HIKARI:
Paving the Way towards
High Speed Air Transport

Emmanuel Blanvillain, Airbus Group Innovations

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SUNJET 2 Forum
ILA Berlin, Germany
The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013), METI and MEXT.
Project Objectives

- Exchange, benchmark and understand
  Build on momentum from high speed projects in Europe and Japan

- Make visions converge into
  Joint design guidelines and technology roadmaps

- Perform technology studies in 3 key areas:
  environment, propulsion, thermal analysis

Duration: February 2013 - January 2015

Budget: ~4M€ of activity
The market is sufficiently large to allow sustainable airline operations (>200 a/c in 100pax configuration), provided that HS flights are fed by connecting network and at affordable ticket prices (<= twice BC price).

- Range: 13 500km, investigate opportunities for supersonic overland.

- Mach 5 is the best compromise speed.

- H2 but ... LHC/CH4

- Passenger Capacity: step-wise growth small for 2030+ → larger 2050+ to accompany market growth and master risks.
Meeting the market demand

by JADC & Airbus

Market Equilibrium

- Nb Aircraft (2032):
  - ~200 a/c

- Market Share:
  - ~20% of premium pax

- Ticket Price:
  - ~x2 BC fare

- Ex: 100 pax a/c

Commercial Requirements
Range and Sonic Boom Strategy

- **Range**: to capture 90% of the market, the required range is the following
  - **11500 km** [6200nm] with no ERF (Extended Range Factor)
  - **13500 km** [7300nm] when including the ERF

- **ERF**: Extended Range Factor (detour)
  - Not a big issue for time savings
  - Issue for fuel burn and vehicle sizing

- **Recommendation**
  - Investigate **low sonic boom** option to suppress the ERF

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Speed

**Commercial Requirements**

- **Speed**
  - **Mach 5** provides huge time savings against subsonic flight
  - No large time benefit beyond this
  - **Mach 5** provides significant cruise phases (>40%) even for medium range and low acceleration

- **Technology Impact**
  - Propulsion options at Mach 5 are larger: ramjet / PCTJ
  - Materials might be simpler / cheaper
  - More test facilities available

<table>
<thead>
<tr>
<th>Mission</th>
<th>Delta from Subsonic to Mach 5</th>
<th>Delta from Mach 5 to Mach 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 000 km</td>
<td>10.3 hours</td>
<td>0.5 hour</td>
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<tr>
<td>14 000 km</td>
<td>13.2 hours</td>
<td>0.7 hour</td>
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</tbody>
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Passenger Capacity: Step wise approach

**2030-2035**
- Business Jet size
- 10 passengers
- to initiate the business, as “niche” market first

**2040-2045**
- Small airliner size
- 100 passengers
- to grow the market, with more ambitious technologies (leading to longer range and cheaper tickets)

**2055+**
- Large airliner size
- 300 passengers
- to capture market growth and progressively develop towards a “mass market”
Main HIKARI Roadmap including Tech. Dev. Roadmap

<table>
<thead>
<tr>
<th>2015</th>
<th>2025</th>
<th>2035</th>
<th>2045</th>
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</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
<td>MS1</td>
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<tr>
<td>System Studies Feeding Tech. Dev.</td>
<td>FS Vehicle Requirements</td>
<td>FS Vehicle Definition / Project Development</td>
<td>MS2</td>
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<tr>
<td>Mission &amp; Conceptual Vehicle Studies</td>
<td>TRL 6 Phasing of Technology Development Roadmap</td>
<td>Reduced Size A/C Demo</td>
<td>MS3</td>
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<tr>
<td>Airborne Subsystem Demonstration Roadmap</td>
<td>MS4 FS Prototype Production &amp; Verification</td>
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<tr>
<td>Ground Based Subsystem Demo. Roadmap</td>
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<td>TRL 1</td>
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<tr>
<td>Environment</td>
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<td>Propulsion</td>
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<td>Thermal Control</td>
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<tr>
<td>Materials</td>
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<tr>
<td>Control</td>
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<tr>
<td>Aerodynamics</td>
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<tr>
<td>Structure</td>
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<tr>
<td>Safety / Operations / Social</td>
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<tr>
<td>Facilities / Tools / Capabilities</td>
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<tr>
<td>Synergies with Other Areas (Spin-Offs)</td>
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</tbody>
</table>

Starting Dates of Technology Streams Vary

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### Synergies and short-medium term benefits to other industries

<table>
<thead>
<tr>
<th>Synergetic topic</th>
<th>Short/Mid-Term application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive <strong>H2 production and use, incl. tanks</strong></td>
<td>Ground transportation, subsonic aviation (propulsion / fuel cell), space launchers</td>
</tr>
<tr>
<td><strong>Thermal and energy</strong> optimization method</td>
<td>More electric subsonic aviation, ground transportation...</td>
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<td>(+ components: lightweight heat exchangers)</td>
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<tr>
<td><strong>High temperature lightweight materials</strong></td>
<td>Subsonic aircraft engines, space re-entry vehicles, space propulsion,</td>
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<tr>
<td><strong>Atmospheric and climate modelling</strong></td>
<td>Subsonic flights : polar trajectories, business jets...</td>
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<tr>
<td><strong>Design methods and tools for highly complex and integrated vehicles</strong></td>
<td>Aerospace vehicle design...</td>
</tr>
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<td><strong>Design Rules evolution</strong> to allow high performance vehicles (single pilot...)**</td>
<td>Subsonic aircraft, sub-orbital vehicles</td>
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Added Value of EU-JAPAN cooperation

- **PARTNERSHIP**
  - Getting to know each other (people / ways of working)
  - Build trust for long term partnership

- **DISSEMINATION**
  - Increase awareness of hypersonic transport to a worldwide scientific and deciders community

- **TECHNICAL**
  - Parallel independent analyses allowed key findings in the market research (role of connecting network)
  - Complementary skills allowed to cover full perimeter of activities (ex: PCTJ in Japan, thermal analysis in EU)
  - Convergence of views on single EU-JAPAN vision towards hypersonic flight and common technology roadmaps to achieve this goal

The team has identified a joint way forward and is ready to initiate HIKARI 2
Thank You!

Any question
http://www.hikari-project.eu
http://www.euronews.com/2015/03/02/hypersonic-airlines/
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Recommendations on the Way Forward

- Develop a joint design following the HIKARI Guidelines, driven by a chief engineer and a collaborative team.

- Develop critical technologies identified in the HIKARI roadmap:
  - Thermal and energy system management
  - Low noise and low sonic boom
  - Propulsion: PCTJ, turbo ramjet: investigate and down select
  - High temp. lightweight materials

- Proceed with Joint demonstrators following the HIKARI roadmap.