# *Update of the ENRI Long Term R & D Vision*

## Kazuo YAMAMOTO

**Director of Research Planning & Management**

**Electronic Navigation Research Institute (ENRI, Japan)**

# *Contents*

1. *What is ENRI?*
2. *Present Long Term Research Vision*
3. *Update of the Present Vision*
4. *Research Roadmap Update*
5. *Conclusions*

# *1. What is ENRI?*

- ✓ **E**lectronic **N**avigation **R**esearch **I**nstitute  (National Laboratory)
- ✓ Established in1967
- ✓ Supported by Ministry of Land, Infrastructure, Transport & Tourism
- ✓ Budget: ¥2.2 billion (2010, including personnel costs）
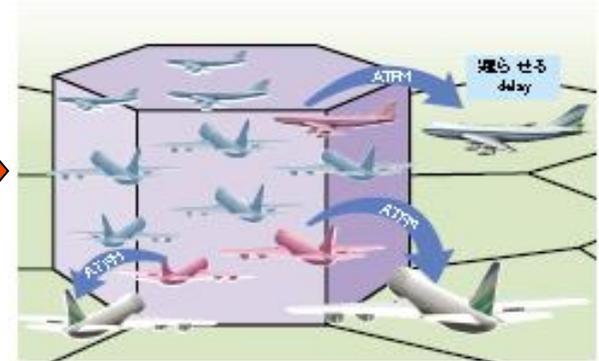- ✓ Personnel: 64 (45 researchers)

*C. Hirasawa*
*President*

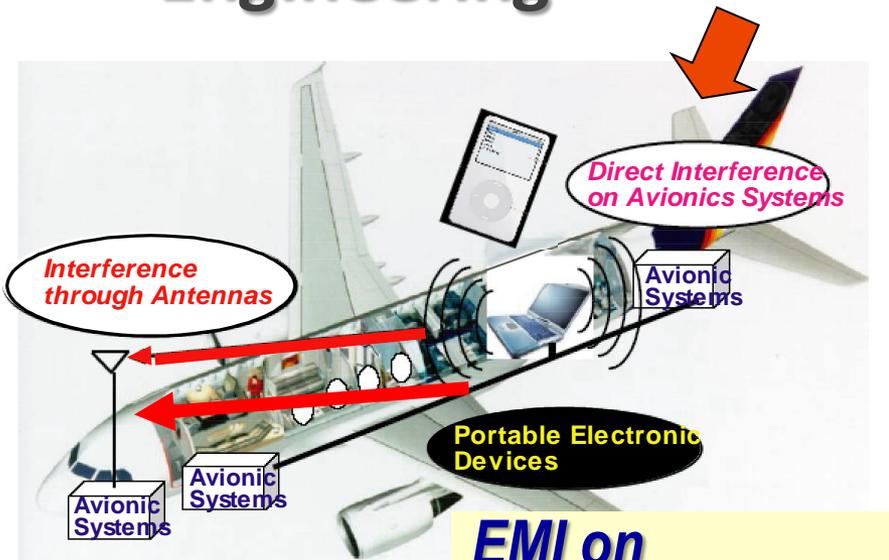**2-24-6 Jindaiji Higashi-machi, Chofu, Tokyo 1820012**

http://www.enri.go.jp/index.shtml
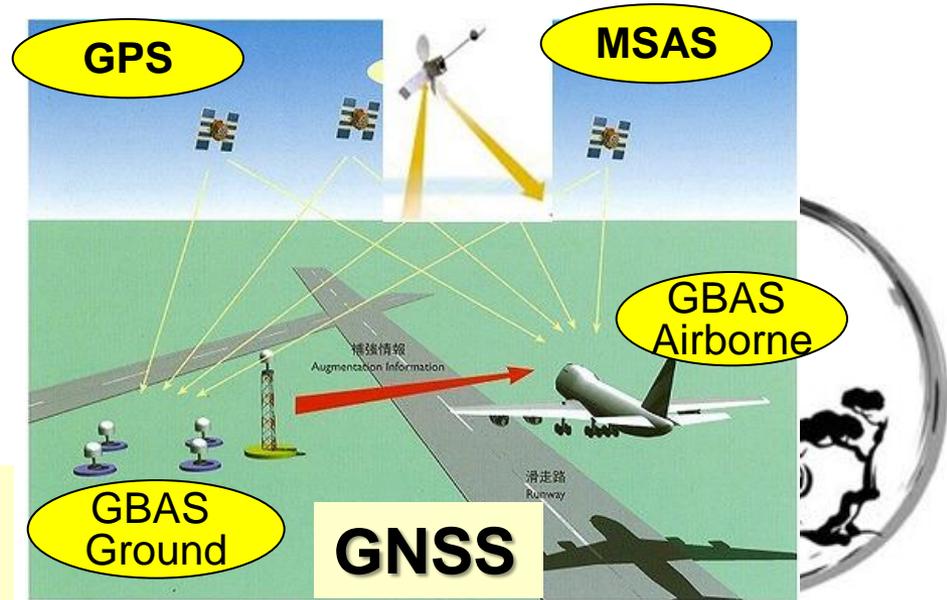
**ENRI**

# ◆ *Major research areas*

- **ATM(Air Traffic Management) Systems**
- **Communication, Navigation and Surveillance**
- **Airborne/Common ground Engineering**

**Separation & Flow Control**

**Direct Interference on Avionics Systems**

**Interference through Antennas**

**Avionic Systems**

**Avionic Systems**

**Portable Electronic Devices**

**Avionic Systems**

*EMI on Aircraft Systems*

**GPS**

**MSAS**

**GBAS Airborne**

**GBAS Ground**

**GNSS**

# ◆*Facilities*
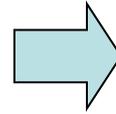
●Radio Anechoic Chamber

● Experimental Aircraft

● Experimental Mode-S Radar

# 2. Present Long Term Research Vision

## - Back ground -

- Traffic Increase in airport/airspace

- Demand to reduce operation cost

- Reduction of environ-mental impact

- Increase safety

To respond such demands....

ICAO "Global ATM Operational Concept" (2005）

Air

Ground

New technology

# ◆ *To realize ICAO's ATM Concept*
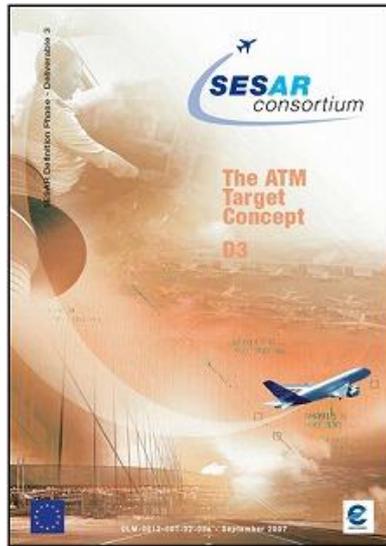
## *- Major World Projects -*

● *NextGen (USA)*

(Next Generation air transportation System)

● *SESAR (EU)*

(Single European Sky ATM Research Programme)

● *CARATS (Japan)*

(Collaborative Actions for Renovation of Air Traffic Systems)

**NextGen**
Next Generation Air Transportation System

Federal Aviation Administration

**SESAR** consortium

The ATM Target Concept D3

**CARATS**
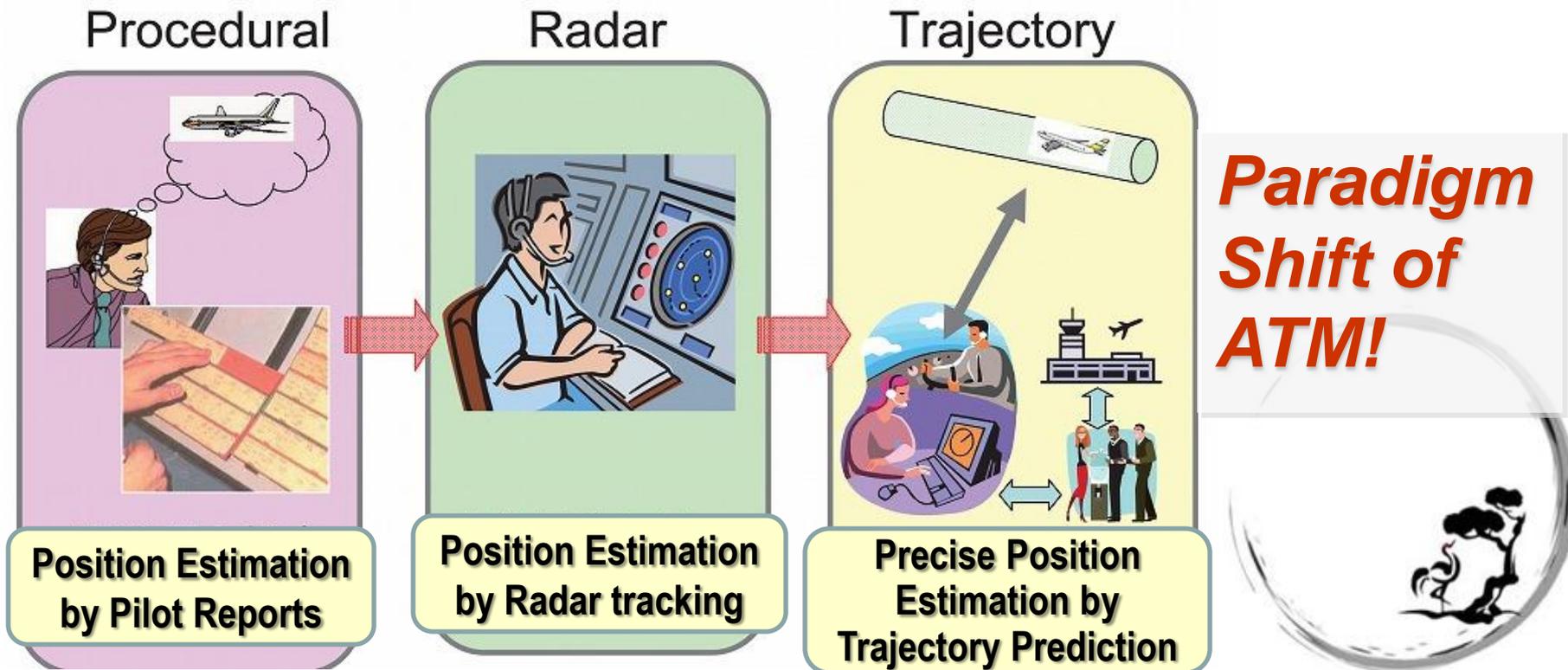Collaborative Actions for Renovation of Air Traffic Systems

*Development and test roadmap up to 2025*

# ◆ *Key words of these projects*

- ✓ *Trajectory Based Operation*
- ✓ *CDM, Interoperability*
- ✓ *Satellite Based Navigation*
- ✓ *Wide Area Data Link*

| Procedural | Radar | Trajectory |
|---|---|---|
| **Position Estimation by Pilot Reports** | **Position Estimation by Radar tracking** | **Precise Position Estimation by Trajectory Prediction** |

*Paradigm Shift of ATM!*

# ◆ *ENRI's Long-term Research Vision*
## *- Features of the present R&D vision -*

**Published in 2008, 5 major domains …**

(2) Highly Accurate, Reliable & Flexible Navigation Technology

(5) Functional Airspace Configuration & Trajectory Management

(4) Advanced Operations of Airport/Airport Surface

(1) ATM Performance Analysis for Bottleneck identification & Efficiency Improvement

(3) Information & Communication Infrastructure for Collaborative Decision Making in ATM

# ◆ *ENRI R&D Roadmap*

**5 Major Research Areas**

2009 ➝ 2020

**16 topics**

| 5 Major Research Areas | Short Term | | | | Middle Term | | | | Long Term | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| ATM Performance Analysis for Bottleneck Identification and Efficiency Improvement | ATM Performance Evaluation & Analysis | | | | | | | | Performance Analysis of Trajectory Management (TM) | | | |
| | Air Traffic Controller Workload Analysis | | | | Techniques for Reducing Human Errors | | | | Safety Assurance taking into account HF | | | |
| Functional Airspace Configuration & Trajectory Management | Evaluation Method for Terminal Airspace | | | | Functional Terminal Airspace Design | | | | Strategic & Integrated Airspace Design & Operations | | | |
| | Oceanic Airspace Operational Procedures | | | | Promoting Dynamical Routes Operation | | | | | | | |
| | RNAV Route Safety Assessment | | | | Development of Safety Analysis Tools | | | | Assessment & Improvement of Safety for Total Flight Phase | | | |
| | Development of Trajectory Model | | | | Use of Trajectory Prediction Model | | | | Operational Efficiency Improvement by TM in High Density Airspace | | | |
| Information and communications infrastructure for collaborative decision making | Traffic Information (Info.) Exchange by Airborne Surveillance | | | | Spacing Applications of Airborne Surveillance | | | | Supplement of Trajectory Management (TM) by Airborne Surveillance | | | |
| | Dev. of Surveillance Data Link for ATCo | | | | Flight Info. Exchange for TM | | | | | | | |
| | Aeronautical Tele-communications Network | | | | Information (Info.) Management among Systems: SWIM | | | | | | | |
| | Evaluation of Air-ground High-speed Data Link Medium | | | | Development (Dev.) of Aeronautical High-speed Communications Techniques | | | | | | | |
| | | | Methods of Surveillance Information Processing (Sensor fusion, Integration of associated Info. and TM) | | | | | | | | | |
| | Radio Environments & Interferences Issues (subjects common to each domain) | | | | | | | | | | | |
| Advanced operations of Airport/ Airport surface | Impl. of Multilateration for ATC Applications | | | | Advanced Airport Operation by TM | | | | | | | |
| | Impl. of ASMGC | | | | Dev. of Airport Surface Navigation | | | | Use of CAT-IIIc GBAS | | | |
| Highly accurate, reliable, and flexible navigation technology | Actual Use of CAT-I GBAS | | | | Use of CAT-II/III GBAS | | | | | | | |
| | Requirement Review for GNSS Curved Approach | | | | GBAS Dynamic Approach Paths Provision for TM | | | | | | | |
| | Performance Improvement of MSAS & Its Use for Precision Approach | | | | Advanced ABAS | | | | Use of CAT-I ABAS | | | |

# ◆ *Effects of the Long-term Vision*

## (1) Acknowledgement and Share of the vision

✓ **Publicity activities at JCAB, many academic meetings**

✓ **ENRI International W/S on ATM/CNS (EIWAC 1$^{st}$ )**

- **March 5-6, 2009**
- **26 presentations, 300 Participants**

## (2) Contribution to developing future plans in aeronautical societies

✓ **Provide information to help construct JCAB "CARATS"**

✓ **ENRI researchers join activities to develop future visions by JAXA and NEDO**

# 3. Update of the Present Vision

## 3.1 Why necessary?

**Present vision is based on information by 2008 …**

a. Change of Social & Administrative Demand
b. New Knowledge, Newly Developed/Introduced Technologies
c. Problems Specific in Japan

## a. Change of Demand

- Rapid increase in East Asian air traffic
- **Haneda** & Narita Airport expansion
- Establishment of JCAB "CARATS"

# ◆ *Rapid increase in East Asian traffic*

- *Increase in domestic, international and over flight in Japan -*
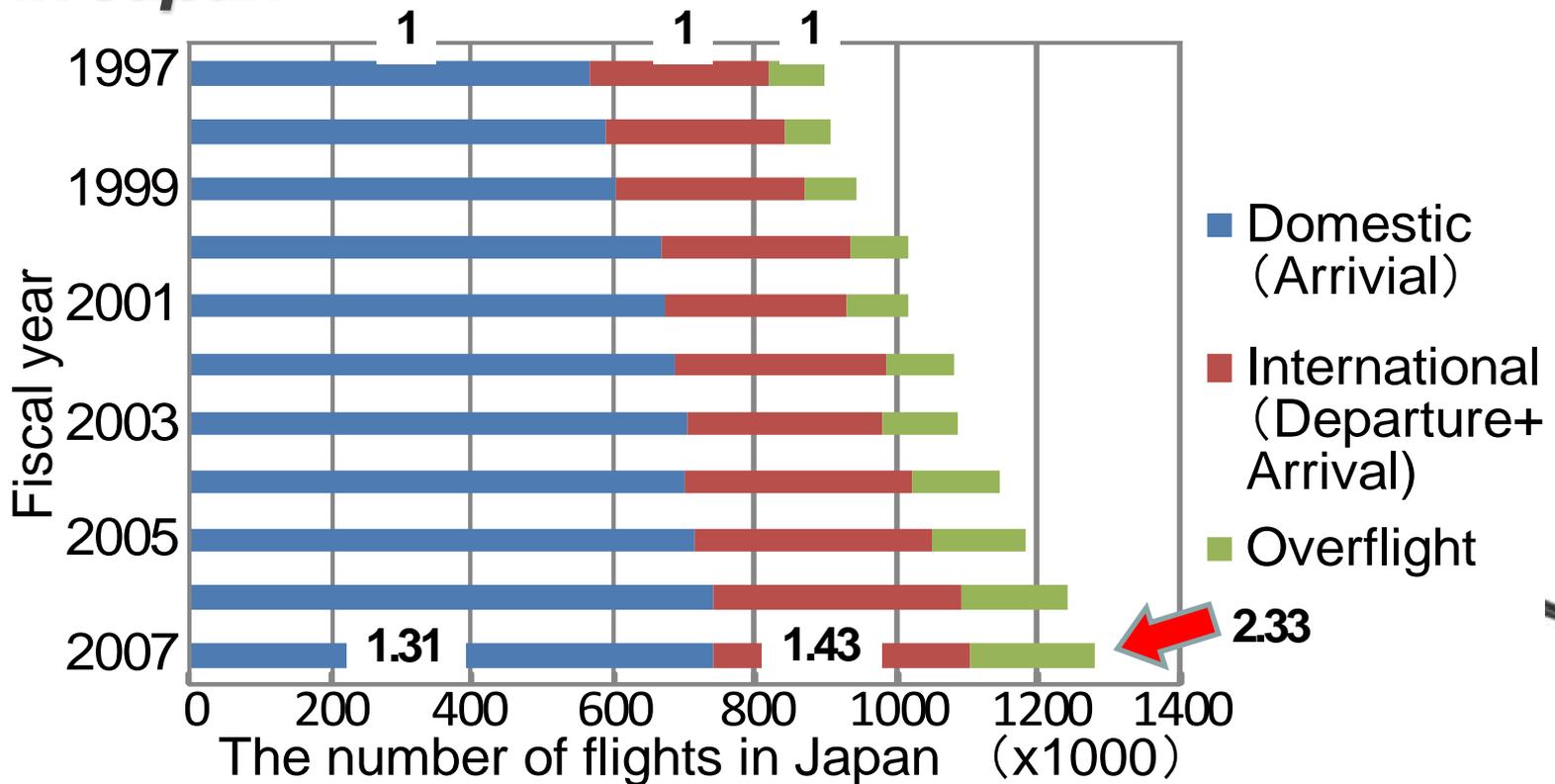
✓ *Highest is over flight*
✓ *Domestic flight is also increasing*

# ◆ *Haneda Airport Expansion*



Int. National Area

B Rwy 2,500m

*New Tower*

A Rwy 3,000m

C Rwy 3,000m

D Rwy  2,500m

# b. *New Knowledge, Technologies*
## *- Obtained by ENRI Research Activities -*

◆ *Taxiing data from MLAT at Haneda Airport*
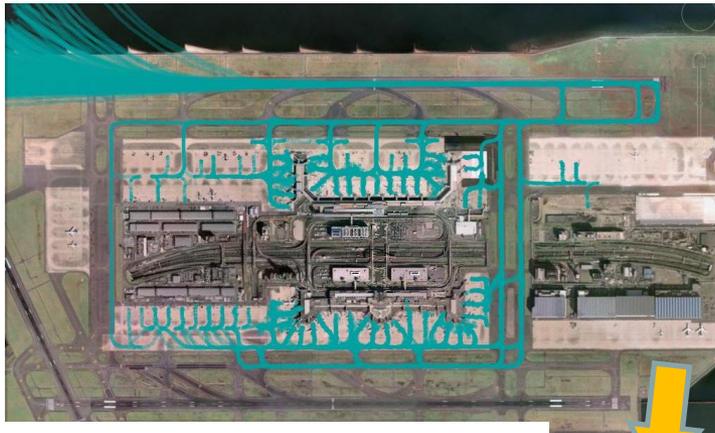


**Trajectory for take-off**
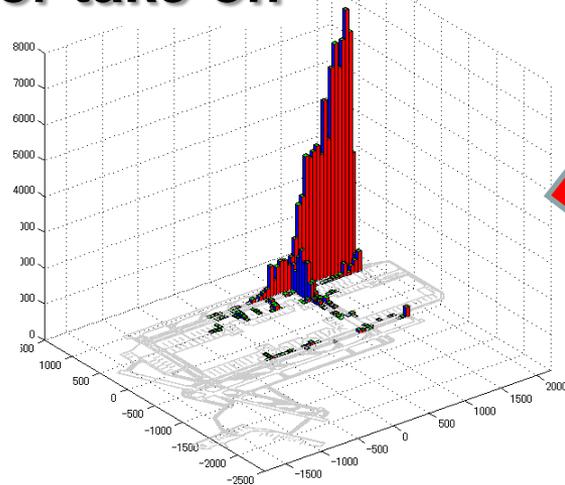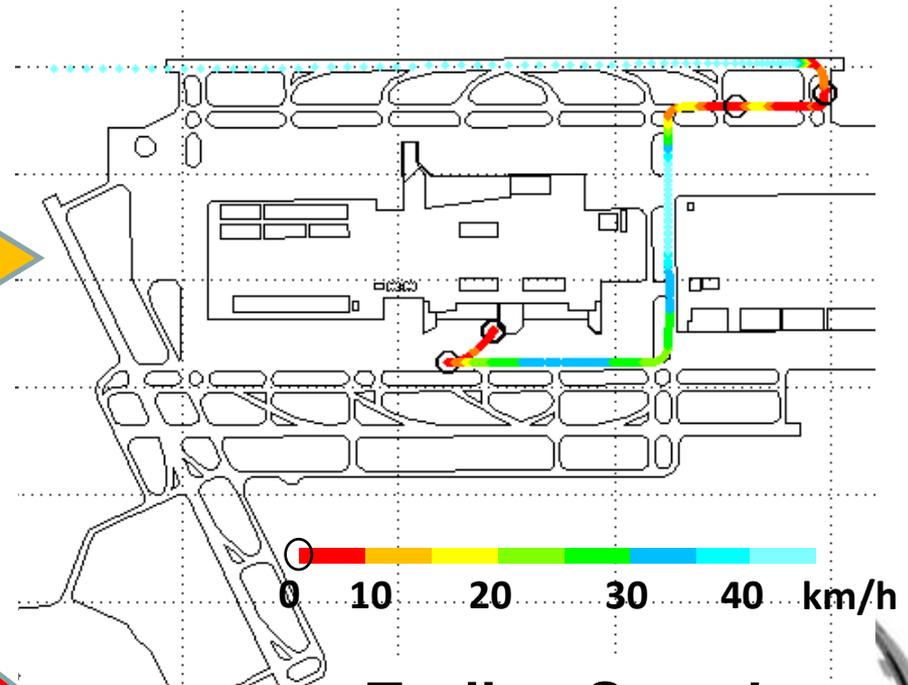
**Congested taxiways for take-off**

**Taxiing Speed**

0   10   20   30   40   **km/h**

**Evolution of Surface Management!**

# ◆*Development of ENRI SSR Mode-S with Downlink Aircraft Parameters (DAPs)*

**Two experimental Mode-S radars in operation**



NWA28
ABCA08
145

**Aircraft without DAPs function**

NWA1
A8C4E8
058 060
G214 I209 H230
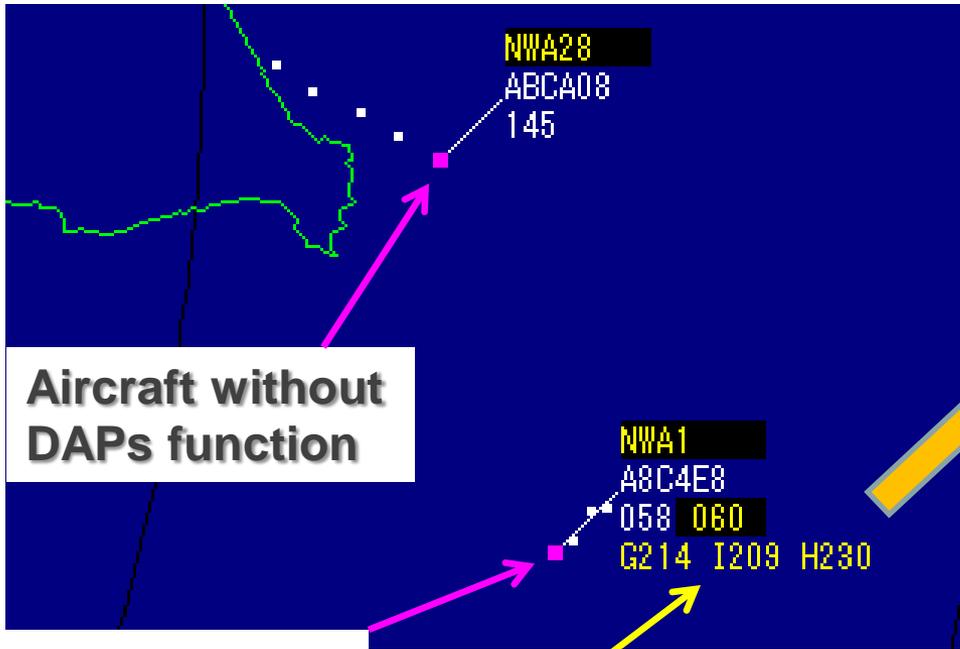
**Aircraft with DAPs function**

**Flight Intention data in FMS**
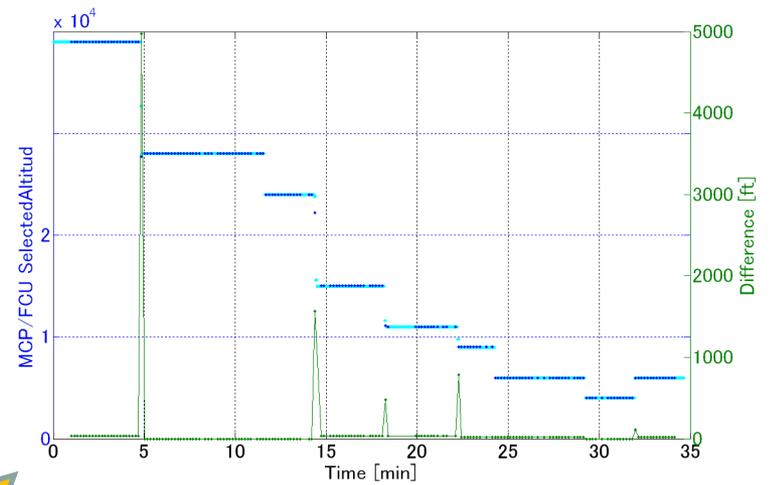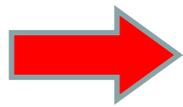
**MCP/FCU Selected Altitude down-linked**
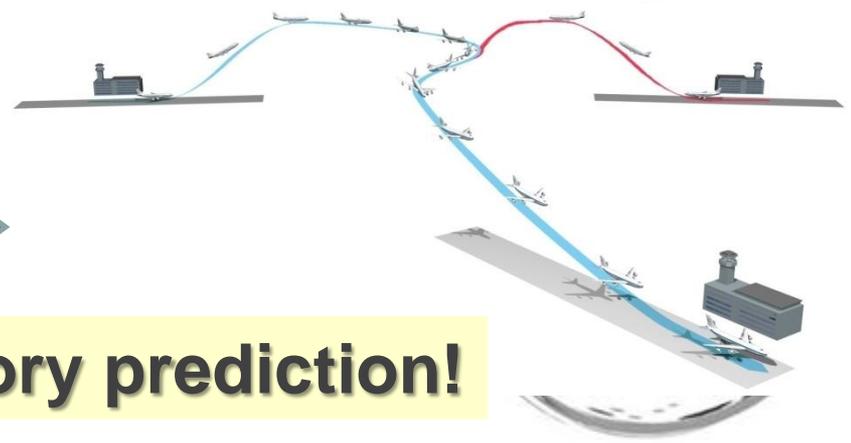
**More precise trajectory prediction!**

# ◆*Electromagnetic environment in L band*
## *- Fast & Sophisticated CNS systems, Higher traffic density -*

**Present Radios**

960MHz — 1215
DME/TACAN

1030 — 1090 — IFF, SSR, TCAS, MLAT, WMLAT, ADS-B

969 — 1008 — 1053 — 1065 — 1113 — 1206
JTIDS

960 — 1024 — 1176 — 1206
AMRS — GNSS
L5/E5A — E5B
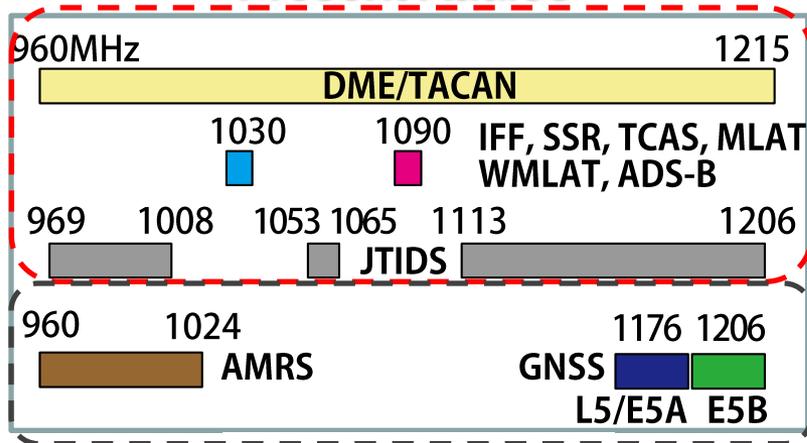
**Future systems**
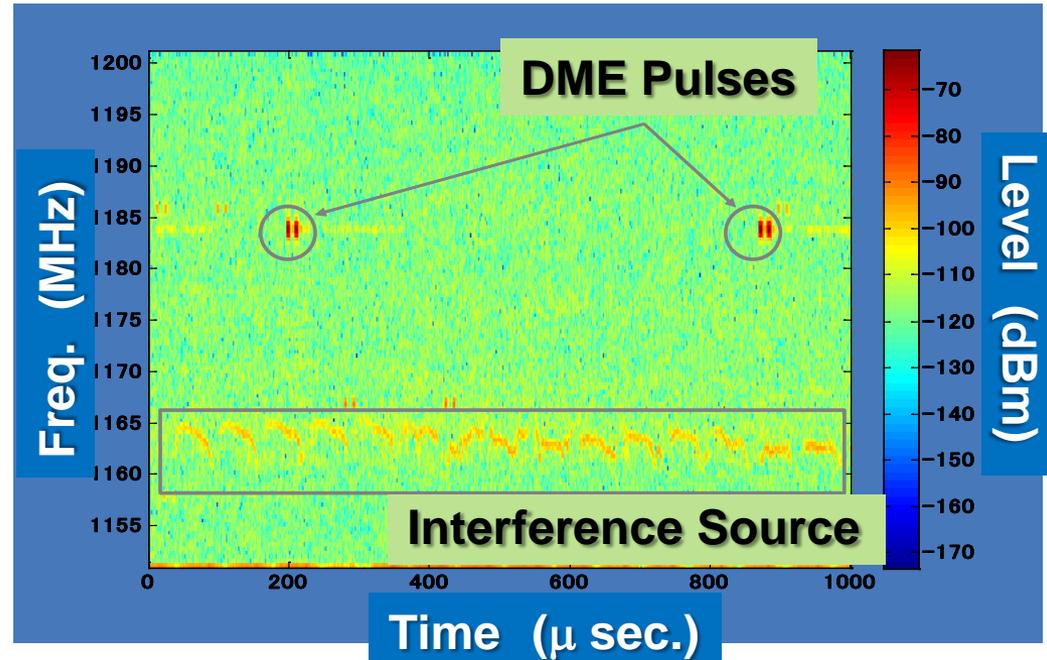
*Can cause EMI on CNS systems …*

**Development of interference tolerant CNS systems!**

DME Pulses

Level (dBm)

Freq. (MHz)

Interference Source

Time (μ sec.)

*Original Fast & Precision Radio Receiver*

GNSS

SSR Mode-S          TACAN

# ◆*Influence of Ionosphere on GNSS*

*- Effect of ionosphere more serious at lower latitude -*
*- MSAS algorithm improvement for coverage extension -*
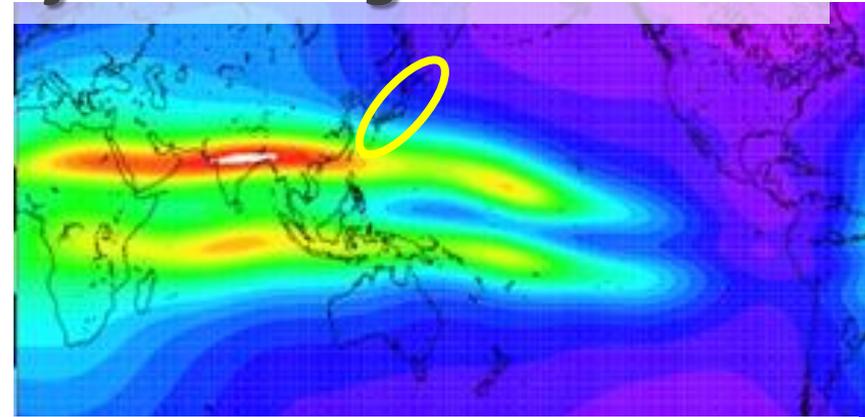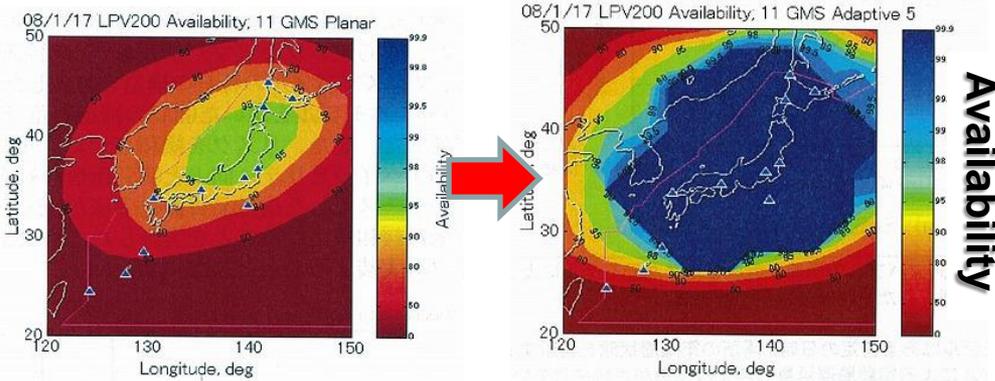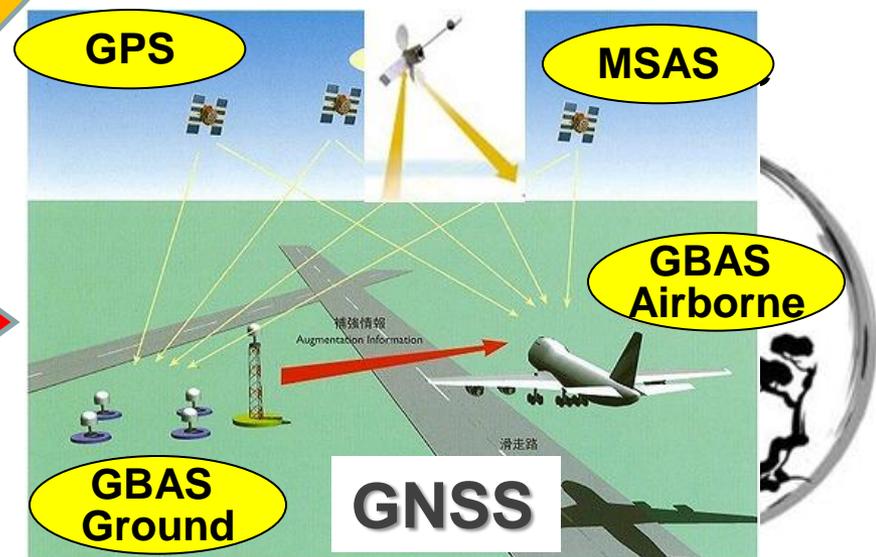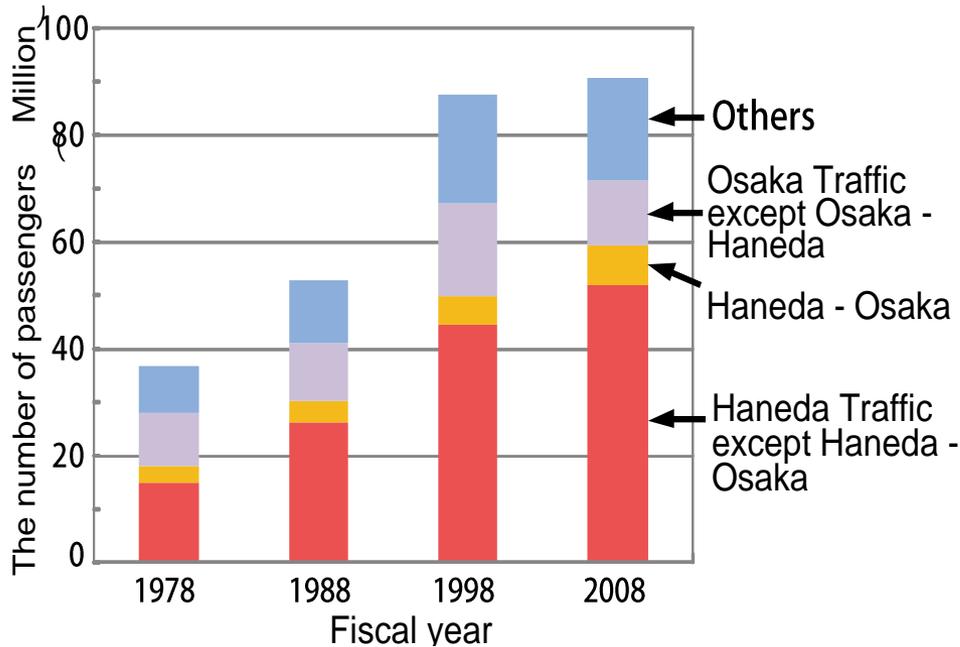


**New Algorithm to improve MSAS Availability**

**Ionosphere observation Framework**

**Realize Dependable and broader GNSS system!**

GPS

MSAS

GBAS Airborne

GBAS Ground

GNSS

18

# ◆ *Visualization of ATCO Workload*

## *- Analysis by real time ATC simulation data -*

3 : 32 : 00

3:30:00

ATCOs' tasks
are analyzed
and classified
into 3 task
levels

L652

JAL836

ANA573

JA8351

**Simulator display**

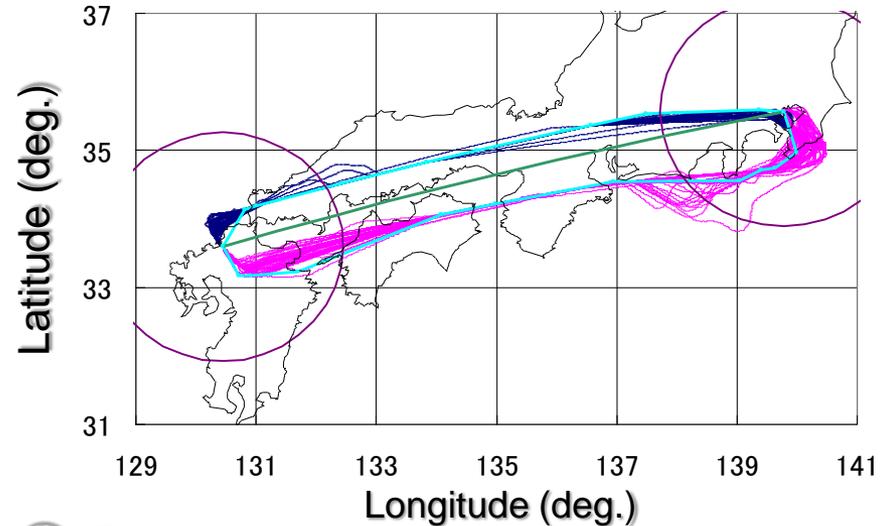**Advancement of Task analysis!**

# c. Problems Specific in Japanese sky

## ◆Concentration on Metropolitan Airports

**Share of Haneda traffic expanding year by year …**
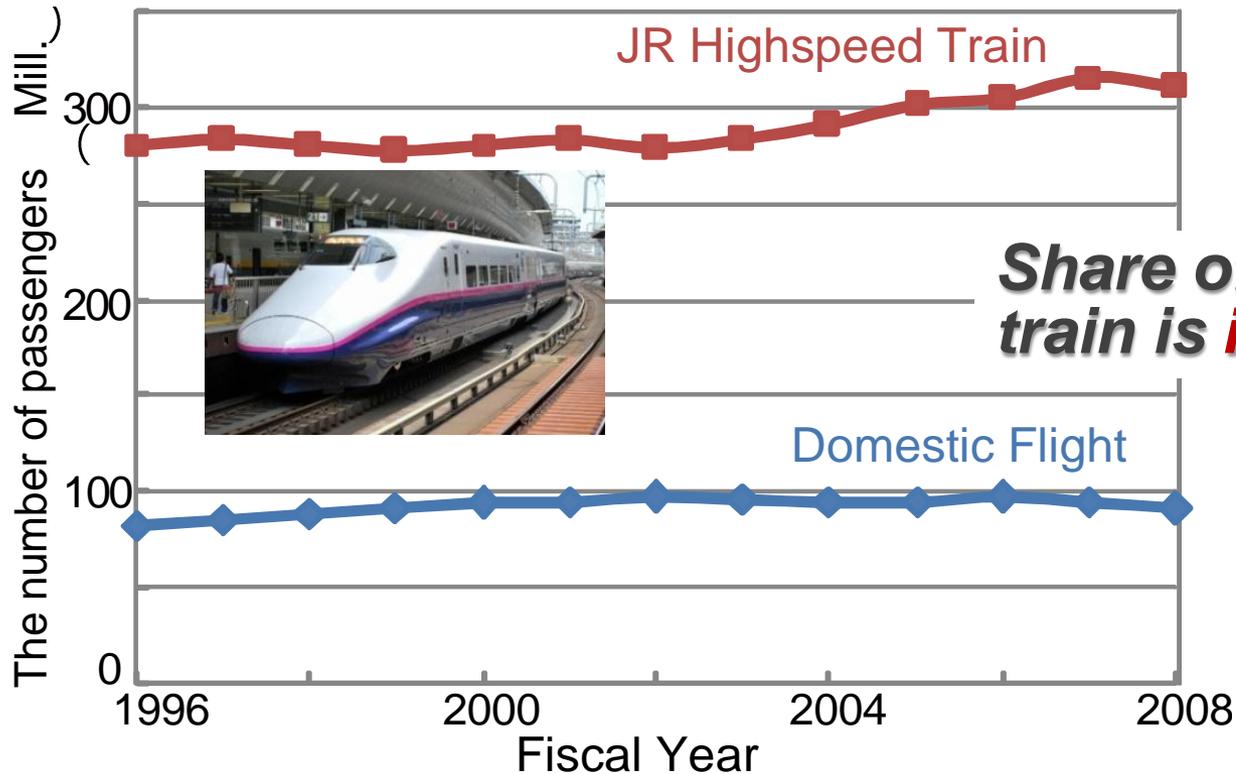
**Domestic flights concentrating on Haneda Airport!**
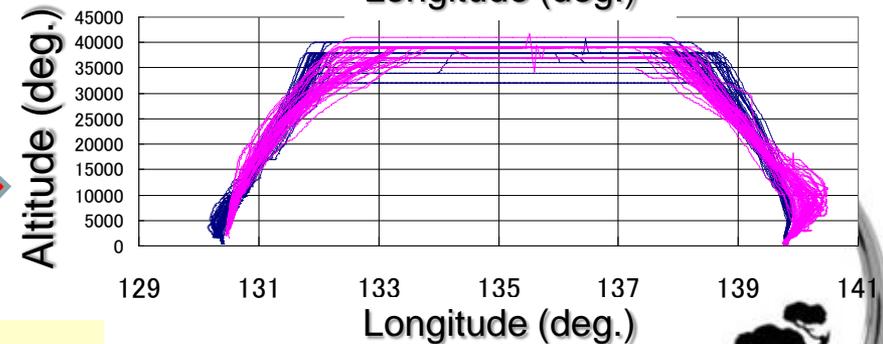
**Haneda - Fukuoka Flight trajectories**

# ◆*Competition with high speed train*

## - *The number of passengers by domestic flight and JR high speed train -*



**Measures necessary to keep the share of domestic flight!**

*Share of high speed train is increasing …*

# 3.2 Recent Short, Mid and Long Term Researches

◆ **Long term target:** *realization of smooth, efficient and on time operation* **= Present target**

◆ **Emphasized short and mid term targets:**

- **Congestion relief and capacity increase in terminal area and airport**
- **Harmonization** of domestic, international and over flights
- On time operation **under increased traffic**
- Expansion of **GNSS operation**
- Performance **evaluation of present technologies** for future operation

# ◆ *ENRI Short, Mid and Long term research objectives*

- **Short term:**
  - Precise analysis and estimation of **present en-route, terminal and surface traffic** characteristics
  - Evaluations of practical navigation systems

- **Mid term:**
  - Propose methods to **respond short term demands**
  - Test the validity of the presented methods

- **Long term:** Development and evaluation of **software/hardware technologies** to realize future ATM system

# 4. Research Roadmap Update

## - In the process of updating ... -

◆ **Review of present ENRI roadmap and *CARATS* to keep compatibility**

◆ **Followings are taken into account to make the roadmap refined and easy**

  ✓ **Reduction** of research subjects
  ✓ **Reduction** of research domains
  ✓ **Mutual relationships** among different subjects
  ✓ **Continuity** of present on going researches

# ◆ *Measures in JCAB "CARATS"*

**Example of specific measures by implementation phase**



- ✓ *Direction of renovation*
- ✓ ***Eight*** *major regions*
- ✓ *Short, Mid and Long term plans*
- ✓ *Base of detailed implementation plan*

# ◆ *Updated Roadmap of ENRI*



**ENRI**

**Expected Results**

**12 research subjects**

**3 major domains**

2010 — 2014 — 2018 — 2022

**Advanced operation in Air**

- Efficient Flight Route Setting → Dynamic and Efficient Route Setting → Trajectory based Operation in all Flight Phases
- Trajectory Prediction → Trajectory based Operation
- Estimation of ATM performance and Safety → Estimation for New Operation Procedures
- Mode-S Communication → Flight Data Exchange by Mode-S → Separation Assurance Onboard

*Expected Results:* Capacity Increase in Terminal and En-Route; Improved Punctuality; Improved Safety; Less Congestion; Emission Reduction

**Connecting Ground & Air and Improving Safety**

- Advanced Surveillance Technology → Performance Based Surveillance System
- Aeronautical Data-Link → Next Generation Fast Data-Link for Air Navigation
- Electromagnetic Propagation and Interference → Frequency Resources and New Radio Systems
- Analysis of ATCO's Workload → Human Error Reduction → Operation taking Human Factors into Account

*Expected Results:* Capacity Increase in all Phases; Improved Convenience; Improved Safety

**Advanced operation on & close to Airport**

- Enhanced MSAS and ABAS → Advanced ABAS → CAT-I ABAS
- CAT-I GBAS → CAT-II and III Operations by GNSS
- GNSS based Curved Approach → Dynamic Approach Route Setting by GNSS
- Analysis of Ground Traffic → Trajectory Prediction on Surface → Trajectory based Operation on Surface

*Expected Results:* Capacity Increase in Approach and Departure; Capacity Increase on Surface; Improved Convenience; Noise Reduction; Less Congestion; Emission Reduction

**Legend:** Efficient Operation | Trajectory based Operation | Communication & Surveillance | Satellite based Navigation

**Research purposes, contents in different colors**

# ◆ *Features of the Updated Roadmap*



| 2010 | | 2014 | |
|---|---|---|---|
| Efficient Flight Route Setting | ① ② | ① ② | Dyna |
| Trajectory Prediction | ② ③ | ② ③ | Trajectory ba |
| Estimation of ATM performance and Safety | | | |
| Mode-S Communication | ③ | ③ | Flight Data E |
| Advanced Surveillance Technology | | ① ③ | |
| Aeronautical Data-Link | ④ | ④ | Next Gene |
| Electromagnetic Propagation and Interference | | ④ ⑤ | |
| Analysis of ATCO's Workload | | | Human Erro |
| Enhanced MSAS and ABAS | ⑤ | | Advanc |
| CAT-I GBAS | ① ⑤ | ④ ⑤ | CAT-II and III Operation |
| GNSS based Curved Approach | ① | ① ⑤ | Dyn |
| Analysis of Ground Traffic | ③ | ③ | Trajectory Prediction on Su |

① **Concentrated traffic at metropolitan Airport**

② **Over-flight**

③ **Punctuality**

④ **Electro-magnetic environment**

⑤ **Ionosphere**

a. **Refinement** of Present Roadmap
b. **Short term:** R&D for Present Issues + Advanced Analysis
c. **Mid term:** Research for Future Challenges
d. **Long term:** D & T for Future ATM Systems

# *5. Conclusions*

- **ENRI Present Long Term Research Vision**
  - **+ Published in 2008**
  - **+ Theme: Smooth, Efficient & Fixed time Operation**

- **Update of the Research Vision**
  - **+ Change of Social & Administrative Demand**
  - **+ New Knowledge, Technologies**
  - **+ Demand Specific in Japan**

- **Research Roadmap Update**
  - **+ Refined ...**
  - **+ Clear in Short, Intermediate & Long Term objectives**

- ***Updated Version* of the Research Vision will be Published in 2010**

**ENRI**

# *Thank you for your attention!*

## *- People in ENRI -*