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, minimum training is required to get started using APP. The manual guides new users through their first steps. The program features powerful built-in post-processing and export functions to further process the data if needed. For the advanced user, APP will provide the necessary flexibility to solve even the most challenging and complex problems.

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
- Feasibility Studies
- ...
APP - Capabilities

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 jet and propeller aircraft, both military & civil
- 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 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 - Aircraft Data

Aerodynamic data:

<table>
<thead>
<tr>
<th>Mach</th>
<th>CL [-]</th>
<th>CDI [·]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.2</td>
<td>0.0057467</td>
</tr>
<tr>
<td>0.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.7</td>
<td>0.2</td>
<td>0.0057467</td>
</tr>
<tr>
<td>0.95</td>
<td>0.3</td>
<td>0.013</td>
</tr>
<tr>
<td>1</td>
<td>0.4</td>
<td>0.0233901</td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Zero Lift Drag (CD0):

Total Drag Polar (Altitude 0 [m]):
Fuel Flow data:

<table>
<thead>
<tr>
<th>Thrust [N]</th>
<th>Fuel Flow [kg/sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1341.58</td>
</tr>
<tr>
<td>2</td>
<td>4996.24</td>
</tr>
<tr>
<td>3</td>
<td>7980.11</td>
</tr>
</tbody>
</table>

Chart showing Fuel Flow at Altitude 0 [m].
### Propeller Propulsion Data:

<table>
<thead>
<tr>
<th>Propeller Revolution</th>
<th>CP</th>
<th>CT</th>
<th>Max. Shaft Power</th>
<th>Min. Shaft Power</th>
<th>Additional Jet Thrust</th>
<th>Fuel File</th>
<th>Description</th>
<th>Sheet</th>
<th>Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Revolution 1800 [rpm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Engine Revolution 1900 [rpm]</td>
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<tr>
<td>Engine Revolution 2000 [rpm]</td>
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<td></td>
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<tr>
<td>Engine Revolution 2100 [rpm]</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Velocity [m/sec]**

<table>
<thead>
<tr>
<th>Velocity [m/sec]</th>
<th>Max. Shaft Power [W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>124597.5216</td>
</tr>
</tbody>
</table>

**Propeller Power Coefficient (CP) at Mach 0.3 [-]**

![Graph showing propeller power coefficient at Mach 0.3](image-url)
APP - Point-Performance

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

<table>
<thead>
<tr>
<th>Performance Parameters:</th>
<th>Standard Charts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Acceleration</td>
<td>• G-Envelope</td>
</tr>
<tr>
<td>• Climb (normal, best angle, best rate)</td>
<td>• SEP-Envelope</td>
</tr>
<tr>
<td>• Cruise (normal, best fuel flow, best specific range)</td>
<td>• Turn-Rate-Chart (const. Acc)</td>
</tr>
<tr>
<td>• Maneuver (maximum performance)</td>
<td>• Turn-Rate-Chart (const. Alt.)</td>
</tr>
<tr>
<td>• Maximum Speed</td>
<td>• Turn-Rate-Chart (const. SEP)</td>
</tr>
<tr>
<td>• Stall Speed</td>
<td>• SEP-Chart (const Alt.)</td>
</tr>
<tr>
<td>• Specific Excess Power (SEP)</td>
<td>• Thrust and Drag Chart</td>
</tr>
<tr>
<td>• Takeoff Acceleration</td>
<td></td>
</tr>
</tbody>
</table>
APP - Point-Performance Example

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

A/C 1: LWF
A/C 2: +20% Thrust, +9% MTOW
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.
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\_r, 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 results can be reviewed in tabulated form or be plotted as XY-Plots, combining any of the over 60 parameters.
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
APP incorporates a unique 2.5-dimensional method to obtain takeoff- and landing- distances with respect to different certifications and environmental conditions.

- 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
APP - Takeoff

- 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
APP - Rejected Takeoff

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

- Graphical V1 Balanced Calculation
- Determine Shortest Possible Runway length

**Optional Input Data**
- Takeoff Run Available: 3000 [m]
- Takeoff Distance: 3100 [m]
- Accelerate-Stop: 3000 [m]

**General**
- Regulation: FAR 23: Utility, Aerobatic: Jet

**Takeoff Method**
- Rotation Speed: 83.5467603 [m/sec]
- Pilot Technique: Constant AoA
- Rotation Rate: 3 [deg/sec]
- Climb AoA: 12 [deg]

**Runway**
- Rolling Runway Condition: Dry
- Braking Runway Condition: Dry
- Roll Coefficient: 0.025 [-]
- Brake Coefficient: 0.3 [-]
- Runway Elevation: 0 [m]
- Runway Slope: 0 [deg]
Determine a landing path from a given sink rate at touchdown

Determine the needed landing distance

Define pilot technique and corresponding details

Define environmental conditions

Check for runway constraints