



34th Annual **INCOSE**
international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024



Offshore Wind to Hydrogen Enterprise

Seeing the bigger picture with the Unified Architecture Framework (UAF)

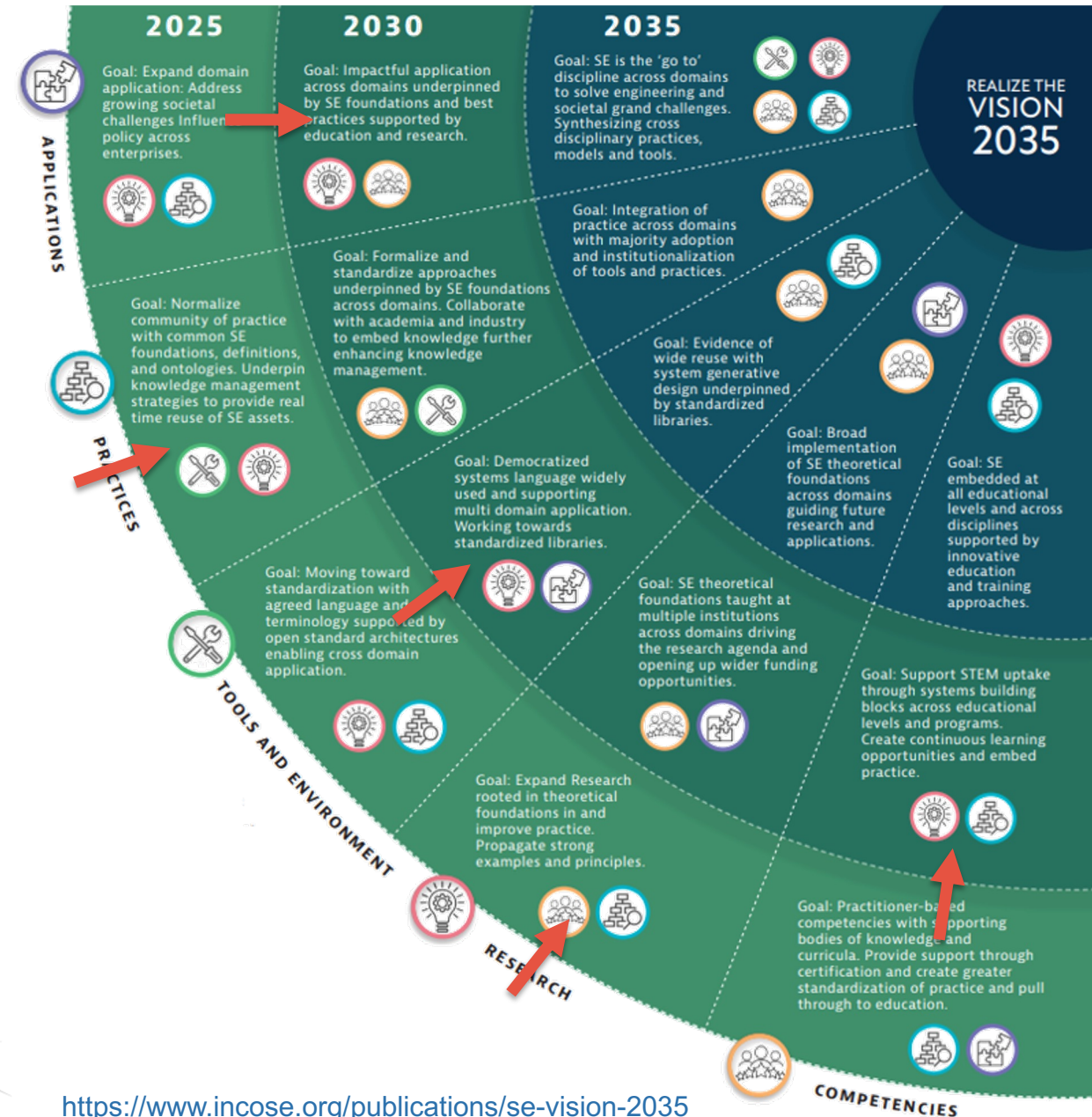


2-6 July 2024

www.incose.org/symp2024 #INCOSEIS

INCOSE Vision 2035

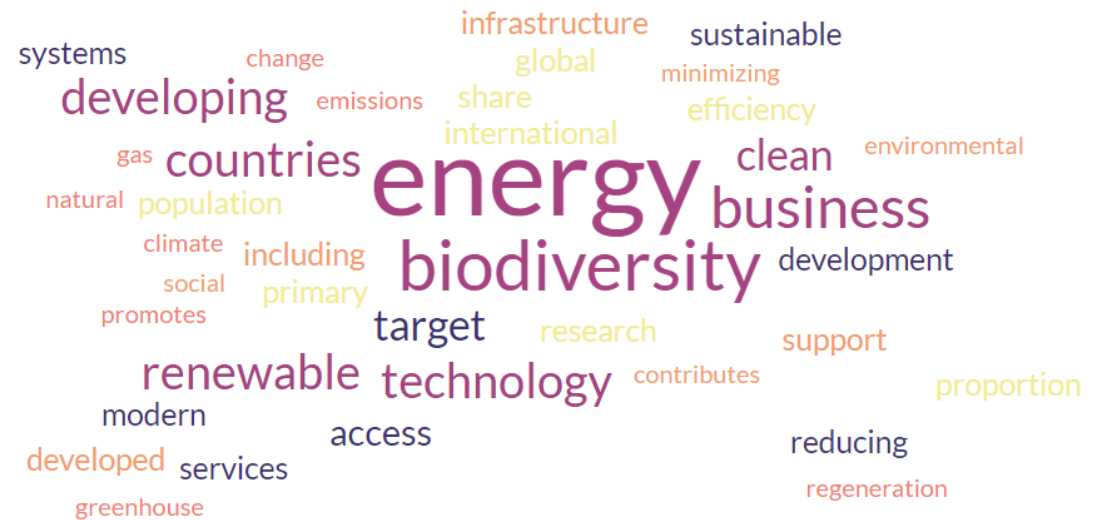
- Applications
- Practices
- Tools
- Research
- Competencies



<https://www.incose.org/publications/se-vision-2035>

Sustainable Development Goal 7

“Ensure access to affordable, reliable, sustainable and modern energy for all”



How can Energy Enterprise meet SD Goal 7?

- Sources (Renewable / Non-Renewable)
 - Nuclear
 - Solar
 - Wind
 - Fossil Fuel
- Distribution & Management
 - Transmission Network
 - Energy Storage
- Environment
 - Geographical Locations
 - Climate
- Market
- Safety, Reliability and Security



AI Generated Image by DALL·E

Stakeholders



Communities



Multiple Regional
Governments



Investors



System / Service
Vendors



Environmental
Agencies



Markets



Regulators

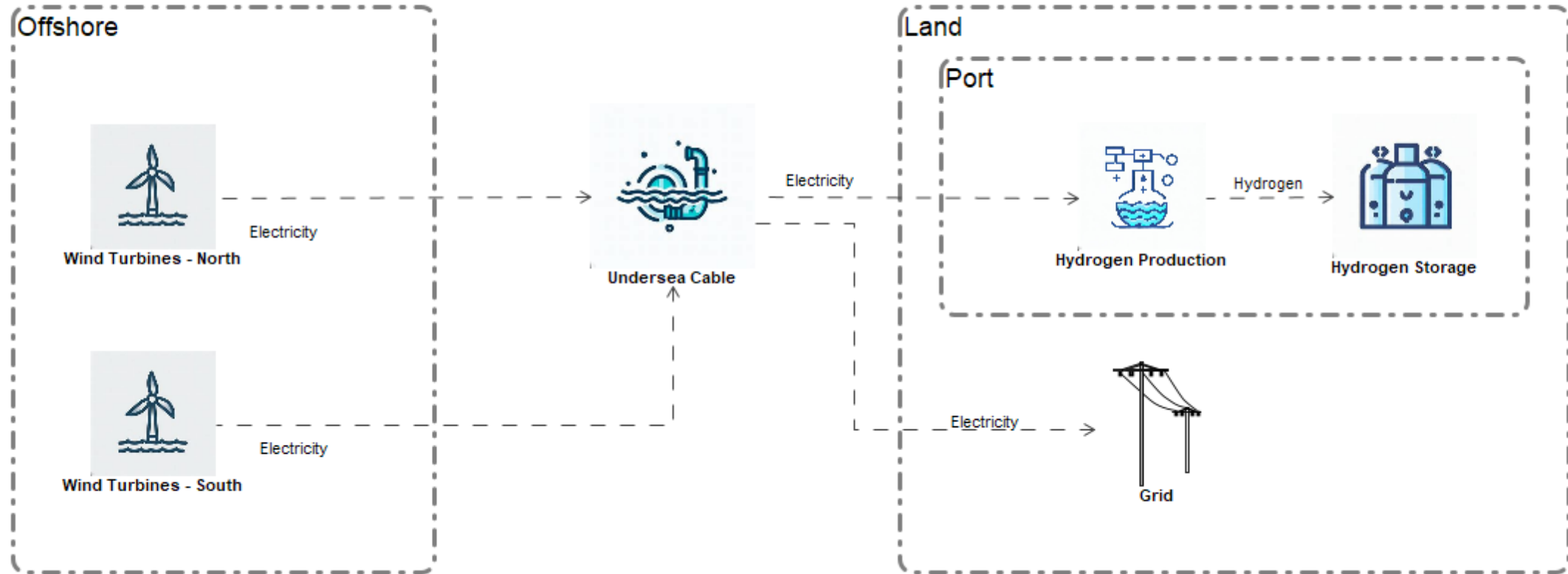
Why Model an Energy Enterprise?

- Complexity
 - Multiple Stakeholders
 - Systems of Systems
- Planning & Efficiency
 - Best Utilisation of Technology & Resources
- Risk and Compliance
- Economic Viability
 - Uncertain Markets
- New Technology
- Mapping to SD Goal 7



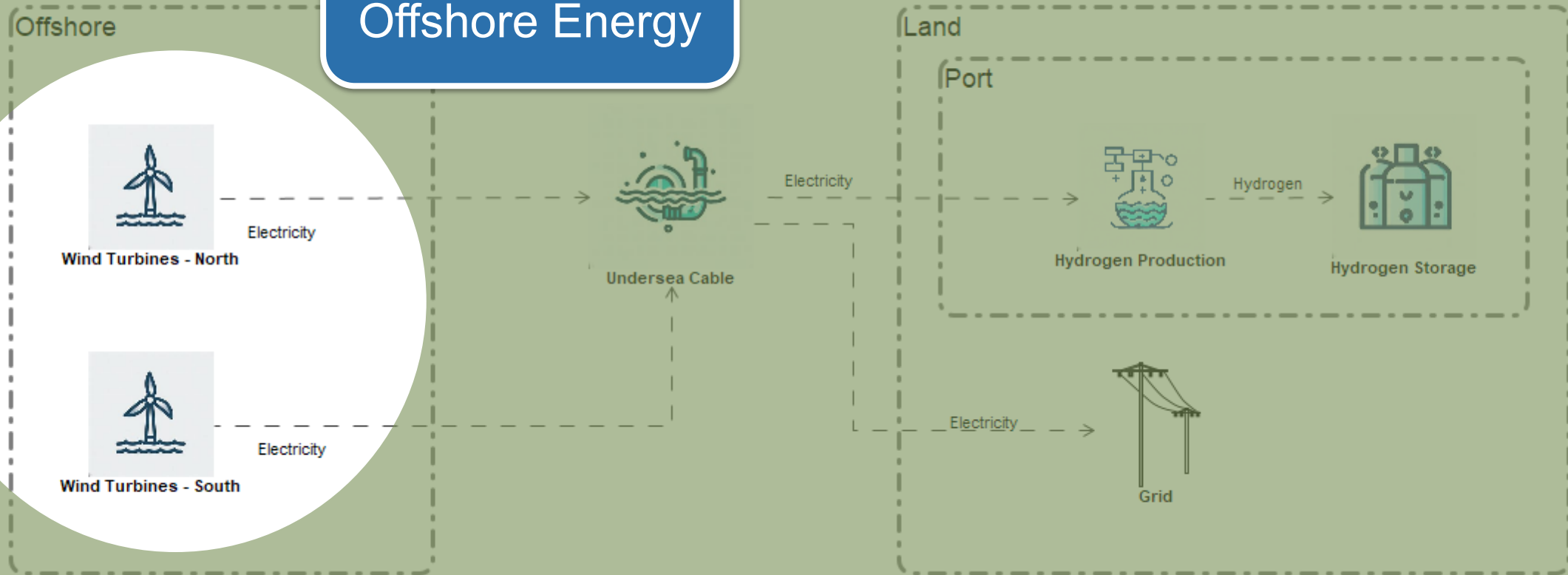
Offshore Wind to Hydrogen Enterprise

Offshore Wind to Hydrogen



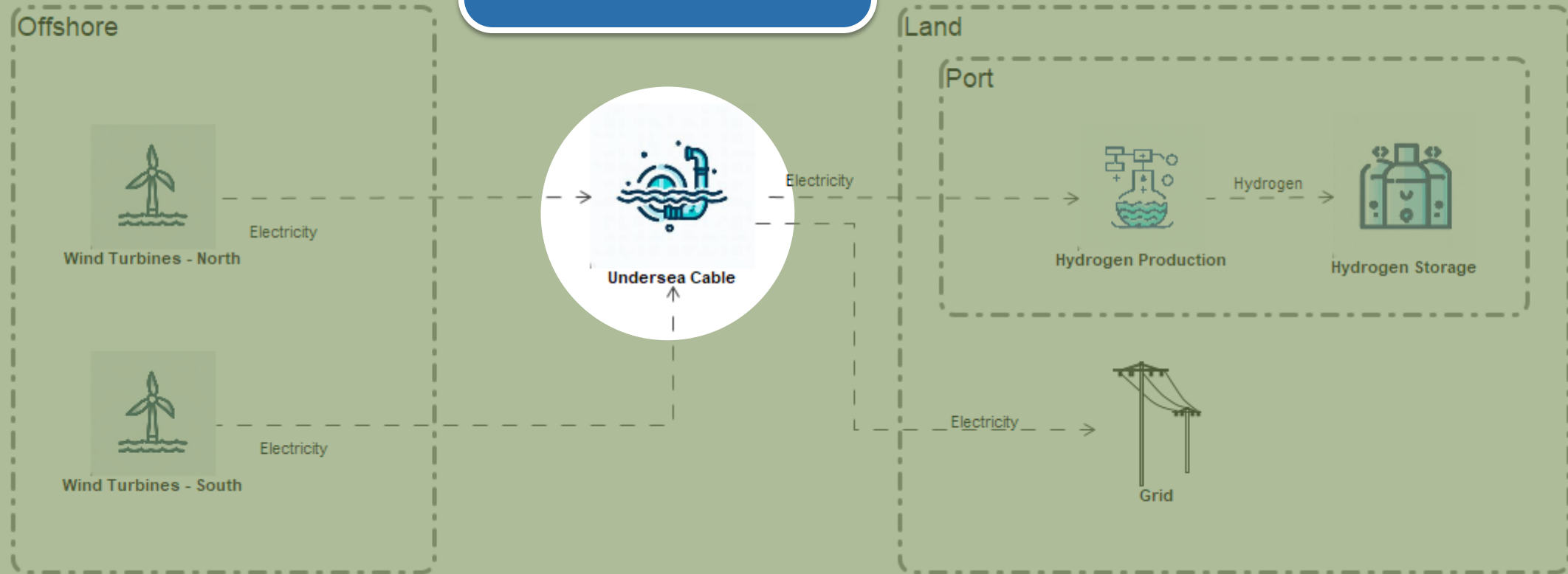
Offshore Wind to Hydrogen

Renewable Offshore Energy



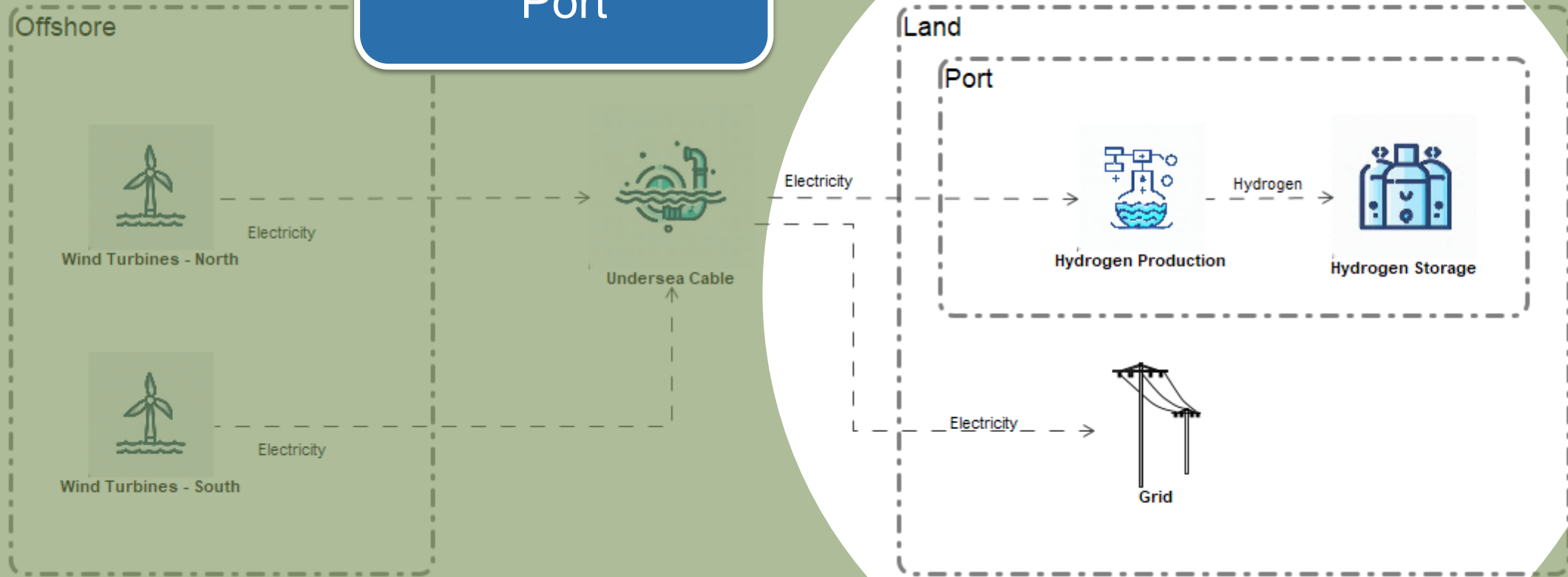
Offshore Wind to Hydrogen

Using Undersea Cables



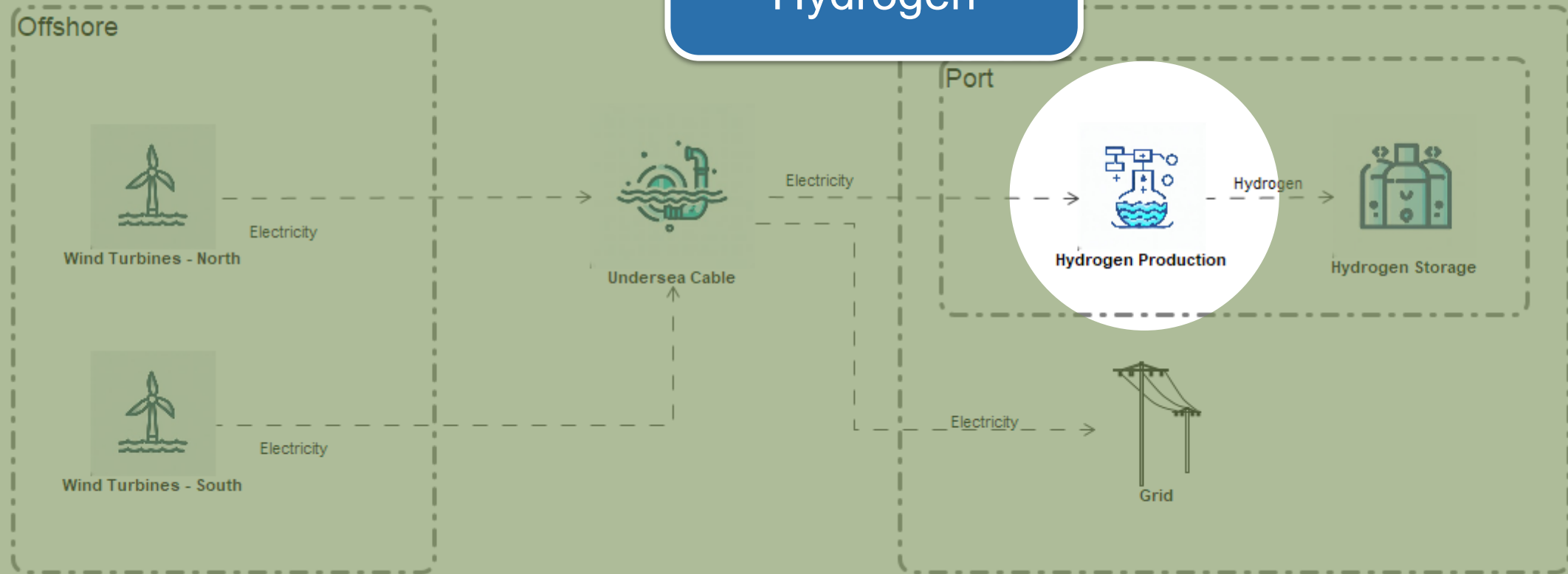
Offshore Wind to Hydrogen

Connected to a
Port



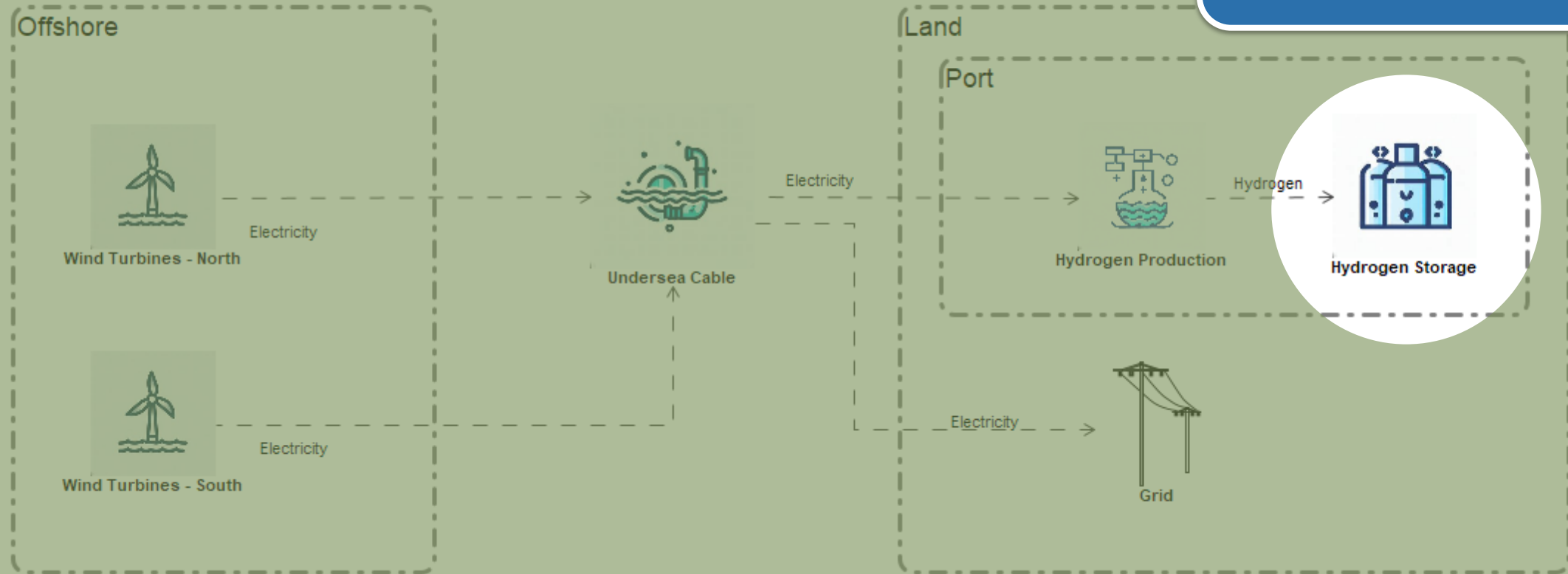
Offshore Wind to Hydrogen

Producing Green Hydrogen

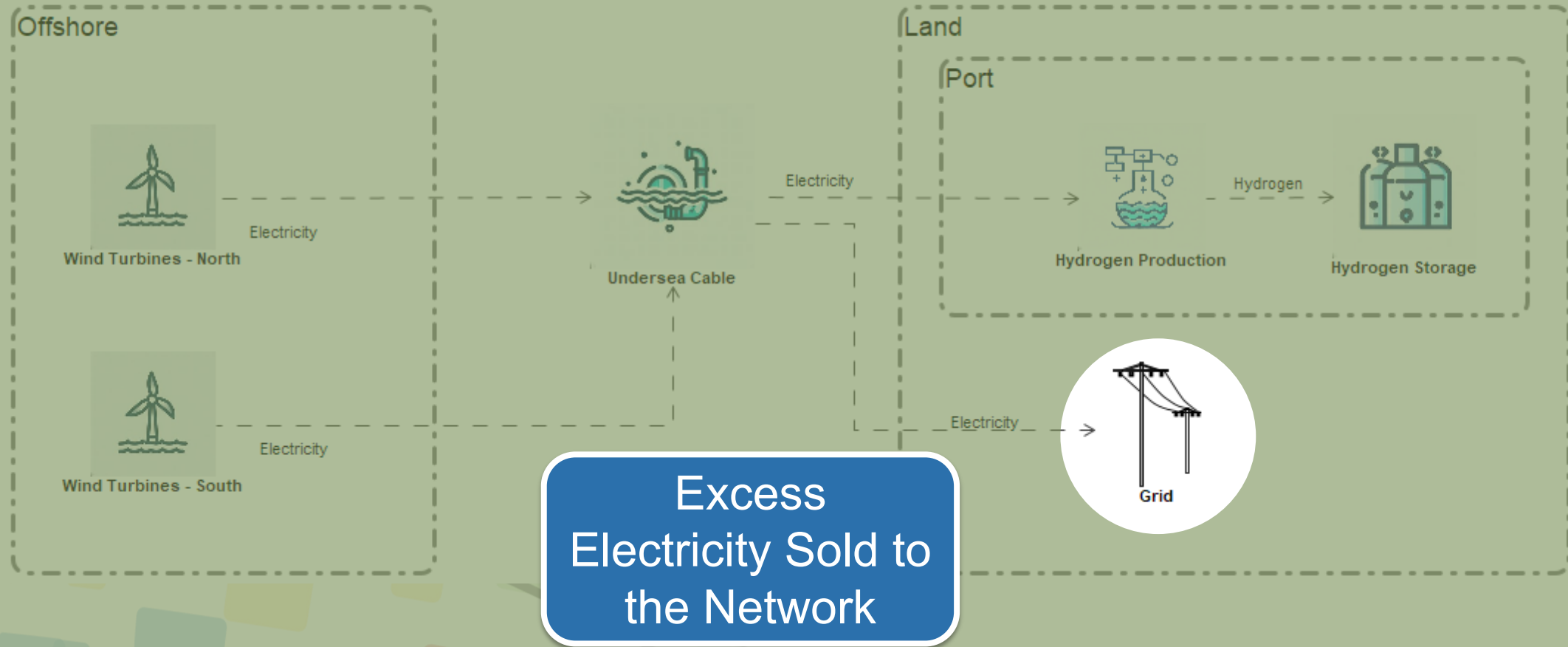


Offshore Wind to Hydrogen

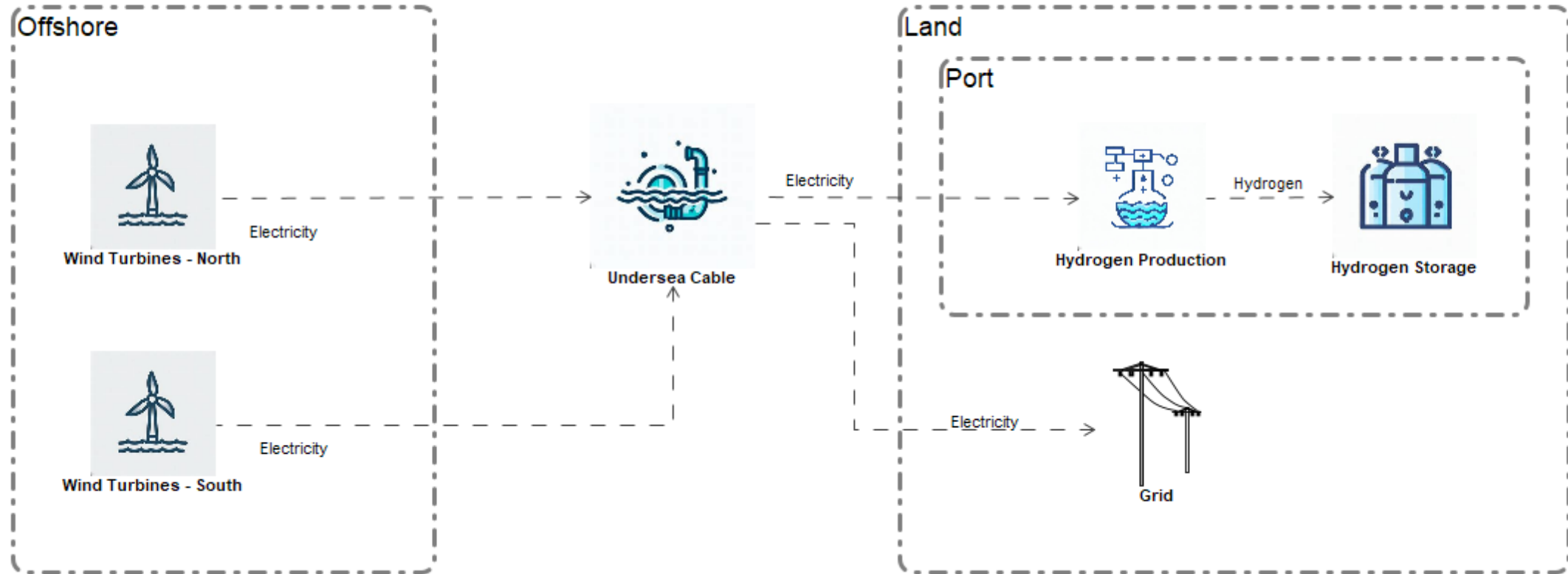
To be Stored &
Sold



Offshore Wind to Hydrogen



Offshore Wind to Hydrogen





Modeling the Enterprise

Frameworks Considered

- Enterprise Frameworks
 - Zachman
 - TOGAF
- Defence Frameworks
 - DoDAF - U.S. Department of Defense's Architecture Framework
 - MoDAF - U.K.'s Ministry of Defence's Architecture Framework
 - NAF - North Atlantic Treaty Organization's (NATO) Architecture Framework
- Unified Architecture Framework (UAF)
- MBSE Grid / MagicGrid



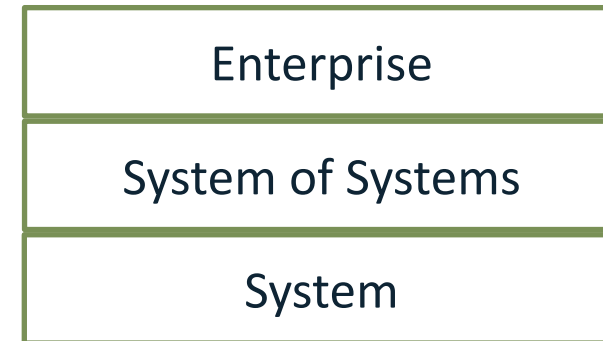
Framework Selection

- What type of thing are you modeling?
 - Enterprise / SoS / System
- Who are you modeling for?
- How will you use your model?
 - Output Formats (Diagrams, Tables etc.)
 - Simulation
- Existing Resources Available?
 - Industry Examples
 - Documentation
 - Capabilities

Why UAF



- Suitable for
 - Enterprise
 - System-of-Systems
 - System
- Based on SysML
- Well Documented with Examples



Application of UAF for an Energy SoS

UAF	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx	Architecture Views Am-Sr	Architectural Relationships Am-Cn	Architecture Development Methods Am-Pr	Architecture States Am-St	Architecture Sequences Am-Sq	Architecture Information Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Information for the Entire Architecture (Dictionary, Viewpoints)												
Summary & Overview Sm-Ov												
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St	Strategic Sequences St-Sq	Strategic Information St-If	Strategic Parameters St-Pm	Strategic Constraints St-Ct	Strategic Roadmaps: Deployment, Phasing St-Rm-D, -P	Strategic Traceability St-Tr
Captures Goals, Objectives and Capabilities												
Operational Op		Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Sequences Op-Sq	Operational Information Op-If	Operational Parameters Op-Pm	Operational Constraints Op-Ct	-	Operational Traceability Op-Tr
Understand the SoS from Operational / Logical Perspective												
Services Sv	Require-	Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq	Services Information Sv-If	Services Parameters Sv-Pm	Services Constraints Sv-Ct	Services Roadmap Sv-Rm	Services Traceability Sv-Tr
Identify Services to Abstract Behavior and Capabilities												
Personnel Ps	Rq-Mv	Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq	Personnel Information Ps-If	Personnel Parameters Ps-Pm	Personnel Constraints Ps-Ct	Personnel Roadmaps: Evolution, Forecast Ps-Rm-A, -E, -F	Personnel Traceability Ps-Tr
Understand Constituent Energy Systems of Systems and Relationships to Personnel / Organizations												
Resources Rs		Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Resources Information Rs-If	Resources Parameters Rs-Pm	Resources Constraints Rs-Ct	Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -F	Resources Traceability Rs-Tr
Perform Security Analysis – Cyber, Physical												
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	Security States Sc-St	Security Sequences Sc-Sq	Security Information Sc-If	Security Parameters Sc-Pm	Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Understand Development Milestones												
Projects Pj	-	Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr	Projects States Pj-St	Projects Sequences Pj-Sq	Projects Information Pj-If	Projects Parameters Pj-Pm	Projects Constraints Pj-Ct	Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr
Capture Government Standards & Compliance												
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	Standards Connectivity Sd-Cn	Standards Processes Sd-Pr	Standards States Sd-St	Standards Sequences Sd-Sq	Standards Information Sd-If	Standards Parameters Sd-Pm	Standards Constraints Sd-Ct	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Execution - Actual Instances of Resources Deployed or Allocated												
Actual Resources Ar	-	-	Actual Resources Structure Ar-Sr	Actual Resources Connectivity Ar-Cn	Actual Resources Processes Ar-Pr	Actual Resources States Ar-St	Actual Resources Sequences Ar-Sq	Actual Resources Information Ar-If	Actual Resources Parameters Ar-Pm	Actual Resources Constraints Ar-Ct	-	-

Application of UAF for *our* Energy SoS

- How will we meet our enterprise goals?
- What will the project cost?
- Can we meet the sustainability targets?
- What design options meet the requirements?

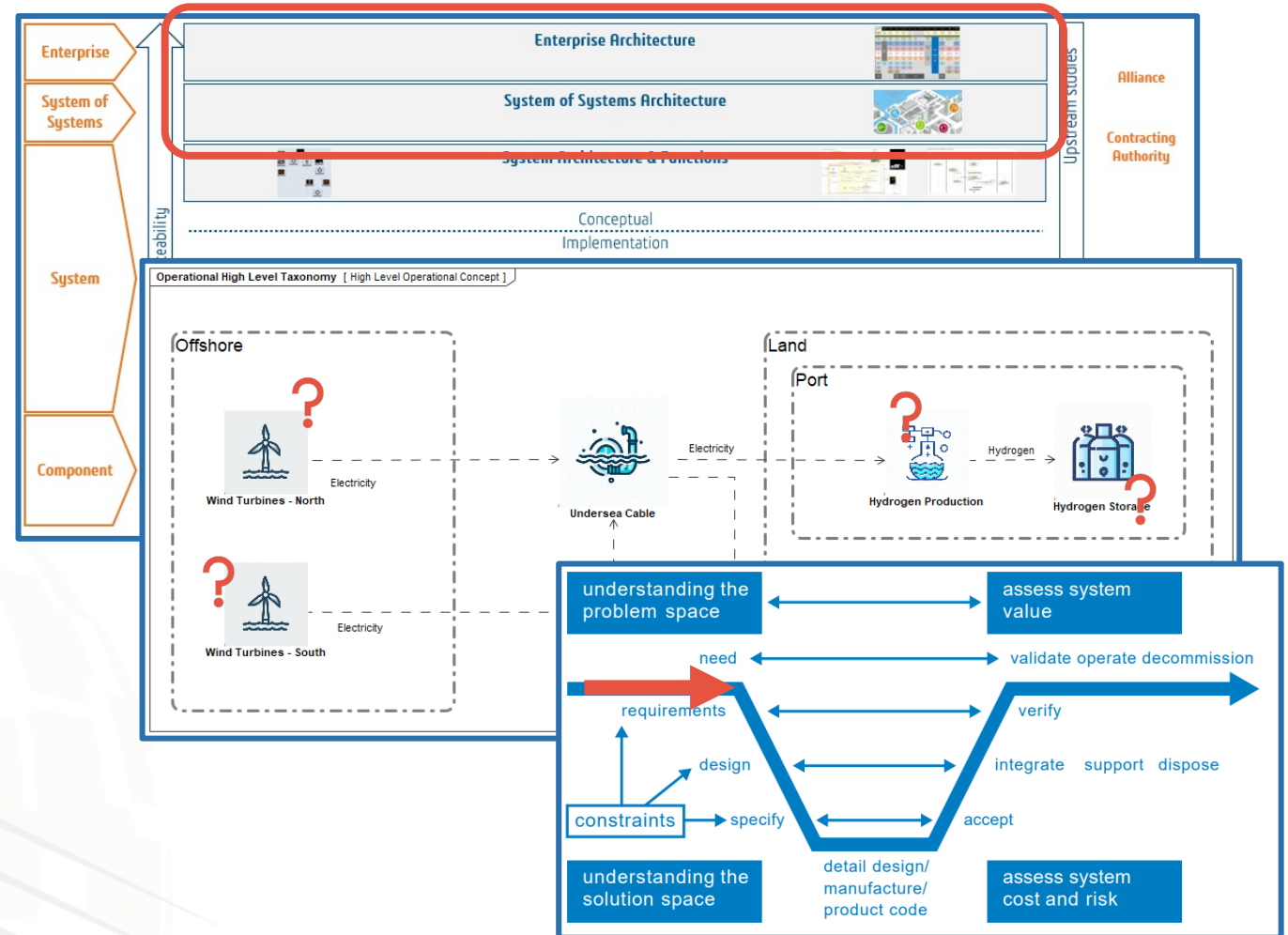
 UAF University of Applied Sciences Frankfurt am Main	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr	
Architecture Management Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx	Architecture Views Am-Sr	Architectural References Am-Cn	Architecture Development Method Am-Pr	-	-	Dictionary Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr	
Summary & Overview, Sm-Or													
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St	-	Strategic Information St-If	Environment En-Pm and Measurements Me-Pm and Risks Rk-Pm	Strategic Constraints St-Ct	Strategic Roadmaps: Deployment, Phasing St-Rm-D, -P	Strategic Traceability St-Tr	
Operational Op	-	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Sequences Op-Sq	-		Operational Constraints Op-Ct	-	Operational Traceability Op-Tr	
Services Sv	Requirements Rq-Mv	Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq	Information Model Op-If		Competence, Drivers, Performance Ps-Ct-C, -D, -P	Services Constraints Sv-Ct	Services Roadmap Sv-Rm	Services Traceability Sv-Tr
Personnel Ps		Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq	Resources Information Model Rs-If			Personnel Constraints Ps-Ct	Personnel Roadmap Ps-Rm	Personnel Traceability Ps-Tr
Resources Rs	-	Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq		Resources Constraints Rs-Ct		Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -F	Resources Traceability Rs-Tr	
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-	-	Security Constraints Sc-Ct	-	Security Traceability Sc-Tr		
Projects Pj	-	Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr	-	-	-	-	Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr		
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-	-	-	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr		
Actual Resources Ar	-	-	Actual Resources Structure Ar-Sr	Actual Resources Connectivity Ar-Cn	Simulation			-	-	Parametric Execution/ Evaluation	-	-	



Demo

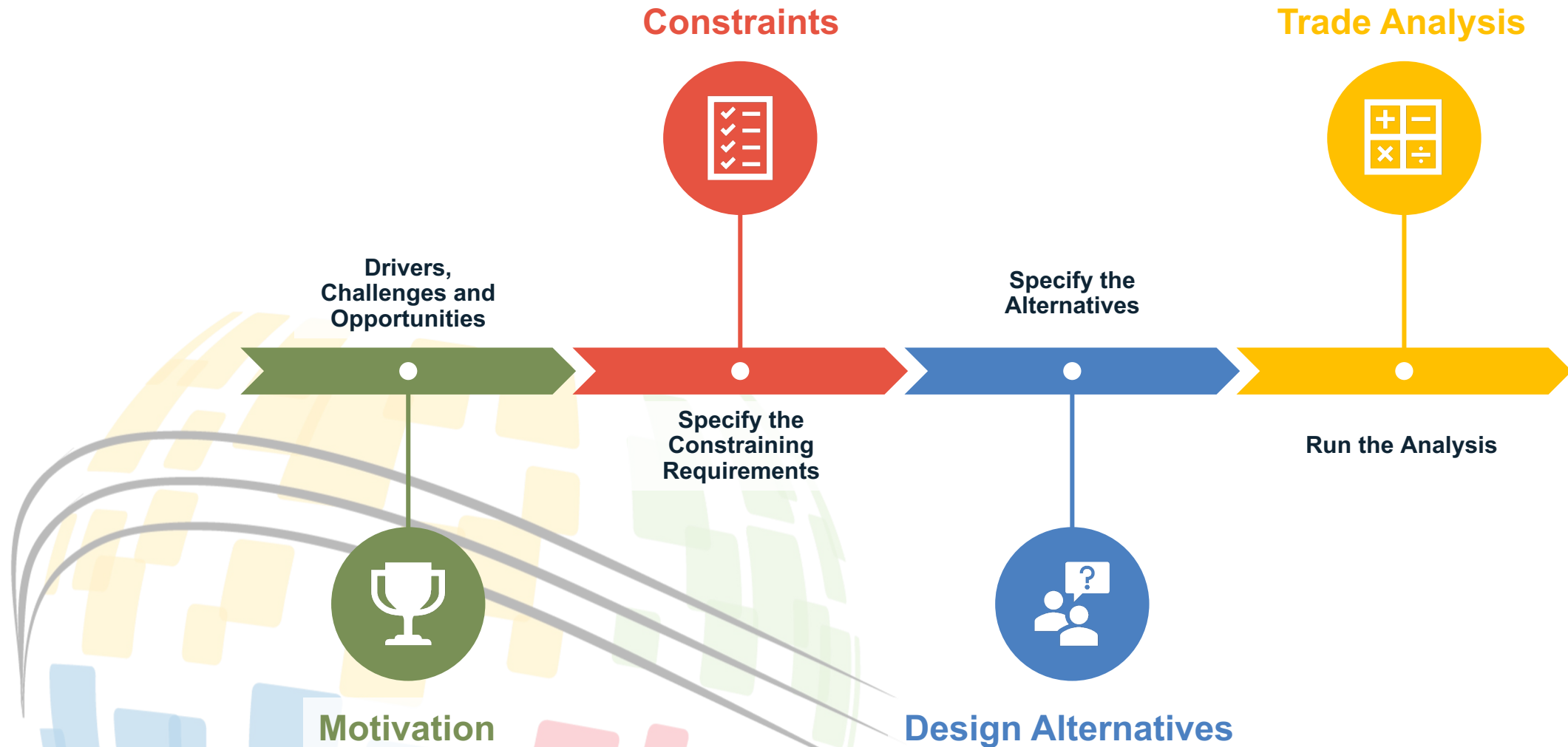
Scenario One

- Strategic Layer
 - Drivers
 - Challenges
 - Opportunities
- Investigating
 - Design Options
 - Constraints
- Techniques
 - Trade Analysis
 - Requirements Validation



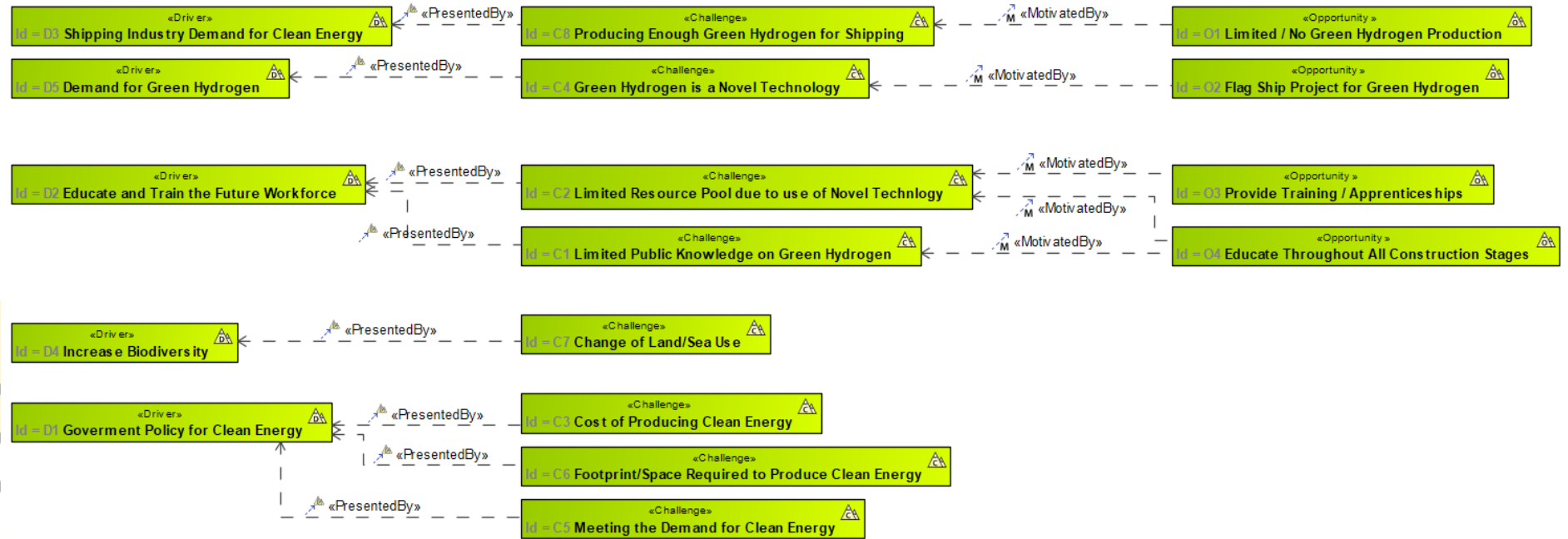
INCOSE UK. (2020). Z1 Guide: What is Systems Engineering? 3.1 (Z1)

Scenario One Steps



Motivation

Drivers,
Challenges and
Opportunities



Motivation

Motivation

Drivers,
Challenges and
Opportunities



Motivation

«Driver»
Id = D3 Shipping Industry Demand for Clean Energy

«PresentedBy»

«Challenge»
Id = C8 Producing Enough Green Hydrogen for Shipping

«MotivatedBy»

«Opportunity»
Id = O1 Limited / No Green Hydrogen Production

Constraints

- Height of North Turbine
 - Aviation Regulations
- Total Cost

Specify the
Constraining
Requirements



Constraints

#	△ Name	Text
1	☐ 1 Total Cost	The total cost shall <u>not exceed 80000 M€</u> .
2	☐ 2 Max Height North	The height of a turbine at the north site shall be <u>less than or equal to 550FT</u> .

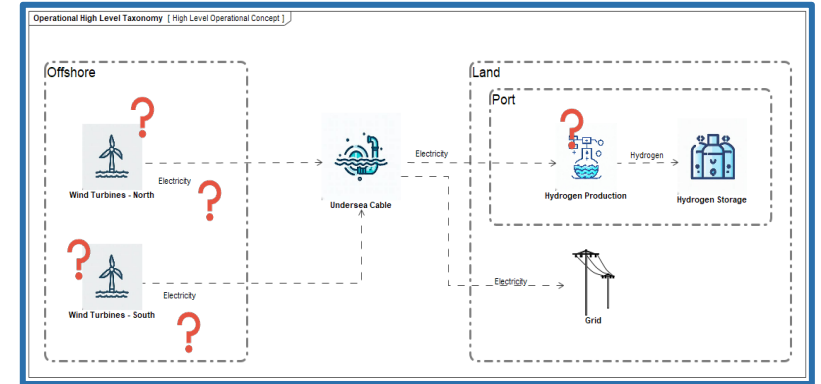
Design Alternatives

Specify the
Alternatives



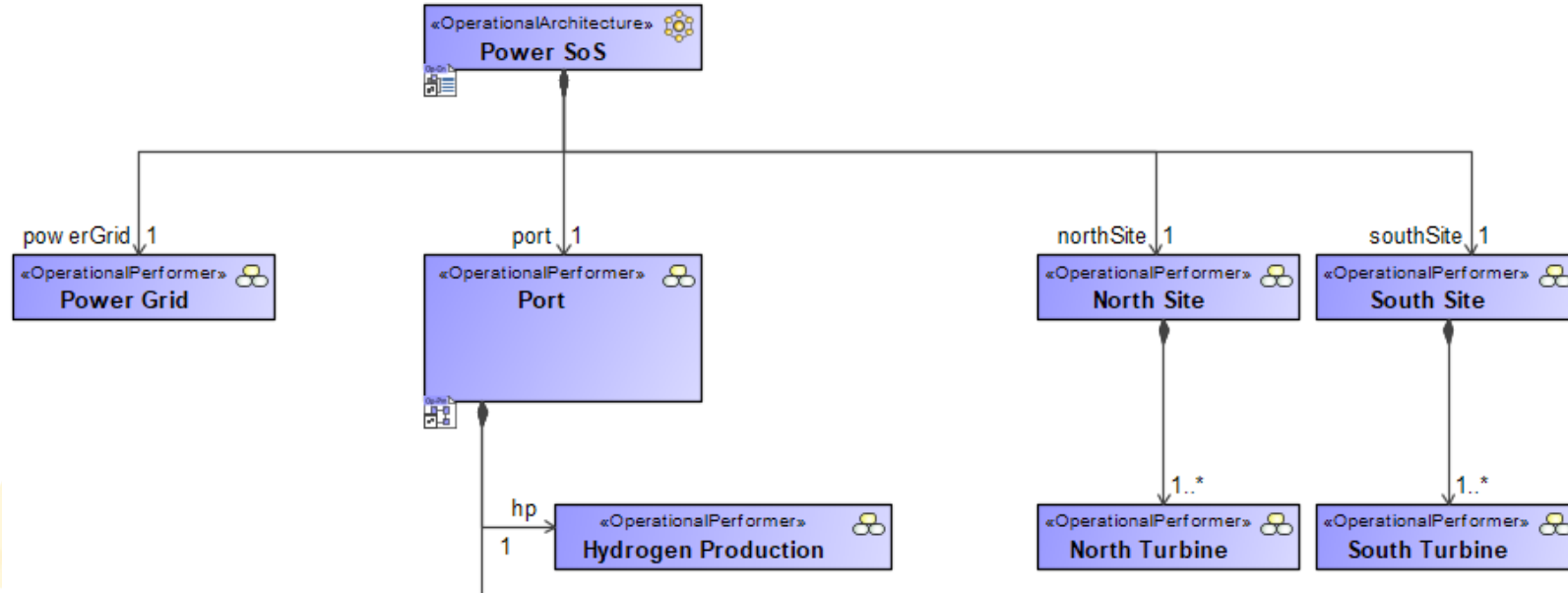
Design
Alternatives

- North and South Sites
 - Three Size Options
 - Four Wind Turbine Options
- Three Hydrogen Production Plants
- $432 \text{ Combinations} = 3 \times 3 \times 4 \times 4 \times 3$



Design Alternatives

Specify the Alternatives



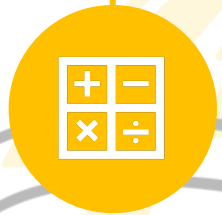
Criteria				
Classifier: Offshore Wind Turbine		Scope (optional): Drag elements from the Model Browser		Filter:
#	Name	developmentCost : Real	electricityMax : Real	height : Real
1	WindyTec X2000+	1900	8800	620
2	WindyTec Z150	1000	6000	500
3	Turbines'R'Us Phoenix	1400	8000	550
4	Turbines'R'Us Value	800	4000	400

Design Alternatives

Trade Analysis

Run the Analysis

- Weighting
 - Total Cost
 - Electricity Produced
 - Hydrogen Production



Trade
Analysis

Trade Analysis

Run the Analysis

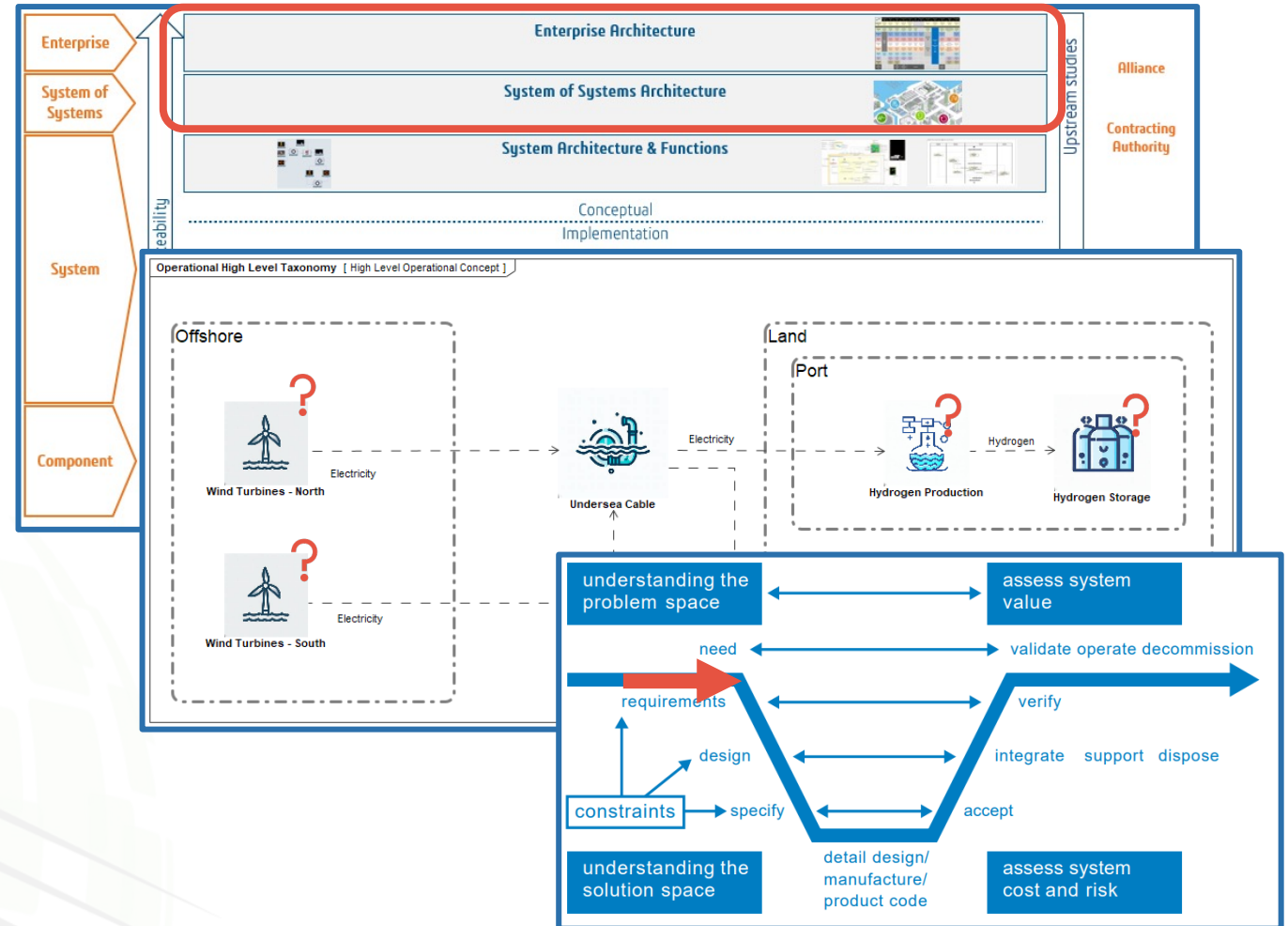
Trade Analysis

The screenshot displays the Magic Systems of Systems Architect 2022x interface for a Trade Analysis. The main window shows the 'Trade Study' configuration with a table of criteria. The table has three rows: weightCost (0.2), weightElectricity (0.4), and weightHydrogen (0.4). The 'Properties' pane on the left shows the 'Trade Study Weight' element. The 'Simulation' pane at the bottom shows the 'Run' button and a console window.

#	Name	Default Value
1	weightCost	0.2
2	weightElectricity	0.4
3	weightHydrogen	0.4

Scenario Two

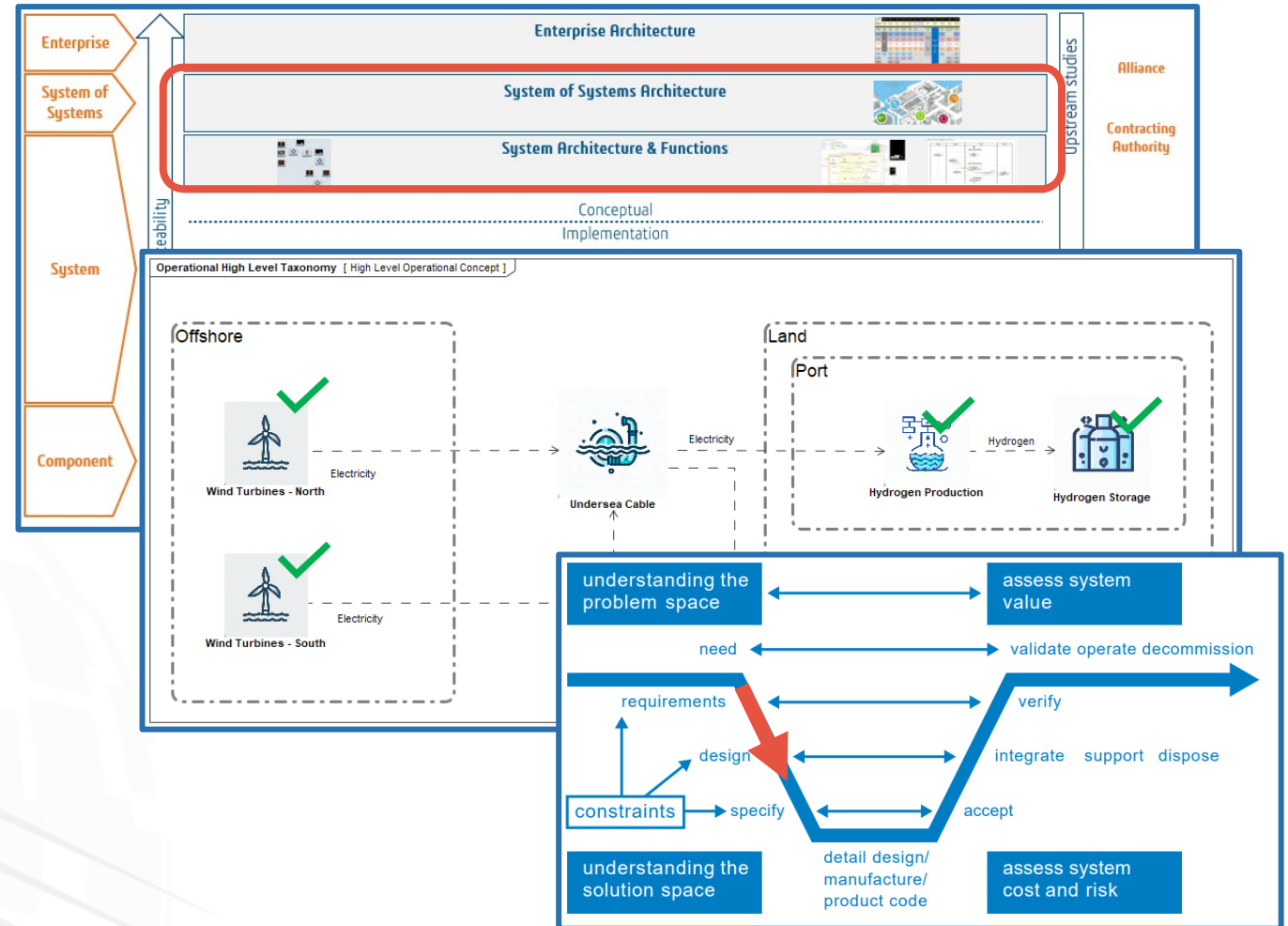
- Operational Perspective
- Investigating
 - System Behaviour
 - System Interactions
- Techniques
 - SoS Simulation
 - Monte Carlo Simulation



INCOSE UK. (2020). Z1 Guide: What is Systems Engineering? 3.1 (Z1)

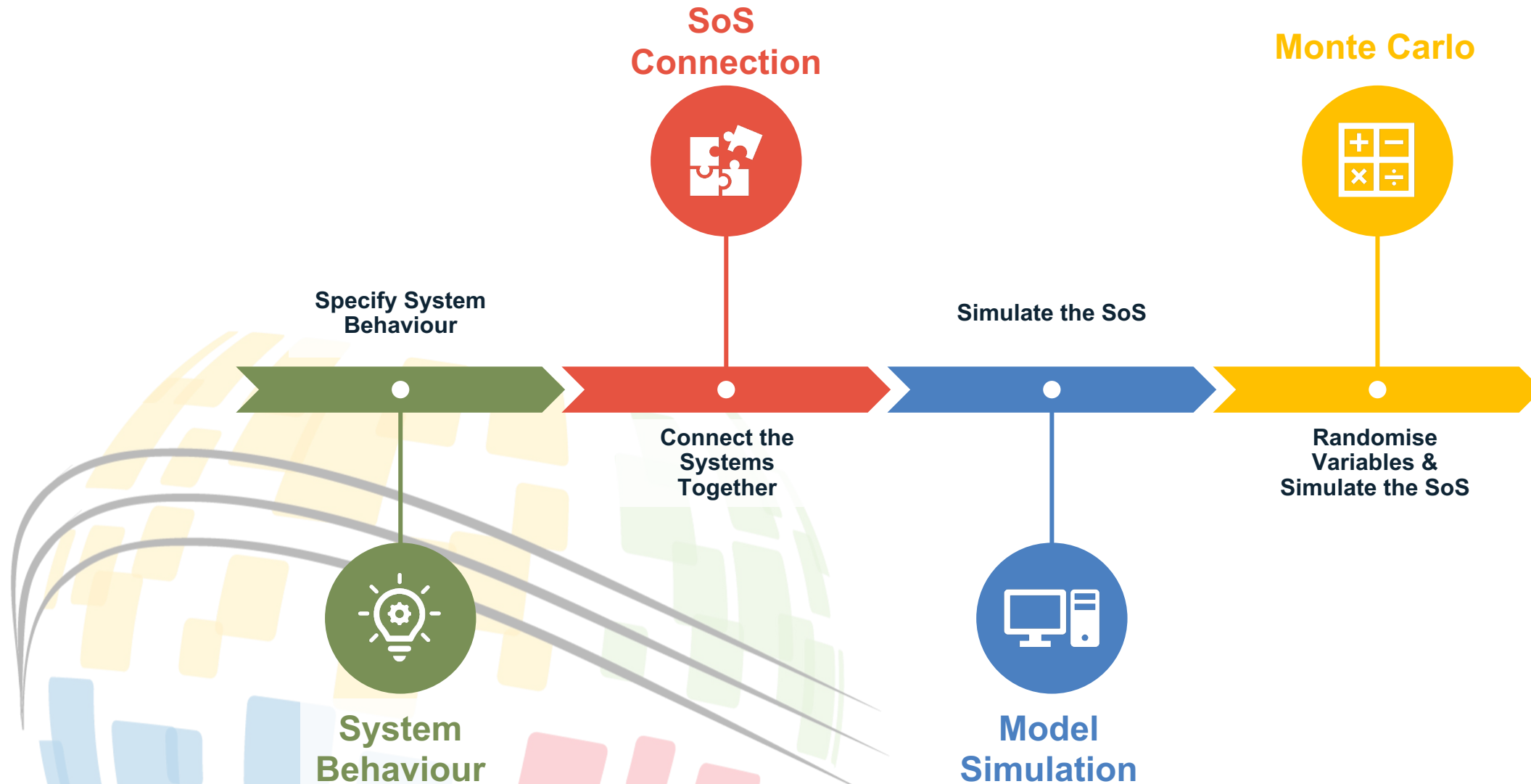
Scenario Two

- Operational Perspective
- Investigating
 - System Behaviour
 - System Interactions
- Techniques
 - SoS Simulation
 - Monte Carlo Simulation



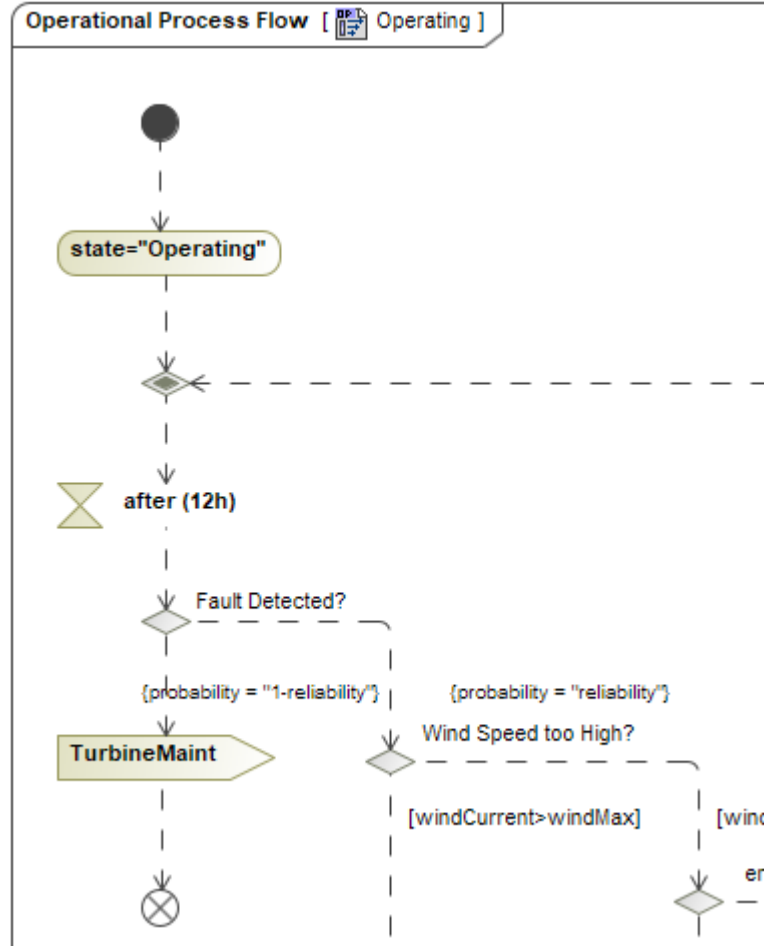
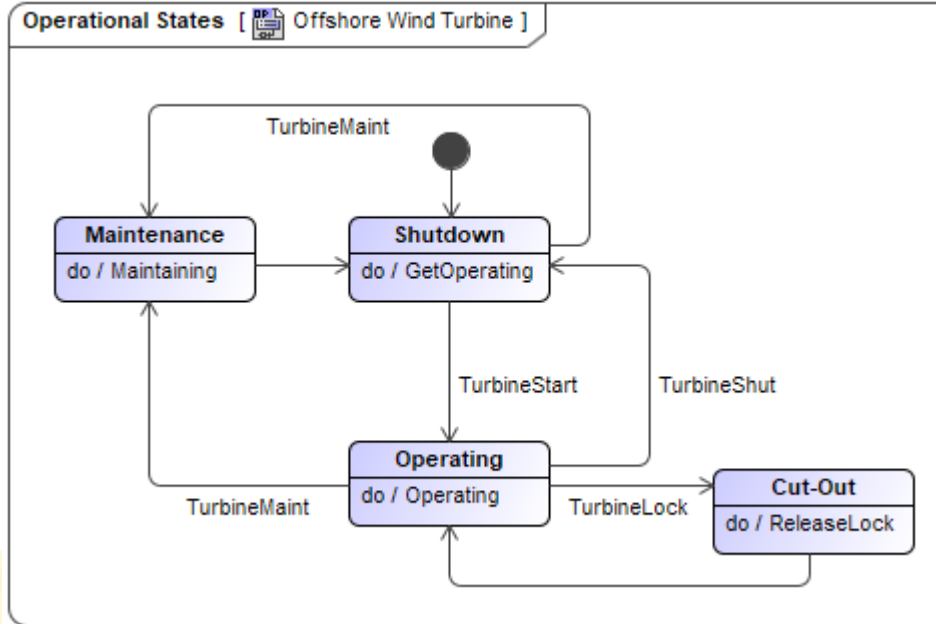
INCOSE UK. (2020). Z1 Guide: What is Systems Engineering? 3.1 (Z1)

Scenario Two Steps



System Behaviour

Specify System Behaviour



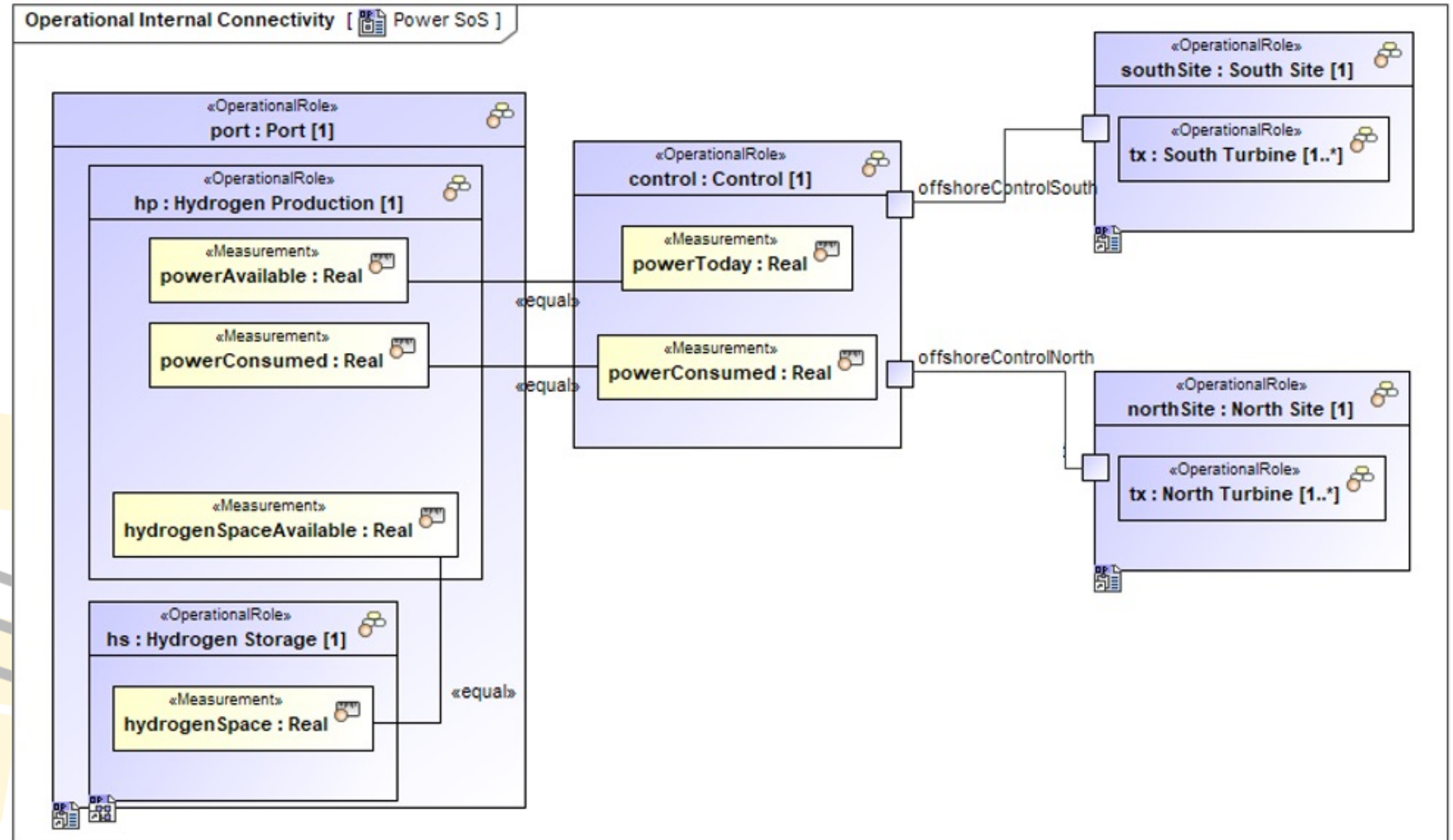
System Behaviour

SoS Connection

Connect the
Systems
Together



SoS
Connection

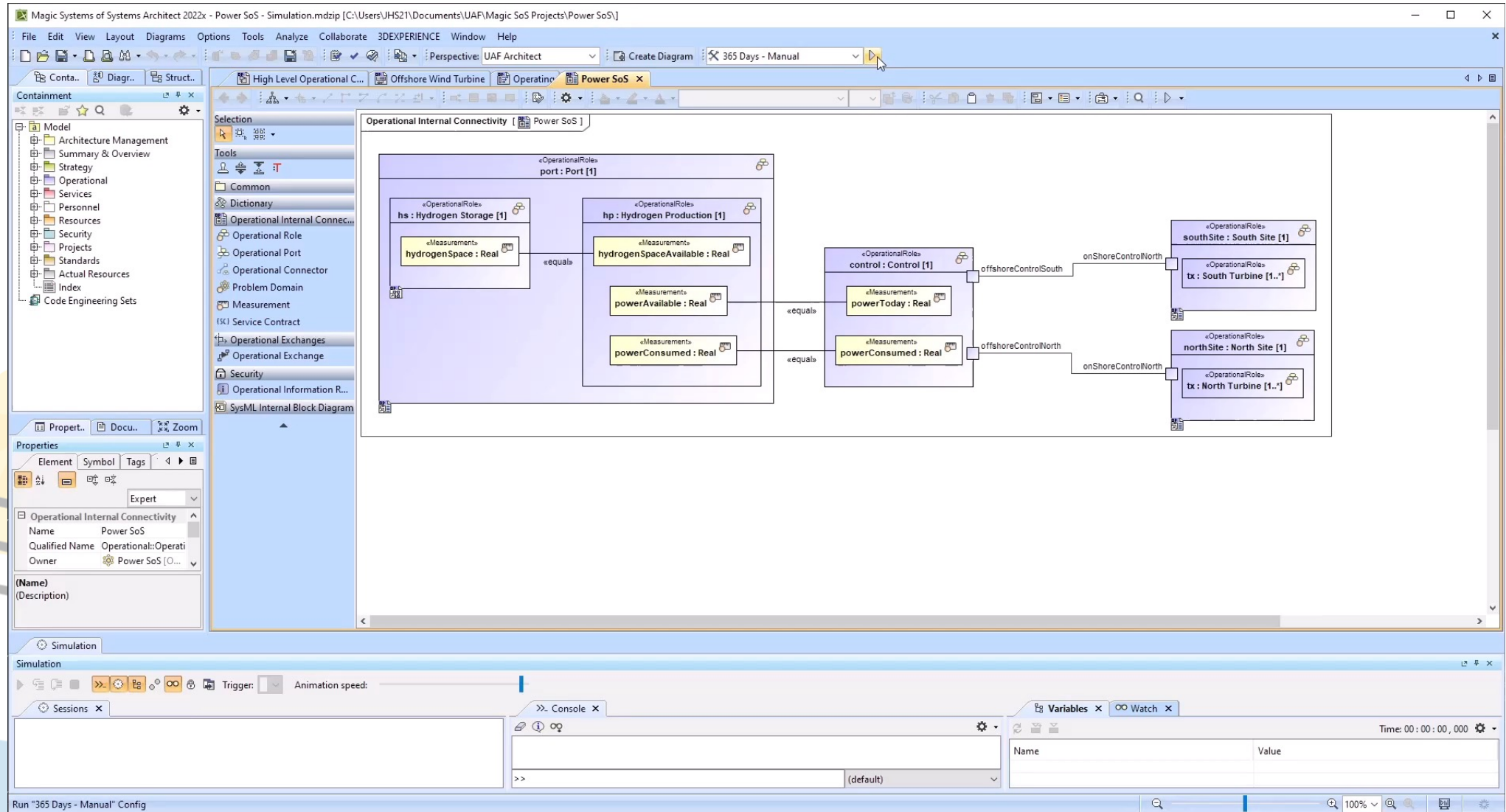


Model Simulation

Simulate the SoS

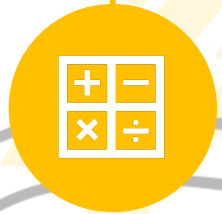


Model
Simulation

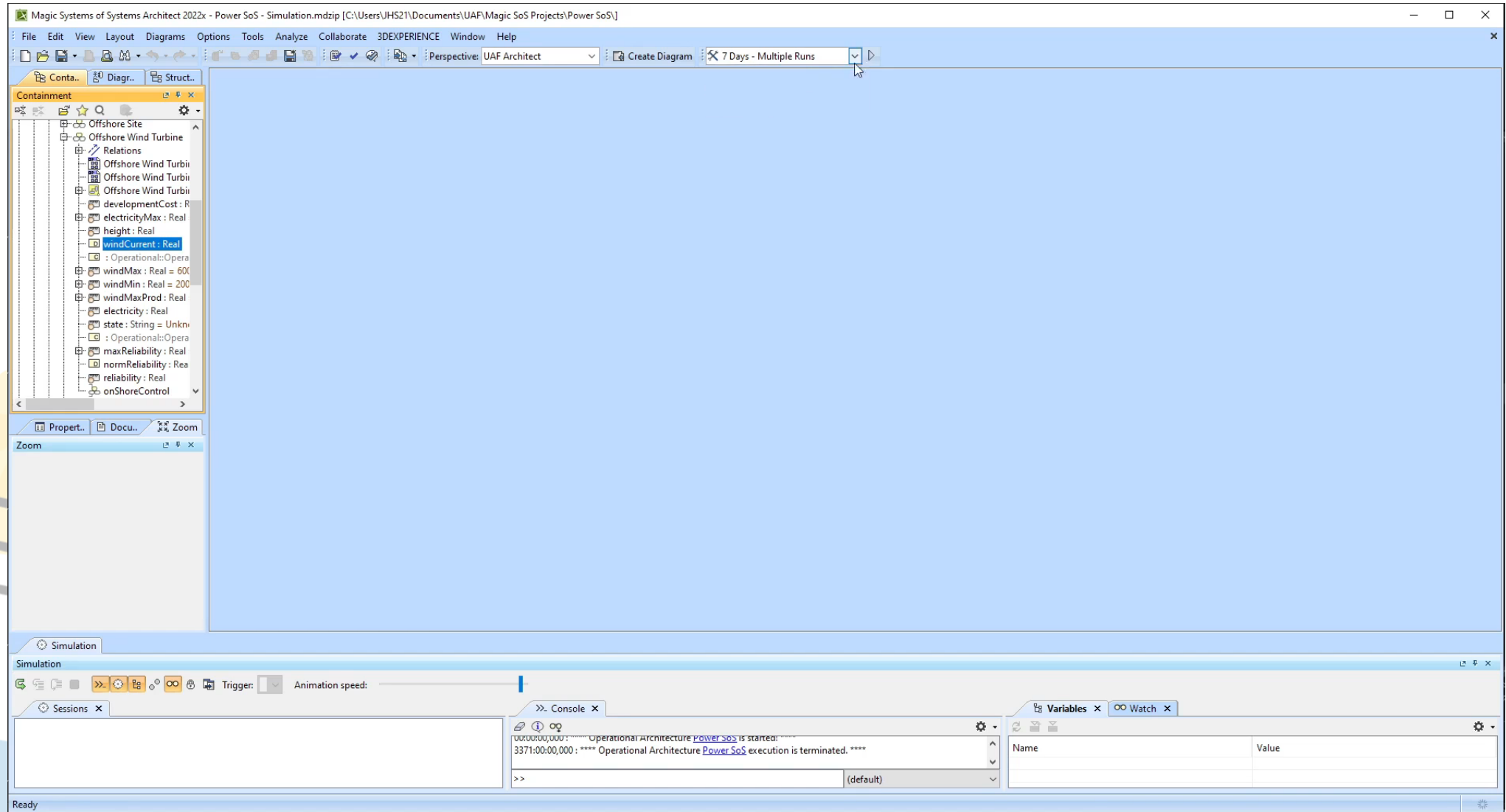


Monte Carlo

Randomise
Variables &
Simulate the SoS



Monte Carlo

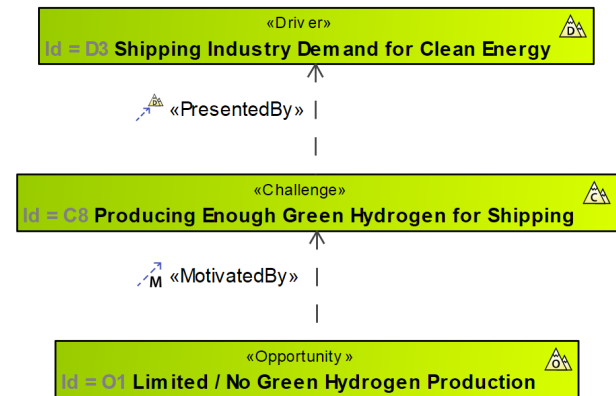




Findings

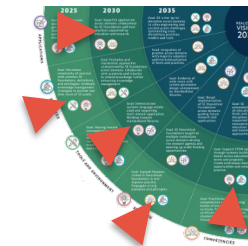
Benefits Realised

- Confidence in Meeting the Enterprise Goals
 - Business Case Simulation
 - Trade Analysis – All Options Considered
- Demonstrate Links to Government Targets
 - Government Support
- Reduced Risk
 - Early Requirements Validation/Verification
 - Common Understanding



Future Enhancements

- Operational Layer
- Detailed Simulation
- System Phasing
 - Pink/Purple Hydrogen (Nuclear Power Source)
- Regulations
- Progressing Vision 2035



Discover More



Booth 6 & 8

What will you model next?



Resources

Presenters

Joseph Hughes

BSc(Hons) CEng MIET CSEP MINCOSE

joseph.hughes@3ds.com



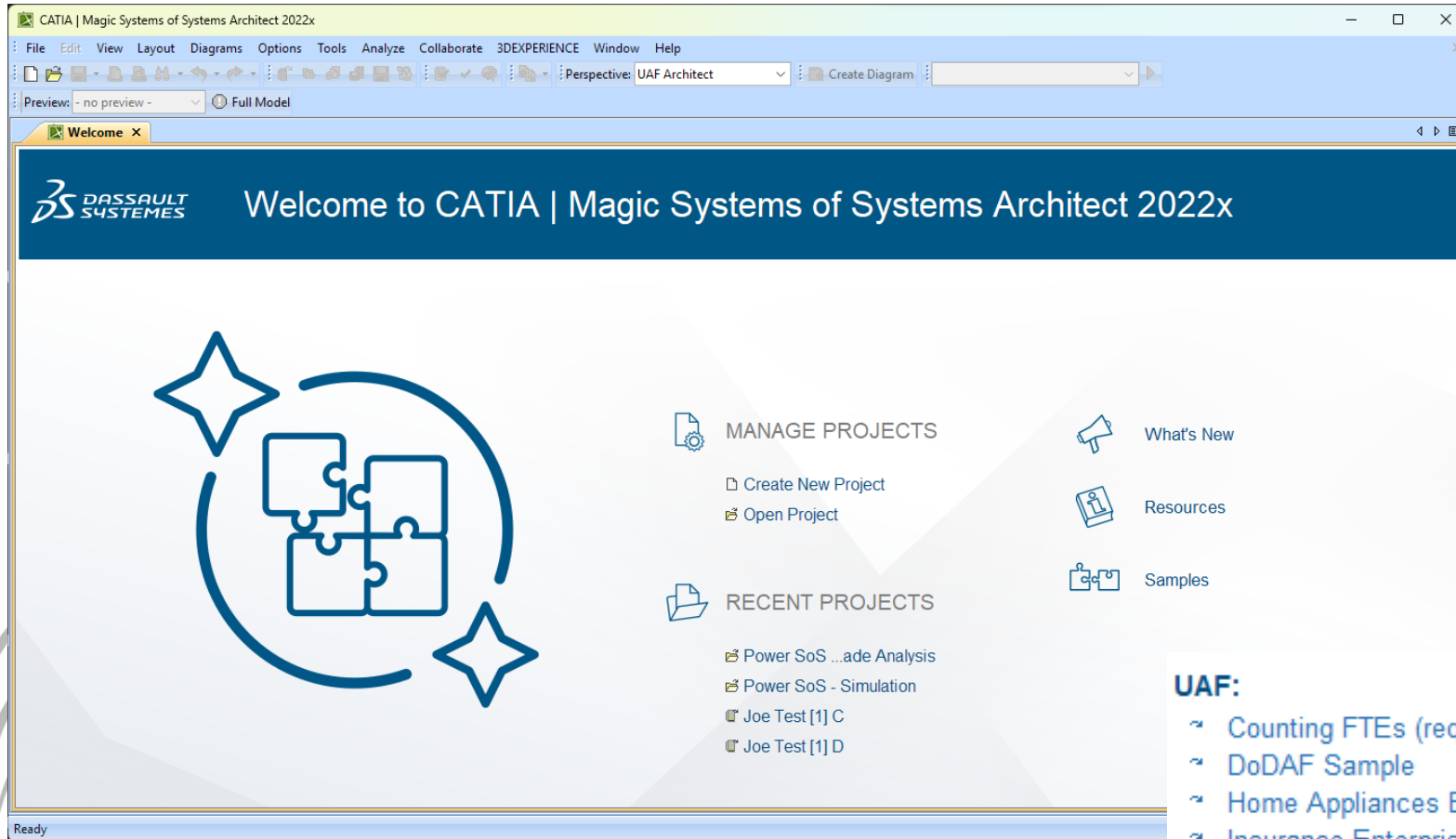
Matti Koskipää

MEng MINCOSE

matti.koskipaa@3ds.com



UAF Example



UAF:

- ~ Counting FTEs (requires CST)
- ~ DoDAF Sample
- ~ Home Appliances Enterprise (DoDAF)
- ~ Insurance Enterprise Architecture (UAF EA)
- ~ MODAF Sample
- ~ NAF 4.0 Sample
- ~ NAF Sample
- ~ UAF sample
- ~ UAF-BPMN Sample

UAF Specification

[ABOUT US](#)[GROUPS](#)[CERTIFICATIONS](#)[RESOURCES](#)[SPECIFICATIONS](#)[MEMBERSHIP](#)

SPECIFICATION DOCUMENTS

NORMATIVE DOCUMENTS

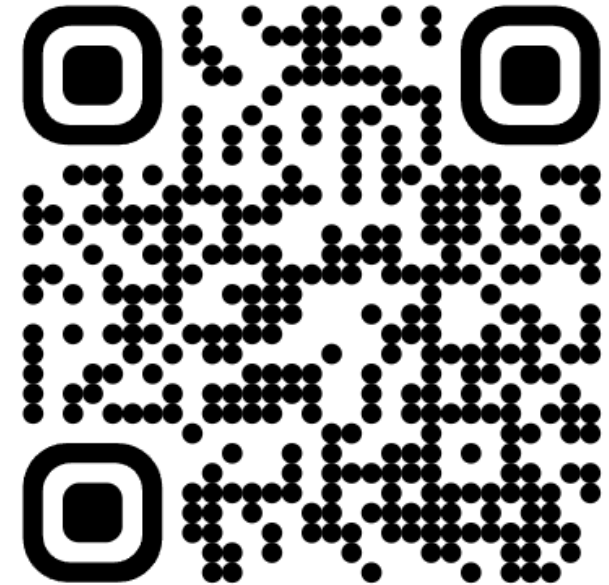
DESCRIPTION	FORMAT	URL	OMG FILE ID
Specification - DMM	PDF	UAF/1.2/DMM/PDF	formal/22-07-03
Specification - UAFML	PDF	UAF/1.2/UAFML/PDF	formal/22-07-05

NORMATIVE MACHINE READABLE DOCUMENTS

DESCRIPTION	FORMAT	URL	OMG FILE ID
UAF 1.2 - XMI file	XML	UAF/20211201/UAF.xmi	dtc/21-12-14
UAF 1.2 - XMI Measurements library	XML	UAF/20211201/MeasurementsLibrary.xmi	dtc/21-12-15

INFORMATIVE DOCUMENTS

DESCRIPTION	FORMAT	URL	OMG FILE ID
Specification changebar - DMM	PDF	UAF/1.2/DMM/PDF/changebar	formal/22-07-04
Specification changebar - UAFML	PDF	UAF/1.2/UAFML/PDF/changebar	formal/22-07-06
UAF 1.2 - Appendix A: Traceability	PDF	formal/22-07-07.pdf	formal/22-07-07
UAF 1.2 - Appendix A: Traceability, Change Bar	PDF	formal/22-07-08.pdf	formal/22-07-08
UAF 1.2 - Appendix B: Sample Problem	PDF	formal/22-07-09.pdf	formal/22-07-09
UAF 1.2 - Appendix C: Enterprise Architecture Guide for UAF	PDF	formal/22-07-10.pdf	formal/22-07-10



<https://www.omg.org/spec/UAF>

SoS Layer – EA Guide



ABOUT US ▾ GROUPS ▾ CERTIFICATIONS ▾ RESOURCES ▾ SPECIFICATIONS ▾ MEMBERSHIP ▾

SPECIFICATION DOCUMENTS

NORMATIVE DOCUMENTS

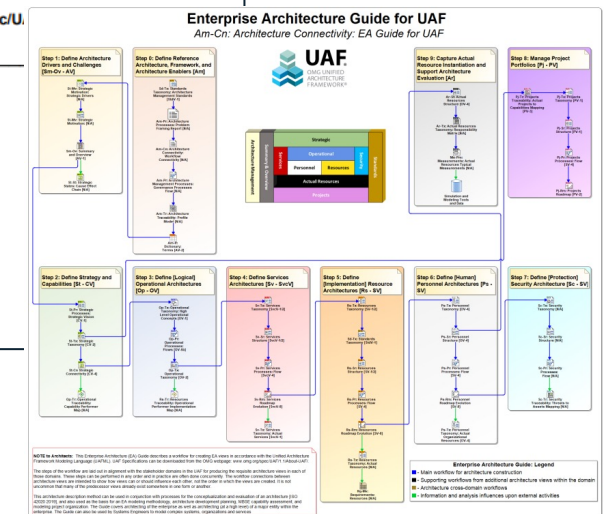
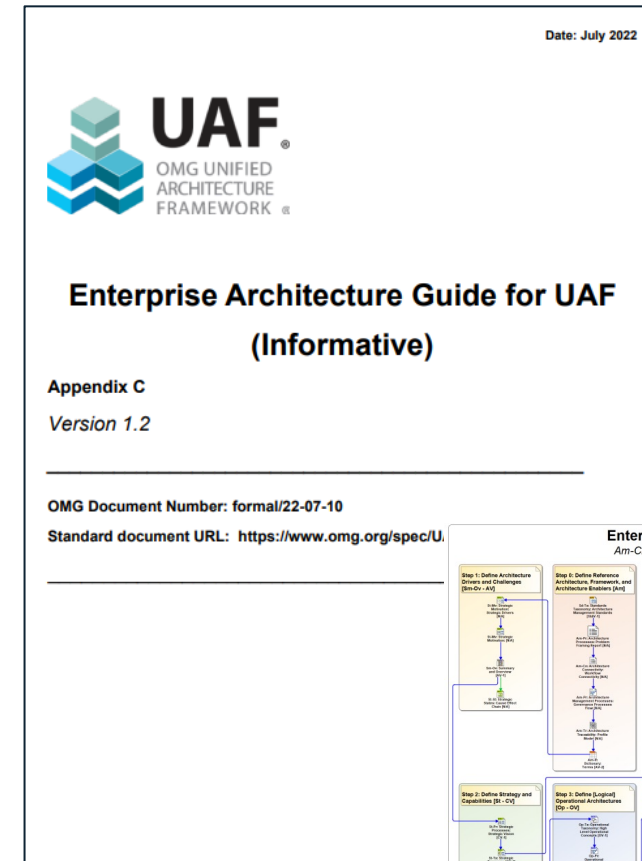
DESCRIPTION	FORMAT	URL	OMG FILE ID
Specification - DMM	PDF	UAF/1.2/DMM/PDF	formal/22-07-03
Specification - UAFML	PDF	UAF/1.2/UAFML/PDF	formal/22-07-05

NORMATIVE MACHINE READABLE DOCUMENTS

DESCRIPTION	FORMAT	URL	OMG FILE ID
UAF 1.2 - XMI file	XML	UAF/20211201/UAF.xmi	dte/21-12-14
UAF 1.2 - XMI Measurements library	XML	UAF/20211201/MeasurementsLibrary.xmi	dte/21-12-15

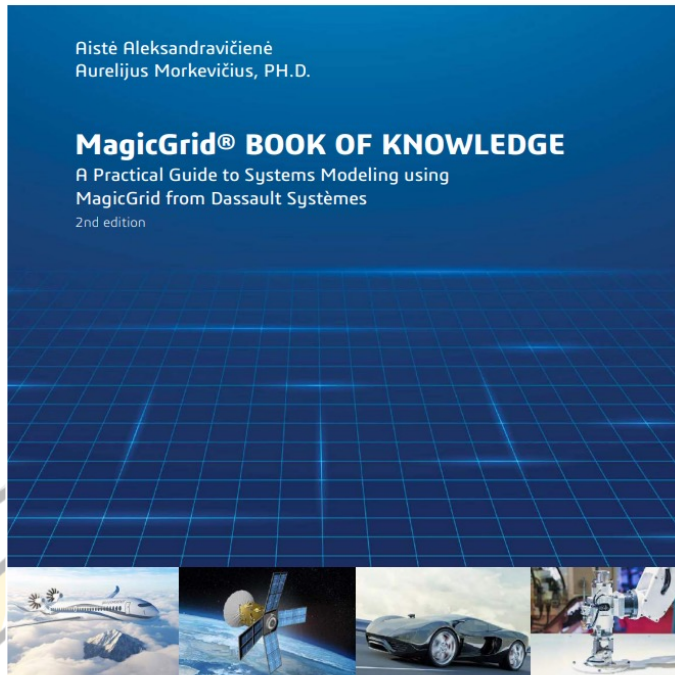
INFORMATIVE DOCUMENTS

DESCRIPTION	FORMAT	URL	OMG FILE ID
Specification changebar - DMM	PDF	UAF/1.2/DMM/PDF/changebar	formal/22-07-04
Specification changebar - UAFML	PDF	UAF/1.2/UAFML/PDF/changebar	formal/22-07-06
UAF 1.2 - Appendix A: Traceability	PDF	formal/22-07-07.pdf	formal/22-07-07
UAF 1.2 - Appendix A: Traceability, Change Bar	PDF	formal/22-07-08.pdf	formal/22-07-08
UAF 1.2 - Appendix B: Sample Problem	PDF	formal/22-07-09.pdf	formal/22-07-09
UAF 1.2 - Appendix C: Enterprise Architecture Guide for UAF	PDF	formal/22-07-10.pdf	formal/22-07-10



Object Management Group. (2022). Enterprise Architecture Guide for UAF V1.2 (OMG Document Number: formal/22-07-10).

System Layer - MagicGrid Approach



Pillar				
Requirements	Structure	Behavior	Parameters	Safety & Reliability
Stakeholder Needs	System Context	Use Cases	Measures of Effectiveness (MoEs)	Conceptual and Functional Failure Mode & Effects Analysis (FMEA)
	Conceptual Subsystems	Functional Analysis	MoEs for Subsystems	Conceptual Subsystems FMEA
System Requirements	System Structure	System Behavior	System Parameters	System Safety & Reliability (S&R)
Subsystem Requirements	Subsystem Structure	Subsystem Behavior	Subsystem Parameters	Subsystem S&R
Component Requirements	Component Structure	Component Behavior	Component Parameters	Component S&R
Implementation Requirements				



<https://discover.3ds.com/magicgrid-book-of-knowledge>

CATIA MAGIC Simulation

- Trade Studies
 - CATIA Magic User Guide – Trade Study Analysis:
<https://docs.nomagic.com/display/MSI2022xR1/Trade+study+analysis>
 - CATIA Magic User Guide – Requirements Verification:
<https://docs.nomagic.com/display/SYSMLP2022xR2/Requirements+verification>
- Simulation
 - CATIA Magic User Guide – Model Simulation:
<https://docs.nomagic.com/display/MSI2022xR1/Model+simulation>
 - CATIA Magic User Guide – Probability:
<https://docs.nomagic.com/display/CST2022xR1/Probability>
 - CATIA Magic User Guide – Using Guards on Transitions:
<https://docs.nomagic.com/display/CST2022xR1/Using+Guards+on+Transitions>

Simulation:

- ~ AircraftProjectAnalysis
- ~ BlackJack
- ~ Calculator
- ~ CarBrakingAnalysis
- ~ Excel_Sync
- ~ Requirements
- ~ VehicleStructure
- ~ CarDashboardSystem
- ~ CoffeeMachine
- ~ CruiseControl
- ~ DHCPInteraction
- ~ DurationConstraint
- ~ DynamicBatteryPowerRollup
- ~ EmergencyResponseAnalysis
- ~ ExcelHelperSample
- ~ FlashingLight
- ~ BouncingBall
- ~ WaterTankFMI
- ~ FUMI -Tests
- ~ HingeMonteCarloAnalysis
- ~ Joystick
- ~ LaptopCostAnalysis
- ~ MoldingPress
- ~ OntologicalBehaviorModeling
- ~ ActParIngerate
- ~ Basic_geometries
- ~ CylinderPipe
- ~ ForwardContractValuation
- ~ MotionAnalysis
- ~ SCARA manipulator
- ~ Simple_parametrics
- ~ SpringDisplacementUsingTimevariable
- ~ SwayOfCrane
- ~ Trade-Study for Brayton Cycle
- ~ SimulationComponentsLibrary
- ~ SmallTestSamples
- ~ SpacecraftMassRollup
- ~ SpaceStation
- ~ Stopwatch
- ~ StopwatchTestingSysML
- ~ StreamingActivity
- ~ TradeStudyExamples
- ~ TradeStudyPattern
- ~ Transmission
- ~ UsingCommandLine

CATIA Magic Community

CATIA MBSE Cyber Systems
Public

CATIA Magic STIMULUS Cyber Systems Enterprise Architecture Hardware In The Loop View More

+ Add a Post

MBSECommunityintro

Replay simulation in Cameo Systems Modeler

Wiki tree

Welcome to the CATIA MBSE Cyber Systems community!

Get Started with Communities

Community Guidelines

Find all topic posts with a tag!

Release Updates

Support

Certification

Self-Learning Material for Beginners

System Architecture Trade Studies

- System Architecture Trade Studies
- MBSE Adoption Use Cases
- 3DEXPERIENCE platform integration
- Simulation and Analysis

Structured Expressions and Queries

- Best Practices
- Scripting

MagicGrid

details

This community is for everyone interested in the CATIA systems engineering. No Magic solutions like CATIA Magic, CAMEO and MagicGrid as well as DYMOLA

Become an author



<https://go.3ds.com/catia-magic>



34th Annual **INCOSE** international symposium

hybrid event

Dublin, Ireland
July 2 - 6, 2024

www.incose.org/symp2024
#INCOSEIS