# CURRENT-GEN COMMUTER BASE AIRCRAFT

DLR

22.11.2024

# Description

## Current-gen Commuter Base Aircraft

The Current-Gen Commuter Base Aircraft is a concept of a conventional 9-seater CS-23 aircraft. It has a twin-turboprop, low-wing and T-tail configuration. The design range is 600 km (324 nm) with 9 passengers or 855 kg of payload. The cruise speed is Ma 0.25 at an altitude of 10000 ft, which corresponds to around 160 kts (300 km/h) TAS.

The aircraft has been developed within the DLR-projects D-Light and FGAA. Its purpose is to serve as a current-gen basis to assess the performance and capability of future aircraft concepts with new configurations or technologies. Since most CS-23 aircraft still use technology developed in the 1970s/1980s, the introduction of advanced technology would have a considerable potential to improve performance and efficiency. The design is based on the technology of the Cessna 441, which was introduced to service in 1977. The TLARs, such as design mission and performance targets are adapted to the requirements of commuter flights.

Moving forward, the aircraft will be developed into a research baseline with a technology level aimed at an entry into service (EIS) of 2030. To achieve this, technology factors will be introduced to relevant parameters, such as fuel efficiency or mass. This research baseline will then be used to evaluate the performance of new technologies developed in current and future projects.

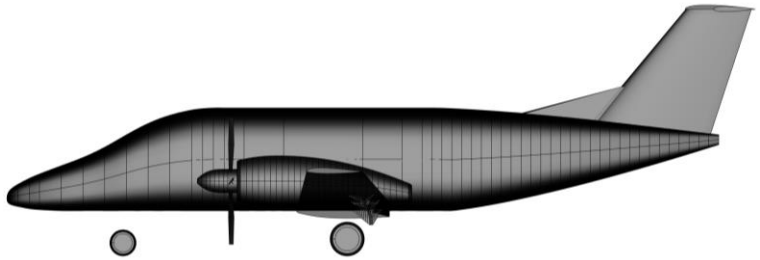
# Acronym Definition

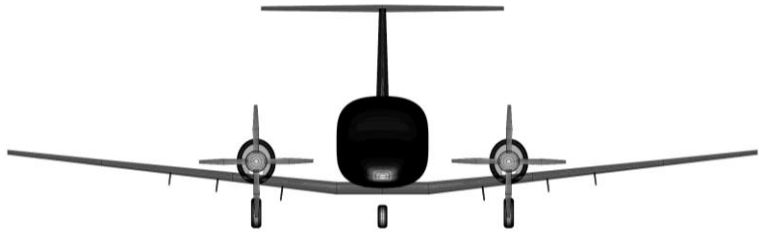
| Acronym | Definition |
|---|---|
| A/C | Aircraft |
| AEO | All Engine Operating |
| AMC | Aircraft Mission Calculation |
| App | Approach |
| APU | Auxiliary Power Unit |
| Avg. | Average |
| BPR | Bypass Ratio |
| CAS | Calibrated Airspeed |
| CS 25 | Certification Specifications for Large Aeroplanes |
| CFRP | Carbon-Fiber-Reinforced Polymers |
| CG | Centre of Gravity |
| CPACS | Common Parametric Aircraft Configuration Schema |
| DC | Drag counts |
| EIS | Entry Into Service |
| EOF | End of Field |
| FL | Flight Level |
| hAP | Airport Altitude |
| HiFi | High Fidelity |

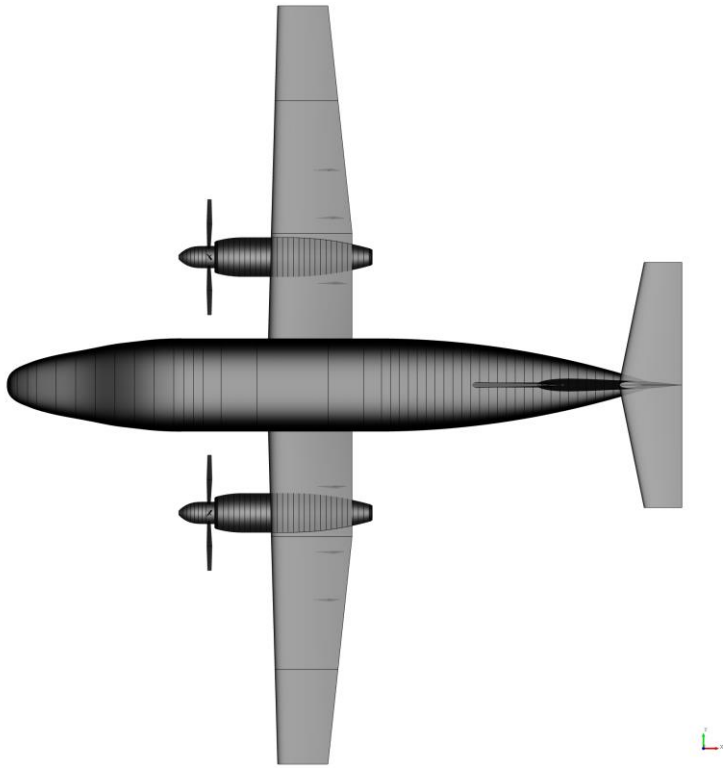
| Acronym | Definition |
|---|---|
| HTP | Horizontal Tail Plane |
| ICA | Initial Cruise Altitude |
| ISA | International Standard Atmosphere |
| IPT | Intermediate Pressure Turbine |
| ITD | Intermediate Turbine Duct |
| JAR | Joint Aviation Requirements |
| klbf | Kilo Pound-Force |
| kn | Knots |
| LE | Leading Edge |
| LFL | Landing field length |
| LoFi | Low Fidelity |
| MCL | Maximum Climb Thrust |
| MCR | Maximum Cruise Thrust |
| MEM | Manufacturer Empty Mass |
| MLM | Maximum Landing Mass |
| MTO | Maximum Take-off Thrust |
| MTOM | Maximum Take-Off Mass |
| MZFM | Maximum Zero-Fuel Mass |

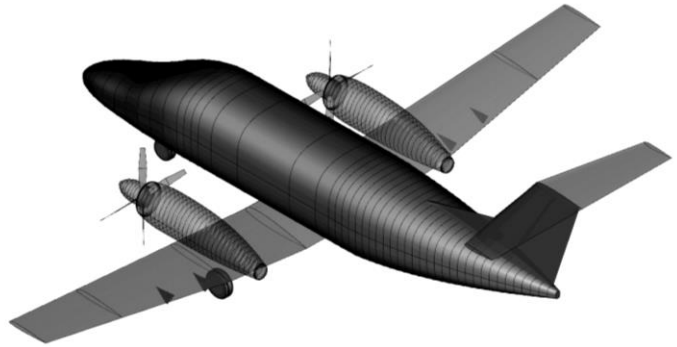
| Acronym | Definition |
|---|---|
| NM | Nautical Mile |
| OAD | Overall Aircraft Design |
| OEI | One engine inoperative |
| OEM | Operating Empty Mass |
| OPR | Overall Pressure Ratio |
| PAX | Passenger |
| RCE | Remote Component Environment |
| ROC | Rate of Climb |
| RTO | Reserve Take-off Thrust |
| RWY | Runway |
| SFC | Specific Fuel Consumption |
| SL | Sea Level |
| TE | Trailing Edge |
| TLARs | Top-Level Aircraft Requirements |
| TOC | Top of Climb |
| TSFC | Thrust Specific Fuel Consumption |
| VTP | Vertical Tail Plane |

# CPACS Output





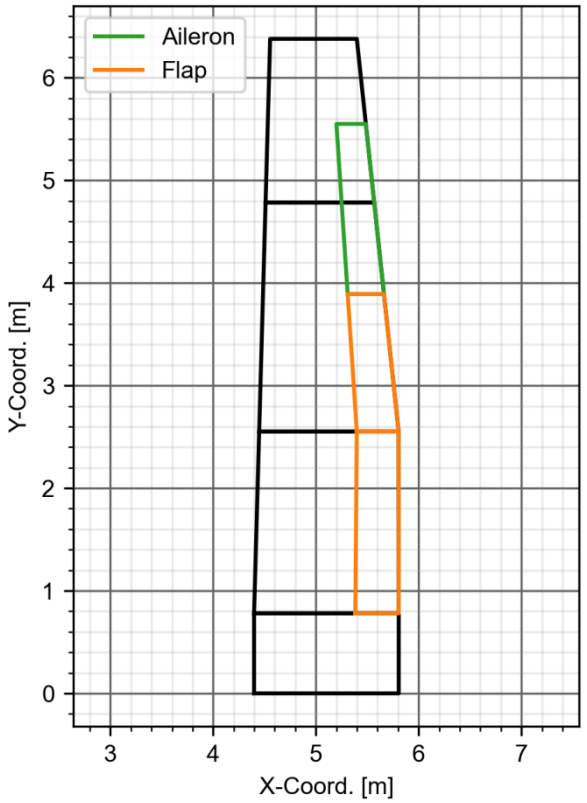


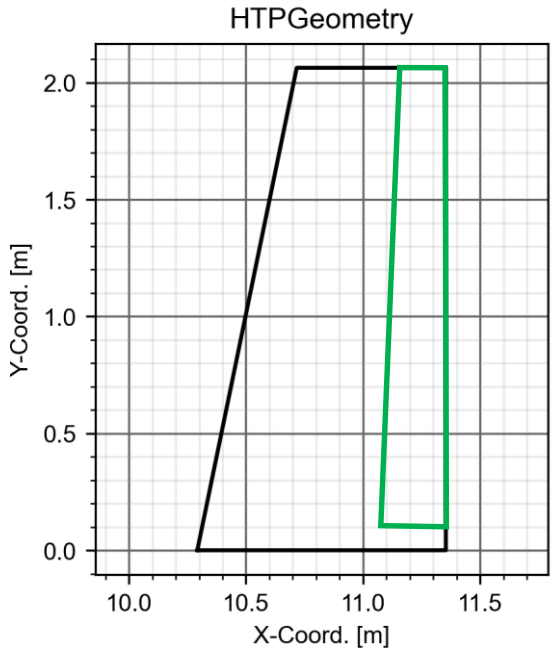


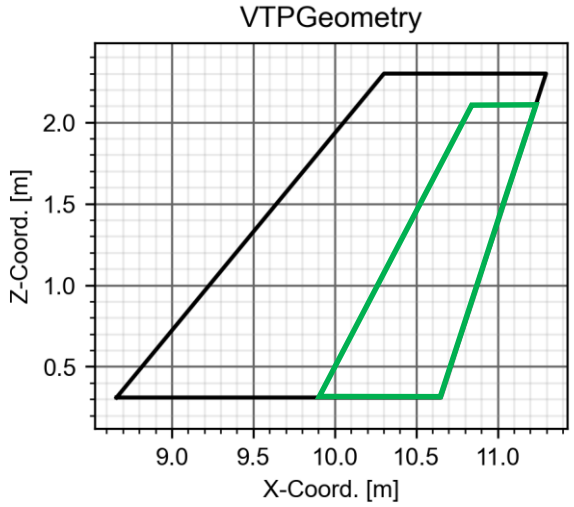
Current-gen Commuter Base Aircraft, DLR, 22.11.2024

# Lifting Surface Geometry Overview

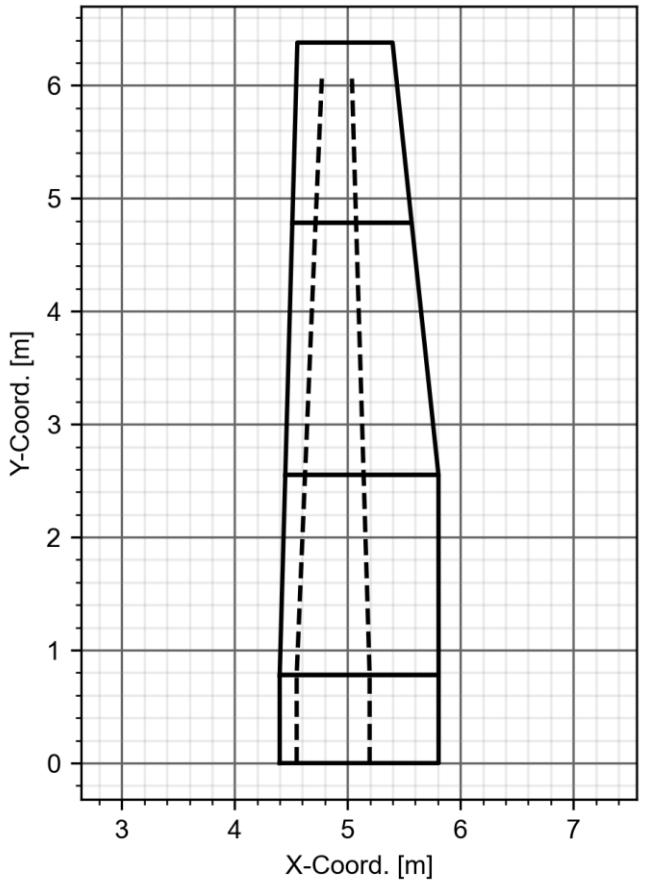
| Parameter | Unit | Wing | HTP | VTP |
|---|---|---|---|---|
| Reference Area | m^2 | 15.50 | 2.92 | 2.47 |
| Span | m | 12.76 | 4.13 | 1.99 |
| Aspect Ratio | - | 10.50 | 5.83 | 1.60 |
| Taper Ratio | - | 0.60 | 0.60 | 0.50 |
| Mean Aerodynamic Chord | m | 1.24 | 0.87 | 1.55 |
| Avg. 1/4 Chord Sweep | deg | 0.25 | 8.78 | 35.00 |
| Avg. Dihedral | deg | 7.00 | 0.00 | - |
| Lever Arm | m | - | 5.93 | 5.01 |
| Volume Coefficient | - | - | 0.9000 | 0.0626 |



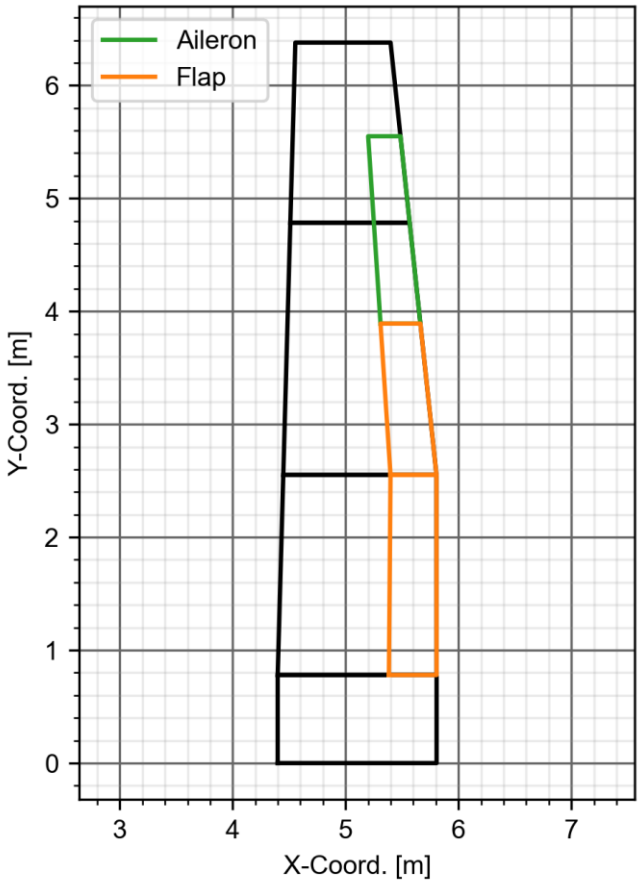



# Wing Box Geometry Overview



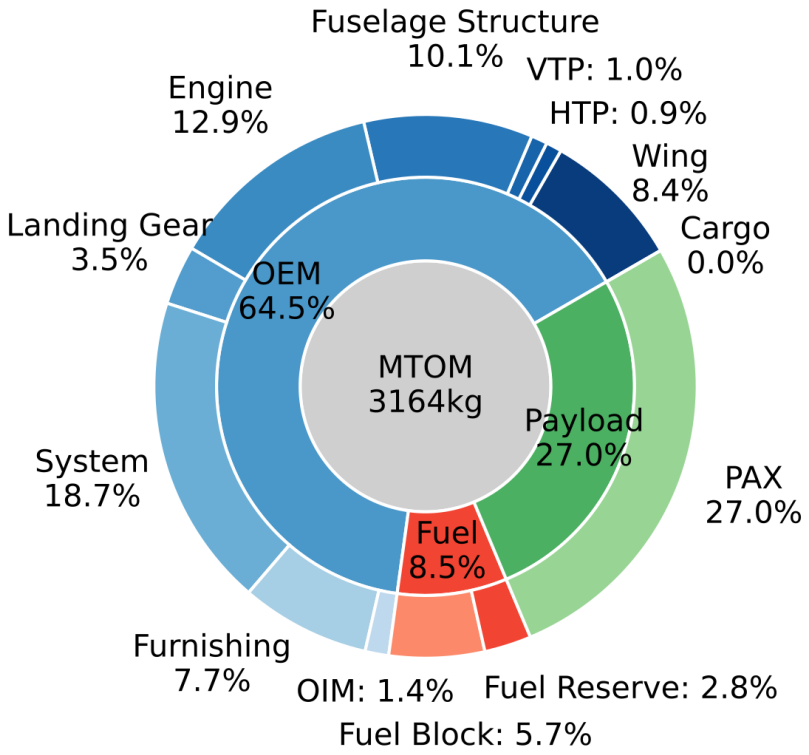

| Wing Section | Unit | Center | Root | Kink | Mid | Tip |
|---|---|---|---|---|---|---|
| Position | m | 0.00 | 0.78 | 2.55 | 4.78 | 6.38 |
| Rel. Position | % | 0.00 | 12.23 | 40.00 | 75.00 | 100.00 |
| Chord | m | 1.41 | 1.41 | 1.36 | 1.06 | 0.84 |
| 1/4 Chord Sweep | deg | 0.00 | 0.00 | 1.20 | -0.32 | -0.32 |
| LE Sweep | deg | 0.00 | 0.00 | 1.60 | 1.60 | 1.60 |
| TE Sweep | deg | 0.00 | 0.00 | 0.00 | -6.05 | -6.05 |
| Dihedral | deg | 0.00 | 0.00 | 7.00 | 7.00 | 7.00 |
| Twist Angle | deg | 3.18 | 3.18 | 2.23 | 1.03 | 0.18 |
| Thickness Ratio | % | 14.00 | 14.00 | 11.00 | 10.42 | 10.00 |
| Rel. Spar Position | | | | | | |
| Front Spar | % | 10.70 | 10.70 | 12.89 | 19.46 | 27.00 |
| Rear Spar | % | 56.60 | 56.60 | 51.14 | 53.45 | 56.10 |

# Wing Movable Arrangement Overview



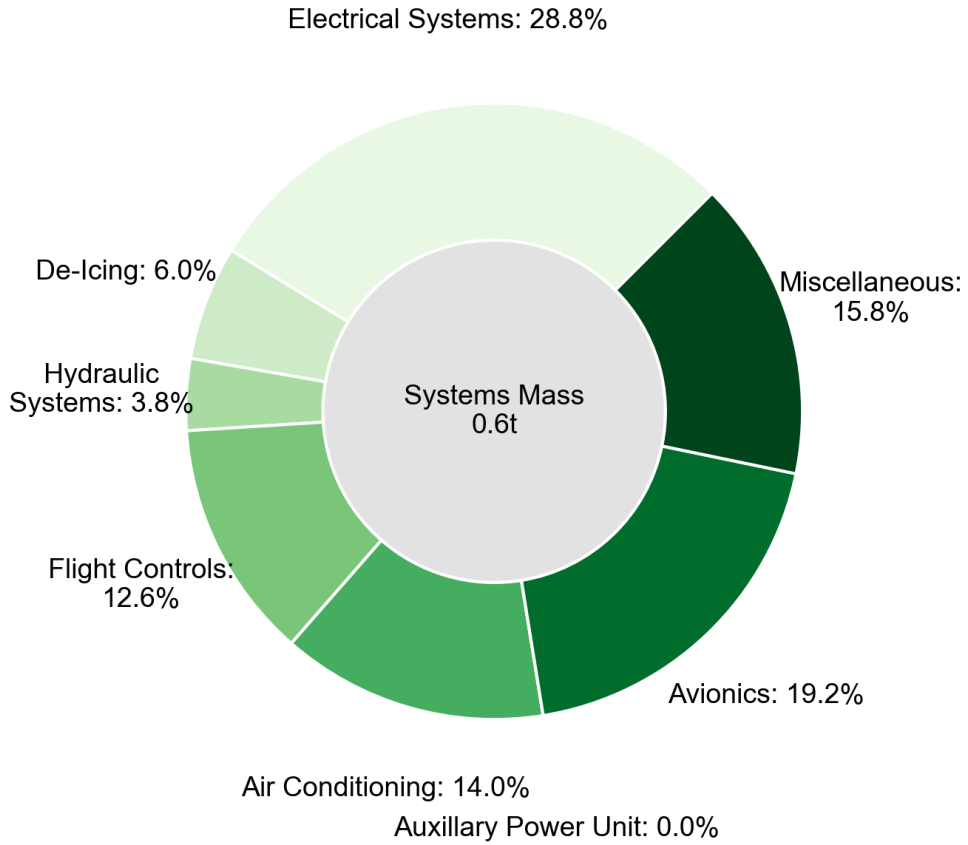

| Control Surface | y Inboard | y Outboard | Chord Inboard | Chord Outboard |
|---|---|---|---|---|
| Aileron | 3.891 | 5.55 | 0.35 | 0.29 |
| Flap1 | 0.78 | 2.552 | 0.42 | 0.41 |
| Flap1 | 2.552 | 3.891 | 0.41 | 0.35 |

# Mass Properties



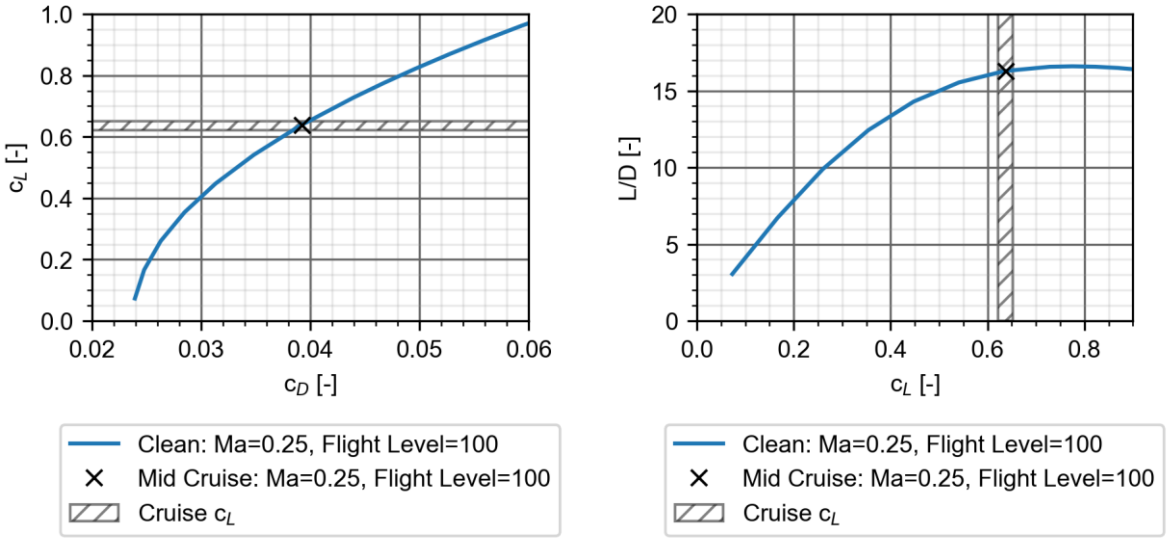

| Component | Mass [kg] | x-Pos [m] |
|---|---|---|
| Wing | 265 | 5.12 |
| Fuselage Structure | 318 | 4.86 |
| HTP | 30 | 10.83 |
| VTP | 31 | 10.17 |
| Power Units | 407 | 4.32 |
| Main Gear | 91 | 5.16 |
| Nose Gear | 21 | 1.76 |
| Systems | 590 | 3.78 |
| Furnishings | 244 | 5.36 |
| Manufacturer Empty Mass (MEM) | 1996 | - |
| Operating Items | 44 | - |
| Operating Empty Mass (OEM) | 2041 | 4.69 |
| Maximum Payload | 910 | 5.36 |
| Maximum Fuel | 515 | 4.88 |
| Maximum Zero-Fuel Mass (MZFM) | 2951 | - |
| Maximum Landing Mass (MLM) | 3164 | - |
| Maximum Take-Off Mass (MTOM) | 3164 | 4.89 |

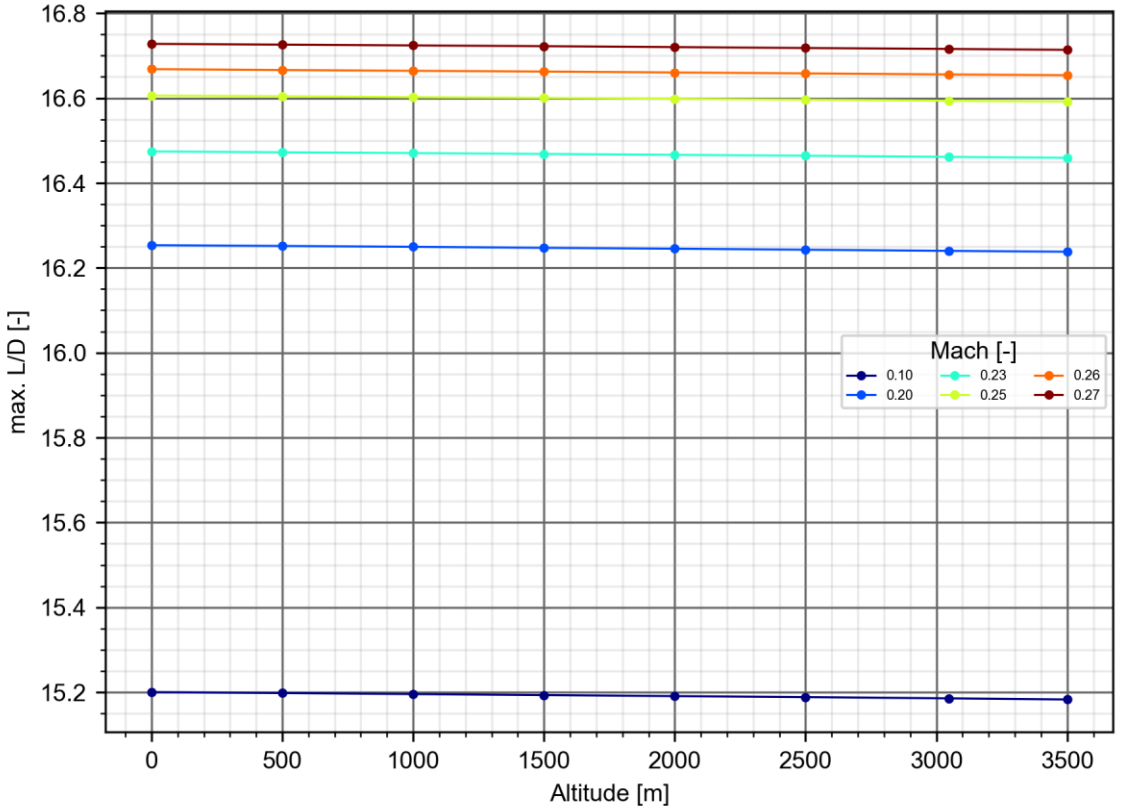
# System Mass Breakdown




| Component | Mass [kg] | Portion [%] |
|---|---|---|
| Air Conditioning | 82 | 14.0 |
| Auxiliary Power Unit (APU) | 0 | 0.0 |
| De-Icing | 35 | 6.0 |
| Electrical System | 170 | 28.8 |
| Flight Controls | 74 | 12.6 |
| Hydraulic System | 22 | 3.8 |
| Avionics | 113 | 19.2 |
| Miscellaneous | 93 | 15.8 |
| Systems | 590 | 100.0 |

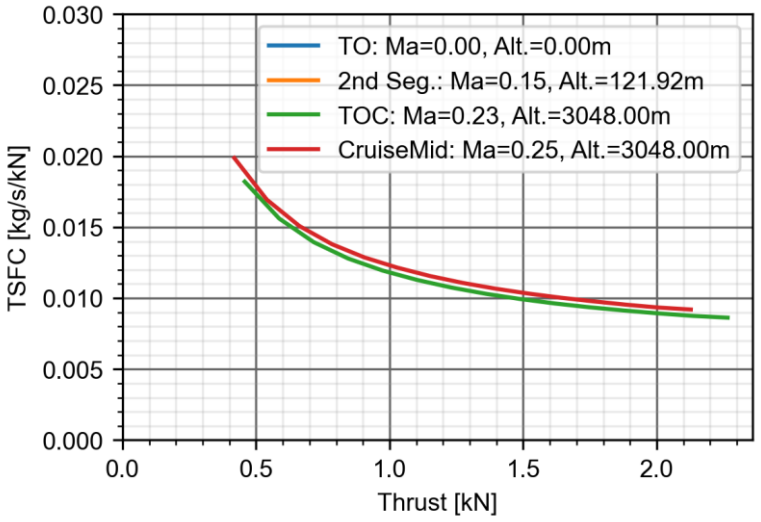
# Aerodynamic Performance



# Performance Requirements

| Parameter | Unit | Take-Off | EOF | 2nd Seg. | TOC | Mid Cruise |
|---|---|---|---|---|---|---|
| Delta Temp. ISA | K | 15.0 | 15.0 | 15.0 | 0.0 | 0.0 |
| Mach-Number | - | 0.0 | 0.147 | 0.147 | 0.23 | 0.25 |
| Altitude | ft | 0.0 | 35.0 | 400.0 | 10000 | 10000 |
| Engine Rating | - | MTO | RTO | RTO | MCL | MCR |
| Shaft Power[1] | kW | 235.4 | 235.4 | 235.4 | 103.6 | 84.1 |
| Shaft Power Offtakes[1] | kW | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 |
| Bleed Air Offtakes | kg/s | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |




[1]per operative engine

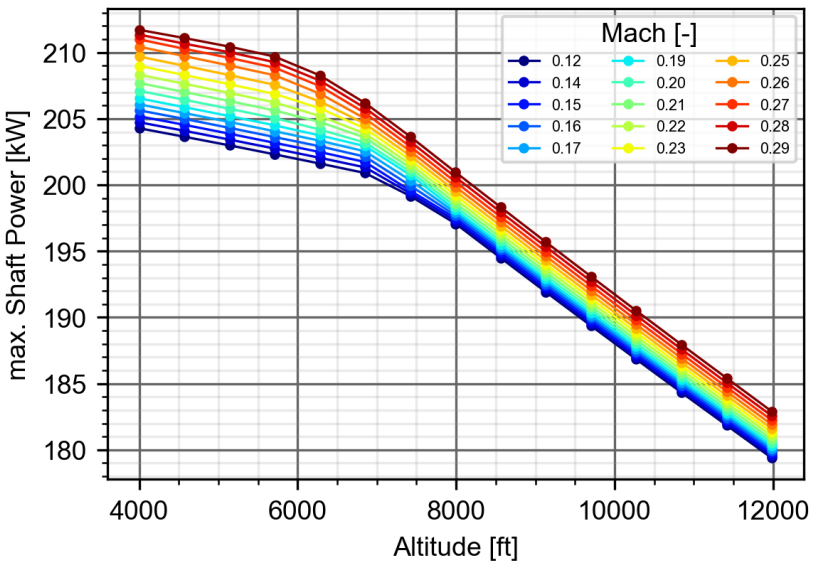
Description

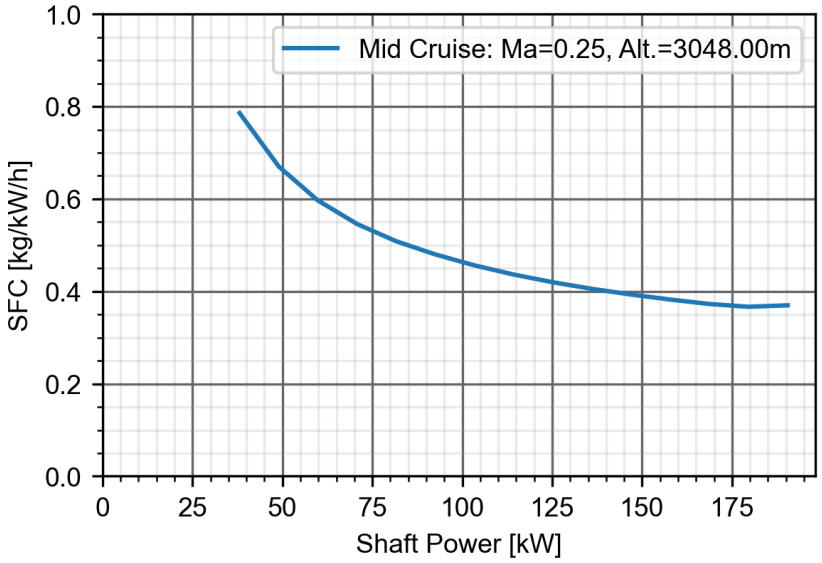
- Take-Off:
  - at MTOM
- EoF:
  - at approx. MTOM
  - Landing gear extended, Without ground effect
  - Critical engine inoperative
  - Gradient of Climb > 0%
- 2nd Segment:
  - at approx. MTOM
  - Landing gear retracted , Without ground effect
  - Critical engine inoperative
  - at V2 Speed
  - Gradient of Climb > 2.4%
- TOC:
  - ROC ≥ 300 ft/min
- Cruise:
  - typically not a thrust sizing point but rather a efficiency related point

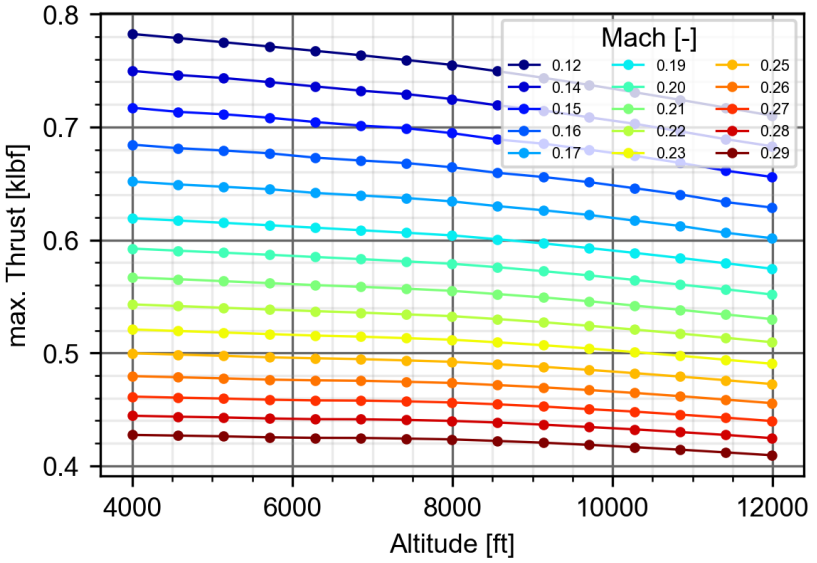
# Engine Performance

Engine modeling:

- Gas turbine performance modeled with semi-empirical engine deck generation calibrated on reference aircraft
- Propeller modeled as actuator disk with a constant efficiency penalty factor

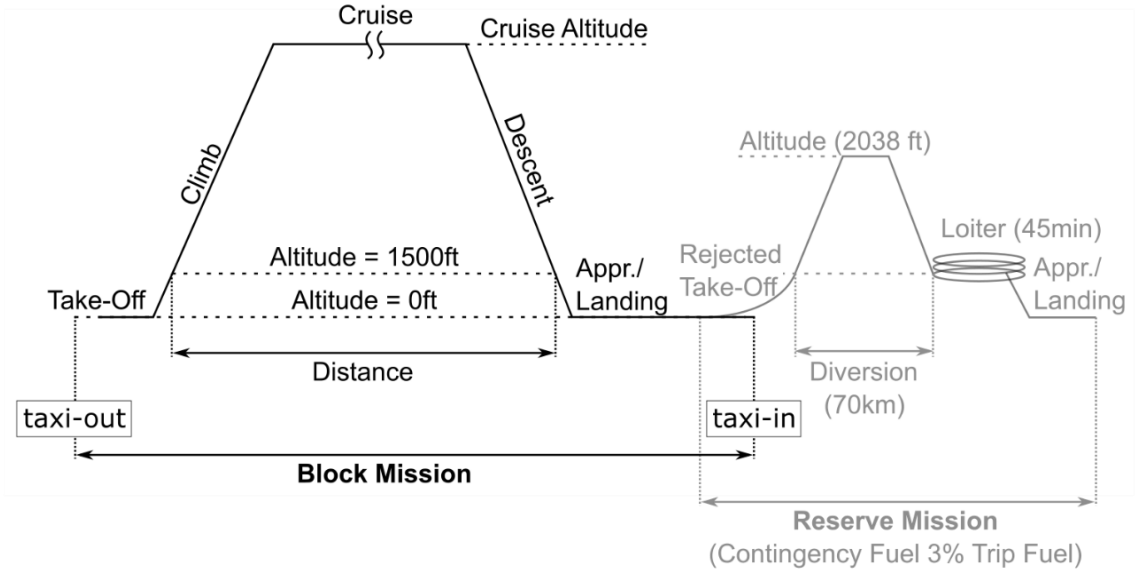


# Mission Definition and Key Aircraft Characteristics

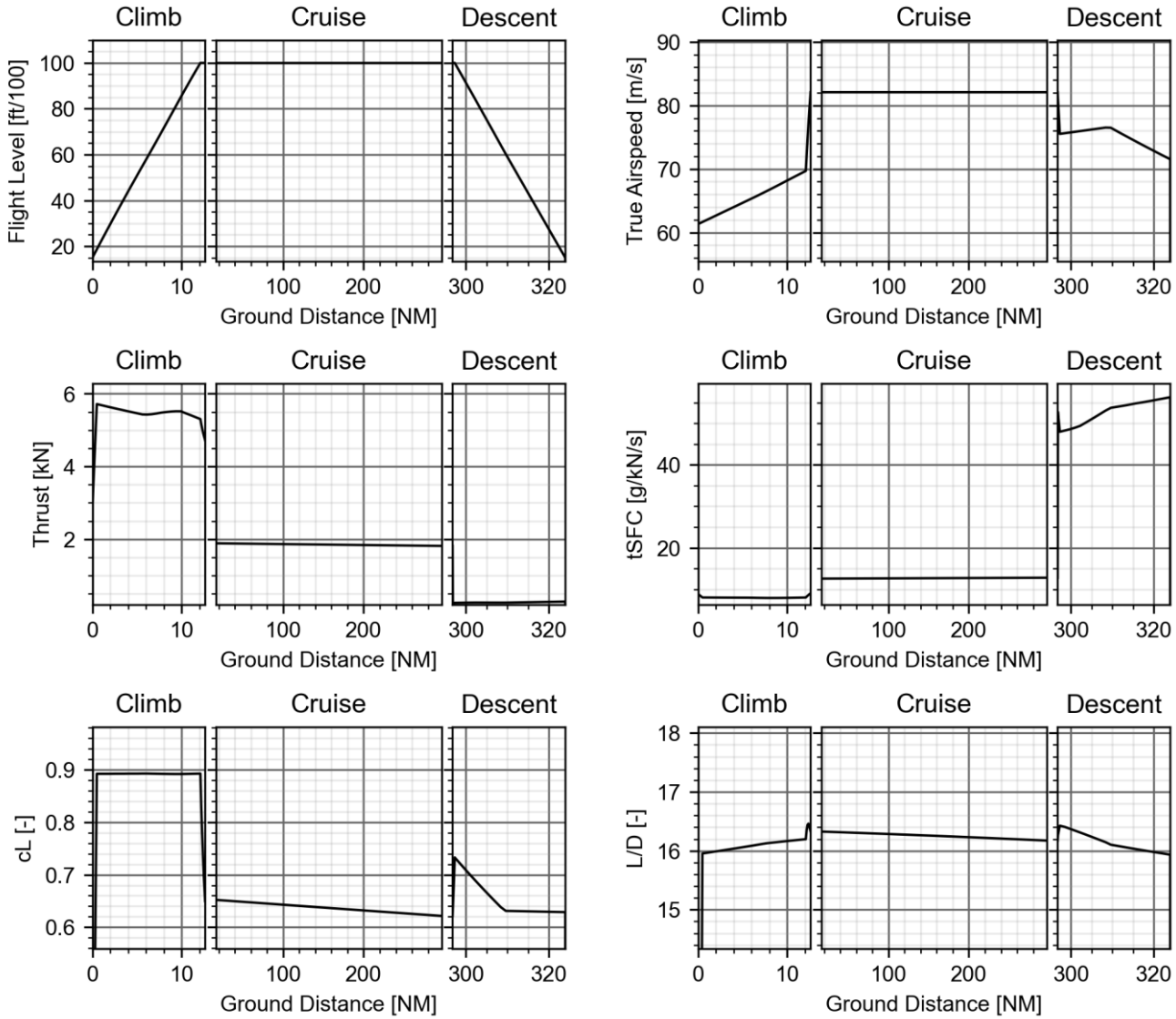
A design mission with a range of 324NM and a number of passengers of 9PAX at 95 kg/PAX was defined according to D-Light specification.



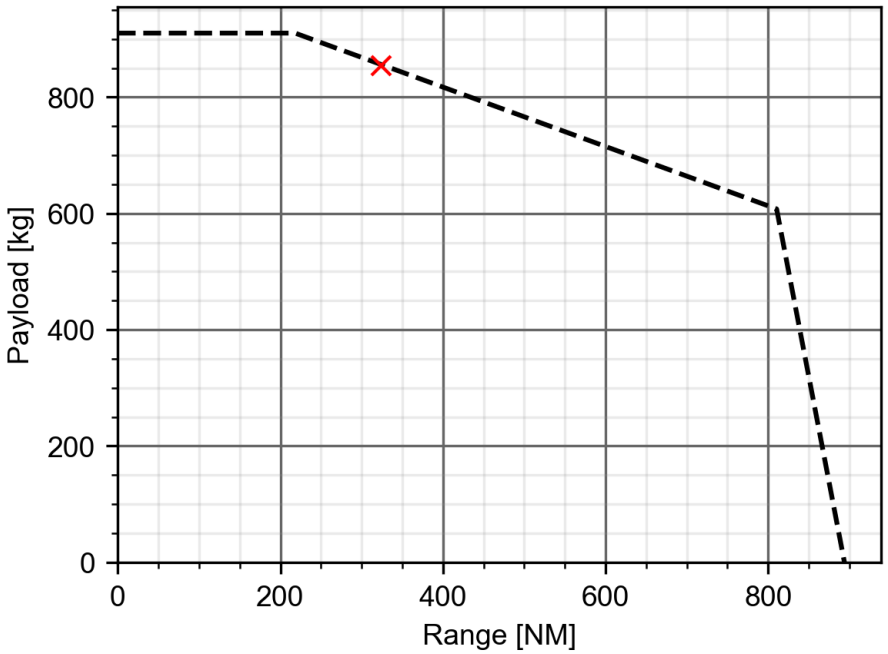

| Parameter | Unit | Value |
|---|---|---|
| Design Range | NM | 324 |
| Design Passenger Capacity | - | 9 |
| Design Cruise Mach Number | - | 0.25 |
| Max. Take-Off Mass | kg | 3164 |
| Max. Landing Mass | kg | 3164 |
| Max. Zero-Fuel Mass | kg | 2951 |
| Operating Empty Mass | kg | 2041 |
| Max. Fuel Mass | kg | 515 |
| Max. Payload | kg | 855 |
| Wing Area | m | 15.5 |
| Wing Span | m | 12.8 |
| Mean Aerodynamic Chord | m | 1.2 |
| Wing Loading (@MTOM) | kg/m^2 | 204.1 |
| Power-to-Weight Ratio (@ISA) | kW/kg | 0.15 |
| Engine Type | - | Turboprop |
| Shaft Power (Sea Level, ISA) | kW | 471 |

# Design Mission Performance

| Mission Phase | Flight Time [min] | Fuel Mass [kg] | Distance [NM] |
|---|---|---|---|
| **Block Mission** | **131.0** | **179.8** | **324.0** |
| Take-Off | 2.0 | 3.1 | 0.0 |
| Climb | 5.9 | 15.7 | 12.6 |
| Cruise | 107.0 | 150.7 | 284.7 |
| Descent | 11.0 | 9.3 | 26.7 |
| Approach & Landing | 4.0 | 0.6 | 0.0 |
| (Taxi-In) | 1.0 | 0.5 | 0.0 |
| **Reserve Mission** | **66.3** | **88.5** | **37.8** |
| Go-Around | 1.6 | 2.8 | 0.0 |
| Diversion Climb | 3.4 | 9.1 | 7.1 |
| Diversion Cruise | 5.5 | 8.0 | 14.0 |
| Diversion Descent | 7.2 | 6.4 | 16.7 |
| Holding | 45.0 | 61.7 | 0.0 |
| Diversion Approach & Landing | 3.6 | 0.5 | 0.0 |
| Contingency | 0.0 | 0.0 | 0.0 |



# Payload-Range Characteristics




General Information:

- Max. Payload: 910 kg
- Design No. PAX: 9 @ 95 per PAX
- Design Mission: 324NM @ 855 kg Payload

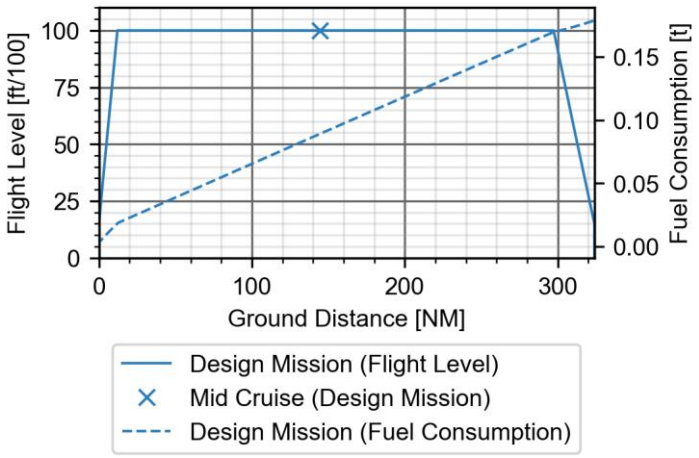
Mission Profile:

- Start/Arrival: Typical Commuter Profile
- Climb: 117kts
- Cruise: Mach 0.25
- Descent: 136kts

Reserve:

- No wind, ISA condition
- 38NM Alternate Airport
- 45min Holding @1500 ft
- Contingency Fuel: 3.0% Trip Fuel

# Cruise Performance Comparison




| Parameter | Design Mission |
|---|---|
| Range [NM] | 324.0 |
| Payload [t] | 0.9 |
| Mach Number (Cruise) [-] | 0.25 |
| Init. Cruise Altitude [FL] | 100.0 |
| Mid Cruise Altitude [FL] | 100.0 |
| End of Cruise Altitude [FL] | 100.0 |
| No. of Cruise Steps [-] | 0.0 |

| Parameter | Design Mission |
|---|---|
| **Mid Cruise Performance** | |
| Lift Coefficient [-] | 0.638 |
| Drag Coefficient [-] | 0.039 |
| L/D Ratio [-] | 16.26 |
| CAS [m/s] | 70.7 |
| TAS [m/s] | 82.1 |
| Angle of Attack [deg] | -0.1 |
| Thrust [kN] | 1.9 |
| Thrust max. [kN] | 4.7 |
| tsfc [g/kN/s] | 12.68 |
| **Avg. Cruise Performance** | |
| Lift Coefficient [-] | 0.637 |
| Drag Coefficient [-] | 0.0392 |
| L/D Ratio [-] | 16.25 |
| CAS [m/s] | 70.7 |
| TAS [m/s] | 82.1 |
| Thrust [kN] | 1.9 |
| tsfc [g/kN/s] | 12.69 |