University Engineering Design Challenge 2017-2018

Ultra-Efficient Commercial Transport: NASA invites students to propose unconventional subsonic transport aircraft designs that demonstrate dramatic reductions in energy consumption relative to today's systems.

Background:
Meeting the projected demand for air transportation in the next few decades will require the introduction of safe, economical, energy-efficient, and community-friendly transport aircraft with the payload, speed, and range performance demanded by the market. The NASA Aeronautics Research Mission Directorate (ARMD) has recently published a Strategic Implementation Plan that sets forth the ARMD vision for aeronautical research aimed at the next 25 years and beyond (https://www.nasa.gov/aeroresearch/strategy). It encompasses a broad range of technologies to meet future needs of the aviation community, the nation, and the world for safe, efficient, flexible, and environmentally sustainable air transportation. The Strategic Implementation Plan organizes the focus of the ARMD's research into six strategic thrusts:

- **Strategic Thrust 1:** Safe, Efficient Growth in Global Operations
- **Strategic Thrust 2:** Innovation in Commercial Supersonic Aircraft
- **Strategic Thrust 3:** Ultra-Efficient Commercial Vehicles
- **Strategic Thrust 4:** Transition to Alternative Propulsion and Energy
- **Strategic Thrust 5:** Real-Time System-Wide Safety Assurance
- **Strategic Thrust 6:** Assured Autonomy for Aviation Transformation

The focus of this design competition is the convergence of technologies and concepts in Strategic Thrust 3 (Ultra-Efficient Commercial Vehicles) and Strategic Thrust 4 (Transition to Alternative Propulsion and Energy) to achieve dramatic energy efficiency improvements in long-haul commercial air transport vehicles. The table below, taken from the Strategic Implementation Plan, presents NASA's targeted improvements in subsonic transport system metrics for the near-term (2015-2025), mid-term (2025-2035), and far-term (beyond 2035). NASA and its partners have identified candidate aircraft designs that approach the lower end of the far-term energy reduction target (60%). These concepts include both unconventional airframe designs (for example, hybrid wing body, truss-braced wing, double-bubble fuselage) and unconventional propulsion systems (for example, open rotor propulsors, hybrid electric propulsion, turboelectric propulsion). It is expected that achieving the upper far-term target of 80% reduction in energy consumption will require new, innovative airframe and propulsion system approaches, synergistic integration of the airframe and propulsion systems, and new operational paradigms.

TECHNOLOGY BENEFITS	TECHNOLOGY GENERATIONS (Technology Readiness Level = 5-6)		
	Near-term 2015-2025	Mid-term 2025-2035	Far-term Beyond 2035
Noise (cumulative below Stage 4)	22 - 32 dB	32 - 42 dB	42 - 52 dB
LTO NO_x Emissions (below CAEP 6)	70 - 75%	80%	>80%
Cruise NO_x Emissions (relative to 2005 best in class)	65 - 70%	80%	>80%
Aircraft Fuel/Energy Consumption (relative to 2005 best in class)	40 - 50%	50 - 60%	60 - 80%

Design Challenge:
In this challenge students are asked to develop innovative subsonic passenger transport aircraft concepts for the 2045 timeframe that have the potential to surpass 60% reduction in energy consumption with a goal of meeting NASA's far-term 80% energy consumption reduction target (80% less energy consumed to fly the same mission as the baseline – same number of passengers/payload carried for the same distance). In this context aircraft energy consumption is defined as the total amount of energy expended by the aircraft to perform the mission, regardless of where that energy comes from. As stated in the above table, the basis for comparison is a 2005 best-in-class aircraft (that is, the most energy efficient aircraft in a given size class that was in service in 2005). As part of this effort, the students will need to establish the performance of a baseline comparator aircraft from which the energy consumption reduction is calculated. The selected baseline aircraft must be in the single-aisle transport class (Boeing 737) or larger. It is expected that achieving a dramatic reduction in energy consumption will require innovative airframe and propulsion system designs, new approaches to integration of the airframe and propulsion systems, and new operational paradigms. As the focus of this challenge is maximizing the reduction in energy consumption, designs that require changes to today's ground infrastructure are allowed, but the report must address the practicality and implementation challenges of any required changes. Additionally, any changes made in flight operations to improve efficiency must be examined for cost and schedule impacts to the air transportation system. Although the student designs are not required to also meet the far-term targets for noise and NO_X emissions, the impact of the design choices on these areas should not be ignored. As with any new aircraft, teams should consider the needs of possible customers, development cost and risk, FAA certification, and passenger acceptance. Special consideration of these factors should be given if using design features that are incompatible with current FAA regulations or passenger expectations. Though some speculation about and projection of technologies available in the 2045 timeframe will be

a necessary part of the design process, the students must provide justification and rationale for any and all assumptions made about the future state of technology.

Mission Requirements:
The specific mission requirements will be dictated by the existing baseline aircraft selected by the teams. The advanced, ultra-efficient aircraft concept must have the same or better mission performance capabilities as the baseline comparison aircraft. This includes matching the range performance at the same payload weight while flying at the same cruise speed. Takeoff and landing performance should also be the same or better than the selected baseline aircraft.

Design Paper (see submission and format section of contest website for complete details on length, required ancillary elements, and appendices):
The paper is limited to 25 pages and should include a discussion of the design requirements, including the identification of the driving design requirements and all derived requirements. A thorough literature search should be performed, and the basis for selection of the baseline aircraft should be given. Dimensions, weights, and key performance parameters of the baseline comparison aircraft should be presented. Several alternative concepts with various airframe layouts and propulsion options should be generated and a systematic qualitative and/or quantitative screening process should be presented to provide justification for the final proposed concept. All tools and methods utilized to design and analyze the concept should be briefly described, including tool validation and verification of results utilizing sanity checks, rules of thumb, historical data, etc.

At a minimum, the following data should be provided for the proposed concept:

- Dimensioned three-view drawing;
- List of key technologies and justification that they will be available for use by 2045;
- Internal arrangement drawing showing location of major sub-systems and structure;
- Table showing weight build-up for both the baseline and advanced aircraft, including structures weight (wing, fuselage, tails, etc.), propulsion system weight, payload, fuel, etc. Table should include empty weight, zero fuel weight (empty weight + payload weight), and takeoff gross weight;
- Table showing key performance parameters for both the baseline and advanced aircraft, such as takeoff and landing distance, climb rate, cruise speed and altitude, aerodynamic and propulsion system characteristics (e.g., L/D, fuel and/or energy consumption rate, etc.), energy consumption by mission segment, total energy use for design mission, etc.;
- Details of the calculation of total energy consumption for both the baseline and advanced aircraft;
- Concept of operations for a typical flight including any required ground operations.