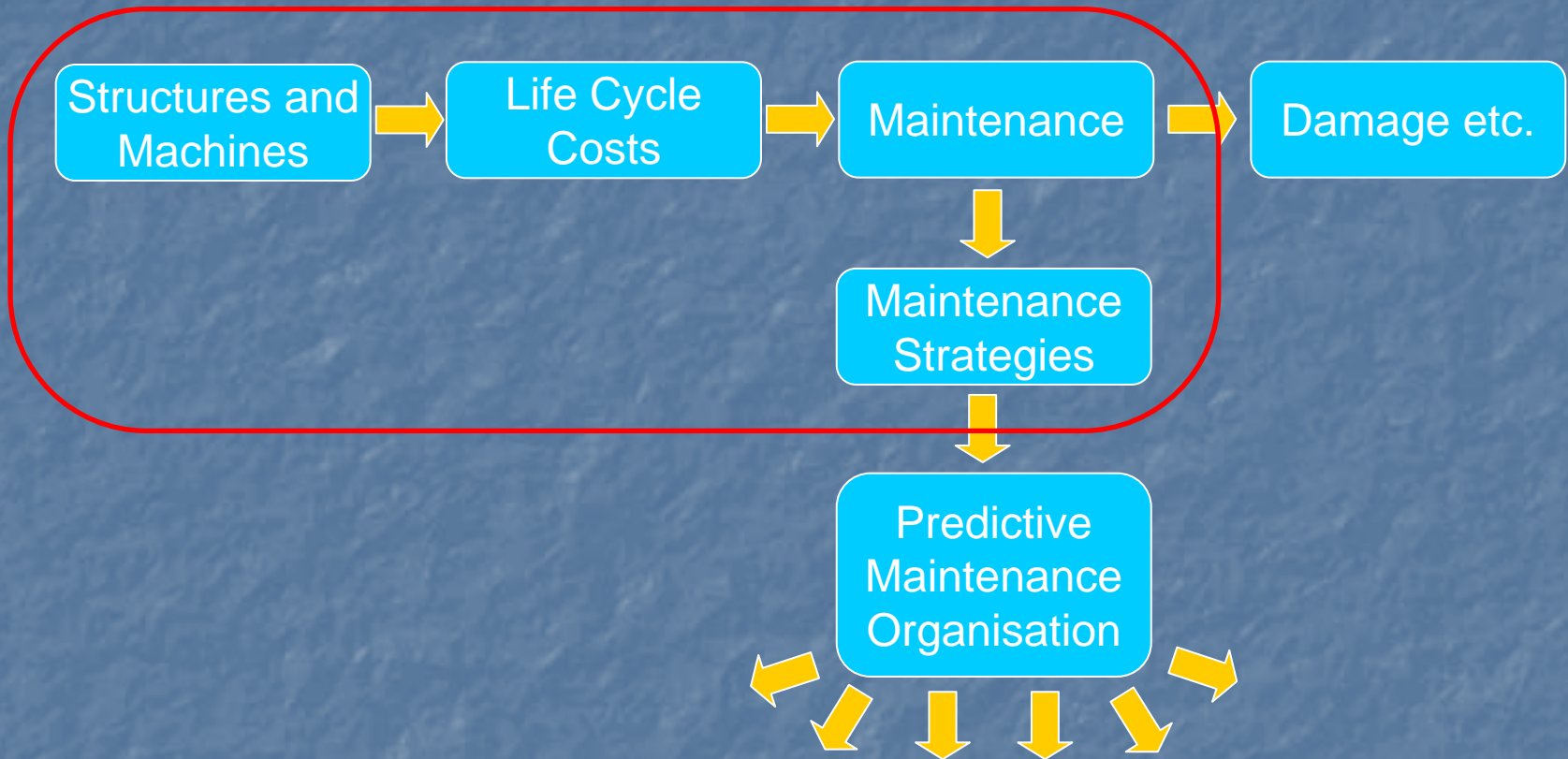


Lecture 2 – Importance of Maintenance in the Life Cycle of Structures and Machines

Lecture Overview

- Introduce the types of machines and structures to be considered.
- Investigate Life-Cycle Costs and importance of maintenance.
- Discuss alternative maintenance strategies.

Module Map



Structures and Machines



Structures



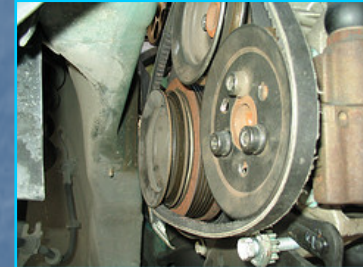
Structures and Machines

Machines

Drivers



Intermediate Drives

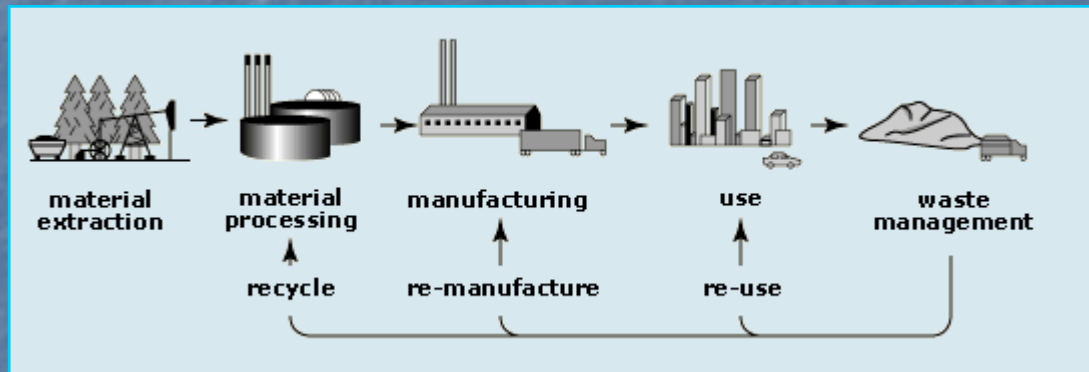


Driven Components



Life Cycle Costs

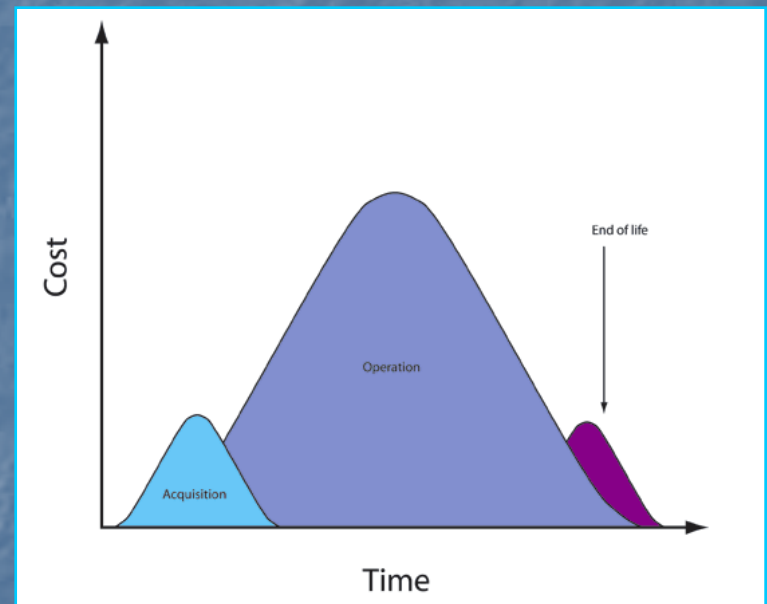
- Life cycle of a product generally involves five distinct phases.



- Life cycle costing (LCC) is a technique to establish total cost of ownership of a product.
 - Structured approach which can be used to produce spend profile over product's life-span.

Life Cycle Costs

- The cost of ownership of an asset or service is incurred throughout its whole life and does not all occur at the point of acquisition.
- Principles of LCC can be applied to both complex and simple products/projects.



Typical product spend profile

Life Cycle Costs

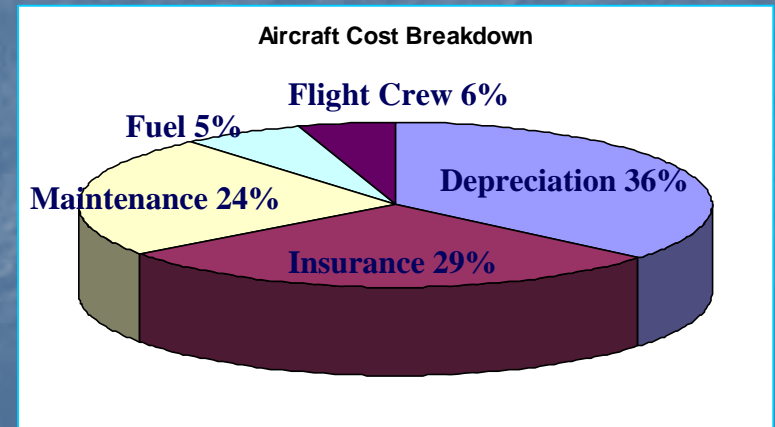
- One-off costs
 - Procurement
 - Implementation and acceptance
 - Initial training
 - Documentation
 - Facilities
 - Transition from supplier
 - Changes to business processes
 - Withdrawal from service and disposal
- Recurring costs
 - Retraining
 - Operating costs
 - Service charges
 - Supplier management costs
 - Changing volumes
 - Downtime/non-availability
 - Maintenance and repair
 - Transportation and handling

Importance of Maintenance

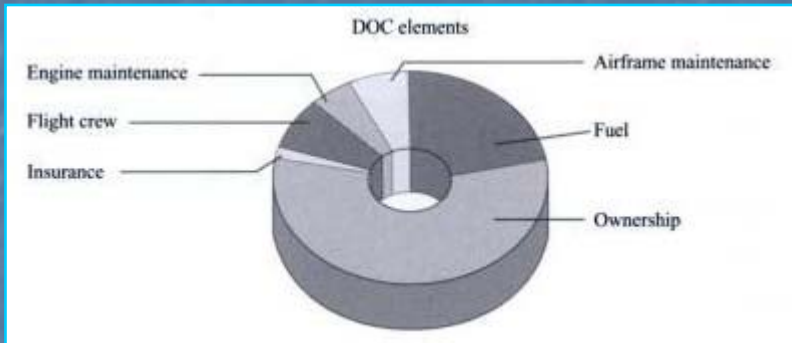
- Depending on industry, maintenance costs can represent between 15 and 60% of production.
- Estimated that one-third of all maintenance costs is wasted due to unnecessary or improperly carried out maintenance. (~\$60bn out of \$200bn).
- Difficult to compete with countries like Japan who have more advanced maintenance strategies.

Importance of Maintenance

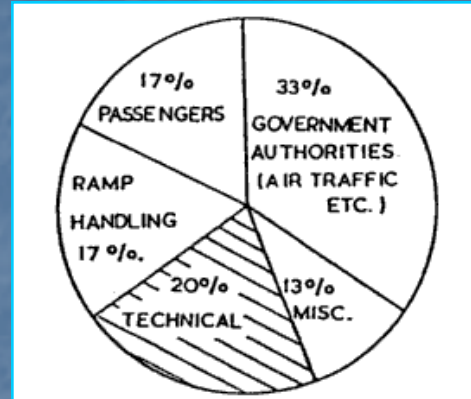
- Maintenance spend is significant cost driver in today's aircraft industry:
 - 70m hours per annum, equivalent to £7bn/annum, is invested in civil aircraft maintenance.
 - 6000 man-hours per aircraft costing about US\$5.5 billion/year for the US air force and navy.
 - In 1993, inspection effort on T-38 cost US\$29 per flight hour and for the F-18 US\$88 per flight hour.
- Maintenance becomes even more important with ageing aircraft problem.



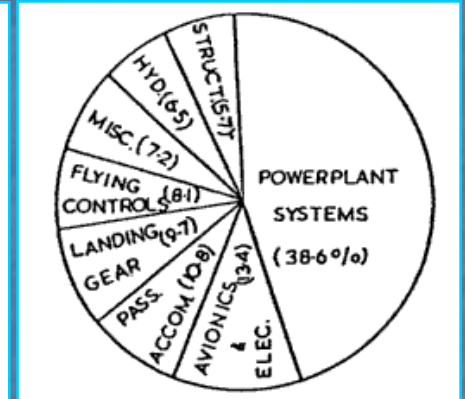
Importance of Maintenance



Boeing 747-400 Direct Operating Costs, 1993



Civil aircraft delay causes



Technical delay causes

Source: *Introduction to Aircraft Design (chapter on Why do aircraft cost so much?)*, J.P. Fielding

- \$59bn in maintenance costs made up 14% of US Department of Defence budget.

Maintenance Strategies

- There are essentially three main approaches to maintenance of structures and machines.
 - Strategy 1 – Run-to failure maintenance.
 - Strategy 2 – Preventive maintenance.
 - Strategy 3 – Predictive maintenance.

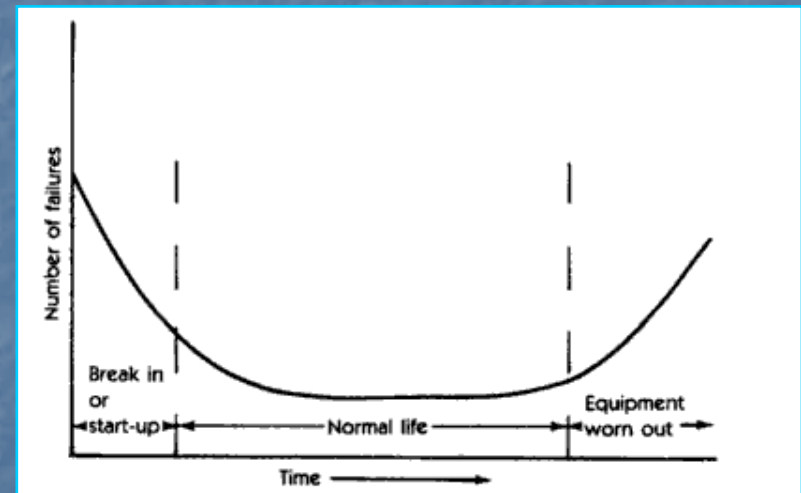
Maintenance Strategies

- Run-to-failure Maintenance.
 - If it ain't broke, don't fix it – sounds reasonable.
 - No money spent on maintenance until machine or structure stops working.
 - Also known as reactive maintenance.
 - Most expensive maintenance method.
 - High spare parts inventory
 - High overtime costs
 - Long machine downtime
 - Low production availability
 - Spare machines required
 - Knock-on effects on other machines and overall loss of production.

Maintenance Strategies

■ Preventive Maintenance.

- Many definitions – all maintenance is time-driven.
- Based on elapsed time or hours of operation.
- Time between maintenance decided on statistical data.
- Generally based on bathtub curve – not reliable in many cases.
- Treats all similar machines as same.
- Scheduled maintenance costs are around one-third of run-to-failure costs.



Maintenance Strategies

- Predictive Maintenance.
 - Also many definitions – common ground is that regular monitoring of actual mechanical condition of machine or structure and other indicators of operating condition provide data for maximum interval between repairs.
 - The NDT techniques are only part of the predictive maintenance strategy. The actual operating condition of the machine is used to optimise total plant or structure operation.

Maintenance Strategies

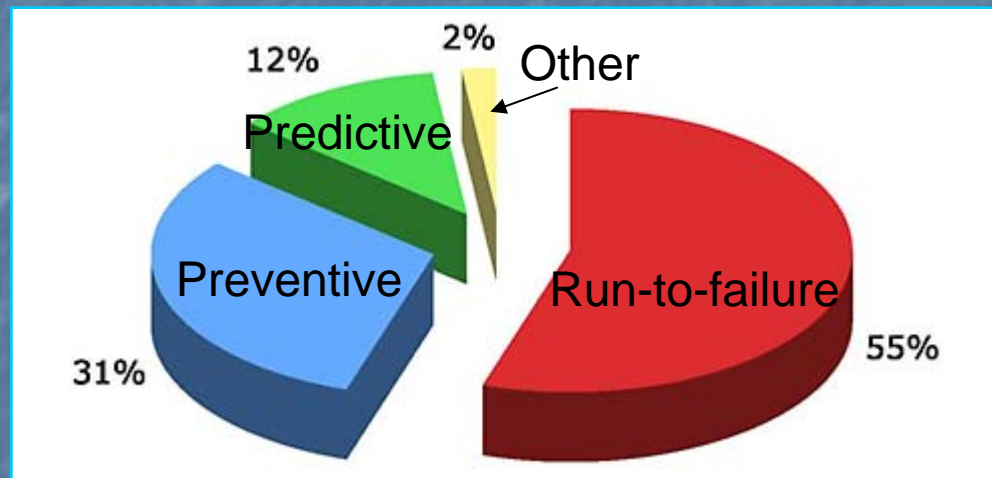
- Predictive Maintenance.
 - Costs
 - design of system
 - monitoring equipment
 - staff training
 - labour costs for measurement and analysis.
 - Savings
 - elimination of unexpected breakdowns and secondary breakdowns
 - increased time between services
 - reduction of spare part stock
 - reduction in insurance premium

Maintenance Strategies

- Predictive Maintenance.
 - Benefits
 - increased reliability
 - increased quality
 - increased profitability
 - increased productivity
 - NDT tools will vary depending upon machine and structure and types of likely damage.

Maintenance Strategies

- Still plenty to do:

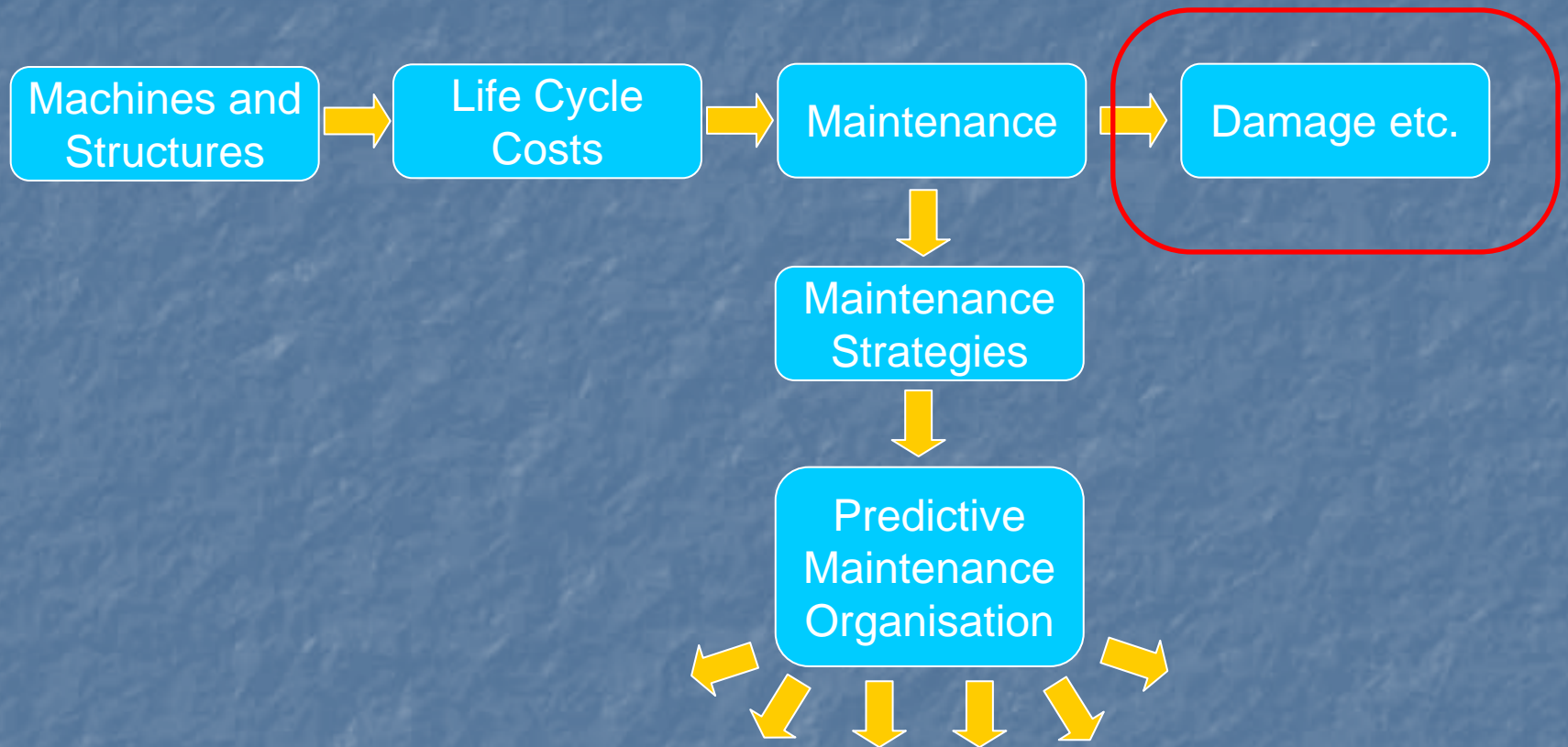


Maintenance strategy in average facility

Lecture Review

- Shown the types of machines and structures that require maintenance.
- Looked at Life-Cycle Costs of products and given examples of proportion of total costs due to maintenance.
- Discussed alternative maintenance strategies and pros and cons.

Next Lecture



Next Lecture

- Investigate the reason for maintenance – damage.
- Consider sources of damage – manufacturing and service-induced.
- Failure modes.
- Common machine problems.
- Damage associated with materials.