Keizai Silicon Valley
Event about Electrification of Aircraft
May 12 (13), 2021

Introduction of ECLAIR and Research on eVTOLs in JAXA

Yasutada Tanabe

Leader, High-Speed Rotary Aircraft Research Section
Aviation Systems Research Unit
Aeronautical Technology Directorate
Japan Aerospace Exploration Agency (JAXA)

Personal Experience: 1991 – 2006, Kawada Industries, Inc.

Kawada RoboCopter

Flight test of an unmanned Schweizer 300C helicopter

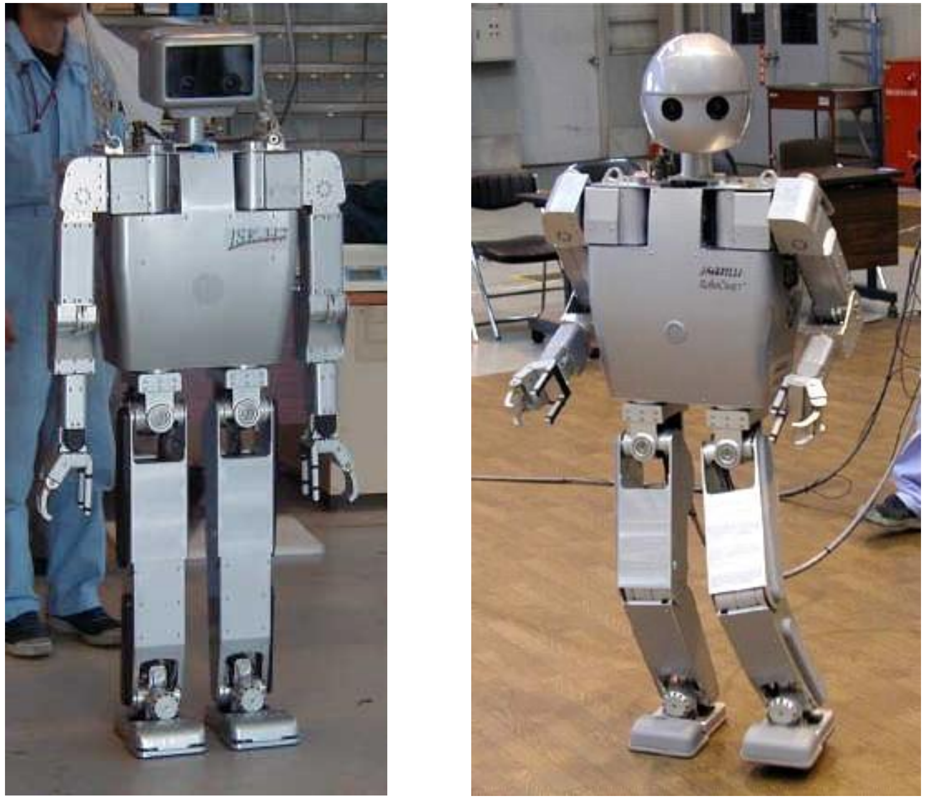
Prototype Kawada RoboCopter Development and test

Personal Experience: 1991 – 2006, Kawada Industries, Inc.

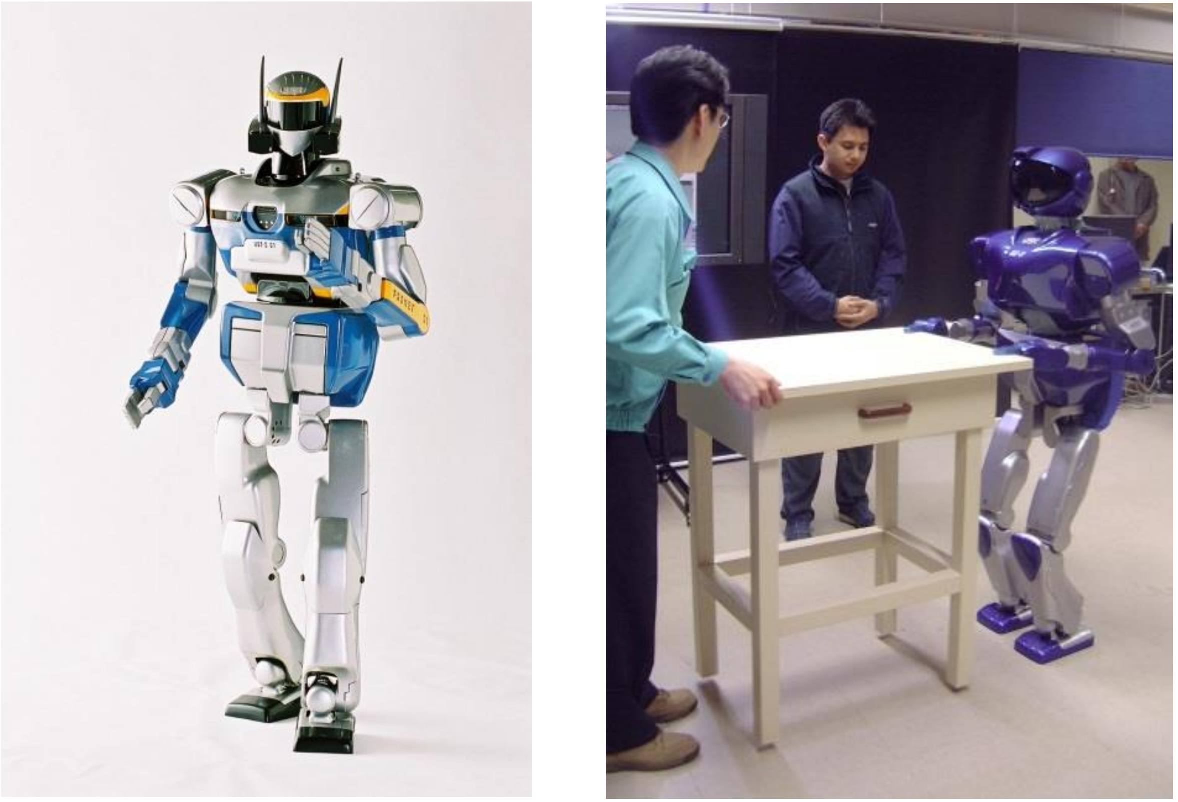
HK-MAV (SAT-UAV) Development

Personal Experience: 1991 – 2006, Kawada Industries, Inc.

Humanoid Development (Motor drivers and attitude estimation)



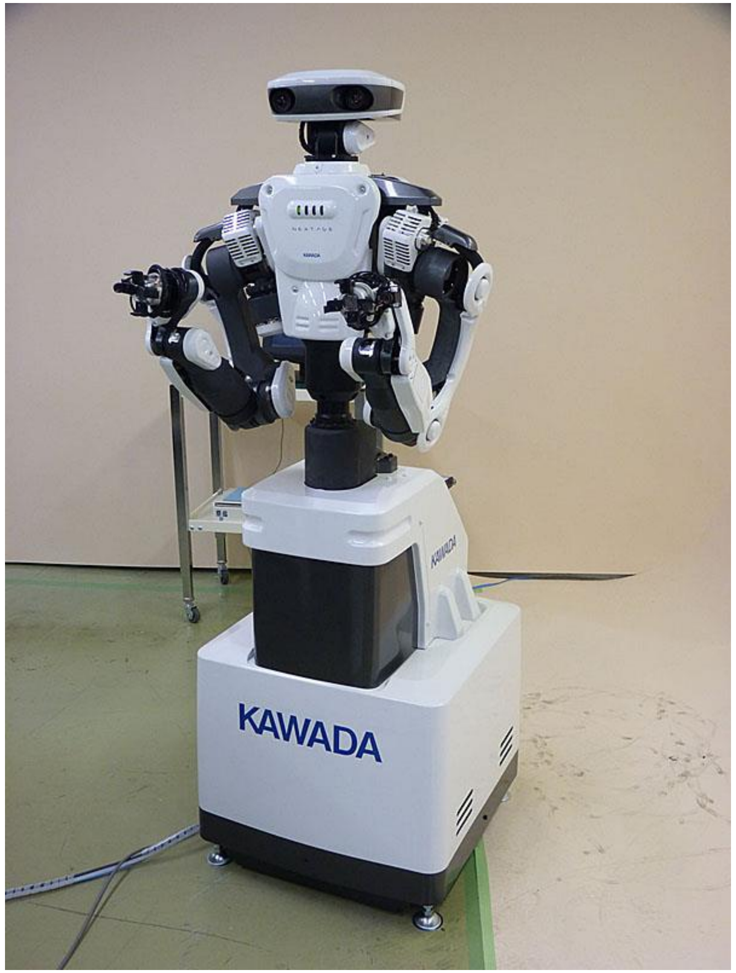
Prototypes for University of Tokyo



Demonstration of HRP together with AIST （産総研）

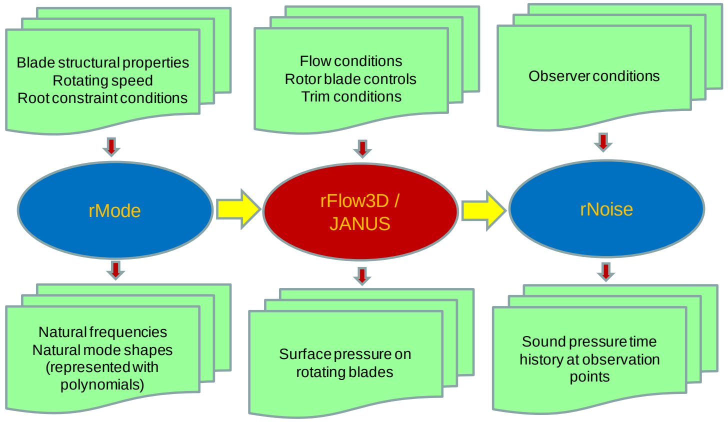
Current productions of Kawada Robotics, Inc

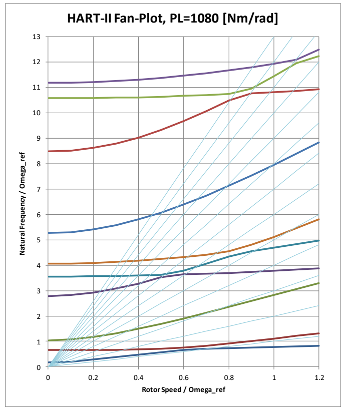
https://www.kawadarobot.co.jp/

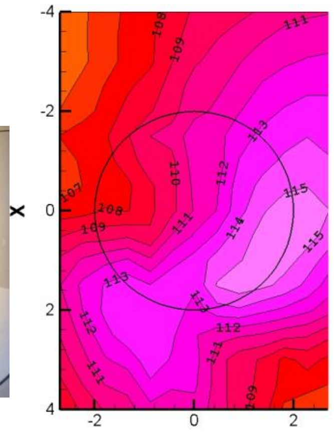


Personal Experience: 2006 – , JAXA, Rotorcraft R&D

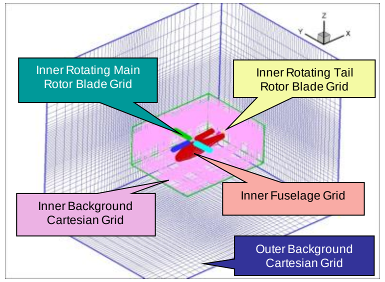
Numerical Analysis Flow

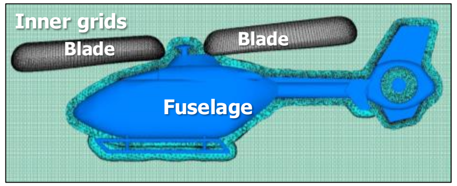


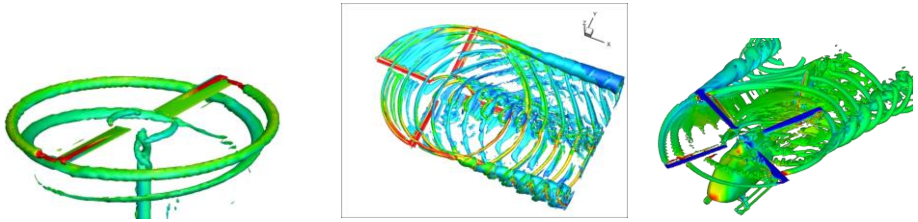




ロータ騒音計測の風洞試験と騒音予測（rNoise）







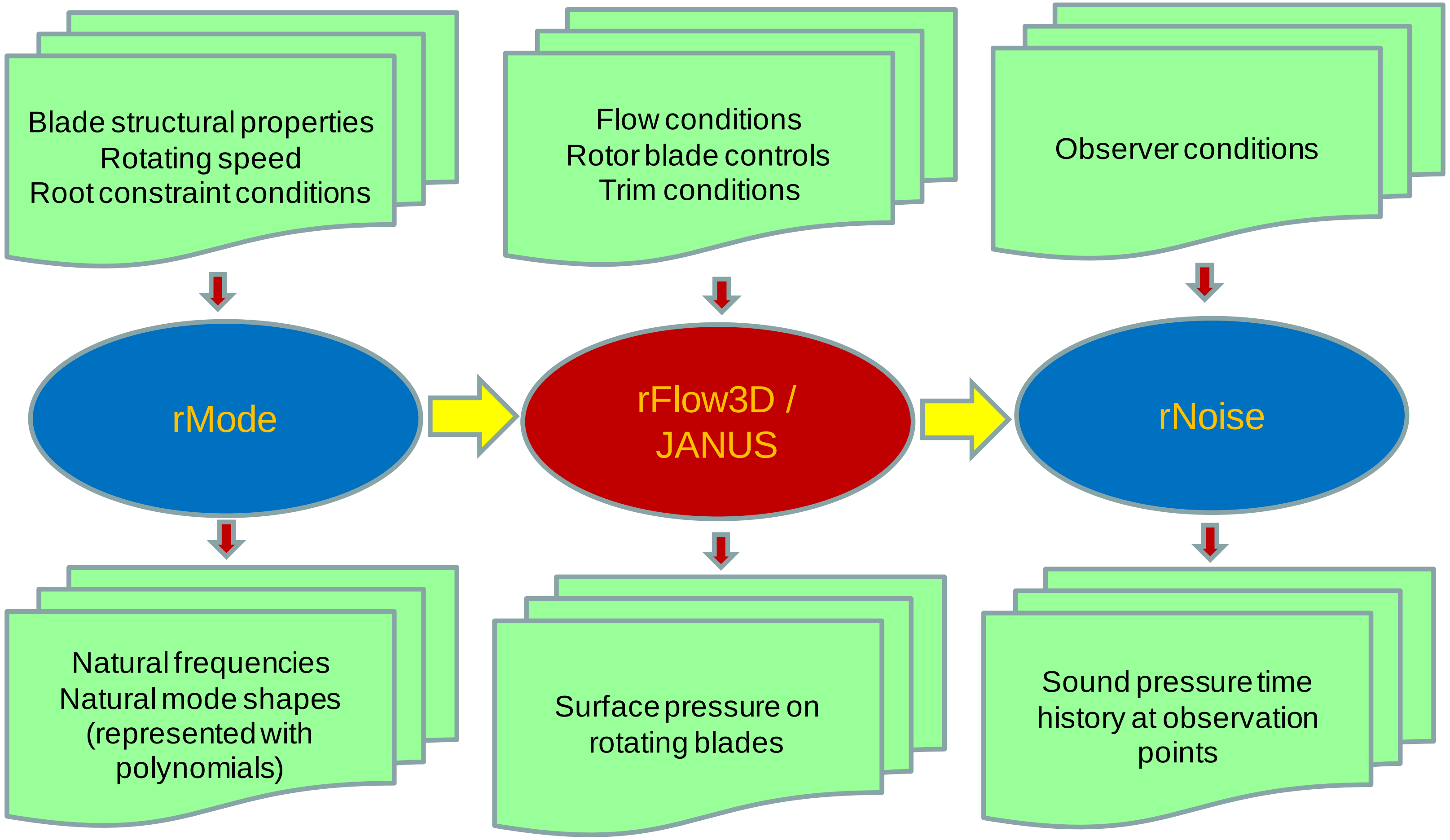
回転翼機空力・弾性・騒音統合解析ツールrFlow3Dの解析例

高速回転翼機（JAXA提案）

可変ピッチ制御マルチコプタに関する研究（ImPACT、科研費）

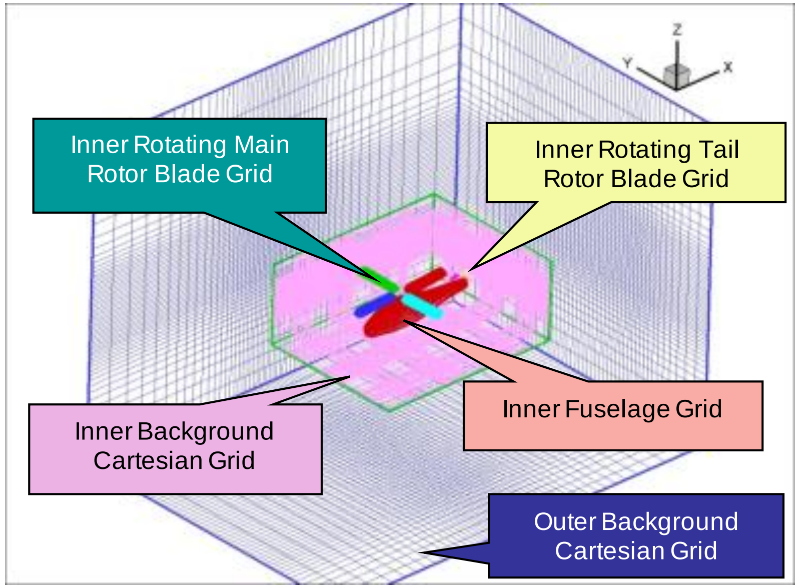
Personal Experience: 2006 – , JAXA, Rotorcraft R&D

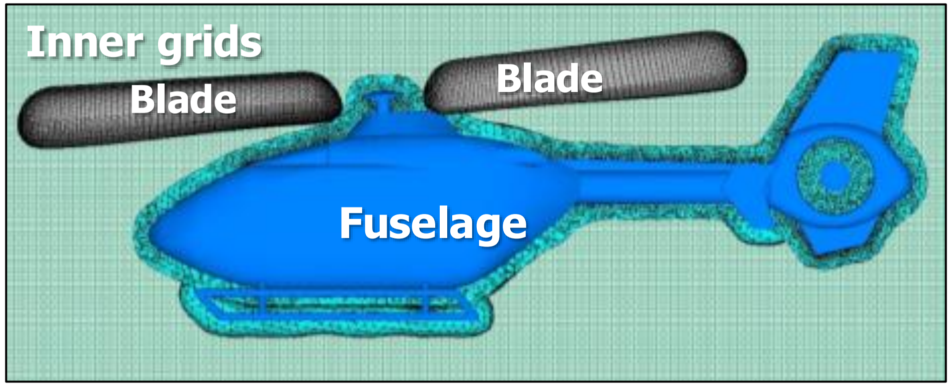
Numerical Analysis Flow

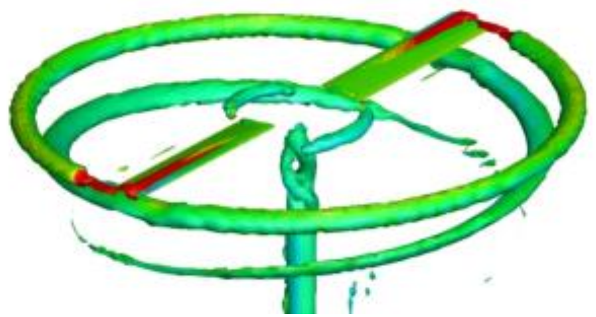


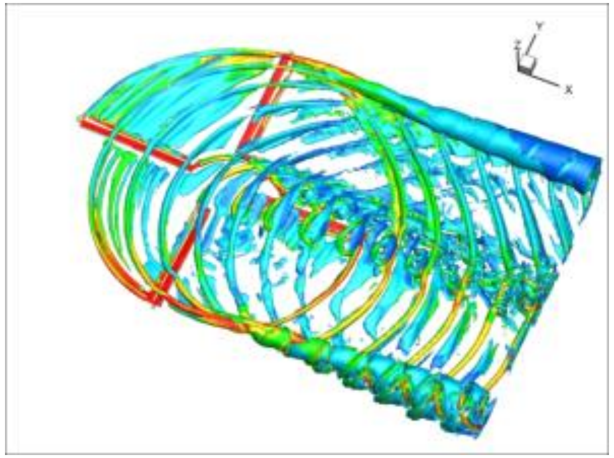
Construction of a Multidisciplinary Analysis Toolchain for Rotary Wings

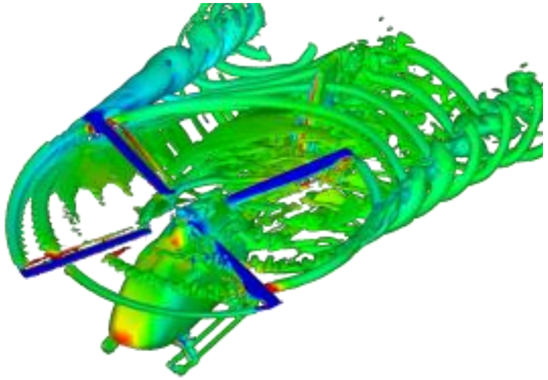
Personal Experience: 2006 – , JAXA, Rotorcraft R&D





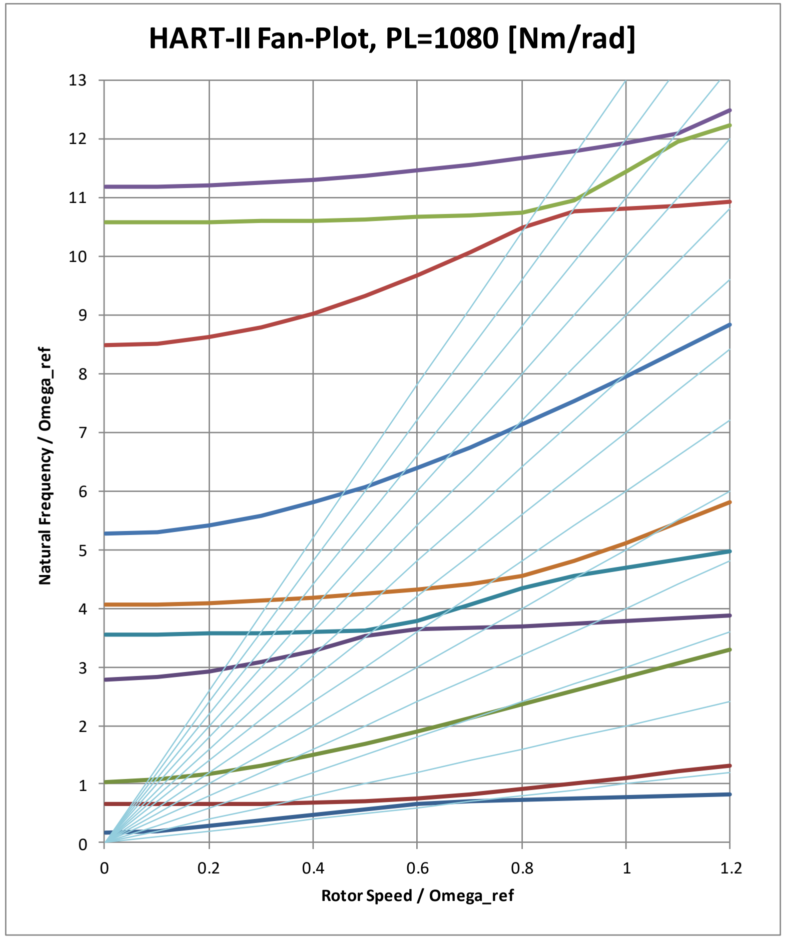


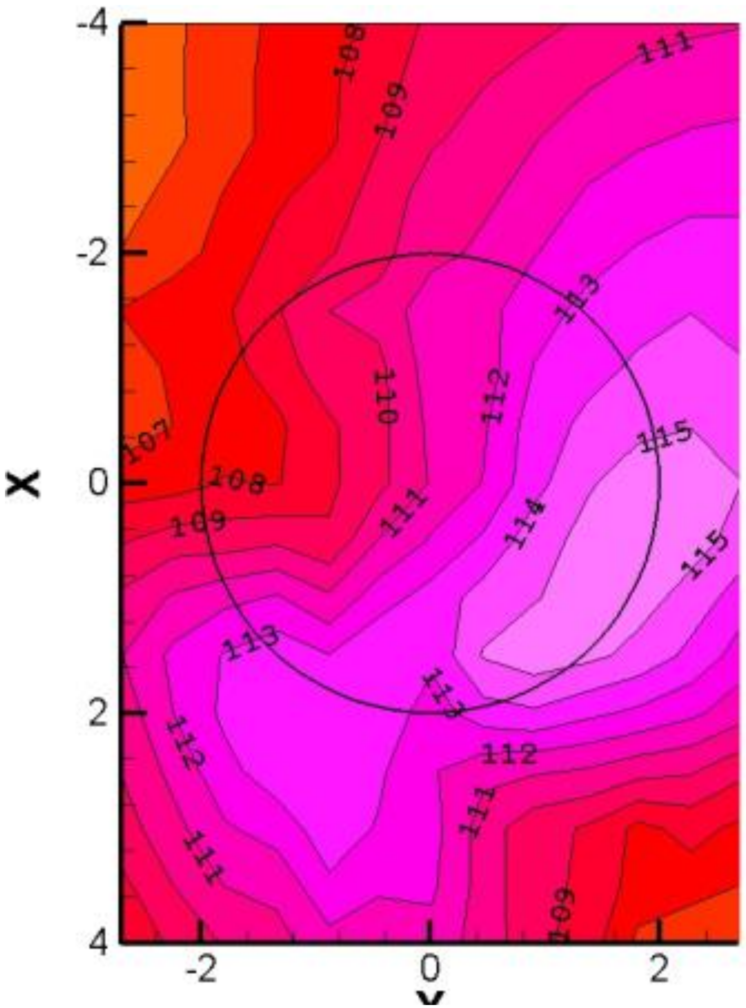




Methodologies and samples of results of rFlow3D/JANUS

Personal Experience: 2006 – , JAXA, Rotorcraft R&D





Result samples of rMode and rNoise

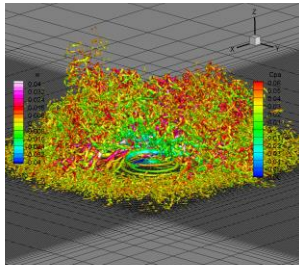
BVI noise reduction test using active flaps

Personal Experience: 2006 – , JAXA, Rotorcraft R&D

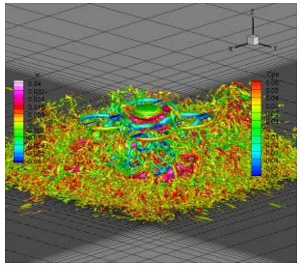
R & D of a concept of high-speed compound helicopter

R & D of variable pitch-controlled multirotor drones [funded by ImPACT and KAKENHI (Grant-in-Aid for Scientific Research)]

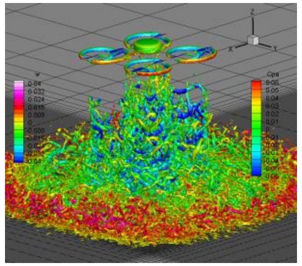
Ground Effect for a Quadrotor Drone



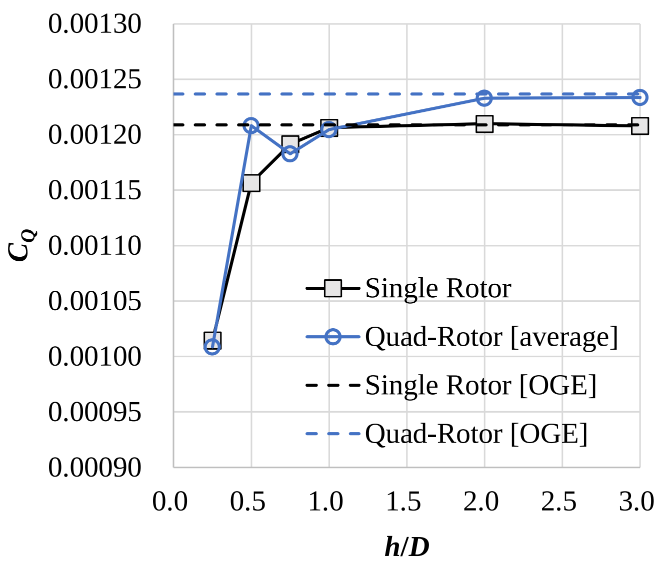
h/D=0.25

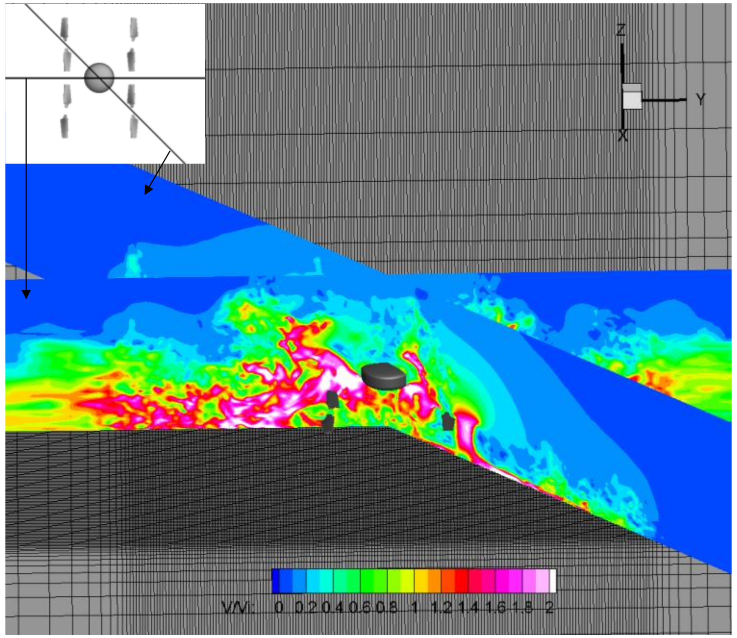


h/D=1.0



h/D=3.0

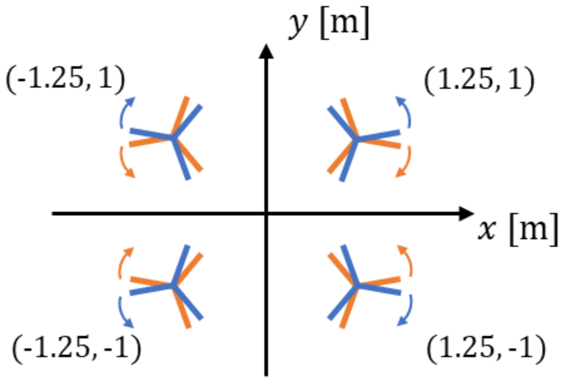


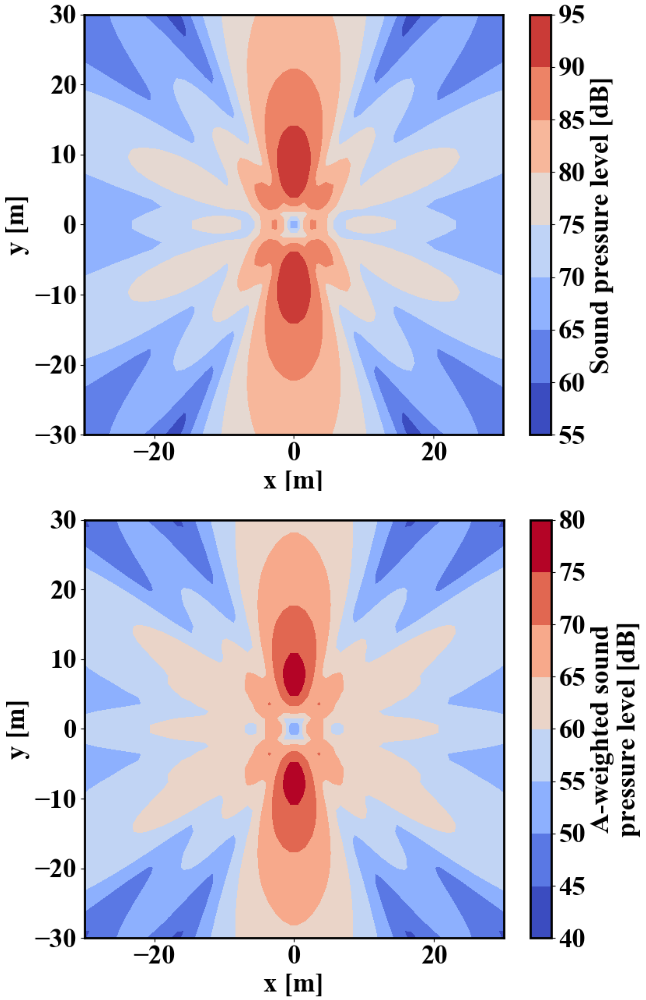


h/D=0.50

Noise prediction for a virtual eVTOL

SkyDrive SD-3
(The noise prediction on this page is NOT based on this aircraft)





Aeroacoustic intensity on the ground

Recent activities on aircraft electrification by JAXA/ECLAIR

Akira Nishizawa (Presented by Yasutada Tanabe)
Aeronautical Technology Directorate
JAXA

Overview of ECLAIR

Established July 1, 2018

Cooperation
Assemble different fields

Aeronautical industry
- Aircraft design, development

JAXA
- Electrified propulsion system
- Aerodynamics · Mechanics · Control
- Ground/Flight tests

Electrical industry, raw material/parts industry
- Electrification elements (Battery, power electronics, motor, …)
- Peripheral technology

Electrification ChaLlenge for AIRcraft Consortium (ECLAIR)

Steering Committee【Members】

IHI Corporation
Japan Aerospace Exploration Agency (JAXA)
Kawasaki Heavy Industries, Ltd.
Ministry of Economy, Trade and Industry
Subaru Corporation
Japan Aircraft Development Corporation
Hitachi, Ltd.
Mitsubishi Heavy Industries, Ltd.
Mitsubishi Heavy Industries Aero Engines, Ltd.
Mitsubishi Electric Corporation

【Observers】

AIATS, SJAC, MLIT Civil Aviation Bureau, NEDO, The University of Tokyo, ATLA, MEXT

Industry × Academia × Government
×
Next Generation Aeronautical Innovation Hub Center
(JAXA Aeronautical Technology Directorate)

- Electrification of passenger aircraft
  Ultra-low fuel consumption, reduction in CO_2 emission
  ⇒ Realization of emission free

- Electrification of small aircraft
- Electrification of components

Application to fields outside aviation

Though it is difficult for JAXA alone to tackle the issue of "electrification", there are a number of domestic companies with high potential with electrification technology.

In July 2018, the "Electrification Challenge for Aircraft Consortium*" was established. With this consortium, we aim for technological development and fortification of globally competitive technology power that are necessary for development of the "emission-free aircraft" enabling the realization of drastic reduction of CO_2 emission by combining Japan's world class electrification technology and aviation technology.

Utilize Japan's strength by cooperating with various sectors.

Electrification **Ch**a**L**lenge for **AIR**craft (ECLAIR) Consortium

http://fanfun.jaxa.jp/jaxatv/detail/12230.html

宇宙航空研究開発機構 次世代航空イノベーションハブ

Electrification ChaLlenge for AIRcraft (ECLAIR) Consortium　Vision for The Future ver.1 [Summary]

Dec. 17, 2018

JAXA Japan Aerospace Exploration Agency

① Societal background: Demand for air transportation will increase to 2.4 times in the next 20 years.

② CO_2 emission reduction target for aircraft: To achieve "half of 2005 by 2050", in addition to introduction of bio-fuel, the innovative technology for electrifying propulsion is essential.

③ International technology trend: Reached the level of practical electrified propulsion system for small aircraft.

④ Purpose of Consortium: Through cooperation and partnership both with aeronautical engineering and other fields, create innovative technologies for electric aircraft in order to drastically reduce the impact on environment such as CO_2 emission, and contribute to sustainable development of aeronautical industry.

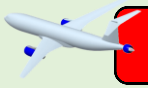
⑤ Significance of formulating Vision for The Future: By sharing the directionality and making communication and cooperation smooth among the consortium participants, promote research and development toward realization of electrifying aircraft and help expand the range of the participants. (The Vision for the Future shall be refined, and it will be updated according to the changes in the trend.)

Summary of the Vision for The Future　Practical implementation and contribution to global aeronautical industry

2020's: Start implementation of electrification technology for low power use (small electrified aircraft and MEA).

①Small aircraft　①MEA

MEA (More Electric Aircraft)



2030's: Expand application of electrification technology to commercial aircraft (Smaller than narrow body).

②Smaller than narrow body

2040's: Greatly reduce the fuel consumption of aircraft with electrification as the core technology.

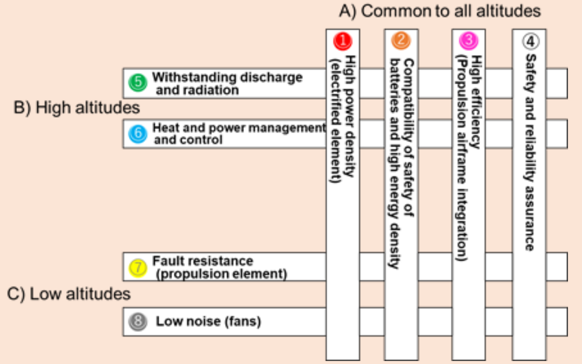
③Up to wide body

2050's: Reach the ideal goal of electrification. Clear contribution to CO_2 reduction.

④Ideal case

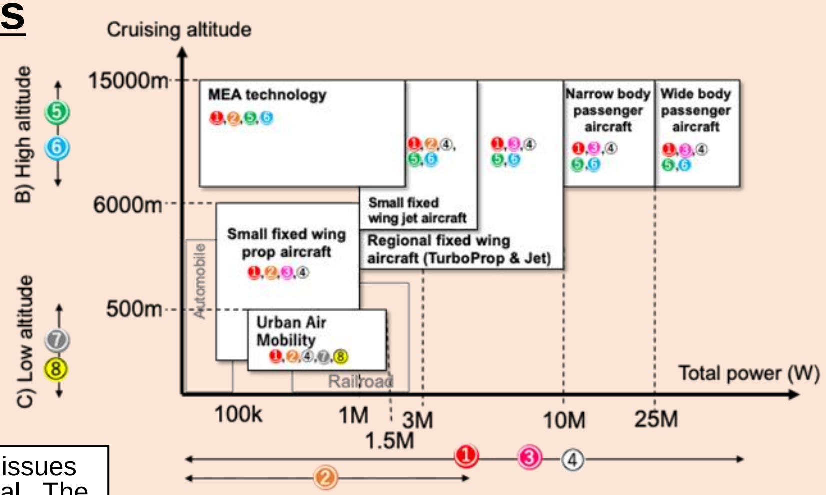
2020　2030　2040　2050　Year

Important technology issues



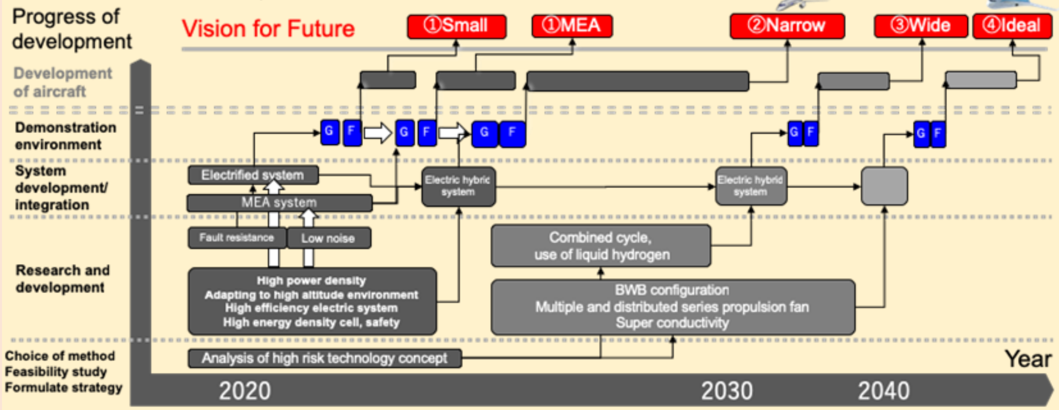
Important technology issues

- For commercial aircraft, solving the technological issues of adapting to high altitude environment is essential. The high power density and adaptation to high altitude environment are specific to aeronautical engineering and with high priority.
- For realization of Urban Air Mobility (Flying car), the technology for low altitude operation is important.



Relationship between important technology issues and their implementation target.

Technology road map

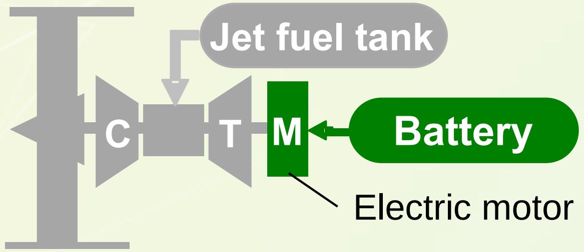


- Conduct ground test and flight demonstration with an appropriate timing for practical implementation.
- The common technology such as the high power density of the electrical element can be applied not only to commercial aircraft but also to MEA and small electrified aircraft in the early stage.

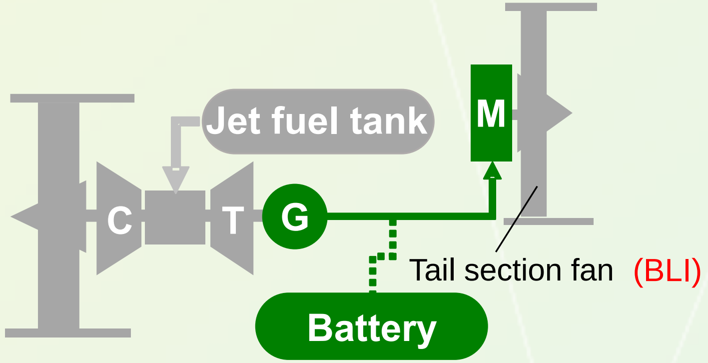
ECLAIR web site: http://www.aero.jaxa.jp/about/hub/eclair/index.html　E-mail to (Consortium office): eclair_sec@chofu.jaxa.jp

3.2 System Types (2/4 Early Stage of Hybrid Mode)

Early stage electric hybrid system which is easily applicable to commercial aircraft.



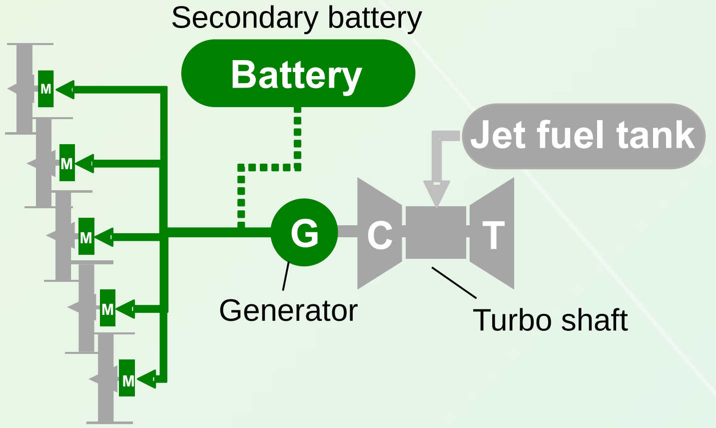
- Parallel hybrid
- Twin engines



- Series-parallel-partial hybrid
- Twin engines + Elec. fan aft fuselage

✓ Possible to continue conventional Tube&Wing design mostly as is.
✓ Possible to suppress the electrification power level to small values.

Relatively high risk system.



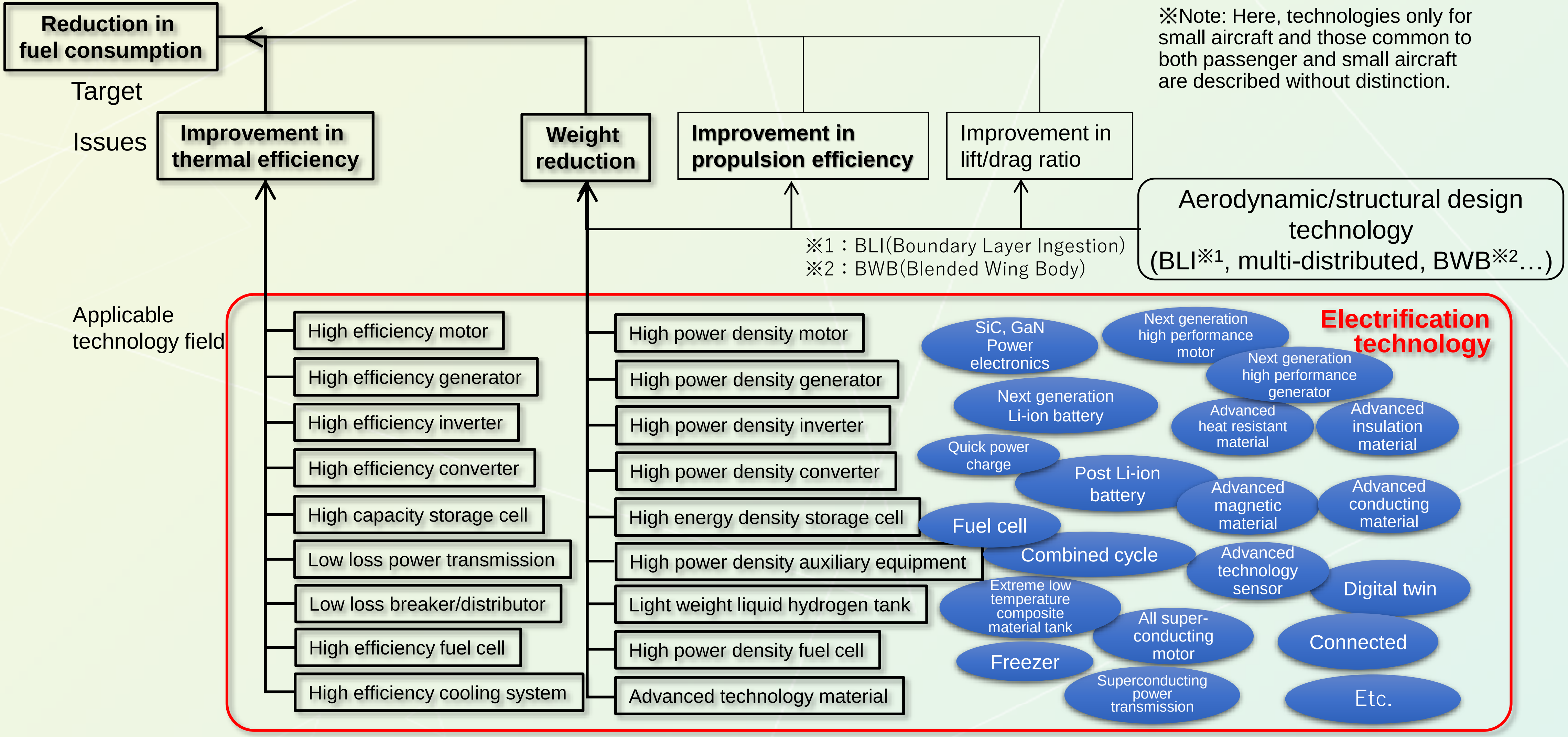
- Series hybrid
- Multi-distributed fan design

✓ Departure from conventional Tube&Wing design
✓ Electrification power level is maximum

- As an early stage electric hybrid system for commercial aircraft, systems such as parallel hybrid and series-parallel-partial hybrid are the strong candidates as these can continue the conventional Tube&Wing design and suppress the electrification power level to small values.

Map of Technological Challenges (1/2 Reduction in Fuel Consumption※)

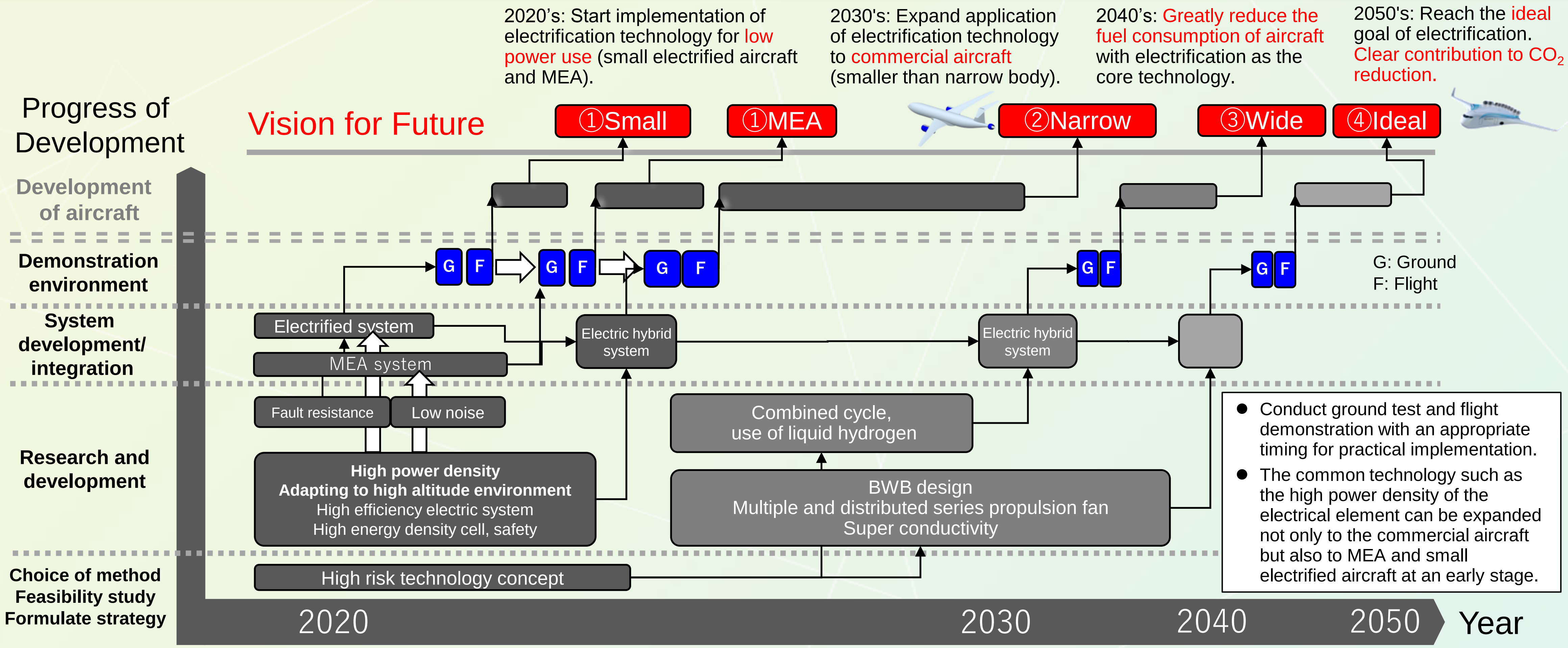
※Note: Here, technologies only for small aircraft and those common to both passenger and small aircraft are described without distinction.



Extraction of Important Technological Issues

Classification	No.	Important Technological Items (Summary)	Elements/System
A) Important technological issues common to all altitudes	①	**High power density** (Feasibility for weight secured; heat-resistance, cooling, and heat dissipation for securing running time with maximum power output.)	Electrical elements (electric motor, generator, power electronics, batteries, circuit breaker, distributor, electrical wires, etc.)
	②	**Compatibility of safety in batteries and high energy density** (Compatibility of containment of runaway over-heating risk and high energy density of the cell system as a whole.)	Batteries (Power storage)
	③	**High efficiency** (Improvement of propulsion efficiency by BLI and distributed propulsion system, improvement of heat efficiency of propulsion system.)	Integration of propulsion and airframe system, hybrid system, electrified elements.
	④	**Assurance of safety and reliability** (Assurance of safety and reliability of the system with increased failure rate due to addition of electrification components.)	Electrified propulsion system, hybrid system, electrified elements.
B) Important technological issues only in high altitude environment	⑤	**Withstanding electrical discharge and radiation** (Managing high voltage element, system discharge, and radiation effect in high altitude environment)	Power electronics, electric motor, generator, electrified elements.
	⑥	**Heat and power management and control** (Heat and power management under low air density and high temperature environment in and out of the gas turbine engine.)	Electrified elements, electrified propulsion system, hybrid system.
C) Important technological issues only under low altitude operation	⑦	**Fault resistance** (Fault resistance and fault tolerance design against emergency landing or continued flight with propulsion system failure)	Electrified propulsion system.
	⑧	**Low noise** (Reduction of aerodynamic noise from fans and propellers)	Fans, propellers.

Technology Road Map



- Conduct ground test and flight demonstration with an appropriate timing for practical implementation.
- The common technology such as the high power density of the electrical element can be expanded not only to the commercial aircraft but also to MEA and small electrified aircraft at an early stage.

Technology Development Group

① Cooperative area
② Competitive area

Area	No	Name of sub group	Objectives	Main organization
① Cooperative	①-1	Aircraft electrification common basis	・Sharing the aircraft concept (Technology Reference Aircraft) to be developed ・Sharing tools and methods for performance evaluation at aircraft levels	JAXA + 15 organizations
	①-2	Business model of small electric aircraft and consideration of ground infrastructure	・Study of use cases and business model for eVTOL in Japan ・Consideration of ground infrastructure such as charge point and verti port	Keio univ. + 13 organizations
② Competitive	②-1	Development of high power density electric motor adapting advanced magnetic circuit technology	・High power density motor ・Demonstration with prop	DENSO
	②-2	High altitude environment adaptive power conversion and distribution system	・High power and light weight power conversion / distribution ・Partial discharge suppression / radiation resistance	MELCO
	②-3	Low-noise propeller for eVTOL application	・CFD & experimental study of loop-shaped low noise propeller for eVTOL applications	JAXA

Summary

- The electrification technology for aircraft is the key to achieve dramatic reduction of CO2 emission from passenger aircraft and innovative changes to everyday transportation services for small aircraft.
- Through open innovation by strengthening cooperation with different sectors, aim for expansion of the aviation industry by applying the electrification technology, which Japan has the technological advantage, to the aviation field.
- JAXA, under the cooperation of Electrification Challenge for Aircraft Consortium, promotes the research and development of the technology that is essential to the common system components of small and passenger aircrafts and that greatly contributes to fuel consumption reduction.
- We shall continue extending the results from above for electrification of the components of small aircraft in the short to mid term plan, and for electrification of the passenger aircraft in the long term plan.

Thank you !

eclair_sec@chofu.jaxa.jp