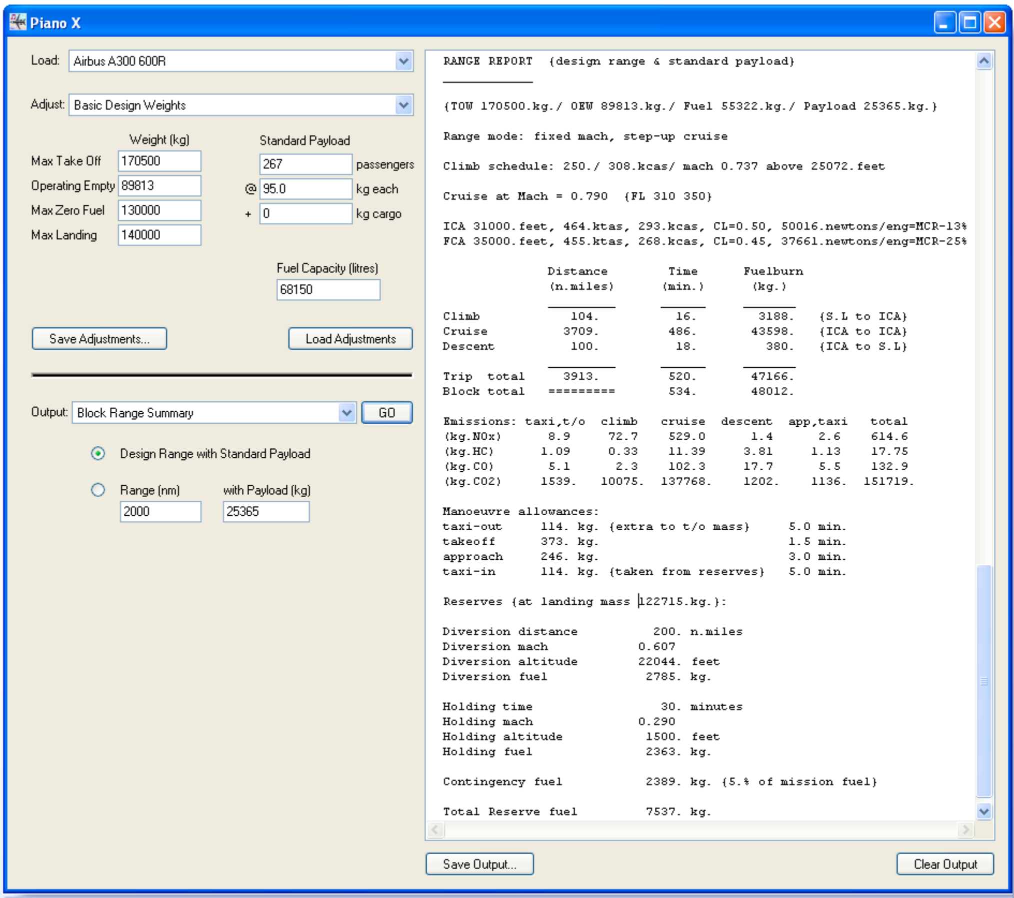
Piano X

Aircraft Emissions and Performance



User's Guide

Getting Started

Double-click on the compressed file you downloaded. This will create a new directory called ‘Piano-X’. Inside it you will find the application itself (‘Piano-X.exe’), and two directories: One called ‘pianox-planes’, which holds all your aircraft files, and another called ‘pianox-adjustments’, in which you can save any adjustments you make. The application always expects to find these two directories at the same hierarchical level as itself. That’s all.

Concept

There are three menus: ‘Load’, ‘Adjust’, and ‘Output’.

Use ‘Load’ first, to choose an aircraft.

If you want to change anything, select an option from ‘Adjust’. You can reset the basic design weights, factor the thrust, drag, or fuel consumption, input your own emissions indices, alter the flight levels and speeds, specify reserves and allowances, or pick the units you prefer.

Finally, select the ‘Output’ you are interested in and click the ‘GO’ button. The report you asked for will be shown in the text output area on the right side.

Outputs can include: Summaries (or detailed step-by-step analyses) of any flight over arbitrary distances with given payloads, tabulations of block missions, instantaneous performance at any particular flight conditions, complete payload-range characteristics, and takeoff / landing field lengths.

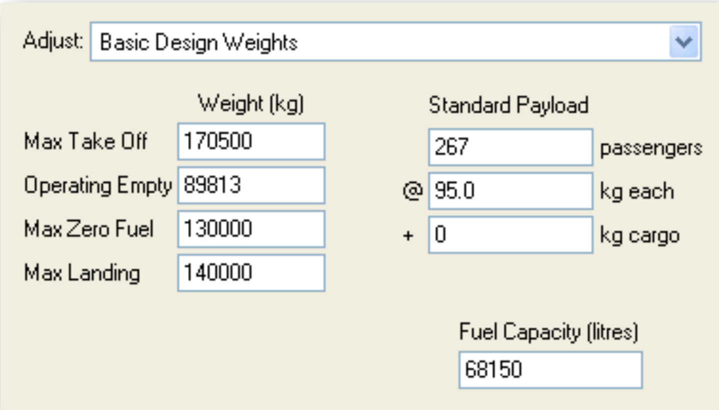
Depending on what you choose from the ‘Adjust’ and ‘Output’ menus, you will be presented with clear input options for specifying your requirements.

Two buttons are available that let you save, and later reload, any adjustments you make to the aircraft. You can create and keep as many adjusted models as you want.

Output reports can be saved to a text file or cleared from the screen at any time.

Basic Weights

Basic aircraft weights are the maximum takeoff weight (MTOW), operating empty weight (OEW), maximum zero fuel weight (MZFW) and maximum landing weight (MLW).



Piano-X weights represent the best available information, and you can always adjust them to any alternative specification. Some aircraft (such as recent versions of the ubiquitous Boeing 737) are marketed in a great variety of certificated weights. Information on weight options is easy to find, though often with one significant exception: Manufacturers may be reluctant to quote a representative OEW. In fact this is the most critical weight needed in assessing performance. Specifications often provide a manufacturer's empty weight (MEW), but this does not include operational items needed by the airline, and is not usable without an indication of the extra weight for a particular operator.

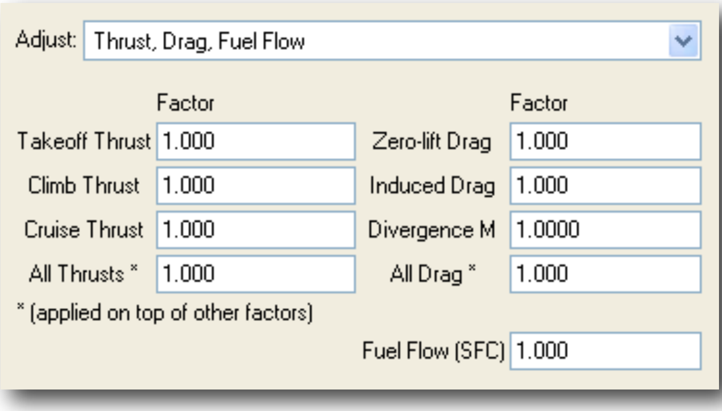
The 'standard payload' is one for which the aircraft is nominally designed, with all seats filled, in a typical seating configuration. Maximum payload (equal to MZFW minus OEW) can be higher, corresponding to extra cargo or dense seating arrangements.

The maximum fuel capacity is not a weight limit, but is required because it will normally constitute a boundary in the Payload-Range capabilities of the aircraft (together with the MZFW and the MTOW).

Thrust, Drag, and Fuel Flow

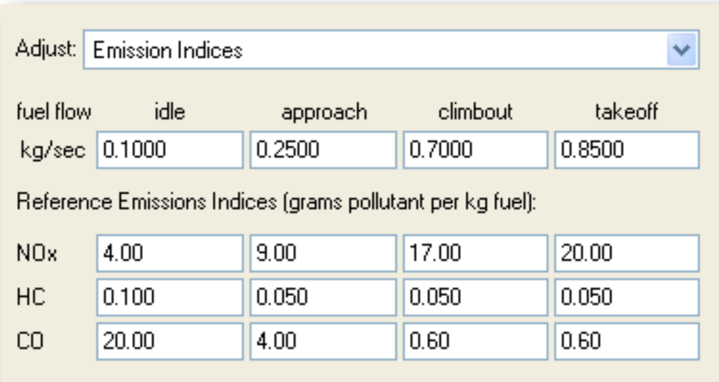
Engine performance in Piano-X is based on calibrated best estimates of typical installed powerplants. In cases where different engine options are available on the same airframe, the calibration will be as representative of the fleet as possible but may not explicitly identify any differences between engine types. Normally, these are small. You can use factors to adjust the maximum takeoff, climb, or cruise ratings of the engine, as well as its specific fuel consumption (SFC). Calculations of engine thrust and fuel flow depend on altitude, Mach number, and power setting; any factors you apply will shift all relevant characteristics up or down in direct proportion.

Aerodynamic drag is calculated in detail (as a function of lift coefficient, Mach number, and Reynolds number) and tuned with actual lift/drag data ('polars') whenever these are known. You can either factor the drag uniformly using one overall value or you can adjust certain items individually. These are the zero-lift and lift-induced drag contributions, and the nominal divergence Mach number (which will influence the high-speed compressibility drag). If you change them, you should know that aerodynamic methodologies generally differ in their accounting of drag items, which may be grouped under various labels.



Emission Characteristics

Aviation pollutant emissions include oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO) and carbon dioxide (CO_2). All except the CO_2 are calculated according to standard procedures based on tested engine characteristics. The best public source for engine emissions is the 'ICAO aircraft engine emissions databank' maintained by the UK Civil Aviation Authority. This uses four sea-level conditions which are representative of idle, approach, climbout and takeoff. Values at arbitrary flight conditions are derived by a method based on fuel flow ('Boeing 2'). Inputs take the form of 'reference emissions indices', which means simply the grams of each pollutant per kilogram of fuel burn.

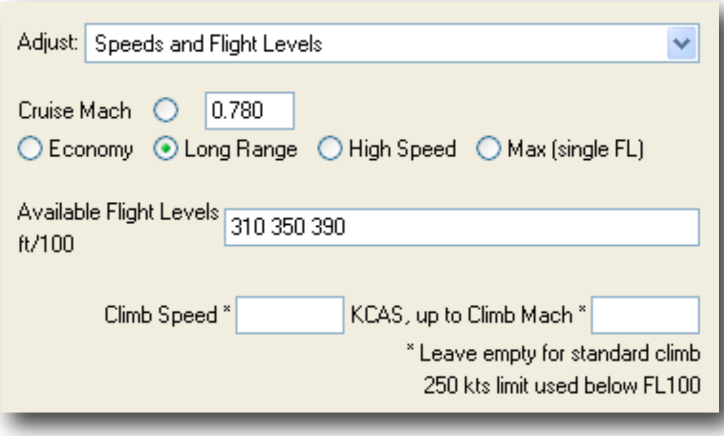


Carbon dioxide is not part of any databank as it is directly proportional to the fuel burn: One kg of jet fuel will produce 3.16 kg of CO_2. It is only shown explicitly in the summary range reports.

Piano-X models include predefined values for emissions characteristics according to either the actual engine or a nearest approximation to an actual engine. Data may not be provided for some 'early project' aircraft and for turboprops. If input boxes are left blank, no emissions will be calculated.

Speeds and Flight Levels

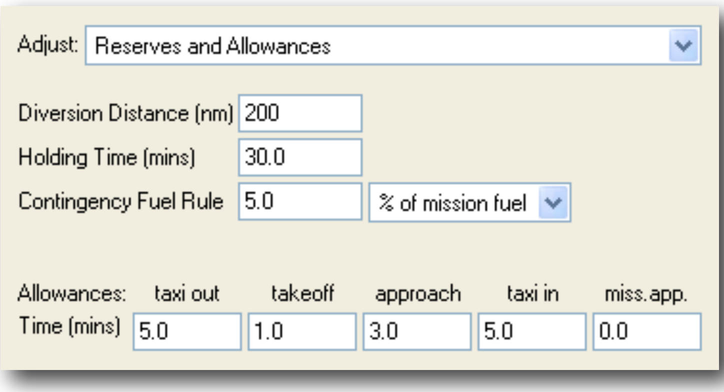
You can obtain mission performance data for any speeds and Flight Levels within the capability of the aircraft (FL is standard pressure-altitude in hundreds of feet). Piano-X selects optimum FLs from those listed as available. Cruise Mach can be set to a specific value, or calculated as 'Economy' (maximum air range), 'Long Range' (99% of max air range), or nominal 'High Speed' (max cruise rating at initial cruise). The 'Max' Mach option keeps max cruise rating throughout, provided only one FL is supplied (this option is used rarely, sometimes by business jets).



Climb speeds are calculated (or assigned) based on a constant calibrated airspeed in knots (kcas), subject to a 250 kt limit below FL 100, and up to some Mach limit at high altitude. Descent uses a similar speed schedule in reverse.

Reserves and Allowances

Range calculations include sufficient fuel reserves to cover some combination of diverting over a fixed distance, holding for a set time, and retaining an amount for contingencies (as a percentage of fuel or time).

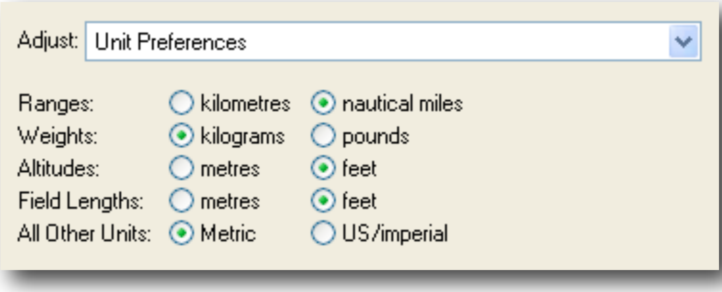


In calculating block fuel, allowances are normally made for taxi-out, takeoff, approach, and taxi-in, based on time spent at a corresponding power setting for each phase.

Note that individual aircraft models may use different assumptions, depending on their calibration and reflecting real-world discrepancies in reserve rules (typical International, US domestic, European shorthaul, etc). Each model can be adjusted as necessary.

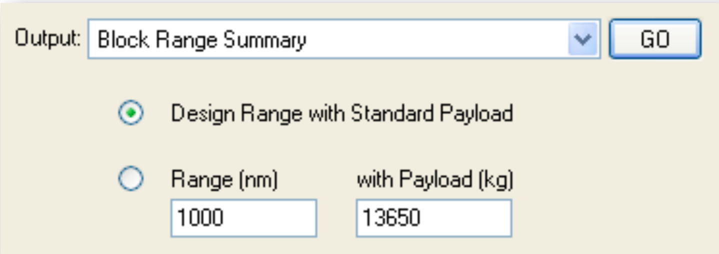
Unit Preferences

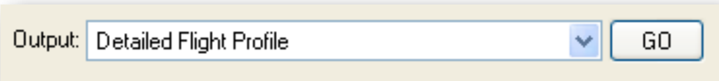
You can choose various combinations of metric and imperial (US) units.



Block Ranges and Flight Profiles

Mission performance can be calculated for any required combination of range and payload within the capability of the aircraft. The nominal design range is also shown, based on the standard payload.

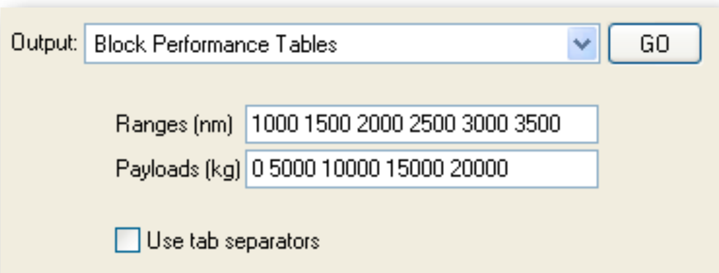




The outputs from a 'Block Range Summary' include all necessary times, distances, fuel burns and pollutant emissions. This is sufficient for most practical purposes. The alternative choice of a 'Detailed Flight Profile' uses the same inputs but generates an exhaustive step-by-step history for the entire flight. From this it is possible to derive any spatiotemporal information and a detailed in-flight distribution of pollutants.

Block Performance Tables

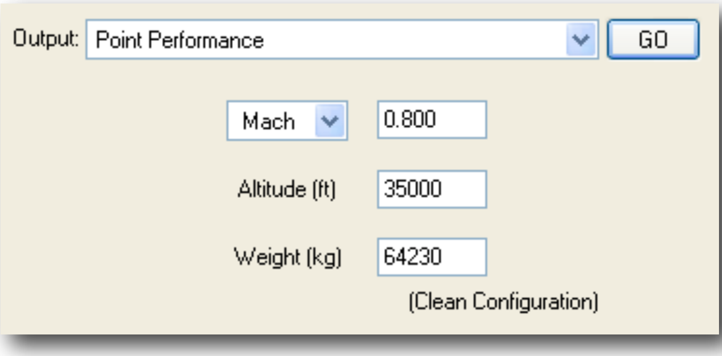
This output option will generate tabulated block mission data for any specified combinations of range and payload.



The resulting tables can be large and you may need to scroll to see specific portions. It is best to save such output in a file (using the 'Save Output..' button) and then examine it separately in any editor (like WordPad). If you tick the box labelled 'Use tab separators', the subsequent text can be copied/pasted into a spreadsheet document and will then align correctly in rows and columns.

Point Performance

The 'point performance' option generates details of instantaneous aircraft performance at a specific speed, altitude, and weight. Speed can be given in terms of Mach or kcas, ktas and keas (calibrated, true, equivalent). Outputs include various drag coefficients, lift/drag ratio, engine thrust, fuel flow and SFC, specific air range (nm/lb or km/kg) and residual performance capability as an available rate of climb.



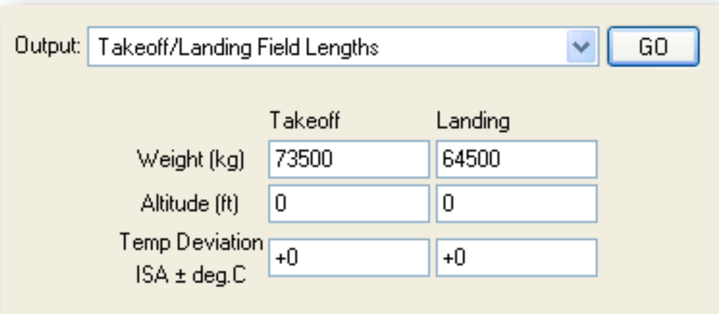
The aircraft is assumed to be in a 'clean' cruise configuration.

Payload-Range Boundary

The boundary of the Payload-Range chart is shown at the standard corner points (which correspond to MTOW with max payload, MTOW with max fuel, and zero payload cases), together with an additional list of intermediate points.

Takeoff and Landing Field Lengths

Takeoff and Landing field lengths are calculated according to FAR/JAR-25 rules at arbitrary combinations of weight, pressure-altitude, and temperature deviation from the International Standard Atmosphere (delta ISA).



Note that (in contrast to in-flight performance predictions) takeoffs and landings are subject to variation from uncertainties regarding retardation systems, high-lift devices, differences in flying techniques, rating structures, etc. Takeoff and Landing performance should therefore be regarded as indicative only.

Using Piano-X

Piano-X is extremely simple to run. Nonetheless, the underlying methods are complex and when a calculation cannot be completed some specific warning will be shown. If aircraft performance is insufficient for a given mission, consider allowing more (lower) Flight Levels or changing the speed mode. For extremely short stage lengths (say 200 nm), you may need to fix a single low level such as FL 200. If you factor thrust ratings individually, the climb, cruise or takeoff may become impossible under different flight conditions.

There may be small differences between numbers given by the ‘Block Range Summary’ and ‘Detailed Flight Profile’ outputs. The latter, more detailed method calculates portions of fuel allowances instead of using fixed time assumptions. Results will be essentially the same for typical allowances.

If you run Piano-X for a considerable time and produce long reports, text output may start to scroll more slowly. You can use the ‘Clear Output’ button to restore full performance.

You will find much more information in the User’s Guide for Piano, the complete aircraft design and performance tool, available at www.piano.aero. This online guide includes a list of terms and abbreviations applicable to all output reports produced by either Piano or Piano-X. There are also descriptions of the basic concepts and methodologies, which are common to both programs.

Contact

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Piano-X Aircraft List*

*Sample as of March ’08. The list of available models is subject to change.

Aerospatiale AS100
Aerospatiale AS100ER
Aerospatiale AS125
Aerospatiale AS125ER
Al(R) 58
Al(R) 70
Airbus A3XX-50R
Airbus A3XX-100
Airbus A3XX-100R
Airbus A3XX-200
Airbus A300 600 light
Airbus A300 600R
Airbus A300 B2-200
Airbus A310-200
Airbus A310-300
Airbus A318 basic
Airbus A319 basic
Airbus A319 option
Airbus A320-200 basic
Airbus A320-200 option
Airbus A321-100
Airbus A330-200 230t
Airbus A330-300 230t
Airbus A340-200 275t
Airbus A340-300 271t
Airbus A340-500 (v03)
Airbus A340-500 (v05)
Airbus A340-600 (v03)
Airbus A340-600 (v05)
Airbus A350 XWB-800
Airbus A350 XWB-900
Airbus A350 XWB-1000
Airbus A350-800 (v05)
Airbus A350-900 (v05)
Airbus A380-800 (v02)
Airbus A380-800 (v03)
Airbus Corporate Jetliner
Airbus Mil A400M
Antonov An-70T
Antonov An-124 Ruslan
Antonov An-124-210
Antonov An-148-100
Antonov An-148-200
ARJ-21 (AVIC1 v05)
ATR 42
ATR 72
Avro RJ 85 basic
Avro RJ 85 option
Avro RJ-70
Avro RJ-100
Avro RJ-115
B707-320C
B717-200 (v00)
B717-200 BGW (v99)
B717-200 HGW (v99)
B727-200A
B737-200
B737-300 (basic)
B737-300 (option)
B737-400 (basic)
B737-400 (option)
B737-500 (basic)
B737-500 (option)
B737-600 (NG basic)
B737-600 (NG option)
B737-700 (NG basic)
B737-700 (NG basic)wnglt
B737-700 (NG option)
B737-700ER(w)
B737-800 (NG basic)
B737-800 (NG basic)wnglt
B737-800 (NG option)
B737-900 (NG option)
B737-900ER(wnglt)
B737-BBJ1
B737-BBJ2
B747-8 Intercontl (v06)
B747-8 Intercontl (v08)
B747-100
B747-200B
B747-400 mfrspec
B747-400 stretch (v91)
B747-400ER
B747-500X (dec96)
B747-600X (dec96)
B747-SP
B747X (v01)
B747X stretch (v01)
B757-200 basic
B757-200 option1
B757-200 option2
B757-300
B767-200 basic
B767-200ER
B767-300
B767-300ER
B767-300ER option
B767-400ER(X)
B777-200 A (506)
B777-200 A (515)
B777-200 A (535)
B777-200 B (580)
B777-200 B (590)
B777-200 ER (IGW)
B777-200 ER (max)
B777-200 LR (v04)
B777-300 (632)
B777-300 (660)
B777-300 ER (v04)
B787-3 (shrink v05)
B787-3 (shrink v08)
B787-8 (baseline v05)
B787-8 (baseline v06)
B787-8 (baseline v08)
B787-9 (stretch v05)
B787-9 (stretch v08)
BAe 125-700
BAe 125-800
BAe 1000
BAe ATP
BAe Jetstream 41
BAe NRA
Beech King Air 200
Beechjet 400A
Boeing 7E7 (v04) baseline
Boeing 7E7 (v04) stretch
Boeing Business Jet (v97)
Boeing model 763-246C
Boeing model 763-246CER
Boeing model 763-246CS
Bombardier BRJ-X-90
Bombardier BRJ-X-110
Bombardier C(v04) 110ER
Bombardier C(v04) 110ST
Bombardier C(v04) 135ER
Bombardier C(v04) 135ST
Bombardier C(v05) 110ER
Bombardier C(v05) 110STD
Bombardier C(v05) 130ER
Bombardier C(v05) 130STD
Bombardier Challenger 300
Bombardier Continental(v02)
Canadair Challenger 601-3A
Canadair Challenger 604
Canadair CRJ 200ER
Canadair CRJ 200LR
Canadair CRJ 700
Canadair CRJ 700ER
Canadair CRJ 900
Canadair CRJ 900ER
Canadair CRJ 900LR
Canadair RJ 100
Canadair RJ 100ER
Cessna Citation III
Cessna Citation V
Cessna CitationJet1
Cessna CitationJet2
Cessna Sovereign
Cessna X
Dash 8 Series 100
Dash 8 Series Q200
Dash 8 Series Q300
Dash 8 Series Q400 HGW
Dassault Falcon 7X
Dassault Falcon 900 C
Dassault Falcon 900 EX
Dassault Falcon 2000
Dassault Falcon 2000EX
Dassault Falcon 9000 (v92)
Dornier 328
Dornier 328JET
Dornier 428JET
Douglas DC 9-14
Douglas DC 9-34
Douglas DC 10-10
Douglas DC 10-30
Douglas MD-81
Douglas MD-82-88
Douglas MD-83 auxCap
Douglas MD-87
Douglas MD-90-30
Douglas MD-90-50
Douglas MD-95 Tay
Eclipse (v00)
Eclipse 500 (v04)
Embraer 170 basic
Embraer 170 LR
Embraer 175 basic
Embraer 175 LR
Embraer 190 basic
Embraer 190 LR
Embraer 195 basic
Embraer 195 LR
Embraer EMB-120
Embraer EMB-135
Embraer EMB-145
Euroflag FLA turbofan
FA-X-100
FA-X-100ER
FA-X-200
FA-X-200ER
FA-X-300
FA-X-300ER
FAAB-Mriya
Fairchild Dornier 528JET
Fairchild Dornier 728JET
Fairchild Dornier 928JET
Fokker F50 Srs 100
Fokker F70 basic
Fokker F70 option
Fokker F100 basic
Fokker F100 option
Fokker F130 basic
Fokker F130 option
Fokker-F28 Mk4000
Global 5000
Global Express (v02)
Global Express (v99)
Global Express XRS (v08)
Gulfstream G IV
Gulfstream G IV-SP
Gulfstream G V (v99)
Gulfstream G V-SP
Gulfstream G550
Gulfstream G650
Honda HondaJet
IAI 1125 Astra
IAI Galaxy G200
Ilyushin IL-62M
Ilyushin IL-96-300
Ilyushin IL-96M
JADC YSX75
KARI-100seater
Learjet 31A
Learjet 31A ER
Learjet 45
Learjet 55C
Learjet 60
Lockheed L-1011-200
Lockheed L-1011-500
MD-11 basic
MD-11 option
MD-12 HC
MD-12X
MD-17 Globemaster
MD-XX (v91)
NLA sample
NSA (G1)
NSA (G2)
NSA (G3)
NSA (G4)
Raytheon Beechjet 400A
Raytheon Hawker Horizon
Raytheon Premier 1
Regioliner R92
Rombac 1-11 ReEng
Saab 340B
Saab 2000
Shorts FJX
Sino Swearingen SJ30-2
Sukhoi-IL RRJ 60B
Sukhoi-IL RRJ 60LR
Sukhoi-IL RRJ 75B
Sukhoi-IL RRJ 75LR
Sukhoi-IL RRJ 95B
Sukhoi-IL RRJ 95LR
Superjet 100-75B
Superjet 100-75LR
Swearingen SJ30 original
Tupolev Tu-154M
Tupolev Tu-204-220
Tupolev Tu-334-100
Tupolev Tu-334-200
Tupolev Tu-334-200Str
Yakovlev Yak-42M (v93)
Yakovlev Yak-46PF (v93)

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