# CRJ family fuel-burn performance

## The fuel-burn performance of the CRJ family's most numerous variants is analysed on routes of 140-963nm.

There are several sub-variants of the four main variants of the CRJ family. Since most CRJs are operated on routes of up to 80 minutes, the differences in specification weights will result in small differences in fuel burn performance between these sub-variants. The main objective is to analyse the fuel burn performance of the most numerous sub-variants as being representative of the performance of each main variant. Four models have therefore been analysed *(see table, page 17)*.

These four aircraft have been examined on four routes of 140nm to 580nm. The performance of the largest model, the CRJ-900, has also been examined on a longer route of more than 800nm, since this aircraft may be used on more than just regional city-pairs.

### Flight profiles

Results of performance calculations have been provided by Jeppesen, based on parameters and specifications provided by the manufacturer. Performance on the four routes was analysed (both outbound and inbound segments) to illustrate the effects of wind speed and direction. This results in an equivalent still air distance (ESAD) for each direction on a city-pair, and affects the fuel burn and flight times.

Average weather for the month of June has been used, with 85% reliability winds and 50% reliability temperatures. Optimum flight levels are used where possible, unless air traffic control (ATC) have restricted this, and International Civil Aviation Organisation (ICAO) flight rules have been used for standard assumptions on fuel reserves, diversion and contingency fuel. Engine manufacturer fuel burn rates have been used for taxi and flight times, with a standard 20-minute taxi time being assumed to give block times. Speed in all cases has been assumed to be long-range cruise for the type/variant combination, which may mean slightly better performance than would be achieved in real operational conditions.

The aircraft are assumed to have single-class cabins with full passenger loads. The standard weight for each passenger and their luggage, as used by airlines in performance calculations, is assumed at 200lbs per person, with no additional cargo in the hold. The passenger numbers and payloads are therefore as follows: CRJ-100 (50 passengers; 10,000lbs); CRJ-200 (50 passengers; 10,000lbs); CRJ-700 (70 passengers; 14,000lbs); and CRJ-900EP (88 passengers; 17,600lbs). Variations in passenger numbers in reality have little effect on fuel-burn figures for a single flight, so the examples are useful illustrations of performance.

### Route analysis

The four routes analysed are operated by Air Canada Jazz, so they are representative of a regional carrier. These are as follows, with International Air Transport Association (IATA) three-letter codes in brackets, followed by to/from track distances in nautical miles):

1. Calgary-Edmonton (YYC-YEG), 139/166nm.
2. Edmonton-Saskatoon (YEG-YXE), 261/261nm.
3. Toronto-Boston (YYZ-BOS), 405/433nm.
4. Toronto-Thunder Bay (YYZ-YQT), 503/528nm.

In addition the one longer-range route analysed for the CRJ-900EP was:

5. Toronto-Winnipeg (YYZ-YWG), 832/857nm.

The first route was from Calgary (YYC) to Edmonton (YEG), and had an equivalent still-air distance (ESAD) of 139nm outbound and 169nm on the inbound (170nm for the -900EP aircraft). These distances reflect the equivalent tracked distance that would have been flown in zero wind conditions. Block time was increased by 3-5 minutes on the return, or about 10%. This illustrates the effect of en-route wind and routeing.

The second route was slightly longer, from Edmonton (YEG) to Saskatoon (YXE). The outbound ESAD was about 260nm, and inbound about 300nm. Wind outbound was negligible, but on the return journey a 46-knot headwind was encountered, causing a block time increase of 3-5 minutes, as in the earlier example. The block times were therefore just over an hour outbound and 1:06-1:08 on the return.

*The CRJ family fuel burn performance improves with larger variants. Fuel burn per seat-mile is higher, however, than the Embraer E-Jets.*

**FUEL-BURN PERFORMANCE OF THE CRJ FAMILY**

| City-pair | Aircraft variant | Engine model | MTOW lbs | TOW lbs | Fuel burn USG | Block time mins | Seats | Payload lbs | ESAD nm | Fuel per seat | Fuel per seat-mile |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YYC-YEG | CRJ-100 | CF34-3A1 | 53,000 | 42,401 | 271 | 45 | 50 | 10,000 | 139 | 5.42 | 0.039 |
| YYC-YEG | CRJ-200 | CF34-3B1 | 53,000 | 42,992 | 269 | 45 | 50 | 10,000 | 139 | 5.38 | 0.039 |
| YYC-YEG | CRJ-700 | CF34-8C5B1 | 72,800 | 61,416 | 369 | 45 | 70 | 14,000 | 139 | 5.27 | 0.038 |
| YYC-YEG | CRJ-900EP | CF34-8C5 | 84,500 | 69,561 | 428 | 44 | 88 | 17,600 | 139 | 4.86 | 0.035 |
| YEG-YYC | CRJ-100 | CF34-3A1 | 53,000 | 44,717 | 305 | 48 | 50 | 10,000 | 169 | 6.10 | 0.036 |
| YEG-YYC | CRJ-200 | CF34-3B1 | 53,000 | 45,379 | 307 | 49 | 50 | 10,000 | 170 | 6.14 | 0.036 |
| YEG-YYC | CRJ-700 | CF34-8C5B1 | 72,800 | 64,446 | 417 | 49 | 70 | 14,000 | 170 | 5.96 | 0.035 |
| YEG-YYC | CRJ-900EP | CF34-8C5 | 84,500 | 72,823 | 489 | 48 | 88 | 17,600 | 170 | 5.56 | 0.033 |
| YEG-YXE | CRJ-100 | CF34-3A1 | 53,000 | 44,769 | 383 | 64 | 50 | 10,000 | 261 | 7.66 | 0.029 |
| YEG-YXE | CRJ-200 | CF34-3B1 | 53,000 | 45,467 | 378 | 63 | 50 | 10,000 | 259 | 7.56 | 0.029 |
| YEG-YXE | CRJ-700 | CF34-8C5B1 | 72,800 | 64,364 | 510 | 61 | 70 | 14,000 | 259 | 7.29 | 0.028 |
| YEG-YXE | CRJ-900EP | CF34-8C5 | 84,500 | 73,041 | 597 | 61 | 88 | 17,600 | 259 | 6.78 | 0.026 |
| YXE-YEG | CRJ-100 | CF34-3A1 | 53,000 | 43,351 | 406 | 67 | 50 | 10,000 | 302 | 8.12 | 0.027 |
| YXE-YEG | CRJ-200 | CF34-3B1 | 53,000 | 43,930 | 402 | 68 | 50 | 10,000 | 303 | 8.04 | 0.027 |
| YXE-YEG | CRJ-700 | CF34-8C5B1 | 72,800 | 62,625 | 541 | 66 | 70 | 14,000 | 301 | 7.73 | 0.026 |
| YXE-YEG | CRJ-900EP | CF34-8C5 | 84,500 | 71,011 | 634 | 66 | 88 | 17,600 | 300 | 7.20 | 0.024 |
| YYZ-BOS | CRJ-100 | CF34-3A1 | 53,000 | 44,509 | 514 | 82 | 50 | 10,000 | 395 | 10.28 | 0.026 |
| YYZ-BOS | CRJ-200 | CF34-3B1 | 53,000 | 45,099 | 494 | 82 | 50 | 10,000 | 393 | 9.88 | 0.025 |
| YYZ-BOS | CRJ-700 | CF34-8C5B1 | 72,800 | 64,122 | 675 | 84 | 70 | 14,000 | 390 | 9.64 | 0.025 |
| YYZ-BOS | CRJ-900EP | CF34-8C5 | 84,500 | 64,592 | 728 | 80 | 88 | 17,600 | 392 | 8.27 | 0.021 |
| BOS-YYZ | CRJ-100 | CF34-3A1 | 53,000 | 45,896 | 604 | 97 | 50 | 10,000 | 514 | 12.18 | 0.024 |
| BOS-YYZ | CRJ-200 | CF34-8C5B1 | 53,000 | 46,417 | 582 | 97 | 50 | 10,000 | 513 | 11.64 | 0.023 |
| BOS-YYZ | CRJ-700 | CF34-8C5B1 | 72,800 | 65,822 | 782 | 97 | 70 | 14,000 | 511 | 11.17 | 0.022 |
| BOS-YYZ | CRJ-900EP | CF34-8C5 | 84,500 | 74,530 | 896 | 93 | 88 | 17,600 | 508 | 10.18 | 0.020 |
| YQT-YYZ | CRJ-100 | CF34-3A1 | 53,000 | 45,904 | 610 | 100 | 50 | 10,000 | 513 | 12.20 | 0.024 |
| YQT-YYZ | CRJ-200 | CF34-3B1 | 53,000 | 46,455 | 588 | 100 | 50 | 10,000 | 514 | 11.76 | 0.023 |
| YQT-YYZ | CRJ-700 | CF34-8C5B1 | 72,800 | 65,897 | 793 | 99 | 70 | 14,000 | 513 | 11.33 | 0.022 |
| YQT-YYZ | CRJ-900EP | CF34-8C5 | 84,500 | 74,619 | 908 | 96 | 88 | 17,600 | 515 | 10.32 | 0.020 |
| YYZ-YQT | CRJ-100 | CF34-3A1 | 53,000 | 45,636 | 659 | 109 | 50 | 10,000 | 577 | 13.18 | 0.023 |
| YYZ-YQT | CRJ-200 | CF34-3B1 | 53,000 | 46,228 | 636 | 109 | 50 | 10,000 | 580 | 12,72 | 0.022 |
| YYZ-YQT | CRJ-700 | CF34-8C5B1 | 72,800 | 65,588 | 855 | 108 | 70 | 14,000 | 574 | 12.21 | 0.021 |
| YYZ-YQT | CRJ-900EP | CF34-8C5 | 84,500 | 74,226 | 972 | 104 | 88 | 17,600 | 573 | 11.05 | 0.019 |
| YYZ-YWG | CRJ-900EP | CF34-8C5 | 84,500 | 77,338 | 1,395 | 154 | 88 | 17,600 | 963 | 15.85 | 0.016 |
| YWG-YYZ | CRJ-900EP | CF34-8C5 | 84,500 | 77,011 | 1,247 | 137 | 88 | 17,600 | 832 | 14.17 | 0.017 |

Source: Jeppesen

The third route was from Toronto (YYZ) to Boston (BOS), with tailwind of about 13 knots outbound, and a 72-knot headwind on the return leg, resulting in a large difference in ESAD. This was 390-395nm outbound and 508-514nm on the return (there is a slight variance between aircraft as performance varies between types). Block time was therefore increased by 11-13 minutes (again, about 10%).

The fourth route was from Toronto (YYZ) to Thunder Bay (YQT) with a headwind encountered on the way out, and a light tailwind on the return. This turned a track of 503nm outbound into an ESAD of 573-580nm (depending on aircraft model), and track of 528nm on the return into ESAD of 513-515nm. Block time was 1:44-1:49 outbound, and 1:36-1:40 returning.

Finally, a trip from Toronto (YYZ to Winnipeg (YWG) in the CRJ-900 had track distances of 832nm out and 857nm back. ESADs were 963nm and 832nm, reflecting the strong 65-knot headwind outbound and a 14-knot tailwind on the return leg. Block times were respectively 2:34 and 2:17.

## Fuel burn performance

The fuel-burn performance of the four CRJ variants is shown for four routes, inbound and outbound legs being shown separately. For the fifth route these are only shown for the CRJ-900 *(see table, this page)*.

The data also include the associated fuel-burn per passenger or per seat, and fuel-burn per passenger-mile for both sectors on each route.

The fuel burn increases on all sectors as the power and size of aircraft increases, apart from the CRJ-100 which has less efficient engines than the similarly-sized CRJ-200. The pattern is not necessarily the same for fuel burn per passenger or per passenger-mile. Fuel-burn per seat increases approximately in proportion to sector length.

The key measure is the fuel-burn per seat-mile, where the CRJ-900 model is always more efficient and is followed by the CRJ-700. It is clear that the real advantage of a stretched variant comes from increasing seat numbers from 70 to 88 seats. The longer sectors are far more efficient with the fuel per seat-mile falling from 0.035-0.039 US Gallons (USG) to 0.020-0.024USG. To a great extent this will reflect the increasing proportion of flight time spent in the cruise, whereas the maximum fuel-burn per mile would occur in the climb phase, a more or less constant factor between the routes.

Although fuel-burn per seat-mile was lowest for the CRJ-900 in all cases, it can be seen how critical it is to fill the seats by comparing the overall fuel burn per route between the CRJ variants. For example, total fuel-burn on the fourth route (to Boston) was 1,103USG for the CRJ-200 and 1,624USG for the CRJ-900. This is a one-third increase in fuel-burn. AC