ECSE-211
Design Principles and Methods

Lecture 3: How Does It All Start? Inputs and the Requirements Document

Date: 16 January 2023

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Review – Last lecture

- The needs of the EDP – concept of Design Space and mapping between input and output parameters
- The definition of a "Model"
- The System Model
- As design detail increases, there is a need for component models

- Questions?

- The need to understand the problem – the requirements

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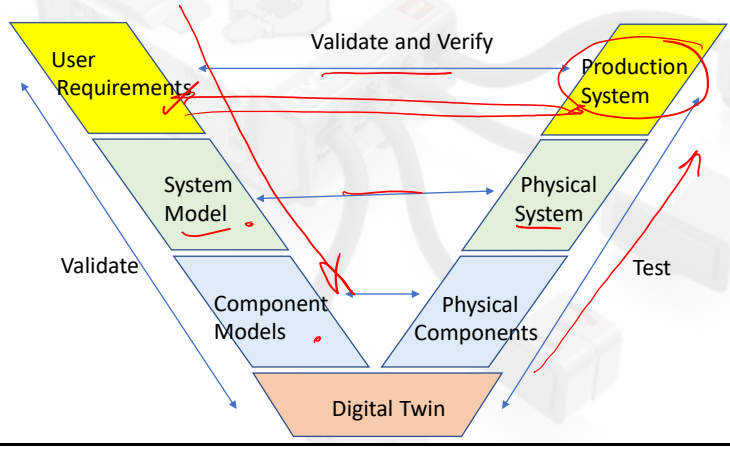
The V-Cycle

- One of several ways of managing the Engineering Design Process
- Illustrates the gradual increase in detail as the process moves forwards



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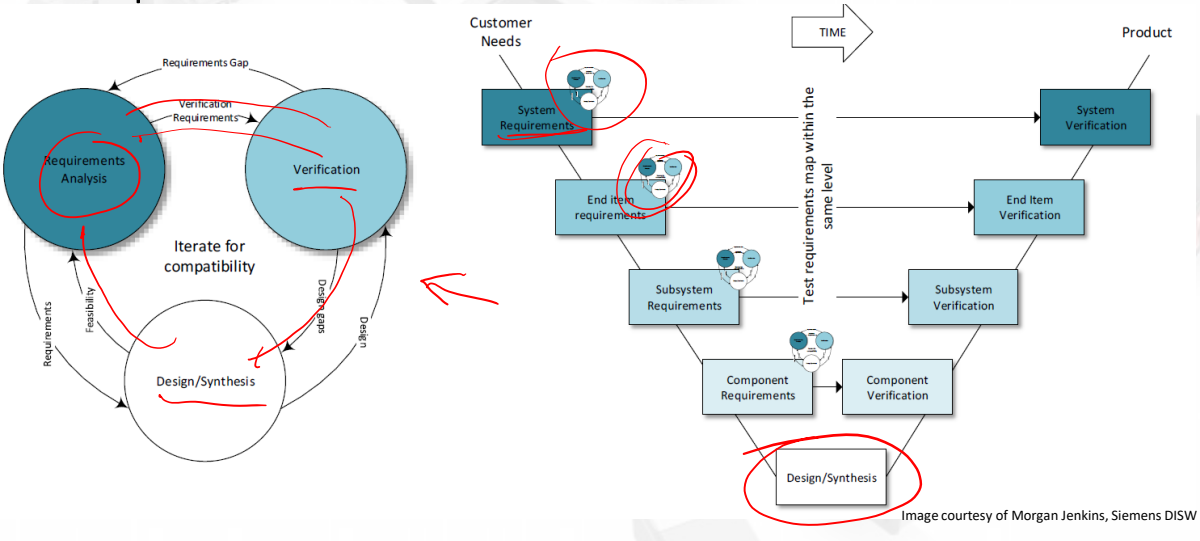
The V-Cycle – Starting with Customer Requirements



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Contents

- Why is Design Difficult?
- The Model of the Engineering Design Process
- Inputs to the Model
- Outputs of the First Step

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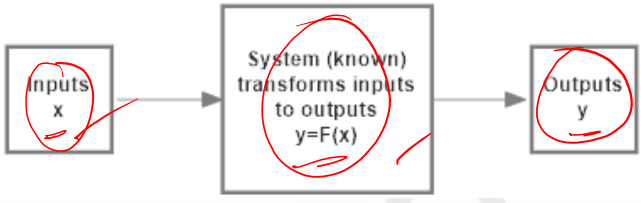
Why is Design Difficult?

- Consider the following:
  - Typical engineering problem:



Three classes of problem can be derived from this diagram:

- Given x and F(x) determine y – *Analysis* – for the set of inputs what will the system do?
  - Conventional – "Easy"

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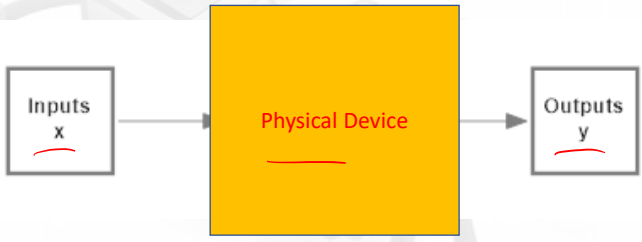
Why is Design Difficult?

- Typical engineering problem:



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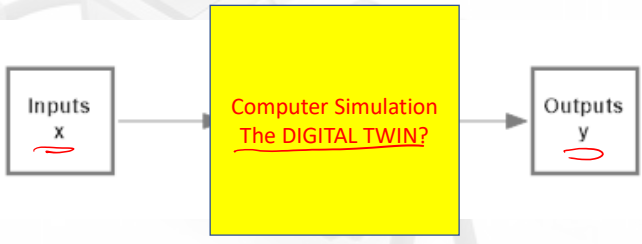
Why is Design Difficult?

- Typical engineering problem:



Three classes of problem can be derived from this diagram:

- Given x and F(x) determine y – *Analysis* – for the set of inputs what will the system do?
  - Conventional – "Easy"
  - If we have an analytical model, this is "simple" to solve

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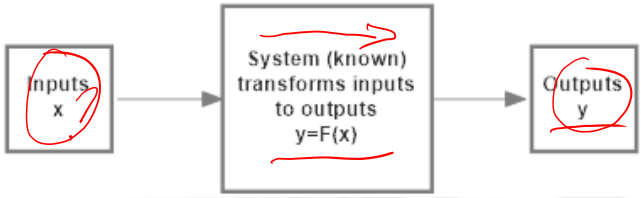
Why is Design Difficult?

- Typical engineering problem:



Three classes of problem can be derived from this diagram:

- Given F(x) and y determine x – *Inverse Problem* – "provide the inputs to generate the desired outputs"
  - Required operational point – inverse problem – *more difficult*
  - This is a typical control problem
    - *E.g. the room temperature should be 20 deg C – adjust the inputs to the heating to achieve this*

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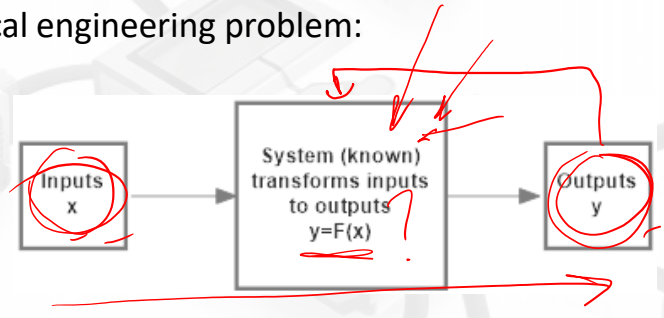
Why is Design Difficult?

- Typical engineering problem:



Three classes of problem can be derived from this diagram:

- Given y and x, determine F(x) – *design problem* – *"find" the device which has the required transfer function*
  - *This is a search problem in a space defined by x and y and? (there is more needed than just x and y!)*

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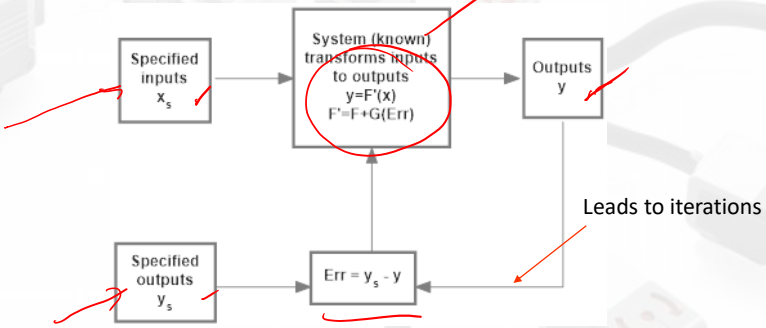
Why is Design Difficult?

- Typical solution to the design problem
  - Guess a structure – does it implement the desired transfer function?



So now let's revisit the Engineering Design Process…

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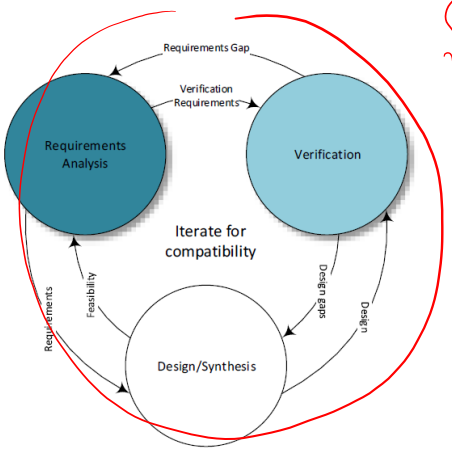
The V-Cycle – Starting with Customer Requirements



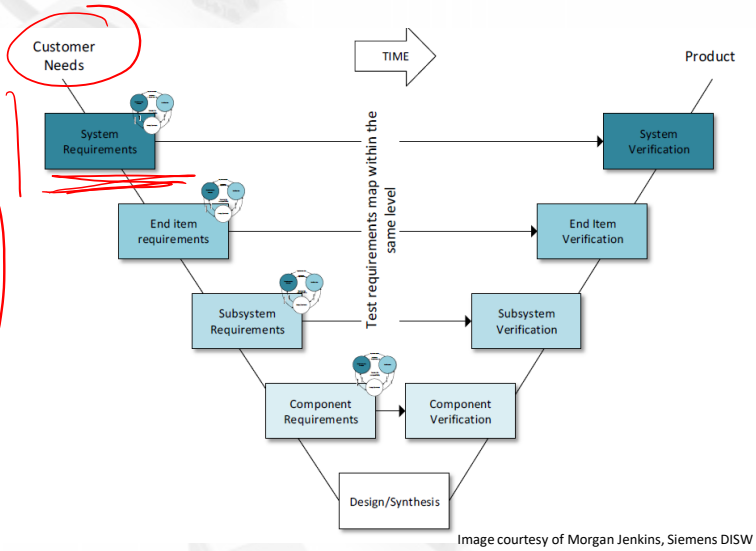


Image courtesy of Morgan Jenkins, Siemens DISW

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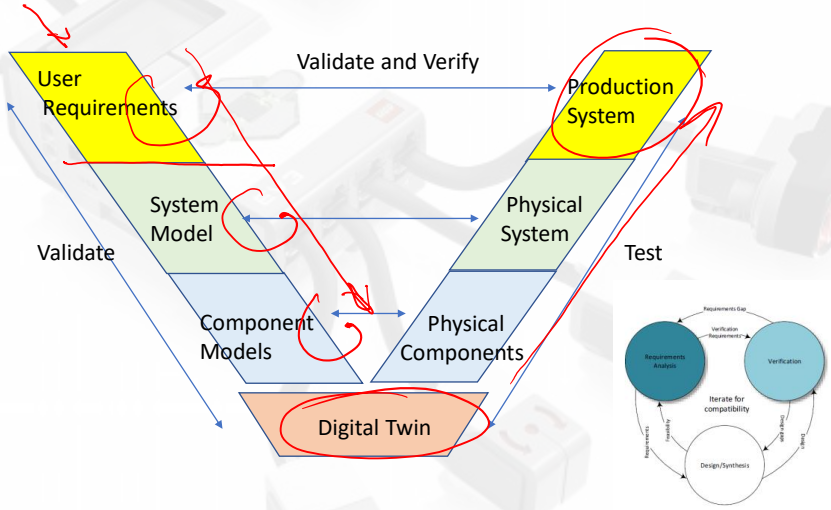
The Model of the Engineering Design Process

- The V-Cycle describes a "process"
- It is a model allowing us to visualize the state of the process
- There is a "flow through the process



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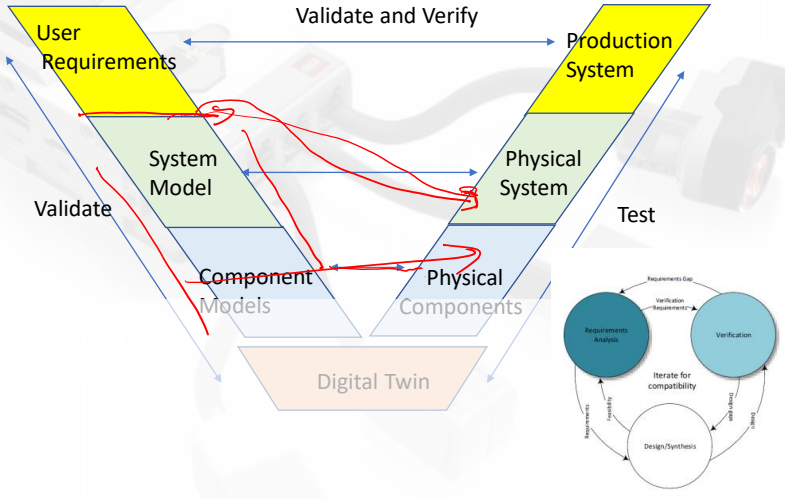
The Model of the Engineering Design Process

- At any stage, a physical prototype could be implemented but…
  - The costs are high
  - If the prototype fails, it is difficult to modify
- In DPM, the physical implementation is at the component design level



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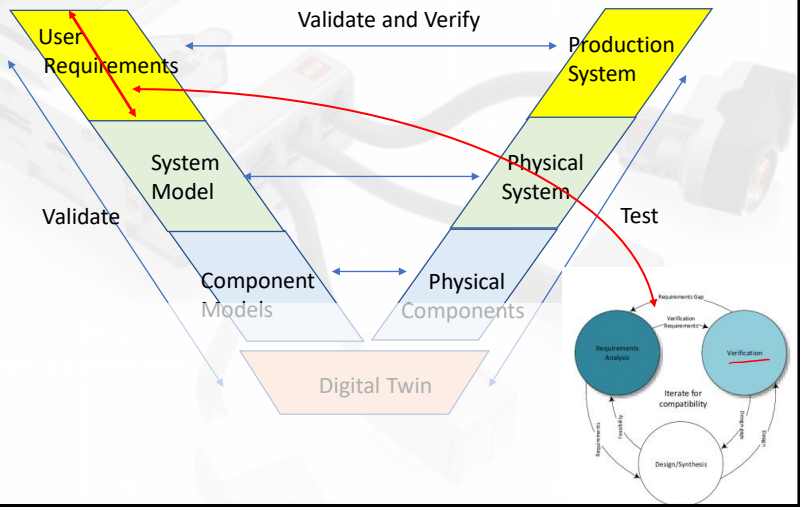
The Model of the Engineering Design Process

- Note that each block of the cycle is an atomic design iteration



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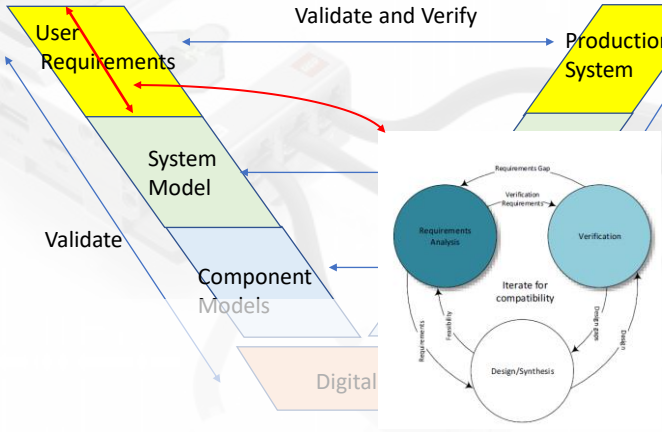
The Model of the Engineering Design Process

- Note that each block of the cycle is an atomic design iteration
- Verifying the requirements is a "test"
- Exit the stage only when the "Requirements Gap" is effectively zero



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The Model of the Engineering Design Process

- Each step has
  - a defined set of inputs
  - A defined set of outputs
  - The output of one step is the input to the next
  - At each step a validation is needed
- This is a control problem
  - The "plant" in this case is the Design Team
  - The job of the Design Team is to generate the output of the step

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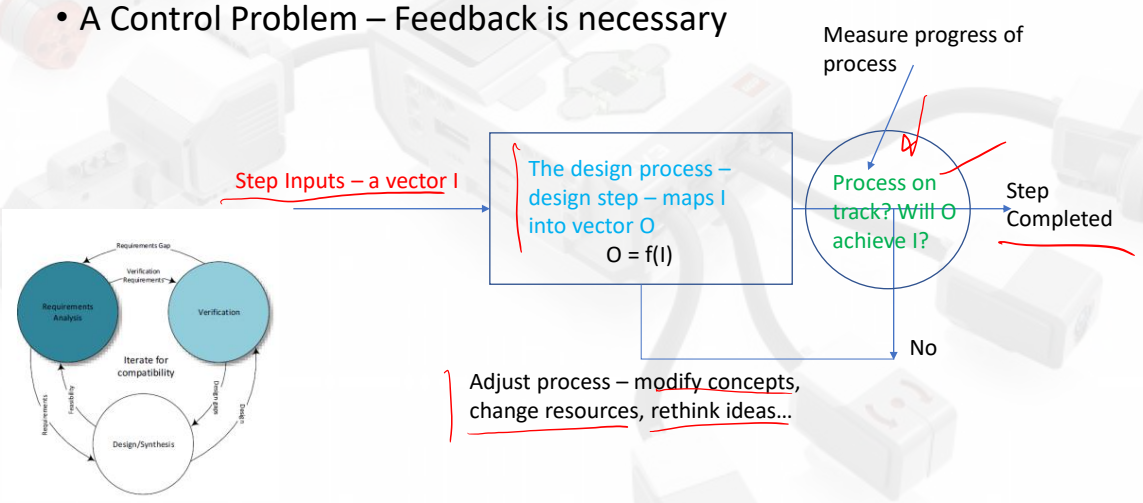
The Model of the Engineering Design Process

- A Control Problem – Feedback is necessary



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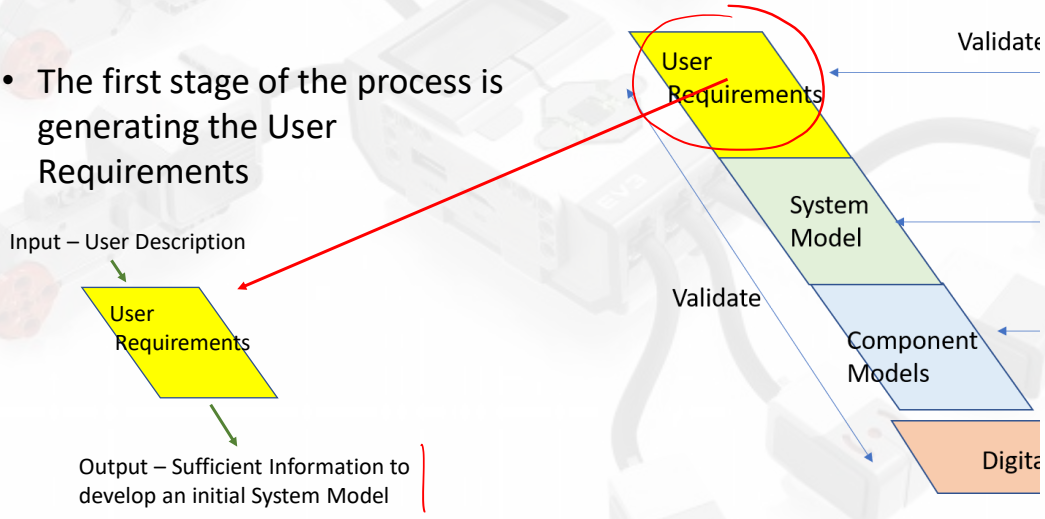
The Engineering Design Process

- The first stage of the process is generating the User Requirements



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Inputs to the First Step

- The User or System Requirements
  - This describes the problem
    - this could be a description of the needs in written form
    - This could be a verbal description from a discussion

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A Typical DPM Needs Document

- The final DPM design project is typically described in the form of a "game" with a set of rules
- The rules define what the design solution must achieve
- The rules also define constraints both on the solution and in the space where the game is played…

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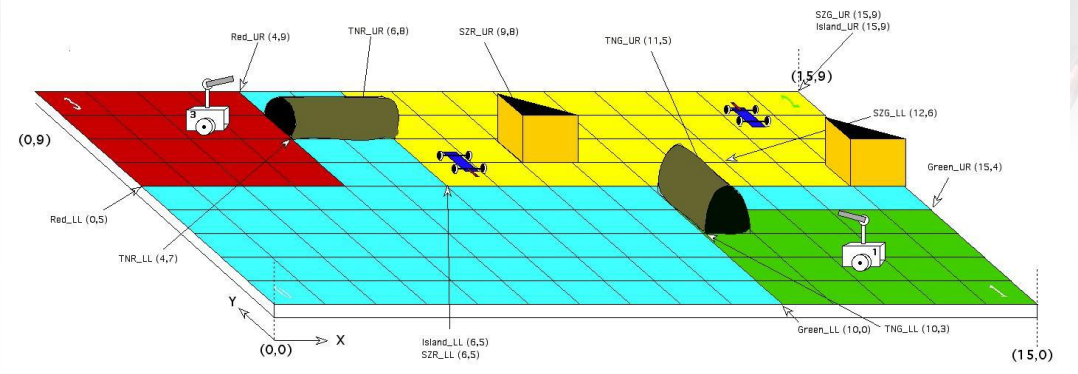
A Typical Project Description

- The game is played in a constrained space:



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A Typical Project Description

- The text of the project description contains information on the rules and constraints of the game..
  - (see edited document)
- The text needs to be read carefully and the main issues identified
  - These will form the basis of the Requirements
  - The issues can be translated into a list of Requirements
  - Constraints can also be identified and added to the Requirements
  - Are there questions?
  - These need to be clarified with the client – possibly leading to a revision of the description
  - (see highlighted document)

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Generate the Requirements Document

- From the description and the answers to questions, a Requirements Document can be created
- This Document is the starting point for the discussions on the potential solutions
- This should
  - Address the main goals to be achieved by the solution
  - Describe any constraints on the solution imposed by the Description
    - These could be performance – e.g. time limits on the game
    - They could be physical structures – e.g. limited number of Lego components and capabilities of those components
    - They could be Software constraints – e.g. limitations on architecture imposed by processor capabilities.

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Generate the Requirements Document

- Once an initial Requirements Document is completed it should be
  - Validated against the Client Description by an in depth review with the Client
- *Note – this document will be under constant revision as decisions are validated and the client is consulted.. It is not complete until the design is complete*

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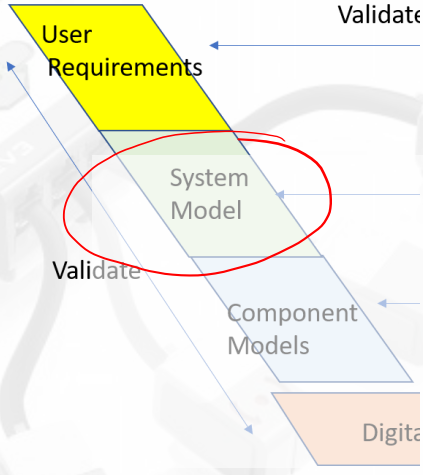
Outputs of the first step

- The main output is the Requirements Document
- The need for documents and their structure will be discussed in the next lecture
- This is followed by the development of a System Model.



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Summary

- We have:
  - Considered why Design is a difficult problem
    - There is no unique solution
  - Revisited the Engineering Design Process and considered the iterations needed at each step to validate the step
  - Discussed the Inputs to the First Step (often referred to as "Identification") in terms of a client description of a problem
  - Examined the extraction of Requirements from the Description
    - The result is a Requirements Document which is continually revised through the design process
    - The Requirements are Validated against the Description
  - Recognized that the Requirements form the input to the generation of a System Model – which can then be validated against the client Description

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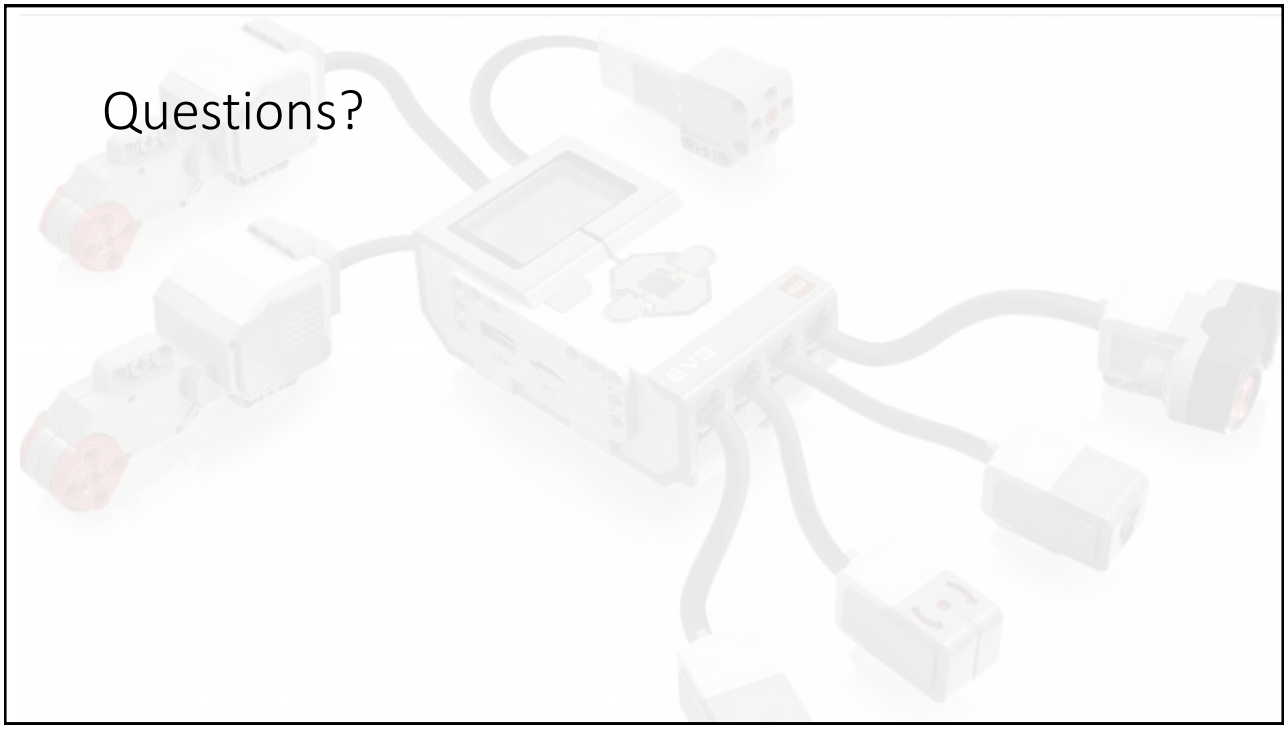
Questions?



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