ECSE-211
Design Principles and Methods

Lecture 4: Documentation and Communication

Date: 18 January 2023

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Review - Last Lecture

- The Difficulty of Design
- The model of the Engineering Design Process
- Inputs to the EDP
- Identification – from the client needs to Requirements
- Outputs of the Requirements process

- Questions?

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Question 1

- Why is Design a difficult problem?

No unique solution - need identifying the best
No Formula to follow.
Exploration
Exploitation

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Question 2

- Why is a model of the design process necessary?

planning
reduce costs!

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Question 3

- What are the inputs to generation of the Requirements Document?

Client needs
previous projects
constraints

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Question 4

- Why is the Requirements Document needed?

helps structure the project
allows validation of client needs
keep track of what you want to achieve
provides the inputs to the System Model.

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Contents

- Why is Communication important in the Design Process?
- What is a Document?
- Why Document?
- The Structure of a Document

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Communication and the EDP

- Engineering design in the 21st Century is carried out by large teams of engineers
- These may be specialist teams covering a small part of a complete design project
- The teams may be organized hierarchically
  - A Design Team working at the System Level
  - Teams working at Component Level

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Communication and the EDP

- Teams may also be multi-discipline
- For example, the design of an electric vehicle involves
  - Electrical engineers
  - Communications engineers
  - Mechanical engineers
  - Thermal engineers
  - Power engineers
  - …

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Question

- For a design team to function effectively, what must happen?

they have to communicate!
synch
asynch

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Communication and the EDP

- Each discipline interacts with the others and decisions taken in one area may impact the design process in another
- E.g. The design of the electric drive for an automobile can result in a significant thermal problem
  - A 95% efficient 75kW motor generates almost 4kW of heat
  - The heat is contained in a small area specified by the mechanical engineer
  - The heat needs to be removed
    - This impacts the design of the cooling system
    - The implementation of the cooling system may affect the mechanical design..

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Communication and the EDP

- A change in any one of these areas can impact design decisions in others
  - A change in the insulation used on the wires in the motor might imply that the maximum operating temperature must be decreased to avoid motor failure
  - The reduction of maximum temperature means a redesign of the cooling system
  - This could impact several other areas of the system

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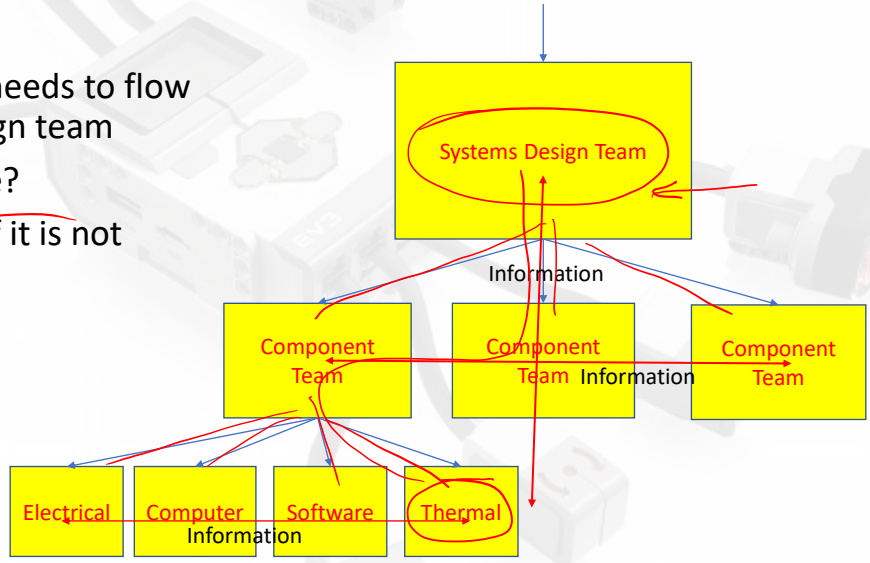
Communication and the EDP

- So information needs to flow around the design team
- How is this done?
- What happens if it is not done?



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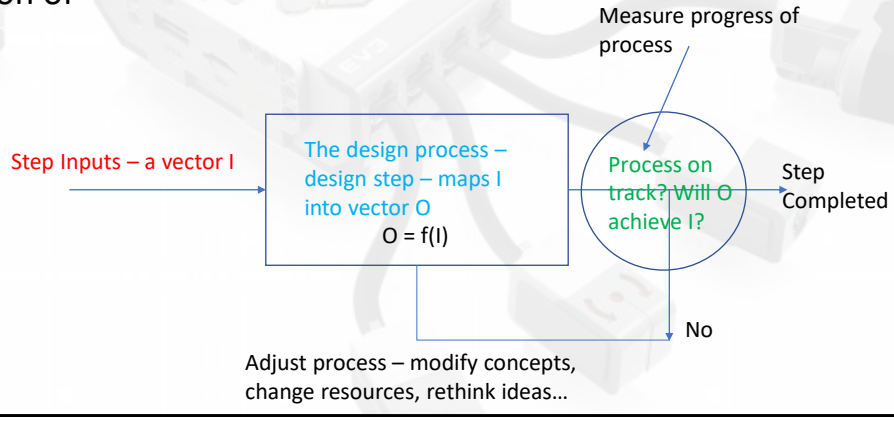
Communication and the EDP

- Controlling the process requires the communication of information



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When Communication Fails…

- Designs fail
- Costs increase
- Potential legal issues…
- …

- The Tree Swing Example

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The Tree Swing – revisited – what went wrong

- A client has talked to marketing about the possibility of a product known as a "Tree Swing" – a simple play structure for children
- Marketing "interpreted" the client's ideas to generate:


Marketing

Marketing have not verified their idea of a solution with the client – no information transfer – a failure in the first phase of the V-cycle

The requirements were vague and open to misinterpretation:
"We need a structure to provide a swing for children which can be supported by a tree – the costs should be minimized"
There was no "proper" Requirements Document


Client

Who should have generated the Requirements Document?

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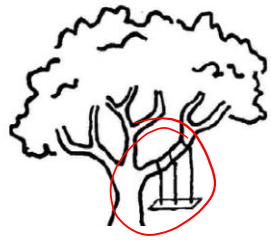
The Tree Swing – revisted – what went wrong?

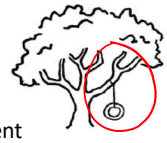
- Instead of verifying the concept with the client, marketing moved the proposal straight to Management.
- Management only saw the proposal – NOT a description of the client's needs.
- Management "simplified" the structure to be more cost-effective
- No Requirements Document meant they had
  - No information on what was actually required
  - No way of estimating the actual cost/budget
  - No way of verifying the solution against the needs

When should Management have been involved?
– After Marketing? After Engineering?



Are these System Models?

Marketing



Client

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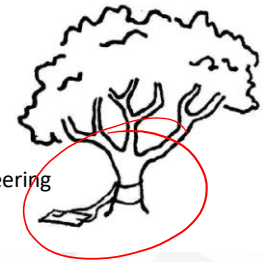
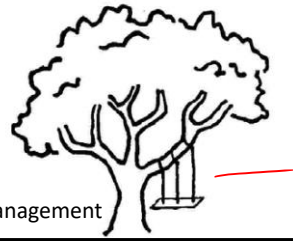
The Tree Swing – revisited – what went wrong?

- Once it was Management approved, the proposal was passed to Engineering who modified the design to account for safety, various regulations and standards
- Note – again, no-one has validated the decisions with the client…

What information should Engineering have been given?



Engineering



Management

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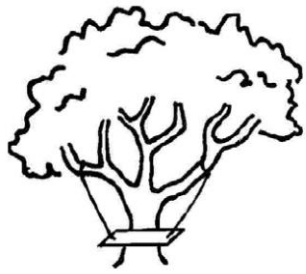
The Tree Swing – revisited – what went wrong?

- While Engineering has applied standards, safety rules, etc., it did not include Manufacturing in the process..
- The question of whether it can be built was not even considered
- However, Manufacturing made some small changes to be able to construct the design



When should Manufacturing have been involved in the process?

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The Tree Swing

- Once the Swing was acquired, it needed to be installed – this is a job done by the Customer or End User…
- What was the process by which the Customer got the swing?
- What might have been missing in what the Customer received?

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So What Went Wrong?

- There was no communication between Departments
  - Each decided it "knew better" and did not reach back to understand the requirements
- There was no verification of the final solution…
- No Documentation…

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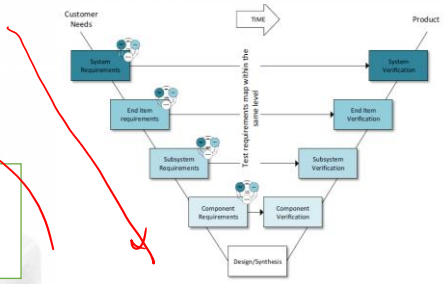
Company Organization?



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Company Organization

- The organization is not set up to enable information flow between the departments
- Management does not seem to have any control – again – no feedback
- The lack of feedback and control leads to most of the issues and the "V" cannot be implemented..
- Result:
  - The Engineering Design Process depends on the company structure to work effectively

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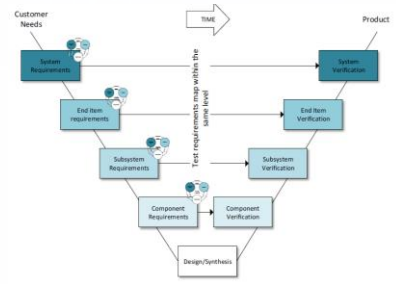
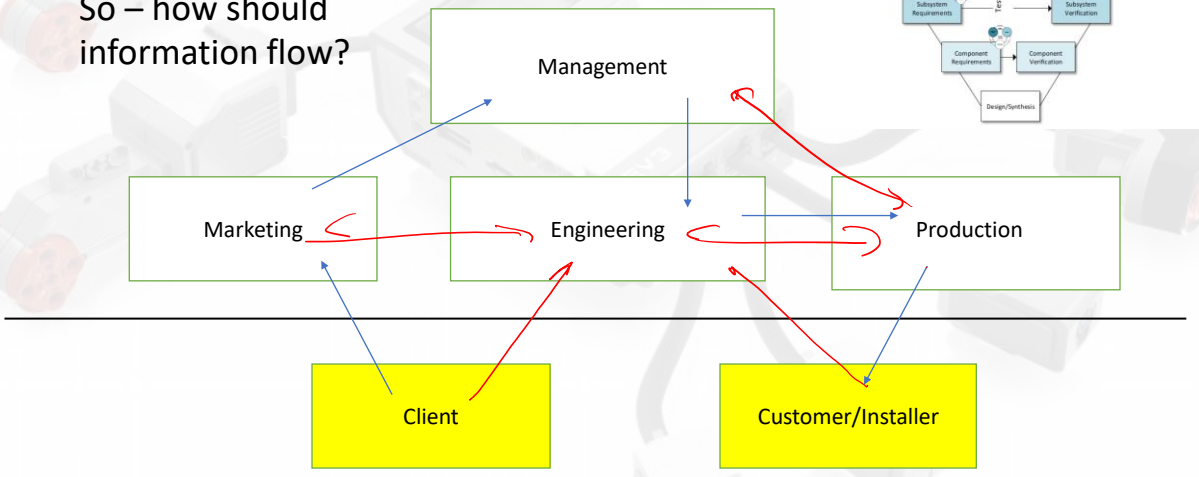
Company Organization?

So – how should information flow?





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What is a Document?

- Dictionary definition:
  - *A piece of written, printed or electronics matter that provides information or that serves as an official record*
- The key word is INFORMATION
  - *Facts provided or learned about something*
  - Note that this is contextual – the facts provide information within a given context
- The goal is to prevent a loss of INFORMATION
- It usually adheres to some form of convention – the structure of a document enables the information transfer

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What is a Document?

- A document provides information which can be transferred asynchronously
  - It also ensures that the same information is accessible to all team members and groups
- E.g. minutes of a meeting provide a record of what was discussed and what was decided.
  - Can be used to resolve disputes later
  - Provides justification for decisions
  - Allows information to be transferred to people who were not present

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What is a Document?

- A document could be
  - A piece of text
  - A drawing
  - An image
  - An analysis
  - …
- It could be stored on a computer or on paper…

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Why Document?

- Information is used to control the design process
  - It describes what has been achieved so far in the process
  - It describes the decisions that have been made
  - It details what is known about the problem
- The documents contain this information together with a track of how the current state was achieved.

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Why Document?

- If a particular design path leads to failure
  - The documents allow the cause of the failure to be identified
  - The documents allow a reset to a previously known state
    - This reduces the costs associated with failure
    - It reduces the time lost due to a failure
- At the end of the design process, two artifacts remain
  - The completed product
  - The design documentation explaining how the product was developed
- The design documentation allows the work to be restarted in the future if the performance of the product is redefined..

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Why Document?

- The documentation represents the investment in the product
- It contains Intellectual Property
- It contains the knowledge and expertise of the design team
- *It is the most valuable asset a company might have*

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Document Structure

- To be useful a document needs to convey basic information about itself
  - This is required for context
- Without structure, a document is of little use
- Typical header information common to all documents :
  - A Title – what is the document about?
  - Who is responsible for it?
    - An individual who can be contacted in the event of questions related to information in the document
  - Who has edited it?
    - Who has been involved in changing the information

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Document Structure

- Typical header information common to all documents (cont'd):
  - Date: When was the document created?
  - Revision Date: When was the document last revised?
    - When put in the context of the EDP, this date can indicate when certain decisions were made
  - Version Number:
    - The current version number
  - Edit History:
    - A list of changes that were made
    - For each change:
      - Why was it made
      - Who made it
      - When was it made

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Document Structure

- Following the Header, the main body of the document addresses the information related to the title
- For example, for the Requirements Document, the main body should include:
  - What is the system meant to do (Purpose and Scope)?
    - List any performance data you have and desired capabilities
  - What can you use to solve the design problem (Constraints)?
    - List any items that are explicitly specified, or limitations imposed by the client
  - Are there tolerances on performance or limits on user interaction?
    - List them
  - Is there a deadline?
    - List it
  - Do you know everything? (Unknowns)
  - …

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Summary

- We have reviewed the issue of communication in a design team
- We have considered how the company organization might impact the EDP
- We have discussed the need for information to implement and control the design process
- The concept of a document and documentation to record information has been developed
- A rationale for effective documentation has been presented
- An example of the structure of the Requirements Document has been provided

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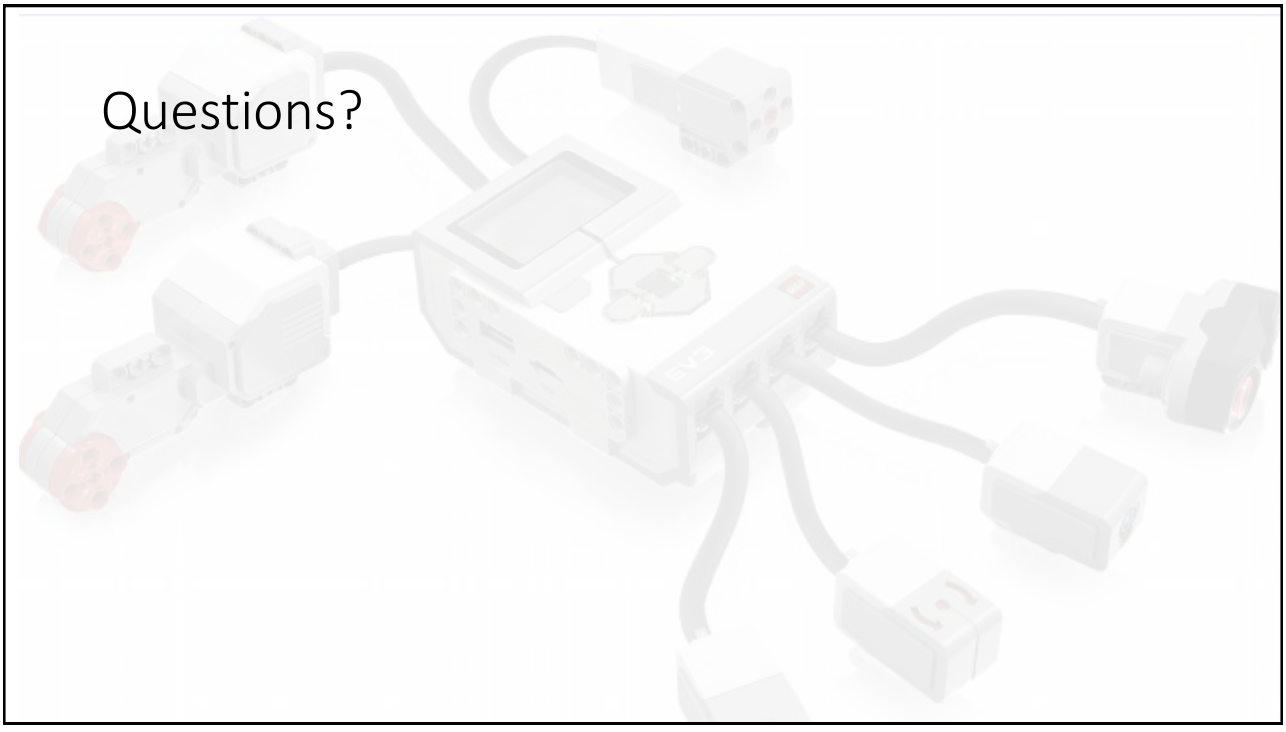
Questions?



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