Environmental issues for a supersonic business jet

ICAS Workshop 2009
28th, September 2009
**Introduction**

- **Supersonic Transport Aircraft in 2009:**
  - Potential strong interest for a small transport aircraft that could significantly reduce travel time (20% to 50%) as compared to current subsonic aircraft
  - Intermediate step towards commercial supersonic airliner
  - New technologies drivers
- But supersonic transport must overcome difficult challenges:
  - “Respect for environment” (emissions, community noise)
  - Regulations for sonic boom (supersonic flights prohibited over the US and in more than 50 countries) contradictory with need for supersonic overland flights
http://www.hisacproject.com

37 partners, from 13 European countries incl. Russia from Industries, SMEs, Research Centers and Universities
HISAC General Objectives

To establish the Technological Feasibility of an Environmentally Compliant SuperSonic Small Size Transport Aircraft*

*S4TA

- Provide specifications for an environmentally friendly and economically viable S4TA

- Make progress on elementary technologies and define road map for their future maturation and validation, up to a future proof of concept.
## HISAC Work Logic

### WP1: Initial objectives
- Environmental objectives & criteria
- Environmental objectives & criteria
- Environmental objectives & criteria

### WP2: Initial Modellings
- Modellings Development
- Modellings Support
- Modellings Support

### WP3: Key Technology
- Key technologies studies & assessments
- Models construction & Tests
- Key technologies assessments & syntheses

### WP4: Global acoustic, sonic boom & aero. concepts
- Models construction & Tests
- Numerical / experimental assessments
- Key integration

- Milestone T0+6
- Decision Point
- Decision Point
- Milestone T0+42

### WP5: Selection of the Aircraft Configuration
- First Iteration Design with available MDO process
- Second Iteration Design with improved MDO trade-off studies
- Third Iteration Design with improved MDO trade-off studies

- MDO Methods
- MDO Benchmarking
- MDO benchmarking

- 18 months
- 12 months
- 12 months

- 3 MDO loops
Environmental targets

- Close work between partners to define criteria

- Definition of a set of ambitious environmental targets for design activities:
  - **Low sonic boom**: criterion used ~65 dBA
  - **Noise**: Chap. IV or less (and local noise constraint)
  - **Emissions**: Temperature change [mK] between 2000 and 2100 (250 a/c and 100 flights/year/ac)

<table>
<thead>
<tr>
<th></th>
<th>anthropogenic</th>
<th>air traffic</th>
<th>SSBJ float</th>
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<tbody>
<tr>
<td>dT [mK]</td>
<td>3000</td>
<td>190</td>
<td>~0.08</td>
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Different accumulation time periods not directly comparable, nor to be scaled
**S4TA design process: a multidisciplinary approach**

- Taking into account conflicting requirements (performances vs. environmental drivers) requires the use of design processes that can exploit the synergisms of interacting disciplines: the MDO methodologies have been used and compared within HISAC.

  - **DA two level design process**
  - **CIAM MDO process**
  - **NLR/DLR design process**

- In addition, different visualization methods provide the designers with intuitive insight of a complicated design space.

- **ALA parallel coordinates**
- **DA Self Organizing Maps**
S4TA design process: a multidisciplinary approach fed by detailed environmental models

- Engine model
- Internal Layout
- External Shape
- Weight & Balance
- Aerodynamics
- Mission analysis
- Low speed performances

- Climate Impact
- Sonic Boom
- Community noise

- Environmental sizing loop

- Geometry sizing loop

- Engines models

- Noise models

- Aero / sonic boom models

- Emissions models

- Surface temp change (10-9 K)

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HISAC : various S4TA concepts

Common requirements
- Certification: JAR/FAR 25 + supersonic conditions
- Size of cabin: 8+ pax
- Range > 4000 nm
- Approach speed < 140kt
- Field length < 6500ft
- Community noise < ICAO chapter IV

Low noise configuration
- chapter IV - 10dB

Long range configuration
- Range: 5000 nm

Low boom configuration
- 65dBA overland

Low Mach configuration
- M0.95-1.2

All configurations share common objectives:

- Passenger comfort:
  - Provide sufficient passenger comfort for all missions
  - Cabin altitude / Cabin noise compatible with existing small size A/C or business jets

- Performance
  - Increased speed with at least transatlantic range
  - Operate from today’s airport
  - Top today’s business jets cruise altitudes
  - Meet the most stringent environmental requirements

- Design and manufacturing
  - Design incorporate the latest technologies
  - Use of best available material for increased weight reductions
HISAC: various S4TA concepts

Low noise configuration (Team A)

Long range configuration (Team B)

Variable geometry configuration (Team B)

Low sonic boom configuration (Team C)

Mach derivatives
Design activities - trade-offs

• Trade-offs on architectures and technologies
• Trade-offs on aircraft performances
• Trade-offs on environmental specifications:

- Very high "cost" of specifications on aircraft design
Key technos: engines, nozzles

Detailed design of a CVC engine:

Tests of a Mixer-ejector concept:
- selection and design (nozzle and liners)
- aero and acoustic tests in Cepra19
- severe and vibratory tests
Key technos: forced laminar, high lift

• Forced laminar flow:
  – The most promising concept is selected and sized (weight, power need, drag reduction): flow suction + anticontamination on inboard wing

• High lift technos:
  – Different concepts of slats / flaps / actuation,
  – De-icing systems sizing
Wind tunnel testing

June 2007: Trans / supersonic in France (S2Ma):

November 2007: Transonic in Russia (T128)

November 2007: Low speed in Switzerland (Emmen):
Way forward

• Synthesis of the project is on-going, mainly about:
  – Roadmap for technologies development
  – Synthesis and Roadmap for environmental targets

• Although compliance with initial HISAC targets seem achievable, technologies and regulation maturation is needed after this 4 year Project

• Interest in Europe is kept for a follow-on of the work and to pave the way for an environmentally compliant supersonic aircraft