Update of the ENRI Long Term R & D Vision

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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?

- Electronic Navigation Research Institute (National Laboratory)
- Established in 1967
- Supported by Ministry of Land, Infrastructure, Transport & Tourism
- Budget: ¥2.2 billion (2010, including personnel costs)
- Personnel: 64 (45 researchers)

C. Hirasawa
President

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◆ Major research areas

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

EMI on Aircraft Systems

Interference through Antennas
Direct Interference on Avionics Systems
Portable Electronic Devices

Separation & Flow Control

GPS
MSAS
GBAS Airborne
GBAS Ground
GNSS
Facilities

- Radio Anechoic Chamber
- Experimental Aircraft
- Experimental Mode-S Radar
2. Present Long Term Research Vision

- Background -

- Traffic Increase in airport/airspace
- Demand to reduce operation cost
- Reduction of environmental impact
- Increase safety

To respond such demands....

ICAO “Global ATM Operational Concept” (2005)
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)

Development and test roadmap up to 2025
Key words of these projects

- Trajectory Based Operation
- CDM, Interoperability
- Satellite Based Navigation
- Wide Area Data Link
ENRI’s Long-term Research Vision
- Features of the present R&D vision -

Published in 2008, 5 major domains ...

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

(2) Highly Accurate, Reliable & Flexible Navigation Technology

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

(4) Advanced Operations of Airport/Airport Surface

(5) Functional Airspace Configuration & Trajectory Management
## ENRI R&D Roadmap

### 5 Major Research Areas

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<tbody>
<tr>
<td>ATM Performance Analysis for Bottleneck Identification and Efficiency Improvement</td>
<td>ATM Performance Evaluation &amp; Analysis</td>
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<td>Performance Analysis of Trajectory Management (TM)</td>
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<td>Functioning Airspace Configuration &amp; Trajectory Management</td>
<td>Air Traffic Controller Workload Analysis</td>
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<td>Techniques for Reducing Human Errors</td>
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<td></td>
<td>Evaluation Method for Terminal Airspace</td>
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<td>Strategic &amp; Integrated Airspace Design &amp; Operations</td>
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<td>Oceanic Airspace Operational Procedures</td>
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<td>Assessment &amp; Improvement of Safety for Total Flight Phase</td>
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<td>RNAV Route Safety Assessment</td>
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<td>Operational Efficiency Improvement by TM in High Density Airspace</td>
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<td></td>
<td>Development of Trajectory Model</td>
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<td></td>
<td>Supplement of Trajectory Management (TM) by Airborne Surveillance</td>
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<td>Information and communications infrastructure for collaborative decision making</td>
<td>Traffic Information (Info.) Exchange by Airborne Surveillance</td>
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<td>Use of Trajectory Prediction Model</td>
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<td></td>
<td>Dev. of Surveillance Data Link for ATCo Aeronautical Tele-communications Network</td>
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<td>Information (Info.) Management among Systems: SWIM</td>
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<td>Evaluation of Air-ground High-speed Data Link Medium</td>
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<td>Development (Dev.) of Aeronautical High-speed Communications Techniques</td>
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<td>Advanced operations of Airport/ Airport surface</td>
<td>Impl. of Multilateration for ATC Applications</td>
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<td>METHODS OF SURVEILLANCE INFORMATION PROCESSING (SENSOR FUSION, INTEGRATION OF ASSOCIATED INFO. AND TM)</td>
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<td>Impl. of ASMGC</td>
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<td>Radio Environments &amp; Interferences issues (subjects common to each domain)</td>
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<td>Actual Use of CAT-I GBAS</td>
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<td>Advanced Airport Operation by TM</td>
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<td>Requirement Review for GNSS Curved Approach</td>
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<td>Dev. of Airport Surface Navigation</td>
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<td>Performance Improvement of MSAS &amp; Its Use for Precision Approach</td>
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<td>Use of CAT-Ill GBAS</td>
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<td>Highly accurate, reliable, and flexible navigation technology</td>
<td>Advanced ABAS</td>
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<td>GBAS Dynamic Approach Paths Provision for TM</td>
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<td>Use of CAT-I ABAS</td>
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<td>Use of CAT-Illc GBAS</td>
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</table>

16 topics
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 1st)

• 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**
- **A Rwy 3,000m**
- **B Rwy 2,500m**
- **C Rwy 3,000m**
- **D Rwy 2,500m**
- **New Tower**
b. New Knowledge, Technologies - Obtained by ENRI Research Activities -

- Taxiing data from MLAT at Haneda Airport

Trajectory for take-off

Evolution of Surface Management!

Congested taxiways for take-off
Two experimental Mode-S radars in operation

Aircraft without DAPs function

MCP/FCU Selected Altitude down-linked

Aircraft with DAPs function

Flight Intention data in FMS

More precise trajectory prediction!
Electromagnetic environment in L band

- Fast & Sophisticated CNS systems, Higher traffic density -

Present Radios

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<th>Frequency (MHz)</th>
<th>Level (dBm)</th>
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<tr>
<td>960</td>
<td>-170</td>
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<tr>
<td>961</td>
<td>-160</td>
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<td>962</td>
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<td>969</td>
<td>-80</td>
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<tr>
<td>970</td>
<td>-70</td>
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</tbody>
</table>

Future systems

Can cause EMI on CNS systems ...

Development of interference tolerant CNS systems!
◆ 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

Realize Dependable and broader GNSS system!
Visualization of ATCO Workload
- Analysis by real time ATC simulation data -

ATCOs’ tasks are analyzed and classified into 3 task levels

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!**

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<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Million Passengers</th>
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<tbody>
<tr>
<td>1978</td>
<td>20</td>
</tr>
<tr>
<td>1988</td>
<td>40</td>
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<tr>
<td>1998</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>80</td>
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</tbody>
</table>

- **Others**
- **Osaka Traffic except Osaka - Haneda**
- **Haneda - Osaka**
- **Haneda Traffic except Haneda - Osaka**

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**Flight Trajectories**

- **Haneda - Fukuoka**

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- **Latitude (deg.)**
- **Longitude (deg.)**
- **Altitude (deg.)**
◆ 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!
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

<table>
<thead>
<tr>
<th>Phase</th>
<th>Measures</th>
</tr>
</thead>
</table>
| 1. Realization of trajectory-based operation | (a) Introduction of flight management in flight phase  
(b) Introduction of trajectory-based operation in enroute phase  
(c) General introduction of flight management of the same phase  
(d) Creation of schedule flexibility by gradient adjustment, etc.  |
| 2. Improvement of predictability | (a) Promotion of utilization of weather forecast information  
(b) Enhancement of precision of meteorological forecasting accuracy by automated  
(c) Utilization of meteorological forecast information in system  |
| 3. Promotion of performance-based operation | (a) Nationwide deployment of RNAV (introduction of RNAV/TPM, RNP10)  
(b) Effective use of short-range high-precision LNAV/TPM, etc.  
(c) Realization of flexible and continuous flight path-random route/sequence/alternative route/直接 use of RNAV  |
| 4. Realization of satellite navigation in all flight phases | (a) Promotion of service in satellite-aided air navigation (GNSS)  
(b) Realization of precision approach using satellites  
(c) Flexible route setting by sensor-based approach  |
| 5. Improving situational awareness performance on the ground and in the air | (a) Improving surveillance capacity on the airport (improving blind spot in blind areas, multilateration and noise-free coordination)  
(b) Improving situational awareness performance through timely ground cooperation (multilateration aircraft data transmission)  
(c) Improving situational awareness performance by air-4hr surveillance/air-4hr detection between aircraft  |
| 6. Maximum use of the capability of humans and machines | (a) Upgrading of control support function (air traffic control, support of airport)  
(b) Upgrading of control support function (traffic control, support of airport)  
(c) Management of control support function for 40T  |
| 7. Full information-sharing and coordinated decision-making | (a) Information-sharing among the participants on the same target (CPA)  
(b) Realization of information-sharing among all common users of airspace (consultative decision-making among airspace participants)  
(c) Establishment of service/NAV/NAV where necessary information can be accessed at any time  |
| 8. Realization of high-density navigation in congested airports and airspace | (a) Effective use of airspace by dynamic airspace management (dynamic management of limited sector and maintaining airspace)  
(b) Upgrading of airport operation (airport management, tming support, etc.)  
(c) Reduction in loss of high-capacity RNP  
(d) Significant improvement in high-density airspace  |

#### Key Points

- **Direction of renovation**
- **Eight major regions**
- **Short, Mid and Long term plans**
- **Base of detailed implementation plan**
### Updated Roadmap of ENRI

**12 research subjects**

<table>
<thead>
<tr>
<th>2010</th>
<th>2014</th>
<th>2018</th>
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<tbody>
<tr>
<td>Efficient Flight Route Setting</td>
<td>Dynamic and Efficient Route Setting</td>
<td>Trajectory based Operation in all Flight Phases</td>
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<tr>
<td>Trajectory Prediction</td>
<td>Trajectory based Operation</td>
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<tr>
<td>Estimation of ATM performance and Safety</td>
<td>Estimation for New Operation Procedures</td>
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<tr>
<td>Mode-S Communication</td>
<td>Flight Data Exchange by Mode-S</td>
<td>Separation Assurance Onboard</td>
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<tr>
<td>Advanced Surveillance Technology</td>
<td>Performance Based Surveillance System</td>
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<tr>
<td>Aeronautical Data Link</td>
<td>Next Generation Fast Data Link for Air Navigation</td>
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<tr>
<td>Electromagnetic Propagation and Interference</td>
<td>Frequency Resources and New Radio Systems</td>
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<tr>
<td>Analysis of ATCO’s Workload</td>
<td>Human Error Reduction</td>
<td>Operation taking Human Factors into Account</td>
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<tr>
<td>Enhanced MSAS and ABAS</td>
<td>Advanced ABAS</td>
<td>CAT-I ABAS</td>
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<tr>
<td>CAT-I GBAS</td>
<td>CAT-II and III Operations by GNSS</td>
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<td>GNSS based Curved Approach</td>
<td>Dynamic Approach Route Setting by GNSS</td>
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<td>Analysis of Ground Traffic</td>
<td>Trajectory Prediction on Surface</td>
<td>Trajectory based Operation on Surface</td>
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<tr>
<td>Efficient Operation</td>
<td>Trajectory based Operation</td>
<td>Communication &amp; Surveillance</td>
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<td>Satellite based Navigation</td>
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**Expected Results**

- Capacity Increase in Terminal and En-Route
- Improved Punctuality
- Improved Safety
- Less Congestion
- Emission Reduction

**3 major domains**

- **Advanced operation in Air**
- **Connecting Ground & Air and Improving Safety**
- **Advanced operation on & close to Airport**

**Research purposes, contents in different colors**
## Features of the Updated Roadmap

### 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
Thank you for your attention!

- People in ENRI -