APPENDIX F. MAINTENANCE CHECK MANHOUR SURVEY AND PERFORMANCE FACTORS

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A. INTRODUCTION

This appendix contains a summary of survey data for manhours and the elapsed time required for periodic maintenance, check interval escalation, performance factors that can influence maintenance costs and blocked versus equalized maintenance.

This appendix does not contain data regarding direct and indirect operating costs. Any questions regarding operating costs should be directed to the Director of BCAG Marketing/Airplane Economics.

B. MAINTENANCE CHECK MANHOUR SURVEY RESULTS

In response to continued requests from various operators for actual check manhour data, 767 operators were requested to provide "Actual Manhours" and "Actual Elapsed Time" required to perform 767 A- and C-Checks. The data received from each airline is kept confidential and airline anonymity is maintained in this summary.

We requested each airline to submit separate manhours for the "Scheduled/Routine" and the "Unscheduled/Non-routine" tasks and the elapsed time to perform each letter check. Manhours for modifications, service bulletins and "housekeeping" tasks (i.e. - painting, exterior/interior clean, etc.) were to be excluded.

The results of this survey are reflected on pages F.0-4 through F.0-6. Because no two operator's maintenance programs are identical, comparing manhours is difficult. Refer to the notes that are contained with the results and Sub-section D. MAINTENANCE PERFORMANCE FACTORS for factors that affect maintenance check manhours.

This survey was taken in 1990 and is not regularly updated.

767 A-CHECK RESULTS				
OPERATOR	MANHOURS		ELAPSED TIME (HOURS)	NOTES
	SCHEDULED	UNSCHEDULED		
1	71	64	12	**[1]**
2	35	19	7	**[2]**
3	150	N/A	8	
4	100	N/A	14	
5	*268	N/A	6	
6	40	20	10	
7	70	17	15	
8	*299	*168	48	**[3]**
9	160	90	9	**[4]**
10	50	30	10	
11	145	82	16	**[3]**
12	20	*4	4	**[5]**
13	80	50	16	
14	37	74	6	**[6]**
15	60	20	7	
16	*300	*0	25	**[7]**
17	*231	N/A	10	
18	170	30	14	
19	125	75	24	
20	98	59	24	
21	66	37	18	**[8]**
22	12	58	12	
23	27	32	12	
24	160	50	24	
25	80	32	9	**[9]**
MEAN	**84**	**47**	**13**	
**** STANDARD DEVIATION**	**50**	**24**	**6**	

N/A = DATA NOT AVAILABLE
SEE PAGE F.0-6 FOR NOTES

767 C-CHECK RESULTS				
	MANHOURS		ELAPSED TIME (DAYS)	
OPERATOR	SCHEDULED	UNSCHEDULED		NOTES
1	*287	*28	N/A	
2	825	472	4	**[3]**
3	*5277	*3015	*9	**[3]**
4	1400	N/A	6	**[15]**
5	1078	839	2	
6	3578	*5175	*28	
7	*400	*90	3	
8	2101	1200	*12	**[3]**
9	2864	1636	*10	**[4]**
10	3100	2400	5	**[10]**
12	*277	*140	*1	**[11]**
13	2560	*3140	*9	
14	*341	681	*1	**[12]**
15	2500	2000	6	
17	1376	N/A	7	**[14]**
18	2400	400	7	**[12]**
19	*380	*126	2	**[13]**
20	2322	812	5	**[12]**
21	*380	*126	2	**[13]**
22	*260	2260	6	
23	1008	1512	4	
25	1683	800	8	
MEAN	**2056**	**1251**	**5**	
**** STANDARD DEVIATION**	**846**	**697**	**2**	

N/A = DATA NOT AVAILABLE
SEE PAGE F.0-6 FOR NOTES

767 4C-CHECK RESULTS				
OPERATOR	MANHOURS		ELAPSED TIME (DAYS)	NOTES
	SCHEDULED	UNSCHEDULED		
6	*8412	*12103	*49	
8	1850	2017	15	**[3]**
14	*143	*286	*1	
17	3144	N/A	22	
20	2667	1804	7	
23	*6276	*9414	20	**[3]**
MEAN	**2554**	**1911**	**16**	
**** STANDARD DEVIATION**	**654**	**151**	**7**	
N/A = DATA NOT AVAILABLE				

NOTES:

[1] A-Check includes some C-Check items.
[2] Scheduled manhours includes both scheduled and unscheduled manhours.
[3] Unscheduled manhours estimates are based on the average ratio of scheduled/unscheduled manhours.
[4] Unscheduled manhour estimates are based on the average ratio of scheduled/unscheduled manhours. Average is based on age and modification content of fleet.
[5] A-Check is the average of 1A through 6A.
[6] A-Check is an average of 1A through 6A + S1A.
[7] A-Check includes 1A + 1/2 2A + 1/3 3A + 1/2 4A + 1/10 1C.
[8] Unscheduled manhours is an estimated value.
[9] A-Check is the average of 1A through 9A.
[10] Frequency of performing the check is stated as 365 calendar days.
[11] Operator performs C-Check in 1/2 C-Check intervals scheduled at 1500 flt. hr. intervals.
[12] Average data from 1C to 3C.
[13] Operator performs C-Checks in 1/2 C-Check intervals scheduled at 2000 flt. hr. Unscheduled manhours are estimates, not actuals.
[14] Average data from 1C to 3C.
[15] Manhours are estimates, not actuals.

* These values were not used to calculate the mean and standard deviation because they differ substantially from the mean and probably reflect invalid data.

** There is a 68% probability that the time (either manhours or elapsed time) will be within one standard deviation of the mean.

C. CHECK INTERVAL ESCALATION

The ideal Scheduled Maintenance Program is one which has escalated the intervals between Scheduled Maintenance Checks to a point which takes maximum advantage of the inherent reliability and serviceability of the airframe, engines, systems and components without compromising airworthiness or generating excessive maintenance and repair costs. FAA Advisory Circular AC 121-1A states that Check Intervals may be increased or revised as often as justified by the operator and approved by their local regulatory authority. This escalation is dependent upon the individual operator's fleet reliability, maintenance program, utilization parameters, flight operations, etc.

767 INTERVAL HISTORY

The following charts show how the Maintenance Review Board Report (MRBR) and Fleet Average Letter Check Intervals have changed over time. The World Fleet Weighted Average Interval is taken from Airlines Maintenance Inspection Intervals document (D6-26100). This document contains actual maintenance intervals that are reported to Boeing by operators and is updated semi-annually.

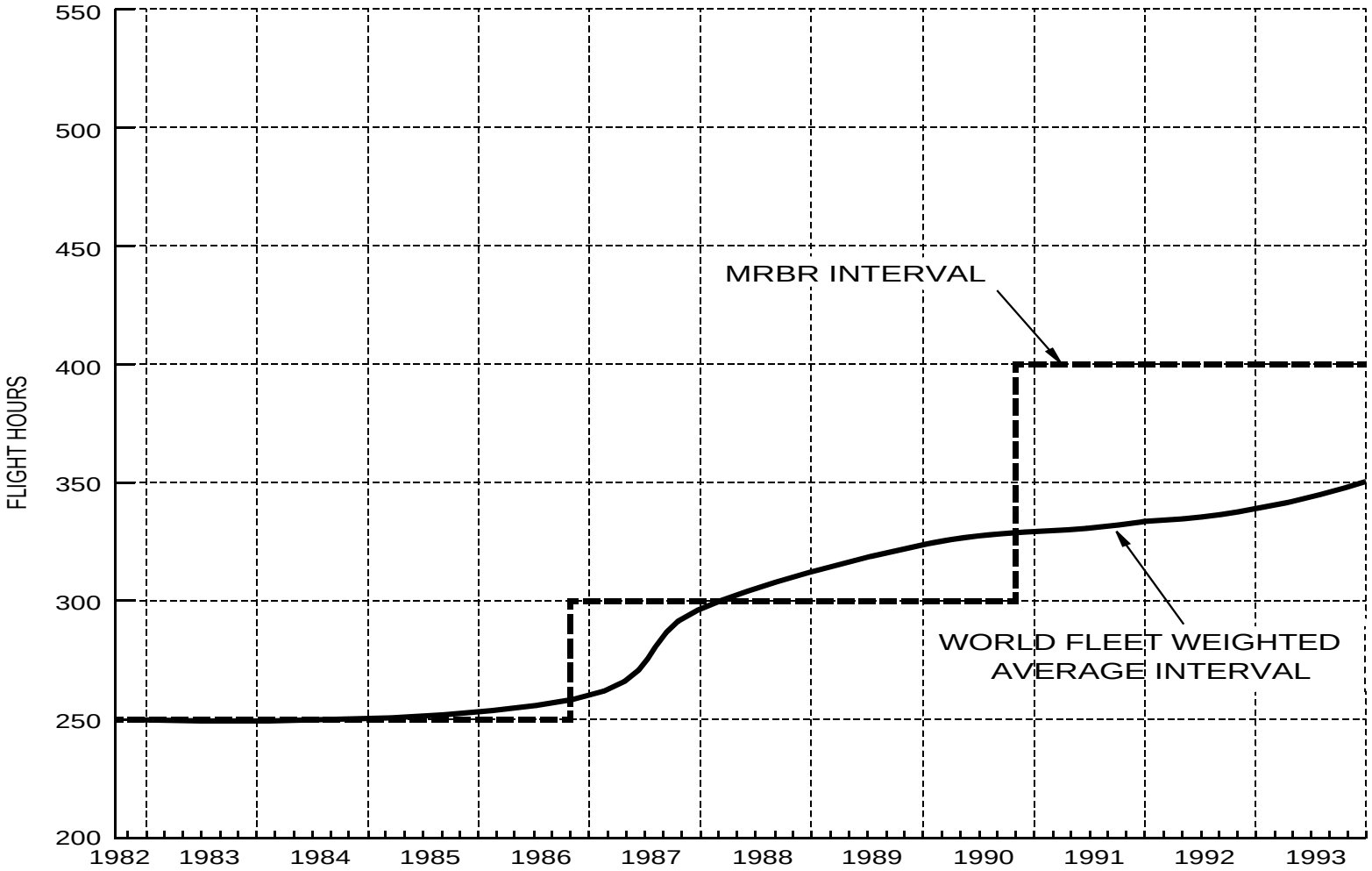

FIGURE 1. A-CHECK INTERVAL HISTORY

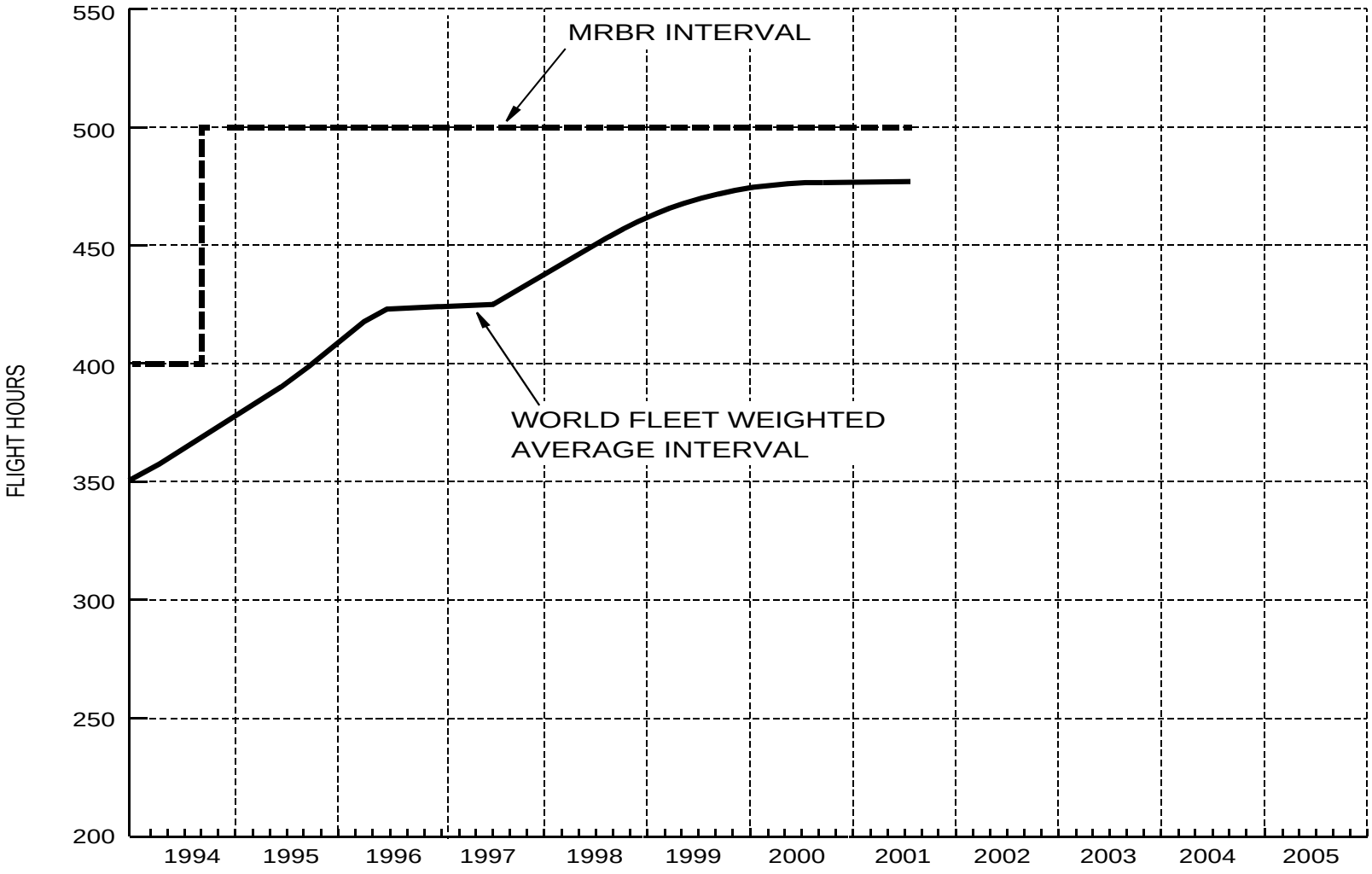

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FIGURE 2. A-CHECK INTERVAL HISTORY

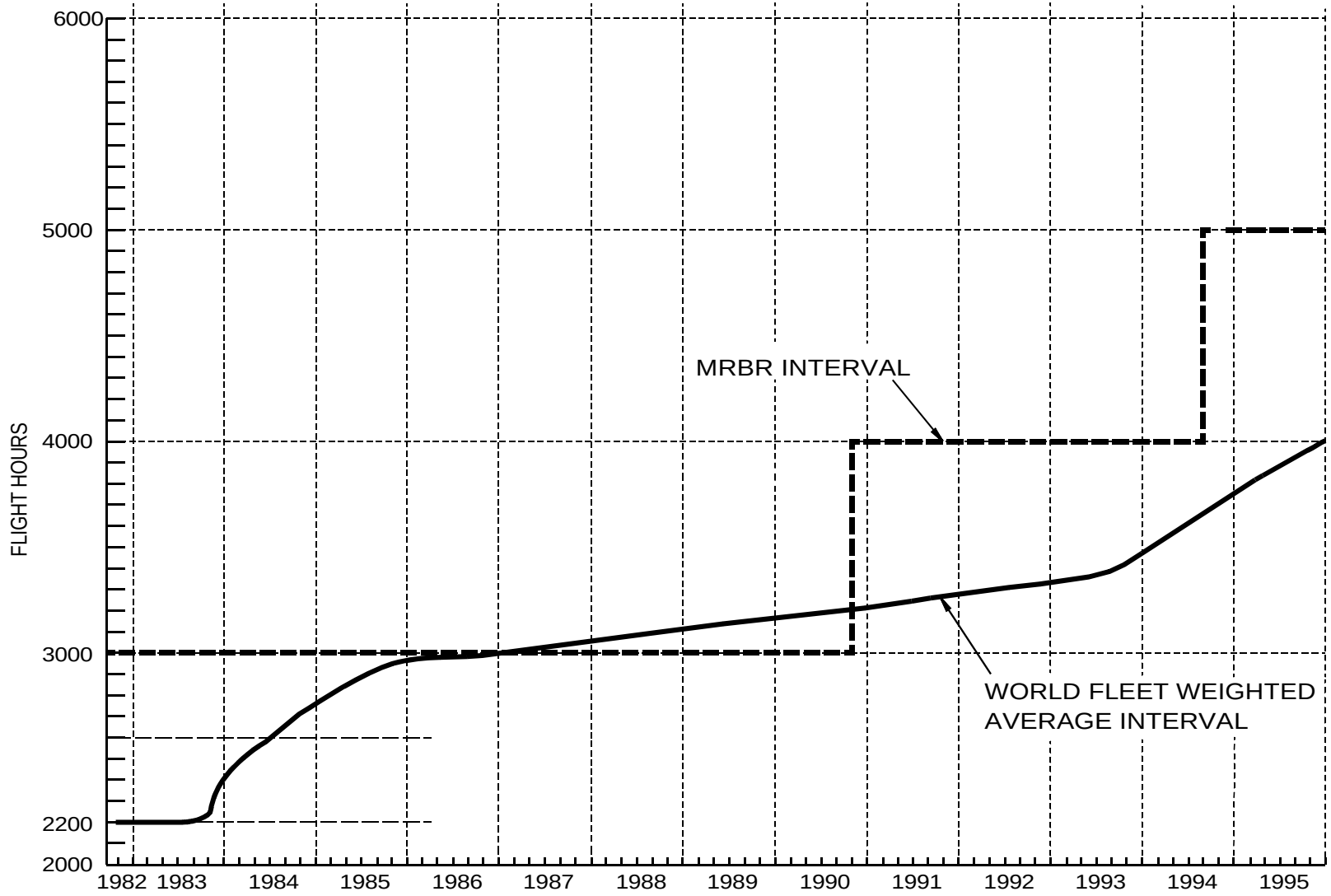

FIGURE 3. C-CHECK INTERVAL HISTORY

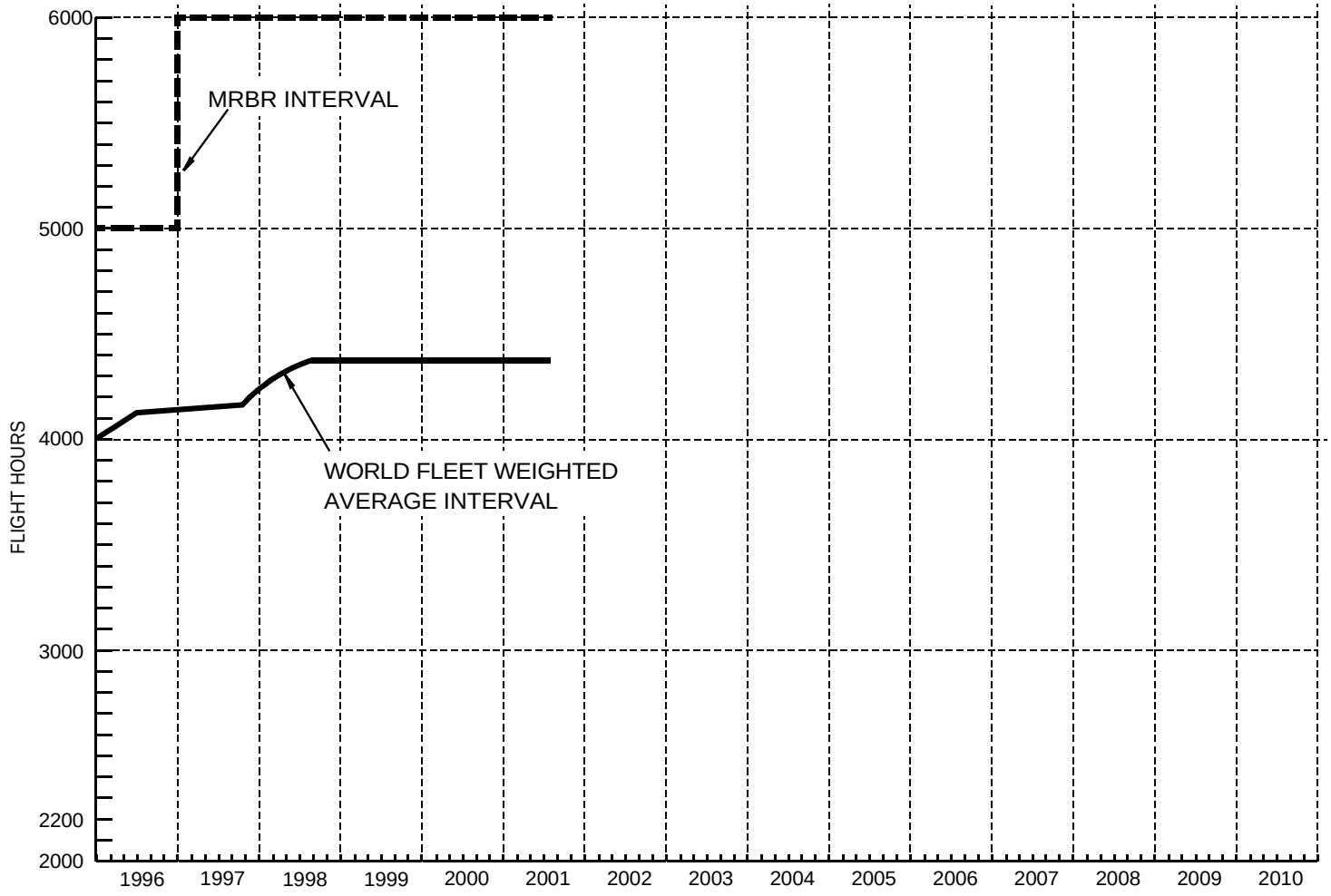

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FIGURE 4. C-CHECK INTERVAL HISTORY

CHECK INTERVAL ESCALATION FACTORS

Extending the intervals between Scheduled Maintenance Checks may become uneconomical when the amount of non-routine maintenance per check and/or the peaking of the check workload is such that maintenance costs per flight hour are increased rather than decreased. The desirability and cost-effectiveness of escalating the interval for Scheduled Maintenance Checks must be based on studies of many factors, including:

1. Additional availability of airplanes for revenue producing flights
2. Increased workload per check versus any decrease in the manhours per flight hour
3. Utilization of maintenance facilities and personnel
4. Size of work crew required (excessive peaking of workload)
5. Number of checks per week, i.e., spacing of workload
6. Age of airplanes (Inspection discrepancies increase with airplane age)
7. Experience level and productivity of personnel
8. Elapsed hours to perform the check (airplane down time)
9. Temporary manpower available from other maintenance functions or crews
10. Phasing of checks, i.e., escalate interval but split check into two or more phases
11. Advisability of greater interval for certain tasks (oil & air filter, lubrication, etc.)
12. Compatibility of maintenance programs on all airplane models
13. Capacity and utilization of shops and other support activities

JUSTIFICATION OF INTERVAL ESCALATION

It is the operator's responsibility to justify escalation of their Check Intervals and other time limitations plus revision of their Check Task Cards/work content. FAA Advisory Circular AC 121-1A states that FAA approval of time limitations and check intervals will be based on the following parameters and considerations:

1. Geographical area or areas of operation
2. Engine operating power, procedures (derating)
3. Number of landings, long haul versus short haul
4. Maintenance organization and inspection procedures
5. Quality control organization and procedures
6. Adequacy of maintenance facilities and equipment
7. Scope and depth of maintenance personnel training
8. Calendar time versus utilization of aircraft
9. Adequacy of the scheduled maintenance program
10. Industry-wide service experience
11. Manufacturers recommendations (**initial** intervals and time limits only)
12. Operator's application of on-condition and condition-monitoring processes
13. The operator's reliability program (or other maintenance record or data program)
14. Operator's experience on aircraft of equal complexity
15. The operator's service experience with the airplane

FAA advisory circular AC 120-17A provides additional guidance for development of reliability programs and describes maintenance interval adjustment based on reliability program results.

AC 121-1A states: "Special reliance will be placed on the operator's service experience, including the information obtained from tests, inspections, checks and measurements that were performed while accumulating service experience." (Information may be in the form of reliability program reports, failure/defect rates and history, shop findings and or other measurements of service experience, reliability and airworthiness.)

AC 121-1A states that time limitations for scheduled maintenance may be revised as often as the operator can submit proper justification and substantiation to warrant a time increase. Justification of airplane or engine interval escalation will normally be based on evaluation of all pertinent service records/history and examination/inspection of at least one airplane/engine which has operated within 5 percent of the currently authorized time limit.

It should be noted that "Manufacturing Recommendations" are applicable to **initial** check intervals and component time limits for introduction of new airplanes into service or for starting intervals and time limits for new operators. "Manufacturer’s recommendations" is not listed in AC 121-1A as justification for check interval escalation.

D. MAINTENANCE PERFORMANCE FACTORS

The cost of maintenance is affected by many factors, many of which are interdependent. It is seldom possible to evaluate one maintenance parameter without due consideration for other interacting factors. For example, if the work content (manhours) for one scheduled check is changed, then the manhours and cost distributions of the other may change. Therefore, when airline maintenance managers compare their airline's maintenance performance to the standards shown in this appendix, they should consider the following factors in their comparison. The diagram on the following page shows another way to demonstrate how maintenance performance factors can affect maintenance costs.

1. Scheduled maintenance program (check plan and pattern)
2. Scheduled check work package (task cards and content)
3. Maintenance ground time (airplane available for maintenance)
4. Check intervals
5. Airline policies and philosophy (maintenance deferral, MEL, airplane appearance, engine operation, etc.)
6. Contract and pool maintenance
7. Productivity and skill level of maintenance personnel
8. Time between overhaul (TBO) for components and engines
9. Structural sampling of a fleet (versus 100% structural inspection)
10. Climatic conditions (effects on hardware and working personnel)
11. Service bulletins and modifications (cost and effect)
12. Airplane and engines, model and age
13. Maintenance historical experience data
13. Performance verification and/or inspection
14. Fleet mix (types of airplane) and size of fleet
15. Route structure and flight schedules (frequency of flights at a station)
16. Effect of flight length or landing cycles per flight hour on maintenance costs
17. Airplane utilization
18. Airline cost accounting methods and variations
19. Labor and materials cost inflation plus dollar devaluations
20. Maintenance historical experience data
21. Reliability and/or condition-monitoring failure data programs
22. Malfunction reporting and maintenance communications
23. Spares availability and location

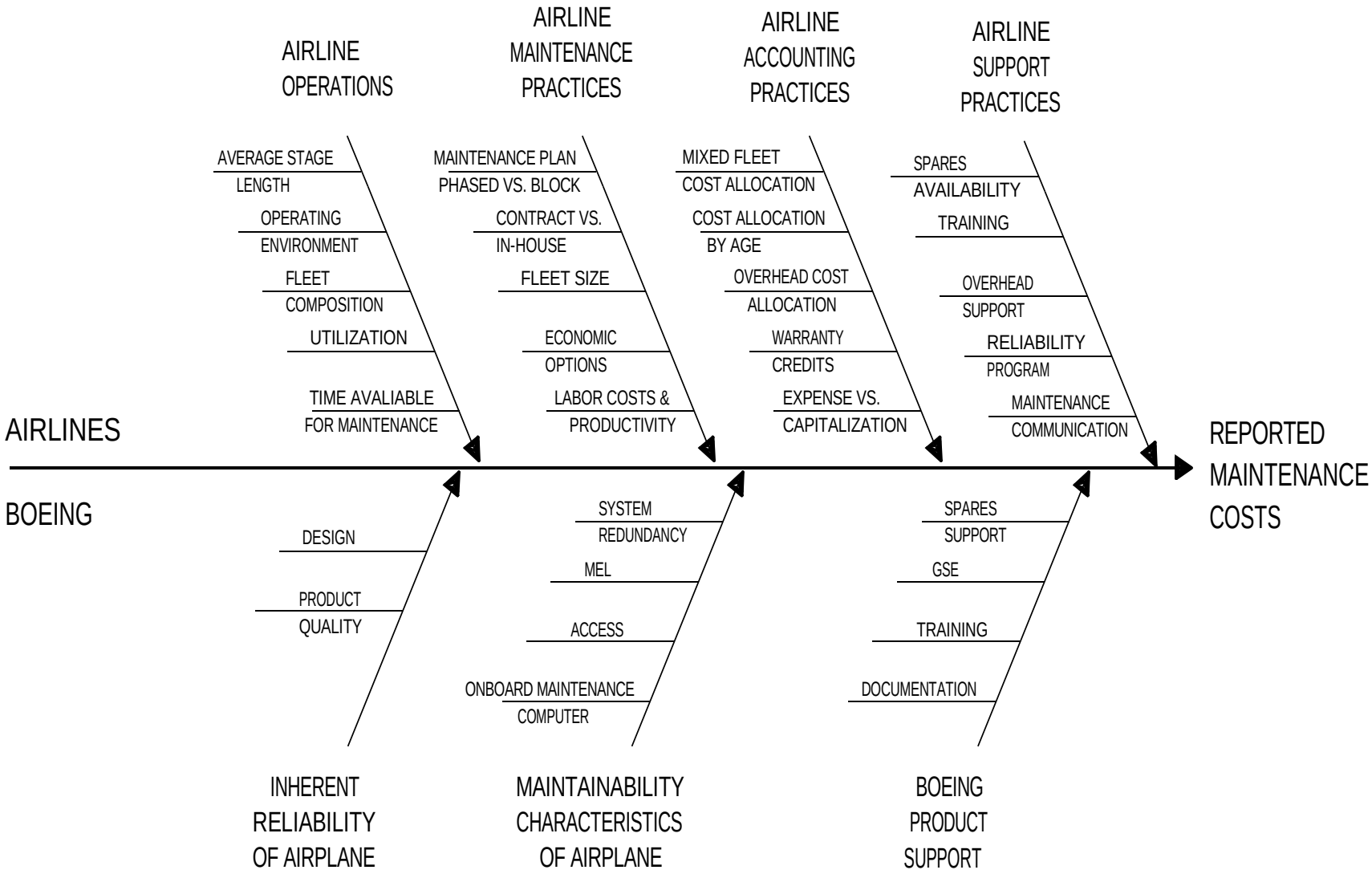

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FIGURE 5. FACTORS THAT AFFECT AIRPLANE MAINTENANCE COSTS

E. BLOCKED VERSUS EQUALIZED MAINTENANCE

The direct maintenance costs are related to the type of scheduled maintenance program being employed, whether "block", "equalized" or some variation between usually referred to as "phased". Section 1, paragraph H of this MPD discusses Packaging Maintenance Tasks to fit an operator's specific utilization.

Traditional "block" maintenance programs group all tasks by period (e.g. all 1C checks are accomplished in one hangar visit) and result in a smaller number of larger work packages than a full or partially phased program. An equalized program groups the tasks into many smaller packages, all having similar elapsed time (usually 8 hours or less) so the work can be accomplished during normal down time such as during overnight stops. Between these two extremes are many maintenance programs which partially phase their tasks, or they phase by access, skill requirements or other criteria suitable to their operation. The degree to which each operator has implemented a phased check program varies with his own unique requirement.

The main advantages of Equalized Scheduled Maintenance Checks are:

1. Reduces the size of workload at any one check by spreading the work into smaller checks at a more frequent interval (i.e. portions of the "C" check accomplished at an "A" or "multiple A" check). This reduces the peaks and valleys in manpower requirements.
2. Reduces extended lay-up periods, and uses available aircraft downtime for maintenance, thus increasing airplane availability.
3. Provides more frequent maintenance visits allowing prompter correction of deferred discrepancies and earlier detection of problem areas.
4. It is easier to take advantage of the full life of a component when frequent maintenance visits are planned.
5. Facilities are required for shorter periods of time, thus become available for other activities.
6. Airplane is more accessible to Operation's demands because it is easier to close up and go into service, compared to a block program.

Some limitations when employing an Equalized Maintenance Program may be:

1. If operator performs lesser checks at remote locations, tools, spare parts, skills, man-power, etc. must be available to perform the more extensive checks. This may increase lead-time to obtain repair parts thus mandating a second visit for repair.
2. Setup and access time may be redundant because not all required tasks can be performed during a single out of service period (e.g. night shifts) and must be planned for two or more visits.
3. Some non-routine tasks identified during the scheduled visit may need to be deferred due to elapsed time limitations, causing the setup, open/close and tear-down time to be duplicated.
4. The first cycle involves performing almost all phased tasks earlier than deemed necessary.
5. The amount of record keeping is increased.
6. More difficult to bridge to a new maintenance plan.

The main advantages of Block Maintenance Checks are:

1. Minimizes the total scheduled maintenance manhours.
2. The cumulative amount of time for open/closure, setup, tear down may be minimized.
3. Non-routine tasks, modification work, and corrective action can be more easily scheduled and avoid or minimize additional airplane down time.
4. Simplifies planning due to longer elapsed time.
5. More commonly used by operators with larger fleets.
6. Spare parts are likely to be available as the maintenance is performed at a major maintenance base. Also, spare parts may be ordered and received for repairs within the lay-up period.

Some disadvantages of Block Maintenance Checks are:

1. Airplane is out of revenue service for a longer period of time.
2. Operators with small fleets may have longer interrupted flight operations.
3. Possible sacrifice of component life limits.
4. Manpower planning may have major peaks and valleys if the fleet's airplane checks cannot be scheduled continuously.

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