Systems integration

Introduction

Designing and building vessels is a technically complex process. The level of complexity is further increased by the introduction of hybrid solutions into the electrical and automated power plant. Systems integration is a challenge and requires an interdisciplinary team and expertise in a range of different technical fields. These specialists provide solutions according to the customer's and class societies' operational and technical requirements.

This integration process plays a crucial role in achieving successful projects.

As an Electrical Systems Integrator, Alewijnse Netherlands Company uses the systems engineering Method described in ISO/IEC 15288 and the INCOSE systems engineering handbook. This method is implemented across different industry sectors in the Netherlands for complex technical projects, where multiple suppliers are involved in the design and realization of the projects.

Early involvement

Ship design demands an interdisciplinary skill set. In order to optimize the SARAD (System Architecture and Requiremends Allocation Design), early involvement in the ship design processs is key. Alewijnse design and consultancy with its R&D department is a strong partner for end clients, shipyards and design companies who aim for the best electrical and automation design.

Design

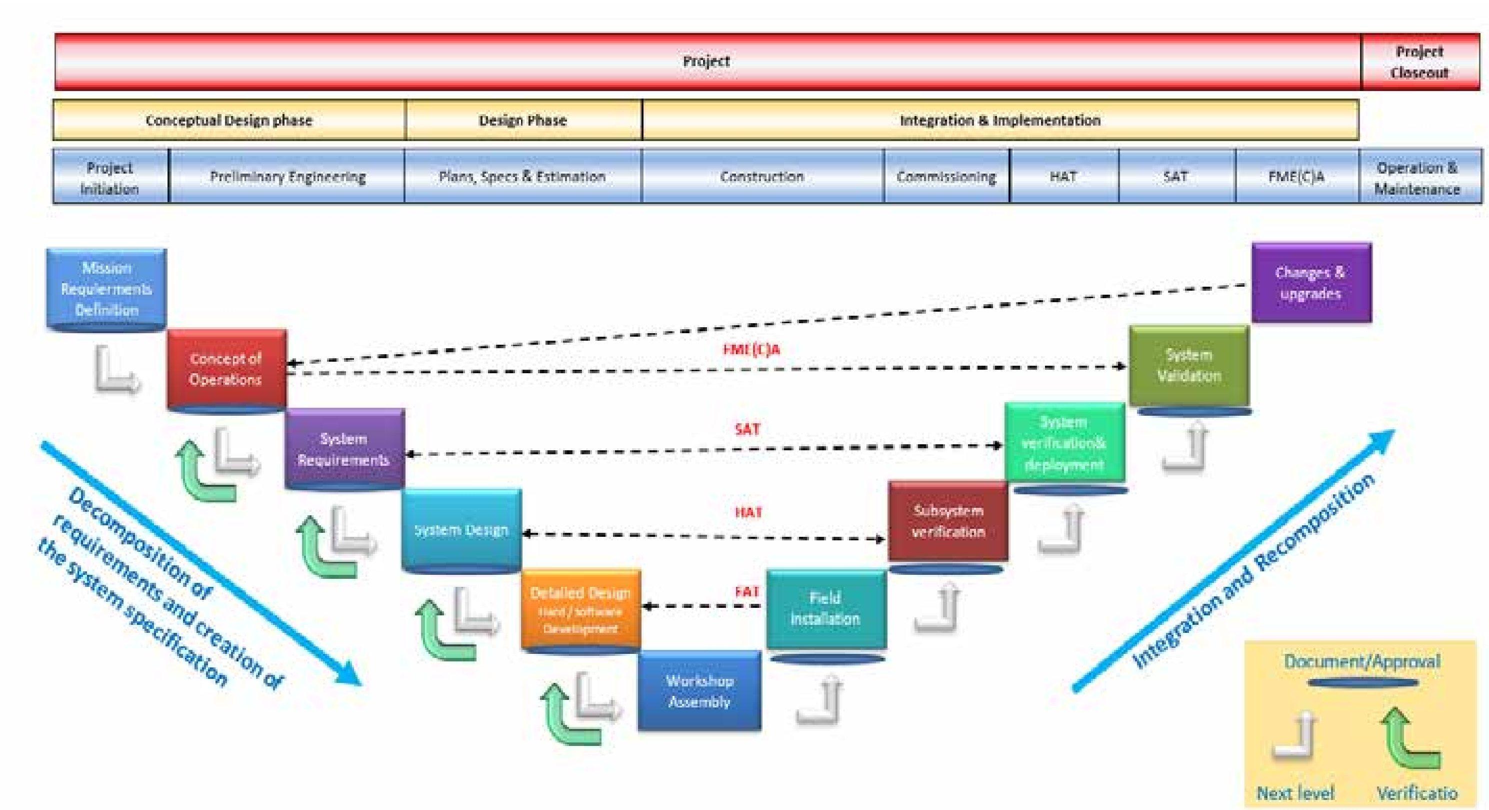
The benefits of the systems engineering model as a design method are possible due to collaboration in the following aspects:

The way of thinking about complex projects (problems)

- Scope: Bigger picture / comprehensive overview
- Trades: Following the SMART principle
- Context: Domain, environment, stakeholders, and partners
- Innovation: Challenging assumptions in a broader context
- Redundancy: Advise on reliable embedded systems engineering
- Servicability: Implementation and acceptance tests before going live
- Upkeep: Application of condition monitoring and predictive maintenance, sensor to cloud technology

A concurrent engineering

- Interdisciplinary cooperation: interactions and dependencies; concurrent engineering
- Reduction of engineering lead time
- Enhancing circular engineering in supply chain



A peak behind the scenes

The following drawing shows the systems engineering process flow. It is a V-model with two main processes.

The model's left side is the breakdown of the requirements and creation of the systems' specification process, and on the right is the Integration, Verification, and Validation process. Both methods have stages that include verification points.

Figure 1: systems engineering process flow

Breakdown of the requirements and creation of the system specifications process

This process consists of the following phases and stages:

- Conceptual design
- Customer requirements analysis
- System design (Basic engineering)
- Detail design (Detail engineering)
- Subsystem Description? (see note.)

Conceptual Design

In this phase, there are the following stages:

- System Requirements Analysis Process
- System Design (Basic Engineering) Process
- System Design (Basic Engineering) output documents

System Requirements Analysis Process

The systematic approach of systems engineering for this activity takes place in two steps, which are:

1. Functional Analysis:
   a. Identify System Functions and summarize them in a function tree
   b. Breakdown the system into objects (function fulfillers) and translate them into an object tree
   c. Summarize the requirements per object into specifications
   d. Write a verification plan to verify that the objects fulfill the requirements
2. Requirements Analysis:
   a. Functional requirements
   b. Interface requirements:
      i. External Interface requirements
      ii. Internal Interface requirements
   c. Aspect requirements
   d. Constraints requirements

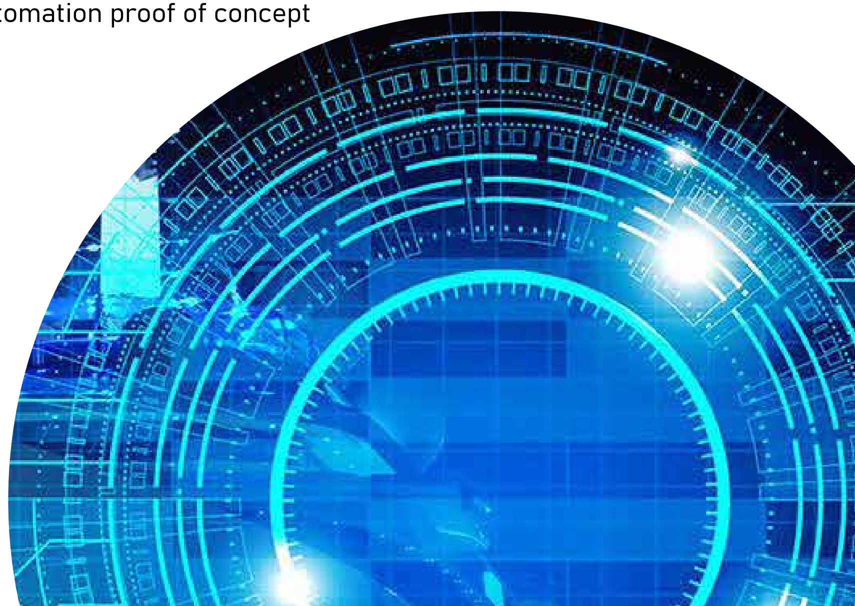
System Design (Basic Engineering) Process

The systematic approach for this stage takes place on two levels:

1. System level in different studies, calculations, etc.
2. Subsystem Description:
   a. Architecture design
   b. Interface requirements (Functional level):
      i. External Interface requirements
      ii. Internal Interface requirements
   c. Functional design specification.

System Design (Basic Engineering) output documents

1. System-level studies(on the ship level):
   a. EMC management plan
   b. Earthing philosophy
   c. Lighting plan
   d. Short circuit calculation
   e. Load balance
   f. Selectivity analysis
   g. Arc-flash study
   h. Availability study
   i. Reliability study
   j. Energy flow analysis study
   k. Common mode study
   l. Resonance study
   m. THD study
   n. FMEA
   o. Ex-zone management plan
   p. Voltage drop
   q. Cable block diagram
   r. Single line diagram
   s. Automation architecture
   t. Automation functional layer design
   u. Automation operational design
   v. Automation proof of concept



2.Subsystem Description:

a. Detail architecture design
b. Interface requirements (Functional level):
  i. External Interface requirements
  ii. Internal Interface requirements
c. Functional design specification

The System Architecture and Requirement Allocation Document (SARAD) is the middle level of the document according to the top-down design method. The following table shows the logical steps to create this document (defined).

Detail Design (Detail Engineering) stage

Process description
The output documents (system studies, calculation) from the previous stage are the input documents for this stage.

Detail Design (Detail Engineering) Process

The approach for this stage has the following activities:
- Detail design of the electrical cabinets
- Verify design utilizing system-level calculations
- Define technical specifications (assemblies, elements)
- Interface specification
- Functional specification

Detail Design (Detail Engineering) output documents

- Wiring schemes
- Cable list
- Detail drawings of the electrical cabinet
- Material lists and order specifications
- Construction drawings
- Detailed design input FME(C)A
- Interface document (I/O list)
- Definitive hardware configuration
- Software applications
- Software specifications

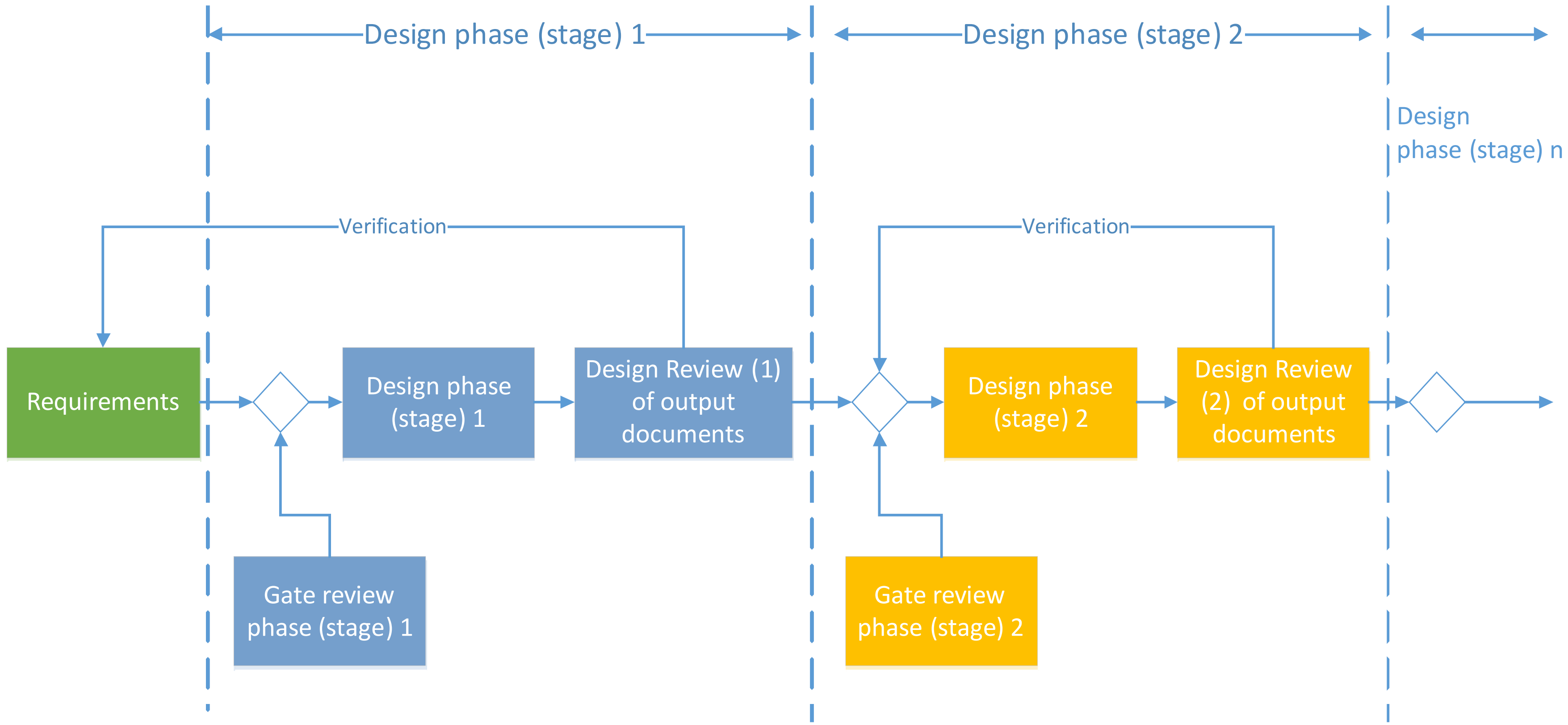


Figure 2: systems engineering process definition

Design verification

The Power Quality measurement activities onboard. The measurement data analyzes and reports as part of the verification process.

General Design process definition

The following diagram shows the general design process flow for each design phase (stage) with each activity described as per the systems engineering design method.

Generally, according to the above diagram, each of the following activies are undertaken in each design phase (stage):

- Gate review
- Design activity
- Design review and verification

Design team

The design team's goal is to realize integrated electrical and automation design according to the customer's requirements and specifications using systems engineering as the design method. The technical profile of the design engineer team is: technical project managers, system(s) engineers, technical specialists and detail engineers.

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Our goal is to co-create value with and for our customers and partners. We aim to develop and improve electrification and automation solutions which are innovative, sustainable and of the highest quality. We focus on making a valuable contribution to successful projects in the maritime and industrial sectors.

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