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Trade Study of Alternative Controls and Power Distribution Architecture in Subsea Processing

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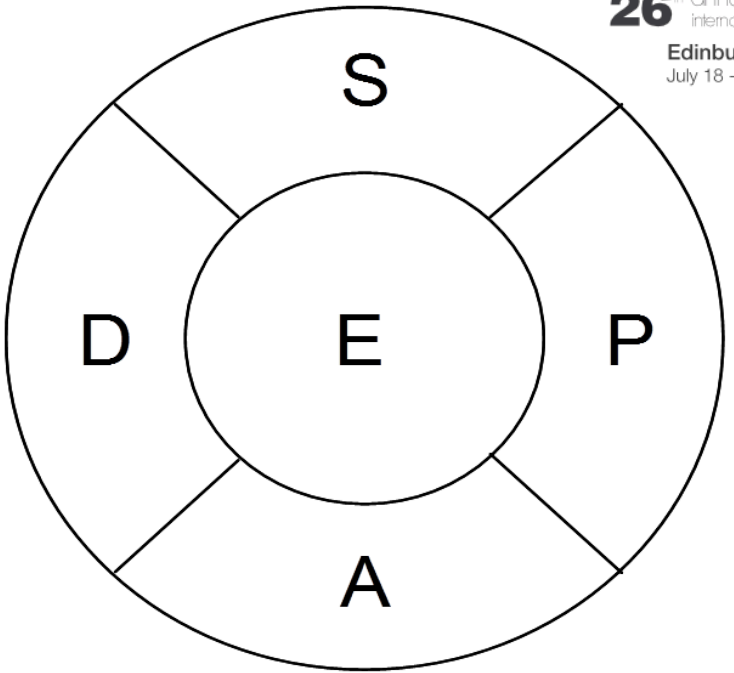
SE as a research method

- SPADE
  - Stakeholders
  - Problem formulation
  - Analysis
  - Decision-making
  - Evaluation



SE in the energy sector

- Complex systems
  - Many stakeholders
  - Deep vertical supply chains
  - Large number of connections/interfaces
  - Long-term contractual commitments
  - Lifecycle extensions of original installations
  - …

Business environment

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- Subsea gas compression is a new process station technology
  - Responding to the market need for extending the lifetime of existing subsea gas fields.
  - Deployed in deeper water, farther offshore and in harsher environments.

- The demand for a more efficient, less complex, and cheaper solution is pushing the technology development and screening for alternative concepts.

The big picture - subsea

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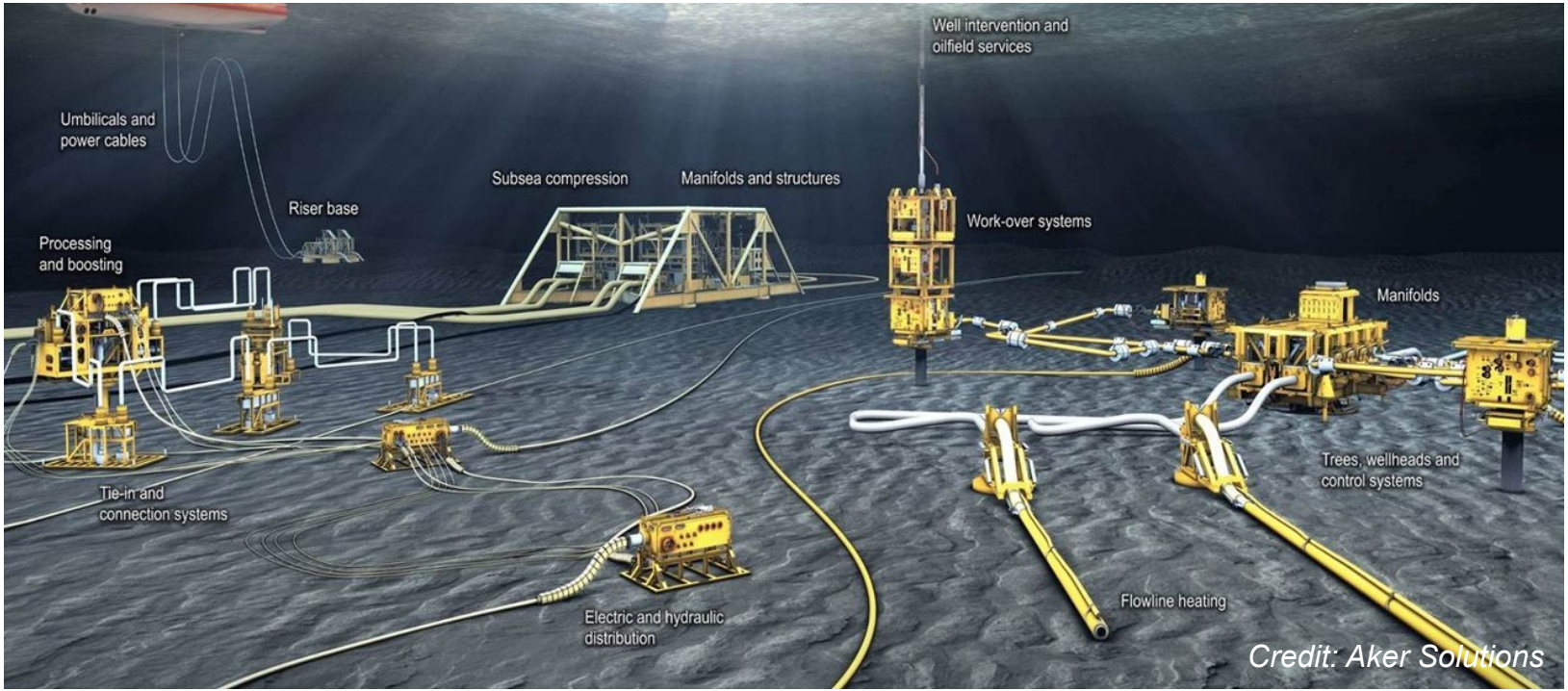
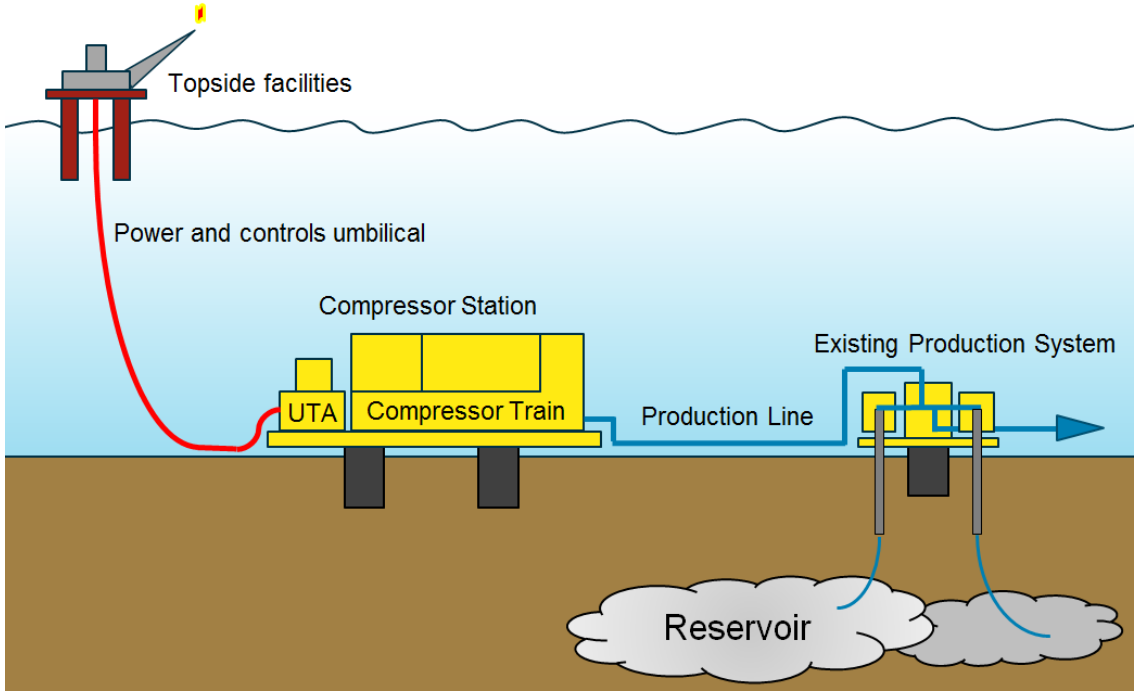


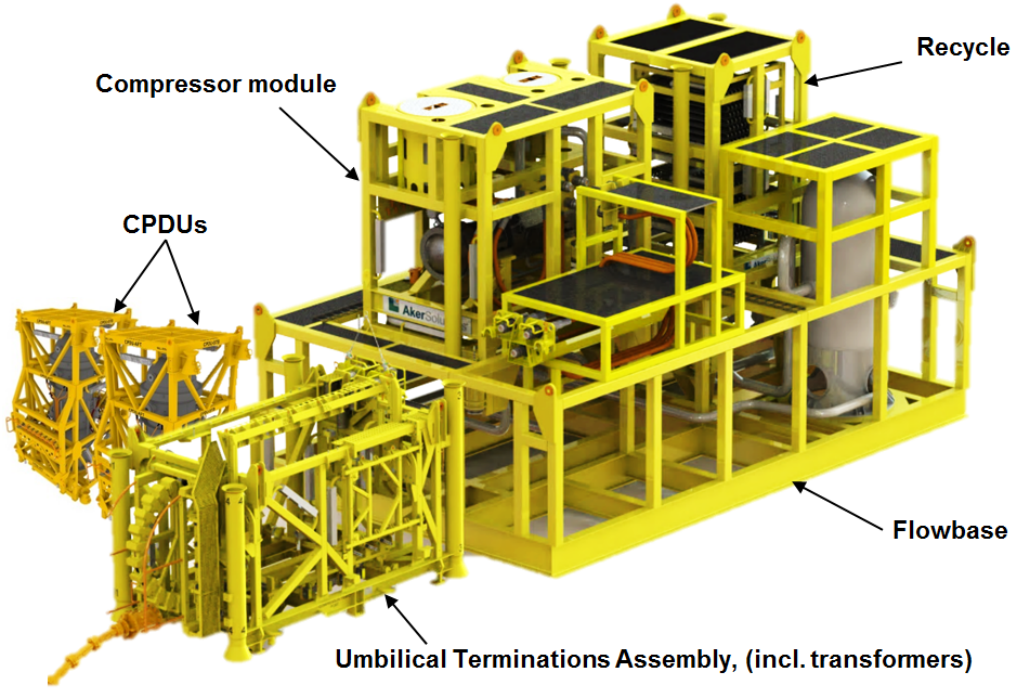
Subsea compressor

Photo: Aker

NSGC System overview



A compression station



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AKSO project execution model

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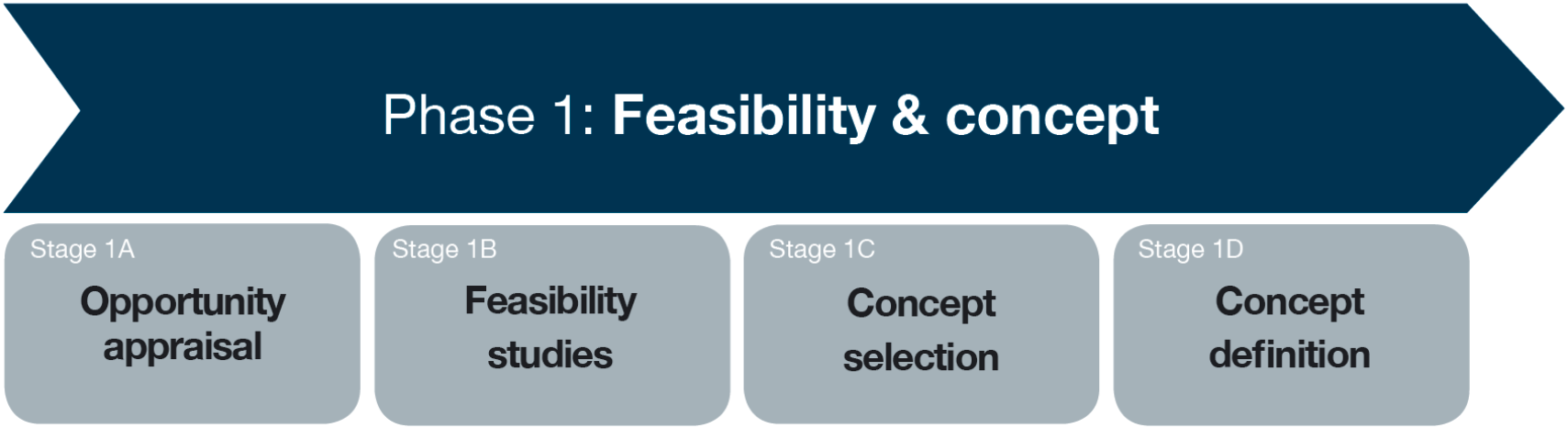

Stakeholders

- Customer: Upper Management AKSO
- Project Systems Engineering Lead
- Control system work group
- World market needs
- The legacy project SE Lead
  - Installation lead
  - Structural lead
  - Product Responsible engineers

Problem

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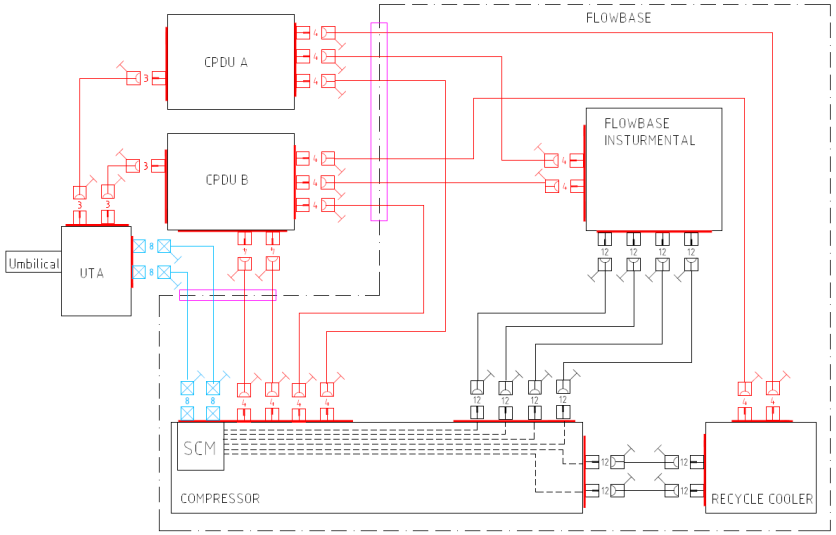
- Explore the system architecture opportunities and possibilities for the next generation compressor station optimization
  - Feasibility
  - Competitive
  - Trade-off

Trade-off method

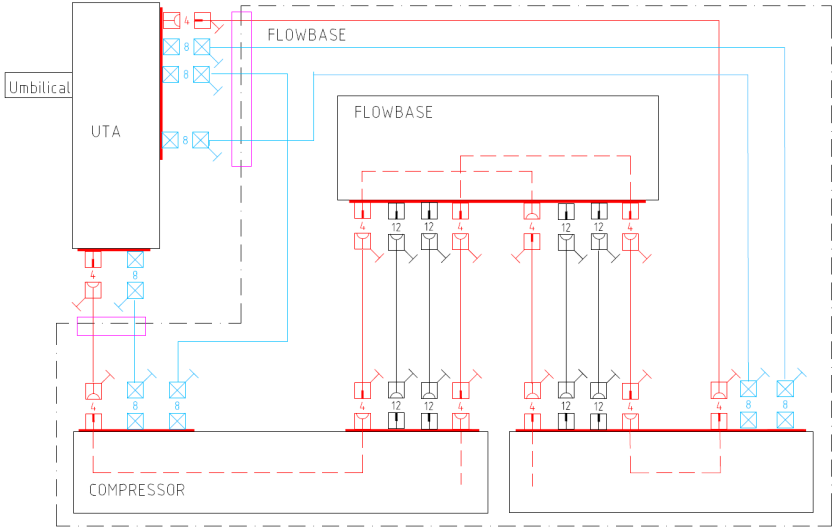
- Pugh Matrix decision-making tool
- Pugh matrix is effective both as an evaluation tool and as a visual communication tool

Alternatives

Concept 1



Concept 2



Options

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- Controls distribution:
  - Centralised controls
  - Distributed controls
- Power distribution:
  - Centralised power
  - Distributed power

1. Fully centralised controls and power (Conventional solution)
2. Fully distributed controls and power (New suggested solution)
3. Centralised Controls and distributed power (Partial new combination)
4. Distributed controls and centralised power (Counter combination)

Criteria (30) and ranking

- Strategy
  - Value AKSO portfolio
- Cost (CAPEX)
  - **Development time**
  - **Technology maturity**
  - Fabrication/production
- Reliability
  - **Total nr. connections**
  - Installation scope
  - Maintainability
- Engineering
  - Scale – instruments
  - Scale – actuators
- Testing
  - FAT, SIT
- Structure
  - Additional weight
  - Module footprint
- Installability
  - Complexity
  - Hook-up connections

Pugh matrix

Archtectural Concepts			1 - Conventional Solution		2 - New Suggested Solution		3 - Partial New Combination		4 - Counter Combination	
			FULLY CENTRALISED CONTROLS AND POWER		FULLY DISTRIBUTED CONTROLS AND POWER		CENTRALISED CONTROLS AND DISTRIBUTED POWER		DISTRIBUTED CONTROLS AND CENTRALISED POWER	
Category	Criteria	Global Weight	Offer	Rating	Offer	Rating	Offer	Rating	Offer	Rating
Strategy	Value to Aker Portfolio	5	Small step in roadmap develpment	2	Great advancement for further projects.	5	Some advancement for further projects.	4	Some advancement for further projects.	4
Cost, CAPEX	Development Time	5	Low	5	High	1	Medium	3	Medium	3
	Technology Maturity	5	Experiecne from execution in legacy project. No new technology	4	low maturity as new power and control Hubs need to be developed	1	Conventional controls distribution. Power distribution is unproven	2	Controls distribution is unproven. Conventional power distribution	3
	Fabrication / Production	3	Complex (CPDU)	1	Several new component	3	lesser new products to produce	4	Complex(CPDU)	1
Reliability	Total Number of Flying Lead Connection	5	Total 50 off. (Flowbase: 12, Compressor: 8, Cooler: 2, Station: 28)	4	Total 108 off. (Flowbase: 46, Compressor: 23, Cooler: 19, Station: 20)	1	Total 83 off. (Flowbase: 32, Compressor: 15, Cooler: 10, Station: 26)	2	Total 80 off. (Flowbase: 22, Compressor: 12, Cooler: 12, Station: 34)	3
	Installation Scope	4	CPDU installation	1	No CPDU.	5	No CPDU	5	CPDU installaion	1
	Optimised Maintainability	3	No production during SCM maintenance/failure.	1	Production during single Control hub / Power Hub maintenance/failure.	4	No production during SCM maintenance/failure.	1	Production during single Control hub / Power Hub maintenance/failure.	4
Engineering	Scaleability for Adding Instruments	3	Easy to scale/expand. Limitation in SCM	5	Easy to scale/expand. Limitation in Control/Power hubs	2	Easy to scale/expand. Limitation: SCM	3	Easy to scale/expand. Limitation: Control hubs	3
	Scaleability for Adding Actuators	3	Limitation in CPDU capacity	4	Module internal: Additional batteries / flying leads from Power hubs.	2	Module internal: Additional batteries /flying leads from Power hubs.	2	Limitation in CPDU capacity.	4
Testing	Factory Aceptance Testing	4	More test equipment required	2	Individual early testing possible. Less equipment required	5	More controls test equipment required	3	Individual early testing possible	4
	System Integration Testing	4	Require CPDU and SCM to test	1	Individual and partly testable	5	Require SCM on compressor	3	Require CPDU to test	2
Structural	Added Weight of Architecture	3	3,5+25 = 28,5 tonne	2	19 tonne	3	13,5 tonne	4	9+25 = 34 tonne	1
	Footprint Needed on Modules for Retrievals	3	Total 11,5m2. (Flowbase: 3m^2, Compressor:8m^2, Cooler: 0,5m^2)	4	Total 22,5m2. (Flowbase: 9m2, Compressor:9m2, Cooler: 4,5m2)	1	Total 20m2. (Flowbase: 7m2, Compressor:10m2, Cooler: 2,5m2)	1	Total 14,5m2. (Flowbase: 5m^2, Compressor:7m^2, Cooler: 2,5m^2)	3
Installability	Complexity of Installation	3	Less equipment on module to protect	4	Most equipment on module to protect	1	Some equipment on module to protect	2	Some equipment on module to protect	2
	Number of Connectors to Hook Up a Station	3	Total 28 off. (Compressor: 12, Cooler: 4, UTA: 2, CPDU: 10)	2	Total 20 off. (Compressor: 7, Cooler: 7, UTA: 6)	3	Total 26 off. (Compressor: 15, Cooler: 7, UTA: 4)	2	Total 34 off. (Compressor: 8, Cooler: 8, UTA: 4, CPDU: 14)	1
Identified Risk		-	A postponement of deep sea solution development > 1000m sea depth.		Multiple Technology Qualification Programs (TQPs). Timeconsuming development of Power and control Hubs.		TQP: Development of power hubs.		TQP: Development of control Hubs.	
Opportunities		-	A more mature solution for a early project delivery.		Verifies a future deep sea power distribution		Verifies a future deep sea power distribution		Verifies an alternative control distribution architecture	
			160		157		156		150	

Criteria, ranking, sensitivity

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- Taking a Decision
  - Criteria weightings can significantly affect the outcome quality of a Pugh Matrix, so it was important to perform a sensitivity analysis of the result.
  - Concept 1, the numerical winner, and 2, second place, have the biggest advantages as well as big risks, but also very close numerical scores.
  - Both concept 3 and 4 have most scores in the middle score range. This makes them more stable but in general in a lower range that 1 and 2.

Extended matrix

- New row evaluates both the uncertainties and the potential of the alternatives
  - Opportunities represent the potential for improving value and enabling creativity in resolving problems
  - Opportunities also usually carry risks of potential problems that should be avoided, if they cannot be mitigated

Evaluation

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- Pugh Matrix is only a SE tool
  - Helps extract the knowledge and experience from the study team
  - Robustness of the result depends on the use of the tool as a process
  - A structured approach provides a documented rationale for decision-making and provides justification for stakeholders

Closing thoughts

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- Subsea domain is project oriented; execution time and cost creates programmatic pressure. This may cause engineering teams to skip preliminary steps in concept selection and place more emphasis on designing and delivering products.
- Incorporating practices, such as trade-off studies in early phases of the PEM, could change the culture of project execution and lead to more time allocated to considering innovative technology options.
- Extensions to the basic matrix structure supported concurrent visibility for assessment of **Risk and Opportunities** associated with each alternative.

Questions?

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