Aircraft maintenance cost prediction

Environment, Air

Aircraft-commerce, Aircraft Operator and owner's guide, [issue 66, October 2009] states Canadair Regional Jet-200 are nominally 50-seat, five-crewmember, twin- turbofan-powered aircraft with a maximum altitude of 41, 000ft and a maximum design airspeed of Mach 0. 85. The only difference between them is that the CRJ-200 has a later engine, the CF34- 3B1. The cabin is 8. 43 feet (2. 53m) wide with four-abreast seating, 50 seats at 31-inch pitch as standard, and checked baggage capacity of 3, 500lbs (308 cubic feet). The CRJ-200 similarly had ER and LR versions; it ranges of 1, 229nm and 1, 585nm.. In all cases, maximum zero-fuel weight (MZFW) is 44, 000lbs, maximum payload weight is 13, 000lbs and maximum take-off weight (MTOW) is 53, 000lbs.

The CRJ-100 programme was launched in March 1989, and the first aircraft was delivered to Lufthansa CityLine in October 1992. The first flight of the CRJ-200, which was essentially a CRJ-100 with updated GE CF34 engines, took place on 13th November 1995.

Bombardier website, states that " The Bombardier CRJ200 has been designed to provide superior performance and operating efficiencies in the fast-growing regional airline industry. Against the closest competition it flies faster and farther while burning less fuel and having lower operating costs. With over 1, 000 units in commercial service it has become the most successful regional airliner program the world has ever known."

Airlines Using CRJ 200

Bombardier website, states that " There are nearly 1, 200 CRJ aircraft in operation in North America, which has a small number of large fleets. Europe is the second largest operator with 239 aircraft."

Following table shows top ten CRJ200 (by numbers) using airlines worldwide.

S. no

Airlines

Numbers Deployed

1

Northwest Airlines

142

2

Comair

110

3

Skywest Airlines

110

4

Delta Connection

94

5

Independence

87

6

Air Wisconsin

64

7

Lufthansa Regional

57

8

Air Nostrum

50

9

ASA

45

10

Air Canada Jazz

41

CRJ-200 Maintenance Programme:

Aircraft-commerce online magazine provide detailed information on The CRJ-200 complex airframe maintenance programme. Maintenance & Engineering, Issue 52, pg. 52, 54 [June/July 2007] points that maintenance programme has been divided into three sections:

Line and light maintenance

A checks

Base checks

These sections have different basic interval. This makes check planning complex, with the result that tasks are performed early and checks are uneven in size.

Sections are further divided into subgroups

Line and light maintenance:

There are no actual line and light checks specified in the MR, although many operators decide to add pre-flight and daily checks into their maintenance programme. The smallest check in the programme is a service check, with an interval of three days. The next largest is a 'routine' check every 100FH (Flying Hours)

A check tasks:

Originally A check tasks were designed for interval of 400 FH but raised to 500 FH after April 2007. There are five multiples of the basic A checks; 1A to be performed every 500 FH. 2A items every 1000 FH; 3A tasks every 1500 FH; 4A tasks every 2, 000 FH and 5A tasks every 2500 FH. First largest A check task is A4 which requires 95 MH (Man Hours) 1A and 3A both require 50 MH to complete and 2A and 5A both require 80 MH.

There are some other small checks, of items such as the Auxiliary Power Units (APU), these have repetitive interval of 300FH, 750 FH, 1200 FH, 1500 FH, 1800 FH and 3000 FH and all use 2MH for the routine tasks. (See Annexure table 1)

C Check Tasks:

There are three groups of C checks having different interval phases.

The first of these are the main C check inspections which have intervals that are multiple of 5000 FH and it requires 210 MH. 2C tasks have 10000 FH intervals and they use 280 MH

The second group of C check tasks are Out Of Phase (OOP) items with FH intervals that are mainly multiples of 4, 000FH. There are six groups, many of the tasks in which are structural inspections. The first group comes due every 3, 000FH, but only uses about 1MH. This group is small, and is often added to the A checks. The second group is one of the largest, using about 70MH, and comes due every 4, 000FH. The third group comes due every 8, 000FH, and uses about 40MH.

The third main group of inspections has calendar intervals that are mainly multiple of one year, and there are 11 different groups of inspection tasks. The 12-month tasks consume about 20MH. This is a relatively small labor requirement. The tasks also have easy access, so they are often included in the A checks. The tasks that come due every 18 months only require about 1MH. Like the 12-month tasks, these have easy access and are often included in the A checks. The 36-month tasks only use about 7MH, require easy access, and are often included in the A checks. The remaining seven groups of inspections come due every four, five, six, eight, ten, twelve and fifteen years. The largest are the four-year, six-year and eight-year groups, each of which uses 240MH, 890MH and 780MH for routine inspections. (see Annexure table 2)

Vertical Integration of Airframe maintenance activity:

Every plane and jetliner have their own schedule of maintenance activity however various airlines try to integrate maintenance program so that maintenance cost can be reduced. At Lufthansa, www. Lufthansa-technik. com/applications/portal, In focus: Aircraft maintenance, 29. 03. 2011 stated that it starts with Trip check: before every take off pilot and co-pilot take a look at the plane followed by D-check under which whole plane is taken apart completely and undergoes an extensive maintenance program such checks are for every plane.

Considering only CRJ-200 jetliners grouping the three sets of inspection tasks for the A and base checks into check packages is complicated by the large number of OOP and calendar tasks with intervals that are not in phase with the FH inspections. How tasks are grouped and formed into checks depends on rates of aircraft utilization. This analysis assumes aircraft operating at 2, 300-2, 400FH and 2, 100FC per year. Aircraft-Commerce, Maintenance & Engineering, Issue 52, pg. 52, 54 [June/July 2007] states that if we proceed with checks as they are due aircraft will be always in hangar rather than flying therefore it becomes essential to club checks so that excess maintenance should not be an issue. As base checks are most time consuming activities it is better to plan those task before all other. Aircraft with annual utilizations of about 2, 000FH can have checks in phases of 24 months. This means that tasks with multiples of 4, 000FH and calendar items with interval multiples of 12 and 24 months and higher can be grouped together. Tasks with intervals that are multiples of 5, 000FH would have to be brought forward and performed early. In the cases where they come due at the same time as large groups of other tasks they are included in base checks. Examples are the 24-month, 48-month and 72-month checks. During five year period, it will leave task group with interval of 48 & 60 month. These are scheduled in the base checks.

Not all these tasks are able to use their full intervals, however. For example small checks at 60 month interval are brought forward to 48 month check. The second group of tasks includes those with interval multiples of 4, 000FH. The first group of tasks (Group 1), with intervals of 3, 000FH, only requires 1MH and can be scheduled in A checks. These tasks can also be scheduled into base checks when their interval coincides with a base check. The second and third groups (Group 2 and Group 3), which come due every 4, 000FH and 8, 000FH can be included in base checks. The third main group of tasks includes those with interval multiples of 5, 000FH. The 1C, 2C and 3C tasks have to be brought forward in multiples of 4, 000FH, 8, 000FH and 12, 000FH. Once these three groups of tasks are grouped together, there are checks every 24 months. The items included in each check and the total routine MH required is summarized. (See Annexure table 3)

A-Checks are relatively easy to plan, however, because the third group of OOP tasks that comes due every 400FH is small. The actual interval of the A check is also likely to be close to 400FH. These OOP tasks can therefore either be scheduled in one of the 'routine' checks at a 100FH interval, or in the A checks if the actual interval is less than 400FH. The APU-related tasks, however, also come due in A checks or a 'routine' check that comes due in multiples of 100FH. The amount of routine labor for A checks is 50-186MH, depending on the size of the check. The group 1 base check tasks come due every 3, 000FH and use about 1MH. These can therefore be scheduled either every fifth or sixth A check, or in a 'routine' check. The other main group of base check tasks that are scheduled with A or line checks are the 12- and sometimes 36- month calendar tasks. The 12-month tasks use about 20MH, and can be scheduled with every fourth or fifth A check. The 36-month tasks will add another 7MH when added once every 15-17 A checks. These tasks therefore increase the range of routine labor for most A checks to 50-130MH.

Air Canada follows extensive procedure for Maintenance, Repair and Overhaul (MRO), http://www. aircanada. com/en/about/career/maintenance clearly states that maintenance program has been divided into various subsections like Line Maintenance, Sheet metal and plumbing, Avionics, and lot more, thus dividing program into various activities and costing is to be done on activity basis.

Inputs:

Aircraft-Commerce, Maintenance & Engineering, Issue 52, pg. 52, 54 [June/July 2007] states that the total work packages for A checks include routine inspections, the clearing of deferred defects that have arisen during operation, some component changes and some interior cleaning work. This takes the total labor for these checks to 80-200MH, with an average of over 130MH. Labor charged at a generic rate of $70 per MH will take the cost of the labor portion to $5, 600-14, 000. The cost of materials and consumables with these checks will be $2, 000-4, 500. Base check work scopes will have similar items to A checks. In addition to routine inspections, base checks will include: non-routine rectifications; clearing any defects left from operation; incorporation of service bulletins (SBs) and airworthiness directives (ADs); additional OOP tasks;

The non-routine ratio starts off at about 50% of routine MH for young aircraft up to three years old. The MH required for non-routine rectifications therefore increase the labor used. In the analysis and check planning used, the sub-total for routine and non-routine labor starts at about 500MH for the 24-month check, rising to 1, 100MH for the 48-month check. The first additional item to be considered is the clearing of deferred defects. The MH required for this is variable, and is 40-200 for base checks. An average of 100MH can be budgeted for base checks. Component changes are the second item. A landing gear ship set, for example, uses about 50MH for removal and reinstallation. Components removed will be hard-timed units, plus on-condition rotables that have failed or require removal. An average of 50MH should be used for this element of the check. An average of 100MH per base check should be used. These additional items therefore add 300-550 MH to the main portions of routine and non-routine labor for the checks. This takes the total for the 24-month check to about 800MH. Most checks are larger, with the 48-month check using 1, 500MH.

Reserves:

Labor rates vary, but a generic rate for base maintenance can be used to illustrate the approximate cost of the checks. A labor rate of $50 per MH results in labor costs of $40, 000-55, 000 for the smaller base checks, and $75, 000- 200, 000 for the larger checks. The associated cost of materials and consumables for these checks will be $15, 000-100, 000, depending on the size of the check. This results in total costs of $55, 000 for the 24-month check and 48-month check has a cost of $100, 000. These checks occur at intervals of 4, 000FH, and reserves can be calculated for each subsequent check over its interval or for the cost of a series of checks over this collective interval. The reserves for the 24-month check are $14 per FH. This amount increases to $25 per FH for the 48-month check. The reserves for all inputs for the first five checks amount to 9, 800MH and $200, 000 of materials and consumables, taking the total cost to about $700, 000.

Heavy components

Heavy components comprise: wheels, tyres and brakes; landing gear; thrust reversers; and the APU. Tyres are not remolded by most operators on the

CRJ, and are instead replaced at every removal. Aircraft-Commerce, Aircraft operator's and owner's guide pg. 18-32 [Issue 66, October/November 2009] gives a detailed maintenance background on Heavy components , Rotable components, Engine and internal refurbishment as: Removal intervals are 250-300FC, while new nose tyres are $300-350, and new main tyres are $1, 300-1, 400. The cost of replacing worn tyres is therefore $19 per FC. Wheels are inspected at tyre removal, and then have an overhaul about every fifth removal. Taking into account the typical costs of wheel inspections and overhauls, the cost of wheel repairs is $8 per FC. Brakes are steel, and have a shop visit about every 2, 000FC. Taking typical third-party shop visit costs into account, the cost of brake repairs is $30 per FC. The total cost for wheels and brakes equal to $50 per FH. Typical landing gear exchange and overhaul fees are $180, 000. Reserves are equal to $9 per FC. Thrust reversers are maintained on condition, and intervals are variable. Taking 15, 000FC as an expected average for a reverser shipset of the appropriate size, the cost per FC is $20.

Internal refurbishment

Interior work must also be taken into consideration. This concerns items such as: carpet cleaning and replacement; seat cover cleaning and replacement; seat cushion replacement; cleaning, refurbishing and servicing panels and many more. Seat cover cleaning and servicing of panels and overhead bins will usually be done every C check. Replacing seat covers and refurbishing these items will usually be done every three or four C checks. Taking these intervals, typical cost of materials and MH inputs into consideration; the overall cost for interior refurbishment will be in the region of $15 per FH. The final element will be stripping and repainting. This will cost in the region of $100, 000, and will be performed on average once every five C checks, resulting in a reserve of $5 per FH

Rotable components

Rotable components are assumed to be supplied, repaired and managed under an all-in total support package. This is structured with three main elements: a homebase stock which is leased, a pool stock of remaining components which the operator has access to; and a fixed rate per FH fee to cover the repair, transportation and management of all components. Typical rates for the lease of home base stock are equal to $15 per FH. The fixed fee per FH for pool access and stock financing is about $50 per FH. The third element of repair and management costs is in the region of $120 per FH. The total costs for the three elements are $190 per FH.

Engine maintenance

The CF34-3A1 was the first variant, and powers the CRJ-100. This engine has an installed thrust rating of 8, 729lbs thrust. Besides a single-stage fan, the engine has a high pressure compressor (HPC), high pressure turbine (HPT) and low pressure turbine (LPT), and multiple life limited parts (LLPs) within these. Operators may therefore have LLPs with varying life limits in new engines. These will be replaced when modules get fully disassembled, and then replaced with later part numbers compared to the original parts in the engine. Engines therefore generally tend to have LLPs with longer lives as they progress through their productive life. The three fan module LLPs have life limits that are as low as 6, 000 engine flight cycles (EFC) for the earliest part numbers, and up to 25, 000EFC. The current list price for these parts is $227, 120. Therefore Engine maintenance will not be an issue for the first five years. Fan disk will be replaced at the end of third year costing $111, 200.

Summary of Costs

Activity

Labor

A-Check

Labor total

Material Consumables

Base Checks

24-month check

48-month check

Heavy Components

Wheels and brakes

Gear exchange and overhaul

Reverser shipset

Internal Refurbishment

Stripping &Painting

Rotable components

Engine Maintenance

Fan disk

Table FH- Flying Hours MH- Man Hours FC-Flying Cycle

Conclusion

CRJ-200's are regional jets and are being extensively used in various locations across the globe, CRJ-200's maintenance is no man's play, it requires extensive study of various complex check task and various limited life components. Organizing such tasks without interrupting schedule and performance essentially need expertise and planning. Maintenance of jetliner is one major cost cutting area if tasks are integrated properly otherwise jetliner will be liability rather than being an asset for the company.

Word Count: 2783

ANNEXURE

Inspection Task Group

Interval Flying hours (FH)

Man Hours (MH) for routine inspection

1A

500

50

2A

1000

80

3A

1500

50

4A

2000

95

5A

2500

80

APU1

300

2

APU2

700

2

APU3

1200

2

APU4

1500

2

APU5

1800

2

APU6

3000

2

Out of Phase tasks

400

3

Table A check tasks for first five years (Aircraft-Commerce) Issue 52 June/July 2007

Inspection task group

Maintenance programme Interval

Man Hours for routine inspection

1C

5000 FH

210

2C

10000 FH

280

Gp1 OOP

3000 FH

1

Gp2 OOP

4000 FH

70

Gp3 OOP

8000 FH

40

12-month calendar

12 months

20

18-month calendar

18 months

1

24-month calendar

24 months

40

36-month calendar

36 months

7

48-month calendar

48 months

240

60--month calendar

60 months

10

Table C check tasks for first five years (Aircraft-commerce Issue 52 June/July 2007

Base check

C check tasks

OOP C check tasks

Calendar tasks

Routine Man hours

24-month

1C

Gp 2

12 &24 month

340

48-month

1C+2C

Gp 2&Gp 3

12, 24, 48 &60 month

658

Table Vertical Integration (Aircraft-commerce Issue 52 June/July 2007

AIRFRAME_LABOR

ENGINE_LABOR

AIRFRAME_REPAIR

ENGINE_REPAIRS

TOT_DIR_MAINT

QUARTER

1082. 8

3383. 16

1326. 55

6338. 18

3

1019. 06

3368. 86

1319. 67

6226. 08

2

3202. 88

4528. 98

3862. 66

16982. 87

1

3398. 37

8238. 96

16622. 18

2

3918

476

12498

13603

32972

1

2979

94

4283

3890

14848

1

684

22

984

894

3411

1

6

1

20

22

53

1

2891

62

3429

3953

13085

2

667

14

791

912

3018

2

2530. 07

8835. 14

1

4676

10220

27581

51767

2

4708

10666

21474

45519

1

2629. 82

8975. 14

53. 19

14546. 24

1

3963

479

13318

3916

26226

2

960. 65

3418. 18

2314. 53

7262. 86

1

8

1

27

8

53

2

643. 53

-12. 13

824. 27

1790. 31

1

2000. 14

4618. 53

3

5034

10865

32201

56954

3

2740. 58

10117. 42

82. 91

17671. 72

3

652. 2

142. 81

1259. 02

2431. 2

2

3593. 14

4754. 91

4514. 41

18383. 52

3

535. 48

31. 47

1740. 94

7277. 29

2

2683. 82

10464. 99

292. 71

17218. 29

2

2823

162

3406

2597

12225

3

693

40

835

637

2999

3

4298

509

14355

7609

29290

3

709. 33

540. 9

1522. 06

3115. 14

3

5

1

18

20

47

3

Table 5 Operating Expenses