Fixed Trade Calculator – Application

Sanity checking Fixed Trade Calculator results

Context

One of the test users for the Fixed Trade Calculator asked the following question having had access to the tool for 15 minutes and having had a chance to explore its functionality.

"I put in a 5kg weight saving in both aircraft variants and the NB resulted in a lower cost reduction even though the number of flights were almost 3 times as much, is this right?"

The first query that follows on from this question from a user is: "What were you expecting?" since as with all tools or models it is important to be able to sanity check the outputs to verify against typos in inputs and the potential for such a tool as this to turn into a "garbage-in garbage-out" machine.

Using the Fixed Trade Calculator – What did this user's calculation look like?

Calculation choices:

- Aircraft type selection: Narrow (short haul) and wide (long haul) body aircraft with technology levels representative of a year 2000 Entry into Service (EIS)[1] date.
- Flight definition: default flight range and utilisation options for each selected aircraft type
- Fuel Price[2] selection: 1.5 $/US Gal

Results:

		Narrow -body	Wide-body
Range	NM	750	3000
Utilisation	flights/year	1700	640
Inputs			
Changes in Operating Empty Weight – δWeight	kg	-5	-5
Outputs			
Increase in block fuel burn per flight	%	-0.01	0
	kg	0	-1
Increase in block fuel burn cost per aircraft per year	$	-300	-300
Increase in cash operating cost per year	%	0	0
Increase in CO_2 emitted per aircraft per year	kg	-1,700	-2,000

Initial Discussion

The first observation worth making is that a 5kg weight saving is a very small change in weight. Therefore, several of the results return null values because the resulting change due to the trade is smaller than the rounding accuracy set.

[1] ATI Fixed Trade Calculator Versions # 1.1.1.1.1 and #1.2.1.1.1 used for this calculation
[2] Fuel price data is available from IATA average jet fuel price for 2017 (22/11/17) $1.55/Gal(US)

Secondly, as per the user's query, the changes when considered over a year of flying result in a smaller reduction in carbon emissions per year for the narrow body than for the wide body, despite the narrow body having a higher utilisation.

The expectation might be that, as well as the greater number of narrow bodied flights each year, as a 5kg weight change is a larger proportion of the OEW on the narrow-body than the wide-body, that the weight change should have a larger impact on the smaller aircraft.

However, in this case the two aircraft missions compared are only very tenuously comparable. The only thing they have in common, is that the default options were selected for each aircraft, making each calculation representative of its type and generation.

Consider the number of flights. While there are many more narrow body flights, each is shorter. In this case the narrow body flight modelled would last less than two hours whereas the wide body flight modelled would be over 6.5 hours. Over the year, this would result in the wide-bodied aircraft will flying for nearly a thousand hours more than the narrow body (and at a much heavier weight, flying faster and therefore requiring more thrust and burning more fuel).

Using the Fixed Trade Calculator – What could this user's calculation have looked like?

One option in this case is to run both aircraft models at the same flight mission settings (range and utilisation). In this case there is an overlap allowing both models to be considered at 2000NM and 850 flights/year. There will still be a difference in flying time between the two aircraft types now (since the wide body aircraft is faster in cruise and will complete a flight of the same distance in a shorter time), but this is down to less than 150 hours difference over the year making the comparison more reasonable.

Note that now the flight being used is representative of neither type of aircraft average fleet usage.

Results:

Outputs - 200NM and 850 flights per year at $1.5gal/US		Narrow -body	Wide-body
Increase in block fuel burn per flight	%	-0.01	0
	kg	-1	-1
Increase in block fuel burn cost per aircraft per year	$	-600	-300
Increase in cash operating cost per year	%	0	0
Increase in CO_2 emitted per aircraft per year	kg	-3,900	-1,700

Further Discussion

This new calculation pair do show the expected differences due to the 5kg saving being a greater proportion of the OEW on the narrow body than the wide body.

However, the impact of rounding on these results due to the small increment applied as a trade variable is still visible in these results. The Fixed Trade Calculator is only valid for small changes, but these are defined as 3% of the baseline value.

Options for next steps following this analysis are challenging. This case is almost the definition of a "dummy calculation". The suggested next step would be to follow one of the published application examples that demonstrate fixed trade calculator use for reasonable examples instead of making up further inputs. Doing the latter would risk a garbage-in garbage-out situation. Or as in this case, a reasonable calculation which is representative of a much more complex and interesting comparison than may at first come to mind.