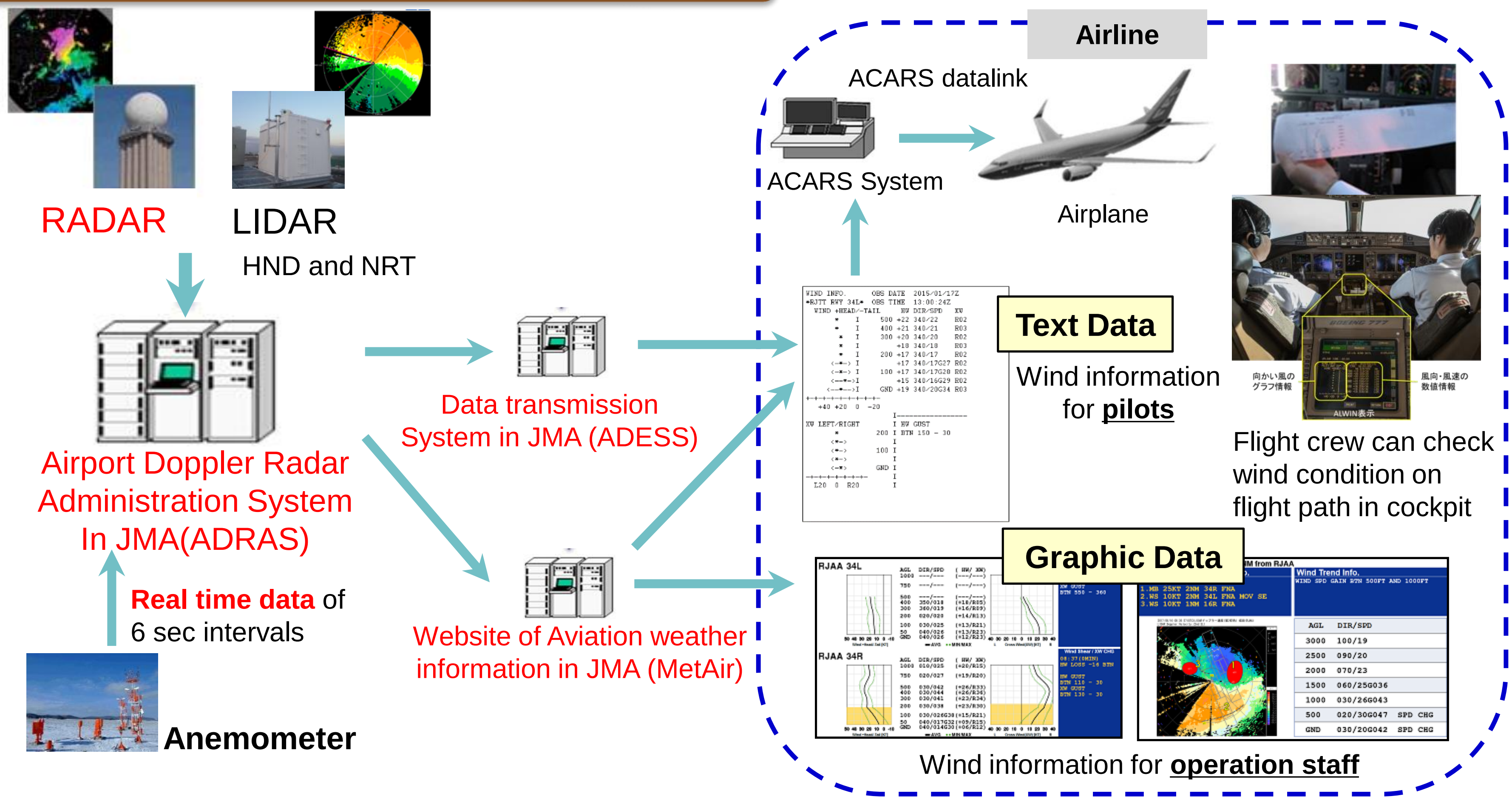
Roadmap EN (4)


Category
Measure ID
Measure name
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026 以降
EN-12
Utilization of aircraft derived data
R&Ds and evaluations on DAPs
DAPs for SSR
R&Ds and evaluations
ADS-B
R&Ds and evaluations on DAPs for WAM
DAPs for WAM
R&Ds on interrogation
DAPs interrogation control
R&Ds on enhanced DAPs data element
Enhanced DAPs data element
R&Ds on division of the roles for communication media / interoperability of different
Division of the roles for communication
EN-13
Downlink of weather observation data from aircraft
R&Ds and evaluations on DAPs
DAPs for SSR
R&Ds and evaluations on DAPs
DAPs for WAM
R&Ds on wind vector calculation
Wind vector calculation funcion
R&Ds on downlinked weather data
Use of downlinked weather data
R&Ds on division of the roles for communication media /
Division of the roles for communication
Communication
EN-14
VHF Datalink
Pre-FANS
FANS-1/A+(POA/Mode2)
ATN-Baseline2
EN-15
Future communication media
AeroMACS L-DACS

Examples of the recent activities on MET in CARATS

Improved weather observation capabilities

ALWIN (Airport Low-level Wind INformation)



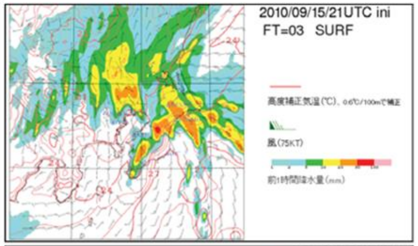
- Wind information detected by Doppler RADAR and LIDAR and measured by anemometer is converted into both graphic data and text data.
- Text data is transmitted to pilots in cockpits via the ACARS system.
- Airline operators can obtain graphic and text data from dedicated website (MetAir).

Examples of the recent activities on MET in CARATS

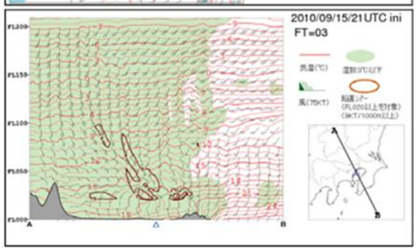
Improved weather forecast capabilities

Development of high resolution NWP model

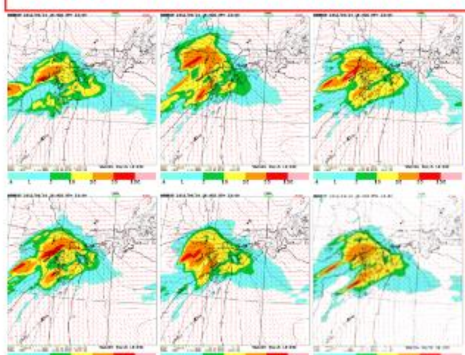
Grid size: 5 km



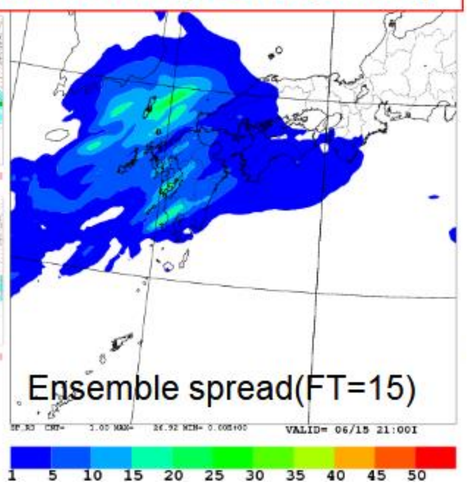
Grid size: 2 km



Meso-scale Ensemble Prediction System (MEPS)

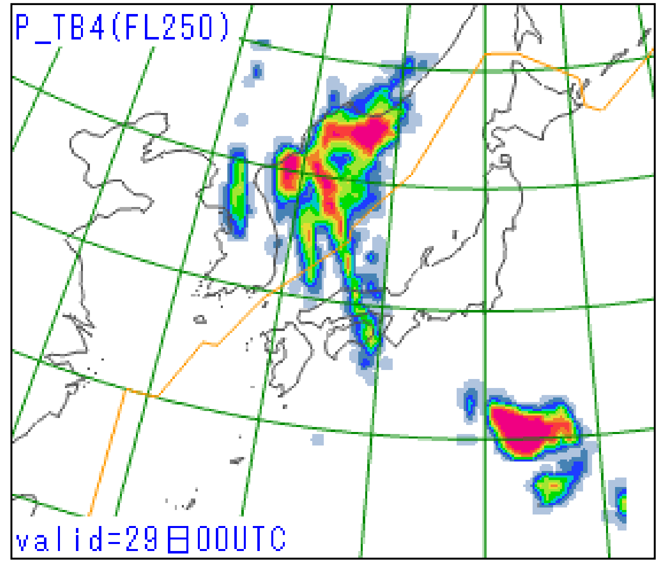


Perturbed forecasts(FT=15)

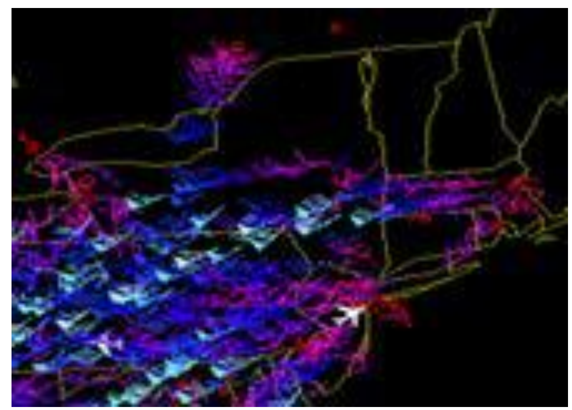


Ensemble spread(FT=15)

Probabilistic forecast using NWP, e.g. TB index



Use of aircraft data via data-link

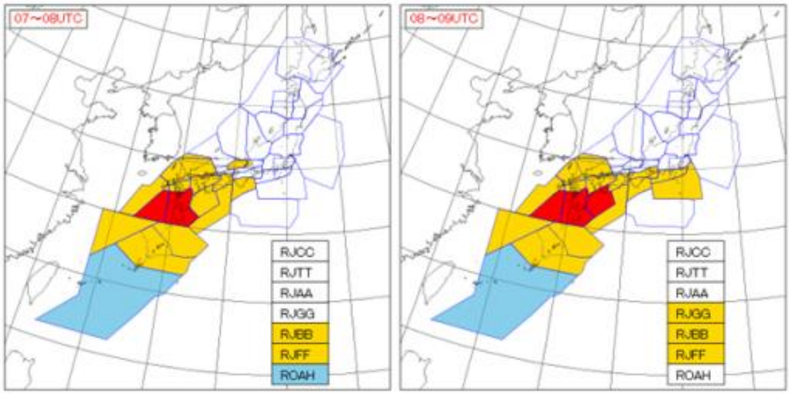


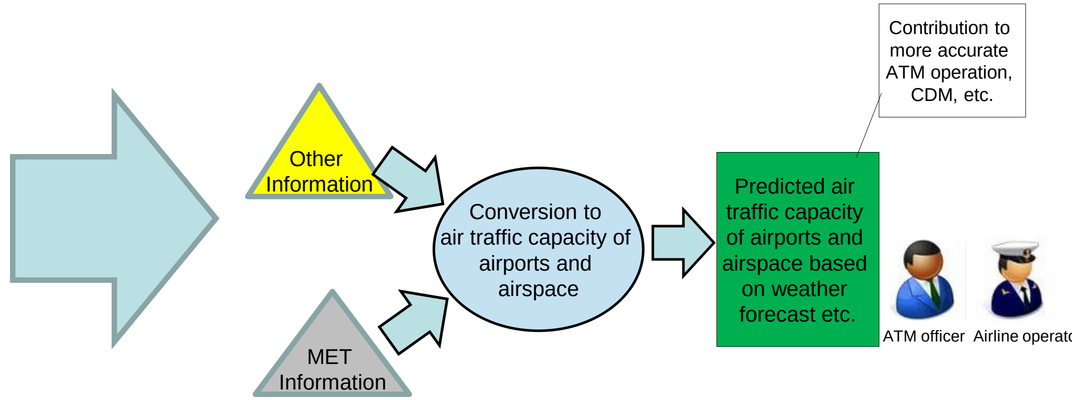
DAPs : Downlink Aircraft Parameters

Examples of the recent activities on MET in CARATS

MET integration into ATM decision support system

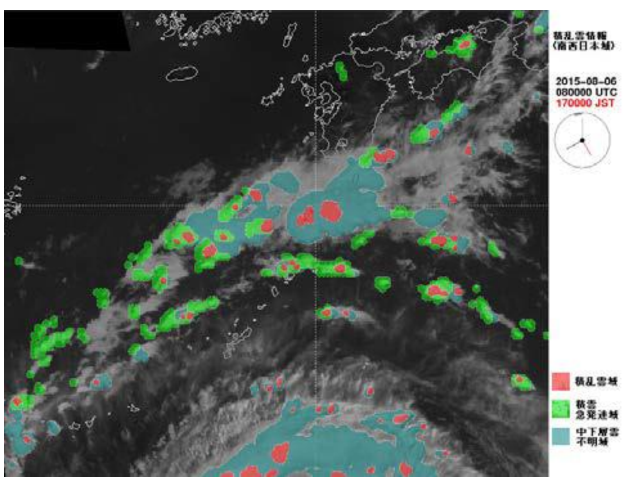
Current ATMet Category Forecast

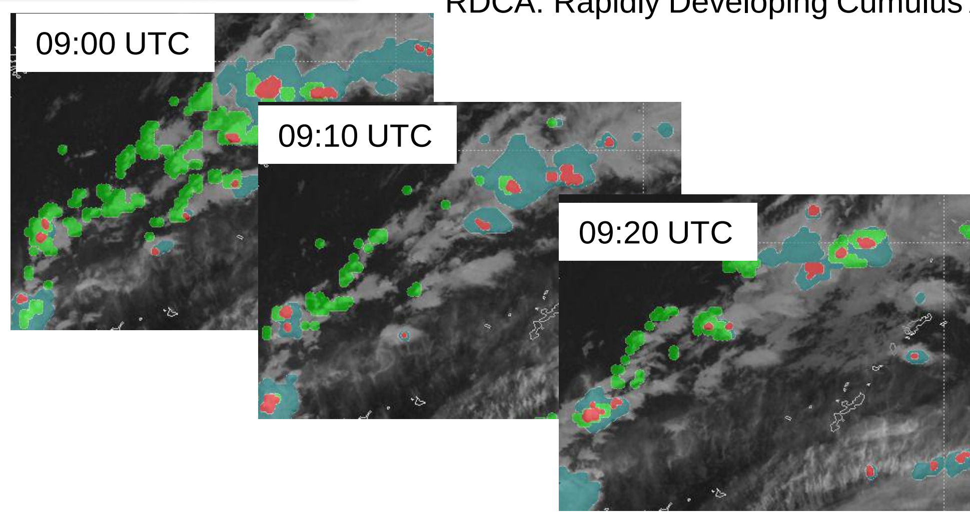




Advanced product using Himawari-8

CBA: Cumulonimbus Areas
MLUA: Mid/Low Cloud Unknown Areas
RDCA: Rapidly Developing Cumulus Areas



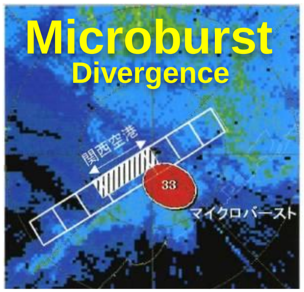


Improvement of Low-Level Wind Information

ALWIN (Airport Low-level Wind INformation)

Conventional Low-level Windshear Information of JMA

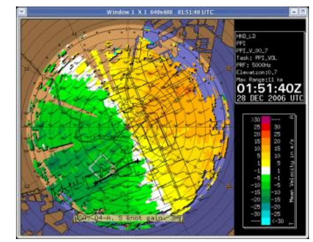
Wind Shear (WS) affects airplane safety operation → **WS Observation in all weather conditions**



DRAW (TDWR) detects low-level wind shear in Rainy condition

Doppler Radar for Airport Weather (DRAW, Japanese version of TDWR)
(from 1996)

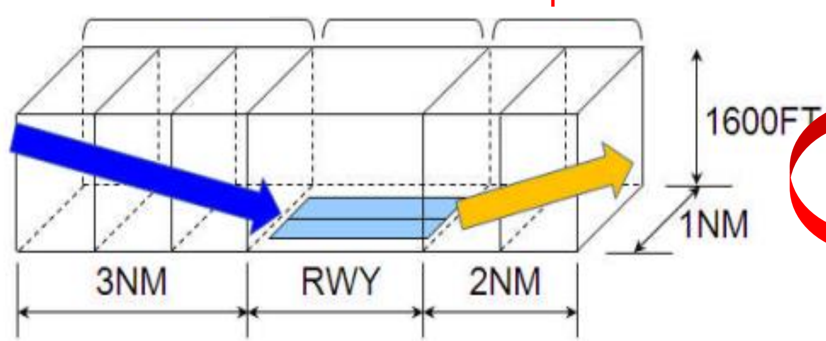
+



Doppler LIDAR detects low-level wind shear in Sunny or Cloudy condition

Light Detection and Ranging (LIDAR)
(from 2008)

Detection Area



TDWR and LIDAR detects Shear Line(SL)and Microburst(MB). Those information are provided as WS Alert and MB Alert.

WS, MB alerts are simple text message, and contents are not enough.

Overview of Wind Shear and Microburst Alert

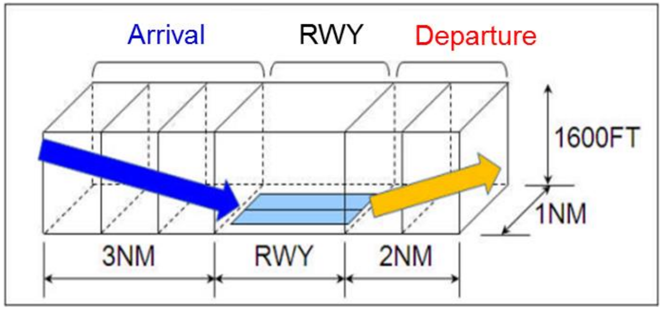
Wind Shear Alert

Over 20 kt Increase or Decrease of Head Wind Component

Microburst Alert

Over 30 kt Decrease of Head Wind Component

Detection Area



（Example）

0837 34LA MBA 39kt- 3nm FNL

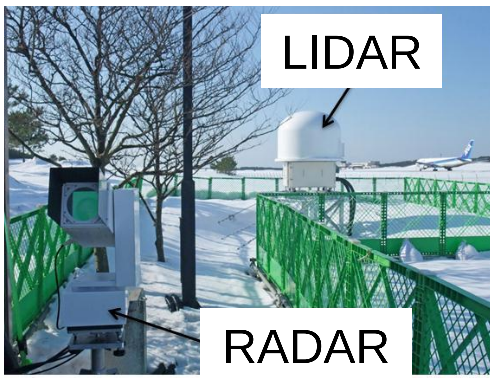
- 0837 : Obs time in UTC
- 34LA : 34L (RWY)
  A: ARRIVAL
  D: DEPARTURE
- MBA : MBA (Microburst Alert)
  WSA (Wind Shear Alert)
- 39kt- : 39 kt (wind speed change)
  ＋ : GAIN
  ー : LOSS
- 3nm FNL: 3 nm (Position)
  FNL (Arrival side)
  DEP (Departure side)
  RWY (Over Runway)

Collaborative Research with JAXA

To provide new WS information, JMA started a collaborative research with JAXA (Japan Aerospace Exploration Agency). JAXA developed information providing system, called LOTAS.

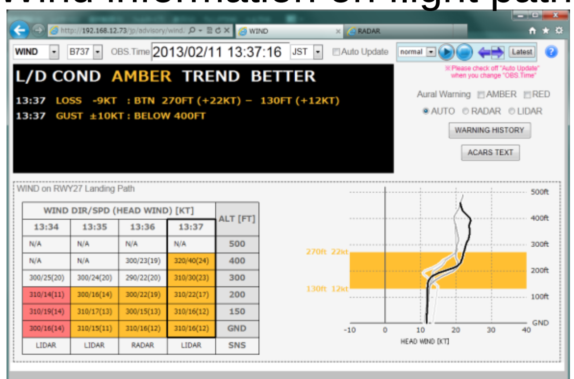
LOTAS

(Low-level Turbulence Advisory System)

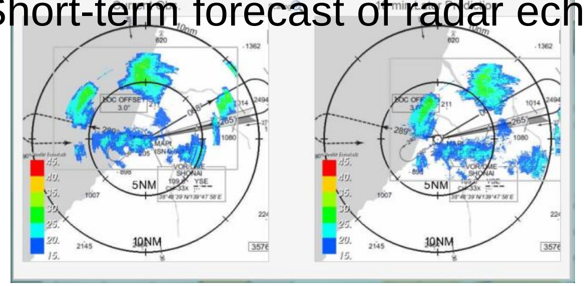


Observation by compact RADAR/LIDAR near airport

Wind information on flight path

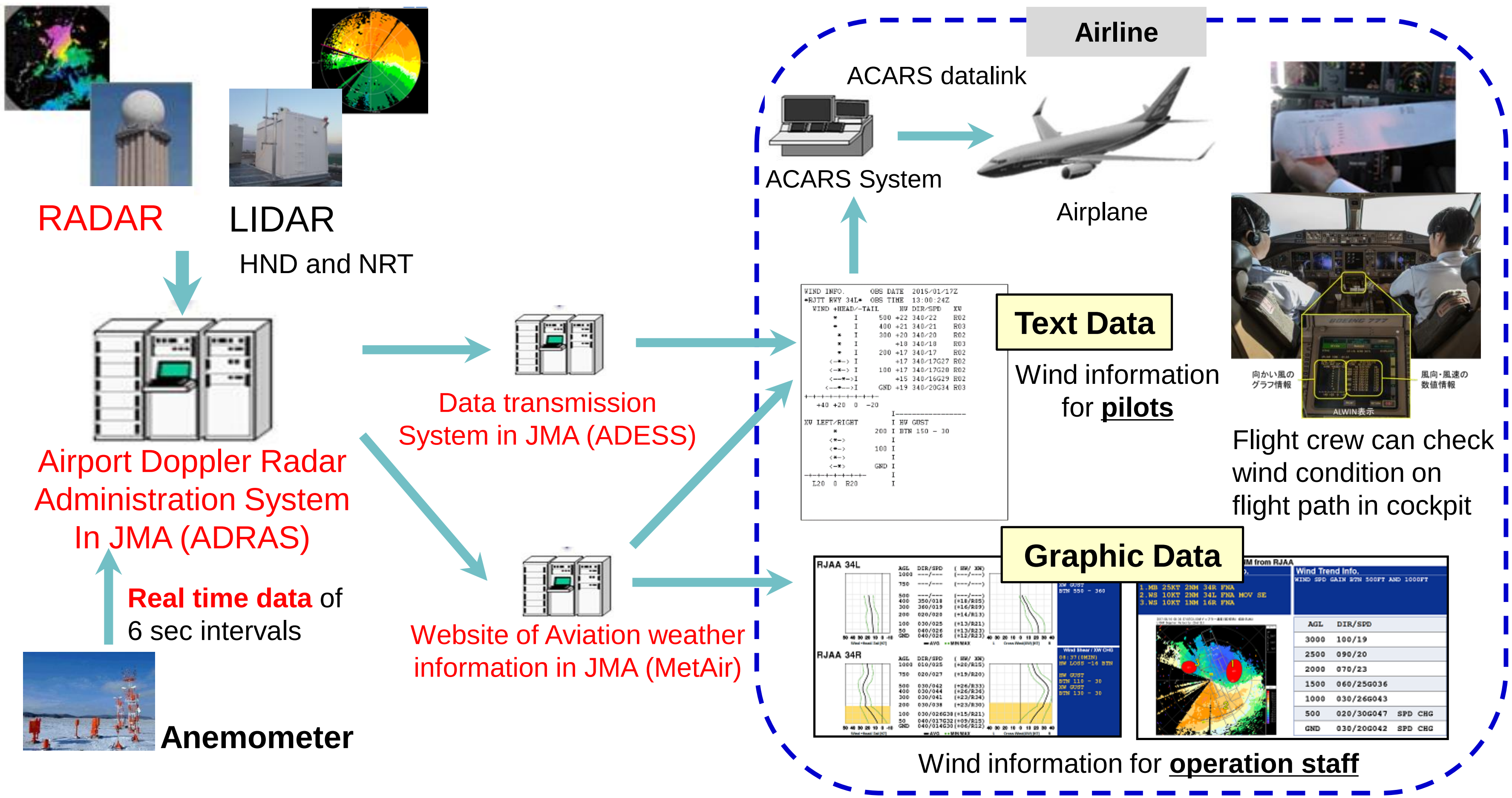


Short-term forecast of radar echo



Users (Airlines)

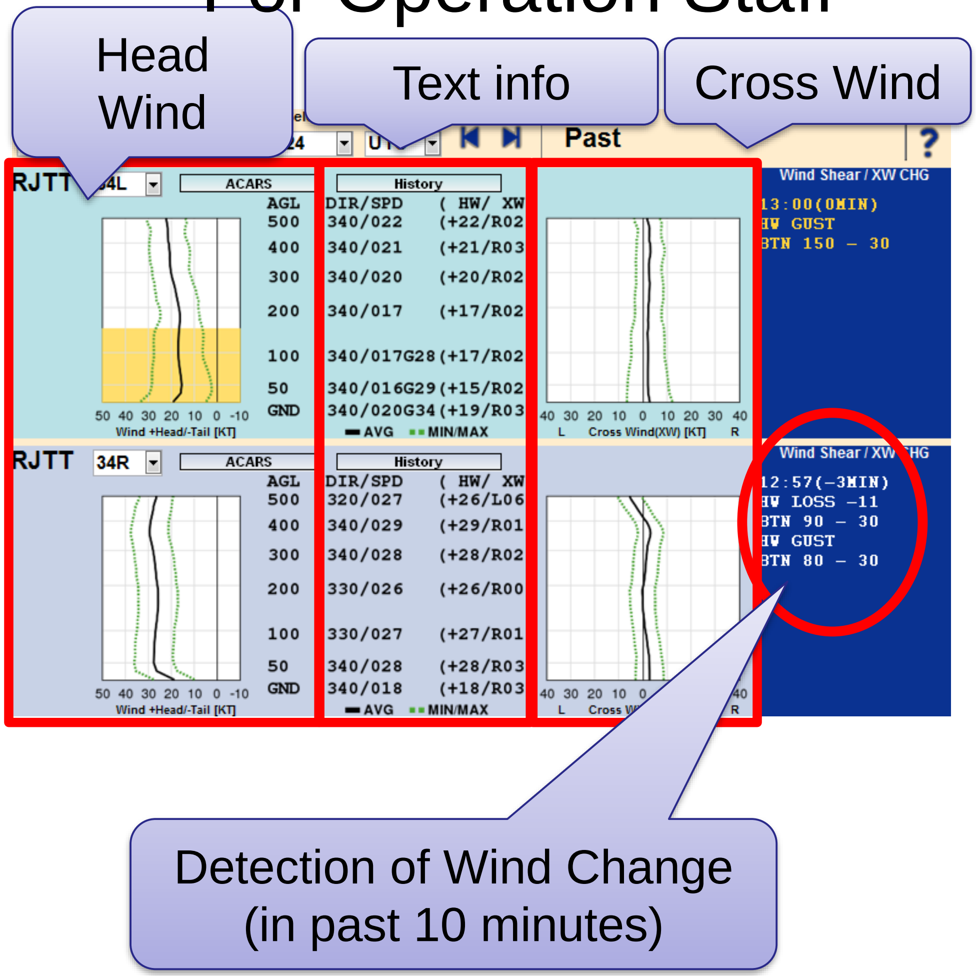
ALWIN Provision Flow



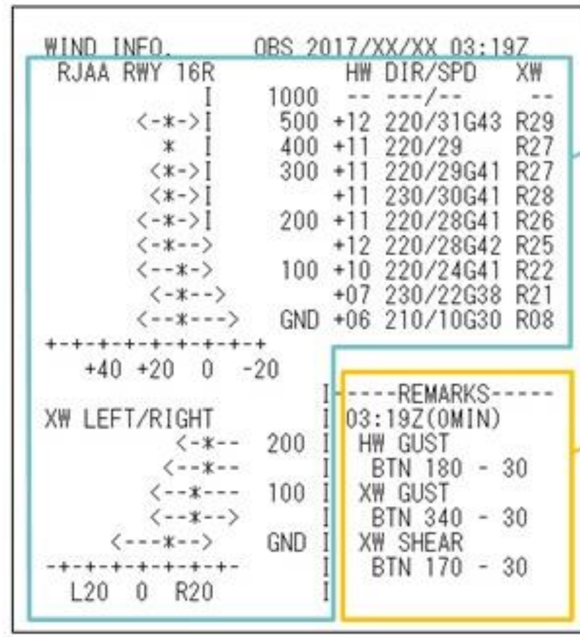
- Wind information detected by Doppler RADAR and LIDAR and measured by anemometer is converted into both graphic data and text data.
- Text data is transmitted to pilots in cockpits via the ACARS system.
- Airline operators can obtain graphic and text data from JMA's website (MetAir).

Display of Flight Path Wind Information

For Operation Staff



For Airplane



<Details: Wind direction/ speed on final approach path, wind shear distribution>

Head wind gust detected between altitude 180-30ft
Cross wind gust detected between altitude 340-30ft
Cross wind shear detected between altitude 170-30ft

Display of Airport Information

For Operation Staff

Detection of Temporal Wind Change (Wind Speed and Direction)

APT

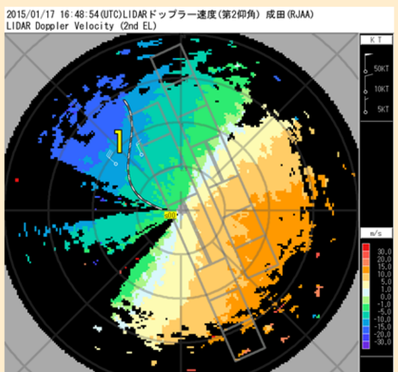
Averaged Wind Info. within 5NM RJAA ACARS History

Shear Line / Microburst Info.

16:48(0MIN)

1.WS 15KT 3NM 16R FNA

Wind Trend Info.



RJAA 16

AGL	DIR/SPD	CHG	HW	XW
3000	320/41		-40	R10
2500	310/40		-38	R12
2000	310/38		-36	R14
1500	310/34		-31	R14
1000	300/30	*	-27	R14
500	300/19	*	-16	R10
GND	300/08	*	-07	R04

SL/MB information (position and moving direction)

3000	110/02
2500	020V100/03
2000	010/06

2500	VRB03

For Airplane

WIND INFO. OBS DATE 2015

RJAA AIRPORT OBS TIME 02:

AVERAGE WIND WITHIN 5NM FRO RJAA

AGL	DIR/SPD	CHG
3000	310/39	
2500	310/37	
2000	300/35	
1500	310/32	
1000	300/31	*
500	300/26	*
GND	300/16	*

WS 5KT OVER A-RWY

Wind Vertical Profile

Detection information

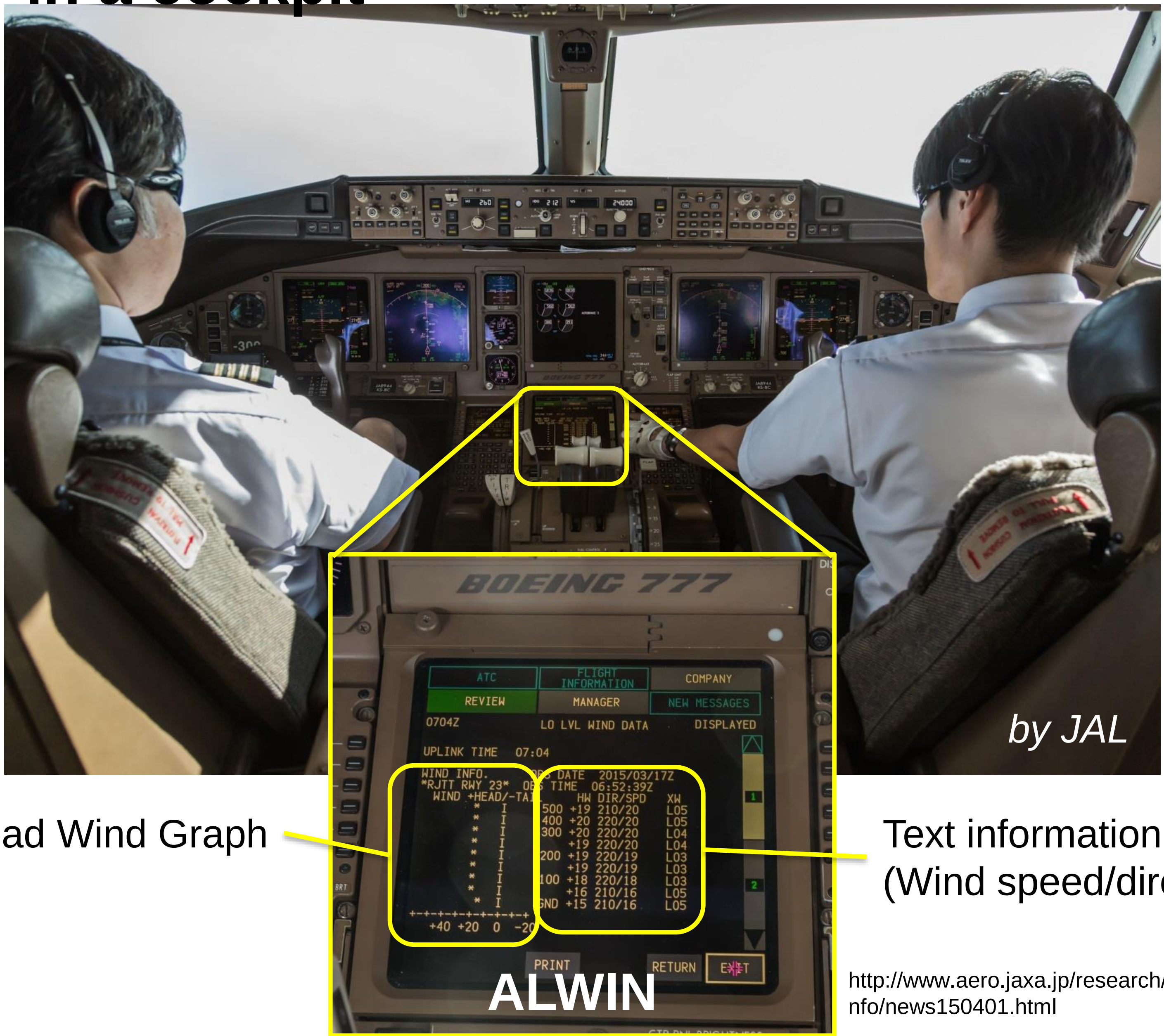
Vertical Wind Profile

[*]indicating existence of large wind change

Wind variable/wind change is indicated by [VRB]or[V], like METAR

CARATS Collaborative Actions for Renovation of Air Traffic Systems

Display in a cockpit



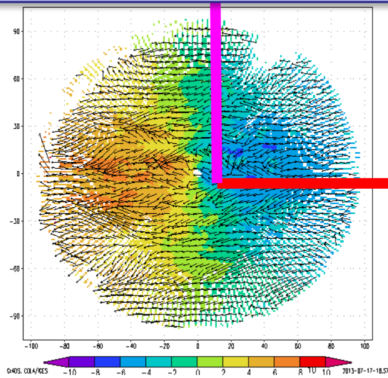
Head Wind Graph

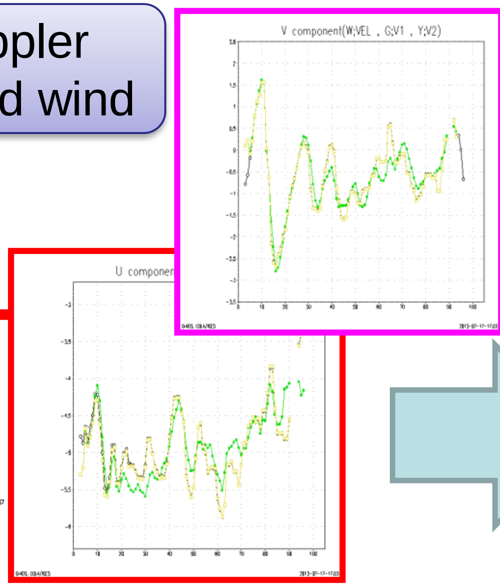
Text information
(Wind speed/direction)

http://www.aero.jaxa.jp/research/star/dreams/weatherinfo/news150401.html

Accuracy of ALWIN Wind

Comparison of Doppler velocity and estimated wind





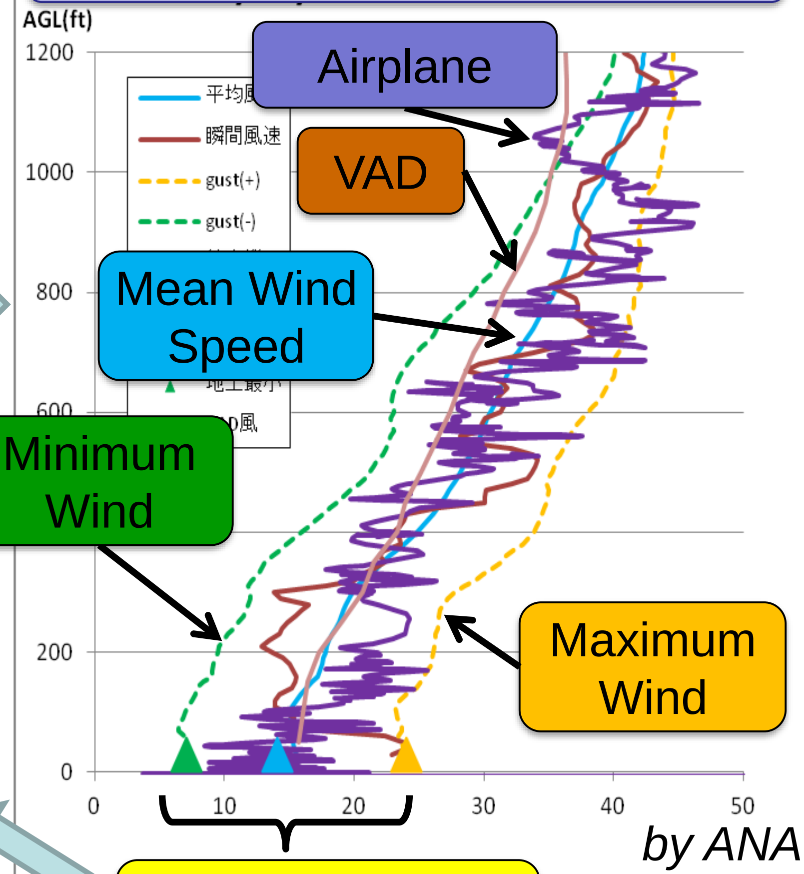
RMSE: 1 kt

Comparison with anemometer

	RMSE
Mean Direction (deg.)	6.48deg
Mean Wind Speed	2.05kt
Max Wind Speed	2.63kt
Min Wind Speed	1.85kt
GUST (MAX－MEAN)	1.61kt

RMSE: 2-3 kt

Comparison with FDR (NRT 16R)



MIN, MEAN, MAX (Anemometer)

Utilization of aircraft-based observations (EN-4-3)

Utilization of aircraft-based observations in CARATS

EN-4-3 involves the utilization of in-situ aircraft-based observation data to improve situation awareness and accuracy of numerical weather prediction.

1. Wind direction and speed data calculated from DAPs (Downlink Aircraft Parameters) for SSR (Secondary Surveillance Radar) or WAM (Wide Area Multilateration)
2. Turbulence data using airborne EDR (Eddy Dissipation Rate) observation
3. Relative humidity data observed by water vapor sensors installed on aircraft

In FY2017, CARATS MET WG made a decision to revise the roadmap as below.

Before revision

Measure ID	Measure name	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 and beyond
EN-4-3	Enhanced weather observation capability / Use of aircraft-based observations		Utilization of aircraft-based observations								

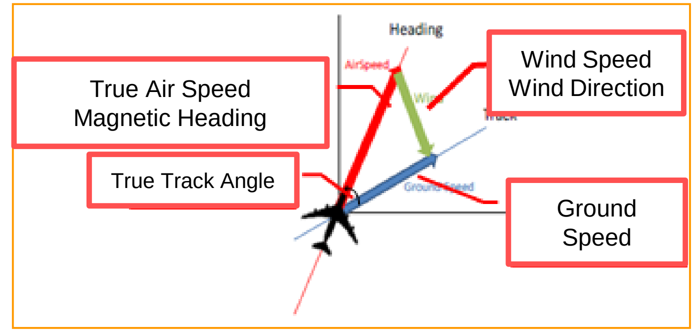
After revision

Measure ID	Measure name	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026 and beyond
EN-4-3	Enhanced weather observation capability / Use of aircraft-based observations		Utilization of in-situ aircraft-based observations by DAPs Utilization of in-situ moisture obsevations by sensors newly attached on aircraft			Utilization of in-situ EDR					

Detailed examples of the recent activities on MET in CARATS (2)

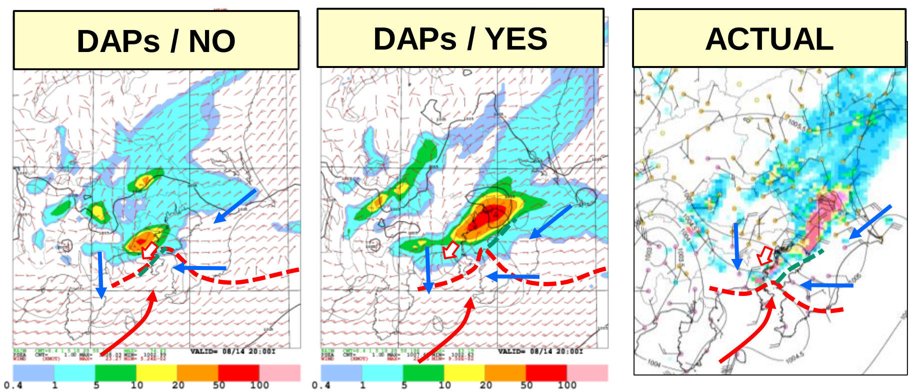
Utilization of wind direction and speed data calculated from DAPs

- In Japan, airframes that can directly downlink wind data as DAPs are very few (less than 1% of the registered airframes).
- Wind direction and speed can be calculated using dynamic information of DAPs, such as air speed, ground speed, magnetic heading, and true track angle.



- ENRI (Electronic Navigation Research Institute) validated the quality of wind data calculated from DAPs downlinked to ENRI's experimental radar stations and confirmed that the data meet WMO's desired accuracy (WMO No.958: Aircraft Meteorological Data Relay (AMDAR) Reference Manual).

- Positive impact on JMA's numerical weather prediction model was found.



With wind data from DAPs, locations of convective clouds and shear lines of surface wind are predicted closer to actual observation.

Expectations for the improvement of accuracy

Utilization of DAPs data was endorsed by the CARATS Steering Committee in March 2018.
Implementation is postponed for 1 year in accordance with JCAB's preparation plan of SSR or WAM.

Detailed examples of the recent activities on MET in CARATS (2)

Utilization of in-situ EDR

- In FY2018, the MET WG conduct a study on utilization of EDR (defined as the cube root of the eddy dissipation rate) downlinked from aircraft as a metric of turbulence intensity.
- Following points are considered as possible advantages.
  - Objectivity of observation data
  - Expectations for improvement of prediction accuracy
  - Possibility for reducing workloads of pilots and ATCs
- <u>Decision will be made by FY2020</u>, because EDR is already ICAO standard in Annex 3.

Utilization of in-situ relative humidity observations

- Currently, water vapor sensor has been implemented in some airlines in the United States.
- <u>Further study on water vapor sensor implementation is required for future implementation</u>, including;
  - Possible benefit (e.g. improvement of numerical weather prediction)
  - Technical/financial issues for installation

Summary

- In the CARATS project of Japan, renovation of Air Traffic System has been discussed among various stakeholders, such as government organizations, research institutes, manufacturers and airlines.

- The measures relating aeronautical meteorology will be effective to address increase of air traffic, to improve safety and efficiency on aircraft operations, and to realize Trajectory-based Operation (TBO) which is one of the main directions of renovation in CARATS.

Thank you !

謝謝 !