***Annex 3***

Update 25 March 2002

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| EUROPEAN COMMISSION | EXPRESSIONS OF INTEREST TO IDENTIFY RESEARCH ACTIONS READY FOR SPECIFIC PROGRAMME TOPICS AS A BASIS FOR THE PREPARATION OF WORK PROGRAMMES FOR THE 6TH FRAMEWORK PROGRAMME FOR RESEARCH |

EoI n°:

(for Commission use only)

## ADMINISTRATIVE INFORMATION

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|---|---|---|---|---|---|---|---|---|
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| *Title of the expression of interest (up to 10 words)* | Supersonic Cruise Jets : SSBJ and ESCT | | | | | | | |
| *Acronym (up to 20 characters)* | SUPERSONIC | | | | | | | |
| *Sub-Thematic Priority[1] most relevant to your topic* | 1.1.4.i | | | | | | | |
| *Other relevant Sub-Thematic Priorities[2]* | | | | | | | | |

*Abstract (max. 10 lines)*

High-speed flight is a major technological challenge of ultimate importance for both commercial and business aviation. High-risk investments are still required to develop and validate the design of commercial supersonic aircraft with low sonic booms. The overall objective of this Integrated Project is to enable industry development and production of an environmentally acceptable, economically viable commercial aircraft capable of supersonic flight overland, at speeds not in excess of Mach 2, in a relatively near term (next decades). The project will develop technical solutions for overcoming the current key barriers. When mature enough, these solutions will be integrated and validated by industry to enable successful commercial development programmes and to contribute to a global European leadership.

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| *I request that the information given in this form is not published[3]* | ~~*YES*~~ |

[1] Indicate only one sub-thematic priority number given in Annex 1, eg. 1.1.6.1.i or 1.1.1.ii.b or 2.3

[2] If appropriate, indicate one or more sub-thematic priority numbers given in Annex 1.

[3] Unless you indicate "yes", the name of the organisation, contact person details, title and abstract of this expression of interest may be published by the Commission.

# Integrated Project 17 – Supersonic Cruise Jets: SSBJ and ESCT

## 1: NEEDS and RELEVANCE

1.1: Contribution to realising an objective of the "Aeronautics and Space" Priority Thematic Area.

The Report of the "Vision 2020" highlighted the need to satisfy rising demands of passengers for better service quality. Taking forward the "Quality and Affordability" recommendations of this Report, the Advisory Council for Aeronautics Research in Europe - ACARE - underlines the importance of the reduction of the required time for a travel from door to door. As demonstrated by Concorde's high load factor, the demand of ever-faster aircraft is there: it is a consequence of the world-wide economy "globalisation". Very long-range aircraft have been developed; they have increased air travel duration to a limit for human acceptance. As a result, today, the speed advantage is magnified by this continuous trend towards ever-longer stage length.
Supersonic aircraft are the obvious major enablers to cut in half the flight time, specially for trans-oceanic flights, and to satisfy the passenger's demand. For decades, the speed of commercial aviation was constrained by the sound barrier. France and Great Britain were able to complete development of the Concorde, which has shown both the possibilities and problems of commercial supersonic aircraft.

High-speed flight is a major technological challenge for both commercial and business aviation. Commercially successful supersonic flight will only occur when technology is developed and assembled into an aircraft that can be profitably manufactured in large quantities (i.e. hundreds of aircraft) and that is affordable for users and environmentally acceptable to society at large. Even the option of conventional supersonic aircraft that closely resemble existing aircraft, requires breakthrough technologies, and turning new technologies into an operational commercial supersonic aircraft is very expensive and takes decades of research and development to satisfy performance, economic, safety, and environmental requirements for aircraft and ground systems.
For the ACARE Council, "the long lead time of related research and the tremendous amount of challenges to be tackled before environmentally acceptable and economically feasible designs will be possible, makes it reasonable to put emphasis on related research". Concorde has shown the way: today, the preparation of the next generation supersonic aircraft is recognised as a major long-term objective of the European Aeronautics to satisfy the passengers' needs and to win a global leadership.

1.2: Requirement for a European mobilisation of activities and resources through the means of an IP

The current concept of a supersonic cruise aircraft is a vehicle:
- capable of long range missions with sustained supersonic flight (flying non-stop across oceans),
- satisfying all the environmental regulations, specially in terms of gaseous emissions, noise and sonic boom (low take-off noise and mitigated sonic boom for supersonic flight over land)
- and, for the Supersonic Business Jet, supported by the airports presently used by business jets.

To meet simultaneously all the goals in terms of cruise range, noise level and operation is presently out of the feasibility domain. The current European large commercial supersonic project (225 seats, 5500 NM range, Mach 2.0) does not comply with Stage 4 noise regulation (which may strengthen in the future). Neither it complies with economics objectives (partly due to unacceptable sonic boom level forbidding overland supersonic flight). The situation is not clear concerning pollutants emissions.

To overcome these key barriers in the domains of performance and environmental acceptability (community noise, sonic boom, emissions), new focused efforts in several areas, as well as continued development of technology on a broad front are required to close the gap between the state of the art and aircraft requirements. Many domains of R&D are concerned (see paragraph 3).The target will be only achieved if we adopt and drive through a holistic approach to design the future supersonic aircraft. The maturation of the concepts will involve airframers, engine manufacturers, equipment manufacturers, regulatory authorities, research centres, academics and SMEs to cover the global approach. This research is very pre-competitive and can be achieved only at the European level.

The development of a supersonic aircraft requires a long-term investment strategy that looks beyond the short-term economic factors that drive much industry-funded research. The importance of a long-term view is especially important with breakthrough technologies. By nature, these technologies require long-term investments to increase their maturity and reduce their risk enough to convince the aerospace manufacturing industry to turn them into commercial products that the regulatory authorities will certify and airlines (or other users: fractional ownership operators, governments, corporate aircraft users) will buy. Unfortunately, both governments and industry are reluctant to make the long-term investments necessary to mature expensive, high-risk technologies. Today, the only available financial support of major importance at the European level, is from the Commission.

Affordable supersonic flight is an exercise in integration: A viable commercial supersonic aircraft cannot be achieved until solutions to the individual technology challenges are brought together in one integrated airframe-engine design. To get over the present limitations cannot be ensured by incremental integration of to-day's technologies alone. The frame of an Integrated Project (IP) with its flexibility aspects is perfect for this type of R&D activities.

## 2: SCALE OF AMBITION & CRITICAL MASS

### 2.1: Ambition objectives

#### 2.1.1: Overall objective

The development of any economically viable commercial supersonic aircraft is currently far from trivial. High-risk investments are still required to develop and validate the design of commercial supersonic aircraft with low sonic booms. Nevertheless, no insurmountable obstacles to the development of such aircraft are identified, especially for aircraft with a cruise speed of less than Mach 2. To close the gap between the state of the art and supersonic aircraft requirements, it is requested to conduct a study:

- that would identify approaches for achieving breakthroughs in research and technology for commercial supersonic aircraft,
- that help meet the challenge by activities in the technical areas where on going work should be continued and new focused research initiated for overcoming key barriers,
- without focusing specifically on a given vehicle configuration or market segment.

The overall objective of this Integrated Project is to enable industry production of an environmentally acceptable, economically viable commercial aircraft capable of supersonic flight over land, at speeds not in excess of Mach 2, in the relatively near term (next two decades).

This IP will develop technical solutions for overcoming the key barriers, solutions that industry is expected to integrate and to validate for enabling successful commercial development programmes. At the end of the project, the industry will assess the new situation and evaluate the closing of the gaps between the advanced state of the art and the aircraft requirements (paragraph 3.1.10).

#### 2.1.2: Notional European supersonic aircraft: SSBJ and ESCT

Determining the level of technology needed requires some consideration of potential products. The purpose of notional vehicles is to help assess the need for advances in the technological state of the art; they are not intended to endorse any particular product or replace the need for detailed design and market studies to validate the performance specifications prior to advanced product development.

The European industry has defined a couple of two notional supersonic aircraft likely to be developed in the foreseeable future:

- a SuperSonic Business Jet (SSBJ) with about 8 to 12 passengers, a weight of 40 t, a range of 4,000 to 5,000 NM, a cruise speed of about Mach 1.6 to 1.8,
- a so-called European Supersonic Commercial Transport configuration (ESCT) with about 200 to 250 passengers, a weight of 400 t, a range of 5,500 to 6,500 NM, a cruise speed of about Mach 2,

both with a sonic boom low enough to enable operations over both land and water.

A high-speed civil transport with a cruise speed in excess of Mach 2 is not considered by the European industry. For this aircraft, the technology is too far from being available and major key barriers are today prohibitive. In 1997, the US National Research Council concluded that the focus on Mach 2.4 was too aggressive and probably not justified by the business analysis.

The key technology barrier for the SSBJ is the elimination or reduction to acceptable levels, of sonic boom for flight over land. Another barrier is the need for an engine that can operate for 2,000 hours

between major overhauls. Significant advances in aerodynamic performance may also be required to achieve the desired aircraft range if the solution to the sonic boom problem imposes aircraft weight or performance penalties.
Sonic boom is an increased barrier to the development of the ESCT with overland capacity. Additionally, community noise and emissions are certainly major barriers to the development of an ESCT, significant advances in the traditional engineering disciplines, such as structures, propulsion and aerodynamics, are still required to close the business case and certificate new systems.

The technology advances necessary to attain the required economic and environmental goals will be easiest to achieve for an SSBJ and most difficult for an ESCT. The economic goals for the SSBJ are easiest to achieve because it can tolerate a very low payload fraction, a shorter-range capability, and a modest cruise speed. Economically, viable sonic boom reduction is also likely to be easier to accomplish for an SSBJ than for an ESCT. The economic goals for the ESCT will be the most difficult to achieve because it needs the highest payload fraction and the longest range. Furthermore, if a cruise speed of Mach 2 is selected, the environmental goals would be harder to achieve.

The consensus view of prospective manufacturers is that the SSBJ will be the first probable future product and is the first step, as a technologic demonstrator, preparing the ultimate goal of developing the ESCT. The scope of this Integrated Project includes both SSBJ and ESCT notional concepts.

2.1.3: Technical objectives
The main technical objectives of this Integrated Project are:
- Improvement of aircraft efficiency in order to allow longer range, lower fuel consumption,
- drastic diminution of community noise,
- mitigation of sonic boom,
- accurate assessment of supersonic fleet emissions impact

This cannot be ensured by integration of to-day's technologies alone. Therefore it is proposed to address new enabling technologies development in addition.

2.2: Strategic importance to Europe of the research activities proposed

Affordable, reliable, and safe air transportation is important to quality of life and economic growth. The global transportation infrastructure would be enhanced by the addition of a truly supersonic transportation element. This IP is a pre-requisite to the launch of a European Supersonic Cruise Jet. It will allow to keep the industrial risk to a level similar to the one associated to a subsonic aircraft programme.

The ultimate importance of commercial supersonic aircraft to the US air transportation system is set forth in long-range technology plans and visions promulgated by NASA (NASA, 1998), the Department of Transportation (DOT, 1999) and the National Science and Technology Council (NSCT, 2000). If Europe intends to improve its presence and to win a global leadership in the commercial aerospace sector, it has to take a long-term perspective and channel adequate resources into research and technology development. The technological challenges to commercial supersonic flight can be overcome, as long as the development of key technologies is continued. Without continued effort, however, an economically viable, environmentally acceptable, commercial supersonic aircraft is likely to languish.

The US is not the only sponsor of supersonic technology. The governments of France, Japan, Russia, and the United Kingdom are also sponsoring developments of supersonic technology with commercial applications, although none has embarked on a formal program to produce a new commercial supersonic aircraft. The development of a commercial supersonic transport that can meet international environment standards and compete successfully with subsonic transports may be a larger effort than the industry of any single nation might wish to undertake. In each of the two segments of the SSBJ and of the large transport aircraft, the first manufacturer to market will have the potential to dominate the respective market. If only one commercial supersonic transport is available, airlines from Europe, from the US and other countries will purchase it regardless of where it is manufactured.

2.3: Justification of the timeliness

Next generation supersonic aircraft are not likely to cover the sky until 2015/2020, but there are signs that we are at the beginning of another "S-curve", illustrating the evolution with time of the emergence of next generation concepts and technologies for supersonic aircraft.

National initiatives are arising (e.g. since two years, the French Research Ministry's network: Réseau de Recherche et d'Innovation Technologique - Recherche Aéronautique sur le Supersonique").
This period is the very appropriate time for a co-ordination of the efforts at the European level.

2.4: Critical mass necessary to achieve the proposed work

The foreseen duration of the Project is of 4 to 5 years. The global financial effort (Commission + partners) is around 40 MEuro. As mentioned above in paragraph 1.2, many domains of R&D are concerned. The target will be only achieved if we adopt and drive through a holistic approach to design the future supersonic aircraft. The maturation of the concepts will involve airframers, engine manufacturers, equipment manufacturers, regulatory authorities, research centres, academics and SMEs to cover the global approach. This research is very dependent of the participation of all the sectors of activities.

2.5: European excellence enhancing

Europe has developed products that have greatly influenced global aeronautics operations and that have caused many of the changes that European citizens have experienced. European Aeronautics has produced many world firsts. The development of the only supersonic airliner in the world - Concorde - has had tremendous spin-offs on European aeronautics industry. The resulting Airbus success story has been beneficial for European citizens in general through contribution to global economy growth and low-cost transportation possibilities. The renewal of a Concorde scenario has now to be considered in order to contribute to sustainable growth and European excellence.
High-speed flight is commonly considered as a flagship domain of research. A number of the investigated/demonstrated/validated technologies will be then available for subsequent subsonic aircraft design and even in non-aeronautics sectors (virtual simulation, materials…) as it has been the case for Concorde.

## 3: INTEGRATION

3.1: Description of activities

The development of economically viable and environmentally acceptable commercial supersonic aircraft will require continuing advances in many disciplines.
Following technological fields will be considered in this Integrated Project:

3.1.1: Aircraft configuration:
Based on the general airframers' specifications and on the propulsion integration requirements with regards to community noise around airport and sonic boom annoyance mitigation, investigation & assessment of innovative configuration for airframe-powerplant integration, empennage accommodation, definition of the main characteristics (configuration, shapes)associated with a weight analysis. Reference configurations will be selected based on theoretical analysis possibly non-conventional and more highly integrated configurations). Their performances and potential hard points will be evaluated through wind tunnel tests and more detailed CFD.

3.1.2: High performance propulsion systems:
Investigation & assessment of innovative architecture for engine, engine inlet, nozzle (benefits and drawbacks of movable parts for improved adaptation to flight conditions …) for increased thrust-to-weight ratio, low specific consumption, low specific weight and reduction of engine noise sources. Different engine and installation configurations will have to be evaluated. Continued development of variable cycle engines is expected. Large specific tests will support these developments and validate the results.

3.1.3: Sonic boom alleviation
Approaches to sonic boom reduction are a main part of this project. Acceptable "shaped" sonic boom signatures with an over-pressure limit throughout the total sonic boom ground footprint will be studied.
Innovative sonic boom alleviation techniques will be investigated: plasma (and ionised flows) for shock reduction (proof of concept and efficiency demonstrators). Acceptance criteria will be developed from human response data. Flight tests will validate the analytical studies with the support of military supersonic aircraft adapted to the demonstration/validation of the developed concepts.

3.1.4: Aircraft aerodynamics:
Validation of criteria and design process for laminar flow at cruise conditions over substantial percentages of the aircraft surface (this would provide key performance improvement, provided it does not require heavy and complex systems), performance assessment at Mach number close to 1, flow control at off-design conditions (devices for inlets efficiency and forgiveness, jet mixing, buffeting and flutter control…). Aerodynamic technology developments will be focused on the resolution of performance and aerodynamic design efficiency drivers (paragraph 3.1.1):

- Supersonic laminar flow.
- Prediction and control of vortices and of shock/boundary layer interactions on highly swept configurations.
- Improvement and validation of aerodynamic and aeroelastic analysis and optimisation procedures.

3.1.5: Aircraft structure and materials:

- Advanced materials and fabrication techniques for efficient lightweight structures under thermal constraints
- Design constraints resulting from aerothermal heating at supersonic cruise speed: outputs for the aircraft configuration/design optimisation
- Tools and processes for structure analysis and design accounting for aero-servo-elastics effects, including high-authority flight control systems as well as structural mode control systems keeping acceptable handling and ride qualities.

3.1.6: Aircraft systems:
Reliable virtual cockpit allowing some degree of indirect vision at high attitude angle flight, flight control systems for noise abatement operational procedures at take-off and landing (aircraft configuration and engine thrust management). Link with certification issues.
Development of virtual windows for passenger cabin in order to limit depressurisation hazard though maintaining passenger access to external situation could be envisaged (see paragraph 3.1.8).

3.1.7: Aircraft optimisation:
Automated, high fidelity, multidisciplinary optimisation tools and methods for design and analysis of highly integrated, actively controlled airframe-propulsion system. Drivers will be defined in the aircraft configuration activities (paragraph 3.1.1).

3.1.8: Crew and passenger cabins
Crew and passenger safety at high altitudes: loss of pressurisation, level of radiation (link with certification issues).
Cabin comfort: noise/vibrations levels, air quality, development of an efficient air conditioning system.

3.1.9: Certification and regulatory issues
Certification and regulatory issues must be resolved to ensure that the regulatory approval process does not impede the development of a supersonic aircraft. They are especially important to enable the use of new systems such as synthetic vision in the cockpit, that relate to passenger and public safety and to allow over land supersonic flight. Generally speaking certification standards that encompass new technologies and operational procedures have to be reviewed. Many topics are to be considered, as: engine (engine burst, loss of engine in cruise, environmental constraints); ETOPS; high altitude operation; avionics (all systems); pilot visibility; environmental constraints (sonic boom, high altitude emissions); aircraft with aerodynamic instability. The development of a FAR36 chapter relative to noise certification of supersonic aircraft for a given state of the art of the technology is to be prepared.

3.1.10: At the end of the project, the industry will assess the new situation and evaluate the closing of the gaps between the advanced state of the art and the aircraft requirements. For each main key barrier, will be performed an identification of what would have to be demonstrated to show that the initial gaps have been significantly reduced or closed.

3.2: Envisaged participants and roles

Industrial participants' role is to assure the global leadership of the project, to determine the relevance ways of research, to assure the global integration and validation of all the developed concepts. Affordable supersonic flight is an exercise in integration under an industrial leadership.

Participants : The main industrial partners are Dassault Aviation (for the activities directly dedicated to the SSBJ); EADS Airbus S.A (for the activities directly dedicated to the ESCT) and Rolls-Royce / SNECMA (for the activities directly dedicated to the engines). Participation of Alenia, EADS Military Aircraft-D, Messier-Dowty is foreseen.

Research organisations' role has to be of prime importance in more fundamental work like:
- unconventional means for drag reduction,
- exotic means for sonic boom reduction (hot or charged gas emission…)
- criteria for impulse noise (like primary sonic boom) perceived annoyance
- criteria for low frequency noise (like secondary sonic boom) perceived annoyance
- criteria for hazard linked to radiation exposure at high altitude flight (crew, passenger)
- chemistry of species due to fuel burn accounting for physical conditions in the high atmosphere, in the aircraft wake
- long term impact of supersonic aircraft fleet on the climate

Participants : A large number of REC is expected to participate. ONERA, INTA, CIMNE, ENS-Cachan, and EPFL have explicitly mentioned their interests.

Regulatory authorities have to take their part in the effort, addressing the extension of existing regulations to the case of supersonic aircraft. Regulatory standards are a key factor in determining the viability of commercial supersonic aircraft.

SMEs have to develop when necessary the peculiar devices issued of the advanced technologies.