Line maintenance is a large planning task for airlines. Donal James analyses line maintenance requirements of the A320 and 737, and the labour and spare parts acquired to complete the process.

A320 & 737 line maintenance guide

The popular misconception about aircraft 'line' maintenance is that all it consists of is engineers and mechanics kicking the tyres, topping up the fuel and sending 'it' on its way. Nothing could be further from the truth.

The whole concept of line maintenance makes it the most essential part of an airline engineering department. This is the front line. All the decisions and actions carried out on the line have an immediate impact on the whole of the airline's operation.

The tasks that must be undertaken by airline line engineers working on the A320 and 737 families and the system designed to support them is outlined here.

Turnaround inspection

The turnaround inspection is carried out usually when an aircraft is on the ground for between one and two hours. This is a light inspection by an individual engineer or by a pilot if the station is a unstaffed.

It consists of walking around the aircraft, viewing all major components to ensure security and fitness for the next flight. The obvious items inspected will be the engines, to check for bird strike or other foreign object damage and oil or fuel leaks.

The undercarriage/landing gear will also be inspected to ensure the tyres are correctly inflated (visual inspection only), that there is no damage to the wheels or tyres themselves and that the brakes are not overheated or leaking.

The rest of the aircraft will have a brief inspection to ensure general serviceability. The fluid levels in the various hydraulic systems and passenger water system will be checked for correctness.

The engineer also reviews the technical logbook for defects entered by the previous flightcrew. Aircraft defects may also have been passed on by the Aircraft Communication Addressing and Reporting System, in flight and forwarded by operations to the line maintenance department for warning and planning purposes.

The engineer will carry out the required built-in test equipment (BITE) tests and inspections to determine the nature of faults and to plan a repair or replacement part as required.

If any immediate fault rectification cannot be provided the engineer has to decide on whether the defect can be 'deferred' in accordance with the manufacturer's or airline's published minimum equipment list (MEL), or delay the flight delayed while the defect is rectified. This requires manpower and parts.

Pre-departure inspection

This is usually carried out prior to the first flight of the day and will include all the items in the transit inspection with additional fluid level and gas pressure servicing and checking.

The level of inspection is generally the same as in turnaround, but since this inspection is generally designed for use by the line mechanics and engineers, rather than flightcrew, an extra level of inspection awareness is expected to detect additional faults prior to departure. This function is more important, because it affects the aircraft's schedule performance for the next 24 hours.

A common mistake is to have the pre-departure inspection delayed just prior to departure, when engineering staff are under pressure of time to correct any faults that may be detected. It is much more prudent to carry out an arrival inspection when the aircraft terminated the previous evening, or at the beginning of the maintenance slot (however long that may be), so that time is allowed to effect repairs and obtain spare parts. The arrival check has some of the same tasks as the pre-departure check.

Many airline planning departments will then split the items in the pre-departure check into the arrival check and the remainder into the pre-departure check. The arrival check will include the actual physical inspection of the aircraft so that any damage picked up by the aircraft during the previous flights can be tackled as early as possible.

This is, however, an inefficient means of carrying out the required inspection in a man-hour (MH) resource plan, because some of the items in the arrival check have to be repeated in the pre-departure check. Each aircraft is therefore absorbing manpower twice to effect a single required inspection. This will incur additional costs, because an engineer or mechanic must be supplied twice, and provision must be made for transport and travelling time. In a manpower-restricted environment the arrival and predeparture inspection will have to be done together just prior to departure.

In these times of intense flight operation planning and tight schedules, where expected aircraft utilisations can reach 18 flight hours (FH) per day with six landings (or conversely fewer hours with a higher flight cycle – FC – programme) all efforts should be made to ensure the first flight of the day is an 'on time' departure.

Roger Page, director of quality at Airline Spares describes how he targeted late departures on a daily basis with a similar procedure when involved in management of various airlines. The 'on time' targets are achievable and the cost-effectiveness of the result is demonstrable with the right management process.

Daily/terminal inspection

The frequency of this inspection varies from operator to operator. The basic requirement as specified in the maintenance planning document (MPD) is for the inspection to be carried out every 24 elapsed hours.

This is quite a restrictive parameter with the type of flying expected by these aircraft, especially in the charter market where services are expected on a 'round the clock' basis.

This restriction is due to the daily inspection not being allowed to expire through the duration of the flight to and from the destination. This means it is quite possible to be carrying out the 'Daily' inspection at a 18-hour interval, just to ensure that the 24-hour time limit does not expire during the flight.

Various methods of maintenance programme or schedule integration have been adopted to overcome this problem. The simplest solution is for the airline to get permission from its local authority to allow the aircraft to leave a main base with the daily check still valid and allow the check to expire en route, with no need for a re-inspection until the aircraft returns to its main base.

Alternative methods are to carry the daily check forward to a terminal or base check, which have intervals of 36 or 48 hours. This has some pitfalls, since there are several maintenance items that drop out of the check because the MPD lists them as 24-hour items.

Planning engineers will also have to ensure that national airworthiness authorities' regulations have been complied with during a proposed check escalation programme. The daily check is usually the only downtime available in which cabin maintenance and defect rectification can be carried out. This would also include the normal or 'routine' cleaning of the cabin and furnishings to the 'deep' clean.

With the more intensive flying schedules of the scheduled airlines and even tighter programmes of the charter market this vital part of the aircraft maintenance gets pushed down the list of priorities. The basic truth is that as long as the aircraft departs and arrives at its destination on time, the cabin is clean, and the in-flight catering adequate, the passenger does not really care what the actual maintenance state of the aircraft is.

This is where many line stations struggle to prioritise the level of maintenance required on the aircraft to maintain its airworthiness status, against the customer required systems and services, for example in-flight entertainment.

The use of the deferred defect logbook for cabin maintenance items is perfect for prioritising a task on line. It allows a method for deferring defect rectification until the next convenient downtime slot. However, the system falls down as soon as the defect remains in the deferred log for more that one or two days. This is because the perceived urgency to rectify the defect is not longer prioritised in the ongoing task of maintaining the aircraft and the volume of new defects that have been logged.

Keeping ahead of this system is difficult for most airlines. It is a task that requires a dedicated planning and maintenance control department input to control the total or global aspect of each defect from the initial logging, spares requesting, spares sourcing and material purchasing. Thereafter the required spares have to be linked to the aircraft with adequate engineering and downtime to carry out the rectification. This effort encompasses all the non-airworthiness defects in the cabin.

The airframe, engine and systems on the aircraft have a completely different set of priorities to maintain control of their progress from start to finish. All aircraft manufacturers, and usually the manufacturer's national airworthiness authority, and possibly the airline's airworthiness authority, will issue a set of MEL items or a deferred defect guide (DDG). These documents will list all major systems and their number in the aircraft and the restrictions that apply if a unit is allowed to be unserviceable. Included will be a guide of the recommended time or interval (in either days, flight hours or FCs) that the aircraft may remain in service while the maintenance organisation sources spares and provides labour and downtime to effect the repair.

Added to this restriction will be the problems imposed by the operational restrictions placed on the aircraft and crew while the defect remains.

Weekly inspection

The weekly or seven-day inspection is adopted by many airlines as a tool to allow the sweep-up of all the deferred maintenance collected during the preceding interval. It allows a regular interval to be set aside for all the items where the documents, spares and material can be located in anticipation of the downtime, with the necessary labour and hangarage.

It would be at this time that any out-of-phase (OOP) task due on the aircraft, its engines or its systems would be carried out. That is assuming the task could not be scheduled for the next greater maintenance task, ie, the A check.

This type of OOP task is nowadays much more common due to the changes in philosophy in the design of MPD and maintenance programmes.

The engineering companies and operator's planning department will also use this interval for the implementation of inspections and work developed by the issuance of service information letters

All variants of the 737, from the -200 series all the way to the -800 model, have similar manpower and downtime requirements to complete line checks.

Technology in the A320 family provides improved engineering aids for trouble-shooting defects and faults in the aircraft and its systems.

(SILs) by the original equipment manufacturer. The operators' engineering departments may also plan the tasks that require a higher MH input at this down-time or maintenance opportunity.

The type of tasks that may be scheduled would be those requiring fuel tank entry for minor inspections or defect rectification. This would also be the time to schedule any minor engine boroscopes. This task is further complicated on a twin-engine aircraft, since the emphasis is now to try to schedule all engine-related tasks to separate inputs to preclude the risk of double engine failure or shutdown due to a maintenance induced error or fault. This can be an additional planning burden.

The cost of adding this separate task to the overall line maintenance budget may be significant. This is because the loading of spares, tooling, labour and downtime is doubled. This is an effective method of dealing with and minimising the effects of maintenance errors.

A/phase check

This check is generally the greatest task undertaken by line personnel and in the line environment. That does not preclude the use of a hangar facility for the accomplishment of the task as a matter of policy. A hangar could be used for any of several factors, but the greatest benefit to the completion of the task is its ready availability of compressed air, electric power, tooling, spare parts and light and heat.

Access to required manuals and documents may not be such a major factor today due to the availability of CD-ROM manuals and Laptop PCs, but all the other factors will produce improvements in productivity as long as the nature of the inspection is understood.

This check is usually part of an equalised A check programme that may have up to 16 parts to it during the C check cycle. The word 'equalised' is a reference to the fact that the work content of all the checks is divided equally into 16 work packages to ensure the MH requirement and elapsed time are roughly similar.

Inevitably, there are differences in each of the packages and in the work loading issued by the engineering technical planning department. This additional work will probably be due to OOP requirement, airworthiness directive compliance and deferred defect rectification.

Planning departments will try to issue the entire work package well ahead of the planned compliance date, and will have usually co-ordinated the sourcing and provision of the consumable and rotable spares.

No time is allowed for the procurement of spares that might not be held on the base or line station. All spares, whether consumable or rotable, will be sourced and shipped from the most cost-efficient source, using a consolidated transport facility. This avoids any delay in completion of a maintenance check by, for example, the shipping of a seal costing less than $1 that needed to be transported by taxi from another spares supplier.

The A or phase check is divided into three or four classes of inspection. A standard check or routine inspection work is completed on every routine input. On every second and fourth completion, additional checks are completed. Local regulatory authorities may impose restrictions to ensure certain routine inspections are completed in an adequate environment, for example, engine boroscopes.

All the zonal corrosion and structural inspections that are called up on these checks should be minor, and will not require any dismantling. The lubrication requirements will include flight control surface bearings, hinges and actuators and landing gears. Usually the rest of the aircraft's requirements are due at C check intervals. Servicing of engine and air-conditioning units that require lubrication will also be undertaken. Usually only a quantity check is carried out at these intervals.

The aircraft may be washed and certainly a deep clean of the cabin will be scheduled. Many companies will call up a seat cover change at this interval. Again this requires additional organisation and control in the planning department to ensure the required areas are cleaned and the correct seats are serviced.

Non-scheduled inspections

This will comprise maintenance requirements raised by operational restrictions, airworthiness issues, or problems with the aircraft due to an incident requiring an additional inspection. This includes: heavy landing, overweight landing or high drag loads. The specific aircraft maintenance manual requirements determine the contents of these checks. The majority of these tasks are not planned and will be carried out as required by the available line staff, along with the routine tasks and non-routine defect rectification.

Staffing and equipment

The Airbus and Boeing aircraft discussed in this article are very similar in terms of figures produced during discussions with the planning departments of the various airlines and engineering companies.

In most respects the two types are very similar in concept and equipment supplied. The greater technology offered in the A320 provides a much-improved engineering aid in troubleshooting defects and faults in the aircraft and its systems.

The New Generation 737s has a much greater content of BITE and computer-generated fault diagnosis and troubleshooting.

The standard equipment fit of both types is similar – if not in the number and quantity of parts, then certainly in technology, reliability and design. The requirements for line maintenance are by their very nature concerned with the

SUMMARY OF A320 FAMILY & 737-200/-300/-400/-500/-600/-700/-800 LINE MAINTENANCE LABOUR AND MATERIAL REQUIREMENTS

Check	Minimum interval	Maximum interval	Minimum man-hours	Maximum man-hours	Comments
Turnaround	n/a	n/a	0.75	1.00	Less than 2 hours on the ground
Pre-departure	n/a	n/a	0.50	0.75	More than 2 hours on the ground
Arrival	n/a	n/a	0.50	2.00	More than 2 hours on the ground
Daily	n/a	24 elapsed hours	2.50	4.00	
Terminal	n/a	48 elapsed hours	2.50	4.00	
Weekly	n/a	8 days	4.00	5.50	Includes arrival & daily checks
A check	250 FH	50 days	30	48	Includes all lower checks

Spare parts basic list: 2 mainwheels, 2 nosewheels, 1 brake unit/4 aircraft, 1 alternator, 1 starter motor, 1 starter valve, 1 VHF transceiver, 1 ILS receiver, 1 ATC transponder

superficial structure and design of the aircraft. This implies that any work carried out on both aircraft will be similar (for example, exterior wash and interior deep cleaning). The line maintenance engineer will carry out a very similar routine of inspection and work on both types and on the different series or generation of aircraft.

Experience has shown that the advent of new technology is a tremendous aid in troubleshooting and in defect analysis and rectification. The gains will show less in the routine daily work on the aircraft, but will provide a great leap forward in defect identification and rectification. It will allow the operator to plan the rectification with the correct engineers and spare parts.

Additional benefits will be accrued by the reduction in the use of rotable spares as a troubleshooting exercise. However, the percentage of rotable spares removed with 'no fault found' is quite high.

The loading of base stations and outstations with spares is one of the major capital outlays in providing support. Based on the built-in reliability of the components, it is hard to justify purchasing and stocking units that will have a low turnover.

This is especially true for the small operators that will have a restricted budget to spread over 'essential' spares stock, but will then have a completely different part fail on the line.

An ideal solution is to link into a spares stockist. The majority of these companies specialise in the supply of rotables only. The supplying of consumables is an additional task to be undertaken by the operator or maintenance organisation. This provides a major complication to the co-ordination of supplying multiple spares to a station and linking the spares with the engineer and the aircraft at the correct time. The maintenance control departments in most airlines will have their own horror stories about the time 'it did not quite work as planned'.

Wheels and brakes are usually dealt with as a separate issue by most airlines. Many companies have a pool of wheels and brakes that they have purchased or have bought into. This is a logical system of controlling a high turnover item. Several wheel manufacturers have their own spares pool and contracts with airlines to supply all requirements on a fixed price deal. This will be an ideal solution, especially if the contract includes collection and delivery. The downside of thid arrangement is the addition of another supplier in the co-ordination equation.

Wheel and brake units are probably the single most logical spares to have in an outstation, along with tooling and nitrogen bottles. A pair of each type of wheel assemblies will need to be stored since the usual failure is due to bursting during landing, which requires the other wheel on that axle to be replaced due to suspected overload.

The placement of additional spares on base stations or outstations is very much dependent on the risk assessment of having a failure. A valuable tool in the calculation of this risk is the reliability report that will be developed from the technical records. This is the component's mean time between removal and the associated technical and operational impact of the failure and resultant delay and/or operational restriction.

It would be productive to carry a stock of consumable material, which will have low capital outlay and will correct many 'nuisance' defects. Examples of this will be most lamps of filaments, oils and greases and a range of aircraft general spares.

Summary

The manpower requirement is a constantly varying question. In discussion it appears that the general rule of thumb is to allow for between 2.5 and three staff per aircraft serviced. This will allow for absence and supervision. It would then vary, depending on the number of transits the aircraft has through manned and unmanned stations.

The work loading will also be varied depending on the support the line engineer gets from the maintenance planning department. This will have a great effect on the efficiency of each MH.

The aircraft all appear to achieve roughly the same amount of FH and cycles per day, with the newer generation equipment achieving a higher average. The figures vary around the 10–11.5 FH with FH:FC ratio of between 2.0:1.0 and 3.2:1.

The required spares for a basic line operation will depend on so many factors as to make a table unusable. The consensus of opinion is that all stations should carry sufficient spares to allow an aircraft to return to base and these would consist of items or units that can be replaced by one or two persons in less than an hour.

With this in mind several *(see table, this page)* items will provide a basic list. Tooling to enable these parts to be changed will also be supplied. Reference to aircraft reliability reports will also assist in developing a suitable spares stocking for an individual airline's requirements.