



The Navy Ship Design Process

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The Navy Ship Design Process

Executive Summary

This document is a resource for everyone involved in U.S. Navy ship design; it shows the activities that need to be completed to design a Navy surface combatant and the activity interdependencies. Every person can identify in this process:

1. The roles they perform,
2. From whom they get information from,
3. To whom they provide information to, and
4. The importance of their role in ship design.

Navy ship design is a complex process for a complex product used for National defense. A single ship design is passed hundreds of times through hundreds of people from the first notion of a concept through to construction and sea trials. This document provides a simple introduction to this intricate process. It starts broadly at a high level and then narrows down to specific tasks, referred to as activities.

The process shown is descriptive; and is not a prescription to design a ship. The ship design process will change from individual to individual, over time, and from program to program. What is captured represents the cumulative knowledge gathered from hundreds of ship design experts in industry, academia, and government during five Navy Ship Design Process Workshops held from 2008 to 2010 focused on the Naval Architecture (Hull, Mechanical, and Electrical design) design process for a conventional surface combatant. The resulting process has:

- 250 activities, with
- 812 dependencies, broken down into
- 42 activity groups.

Additional effort is being expended to capture the Mission Systems' Design Process for a surface combatant and integrate it into the Naval Architecture centric process described.

The documented process focuses on the Preliminary Design stage. The Exploratory and Concept Design stages include differing types of studies (such as Analysis of Alternatives and Technology Assessment Studies) which are generally subsets of the activities included in Preliminary Design. The set of Preliminary Design activities represents the foundation for expanded activities in Contract Design, and Detail Design and Construction.

This document is separated into the following sections of progressively more detail:

1. Section A - High Level Overview
2. Section B - Design Activity Groups
3. Section C - Activity Descriptions

An Appendix includes details on how activities are defined and populated in this process description.



The Navy Ship Design Process

Benefits

Navy Ship Design Process Model **STATIC VIEW**

- The Navy Ship Design Process Model captured on this Web site is a **TEMPLATE** showing the steps needed to design a ship.
- The Benefits of this view are in the Executive Summary.

DYNAMIC, INTERACTIVE Navy Ship Design Process Model

- Was used to generate the static view shown on this Web page.
- Is from the interactive design process software being used by NAVSEA and the Navy Warfare Centers.

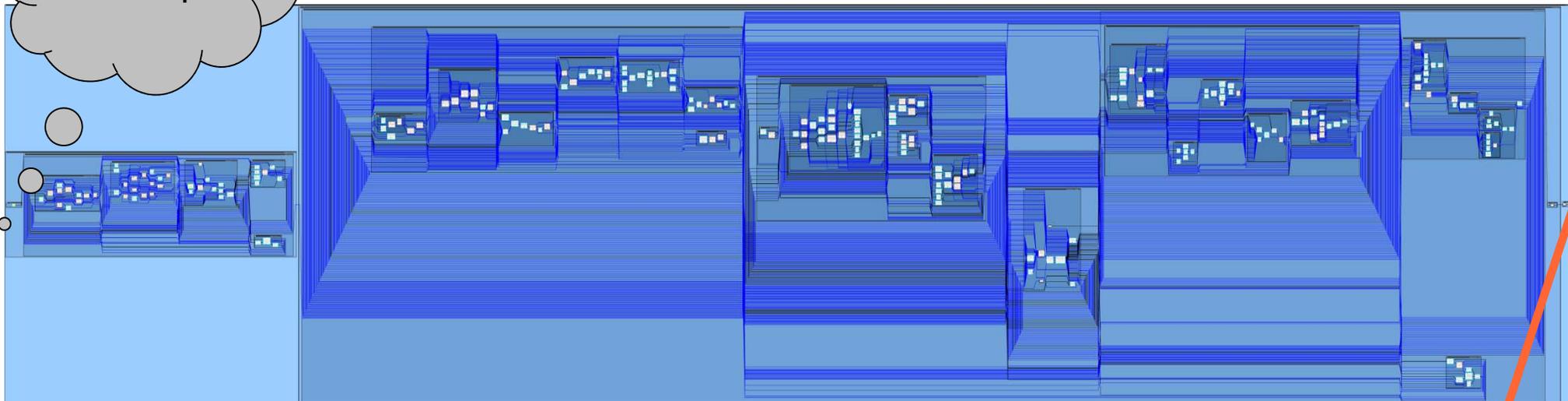
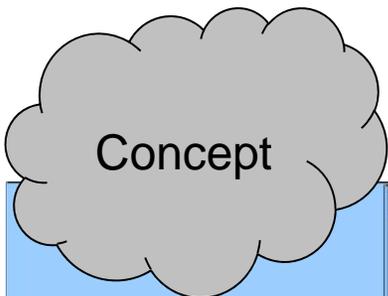
THE INTERACTIVE DESIGN PROCESS MODEL:

- Is to be used to easily **CUSTOMIZE THE TEMPLATE** for different ship types.
- Shows the process in **MULTIPLE FORMS**:
 - Process flow diagrams,
 - Gantt charts,
 - Resource Tables, or
 - Design Structure Matrices.
- Has Import/Export with Excel and Microsoft Project.
- Is saved as a generic SQL database.
- Can be viewed by organization & geographic location to **ENABLE COLLABORATION** across the Navy.
- Can be used **TO IMPROVE DESIGN** execution by:
 - Enabling a program team to understand what needs to be done by whom, when and at what cost to plan projects.
 - Re-ordering process activities to compare the time, relative risk, and cost of different process options.
 - Identifying design process strengths, weaknesses, and interdependencies providing the process knowledge needed for improvement.
- Can be used to analyze the capabilities of both the staff and design tools to **KNOW WHAT INVESTMENTS ARE NEEDED**.
- Can be used to **TRAIN** all personnel involved in, or associated with Navy ship design and acquisition.

This knowledge will reduce the time and cost needed for ship designs, and enable more accurate estimates in Preliminary Design and other planning efforts.



Section A – High Level Overview



Design



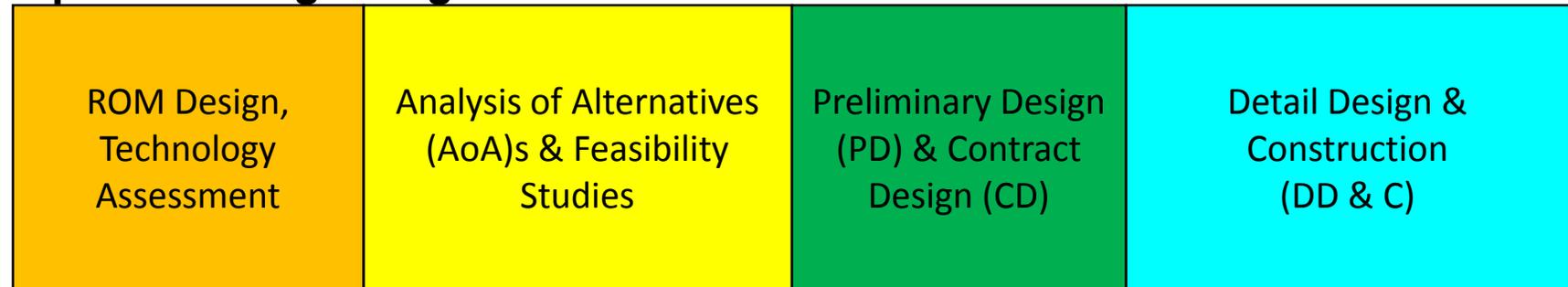
The Navy Ship Design Process

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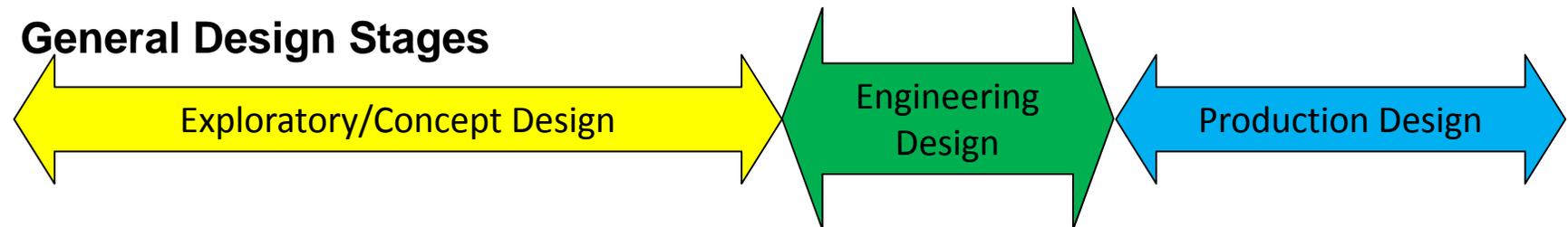
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Design Stages

Specific Design Stages

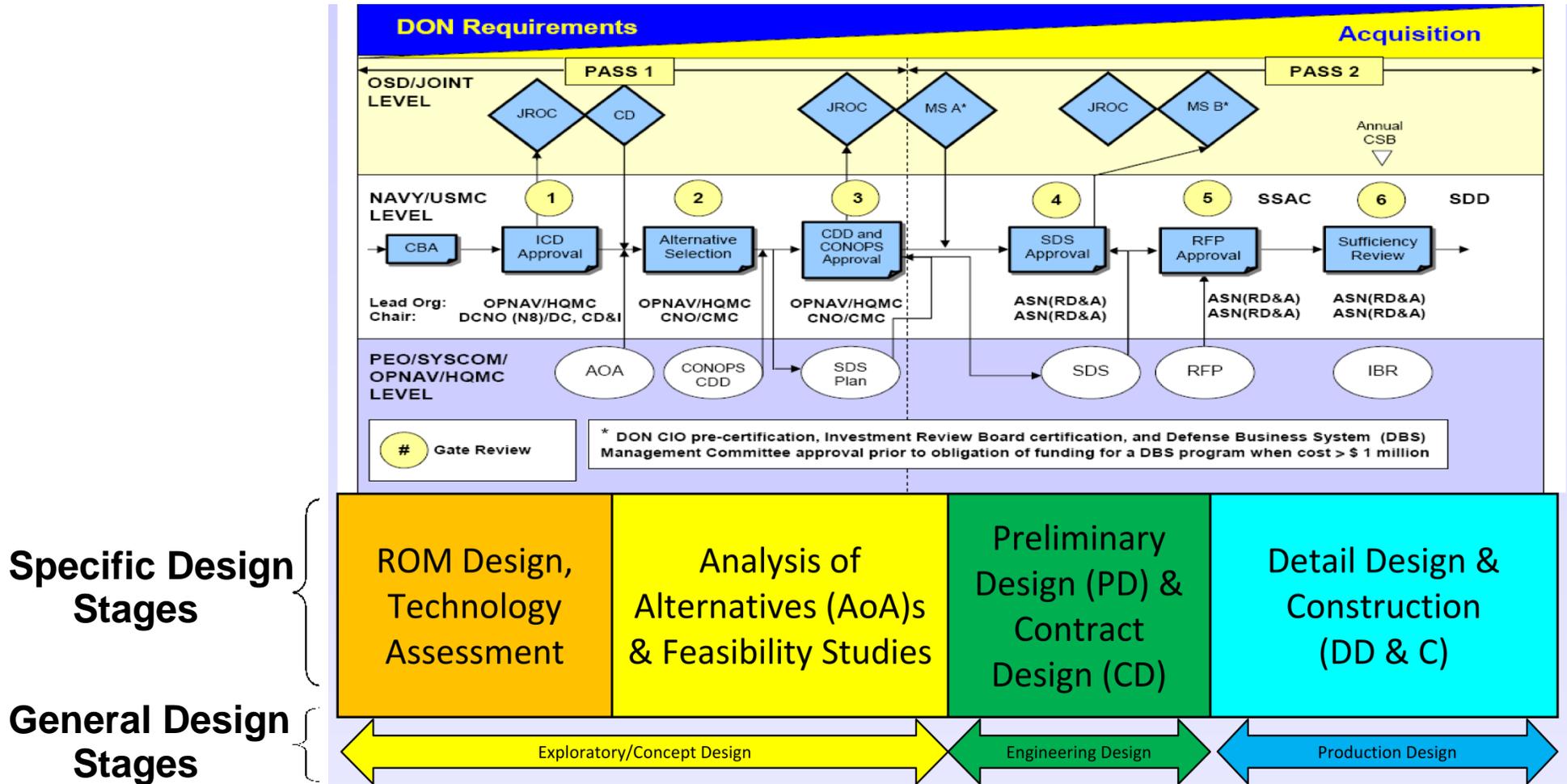


General Design Stages



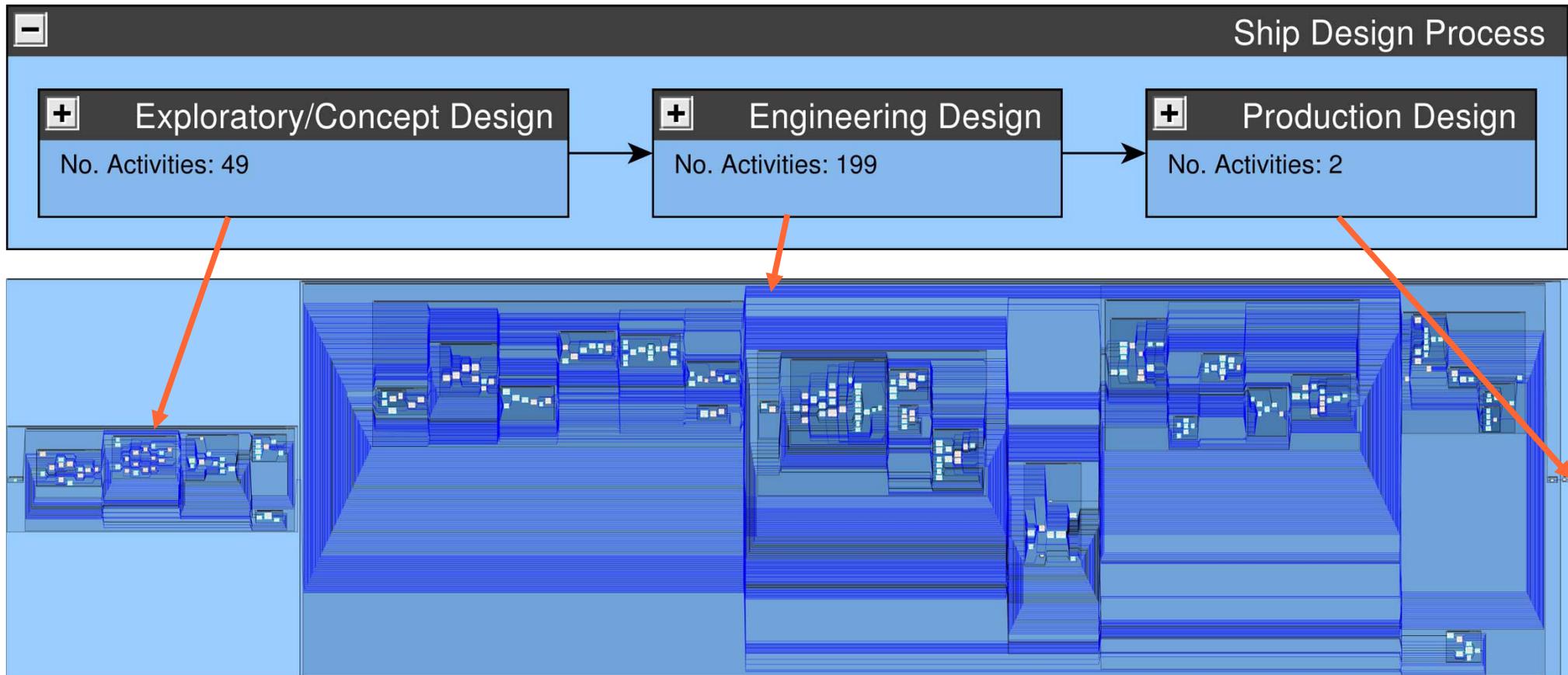
The specific and general design stages are shown relative to each other. As each design stage progresses design fidelity and complexity increase.

Acquisition Stages



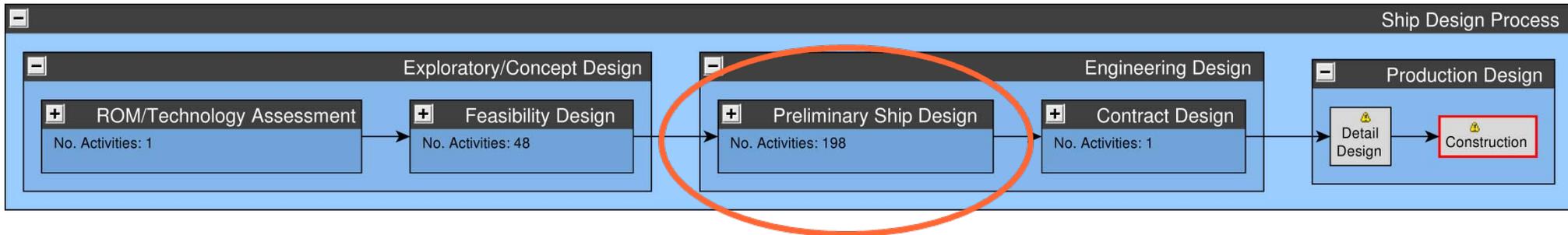
The stages of the Ship Design Process are shown relative to the Department of Defense/ Department of Navy Acquisition Stages.

Ship Design Process



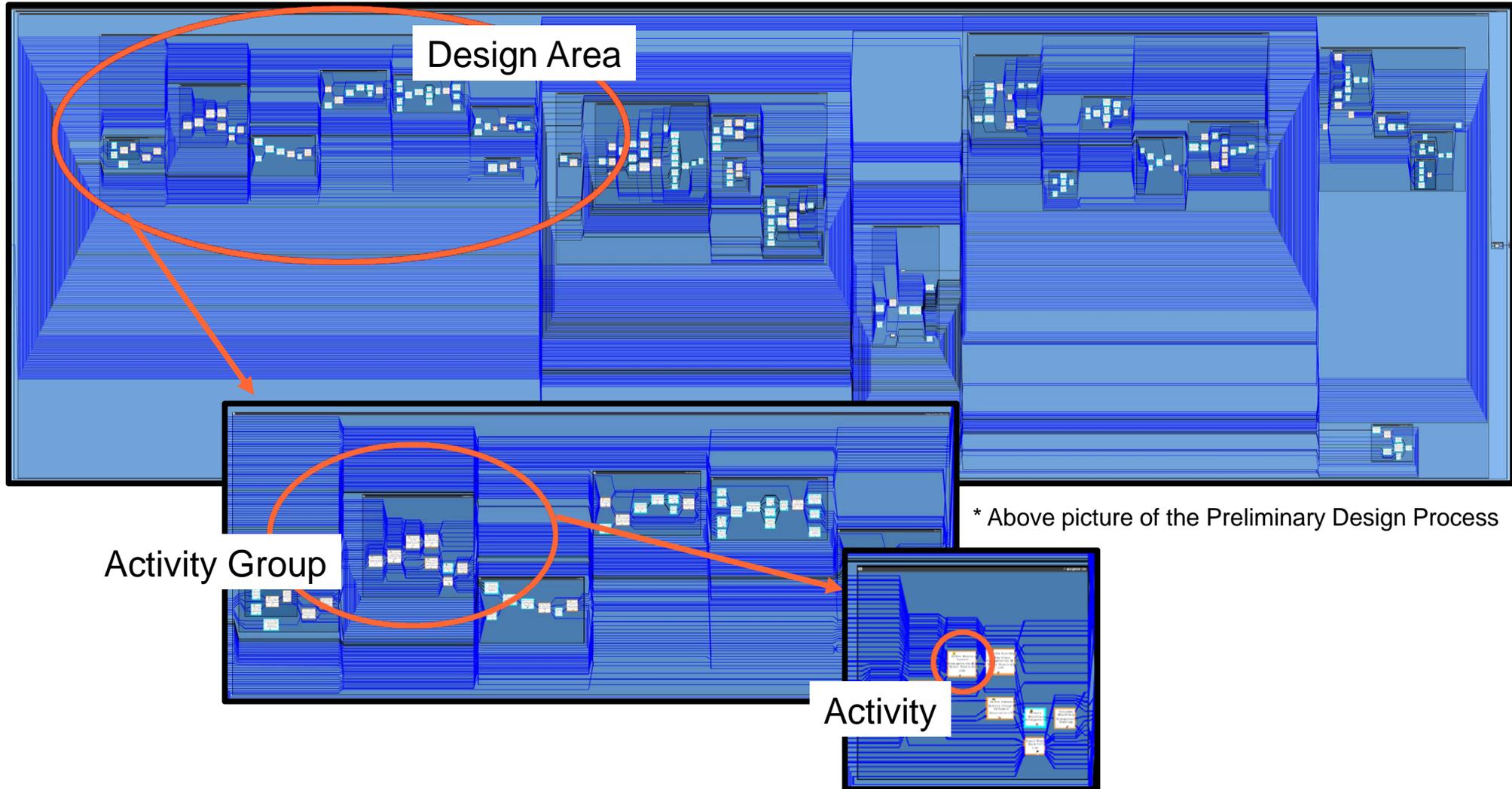
The General Design stages easily expands into the more complex Ship Design Process. Shown is a Box&Arrow flowchart view of the process. The view of Navy Ship Design Process portrayed consists of 250 activities, 812 arrows and 42 Activity Groups.

Ship Design Process - Preliminary Design



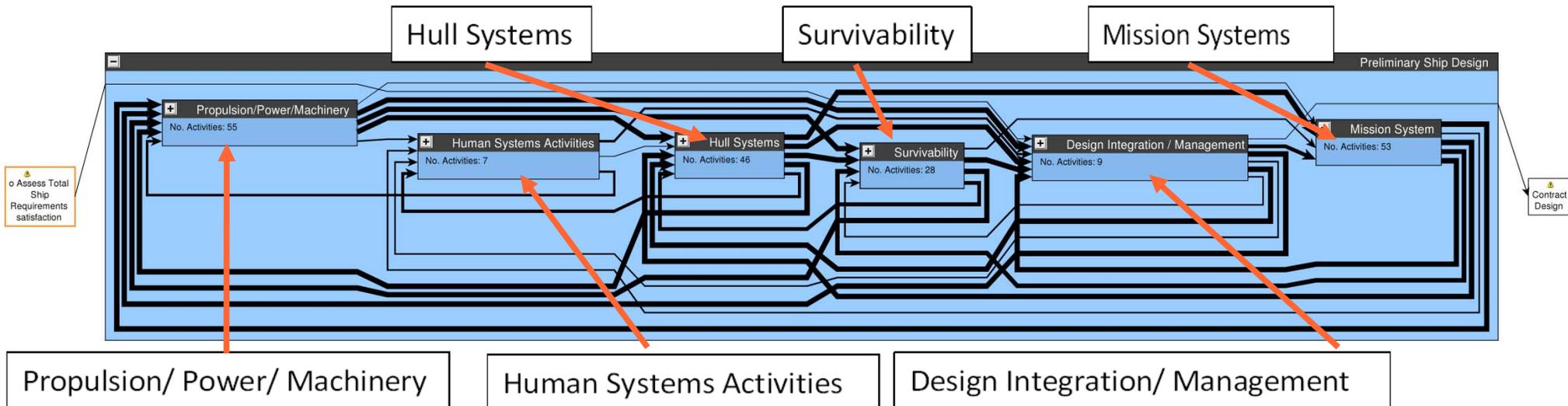
The process shown in this document depicts the Preliminary Design stage of a surface combatant. The Exploratory and Concept Design stages are generally subsets of the activities included in Preliminary Design. The set of Preliminary Design activities represents the foundation for expanded activities in Contract Design, and Detail Design and Construction.

Process Model - Structure



The Ship Design Process Model is shown in a Box & Arrow format using the Plexus program. The process is modeled at a high level and progressively further down in the Design Areas and Activity Groups that represent particular functionality. Activity Groups are made up of Activities which represent tasks. The process model is broken down into levels needed to provide an understandable description of what needs to be done. The arrows connecting activities represent the transfer of information in the process. Section B describes the different Activity Groups. The definitions of different activities are found in Section C.

Preliminary Design – Design Areas

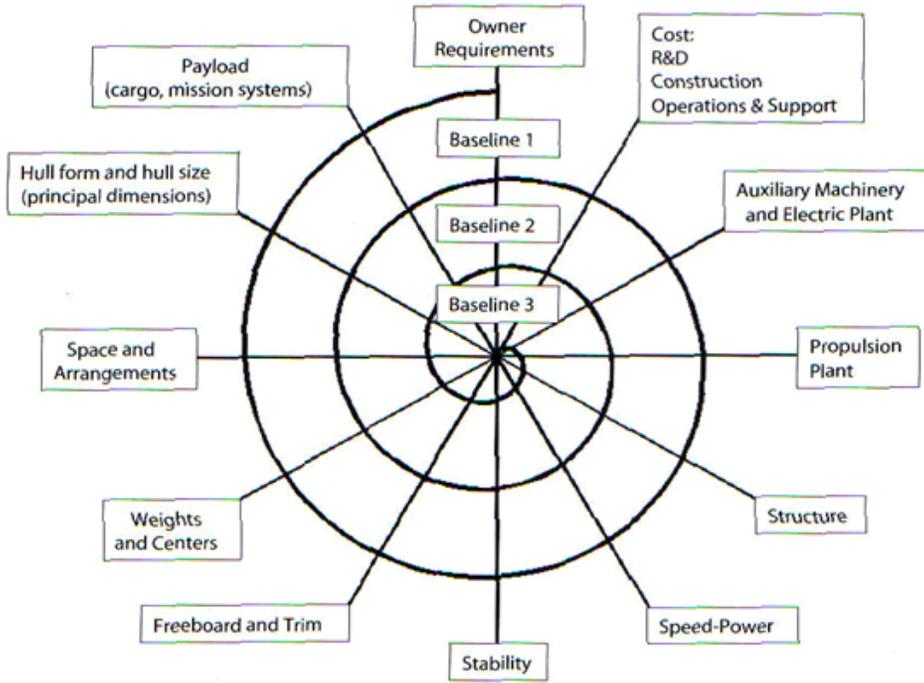


Shown is the expanded view of Preliminary Design. Preliminary Design is made up of six general Design Areas:

- | | | |
|------------------------------------|----|-------------|
| 1. Hull Systems | to | “Float” |
| 2. Mission Systems | to | “Fight” |
| 3. Propulsion/ Power /Machinery | to | “Move” |
| 4. Human Systems | to | “Enable” |
| 5. Survivability | to | “Survive” |
| 6. Design Integration & Management | to | “Integrate” |

Interactions are needed between the Design Areas, with iterations and trade-offs required to converge to a baseline.

Preliminary Design - Design Iteration

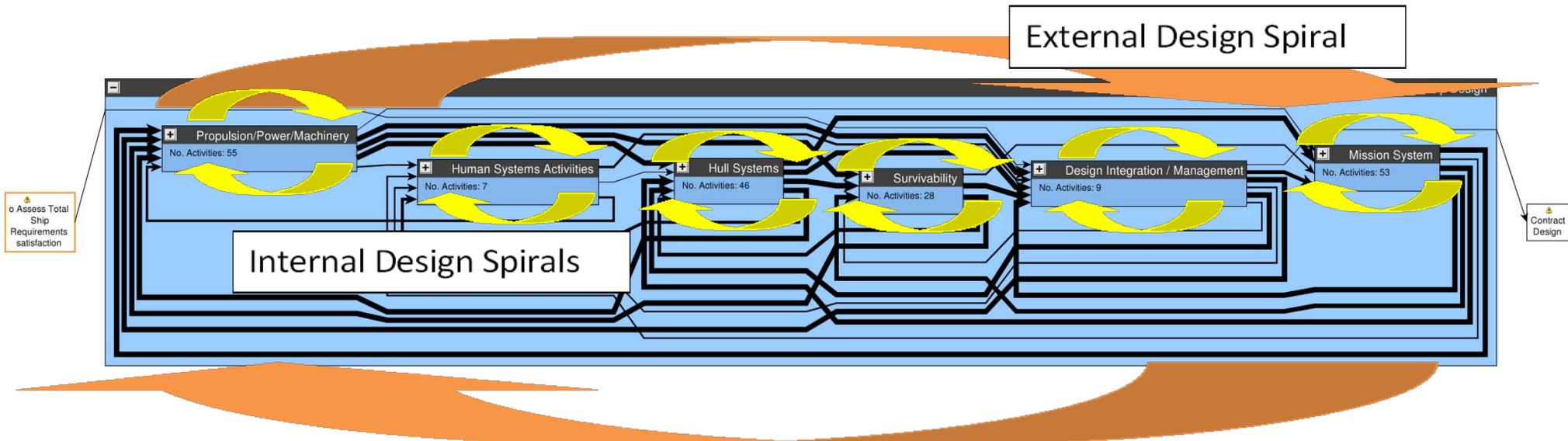


Design is an iterative process, which is difficult to capture in a model. The design spiral to the left is a traditional way of “capturing” the ship design process. As the design progresses, it converges to a single point. Each baseline is a new iteration of the design.

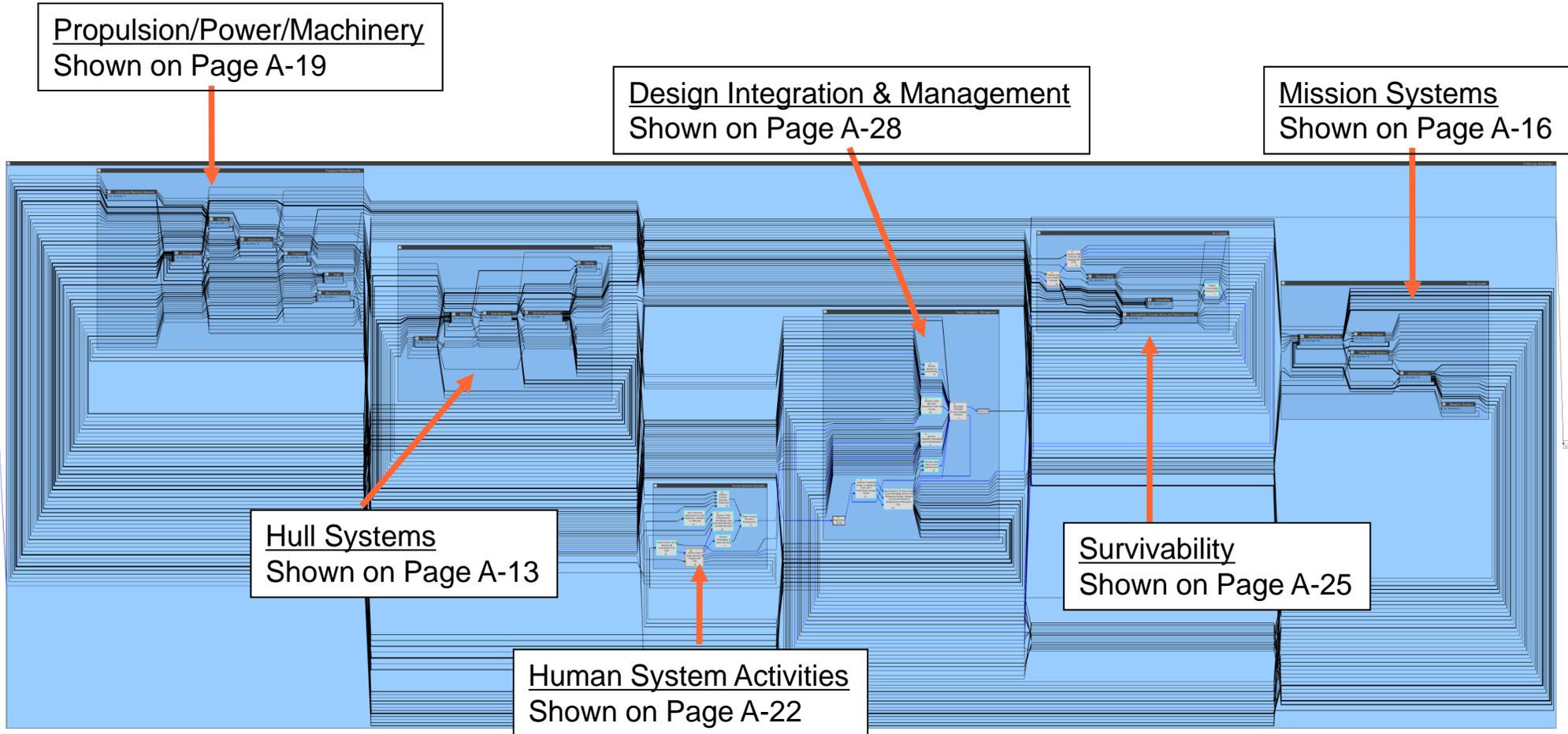
The design spiral does not show the interaction between the engineering areas as iterations progress. These interactions are shown below. The design has an overall spiral, shown in the orange arrows. Within the spiral, there are internal spirals (yellow arrows) which represent the different engineering groups iterating their own work in that iteration's baseline.

Arrows in the process viewed in this document show major information flow. While the arrows capture some of the design interaction, all of the iteration that needs to take place cannot be detailed in a process model.

Taken From: *Ship Design and Construction*. Thomas Lamb (2003)



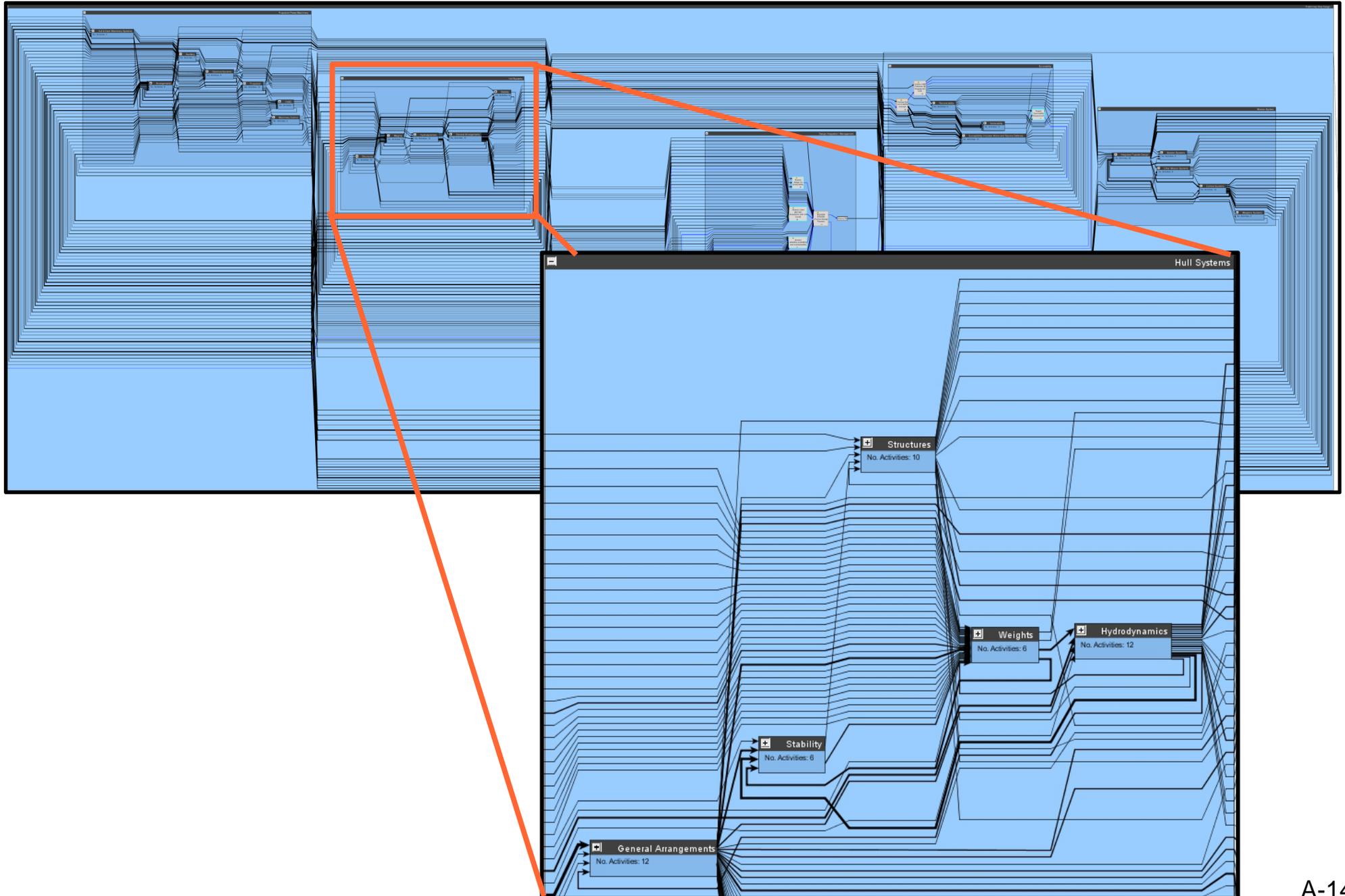
Preliminary Design – Expanded View



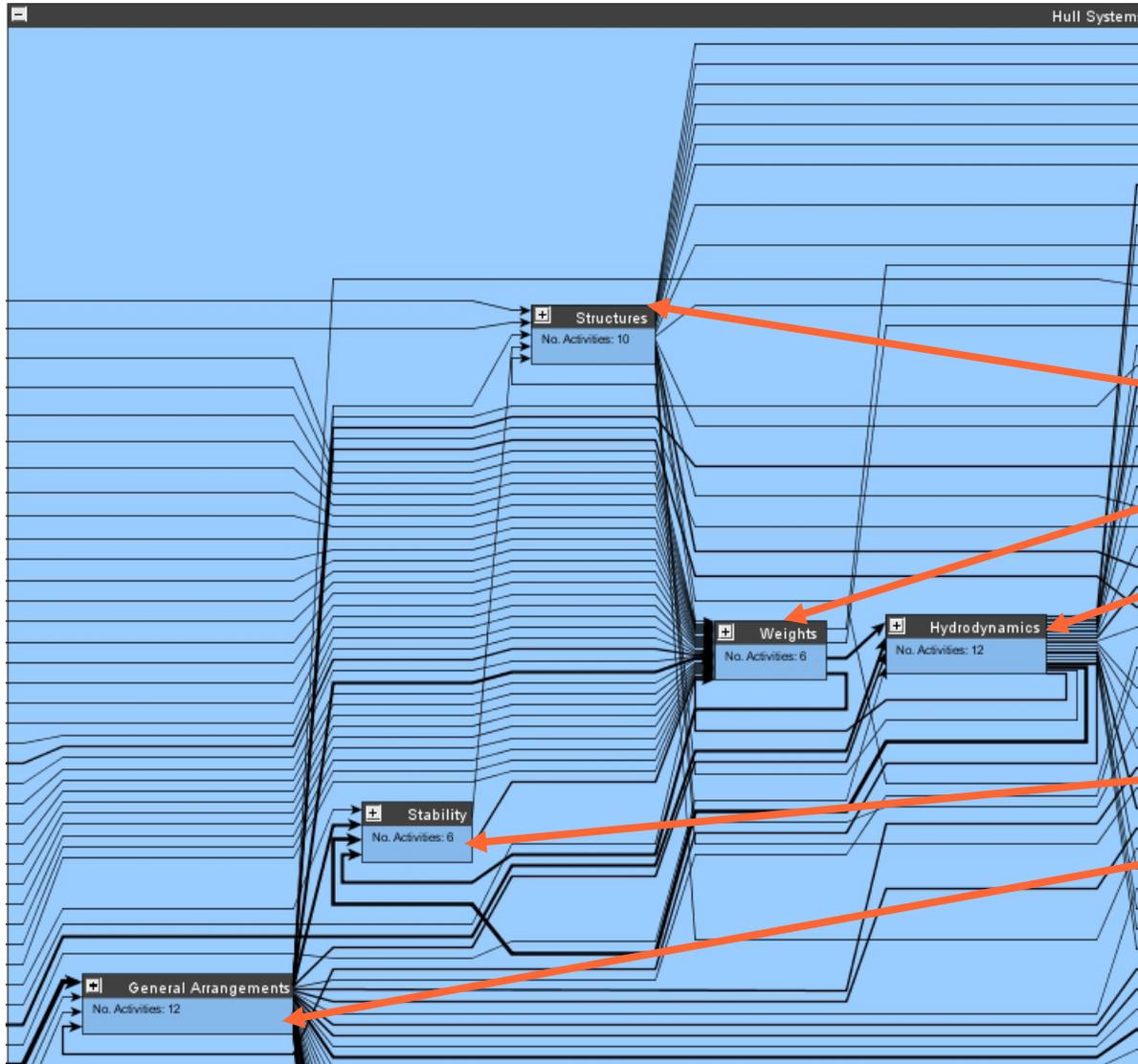
The Preliminary Design Process expanded to 2-levels of detail.

Hull Systems Design Area

Shown is the Hull Systems Design Area from the greater Preliminary Design Process. The Activity Groups are discussed on the next page.



Hull Systems Activity Groups



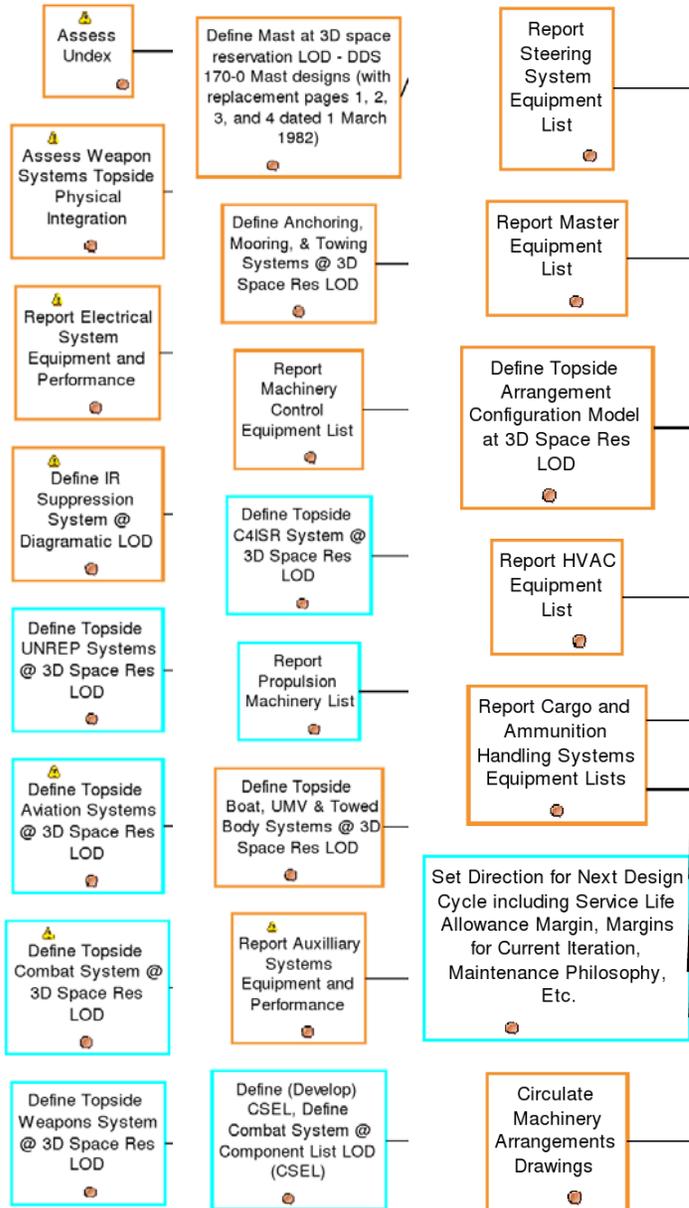
This picture shows the activity groups involved with the Hull Systems Design Area. The next page shows the input and out put activities that link Hull Systems Activity Groups. This group focuses on the activities needed to ensure the ship “floats”.

The primary Activity Groups include:

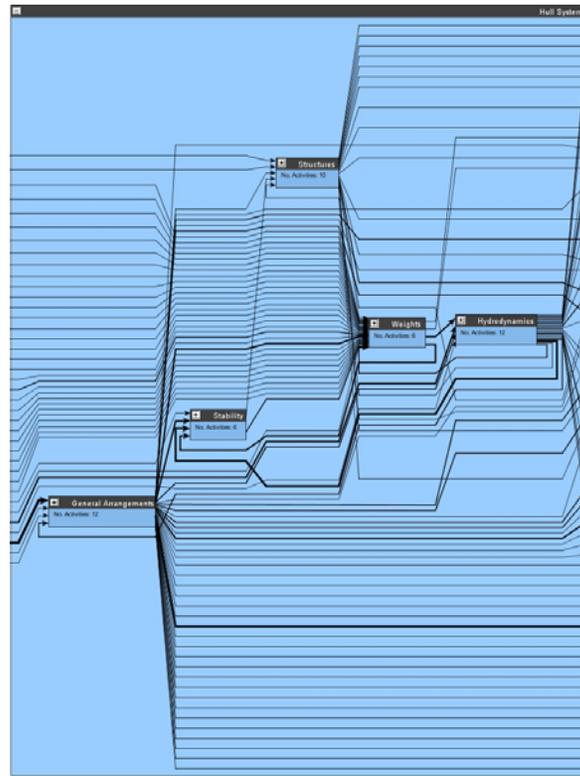
1. Structures
2. Weights
3. Hydrodynamics
4. Stability
5. General Arrangements

Hull Systems Activity Groups

Inputs



Activity Groups

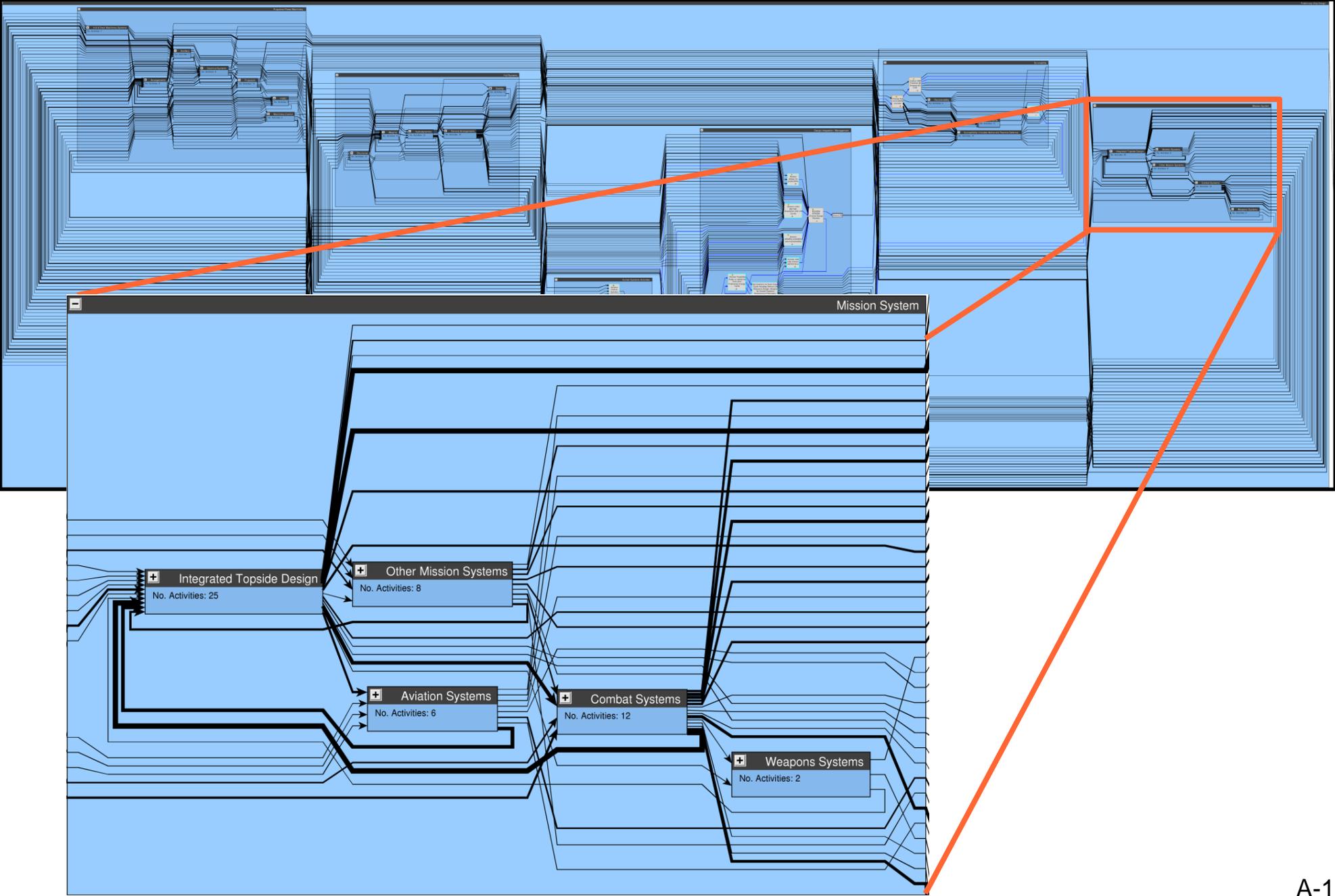


Outputs



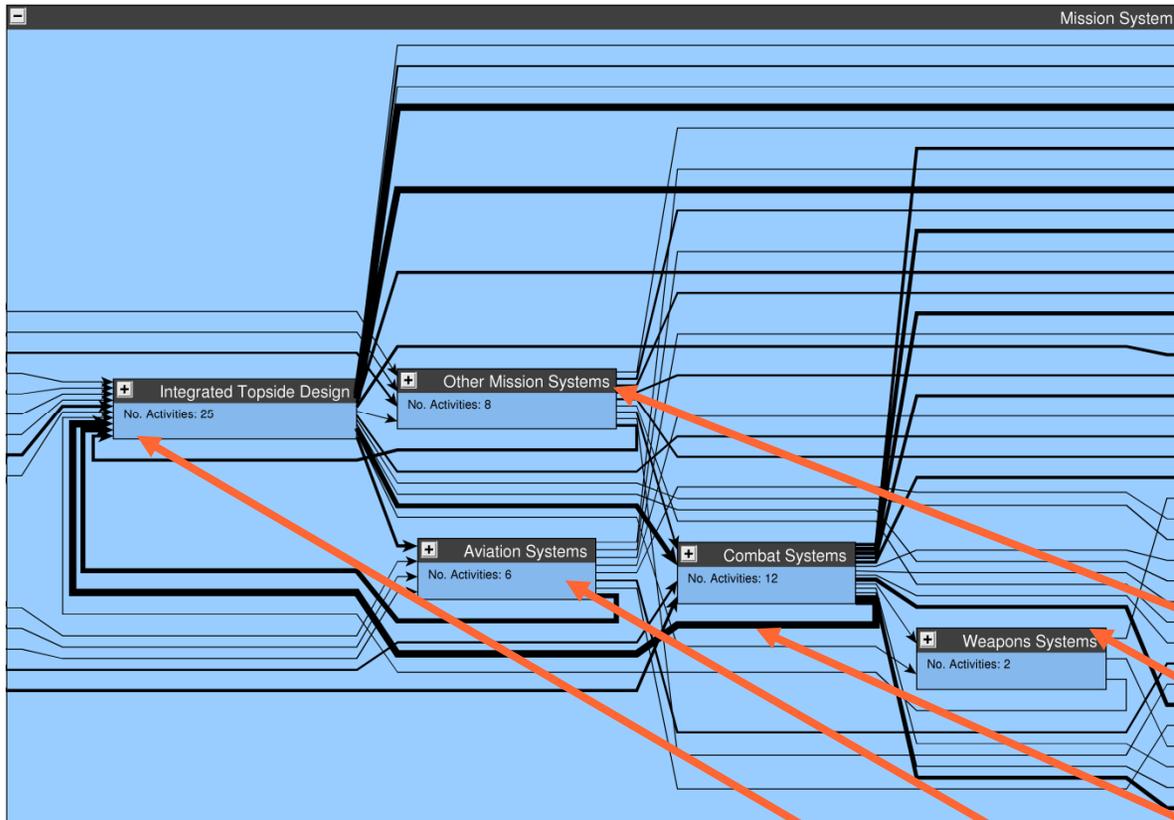
Mission Systems Design Area

Shown is the Mission Systems Design Area from the greater Preliminary Design Process. The Activity Groups are discussed on the next page.



Mission System Activity Groups*

* From a Naval Architect Perspective



This picture shows the activity groups involved with the Mission Systems Design Area. The next page shows the input and output activities that link Mission Systems Activity Groups. This group focuses on the activities needed to ensure the ship “fights”.

The Mission Systems is one of the critical Naval Design Areas; without it, there is little to distinguish the design with a commercial ship.

The Activity Groups shown in this model are from a Hull, Mechanical & Electrical (ie. Naval Architect and Marine Engineer) perspective. The primary Activity Groups are:

1. Other Mission Systems

2. Weapon Systems

3. Combat Systems

4. Aviation Systems

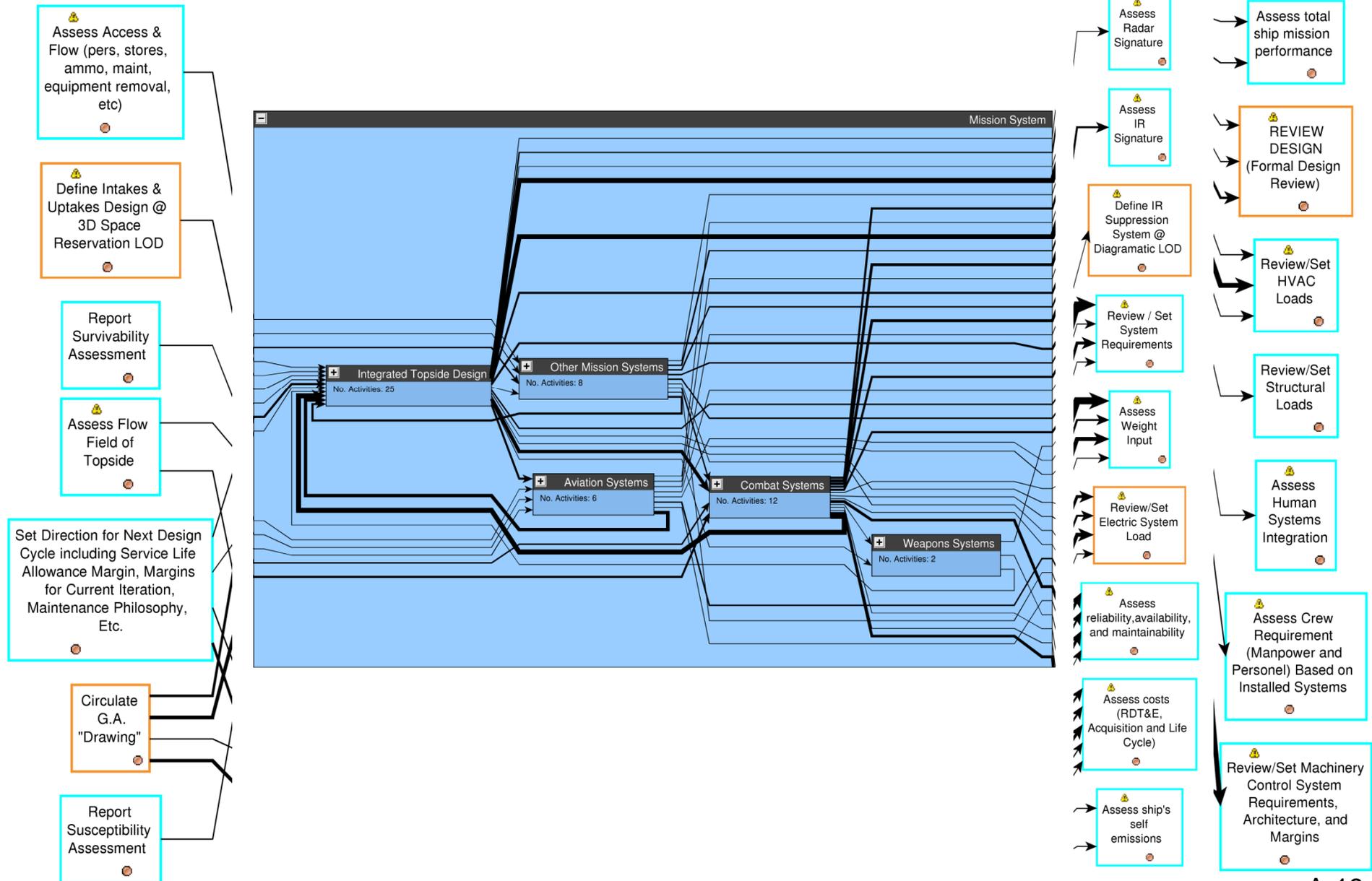
5. Integrated Topside Design

Mission System Activity Groups

Inputs

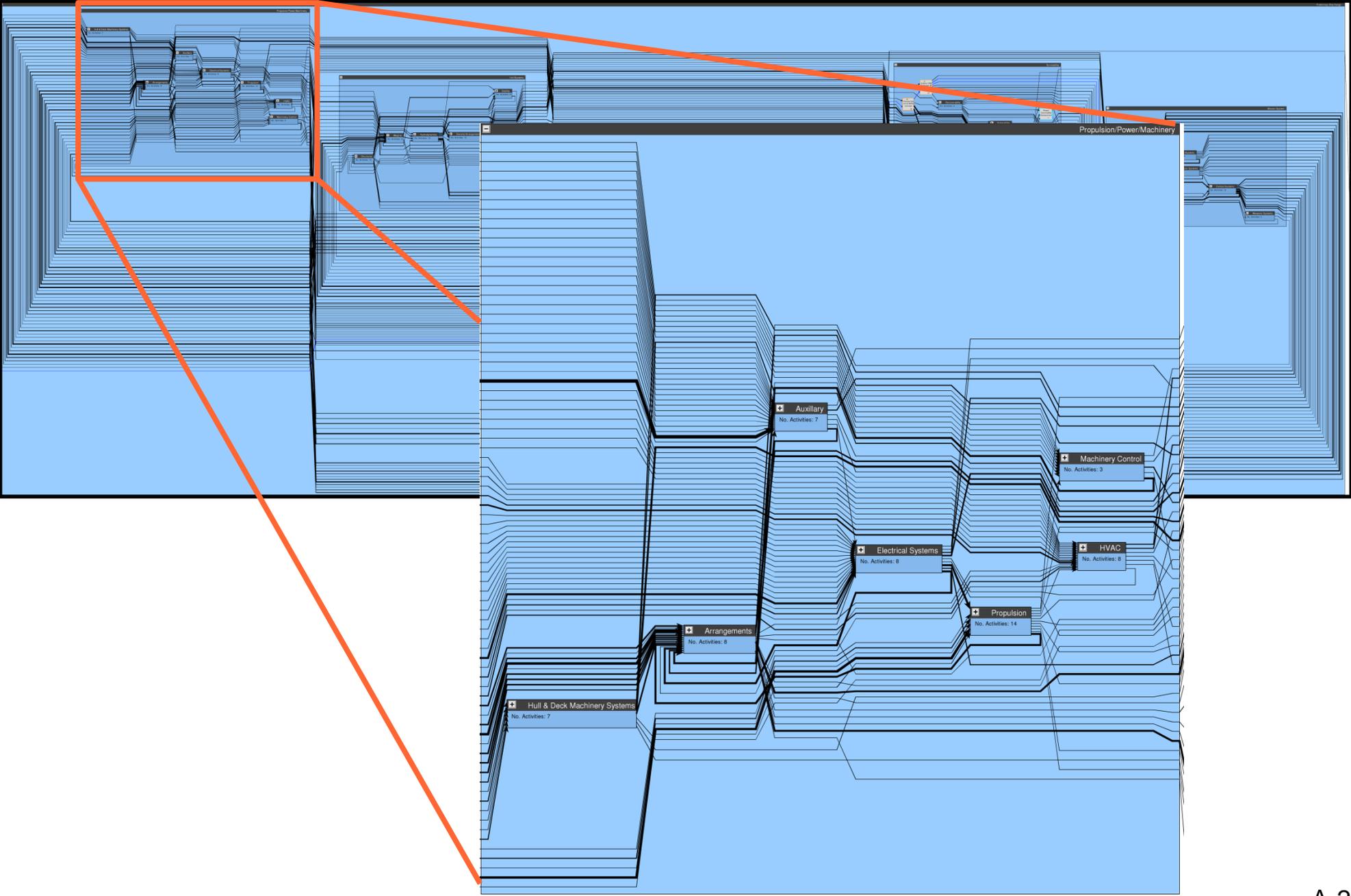
Activity Groups

Outputs

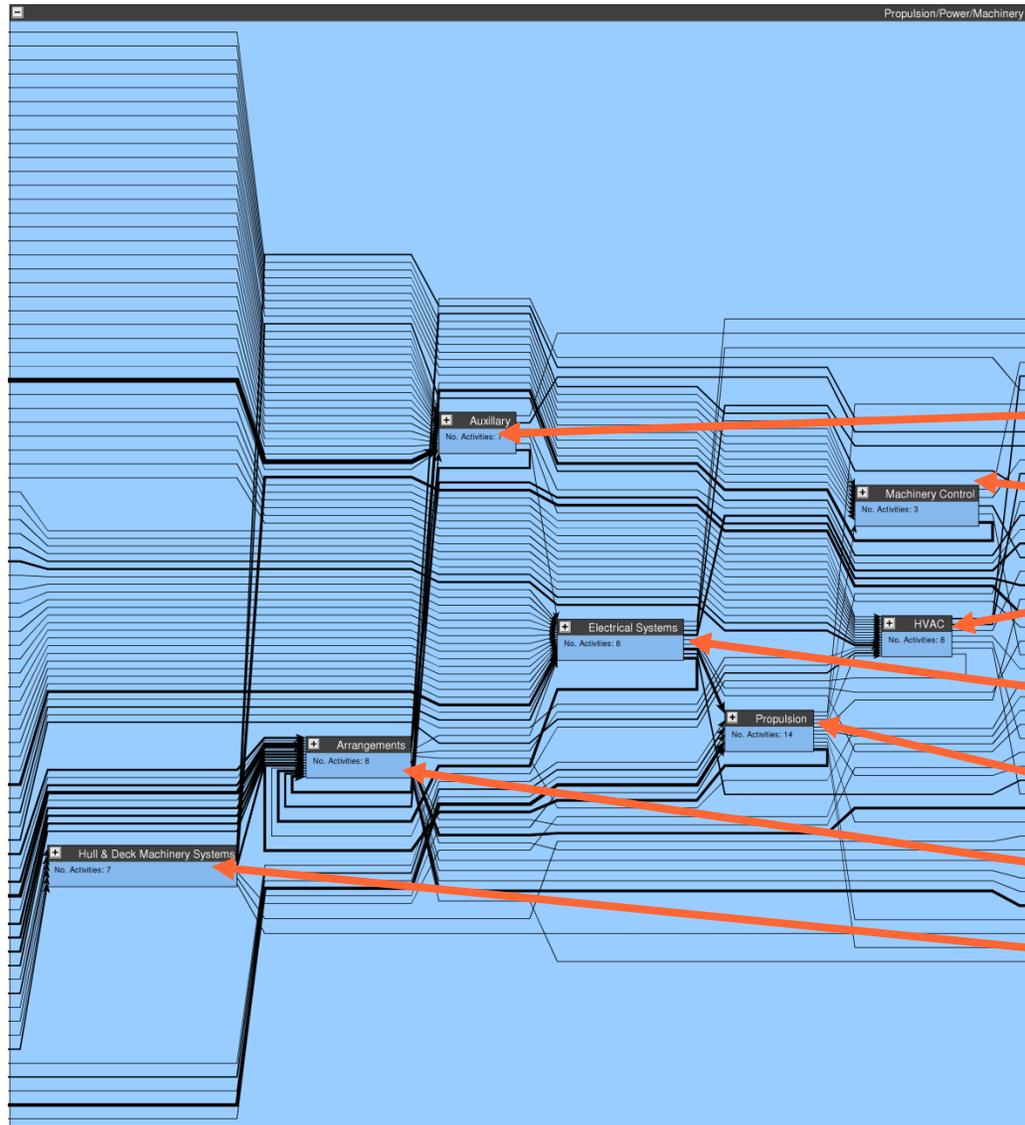


Propulsion /Power /Machinery Design Area

Shown is the Propulsion/Power/Machinery Design Area from the greater Preliminary Design Process. The Activity Groups are discussed on the next page.



Propulsion /Power / Machinery Activity Groups



This picture shows the activity groups involved with the Propulsion /Power /Machinery (PPM) Design Area. The next page shows the input and out put activities that link PPM Activity Groups. This group focuses on the activities needed to ensure the ship “moves”.

The key Activity Groups are:

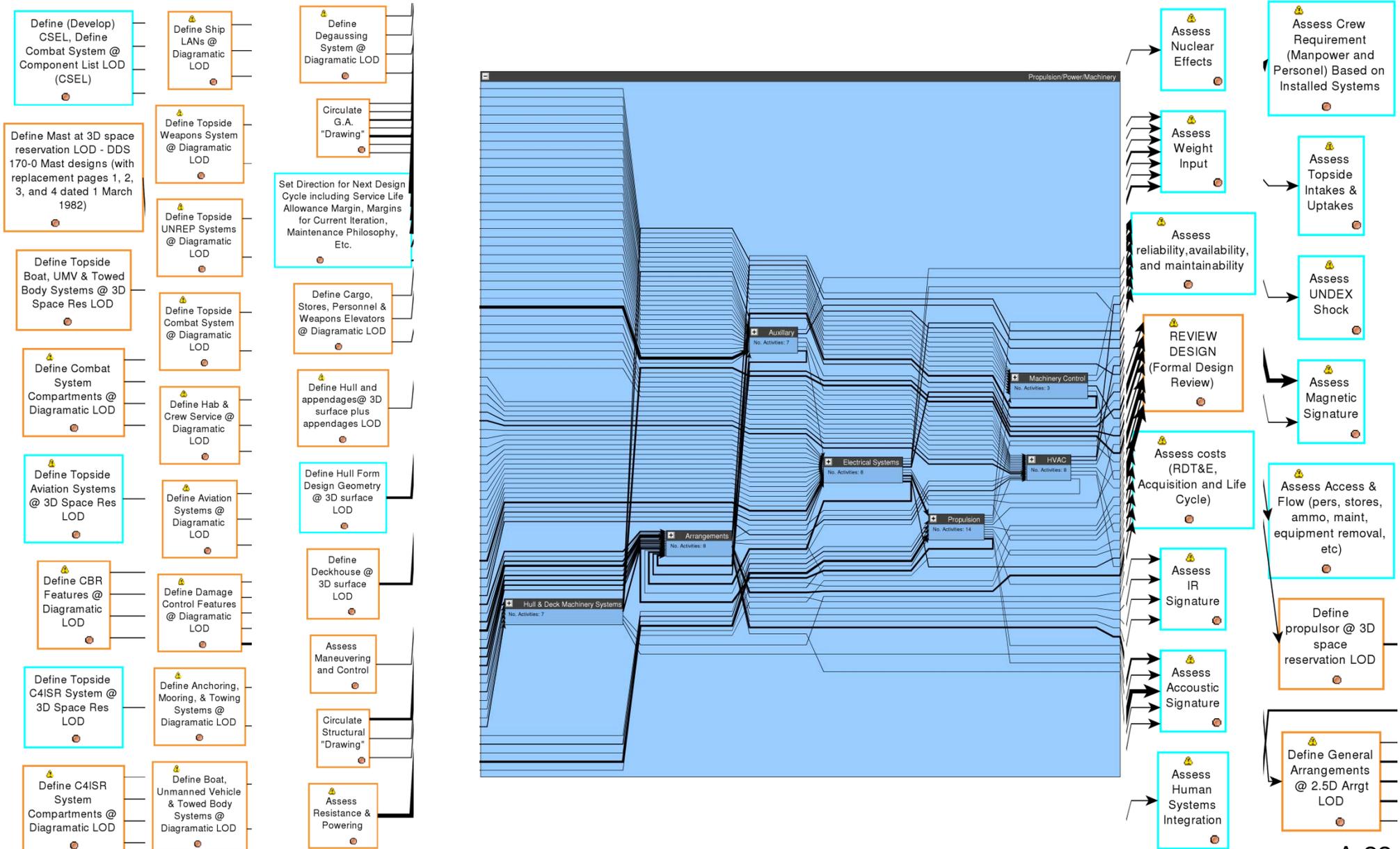
1. Auxiliary Systems
2. Machinery Control
3. HVAC (Heating, Ventilation, Air Conditioning)
4. Electrical Systems
5. Propulsion
6. Machinery Arrangements
7. Hull & Deck Machinery Systems

Propulsion /Power / Machinery Activity Groups

Inputs

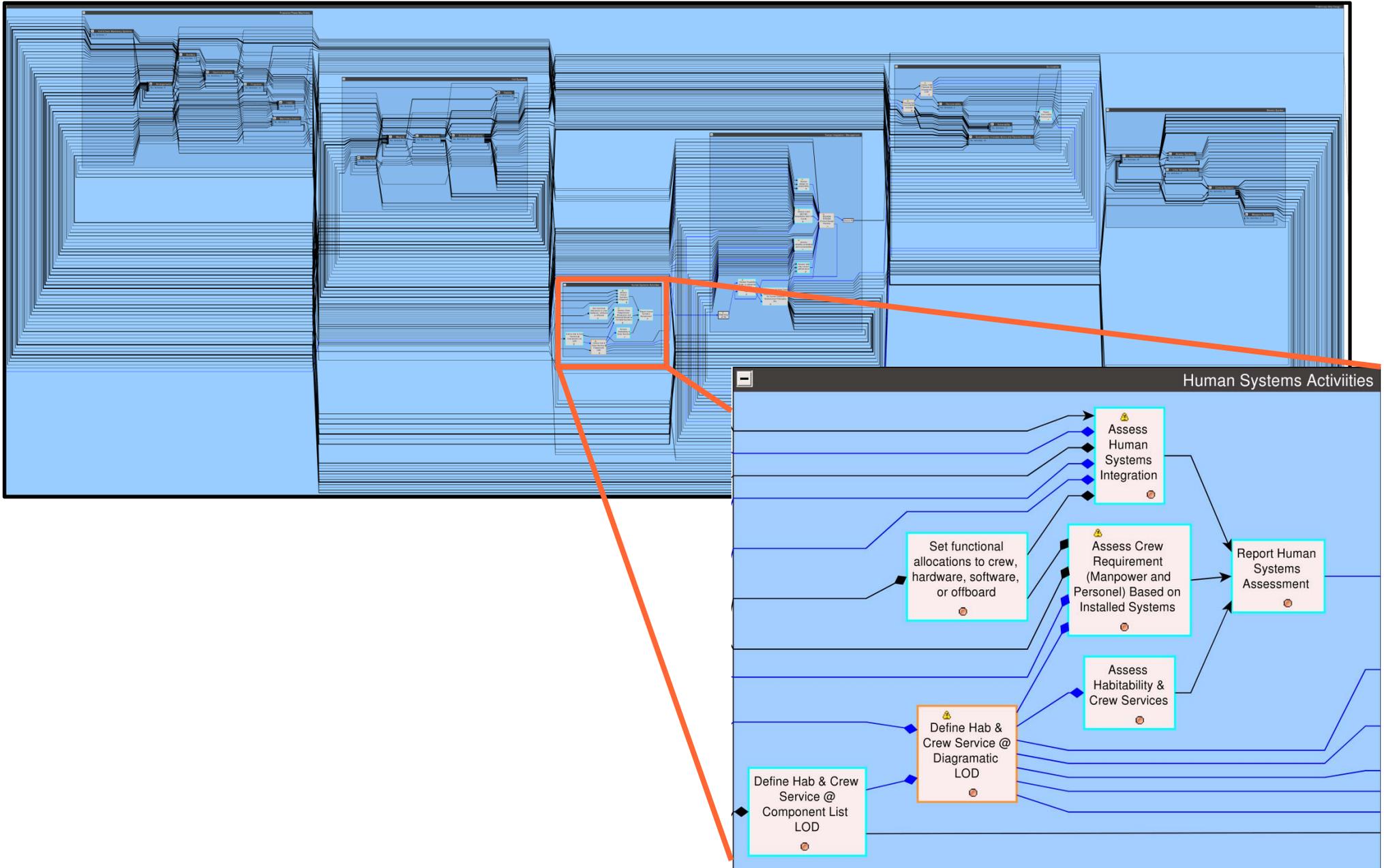
Activity Groups

Outputs

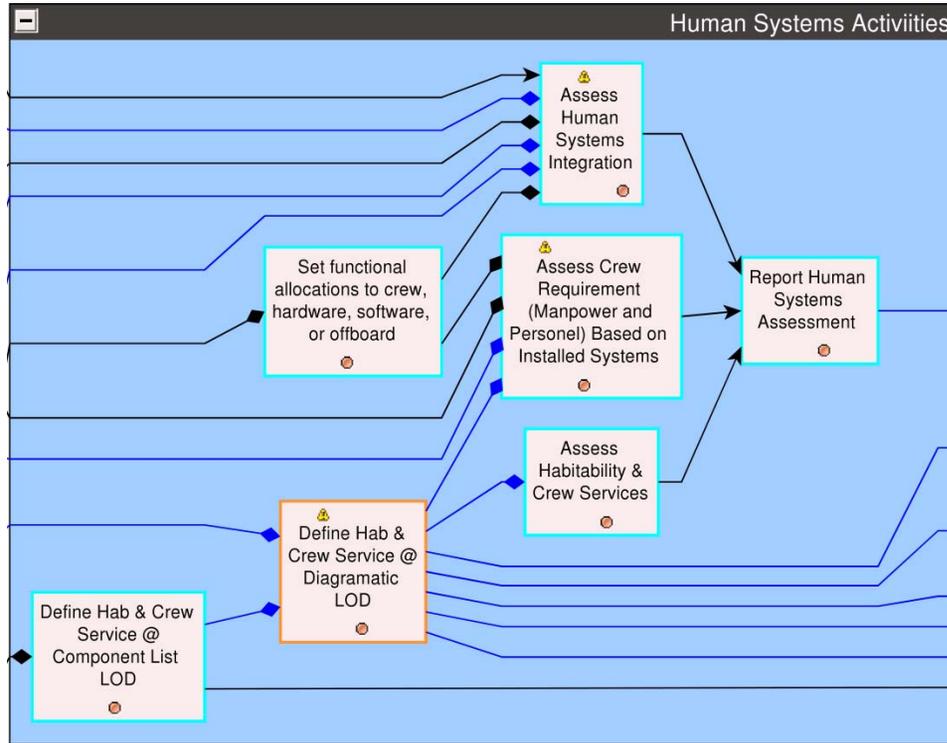


Human Systems Design Area

Shown is the HumanSystems Design Area from the greater Preliminary Design Process. The Activities are discussed on the next page.

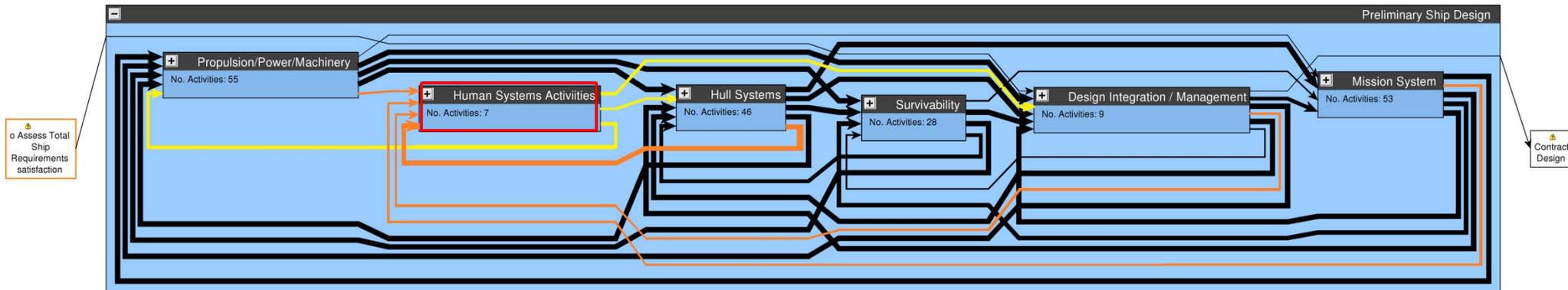


Human Systems Activities



The picture to the left shows the activities involved with the Human Systems Design Area. The next page shows the input and output activities that link to Human Systems Activities. This group focuses on the human factor.

While there are no Activity Groups or iterations shown Human Systems Activities. When taken as part of the whole, iterations can be seen with the other Design Areas (see picture below).



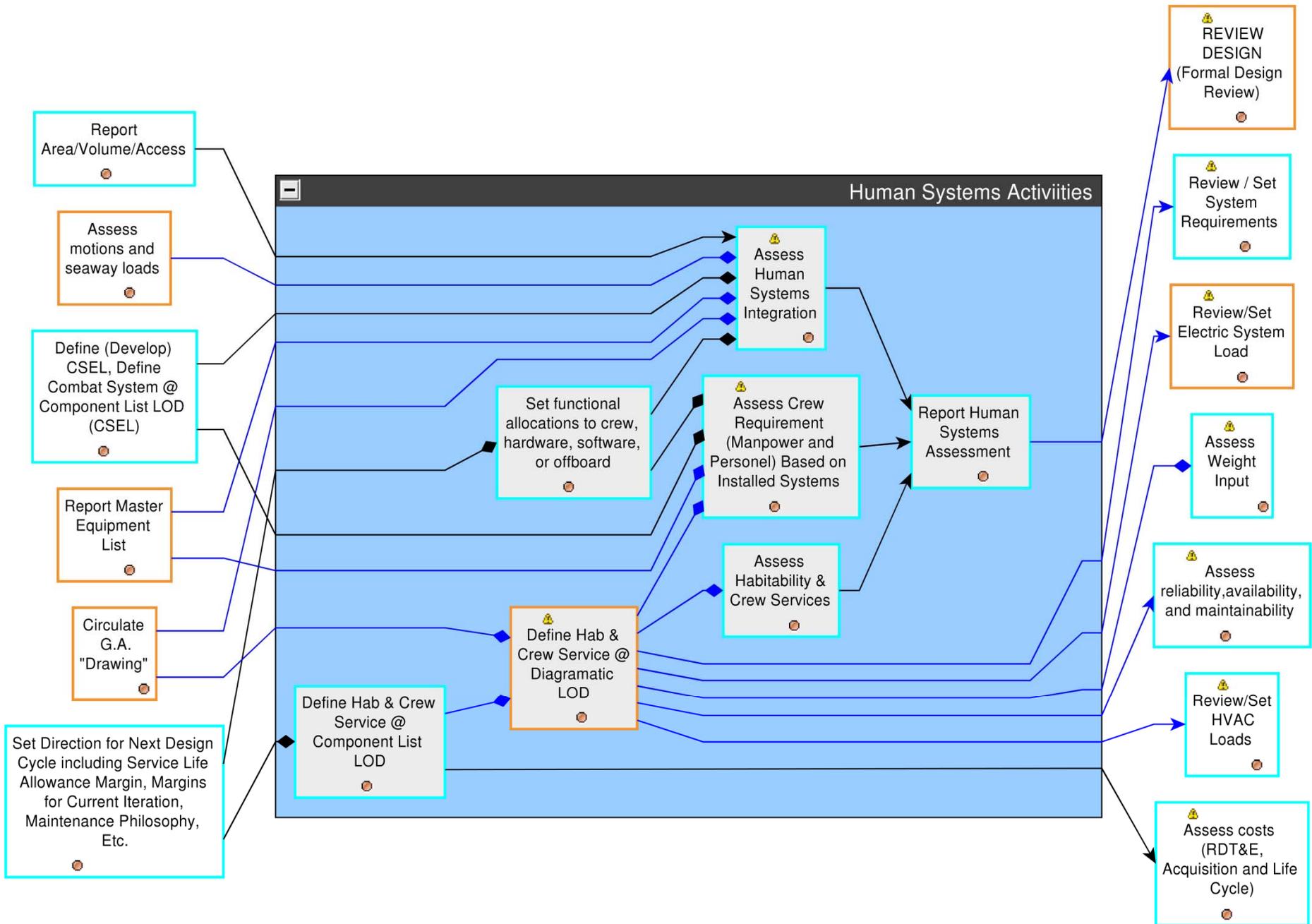
Legend: Yellow – Output of Human Systems
 Orange – Input of Human Systems

Human Systems Activities

Inputs

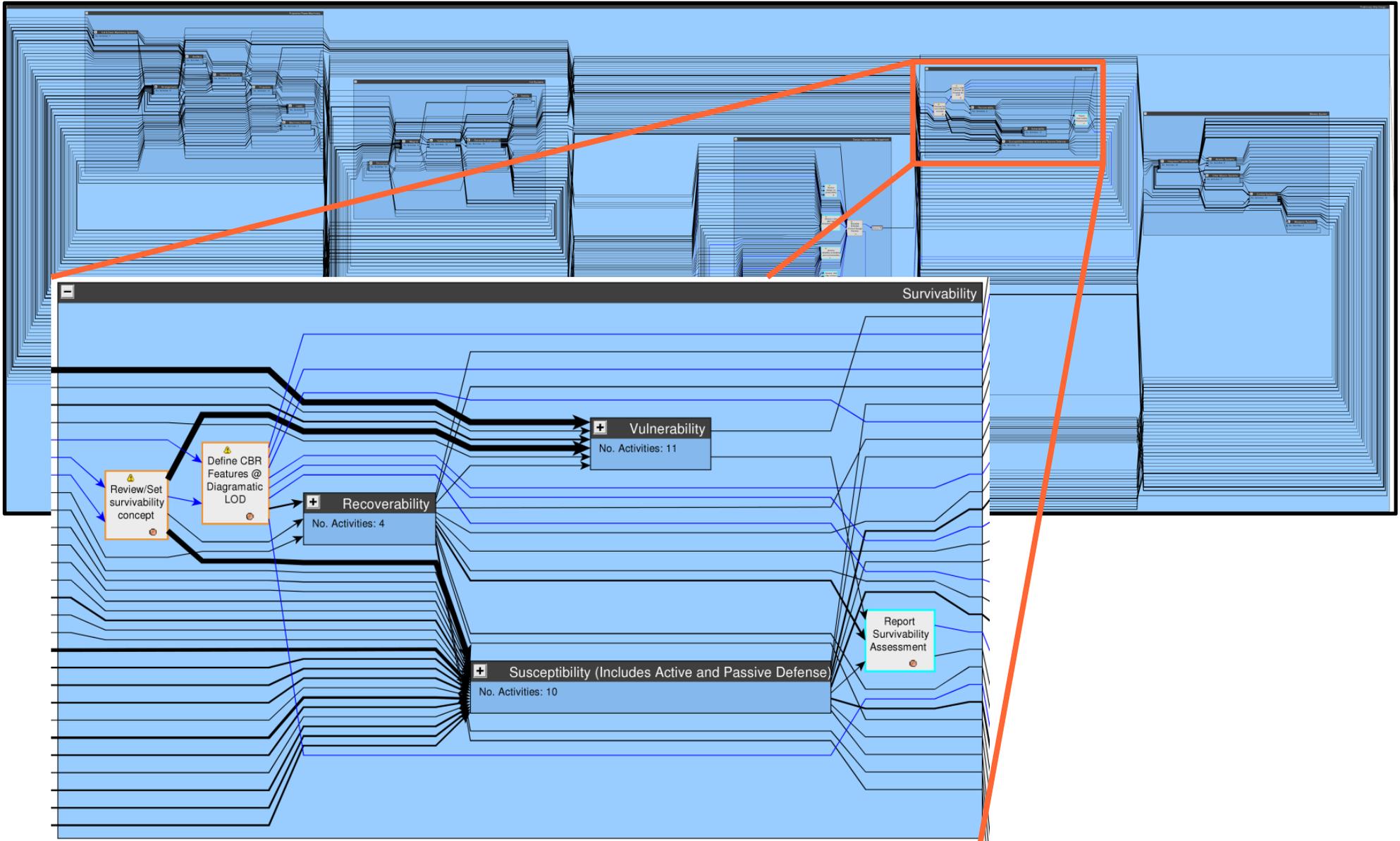
Activities

Outputs

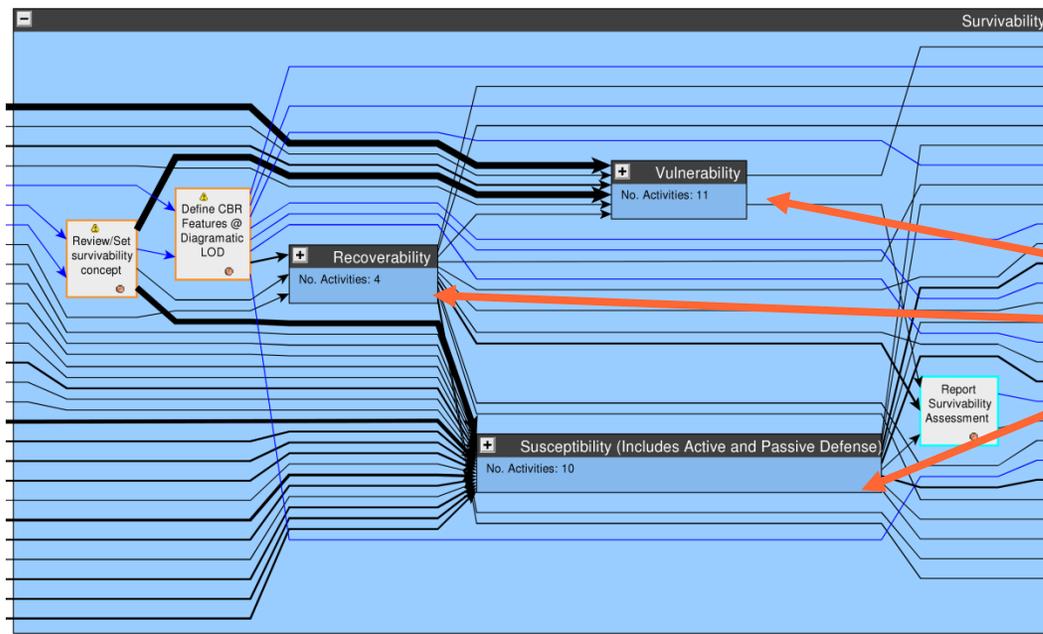


Survivability Design Area

Shown is the Survivability Design Area from the greater Preliminary Design Process. The Activity Groups are discussed on the next page.



Survivability Activity Groups



This picture shows the activity groups involved with the Survivability Design Area. The next page shows the input and out put activities that links Survivability Activity Groups. This group focuses on the activities needed to ensure the ship “survives”.

The key Activity Groups are:

1. Vulnerability
2. Recoverability
3. Susceptibility

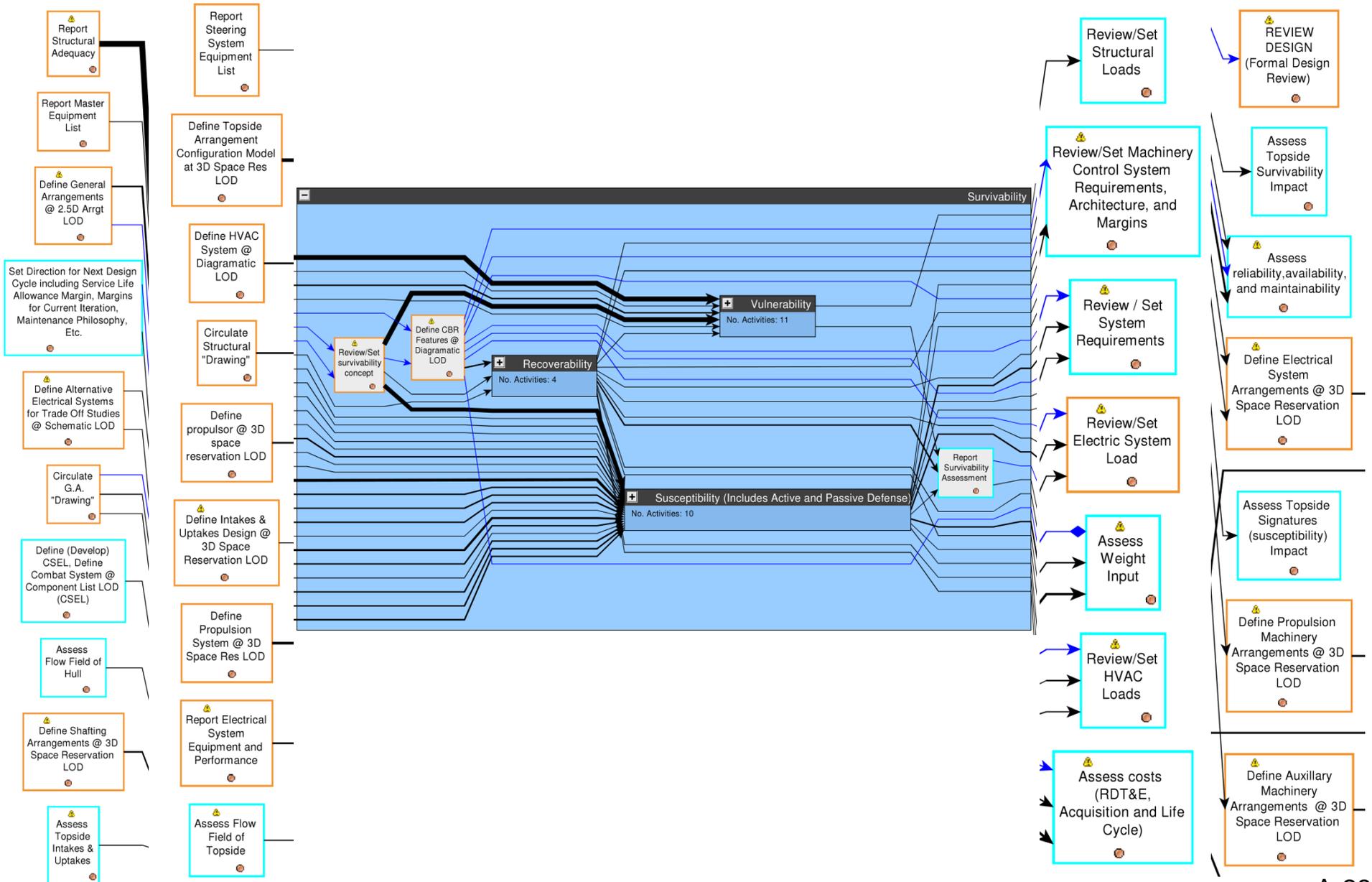
The Vulnerability Activity group accesses the design’s expected capability degradation due to damage. The Recoverability Activity Group accesses the design’s ability to prevent damage spread and to restore degraded capabilities. The Susceptibility Activity Group accesses the design’s likelihood of being damaged by weapons or environmental threats.

Survivability Activity Groups

Inputs

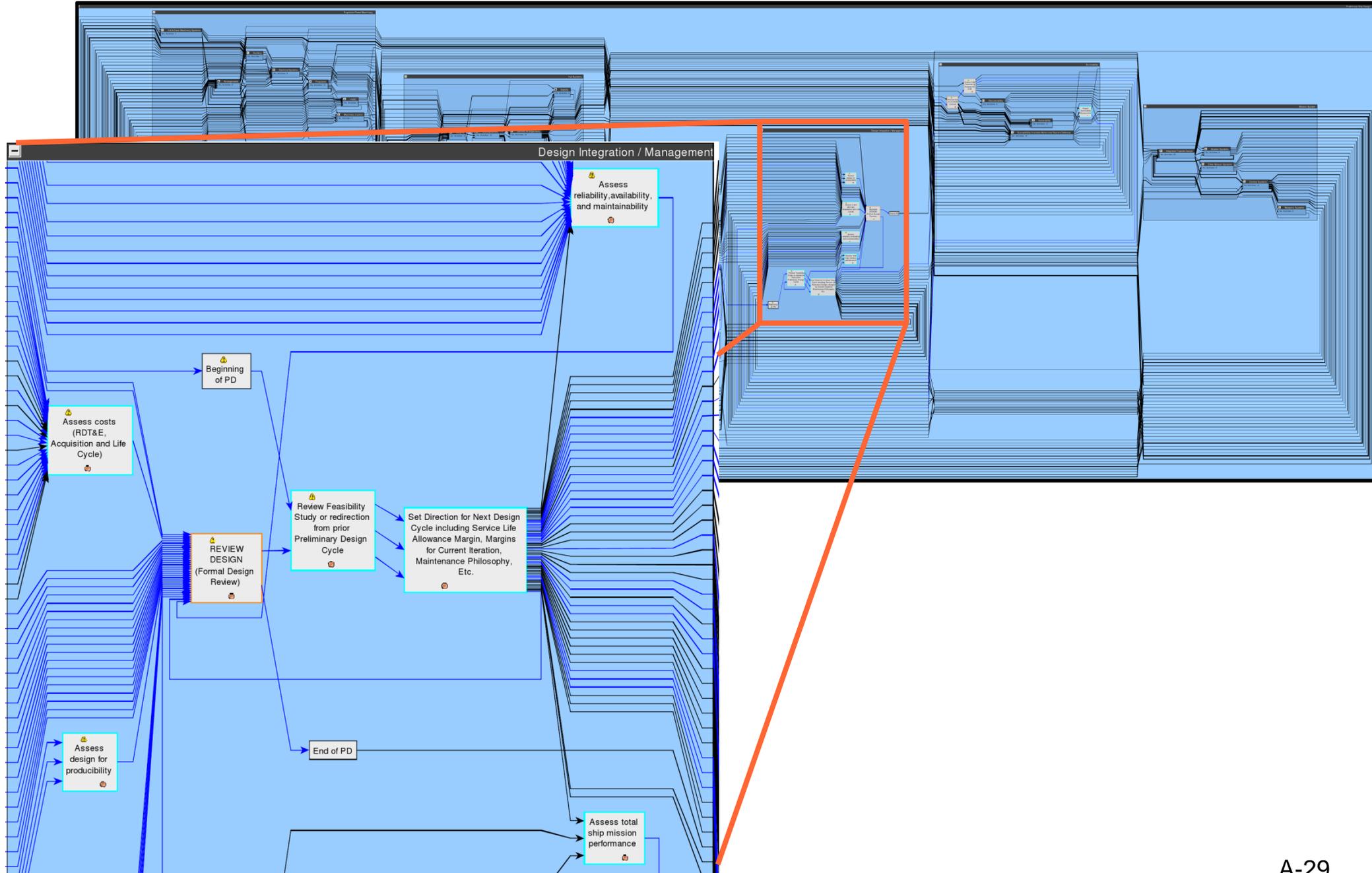
Activity Groups

Outputs

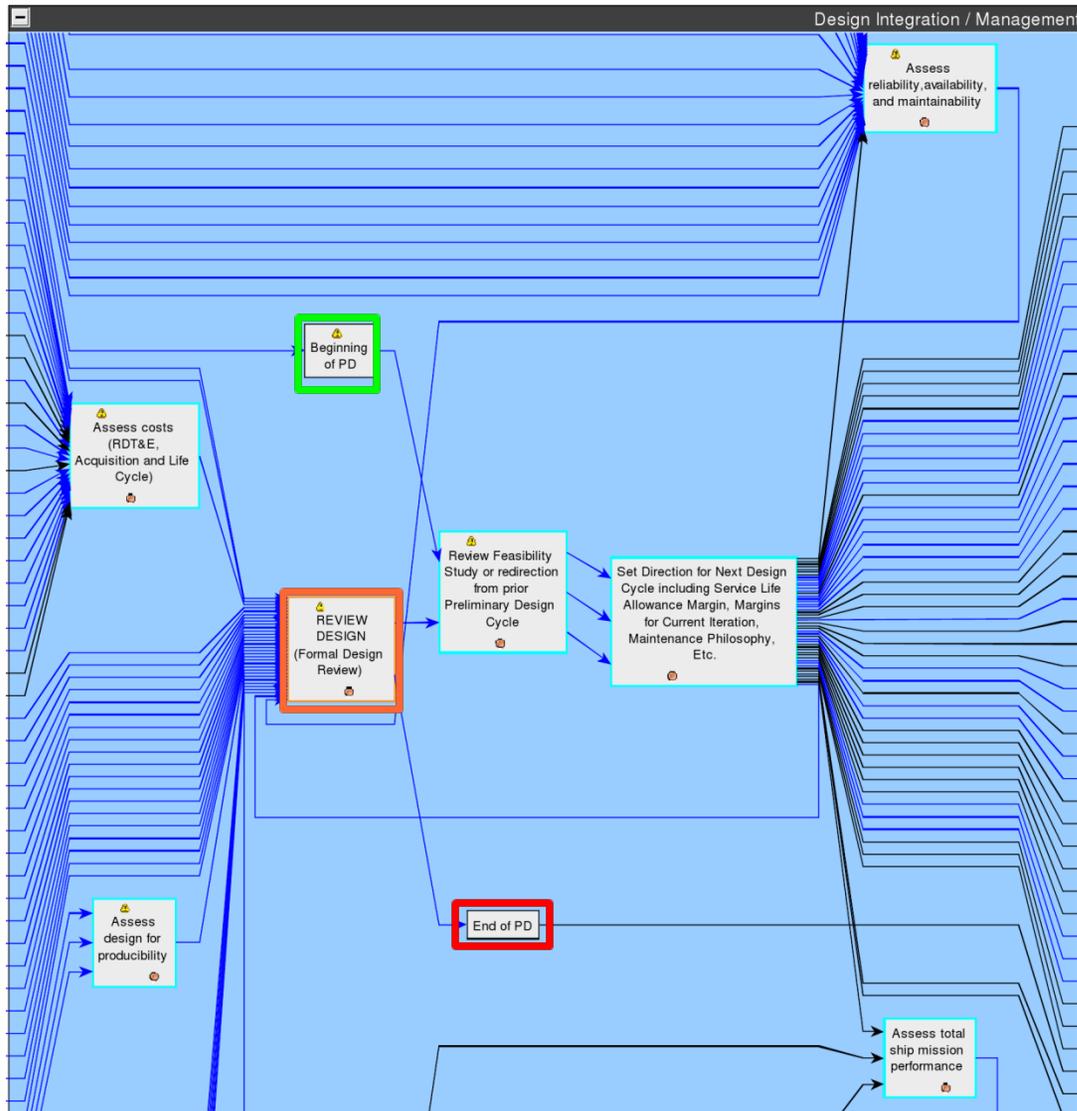


Design Integration & Management Design Area

Shown is the Design Integration & Management Design Area from the greater Preliminary Design Process. The Activities are discussed on the next page.



Design Integration/ Management Activities



This picture shows the activity groups involved with the Design Integration & Management Design Area. The next page shows the input and out put activities that links Design Integration & Management Activity Groups. This group focuses on the activities needed to “integrate” the ship.

The critical Activity in the Design Integration & Management Design Area is the “Formal Design Review”, shown in the orange box. All the information developed through the other Design Areas come together and the design is analyzed as a product.

Depending on the outcome of the Formal Design Review another iteration may begin with the “Begin Preliminary Design (PD)” Activity or continue to another Design Stage with the “End PD” activity; shown in the green and red boxes respectively.

Design Integration/ Management Activities

