2020 E-GA (Electric – General Aviation) NASA ARMD Design Challenge

Background:

Electrically-powered aircraft have the potential to revolutionize the way we travel. The dramatic increases in efficiency, reliability, and reduced environmental impact have been well-documented for electric powertrains, as is the potential for significant reductions in community noise. Yet, the largest drawback of electrically-powered vehicles has been the onboard energy storage system – namely, its weight, cost, and logistical needs. Battery weight (or reactant storage volume) has especially precluded their utility on aircraft, and the equipment (as well as time) needed to recharge these energy storage systems is lacking at most public-use airports. There is dramatic improvement in electric aircraft utility as the mass and volume of the energy storage system is reduced, particularly if such approaches leave the logistics landscape unchanged.

Design Requirements:

Design an all-electric (i.e., no combustion) general aviation aircraft capable of meeting the performance requirements listed in Table 1 and ready for operational service by 2020. Note that all of the requirements are linked, that is, they must be met simultaneously. For example, the threshold requirements yield a 500 nm design mission carrying 400 lbs of payload at a cruise speed of 130 kts with a 30 minute reserve. The technology levels needed to meet the goal requirements simultaneously should be quantified as well, however trade-offs among the goal requirements are acceptable for the 2020 preferred system concept.

Table 1. 2020 E-GA Design Requirements

		Threshold	Goal
# Seats		4	4
Range	nm	500	800
Payload (includes crew and passengers)	lb	400	800
Cruise Speed	knots	130	175
Reserve (at cruise power setting)	min	30	30

Note: All requirements should be met simultaneously, e.g., threshold design mission is 500 nm range with 400 lb of payload at 130 kts cruise speed and 30 minutes of reserve flight time at cruise power setting.

If any portion of the flight profile exceeds 12,500 feet for 30 minutes or more then supplemental oxygen requirements must be taken into account (see reference below). Structural design criteria are +2.5/-1.0 g with a factor of safety of 1.5. Takeoff field length is required to be 3000 feet or less (max ground roll, there is no obstacle requirement) on a 95°F day at sea level.

It is unlikely that currently available energy storage technology will enable a solution that meets even the threshold requirements. Therefore, a key element of this design challenge is to perform trade-studies on various electric propulsion and energy storage systems and quantify the required technology levels to make this a feasible concept at both the threshold and goal requirement levels. At a minimum, investigate secondary battery technology and fuel cells. The trade-studies should take into account the airport infrastructure impacts and other system level attributes such as system cost, producability, reliability, and maintenance. The 2020 timeframe preferred system concept should reflect the results of the trade studies and represent a balanced design that would be the most feasible given today's technology levels and projected improvements over the next five years. The required technology improvements over today's state-of-the-art to meet the threshold and goal targets should be quantified and assessed in terms of likelihood of achievement by the 2020 timeframe.

Written Report:

The written report should include a discussion of the requirements, including the identification of the design driving requirements and all derived requirements (an example of a derived requirement would the required infrastructure to support the propulsion system). A thorough literature search should be performed, and comparator aircraft identified. Comparator aircraft are existing or previously flown aircraft with similar performance requirements. These represent a good point-of-departure for a new design and help to benchmark the current state-of-the-art and quantify the required technology improvements. Top-level dimensions, weights, and key performance parameters should be presented for comparator aircraft. Several alternative solution concepts with various propulsion options should be generated and a systematic qualitative and/or quantitative screening process should be presented to provide justification for the preferred system 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 preferred system concept:

- Dimensioned three-view drawing
- List of key technologies and required performance levels to meet threshold and goal requirements and assessment of technology maturation timeframe
- Internal arrangement drawing showing location of major sub-systems and structure
- Table showing weight build-up 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 such as takeoff and landing distance, climb rate, cruise and loiter speeds and altitudes, endurance, cruise L/D, cruise SFC, and payload
- Cost analysis for development, production, and operation of the proposed vehicle

Scoring will be based only on material provided in the 25 page main body of the report. Appendices are acceptable as a means to provide more details, however all key elements should be addressed in the main body of the report in order to receive scoring credit.

References:

1. Supplemental Oxygen Regulations (14 CFR 91.211) http://www.ecfr.gov/cgi-bin/text-idx?SID=1b66207467b6679b9b597b15b812dca4&node=se14.2.91_1211&rgn=div8