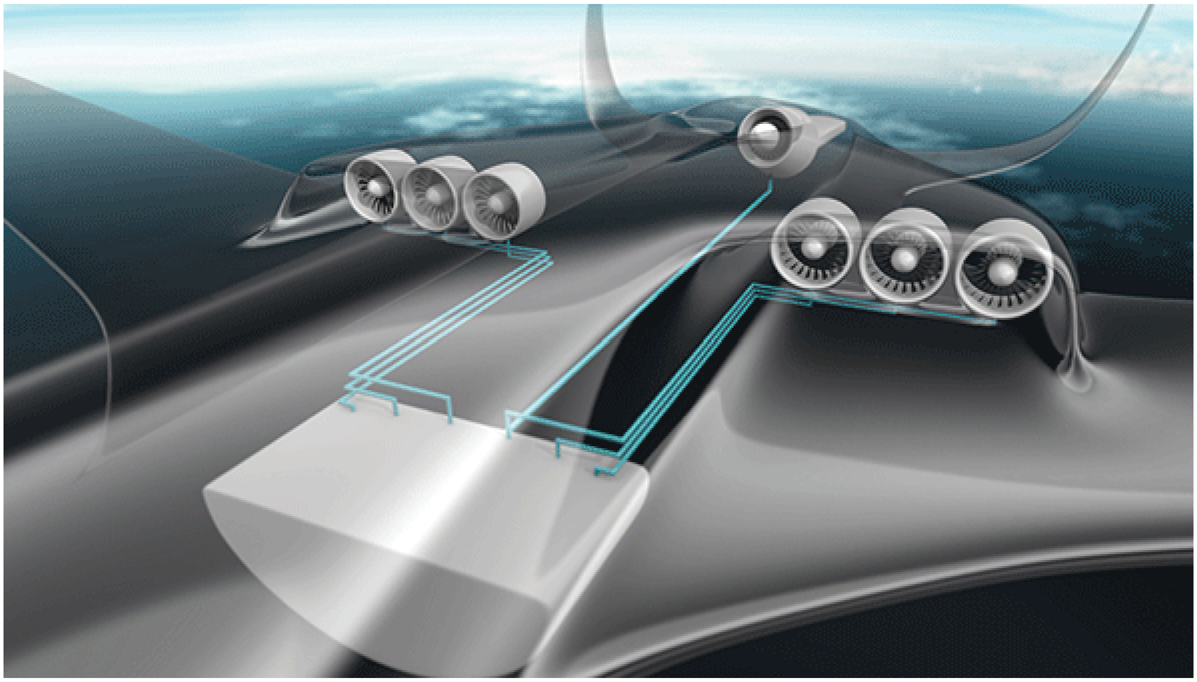
AIAA Foundation Student Design Competition 2018/19
Undergraduate Team – Engine

Candidate Engines for a Hybrid Electric Medium Altitude Long Endurance Search and Rescue UAV



- Request for Proposal –

Abstract

Current world events have called for the updating of unmanned search and rescue flight vehicles capabilities and flight times. The current flight vehicle uses a turboprop gas turbine engine that can sustain significant flight times. The intended replacement will use the same gas turbine engine as a baseline to power a hybrid electric unmanned flight vehicle. The intended customer is looking to purchase an optimized gas turbine generator to mate up with the current hybrid electric propulsion system. The hybrid electric propulsion system is already designed by the airframer. The new engine must be able to sustain the flight vehicle for a cruise and long endurance loiter capability.

The Current baseline engine is the TPE331-10. The TPE331-10 is a single shaft turboprop engine that has a three stage axial turbine. The sea-level static shaft horsepower (shp) is approximately 940 shp, at roughly 0.534(lb/hr/shp) brake specific fuel consumption (bsfc). This power is made possible by the 2 centrifugal compressors providing an overall pressure ratio (OPR) of 10.55. The turbine is a 3 stage axial turbine and the turbine rotor inlet temperature (TRIT) is roughly 2117°F. The engine inlet airflow is approximately 7.7 lb/s with an outer casing diameter of 27" at approximately 43" long. The engine weights roughly 385lb.

The new aircraft is expected to cruise at 12,500ft at speeds in excess of 220knts, loiter at 7,000ft at 190knts and have a range greater than 1000nm. The expected loiter time will be 20+ hours on with a 602 gallon fuel capacity.

The challenges of successful economical operation, while maintaining high performance, are quite substantial for any gas turbine engine, however, light weight, while maintaining high fuel efficiency are paramount. Candidate engines should be lighter than the current power plant, have an improved fuel burn at loiter of at least 25%, show a SLS power to weight increase of 10% and should have a power output within 5% of the baseline.

A generic model of the current power plant is supplied. Responders should generate a typical, multi-point mission that addresses the above-listed general improvements specifically and covers design point and off-design engine operations. The performance and total fuel consumption of the candidate engine should be estimated over the mission and stated clearly in the proposal. Special attention should be paid to engine mass, dimensions and integration with the aircraft. Technical feasibility and operating costs should also be addressed.

Name
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1.0 Introduction

The objective of the competition is to introduce to the students the fundamental design trades associated with propulsion systems design and in the process foster their desire to work in air breathing propulsion related field. Examples of these trades are propulsive efficiency and aircraft fuel efficiency, thermal efficiency vs. core size, etc. The competition is also meant to give the student an experience working to "real-world" requirements. In other words, the answer is not known; requirements are sometimes unclear and/or conflicting which require justified decision making. Therefore, the RFP response should NOT contain detailed analysis (such as CFD). The emphasis of the design competition is on on-design performance for air breathing propulsion systems.

1.1 Aircraft Specification

The current engines are described in a generic model, given in Section 3.0. Aircraft dimensions are given in Table 1, from which the overall nacelle length may be estimated to be 55 inches.

Table 1: Some General Characteristics of the Next Single-Engine Turboprop Aircraft

General characteristics	
Length	36 ft
Wing span	65.5 ft
Height	12.5 ft
Max. take-off weight	10,500 lbm
Power plant	1 × Honeywell TPE331-10 @940 SHP, SLS
Performance	
Maximum speed	260 KEAS
Cruise speed	220 KTAS at 12,500 feet
Range	1,000 NM
Service ceiling	50,000 ft (15,240m)

At take-off the total Shaft horsepower needed from the engine is 1000hp. In-flight engine power requirements are summarized in Table 2.

Table 2: In-Flight Thrust Requirements

General Thrust Requirements (Total for 1 engine)		
Takeoff	Sea Level Static +27F Std. Day	953 shp
Cruise	220 KTAS, 12,500 feet	690 shp
Loiter	190 KTAS, 7,000 feet	603 shp

1.2 Electrical System Specification

The airframe gas generator will feed an electrical propulsion system. The system has been designed to fit the required shaft horsepower provided by the baseline engine during its flight envelope. The customer does not want any modification to their electrical generator or system.

2.0 Design Objectives & Requirements

- A new engine design is required for a future version of the hybrid electric search and rescue UAV, with an entry-into-service date of 2025.

- The future flight envelope ranges from take-off at static sea-level conditions to cruise at 12,500 feet/220 KTAS. It is hoped that the endurance might be extended by reducing the fuel consumption and minimizing engine mass.

- The engine will be expected to provide a 25% fuel savings to reach a 20+ hour loiter at 7,000ft / 190 KTAS for a long endurance search.

- The generic baseline engine model should be used as a starting point, and the new design should be optimized for minimum engine mass and fuel burn, based on trade studies to determine the best combination of fan pressure ratio, bypass ratio, overall pressure ratio and turbine entry temperature. Students should attempt to maximize vehicle flight loiter time. Values of these four major design parameters should be compatible with those expected to be available in 2025 and the selected design limits should be justified in the proposal. Teams should use the provided aircraft trade factors to justify tradeoffs between engine weight and fuel consumption on vehicle performance.

- Based on the entry into service date, the development of new materials and an increase in design limits may be assumed. The development and potential application of carbon matrix composites is of particular interest. Based on research of available literature, justify carefully your choices of any new materials, their location within the engine and the appropriate advances in design limits that they provide.

- Different engine architecture is permitted, but accommodation within the existing inlet and airframe envelope is preferred (<27 inches engine diameter). Team should avoid considering variable cycle engines as low acquisition cost is a requirement of the new engine.

- An appropriate inlet must be designed.

- Design proposals must include engine mass, engine dimensions, shaft power output values, specific fuel consumption, specific power and thermal efficiencies at take-off (standard sea-level conditions), Loiter and Cruise. Details of the major flow path components must be given. These include inlet, fan, HP compressor, primary combustor, HP turbine, LP turbine, exhaust nozzle, and any inter-connecting ducts. A complete compliance matrix is provided in Table 3.

- In addition to providing details of the design, teams must provide justification of design choices through appropriate trade studies and presentation of publically available information regarding chosen technology levels and assumptions. To help guide teams a list of required trade studies, tables, and plots to be carried out and presented are listed below:

    - An in-depth cycle summary showing information from Table 5
    - Perform a design point design of the engine and show:

        - Velocity triangles for each stage of the compressor and turbine at the hub, mid-section, and tip
        - Provide a cross-section of the engine flowpath, showing 2D geometry for the inlet, all compressors, the combustor, turbines, nozzle(s), and any transition ducts
        - Provide one set of hand calculations showing velocity triangle calculations for the first stage of each component

    - As a guide, a graph of component efficiency vs. stage loading is provided in Figure 1.
    - Bonus points may be awarded for 3D drawings of the engine components.
    - **Error! Reference source not found.** shows some of the required detailed stage information for all compressors and turbines, other stage and component performance may be required to complete this information and should be shown as appropriate.

Table 3: Compliance Matrix

Performance	
Maximum speed	
Cruise speed	
Mission Fuel Burn	
Cruise TSFC	
Takeoff TSFC	
Engine Weight	
Fan Diameter	
Required Trade Studies	
Engine Cycle Design Space Carpet Plots Page #	

In-Depth Cycle Summary Page #	
Final engine flowpath (Page #)	
Final cycle study using chosen cycle program (Page #)	
Detailed stage-by-stage turbomachinery design information (page # for each component)	
Detailed design of velocity triangles for first stage of each component (list page #'s and component)	

Table 4: Engine Summary Table

Summary Data	
Design MN	
Design Altitude	
Design Fan Mass Flow	
Design Shaft Horsepower	
Design BSFC	
Design Overall Pressure Ratio	
Design T4.1	
Design Engine Pressure Ratio	
Design Fan / LPC Pressure Ratio	
Design Chargeable Cooling Flow (%@25)	
Design Non-Chargeable Cooling Flow (%@25)	
Design Adiabatic Efficiency for Each Turbine	
Design Polytropic Efficiency for Each Compressor	
Design Shaft Power Loss	
Design HP/IP/LP/PT Shaft RPM	
Flow Station Data (List for Each Engine Component at Design Condition)	
Inflow	
Corrected Inflow	
Inflow Total Pressure	
Inflow Total Temperature	
Inflow Fuel-air-Ratio	
Inflow Mach #	

Inflow Area	
Pressure Loss/Rise Across Component	
Additional Information as deemed necessary	

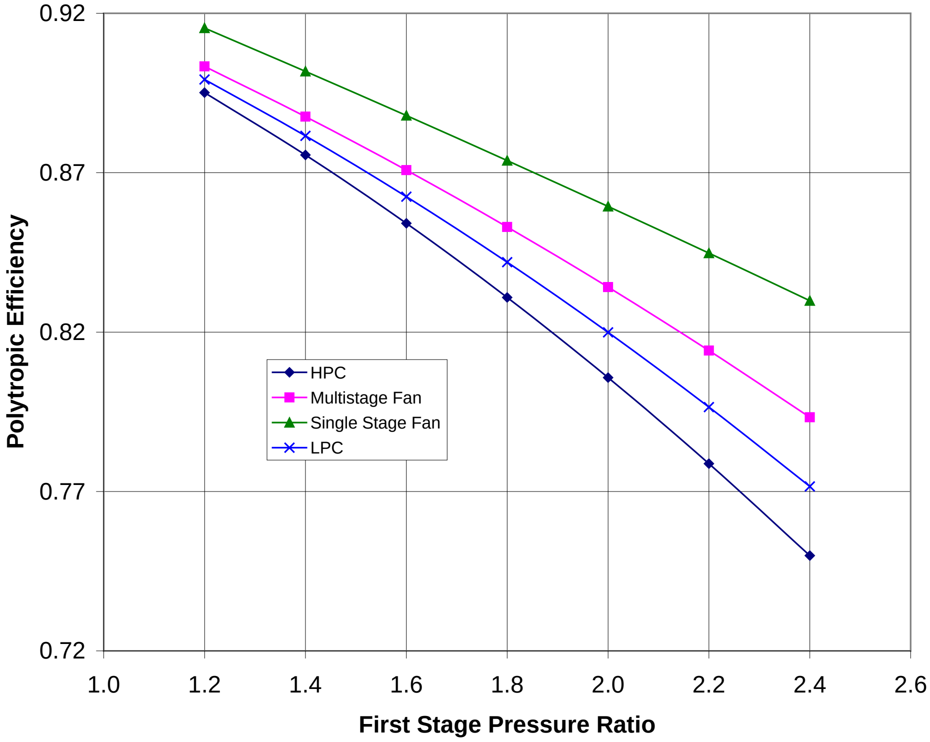


Figure 1: Compressor component efficiency vs. stage loading

3.0 Baseline Engine Model

As stated previously, the baseline engine is a turboshaft. A generic model has been generated from publically-available information using *NPSS V2.8*. Certain details of this model are given below to assist with construction of a baseline case and to provide some indication of typical values of design parameters.

3.1 Overall Characteristics

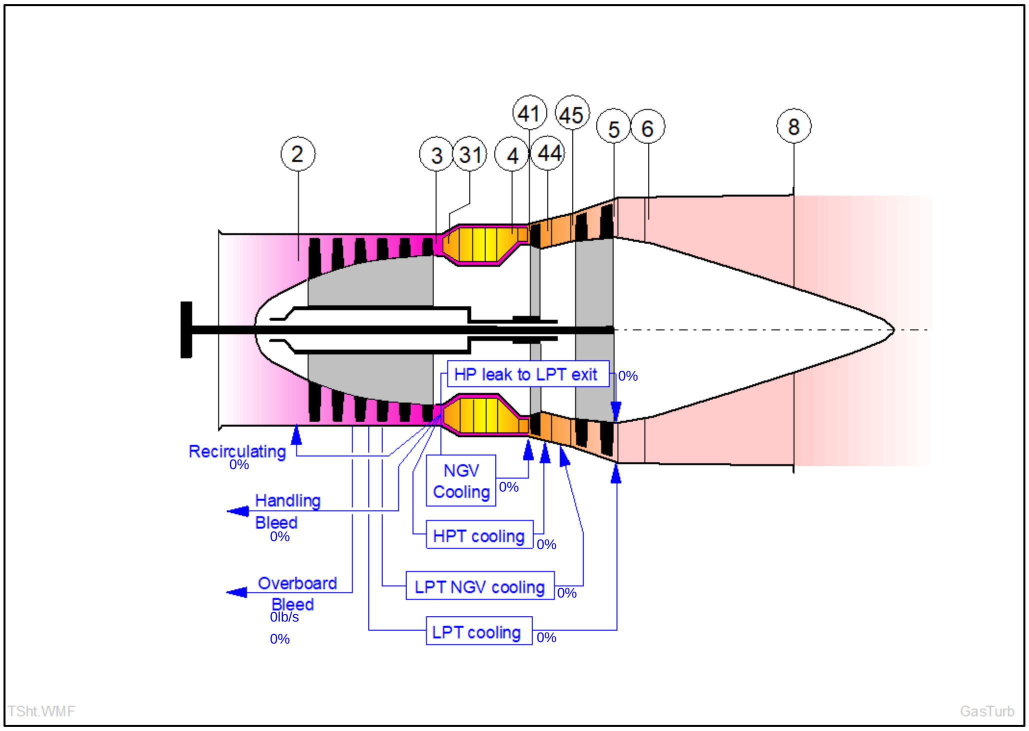
Table 6 contains a summary of basic engine characteristics, taken directly from Reference 7.

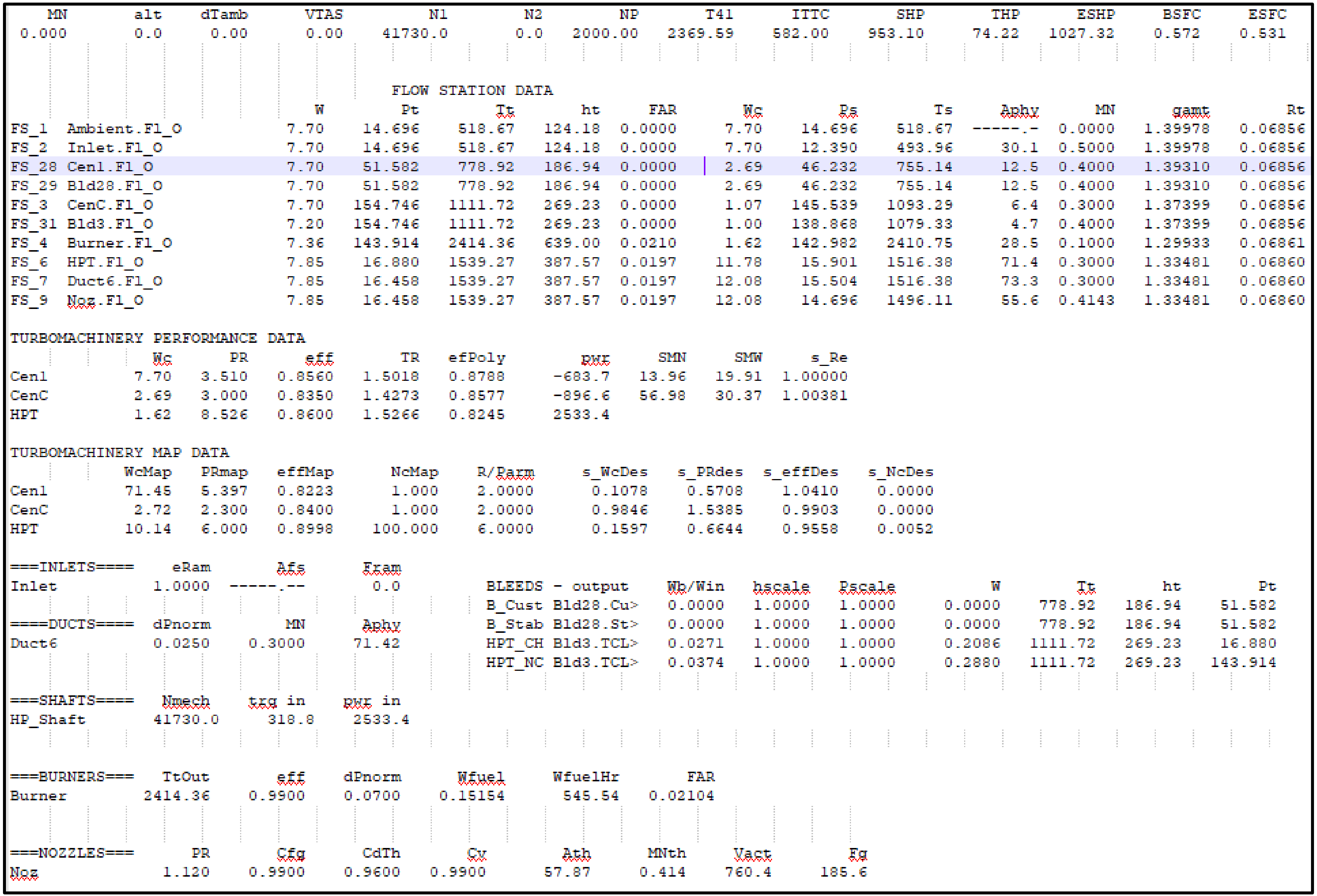
Table 5: Baseline Engine: Basic Data, Overall Geometry and Performance

Design Features of the Baseline Engine	
Engine Type	Single Spool
Number of compressor stages	2 Centrifugal
Number of HP turbine stages	3 Axial
Combustor type	Reverse Annular
Maximum power at sea level	1000 shp
Specific fuel consumption at max. power	0.534
Overall pressure ratio at max. power	10.55
Max. envelope diameter	27”
Max. envelope length	43”
Dry weight less tail-pipe	385

3.2 Cycle Performance Summary

A summary of baseline engine performance at the design condition is provided in Table 8 for reference. Component flowstation and cooling data is provided for reference.





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    MN       alt    dTamb      VTAS         N1        N2        NP       T41      ITTC       SHP       THP      ESHP     BSFC     ESFC
 0.000       0.0     0.00      0.00    41730.0       0.0   2000.00   2369.59    582.00    953.10     74.22   1027.32    0.572    0.531


                                        FLOW STATION DATA
                                W         Pt        Tt       ht     FAR       Wc        Ps        Ts     Aphy      MN      gamt        Rt
FS_1  Ambient.Fl_O           7.70    14.696    518.67   124.18  0.0000     7.70    14.696    518.67 ------.-  0.0000   1.39978   0.06856
FS_2  Inlet.Fl_O             7.70    14.696    518.67   124.18  0.0000     7.70    12.390    493.96     30.1  0.5000   1.39978   0.06856
FS_28 Cenl.Fl_O              7.70    51.582    778.92   186.94  0.0000     2.69    46.232    755.14     12.5  0.4000   1.39310   0.06856
FS_29 Bld28.Fl_O             7.70    51.582    778.92   186.94  0.0000     2.69    46.232    755.14     12.5  0.4000   1.39310   0.06856
FS_3  CenC.Fl_O              7.70   154.746   1111.72   269.23  0.0000     1.07   145.539   1093.29      6.4  0.3000   1.37399   0.06856
FS_31 Bld3.Fl_O              7.20   154.746   1111.72   269.23  0.0000     1.00   138.868   1079.33      4.7  0.4000   1.37399   0.06856
FS_4  Burner.Fl_O            7.36   143.914   2414.36   639.00  0.0210     1.62   142.982   2410.75     28.5  0.1000   1.29933   0.06861
FS_6  HPT.Fl_O               7.85    16.880   1539.27   387.57  0.0197    11.78    15.901   1516.38     71.4  0.3000   1.33481   0.06860
FS_7  Duct6.Fl_O             7.85    16.458   1539.27   387.57  0.0197    12.08    15.504   1516.38     73.3  0.3000   1.33481   0.06860
FS_9  Noz.Fl_O               7.85    16.458   1539.27   387.57  0.0197    12.08    14.696   1496.11     55.6  0.4143   1.33481   0.06860

TURBOMACHINERY PERFORMANCE DATA
               Wc      PR      eff       TR   efPoly        pwr     SMN     SMW     s_Re
Cenl         7.70   3.510   0.8560   1.5018   0.8788     -683.7   13.96   19.91  1.00000
CenC         2.69   3.000   0.8350   1.4273   0.8577     -896.6   56.98   30.37  1.00381
HPT          1.62   8.526   0.8600   1.5266   0.8245     2533.4

TURBOMACHINERY MAP DATA
            WcMap   PRmap   effMap      NcMap    R/Parm     s_WcDes   s_PRdes  s_effDes   s_NcDes
Cenl        71.45   5.397   0.8223      1.000    2.0000      0.1078    0.5708    1.0410    0.0000
CenC         2.72   2.300   0.8400      1.000    2.0000      0.9846    1.5385    0.9903    0.0000
HPT         10.14   6.000   0.8998    100.000    6.0000      0.1597    0.6644    0.9558    0.0052

===INLETS====    eRam       Afs      Fram
Inlet          1.0000 ------.--       0.0         BLEEDS - output    Wb/Win   hscale   Pscale          W        Tt       ht        Pt
                                                  B_Cust Bld28.Cu>   0.0000   1.0000   1.0000     0.0000    778.92   186.94    51.582
====DUCTS====  dPnorm        MN      Aphy         B_Stab Bld28.St>   0.0000   1.0000   1.0000     0.0000    778.92   186.94    51.582
Duct6          0.0250    0.3000     71.42         HPT_CH Bld3.TCL>   0.0271   1.0000   1.0000     0.2086   1111.72   269.23    16.880
                                                  HPT_NC Bld3.TCL>   0.0374   1.0000   1.0000     0.2880   1111.72   269.23   143.914

===SHAFTS====   Nmech    trq in     pwr in
HP_Shaft       41730.0     318.8     2533.4


===BURNERS===   TtOut       eff    dPnorm      Wfuel     WfuelHr       FAR
Burner        2414.36    0.9900    0.0700    0.15154      545.54   0.02104


===NOZZLES===      PR       Cfg      CdTh       Cv        Ath      MNth     Vact        Fg
Noz             1.120    0.9900    0.9600   0.9900      57.87     0.414    760.4     185.6
```

Table 7: Summary of Baseline Engine Performance at the Design Condition

	Summary Output Data	
MN	Flight Mach number	
alt	Altitude	Feet
dTs	Delta temperature from standard day	degrees R
W	Mass Flow	lbm/sec
Fg	Gross Thrust	lbf
Fn	Net Thrust	lbf
TSFC	Thrust Specific Fuel Consumption	lbm/hr/lbf
Wfuel	Fuel Flow	lbm/sec
OPR	Overall Pressure Ratio, Pt3/Pt2	
T41	Turbine Rotor Inlet Temperature	degrees R
	Flow Station Data	
W	Mass Flow	lbm/sec
Pt	Stagnation pressure	psi
Tt	Stagnation temperature	degrees R
ht	Stagnation enthalpy	BTU/lbm
FAR	Fuel/Air ratio	
Wc	Corrected flow	lbm/sec
Ps	Static pressure	psi
Ts	Static temperature	degrees R
Aphy	Cross-section area	square inches
MN	Mach number	BTU/lbm/deg R
Rt	Gas constant	
gamt	Ratio of specific heats	
	Compressors and Turbines	
Wc	Entrance corrected flow	lbm/sec
PR	Pressure Ratio	
effPoly	Polytropic efficiency	
eff	Adiabatic efficiency	
Nc	Corrected speed	
pwr	Power	Horsepower
	Bleeds	
Wb/Win	Bleed flow ratio to entrance flow	
W	Mass Flow	lbm/sec
Tt	Stagnation temperature	degrees R
ht	Stagnation enthalpy	BTU/lbm
Pt	Stagnation pressure	psi

	Inlets	
eRam	Ram recovery, Pt1/Pt0	
Afs	Free stream area	square inches
Fram	Ram drag	lbf
	Ducts	
dPqP	Stagnation pressure loss fraction	
MNin	Entrance Mach number	
Aphy	Cross-section area	square inches
	Splitters	
BPR	Bypass ratio, secondary flow / primary flow	
dPpri/P	Total pressure loss fraction in pri stream	
dPsec/P	Total pressure loss fraction in sec stream	
	Mixers	
Aout	Exit area	square inches
PtRatio	Ratio of total pressures, sec stream / pri stream	
MN_I1	Mach number at primary stream entrance	
MN_I2	Mach number at secondary stream entrance	
	Shafts	
Nmech	Shaft mechanical speed	RPM
pwrIn	Shaft input power	Horsepower
HPX	Customer horsepower extraction	Horsepower
	Burners	
TtOut	Exit temperature	degrees R
eff	Efficiency	
dPqP	Stagnation pressure loss fraction	
LHV	Fuel lower heating value	BTU/lbm
Wfuel	Fuel flow	lbm/sec
FAR	Fuel/Air ratio	
	Nozzles	
PR	Pressure Ratio, Pt entrance / Ps exit	
Cfg	Gross Thrust coefficient	
CdTh	Discharge or Flow coefficient	
Cv	Velocity coefficient	
Cang	Angularity coefficient	
CmixCorr	Mixing effectiveness	
Ath	Throat area	square inches
MNth	Throat Mach number	
PsExit	Exit static pressure	psi
Aexit	Exit area	square inches

4.0 Hints & Suggestions

- You should first model the baseline engine with the same software that you will use for your new engine design. Your results may not match the generic baseline model exactly but will provide a valid comparison of weights and performance for the new concept.
- In general, engines tend to be sized at “top-of-climb” (the beginning of cruise) conditions, rather than at take-off.
- The efficiencies of the turbomachinery components may be improved relative to the baseline engine, sufficient justification should be provided.
- This is not an aircraft design competition, so credit will not be given for derivation of aircraft flight characteristics. Power requirements for the mission are given in Table 2.
- This is not an electrical system design competition, so credit will not be given for a derivation of the electrical system. Students should use the electrical system as it is provided.
- The use of design codes from industrial or government contacts, that are not accessible to all competitors, is not allowed.

5.0 Competition Expectations

The existing rules and guidelines for the *AIAA Foundation Student Design Competition* should be observed and these are provided in *Appendix*. In addition, the following specific suggestions are offered for the event.

This is a preliminary engine design. It is not expected that student teams produce design solutions of industrial quality, however it is hoped that attention will be paid to the practical difficulties encountered in a real-world design situation and that these will be recognized and acknowledged. If such difficulties can be resolved quantitatively, appropriate credit will be given. If suitable design tools and/or knowledge are not available, then a qualitative description of an approach to address the issues is quite acceptable.

In a preliminary engine design the following features must be provided:

- Completion of the compliance matrices and required trade studies listed on Table 3, Table 5, and Table 6, including but not limited to:
    - Clear and concise demonstration that the overall engine performance satisfies the mission requirements.
    - Documentation of the trade studies conducted to determine the preferred engine cycle parameters such as fan pressure ratio, bypass ratio, overall pressure ratio, turbine inlet temperature, etc.
    - An engine configuration with a plot of the flow path that shows how the major components fit together, with emphasis on operability at different mission points.
    - A clear demonstration of design feasibility, with attention having been paid to technology limits. Examples of some, but not all, velocity diagrams are important to demonstrate viability of turbomachinery components.
    - Stage count estimates, again, with attention having been paid to technology limits.
    - Estimates of component performance and overall engine performance to show that the assumptions made in the cycle have been achieved.

- CFD (Computational Fluid Dynamics) & FEA (Finite Element Analysis) will be excluded from judging and is encouraged not to be used.
- If a CAD model is shown it must be consistent with Analysis provided.

While only the preliminary design of major components in the engine flow path is expected to be addressed quantitatively in the proposals, it is intended that the role of secondary systems such as fuel & lubrication be given serious consideration in terms of modifications and how they would be integrated in to the new engine design. Credit will be given for clear descriptions of how any appropriate upgrades would be incorporated and how they would affect the engine cycle.

Each proposal should contain a brief discussion of any computer codes or *Microsoft Excel* spreadsheets used to perform engine design & analysis, with emphasis on any additional special features generated by the team.

Proposals should be limited to fifty pages, which will not include the administrative/ contents or the "signature" pages.

6.0 References

1. "*GE Tests CMCs for Future Engine*", Aviation Week & Space Technology, July 30, 2012.
2. "*Aerospace Source Book",* Aviation Week & Space Technology, January 15, 2007.
3. *"GasTurb 12: A Design & Off-Design Performance Program for Gas Turbines",* http://www.gasturb.de, Joachim Kurzke, 2012.
4. "*A Simple Correlation of Turbine Efficiency*", S. F. Smith, Journal of the Royal Aeronautical Society, Volume 69, 1965.
5. *"Aeronautical Vest Pocket Handbook", Pratt & Whitney Aircraft*, Circa 1980.
6. Roux, Elodie, "*Turbofan and Turbojet Engines: Database Handbook*", 2007, ISBN: 978-2-9529380-1-3
7. *TPE331-10 Turboprop Engine*, Honeywell International Inc., 2006, aerocontent.honeywell.com/aero/common/documents/myaerospacecatalog-documents/BA_brochures-documents/TPE331.10.pdf.
8. "*Overview of NASA Electrified Aircraft Propulsion Research for Large Subsonic Transports*", https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170012222.pdf Jansen, Ralph H., Bowman, Dr. Cheryl, Jankovsky, Amy, Dyson, Dr. Rodger, Felder, James L., NASA Glenn Research Center, Cleveland, OH

7.0 Suggested Reading

1. "*Gas Turbine Theory*"**,** H.I.H Saravanamuttoo, G.F.C Rogers &.H. Cohen, Prentice Hall, 5th Edition 2001.
2. "*Aircraft Engine Design*", J.D. Mattingly, W.H. Heiser, & D.H. Daley, AIAA Education Series, 1987.
3. "*Elements of Propulsion – Gas Turbines and Rockets*", J.D. Mattingly, AIAA Education Series, 2006.
4. "*Jet Propulsion*", N. Cumpsty, Cambridge University Press, 2000.

5. "*Gas Turbine Performance*", P. Walsh & P. Fletcher, Blackwell/ASME Press, 2nd Edition, 2004.
6. "*Fundamentals of Jet Propulsion with Applications*", Ronald D. Flack, Cambridge University Press, 2005.
7. "*The Jet Engine*", Rolls-Royce plc. 2005.
8. "*Mechanics and Thermodynamics of Propulsion*", Hill, Philip G. and Peterson Carl R., Addison-Wesley Publishing Company, Reading, Massachusetts, 1965.

8.0 Allowable and Available Software & Additional Reference Material

Students may use the following approved cycle analysis and design codes:

- Student-developed codes written specifically for this project (i.e., Excel or Matlab)
- NPSS® Learning Edition
    - www.npssconsortium.org

  Numerical Propulsion System Simulation (NPSS®) is an object oriented, multi-physics, engineering design and simulation environment used by many of the major aerospace companies. Primary application areas for NPSS include aerospace systems (i.e. engine performance models for aircraft propulsion), thermodynamic system analysis such as Rankine and Brayton cycles, various rocket propulsion cycles, and industry standardization for model sharing and integration. However, since it is fundamentally a flow-network solver, it has also been applied to a variety of other fluid/thermal subjects such as multiphase heat transfer systems, refrigeration cycles, variations of common power cycles (i.e. Brayton), and overall vehicle emission analyses. NPSS is available for free to academia throughout the world in support of the AIAA engine design competition, and comes with an example model ready for use in the contest.
- AxSTREAM EDU™ by SoftInWay Inc.
    - http://www.softinway.com/

  AxSTREAM® is a turbomachinery design, analysis, and optimization software suite used by many of the world's leading aerospace companies developing new and innovative aero engine technology. By utilizing the educational version of the software (AxSTREAM EDU™), students will have the opportunity to work with real-world design tools for practical experience in topics including, but not limited to, propulsion, energy, and power generation. AxSTREAM EDU™ allows students to work through the entire design process including, but not limited to:
    - Preliminary design
    - Meanline (1D) and axisymmetric (2D) analysis
    - Profiling and 3D blade design

  The software can be utilized for axial, radial, mixed-flow, and diagonal configurations for turbines, compressors and fans. In addition, students also have the option of utilizing AxCYCLE™ as an add-on to AxSTREAM EDU™ for thermodynamic cycle design and analysis. Participants in the AIAA Undergraduate Team Engine Design Competition can acquire an AxSTREAM EDU™ license via the following steps:
    - Submit a **Letter of Intent** (LOI) to AIAA

  - Once the letter of intent has been received and approved, names of team members will be recognized as being **eligible to be granted access** to the AxSTREAM EDU™ software by AIAA.
  - From there, students **must** contact the AIAA Student competition Chair, listed with the abstract, who will then contact SoftInWay to grant the licenses

In addition to the software, students will also gain free access to STU, SoftInWay's online self-paced video course platform with various resources and video tutorials on both turbomachinery fundamentals as well as use of AxSTREAM EDU™.

Design Competition Rules

Eligibility Requirements

- All AIAA Student members are eligible and encouraged to participate. Membership with AIAA must be current to submit a report and to receive prizes.
- Students must submit their letter of intent and final report via the online submission to be eligible to participate. **No extensions will be granted**.
- More than one design may be submitted from students at any one school.
- If a design group withdraws their final report from the competition, the team leader must notify AIAA Headquarters immediately.
- Design projects that are used as part of an organized classroom requirement are eligible and encouraged for competition.

Schedule

- Letter of Intent — 10 February 2019 (11:59 pm Eastern Time)
- Proposal delivered to AIAA Headquarters — 10 May 2019 (11:59 pm Eastern Time)
- Announcement of Winners — 31 August 2019 (11:59 pm Eastern Time)
  - Engine Design Competition dates
    - Letter of Intent – 14 February 2019 (11:59 pm Eastern Time)
    - Proposal submitted, via online submission site to AIAA Headquarters – 16 May 2019 (11:59 pm Eastern Time)
    - Round 1 evaluation completed – 30 June 2019 (11:59 pm Eastern Time)
    - Round 2 presentations at AIAA Propulsion and Energy Forum 2019

Categories/Submissions

- Team Submissions
  - Team competitions will be groups of not more than ten AIAA Student Members per entry.
- Individual Submissions
  - Individual competitions will consist of only one AIAA Student member per entry.
- Graduate
  - Graduate students may participate in the graduate categories only.
- Undergraduate

  - Undergraduate students may participate in the undergraduate categories only.
- Letter of Intent (LOI)
  - A Letter of Intent indicating interest in participating in the design competitions is required before submitting a final report.
  - All Letters of Intent must be submitted through the online submission system.
  - Letter of Intent must include student's names, emails, AIAA membership numbers, faculty advisor(s) names, emails, and project advisor(s) names and emails. Incomplete LOI's will result in the Team or Individual being ineligible to compete in the competition.
- Submission of Final Design Report
  Each team or individual must provide an electronic copy their design report as outlined below to the online Submission site
  - An electronic copy of the report in Adobe PDF format must be submitted to AIAA using the online submission site. Total size of the file cannot exceed 25 MB.
  - Electronic report files must be named: "2019_[university]_DESIGN_REPORT.pdf"
  - A "Signature" page must be included in the report and indicate all participants, including faculty and project advisors, along with students' AIAA member numbers and signatures.

  - Electronic report should be no more than 100 pages, double-spaced (including graphs, drawings, photographs, and appendices) if it were to be printed on 8.5"x11.0" paper, and the font should be no smaller than 10 pt. Times New Roman.

Copyright

All submissions to the competition shall be the original work of the team members.

Authors retain copyright ownership of all written works submitted to the competition. By virtue of participating in the competition, team members and report authors grant AIAA non-exclusive license to reproduce submissions, in whole or in part, for all of AIAA's current and future print and electronic uses. Appropriate acknowledgment will accompany any reuse of materials.

Conflict of Interest

It should be noted that it shall be considered a conflict of interest for a design professor to write or assist in writing RFPs and/or judging proposals submitted if (s)he will have students participating in, or that can be expected to participate in those competitions. A design professor with such a conflict must refrain from participating in the development of such competition RFPs and/or judging any proposals submitted in such competitions.

Awards

The prize money provided for the competitions is funded through the AIAA Foundation. The monetary awards may differ for each competition, with a maximum award of $1,000. The award amounts are listed below.

The top three design teams will be awarded certificates. One representative from the first-place team *may be* invited by the Technical Committee responsible for the RFP to make a presentation of their design at an AIAA forum. A travel stipend *may be* available for some competitions, with a maximum travel stipend of $1,000 which may be used to help with costs for flight, hotel, or conference registration to attend an AIAA forum.

Aircraft Design Competitions

- Graduate Team Aircraft – Electric Vertical Takeoff and Landing (E-VTOL) Aircraft
- Undergraduate Team Aircraft – Thin Haul Transport and Air Taxi
    - 1st Place: $500; 2nd Place: $300; 3rd Place: $250
- Undergraduate Individual Aircraft – Power Line Survey Unmanned Aircraft Systems
    - 1st Place: $1,000; 2nd Place: $500; 3rd Place: $300

Engine Design Competition

- Undergraduate Team Engine –Candidate Engines for Hybrid Electric Medium Altitude Long Endurance Search and Rescue UAV
    - 1st Place: $500; 2nd Place: $300; 3rd Place: $250

Space Design Competition

- Undergraduate Team Space Design – Reusable Lunar Surface Access Vehicle
    - 1st Place: $500; 2nd Place: $300; 3rd Place: $250

Structures Design Competition

- Graduate Team Structures – Design of the Structure for a VTOL Taxi
- Undergraduate Team Structures – Design of Deployable Solar Array Structure
    - 1st Place: $500; 2nd Place: $300; 3rd Place: $250

Missile Systems Design Competition

- Undergraduate Team Missile Systems - Design of a Long-Range Strategic Missile
    - 1st Place: $500; 2nd Place: $300; 3rd Place: $250

Proposal Requirements

The technical proposal is the most important factor in the award of a contract. It should be specific and complete. While it is realized that all the technical factors cannot be included in advance, the following should be included:

- Demonstrate a thorough understanding of the Request for Proposal (RFP) requirements.
- Describe the proposed technical approaches to comply with each of the requirements specified in the RFP, including phasing of tasks. Legibility, clarity, and completeness of the technical approach are primary factors in evaluation of the proposals.

- Emphasis should be directed at identification of critical, technical problem areas. Descriptions, sketches, drawings, systems analysis, method of attack, and discussions of new techniques should be presented in enough detail to permit engineering evaluation of the proposal. Exceptions to proposed technical requirements should be identified and explained.
- Include tradeoff studies performed to arrive at the final design.
- Provide a description of automated design tools used to develop the design.

Basis for Judging

The AIAA Technical Committee that developed the RFP will serve as the judges of the final reports. They will evaluate the reports using the categories and scoring listed below. The judges reserve the right to not award all three places. Judges' decisions are final.

1. ***Technical Content (35 points)***
This concerns the correctness of theory, validity of reasoning used, apparent understanding and grasp of the subject, etc. Are all major factors considered and a reasonably accurate evaluation of these factors presented?
2. ***Organization and Presentation (20 points)***
The description of the design as an instrument of communication is a strong factor on judging. Organization of written design, clarity, and inclusion of pertinent information are major factors.
3. ***Originality (20 points)***
The design proposal should avoid standard textbook information and should show the independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the method show an adaptation or creation of automated design tools?
4. ***Practical Application and Feasibility (25 points)***
The proposal should present conclusions or recommendations that are feasible and practical, and not merely lead the evaluators into further difficult or insolvable problems.