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MANAGEMENT REVIEW

Management without theatre.



OPERATIONS

MAINTENANCE THAT FITS HOW THINGS FAIL

How airlines learned that overhauls did not control failures, six patterns of failure and the 4% bathtub, three questions and four tasks, what an age limit would cost an engine shop, what “a life of 2,000 hours” can mean, and a card.

89% of the aircraft components United Airlines analysed had no wearout zone: no age limit could improve them.

NOWLAN & HEAP, 1978

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In this issue

Most maintenance plans still say: every so many hours or months, take it apart, renew it, put it back. It feels like care. Airlines tested that belief against their own failure data fifty years ago and found it held for a few items only. This issue asks which failures a fixed interval prevents, which it does not, and what to do instead.

Under the old rules the Douglas DC-8 started with 339 items on scheduled overhaul; the DC-10, planned with the new logic, with seven. Of the components United Airlines analysed, only 6% wore out at a clear age, and 4% followed the bathtub. Nowlan and Heap asked three questions about each failure and chose among four tasks. Their engine example shows an overhaul limit filling the shop. NASA's guide adds how to watch a part that is degrading. A card closes the issue.

Stiven Janaqi EDITOR · STIVEN CATALYST

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HOW TO READ THIS ISSUE

Figure
Every figure has its source and year at the foot of its page.

Our reading
Where the editor interprets rather than the research, it says so.

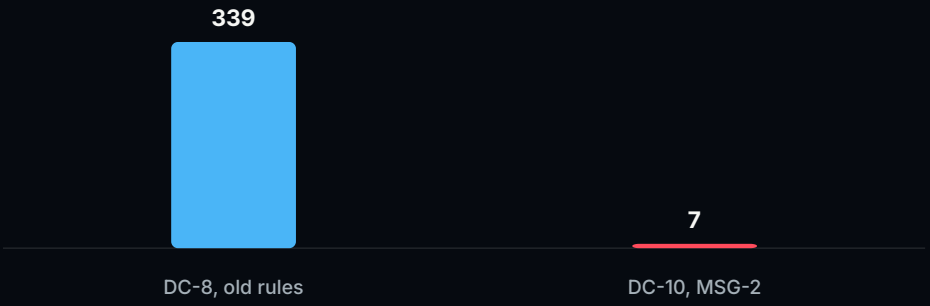
Practice
The steps and the card are proposals to try, not research results.

COVER STORY

From 339 overhauls to seven

By the late 1950s airline maintenance costs had grown enough to force a new look. In 1960 the US aviation regulator and the airlines formed a task force; its reliability programme of November 1961 stated that reliability and the control of overhaul times “are not necessarily directly associated topics”.

ITEMS ASSIGNED TO SCHEDULED OVERHAUL IN THE INITIAL MAINTENANCE PROGRAMME



The turbine engine was among the items taken off fixed overhaul, which cut the spare engines held for shop work by more than half. On the Boeing 747, United Airlines spent 66,000 manhours on major structural inspections to reach a 20,000-hour interval; on the smaller DC-8 the old policies had taken over 4 million.

OUR READING

The overhauls were not too rare or too careless. For most items, the chance of failing simply did not rise with age.

Source: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978

Nowlan & Heap (1978), section 1·1. The authors write that the cuts came with no loss of reliability. Both programmes are airline examples from the report, not a controlled comparison: the DC-10 is a later and different aircraft. The callout paraphrases the report's own explanation.

THE NUMBERS

Six patterns, one bathtub

While overhaul intervals were being stretched, United Airlines plotted, for many aircraft components, the chance that a unit which had reached a given age would fail in the next interval. The curves fell into six patterns.

SHARE OF THE COMPONENTS ANALYSED, BY FAILURE PATTERN (UNITED AIRLINES, 1978)



Only A and B, 6%, wore out at a clear age, mostly simple items such as tyres, brake pads and compressor blades. Another 5% grew steadily more likely to fail. The other 89% had no wearout zone, so no age limit could improve them.

OUR READING

The most common pattern starts with failures right after installation. For it, the riskiest time is the start, not the end.

Sources: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978; National Aeronautics and Space Administration (NASA), 2008

Exhibit 2·13 and section 2·8. Shares of components, not of failures; the report gives neither their number nor the years. NASA's guide (2008) cites a Swedish study (1973) and a US Navy one (1982): with the airline data, 77–92% of failures “random”, not age-related; the Navy found pattern B in 17%.

THE MODEL

Three questions, four tasks

Nowlan and Heap start not from the part but from what its failure does. The decision runs in two steps: first the consequence, which sets what a task must achieve, then the tasks in a fixed order of preference.

Ask of each failure

Would the crew notice it? If not, the function is hidden and needs a check.

Could it harm safety? Then a task must prevent every case, or the design changes.

Does it stop operations? Then a task must cost less than the loss.

Then try, in this order

Inspect for signs of a coming failure

Rework at an age limit

Discard at a life limit

For hidden functions: a check that finds failures

An inspection works only if a coming failure can be seen, defined as a limit and found in time, like a crack growing at a known rate or a brake pin worn below 0.25 inch. If no task passes, an evident failure without safety risk gets no scheduled task.

OUR READING

“Run to failure” is a decision with a reason written next to it, not a gap in the plan.

Sources: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978; National Aeronautics and Space Administration (NASA), 2008

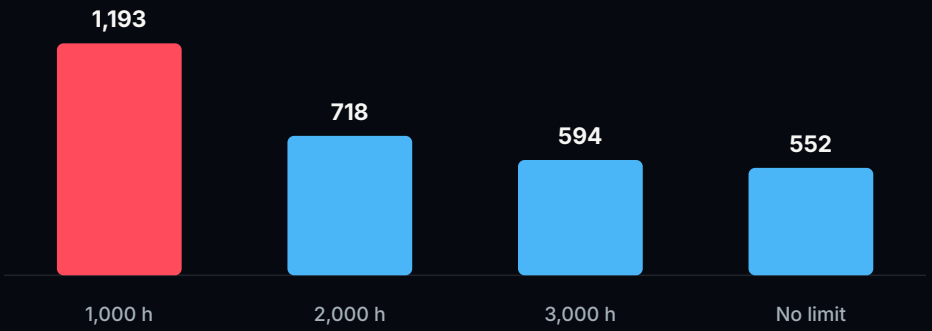
Exhibits 4·2 and 4·3 and sections 3·1–3·4 of Nowlan & Heap (1978); the wording is the editors'. The brake pin is one of United Airlines' task cards in Exhibit 3·2. NASA's guide (2008) keeps the same logic and names run-to-failure “a conscious decision”. Risk ranking with FMEA is in No. 28.

WHAT THE RESEARCH SAYS

What an age limit costs the shop

The report's worked example is the Pratt & Whitney JT8D-7 engine of United's Boeing 737s, from 58,432 operating hours between May and July 1974. Without an age limit an engine lasted 1,811 hours on average. The authors then computed the shop load under three overhaul limits.

ENGINES SENT TO THE SHOP PER 1,000,000 OPERATING HOURS, FAILED PLUS SCHEDULED, BY OVERHAUL LIMIT (1978)



A limit of 2,000 hours would bring about 135 fewer failures but 166 more engines into the shop. It pays only if a planned overhaul costs less than 45.1% of a failure repair, or if failures bring other losses. For complex items the authors add that overhaul often raises the failure rate, by bringing back the early failures of a fresh unit.

OUR READING

An age limit always sends more units to the shop. The question is whether the failures it saves are worth that.

Source: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978

Exhibit 3·3 and section 3·2; the columns round the report's totals (1,193.3; 717.9; 593.5; 552.2). These are the authors' calculations from one engine's survival curve, not counts of real overhauls. With no limit all 552 are failures; at 1,000 hours 825 of the 1,193 are planned removals.

HOW IT IS MEASURED

What “a life of 2,000 hours” means

Nowlan and Heap list six things the same sentence can mean: no engine fails before 2,000 hours; no critical failure before then; half fail before; the average failed engine is 2,000 hours old; the risk is constant until then; or one part has a 2,000-hour limit.

0.692
of the engines reached 1,000 hours

0.053
of all engines failed between 1,000 and 1,200

0.077
the risk for an engine that reached 1,000 hours

The last figure is the one that guides maintenance: the chance of failing in the next interval for a unit that has survived so far, .053 divided by .692. Plotted by age, it shows whether failures pile up. A failure rate or an average life does not, and the authors give it a minor role. NASA's guide adds a rule for parts watched for wear: once a reading passes the alert limit, check three to four times as often, for example every three to four weeks instead of quarterly.

OUR READING

Count failures by the age of the unit since its last overhaul, not only by month. Only then can a curve be drawn.

Sources: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978; National Aeronautics and Space Administration (NASA), 2008

Section 2·7 and 2·8 of Nowlan & Heap (1978), the JT8D-7 engine; section 4·1 of NASA's guide (2008). The callout is the editors' reading. MTBF in the site's maintenance planner is a failure rate: useful for intervals and costs, silent on which task fits. OEE is in No. 48.

TOOL OF THE ISSUE

A card for each task

One card for each task in the maintenance plan, to say why it is there. The Maintenance Planner keeps the tasks, their intervals and the breakdowns per asset; the card adds the reason, and the date to look at it again.

01	**Function and failure**	what it must do, with a limit, and how it fails to
02	**Would anyone notice?**	if not, it is hidden: plan a check that finds the failure
03	**Consequence**	safety, stopped work, or only the repair
04	**Warning sign and lead time**	what shows it coming, and how long before it fails
05	**Task and why this interval**	inspect, rework, discard, find, or run to failure
06	**Failures by age, next review**	hours since last overhaul at each failure; the date to decide again

Sources: F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978; National Aeronautics and Space Administration (NASA), 2008

The card is the editors' proposal, built on the decision questions and task criteria of Nowlan & Heap (1978) and on NASA's guide (2008); it is not a tested instrument. Reviewing tasks as failure data arrive is what the report calls age exploration.

Open the tool: Maintenance Planner stivencatalyst.com/tools/maintenance-planner/

SOURCES AND METHOD

Every figure has a source.

The figures in this issue come from the sources below. The year shows how recent each one is.

Reliability-Centered Maintenance (report AD-A066579)
F. Stanley Nowlan & Howard F. Heap, United Airlines, for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), 1978
https://apps.dtic.mil/sti/citations/ADA066579

Reliability-Centered Maintenance Guide for Facilities and Collateral Equipment
National Aeronautics and Space Administration (NASA), 2008
https://www.nasa.gov/wp-content/uploads/2023/06/nasa-rcmguide.pdf

EDITORIAL METHOD

Each figure was checked for its year, its publisher and what it measures, in the full text where it could be opened. A source read only in a summary, an abstract or excerpts is marked “via”. A figure not confirmed in what was read is marked so on its page, or left out. The editor's interpretation is marked “Our reading”.



MANAGEMENT REVIEW

Management without theatre.

Every issue, one management question, checked against the best research.

ALL ISSUES

stivencatalyst.com/magazine/management-review.html

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Edited by Stiven Janaqi, who answers for it; “the editors” in this publication means him. Its texts, translations, layout and the checking of figures against their sources are done in working sessions with Claude, an AI model by Anthropic.
stivencatalyst.com/how-this-is-made.html