Systems Engineering Tools

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Compiled with input from
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Burge Hughes Walsh Partnership

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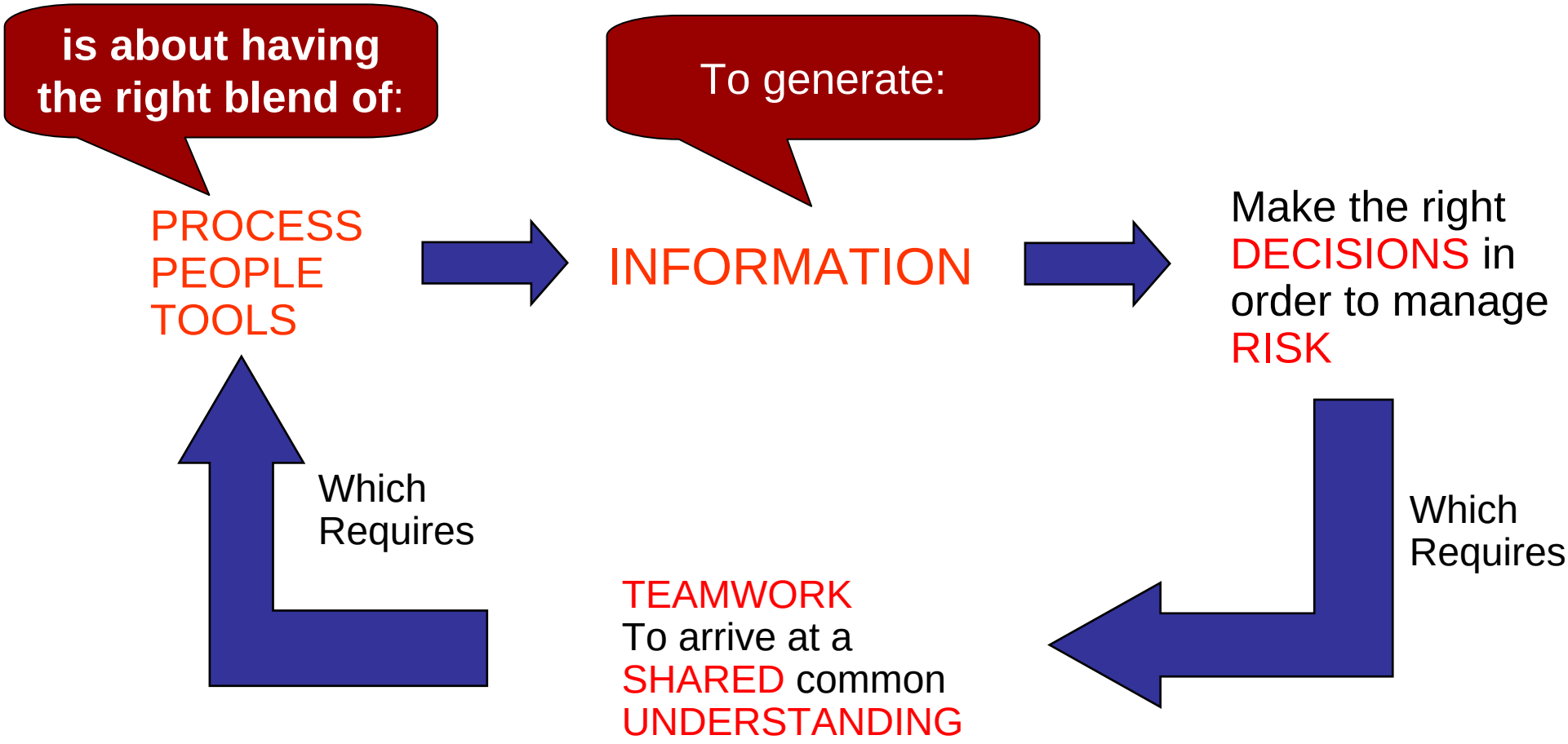
Systems Engineering in Practice



There is a fourth element to Systems Engineering which is the infrastructure to support the Processes, People and Tools and includes the buildings, the IT system, training etc.

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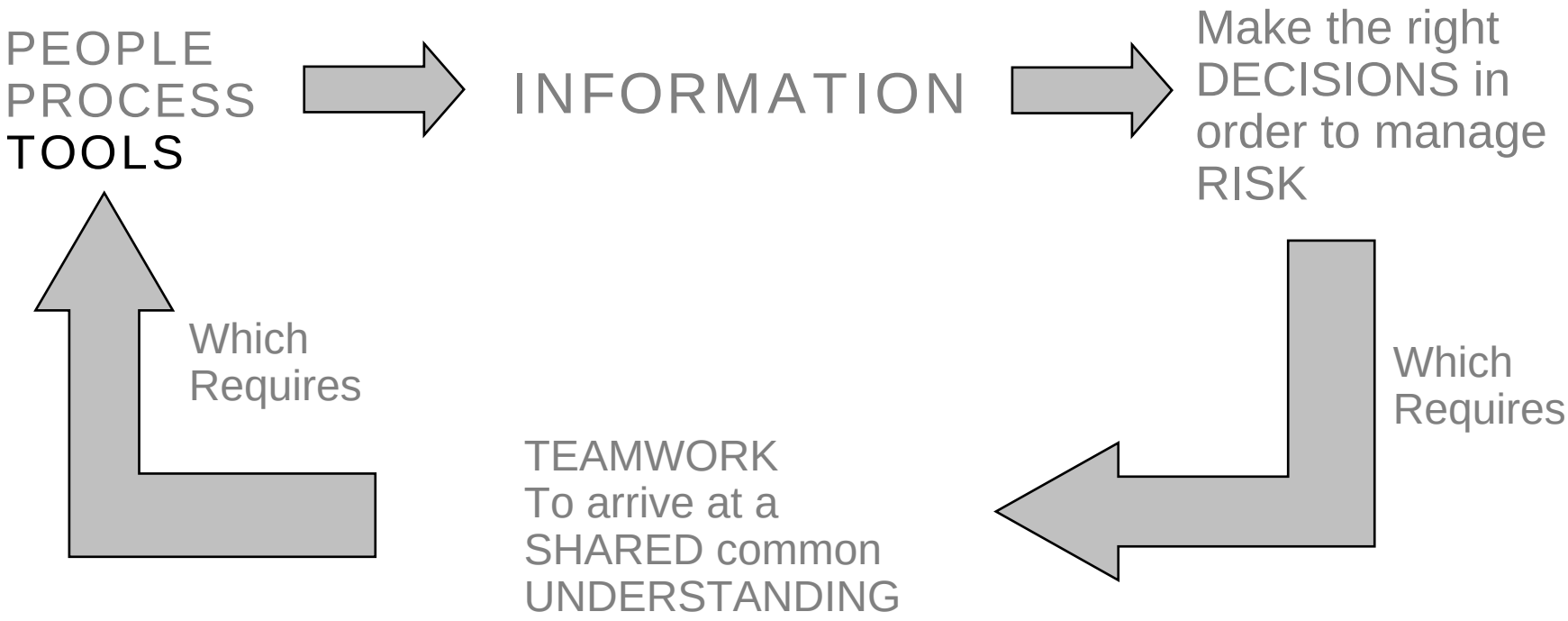
Tools – The Missing Ingredient



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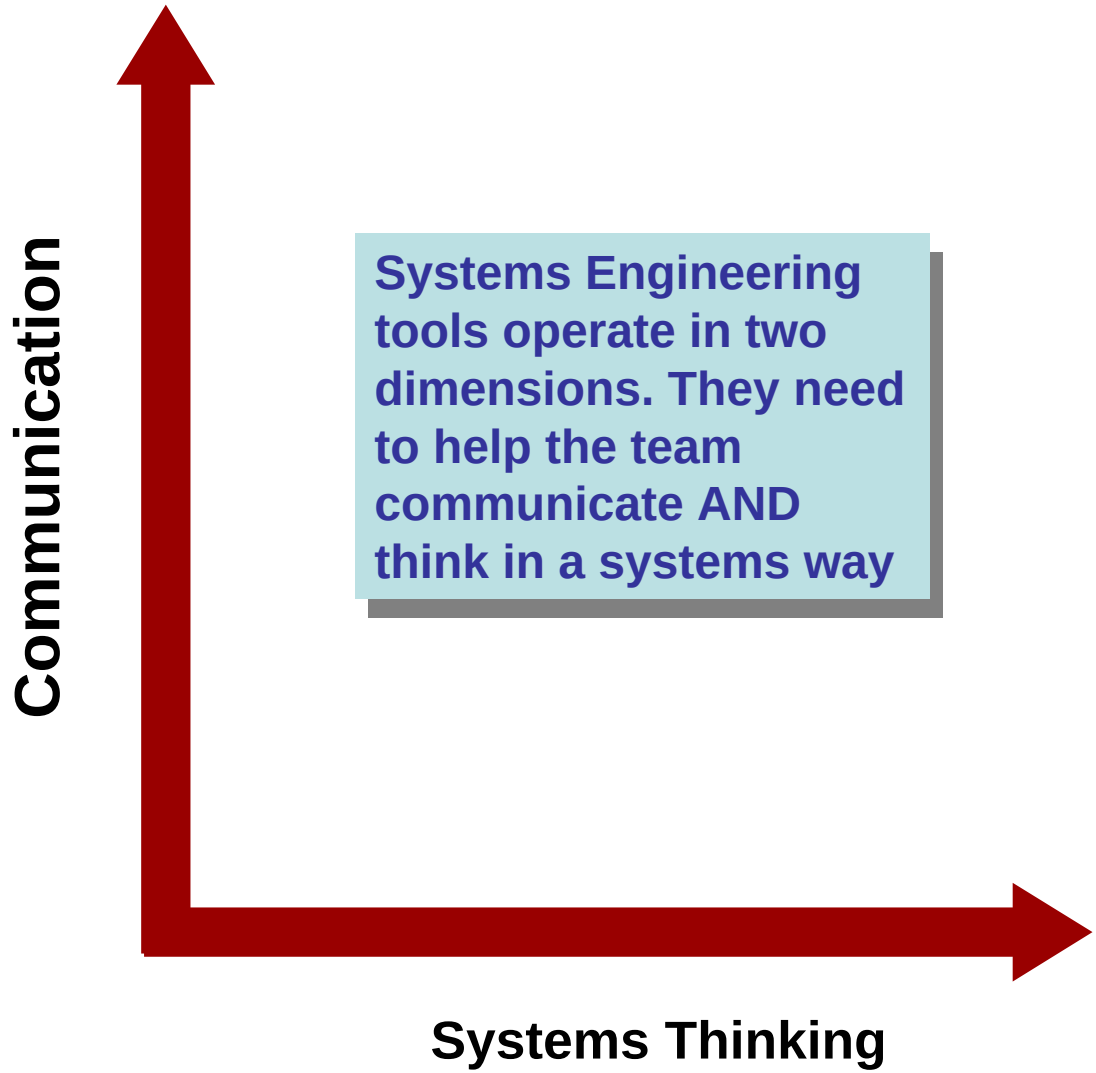
Two Dimensions



Systems Engineering tools operate in two dimensions. They need to help the team communicate AND think in a systems way

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Communication

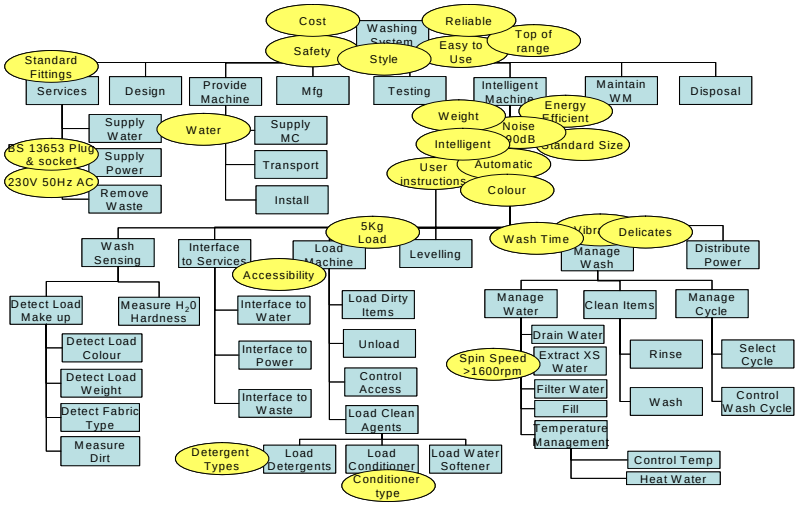
- For a multidisciplinary team to deliver they must be able to communicate with each other to share information and have a common understanding to avoid having different perceptions
- Specialist tools are necessary but can cause communication breakdown
- Therefore we need a set of tools that all teams members can use
- Therefore we need tools that can allow us to handle the complexity of the system/product but at the same time are simple enough for the whole team to use – we need generalist systems tools
- **Systems Engineering tools are primarily communication tools that allow different disciplines to explore systems issues, often by building abstract models. They are scalable, universal and above all simple**

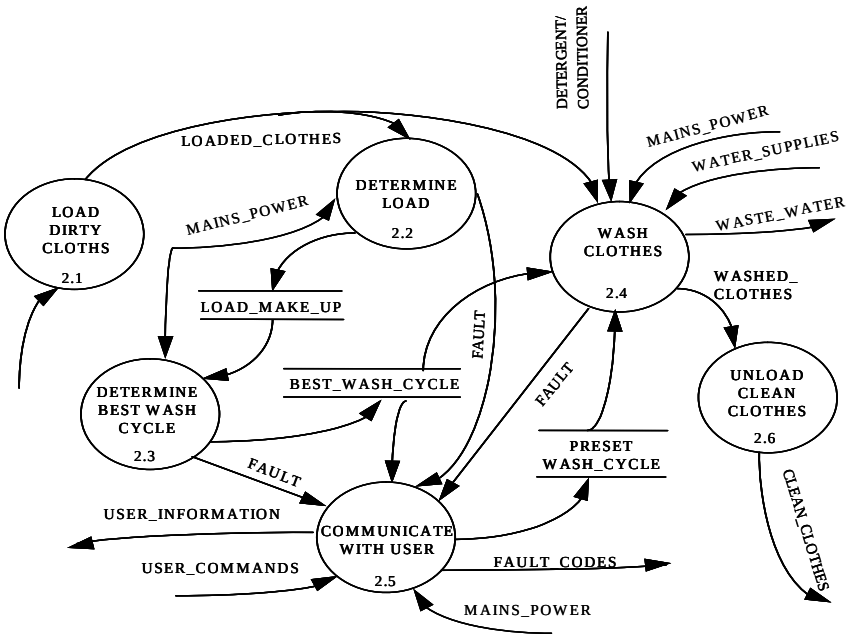
Systems Thinking

- Systems Thinking requires us to consider the whole problem together with its context– but how can we be holistic without getting bogged down in detail?
- Systems Thinking requires us to understand and appreciate the system structure and dependencies between elements (interconnectedness) of the system in order to predict potential emergent behaviour – but how can we do this without becoming confused by the complexity?
- Systems Thinking requires us to understand the system from the different perspectives of numerous stakeholders – but how can we achieve this and reflect the different views whilst combining them into a comprehensive understanding of the overall system?
- **Systems Engineering (thinking) tools make use of diagrams to build models of situations/systems**

Systems Tools Build Models to Help the Team reach a Common Understanding

- Systems Engineering makes great use of MODELS to look for structures, relationships and dependencies at an abstract level to help predict behaviour at the real level





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Systems Tools are NOT Software Tools

- Most systems engineering tools are not software based they are simple tools that generate their maximum benefit by getting the team to stand around a white board or flip chart - helping the team to THINK
- Once the thinking is done the output is often captured using software tools
- Systems Engineering is about applying systems thinking – the thinking is done by the people

The Tools

- The following slides present a few systems engineering tools organized around the basic systems engineering process

  - DEFINE REQUIREMENTS: Understand the problem – what does the customer want
  - CREATE SOLUTION: Determine a system concept - develop a conceptual solution that meets the customer requirements
  - OPTIMISE SOLUTION: Search for the robust optimum – make as good as it can be
  - VERIFY SOLUTION – confirm that the solution meets all the expectations

Define Requirements

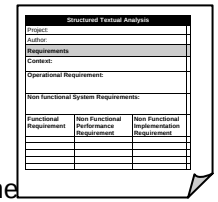
Stakeholder Analysis

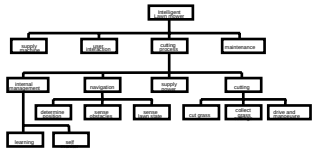
Identify customers and Elicit requirements

Stakeholder Requirements

Textual Analysis

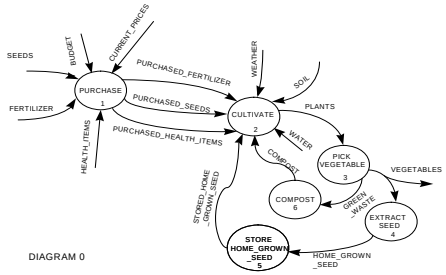
Capture stated customer requirements and determine Operational, Functional and Non-Functional Requirements





Viewpoint Analysis

Determine system functionality (Y = f) and structure



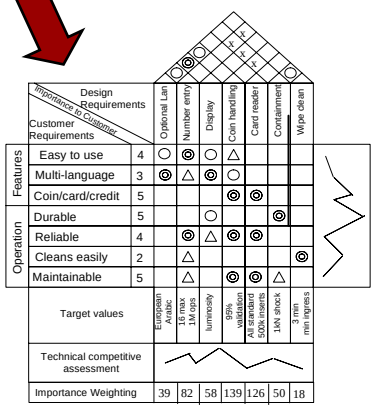
Functional Modelling

Develop a functional model of the system Y= f(x) to identify logical interfaces and Functional dependencies

Manage Requirements

Generate acceptance criteria

Acceptance Test Spec

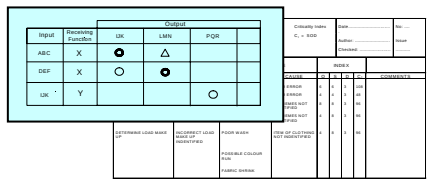


Quality Function Deployment 1

Correlate and cross check requirements for completeness and consistency

Sensitivity Analysis & FFMEA

Assess the functional sensitivity and potential functional failure modes to identify potential emergent functionality and risk



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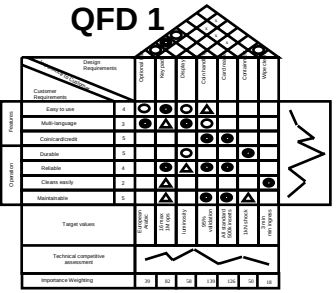
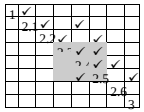
Create System Concept Design and Architecture



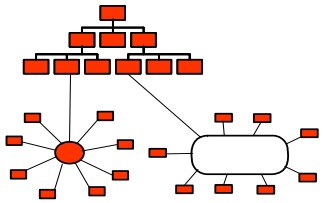
Function Means Analysis

Identify means of achieving functionality



N^2 Analysis

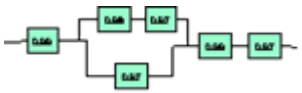
Assess degree of natural functional binding and coupling to identify natural Architecture and system redundancy



Architecture Modelling

Determine and model system physical architecture

Fault Tree Analysis

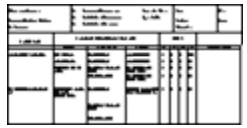


Reliability Model

Determine design reliability

DFMEA

Determine failure modes & mechanisms



QFD 2

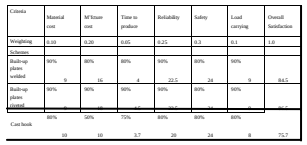
Requirements-concept solution compliance and determine sub system targets

Whole concept Selection

Determination of whole concept solutions

Pugh/Decision Matrix

Evaluate whole concepts against CTQs for further down-selection



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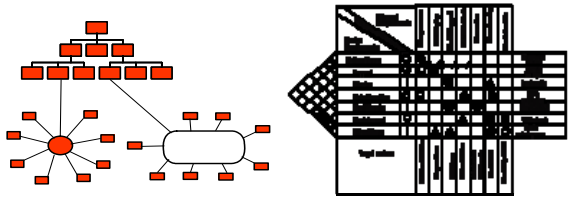
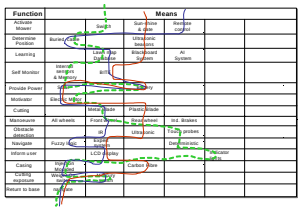
Optimise and Detailed Design

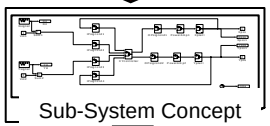
Architecture and Requirements

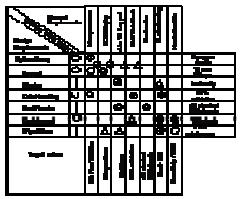




Sub-System Design

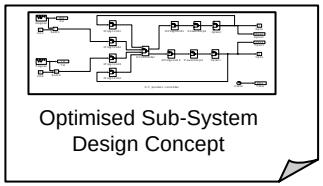
Determination of sub-system concept solutions

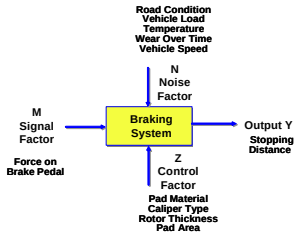




QFD 2 Level 2

Flow-down requirements-to Sub-systems

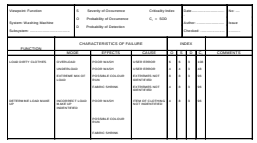




Establish Critical System Parameters

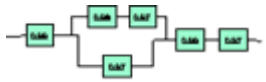
Identify control and noise Parameters of the sub system design

Design FMEAs



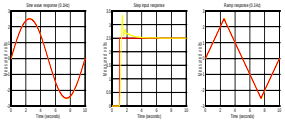
Identify sub-system and failure modes

Fault Tree Analysis

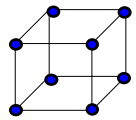


Reliability Model

Determine Transfer Functions



Simulation Studies



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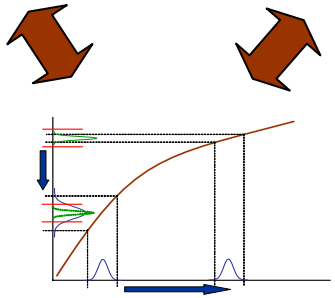
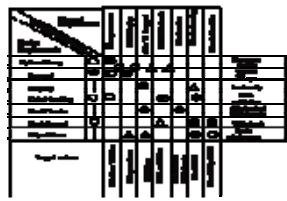


Parameter & Tolerance Design

Establish Y = f(x, x, ...x) and optimise sub-system design and assess robustness



QFD 2 Level 2

Complete QFD and flow-up requirements

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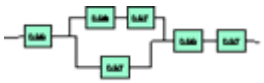
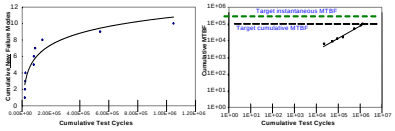
Verify System

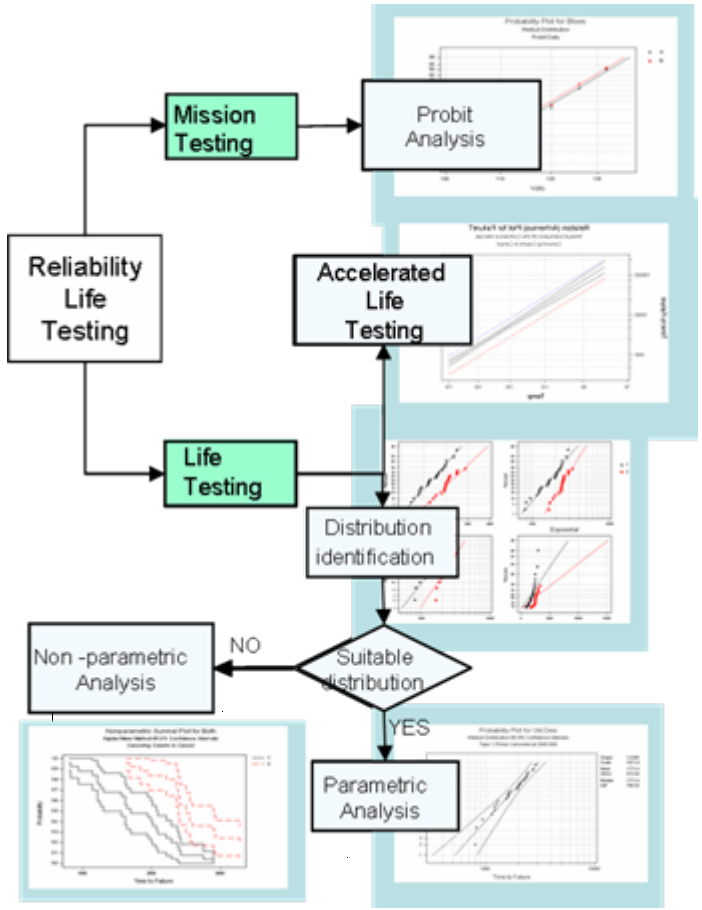
Reliability Model

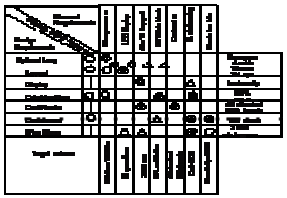


Crow & Duane Plots



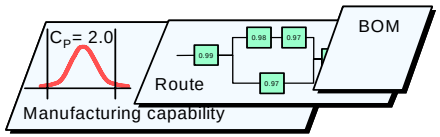
Reliability Growth Testing





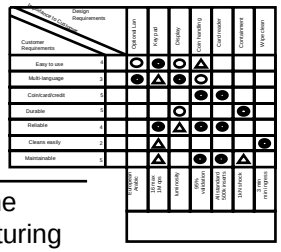
QFD 2 Level 2

Complete QFD and flow-up requirements



Capability Predictions

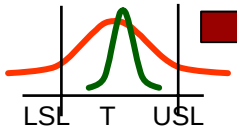
Determine robustness of design To manufacturing variation



QFD 3

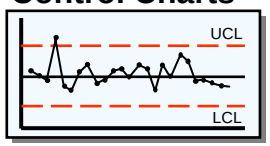
Determine Manufacturing System

Statistical Tolerancing

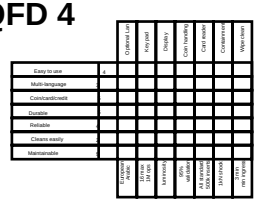


Define Statistical tolerances

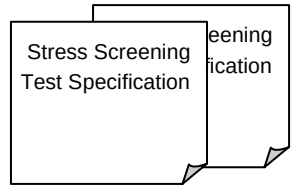
Control Charts



QFD 4



Plan Production control



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Summary

- Systems Tools about
  - Communication
  - Promoting systems thinking
- Systems Tools are scalable, universal, and above all simple

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