The 777 has been in operation for over 20 years, and now comprises five main series of 777-200 and -300 aircraft. An MPD that meets the requirements of each series and variant requires a sophisticated and adaptable format, which can thereby optimise 777 reliability and support the family as it ages. Charlotte Daniels provides a summary.

Ageing 777 airframe maintenance analysis

The 777 family has been in commercial service since 1995, starting with the 777-200, and now also including the -300 series. The maintenance planning document (MPD) for the 777 family incorporates the 777-200, -200LR, -200ER, -300 and -300ER (extended range) series, and its freighter companion the 777F. This MPD has been revised several times since *Aircraft Commerce's* previous analysis *(see Assessing the 777's long-term base maintenance costs, Aircraft Commerce, April/May 2013, page 28)*, most recently in September 2017. An updated analysis is therefore provided, highlighting where appropriate interval changes, check alterations and significant airworthiness directives (ADs) and service bulletins (SBs).

MPD observations

The 777 MPD demonstrates the true potential of maintenance steering group 3 (MSG-3) flexibility, intelligence and logic. It can be fully adapted, with checks customised according to individual aircraft utilisation. For instance, aircraft generating high annual flight cycles (FCs) will see structurally-focused tasks begin in volume earlier than aircraft with high flight hour (FH) utilisation. Conversely, high-FH aircraft will undergo zonal, system and corrosion prevention control programme (CPCP) inspections differently to accommodate the longer mission lengths flown. Planning, structuring and establishing the C check requirements of the 777 family is therefore complex.

The 777's MPD is FH- and FC-driven to the extreme, which is illustrated by the number of FH- and FC-dependent tasks. While calendar-driven backstops in days are evident across the system, structural and zonal chapters, there is only one year-driven parameter in the entire MPD. This relates to a functional check of the ATC transponder system, and is due to regulation FAR 91-413. There are also no 'C' check defined tasks referenced in any MPD section, although check phases are suggested in Appendix B.

The MPD comprises 1,914 tasks that cover core task requirements for each aircraft series. Of these tasks: 1,172 apply to all series, known as 'applicability all'; 89 apply only to freighter variants; 141 are specific to the -200; and 122 are for the -300 series aircraft only. Last, there are 390 engine-related tasks for the Trent 800, GE90 and PW4000 engine options available across the 777 family. 138 of these engine tasks are specific to the Trent 800, 128 are related to the GE90, and the remaining 124 tasks are for PW4000-equipped airframes. The 1,914 tasks that form the September 2017 revision of the MPD are divided among system, structural and zonal chapters. These do not include certification maintenance requirement (CMR) or airworthiness limitation (AWL) items. Research into the MPD since the 2013 article reveals that there have been several revisions to task intervals. The increase of an interval is known as an escalation. "Examples are January 2013 revisions to structural tasks, whereby 3,000 days (DY) interval tasks were increased to 3,750DY, and zonal task revisions from 3,000DY to 3,500DY & 4,500DY intervals," says Peter Cooper, planning manager at Civil Aviation Services.

Further structural and system-based revisions took place in 2014, which suggest that the worldwide fleet is generally performing well, and that historical base or 'C' check data will vary with the aircraft's age. This means that an older 777, such as the -200, will have undergone several more check task revisions than the -300ER. A five-year-old -300ER will have undergone a different number of C checks to date, compared to the older-build aircraft.

General observations on the September 2017 edition of the 777 MPD, which will be explored, are:

- The man-hours (MH) provided in the MPD are for inspection MH only. Access MH are therefore additional, and have to be determined separately by planners. Access MH for each panel can be found in Appendix AA.
- In general, the structures and zonal section mainly have (but are not limited to) FC/DY whichever comes first (wcf) related groupings, and the systems section tasks mainly have FH and DY backstop groupings.
- Some tasks also have intervals attributed followed by a fraction. According to the MPD, 'intervals followed by a fraction indicates the required fraction of the operator's fleet that require the inspection'. For example, '24,000 HRS 10%' requires 10% of the operator's fleet to be inspected at each 24,000FH interval. Ideally, the oldest aircraft in the operator's fleet should be used for the sample. Additionally, the inspections should be staggered to different aircraft to maximise the inspection coverage across the fleet.
- Large access requirements: the MPD does not generally list in the task description of monuments, such as the galley and lavatories, for every task. The access labour needed for inspecting areas of the fuselage structure where a specific operator layout has cabin modules in the way will therefore have to be determined individually by the operator, and included

The 777 MPD incorporates the core maintenance requirements of the entire family, including -200, -300 and freighter variants. 1,172 of the 1,914 tasks apply to each series.

in any MH total for check estimating.

Minor changes to the MPD since its last revision include:

Section 1 - systems

- Three revisions to MH (one revised MH task has a revised task procedure).
- One change to a 'Special Note' in the MPD task description columns outlining additional applicable information to the task.

Section 3 - zonal

- 10 changes to 'Special Notes' in the MPD task description columns outlining additional applicable information to the task.
- Two revised access notes (one with a revised task procedure for the CPCP requirement).

Appendices

- Appendix A – minor panel nomenclature and graphic changes.
- Appendix L – revised intervals for listed specific tasks and effectivity changes.

As of October 2017, the core MPD for the 777 family has a total of 1,914 tasks. These are split between; systems & powerplant tasks (820 tasks), structural tasks (762) and zonal-related tasks (332).

Fleet profile

The 777 family comprises the 777-200, -200LR, -200ER, -300 and -300ER. According to Flight Global FleetsAnalyzer, about 1,250 passenger-configured 777s are in operation with 54 main operators. The General Electric GE90 engine powers 950 -200, -200-ER, -200LR and -300ER aircraft, while 139 -200, -200ER and -300 aircraft are fitted with Pratt & Whitney PW4000-112 engines. Last, 166 -200, -200ER and -300 aircraft have the Trent 800 engine. The engine option also affects the engine-related tasks referenced for each series and aircraft within an MPD, and will be further affected by AD and SB releases that are specific to an engine type.

Almost 460 of the 1,250 aircraft in operation today are 777-200 series, comprising 62 -200s, 340 -200ERs and 55 -200LR (long-range) aircraft. For the -200 series of aircraft, the oldest aircraft in operation is just over 23 years of age. The highest cumulative FH and FC in the global -200 fleet is about 90,000FH and 25,000FC. For the -200ER, the highest is 99,000FH and 22,500FC. Last, the -200LR's highest fleet utilisation sits at almost 54,000FH and 8,500FC.

The remaining 800 aircraft are 777-300s, split between the -300 and -300ER (47 and 751 aircraft respectively). For the -300 series, the highest cumulative FH and FC in the fleet are about 72,000FH and 20,000FC, while the -300ER has its highest cumulative utilisation figures at 62,000FH and 11,000FC for its oldest serial numbers (SNs). The oldest -300 in operation is about 20 years old.

This shows a clear and significant difference in utilisations across each series of aircraft in the 777 family, yet each series is contained within a single MPD. This shows the flexibility of the MSG-3 logic, but also suggests large deviations in the structure of checks across each series, since these are clearly at different stages of their operational life, and operating at different rates of utilisation. Aircraft age is, therefore, of secondary importance.

Regional utilisation

The region in which the 777 is operating will affect its rate of utilisation, and so its FH:FC ratio. An aircraft performing long sectors (and higher annual FHs), for example, will have different maintenance requirements to an aircraft operating higher annual FCs. This is where the MSG-3 logic of the 777 MPD comes into its own, because it can address the specific needs of each individual aircraft. It also means, however, that it is difficult to maintain a rigid stance on the structure of big checks, commonly referred to as 'C' checks or base checks.

See table *(page 49)*, for a regional breakdown of 777-200 and -300 utilisations extracted from Global FleetsAnalyzer. The FH:FC ratio differentials illustrate just how varied the 777s operational profile can be.

For example, the -200's FH:FC ratio varies from 1.79:1 to 5.40:1, depending on whether the aircraft is operating in North America, East Asia or Europe. The -200ER has a global average FH:FC of 7.02:1, yet this average ranges from 3.03:1 for Middle Eastern operators to 8.35:1 for North American operators.

The -200LR, which is most prevalent in North America, East and West Asia, and Africa, has an FH:FC ratio varying from 6.16:1 to 10.78:1, depending on the region.

Meanwhile, variations between the -300's and -300ER's utilisation show annual FH:FCs of 2.6:1 and 7.09:1 respectively. The average age of -300 aircraft in Asian and European countries ranges from 15.3 to 18.7 years old, with Middle Eastern operators achieving the highest FHs annually, and East Asian carriers completing the highest FCs on average according to database figures.

Last, the -300ER has its longest sector lengths operating in the Oceanic (Australia/New Zealand) region, with the average sector length over 9.3FH. Conversely, Middle Eastern operators of the -300ER operate sector lengths of nearly 6FH on average.

As will be seen, the extent of this regional variance shows the different

777 IN SERVICE PASSENGER FLEET REGIONAL UTILISATIONS

Series	No. Active	Region	Average Age	Annual FH	Annual FC	Average FH	Average FC	Average FH:FC	Average FH/DY	Average FC/DY	Highest FC	Highest FH
777-200												
	62		19.6	1,998-4,113	651-2,049	3,092	1,215	2.54:1	8.47	3.33	25,165	90,159
		N.America	20.7			3,831	710	5.40:1	10.50	1.95		
		East Asia	18.8			2,663	1,490	1.79:1	7.30	4.08		
		Europe	22.4			3,999	847	4.72:1	10.96	2.32		
777-200ER												
	340		15.7	1,374-5,547	151-1,235	4,434	632	7.02:1	12.15	1.73	22,333	99,421
		N. America	17.2			4,309	516	8.35:1	11.81	1.41		
		East Asia	13.3			4,255	715	5.95:1	11.66	1.96		
		Europe	16.4			4,853	613	7.92:1	13.30	1.68		
		S. America	13.1			4,449	535	8.32:1	12.19	1.47		
		Africa	15.5			3,486	919	3.79:1	9.55	2.52		
		Oceanic	11.5			4,718	584	8.08:1	12.93	1.60		
		West Asia	16.2			3,327	1,099	3.03:1	9.12	3.01		
777-200LR												
	55		8.5	2,483-5,925	342-818	5,010	589	8.51:1	13.73	1.61	8,325	53,671
		N. America	9.1			5,163	479	10.78:1	14.15	1.31		
		East Asia	8.3			3,064	440	6.96:1	8.39	1.21		
		Africa	6.3			4,987	810	6.16:1	13.66	2.22		
		West Asia	8.7			5,146	624	8.25:1	14.10	1.71		
777-300												
	47		16.9	1,943-4,252	812-1,914	3,132	1,206	2.6:1	8.58	3.30	20,064	72,140
		East Asia	16.9			2,984	1,268	2.35:1	8.18	3.47		
		Europe	18.7			3,451	860	4.01:1	9.45	2.36		
		West Asia	15.3			4,143	1,051	3.94:1	11.35	2.88		
777-300ER												
		751	5.4	1,563-5,792	156-1,146	4,829	681	7.09:1	13.23	1.87	11,232	61,570
		N. America	4.2			4,677	554	8.44:1	12.81	1.52		
		East Asia	5.6			4,813	614	7.84:1	13.19	1.68		
		Europe	5.7			4,868	587	8.29:1	13.34	1.61		
		S. America	6.5			4,280	507	8.44:1	11.73	1.39		
		Africa	5.0			4,770	740	6.45:1	13.07	2.03		
		Oceanic	6.7			4,993	536	9.32:1	13.68	1.47		
		West Asia	5.2			4,898	846	5.79:1	13.42	2,32		
Total		1,255										

Note: Aircraft with FH/FC information missing have been discounted in the Average figures used
Aircraft under 1YR old have also been discounted

ways in which operators a) structure heavy checks, b) incorporate out-of-phase (OOP) tasks, and c) manage future tasks that might need to be brought forward to accommodate peak seasonal activity. It is impossible therefore to provide a definitive 777 cycle of routine checks. Instead it is best to draw on operational experience to provide examples as to how carriers and maintenance, repair & overhaul (MRO) providers plan large groups of tasks according to operational activity.

The operational history of each aircraft also needs to be considered. For instance, a -200 leased in North America, whose lease is then transferred to a European operator, could undergo a radical change in operating profile. If this happens in its 12-15th year, which is typically the length of an initial operating lease, the second cycle of routine tasks will look very different to the first, even before other considerations such as ageing tasks or MPD escalations apply.

Task summary

There are 10 main types of task interval, known as parameters, included in the MPD *(see table, page 50)*. The chart is specific to 777 aircraft powered by the GE90, which comprises most of the global fleet. These parameters include FH, FC, day (DY), FC/DY wcf, FH/DY wcf, year (YR), HR or auxiliary power unit (APU) Hour (AH), engine/APU change, life limit and other (such as vendor or note-determined). These life-limit and other tasks are typically determined in other component, equipment or engine manuals. Of the 1,914 core 777 MPD tasks, 1,563 are relevant to GE90-powered 777s. This will vary further depending on whether the aircraft is a 777-200 or -300.

The MPD has about 190 different intervals across its system, structural and zonal task chapters for this subject aircraft. The most MPD task intervals are for tasks with FH parameters. The systems tasks are mainly FH- and FC-driven, with 261 tasks having FH-driven intervals and 1,027 being mainly FC-determined. Of the 261 FH tasks, eight have DY backstops, while 724 of the FC-driven tasks have a DY interval

SUMMARY OF 777 TASK INTERVALS: GE90 ENGINE

Interval Parameter(s)	System tasks	Structure tasks	Zonal tasks	Total	Interval Range (Initial/Repeat)	No. of Intervals
FH	236		17	253	200FH/200FH to 48,000/48,000FH	61
FC	21	282		303	100FC/100FC to 40,000FC/16,000FC	10
DY	141	1		142	80DY/80DY to 5,625DY/1,875DY	49
FC/DY	159	303	262	724	50FC or 25DY/50FC or 25DY 8,000FC or 2,250DY/8,000FC or 1,500DY	52
FH/DY	8			8	3,000FH or 400DY/3,000FH or 400DY to 25,000FH or 1,875DY/25,000FH or 1,875DYy	5
YE	1			1	2YR	1
HR or AH	5			5	24HR/24HR to 72HR/72HR & 400AH	4
ENG/APU CHANGE	5	4	1	10	AT ENGINE/APU CHANGE	3
LIFE LIM	27			27	OEM DETERMINED	1
OTHER (SV/ VEN REQ/NOTE)	36	54		90	VARIOUS PER COMPONENT	5
Total				1,563		19

associated. Again, this is specific to 777 aircraft with installed GE90 engines.

Structural-focused tasks are almost entirely FC dependent, with 585 of the 644 structural tasks having FC parameters attributed. 303 of these tasks have a DY backstop, should this interval be reached first. This will depend on the utilisation of the aircraft. Meanwhile, the 280 zonal tasks referenced in the table are primarily determined at FC/DY intervals, with only 17 subject to FH.

This table highlights the extent of the flexibility that the MSG-3 logic provides. The 777's MPD is almost entirely driven by utilisation; and as utilisation varies by operator, season and aircraft, heavy base check intervals and workscopes can vary wildly. The number of task intervals, which are primarily FH and FC-led, confirms this flexibility.

It is not just the utilisation of each aircraft that will govern the structure of its base checks throughout its routine maintenance cycle. The aircraft will also be subject to its operator's operational and fleet planning considerations, which will include the minimum clearances required to clear an aircraft ahead of peak activity or its return to lessor. Return-to-lease conditions will comprise a large part of maintenance planning for 12- to 20-year-old leased aircraft, which account for a significant portion of the 777 fleet. An operator may also align a base check with a cabin modification programme or reconfiguration (such as new business-class layout of passenger accommodations (LOPA)). This will further affect the workscope and base check interval, in addition to direct utilisation. There is, therefore, no rule when it comes to 777 check planning.

For the purposes of this article, the average regional utilisations shown on page 49 will be taken into account when summarising check groupings. These demonstrate that the day backstop is still often met over FH and FC parameters. For example, the 8,000FC or 2,250DY parameter outlined *(see table, this page)* for a 777-200ER with an average annual utilisation of 632FC, means that the 2,250DY (6.14YR) backstop will be met ahead of the aircraft achieving 8,000FC. 8,000FC would take an aircraft operating 632FC a year, over 12.5YR to meet.

MPD man-hours (MH)

Boeing provides inspection MH within the 777 MPD for most core tasks, as defined in the 'MH' column. Time to prepare and gain access for each and every task, therefore, is not provided. Maintenance planners need to take this into account when compiling task cards for 777 maintenance, as panel access, cleaning, and monument removal need to be considered depending on the task.

For some tasks, access will be minor whereas for others it may exceed the MH required to perform the inspection. Determining access and preparation time per task is therefore not an exact science, and can be subject to a large number of factors including the experience of the MRO provider.

The 'access column' provides panel numbers relevant to the MPD task. Where 'note' is included, further information is given in the 'description' column as to the level and extent of access required. This note can describe the removal or displacement of sealant required to perform a particular task, for example, to determine the removal of floorboards and sidewall items. These need to be determined by maintenance planners on a task-by-task basis. Appendix A outlines how to interpret the MPD-listed panels, and provides access numbers to locate the area within each aircraft zone.

The access required for a task can also depend on the specific configuration of an aircraft, which can vary within the operator's fleet. The level of access for tasks can also change if an aircraft undergoes a cabin modification programme. This makes determining the access per task difficult to define, and can lead to a large portion of customer-specific job cards, and additional MH.

By MPD section, there are: 123 system tasks with 'note' in the access column; 412 system tasks left blank, which relate to functional checks, and so do not require panel removals; 285 in the structural section with 'note' attributed; and 229 tasks with no access information provided, because they relate to either a general visual inspection (GVI) or special detailed inspection of an area. In the zonal section, 198 tasks have 'note' ascribed, and 48 have no direct access requirements.

The majority of tasks within the MPD have FH or FH-driven parameters followed by a DY alternative. There are no 'check-defined' parameters in the document, allowing greater flexibility for operators to structure checks.

MPD task groupings

The MSG-3 logic that underpins the 777 MPD highlights the fluidity of the 'C' check concept. The document does not reference tasks against 'C' check parameters, which further enhances operators' flexibility to group tasks according to their individual utilisations.

The MPD does, however, provide a guide A and C check cycle example in Appendix B, based on some utilisation assumptions. Boeing assumes an average utilisation of 14FH a day, at an FH:FC ratio of 5.6:1 when structuring its phases and check structures. The MPD suggests that lighter, 'A' checks take place at 1,000FH intervals. Based on this utilisation, Boeing anticipates A checks to occur every 179FC, which equates to just over every two months.

Meanwhile, the MPD also suggests that 'C' or base check groups of tasks be carried out every 14,000FH. Given an FH:FC ratio of 5.6:1 this equates to the aircraft achieving about 2,500FC. Tasks with threshold intervals of either 14,000FH or 2,500FC would therefore be likely to be grouped together if an aircraft is achieving this utilisation. The grouping of these tasks, however, will vary if the aircraft is undertaking a different FH:FC ratio, so task groups for the light and base checks will differ to a large extent between operators. This further emphasises the MSG-3 logic inherent within the MPD.

For example, the MPD places a large group of system-based tasks at 15,000FH, which require about 40MH of inspection time. If an aircraft is performing a high number of FH annually, say 5,000FH, these tasks will come due every three years, and are likely to form part of the first C check. If, however, the operator is performing closer to 2,500FH, which the lower utilisations *(see table, page 43)* show, these intervals are likely to be reached in six years instead, at the second C check. If an operator's utilisation is between these rates, it might bring the group of tasks forward to a C check, or incorporate them with OOP tasks into an A check, if the access is not too extensive. There are multiple considerations to be given when grouping tasks, therefore.

Based on the above Boeing C check phase intervals, an aircraft with a utilisation of 14FH a day would reach 14,000FH or 2,500FC every 1,000DY. This is equal to nearly three years (YE).

There is a breakdown of the 1C to 8C checks at the back of appendix AB. The MPD notes that some tasks are de-escalated for packaging into Base or HMV. The sample charts displayed within the MPD show a duration of 24 years.

Core tasks

As of October 2017, the core MPD for the 777 family has a total of 1,914 tasks: systems & powerplant (820 tasks), structural (762) and zonal tasks (332).

System task observations

There are 820 system tasks in the 777 MPD. Almost 500 of these apply to each 777 series, while 38 are specific to freighter variants (the 777F). In addition, 28 tasks are relevant to just -200 series aircraft and 45 to the -300. There are 211 engine-specific tasks: 81 for Trent 800 installed engines, 68 for the GE90; and 62 for the PW4000. Applicable system tasks therefore vary by aircraft.

There are 134 different thresholds provided across the system tasks. The thresholds applicable will depend on the series configuration and engines installed. Focusing on the airframe tasks that apply to all, the largest groups of tasks fall at:

- 1,125DY (13 tasks). These tasks therefore fall due about every three years. Tasks requiring deep access/high MH include nacelle panels, and life raft restoration.
- 12,000FC/2,250DY (11 tasks). Assuming the -300ER's average utilisation of 4,800FH and 700FC, the DY backstop will be met first. These tasks therefore fall due every six years. Tasks require access to aft cargo and bulk cargo compartments.
- 15,000FH (40 tasks). Again, assuming the -300ER's utilisation, these will fall due just over every three years. Tasks include the restoration of the nitrogen generator system, which requires removal from the aircraft. There are an additional five tasks with a threshold of 15,000FH, but a different repeat interval. Three have a repeat of 7,500FH and two have a repeat of 12,000FH.
- 16,000FC/3,000DY (25 tasks). Average -300ER utilisation suggests the DY is met first, falling due at every eight years. Heavy access is required for wing, internal cabin and flight compartment enhanced zonal analysis procedure (EZAP) and electrical wiring interconnection systems (EWIS) inspections.
- 18,000FH (17 tasks) would fall due just over every three years assuming average utilisation.
- 2,250DY (18 tasks) would fall due every six years.
- 24,000FC/4,500DY (12 tasks), DY met first, would fall due every 12 years therefore. Heavy access is required for fuel tank and environmental EWIS inspections.
- 4,000FH (16 tasks) fall due every five years if performed at a consistent utilisation of 4,800FH per year.
- 2,625DY (16 tasks) would fall due every seven years.
- 36,000FH (16 tasks) would become due every seven to eight years.
- 4,500DY (23 tasks) equates to just

While inspection hours are provided by the MPD per-task, access needs to be determined by maintenance planning departments on a task-by-task basis. Access requirements will significantly influence MH consumption in a base check.

over every 12 years.

- 6,000FC/1,125DY (25 tasks) would fall due every three years, assuming the DY interval is met first.
- 7,500FH (34 tasks). These tasks form a large grouping of operational checks, functional checks and specific filter inspections, totalling over 40MH of MPD inspection MH. Assuming -300ER average utilisation, these would come due roughly every 18 months.
- 8,000FC/1,500DY (13 tasks). These would come due every four years.

Each of the above sets of tasks has the same repeat interval as the threshold; for instance the 2,625DY set of tasks has a repeat interval that is also 2,625DY. This suggests a regular cycle of checks that can be structured by planners. There are also multiples of 3YE prevalent within most of these tasks, again suggesting a potential interval of 3YE for some of the heavier checks in the 777's maintenance cycle. This again assumes a utilisation for the 777-300ER of 4,800FH and 700FC per year for the purposes of this article *(see table, page 49)*.

279 of the 498 tasks therefore fall into recognisable task groups under the -300ER's anticipated utilisation. The remaining tasks could be regarded as OOP tasks, which are either brought forward to form larger base checks, or are carried out in a lighter A check. OOP tasks are most likely to be affected by the future plan of the individual aircraft. That is, whether the operator needs to plan the clearance of these tasks to make the aircraft available for peak seasonal activity, or changing route demands. Check sizes will be impacted by approaching large groups of OOP tasks that are brought forward, but the degree to which these are OOP will again depend on how individual aircraft are operated. Air France, for instance, might allocate ground time for specific OOP tasks, although it will mostly try to incorporate these into scheduled checks. OOP task MH allocations *(see table, page 49)* are therefore speculative and assume a calendar backstop met rather than FH or FC parameters.

Structural task observations

The structural section of the 777 MPD covers the following ATA sections: 27 (Flight Controls); 52 (Doors); 53 (Fuselage); 54 (Nacelles/Pylons); 55 (Stabilizers); and 57 (Wings). There are 762 tasks within this section, 439 of which are applicable across the family. 45 tasks are specific to the 777F, 50 are for the -200 series only, and 65 are for the -300 series. 33 tasks relate to the Trent 800 engine, 36 to the GE90 and 40 are specific to the PW4000.

As already established, the structural-focused tasks are almost entirely FC-dependent, with almost all of the tasks in this section having an FC-driven interval. Again, a large portion of these also have a DY secondary interval, which is likely to be met first if 'average' utilisation is adopted. In total, there are 62 different task groupings, covering all series and engine options within the 777 family.

FC threshold parameters largely range from 1,000FC to 40,000FC within the structures section of the MPD. More than half of the task groupings have different repeat intervals to the initial threshold, with 32 of the sets of task groups having shorter repeat parameters. For example, 20 tasks that first come due at 32,000FC/6,000DY have a repeat interval of 16,000FC/3,000DY. Tasks in this group require extensive access, such as the removal of the main cabin ceiling, sidewalls, insulation and horizontal stabiliser pins. Boeing gives 86MH for inspection in the MPD. Again, this figure does not take into account the access time required, so extensive access MH should be factored in. Assuming the DY interval is met first, these tasks initially come due when the aircraft is 16 years old, and again when it is 24 years old.

The largest groups of tasks (those with 10 or more tasks with the same thresholds) within the structural section are as follows:

- 12,000FC/2,250DY (39 tasks). This large group of inspections requires a total of 80MH for access to the aft cargo bay, nacelles, above ceiling main deck, empennage and wings. Assuming the DY parameter is met first, these come due every six years. The repeat interval is the same as the threshold.
- 16,000FC (11 tasks). Tasks include a number of internal special detailed, and external detailed inspections of fuel tanks, the horizontal stabiliser, and wing flap support fairings. Assuming the -300ER utilisation of 700FC, these come due every 22 years. The repeat interval remains the same.
- 16,000FC/3,000DY (42 tasks). Another group of tasks for inspection of the cargo bays, main deck, wing centre section, empennage and fuel tanks, with 80MH provided in the MPD. With the DY backstop of 3,000DY provided, these come due at eight years, with the repeat interval the same as the threshold. For an aircraft to reach the 16,000FC threshold before 3,000DY, it would need to operate more than 2,000FC annually.
- 16,000FC/4,500DY (55 tasks). These tasks cover the inspection of main cabin and cargo door cut-outs, wing and empennage area. Guideline inspection

Air France carries out A checks every quarter/ three months. Typical downtime for an A check is 36 hours, according to the airline.

MH of 110MH is provided. The repeat interval is shorter, at 16,000FC/3,000DY. These are expected to fall due every 12YE according to average -300ER utilisation.

- 30,000FC (51 tasks). This group of tasks requires heavy non-destructive testing (NDT) across several major structural areas. These come due when the aircraft is about 40 years old. Boeing provides 175MH of inspection time.
- 32,000FC/6,000DY (20 tasks). Tasks are outlined above.
- 40,000FC (105 tasks). These are ageing tasks requiring extensive NDT inspections around door structures, fuselage and wings. The tasks within this structural group have several different repeat intervals: 13 tasks have a short repeat interval of only 4,000FC; 10 have a repeat interval of 10,000FC; 17 have a repeat of 12,000FC; and the remaining 65 have a repeat interval of 16,000FC.
- 6,000FC/1,125DY (23 tasks). These come due every three years, depending on utilisation. The repeat interval for these 23 tasks is the same as the threshold.

Of the 62 groups of task intervals, only 11 have significant groupings of 10 or more tasks. The remaining 93 'applicable for all' tasks are divided among 28 different sets of intervals. A lot of these, however, have common FC and DY-based intervals, such as 16,000FC, 30,000FC, 40,000FC and 1,125DY. The rest could be deemed OOP tasks, which would be handled subject to the operator's approved maintenance plan (AMP).

Several interesting observations arise from the structural section of the 777 MPD. For example, there are 17 'applicable all' tasks with repeat intervals of 0FC and/or 0DY, including tasks at:

- 16,000FC (two tasks).
- 16,000FC/3,000DY (eight tasks). These require extensive internal access of the passenger compartment for GVI, so sidewall liner, floor panels, insulation blankets and ceiling panels are removed.
- 16,000FC/4,500DY (seven tasks). Tasks cover the access and inspection of passenger cut-out door area, requiring the removal of internal cabin equipment and linings within a distance set by the MPD.

For these tasks, the 'task description' column refers the engineer to the repeat inspection MPD number, which then satisfies the inspection in the area going forward. It states that 'Repeat interval satisfied by item XX-XXX-XX', meaning that once the task has been completed at the initial threshold, a future MPD task will go on to cover the repeat task requirements. The subsequent MPD inspection number can be referenced against more than one initial threshold/0FC and 0DY task. This is the mark of an efficient MPD, which has benefited from experience of operation.

A small group of three tasks has an initial threshold and repeat of 12,000FC/2,250DY. These involve a GVI of the area above the main deck compartment ceiling, according to the MPD. The repeat interval mirrors the initial threshold until 28,000FC or 5,250DY (14YR) is reached. These three tasks then separate from the main group of 12,000FC/2,250DY tasks listed above. After 14 years, the repeat interval changes to 4,000FC or 750DY, so that in reality these tasks start to repeat every two years, which is a significant interval reduction.

Last, there is a group of 54 tasks that applies to the 777-200ER only, with a threshold defined by 'note'. Specifically, these apply to -200ERs operating an average flight length of longer than 7:1. These task thresholds are Flight Length Sensitive (FLS), so maintenance planners refer to section 9, figure 1 of the MPD to determine the threshold at which to perform the tasks. The repeat inspection intervals vary per task and are listed in the task description column against the MPD number, as a 'Boeing recommended repeat inspection interval'. Tasks within this set have special detailed inspections, including the wing centre section.

Supplemental structural inspection (SSI) tasks

Section 9 of the MPD, Airworthiness Limitations details the supplemental structural inspection (SSI) programme, which covers the 777s fatigue-related tasks *(see Assessing the 777's long-term base maintenance, Aircraft Commerce, April/May 2013, page 28)*. The SSI tasks are listed with a brief explanation in section 9, and have a detailed cross-referenced description to the SSI in more detail, together with a recommended repeat interval provided in the structures section 2 of the MPD. The tasks in Sections 9 and 2 are therefore the same. Repeat intervals are subsequently calculated by engineers using the damage tolerance rating (DTR) form within the corresponding DTR manual.

According to the previous 777 article, SSI tasks can be divided into three main groups, referred to as Group 1, Group 2 and 3, also known as FLS tasks. All FLS tasks in the structures sections of the MPD are currently specific to the 777-200ER, so they do not apply to the remaining series. The MPD states that FLS items require both FH and FC to determine the Implementation Threshold.

The initial SSI inspection threshold for Group 1 tasks is 30,000FC, and 40,000FC for Group 2. Most Group 1 and all Group 2 tasks are heavy, with deep access requirements and the scope for significant non-routine rectifications, and reality factor considerations.

The 30,000FC and 40,000FC initial intervals are high for most aircraft in the fleet. Established cumulative FH and FC figures show that even the oldest in the -200 and -300 fleets are a long way off meeting the thresholds of these FLS tasks.

Zonal task observations

The zonal section comprises the smallest number of MPD items, with 332 tasks: 235 are specific to all 777 aircraft; six to the 777F; nine to the -200 series; 12 to the -300 only; and 70 are engine-related, split between 24 Trent 800 tasks, 24 GE90 tasks and 22 PW4000 tasks. The ATA sections that fall within the zonal tasks include 32 (Landing Gear), 52 (Doors), 53 (Fuselage), 54 (Nacelles/Pylons), 55 (Stabilizers), 57 (Wings), and 71 (Powerplant/Engines).

Of the 235 ‘applicable all’ tasks, 201 comprise five key groupings:

- 12,000FC/2,250DY (25 tasks). These tasks include inspections of the cargo compartment, and wing to body fairings. Total inspection MH provided is 25MH. The repeat interval is the same as the initial threshold.
- 16,000FC/3,000DY (16 tasks). These items relate to the cargo and flight compartments, and fuel tank tests and inspections. Boeing allows 20MH for inspection.
- 16,000FC/4,500DY (35 tasks). These tasks require access to the fuel tanks, wing tips, slats and vertical stabiliser. Indicative MH of 26MH is provided for the inspections. The repeat interval for these tasks is shortened to 16,000FC/3,000FC, meaning that after the first threshold is met at (most likely) 12YR the task interval decreases to 8YR.
- 6,000FC/1,125DY (110 tasks). These require numerous panel removals across the entire aircraft for both internal and external NDT and GVI, and should take place every 3YE assuming normal utilisation. 90MH for inspection is provided by Boeing within the MPD.
- 8,000FC/1,500DY (15 tasks). These detail inspections of the aft cargo area, flap fairings and nacelle panels. The repeat interval is the same as the initial threshold.

In the zonal section of the MPD, the notes relating to threshold and repeat intervals on some tasks cross-reference different MPD inspections and intervals. For instance, task 57-882-01 comes due at 8,000FC/1,500DY, and ‘note’ is ascribed in the threshold column. The task requires an internal GVI of the No.3 flap support fairing and inboard flaperon support bearing, the MPD states. The note related to the threshold column advises that ‘The EZAP inspection requirement with Interval 24,000FC or 4,500DY is satisfied by this zonal inspection,’ thereby increasing the efficiency of this MPD and streamlining the tasks within checks. About 150 zonal tasks incorporate EZAP requirements, which is a substantial portion of the 332 total tasks. However, a sophisticated maintenance and engineering IT system (M&E IT) is needed to fully realise the potential offered by the cross-referral of tasks within the MPD, avoid duplicating task work, and thereby wasting MH.

CPCP tasks are also covered by some Zonal inspection tasks within the MPD. The same MPD-referenced tasks can appear against more than one MPD inspection listing. About 85 zonal tasks refer to CPCP tasks. For example, task 55-800-00, which outlines an internal inspection of the stabiliser torsion box compartment, includes a CPCP note within its task description. This advises that CPCP tasks 53-681-00 and 53-683-00 are incorporated into task 55-800-00.

Ageing maintenance tasks

It is confirmed, given the utilisations found via Global FleetsAnalyser, that ageing maintenance programmes have not yet started to take effect across the worldwide 777 fleet, as even the oldest -200 aircraft have yet to hit the required thresholds for these tasks. Assuming the current average -200 utilisation *(see table, page 49)* of 1,200FC, the oldest -200 series airframes could begin these ageing tasks within the next four years, because the earliest S/Ns still in operation have only just reached 25,000FC.

The CPCP programme has recently been incorporated into core MPD tasks, with references to ‘CPCP note’ in the task description. As established, about 85 zonal tasks currently have CPCP tasks. According to Air France KLM Engineering and Maintenance (AFI KLM E&M), the impact of the introduction of these CPCP tasks has yet to be established. “This is in process right now at Air France,” confirms Thomas Sonigo, Head of Boeing fleet at Air France Industries. “These will form part of our C check work packs, however.” Air France is assessing the impact of the new MPD approach via a working group, including Air France structural engineers, heavy maintenance support engineers, and ground checks planning manager.

“Ethiopian Airlines has grouped CPCP tasks along with structural tasks within its AMP,” says Dawit Negash, senior engineer, aircraft maintenance programme & task card engineering at Ethiopian Airlines.

Once met, age-related structural tasks will present planners with additional complexity, because the repeat thresholds will alter the way that subsequent checks are planned. These will vary further in accordance with the aircraft’s future utilisation, so the structure of ageing checks will differ vastly to the groups of tasks formed before and as the initial threshold is met.

Ultimately, the ageing, FLS, and CPCP tasks are not yet affecting the global 777 fleet, based on the utilisations provided by Global FleetsAnalyzer. The oldest 777s in the fleet have currently accumulated about 25,000FC, while the FLS tasks start to kick in from 30,000FC depending on the ‘group’ of the aircraft (defined in Chapter 9). In addition, the limit of validity (LOV) placed on the airframe is a long way from being met.

Lighter checks

AFI KLM E&M undertakes light, ‘A’ checks every quarter, or every 105DY, in accordance with Air France’s utilisation,

Turkish Technic's -300ER fleet performs 6.1:1 on average. OOP tasks are incorporated into A and C checks depending on aircraft availability. CMR, AWL and CPCP tasks are sometimes added to A check packages.

which is 8.4FH per FC. "We try to level out our A checks over the cycle, and limit downtime per A check to 36 hours (1.5 days)," explains Sonigo. Air France's A checks typically include light visual inspections, lubrication tasks, and cabin inspections.

Meanwhile, Turkish Technic places its in-house average 777-300ER utilisation ratio as 6.1FH per FC. An average A check lasts two to three days depending on the workscope, according to the MRO provider. Turkish Technic's production planning department plans A checks so that the MH are distributed as equally as possible. A check packages are prepared about 10 days before the A check is due to be carried out, while OOP tasks are planned and incorporated into either the A or C check according to the availability of the aircraft. This is influenced by the season and how busy the aircraft is. CMR, AWL and CPCP tasks are also sometimes allocated into light A checks for Turkish Technic, if the working area and task threshold matches the workscope of the approaching A check.

Ethiopian Airlines operates six 777-200LRs, four 777-300ERs and six 777Fs. Its oldest aircraft was manufactured in 2010. Ethiopian Airlines operates at a high rate of utilisation, achieving an FH:FC ratio of 5.6-6:1 depending on the aircraft. On average, its 777s achieve over 5,100FH a year. "We have a turnaround time (TAT) of 14 hours for the lighter checks in the A check cycle," says Negash. "Every A check is handled similarly, except the 6A, which we divide into two equal block checks due to the ground time needed for maintenance." Since the MH required for the 6A check block is higher than the other A-check blocks, it is divided into two sub blocks. Ethiopian Airlines carries out A-checks every 2-3 months, depending on the aircraft's utilisation.

Base check group guide

The data provides a guideline example of how checks could, in theory, be structured throughout a cycle of six C checks *(see table, page 57)*. Check habits, however, will inevitably vary wildly by operator.

Air France performs C checks every three years. The lightest C checks it plans typically require a five-day TAT, whereas the heavier checks, which comprise the structural sets of tasks, can take three weeks. Structurally-focused C checks occur every six and nine years, which equates to the C2 and C3 checks in the first C check cycle of tasks. "The structural checks comprise 3,000MH for routine MPD inspection," says Sonigo. "Meanwhile, additional work for modifications and cabin refurbishment often requires an extra 2,000MH during these checks." Engine changes also happen every five to six years. "This requires about 200MH," adds Sonigo.

Lufthansa Technik Philippines (LHTP) places the average utilisation of the fleet at 14FH and 2FC per day. For LHTP planning and forecasting purposes, it adds 10% to this average to give an anticipated utilisation of 16FH and 3FC, or a ratio of 5.3:1. LHTP includes OOP tasks in base checks, subject to the forecasted due date and task interval. LHTP explains that C checks take place every 18-24 months given the utilisation in the region, which shows the difference between the C check intervals taking place globally. While a lighter C check, such as the 1C, might take 7-10 days to carry out, heavier base checks such as the 6C can take 15-20 days to complete.

Negash says that Ethiopian typically undertakes C checks every 2-2.5 years depending on aircraft utilisation. "Our C check cycle takes 12-15 years given our high utilisation rate, with six C checks in a cycle" he adds. "According to the 777 MPD, if we had a daily utilisation of 14FH then the C1 check is expected to be performed at 15,000FH, 2,500FC or 1,125 wcf. "When we see the historical data, however, C checks are mainly driven by the FH parameter for our fleet. We also carry out C checks ahead of time to avoid grounding aircraft during peak season, so we aim to position them during off-season, winter periods. Generally there is significant variance between the MPD programme C check interval and the actual interval at which these checks are performed."

According to Negash, a light, 1C check takes about 6.5 days for Ethiopian Airlines to complete. "We assign 15 mechanics to perform a C check, with two daily shifts of eight hours. The C1 check therefore takes about 1,560MH to complete the workscope assigned in our AMP." This includes all Ethiopian-specific job cards, non-routine (NR) findings and also considers a reality factor. Meanwhile, a 2C group of tasks takes about nine days for the airline MRO provider to complete. The MH requirements for the C2 check are about 2,200MH, specific to Ethiopian's AMP and utilisation. In accordance with the airline's utilisation, deep access removal involving galley removal, floor panel and sidewall panel removals happen from the C2 check. "For example, MPD task 57-630-00 is a CPCP task which needs this level of access," says Negash. "This is a routine MPD item that we perform regularly at 8,000FC or 1,500DY wcf." The MRO has yet to undertake the C3 check. "We are preparing task cards for the C3 check and above," adds Negash.

Given the variance in check patterns described by operators, in addition to the heavy dependence on individual FH and FC usage, this table should not be seen as a definitive way of grouping tasks. Instead, it should be treated as an interpretation, given listed assumptions, as to how the size of the checks can increase MH requirements and certain planning considerations as the aircraft accumulates FH and FC. Check groupings are also relative to the FH:FC, due to the MSG-3 logic in the 777 MPD.

GUIDE SUMMARY MH & MATERIAL INPUTS OF PAX-CONFIG 777-300 (GE90)

CHECK	MPD interval	Main task groups	Groups of tasks	Year	MPD Rout' MH	A check MH	OOP MH	Defect ratio	N-R MH	Rout' sub MH	Interior clean MH	Refurb MH	EO, AD & SB MH	Heavy comp	Total MH
C1	15,000FH/ 2,500FC/ 1,000DY	1,125DY	1C	2.7 -3	1,307	250	200	20%	351	2,109	300	500	300		3,209
C2	30,000FH/ 5,000FC/ 2,000DY	2,250DY	1C + 2C	5.5-6	2,283	250	500	30%	910	3,943	500	850	300	450	6,043
C3	45,000FH/ 7,500FC/ 3,000DY	3,000DY & 3,375DY	1C + 3C	8.2-9	3,202	250	500	50%	1,976	5,928	500	600	500		7,528
C4	60,000FH/ 10,000FC/ 4,000DY	4,500DY & gear cng	1C + 2C +4C	10.9-12	4,259	250	500	60%	3,006	8,015	500	850	300	1,600	11,265
C5	75,000FH/ 12,500FC 5,000DY	5,250DY*	1C	13.7-15	1,319	250	200	40%	708	2,477	300	600	300		3,677
C6	90,000FH/ 15,000FC/ 6,000DY	6,000DY**	1C + 2C +3C + 6C	16.4-18	4,170	250	500	70%	3,444	8,364	500	850	600	450	10,764

Average utilisation of 4,800FH and 700FC per year

chart based on calendar target for tasks being reached before FH or FC threshold/repeats

* large group of tasks at 5,250DY threshold but repeat interval is 1,500dDY

** Large group of tasks at 6,000dy threshold but repeat interval is 3,000DY

Notes

chart assumes 6 checks in a cycle. this may vary per operator

'mpd interval' column provides guide interval w.c.f.

For example, a high FH aircraft, achieving high FH:FC will meet the high FH tasks long before ageing FC-related tasks. An aircraft undergoing shorter sectors, however, and higher FCs per year will meet the ageing FC-related tasks more quickly.

Turkish Technic's 777 fleet comprises the -300ER. Airline FH:FC ratio of 6.5:1 means the MRO carries out C checks on the -300ER at the 1,125DY interval. It includes eight C checks in the C check cycle for the 777, with the C3, C6 and C8 checks requiring the most MH for deep access and structural tasks. A lighter base check such as the C1 takes 3-5 days for Turkish Technic to perform, whereas the heavier C6 and C8 checks require up to two weeks of downtime.

C checks do not just vary by operator or region. Cooper describes two aircraft of the same age and from the same fleet, undergoing C4 checks earlier than the anticipated threshold of 12YR. "One check was substantially heavier than the other because the previous check activity and utilisation of that aircraft was lower than the other airframe," he says. "This shifted the heavier tasks into the C4, whereas the other aircraft had heavier tasks in the C3 as it had accumulated a higher number of FC."

Another consideration is that it is almost impossible to anticipate an entire cycle of base checks. "Planners will allocate C checks to aircraft depending on the task parameters set by the MPD at the time the check is undertaken or coming due," adds Cooper. "This is likely to change over the years, however, as is demonstrated by the interval changes described in the MPD. C check sizes, frequency and cycle structure will therefore evolve several times throughout the C check cycle."

The table also takes into account various refurbishment and material cost considerations where appropriate. These are generic, guideline figures provided by sources to reflect potential airline cabin refurbishment programmes. A standard interior refurbishment, including carpets and sidewall panels, can take 1,500MH, for example, while a more extensive interior modification programme, involving moving/reconfiguring major monuments such as toilets, replacing seats and changing or installing in-flight entertainment (IFE), can take 4,500MH. Further modifications such as lighting change can increase this to 5,000MH.

New cabin modifications may also require the installation of connectivity systems, because these are increasingly in demand. Installation of WiFi, including antennae, takes 800-1,000MH, depending on whether it is happening during reconfiguration or refurbishment. Connectivity installation is a standalone task, because it has to be carried out when the aircraft is 'stable'; if a lavatory is removed, its weight has to be replaced to preserve weight and balance during installation.

Interior refurbishment will also require an aircraft re-weigh, which costs up to $3,000.

Major ADs and SBs

There have been four main ADs and SBs released for the 777 in the last two years.

- AD 2017-16-10 relates to the fuselage and wings, and has been released upon finding cracks on the underwing longerons. The AD requires repetitive inspections to assess condition. The related SB is SB 777-53A0081. The AD states the cost of compliance as an initial

Ethiopian Airlines operates 16 777s. It carries out C checks every 2-2.5 years depending on individual aircraft utilisation. CPCP tasks are now being incorporated alongside structural items in Ethiopian's AMP.

12MH for ultrasonic inspection to be performed, and should the left or right side longeron require replacement it allocates 102MH per side. Labour is estimated to cost $8,670, and parts $31,000 per side.

- AD 2017-11-14 covers wings, and requires inspection and Teflon sleeving under certain wire bundle clamps routed along the fuel tank boundary structure, and to perform cap sealing of certain penetrating fasteners of the main and centre fuel tanks. This AD supersedes 2011-26-03 to include additional aircraft. The SB connected to this AD is SB 57A0050. Installing the Teflon sleeving and cap sealing (retained actions from AD 2011-26-03) uses up to 358MH and costs $30,430, while parts are estimated to cost $2,241.
- AD 2016-23-02 covers nacelles and pylons. It requires inspection of the lower web of the aft fairing of the engine struts for any discolouration, and inspection of the heat shield castings for any damage, installing gap cover strips, and replacing insulation blankets. It also requires, depending on aircraft configuration, one-time or repetitive detailed inspections for cracking and deformation, as applicable, of the aft fairing lower structure, and one-time or repetitive conductivity inspections of the aft fairing lower structure, and related investigative and corrective actions if necessary. This new AD superseded 2006-19-12 and adds additional S/Ns to the applicability. Cost of compliance for the inspection retained up to 11MH, costing $935, while parts costs are estimated at $16,179 (both costs depending on a/c configuration). New inspections set by the new AD require up to 24MH, costing $2,040 (depending on a/c configuration. Related investigative actions are provided, including up to 36 MH costing $3060.
- AD 2016-17-10 relates to new work requirements of the landing gear, specifically, the identification and replacement of certain main landing gear (MLG) aft trunnion pins. The cost of compliance estimates 2MH ($170) per trunnion pin for inspection. The total cost of replacing these pins is 211MH ($17,935) and $5,291 for parts.

Defects and reality factors

As has been extensively covered in previous aircraft analysis, it is important for maintenance planners to allow for the expected downtime of an aircraft undergoing routine checks. For third-party providers compiling bids and estimates, this is vital to furnish customers with a realistic expectation of the MH (and therefore cost) requirements of each check, and thereby avoid incurring disruption and unforeseen costs for the operator. Meanwhile, for an airline in-house MRO, establishing the expected downtime of a planned check is vital to ensure that the aircraft meets the operating requirements of its fleet.

The two main considerations are reality factors and NR ratios. The reality factor is assigned on top of each MPD routine task, to provide a realistic idea of how long each task will take. Truly efficient AMPs will also take into account the time saved by tasks with 'mutual access' that can save MH within a check. This depends on the sophistication of the M&E system in place, and the experience of the MRO. Access also needs to be factored in; according to Cooper, access-related reality factors can be higher than the MPD inspection reality factors.

Reality factors can range from 2 to 4 depending on the task, and whether it requires 'special access' or specialist skill. "Varying factors are often used for 'special access' tasks, such as tasks requiring the removal of cabin equipment or insulation," adds Cooper. "Different skills will also require different reality factors. For example, avionics-related tasks often attract a higher factor, while those referring to NDT are quite close to the MPD's allocated inspection MH."

Ethiopian, AFI KLM E&M and Turkish Technic each add a factor of 2 for most tasks, to account for the opening and closing of standard panels. According to Turkish Technic, some tasks require a much higher reality factor than others. This depends on the accessibility of the task working area, in addition to the job procedure. Turkish Technic analyses this on a task-by-task basis when planning for checks. A factor of 2 has been applied *(see table, page 57)* for zonal and MPD tasks. A factor of 4 has been applied to larger tasks requiring special access.

In addition, the N-R ratio is implemented into check planning to accommodate downtime and costs for unexpected defects. The number of N-R findings is expected to increase as an aircraft matures and progresses throughout a C check cycle, and is expected to be at its highest by the C6 or C8 check. Upon completion of this heavy check it is anticipated that most defects will be cleared and overcome, so the N-R escalation should reset.

The rate at which the N-R increases throughout the check cycle depends on where the heaviest tasks fall, the airlines' individual AMP requirements, and the MRO provider's experience. AFI KLM E&M's N-R ratio mostly depends on SB implementation. On average it places 30% across its C checks. LHTP's N-Rs are relatively stable for light checks at 30%, rising to 60% for heavier C checks.

The above shows an MPD that takes into account past, present and future utilisation and the operating profiles of individual aircraft within the 777 family. These characteristics provide scope for engineers and planners to tailor the maintenance management of the 777 to optimise their AMPs. AC