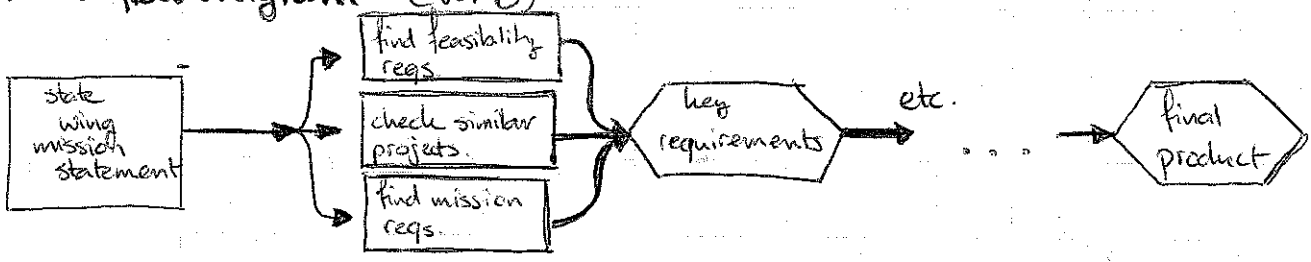
- mission need statement
  - tells what the product needs to do

- project objective statement
  - tell what the product is going to deliver.

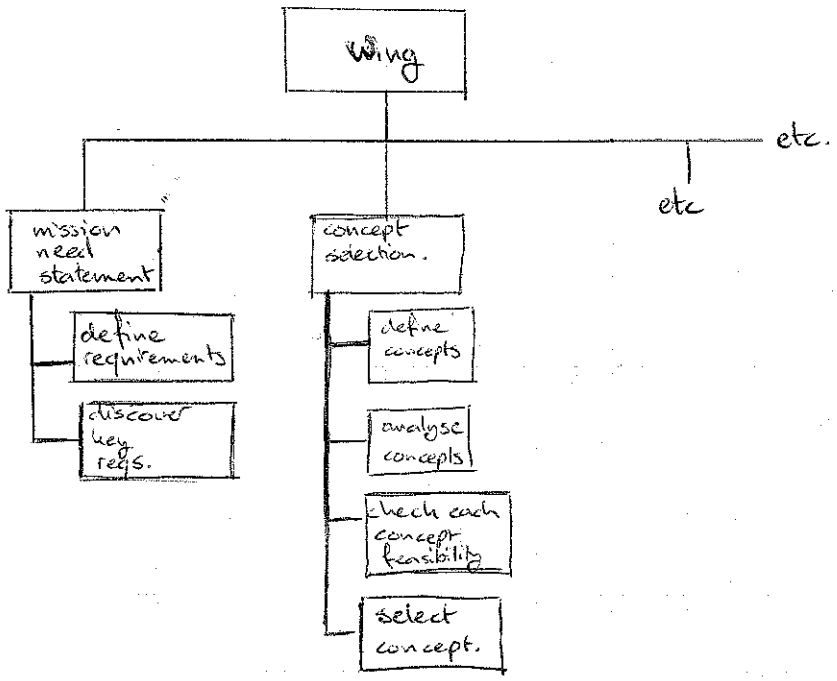
- work flow diagram (WFD)



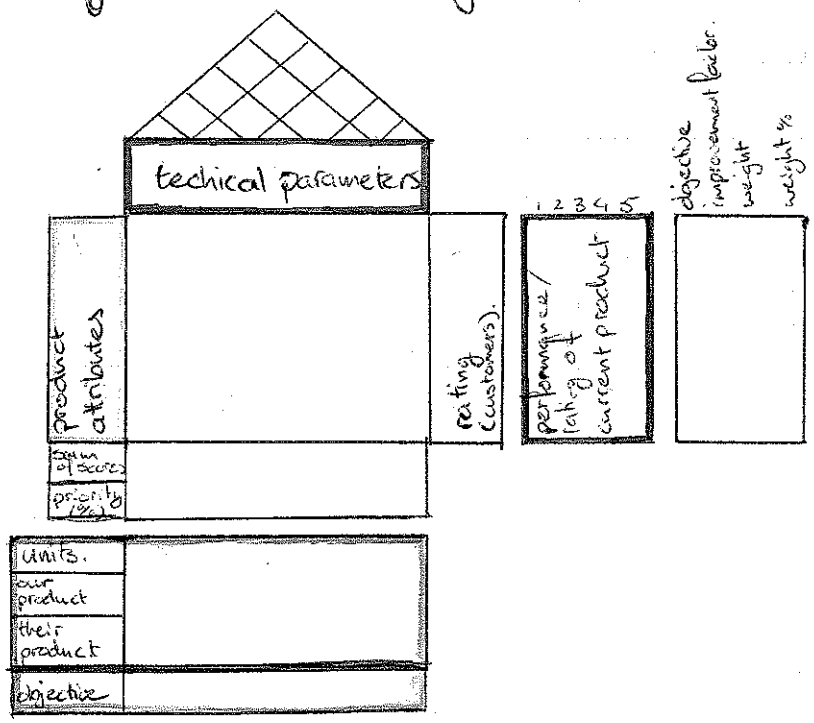
* note that one should make a clear difference between tasks (expressed with verbs) and inputs / outputs (expressed with nouns).

→ be careful with loops in a WFD, since you cannot go back in time.

- Work Breakdown Structure (WBS)
  - the WFD and the WBS should be very closely linked
  The WBS organises all tasks found in the WFD into a tree.



- Quality Function Diagram (QFD).



- Design Option Tree
  - Note that the design option tree is always an **OR-tree** → each branch should give a different solution for the same function.

  The design option tree is NOT a list of (technical) parameters!

- Trade-Off
  - use of trade-off table.

	parameter 1		parameter 2		parameter 3		solution score
weighting factor (1-10)	10		7		8		
	raw	wtd	raw	wtd	raw	wtd	
option 1	5	50	5	35	6	48	133
option 2	7	70	4	28	5	40	138
option 3	4	40	5	35	8	64	139
option 4	3	30	8	56	6	48	134

} the best overall design is chosen.

- Risk Mapping
  - identifying risks of the particular phase. Try and maintain some level of detail → look through the eyes of someone that must make decisions based on risk mapping.

- the actual risk map will look as follows:

step (1)

		consequence (ordinal)	probability (ordinal)
1	stall	critical	frequent
2	structural failure	catastrophic	improbable
3	fuel leakage	critical	improbable
4	bird strike	severe	probable
5	lightning strike	severe	probable.

step (2) (the actual map)

	frequent	probable	improbable
catastrophic			3
critical	1		2
severe		4, 5	

Decision methods.

we distinguish 'ordinal' and 'cardinal' methods, that also called 'qualitative' and 'quantitative' methods.

1) **ordinal methods:** do not require from decision makers anything more than that they rank the alternatives on an ordinal scale per criterion from 'worst' to 'best'

2) **cardinal methods:** the decision maker has to quantify the measure of satisfying a criterion on an interval scale (rating)

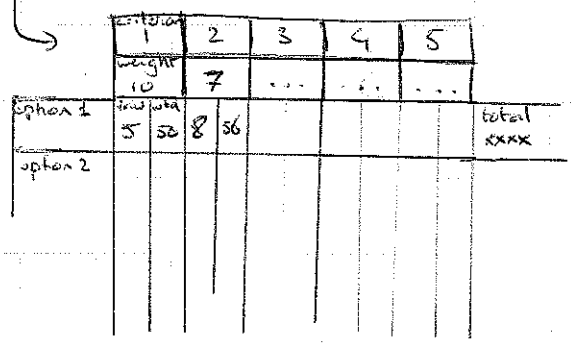
decision rules for

ordinal:

- majority rule
- Copeland rule
- rank-sum rule
- lexicographical rule
- datum method (group of people)

cardinal:

- weighted objectives method



Reliability, Maintainability, Availability and Safety.

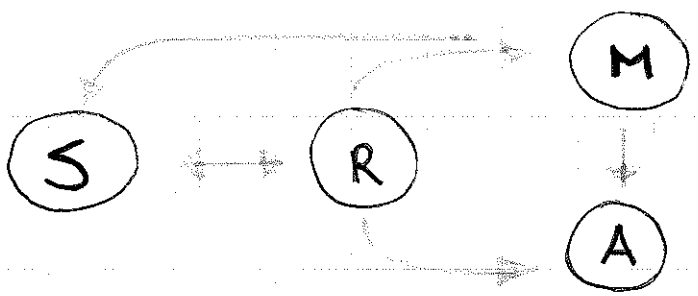
definitions.

- **Reliability (R)**; the probability that a system will perform in a satisfactory manner under specified opt. conditions in a given period of time.

- **Maintainability (M)**; the ease, accuracy, safety and economy in performance of maintenance actions.

- **Availability (A)** ; the degree/percent/probability that a system will be available when required for use.

- **Safety (S)** ; the freedom from hazards



Probability; $P(A \cup B) = P(A) + P(B)$

(mutually exclusive events ↑)

Bayes Rule; $P(A|B) = \frac{P(B|A) \cdot P(A)}{\sum_i P(B|A_i) \cdot P(A_i)}$

probability distribution (graphical display of reliability)

- types of distributions:

1) Continuous probability distributions
   - (negative) exponential
   - normal
   - Weibull
   - log-normal
   - gamma.

2) Discrete distributions.
   - Binomial
   - Poisson.

definition: MTBF = Mean Time Between Failure

(PM&SE tool) FME(C)A = Failure Mode, Effect and Criticality Analysis

→ note: FME(C)A adds ranking to FMEA

(PM & SE tool) FTA = Fault Tree Analysis.

* symbols for FTA:

- (A) = single event
- <A> = multiple events.
- (A) = OR-gate
- (A) = AND-gate.

Note: the tree starts with a 'top event', displayed in a rectangle. eg: engine start failure

note: (FTA) always determine the minimum cutset → the combination of events that leads to the top event.

- an OR-gate increases the number of cut sets.
- an AND gate increases the size of a cut set

Maintainability:

abbreviations:

- MTTR = Mean Time To Repair
- MPMT = Mean Preventive Maintenance Time
- MTTM = Mean Time To Maintenance
- MDT = Mean Down Time

Verification and Certification

(I) Verification methods.

1 - review of design

2 - inspection

3 - analysis

4 - Test

acceptance testing ^

note: verification shall be done on the lowest hardware and contractor level possible. to keep it as least complicated as possible.

* an acceptance test is a subset of all the tests carried out on the product during development. The conditions used however, are more benign.

Product support & Maintenance

(I) Product support elements:

1- maintenance planning (specified tasks and frequency).
2- manpower & personnel (quantity and skill required)
3- support & test equipment (required equipment)
4- supply support (initial & spare parts).
5- training & training devices (-)
6- technical documentation (identification, recording, revision).
7- facilities (identify required facilities.).

note: development of the maintenance program occurs during full scale development of the product.
The maintenance plan and specification of product support elements occurs during the design definition. (one stage earlier)

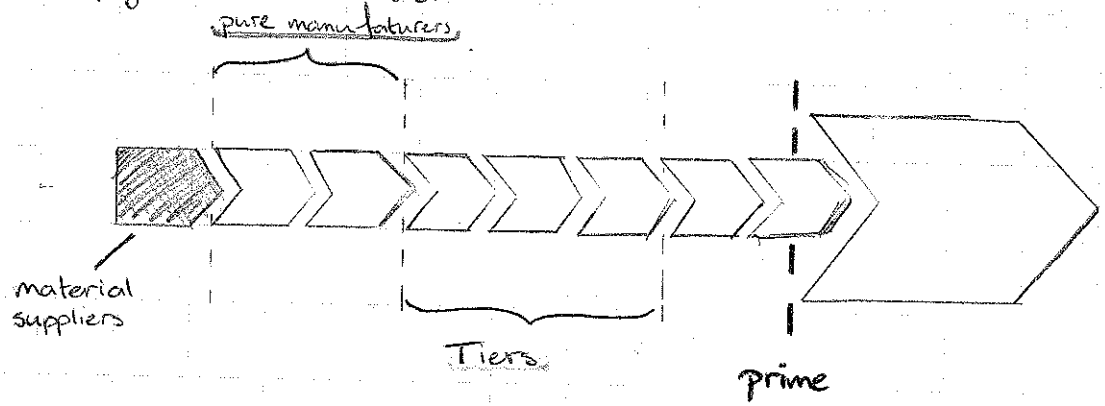
definition: Safety-Critical → failure of part or system may cause serious injury or death to human beings.

chapter 10 - Design for Production

production: all activities needed to come from a recorded design to a product that can be delivered to the customer

- 3 core processes running during product development
  1 - Marketing
  2 - Product design
  3 - Production

* supply chain reminder



Supply Vs. Demand

In production, there are two types of processes (traditionally) →
1) Recurring
2) Non-Recurring (only once)

* Also, Production is developed in close relation to product design itself

optimum for production:

→ 1) **Quality**; product quality within specifications.
2) **Time** ; delivery reliability
3) **Money**; within cost limits.
4) **Volume**; flexibility
5) **Law** ; obedience to (local) law and reg.

definition: **Lean thinking / manufacturing**

→ minimising / eliminating waste

All types of waste:

- **Direct waste**:
  1) Overproduction
  2) Waiting Time
  3) Work in Progress (WIP) or Inventory
  4) Processing Waste
  5) Transportation.
  6) Movement or Motion
  7) Rework

- **Indirect waste**:
  8) Underutilizing people / personnel

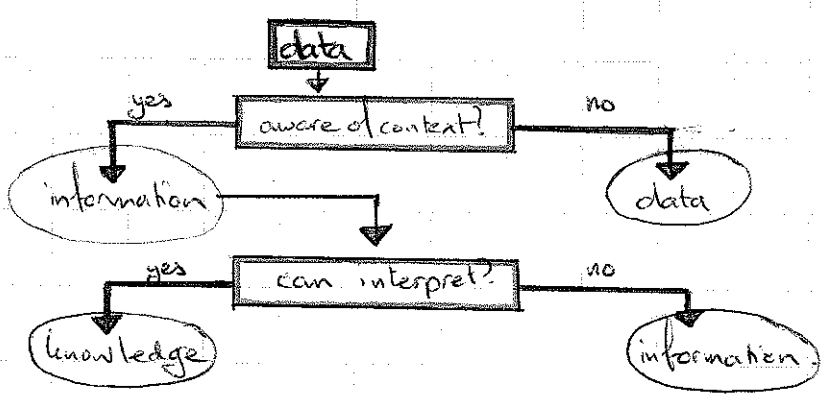
Chapter 13 - Documentation & Configuration Management

- configuration items → has the characteristics:
  1) Fit
  2) Form
  3) Function
  4) Flow

- configuration management → two types of usage:
  1) internal → enable cost effective running of program.
  2) external → ensure customer gets what he wants.

Documentation → used to control the lifecycle & record knowledge.

types:
1) Requirements Definition
2) Specifications
3) Planning
4) Drawings
5) Reports
6) knowledge models.



- document numbering

  documents within Euro-ENAER are designated as:

  ↳ doc no. = = EE-group [#code[#id[#id]]][-part no. [-no[-no]]].issue]

- creation of design information

  - three stages: (1) Order → (2) Preparation → (3) Check

Knowledge Based Engineering (KBE)

definition: the use of advanced software techniques to capture and re-use product and process knowledge.

- product model
  - what → list of product components.
  - why → reason for selection/configuration.
  - how → build-up of process.

- the O-O approach → *(object-oriented)
  - identity: the fact that data is discretized into distinguishable entities called objects.
  - classification: objects with the same data structure (attributes) and behaviour (operations) are grouped into a class.

- polymorphism ; the same operation may behave differently on different classes.
- inheritance ; the sharing of attributes and operations among classes based on hierarchy.

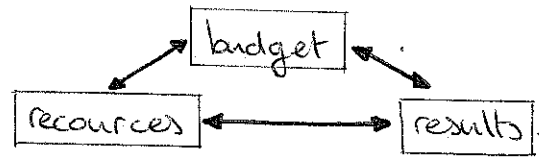
chapter 14 - Concurrent Engineering

definition: The concurrent running of seperate phases during the [redacted] product definition trajectory. It's aim is to have designers take into account <u>all</u> aspects of the product [redacted] life cycle <u>from the start</u>

* concurrent engineering (CE) is not a recipe, but rather a phelosophy

chapter 15 - Project Management

- PM as risk management



- how to approach problems. ⟶

project plan:
1) work flow diagram / D&D logic.
2) work breakdown struct.
3) organogram. *
4) Gantt chart *

steps:
1) identify risk
2) analyse risk
3) prioritize and map risks
4) resolve risks.
5) monitor risks

} develop a risk management plan.

- define the project organisation:
  - who is paying
  - who is responsible
  - who brings in what competence.
  - what deliverable.
  - what money goes where

an important element is the Project Objective Statement (POS)
→ ± 25 words. The POS defines result, schedule and recources.

* Normally, the project manager puts the POS together with the major deliverables, milestones and budget limits in a document, which is distributed over project team members.

* Is / Is not - process.

- WBS - practical approach;
  do not use fancy comp. programs to draw from scratch!
  → use post-its first → different colours on large sheet of paper.

- Analyse Recourses
  check for under- or overutilization of recources and how parallel activities affect the available recources.

- Collecting Status information

  - decide how, how often and what kind of info should be collected/monitored.

A good tracking system collects status info on only 3 limited topics:

1) schedule status.
2) open issues.
3) risks.

- Close-out of the project

  - which elements were effective and which not?
  - is documentation complete?
  - improvements?
  -