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Cause and Impact Analysis of Cost and Schedule Overruns in Subsea Oil and Gas Projects

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The authors

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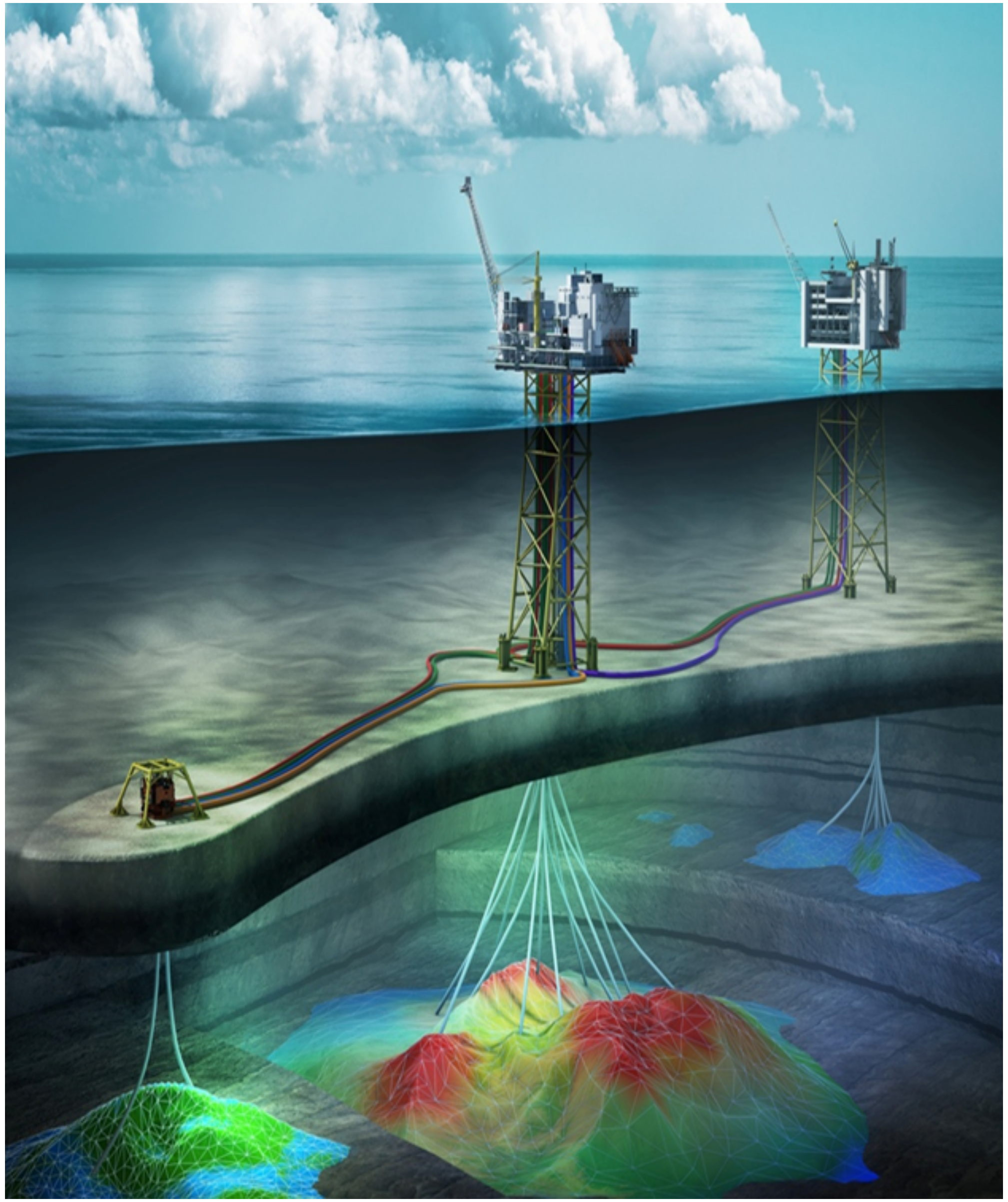
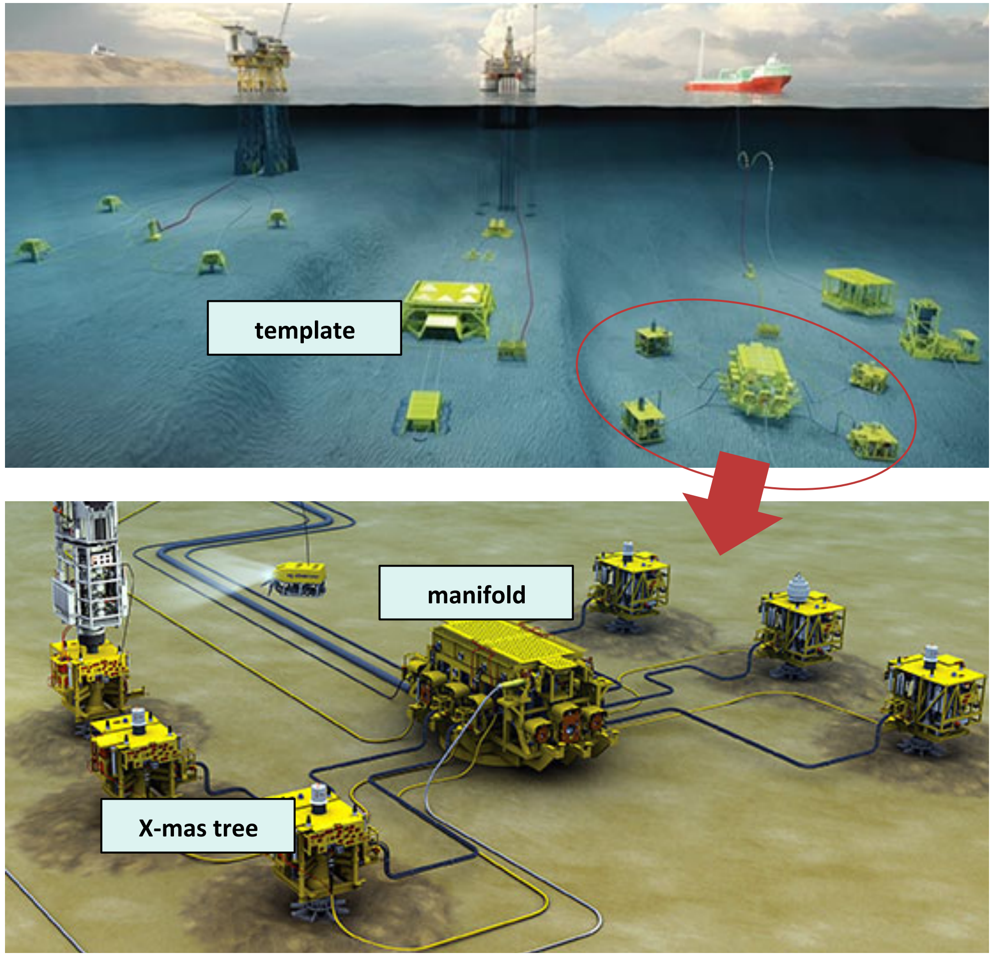
Field development on the
Norwegian Continental Shelf (NCS)
Engineering, Procurement, Construction (EPC) projects

Background



Domain

- Research conducted in the subsea oil and gas domain
- Subsea production systems (SPS) installed on the seabed to control and collect oil and gas from subsea reservoirs
- An SPS typically comprises x-mas trees, manifolds, and templates



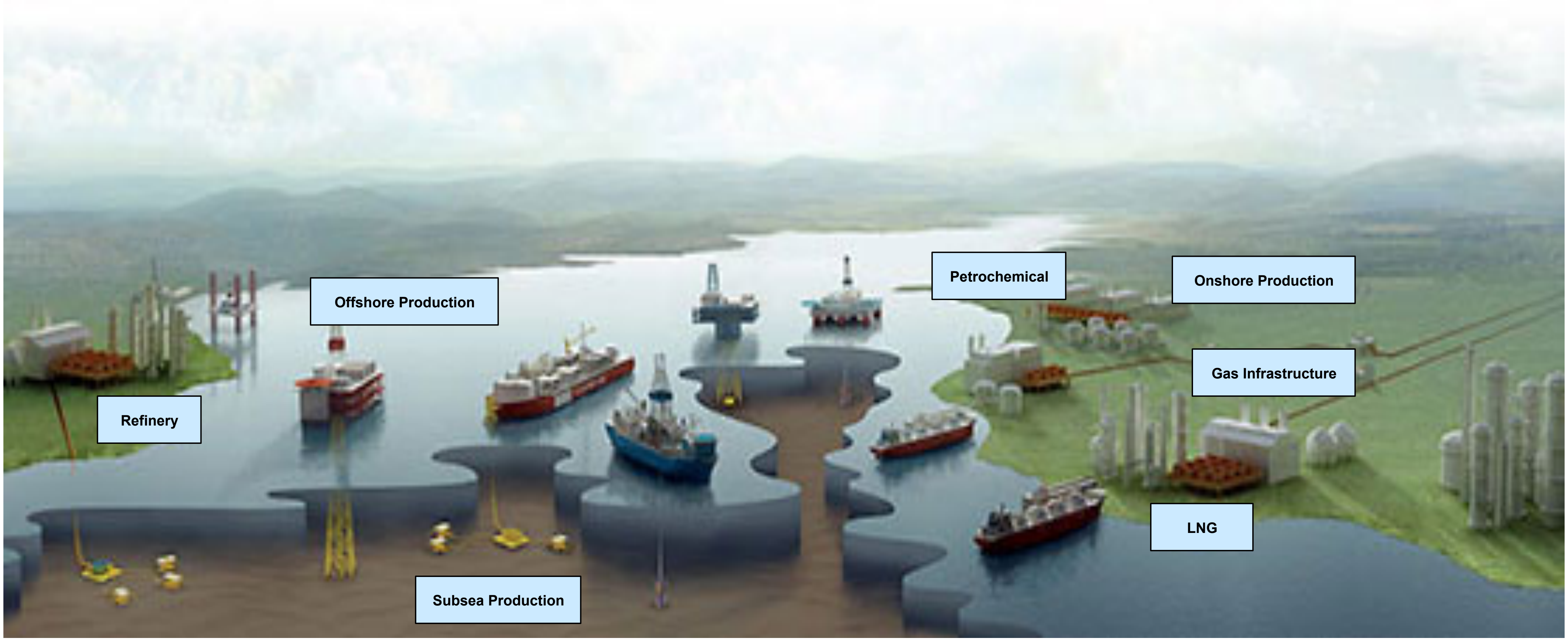
Subsea Production System (SPS)
Illustration of installations at different depths

Qualification requirements

- Subsea equipment faces under extreme pressure from above in terms of high/low seawater pressure/temperature, and below high oil and gas pressure/temperature
- Field developments move towards increasingly deeper waters → deeper = more demanding; existing technology is modified or new technology is introduced to cope with new new demands
- Requirement: Modified/new tehcnology must be qualified to prove it is fit for its intended purpose (per the ConOps)

- «Qualification is the process of providing the evidence that the technology will function within spesific limits with an acceptable level of confidence» (DNV GL)

The BIG picture



Current situation in field development

M: cost overrun (33%)

M: schedule overrun (30%)

EY: cost overrun (64%)

EY: schedule overrun (73%)

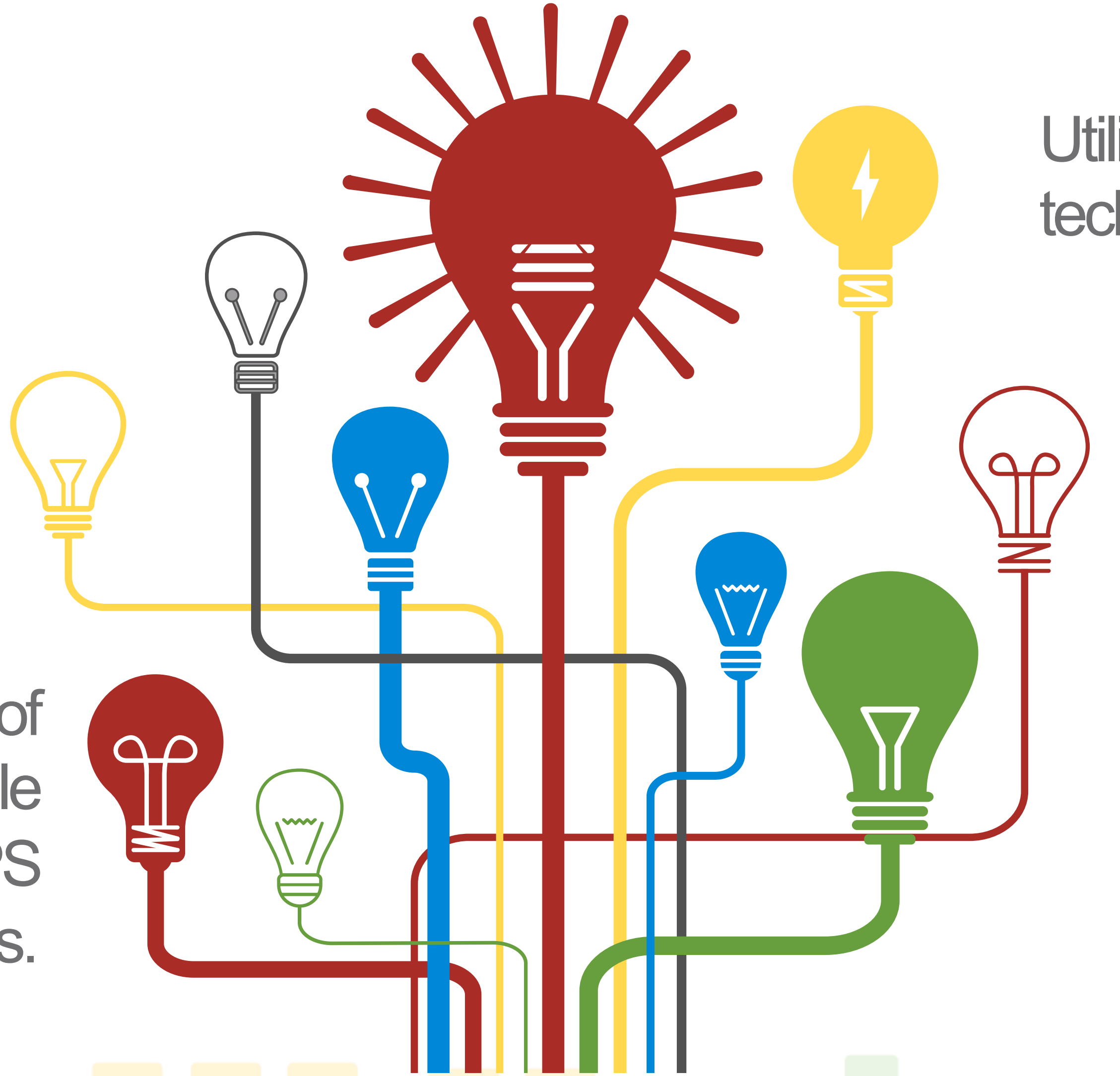
Over 200 projects analyzed by Merrow (2012)
Similar study by EY (2014)

Industry response: Re-use solutions and strengthen supplier management and efficiency

Problem statement

Reduce cost and schedule overruns in SPS projects.

Identify key drivers of cost and schedule overruns in SPS projects.



Utilize tools and techniques from SE.

Recommend means to reduce the risk of overruns in future projects.

Research methods

1. Literature review & Analysis of reference project
2. Conduct workshops with experts (find causes)
3. Apply root cause analysis (RCA) techniques
4. Compare RCA findings with literature
5. Recommend improvements in project execution

Project evaluations and industry experience

«high quality work in early phases is crucial for succesful project implementation» (NPD)

«half of the cost and schedule overruns in offshore projects can be mitigated» (DNV-GL)

mitigated through improvements in early risk reviews, technology qualification programs, and classification schemes

NPD: Norwegian petrolieum directorate
DNV-GL: Det norske veritas - global

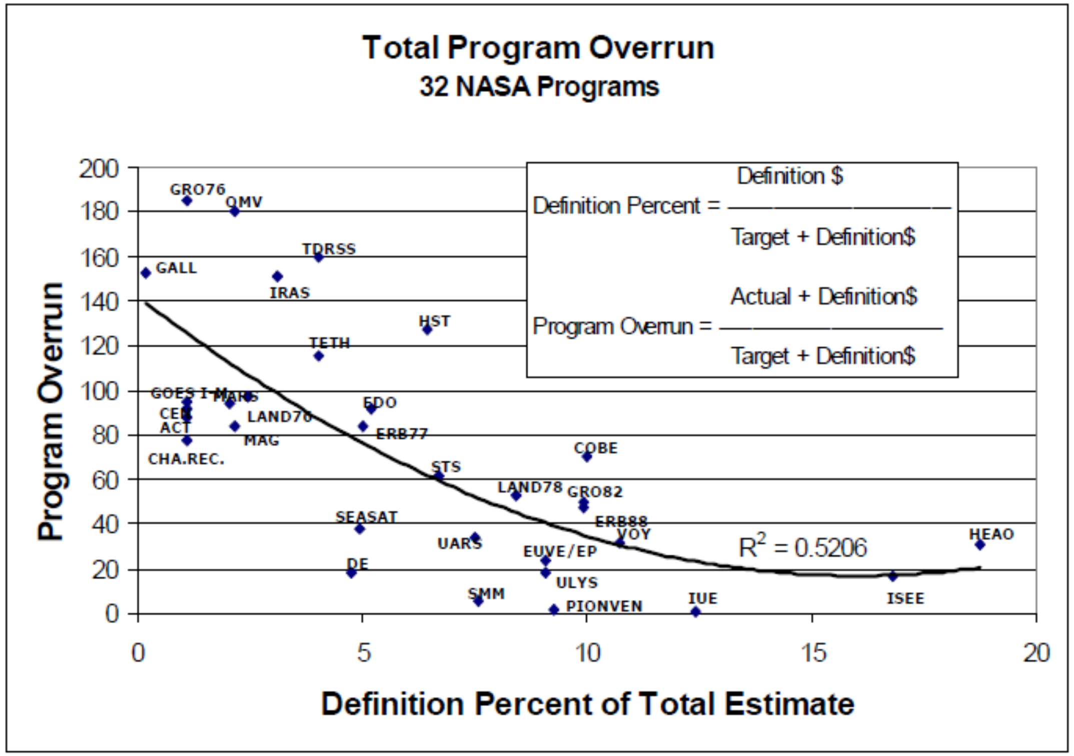
Customer – supplier communication

- Research shows a positive effect on product development
  - Decreases cost and development time
  - Integrate suppliers into the product development system, and help them with product strategy
  - Involve suppliers in early phases to ensure that they understand the needs and goals of the customer

(*The Toyota Way*)

Systems engineering foundations

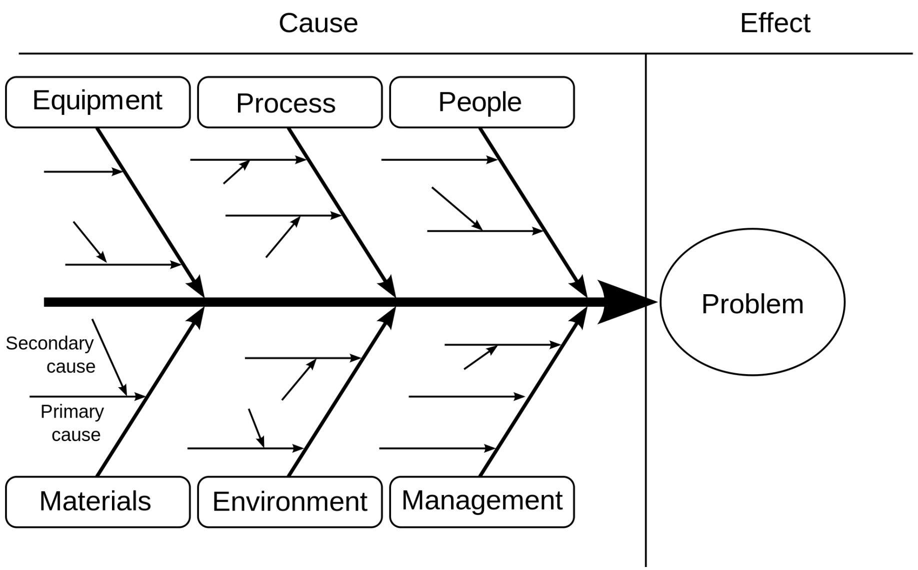
- SE sources used:
  - SEBoK
  - INCOSE SE Handbook
- Research (NASA)
  - Correlation between increased early phase effort and fewer program overruns

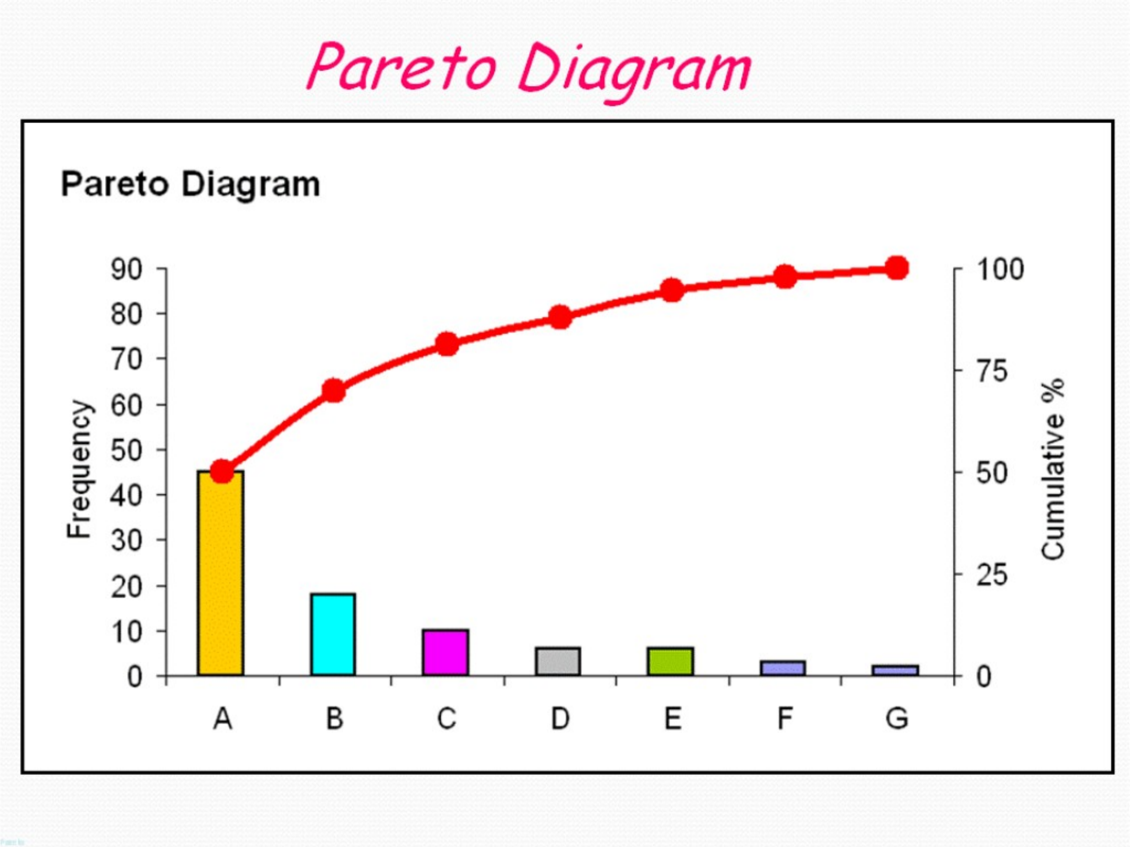


Source: Werner M. Gruhl. Chief Cost and Economics Analysis Branch, NASA (2005)
http://sebokwiki.org/wiki/Economic_Value_of_Systems_Engineering

SE Tools and Techniques

- Root cause analysis





Root cause analysis – workshop arrangement

- Initial workshop with 9 senior experts (180+ years of experience)
  - Applied cause and effect diagram (also called fishbone or Ishikawa)
    - Good brainstorming technique
    - Capture and categorize root causes
    - Not shown today for reasons of confidentiality
  - Asked to prepare a list of causes for schedule slips and cost escalation in SPS projects

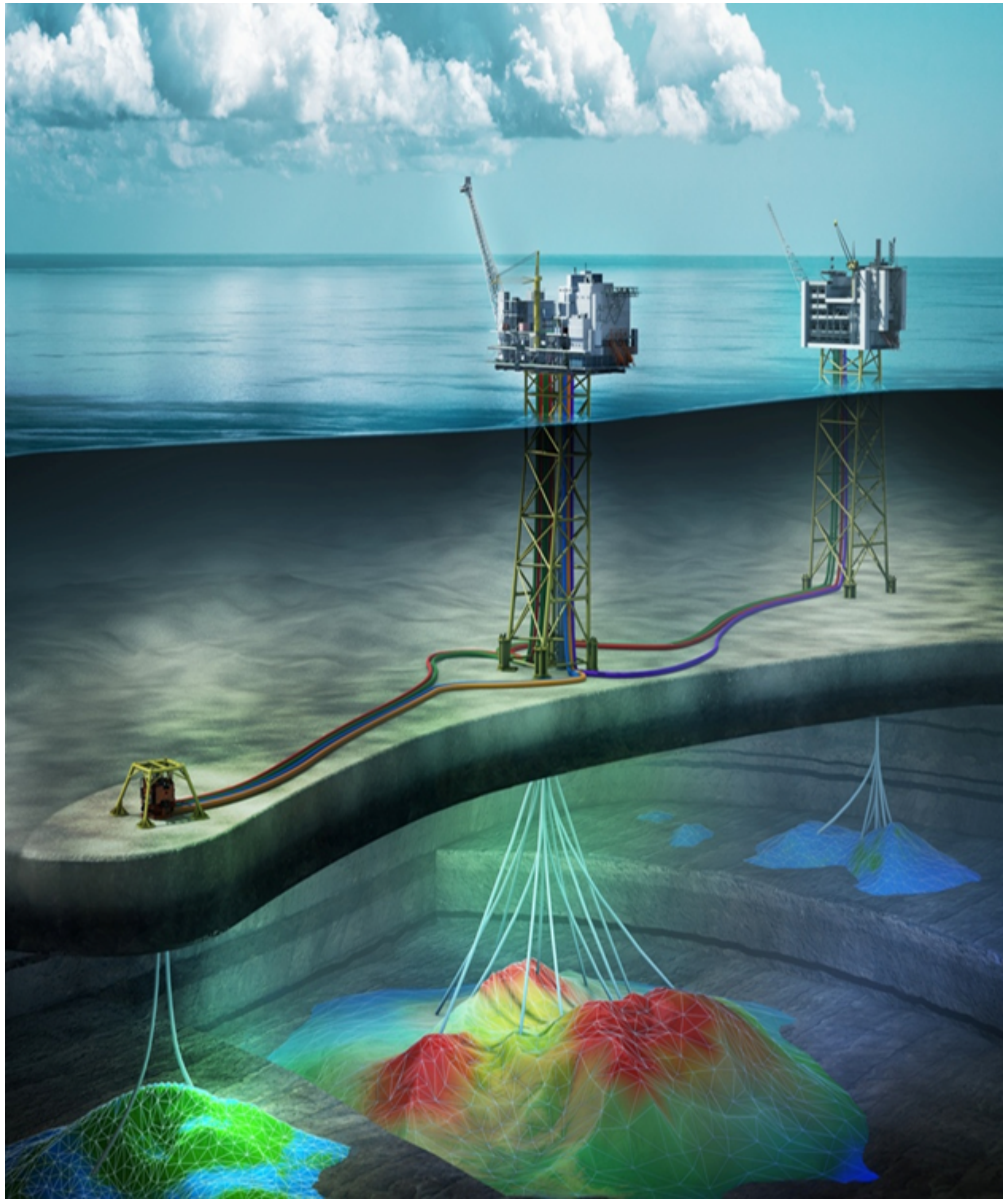
- 3 parts:
  - Part 1. Share individual identification of incidents and root causes
  - Part 2. «Scoring» of the impact of each cause
  - Part 3. «Scoring» of how easy it is to improve/reduce respective impacts

Root cause analysis – workshop details

- Part 1: Share «around the table», then brainstorming and discussion
- Part 2: Each participant was given six votes:
  - One vote with «High», two votes with “Medium”, and three votes with “Low”
- Part 3: Determine the most critical causes by applying matrix diagram and pareto chart
  - Weight: «high» = 9; «medium» = 3; «low» = 1
  - The sum determines the ranking of the causes

Root Cause Analysis
Industry Comparisons

Results



Causes of schedule and cost overruns

- Top 3
  - Qualification of products in parallel with project execution
  - Changing vendors frequently
  - Project management/ execution methodology

Simplified matrix diagram

No.	Incident/ Cause	Score			Weighted score
		# of H	*# of M*	*# of L*	
A	Qualification of products in parallel with projects	3 of	2 of	3 of	36
B	Changing vendors frequently	2 of	0 of	0 of	18
C	Project management/ execution methodology	1 of	1 of	2 of	14

Causes of schedule and cost overruns

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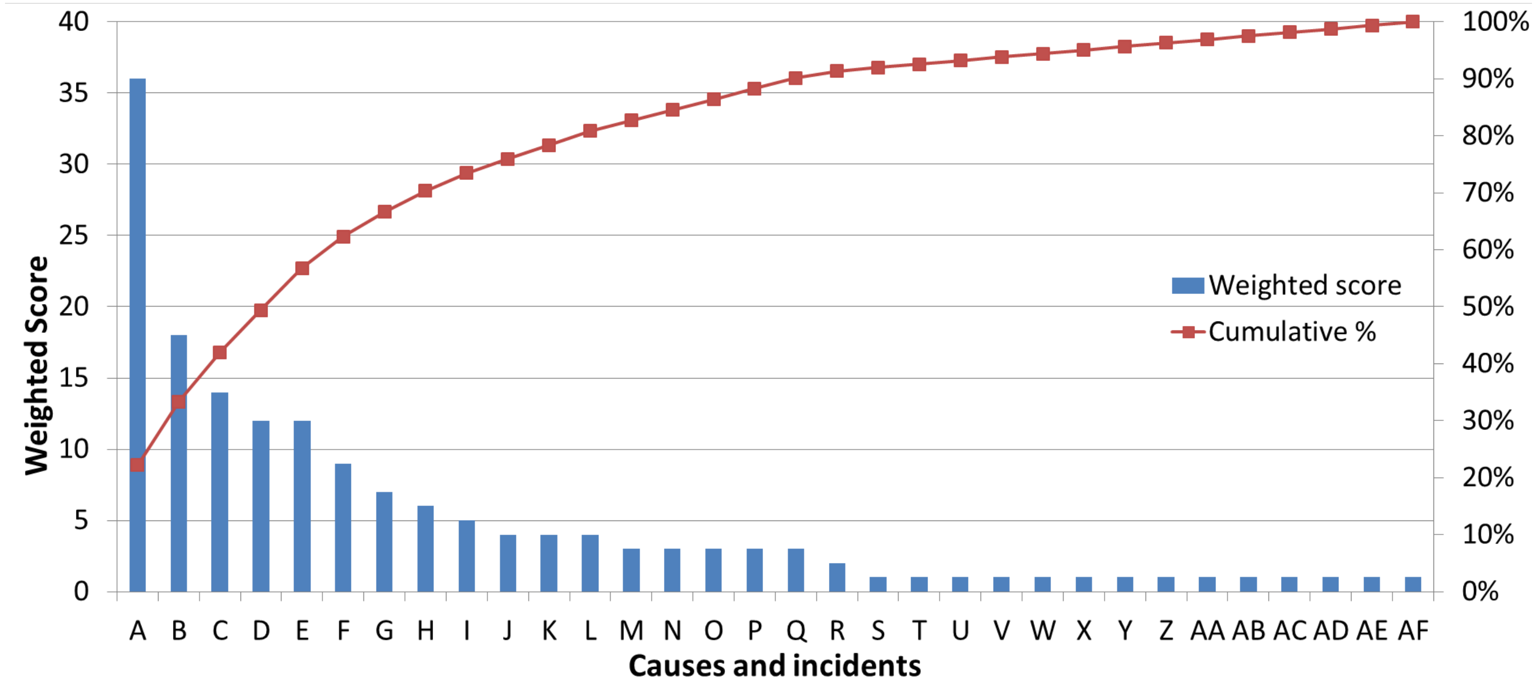


Other causes of schedule and cost overruns

- Additional causes and incidents are:
  - Longer than scheduled fabrication time
  - Insufficient competence level and heavy internal systems
  - Contractual issues
  - Requirements and technical regulations issues
  - Equipments failure/ issues
  - Inadequate testing
  - Engineering errors
  - Insufficiently qualified products and suppliers

Reference project – Qualifications

- Compared the top workshop result against a recent SPS project
- Contract and documentation of qualification programs were reviewed

21 TQP planned initially

- 12 internal TQPs
- 9 third party TQPs

53 TQP actually performed

- 23 internal TQPs
- 30 third party TQPs

Many of the TQPs were identified after 1-2 years into the project execution phase

technology qualification programs (TQP)

Reference project – cost of TQP

Cost of unplanned or unbudgeted TQPs contributed to a 69% cost increase in a project that cost several million USD*

Additional cost of TQP absorbed by the project

22%

51%

Cost of TQP not included in the original tender (contract)

Amount budgeted for the original 21 TQP in the tender

27%

49%

Cost of the 21 original TQP included in the tender

*Actual costs not available for reasons of confidentiality aggregated total cost of all TQPs is several million USD

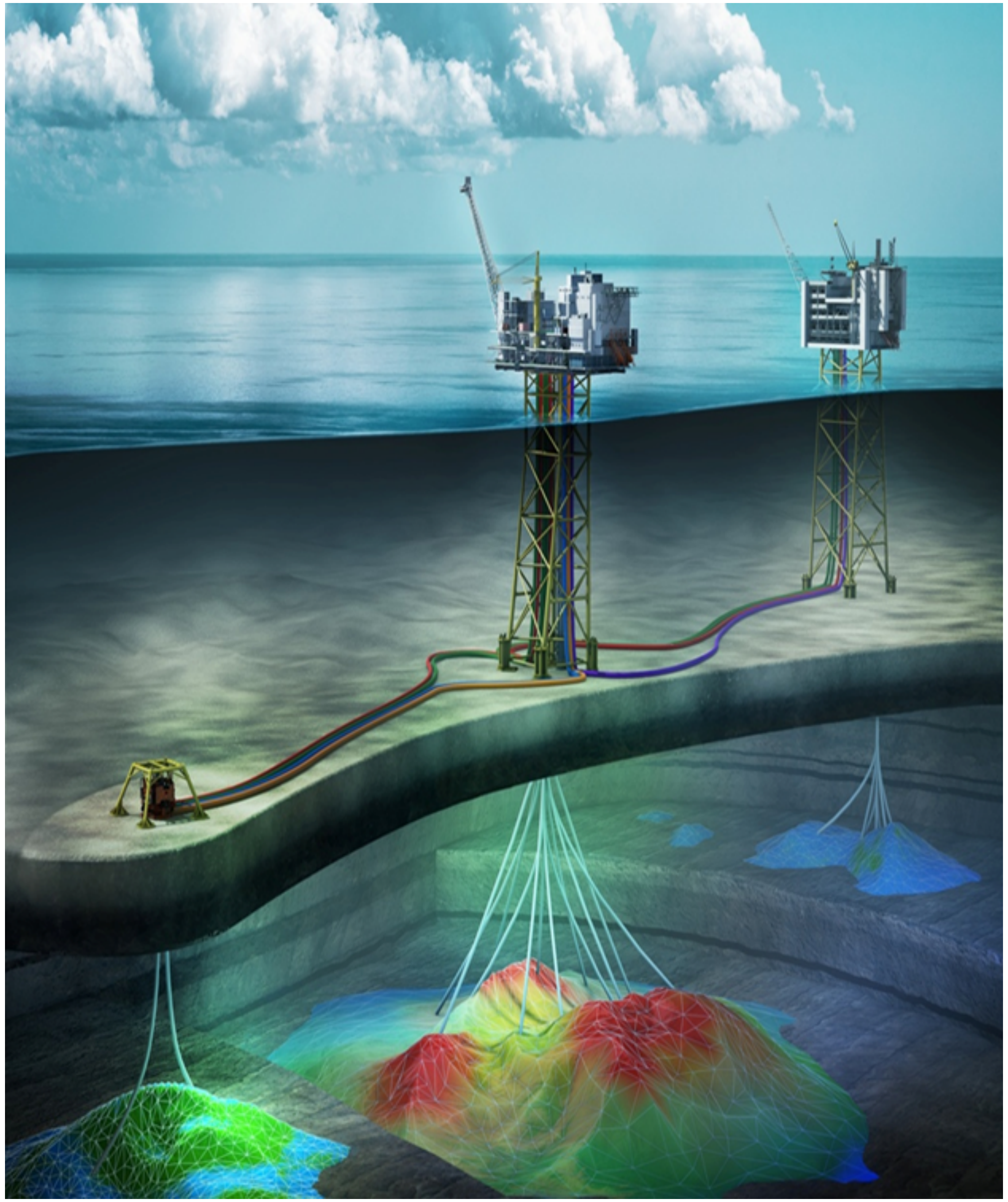
Reference project and the experts

- Conversations with experienced managers and technical experts
  - They agree that the findings are typical
  - Many undiscovered TQP are caused by poor communication, both with suppliers and internally in the case company
  - Some errors trace back to the tendering process because the tender team lacks either expertise or sufficient information to challenge the ITT
- Conversation with lead engineer
  - No two fields are identical, thus some components must be requalified as their functions or properties differ from field to field
  - This means that measures, such as TRL, are not automatic indicators for qualification
  - Re-qualifications are hidden costs in the project, usually not included in the bid, and result in increased expenditures

ITT – Invitation to tender

Discussion
Conclusions
Future work

Closing



Reference project – increase in TQP

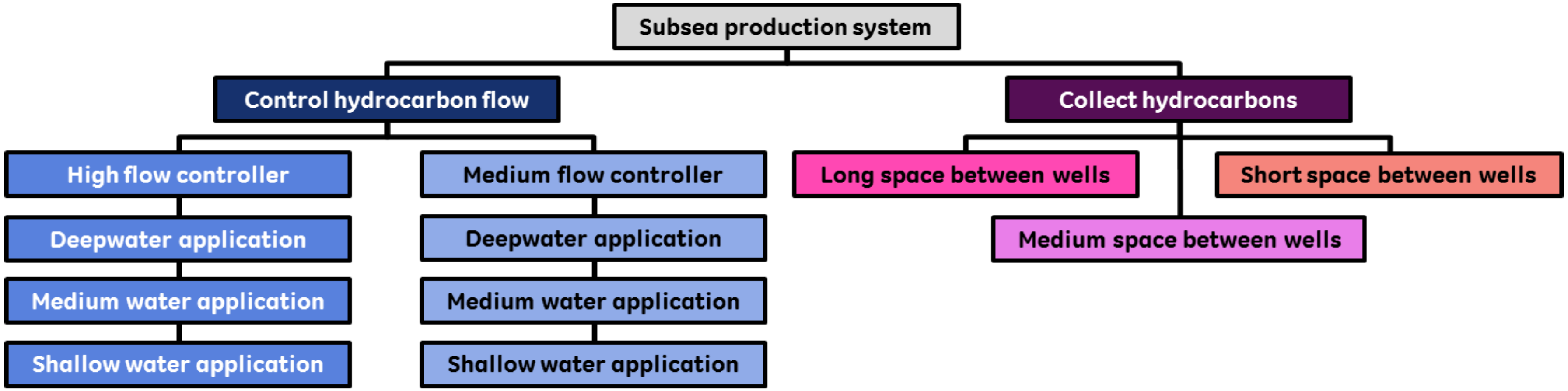
- Summary of TQPs:
  - Total number of TQPs increased by 152%
  - Internal TQPs increased by 92%
  - Third party TQPs increased by 233%
- Cost of TQPs:
  - Total cost increased by 273%
  - Cost of initial TQPs increased by 84%
- Not enough evidence to assert that TQPs in parallel with project execution have schedule impact

Standardization approach for the future

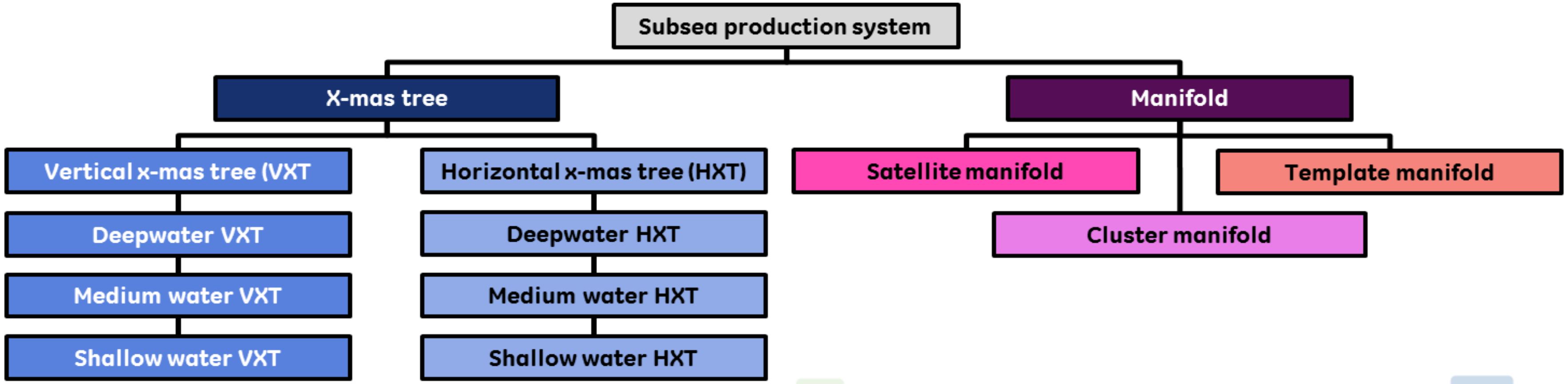
- Standard products approved by the oil and gas industry
- Customers will know what they buy; improved supplier communications
- Will reduce customizations for «each project»
- Improved estimates of cost and time for fabrication, testing, and installation phases

Standardize architectures – product families

- **Foundational Architecture**



- **Domain specific Architecture**



Summary

- The oil and gas industry strives to cut cost and reduce schedule slips
- The cause and impact analysis shows:
  - Case company failed to identify required TQPs in the bid for the reference project
  - This caused cost escalation and possible schedule slips
  - Indications of poor communication with suppliers and internally in the case company
- Propose to implement standardized architectures for SPS projects
  - Potential to increase communication and understanding of stakeholders' needs
  - Facilitates multiple views to understand the impact of changes → reducing TQPs
  - Apply extra efforts during feasibility and concept stage to identify TQPs

Further work

- Do these findings apply to other projects?
-
- Do TQPs in parallel with project execution impact the schedule?
- What, if any, is the impact of schedule and cost overruns in SPS projects on downstream offshore field developments (production start and total investment cost)?

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