ARCHITECTURES

Tsunami Warning System

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This presentation covers a personal elaboration of topics addressed during a post-grad certificate in Space System Engineering completed at the Stevens Institute of Technology (New Jersey USA).

This presentation uses concepts addressed by Stevens lectures, by SE books (see bibliography at the end of the presentation), and notions detailed in the NOAA website.

The personal elaboration is enriched by thoughts developed throughout my job experience.

Sunch presentation is intended to be a vehicle of information sharing totally profit-free in accordance to the spirit of the INCOSE Swiss Chapter.

Manolo Omiciuolo

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TSUNAMI | NEED | CONTEXT DIAGRAM | OPERATION SCENARIO

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- **sudden displacements in the sea floor;**
- **landslides;**
- **volcanic activity;**

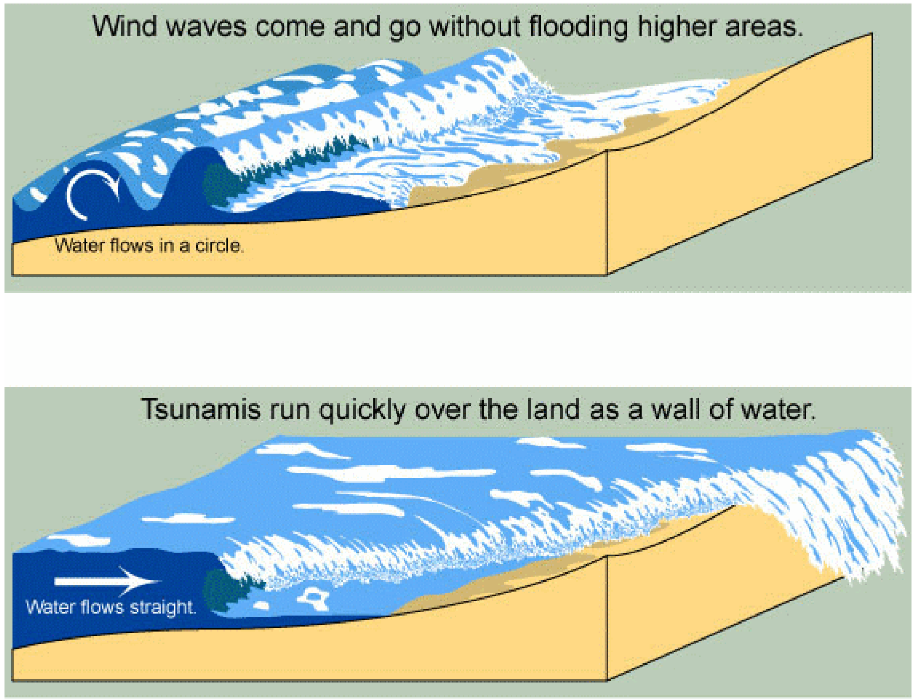

Figure 1: TSUNAMI versus WINDWAVES (Source: www.meteoweb.com)

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TSUNAMI | **NEED** | CONTEXT DIAGRAM | OPERATION SCENARIO

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Can we PREVENT a Tsunami? NO

Can we MITIGATE the impact of a Tsunami? YES, IF

- community preparedness;
- timely warnings;
- effective response;

Detect Data	Process Data	Communicate

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TSUNAMI | NEED | **CONTEXT DIAGRAM** | OPERATION SCENARIO

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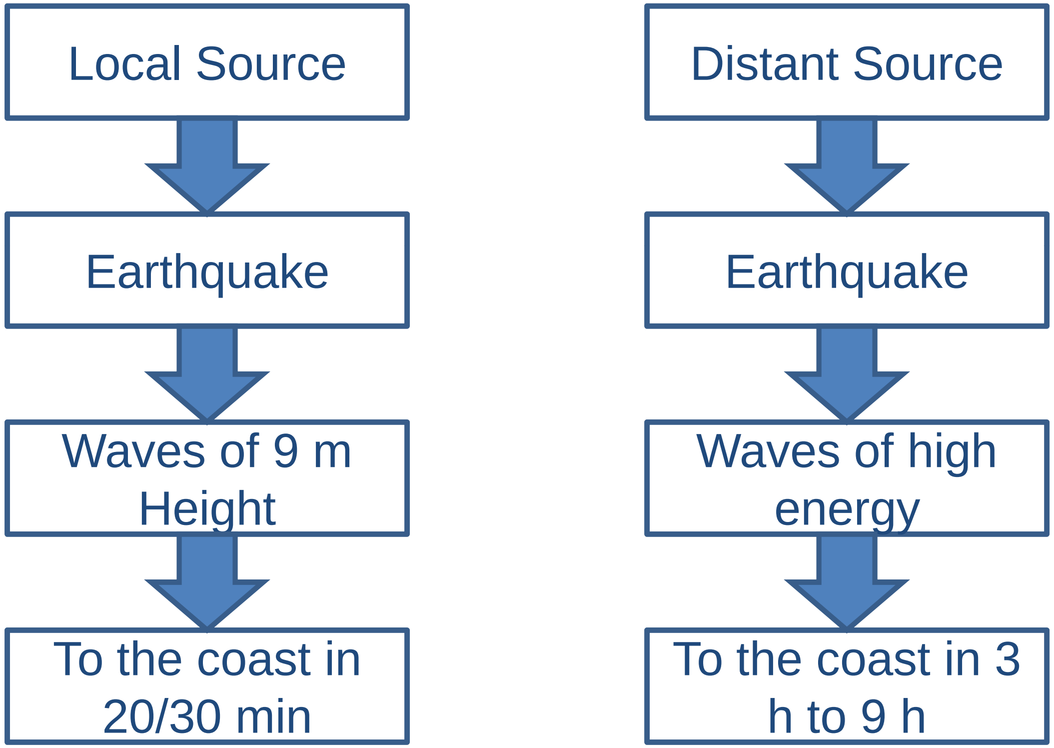

TSUNAMI

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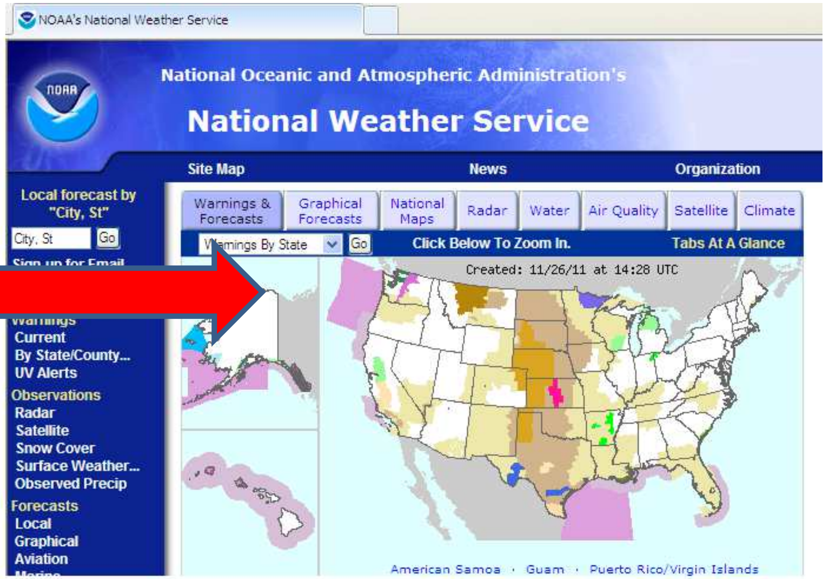
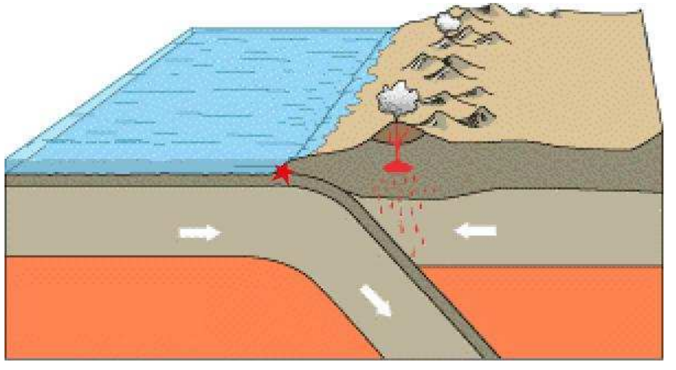
Pacific North West Area

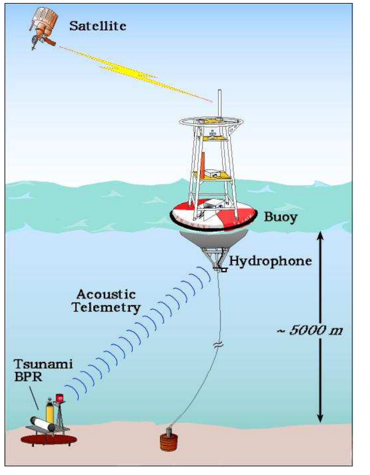
Earthquake

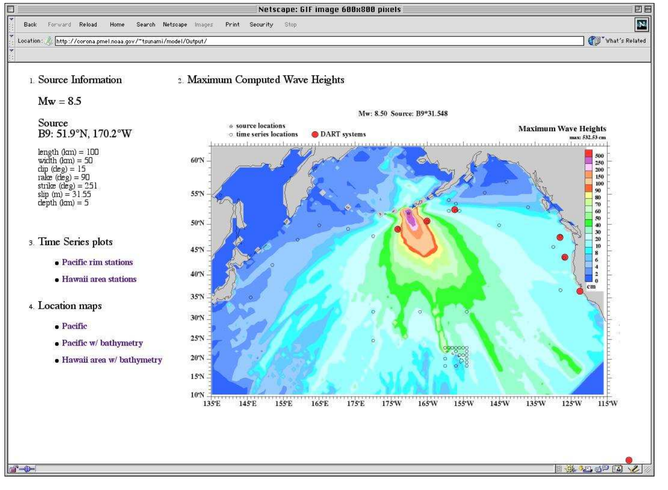
Tsunami Warning System

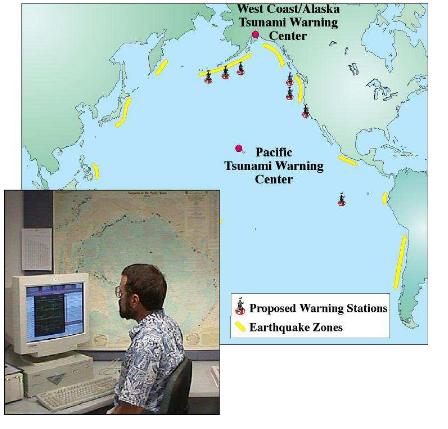


Earthquake *t=0*









Warning *t=1 hour*

- System Engineering can be seen as:
  - **Process** by which a **set of objectives**
  - are transformed into **an operational system**
  - that **meets** the **stakeholders' objectives**
  - and **implements** the necessary **business process**
  - **over its useful life**;

- The SE Bible in a few words:
  - Requirements for the entire life cycle;
  - **Functions, components and interfaces**;
  - Behavior and performances.

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System Engineer | Architecture | Functional Architecture | Physical Architecture

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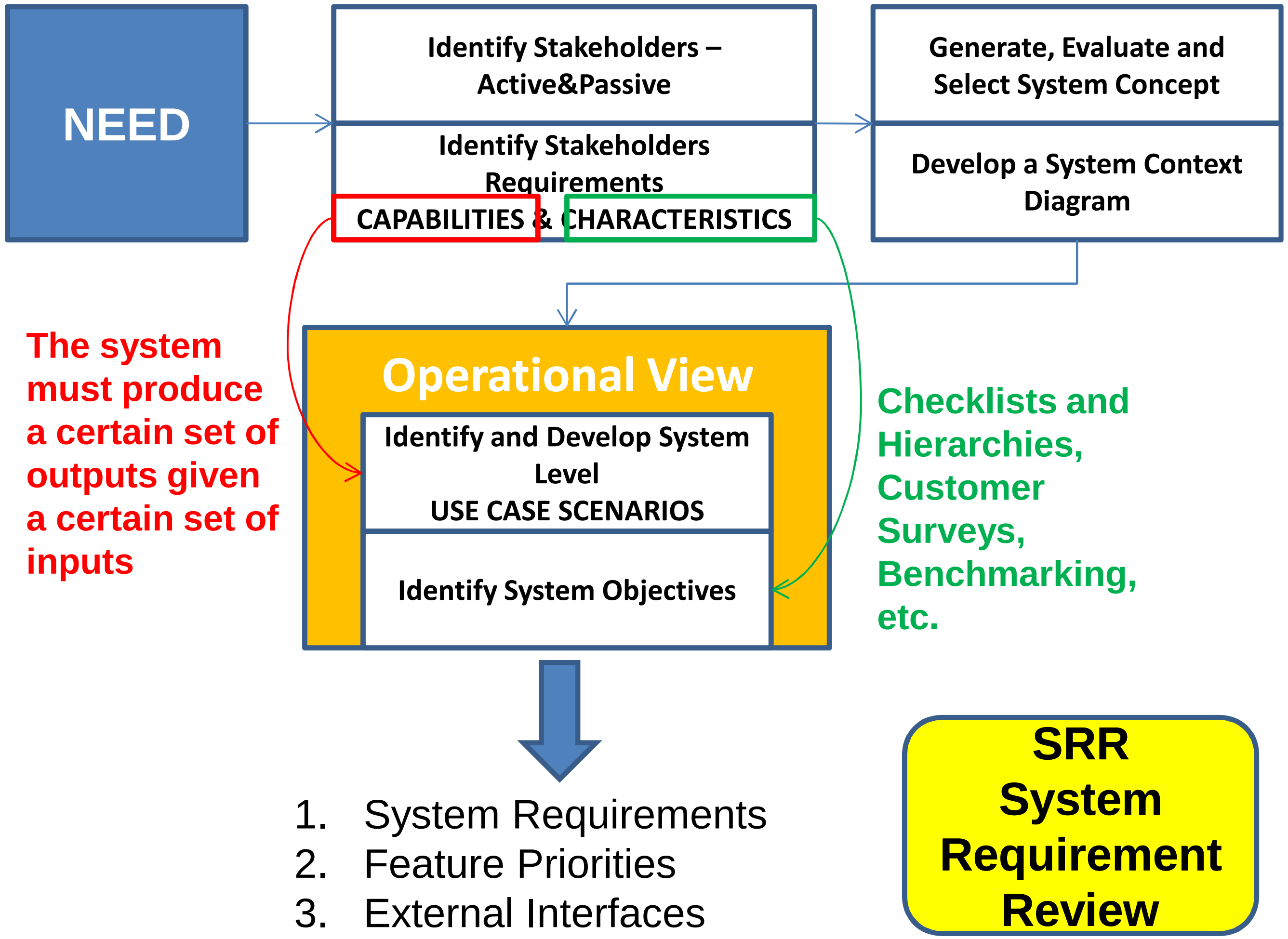

So far we have described what the system must do by focusing on its inputs and outputs (rem. ***capabilities***), and system objectives (rem. ***charachteristics***).

- ❑ Write the System Requirement Document to support the design;
- ❑ Follow the traceability of the requirements;
- ❑ To support early verification (the as-designed system is designed in the right way) and validation (the as-designed system is the right system);
- ❑ To support the generation of the needed documents to tackle the PDR (Preliminary Design Review);
- ❑ To be able to follow any change in the design through flexible tools and/or graphical ways to represent our system.

ARCHITECTURE DEVELOPMENT

System Engineer | **Architectures** | Functional Architecture | Physical Architecture

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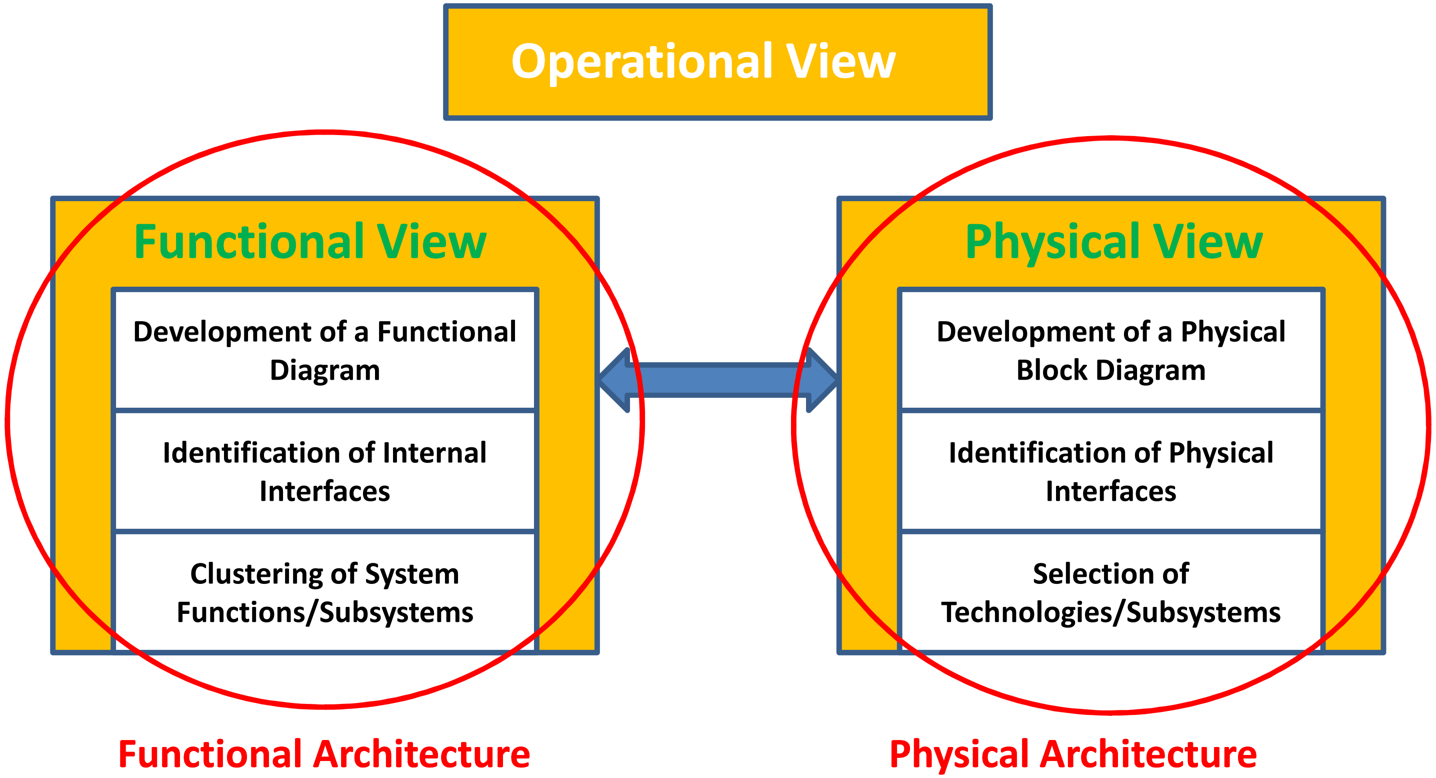

PDR
Preliminary Design Review

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- **FUNCTIONAL ARCHITECTURE**: it **defines what the system must do** (i.e., the system's functions and the data that flows between them).

- **PHYSICAL ARCHITECTURE**: it **represents** the **partitioning of physical resources** available **to perform** the system's functions.

- **ALLOCATED ARCHITECTURE**: it is the **mapping of functions to resources** in a manner that is suitable for **discrete-event simulation** of the system's functions (such architecture goes beyond the scope of this lecture).

From an external view of the system (what it is intended to do) to an **internal view** (how it will accomplish its intent)...

FUNCTION:
- A function is a **process** that transforms inputs into outputs;
- A function describes an **action** taken by the system or one of its elements;
- A function is represented by a **verb** or **verb-noun** pair.

There are several standardized ways to represent a functional architecture (**a hierarchical description of a system's functions**):

- ❑ **FFBD Functional Flow Block Diagram**;
- ❑ **N-Squared Charts**;
- ❑ **IDEF Integrated Definition for Function Modelling**;

From an external view of the system (the system itself and its universe) to an **internal view** (which resources will comprise the system to accomplish the functions)...

RESOURCE:
- A resource could be a **hardware**;
- A resource could be a **software**;
- A resource could be represented by either **people, facilities, documents, procedures**;
- Resources are also a combination of the above mentioned resources.

There are many graphical representations of a physical architecture with little standardization (**a hierarchical description of a system's resources**) however SysML is now accepted as a convention:

- ❑ **Block Definition Diagram**;
- ❑ **Internal Block Diagram**;

DART Buoy Functional Architecture | DART Buoy Physical Architecture | Analysis & Validation | Evaluation

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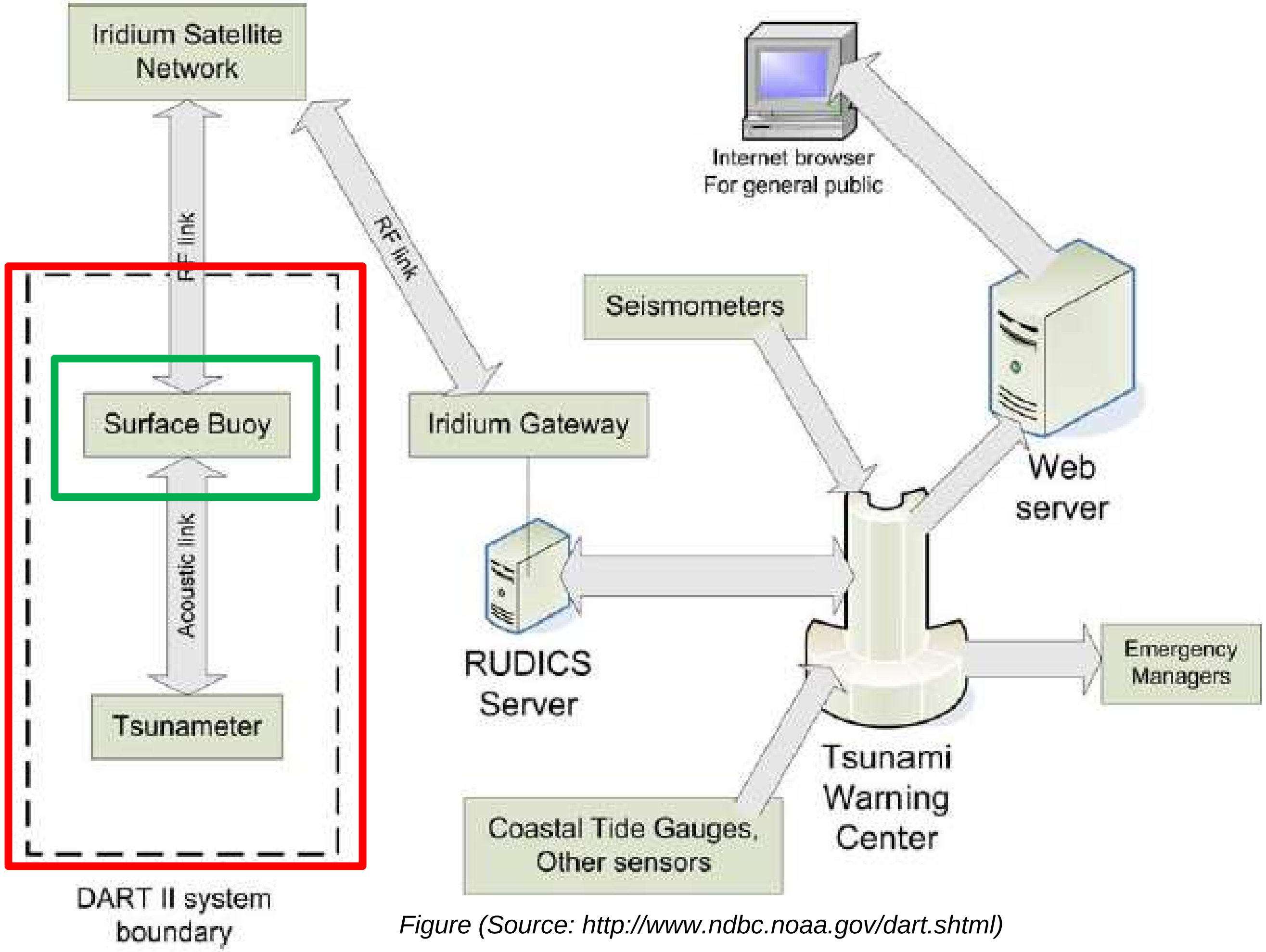

Figure (Source: http://www.ndbc.noaa.gov/dart.shtml)

DART Buoy Functional Architecture

DART Buoy Physical Architecture

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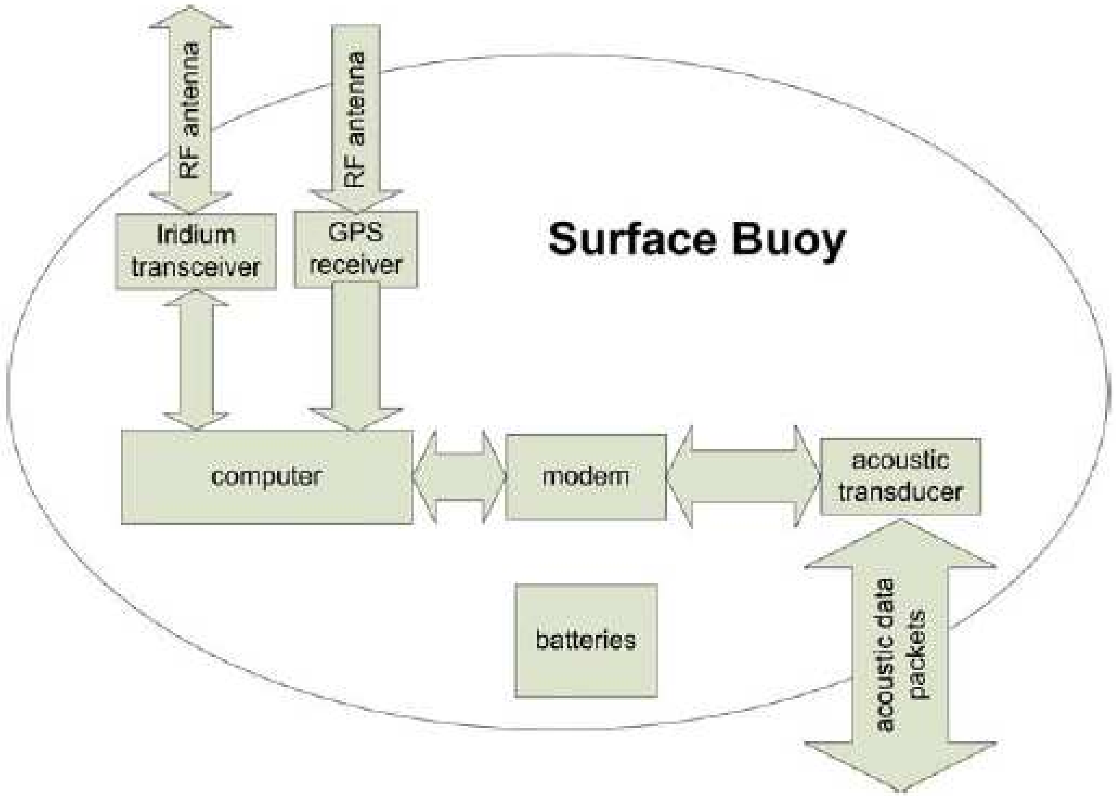

Figure (Source: http://www.ndbc.noaa.gov/dart.shtml)

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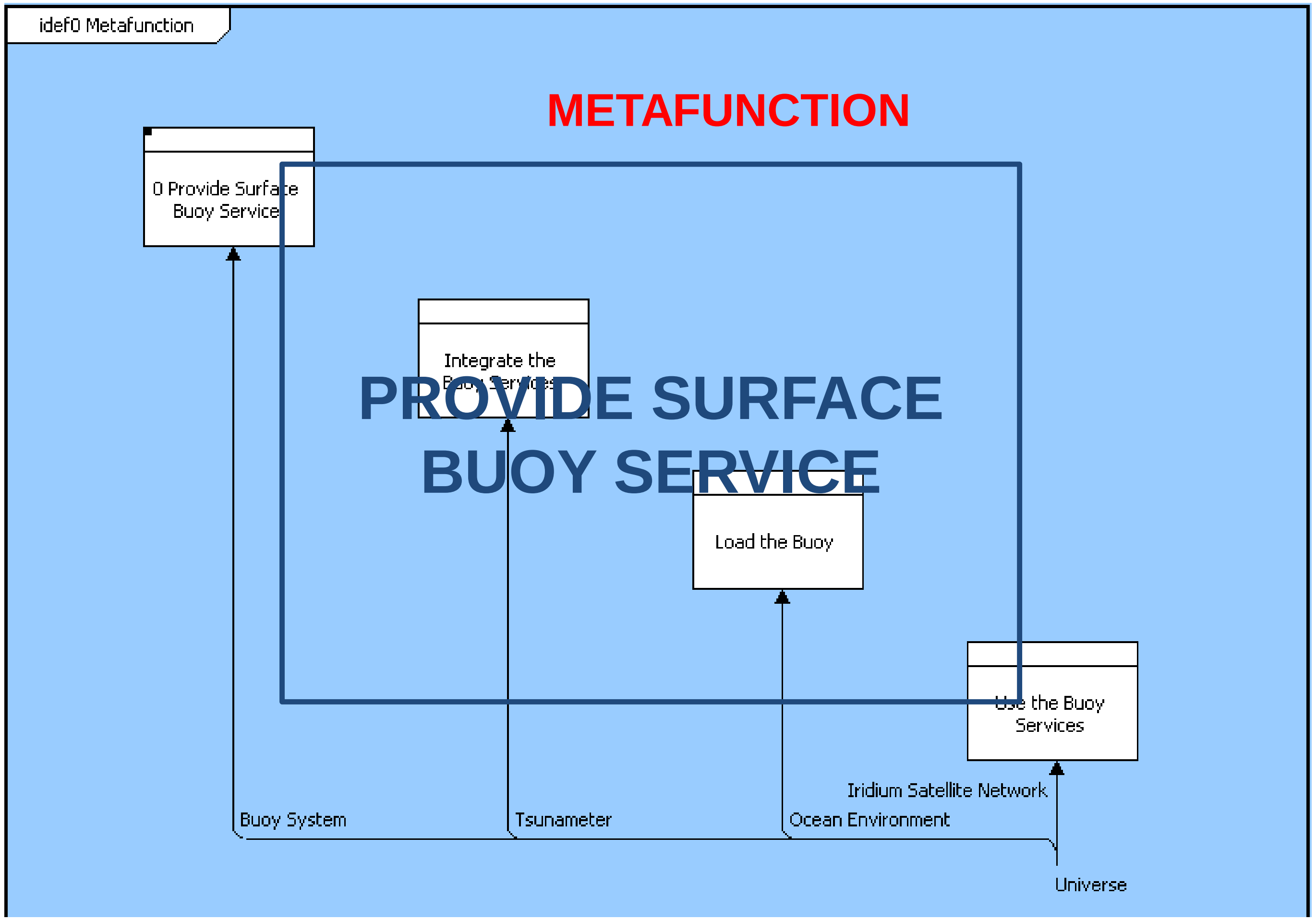
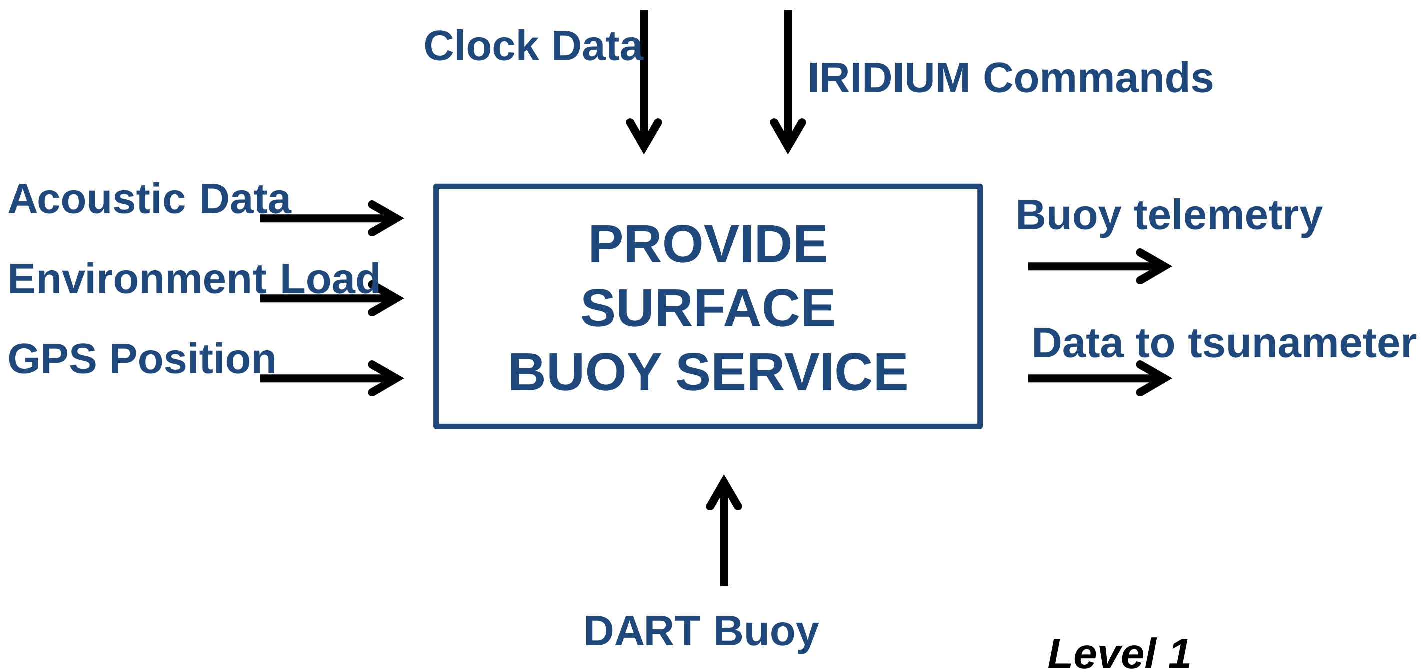


IDEF Integrated Definition for Function Modelling



Level 1

DART Buoy Functional Architecture | DART Buoy Physical Architecture | Analysis & Validation | Evaluation

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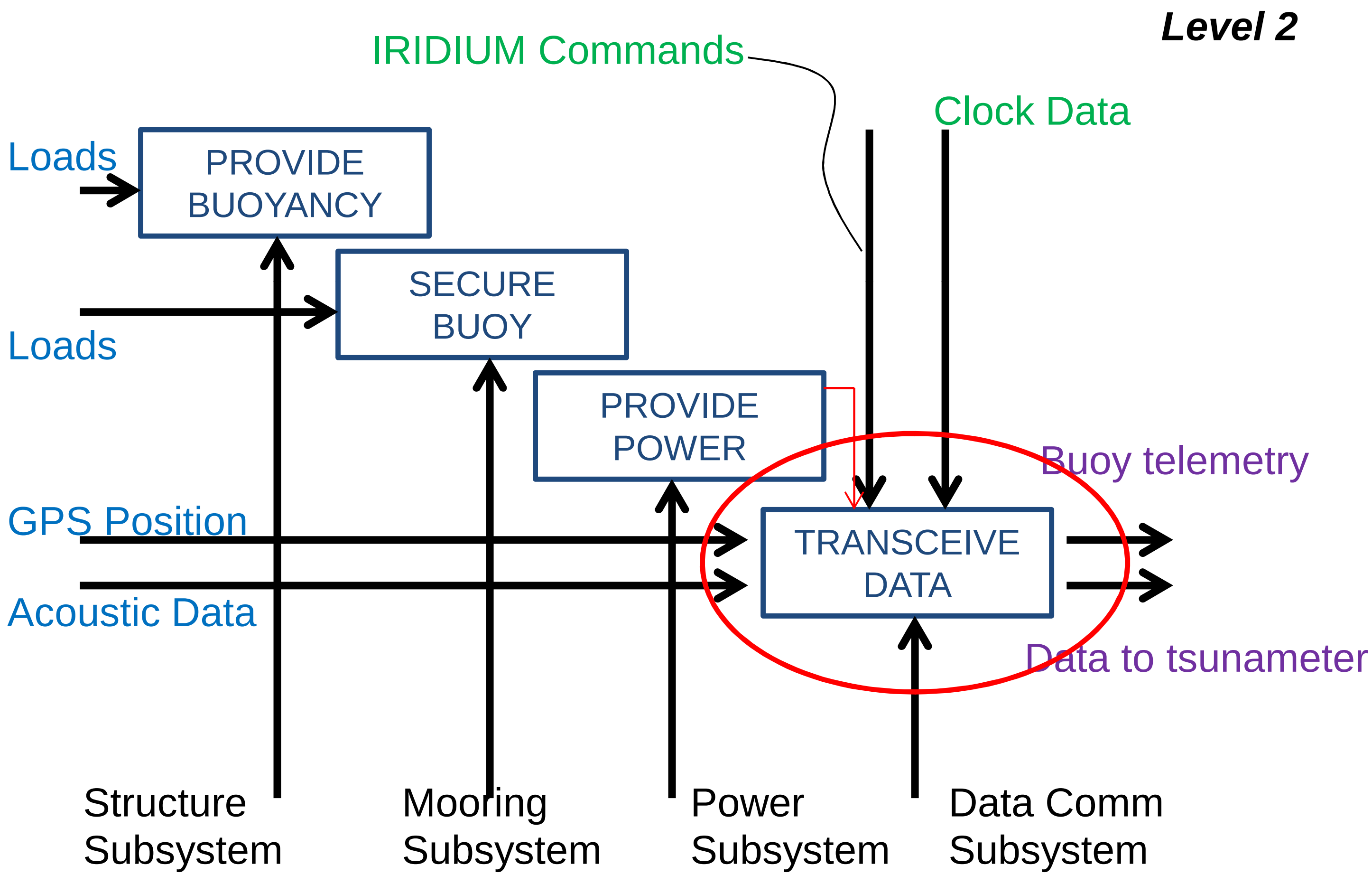
IDEF Integrated Definition for Function Modelling



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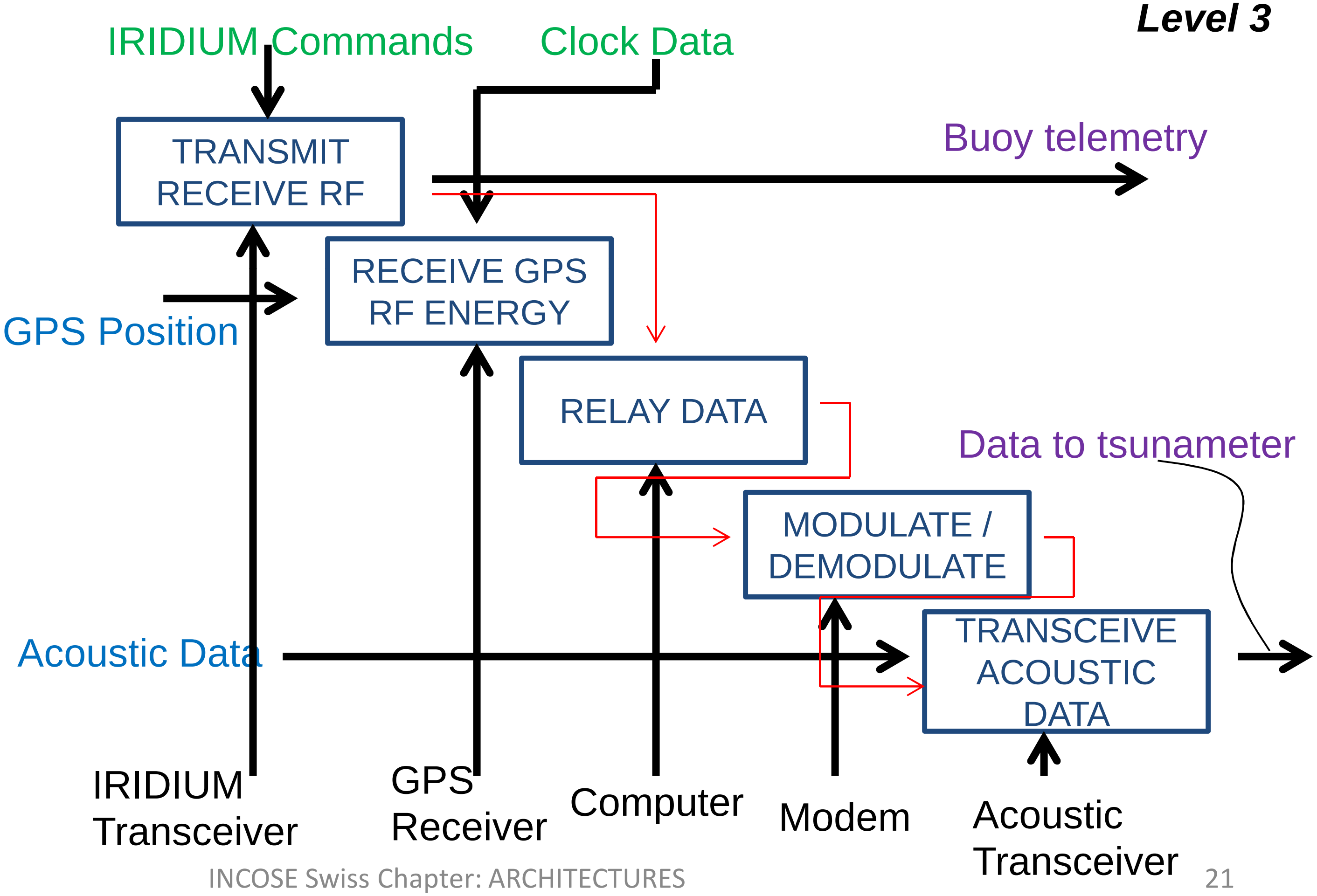
IDEF Integrated Definition for Function Modelling

Level 3



DART Buoy Functional Architecture

DART Buoy Physical Architecture

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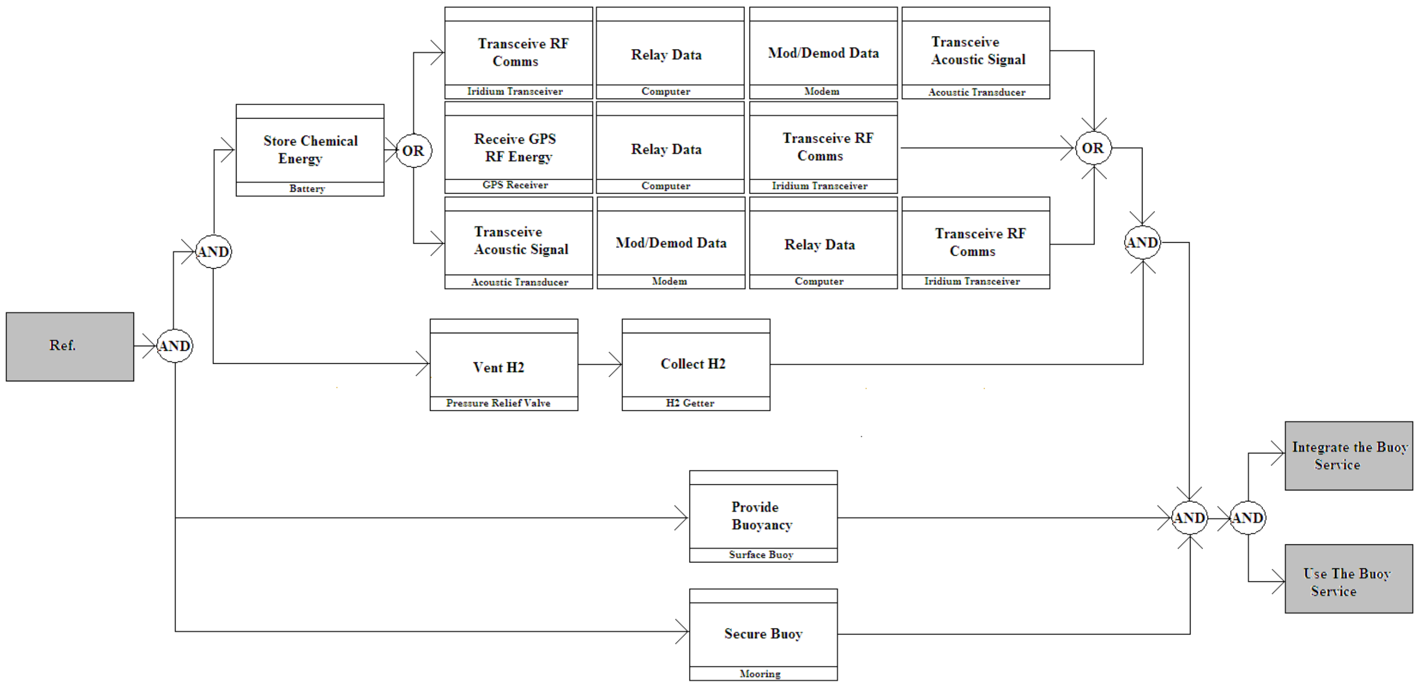
FFBD Functional Flow Block Diagram



- Specifies what the system must do, but does not address its inputs and outputs;
- Can represent both parallel and sequential operations;

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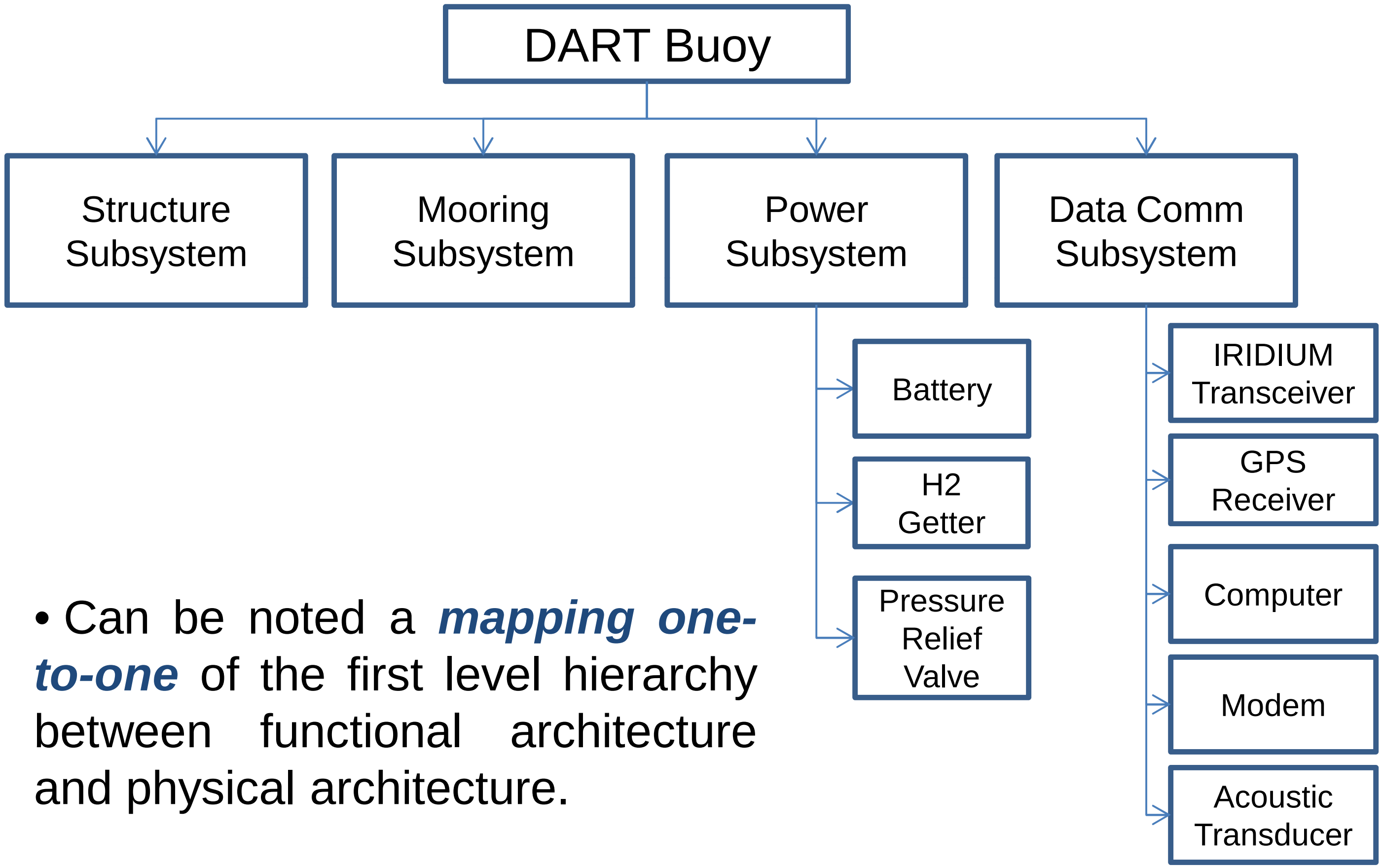
N-Squared Charts

WAVE IMPACTS THERMAL LOADS CHEMICAL LOADS	WAVE LOADS EARTH LOADS				IRIDIUM COMMANDS	CLOCK DATA GPS POSITION			ACOUSTIC DATA PACKETS	
Provide Buoyancy (Surface Buoy)		*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	*LOADS THERMAL LOADS*	
STRUCT. LOADS	**Secure Buoy (Mooring)**									
		Store Chemical Energy (Battery)		*H2 GAS*	*POWER*	*POWER*	*POWER*	*POWER*	*POWER*	
		CHEMICAL ACTION	**Collect H2 (H2 Getters)**							
			H2 GAS FLOW	**Vent H2 (Pressure Relief Valve)**						H2 FLOW
HEAT					**Transmit/ Receive RF Comms (Iridium Transceiver)**		*DATA TO BE PROCESSED*			BUOY TELEMETRY
HEAT						**Receive GPS RF Energy (GPS Receiver)**	*GPS INPUT*			
HEAT					*PROCESSED DATA*		**Relay Data (Computer)**	*DATA TO TSUNAMETER*		
HEAT							*DATA FROM TSUNAMETER*	**Modulate/ Demod Signal (Modem)**	*MOD. DATA*	
HEAT								*DEMOD. DATA*	**Transceive Acoustic Signal (Acoustic Transducer)**	ACOUSTIC DATA PACKETS

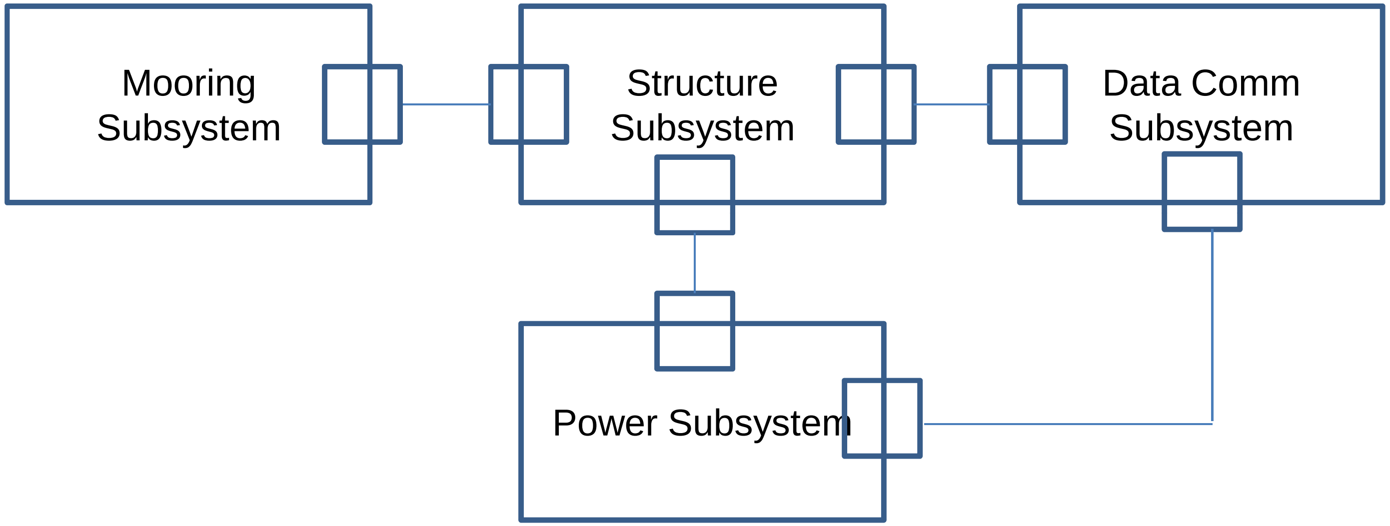
- Capture systems' input and outputs;
- Say nothing about process flow sequence;

Block Definition Diagram



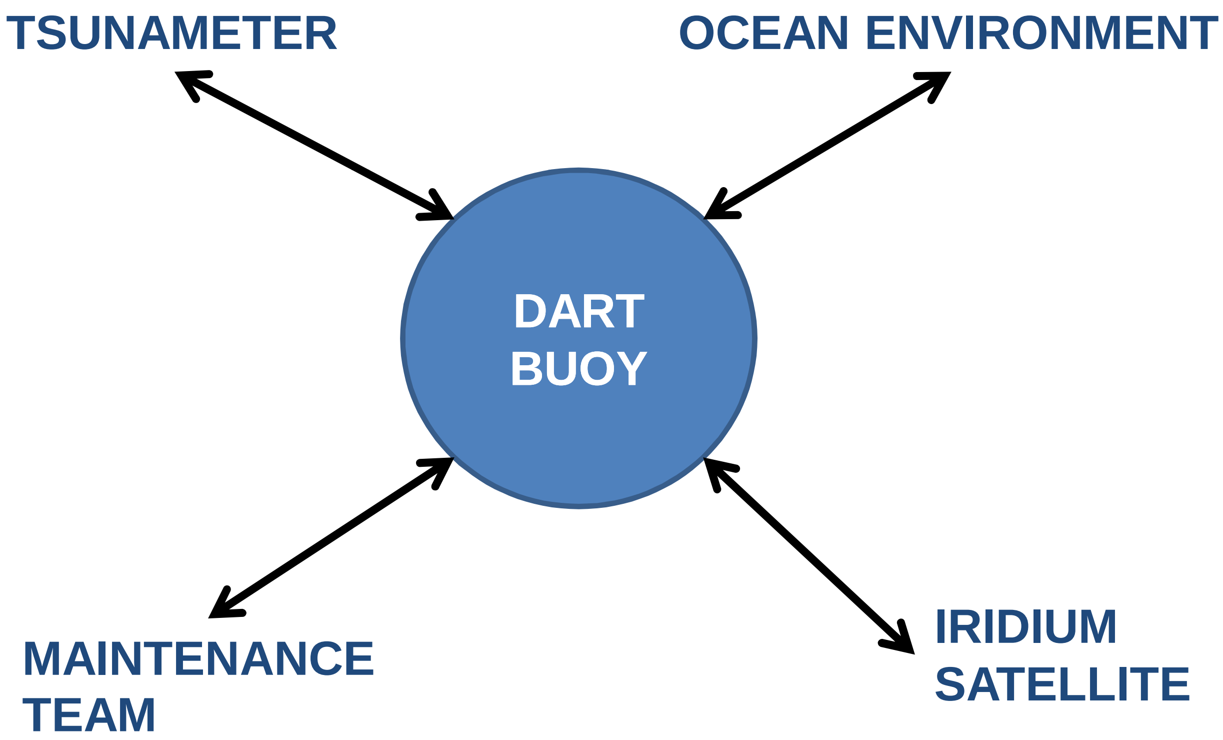
- Can be noted a ***mapping one-to-one*** of the first level hierarchy between functional architecture and physical architecture.

Internal Block Diagram



- Show the interface connections among the subsystems of a DART Buoy;
- The empty little square is a port associated with the component and the connector, designating the connection of the two;

USE CASE SCENARIOS



USE CASE SCENARIOS

Use case scenarios to be traced onto the functional architecture!

EARLY VALIDATION OF THE ARCHITECTURE: WE DESIGNED THE RIGHT ARCHITECTURE TO ADDRESS THE INITIAL NEED!

Figure (Source: http://forum.woodenboat.com/showthread.php?31625-Tidal-Wave)

Figure (Source: http://fwww.tsunami.noaa.gov)

ARCHITECTURE EVALUATION METHODS

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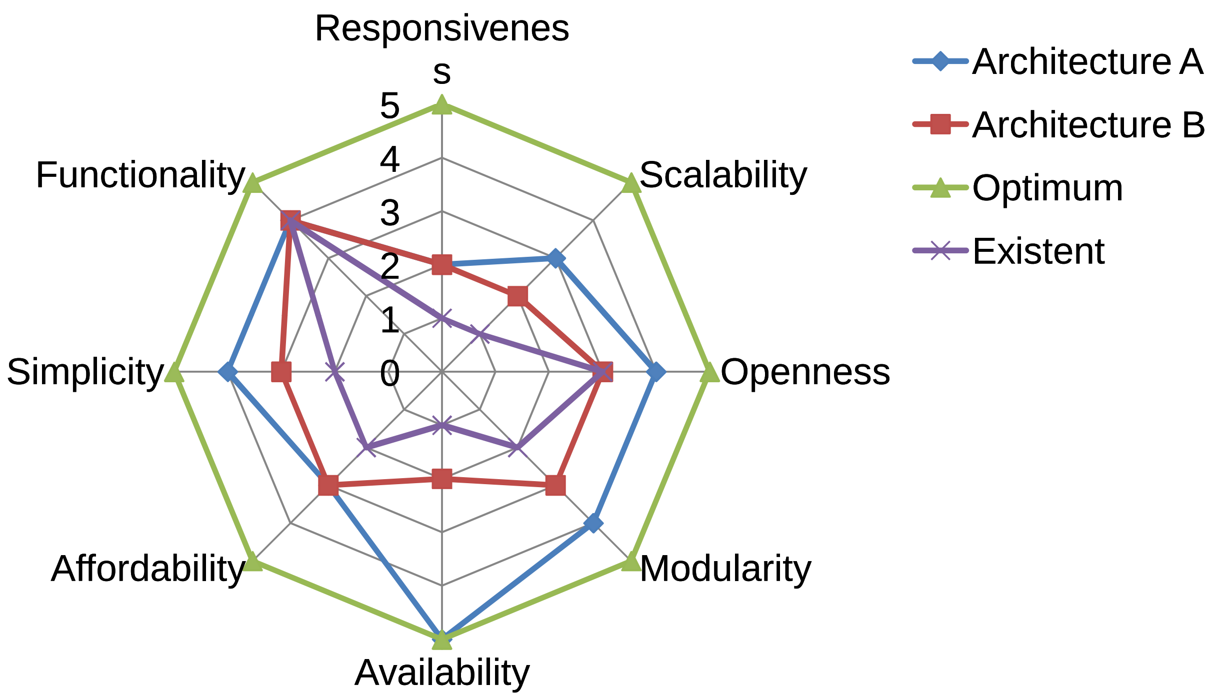

ARCHITECTURE EVALUATION METHODS

Tsunami DART Buoy

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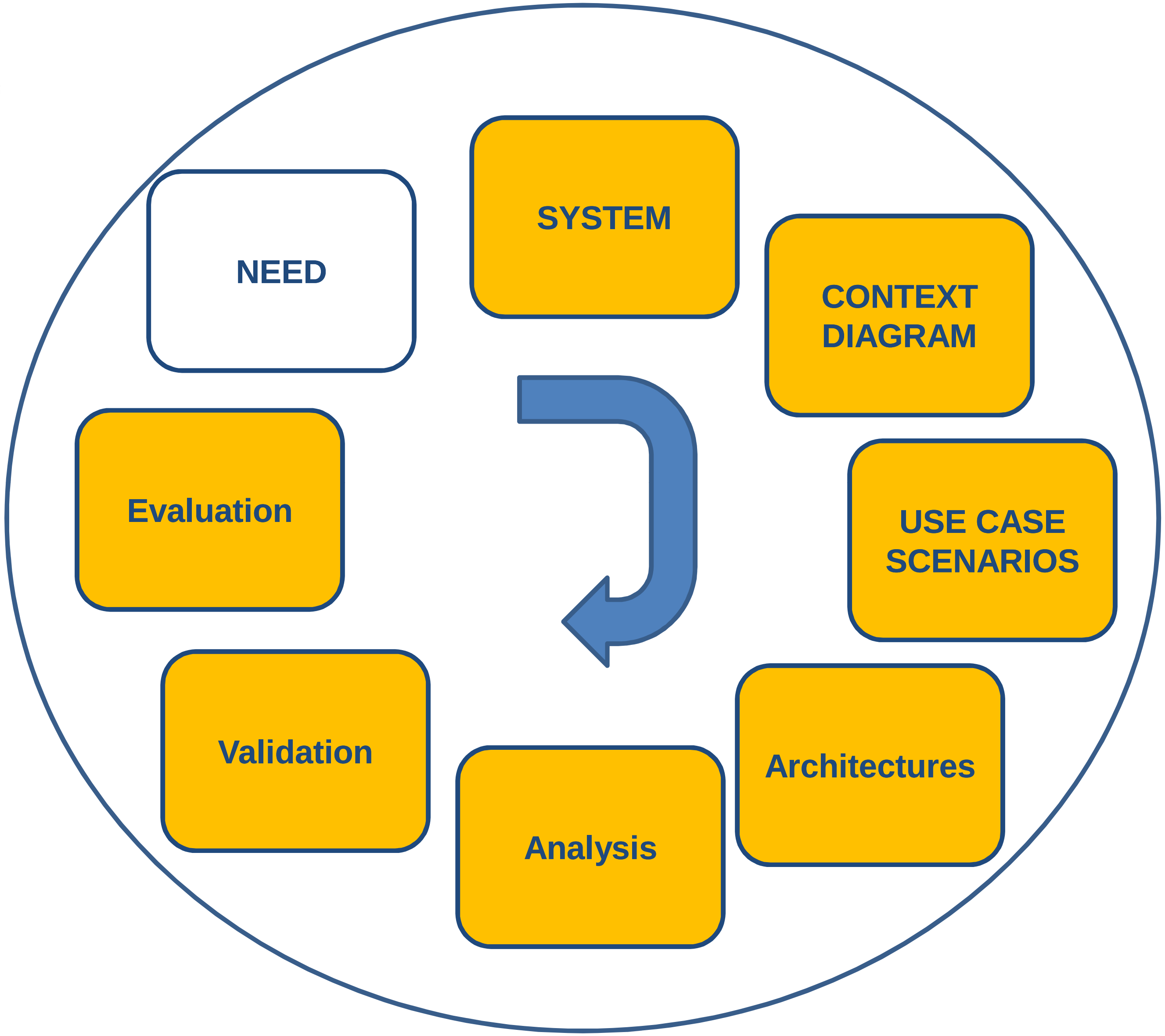

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MODEL TRACEABILITY

CONSISTENT GRAPHIC AND DOCUMENTATION

MORE PRECISE COMMUNICATION

V&V TRACEABILITY

THANK YOU FOR THE ATTENTION

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TIPS & TRICKS

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- The rule of thumb is to **partition** each function (at any level) **into 3 to 6 subordinate functions**;

- Two basic approaches are used to develop functional architectures:
  - **DECOMPOSITION** (top-down);
  - **COMPOSITION** (bottom-up);
  - Using **both** is the **best solution**.

- First work on the **Use Case Scenarios** (all the possibilities the product/system can be used for) than think of the functional architecture;

- **Iterate continuously** between the **System Requirement Document** (functional requirements) and the **functional architecture**;

- The **Physical Architecture** should be as far as possible a **one-to-one** mapped **to the functional architecture**;

- A **good architectural analysis** helps defining properly the **Subsystems Requirements Documents**.

- A very important part of the SE role is the **evaluation** of the architectures (i.e., are there any shortfalls? Overlaps?)

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MBSE SW

Vitech MBSE: ONION MODEL

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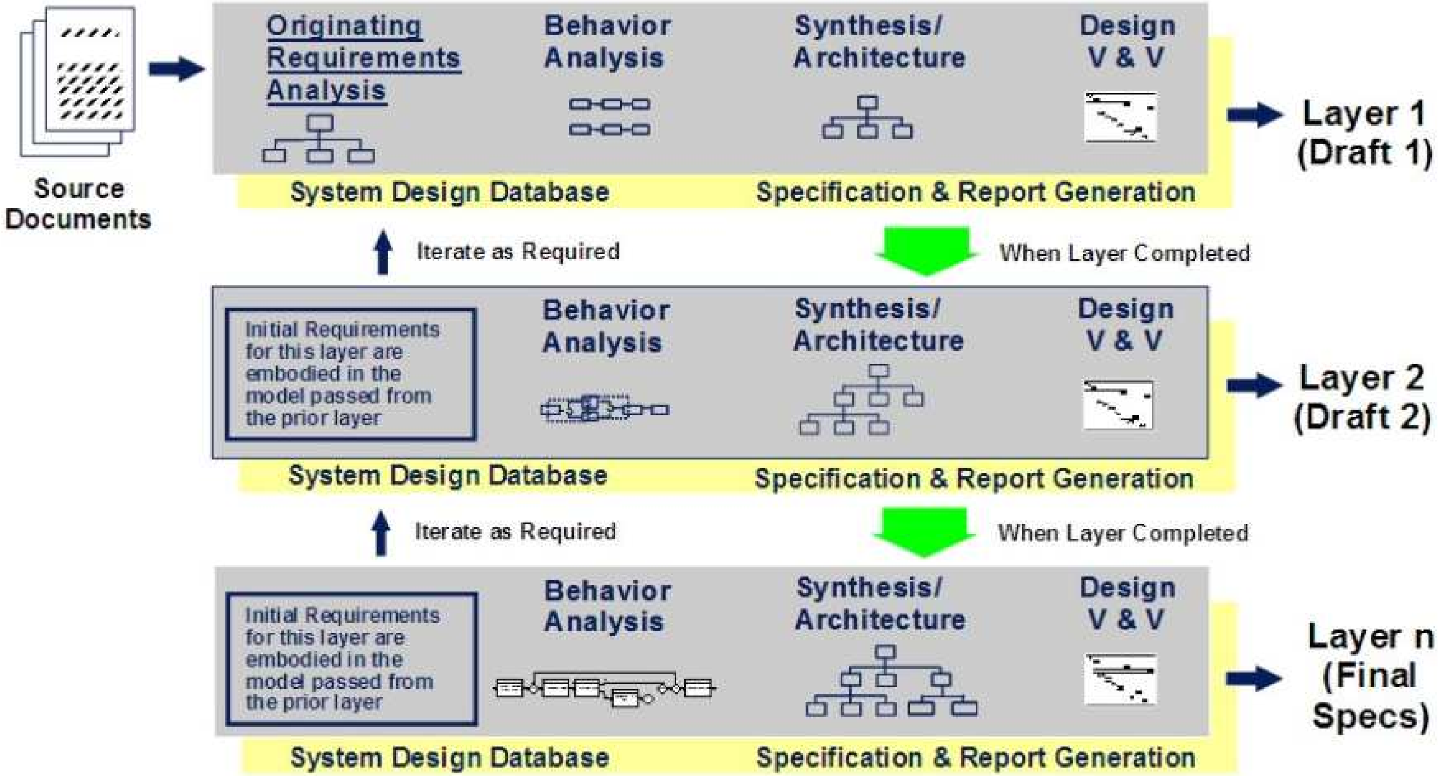

J. A. Estefan, Survey of Model-Based System Engineering Methodologies, INCOSE MBSE Initiative.

TSUNAMI
More Info

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http://www.tsunami.noaa.gov

http://ptwc.weather.gov/

http://www.ess.washington.edu/tsunami/general/warning/warning.html

http://wcatwc.arh.noaa.gov/

http://itic.ioc-unesco.org/

DART	Deep ocean Assessment and Reporting of Tsunamis systems
BPR	Bottom Pressure Recorder
NOAA	National Oceanic and Atmospheric Administration
PICO	Platform Instrumentation for Continuous Observation
TWC	Tsunami Warning Center
TWS	Tsunami Warning System

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Bibliography

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