*JAXA Aeronautics Symposium in NAGOYA*
*Oct. 12, 2012*

# *JAXA's Research Activities for Environmentally-Friendly Aviation*

Kazuhiro NAKAHASHI

Japan Aerospace Exploration Agency

# My Favorite Airplanes

*Wright Flyer I*

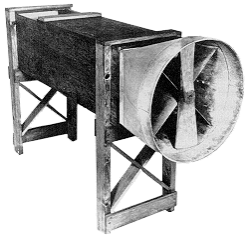
*(Dec. 17, 1903)*


*SpaceShipOne*

*mounted under White Night*

*(Oct.4, 2004)*

# New Technology Leads the Aircraft Innovation

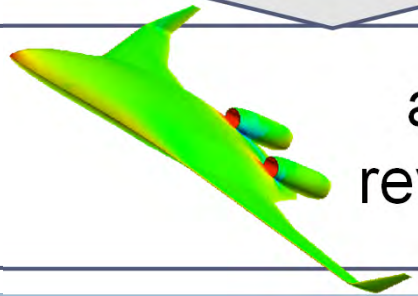
Wind tunnel

100 years


CFD

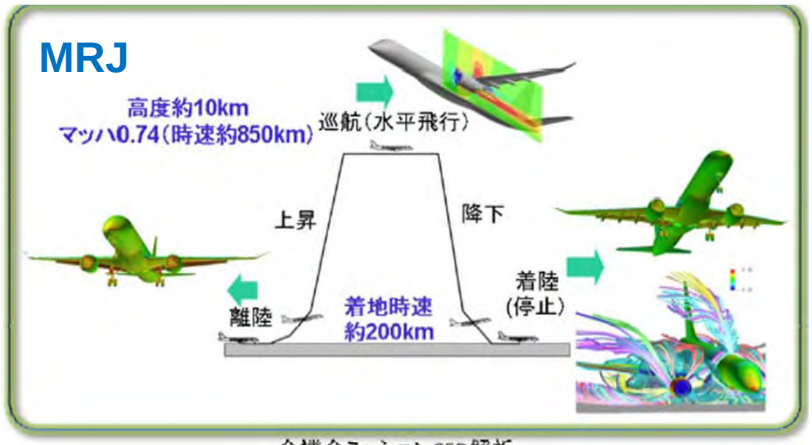
(Computational Fluid Dynamics)

future



another revolution?

| Number of wings tested in wind tunnels (NASA CP-2004-213028) | |
|---|---|
| B-767 (80s) | Testing 77 wings |
| B-737NG (90s) | Testing 11 wings |
| B-787 (2000s) | Testing 5 wings |



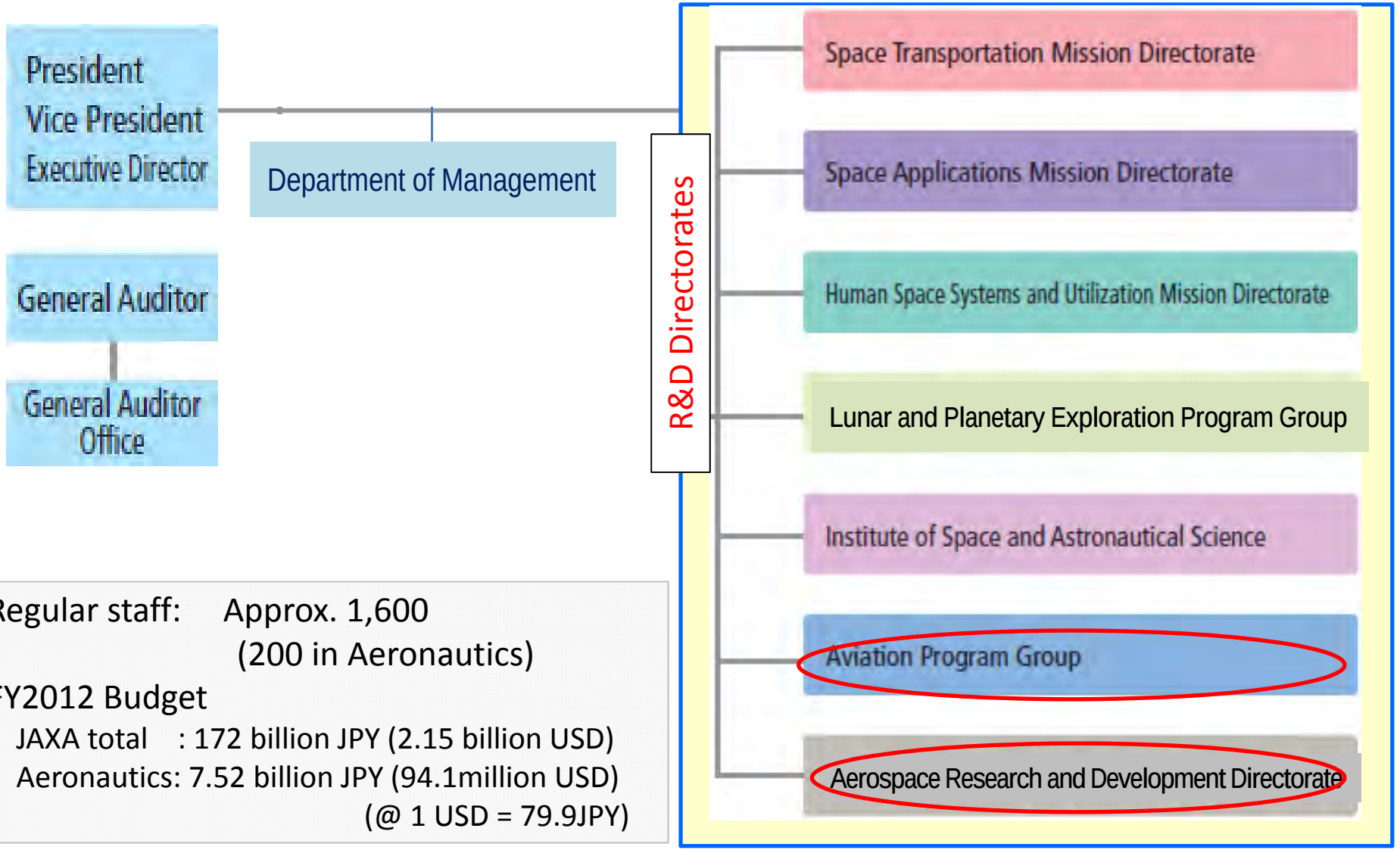

全機全ミッションCFD解析

JAXA's important role is to create new technologies which lead to the aircraft innovation.

# *Outline*

- Introduction of JAXA Organization for Aeronautics R&D
- JAXA's Current R&D
  - *Efficient & Clean Engine Technology*
  - *Composite Material Structure Technology*
  - *Noise Reduction Technology*
- Importance of R&D for Environmental and Safety Issues
- JAXA's New Research Initiative
  - *Environment Conscious Aircraft Technology(ECAT) Program*
- Conclusion
- Introduction of IFAR Summit

# JAXA's Organizational Structure, Workforce and Budget




Regular staff: Approx. 1,600
(200 in Aeronautics)

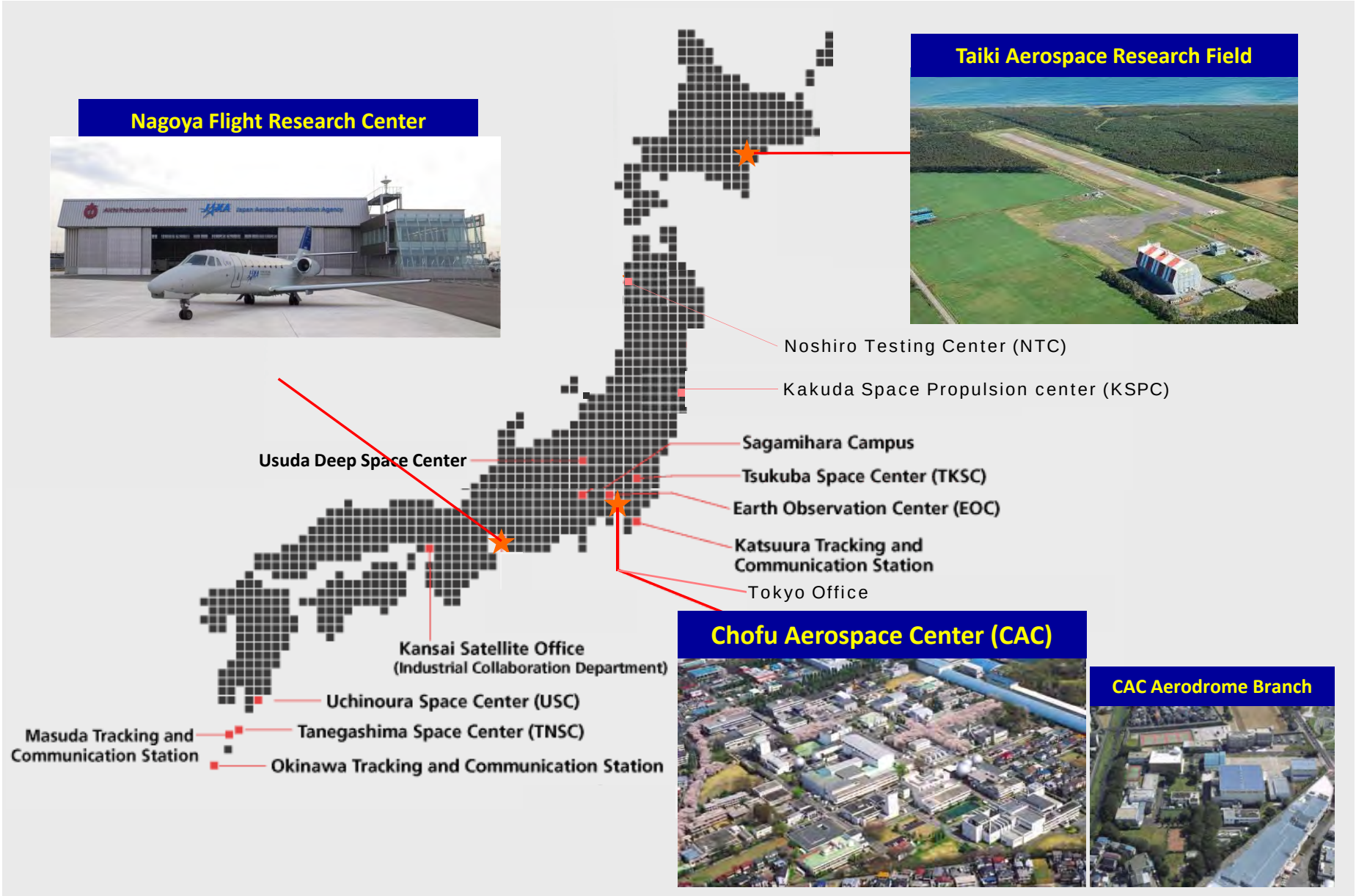
FY2012 Budget

JAXA total : 172 billion JPY (2.15 billion USD)

Aeronautics: 7.52 billion JPY (94.1million USD)

(@ 1 USD = 79.9JPY)

# Sites/Locations of the JAXA Aviation Activities



# JAXA Aviation; Contributions of R&D to Society

## Society's needs

( Safe and Secure Society, Enhancement of industrial base, environment protection)

## JAXA R&D

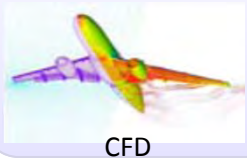
Advancing the flight science and technologies

1970s～1980s

FJR710

STOL-ASKA

1990s～2000s



CFD

Low cost manufacturing tech. (VaRTM)

2010s ～

Turbulence detection System

Clean engine

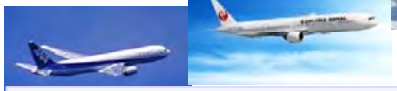
Silent supersonic airplane

## Industries

V2500 by International Aero-engine

Composite wing

YS-11( 1962-)



B787

Manufacturing B767 (15%), B777 (21%), B787 (35%)

MRJ

By Mitsubishi Aircraft Co.

## Contribution to the future aviation

## JAXA's facilities

Providing facilities to industries & universities

6.5m x5.5m low speed WT

2mx2m transonic WT

Test facilities of composite materials

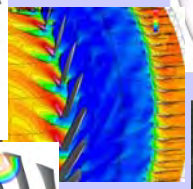
Dornier228-202

Hisho

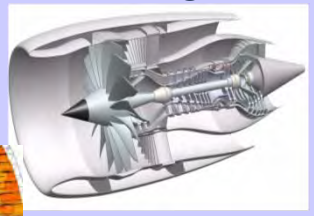
Flying test beds

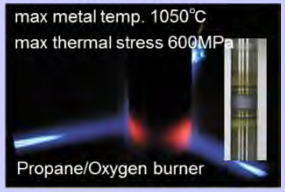
# JAXA's Current R&D for Environment/Safety

## Efficient & Clean Engine Technology

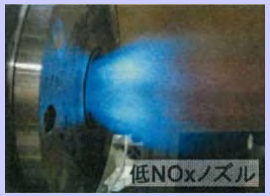


Advanced Fan Blades



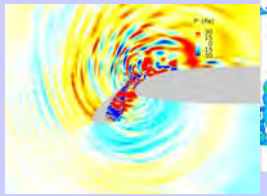


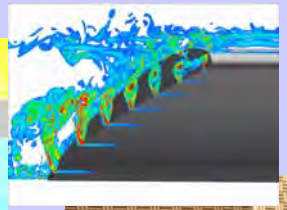

Advanced Material Research

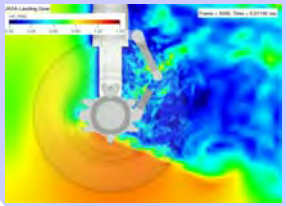


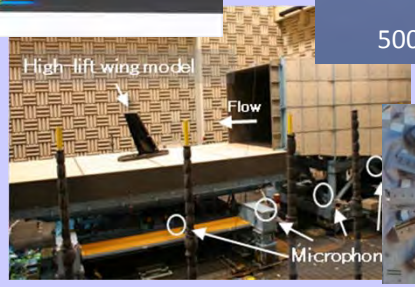

Low NOx Combustor (74% reduction)

## Noise Reduction Technology








## Composite Material Structure Technology

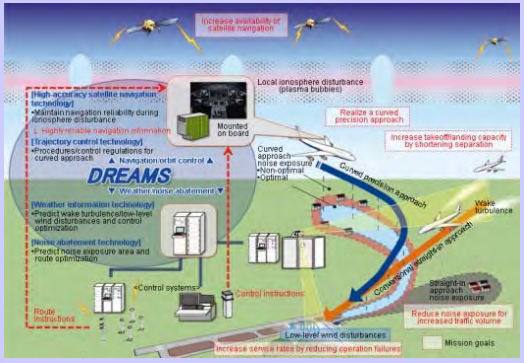
full scale

coupon



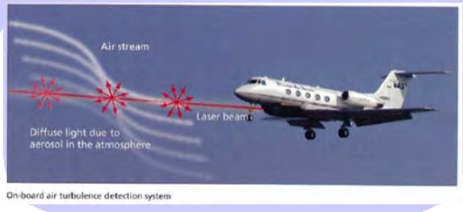


## DREAMS (advanced air traffic management)




## Silent supersonic airplane

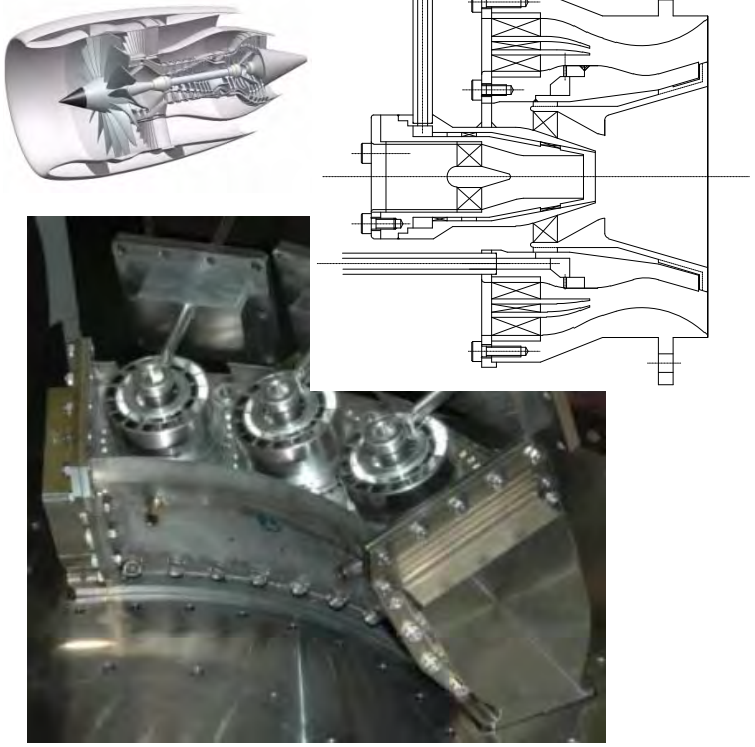
## Operation and Safety Technology



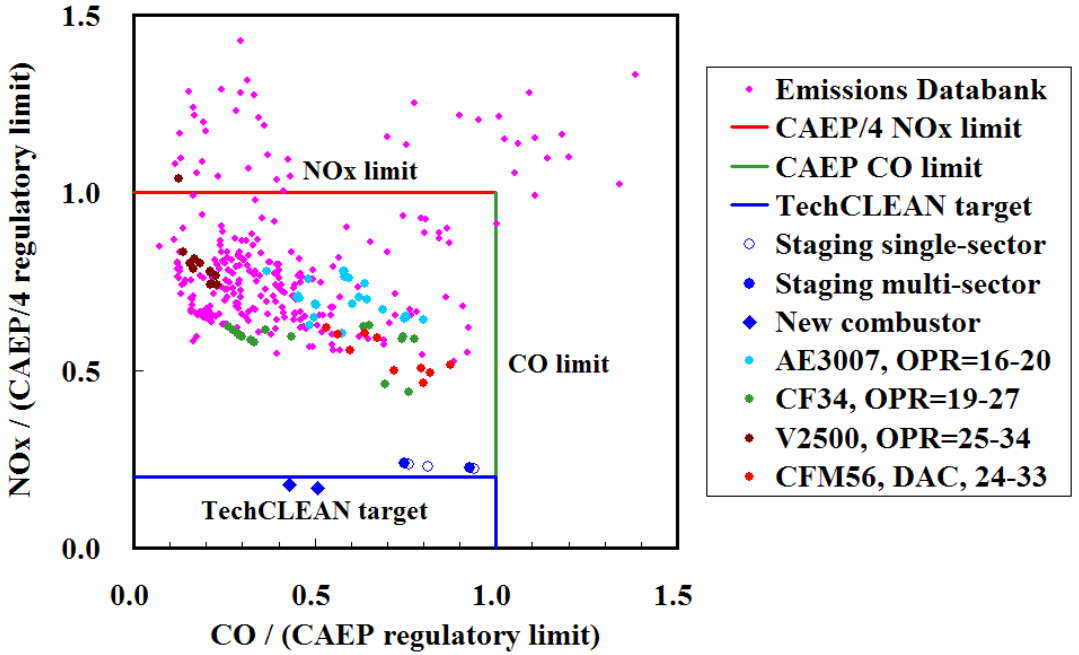
# JAXA's Current R&D for Environment/Safety

## NOx Emission Reduction Research

- Recent turbofan engines are designed with higher pressure compression and higher turbine inlet temperature.
- In such a condition, nitrogen oxides tend to be generated and difficult to suppress.
- Unique fuel nozzle systems were developed using a lean premix combustion technology, and achieved a 74% reduction of the 2004 NOx standard (CAPE/4) by ICAO.



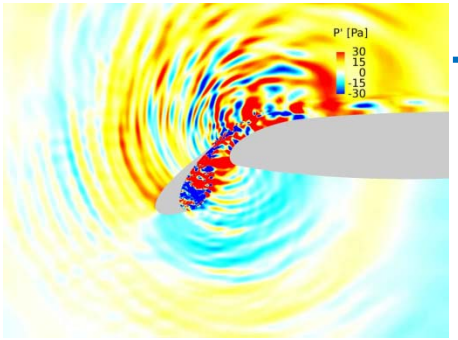
**Lean-premix staging combustor**



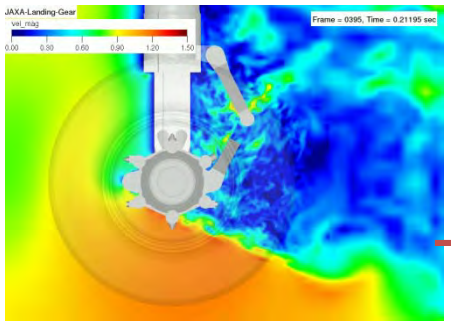
# JAXA's Current R&D for Environment/Safety

## Airframe Noise Reduction Technology Research

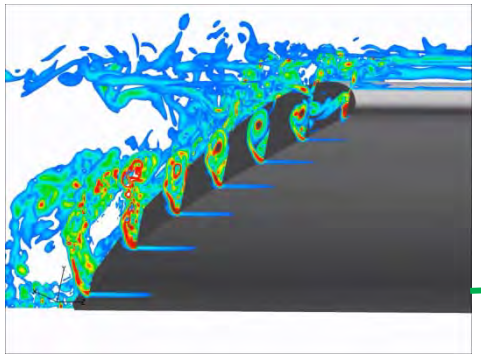
- For modern aircraft, airframe noise is prominent at approach condition.
- Computational Aero-Acoustics techniques are developed for better understanding of the main noise sources.



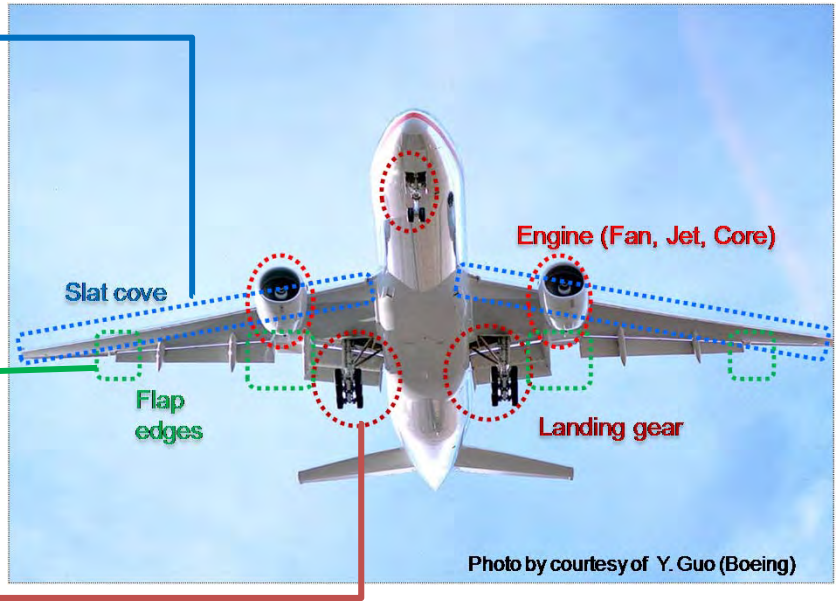

Slat noise generation



Landing gear noise source
- flow separation at bogie region



Flap edge noise source
- turbulent vortices




Main sources of aircraft noise

# *Recent Jet Passenger Planes*

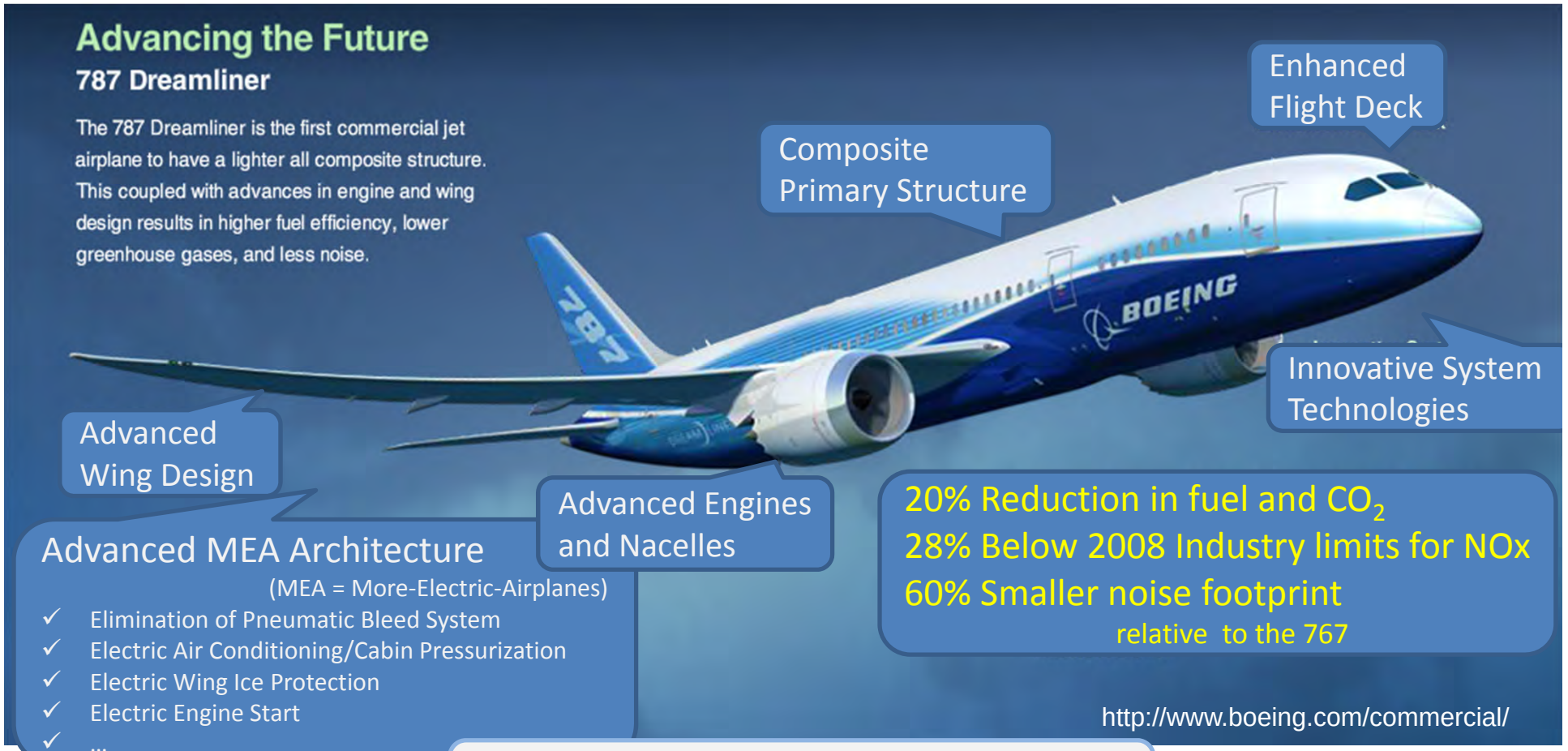

- First flight; April 2005,
- Entry into service; 2007
- Passengers; 500 to 800
- Mach 0.85,  Range 15,000km
- 13% lower fuel consumption
- Quieter than the  competitor


- First flight; Dec. 2009,
- Entry into service; 2011
- Passengers; 210 to 290
- Mach 0.85, , Range 15,000km
- 20% lower fuel consumption
- Quieter

Common key words for the recent jet passenger planes are the **lower fuel consumption** and the **lower noise.**


- First flight, 2013
- Passengers; 70 to 99
- More that 20 % lower fuel consumption
- Drastic reduction of airport noise

# *Boeing 787, the "Game-Changer"*



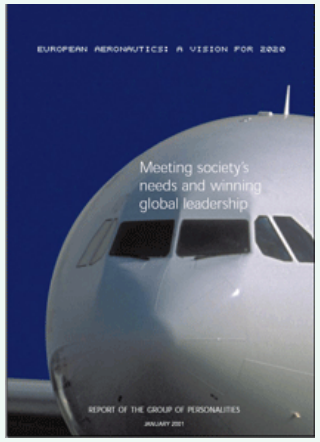

These aggressive challenges delayed the first flight of the 787 three years.

*Why did Boeing take the risks?*

- Competitions among aircraft manufacturers, especially against Airbus.
- Emerging technological challenges, especially for the environment.

# *Competition between EU and U.S. to gain global aeronautics leadership*

## European Aeronautics: A Vision for 2020 (2001)

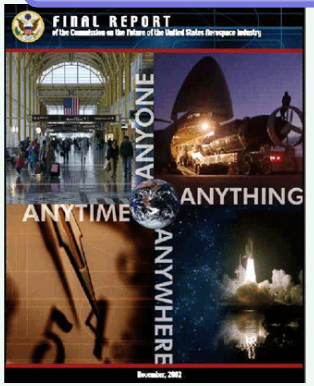



INTRODUCTION : Today's strength of European aeronautics was built on earlier strategies. The seeds were sown in the 1960s. The benefits are now being harvested. Airbus is one of the world's two dominant civil aircraft producers.・・・

*Vision: Responding to society's needs.*
*"More Affordable, Safer(80% reduction), Cleaner (50% fuel use), and Quieter"*

⇨ In 2020, European aeronautics is the world's number one.

## FINAL REPORT of the Commission on the Future of the U. S. Aerospace Industry (2002)



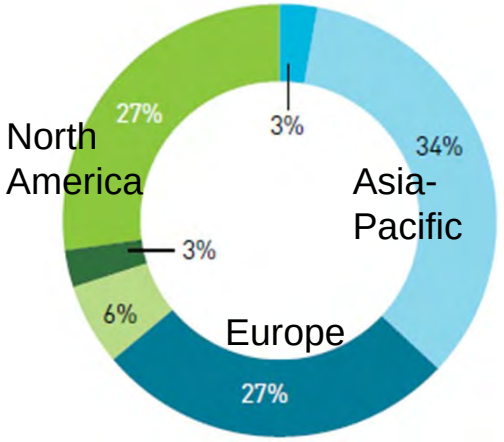

***An Aerospace Vision: "Anyone, Anything, Anywhere, Anytime"***

SUMMARY: Aerospace will be at the core of America's leadership and strength in the 21st century. ・・・ It is imperative that the U.S. aerospace industry remains healthy to preserve the balance of our leadership today and to ensure our continued leadership tomorrow.

# *Aviation is vital for economy.*

- ✓ Passengers carried by airlines; 2.8 billion.
- ✓ Jobs supported by aviation worldwide; 56.6 million.
- ✓ Aviation's global economic impact; $2.2 trillion.
- ✓ Of global GDP is supported by aviation, 3.5%

source : ATAG "Aviation /Benefits Beyond Borders/" (2012)



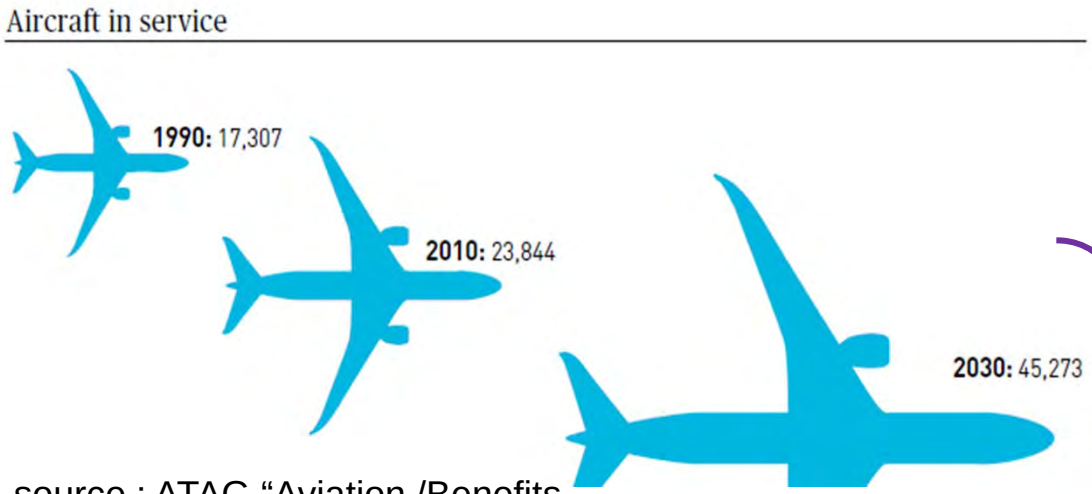

Regional passenger traffic split

- ✓ Jobs supported by civil aviation in U.S.; 10 million.
- ✓ Economic activity in U.S. ; $1.3 trillion.
- ✓ U.S. GDP is supported by aviation, 5.2%
- ✓ U.S. civil aviation manufacturing industry supported a positive trade balance of $75 billion (2009).

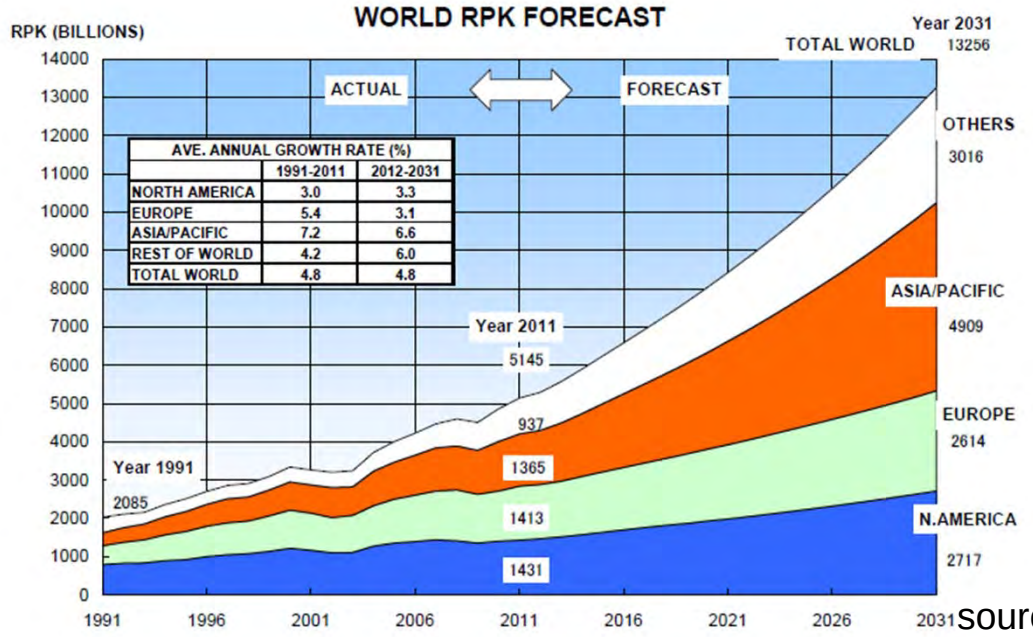
U.S. trade balance by industry (2009)
(Best five)


source : FAA "The Economic Impact of Civil Aviation in the U.S. Economy" (2011)

# *Aircraft-in-Service Doubled in 2030*




source : ATAG “Aviation /Benefits Beyond Borders/” (2012)




source : JADC (2012)

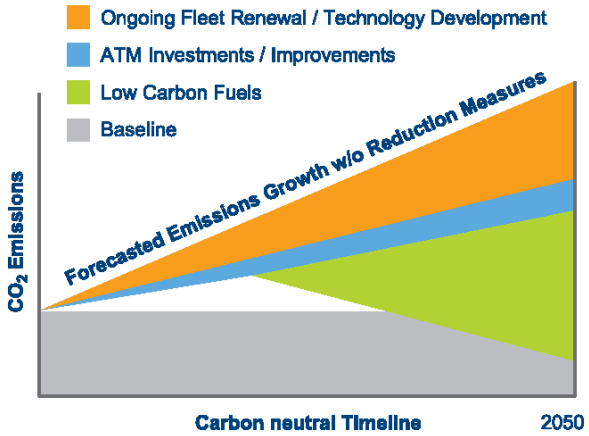
*Need to solve the emerging technological challenges for Environment, Energy, and Safety Issues*

*Cleaner,*
*Quieter*
*and Safer*

# *Importance of R&D for "Cleaner, Quieter and Safer" Aviation*

- Global Warming issue presents new technological challenges.

  IATA'S VISION:
  - By 2020, new technologies to result in at least 50% more fuel efficiency than today and 80% reduction of NOx emissions.
  - Zero carbon emission within the next 50 years.

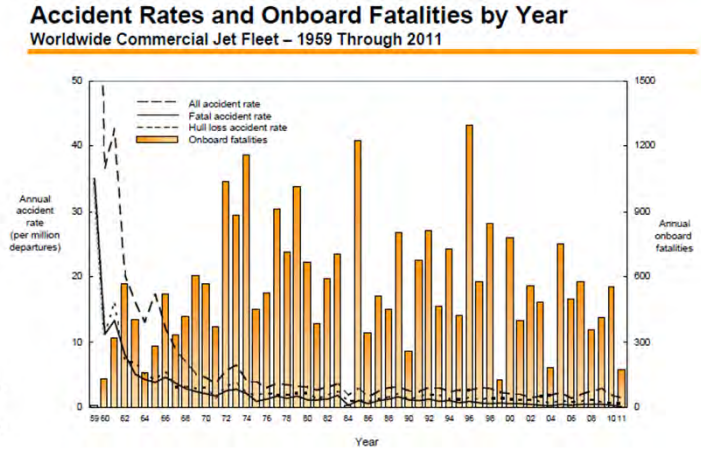



- Airport noise problem may hamper the convenience of air-traffic.

  Takeoffs and landings at night are inhibited at Narita and Osaka-Itami airports due to the airport noise.

- Safety is the paramount importance for the further development of aviation.

  With the increase of the number of airplanes, total number of aircraft accidents may increase, if the accident rate is constant.

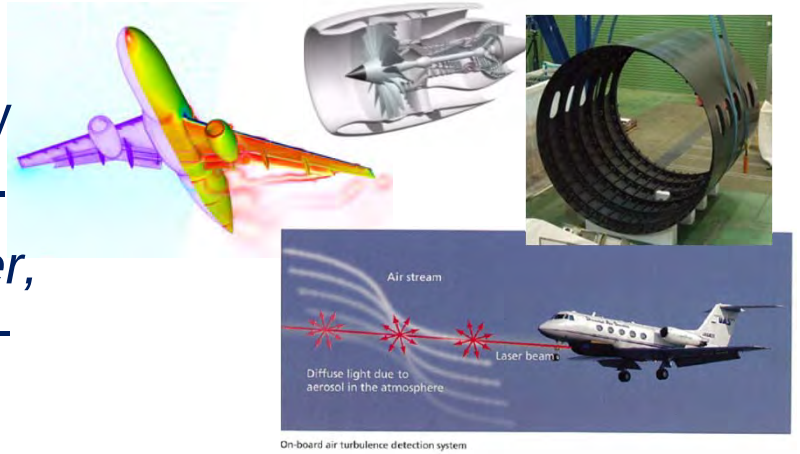



Commercial Jet airplane accider
http://www.boeing.cor

# *JAXA's Role for "Cleaner, Quieter and Safer" Aviation*

- Japan is not in a position to compete with EU and U.S., but has to technologically keep up to them for the further co-development of new passenger airplanes.
- Japan has been leading in the fields of energy-efficient products such as automobiles, trains, and so on. Japan should also contribute to the energy-efficient aviation.
- Aviation safety is also very important in Japan.
  - ✓ Haneda (Tokyo) is the fifth busiest airport in the world.
  - ✓ The route between Tokyo-Sapporo is one of the most frequent routes in the world.


- JAXA has been studying for environmentally friendly and operational safety technologies.
- We plan to strengthen these fields, "*cleaner, quieter, and safer*" airplane, in the next mid-term plan for FY2013-FY2017.

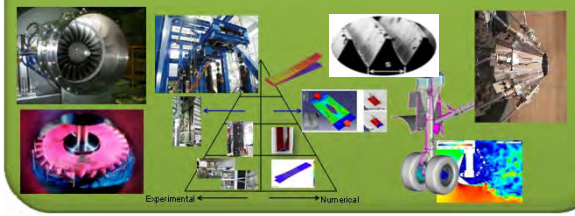


On-board air turbulence detection system

# *JAXA's New Research Initiative for Aviation*

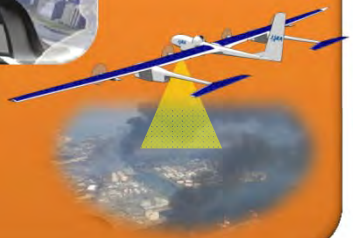
## ECAT

Environment Conscious Aircraft Technology Program




## STAR

Safety Technology for Aviation and Disaster-Relief Program

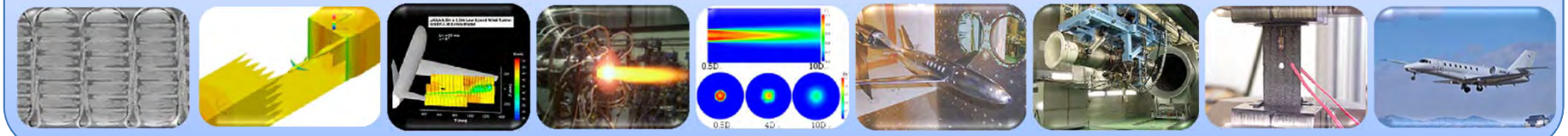


## Sky Frontier

Sky Frontier Program

## Science & Basic Tech.

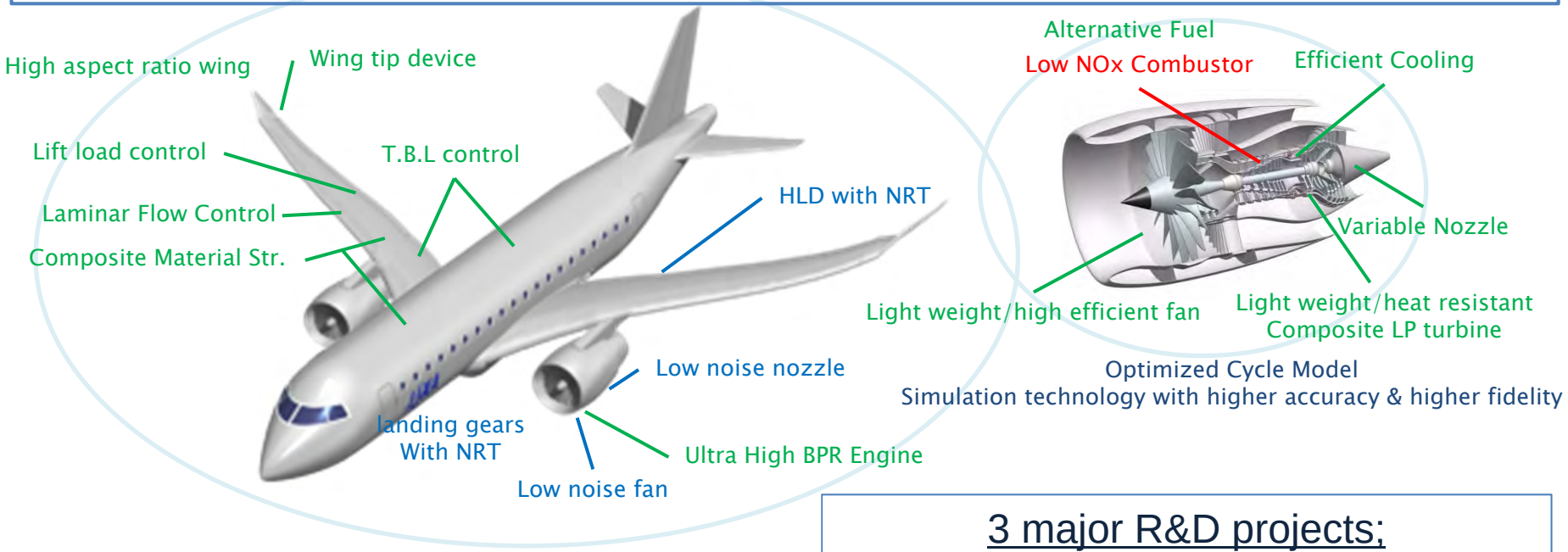
Aeronautical Science & Basic Technology Research Program



# JAXA's ECAT Program
## (ECAT = Environment Conscious Aircraft)

Program Objective: To develop and mature advanced technologies for environmentally-friendly subsonic transport, and transfer them to industries and society.

| | | |
|---|---|---|
| $CO_2$Emissions(Fuel Burn） | : | -30% (relative to same sized current aircrafts) |
| Airport Noise | : | -20dB (relative to ICAO Chap.4) |
| NOx Emissions | : | -70% (relative to CAEP/6) |




TRA2022-1

Multi-disciplinary optimization design technology
CFD technology with higher accuracy & higher fidelity

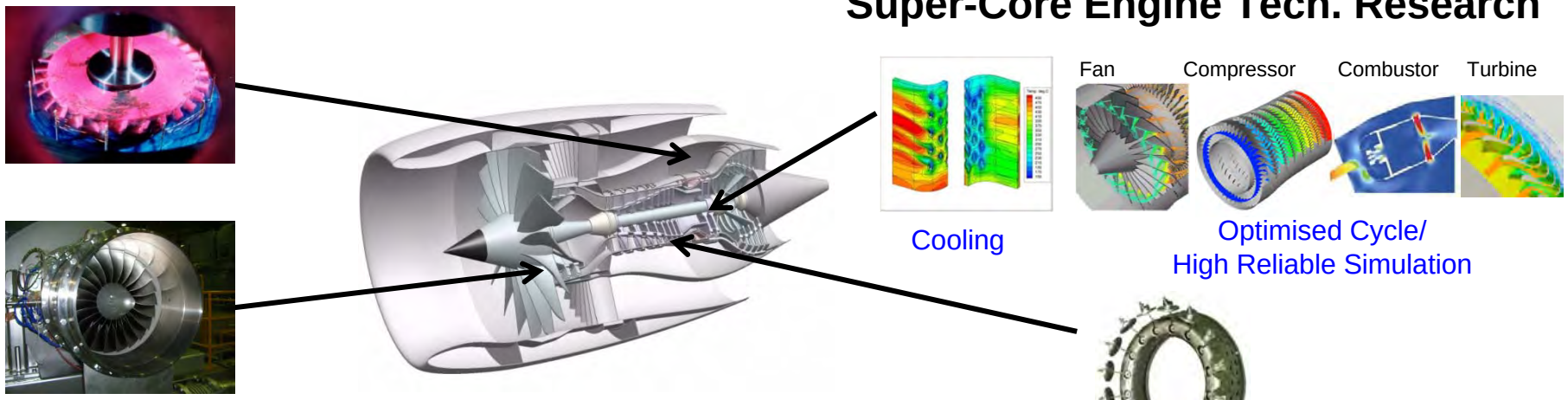
● : Fuel Burn(CO2 Emission) ● : Airport Noise ● : NOx Emission

3 major R&D projects;
1) Green Engine Technology Project
2) Eco-Wing Technology Project
3) Quieter Aircraft Technology Project

# 1. Green Engine Technology Project

**Next Generation High Performance Fan/Turbine Technology Research**
R&D on application of composite materials to the fan blades and low pressure turbine blades and/or the case.

**SuperCore Engine Technology Research**
R&D of elemental technologies such as cooling technology for super-high pressure turbine, high load compressor technology, and low NOx combustor technology.



# 2. Eco-Wing Project

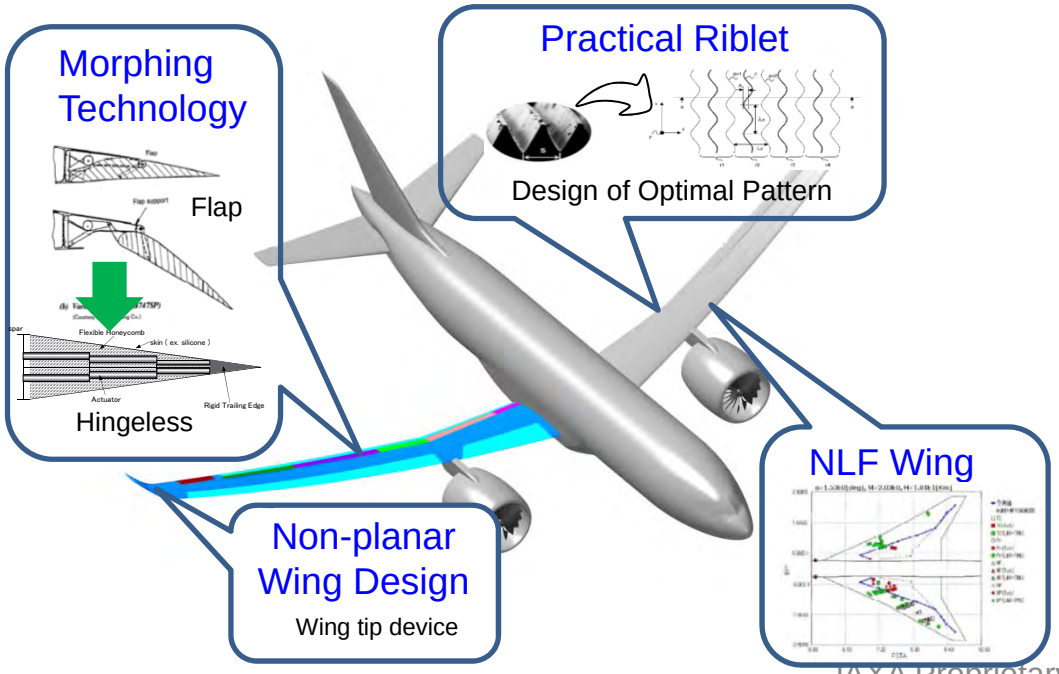
## Drag Reduction Technology Integrated Research

R&D on boundary layer control technologies, wing design technology and morphing technology, also flight experiments to demonstrate drag reduction technologies

## Composite Structure Application Technology Research

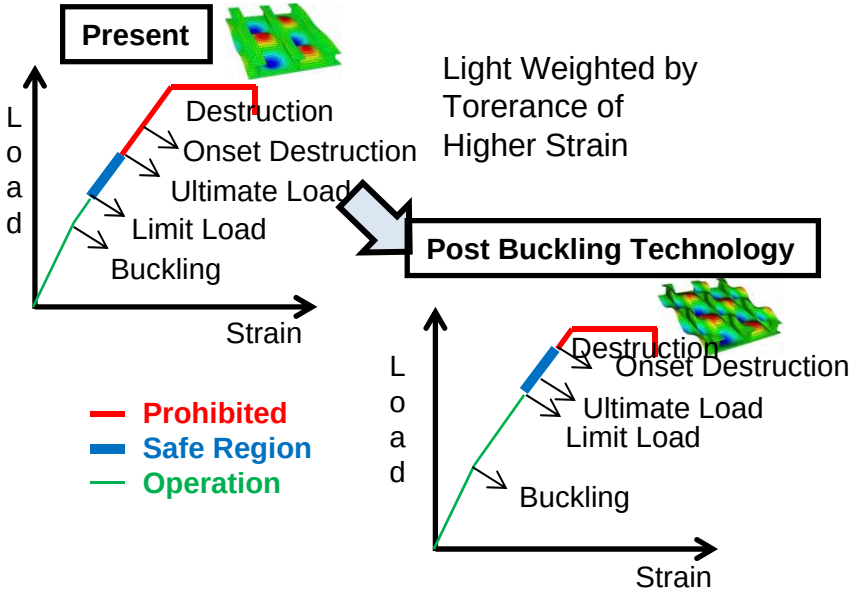
R&D on design philosophy and high reliable analysis tool to tolerate higher strain of composite structure(to enable post-buckling composite structure design), and to contribute to low cost process.

### Drag Reduction Tech. Integrated Research




### Composite Str. App. Tech. Research

R&D on high reliable analysis tool



# 3. Quieter Aircraft Technology Project

## Quieter Aircraft Technology Demonstration Research

Flight demonstration of airframe noise(landing gear, HLD) reduction technologies developed in cooperation with industries.

## Low Noise Aircraft Design Technology Research

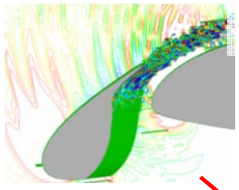
R&D on airframe/propulsion integrated design technology to reduce drastically airport noise.

## Engine Noise Reduction Technology Research

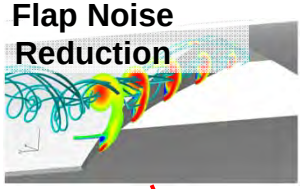
R&D on jet & fan noise reduction technologies in cooperation with industries, and demonstration by ground tests

## Quieter A/C Tech. Demo. Research

**Slat Noise Reduction**



**Flap Noise Reduction**



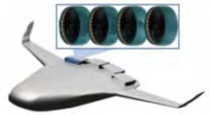
**Landing Gear Noise Reruction**

http://www.mrj-japan.com/j/index.html

Flight Demonstration

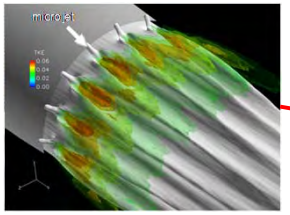
## Low Noise A/C Design Tech. Research

R&D on airframe/propulsion integration design technology(ex. MDO), including noise shielding



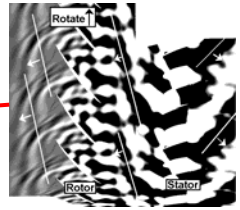
## Engine Noise Reduction Tech. Research

**Jet Noise Reduction**



Demonstration Using Existing Engine

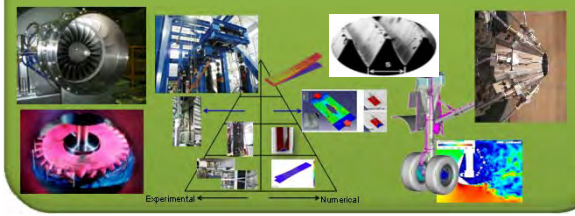
**Fan Noise Reduction**



# *JAXA's New Research Initiative for Aviation*

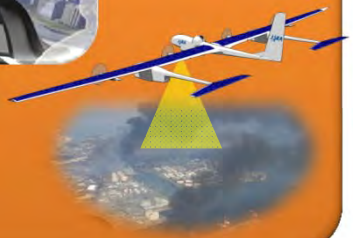
## ECAT

Environment Conscious Aircraft Technology Program




## STAR

Safety Technology for Aviation and Disaster-Relief Program

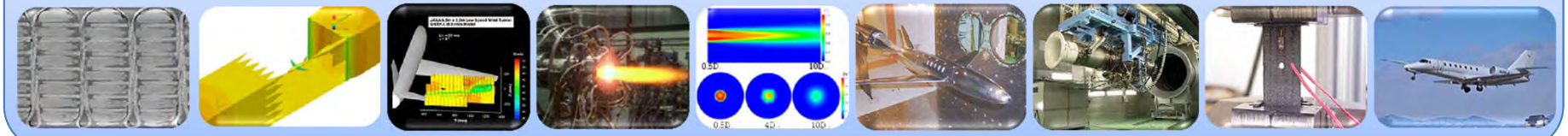


## Sky Frontier

Sky Frontier Program

## Science & Basic Tech.

Aeronautical Science & Basic Technology Research Program



# *Conclusion*

- ✓ Environmental and Safety Issues are the most important subjects for the further development of the world aviation.
- ✓ JAXA aviation research group, which has been working on these fields, will strengthen the activities to realize the "*Cleaner, Quieter and Safer*" Aviation.
- ✓ Breakthrough technologies are required for drastically resolving the environmental issues.
- ✓ Such a breakthrough may be created in the *interdisciplinary R&D*, such as introducing more intelligence, more electricity, more micro-technology, and so on to the aircrafts.
- ✓ For the interdisciplinary R&D, our knowledge and human resources are not enough.
- ✓ Collaborations with universities, industries, and other research organizations are required, not only domestic but international.

# International Forum for Aviation Research (IFAR)

## What is IFAR?

IFAR is the world's only aviation research establishment network, founded in 2010 and operates on voluntary, non-binding basis.

**Members**: Publicly-funded aviation research organizations from around the world, currently from 21 nations.

## Mission:

1. To connect the aviation research community worldwide
2. To serve as a venue for information exchange and communication
3. To develop among its members a shared understanding on challenges faced by the global aviation research community
4. To develop the IFAR Framework Document, to inform on future research strategies, and - where appropriate - to develop a combined research strategies for the future
5. Publishing and disseminating information (via website, flyers, publications, conferences)
6. To issue IFAR views and recommendations and give advice on aviation topics

## IFAR Summit:

IFAR holds an annual leadership meeting called "IFAR Summit". The 1st IFAR Summit was held in Berlin in 2010 with representatives from 13 nations taking part, while the 2nd IFAR Summit, held in north of Paris, brought together 21 nations.

## 3rd IFAR Summit in NAGOYA

IFAR | INTERNATIONAL FORUM FOR AVIATION RESEARCH

- ✈ JAXA will host the first Summit to be held in Asia at a historic temple built in 1688.
- ✈ 36 aeronautics experts from 17 public aviation research institutions will gather in Nagoya.
  - ■ Date: October 13-14th, 2012
  - ■ Place: "Yagoto Koshoji" temple
  - ■ Participating institutions: NASA (USA), DLR (Germany), ONERA (France), TsAGI (Russia), CIRA (Italy), INTA (Spain), NLR (Netherland), VKI (Belgium), KTN (UK), CSIRO (Australia), KARI (Korea), NAL (India), VZLU (Czech), ILOT (Poland), BME (Hungary), INCAS (Romania), JAXA (Japan)
  - ■ Issues to be discussed
    - Developing a regularly updated IFAR Framework Document outlining global research objectives and technological opportunities for use by its members.
      - ➢ Topics:
        - ① Climate Change (Emission)
        - ② Noise
        - ③ Alternative Fuels
    - Also on:
      - ① Education and promotion of young scientists and engineers
      - ② Public Relations
      - ③ Networking