Flight Safety Research in Japan

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   - Turbulence detection laser radar (lidar) development
3. Human Factors
   - CRM and human model research
4. New technology in ATC
   - CNS/ATM applications research
5. Crashworthiness
   - Full scale model test and numerical simulation
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Flight safety in Japan: Organization structure

MLIT: Ministry of Land, Infrastructure and Transport
CAB: Civil Aviation Bureau
ENRI: Electronic Navigation Research Institute
ATEC: Association of Air Transport and Research
MEXT: Ministry of Education, Culture, Sports, Science and Technology
JAXA
METI: Ministry of Economy, Trade and Industries
NEDO: New Energy and Industrial Technology Development Organization
SJAC: Society of Japanese Aerospace Companies
Prime Minister
Airline Operators
Universities
Manufacturing Companies
MLIT: Ministry of Land, Infrastructure and Transport
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DA: Defense Agency
TRDI: Technical Research and Development Institute
Safety record in Japan (scheduled flight)

No fatal accident in Japanese scheduled flight for 20 years
1 fatal accident/ 11 million flights = 0.09 per million flights (1985-2003)
Number of flight increases nearly twice in 20 years
Accidents due to turbulence: 21/42 = 50%

ARAIC: Aircraft and Railway Accidents Investigation Commission
Cabin Safety

Airline operators made efforts to prevent cabin injuries due to turbulence.

- Seatbelt fastened while seated
- Flight attendant procedures
- Handhold installation
- Sharing turbulence information with other aircraft

It is difficult to prevent all the cases, especially those due to Clear Air Turbulence. (CAT)
JAXA researchers challenge CAT warning system.
JAXA’s Challenge:
Development of an airborne turbulence warning system for jet transports which can detect clear air turbulence (CAT) up to 5NM (9.2km) at cruise altitude (30,000–40,000ft).
Key points of onboard CAT warning system

- Eye safety
- Compact and low power
- Reliable

1.5 µm all-fiber pulsed Coherent Doppler Lidar (CDL) system

All the optical components are fiber-based and they are connected by optical fiber.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Wavelength</td>
<td>1.54 µm</td>
</tr>
<tr>
<td>Laser power (Peak)</td>
<td>10W</td>
</tr>
<tr>
<td>Pulse repetition frequency</td>
<td>50kHz</td>
</tr>
<tr>
<td>Pulse width</td>
<td>1 µs</td>
</tr>
<tr>
<td>Range resolution</td>
<td>150m</td>
</tr>
<tr>
<td>Beam diameter (1/e²)</td>
<td>50mm</td>
</tr>
</tbody>
</table>
1NM experimental model

- Steering mirror
- Transceiver optics
- Laser transceiver
- Signal processor
- Scanner controller
- Optical fiber

2002
Flight test evaluation

Measured airspeed and detectability
(Level flight, h=5,000ft)

Correlation between aerosol density and lidar system detectability
(150m range bin)
Flight test evaluation

Wind measurement results
(previous data compensated with pitch angle)
Further development: 3-5NM experimental model

- 3 NM model (100W) is under development, flight evaluation of which will be in 2006.

- JAXA’s researchers study CAT warning system from Lidar data
  - Detection method and warning algorithm
  - Collaboration with computational fluid dynamics researchers and meteorologist

- Turbulence prediction will be in their future scope
Lidar Application to Helicopters

Helicopter is a good application of Lidar

- **Type 1**
  - TAS Sensor
  - Measure 2 or 3 axis airspeeds even in hover
  - 2 or 3 axis airspeeds measurements
  - >100m detection range

- **Type 2**
  - Turbulence Sensor
  - Detect severe local turbulence
  - 2 or 3 axis wind speeds measurements
  - 1~2km detection range
  - Multiple observation points
  - Real-time pilot display

- low velocity
- low altitudes
- detection range is short
- aerosol density is high
Real-time Cockpit Display

- Wind Display
  Wind speed & direction
  LOS components of wind speed

- TAS Indicator
  Horizontal 2-axis airspeed with limitations
A railroad accident, which killed 107 people raised public interest on human factors. The train passed a curve at a speed of over 115km/h, the limitation of which is 70 km/h.

At the same period, a series of incidents occurred in Japanese major airline companies more than previous years. CAB organized a committee to assess the safety status. It recommended to reconsider the followings.

- Risk Management System
- Safety information
- Crew Training
- Procedures and manuals
- Audit by government

Railroad accident, April 25 2005
JAXA researchers propose CRM skill measurement method to make CRM training more effective.
Human factors research: Human model application

- Human model introduces quantitative evaluation for pilot workload.
- JAXA researchers collaborate with Sun Jose State Univ. on this subject.
- They plan to apply their tools to Japanese domestic small passenger transport development.
- Flight data review with a human model as a reference will be a next step.
New technology in ATC

CNS/ATM applications research

- JAXA constructed a new technology experimental model to evaluate the concept by simulator and flight tests
- They plan to apply their technology in the two areas
  - Inter-Island flight operation
  - Disaster relief air operation
- They study reliable GPS navigation system
JAXA constructed an experimental model of CNS/ATM concept for small aircraft operation to evaluate it by simulation and flight test. NOCTARN: New Operational Concept using Three-dimensional Adaptable Route Navigation
NOCTARN: Experimental model setup

- MuPAL-ε
- MuPAL-α
- N-Station Federate
- N-Station Federate
- N-Station Federate
- N-Station Federate
- Wind Federate
- Wind Federate
- Wind sensor

- ATC workstation
- HLA network
- Flight Tests
- NOCTARN: Experimental model setup
Operations Concept
• Ground evaluation test with ENRI’s air traffic control simulator

• Flight test
  – at Taiki airfield (for experiment)
  – Helicopter and Airplane
  – Cases: Non-towered operation/Towered operation
JAXA plans to collaborate with FAA introducing Capstone technology.

DREAMS: Distributed and Revolutionary Efficient Air Safe Management System

Inter-island flight operation is a candidate of the future application.
Disaster relief

- Disaster relief operation is another candidate of the application
- Japan has experienced strong earthquakes, in which disaster relief by air, especially by helicopters, is essential.
- Data communication network and high density operation are most required in the operation

<table>
<thead>
<tr>
<th>Organization</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Defense Force</td>
<td>660</td>
</tr>
<tr>
<td>Firefighting</td>
<td>69</td>
</tr>
<tr>
<td>Police</td>
<td>95</td>
</tr>
<tr>
<td>Coast Guard</td>
<td>46</td>
</tr>
<tr>
<td>Doctor Heli.</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>879</strong></td>
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</tbody>
</table>

Number of aircraft in possible relief operation
Navigation system research

- GPS navigation research since eighties
- Fully automatic take-off and landing flight experiment of a spaceplane model vehicle HSFD installing GAIA in 2002
  GAIA: GPS Aided Inertial Navigation Avionics
- Integrity assurance:
  HSFD-GAIA(GBAS), MSAS-GAIA(SBAS), \( \mu \)-GAIA (INS integration)
- study on miniaturization

![HSFD (2002)]

![HSFD-GAIA (2001)]  ![MSAS-GAIA (2004)]  ![\( \mu \)-GAIA (2004)]
Cabin Safety: Crashworthiness research

- JAXA researchers challenge crash numerical simulation technique establishment for aircraft crashworthiness
- Their goal is cabin safety improvement to increase survivability in case of accidents

Components  Substructure  Full-structure
International collaboration: ATR42-300 Drop Test


JAXA provided Experimental Seats With Shock Absorbing Devices.
JAXA collaborates with MHI in numerical simulation of the test

They plan to apply their numerical simulation tools to future development, such as a small passenger transport and helicopter.
Conclusion

- Japan maintains good record in aviation safety.
- A Series of incidents occurred early this year, however, raised concerns about major airlines’ safety status. They reminded us the influence of deregulation and competition between airlines.
- Further activities for safety promotion including basic research are necessary.
- JAXA researchers study,
  - Turbulence detection and warning system development
  - Human factors research
  - CNS/ATM new technology application
  - Numerical simulation for crashworthiness

They will present their results in 2006 ICAS, Humburg Germany.