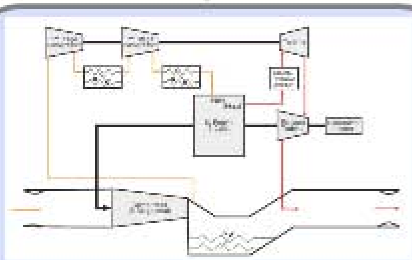
High Altitude Low Cost Configurable Jet Engine Trade Study

STATUS QUO

Current UAV High Altitude Record for Air-Breathing Power Plants is 65,381 feet, Combined with High SFC's and Lower On-Station Persistance

NEW INSIGHTS



Recent Research on Turbocharged Compound 2-Stroke IC Engines at High Altitude Combined with Low Pressure Ratio Jet Propulsion, has Demonstrated High Power Density & Substantial Reductions in SFC's up to 100 kft

TRADE STUDY ACHIEVEMENT

MAIN ACHIEVEMENT:

- Qualitative & Quantitative Assessment of Propulsion Concept and Air Vehicle Configuration Compromises and Performance Benefits
- Major Trades to be Assessed: Adiabatic Expansion Chamber and Port Area Time, 3-Wheel High Pressure Ratio Turbocharger, Primary Shaft-Driven Compressor, Compound Power Recovery Turbine, ICE Compression Ratio, 2-Stream Droplet Heat Exchanger, Thermal Management, Mass Properties, Scaling, & Performance
- Configuration & Performance in Subsonic Airframes & Flow Regimes to be Assessed

HOW IT WORKS:

- Adiabatic Expansion Chamber Operates Choked at High Power Density Level
- Leverages Choked Characteristic to Reduce SFC via Compound Power Recovery Turbine
- Leverages Remaining ICE Exhaust Stream Energy to Increase Jet Pipe Stream Enthalpy
- Low Pressure Ratio Jet Propulsion Provides Lower SFC's at Higher Altitudes with Low Plume Temps

ASSUMPTIONS AND LIMITATIONS:

- ICE Derived From Rotax FR125 Max COTS Engine
- Breadth & Depth of Study Analyses will be Dependent on DARPA Program Schedule & Funding

QUANTITATIVE IMPACT

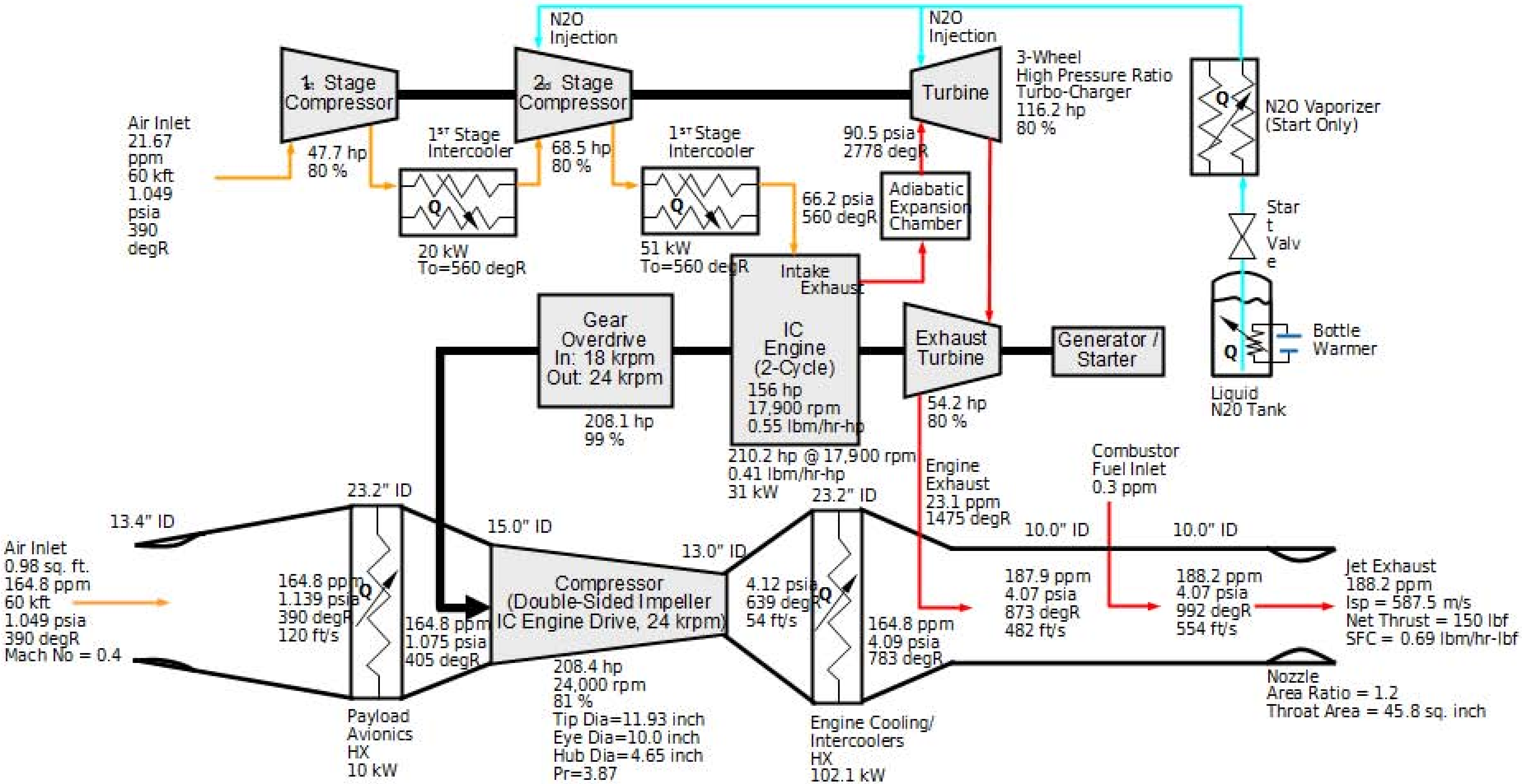
Trade Study Reduces Technical Risks Associated with Airframe Integration of Propulsion Concept while Narrowing the Design & Development Space Toward Optimal Configurations & Technology

END-OF-PHASE GOAL

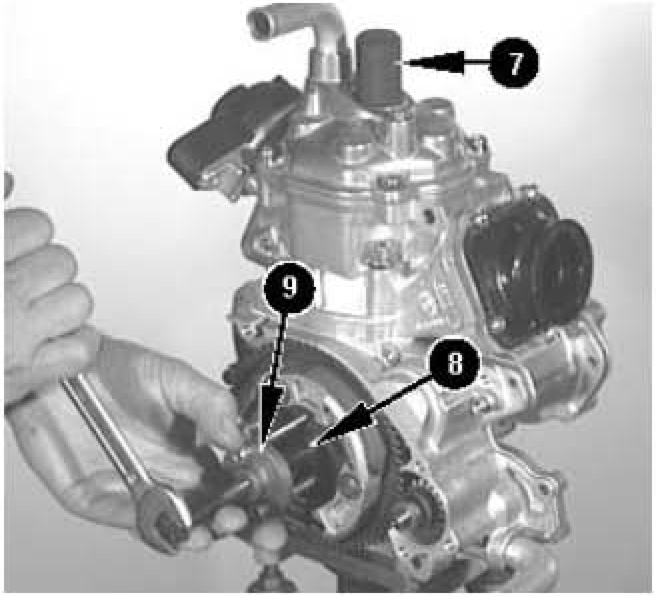
- *Qualitative & Quantitative Description of Relationships Between Major Trade Parameters and Air Vehicle Performance*
- *Parameter Ranges for Optimal Performance & Endurance*
- *Identification of Component Sizing to Maximize Performance and Flight Envelope*

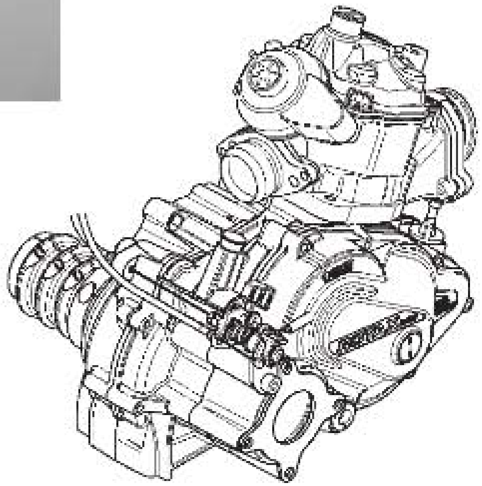
Specific Fuel Consumption of Less Than 0.6 pph/lbf is Attainable at 100 kft and Mach 0.4

Proposed AV Integrated Propulsion/Thermal Jet Engine System Schematic Overview

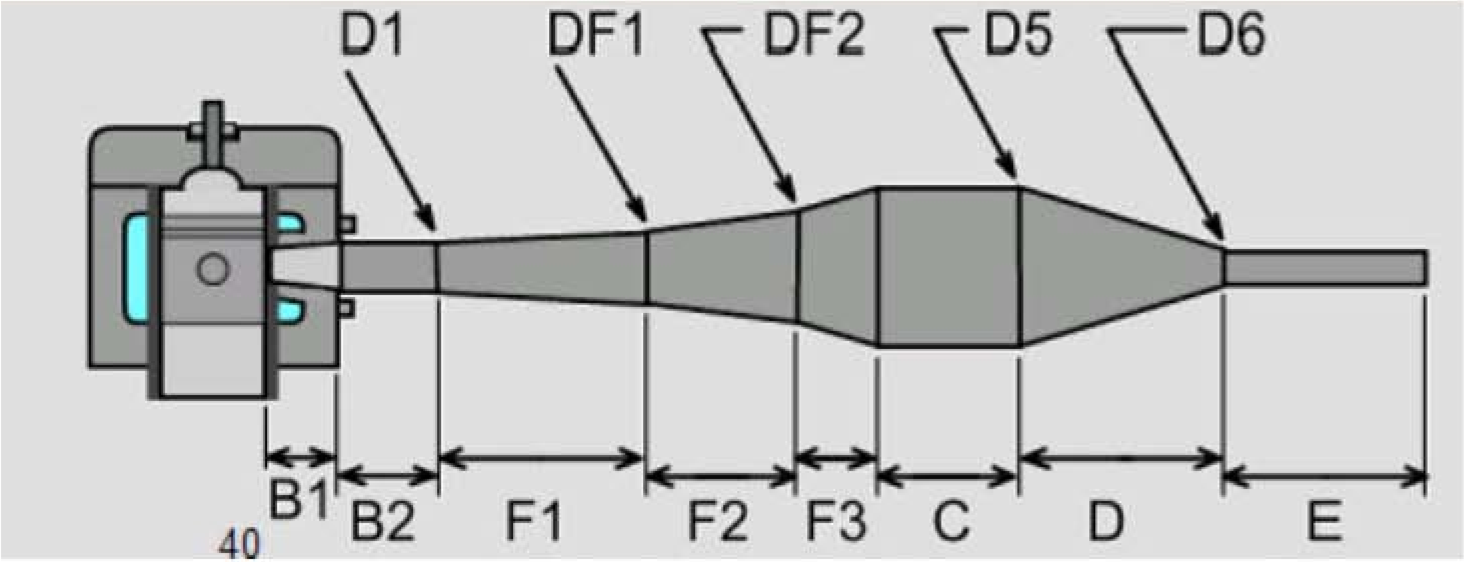


Rotax FR125 Max Modified COTS IC Engine





3-Stage Adiabatic Expansion Chamber Design

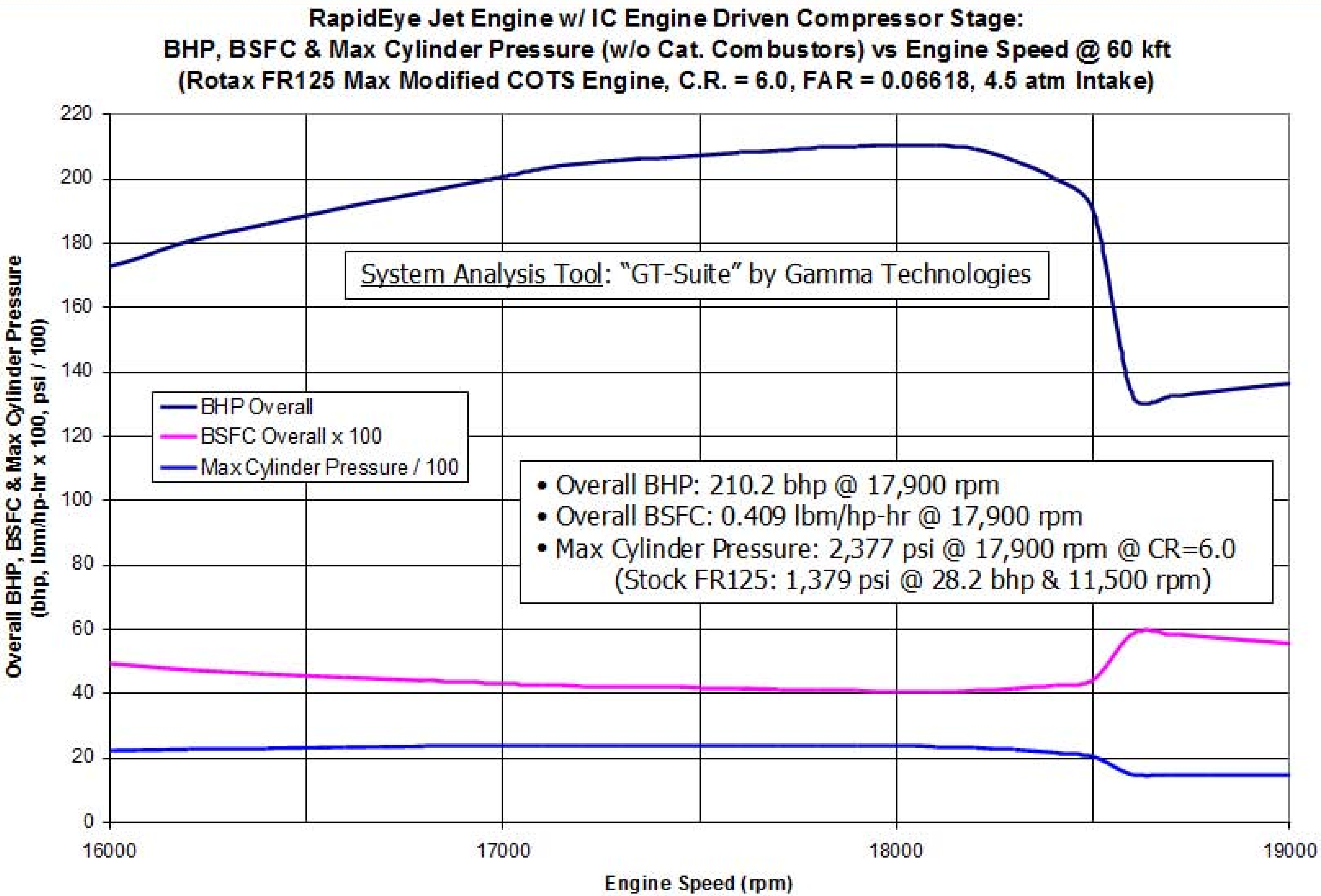


- B1+B2: 31.3 mm
- F1: 200.5 mm
- F2: 138.4 mm
- F3: 104.3 mm
- C: 155.3 mm
- D: 249.2 mm
- E: 224.2 mm
- D1: 36.5 mm
- DF1: 63.5 mm
- DF2: 105.1 mm
- D5: 136.6 mm
- D6: 19.1 mm

- BHP: 156.0 bhp @ 17,900 rpm
- BSFC: 0.55 lbm/hp-hr @ 17,900 rpm
- Max Cylinder Pressure: 2,377 psi @ 17,900 rpm @ CR=6.0
  (Stock FR125: 1,379 psi @ 28.2 bhp & 11,500 rpm, CR=14.8)

<u>System Analysis Tool</u>: "GT-Suite" by Gamma Technologies

Propulsion System Analysis



Rotax FR125 Max Modified COTS IC Engine

- 210.2 bhp Overall @ 17,900 rpm & Overall BSFC of 0.409 lbm/hr-hp
- 156 bhp @ 17,900 rpm & BSFC of 0.55 lbm/hr-hp IC Engine Only
- 54.2 hp Power Recovery via Combustion Gas Power Recovery Turbine Attached To IC Engine Shaft
- IC Engine Piston, Con Rod & Crankshaft Redesigned for Higher Power Output Level & Speed of Operation
- Adiabatic Expansion Chamber Design Provides Higher Power Recovery Prior to Exhaust Stream Injection into Jet Engine Flow Stream
- 3-Wheel/2-Stage High Pressure Ratio Turbocharger (Pr_max = 8.5 per stage) w/ Gaseous N2O Compressor Injection for Engine Start Sequence
- (2) Part-Time Catalytic Combustors, Pre- and Post-Turbocharger, for Hyper bar and Gas Turbine Operation Modes