

A graphic for the Aircraft Performance Program (APP). It features a large, bold, black 'APP' logo with a red swoosh underline. To the right, the words 'AIRCRAFT PERFORMANCE PROGRAM' are stacked in a bold, black, sans-serif font. The background is a blue-toned collage of various aircraft: a large transport plane on the left, a fighter jet at the top right, a smaller aircraft in the center, and another fighter jet at the bottom right. A bright red arrow points from the center towards the top right. The background also contains faint technical data and grid lines.

**APP**

**AIRCRAFT  
PERFORMANCE  
PROGRAM**

## Introduction

APP is an aircraft-performance calculation program, specifically designed to provide a fast and easy way to evaluate aircraft performance. Another major design requirement was to impose no restriction upon the type of aircraft that can be handled by APP. Due to the simple, self-explaining user interface, no training is required to use APP and even the manual is rarely used. The program features powerful built-in post-processing and export functions to further process the data if needed.

APP can accomplish a wide range of different tasks:

- Fast and easy evaluation of an aircraft design
- Comparison of different aircraft
- Competitor performance analysis
- Evaluation of design-changes
- Mission optimization
- Creating plots for flight manuals and marketing brochures
- Flight test and certification support
- Helping students to understand the impact of different parameters
- ...

## Capabilities/Functionalities

The most important capabilities and functionalities of APP:

- Computation of aircraft **point performance**
- Computation of **mission performance**
- Optimization and variation of **mission-profiles**
- Detailed **Take-off and Landing calculations**
- Applicable to jets, turboprops, military & civil a/c, etc.
- Easy data input and manipulation
- Built-in powerful **graphical post-processing**
- Over **60 output parameters**
- **4 unit systems** (SI, imperial, ...) for input and output
- **Export** of tables (excel) and plots

## Flight Physics/Numerics

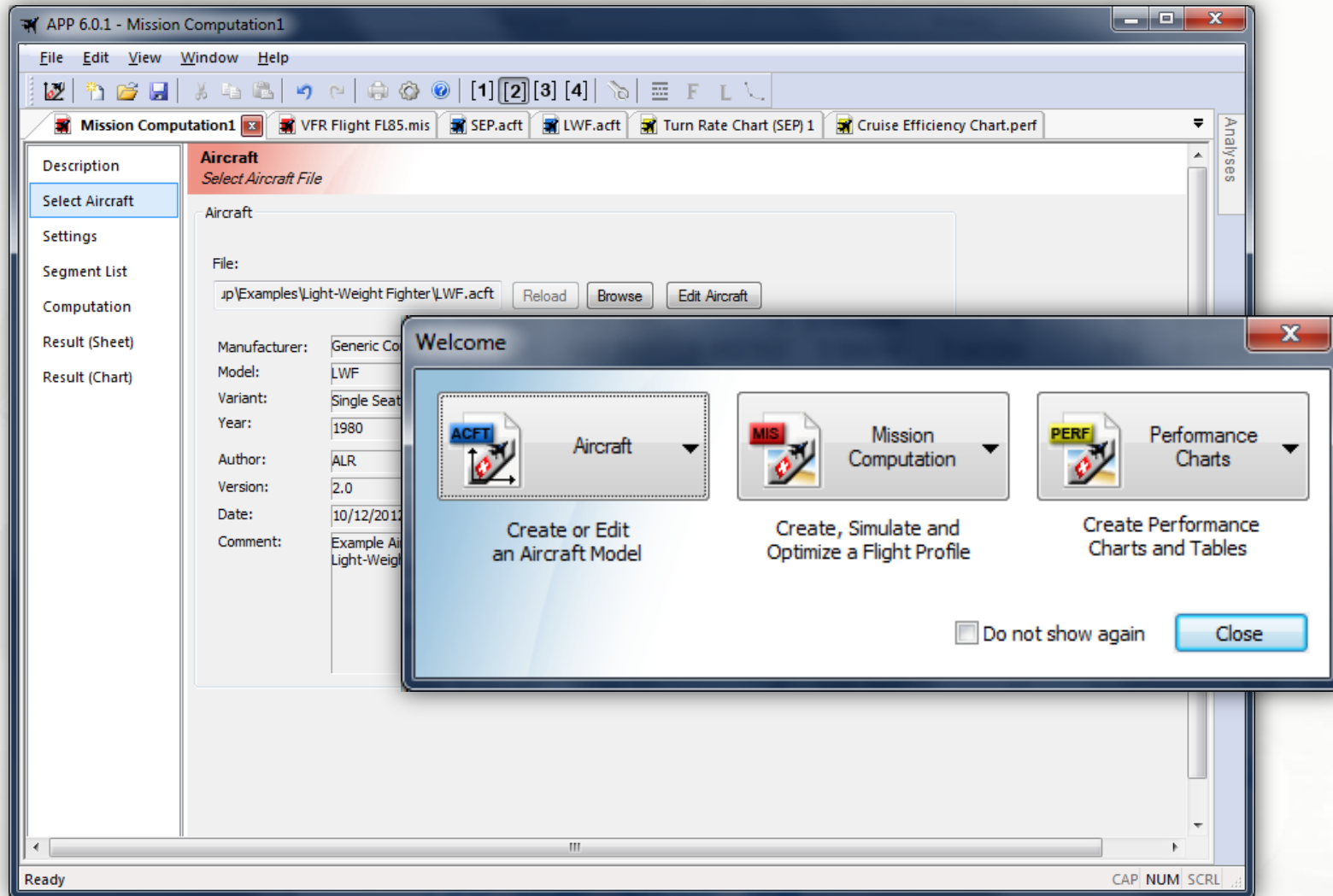
The physical and numerical principles behind APP were chosen to achieve accurate solutions while requiring only few computational resources:

- All calculations are based on 2 DOF point-mass equations
- No analytic simplifications or linearizations
- Mission integration and optimisation with Runge-Kutta (4th-order, fixed step)
- Using tabulated data depending on Altitude and Mach for thrust,  $C_L$  vs  $C_D$ ,  $C_L$  vs AoA, fuel-flow, stores, ...

APP PERFORMANCE PROGRAM

# APP - Modern User Interface

APP has a modern and easy to use graphical interface. All computation modes are easily found and results can be generated quickly.



The following examples should give you an impression of the data-input interface and the level of detail possible to achieve. Shown here is the main-program window and a mass data table.

APP 6.0.1 - SEP.acft

File Edit View Window Help

VFR Flight FL85.mis SEP.acft

General Data  
**Mass & Limits**  
 Aerodynamics  
 Propulsion  
 Stores  
 Configuration

**Mass & Limits**  
*Mass, Limits, Basic Aircraft Data*

Data

+ Add Clean

x Del

Rename

Duplicate

Import

Mass	Engine	Aero	Gear	Limit	Mach Limiter	AoA-G Limiter	Description	Sheet	Chart
Structure				1001					
Propulsion Group				0					
Equipment				0					
Mass Deviation				0			= Standard Empty	1001	[kg]
Fixed Op. Equipment				0			= Empty Mass	1001	[kg]
Unusable Fuel and Oil				0					
Gun				0					
Removable Op. Equipment				0			= Basic Mass	1001	[kg]
Usable Oil				0					
Crew				0					
Spec. Mission Equipment				0			= Operating Empty	1001	[kg]
Ammunition				0					
Payload				248			= Zero Fuel Mass	1249	[kg]
Fuel Mass				151			= Operating Mass	1400	[kg]

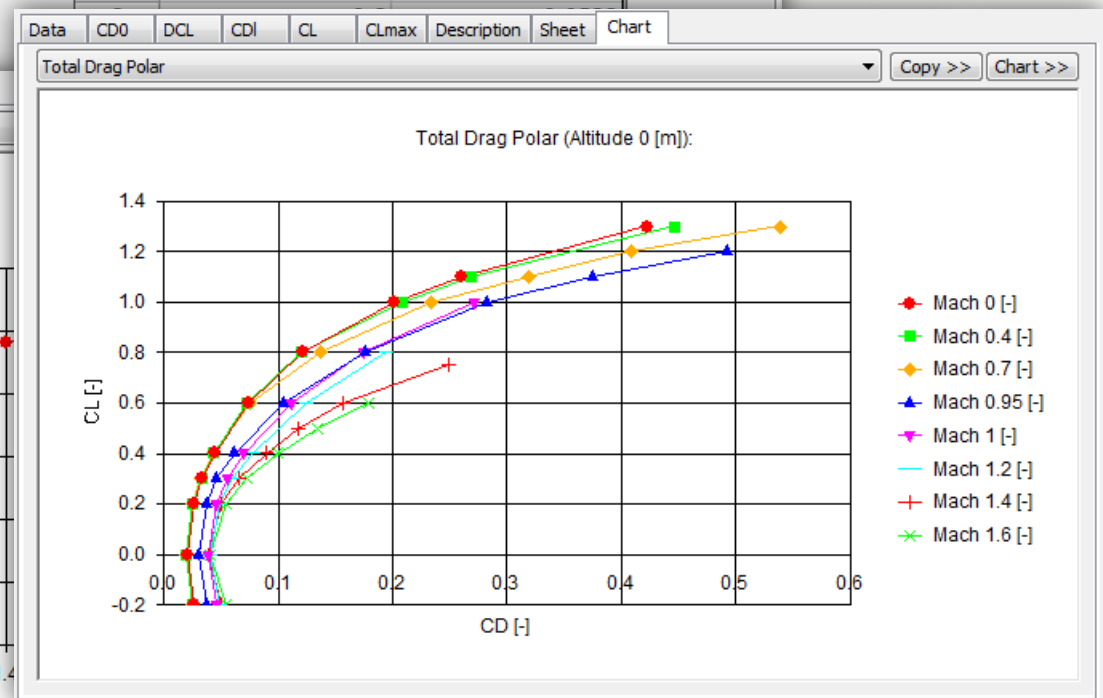
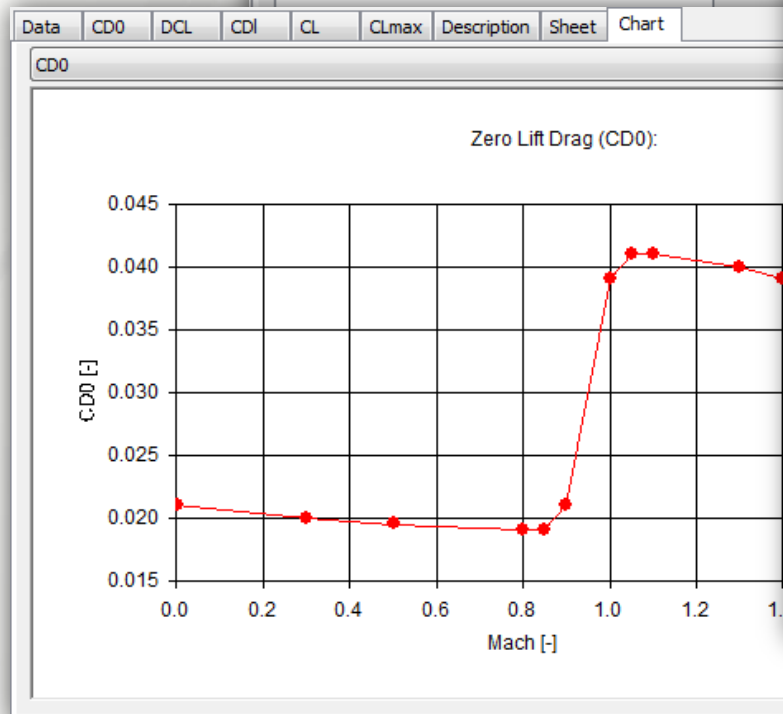
Ready

CAP NUM SCRL

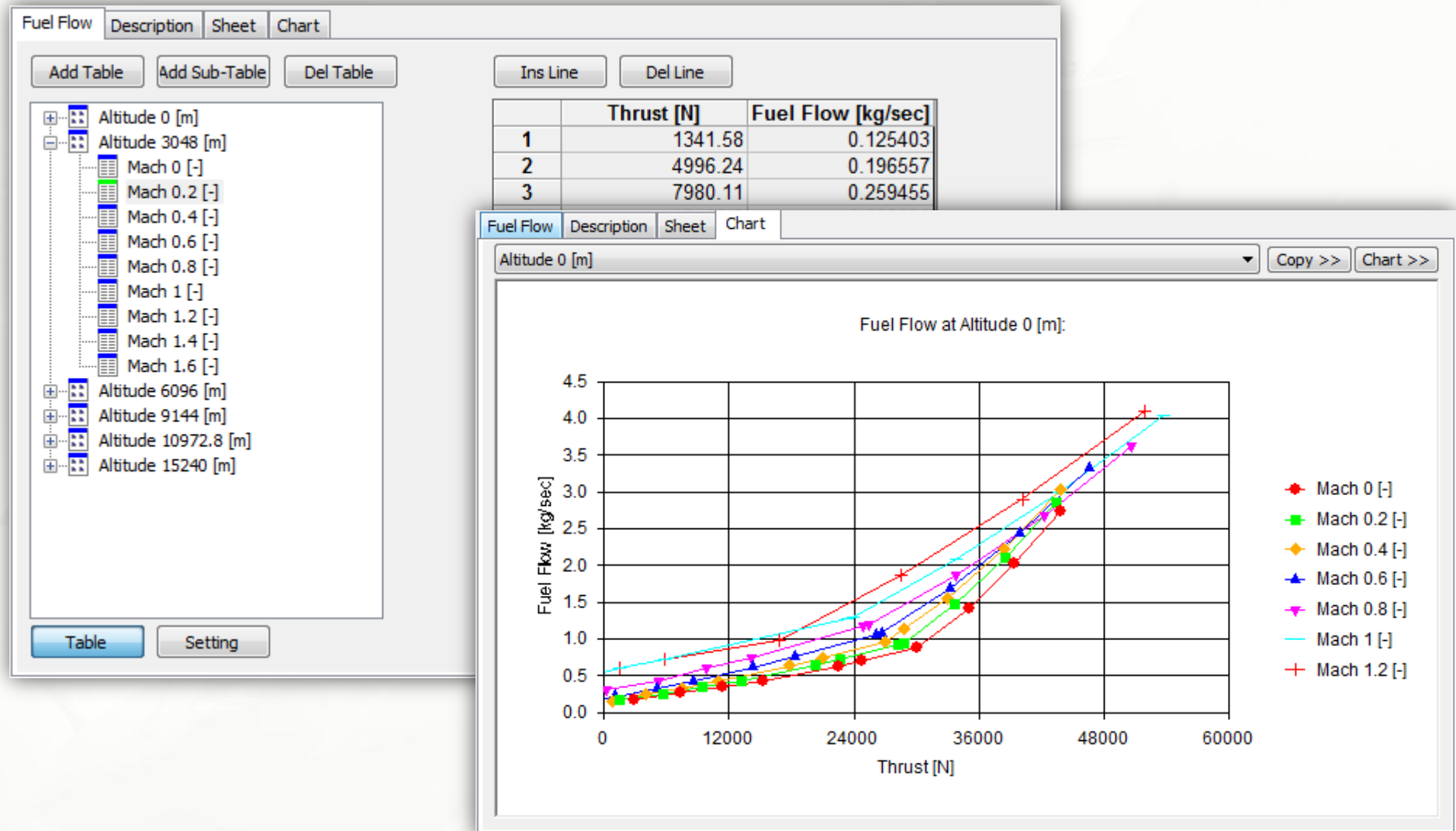


Aerodynamic data:

Data	CD0	DCL	CDI	CL	CLmax	Description	Sheet	Chart																		
<div style="display: flex; justify-content: space-between;"> <span>Add Table</span> <span>Del Table</span> </div>																										
<div style="display: flex; justify-content: space-between;"> <span>Ins Line</span> <span>Del Line</span> </div>																										
<ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Mach 0 [-]</li> <li><input type="checkbox"/> Mach 0.4 [-]</li> <li><input type="checkbox"/> Mach 0.7 [-]</li> <li><input type="checkbox"/> Mach 0.95 [-]</li> <li><input type="checkbox"/> Mach 1 [-]</li> <li><input type="checkbox"/> Mach 1.2 [-]</li> <li><input type="checkbox"/> Mach 1.4 [-]</li> <li><input type="checkbox"/> Mach 1.6 [-]</li> </ul>				<table border="1"> <thead> <tr> <th></th> <th>CL [-]</th> <th>CDI [-]</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>-0.2</td> <td>0.0057467</td> </tr> <tr> <td>2</td> <td>0</td> <td>0</td> </tr> <tr> <td>3</td> <td>0.2</td> <td>0.0057467</td> </tr> <tr> <td>4</td> <td>0.3</td> <td>0.013</td> </tr> <tr> <td>5</td> <td>0.4</td> <td>0.0233901</td> </tr> </tbody> </table>			CL [-]	CDI [-]	1	-0.2	0.0057467	2	0	0	3	0.2	0.0057467	4	0.3	0.013	5	0.4	0.0233901			
	CL [-]	CDI [-]																								
1	-0.2	0.0057467																								
2	0	0																								
3	0.2	0.0057467																								
4	0.3	0.013																								
5	0.4	0.0233901																								



Fuel Flow data:





The user can choose several pre-prepared standard-charts or calculate specific performance parameters:

## Performance Parameters:

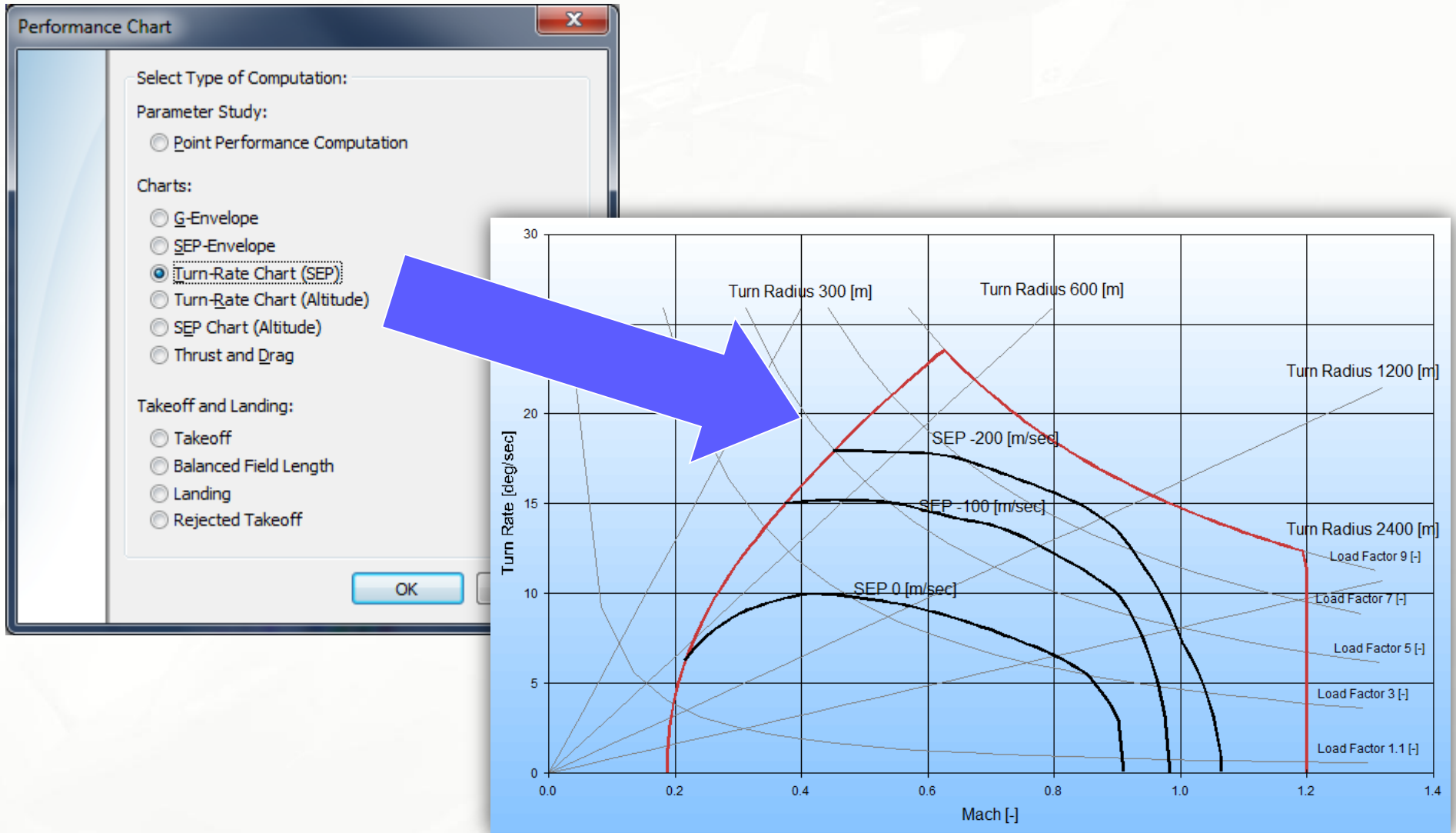
- Acceleration
- Climb (normal, best angle, best rate)
- Cruise (normal, best fuel flow, best specific range)
- Maneuver (maximum performance)
- Maximum Speed
- Stall Speed
- Specific Excess Power (SEP)
- Takeoff Acceleration

## Standard Charts:

- G-Envelope
- SEP-Envelope
- Turn-Rate-Chart (const. Acc)
- Turn-Rate-Chart (const. Alt.)
- Turn-Rate-Chart (const. SEP)
- SEP-Chart (const Alt.)
- Thrust and Drag Chart

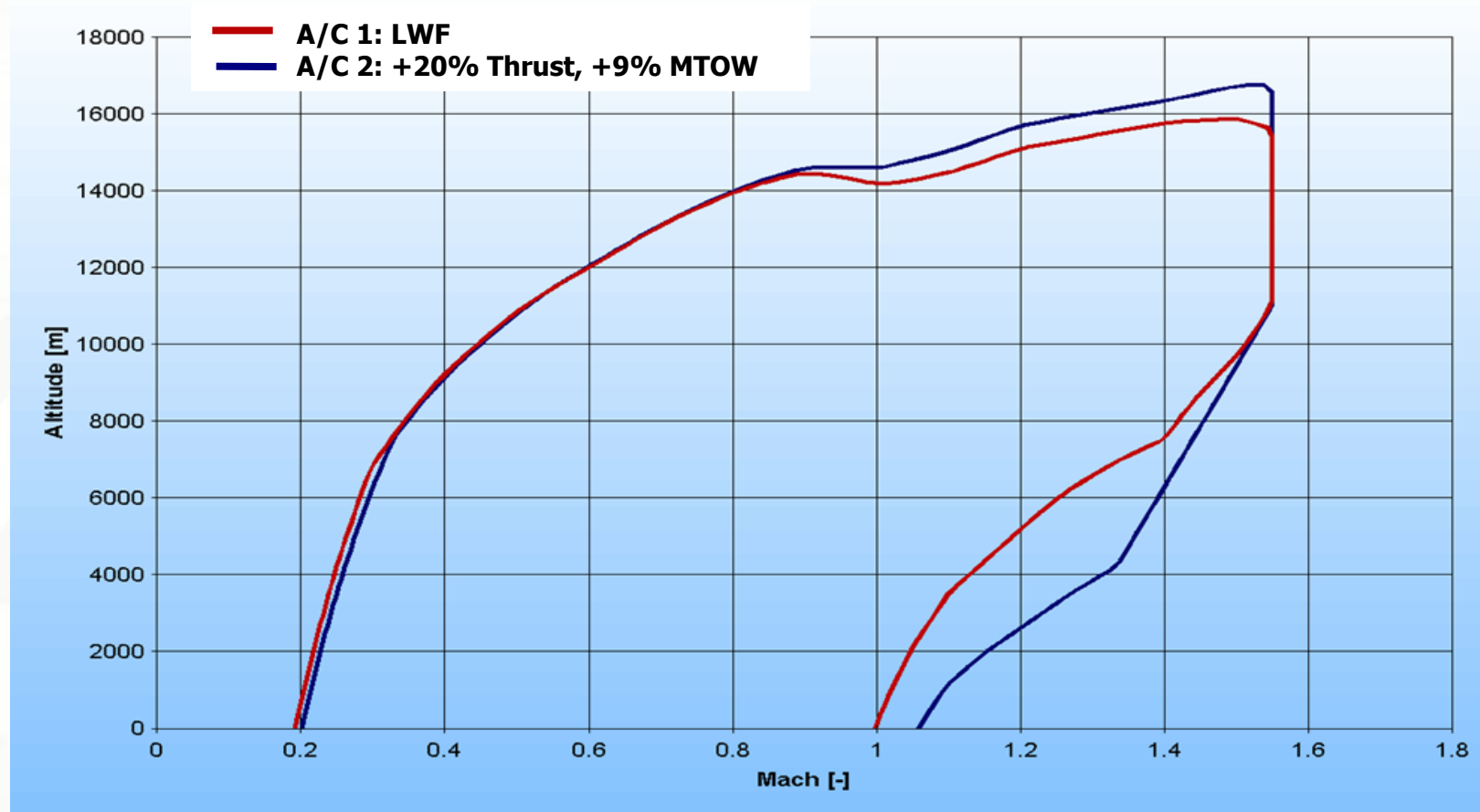
# APP - Point-Performance Example

On the following pages point-performance-examples are presented, starting with a standard Turn-Rate-Chart:



# APP - Point-Performance Example

To evaluate the effects of an engine upgrade, the user just has to change the new engine-mass and specify a thrust-multiplier:



# APP - Point-Performance Example

After the calculation, over 60 parameters are available to be plotted in XY-Plots or presented in tabulated form. It is possible to edit the data and to customize the plots.

The screenshot displays the Mission Computation Sheet software interface. The main window shows a table of flight data. Overlaid on this are three dialog boxes: 'Edit Chart Data', 'Chart Designer', and 'Performance Chart'.

**Mission Computation Sheet Data:**

	A	B	C	D	E	F	G
1	App 6.0.1						
2							
3	Date (Time):						
4	Tuesday, December 18, 2012 (20:47:34)						
5							
6	File Name						
7	vfr flight at f85						
8							
9							
10	Flight Data						
11	Altitude	609.6 [m]					
12	Mach	0 [-]					
13	Fuel Percent	100 [%]					
14	Payload	100 [%]					
15	Distance	0 [km]					
16	Time	0 [sec]					
17	Mass	1400 [kg]					

**Edit Chart Data Dialog:**

SEP -200 [m/s]	C2	SEP -100 [m/s]	C4
0.451641	17.9175	0.375156	15.0199
0.463641	17.9121	0.387156	15.0465
0.475641	17.9219	0.399156	15.0997

**Chart Designer Dialog:**

- Chart
- Title
- Footnote
- Legend
- Plot
- X Axis
- Y Axis
- Second Y Axis
- Z Axis
- Series
- Series Labels

**Performance Chart:**

Parameter Study: Cruise

X-Axis: Mach [-] Y-Axis: Specific Range [km/kg]

Altitude 0 [m]  
Fuel Percent 50 [%]  
Payload 80 [%]  
Mass 295266 [kg]  
Cruise boeing 747-100 clean cruise rating jt9d

Mach [-]	Specific Range [km/kg] (Red)	Specific Range [km/kg] (Green)	Specific Range [km/kg] (Yellow)	Specific Range [km/kg] (Blue)
0.3	0.028			
0.4	0.042	0.030		
0.5	0.044	0.055	0.055	
0.6	0.040	0.055	0.065	0.055
0.7	0.035	0.050	0.065	0.070
0.8		0.045	0.060	0.075
0.9			0.055	0.070

APP can calculate user specified missions and optimize them. Empty Fuel-Tanks can be dropped automatically. The following segments and optimizers are available:

## Segments:

- Acceleration
- Climb (best angle, best rate)
- Climb (const Ma, EAS, CAS)
- Cruise (best SR, const Ma., opt. Alt)
- Descent
- Ground Operation
- Landing Roll
- Loiter (at best FF)
- Maneuver (const  $N_L$ , max  $N_L$ )
- Refuel
- Store Drop
- Take-off
- Tank Drop

## Optimizers:

- Range Optimization
- Endurance Optimization
- Maximum Operating Range Optimization

# APP - Mission-Computation

To build your mission, simply choose a segment and specify the condition at which it should end. You can also specify the segment on that should be optimized by APP if you wish to do so.

The screenshot displays the 'Optimizer' software interface. On the left, the 'Optimizer' section has four radio buttons: 'No Optimization', 'Range Optimization', 'Endurance Optimization', and 'Radius-of-Action Optimization' (which is selected). The 'Adv. Computation' tab is active. The 'Optimizer Settings' section shows a flight profile diagram with segments s1, e1, and s2, and a range 'r'. Below the diagram, a list of segments is shown: s1 (2) Takeoff, ① (6) Cruise at Mach, e1 (7) Maneuver at Max. LF, s2 (11) Loiter, ② (12) Cruise at Best SR, and e2 (14) Descent. At the bottom of this section, mission parameters are listed: Fuel at End of Mission (5), Fuel Mass at End of Mission (100), Distance at End of Mission (0), and Precision of Optimizer (0.1).

The 'Mission Segments' dialog box is open, titled 'Mission Segments' and 'Mission Flight Profile'. It contains a table of segments and a configuration panel on the right.

Segment	Segment Name	Configuration
1)	Ground Operation	Cruise, Dry
2)	Takeoff	Cruise, Reheat
3)	Climb	Cruise, Reheat
4)	Climb at Best Rate	Cruise, Dry
5)	Acceleration	Cruise, Dry
6)	Cruise at Mach	Cruise, Dry
7)	Maneuver at Max. LF	Cruise, Reheat
8)	Store Drop	Cruise, Dry
9)	Maneuver at Max. LF	Cruise, Reheat
10)	Store Drop	Cruise, Dry
11)	Loiter	Cruise, Dry
12)	Cruise at Best SR	Cruise, Dry
13)	Descent	Cruise, Dry
14)	Descent	Cruise, Dry
15)	Landing Roll	Cruise, Dry

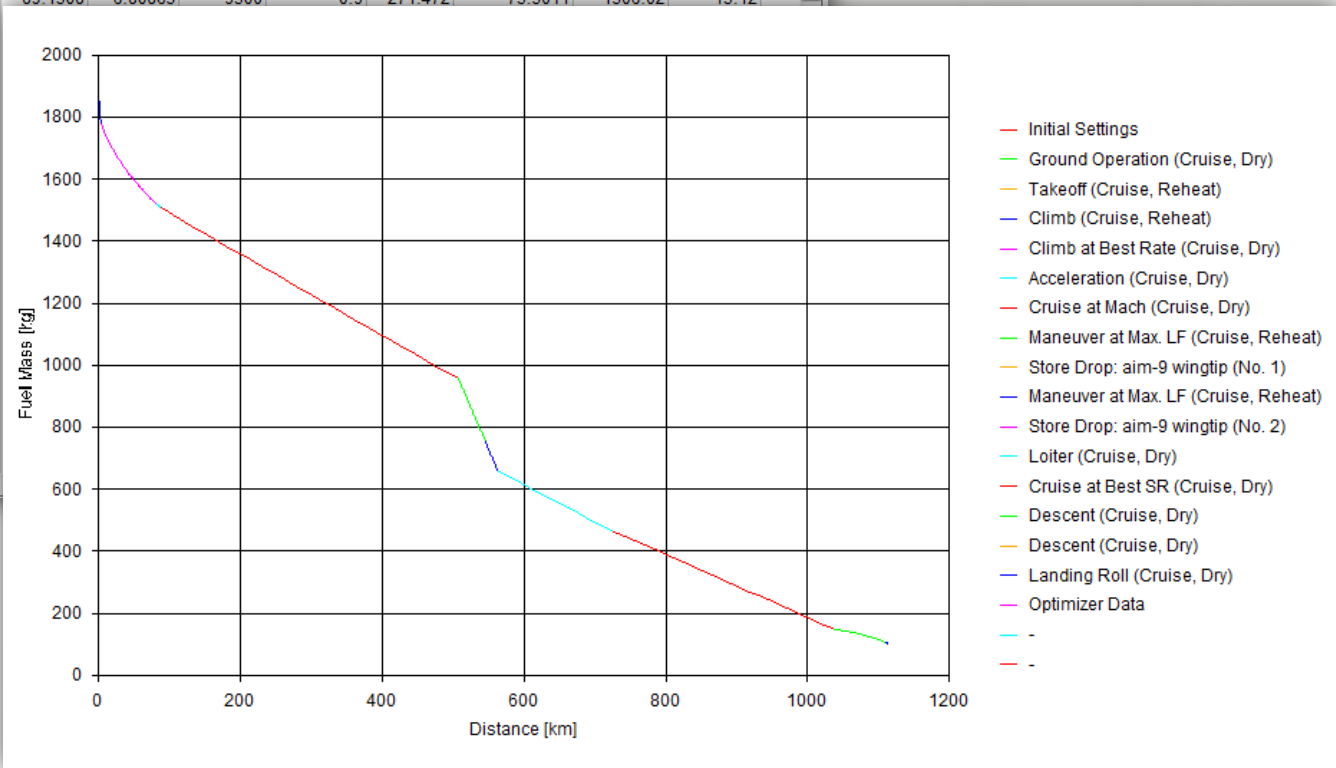
The configuration panel on the right includes:

- Segment stops at: Turns > 2 [turn] or at: None > 0 [-]
- Time Step: 5 [sec]
- Integrate x-Position
- Integrate z-Position
- Power Setting: 100 [%]
- Thrust: 43850.6 [N]
- Acceleration: 0 [m/sec<sup>2</sup>]
- Climb Angle: 0 [deg]
- Climb Speed: 0 [m/sec]
- dT: 0 [K]
- Engine Revolution: 0 [rpm]

# APP - Mission-Computation

The results can be reviewed in tabulated form or be plotted as XY-Plots, combining any of the over 60 parameters.

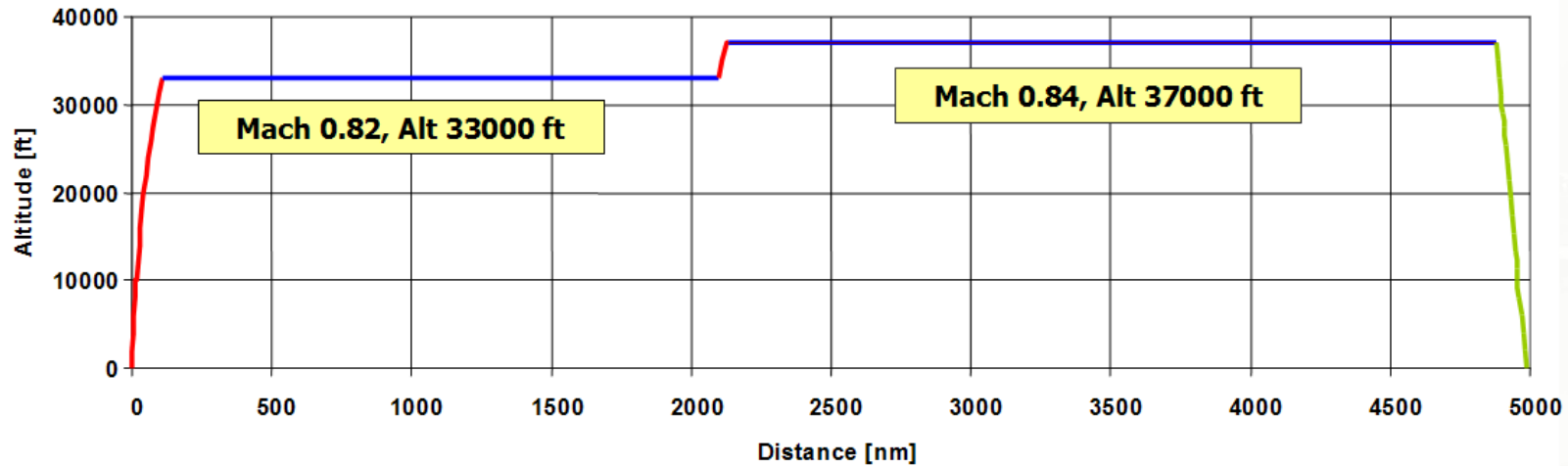
	A	B	C	D	E	F	G	H	I	J	K
		[sec]	[min]	[km]	[km]	[m]	[-]	[m/sec]	[%]	[kg]	[kg]
31											
32	Initial Settings	0	0	0	0	0	0	0	100	2000	0
33	Ground Operation (Cruise, Dry)	0	0	0	0	0	0	0	100	2000	0
34	Stop at Seg. Time: 10 [min]	600	10	0	0	0	0	0	94.8109	1896.22	103.782
35	Takeoff (Cruise, Reheat)	600	0	0	0	0	0	0	94.8109	1896.22	0
36	Stop at Velocity: 75.4456 [m/sec]	613.109	0.218489	0.500898	0.500898	0	0.221707	75.4456	92.9746	1859.49	36.7258
37	Climb (Cruise, Reheat)	613.109	0	0.500898	0	0	0.221707	75.4456	92.9746	1859.49	0
38	Stop at Altitude: 516 [m]	640.852	0.462382	3.94414	3.44324	516	0.516833	174.849	88.8685	1777.37	82.1216
39	Climb at Best Rate (Cruise, Dry)	640.852	0	3.94414	0	516	0.516833	174.849	88.8685	1777.37	0
40	Stop at Altitude: 9500 [m]	975.29	5.57396	82.3222	78.378	9500	0.851203	256.753	75.9571	1519.14	258.229
41	Acceleration (Cruise, Dry)	975.29	0	82.3222	0	9500	0.851203	256.753	75.9571	1519.14	0
42	Stop at Mach: 0.9 [-]	1001.04	0.429226	89.1308	6.80863	9500	0.9	271.472	75.3011	1506.02	13.12
43	Cruise at Mach (Cruise, Dry)	1001.04	0								
44	Stop at Seg. Dist.: 419.263 [km]		25.7401								
45	Maneuver at Max. LF (Cruise, Reheat)	2545.45	0								
46	Stop at Turns: 2 [turn]	2684.72	2.32123								
47	Store Drop: aim-9 wingtip (No. 1)	2684.72	0								
48		2684.72	0								
49	Maneuver at Max. LF (Cruise, Reheat)	2684.72	0								
50	Stop at Turns: 1 [turn]	2750.67	1.09907								
51	Store Drop: aim-9 wingtip (No. 2)	2750.67	0								
52		2750.67	0								
53	Loiter (Cruise, Dry)	2750.67	0								
54	Stop at Seg. Time: 10 [min]	3350.67	10								
55	Cruise at Best SR (Cruise, Dry)	3350.67	0								
56	Stop at Seg. Dist.: 311.359 [km]	4742.33	23.1944								
57	Descent (Cruise, Dry)	4742.33	0								
58	Stop at Altitude: 516 [m]	5108.55	6.10367								
59	Descent (Cruise, Dry)	5108.55	0								
60	Stop at Altitude: 500 [m]	5109.56	0.0168358								
61	Landing Roll (Cruise, Dry)	5109.56	0								
62	Stop at Velocity: 1 [m/sec]	5151.99	0.707159								



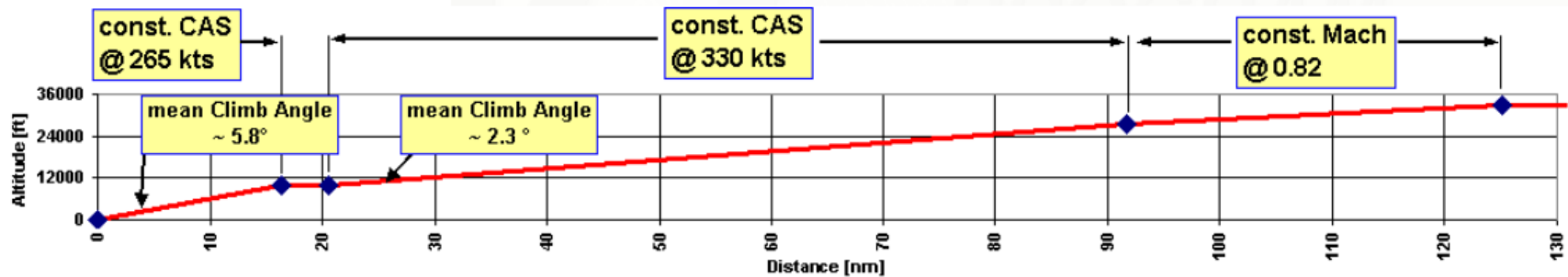


# APP - Mission Example

The modular approach to define a mission enables you to easily setup complex (realistic) climb schedules:



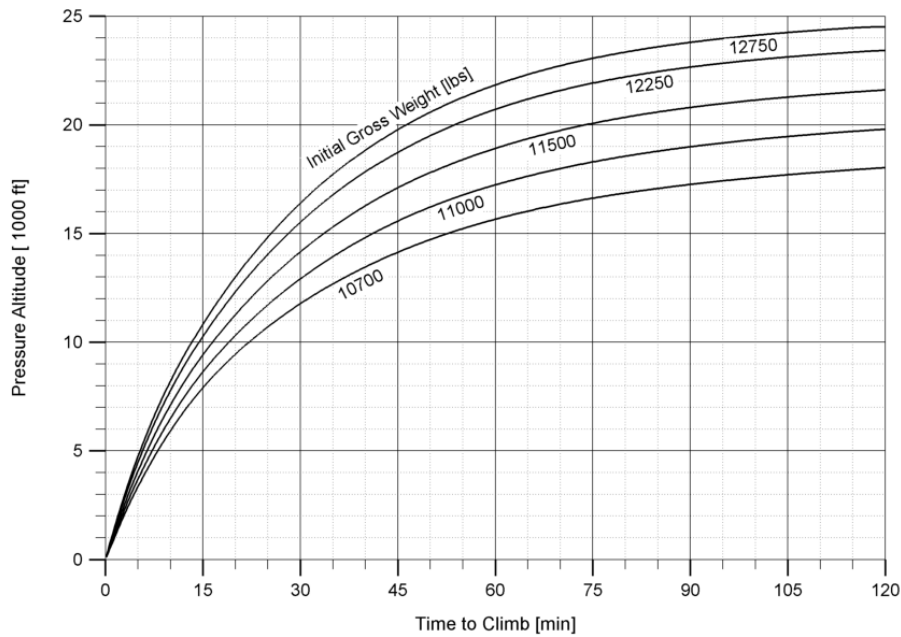
Detailed view of climb schedule:



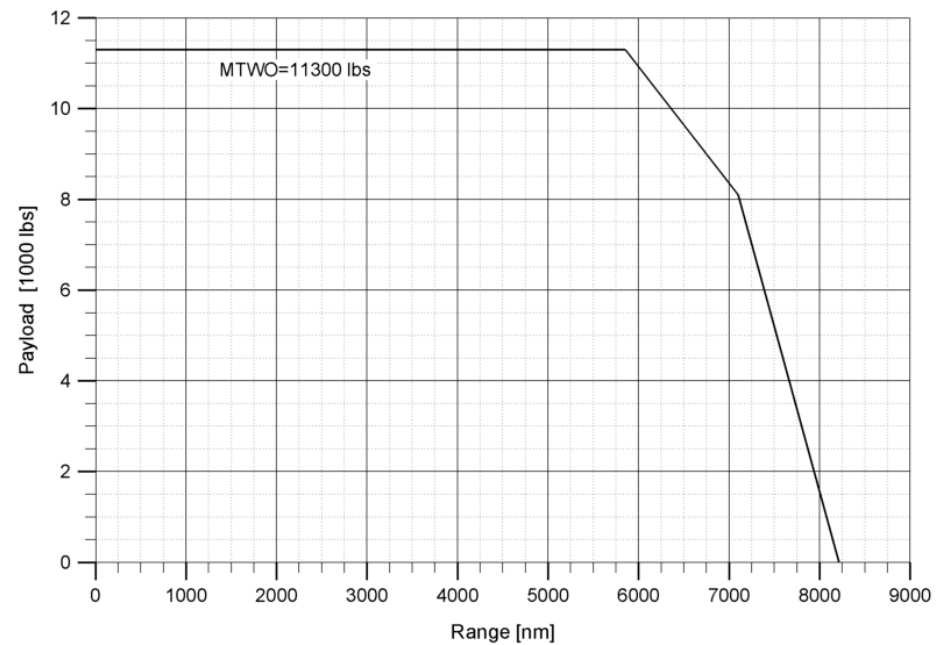
# APP - Mission Example

Due to the wide variety of charts and plots used in manuals, handbooks and so on, its not possible to have a template for all of them in APP. However, APP can significantly reduce the time required to generate such charts. The following two charts were produced by defining a mission-segment once, calculate it several times varying one parameter (payload, target altitude) and combine the results in one chart:

Time-To-Climb-Chart

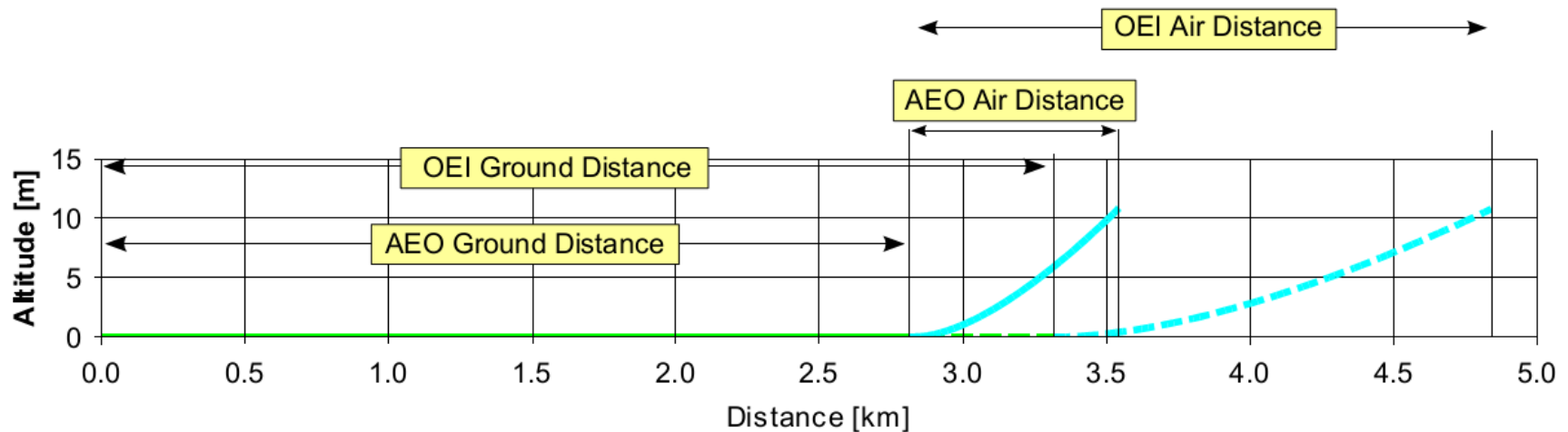


Range-Payload-Diagram

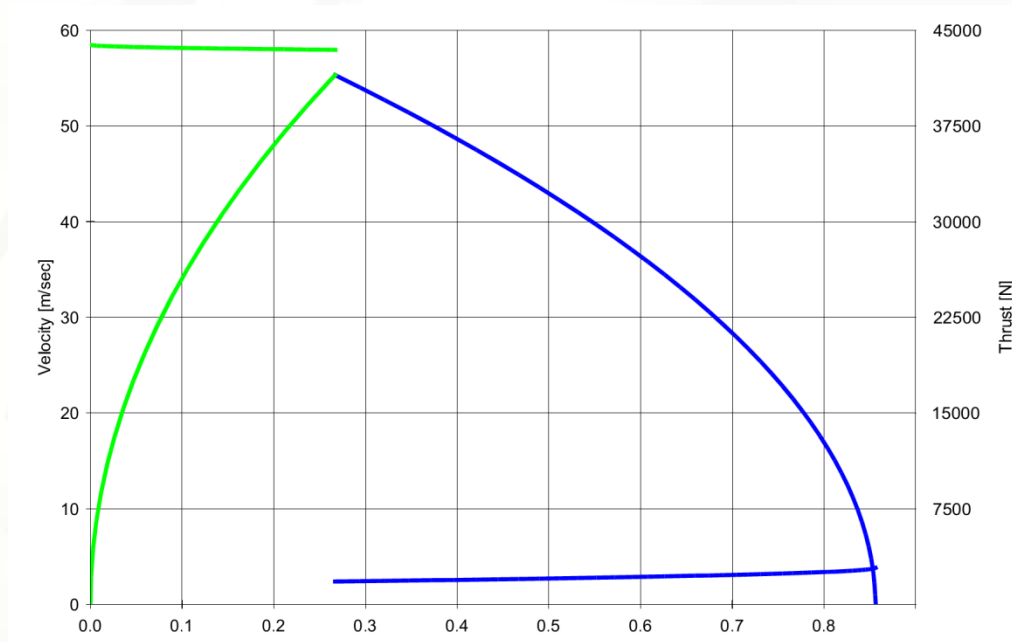


- 4 Types of calculations:  
*Takeoff, Rejected Takeoff, Balanced Field Length, Landing*
- Regulation conform calculations respecting military and civil airworthiness:  
*MIL-STD-3013, FAR Part 23 & 25, EASA CS 23 & 25*
- All Engines Operative (AEO) and One Engine Inoperative (OEI) calculations
- Respecting runway dimensions as:  
*Runway Length, Runway Altitude, Runway Slope*
- Different runway conditions are available:  
*Dry, Wet, Snow, Ice*
- Calculations possible with or without afterburner

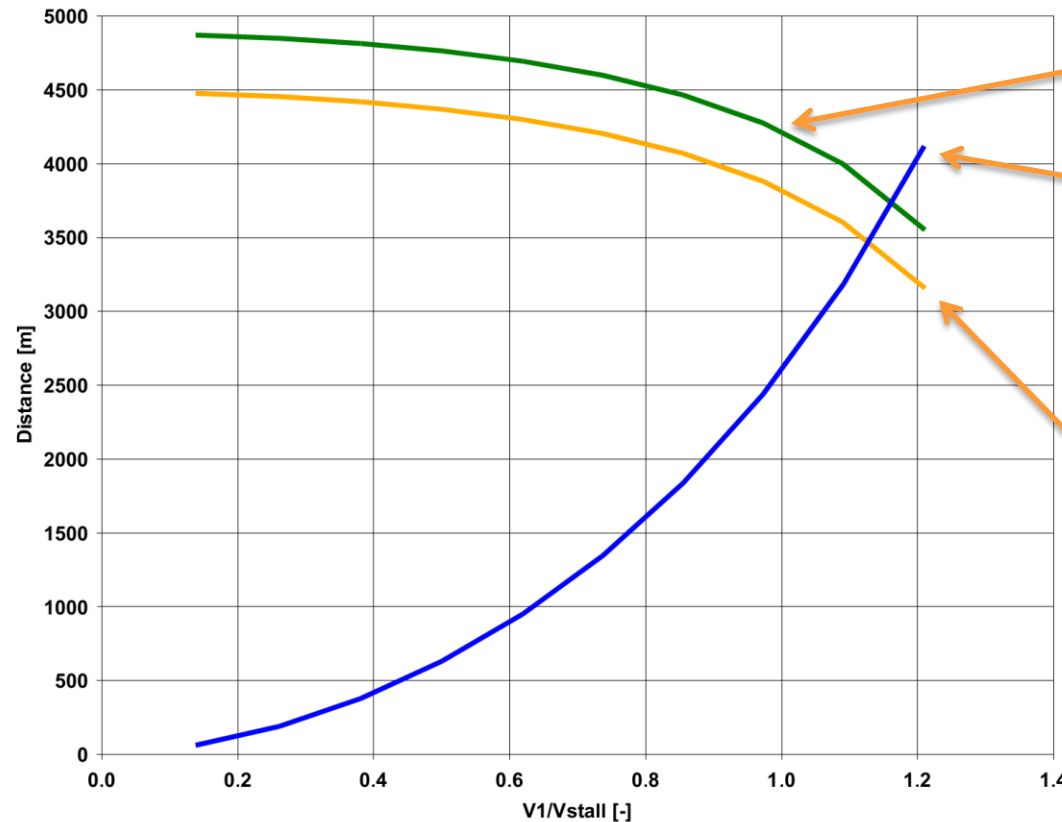
- 2 Pilot techniques are available
- Calculate the ground run distance and the air distance
- Calculate regulated takeoff distance
- Tailstrike angle will be respected
- Takeoff time determination



- Pilot reaction time will be respected
- Time needed to apply brakes and retract throttles is respected
- Determine refusal speed from an engine failure speed



- Graphical V1 Balanced Calculation
- Determine Shortest Possible Runway



**OEI Takeoff**

**V1 Balanced**

**OEI Ground Run**

- Determine a landing path from a given sink rate at touchdown
- Determine the needed landing distance

