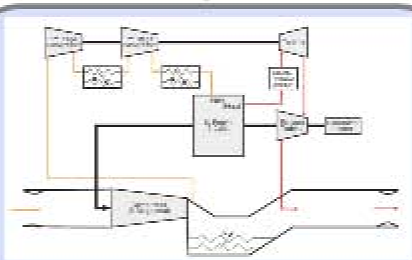
High Altitude Low Cost Configurable Jet Engine Trade Study

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

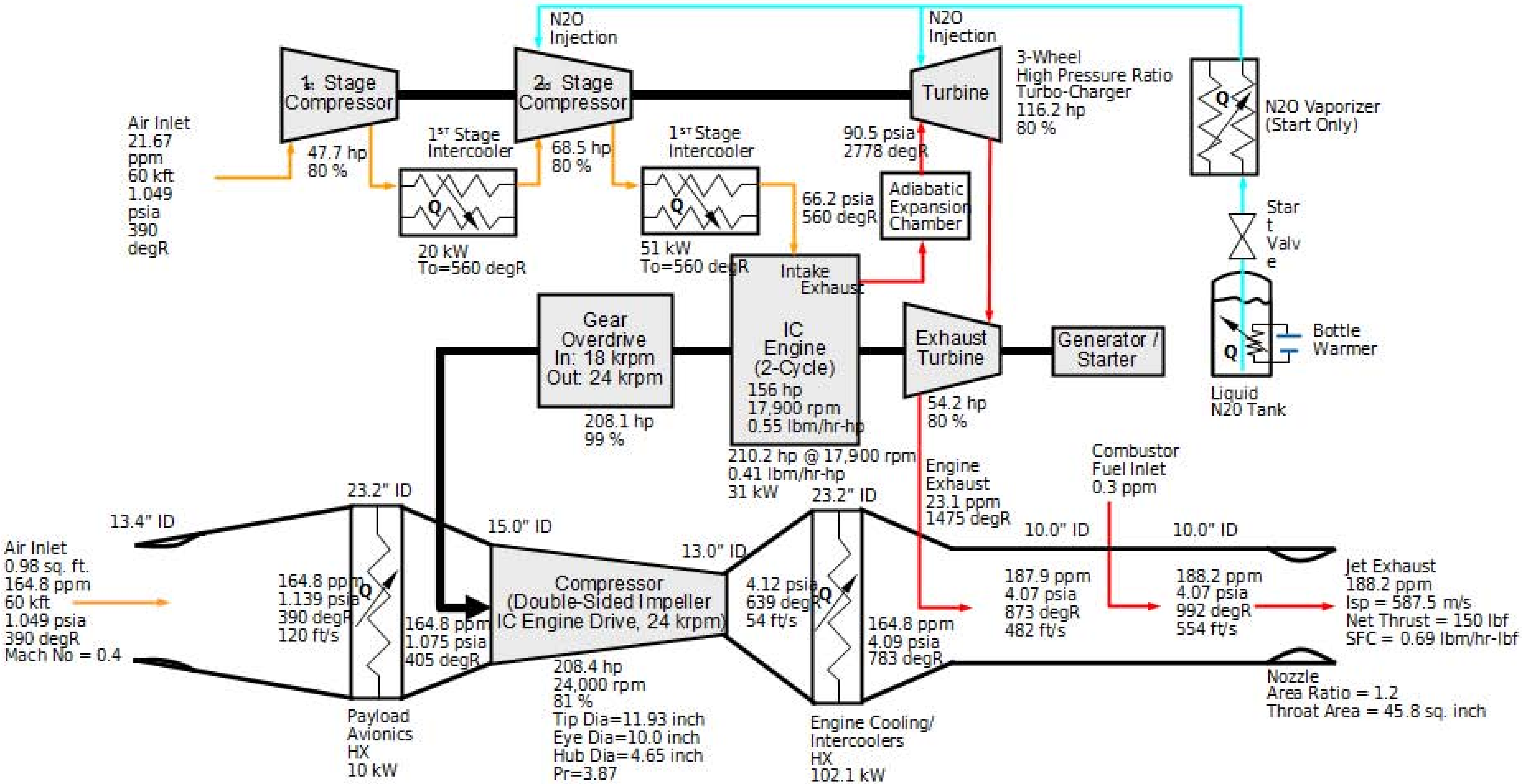
Trade Study Reduces Technical Risks Associated with Airframe Integration of Propulsion Concept while Narrowing the Design & Development Space Toward Optimal Configurations & Technology

END-OF-PHASE GOAL

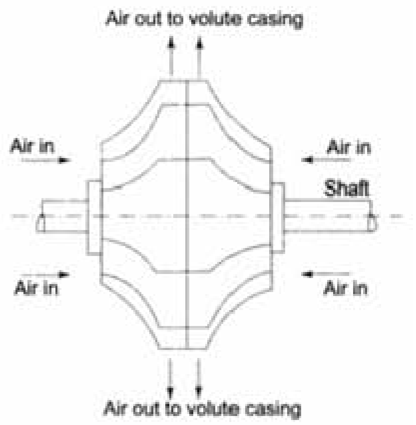
- *Qualitative & Quantitative Description of Relationships Between Major Trade Parameters and Air Vehicle Performance*
- *Parameter Ranges for Optimal Performance & Endurance*
- *Identification of Component Sizing to Maximize Performance and Flight Envelope*

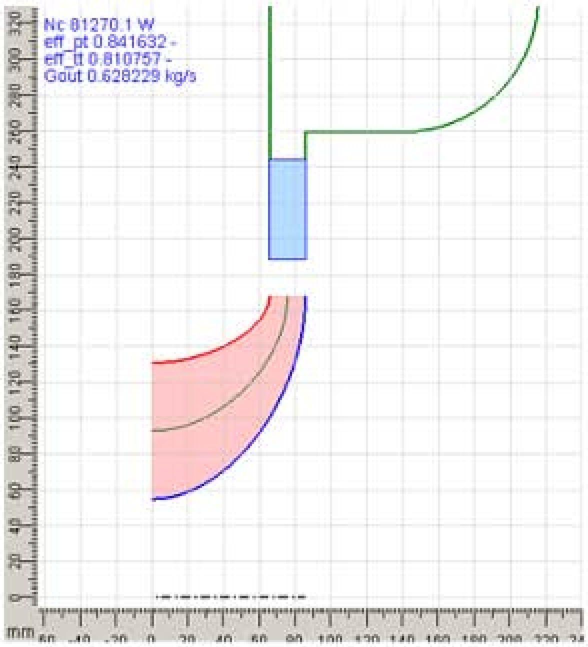
Specific Fuel Consumption of Less Than 0.6 pph/lbf is Attainable at 100 kft and Mach 0.4

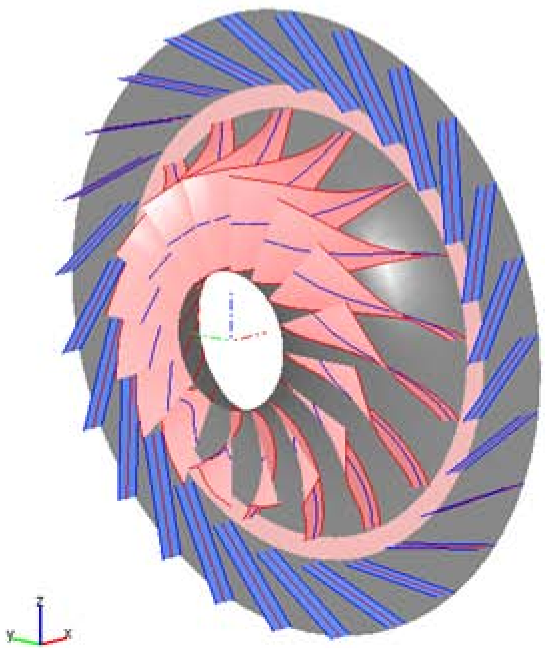
Proposed AV Integrated Propulsion/Thermal Jet Engine System Schematic Overview

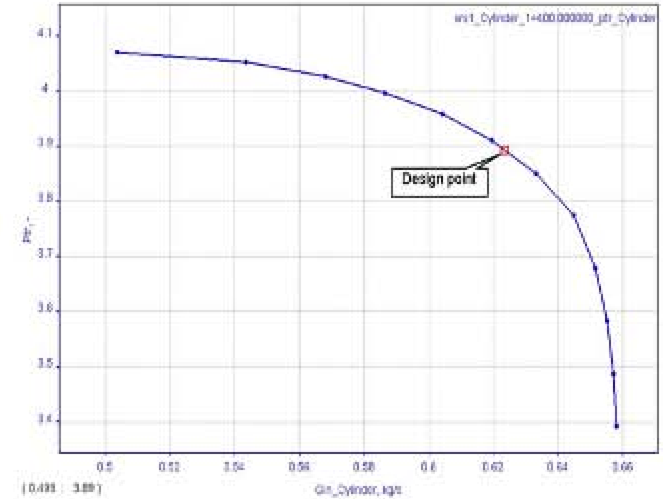


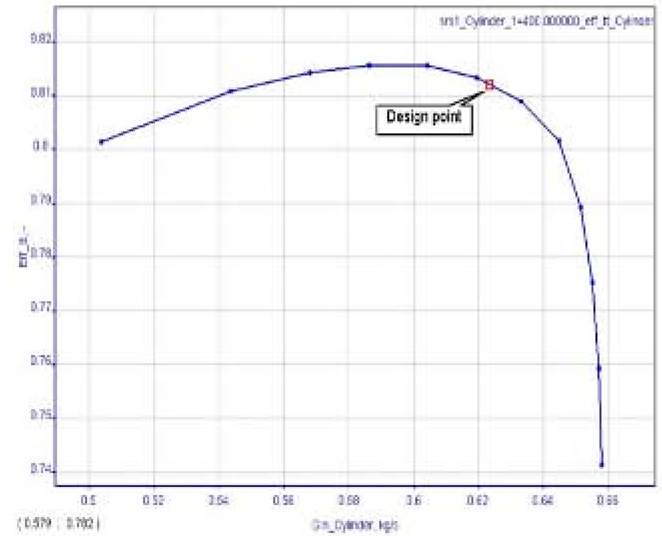
Double-Sided Shaft-Driven Compressor (Performance data using AxStream software from SoftInWay Inc.):











Double-Sided Shaft-Driven Compressor
(Performance data using AxStream software from SoftInWay Inc.):

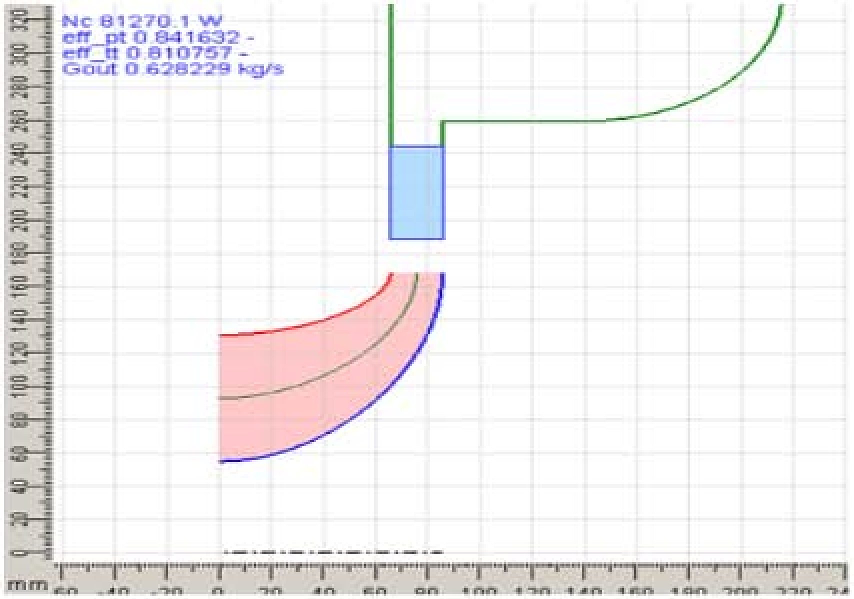
Final meridional dimensions

Stator			
z	number of nozzles	-	25
l2	airfoil LE meridional length	mm	20
D2	channel inlet mean diameter	mm	376.432
l3	airfoil TE meridional length	mm	20
D3	channel outlet mean diameter	mm	489.4
Rotor			
z	number of blades	-	16
D1t	channel inlet shroud diameter	mm	262
D1h	channel inlet hub diameter	mm	110
lc2	channel outlet width	mm	20
D2	channel outlet mean diameter	mm	337
B	axial chord length	mm	85.5

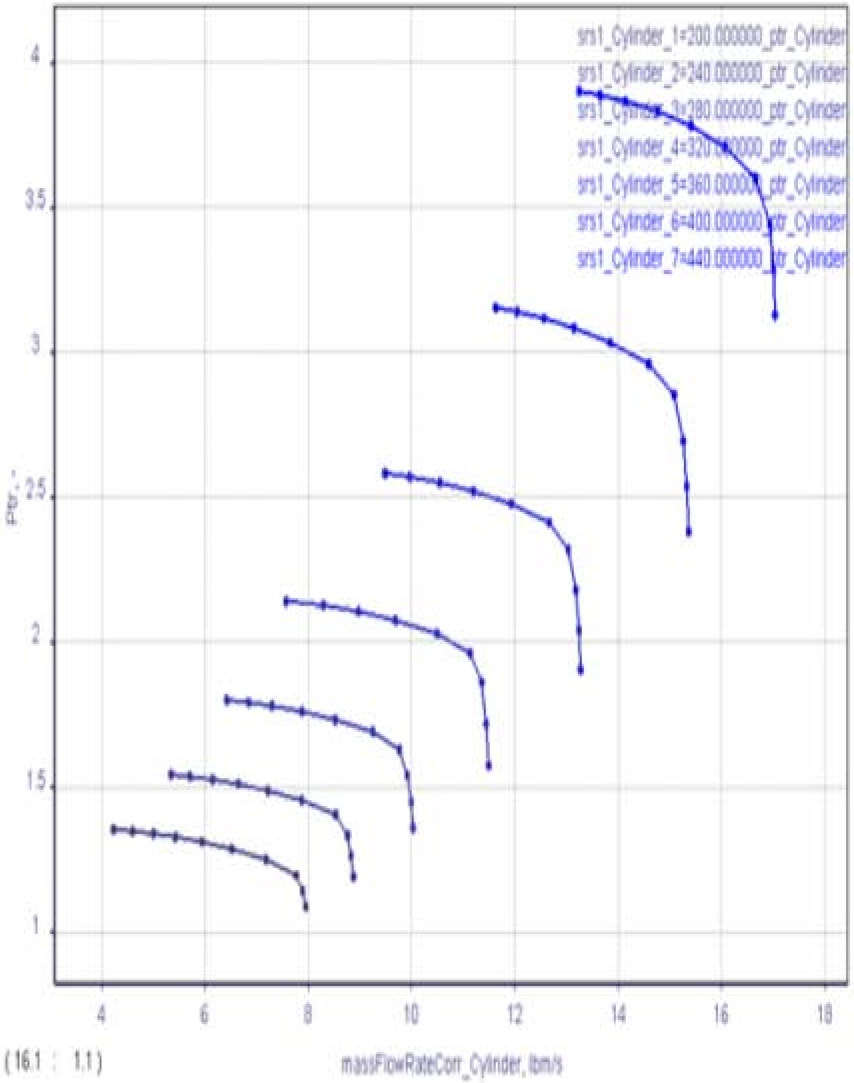
Angles on mid section (tangential)

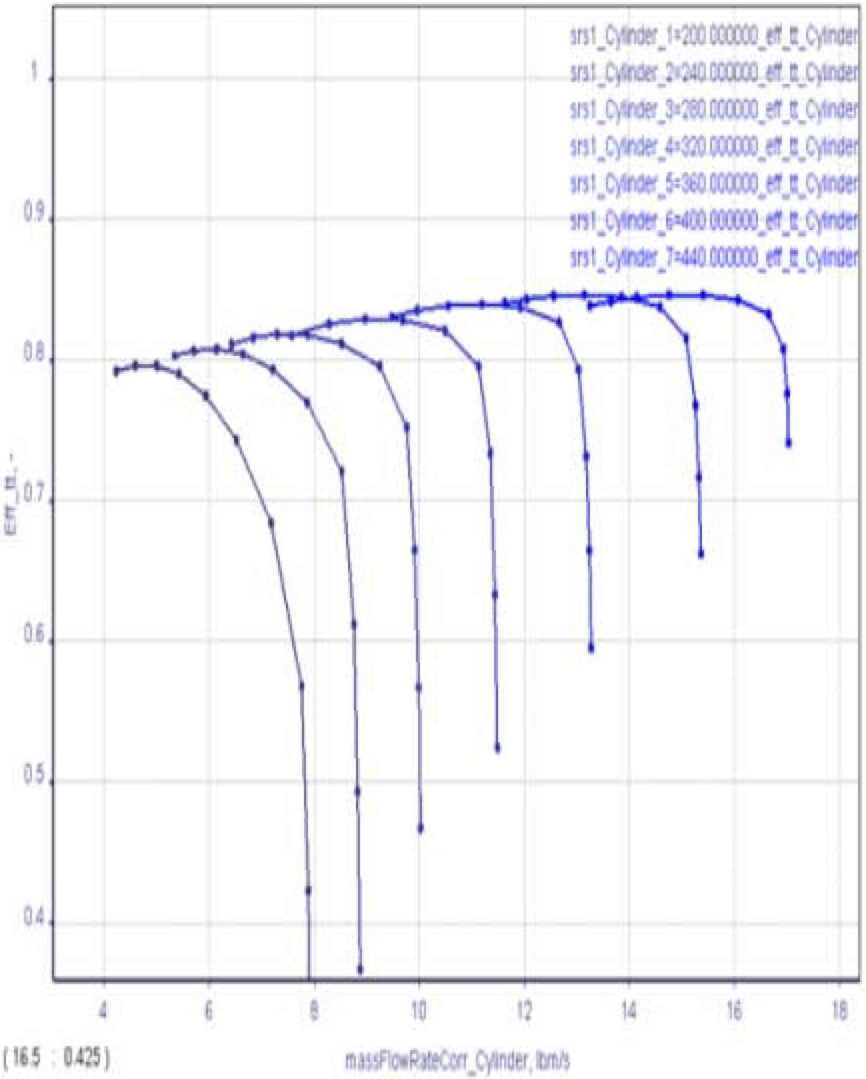
Stator			
A2m	inlet metal angle	deg	28
A3m	outlet metal angle	deg	44.5
Rotor			
B1m	inlet metal angle	deg	33.5
B2m	outlet metal angle	deg	62

	Property	Unit	Value
Pt_in	total pressure at inlet	Pa	7370.500000
It_in	total enthalpy at inlet	J/kg	222044.725000
Tt_in	total temperature at inlet	°C	-52.100000
Pst_out	stat. pressure at outlet	Pa	27105.666668
Pt_out	total pressure at outlet	Pa	28545.302236
Gin	mass flow rate at inlet	kg/s	0.628229
	inlet flow angle in abs frame	deg	90.000000
srs1	shaft1 rotational speed	rps	400.000000
Gv	volume flow rate at outlet	m^3/s	2.277330
Nc	capacity	W	81270.116911
eff_tt	internal total-to-total efficiency	-	0.810757
psr	total-static pressure ratio	-	3.677589
ptr	total-total pressure ratio	-	3.872913

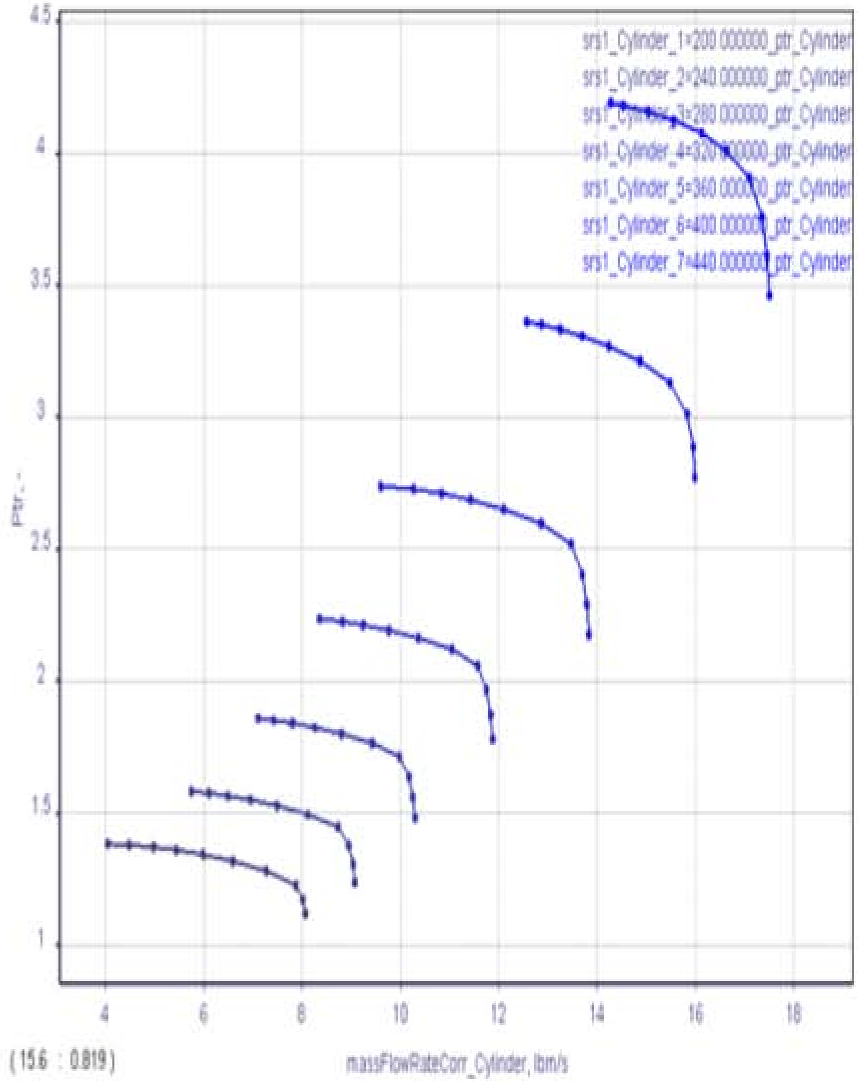


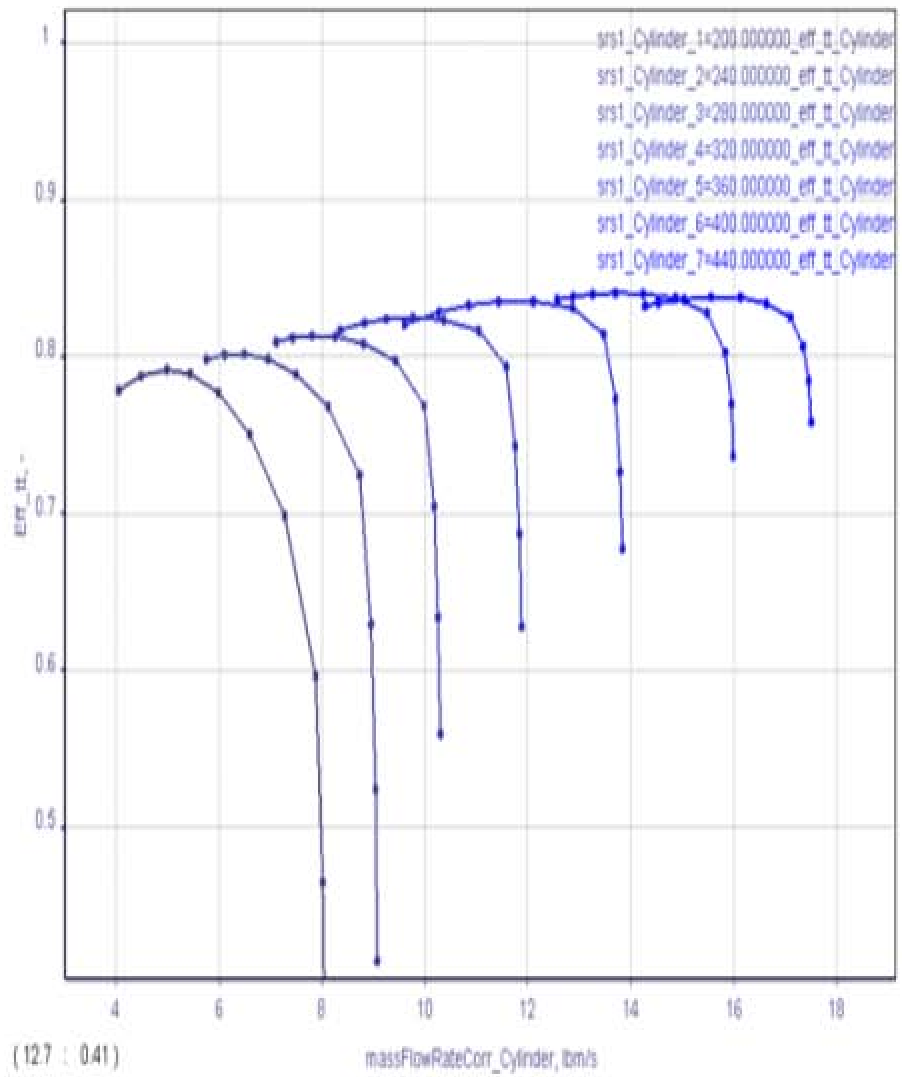
Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 0 kft:



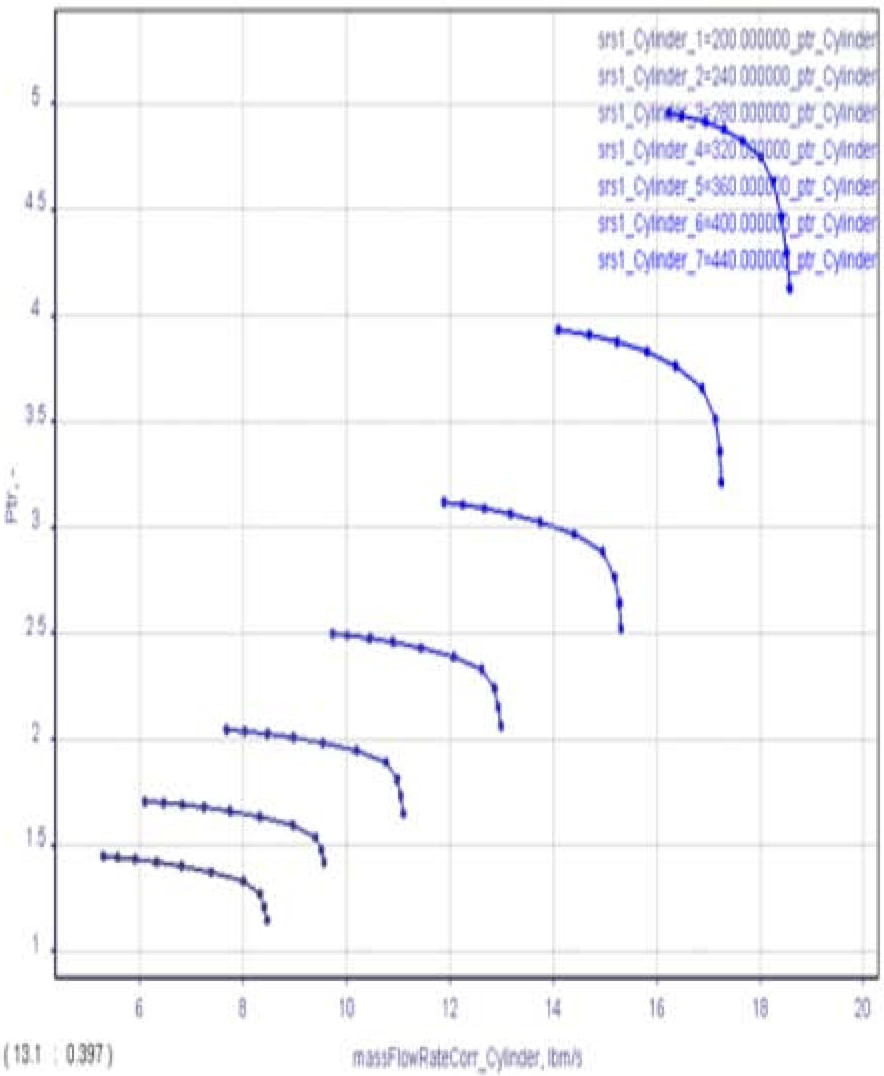


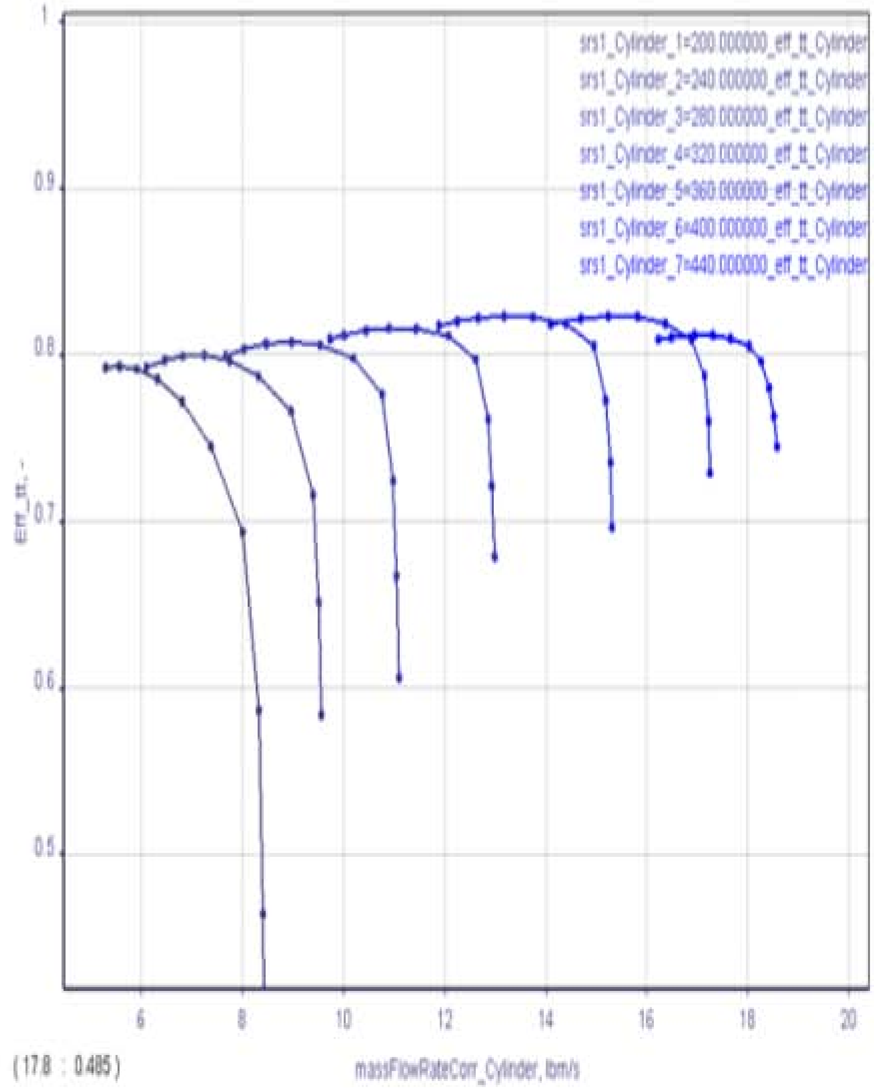
Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 10 kft:



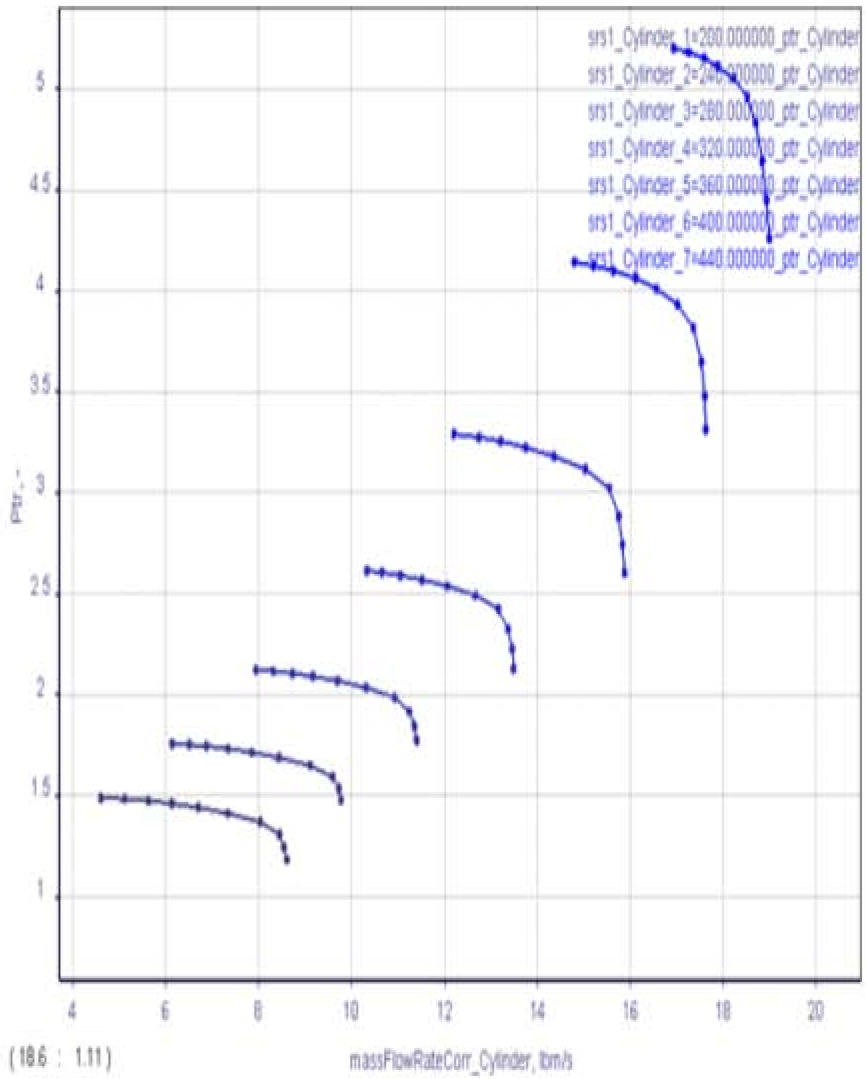


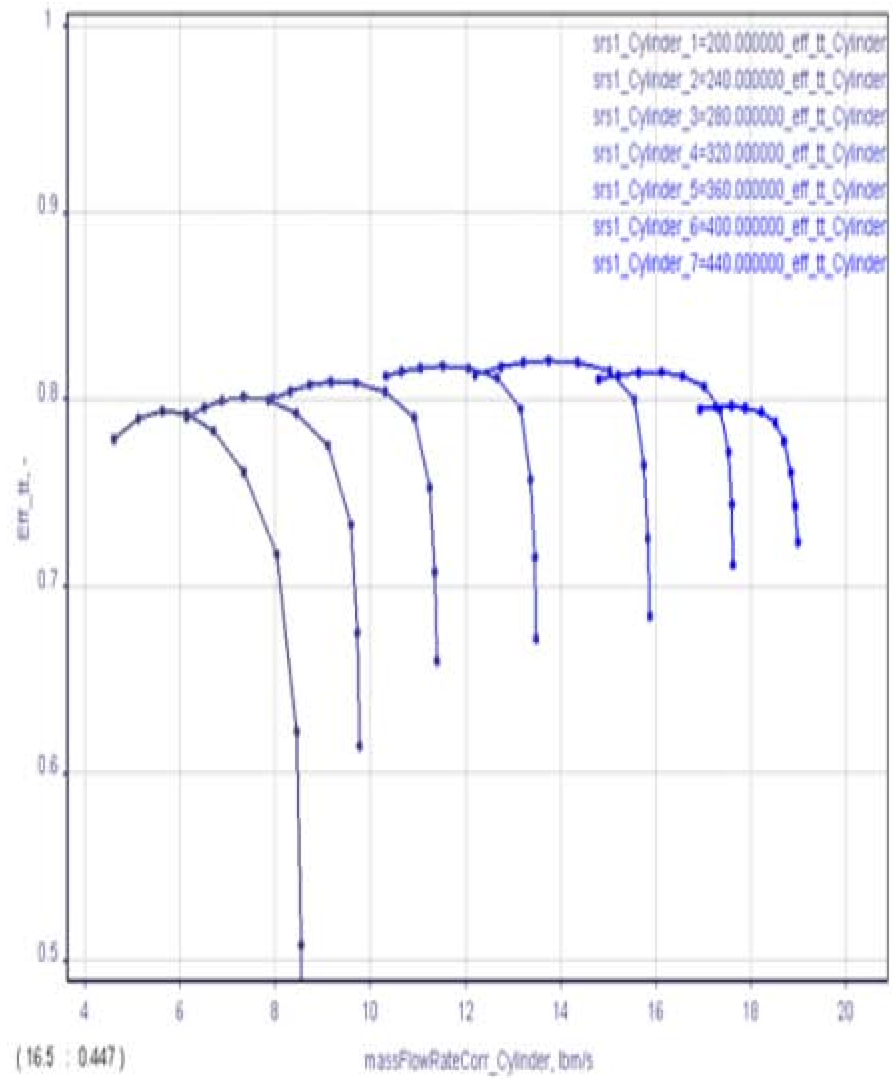
Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 30 kft:



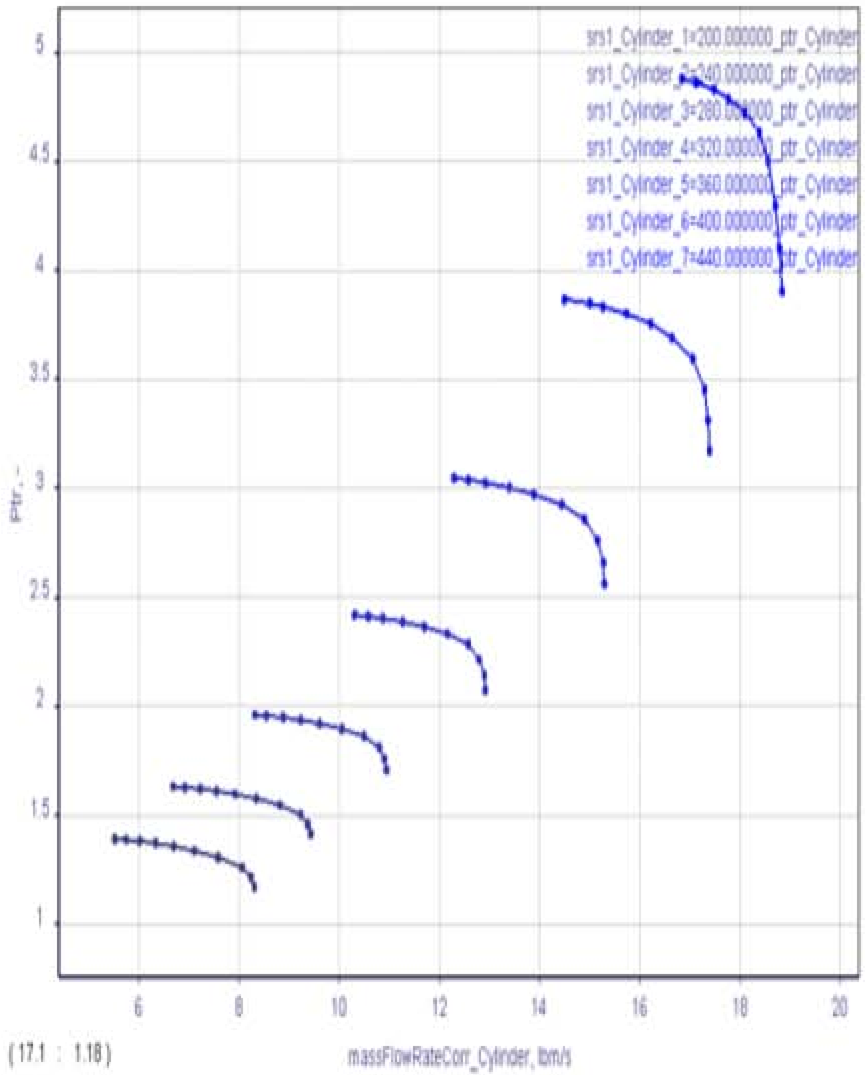


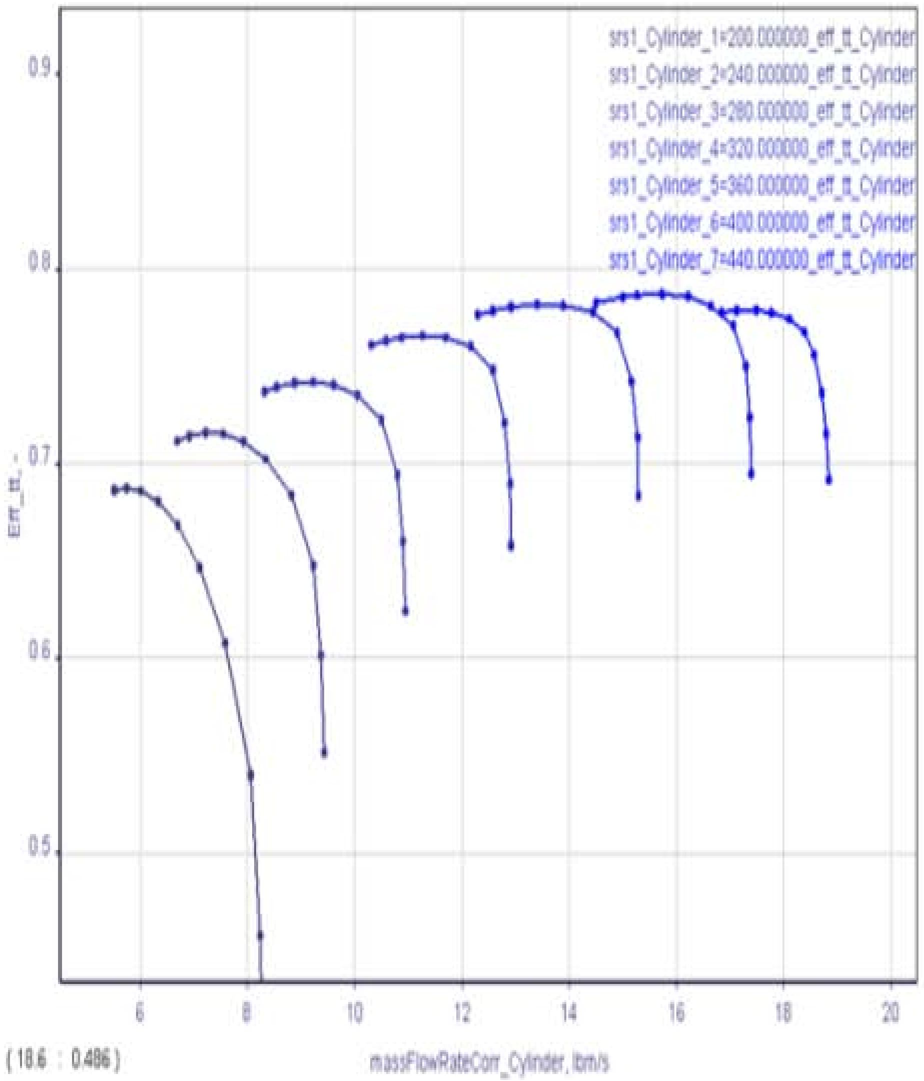
Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 50 kft:





Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 80 kft:





Shaft-Driven Compressor Corrected Mass Flow Rate vs. Total Pressure Ratio and Efficiency (tt) @ 80 kft w/ High Pr: