Fixed Trade Calculator – Application

Use of fixed trades to support a hypothetical engine selection case based on the impact of engine options on whole aircraft attributes

Context

It is difficult to find examples in the public domain of applications that might require fixed trade assessments that include weight, drag and thrust specific fuel consumption (s.f.c.). One of the few examples might be an engine selection decision. The associated hypothetical context would involve an airline or lessor considering a new aircraft purchase, where the aircraft being considered is available with more than one engine. In this case a choice must be made between the engine options available.

Considering two potential engines for the same aircraft. Assuming that two engine options would not be available if they did not deliver the same bulk performance, it is reasonable to presume that they will have largely the same ratings (thrust settings). If this assumption holds, then their s.f.c. levels can be compared (this would not be the case if the thrust ratings were manifestly different). The engines will also differ in terms of their weight, and if they have different external shapes (driven in part by fan diameter) they will also have different drag implications for the aircraft.

Using the Fixed Trade Calculator

Consider an engine selection where the differences between the two engines available for a long haul aircraft were:

- +3,500kg increase in operating empty weight
- -5% s.f.c reduction
- +10% fan diameter resulting in a +1% drag increase

This represents a competitor engine to the baseline which is heavier with more drag but is also more efficient and requires less fuel to deliver the same thrust.

Calculation choices:

- Aircraft type selection: Wide-body (long haul) aircraft with technology levels representative of a year 2015 Entry into Service (EIS)[1] date.
- Flight definition: default flight range and utilisation options for selected aircraft type 3000NM and 640 flights/year
- Fuel Price[2] selection: 2.0 $/US Gal

Running this calculation will give a message that the delta applied is larger than is considered to give reliable results with this tool. The results should therefore be treated with caution, although as in this case may give useful indicative output. It is recommended that deltas should be kept with +/-3% to give reasonable results.

[1] ATI Fixed Trade Calculator Version # 1.4.1.1.1 used for this calculation
[2] Fuel price data is available from IATA average jet fuel price for 2019 (27/12/19) $1.98/Gal(US)

Results:

Inputs		
Changes in weight – δOEW	kg	3500
Changes in shape – δdrag	%	1
Changes in engine efficiency – δs.f.c	%	-5

Outputs		
Increase in block fuel burn per flight	%	-2.68
	kg	-870
Increase in block fuel burn cost per aircraft per year	$	-366,400
Increase in cash operating cost per year	%	-0.81
Increase in CO_2 emitted per aircraft per year	kg	-1,760,000

Discussion

This application example is a rare example where a fixed trade calculation will require drag, weight and s.f.c changes to be combined. In this case, the benefit of the improved s.f.c, outweighs the negative impacts of a heavier, engine with more drag.

At aircraft-type driven default range, this alone could be a significant contributor to the acquisition choice for some users.

The relative importance of the three trade variables will however change when the aircraft range and utilisation change. This combination of trade factors will have a greater impact at longer ranges.

In this hypothetical case several assumptions have been made for illustration purposes. In a real engine selection example the engine provider would be in a position to provide actual data, and trade analysis. However, even in such a case, simplified fixed trade calculations such as these could help inform discussion and identify focus areas for discussion.

Options for next steps following this analysis could include:

- Conducting a small parametric study using the Fixed Trade Calculator to understand the sensitivity of the results to fuel price. This could help turn the question into: “At what fuel price would the alternate engine stop being the most viable?”

- Turning the calculation around, to set design targets. For example:

  If developing a competitor engine for this type of aircraft, would it be better to prioritise weight or s.f.c? At what weight would the s.f.c benefit be lost, or lead zones of the operating envelope which would stop being profitable to the operators?