

# **PERF Program**

## **User Guide**

**Version 5.0**

**April 2016**

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**Hint for Data Editing:** This program uses edit fields for user editing of each piece of data. The program waits until you enter the “tab” or “enter” key to accept your data entry in that field. Use the “tab” key to move between data edit fields.

## 1. GENERAL DESCRIPTION OF PROGRAM

The program **PERF** is based on the design tools in Chapter 8 of the AIAA Education Series textbook *Elements of Propulsion: Gas Turbines and Rockets, Second Edition* by Mattingly and Boyer. This program was written to help engineers and students do the repetitive calculations of an engine's performance with engine control limits. The program has eight (8) engine models and two (2) unit systems. Data windows with input data fields show the user what input data is needed to perform each set of calculations.

Plotting of results is incorporated into each analysis using the Olectra Chart 6.0 software package. Plots can be customized and printed. Screens can be saved/printed by first pressing the **Alt** and **PrtSc** buttons at the same time (this captures a bit map of the current window onto the clip board); start the **Paint** program and paste the image from the clip board onto the blank screen; and then save/print the image.

## 2. ENGINE DATA WINDOW

When the **PERF** program is started, the default input data is loaded from within the program and the **PERF Engine Data** window is displayed with the **Reference Engine Performance** tab displayed as shown below. The pull-down menu system and push buttons help navigate the user. The pull-down menus are shown on the next page.

**PERF Engine Data**

File Engine Cycle Units Component Interfaces Help

File: Default Data Engine Test Done

**Engine Performance Analysis (EPA) Program - V5.0**  Change Design and Data

**Reference Engine Performance** Component Efficiencies and Gas/Fuel Properties

**Reference Engine: Turbofan w/AB**

**Flight Condition:**  
 Mach Number: 0.7  
 Altitude: 0 feet  
 Temperature: 518.67 R  
 Pressure: 14.696 psia

**Design Limits:**  
 Total Temperature Lvg Combustor (Tt4): 3200 R  
 Total Temperature Lvg Afterburner (Tt7): 3600 R

**Design Variables:**  
 Compressor Pressure Ratio (Pt3/Pt2): 20  
 Low Pressure Compressor PR (Pt2.5/Pt2): 3.9  
 Fan Pressure Ratio (Pt13/Pt2): 3.9  
 Bypass Ratio: -1

\* Enter -1 for Fan Pressure Ratio or Bypass Ratio to obtain value that gives matched total pressures as stations 6 and 16

**Size**  
 Mass Flow Rate: 200 lbm/s

**Uninstalled Engine Performance at Reference Point**

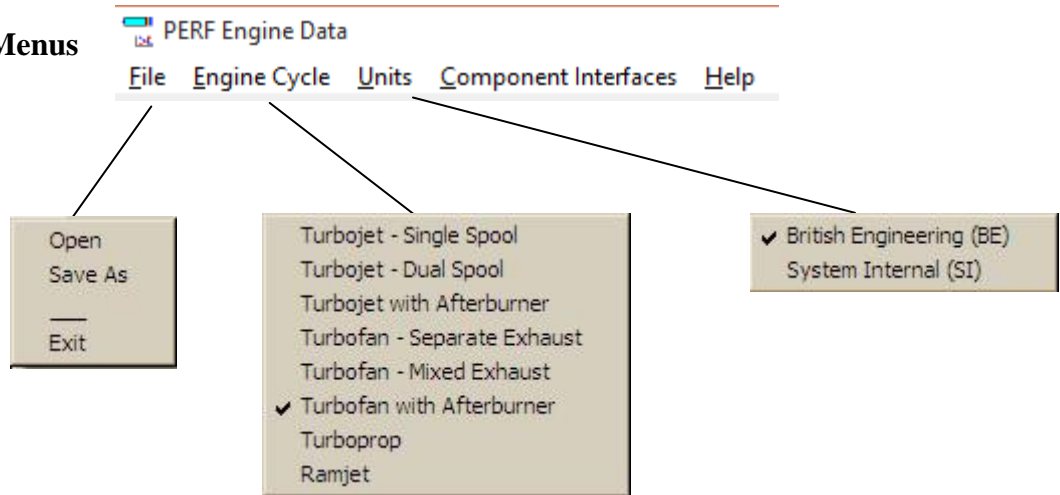
<b>Thrust</b>	21110 lbf		<b>Turbomachinery Efficiency (%)</b>	LP Compressor	86.74
<b>Thrust Specific Fuel Consumption</b>	1.7607 lbm/(hr-lbf)			HP Compressor	87.51
Bypass Ratio	0.6821			Fan	86.74
Thermal Efficiency (%)	33.61			HP Turbine	89.86
Propulsive Efficiency (%)	33.21			LP Turbine	90.81

Station:	2	1.3	2.5	3	4	4.5	5	8	9
Tt (R)	569.50	881.54	881.54	1481.25	3200.00	2723.97	2307.32	3600.00	3600.00
Pt (psia)	19.57	76.32	76.32	391.39	371.82	169.73	76.32	69.65	67.56
Mach					1.00	1.00		1.00	1.6772

Turbojet - Single Spool    Turbojet - Dual Spool    Turbojet with Afterburner    Turbofan - 2 Exhausts

Turbofan - Mixed Exhaust    **Turbofan with Afterburner**    Turboprop    Ramjet

## Pull-down Menus



### File Pull-down Menu

Many of the file pull-down menu functions are similar to that of other programs.

- Open** - Display a dialog window to open **PERF** input files (extension “EPA”).
- Save As** - Display a dialog window to save the current data file as a PERF data file (extension “EPA”).
- Exit** - Exit program.

### Engine Cycle Pull-down Menu

User can select from the eight (8) engine cycles shown above.

### Units Pull-down Menu

The user can select British English (BE) or System Internal (SI) unit systems. When unit system changes, the data are converted to the new unit system and the reference engine results updated.

### Component Interface Pull-down Menu

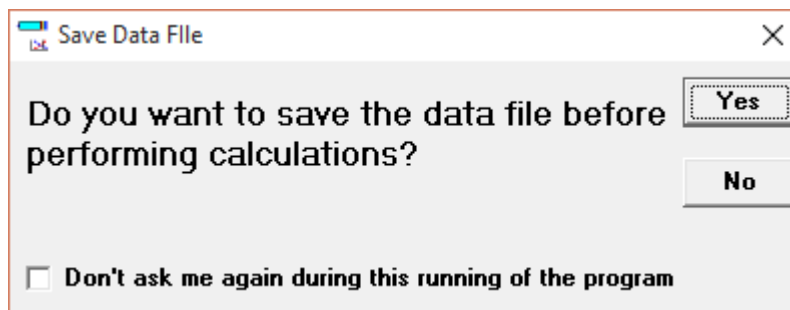
Selecting this item opens the Component Interface window that allows the user to calculate properties at each engine station.

### Help Pull-down Menu

Selecting this item refers the user to the PERF User Guide

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**NOTE:** When the user first presses the **Engine Test** or **Calculate** button in many **PERF** windows, they will be asked if they want to save the input data before the calculations are performed using the following window. The user can check the box and turn off this reminder.



When the **Component Efficiencies and Gas/Fuel Properties** tab of the **PERF Engine Data** window is selected, the following data entry window is displayed.

PERF Engine Data

File Engine Cycle Units Component Interfaces Help

File: Default Data **Engine Test** **Done**

**Engine Performance Analysis (EPA) Program - V5.0**  Change Design and Data

Reference Engine Performance

**Fuel and Gas Properties**

Fuel Heating Value (Btu/lbm)	18400
Cp c {Btu/(lbm-R)}	0.24
Gamma c	1.4
Cp t {Btu/(lbm-R)}	0.295
Gamma t	1.3
Cp AB {Btu/(lbm-R)}	0.295
Gamma AB	1.3

**Component Efficiencies**

Burner	0.999
Mechanical Shaft - LP Spool	0.995
Mechanical Shaft - HP Spool	0.995
Afterburner	0.99

**Component Total Pressure Ratios**

Pi Diffuser Max (Pt2/Pt1)	0.96
Pi Burner (Pt4/Pt3)	0.95
Pi Nozzle (Pt9/Pt7)	0.97
Pi Afterburner	0.95

**Polytropic Efficiencies**

Fan	0.89
LP Compressor	0.89
HP Compressor	0.9
HP Turbine	0.89
LP Turbine	0.9

**Exhaust Nozzle**

P0/P9	1
-------	---

**Mixer**

Pi Mixer Max	0.97
Mach Number @ 6	0.4

### Changing Design Data

The **Mass Flow Rate** edit field is always active so that an engine can be resized at any time. To change any other design data, the check box beside **Change Design and Data** must be checked. This will activate the edit fields and Engine Cycle pull-down menu for selection.

## Component Interface

Selecting the **Component Interface** pull-down menu item opens the Component Interfaces window. Press the **Calculate** button to display the component flow properties based on the user input Mach number data (initial estimates) at the top of the window and the Thrust Scale Factor as shown below. The resulting annular flow areas are used in Engine Station Test Results calculations within the Engine Test window.

Component Interfaces x

Mach @ 1 
Mach @ 2 
Mach @ 3.2 
Mach @ 5 
Mach @ 7

Design Interface Quantities (Version 5.0)      Date:1/20/2016 7:11:51 AM  
 File Name: Default Data

Station	m dot (lbm/s)	gamma	Pt (psia)	Tt (R)	P (psia)	T (R)	Mach	Velocity (ft/s)	Area (ft <sup>2</sup> )	Area* (ft <sup>2</sup> )	I (lbf)
0	200.00	1.4000	20.385	569.50	14.696	518.67	0.7000	781.46	3.347	3.058	11940.6
1	200.00	1.4000	20.385	569.50	10.769	474.58	1.0000	1067.88	0.000	3.058	0.0
2	200.00	1.4000	19.569	569.50	16.497	542.38	0.5000	570.81	4.268	3.185	13687.9
13	200.00	1.4000	76.321	881.54	68.416	854.43	0.3984	570.81	1.621	1.016	19521.6
core	118.90	1.4000	76.321	881.54	68.416	854.43	0.3984	570.81	0.964	0.604	11605.3
bypass	81.10	1.4000	76.321	881.54	68.416	854.43	0.3984	570.81	0.657	0.412	7916.3
2.5	118.90	1.4000	76.321	881.54	68.416	854.43	0.3984	570.81	0.964	0.604	11605.3
3.0	118.90	1.4000	391.389	1481.25	366.884	1454.13	0.3054	570.81	0.306	0.153	18270.0
MB fuel	3.5756										
4	122.47	1.3000	371.820	3200.00	202.912	2782.61	1.0000	2483.05	0.249	0.249	16722.6
4.5	122.47	1.3000	169.731	2723.97	92.627	2368.67	1.0000	2290.92	0.503	0.503	15428.7
5	122.47	1.3000	76.321	2307.32	60.767	2189.11	0.6000	1321.43	1.228	1.029	15778.2
6	122.47	1.3000	76.321	2307.32	68.867	2253.24	0.4000	893.76	1.649	1.029	19758.8
16	81.10	1.4000	76.321	881.54	68.867	856.03	0.3860	553.67	0.675	0.412	8086.6
6A	203.58	1.3333	73.320	1808.13	65.230	1756.04	0.4218	843.90	2.396	1.565	27845.4
AB fuel	6.7489										
7	210.32	1.3000	69.654	3600.00	59.383	3469.88	0.5000	1386.39	3.261	2.419	36949.1
8	210.32	1.3000	69.654	3600.00	38.012	3130.43	1.0000	2633.67	2.419	2.419	30460.0
9	210.32	1.3000	67.564	3600.00	14.696	2531.71	1.6772	3972.44	3.355	2.494	33069.2

Print
Calculate
Done

### 3. ENGINE TEST WINDOW

Pressing the **Engine Test** button on the **PERF Engine Data** window opens the **Engine Test** window, shown below, and performance analysis of the reference engine. Pressing the **Test** button causes the performance analysis software to calculate the engine performance at the percent thrust set in the % Thrust data field and update results on the right side of the Engine Test window. The **Engine Control** data on the left limits the engine's operation.

Engine Test
✕

**Engine Cycle:** Turbofan w/AB  
File: Default Data

**Operating Condition**

Mach number

Altitude  ft

Temperature  R

**Engine Controls**

Max Temperature at Station 4  R

Max Compressor Pressure Ratio

Max Pressure at Station 3 \*  psia

Max Temperature at Station 3 \*  R

Max % Ref RPM - LP Spool \*

Max % Ref RPM - HP Spool \*

Max Temperature at Station 7 +  R

P0/P9    A9/A8

\* Enter 0 for no control limit on this property  
+ Enter 0 to turn off afterburner

**Atmosphere**

Standard    Hot Day

Cold Day    Tropical Day

**Independent Variable**

Mach Number

Altitude (ft)

Ambient Temperature - T0 (R)

Ambient Pressure - P0 (psia)

Total Temperature Lvg Combustor - Tt4 (R)

Total Temperature Lvg Afterburner - Tt7 (R)

Exhaust Pressure Ratio - P0/P9

No Mach Altitude Day

% Thrust 

**Single Point Test**

**Done**

Thrust (uninstalled)	17637	lbf
TSFC (uninstalled)	1.6115	lbm/(lbf-hr)
Mass Flow Rate	150.97	lbm/sec
Tt4	2913.9	R
Tt7	3600.0	R
Limit:	<b>PIC Max</b>	Tt3 1349.1 R
CPR (Pt3/Pt2)	20.00	mdotc @ 4 12.02
Fan PR	3.902	Pt4/Pt4.5 2.1906
mdotc @ 2	157.25	Tt4.5/Tt4 0.8512
LPC PR	3.902	mdotc @ 4.5 24.30
HPC PR	5.13	Pt4.5/Pt5 2.2232
mdotc @ 2.5	29.84	Tt5/Tt4.5 0.8471
% RPM - LP spool	95.46	Bypass Ratio 0.6804
%RPM - HP Spool	95.43	A9/A8 1.1953
Tt5	2101	R
EPR (Pt6/Pt2)	3.90	
Max Thrust	17637	
TSFC @ Max	1.6115	
Mil Thrust	11555	

**Perform Calcs**

Minimum

Maximum

Step Size

No of Lines

**Partial Throttle Tests**

Min % Thrust

Number of Lines

**Summary of Test Results**

**Engine Station Test Results**

Color

Wide Lines

Symbols

Legend

After performing a test, press the **Summary of Test Results** button in the Engine Test window to open the Results window and display a comparison of engine performance at the reference and test points as shown below.

Results ✕

PERF (Ver. 5.0)      Turbofan with AB - Dual Spool      Date:4/11/2016 7:54:05 AM  
 Engine File: Default Data

Input Constants

Pidmax= 0.9600	Pi b = 0.9500	Eta b = 0.9990	Pi n = 0.9700
cp c = 0.2400	cp t = 0.2950	Gam c = 1.4000	Gam t = 1.3000
Pi AB = 0.9500	Eta AB= 0.9900	cp AB = 0.2950	Gam AB= 1.3000
Eta cL= 0.8674	Eta cH= 0.8751	Eta tH= 0.8986	Eta tL= 0.9081
Eta mL= 0.9950	Eta mH= 0.9950	Eta f = 0.8674	hPR = 18400

Control Limits: Tt4 = 3200.0    Pi c = 20.00

Parameter	Reference**	Test**
Mach Number @ 0	0.7000	0.7000
Temperature @ 0	518.67	518.67 R
Pressure @ 0	14.6960	14.6960 psia
Altitude @ 0	0	0 ft
Total Temp @ 4	3200.00	3200.00 R
Total Temp @ 7	3600.00	3600.00 R
Pi r / Tau r	1.3871/ 1.0980	1.3871/ 1.0980
Pi d	0.9600	0.9600
Pi f / Tau f	3.9000/ 1.5479	3.9000/ 1.5479
Pi cL / Tau cL	3.9000/ 1.5479	3.9000/ 1.5479
Pi cH / Tau cH	5.1282/ 1.6803	5.1282/ 1.6803
Pi tH / Tau tH	0.4565/ 0.8512	0.4565/ 0.8512
Pi tL / Tau tL	0.4497/ 0.8470	0.4497/ 0.8470
Control Limit		Tt4max
LP Spool RPM (% of Reference Pt)	100.00	100.00

Print

Done



After performing a test, press the **Engine Station Test Results** button in the Engine Test window to open the Engine Station window and display the component interface flow properties as shown below. These are based on the annular flow areas calculated using the **Component Interface** button within the Engine Data window. If the **Component Interface** button has not been pressed and the annular flow areas calculated, then only the mass flow rates, ratio of specific heats, and total properties are shown for each engine station.

Engine Stations x

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Test Results at Engine Stations (PERF Ver 5.0)      Date:1/20/2016 7:32:23 AM  
 Filename:  
 Percent Thrust = 100    Altitude = 0 ft    Mach = 0.01    Standard Day

Station	m dot (lbm/s)	gamma	Pt (psia)	Tt (R)	P (psia)	T (R)	Mach	Velocity (ft/s)	Area (ft <sup>2</sup> )	Area* (ft <sup>2</sup> )	I (lbf)
0	150.97	1.4000	14.697	518.68	14.696	518.67	0.0100	11.16	176.80	3.055	374202.7
1	150.97	1.4000	14.697	518.68	14.368	515.33	0.1803	200.59	10.000	3.055	21630.5
2	150.97	1.4000	14.109	518.68	11.900	494.04	0.4993	544.05	4.268	3.182	9866.2
13	150.97	1.4000	55.059	803.03	49.375	778.41	0.3976	543.84	1.621	1.015	14079.1
core	89.84	1.4000	55.059	803.03	49.375	778.41	0.3976	543.84	0.965	0.604	8378.4
bypass	61.13	1.4000	55.059	803.03	49.375	778.41	0.3976	543.84	0.656	0.411	5700.7
2.5	89.84	1.4000	55.059	803.03	49.361	778.35	0.3981	544.50	0.964	0.604	8371.4
3	89.84	1.4000	282.215	1349.12	264.543	1324.42	0.3053	544.72	0.306	0.153	13173.5
MB fuel	2.3895										
4	92.23	1.3000	268.105	2913.91	146.312	2533.83	1.0000	2369.45	0.249	0.249	12058.0
4.5	92.23	1.3000	122.386	2480.43	66.790	2156.90	1.0000	2186.12	0.503	0.503	11125.0
5	92.23	1.3000	55.050	2101.18	43.841	1993.63	0.5997	1260.42	1.228	1.029	11379.7
6	92.23	1.3000	55.050	2101.18	49.676	2051.96	0.3999	852.69	1.649	1.029	14251.5
16	61.13	1.4000	55.059	803.03	49.718	779.95	0.3846	526.49	0.675	0.411	4830.5
6A	153.36	1.3334	52.888	1646.47	47.099	1599.43	0.4201	802.01	2.396	1.560	20072.9
AB fuel	5.5058										
7	158.87	1.3000	50.244	3600.00	41.912	3452.48	0.5337	1476.19	3.261	2.534	26970.3
8	158.87	1.3000	50.244	3600.00	27.419	3130.43	1.0000	2633.67	2.534	2.534	23007.5
9	158.87	1.3000	48.736	3600.00	14.696	2729.93	1.4577	3585.01	3.028	2.612	24110.2

Print Done

<b>Independent Variable</b> <input checked="" type="radio"/> Mach Number <input type="radio"/> Altitude (ft) <input type="radio"/> Ambient Temperature - T0 (R) <input type="radio"/> Ambient Pressure - P0 (psia) <input type="radio"/> Total Temperature Lvg Combustor - Tt4 (R) <input type="radio"/> Total Temperature Lvg Afterburner - Tt7 (R) <input type="radio"/> Exhaust Pressure Ratio - P0/P9  No Mach Altitude Day 1 - 0.01M/00.0kft/ Standard	<b>Perform Calcs</b> Minimum <input type="text" value="0"/> Maximum <input type="text" value="2"/> Step Size <input type="text" value="0.05"/> No of Lines <input type="text" value="1"/> <b>Plot</b> <b>Remove Plot Line</b> <b>Zero Plot File</b>	<b>Partial Throttle Tests</b> Min % Thrust <input type="text" value="20"/>  Number of Lines <input type="text" value="0"/>
	<input checked="" type="checkbox"/> Color <input type="checkbox"/> Wide Lines <input type="checkbox"/> Symbols <input checked="" type="checkbox"/> Legend	

The engine performance can be calculated at full throttle (military and maximum power) and plotted using the lower left of the Engine Test window as shown above. After the **Perform Calcs** button is pressed, the Results window is opened and the predicted engine performance displayed as shown below. The program saves the variation of the engine performance with the independent variable for later plotting. The status of the saved plot data is updated in the Engine Test window. Up to 21 plot lines can be plotted.

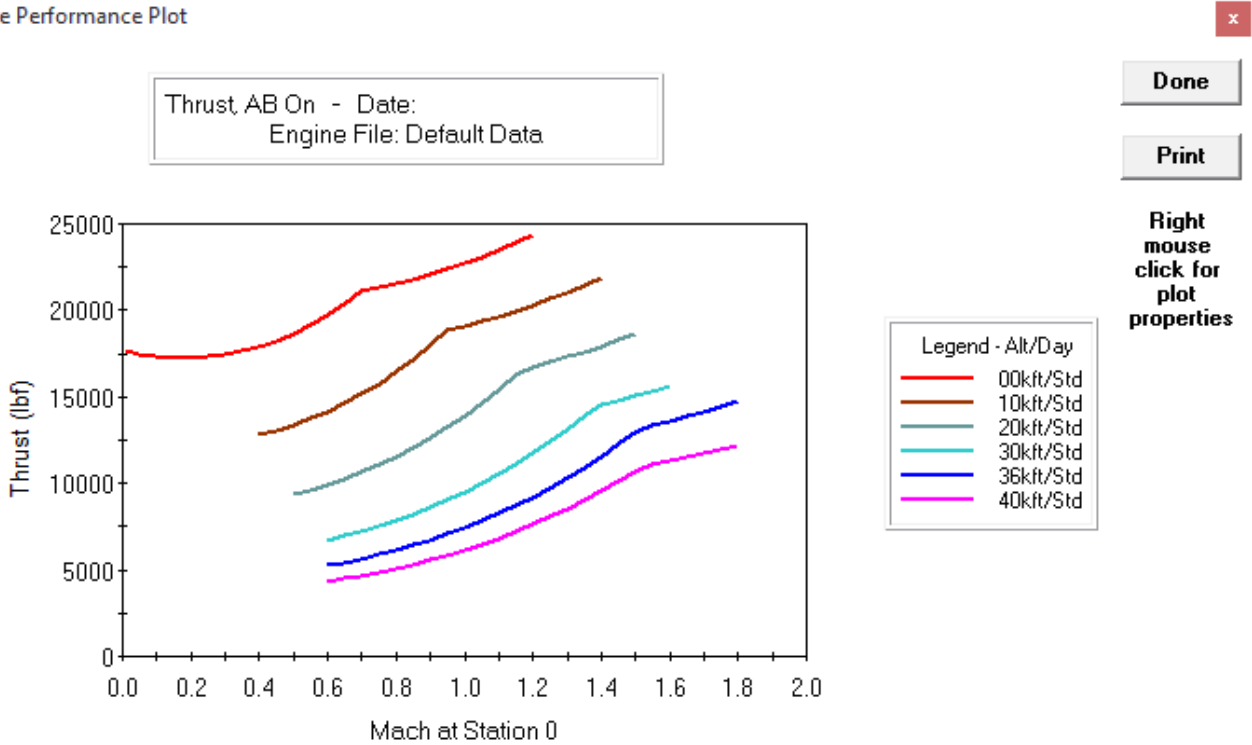
M0	Thrust	S	mdot	Pic	Pif	Alpha	Pt9/P9	PitL	Tt4	A0 A0*	Area9	Limit
0.01	17637	1.6115	150.97	20.00	3.902	0.680	3.3163	0.4498	2913.9	3.055	3.028	PIC Max
0.05	17476	1.6286	151.19	20.00	3.902	0.680	3.3219	0.4498	2915.3	3.055	3.030	PIC Max
0.10	17324	1.6500	151.87	20.00	3.902	0.680	3.3393	0.4498	2919.7	3.056	3.034	PIC Max
0.15	17245	1.6695	153.01	20.00	3.902	0.680	3.3684	0.4498	2926.9	3.056	3.041	PIC Max
0.20	17236	1.6871	154.61	20.00	3.902	0.680	3.4098	0.4498	2937.1	3.055	3.051	PIC Max
0.25	17299	1.7027	156.71	20.00	3.902	0.681	3.4635	0.4498	2950.4	3.056	3.064	PIC Max
0.30	17429	1.7164	159.28	20.00	3.902	0.681	3.5294	0.4498	2966.4	3.056	3.081	PIC Max
0.35	17630	1.7281	162.35	20.00	3.902	0.681	3.6089	0.4498	2985.3	3.056	3.101	PIC Max
0.40	17902	1.7378	165.95	20.00	3.902	0.681	3.7023	0.4498	3007.2	3.056	3.124	PIC Max
0.45	18254	1.7456	170.16	20.01	3.903	0.681	3.8112	0.4497	3032.6	3.057	3.152	PIC Max
0.50	18664	1.7518	174.83	20.00	3.901	0.681	3.9331	0.4498	3059.8	3.057	3.183	PIC Max
0.55	19155	1.7561	180.13	20.00	3.901	0.681	4.0724	0.4498	3090.4	3.057	3.219	PIC Max
0.60	19741	1.7587	186.18	20.02	3.903	0.681	4.2314	0.4497	3125.1	3.059	3.260	PIC Max
0.65	20378	1.7604	192.70	20.00	3.901	0.682	4.4038	0.4497	3160.7	3.058	3.305	PIC Max
0.70	21110	1.7607	200.00	20.00	3.900	0.682	4.5975	0.4497	3200.0	3.058	3.355	Tt4 Max
0.75	21292	1.7751	203.85	19.37	3.803	0.691	4.6832	0.4513	3200.0	2.997	3.388	Tt4 Max
0.80	21510	1.7889	208.04	18.73	3.703	0.700	4.7767	0.4531	3200.0	2.934	3.423	Tt4 Max
0.85	21763	1.8019	212.58	18.08	3.604	0.710	4.8787	0.4551	3200.0	2.870	3.461	Tt4 Max
0.90	22052	1.8143	217.51	17.44	3.503	0.721	4.9890	0.4571	3200.0	2.806	3.503	Tt4 Max
0.95	22380	1.8261	222.84	16.80	3.403	0.732	5.1083	0.4593	3200.0	2.742	3.547	Tt4 Max
1.00	22747	1.8372	228.58	16.16	3.304	0.744	5.2371	0.4616	3200.0	2.677	3.595	Tt4 Max
1.05	23113	1.8484	234.46	15.53	3.206	0.756	5.3694	0.4640	3200.0	2.616	3.643	Tt4 Max
1.10	23497	1.8594	240.63	14.92	3.109	0.769	5.5076	0.4665	3200.0	2.562	3.693	Tt4 Max
1.15	23910	1.8701	247.16	14.31	3.014	0.782	5.6542	0.4691	3200.0	2.517	3.747	Tt4 Max

As an example of a performance plot, the performance of the default data (PERF.EPA) engine is calculated at maximum power over the range of Mach numbers listed for each altitude listed below for a standard day atmosphere.

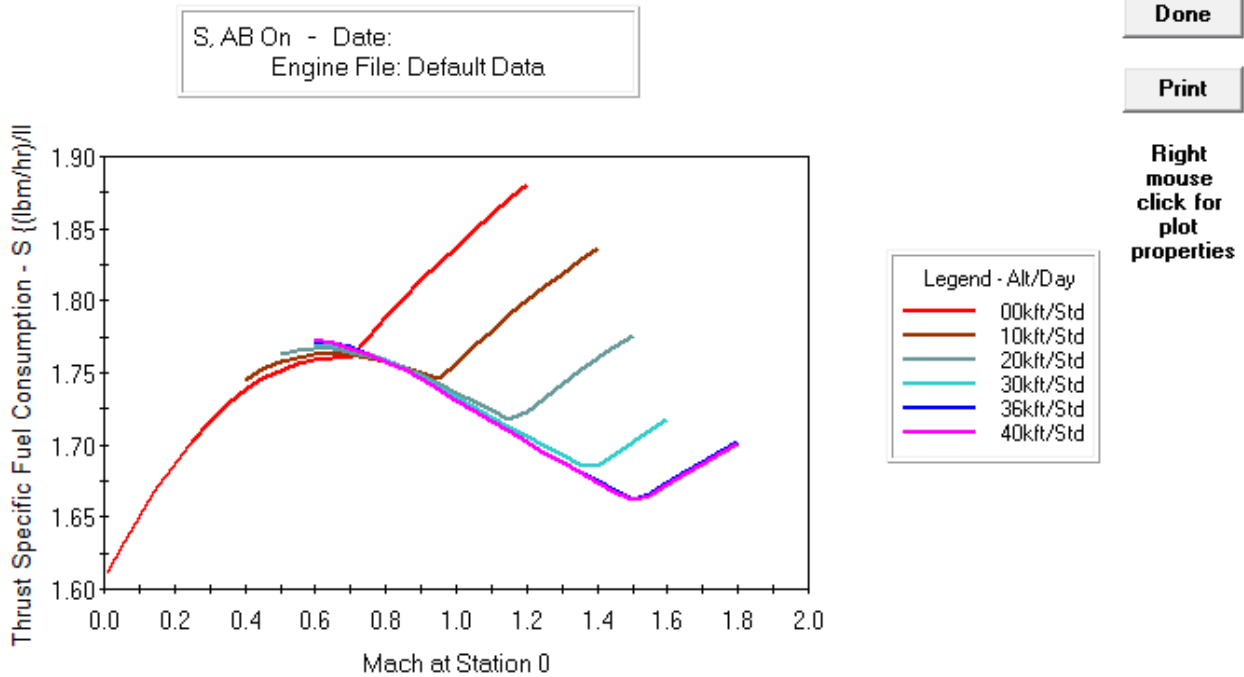
Altitude (kft)	Min Mach	Max Mach
0	0	1.2
10	0.4	1.4
20	0.5	1.5
30	0.6	1.6
36	0.6	1.8
40	0.6	1.8

Once these calculations were done, the uninstalled thrust was plotted and is shown below. The uninstalled thrust specific fuel consumption (S) is shown on the next page.

Engine Performance Plot



## Engine Performance Plot



Similarly, the partial throttle performance of an engine can be calculated and plotted using the lower right of the Engine Test window (shown below). Press the **Partial Throttle** button to calculate the uninstalled performance of an engine from 100% down to the minimum thrust entered in the Min % Thrust data field (minimum value is 4%). The results are displayed in a Throttle Hook results window as shown on the next page.

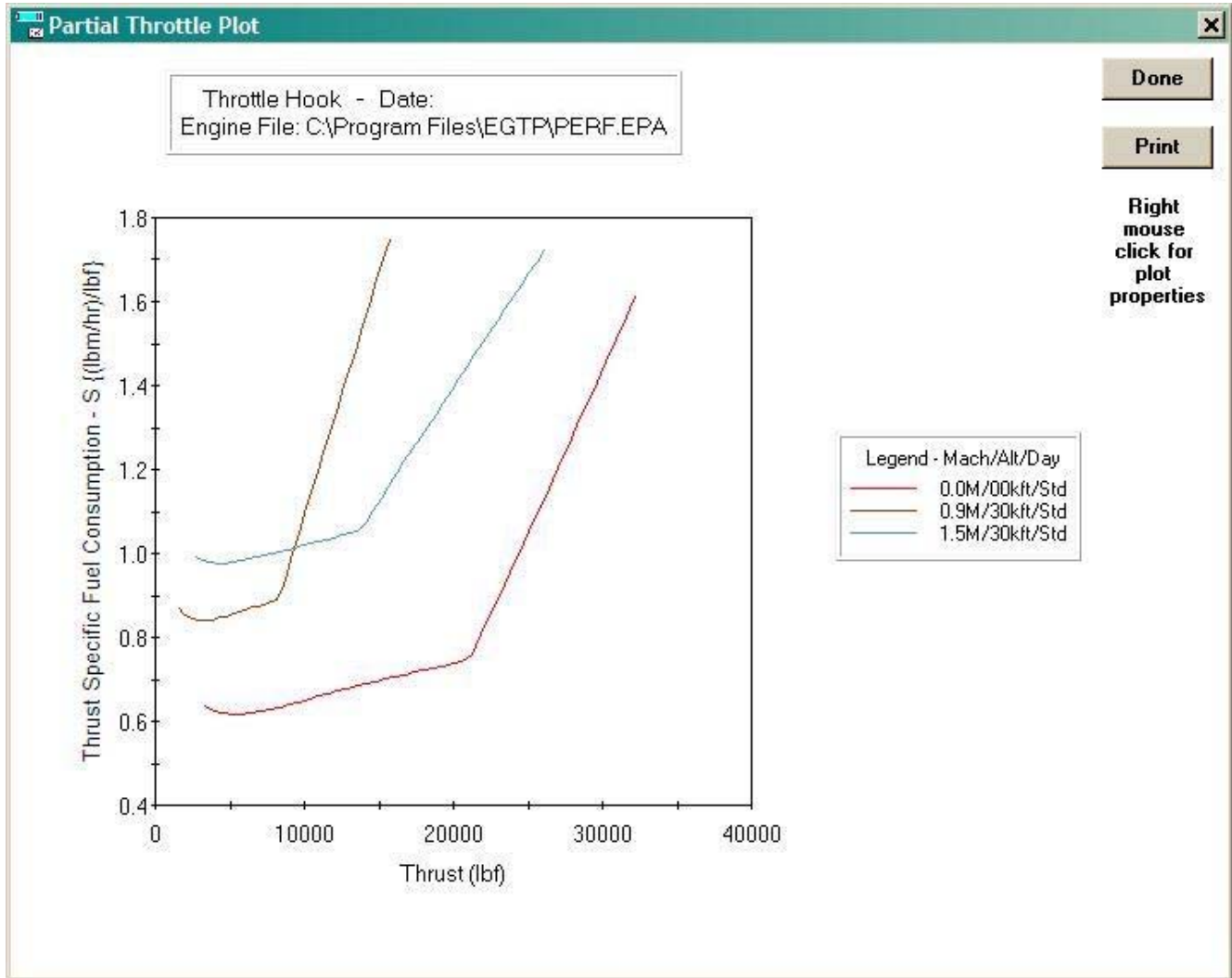
<b>Independent Variable</b> <input type="radio"/> Mach Number <input type="radio"/> Altitude (ft) <input type="radio"/> Ambient Temperature - T0 (R) <input type="radio"/> Ambient Pressure - P0 (psia) <input type="radio"/> Total Temperature Lvg Combustor - Tt4 (R) <input type="radio"/> Total Temperature Lvg Afterburner - Tt7 (R) <input type="radio"/> Exhaust Pressure Ratio - P0/P9  No Mach Altitude Day <div style="border: 1px solid gray; height: 40px; width: 100%;"></div>	<b>Perform Calcs</b> Minimum <input style="width: 50px;" type="text" value="0"/> Maximum <input style="width: 50px;" type="text" value="2"/> Step Size <input style="width: 50px;" type="text" value="0.1"/> No of Lines <input style="width: 50px;" type="text" value="0"/>	<b>Partial Throttle</b> Min % Thrust <input style="width: 50px;" type="text" value="10"/>  Number of Lines <input style="width: 50px;" type="text" value="0"/>
<input checked="" type="checkbox"/> Color <input type="checkbox"/> Wide Lines <input type="checkbox"/> Symbols <input checked="" type="checkbox"/> Legend		

Thrust	S	mdot	mdotc2	Pif	mdotc25	PicH	Tt4	Tt7	AB	Limit
32194	1.6139	275.67	287.13	3.902	51.50	5.126	2990.5	3599.9	AB On	PIC Max
31552	1.5616	275.67	287.13	3.902	51.50	5.126	2990.5	3473.5	AB On	PIC Max
30908	1.5095	275.67	287.13	3.902	51.50	5.126	2990.5	3348.0	AB On	PIC Max
30264	1.4577	275.67	287.13	3.902	51.50	5.126	2990.5	3224.0	AB On	PIC Max
29621	1.4063	275.67	287.13	3.902	51.50	5.126	2990.5	3101.5	AB On	PIC Max
28977	1.3551	275.67	287.13	3.902	51.50	5.126	2990.5	2980.5	AB On	PIC Max
28332	1.3041	275.67	287.13	3.902	51.50	5.126	2990.5	2860.8	AB On	PIC Max
27689	1.2535	275.67	287.13	3.902	51.50	5.126	2990.5	2743.0	AB On	PIC Max
27045	1.2032	275.67	287.13	3.902	51.50	5.126	2990.5	2627.0	AB On	PIC Max
26402	1.1532	275.67	287.13	3.902	51.50	5.126	2990.5	2512.8	AB On	PIC Max
25758	1.1033	275.67	287.13	3.902	51.50	5.126	2990.5	2400.4	AB On	PIC Max
25113	1.0536	275.67	287.13	3.902	51.50	5.126	2990.5	2289.7	AB On	PIC Max
24469	1.0043	275.67	287.13	3.902	51.50	5.126	2990.5	2181.3	AB On	PIC Max
23826	0.9551	275.67	287.13	3.902	51.50	5.126	2990.5	2075.0	AB On	PIC Max
23182	0.9061	275.67	287.13	3.902	51.50	5.126	2990.5	1970.7	AB On	PIC Max
22537	0.8572	275.67	287.13	3.902	51.50	5.126	2990.5	1868.4	AB On	PIC Max
21894	0.8085	275.67	287.13	3.902	51.50	5.126	2990.5	1768.6	AB On	PIC Max
21250	0.7600	275.67	287.13	3.902	51.50	5.126	2990.5	1671.0	AB On	PIC Max
20603	0.7415	272.50	283.83	3.846	51.38	5.107	2968.3	1627.7	AB Off	%Thrust
19962	0.7368	267.87	279.01	3.765	51.20	5.077	2935.5	1608.7	AB Off	%Thrust
19318	0.7319	263.19	274.13	3.683	51.01	5.047	2901.8	1589.3	AB Off	%Thrust
18674	0.7270	258.48	269.22	3.602	50.81	5.015	2867.3	1569.4	AB Off	%Thrust
18031	0.7220	253.73	264.29	3.519	50.60	4.982	2832.0	1549.1	AB Off	%Thrust
17386	0.7168	248.95	259.30	3.437	50.39	4.947	2795.7	1528.3	AB Off	%Thrust
16743	0.7116	244.14	254.29	3.354	50.16	4.911	2758.5	1507.0	AB Off	%Thrust
16098	0.7062	239.29	249.24	3.271	49.93	4.873	2720.2	1485.2	AB Off	%Thrust

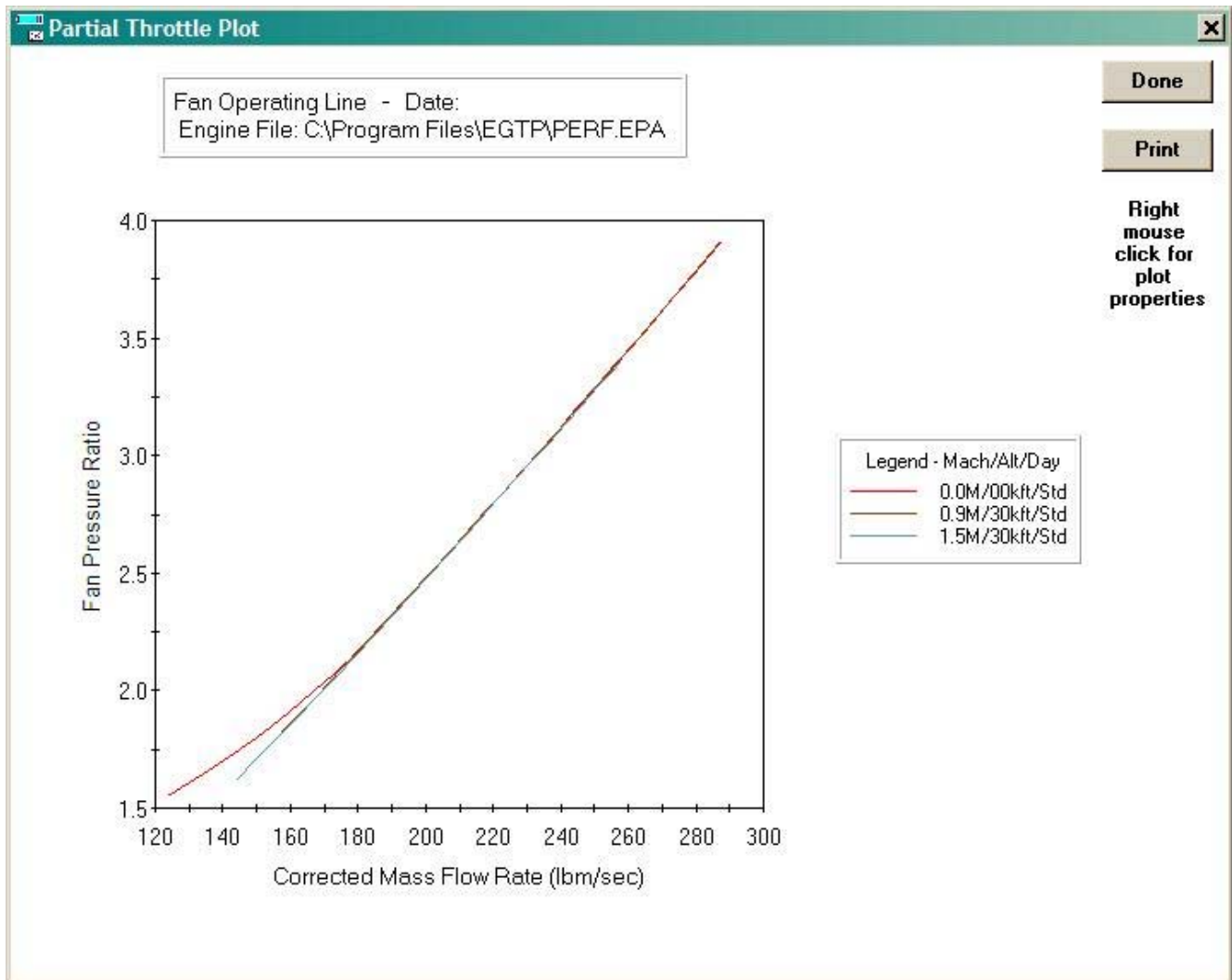
Once the partial throttle has been calculated, the partial throttle plot buttons become visible in the lower right of the engine test window as shown below.

<b>Independent Variable</b> <input type="radio"/> Mach Number <input type="radio"/> Altitude (ft) <input type="radio"/> Ambient Temperature - T0 (R) <input type="radio"/> Ambient Pressure - P0 (psia) <input type="radio"/> Total Temperature Lvg Combustor - Tt4 (R) <input type="radio"/> Total Temperature Lvg Afterburner - Tt7 (R) <input type="radio"/> Exhaust Pressure Ratio - P0/P9 No Mach Altitude Day <input type="text"/>	<input type="button" value="Perform Calcs"/>	<input type="button" value="Partial Throttle"/>
	Minimum <input type="text" value="0"/> Maximum <input type="text" value="2"/> Step Size <input type="text" value="0.1"/> No of Lines <input type="text" value="0"/>	Min % Thrust <input type="text" value="10"/>
	<input checked="" type="checkbox"/> Color <input type="checkbox"/> Wide Lines <input type="checkbox"/> Symbols <input checked="" type="checkbox"/> Legend	<b>Plots</b> <input type="button" value="Throttle Hook(s)"/> <b>Operating Line(s)</b> <input type="button" value="Fan"/> <input type="button" value="HPC"/> <input type="button" value="LPT"/> Number of Lines <input type="text" value="1"/> <input type="button" value="Zero Plot File"/>

As an example, the partial throttle performance was calculated at the following altitude/Mach number conditions in a standard atmosphere: 0 kft/0.0M, 30 kft/0.9M, and 30 kft/1.5M. The uninstalled throttle hooks (thrust specific fuel consumption versus thrust) are displayed below and the fan operating line is shown on the next page.







The Oletra Chart plotting package allows the user to customize each plot using the chart control properties window. Clicking the right mouse button over the plot will open the **2D Chart Control Properties** window as shown below. See pages 8 and 9 of the **PARA User Guide** for an example of using these properties.

