The curious tale of the Long Dragon

Being a light diversion from dry numbers, or a none too systematic examination of a presently mythical aeroplane and of its various consequences were it to be brought to life.

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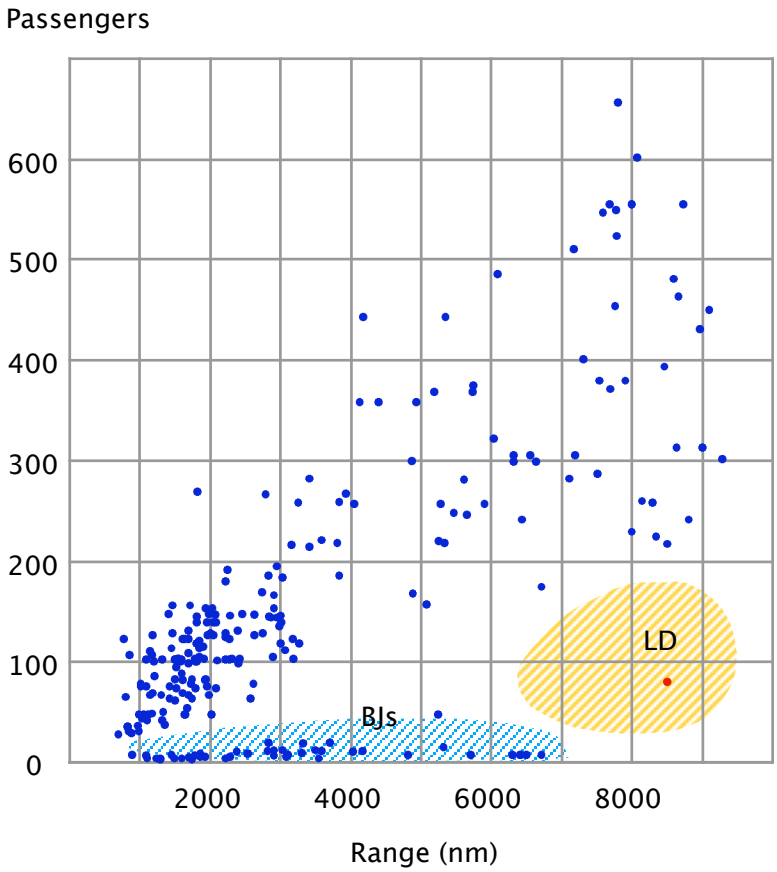
This is a brief, informal monograph about an unexplored aircraft market. Its intention is to illustrate the kind of original design that Piano (www.piano.aero) can generate entirely from scratch. There are no hidden agendas or industrial politics behind it. Nonetheless, the existence of such an aircraft would have significant strategic implications for current long-range designs. In the late 1990's, from a neutral position, the author presented a similar concept to Airbus, RR, the Dti, and Boeing. The time has now come to let this cat out of the bag. Whether or not there are enough commercial reasons to justify someone building a 'Long Dragon' is for you to judge.

Does it make sense to create an airliner designed to carry less than 100 people to almost anywhere around the globe? Such an aircraft does not yet exist, and some people will automatically assert that it could not ever be a commercial success. Of course, it's always possible to take an existing aircraft like an A340 and operate it with a reduced number of seats; similar things have been done - unsurprisingly, unprofitably. But what about a purpose-built smaller aircraft that can provide a viable, regular commercial airline service for medium-sized groups of people? The planet may already be bursting with money-making, city-hopping, businessmen-carrying 70 or 100-seaters, but they only serve regional markets.

The statistical data shown on the next page cover all aircraft in Piano's database (including many projects that never flew, like the Boeing model 763-246C and NLA). A loose trend emerges correlating seating capacity and range, but are we to deduce that there is an inevitable direct connection between the two? You can look hard for technical explanations, yet you will find none that are satisfactory. Not any vague invocations of square-cube laws (aircraft simply don't scale like solid lumps), not snowball effects between fuel and structural mass (existing long-range aircraft cope with them nicely). Not questions of engine efficiency or minimum gauge (which may affect much smaller aircraft). The underlying (and far from obvious) reasons for this trend appear to come from a hard-to-quantify blend of geographic and historical accidents, or social, economic and infrastructural issues. Indeed, a lot of people do need to be carried across continents to big cities with large and well established hub airports. But that is far from being the only game in town, and substantial opportunities can be missed by succumbing to an industrial herding instinct.

A clearly separate line of business jets (BJs) lies along the bottom of the graph in the blue mist. Some of them are quite capable of taking 5 people out to nearly 7000 nm, underscoring the suggestion that there are no significant technical issues at play - even as they hint at the deeper social and financial ones.

Large aircraft evolved rapidly to serve large and distant cities, and did so in parallel with sprawling airports. Despite industrial politics and marketing hyperbole, there is no real change yet on the drawing board. The smallest new long-range design, the 224-seat B787-8, will still require 9000+ ft of takeoff field length, which is not much less than the A380. It is hardly a so-called 'hub buster'. And it's difficult to know how stable this status quo will prove to be in the long term.



An entirely empty region, marked in orange in the chart, is where 'Long Dragons' are presumed to be hiding. Creatures 'Long' in range, invoking the mythical label on terra incognita and ancient mariners' maps: "Here be Dragons".

It is no surprise that the exploitation of an uncharted territory presents a scary prospect to naturally conservative, trend-following manufacturers and airlines. Does the LD region spell commercial doom? Understanding can only follow a full technical analysis, from scratch, of the kind of designs that might occupy the region. There is no existing aircraft to work with. That's where Piano comes into its own. A vast number of issues need to be quantified. Comfort, technology baselines of the engine, structures, aerodynamics, seating classes, field

requirements, all of these must be examined in a comprehensive matrix of parametric studies and design optimisations. Lissys has made some informal in-house studies, but I do not propose to give an account of these here; I'd rather hope you would use Piano and generate systematic requirements! Instead, this report will briefly outline one baseline design that demonstrates some of the possibilities inherent in the entire LD region.

The LD80 aircraft illustrated here is sized to carry 80 passengers in a single-class, very high-comfort, 4-abreast, single-aisle configuration over 8500 nautical miles. That's only slightly less than the number of business-class passengers you might expect to find in an A380 over a comparable range. Fuselage dimensions are very similar to an A321 (a 200-seater), but the wing is substantially larger.

It would of course be possible to outfit an LD80 for a higher number of passengers in a mixed-class layout. However, the 80-seat configuration is intended to provide a tempting alternative travel solution to those passengers that pay the greatest fares. A preliminary comparison of the operating costs of the LD80 relative to bigger designs indicates that this configuration offers a comfort level roughly halfway between first and business class at a fare level only marginally higher than business class fares. Alternatively, a more dense layout could match existing business fares and comfort levels, with only a slight reduction in range. At higher still passenger counts, using traditional class splits (economy + business + first) the LD80 becomes less competitive against the bigger aircraft. I have to refrain from discussing the possible arrangements and 'aircraft family' options that can be constructed around the baseline, as these are effectively endless.

A key attraction of the LD80 lies in its excellent field performance. It can operate at its maximum weight out of 6000 ft runways, much shorter than those required by any bigger competitors. Global operations from small, truly regional airports are well within the capabilities of the aircraft.

The LD80 is an entirely conventional configuration based on realistic, even somewhat conservative assumptions regarding the levels of technology. It is meant to represent what could almost be flying today. Some use of composites has been factored into the structural mass, but not to the same extent as the Boeing 787. With current aerodynamic standards, its typical cruise Mach is 0.85, and its calculated maximum Lift/Drag ratio (around 19.5) is slightly less than that of the B787. That is partly due to size-related Reynolds effects and partly due to a slightly lower aspect ratio, and despite the fact that its fuselage diameter is comparatively small. The engines are in the 47k lbf. class, with SFC levels marginally better than what might be found today in an A340-500, but again significantly more conservative than the fuel efficiency that will be required of the 'bleedless' engines currently under development for the 787.

The basic design range requirement was set at 8500 nm with 80 pax, combined with a TOFL constraint no greater than 6000 ft. Piano's multivariate optimiser was then used to produce a minimum-mass aircraft. Alternative solutions are possible that will yield reduced fuel burns and higher aspect ratios, and all kinds of other tradeoffs can be contemplated. Nonetheless, various design considerations merge together in this baseline to give a good engine-airframe match. The wing size is large enough to accommodate all fuel inside the structural box. It provides an initial cruise altitude capability (ICAC) higher than 39000 ft, which would allow great flexibility in operational routing. The specified field performance can be achieved with simple high-lift devices (single-slotted flaps and slats). A clean and uncomplicated wing with no fuselage fuel helps with aerodynamic fine-tuning and, critically, lowers production costs.

Although it is still very much an airliner, the LD80 shows a natural leaning towards the higher thrust-to-weight ratios and lower wing loadings that characterise the greater performance margins of business jets. It is what you might expect of an aircraft providing premium levels of comfort and convenience but in the context of a regular passenger service.

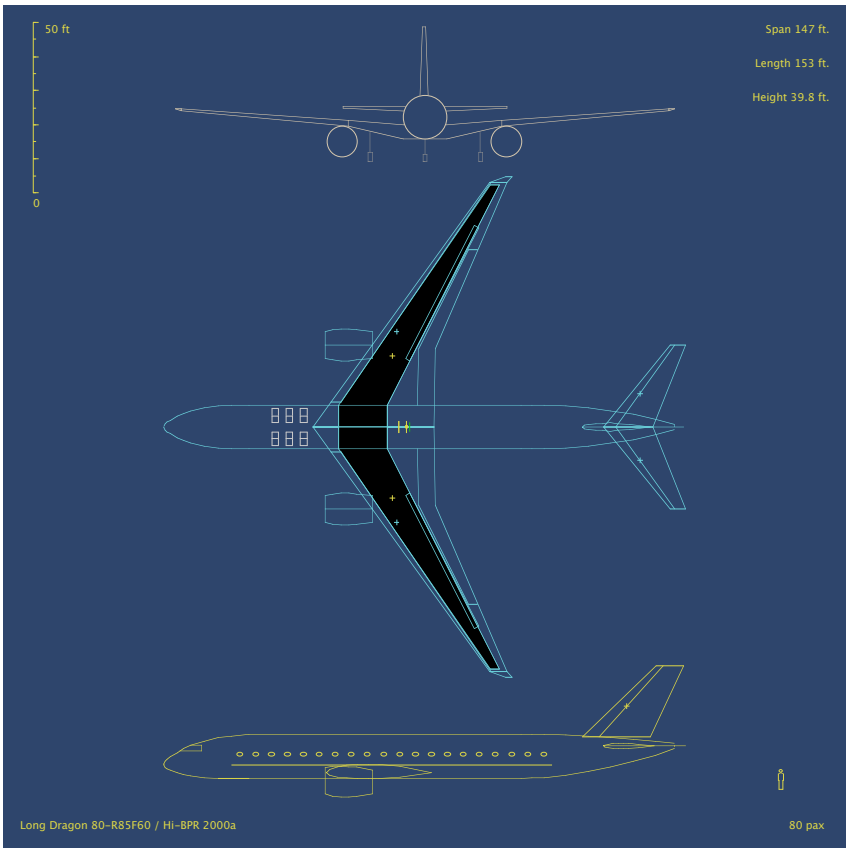
There are no obvious technical 'show stoppers' for the LD80, although particular areas will require more attention, as always. The higher cruising altitudes might make an all-composite fuselage more attractive. One contentious issue is likely to be the need or otherwise for a second flight crew, which could have a disproportionate effect on DOC because of the smaller payload. Social and environmental impacts are mixed. Its good takeoff performance and simple high-lift system make this aircraft a quiet neighbour for local residents around airports. Inevitably, it does also mean that wealthier people again end up consuming a higher proportion of energy resources, although this is arguably no different to the existing situation for larger aircraft if you account for a fair allocation of fuel burn between the different seating classes.

There is undoubtedly a predatory streak in the LD80, which is normal by the nature of the industry. It would seek to entice business and first-class passengers away from an A380 or B787 by virtue of its operational flexibility. Even when competing directly at large hub airports, a small and easily handled aircraft with fast turnaround times lets the operator provide a more attractive and exclusive service in both psychological and practical terms. But whenever convenient alternative regional airports can be used, for at least some established city-pairs and for many others that are currently totally inaccessible, the possibilities of reduced costs and improved commercial arrangements to the airline become very significant. Ultimately however, the LD80 should not be viewed as a replacement for the larger aircraft. The great numbers of people that need to travel over long distances will

necessarily continue to be served by these, as before.

This focused target market for the LD80 might suggest that the number of units sold would be low. But such an assumption could prove to be far too pessimistic given the steady increase in wealthier global travellers. Crucially, the first aircraft to enter the arena will have a unique opportunity to expand and fill an entirely empty market sector, which is a rare luxury. I suspect that the rewards will prove to be worth the risks; but don't quote me on this.

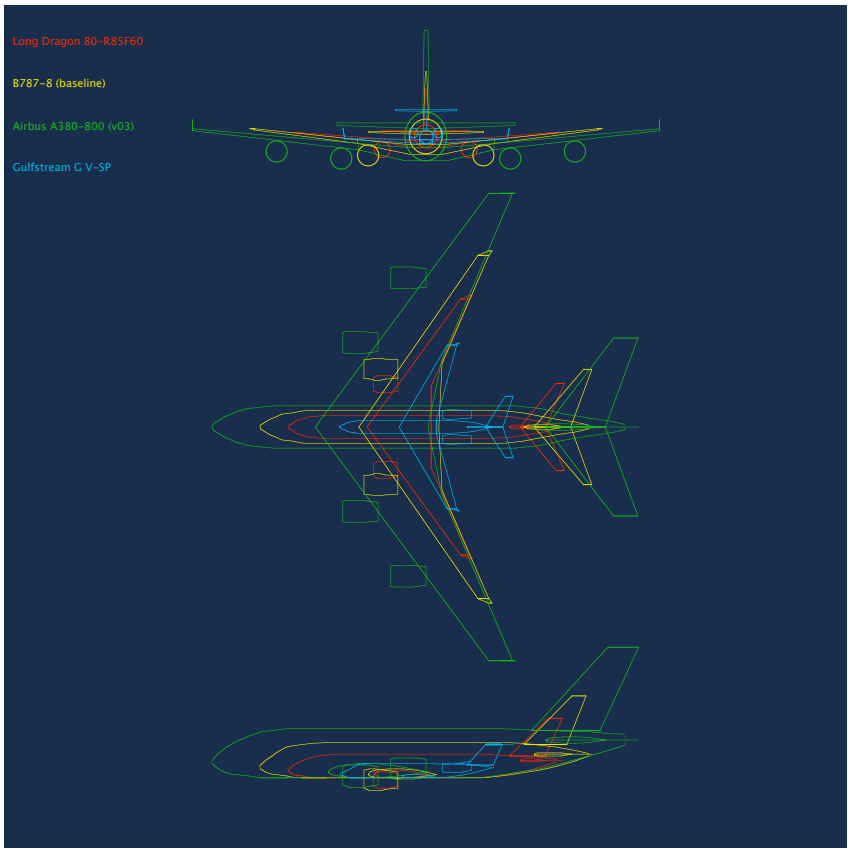
Since business and first class passengers are mostly the ones that fill the 'money-making' seats, their loss would impact the profitability of existing large aircraft. For that reason alone, neither of the two largest manufacturers are likely to be instantly enamoured of the LD concept. So could an LD80-like aircraft ever be built by some other global players? It is perhaps a larger project than the Canadian or Brazilian aerospace industries might care to contemplate, with some international cooperation seeming necessary. Russia could conceivably play a role. Then again, it might be done by the growing Chinese aircraft industry. And that would be a fitting fate indeed, if a Long Dragon was to emerge from its original natural habitat.



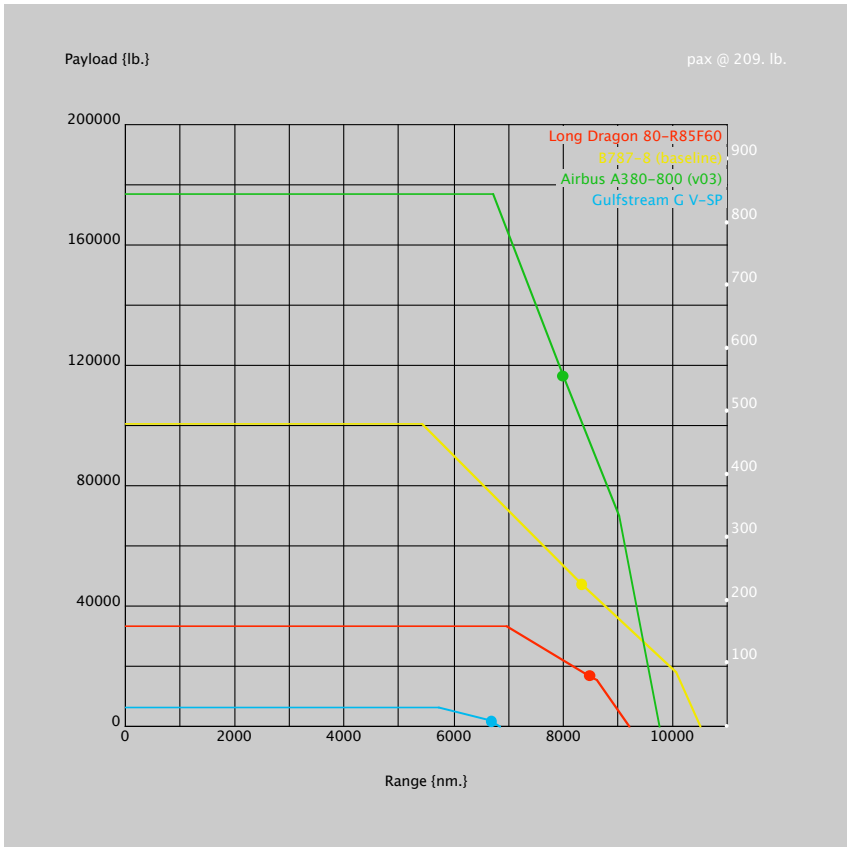
Long Dragon 3-View

Long Dragon LD80 – Basic Characteristics

Weights	lb	kg
MTOW	269600	122300
OEW	131200	59500
MZFW	164800	74700
MLW	176300	80000
Design Payload (80 pax)	16760	7600
Design Range	8500 nm	15740 km
TOFL (SL-ISA)	6000 ft	1830 m
LFL (SL-ISA)	4690 ft	1430 m

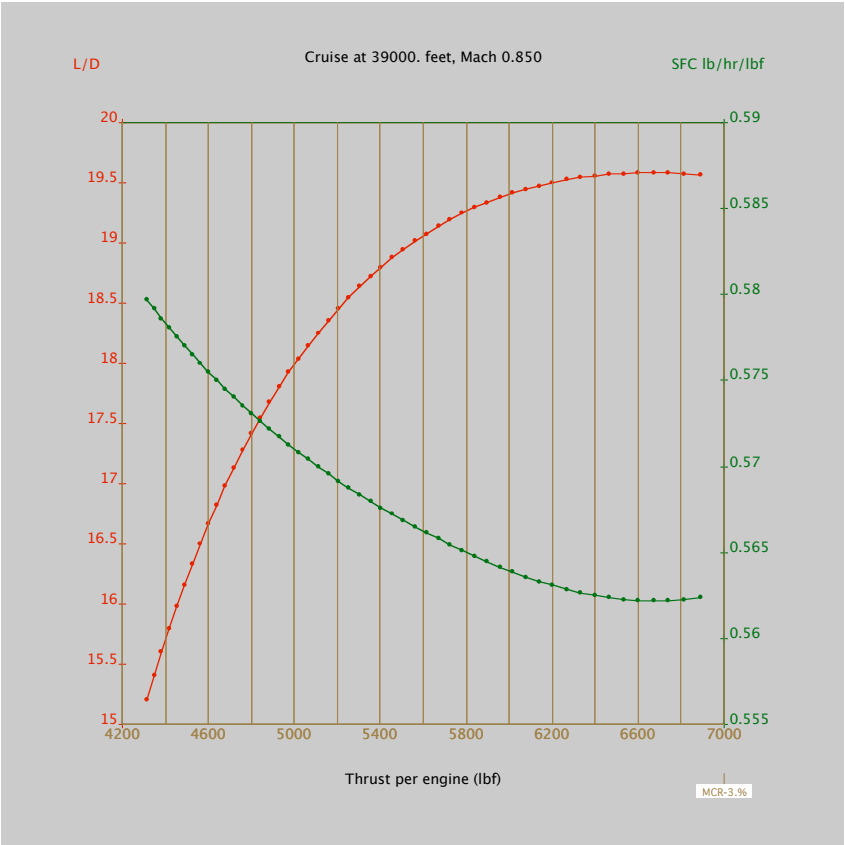


Comparison: 3-View Overlay

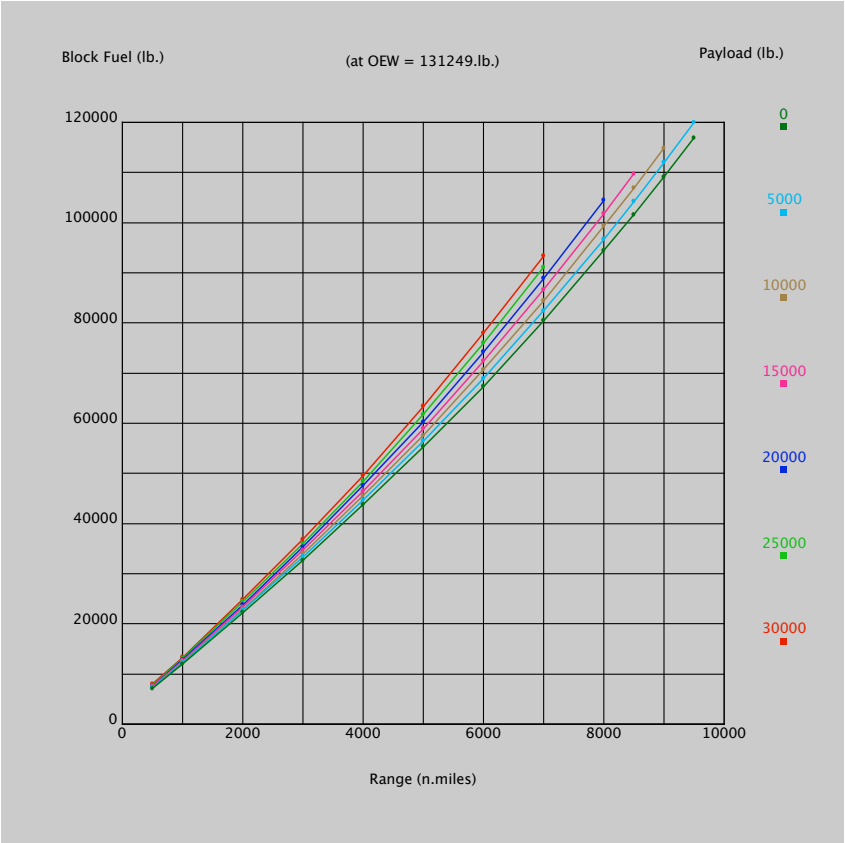


Comparison: Payload-Range Overlay

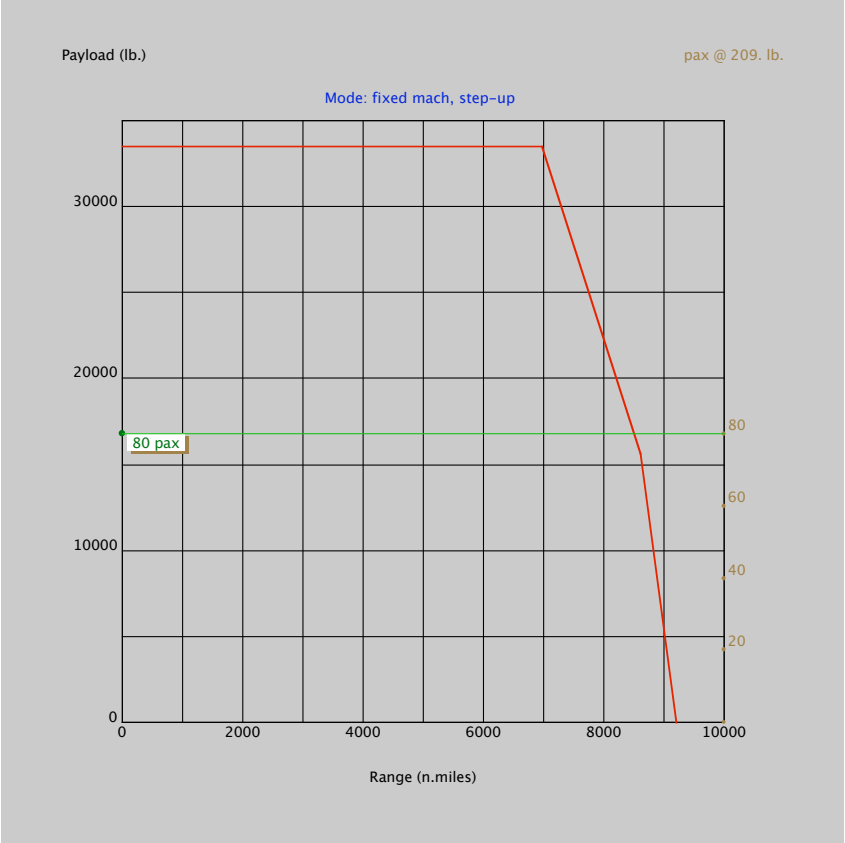
Altitude Capability



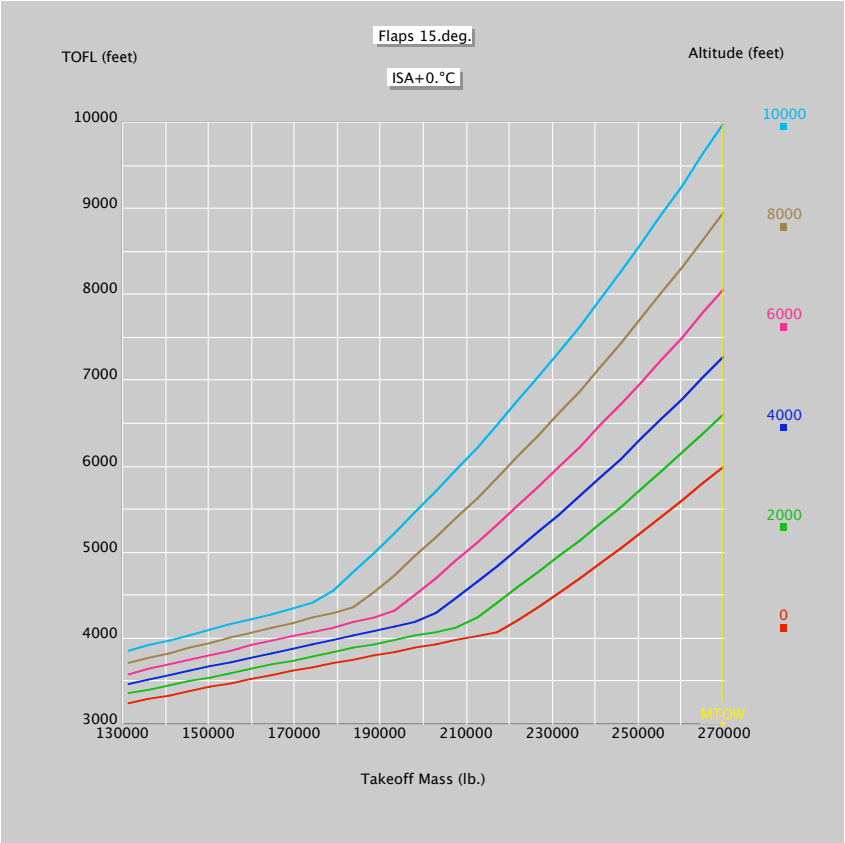
Airframe-Engine Cruise Performance



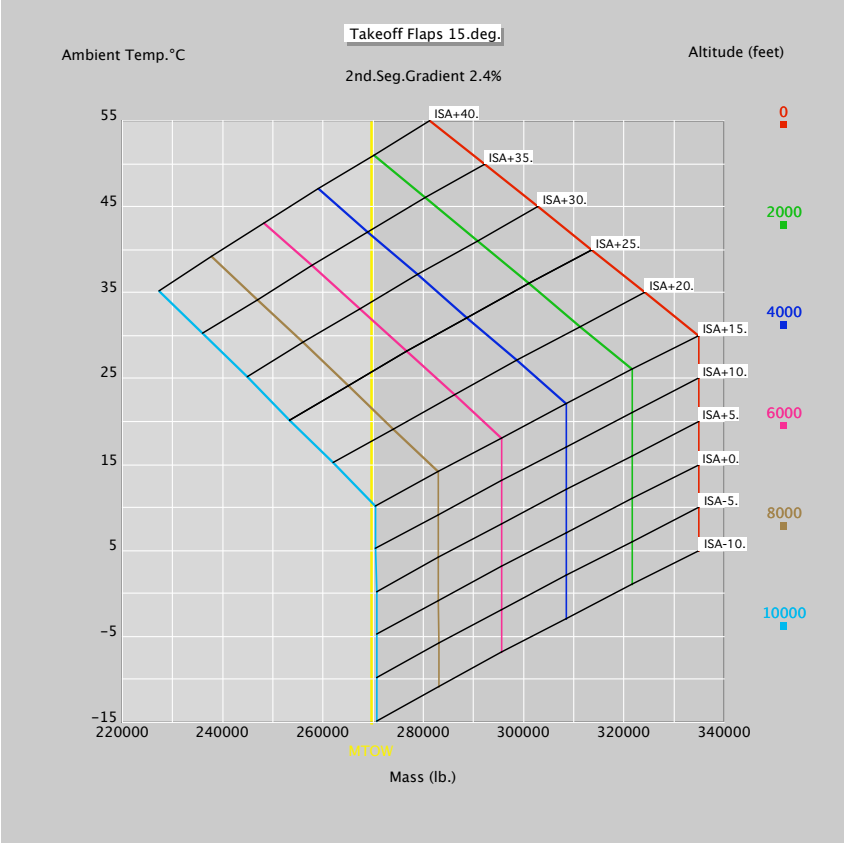
Block Fuel



Payload-Range



Takeoff Performance



WAT Limits

All data in this report were produced by Piano, an aircraft analysis software package developed by Lissys Ltd. (www.piano.aero). Pictures on pages 7-11 are directly copied from Piano. Enquiries regarding distribution or publication should be addressed to Lissys Ltd.