Global Supersonic Initiatives
Overview and the Russian Approach

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Supersonic Flight — a New Quality of Aviation Mobility
Case Study: Moscow–Vladivostok Flight

Supersonic aircraft expands the one-day trip flight range up to 7,500 km and halves the flight time and better.
First Generation of Supersonic Passenger Aircraft

Tu-144 (USSR, 1968—1978)

Concorde (Great Britain—France, 1969—2003)

<table>
<thead>
<tr>
<th>Key Problems</th>
<th>Tu-144, Concorde</th>
<th>Current Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable level of sonic boom, dBA</td>
<td>96—106</td>
<td>Less than 65</td>
</tr>
<tr>
<td>High level of initial shock overpressure, Pa</td>
<td>120—140</td>
<td>7—10 times less</td>
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<tr>
<td>High level of noise near airport, exceeding current standards, EPNdB</td>
<td>By 25 EPNdB</td>
<td>ICAO Ch.14 — 2 EPNdB</td>
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<tr>
<td>High level community noise, EPNdB</td>
<td>Chapter 3 ICAO + 30</td>
<td>less 2 EPNdB to ICAO Ch.14</td>
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<tr>
<td>High level LTO NOx EI, g/kN</td>
<td>50, CAEP6</td>
<td>60%—75% reduction</td>
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<tr>
<td>High level NOx EI, g/kN</td>
<td>More than 20</td>
<td>Less than 10</td>
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Moscow Khabarovsk 6148 km, 3 h
Concorde Paris New York 5839 km, 3.5 h

Tu-144

Concorde
# Global Projects of Supersonic Business Jets

<table>
<thead>
<tr>
<th></th>
<th>Flight Mach Number</th>
<th>Range, km</th>
<th>Q-ty PAX</th>
<th>First Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerion AS2, USA</strong></td>
<td>0.95 — 1.4</td>
<td>9300</td>
<td>9</td>
<td>First flight in 2023</td>
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<tr>
<td><strong>Gulfstream QSJ, USA</strong></td>
<td>1.6</td>
<td>7500</td>
<td>8</td>
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<tr>
<td><strong>SAI &amp; LM QSST, USA</strong></td>
<td>2.0</td>
<td>7500</td>
<td>8</td>
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<tr>
<td><strong>Spike Aerospace S-512, USA</strong></td>
<td>1.6</td>
<td>10300</td>
<td>18</td>
<td>First flight in 2021</td>
</tr>
<tr>
<td><strong>Boom Supersonic, USA</strong></td>
<td>2.2</td>
<td>8800</td>
<td>55</td>
<td>Demonstrator in 2019</td>
</tr>
<tr>
<td><strong>UAC / Sukhoi, Russia</strong></td>
<td>1.8</td>
<td>7500</td>
<td>12</td>
<td>First flight — in late 2020’s</td>
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</table>
Test aircraft (X-Plane) NASA, USA

<table>
<thead>
<tr>
<th>Flight Mach Number</th>
<th>Flight Altitude, km</th>
<th>Propulsion</th>
<th>Project start</th>
<th>Current status</th>
<th>First fly</th>
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<tbody>
<tr>
<td>1,4</td>
<td>17</td>
<td>from F-18</td>
<td>2016</td>
<td>In progress</td>
<td>In early 2020s</td>
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Global Technological Demonstrators

Japan Aerospace Exploration Agency (JAXA)

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<tr>
<th>Flight Mach number</th>
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Aerodynamic concept of Supersonic Business Jet with low level of sonic boom

<table>
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<tr>
<th>Flight Mach Number</th>
<th>Flight Altitude, km</th>
<th>Weight, t</th>
<th>Sonic Boom</th>
<th>Current Status</th>
<th>Lead Time</th>
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<tr>
<td>1.8</td>
<td>A/C – 15...17</td>
<td>A/C – 55</td>
<td>65 dBA</td>
<td>State Funding</td>
<td>Demonstrator</td>
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<td>Dec 2019</td>
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Key Technology Challenges

- Low sonic boom and low community noise
- High fuel efficiency and low DOC
- External visualization via artificial vision system
- Variable-cycle powerplant design
- Composite/composite-metal isogrid (bionic) fuselage
- Artificial intelligence
- 4D trajectory / traffic management
### International Supersonic Technology Projects

**Acronym:** HISAC  
**Project Title:** Environmentally-friendly high-speed aircraft  
**Objective:** Research on supersonic business jet providing low sonic boom and noise near airport areas  
**Coordinator:** Dassault Aviation (France)  
**Time Frame:** 01.05.2005 — 31.10.2009  
**Partners:** 38 partners, incl. TsAGI, Alenia Aeronautica, ONERA, EADS, SNECMA, Rolls-Royce, Sukhoi Civil Aircraft Company, CIAM and others
International Supersonic Technology Projects

Acronym: RUMBLE

Project title: Regulation and norm for low sonic boom levels

Objectives: Formulation of proposals to determine the permissible overland sonic boom level and the corresponding measurement methods

Coordinator: Airbus Group Innovations (AGI)

Time frame: 2017—2020

Partners: 18 partners, incl. ONERA, Dassault Aviation, TsAGI, Gromov Flight Research Institute, MAI, CIAM, SCAC, GosNIIAS, GkNIPAS
RUMBLE Contribution to ICAO Supersonic Research Roadmap

**Formulate Standards**
- Apply methodologies & protocols for certification scheme based on R&D findings
- ICAO SSTG: Monitor R&D progress & State of Art for sonic boom mitigation
- ICAO SSTG: Formulate “Preliminary” standards
- ICAO SSTG: Validate “Preliminary” standards

**Metrics Studies**
- Initial indoor simulator & outdoor boom metric R&D studies
- NASA: Predictive model of building response
- ICAO SSTG: Metrics & thresholds

**Propagation & flight effects**
- Atmospheric: Temp, RH, turbulence influences
- Terrain, geographic, climatic & seasonaleffects
- Test flight procedures
- Focus & Secondary Boom
- Cut-off Mach No.
- PSU: Atmospheric Turbulence filters
- PSU: Terrain effects model
- ICAO SSTG: Noise test flight procedures development
- NASA: Focus Boom Prediction & Validation (SCAMP project)
- NASA: Turbulence effects on low boom signatures
- NASA: Carpet edge and Mach cutoff boom study (FaINT proj.)

**Research Aircraft Design & Fabrication**
- Small jet low boom a/c design
- Small jet low boom a/c fabrication
- D-SEND (ph 2)
- NASA: Low Boom Flight Demonstration (Business and Small Airliner Class a/c)

**Demonstrator(s)**
- Rolls out
- R

**Community Exposure tests**
- NASA: Initial community survey tools and data collection (WSPR Project)
- Pre-demonstrator community Survey – protocol & best practices
- 1st community test ~ 2020

**Statistical extrapolation & Acceptability Criteria**
- Preliminary route simulation exposure modeling
- Correlation & assessment of data & “prelim” standards

**Focus**

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<td>WP 4 RUMBLE: WT Low boom a/c design</td>
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**WP 4 RUMBLE**
- Acceleration Flight profile scenario test & CFD validation
- Turbulence effect modeling

**WP 3 RUMBLE**
- Terrain/relief effect modeling

**WP 4/6 RUMBLE**
- Certification procedures test flight
- Acceleration Flight profile scenario test & CFD validation
- Turbulence effect modeling
- Terrain/relief effect modeling
- WT Low boom a/c design
Key Challenges to be addressed for the New Generation Supersonic Transport

- International standards for acceptable sonic boom level for overland flight
- Ready-to-use jet engines that provide the required aircraft range and conform with ICAO Noise Standards near airport areas
- A difficult trade-off between high performance and low environmental impact
- Special aircraft operation conditions and its integration into the existing ATM system
The Success of New Generation Supersonic Passenger Aircraft Program Requires:

- Involvement and cooperation of all aviation leader organizations in supersonic (IFAR members)
- Advanced supersonic variable-cycle engines development on the basis of a modern or future core engines
- Development of a flight demonstrator
- Comprehensive R&D work to create full-size business and passenger jets
Thank you for your attention!