



## **Advanced Concept Studies for Subsonic and Supersonic Commercial Transports Entering Service in the 2030-35 Period**

### **NASA Research Announcement, Pre-Proposal Conference**

**November 29<sup>th</sup>, 1-5 pm**

L'Enfant Plaza Hotel • Ballroom A/B • 480 L'Enfant Plaza • Washington, DC 20024

### **1. Solicitation Summary**

With this NRA solicitation, NASA is seeking to stimulate innovation and foster the pursuit of revolutionary conceptual designs for aircraft that could enter into service in the 2030-35 period, market permitting. The focus is on both subsonic and supersonic commercial transports that can overcome significant performance and environmental challenges for the benefit of the general public. These conceptual studies will identify key technology development needs and opportunities that will enable such vehicles. Additional details including specific metrics and objectives, vehicles classes, range and scope of technologies of interest, and expectations for proposals will be discussed at the pre-proposal meeting (to be held on November 29, 2007 in Washington, DC) and are included in this document. The Subsonic Fixed Wing (SFW) and Supersonics (Sup) projects are leading this solicitation.

This solicitation is intended to identify advanced airframe and propulsion concepts, as well as corresponding technologies for passenger aircraft anticipated for entry into service in the 2030-35 period ("N+3"), market permitting. Very large design changes may be required to address very significant changes in environmental sensitivity, demand shift, and energy costs. Environmental impacts for future commercial aircraft will need to be reduced, especially as air traffic increases up to two or three times compared to 2004 levels. Effective reductions in noise and emissions will require new configurations and technologies that are currently not available. Alternative energy sources need to be evaluated for aircraft propulsion systems and should leverage technology development for other transportation and power systems.

NASA is seeking advanced concept studies that methodically identify and evaluate such concepts, and prioritize the enabling technologies that will need to be developed to achieve significant breakthroughs. The results should include closely integrated airframe/propulsion concepts supported by detailed analysis, and technology roadmaps with an associated risk analysis of the key technology challenges. The results may be used to plan follow-on technology programs.

Approximately \$10M (~5 awards: 3 subsonic, 2 supersonic) is anticipated to be invested in Phase I of this solicitation (12 months duration). The actual number and value of the Phase I awards will depend on the quality of the proposals received. There will be a down select for Phase 2 (additional 18-24 months). The down-select decision at the end of Phase I is expected to be based on:

- NASA's judgment of the progress made during Phase 1 relative to quantifiable metrics defined in the proposal and agreed to by the NASA Technical Monitor at the beginning of the award.
- NASA's judgment of the impact the vehicle concept(s) on the goals of the SFW or Supersonics projects.
- NASA's judgment of the ability to address the key technology challenges and to refine the vehicle concept(s) identified in Phase 1.
- The availability of resources to support the proposed work for Phase 2.

In order to support the down-select decision before Phase 2, proposers should deliver a summary report at the end of Phase 1 that describes the advanced vehicle concept(s) developed in Phase 1, along with a detailed work plan for Phase 2 and justifications of what further developments are needed to refine the design, to conduct technology demonstration(s), and to address the key technology challenges.

NASA expects to adhere to the following tentative schedule:

- Solicitation release: January 14, 2008
- Proposals due 45 days after release: February 29, 2008
- Evaluations completed: April 14, 2008
- Award negotiations begin: April 21, 2008
- Awards in place: early summer 2008

## 2. SFW Advanced Concepts

Table 1 summarizes NASA's technology goals for future generation aircraft and represents the "corners" of the trade space. It is desirable to identify solutions that meet all three goals for noise, emissions, and energy usage (fuel burn). NASA recognizes that it may not be feasible to meet all of the goals simultaneously; therefore these multi-objective studies will identify vehicle concepts that have the best potential for meeting the combined goals, but may suggest compromises to individual goals. NASA also desires to understand the effects of shortened runway lengths on advanced aircraft designs. The studies must develop both standard and shortened runway length aircraft designs to be considered responsive to the solicitation.

CORNERS OF THE TRADE SPACE	N+1 Generation Conventional Tube & Wing (relative to B737/CFM56) (EIS 2015)	N+2 Generation Unconventional Hybrid Wing Body (relative to B777/GE90) (IOC 2020)	N+3 Generation (relative to B737/CFM56) (EIS 2030-2035)
Noise (cum below Stage 3)	- 42 dB	- 52 dB	better than -81 dB (55 LDN at average boundary)
LTO NOx Emissions (below CAEP 2)	-70%	-80%	better than -80% plus mitigate formation of contrails
Performance: Aircraft Fuel Burn	-33%	-50%*	better than -70% plus non-fossil fuel sources
Performance: Field Length	-33%	-50%	exploit metro-plex concepts

\* Value still being evaluated

Table 1 – NASA's Technology Goals for Future Subsonic Vehicles

## ***2.1 Mission Definitions***

NASA anticipates that highest demand for future aircraft will be in the medium-haul, 160 passenger vehicle class with a nominal cruise Mach number of 0.80. The scope of the study shall be limited to this vehicle class, although enabling technologies resulting from a subsequent development program are expected to benefit a wide range of vehicle classes. Noise, emissions and performance evaluations must be done using both missions defined below. If additional benefits are possible by deviating from these missions, the new missions should be clearly defined and results should be included as direct comparisons with the provided missions' results.

Reference Vehicle: 737-800

Reference Engine: CFM56-7B26

Mission 1 (baseline):

- 162 passengers
- 6,890 ft takeoff field length
- Initial cruise altitude of 38,300 ft
- Cruise Mach # = 0.80
- Total distance = 3000 nautical miles
- Approach descent rate = 750 ft/min
- Meets all applicable FAR mission constraints

Mission 2:

Same as Mission 1 except with 3000 ft takeoff field length.

### ***Noise***

The ultimate goal for noise reduction is to contain objectionable noise within the average airport boundaries. It is assumed that this will be accomplished by replacing nominal 160 passenger vehicles with N+3 vehicles that reduce noise levels by 81 EPNdB (Effective Perceived Noise Level in decibels) cumulative relative to Stage 3. It is expected that other vehicle classes will benefit from the technologies developed for the 160 passenger vehicle class, but this study will only address the single vehicle class.

### ***Emissions***

The primary emissions goal is to reduce LTO (Landing/Takeoff) NO<sub>x</sub> by 80% relative to CAEP 2 standards. The study should also identify technologies to reduce cruise NO<sub>x</sub> and CO<sub>2</sub>; mitigate the formation of contrails; and reduce aerosols and solid particulates that contribute to the formation of clouds. It is expected that other vehicle classes will benefit from the technologies developed for the 160 passenger vehicle class, but this study will only address the single vehicle class.

### ***Performance***

In order to minimize aircraft operating costs and environmental impact, it is necessary that anticipated near-term trends in improved energy efficiency be continued into the 2030-35 time frame considered for this study. Toward this end, a goal of reducing overall on-vehicle aircraft energy usage (gigajoules) by 70% over the prescribed missions (see mission definition section), relative to a Boeing 737-800 with CFM56-7B26 engines, has been set for this conceptual design study. This does not include the energy required to manufacture, refine, transport, or store the fuel prior to being loaded onto the aircraft. It is anticipated that this ambitious goal will be met through a combination of airframe and engine efficiency improvements, potentially including the use of non-traditional airframe configurations, alternate engine cycles, and alternate/synthetic fuels. Alternate mission scenarios that may contribute to more energy efficient aircraft operations enabled by the new configurations should be documented, but shall not be included in determining a vehicle concept's overall improvement in energy efficiency against the baseline so that configurations can be compared on an equal basis. If an alternate fuel is used in the design, differences in fuel energy density, and therefore fuel tank volume, must be considered. NASA anticipates that the capacity problems at existing airports will require increased utilization of regional airports with shorter runway lengths, necessitating the study of shorter runway lengths.

## **2.2 Outcome**

The scope of the studies shall include:

- A list of advanced concepts (including a comprehensive literature search) that identifies the pros/cons for each concept towards meeting the N+3 goals (Table 1).
- A conceptual design study that evaluates the most promising concepts on an equal basis using the Mission Definition provided by NASA.
- Credible (+/-10% or better, with associated confidence levels) estimates of overall system (airframe/propulsion integrated systems) lift, drag, thrust and weight, and credible quantitative assessment of expected noise, emissions and performance levels.
- Recommendations and prioritized list of concepts identifying enabling technologies.
- Detailed NASA Contractor Report (CR) for public release.

## **3. Supersonics Advanced Concepts**

This portion of the solicitation is intended to identify advanced vehicle and propulsion concepts, as well as corresponding technologies, for a new generation of supersonic airliners entering into service in the 2030-35 period ("N+3"). These concepts represent a new generation of supersonic aircraft that extend the benefits of supersonic travel to a broader segment of the population while keeping pace with the improvements to efficiency and environmental impact being incorporated in subsonic aircraft. The results of these studies may be used to direct follow-on technology programs.

### **3.1 Mission Definition**

Table 2 summarizes NASA's vision of the mission parameters and environmental and performance goals for future supersonic airliners. These goals have been chosen to define increasingly capable

supersonic aircraft that are compatible with a greener world from the perspectives of noise, emissions, and energy usage (fuel efficiency) These parameters and goals are based on NASA's internal estimates of what the N+2 and N+3 vehicles should be capable of. A current NASA NRA project is conducting trade studies to refine the set vehicle, propulsion and mission requirements for the N+2 vehicle. The N+3 vehicle study should include trades studies that help define appropriate mission and performance parameters for vehicles entering service in that time frame. Similarly trade studies should be used to define an appropriate balance for the environmental goals. Innovative conceptual designs that meet these goals should be developed. Promising concepts should be refined using more detailed analysis approaches. Key technology and tools gaps should be identified. The concept development process should consider as large a set of relevant constraints as possible, including, but not limited, to manufacturing and vehicle operations.

### 3.2 Outcome

The expected outcome is a detailed, publicly released NASA Contractor Report (CR) containing:

- Trade study results describing refinements to the N+3 mission parameters and goals of Table 2.
- Conceptual design definition for each proposed vehicle that identifies the pros/cons for each concept relative to meeting the defined goals.
- Concept refinement study results that evaluate the most promising concepts on an equal basis using the defined mission parameters.
- Quantitative assessment of expected noise, emissions and performance levels.
- Recommendations and prioritized list of concepts identifying enabling technologies.

CORNERS OF THE TRADE SPACE	N+1 Supersonic Business Class Aircraft (2015)	N+2 Small Supersonic Airliner (2020)	N+3 Efficient Multi-Mach Aircraft (2030-2035)
Cruise Speed	Mach 1.6-1.8	Mach 1.6-1.8	Mach 2.0 Unrestricted Mach 1.6-2.0 Low Boom
Range (nmi)	4,000	4,000	6,000
Payload	6-20 pax	35-70 pax	100-200 pax
Sonic Boom	65-70 PLdB	65-70 PLdB	65-70 PLdb low boom flight 75-80 PLdB unrestricted flight
Airport Noise (cum below Stage 3)	10 EPNdB	10-20 EPNdB	20-30 EPNdB
Cruise Emissions Cruise Nox EI Other	Equivalent to current subsonic	< 10 ?	< 5 ?
Fuel Efficiency (passenger mpg)	Baseline	15% Improvement	25% Improvement

Table 2 – NASA’s Technology Goals for Future Supersonic Vehicles (note: goals under development)

## Frequently Asked Questions

### **Q. How will the program be structured? Phase I, Phase II? Level of investment?**

A. Phase I, 12 months, approximately \$10M, 3 SFW concepts, 2 Sup concepts, approx \$2M each. Phase II will follow (18-24 months). Details will depend on outcome of Phase I. Downselect to most promising Phase I studies, higher details/refinement of ideas, significant technology experiments.

### **Q. What are the criteria for down selection for Phase II awards?**

A. The down-select decision at the end of Phase I will be based on:

- NASA's judgment of the progress made during Phase I relative to quantifiable metrics defined in the proposal and agreed to by the NASA Technical Monitor at the onset of the contract.
- NASA's judgment of the impact the vehicle concept(s) will have on the goals of the SFW or Supersonics projects.
- NASA's judgment of the ability to address the key technology challenges and to refine the vehicle concept(s) identified in Phase I.
- The availability of resources to support the proposed work for Phase II.

### **Q. What do we mean by "...the period 2030-35"?**

A. This means the introduction into service of a vehicle in that period. This means that technologies must be available some years before then. Assume "reasonable" technology development trends.

### **Q. Will a list of participants be provided?**

A. Yes, for those participants who do not request that their name be withheld. The participant list will be posted on the Fundamental Aeronautics Program website.

### **Q. Will NASA provide any additional information?**

A. No, in addition to this session, the slides presented, and the materials handed out (draft solicitation, FAQ) a solicitation will be posted by mid January. An e-mail will be sent out through the NSPIRES system once the final solicitation is ready. Please register at <http://nspires.nasaprs.com>

### **Q. What is the timeline?**

A. A final solicitation will be posted in mid January. Proposals will be due by the end of February. Awards expected to be in place early summer 2008. Phase I will be complete in early summer 2009.