1. Introduction of MRJ

2. EFD/CFD for MRJ Development

3. Future prospect on EFD and CFD
Vision and Key Features

【Vision】
• Apply advanced mainline jet technology to regional jet and create the standard for next-generation regional jet.
• Offer unprecedented values for environment, passengers, and airlines.

Environment
Lowest Fuel Burn, Noise, Emissions
- Game-Changing Engine
- Advanced Aerodynamics

Passengers
Most Comfortable Cabin
- Passenger-Oriented Cabin
- New Slim Seat

Airlines
Most Efficient Aircraft
- Game-Changing Engine
- Advanced Aerodynamics
- Human-Centered Flight Deck
- Composite Structure
MRJ Family

- Three models to cover global market needs
- High commonality for airline economics
  pilot type rating, engines, maintenance program and spare parts

**MRJ100X (Plan)**
100 seats

**MRJ90**
92 seats

**MRJ70**
78 seats

General Arrangement - MRJ90

- Designed for fuel efficiency without compromising cabin comfort

- High aspect ratio wing with winglets, small diameter fuselage, and innovative GTF engine

GTF: Geared Turbo Fan

- 29.2 m / 95.9 ft
- 35.8 m / 117.4 ft
- 10.5 m / 34.4 ft
- 5.3 m / 17.5 ft
- 14.0 m / 45.9 ft
Range Capability

- Optimum range capability for regional operations
- Well accepted by US, Europe, Asia and other global markets

Range Circle with Wind

From Nagoya

From Paris

From Denver

Passengers – Most Comfortable Cabin

Mainline jet comfort

- Same seat width as 787 with 8 abreast
  - MRJ: 18.5 in
  - 787 (8 abreast): 18.5 in
  - 787 (9 abreast): 17.2 in
  - EMB170/190: 18.25 in
  - CRJ: 17.3 in

- Ample head & foot clearance at the seat
- Large overhead bin

† IATA-recommended maximum size bag

Maximum size roller bag:
- 25 x 45 x 56 cm
- 9.8 x 17.7 x 22.0 in
- 2.03 m / 80 in
- 2.76 m / 108.5 in
- 1.88 m / 74 in
- (US Male 97.5%ile)
Environment – Lowest Noise

• Advanced aerodynamics and GTF engine for low noise
• MRJ90 noise area reduced by 40%

Current RJ

MRJ90

Environment – Lowest Emission

• Advanced aerodynamics and GTF engine for low fuel burn
• Significantly Lower Fuel Burn & CO₂ Emissions

CO₂ Reduced by More than 4,000 t./ year / a/c

* Mitsubishi Aircraft Estimation at Schiphol Airport (AMS)

* Mitsubishi Aircraft estimation, 500nm Trip, 2,200 cycle/year, Fuel price 3$/USG
Milestones and Events

Metal Cut Ceremony Sep./2010  Last Bolt Ceremony Mar./2011  First Rivetting April/2011  First Engine to Test May/2011


EFD/CFD for MRJ Development: outline

Aerodynamic characteristics will be validated by flight test.
Aerodynamic design: designed by CFD and evaluated by EFD
Aerodynamic data: estimated by EFD interpolated or corrected with CFD
Noise prediction: investigated/estimated/evaluated by EFD and CFD

EFD application
- Wind tunnel tests (examples)
- Flow visualizations by advanced optical measurements
- Noise source survey at low speed wind tunnel

CFD application
- CFD technology
- Simulation for all configurations
- Aerodynamic design based on MDO
- Equipment installation design for ADS and ECS
- Investigation for noise generation and propagation
Advanced optical measurement technologies (JAXA/MHI collaborative work)

- PSP (Pressure Sensitive Paint): aerodynamic load estimation.
- PIV (Particle Image Velocimetry): evaluation of chine design.

$\delta_{sp} = 0\text{deg} \quad \delta_{sp} = 20\text{deg} \quad \delta_{sp} = 60\text{deg}$

with Chine \hspace{2cm} w/o Chine

Velocity distribution around the wing-pylon junction (PIV)@High AoA of HLD cfg.
EFD for MRJ Development: Noise prediction

Noise source survey (JAXA/MHI collaborative work)
- Evaluate aerodynamic properties and noise level simultaneously.
- Understand where the noise comes from.

- Microphone array
- Noise visualization for HLD cfg.

CFD for MRJ Development: CFD Technology

Apply CFD technology developed by collaborative work with Tohoku Univ. and JAXA
⇒ Over 100,000 CPU hours calculation!

- CFD Tool for Complex Geometry (Collaborative work with Tohoku Univ.)
  - Unstructured Mesh: TAS (Tohoku Univ. Aerodynamics Simulation)
  - Cartesian Mesh: BCM (Building-Cube Method)

- Parallel Computing with Supercomputers (JSS, Cyber Science Center)
  Collaborative work with JAXA and Tohoku Univ.
  - Standard Steady Calculations: Aerodynamic Design etc.
  - Large Scale Unsteady Calculations: Noise and Flutter Analysis

- TAS
- BCM
### CFD for MRJ Development: All Configurations

**Data productivity criteria for practical aircraft design:** more than 1 case/day.
- Simulate all configurations of aircraft operation in a practical time.
- Apply to thrust reverser design to improve design efficiency and reduce risks before flight test.

- **Take-off/Landing Configurations**
  - 10 million mesh points, 3 cases/day
- **Cruise Configuration**
  - 7.5 million mesh points, 10 cases/day
- **Braking with Thrust Reverser**
  - 15 million mesh points, 1 case/day

### CFD for MRJ Development: Aerodynamic Design

**MDO (Multidisciplinary Design Optimization) developed by Tohoku Univ.**
- Apply to aerodynamic designs of wing/engine configuration and winglet
- Optimize aerodynamics (drag, lift) and structure (size, weight) simultaneously under constraints from design requirements.

**Design of Wing/Engine Configuration**
- CFD: Aerodynamic characteristics and aerodynamic load
- FEM: Internal forces and displacement of structure

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This document is provided by JAXA.
CFD for MRJ Development: High fidelity simulation

Toward CFD for “Actual aircraft”, instead of aero “Aircraft model”

- Protuberance drag, conventionally estimated with hand-book method.
- Location of ADS, conventionally defined at WT and FT.
- Performance of air inlet/outlet for ECS, APU, ventilation etc.

CD = 0.0300 : Total Drag of Airplane
(about 1/10 of Car)

ΔCD = 10^{-4} (1 count) : Low-Drag Design

ΔCD = 10^{-6} : Drag of a Sensor

Miscellaneous drag = 5% of CD!!!
Future prospect on EFD and CFD

Issues to be improved:

EFD
- Lead time for test model preparation: design/manufacturing
- Data productivity: per day/per test run
- Accuracy of measurement: drag
- Compensation for the effects due to flow condition differences: Re/facility etc.

CFD
- Lead time for calculation model preparation: geometry/grid generation
- Data productivity: hardware, algorithm

Further application:

EFD
- Extension to flight test: optical measurement/noise source survey
- Unsteady measurement: PSP for buffet

CFD
- Integration of multi-flow field: internal/external flow of equipment
- Unsteady simulation: dynamic stability/noise prediction

Flying into the future.

Mitsubishi Regional Jet, a new concept from Japan for the skies of the world.

http://www.mrj-japan.com/