Flight Safety Research in Japan

October 3, 2005
ICAS PC Meeting Workshop, Mykonos, Greece

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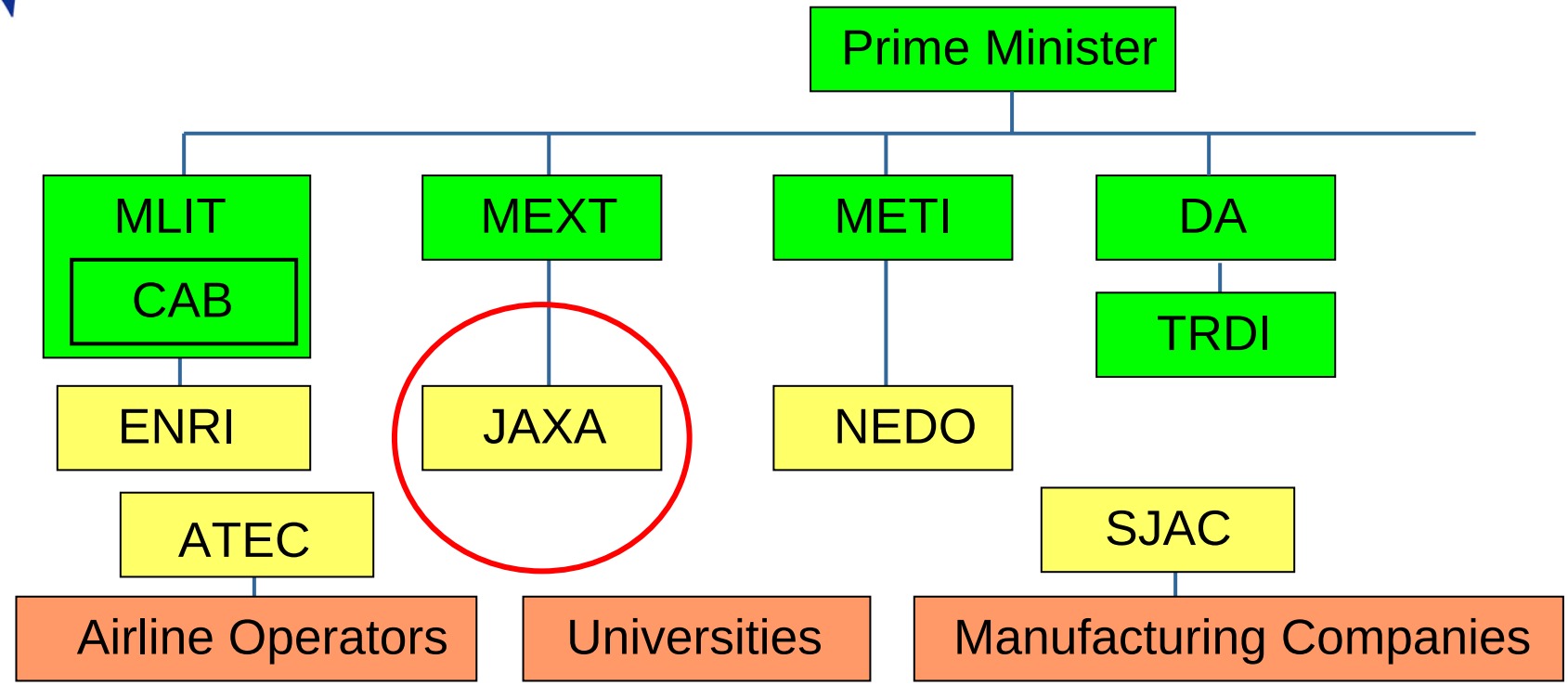
Outline

1. Introduction
2. Cabin Safety
   - 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
6. Conclusion

Flight safety in Japan: Organization structure



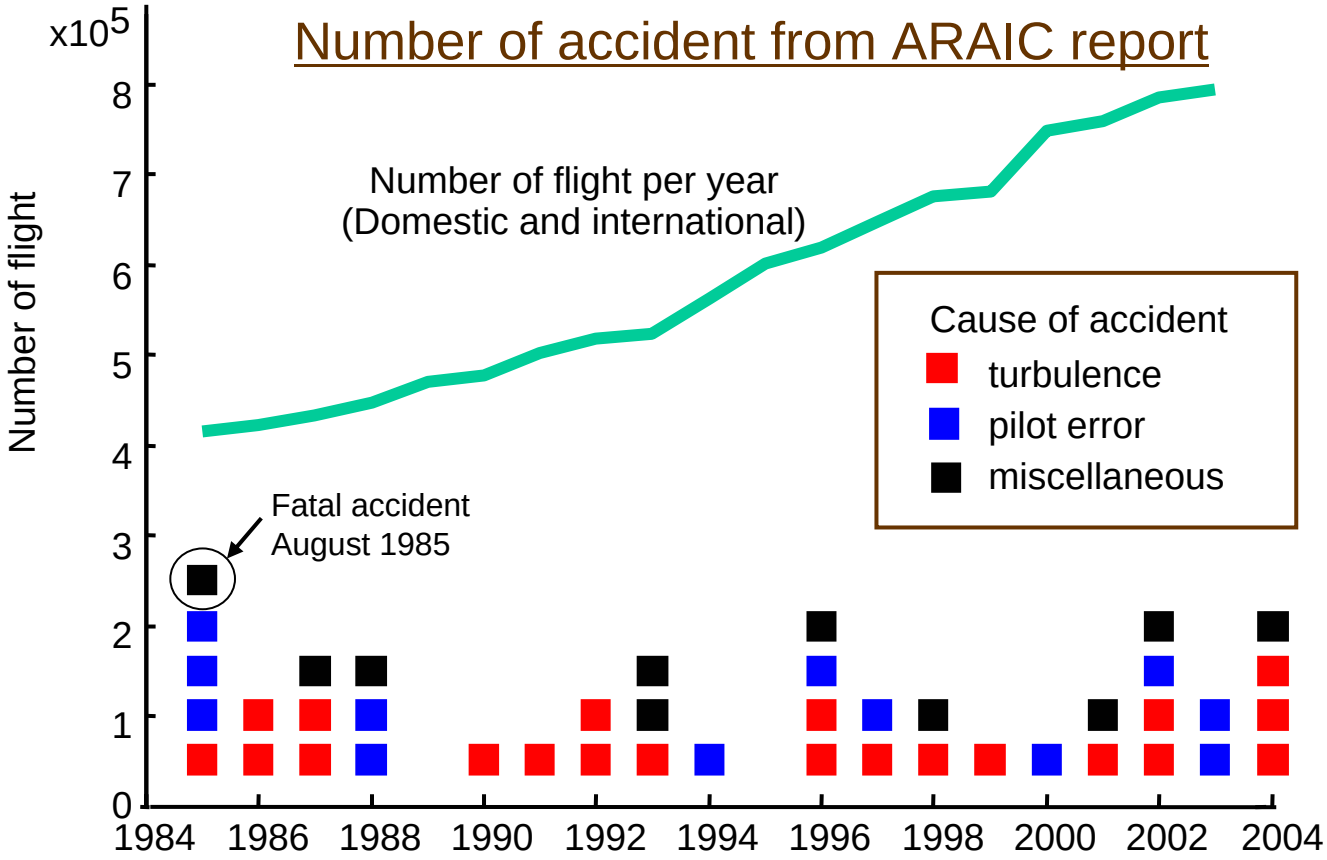
MLIT: Ministry of Land, Infrastructure and Transport
CAB: Civil Aviation Bureau ENRI: Electronic Navigation Research Institute
ATEC: Association of Air Transport and Research
MEXT: Ministry of Education, Culture, Sports, Science and Technology

METI: Ministry of Economy, Trade and Industries
NEDO: New Energy and Industrial Technology Development Organization
SJAC: Society of Japanese Aerospace Companies
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

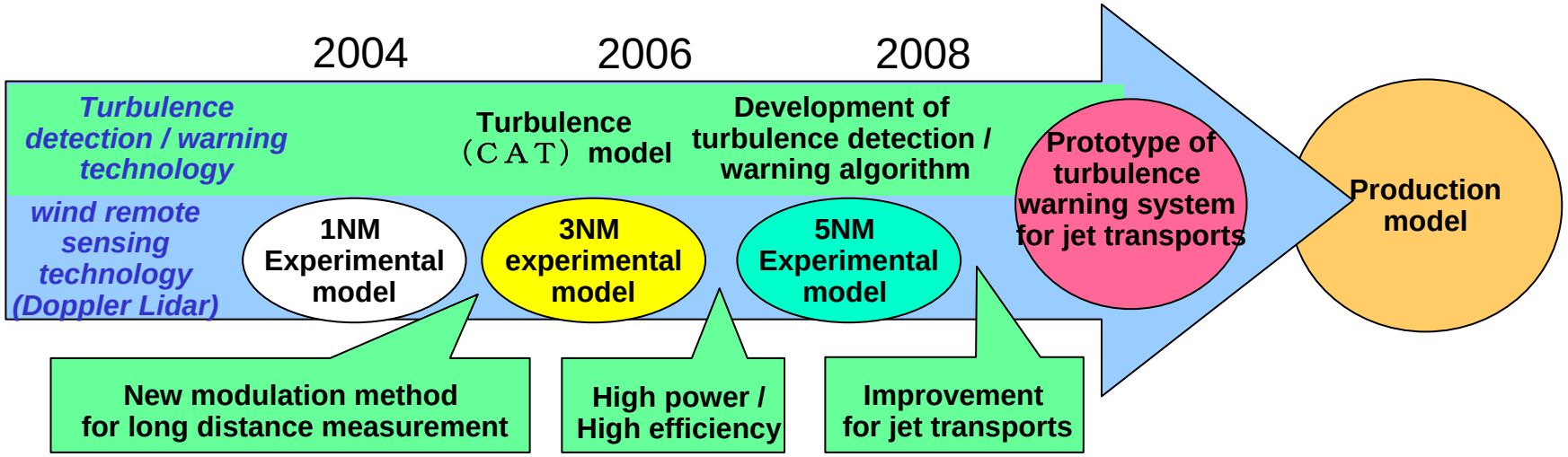


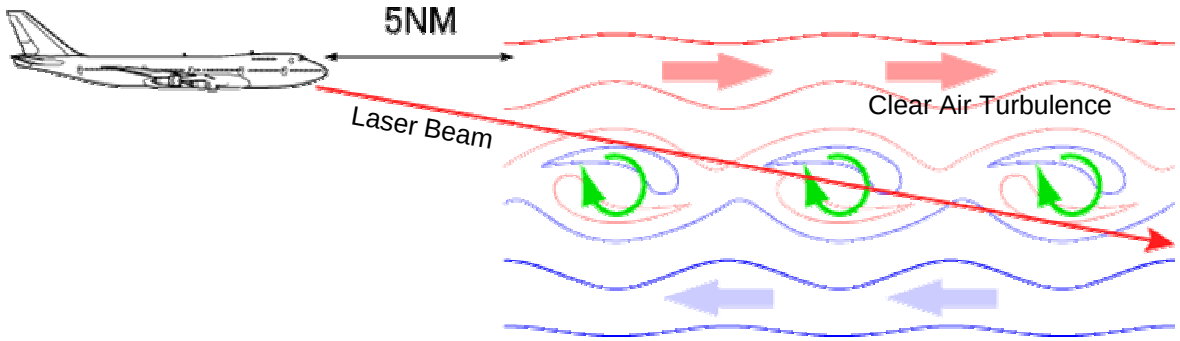
It is difficult to prevent all the cases, especially those due to Clear Air Turbulence. (CAT)

JAXA researchers challenge CAT warning system.

Turbulence detection by Lidar: Plan

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).





1NM experimental model

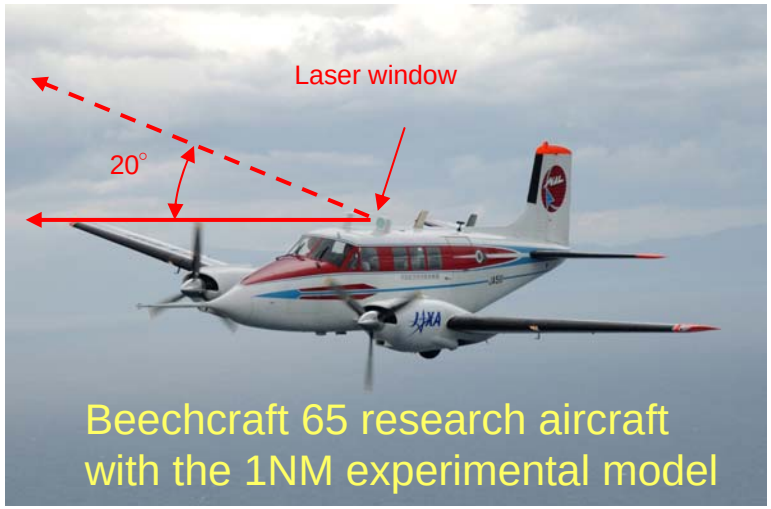
Key points of onboard CAT warning system

- Eye safety
- Compact and low power
- Reliable

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

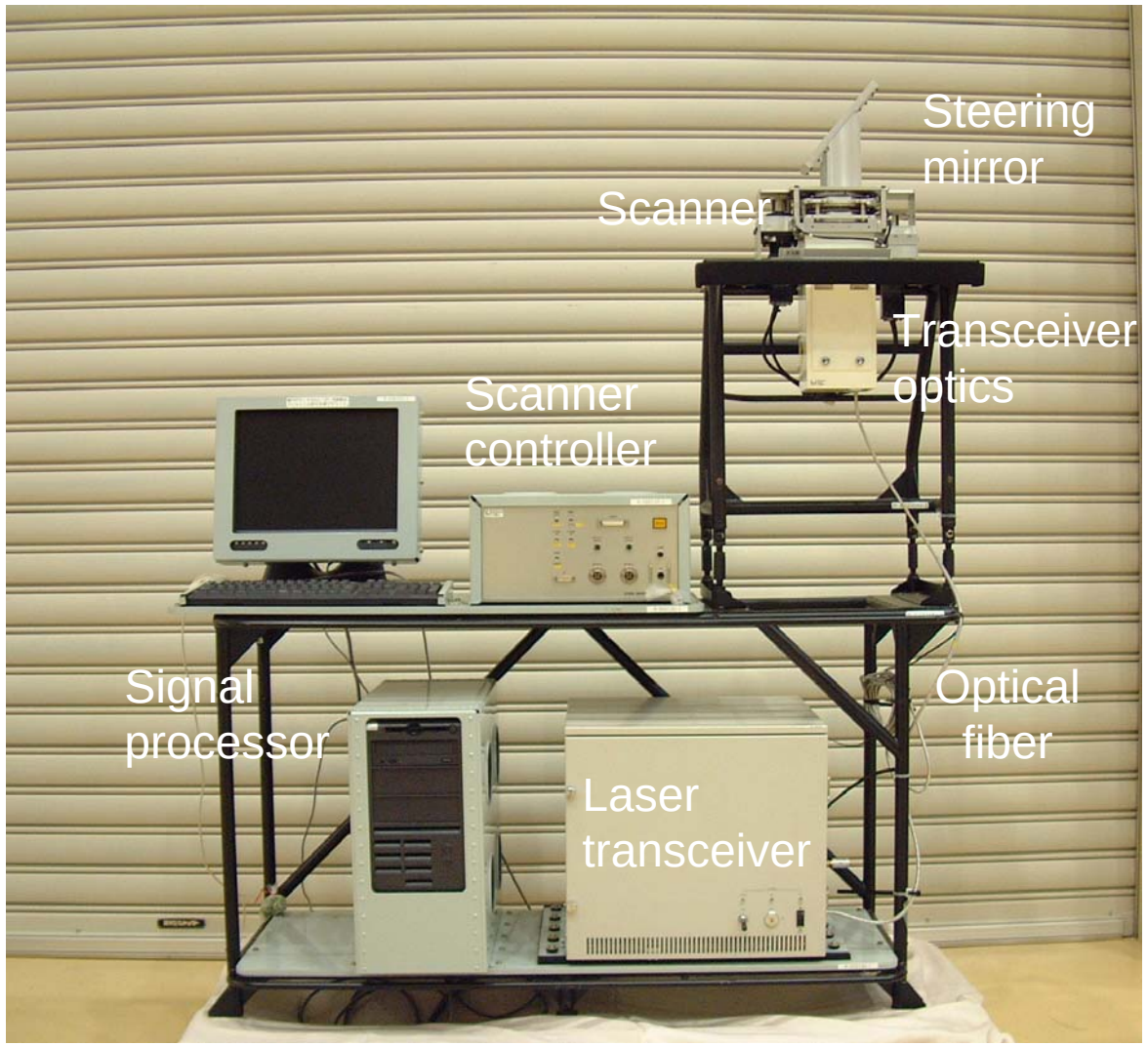
All the optical components are fiber-based and they are connected by optical fiber.

Wavelength	**1.54μm**
Laser power (Peak)	**10W**
Pulse repetition frequency	**50kHz**
Pulse width	**1μs**
Range resolution	**150m**
Beam diameter (1/e ^{2})	**50mm**



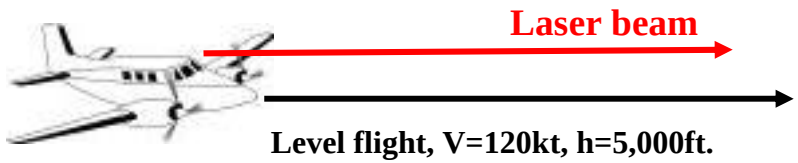
Beechcraft 65 research aircraft with the 1NM experimental model

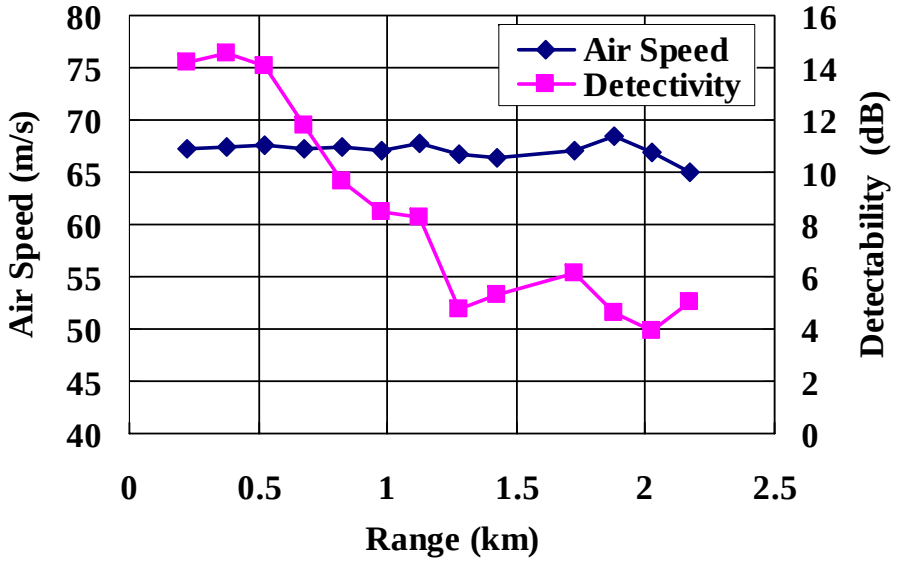
1NM experimental model



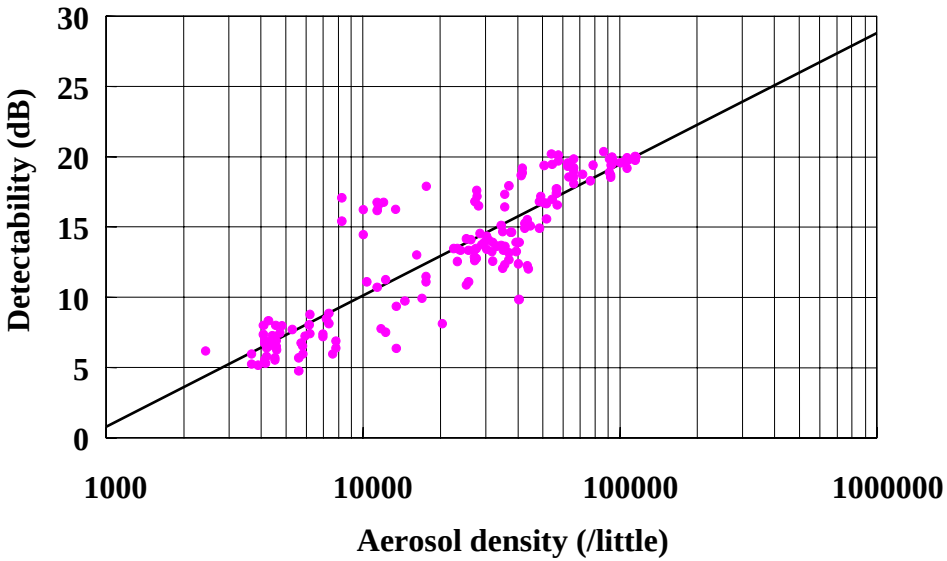
2002

Flight test evaluation



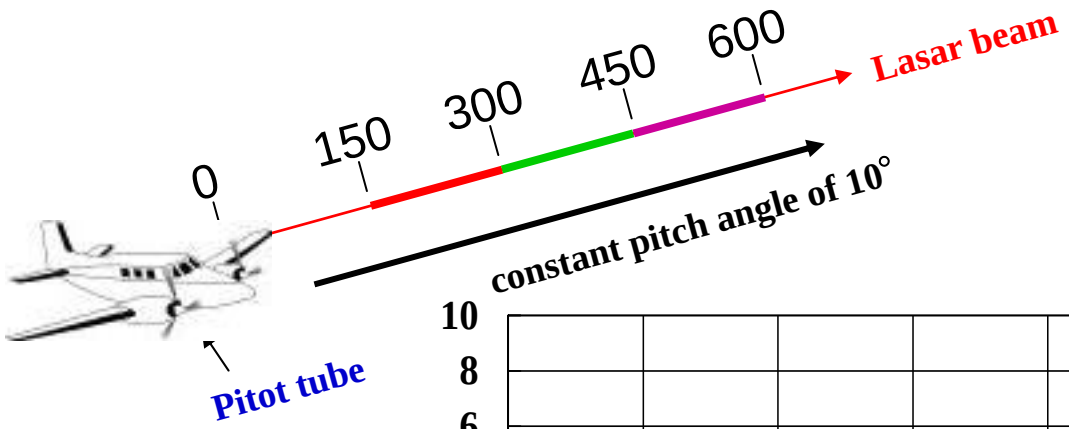


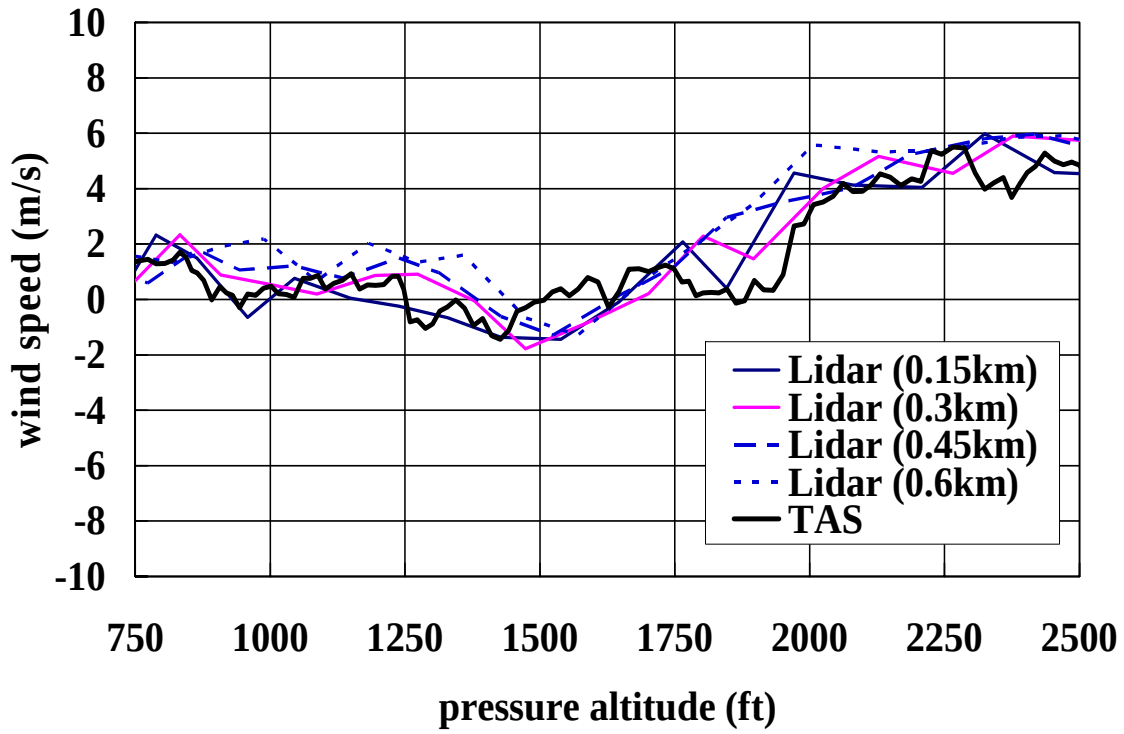
Measured airspeed and detectability
(Level flight, h=5,000ft)



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

Flight test evaluation





Wind measurement results
(preview 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

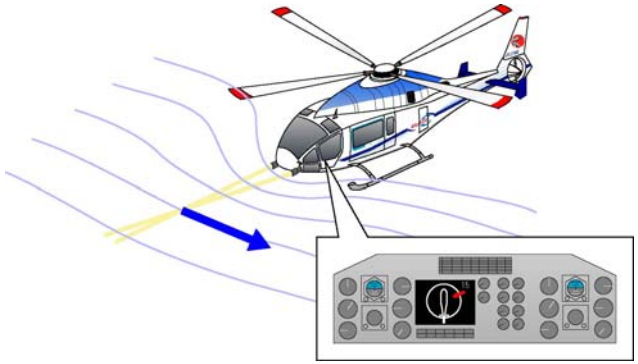
- Turbulence prediction will be in their future scope

Lidar Application to Helicopters

Helicopter is a good application of Lidar

low velocity
low altitudes → detection range is short
aerosol density is high

Type 1

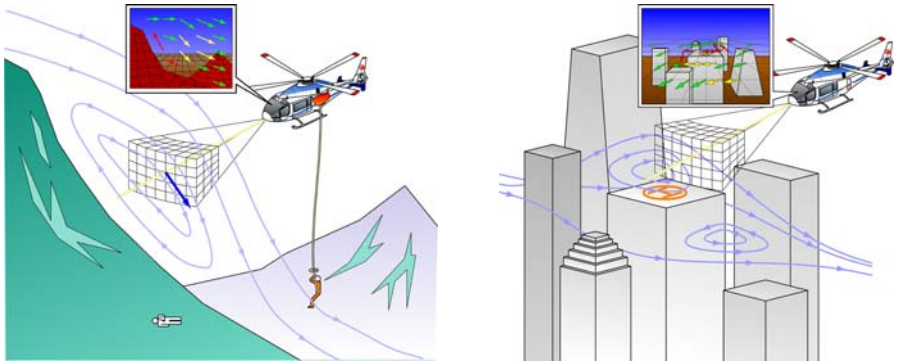


TAS Sensor

measure 2 or 3 axis
airspeeds even in hover

2 or 3 axis airspeeds measurements
>100m detection range

Type 2

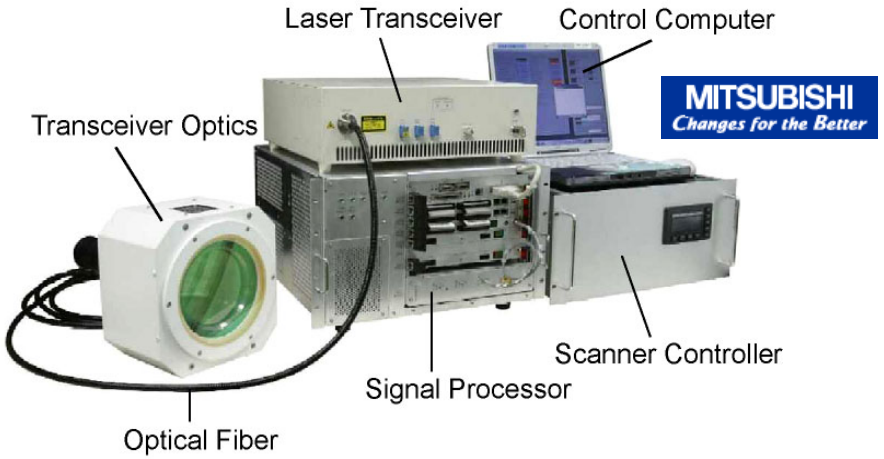


Turbulence Sensor

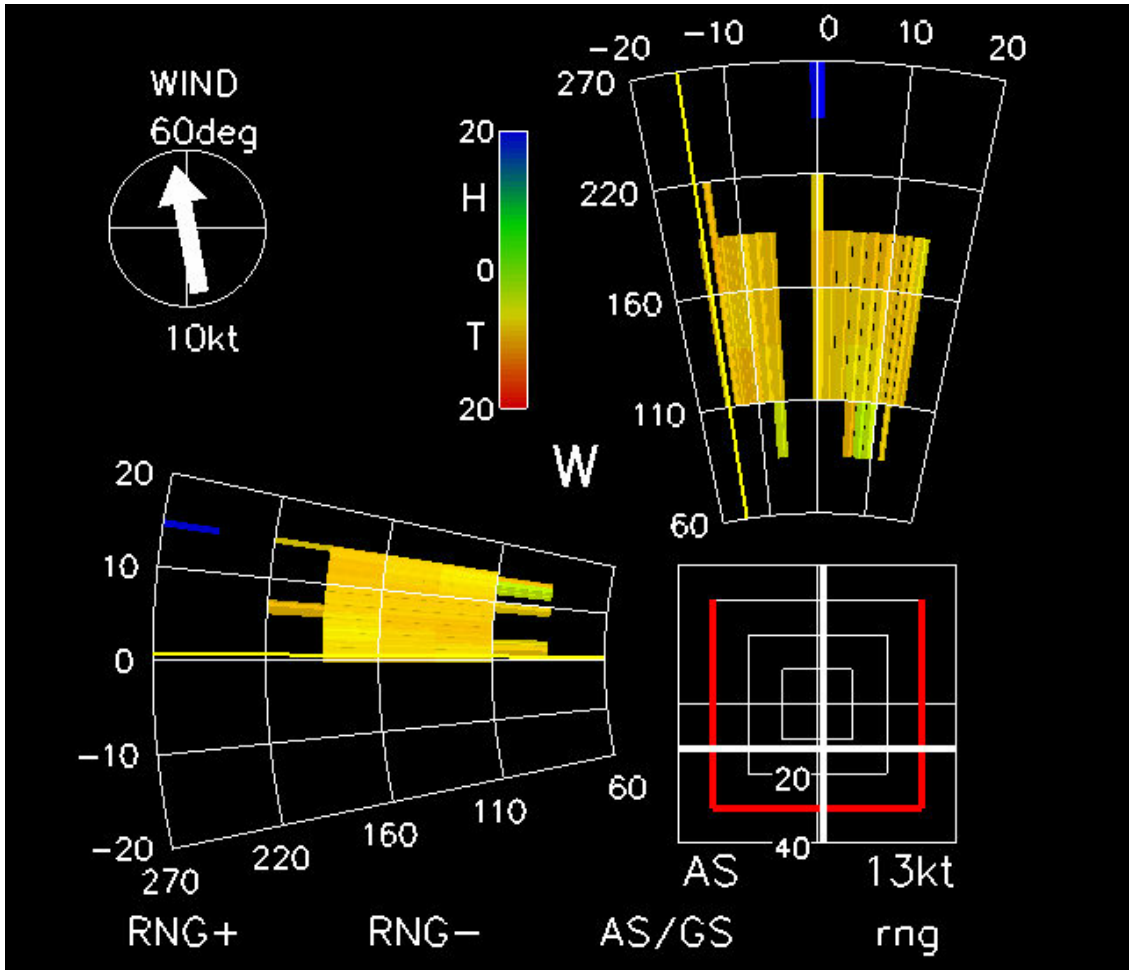
detect severe local turbulence

2 or 3 axis wind speeds measurements
1−2km detection range
Multiple observation points
Real-time pilot display

Helicopter application of 1NM experimental model



Real-time Cockpit Display



- Wind Display
  Wind speed & direction

  LOS components of wind speed

- TAS Indicator
  Horizontal 2-axis airspeed with limitations

Human factors

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.

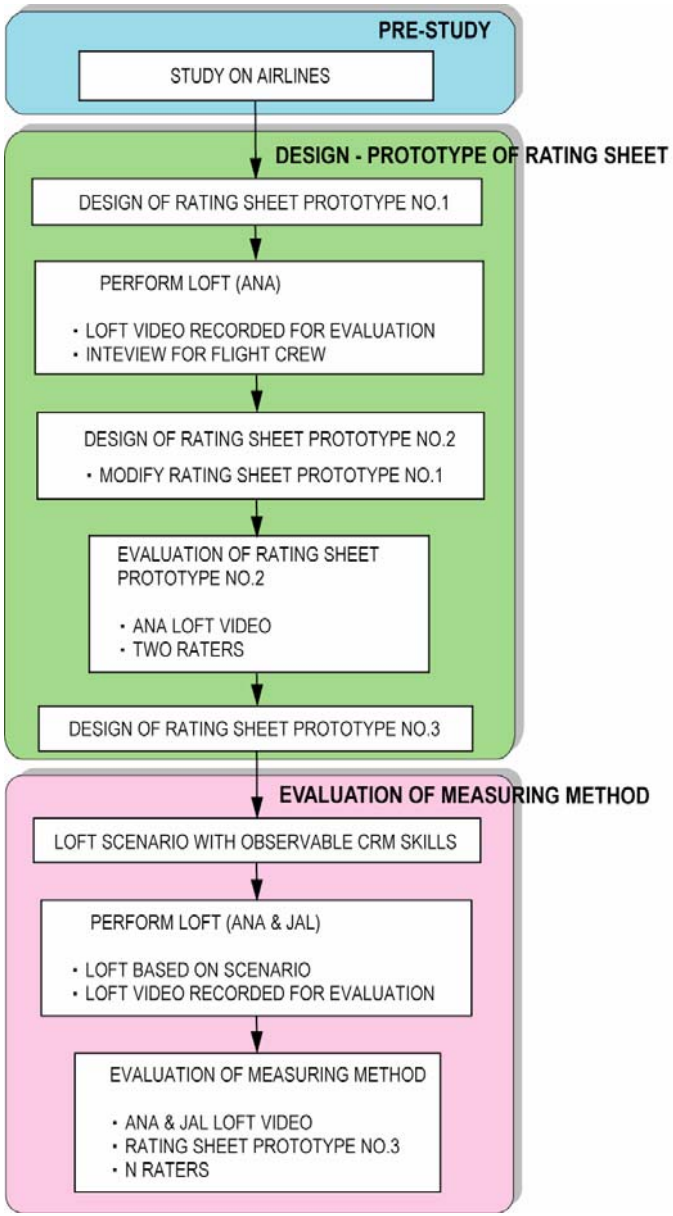
At the same period, a series of incidents occurred in Japanese major airline companies more than previous years.
CAB organized a committee to assess the safety status. It recommended to reconsider the followings.

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

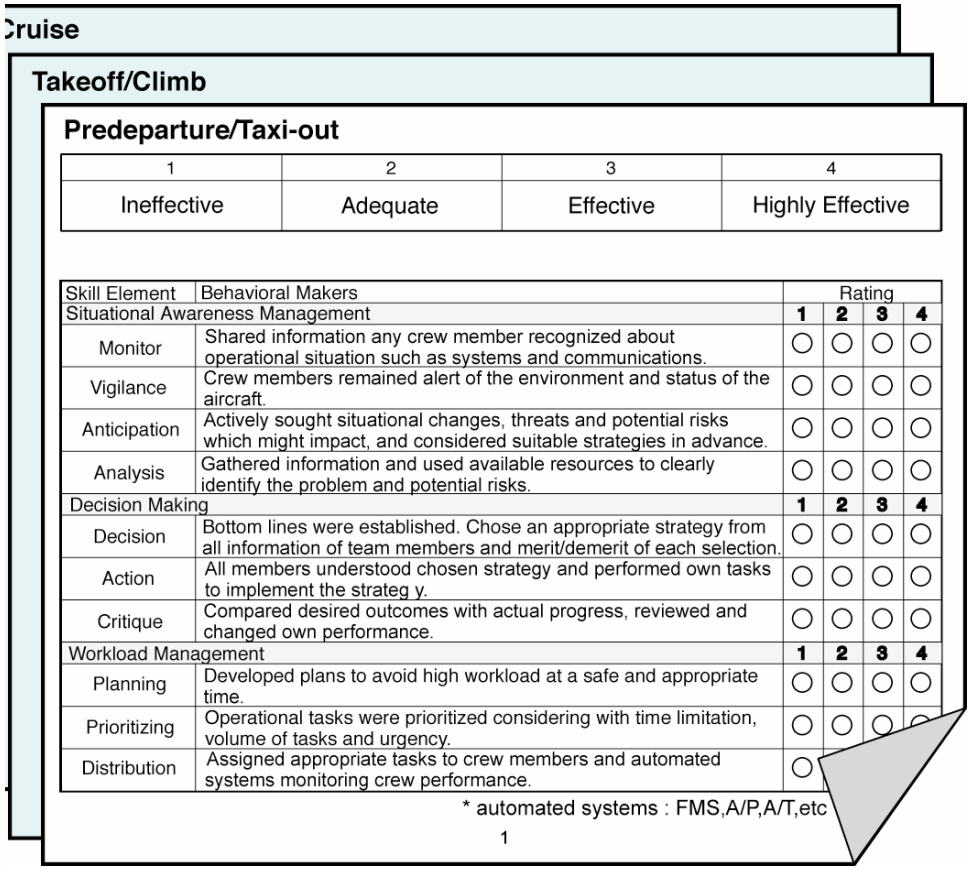
from Asahi News Paper

Railroad accident, April 25 2005

Human factors research: CRM skill measurement



JAXA researchers propose CRM skill measurement method to make CRM training more effective.



Cruise

Takeoff/Climb

Predeparture/Taxi-out

1	2	3	4
Ineffective	Adequate	Effective	Highly Effective

Skill Element	Behavioral Makers	Rating			
Situational Awareness Management		1	2	3	4
Monitor	Shared information any crew member recognized about operational situation such as systems and communications.	○	○	○	○
Vigilance	Crew members remained alert of the environment and status of the aircraft.	○	○	○	○
Anticipation	Actively sought situational changes, threats and potential risks which might impact, and considered suitable strategies in advance.	○	○	○	○
Analysis	Gathered information and used available resources to clearly identify the problem and potential risks.	○	○	○	○
Decision Making		1	2	3	4
Decision	Bottom lines were established. Chose an appropriate strategy from all information of team members and merit/demerit of each selection.	○	○	○	○
Action	All members understood chosen strategy and performed own tasks to implement the strateg y.	○	○	○	○
Critique	Compared desired outcomes with actual progress, reviewed and changed own performance.	○	○	○	○
Workload Management		1	2	3	4
Planning	Developed plans to avoid high workload at a safe and appropriate time.	○	○	○	○
Prioritizing	Operational tasks were prioritized considering with time limitation, volume of tasks and urgency.	○	○	○	
Distribution	Assigned appropriate tasks to crew members and automated systems monitoring crew performance.	○			

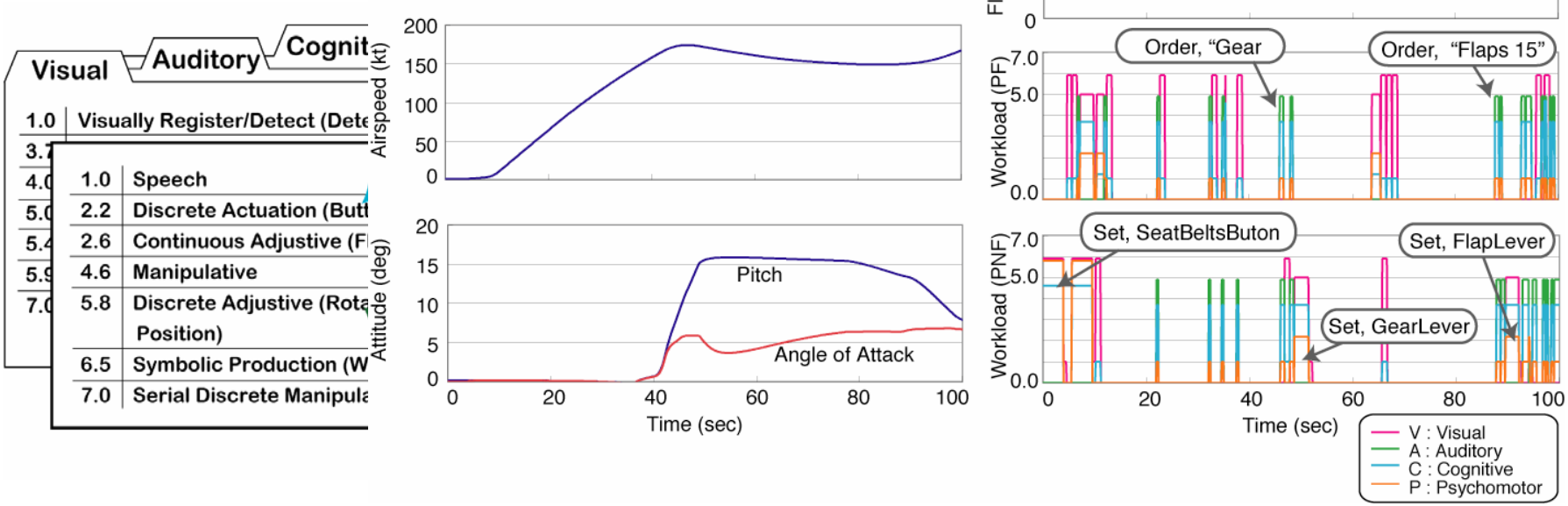
* automated systems : FMS,A/P,A/T,etc

1

CRM skills rating sheet

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



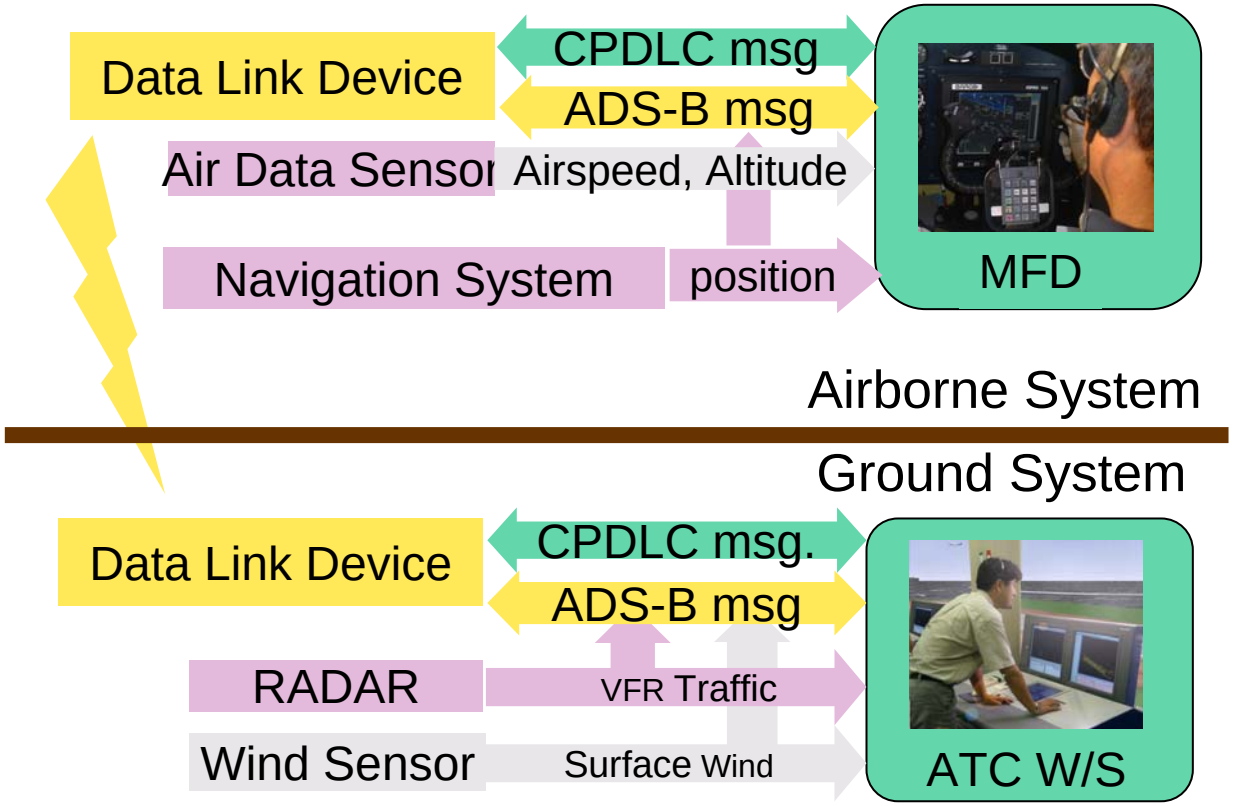
New technology in ATC

CNS/ATM applications research

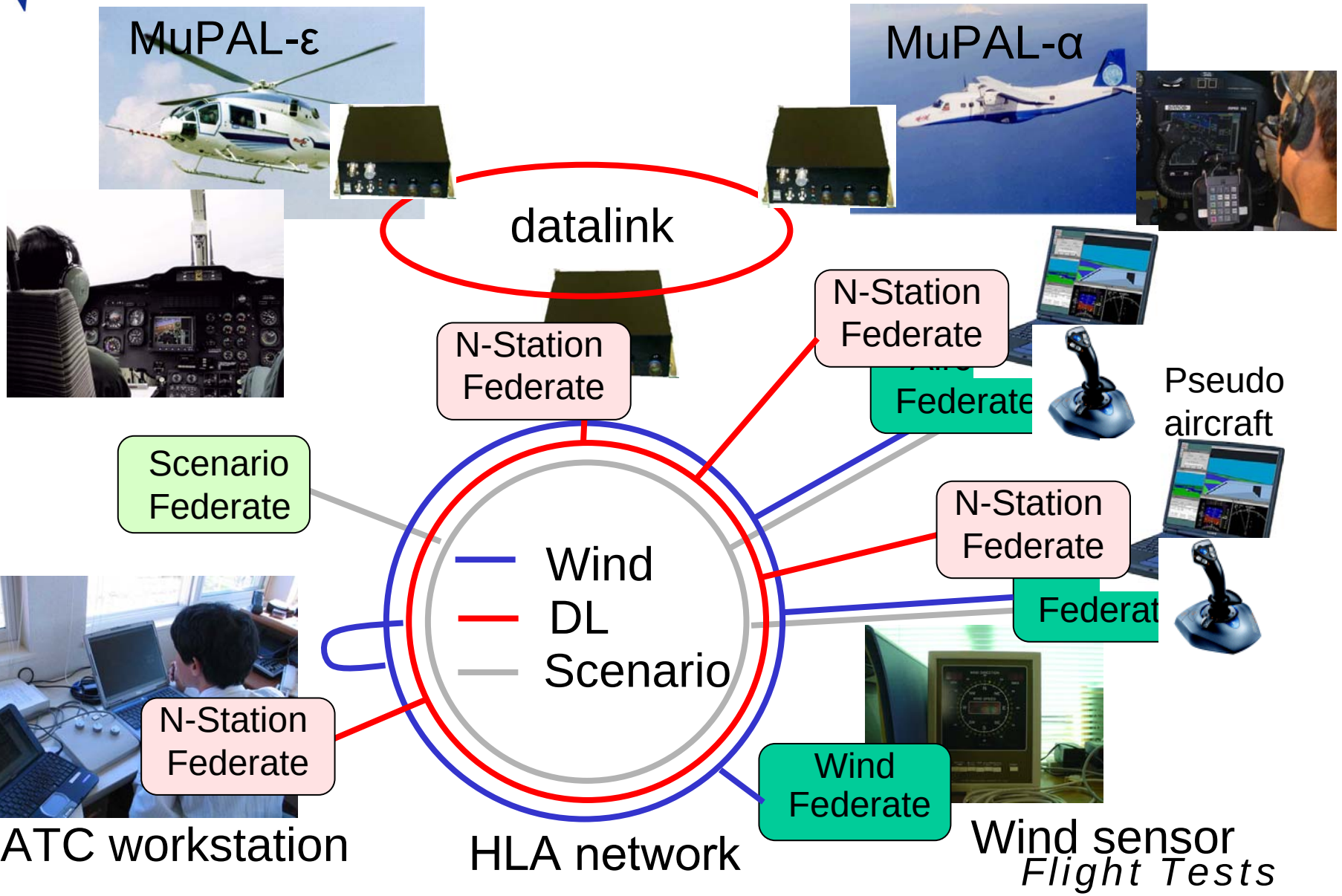
- JAXA constructed a new technology experimental model to evaluate the concept by simulator and flight tests
- They plan to apply their technology in the two areas
  - Inter-Island flight operation
  - Disaster relief air operation
- They study reliable GPS navigation system

New technology in air traffic control: NOCTARN

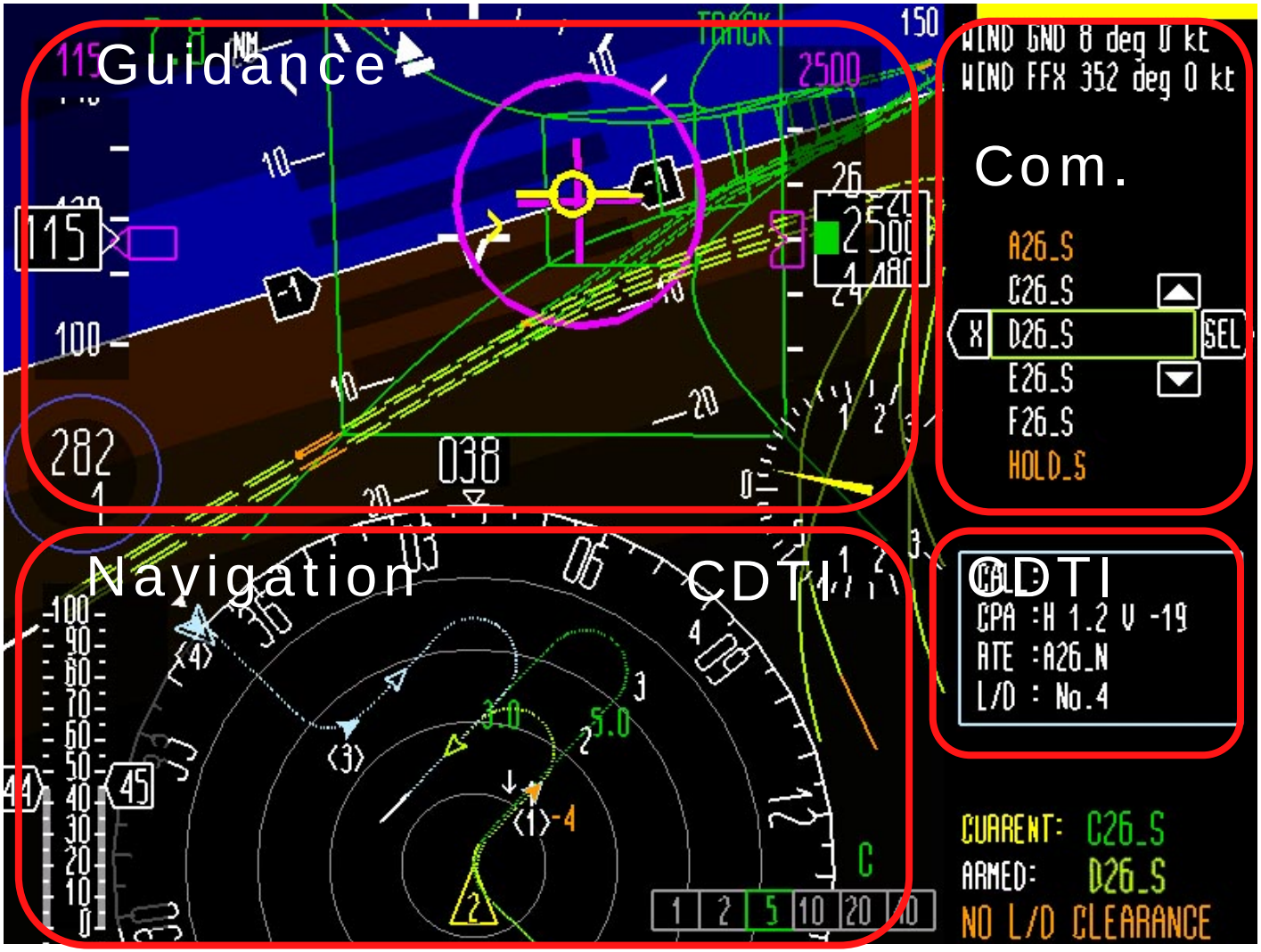
- JAXA constructed an experimental model of CNS/ATM concept for small aircraft operation to evaluate it by simulation and flight test.
  NOCTARN: New Operational Concept using Three-dimensional Adaptable Route Navigation



NOCTARN: Experimental model setup



NOCTARN: MFD



Operations Concept

NOCTARN simulation test and flight test

- Ground evaluation test with ENRI's air traffic control simulator

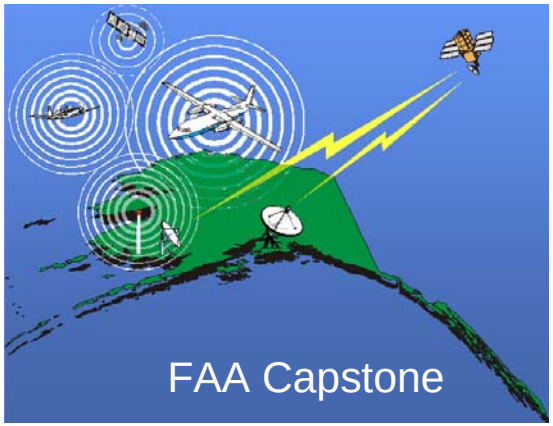
- Flight test
  - at Taiki airfield (for experiment)
  - Helicopter and Airplane
  - Cases: Non-towered operation/Towered operation

Application plan: DREAMS

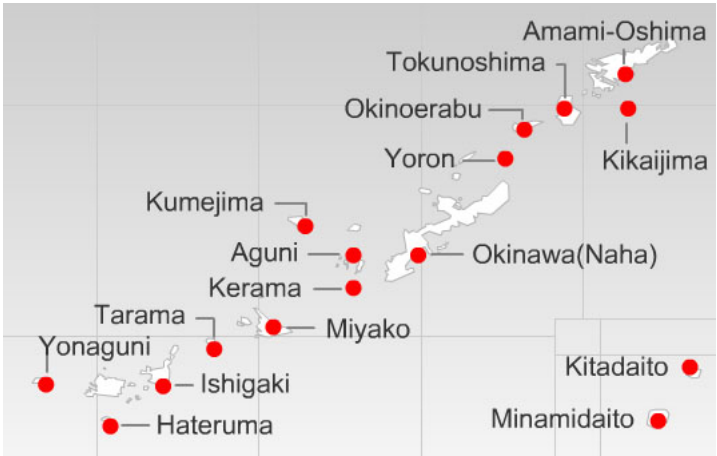
- JAXA plans to collaborate with FAA introducing Capstone technology

- DREAMS: Distributed and Revolutionary Efficient Air Safe Management System

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



(from Capstone home page)



(route map from JAL home page)

Airports in Okinawa Islands

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

Organization	Number
Defense Force	660
Firefighting	69
Police	95
Coast Guard	46
Doctor Heli.	9
Total	879

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),
  μ-GAIA (INS integration)
- study on miniaturization

HSFD (2002)

HSFD-GAIA (2001)

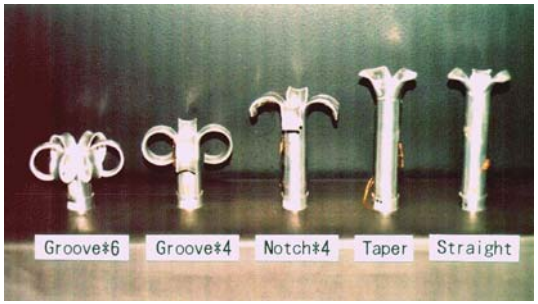
MSAS-GAIA (2004)

μ-GAIA (2004)

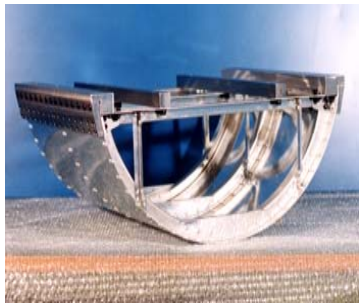
Cabin Safety: Crashworthiness research

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

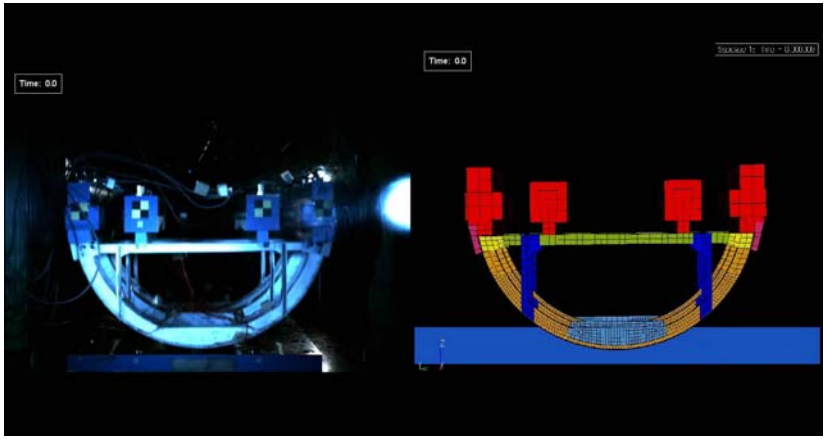
Components



Substructure



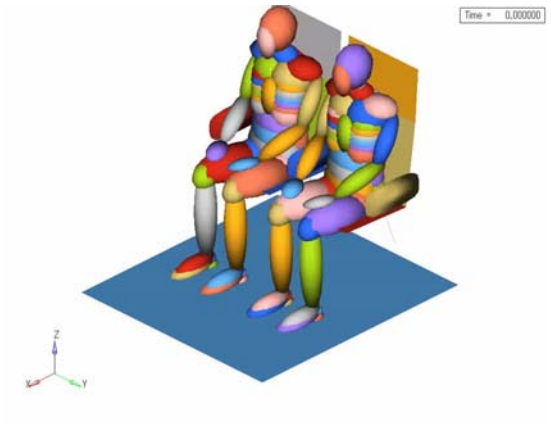
Full-structure



International collaboration: ATR42-300 Drop Test

Conducted by FAA William J. Hughes Technical Center on July 30th, 2003.

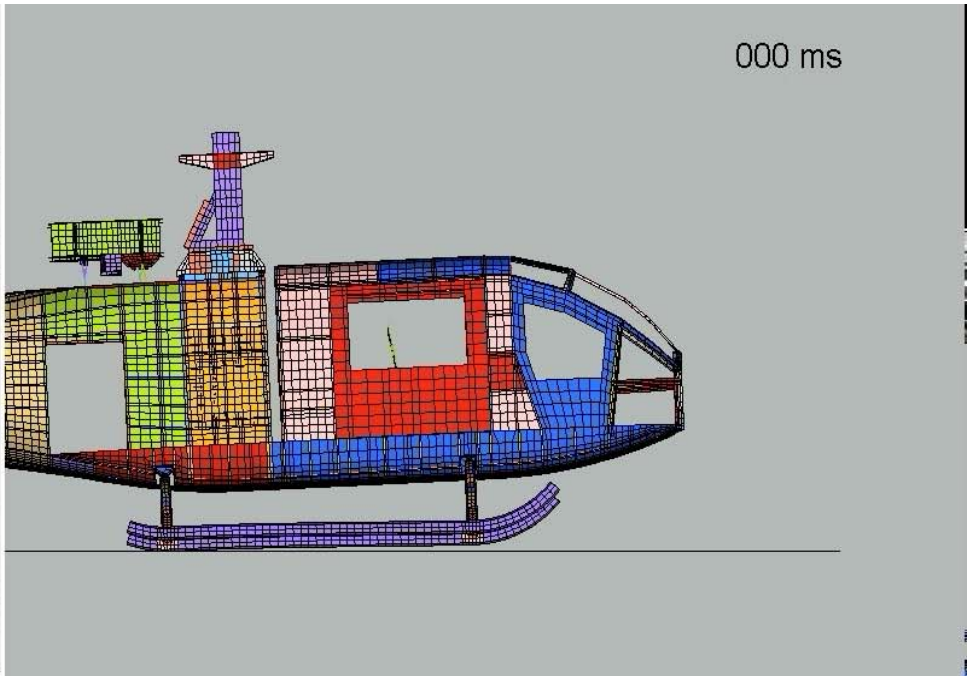
JAXA provided Experimental Seats With Shock Absorbing Devices.



MH2000 Crash Test, February 25, 2004

MH2000 Crash Test, February 25, 2004

JAXA collaborates with MHI in numerical simulation of the test



test

Numerical simulation

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.


MuPAL-ε
MuPAL-α