Overview of MRJ Program and Systems

ICAS Biennial Workshop – 2015
“Complex Systems Integration in Aeronautics”
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Krakow, Poland

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Mitsubishi Heavy Industries Ltd
1. Program Overview
2. Diagram of System Integration
3. Example in MRJ Design
Program Status

- 2008  Launch
- 2009  Preliminary Design Review
- 2010  Critical Design Review
- 2012  PW1217G Engine First Flight
- 2013  Final Assembly Commenced
- 2015  First Flight
- 2017  First Delivery
General Arrangement

- Fuel Efficiency
  - without Compromising Cabin Comfort
    - High Aspect Ratio Wing
    - High Fineness Ratio Fuselage
    - Sharp Nose

- Innovative GTF Engine
Key Features

**Environment**
Lowest Fuel Burn, Noise, Emissions

**Passengers**
Most Comfortable Cabin

**Airlines**
Most Efficient Aircraft
State-of-the-Art Technologies

- Human-Centered Cockpit
- Passenger-Oriented Cabin
- Composite Structure
- Advanced Aerodynamics
- GTF Engine
MRJ Family

- Ultimate Commonality
  - Same Pilot Type Rating
  - Same Engines
  - Same Maintenance Program
  - Same Spare Parts

MRJ100X (Plan)
100 seats

MRJ90
88 seats

MRJ70
76 seats

Typical single-class seating at 31” pitch
### Principal Characteristics - MRJ90

<table>
<thead>
<tr>
<th></th>
<th>MRJ90STD</th>
<th>MRJ90ER</th>
<th>MRJ90LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passengers</td>
<td>88 (Typical single-class seating at 31” pitch)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cargo compartments</td>
<td>m³ (ft³)</td>
<td>18.2 (644)</td>
<td></td>
</tr>
<tr>
<td>Engine</td>
<td>PurePower® PW1217G Engine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrust</td>
<td>kN (lbf)</td>
<td>78.2 (17,600) x 2</td>
<td></td>
</tr>
<tr>
<td>Maximum takeoff weight</td>
<td>39,600 (87,303)</td>
<td>40,995 (90,378)</td>
<td>42,800 (94,358)</td>
</tr>
<tr>
<td>Maximum landing weight</td>
<td>38,000 (83,776)</td>
<td>38,000 (83,776)</td>
<td>38,000 (83,776)</td>
</tr>
<tr>
<td>Maximum zero-fuel weight</td>
<td>36,150 (79,697)</td>
<td>36,150 (79,697)</td>
<td>36,150 (79,697)</td>
</tr>
<tr>
<td>Operational empty weight</td>
<td>25,100 (55,336)</td>
<td>25,100 (55,336)</td>
<td>25,100 (55,336)</td>
</tr>
<tr>
<td>Fuel capacity †</td>
<td>lit. (USG)</td>
<td>12,100 (3,200)</td>
<td>12,100 (3,200)</td>
</tr>
<tr>
<td>Range * @88PAX x 102kg (225lb)</td>
<td>2,120 (1,150)</td>
<td>2,870 (1,550)</td>
<td>3,770 (2,040)</td>
</tr>
<tr>
<td>Maximum operating mach number</td>
<td>M 0.78</td>
<td>M 0.78</td>
<td>M 0.78</td>
</tr>
<tr>
<td>Maximum operating altitude</td>
<td>11,900 (39,000)</td>
<td>11,900 (39,000)</td>
<td>11,900 (39,000)</td>
</tr>
<tr>
<td>Takeoff field length (MTOW, SL, ISA)</td>
<td>1,490 (4,890)</td>
<td>1,600 (5,250)</td>
<td>1,740 (5,710)</td>
</tr>
<tr>
<td>Landing field length (MLW, Dry)</td>
<td>1,480 (4,860)</td>
<td>1,480 (4,860)</td>
<td>1,480 (4,860)</td>
</tr>
<tr>
<td>Approach speed (MLW)</td>
<td>km/h (kt)</td>
<td>252 (136)</td>
<td>252 (136)</td>
</tr>
</tbody>
</table>

† NOT include Unusable Fuel

* ISA, No Wind, LRC, Alternate 100nm
Range Capability: PARIS

ISA, 85% Annual Wind, LRC @37,000ft, Alternate 100nm, 5% Airways Allowance
Payload: MRJ90 88PAX X 102kg (225lb), MRJ70 76PAX X 102kg (225lb)
Significant Noise Reduction

- Noise area reduced by 40%
- Great benefit by lower community noise
  - Lower noise charge
  - Extending operations into noise curfews
  - Free from noise abatement flight tracks and runways

* Mitsubishi Aircraft Estimation at Schipol Airport (AMS)
Most Environmentally Friendly

Greenest in class to meet future environmental requirement

ICAO CAEP/6 Requirements

Characteristic % of Reg. limit.

- **NOx**: 50%
- **CO**: 70%
- **HC**: 85%
- **Smoke**: 75%

CRJ900
E190
MRJ
Best Cabin Comfort

- **Widest and Highest Cross Section**
- **Widest Seat**
- **Largest Overhead Bin**

**E170/190**
- 18.25 in
- 19.75 in
- 108.0 in
- 118.5 in
- 79 in
- 132 in

**MRJ70/90**
- 18.5 in
- 108.5 in
- 80 in
- 116.5 in
- Widest and Highest in class

**CRJ700/900**
- 17.3 in
- 16.1 in
- 106 in
- 106.0 in
- 74.4 in

Equivalent to 787

† IATA-recommended maximum size bag
(56 x 45 x 25 cm (22 x 18 x 10 in))
* Passenger Scale: 74 in (1.88 m) (US Male 97.5 %ile)
Game Changing Fuel Efficiency

* Mitsubishi Aircraft Estimation, Single Class Typical Seat, LRC, 500nm Trip
## Orders Received

<table>
<thead>
<tr>
<th>Company</th>
<th>Orders</th>
<th>Option/ Purchase Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANA</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>TRANS STATES HOLDING</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>SKYW EST, INC.</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Air Mandalay</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>EASTERN</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>JAPAN AIRLINES</td>
<td>32</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>223</td>
<td>184</td>
</tr>
</tbody>
</table>

**Total: 407**
Roll-out

2014.10.18
Low Speed Taxi Test

This picture is available for public use.

2015.6.8

This picture is available for public use.
Diagram of Product Development

- Product Planning
- Customer Support
- Customers
- Supply Chain Management
- OEM: System Integration
- Suppliers
- Airworthiness Certification
- Regulatory Authority
Diagram of System Integration (Design)

**Input**
- Market Needs
- Regulations
- Social Needs
- Technology Readiness
- Resource Constraints

**Requirement Capture**
- Performance Requirement
- Function Requirement
- Design Constraints

**System Analysis**
- Trade-Off Study
- Design Analysis
- Design Evaluation

**Function Analysis**
- Function Breakdown
- Requirement Allocation
- Interface Definition
- Architecture Definition

**Design Synthesis**
- Physical Transformation
- Alternative Definition
- Interface Definition
- Architecture Decision

**System Control**
- Traceability Management
- Configuration Management
- Data Management
- Schedule Management
- Cost Management
- Risk Management

**Output**
- Configuration Architecture
- System Specifications
- Decision Database
Diagram of System Integration (Design: Airplane System)

**Input**
- Fuel Efficiency
- Cabin Comfort
- Airworthiness
- Market Needs
- Regulations
- Low Emission
- Low Noise
- Social Needs
- Composite Material
- High BPR Engine
- Technology Readiness
- Resource Constraints
- Manpower Cost

**Requirement Capture**
- Performance Requirement
- Function Requirement
- Design Constraints
- Fuel Burn
- Cabin Noise
- Community Noise
- Thrust
- Electrical Power
- Redundancy
- Fail Safe

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Example: Engine Integration

Input
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- Resource Constraints

1. High BPR Engine

Requirement Capture
- Performance Requirement
- Function Requirement
- Design Constraints

2. Ground Clearance
- Water Ingestion Prevention

Requirement Analysis
- Trade-Off Study
- Design Analysis
- Design Evaluation

3. Rotor Burst Analysis
4. Thrust Reverser Analysis

Function Analysis
- Function Breakdown
- Requirement Allocation
- Interface Definition
- Architecture Definition

System Analysis
- System Control
- Traceability Management
- Configuration Management
- Data Management
- Schedule Management
- Cost Management
- Risk Management

Design Synthesis
- Lower Wing Surface
- Nacelle Position
- Aero Contour
- Pylon/Nacelle Configuration

Output
- Configuration Architecture
- System Specifications
- Decision Database

Example: High BPR Engine

- Market Needs
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- Performance Requirement
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- Design Evaluation

- Rotor Burst Analysis
- Thrust Reverser Analysis

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- Decision Database
Geared Turbo Fan Engine has emerged for step change fuel efficiency
② Design Constraints

Ground Clearance (Nose Landing Gear Collapse)
Avoid damage on engine at hazardous situation

Water Ingestion Prevention
Avoid water ingestion into engine at landing on water contaminated runway

Source: http://www.a350xwb.com
Avoid simultaneous loss of system for continued safe flight and landing.
Evaluate performance and impact by thrust reverser airflow

Isolated Test

Integrated Test

Thrust reverser performance and impact by thrust reverser airflow are evaluated by wind tunnel test and CFD
Design Synthesis: Lower Wing Surface

Complex lower wing contour made possible by advanced forming technology

Ultrasonic Peen Forming

- Steep span-wise curvature to house large diameter engine with clearance
- Sophisticated chord-wise airfoil shape for excellent aerodynamic performance
Design Synthesis: Nacelle Position

Optimized position for interference drag and structural weight

Distance to wing L.E, x/c

- Forward
- 0.0
- Aft

Height, h/c

- Forward
- 0.0
- Aft

- Reduce interference drag
- Increase pylon size

Interference boundary

- Reduce interference drag
- Increase pylon size
- Increase landing gear length

B737-300

MRJ
Careful tailoring in Pylon/Nacelle Configuration
- Optimization by CFD
- Free from shock and separation
Flying into the future.

Thank you for your attention

www.mrj-japan.com