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Maintenance of interiors on narrowbody aircraft concerns work to maintain airworthiness and interior standards, and reconfiguring aircraft in the event of airline re-branding or aircraft changing operators. The elements of interior work, their maintenance intervals, and costs are examined.

Costs of narrowbody interior refurbishment

The interior maintenance and refurbishment of narrowbody aircraft varies in complexity from the regular maintenance required to maintain a satisfactory level of cabin appearance, to the complete refurbishment of the interior. Like widebodies, narrowbodies undergo a complete refurbishment of their interiors at heavy hangar checks, but their interiors are rarely completely reconfigured. The cost of interior maintenance, refurbishment and reconfiguration of narrowbodies is considered here, using the A319 and A320 as examples.

Interior items

An aircraft's interior includes several categories comprising many different items: carpeting in the aisle and seating areas; floor lighting; passenger seats; the sidewall and ceiling panels, bulkheads, cabin dividers, curtains, passenger service units (PSUs) and overhead bins; the galleys, galley equipment, lavatories and wardrobes; the servicing areas, such as the flooring areas in the galleys, toilets, doorways and common areas; and a few other items, such as fire extinguishers, dog houses or small stowage boxes, crew seats and dado panels.

These items can be divided into those that are selected by the original equipment manufacturer (OEM), which are referred to as seller-furnished equipment (SFE); and those selected by the airline, which are referred to as buyer-furnished equipment (BFE). "SFE includes the panels, bulkheads, lavatories, servicing areas, PSUs, lighting and overhead bins," explains Roberto Rosell de Celis, interiors engineer at Iberia Maintenance. "The OEM selects from several suppliers for each of these items, and may on occasion change supplier during the production run, while the

supplier may change the design of the equipment they are providing. For example, the PSUs now being built for the A320 family types are not the same PSUs that were found on earlier A320 aircraft.

"In the case of lavatories, for example, airlines can make a few modifications, such as decorating and mirrors, for aesthetic purposes," continues Rosell de Celis. "The same applies to servicing areas, where the airline can specify the colour of the flooring material. There can be some choices with bulkheads. Some airlines, for example, choose bulkheads with perspex glass windows. Lighting is SFE, because about half of it is emergency lighting for evacuation, and therefore has to comply with safety standards."

The remaining items are BFE, and airlines select the manufacturers. "The most important BFE item is passenger seats," says Luis Fraga, aircraft maintenance cabin interior engineer, at TAP Maintenance & Engineering. "BFE also includes carpets, galleys, wardrobes and in-flight entertainment equipment (IFE). Galleys and lavatories are also BFE to a degree, since the airline can choose from two or three manufacturers. BFE items are those that make the most difference to cabin appearance and passenger comfort. Airlines can choose from five or six seat manufacturers for the A320 family, which have been selected by Airbus."

Frequency of maintenance

The intervals between maintenance, refurbishment and replacement of each of these items are dependent on several factors. The first deciding factor is which items have mandatory maintenance. Only some interior items require mandatory maintenance to keep the aircraft airworthy, so they are included in the

maintenance programme. Other items do not have mandatory maintenance specified in the maintenance programme, but they are maintained at intervals specified by airlines in order to keep the appearance of the aircraft's interior up to a required standard for marketing purposes.

"Items that have mandatory maintenance, and are included in the maintenance programme are: the lights, seat frames and seat belts; safety and smoke detection equipment; panels, galley structures and attachments; lavatory attachments; wardrobe attachments; servicing areas, overhead bins and PSUs," says Rosell de Celis.

Mandatory inspection limits vary slightly between airlines and national authorities. Iberia performs a seat-frame inspection every 12,000 flight hours, or about every 80 months on its A320s.

The attachments for galleys, lavatories, wardrobes and overhead bins are all inspected at the C4 and C8 checks, because they have to be removed to allow structural inspections to be made.

"In addition to mandatory maintenance, we have our own interiors maintenance programme (IMCP)," says Rosell de Celis.

TAP Maintenance & Engineering has a similar interior programme in its own maintenance schedule.

These programmes include visual inspections of the seats and working parts, cleaning seat covers and replacing seat cushions at regular intervals.

Other non-mandatory interior maintenance includes the regular cleaning and replacement of aisle and seat area carpets.

General interior work

The A320 family aircraft have a base maintenance programme of eight C checks in a cycle, with the interval



The regular maintenance and refurbishment of narrowbody interiors results in maintenance at varying intervals. Heavy hangar checks present the best opportunity to perform maintenance on monuments, sidewall panels, overhead bins and servicing areas.

between each C check at 15-18 months. The C4 and C8 checks are heavy visits, and include structural inspections, and are performed every five to six years. The other six C checks are lighter.

Large interior items like overhead bins, PSUs, galleys, wardrobes, bulkheads and flooring panels and material all have to be removed to make these inspections possible, which provides a good opportunity to carry out some maintenance on interior items. "The C4 and C8 checks go deep, particularly the C8 check where everything is removed," says Fraga. "At this check we paint all interior items; repair all large monuments, including galleys, lavatories and wardrobes; replace seat foam cushions and decorative foils; and inspect and overhaul the galleys. The C4 check is an opportunity to overhaul seats, replace seat foam cushions, and paint lavatories.

Fraga estimates that the inputs used during the C4 check for this interior work are 400-500 man hours (MH) of labour and \$30,000 for materials. Using a standard labour cost of \$50 per MH, the total cost for this input will be \$55,000. Amortised over a five-year interval, and assuming an aircraft operating at 3,000 flight hours (FH) per year, the reserve for this will be about \$4 per FH.

The maintenance performed in relation to this interior work at the C8 check consumes about 1,000MH of labour and another \$70,000 in materials. This includes general materials and replacement parts.

Charged at a labour rate of \$50 per MH, the total cost for this portion of the C8 check will be about \$120,000. Amortised over an interval of another five years, it will be equal to a reserve of \$6

per FH (see table, page 29).

"The other six C checks are lighter, and we use these to replace textile seat covers or clean and wash leather seat covers, and clean and make functional tests of many of the interior items," continues Fraga.

Panels & overheads bins

There are six main items in this category: sidewall panels; PSUs; overhead bins; dado panels; cabin dividers, bulkheads and curtains; and lighting.

Sidewall panels have on-condition visual inspections about every year, depending on the airline, and will usually be cleaned at C checks. "The wall panels are some of the items removed during C4 and C8 checks. At this check they have decorative foils replaced or are repainted," says Fraga. "The cost of this is part of the general interior refurbishment costs at these two checks."

Rosell de Celis comments that panels are only replaced when they are damaged, or when the airline has a re-branding scheme. Each sidewall panel has a width equivalent to two windows, and costs about \$7,000. A complete shipset will therefore cost \$300,000-400,000.

PSU maintenance and refurbishment is an integral part of airframe checks. Most airlines clean them at every A check. TAP Maintenance & Engineering overhauls the units at every C4 and C8 check. Iberia performs a mask drop test every 18 months, and makes a full automatic mask release and oxygen test and mask assembly test at every C4 and C8 check. "The PSUs will be relocated if the cabin interior layout is changed," says Rosell de Celis.

Overhead bins are treated similarly to

sidewall panels. Bins are cleaned and inspected at every A check. "We give the bins a functional check every year. They are removed at C4 and C8 checks so that wiring inspections can be made," says Rosell de Celis. "Once removed they will be cleaned and refurbished, and any broken parts will be replaced."

The cost of removing, overhauling and reinstalling overhead bins is an element of the general interior refurbishment cost at these two checks. Overhead bins are rarely replaced.

Dado panels, at the base of the sidewall panels and running along the edge of the cabin floor, are visually checked at C checks. They are removed together with all other interior items at C4 and C8 checks, and the cost is an element of the general interior refurbishment costs. They are rarely replaced, but a shipset costs about \$5,000 for an A320.

The next group includes bulkheads, cabin dividers and curtains. These will be inspected and cleaned at A checks by most airlines. The items are then removed at C4 and C8 checks for refurbishment. Their maintenance comes under the general interior refurbishment costs. These pieces are rarely replaced, but may be in the case of a cabin reconfiguration. New dividers with a curtain can cost about \$21,000. In some cases, curtains are replaced as frequently as aisle carpeting.

Lighting is the final element in this group. Like most other items in this category lighting is inspected and treated on-condition. Ceiling and floor lighting has to be removed at C4 and C8 checks so that structural inspections can be made. Plastic fittings and bulbs occasionally have to be replaced, and the cost of this is an element of regular A and C check maintenance, as well as general interior refurbishment costs during heavy checks.

Monuments

Monuments are large structures in the cabin such as galleys, toilets and wardrobes, and their servicing areas.

Most airlines configure their A320s and A319s with two or three galleys, and one or two wardrobes. In many cases there is one galley at either end of the

cabin. "We perform on-condition maintenance and functional checks at A and C checks. We also check galley filters every two or three C checks," says Rosell de Celis. "Galleys have various types of equipment, including carts, fridges, ice machines and coolers, ovens and coffee machines. The galley and wardrobe attachments have to be inspected at C4 and C8 checks, so they are removed to allow structural inspections on the aircraft. Galleys and wardrobes are also disassembled, inspected and refurbished at the C4 and C8 checks. It takes about 100MH to remove and reinstall each galley, and up to another 100MH to refurbish it. Total labour for two galleys will therefore be 400-500MH. It takes about 10MH to remove and reinstall a wardrobe, and another 20-30MH to refurbish it." The cost of galley and wardrobe refurbishment is included in the general interior refurbishment costs performed at heavy checks.

Most A319s and A320s are equipped with three lavatories, with one at the front and two at the rear of the cabin. Maintenance for lavatories is similar to that for galleys. "We give our toilets a functional test every year, and then inspect walls and floor panels every 15-20 months," says Rosell de Celis. "The attachments have to be inspected every C4 and C8 check, and the lavatories are removed during these checks. About 20MH are used to remove and reinstall each lavatory, and additional labour is required for maintenance and refurbishment, which can be 10MH for a lavatory in good condition, and up to 80MH for one that has a lot of corrosion."

Fraga explains that the largest amount of general interior refurbishment is performed at the C4 and C8 check, and this includes removing, overhauling and installing the toilets.

Servicing area flooring is also removed and inspected, and cleaned or replaced as necessary at C4 and C8 checks. "The flooring is one major item that has to be removed at C4 and C8 checks to allow structural inspections," says Fraga. It takes about 80MH to remove and install new flooring material each time, at a cost of about \$3,000.

Carpets

Aisle carpets tend to be replaced several times a year on narrowbodies. "Cabin carpets are not normally damaged, but they do get dirty and suffer wear and tear, so they have to be cleaned or replaced," explains Marie-Louise Nordlund, commercial director and Sollentuna Cabin Interiors. The carpet area under the seats experiences the least wear, while aisle carpet wears the most, especially where passengers have brought

INTERIOR REFURBISHMENT COSTS FOR A320

Interior item	Interval FH	Cost \$	Reserve \$/FH
Replace aisle carpet	1,000FH	2,300	2.30
Replace whole cabin carpet	3,000FH	7,600	2.50
Clean seat covers	2,000FH	8,000	4.00
Replace seat covers	10,000FH	28,000	2.80-3.30
Replace seat cushions	15,000FH	23,000	1.50
Overhaul seat frames	15,000FH	32,500	2.20
Maintenance of monuments, sidewall panels, overhead bins, PSUs and dado panels at C4 & C8 checks	15,000FH & 30,000FH	175,000	12.00
Total cost of regular interior maintenance			27-28

dirt and snow onto the aircraft. Nordlund explains that an aisle carpet can be cleaned four or five times before it needs replacing. Carpet cleaning must be done with care, however, since it can result in carpets losing their fire-resistant qualities.

"We carry out a visual inspection of carpets and curtains at every A check, and then replace the carpet on-condition," says Fraga. "We replace aisle carpets about once every four months, and tend to replace carpet in the seating area about once a year. It takes 5-10 MH to replace carpet in the aisle of an A319 or A320, and about 80MH for the whole cabin with the seats removed." Carpet material costs \$55-60 per square metre. The aisle area will use 25-30 square metres, while the whole cabin will use up to 80 square metres for the largest narrowbodies and about 60 square metres on the A320. Material cost for the aisle is therefore \$1,800, while it is about \$3,600 for the whole of the cabin in an A320. Labour charged at \$50 will result in a total cost of \$2,300 for aisle carpet replacement, and \$7,600 for the whole cabin. At the intervals described, it is equal to \$2.30 per FH for aisle carpet replacement and \$2.50 per FH for whole cabin carpet replacement (see table, this page).

Passenger seats

Passenger seats are considered in three parts: seat frames and belts; seat covers; and seat cushions, which are made of foam and are required to be fire resistant.

"We give seats a general visual inspection at every A check, to assess their general condition and wear, make sure the seat belts and seat reclines are working, and that seat attachments are correct," says Fraga.

The cleaning of seat covers depends on the material. Airlines have the choice of fabric and leather seat covers. "Fabric covers are frequently sent for dry cleaning, as often as every second A check. Covers need to be replaced after about five dry cleans," says Nordlund.

Each fabric cover costs about \$120 per seat, so the cost for the whole shipset is \$20,000 for an A320. Leather covers are more expensive, at \$150 each, but as they are easier to clean and do not require dry cleaning, they are more economic in the long term. A shipset of leather seat covers for the A320 costs \$25,000.

Fraga says that leather seat covers can be cleaned about once every second A check. Removing and reinstalling fabric seat covers for cleaning uses 160MH for the whole shipset. At \$50 per MH this is equal to about \$8,000. For fabric seat covers removed every 2,000FH this is equal to \$4 per FH (see table, this page). The cost of dry cleaning is extra.

Replacing seat covers uses about \$8,000 for labour, while the cost of fabric covers takes the total to \$28,000, and the cost of leather covers takes the total to about \$33,000. At an interval of 10,000FH, the overall cost is equal to \$2.80 per FH for fabric covers, and \$3.30 per FH for leather covers (see table, this page).

COST OF NEW INTERIOR ITEMS FOR A320

Interior item	Unit cost-\$	Total cost-\$
Shipset of seats		150,000
Shipset of seatbelts		7,000
Shipset of seat covers & cushions		9,000
New carpet		4,000
Cabin divider		29,000
1 curtain for cabin divider		1,000
Sidewall panels		300,000-400,000
Dado panels		7,000
Shipset of galleys		600,000
Wardrobes	15,000	45,000
Lavatories	120,000	360,000
Decorative materials		10,000

Replacement of foam seat cushions is carried out every four to five years, and has to take into account the regulations on fire resistance. "We replace seat cushions at the same time that we overhaul the seat frames, which is about every 60 months and during the C4 or C8 check," says Rosell de Celis. "It requires about 1MH per seat to change cushions and covers, so a shipset will use about 160MH on an A320. A shipset of new seat cushions therefore costs about \$15,000."

Using the standard labour rate of \$50 per MH, the cost for seat cushion replacement is about \$23,000. At an interval of up to 15,000FH, the reserve for seat cushions is \$1.50 per FH (see table, page 29).

Seat frames are overhauled when the seats are removed at the C4 and C8 checks every four to five years. "Seat frame maintenance is mandatory, and we have to inspect them every 12,000FH or 80 months," says Rosell de Celis. "Removal and installation of the seat frame use 1MH per seat. A triple seat set uses 7-9MH for deep maintenance, which would be required at a C4 or C8 check. On this basis 650MH would be used for seat removal, overhaul and reinstallation."

Labour cost for this at \$50 per MH is about \$32,000, and equal to a reserve of \$2 per FH when amortised over the interval of a C4 and C8 check.

The reserve for cleaning covers, replacing cushions and overhauling seat frames at heavy checks is therefore about \$9 per FH. The cost of visual inspections

performed at A checks is an integral part of the total cost of A checks.

Summary

The total reserve for the regular refurbishment of all major interior items is \$27-28 per FH (see table, page 29) for the A320 and similar-sized aircraft. It will be lower for the A319, 737-600 and 737-700, and higher for the 737-900, A321 and 757-200. The cost of refurbishing and overhauling galleys, toilets and other monuments only varies between aircraft types because these items vary in number. The differences in reserves for aircraft smaller and larger than the A320 will therefore be more or less proportionate to differences in aircraft size.

In addition to this reserve for refurbishing and overhauling major interior items, there is also the cost of functional tests, on-condition maintenance, regular cleaning and light work performed in A and C checks. The labour and material costs for this maintenance are part of the A and C checks.

Cabin reconfiguration

Reconfiguring cabins and interiors is less common on narrowbodies than it is on widebodies. The two main reasons why narrowbody cabins have to be reconfigured are because aircraft have changed operators, and airlines are carrying out a rebranding programme. In both cases some items, like the overhead bins, bulkheads, PSUs, dado panels, cabin

dividers and toilets, are likely to be unchanged. Most airlines have similar locations for galleys, toilets and wardrobes; repositioning toilets, for example, involves considerable expense.

Items that may be changed are seats and galleys. Items that are most likely to be changed are carpets, seat covers, and sidewall panel decorative foils. Airlines will clearly try to avoid changing items to minimise costs but may have to bring some aircraft up to the same interior configuration as the remainder of a fleet. This may involve changing seats and galleys, as well as seat covers and decorative foils. This is also the case when airlines go through a rebranding campaign. In these circumstances, however, airlines will try to minimise changes to the economy-class cabin, and will usually just make changes to the seats, panels and carpets in the business-class cabin.

Installing in-flight entertainment equipment (IFE) will not require a complete cabin reconfiguration, but will involve changing seats and installing wiring.

The cost of new interior items can mount up. A shipset of seats for an A320 is about \$150,000. Seatbelts need to be added to this, at a further cost of \$7,000. "Seat covers and cushions cost \$20,000 and \$9,000 respectively," says Rosell de Celis.

New carpet for the whole aircraft is about \$4,000, and curtains add a further \$1,000.

A cabin divider will cost \$29,000, and the curtain an additional \$1,000.

A new set of sidewall panels will cost \$300,000-400,000, while dado panels will cost \$7,000 for the aircraft.

The major items are monuments. "The cost of three new galleys is in the region of \$180,000," says Fraga. "This does not include the cost of galley equipment, however, which can easily add at least another \$150,000. The cost of engineering and certifying the process usually exceeds the cost of the galleys, so the total cost for installing a new shipset of galleys is therefore about \$600,000."

Each new wardrobe costs about \$15,000, so three new units for the aircraft will cost \$45,000. Each lavatory costs about \$120,000, so three units will cost \$360,000. Decorative materials that will be used in the galleys, lavatories and wardrobes will add another \$10,000.

There is also the cost of PSUs, lightning and IFE in addition. The total cost for a shipset of new interior equipment and furnishings for an A320 will therefore total in excess of \$2.0 million. **AC**

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