Japan-Korea Joint Workshop on Rotorcraft
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Keynote Speech

Overview on Rotorcraft R&D in Japan

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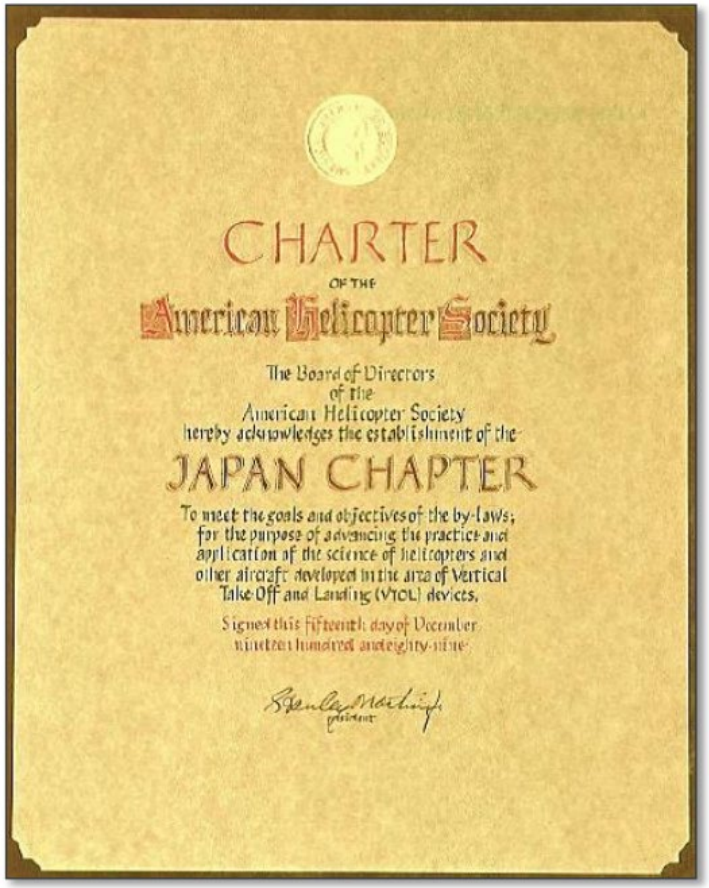
Outline

- **Introduction of Japan Helicopter Society (JHS)**
- **Activities of Manufacturers**
  - Kawasaki Heavy Industries (KHI)
  - SUBARU
  - Mitsubishi Heavy Industries (MHI)
  - Yamaha Motor
  - Yamato Transport
- **Activities of Universities**
  - Nagoya University
  - Kanazawa Institute of Technology
  - Shizuoka Institute of Science and Technology
- **Activities of Research Institute**
  - Japan Aerospace Exploration Agency (JAXA)

Japan Helicopter Society (JHS)

日本ヘリコプタ協会
Japan Helicopter Society

- Established in 1989 with the aim of contributing to the community of helicopter and VTOL, from R&D, design, testing, manufacturing to operation
- Approved as the Japan Chapter of the American Helicopter Society (AHS) since its foundation and evaluated as one of the most active chapters outside U.S.
- Members: researchers, engineers, pilots, government officials, journalists, trading company workers, students…
- Main activities: Asian Rotorcraft Forum (ARF)/Heli Japan, Japan Helicopter Safety Team (JHST), publication of annual report, research meetings …

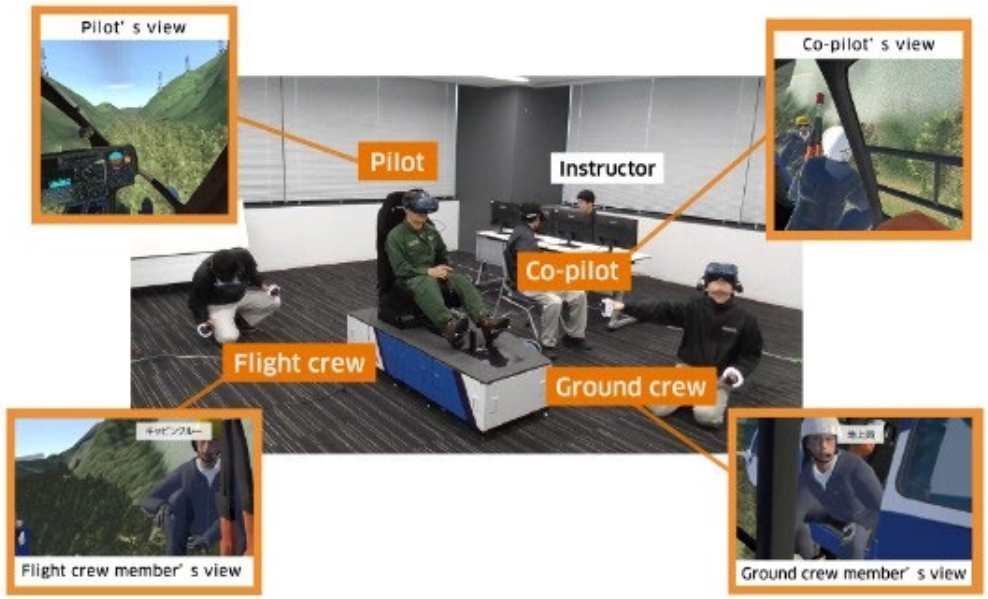

CHARTER
OF THE
American Helicopter Society
The Board of Directors
of the
American Helicopter Society
hereby acknowledges the establishment of the
JAPAN CHAPTER
To meet the goals and objectives of the by-laws;
for the purpose of advancing the practice and
application of the science of helicopters and
other aircraft developed in the area of Vertical
Take-Off and Landing (VTOL) devices.
Signed this fifteenth day of December
nineteen hundred and eighty-nine

Kawasaki Heavy Industries

Delivery to National Police Agency

Delivery of H145/BK117 D-3

- The latest version of BK117 codeveloped with Airbus Helicopters
- 5 bladed, GW=3.8ton, ducted fan, Rotor dia.=10.8m
- T/C by JCAB in 2021
- 14 aircraft had been ordered by the end of 2022 in Japan



CRM training

CRM: Crew Resource Management

- CRM training services using a virtual reality (VR) simulator, intended to foster safer helicopter operations
- Training is intended to integrate not only the pilot, but also ground crew and other flight crew functioning in various capacities
- The goals include improving team communication, situational assessment skills and decision-making skills, which enable safer flight operations.

SUBARU

SUBARU BELL 412EPX: Civil version

SUBARU BELL 412EPX

- The latest version of BELL 412 codeveloped with BELL Helicopter
- T/C by FAA in 2018
- GW=5.5ton, Rotor dia.=14.02m
- 3 aircraft had been ordered by the end of 2022 in Japan

UH-2: Military version

UH-2 for Japan Ground Self Defense Force

- In 2015, Ministry of Defense selected SUBARU BELL 412EPX as a platform of UH-2, the successor of UH-1J
- Maiden flight of mass production model and delivery started in 2022
- 26 aircraft were procured by the end of 2022
- Total 150 aircraft will be delivered by 2041

Mitsubishi Heavy Industries

Patrol helicopter XSH-60L

- New helicopter based on the SH-60K for the Japan Maritime Self Defense Force with improved on-board systems and flight performance
- Maiden flight and delivery of prototype in 2021

CoasTitan™ Networked Security System with Uncrewed Vehicles

- Provides security solution with networked sensors and uncrewed aerial/surface/underwater vehicles
- UAV demonstrated its stable take off/landing capability on high-speed cruising ship in 2021

Yamaha Motor

FAZER R AP: New type of unmanned agricultural helicopter

- Automatic flight application “agFMS-IIH” installed
  to reduce workload for novice pilots
  to increase efficiency of pesticide/fertilizer spray operation

YMR-II: New type of industrial use multirotor YMR series

- Sales start in 2023 spring, ¥1,859,000
- Automatic flight application “agFMS-IIH” installed
- GW=24.9kg, Size=L1,970mm W2,157mm H786mm

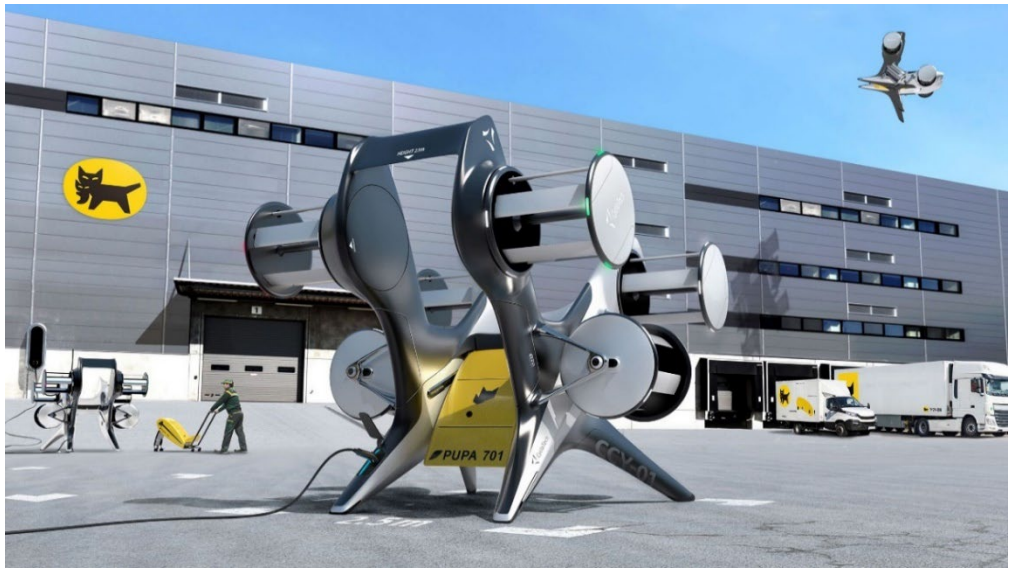
FAZER R G2 with enhanced transportation capability

- Larger main rotor Dia.=3.115m ➡ 3.6m
  Payload 35kg ➡ 50kg
- For long distance automatic cargo transportation over unmanned area.

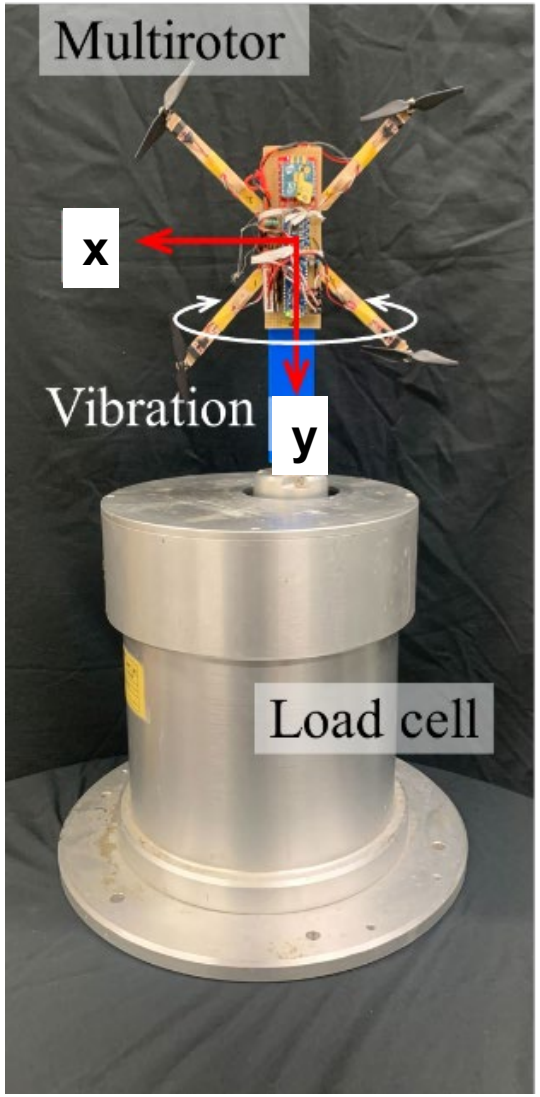
Yamato Transport

CycloRotors: mid-class cargo eVTOL

- Yamato Holdings Co., Ltd. + CycloTech GmbH (Austria) have successfully completed a joint feasibility study on applying a new thrust vectoring propulsion technology
- Key features for urban airborne logistic operations
  - = compact in size
  - + precision landing into confined areas (5 m in diameter)
  - + handling quality of challenging wind conditions
  - + transporting 45 kg payload over a distance of 40 km
- The unique characteristics of CycloRotors were used to design a mission optimized for unmanned cargo eVTOL.



Nagoya University



Stability derivative measurement of multirotor

- Stability characteristics of multirotor on hover conditions are studied analytically and experimentally.
- Especially, Mu and Mq are measured for analysis validation.
- Mq is measured with respect to q as shown in figure.

Vibration reduction by shifting c.g. position

- Analytical work by CAMRAD II demonstrated the effect without airframe instability.

Methodology to design multirotor type flying car

- JAXA developed rFlow3D and rNoise are utilized with aerodynamic performance and noise as evaluation function.

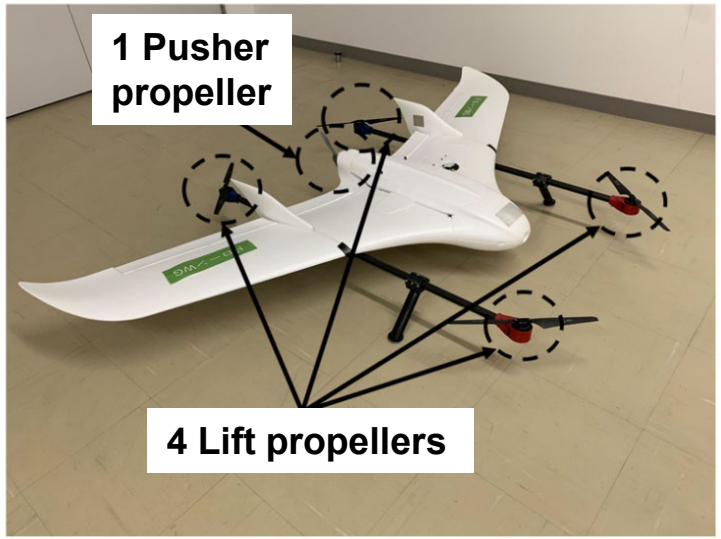
Aerodynamic interaction between rotor and wing when encountering crosswinds

- Studied by rFlow3D and wind tunnel test.

Kanazawa Institute of Technology

Aerodynamic interaction between rotor and wing

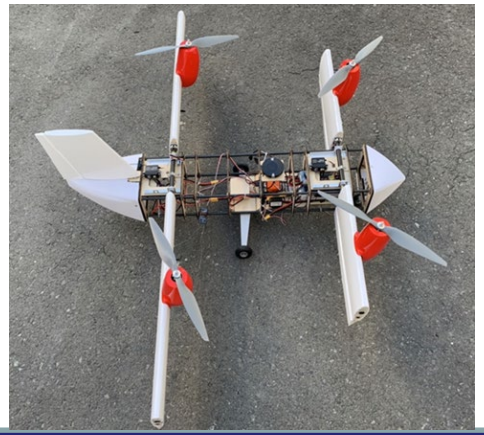
- Aerodynamic interaction of compound helicopter on hover and forward flight conditions are studied.
- Experimentally, 1m diameter radio-controlled helicopter with wing equipped with flaps is flight tested as shown in figure.
- It is shown that the flaps have favorable effect to reduce download during hover at the cost of diminishing roll damping.
- Analytical works are performed by JAXA developed rFlow3D.



Flying wing (tailless fixed wing) type drone

- Prototyped, flight-tested and dynamic model formulated.
- Stable hover capability is demonstrated by flight test.
- Dynamic analysis shows wing aerodynamic effect becomes favorably dominant to static/dynamic stability along with velocity increase.

Shizuoka Institute of Science and Technology



Downwash prediction by LMT (Local Momentum Theory) on hover

- Effective inboard blade plan form of YAMAHA FAZER to generate engine cooling airflow is studied by LMT.
- Analysis by LMT and wind tunnel test result had excellent agreement.

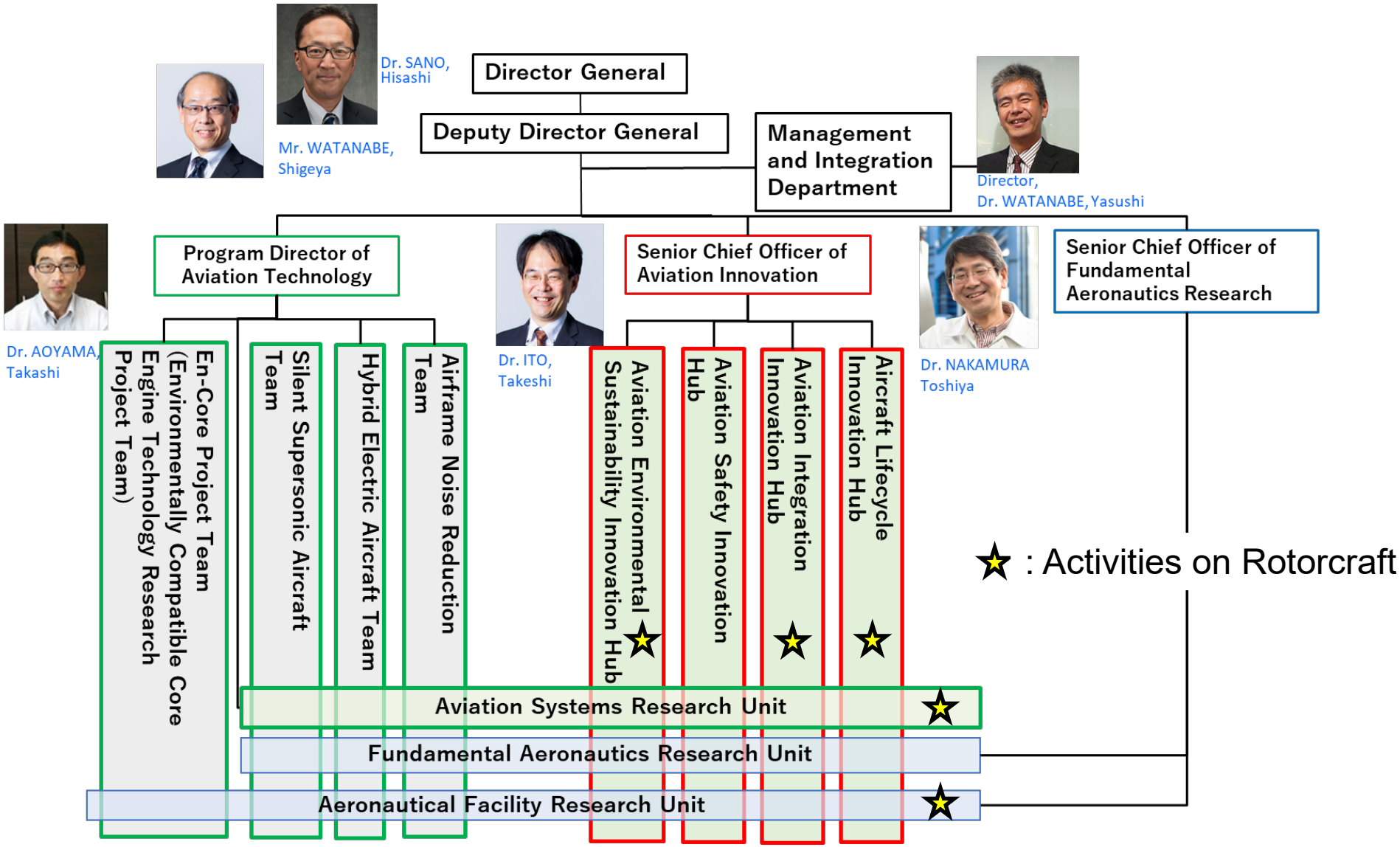
Optimization of multirotor arrangement by LMT

- Reducing aerodynamic interaction and airframe size is studied by LMT and validated by a test using rotors of YMR-08

eVTOL prototyping

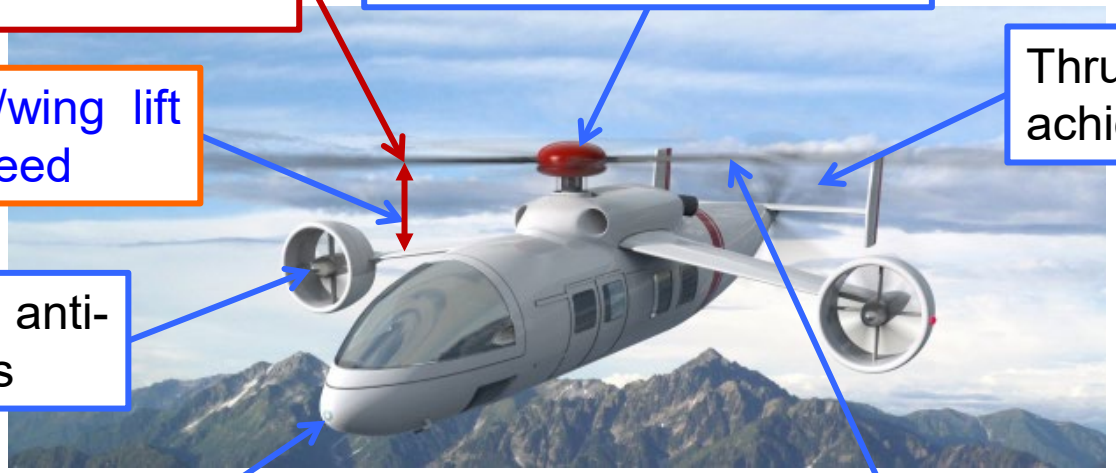
- Production design and prototyping for JAXA conceptual designed QTW
- Commercial “Pixhawk” is utilized for flight controller

Organization of JAXA ATD

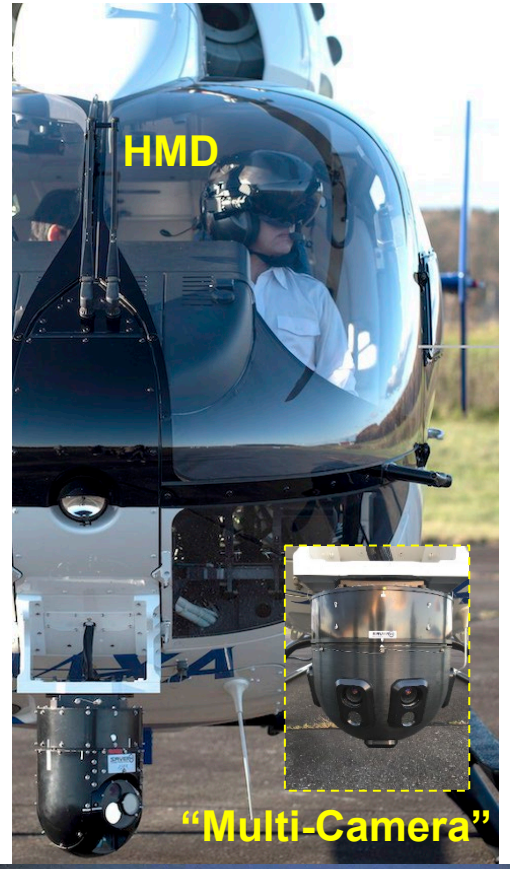


JAXA: high-speed compound helicopter

Technical challenges for high-speed compound helicopter



JAXA: SAVERH



JAXA's Research Helicopter in night

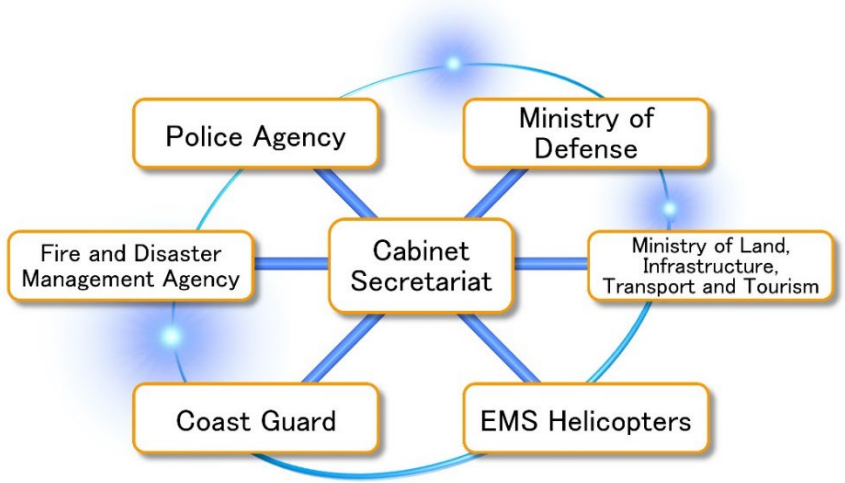
SAVERH (Situation Awareness and Visual Enhancer for Rescue Helicopter)

- Guaranteeing low altitude mission under the DVE (Degraded Visual Environment).
- JAXA together with Shimadzu Co. has been conducting joint research project aiming at inventing method of presenting suitable information to the pilot to support search and rescue missions in DVE.
- An integrated system comprising an HMD (Helmet Mounted Display) and a variety of image sensors were installed in the JAXA research helicopter.

JAXA: D-NET

Disaster Relief Aircraft Management System – Network

- Enables safe and efficient disaster response
- Connects helicopters and ground operation centers/ headquarters
- Enables information sharing
  - Flight plans
  - Telemetry data (positions)
  - Disaster mission type (rescue, reconnaissance, etc.)



Adopted by the Japan Disaster Relief Agencies

- D-NET is adopted by most disaster relief agencies in Japan.
- D-NET enables intra-agency information sharing which contributes to efficient large-scale disaster response

Unstructured Based CFD Solver for Rotorcraft and its Applications

- **JAXA has been devoted to developing a fast CFD solver, FaSTAR-Move (Fast Aerodynamic Routine-Move) in order to be applied complex shaped moving objects according to industrial needs.**
- **Recently, several rotorcraft simulations have been performed using FaSTAR-Move.**