25th anniversary
annual INCOSE
international symposium
Seattle, WA
July 13 - 16, 2015

Creating an A3 Architecture Overview; a Case Study in SubSea Systems

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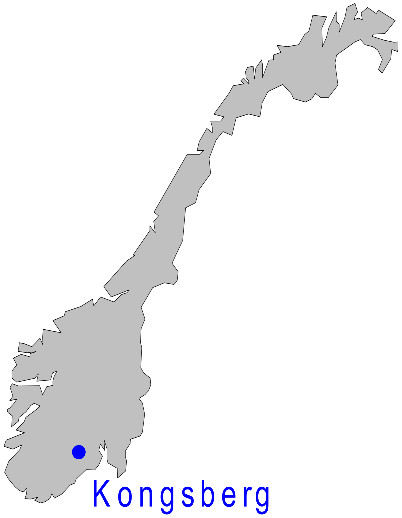
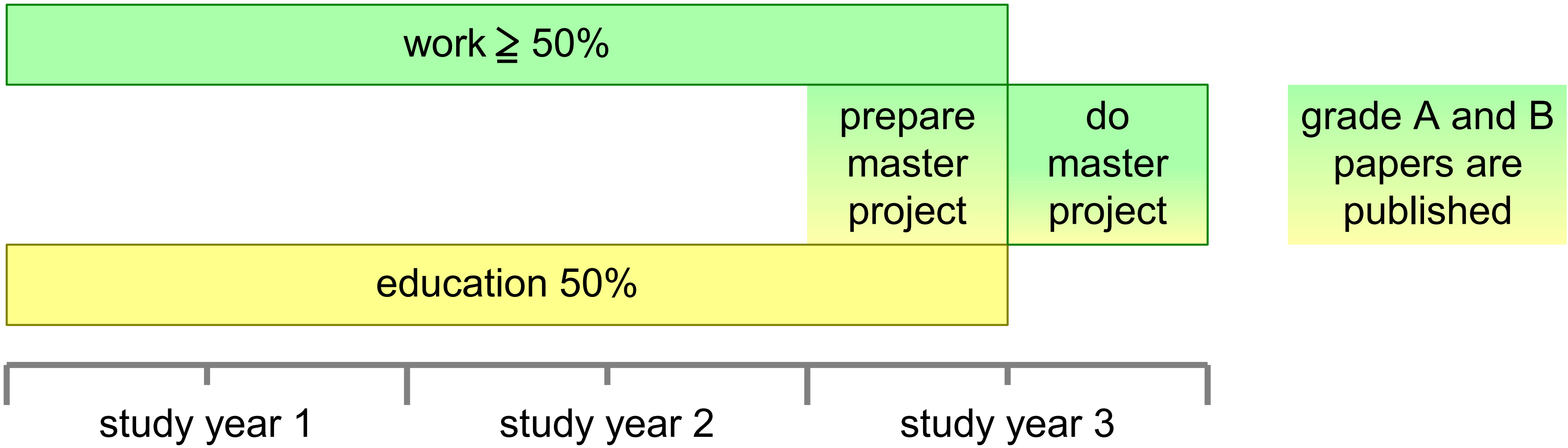
Technology park Kongsberg



Research Model Master Students Systems Engineering in Kongsberg, Norway

students know:
+ domain
+ SE methods
and techniques

students:
+ apply
+ reflect
+ evaluate



work ≧ 50%

prepare master project

do master project

grade A and B papers are published

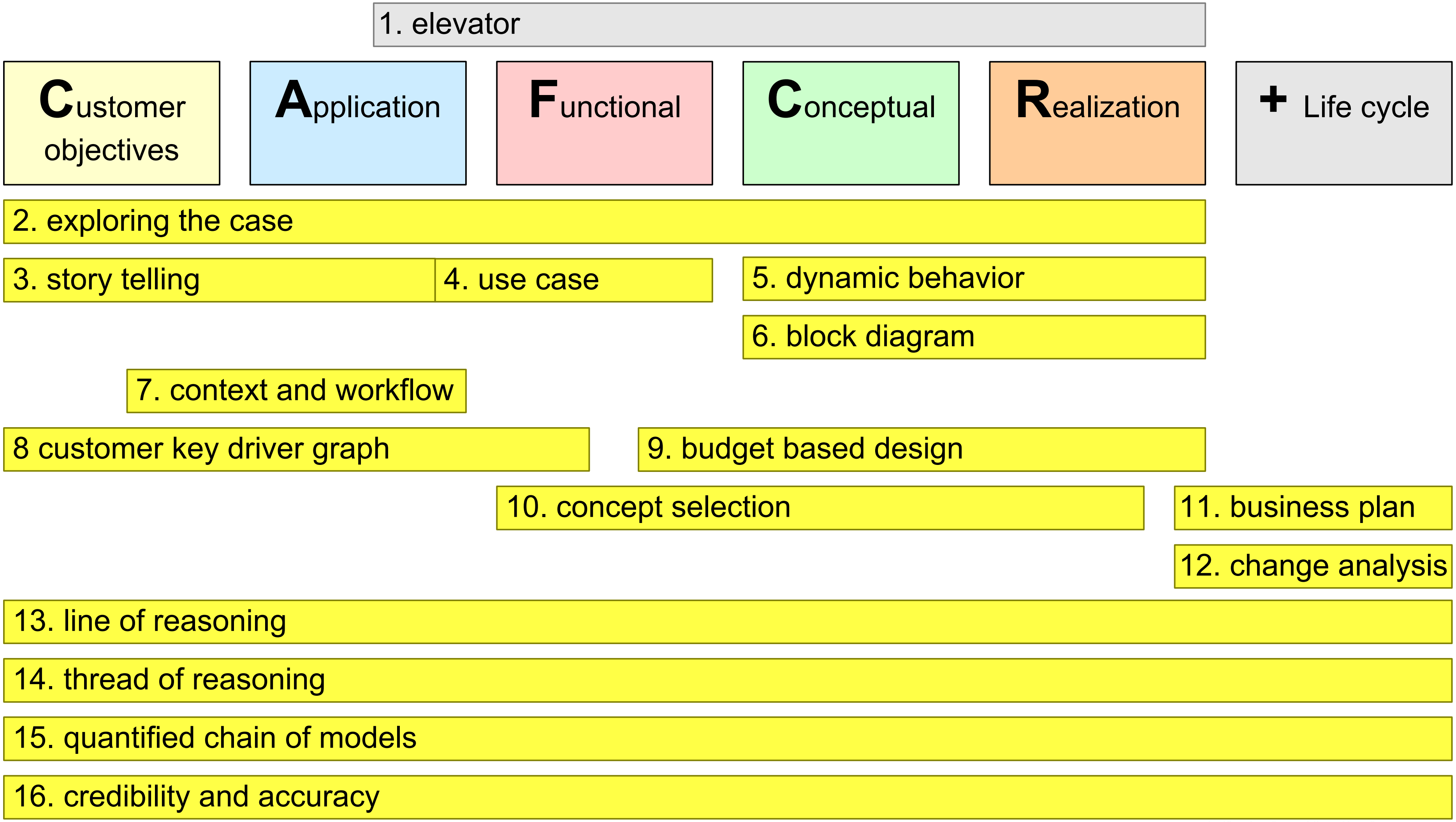
education 50%

study year 1

study year 2

study year 3

Exercises during 1 week: multiple iterations



1. elevator

Customer objectives

Application

Functional

Conceptual

Realization

+ Life cycle

2. exploring the case

3. story telling

4. use case

5. dynamic behavior

6. block diagram

7. context and workflow

8 customer key driver graph

9. budget based design

10. concept selection

11. business plan

12. change analysis

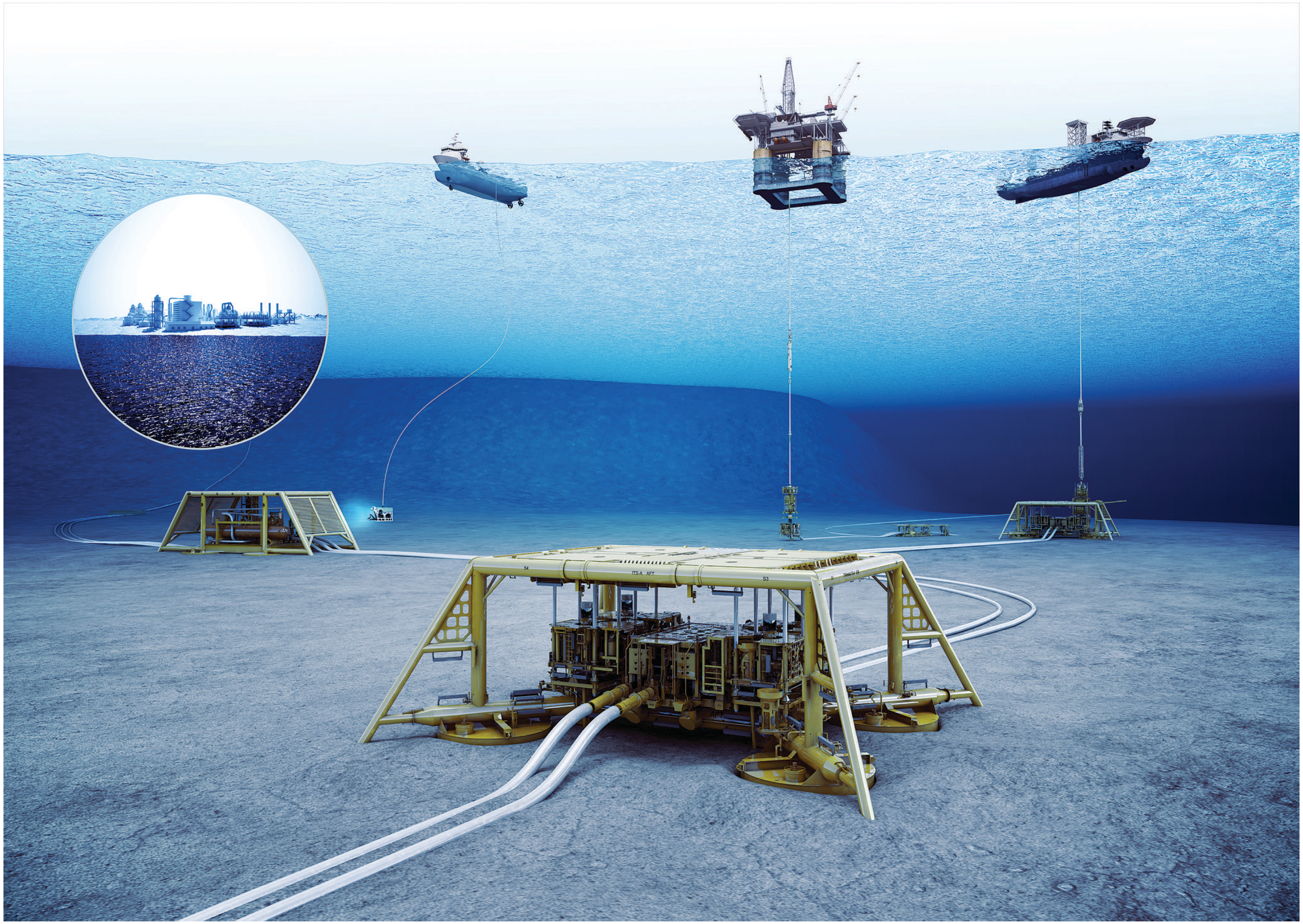
13. line of reasoning

14. thread of reasoning

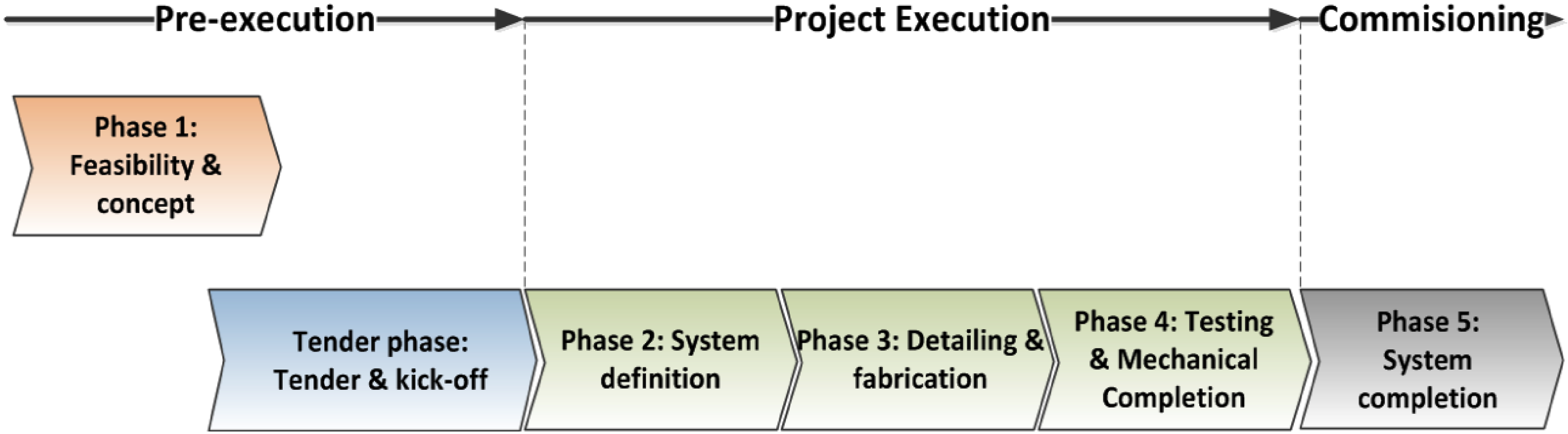
15. quantified chain of models

16. credibility and accuracy

Artistic impression of a subsea production system, by FMC Technologies



Typical project execution process.



Pre-execution

Project Execution

Commisioning

Phase 1: Feasibility & concept

Tender phase: Tender & kick-off

Phase 2: System definition

Phase 3: Detailing & fabrication

Phase 4: Testing & Mechanical Completion

Phase 5: System completion

Requirements; complex reqiements precendence

high ⟵ typical order of precedence for a Norwegian field ⟶ low

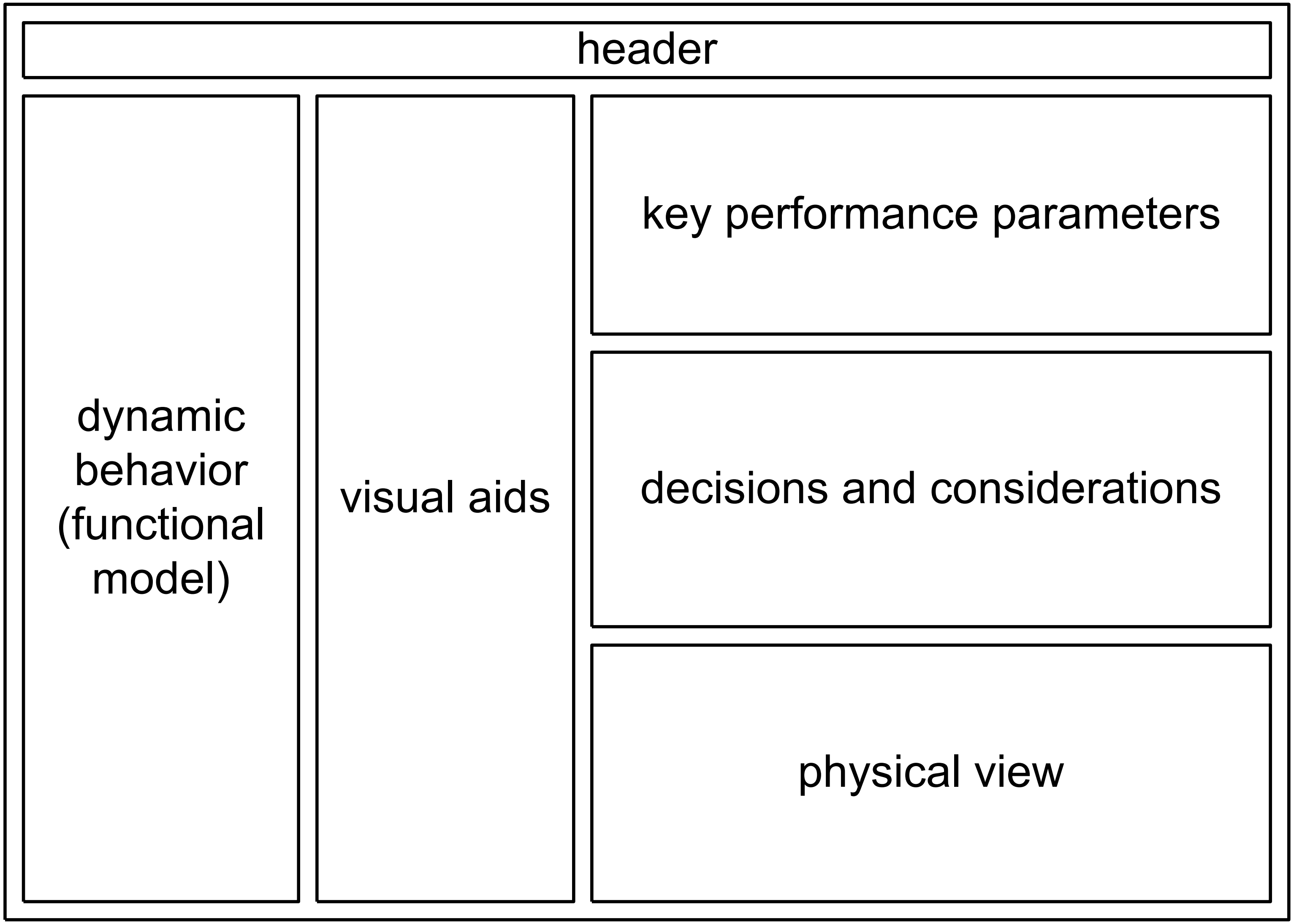
Petroleum Safety Authority Norway	Oil and gas company project specific requirements	Oil and gas company specifications (frame agreement)	supplier project specific requirements	ISO NORSOK API standards	others (DNV, IEC, ..)

- Many requirements specify *how* (the solution) rather than *what* (black box level function and performance)
- Many requirements are ambiguous
- Many requirements are not quantified and verifiable

Problems with current knowledge system

- Dynamic behavior is lacking
- Explicit definition of key performance parameters, and how the system achieves key performance parameters is lacking
- The overview (how do all parts fit together and how will they fit stakeholder needs) is missing
- The overview of the documentation is missing.
  - excessive amount of documentation.
- Customer and operational needs are missing (the rationale behind most requirements)

Borches: A3 architecture overview, example layout



header

dynamic behavior (functional model)

visual aids

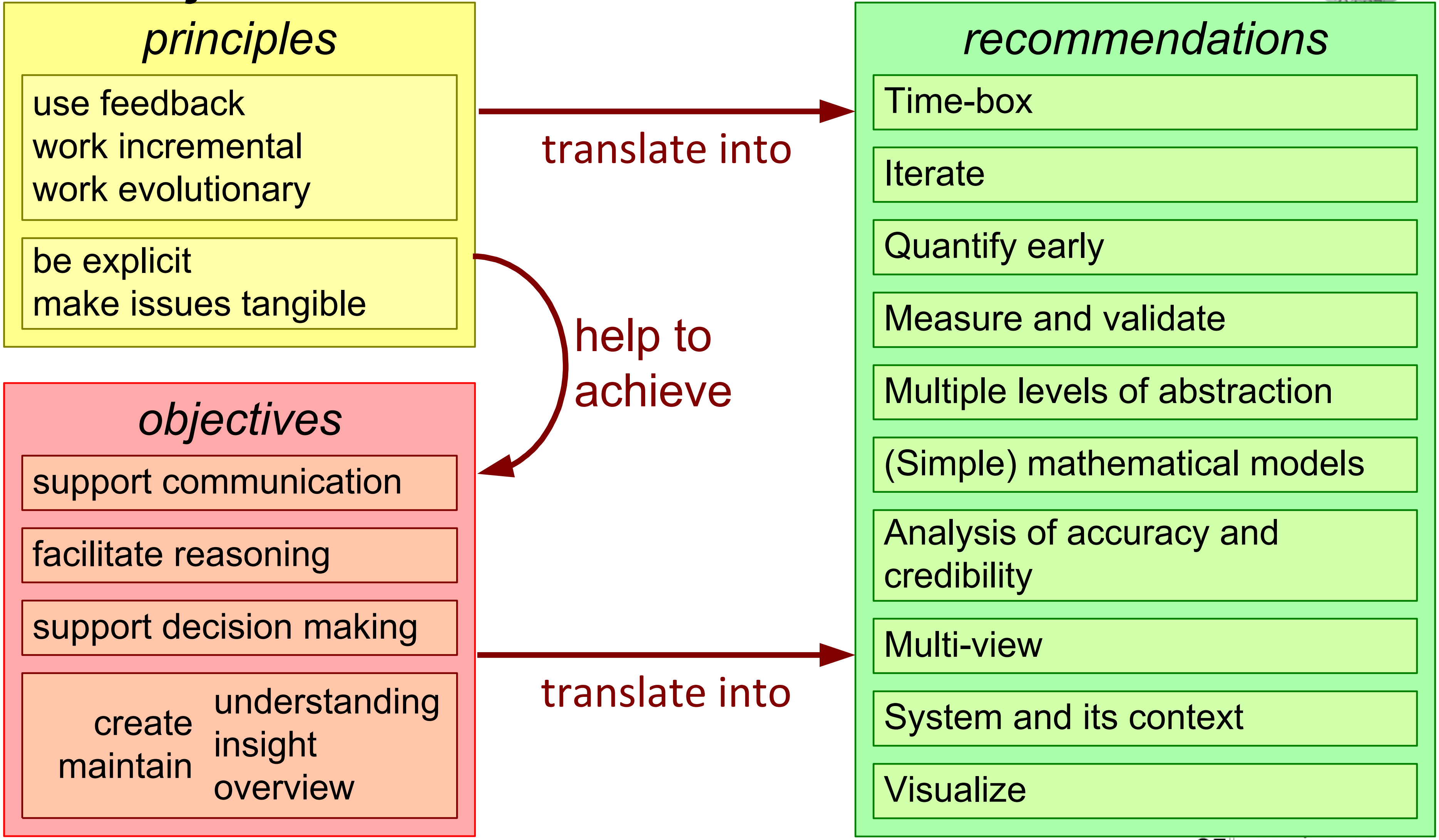
key performance parameters

decisions and considerations

physical view

simplified from http://www.gaudisite.nl/BorchesCookbookA3architectureOverview.pdf

Conceptual modeling principles, objectives, and recommendations



principles

use feedback
work incremental
work evolutionary

be explicit
make issues tangible

translate into

help to achieve

objectives

support communication

facilitate reasoning

support decision making

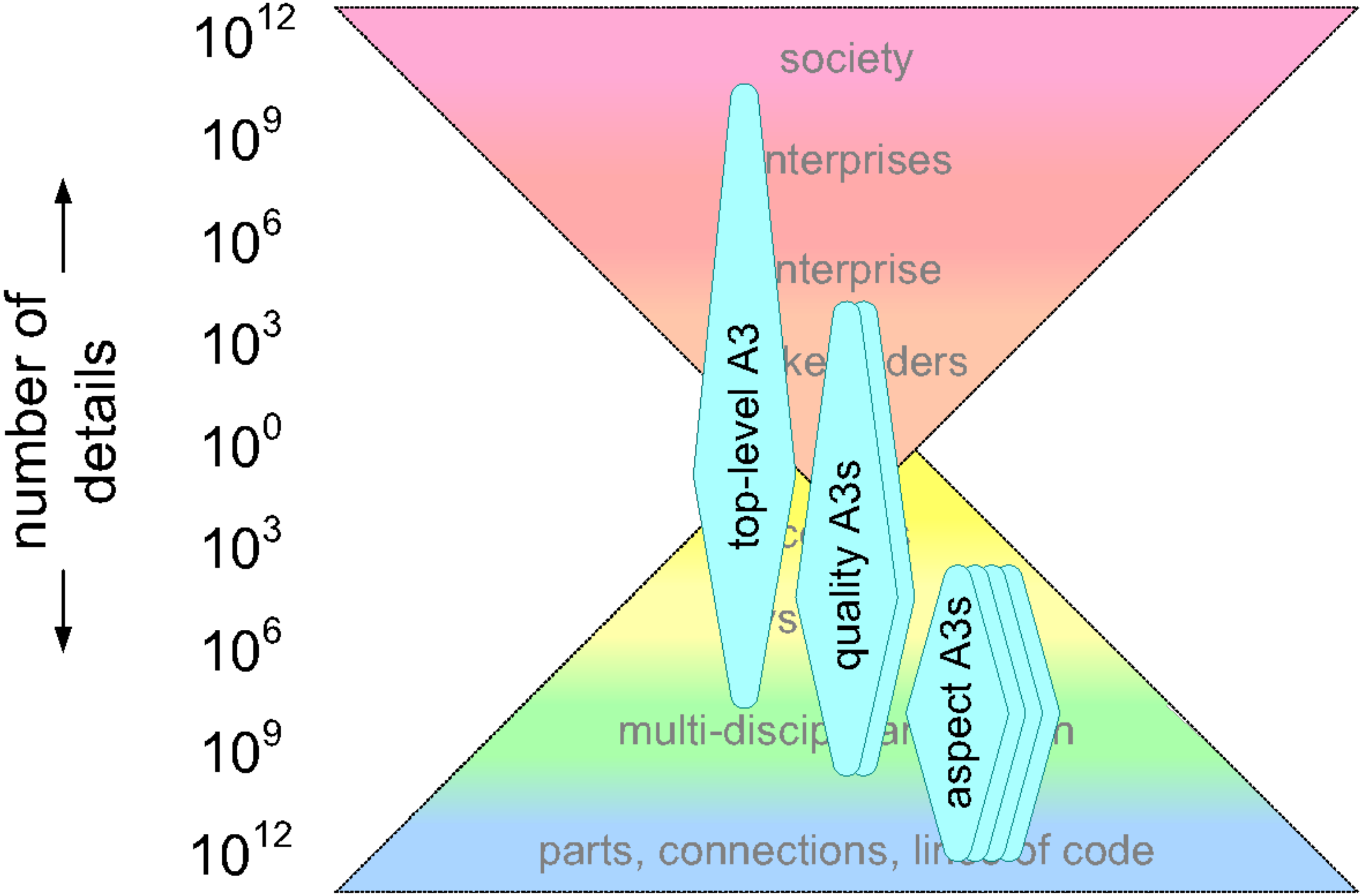
create
maintain
understanding
insight
overview

translate into

recommendations

- Time-box
- Iterate
- Quantify early
- Measure and validate
- Multiple levels of abstraction
- (Simple) mathematical models
- Analysis of accuracy and credibility
- Multi-view
- System and its context
- Visualize

Using multiple levels of A3s to capture multiple levels of abstraction



Colophon

The examples in this presentation are based on the work of SEMA participants: Martin Moberg[a], Tormod Strand[a], Vazgen Karlsen[f], and Damien Wee[f], and the master project paper by Dag Jostein Klever[f]. Sensitive and confidential information is removed or obfuscated.

All mistakes are to be blamed to the author.

Gunnar Berge stimulated the creation of a subsea example.

[a]Aker Solutions
[f] FMC Technologies

Story: Workover Anno 2015

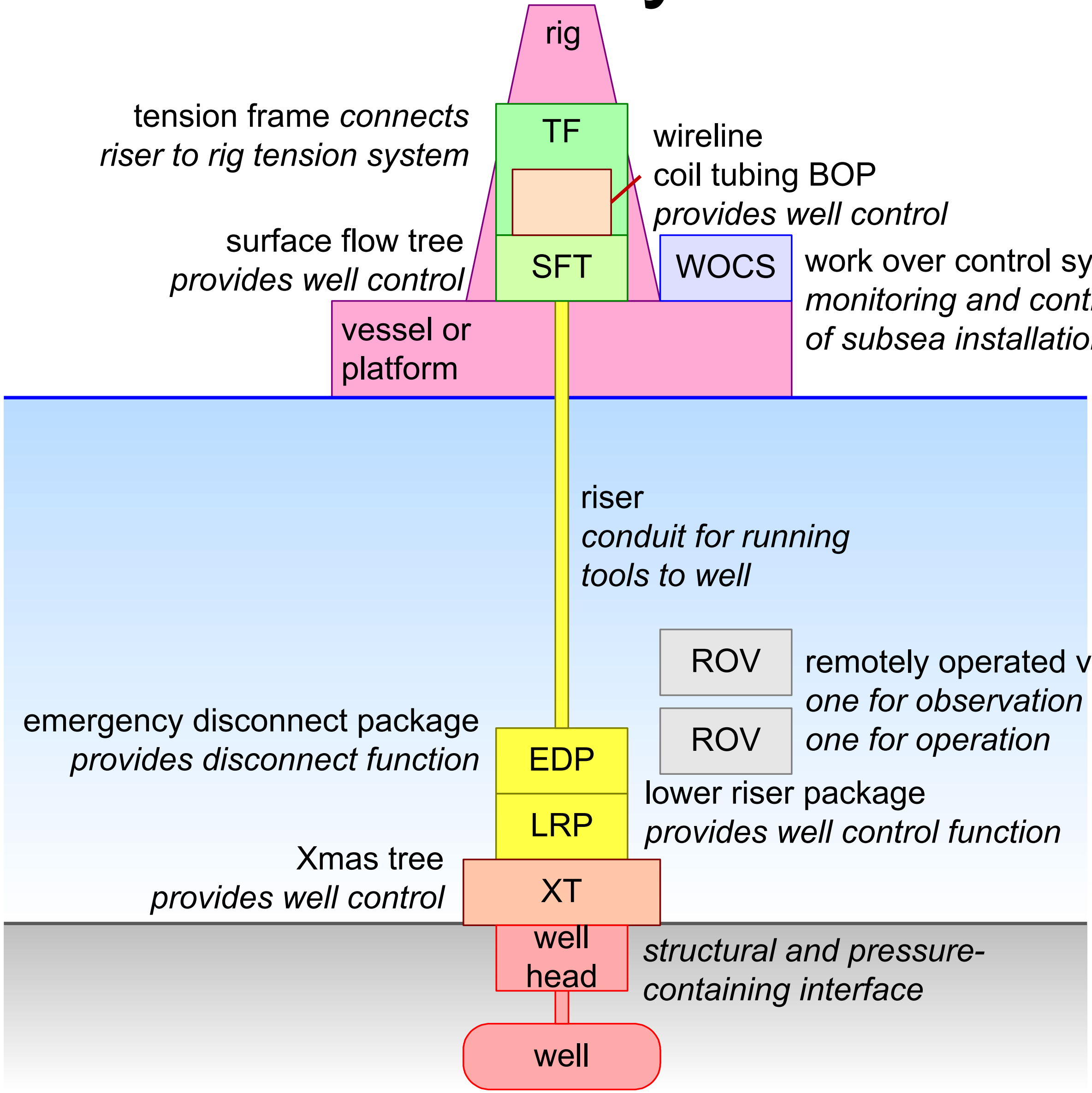
On September 4, Captain Frode Johansen was discussing the plans for the upcoming workover of South Gulfaks (see http://www.npd.no/en/Publications/Facts/Facts-2011/Chapter-10/Gullfaks-Sor-/) with his crew. Their vessel had been out of operation for recertification of the equipment much longer than anticipated, so there was a lot of pressure from Statoil on their schedule. Statoil sees diminishing production in several of the wells, so workover operations are urgent.

With the upcoming fall and winter storms, Frode hopes to finish the next three workover operations in a new record time. The equipment supplier had not only recertified all equipment, but also renovated parts of the riser system allowing for faster deployment and retrieval. The supplier tested and installed equipment in Horten. Tomorrow they will arrive in Sotra, their company support station. Here they will stock their fuel, food, coiled tubing, and other material.

The weather forecast shows a depression close to Iceland that moves slowly in Norway's direction. If they can start deployment of the riser on September 7, then they probably finish the workover before the storm associated with the depression is too severe.

Since the schedule is so tight, the captain proposes to preassemble the riser system as far as possible while traveling. In addition, the accumulators can already be charged. The captain asks the foreman to make a schedule and to allocate tasks to the crew. Safety will be a key attention point, since working with such equipment with sea state 3 provides risks.

Annotated Physical Diagram of WorkOver System



tension frame *connects riser to rig tension system*

wireline
coil tubing BOP
provides well control

surface flow tree
provides well control

work over control system
monitoring and control of subsea installation

riser
conduit for running tools to well

remotely operated vehicle
one for observation
one for operation

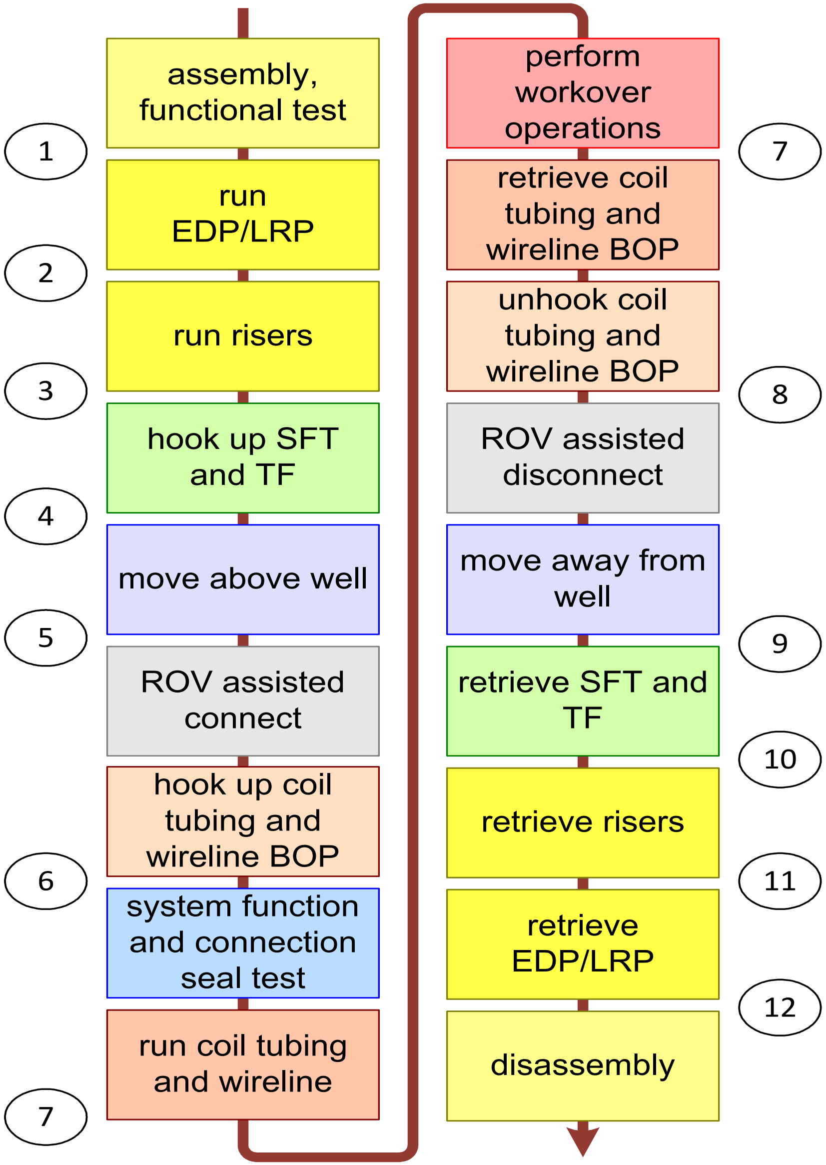
emergency disconnect package
provides disconnect function

lower riser package
provides well control function

Xmas tree
provides well control

structural and pressure-containing interface

Typical Workover Operation



assembly, functional test

1

run EDP/LRP

2

run risers

3

hook up SFT and TF

4

move above well

5

ROV assisted connect

hook up coil tubing and wireline BOP

6

system function and connection seal test

run coil tubing and wireline

7

perform workover operations

7

retrieve coil tubing and wireline BOP

unhook coil tubing and wireline BOP

8

ROV assisted disconnect

move away from well

9

retrieve SFT and TF

10

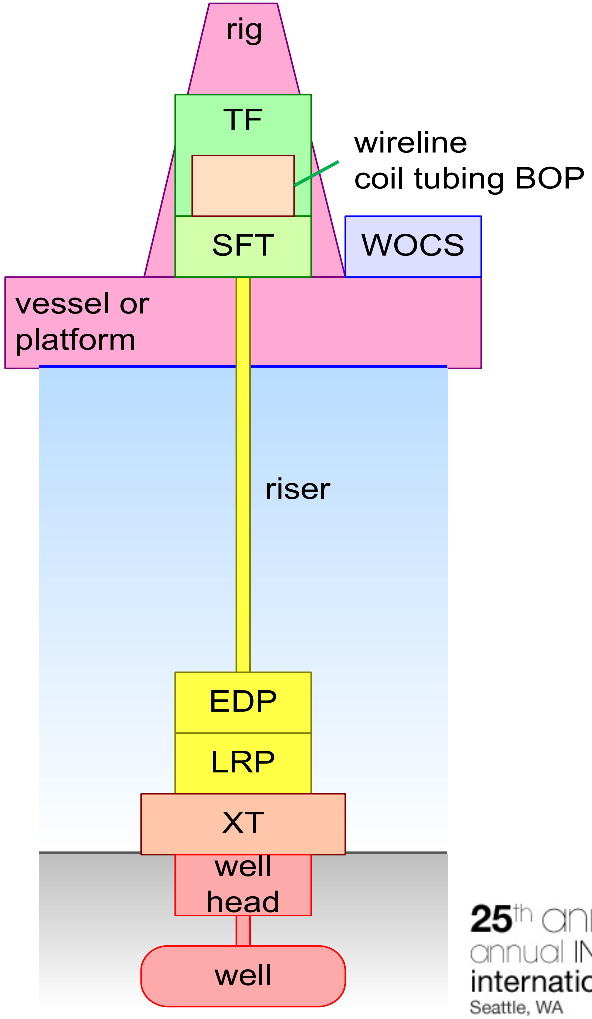
retrieve risers

11

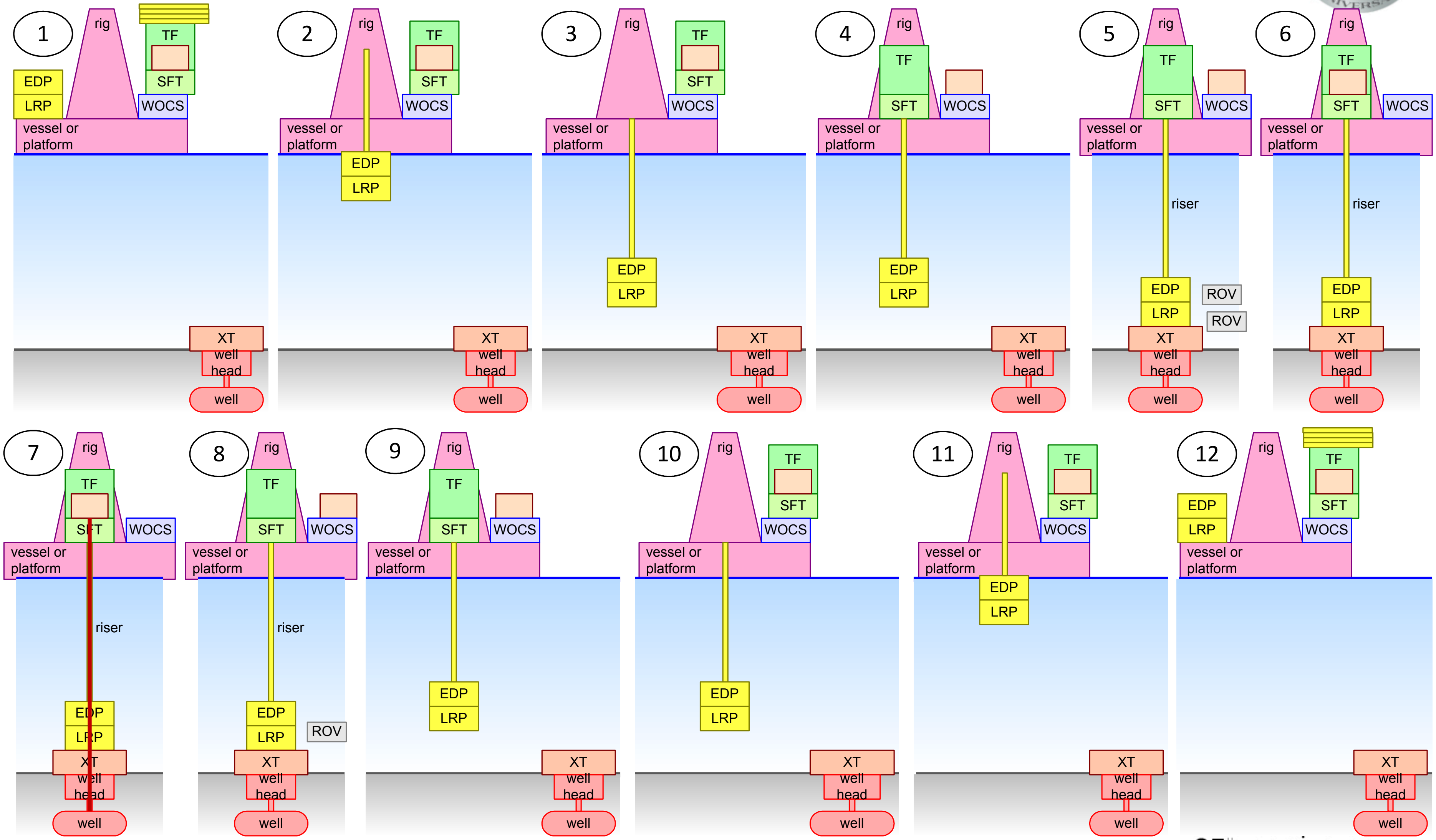
retrieve EDP/LRP

12

disassembly



Typical Workover Operation as Cartoon



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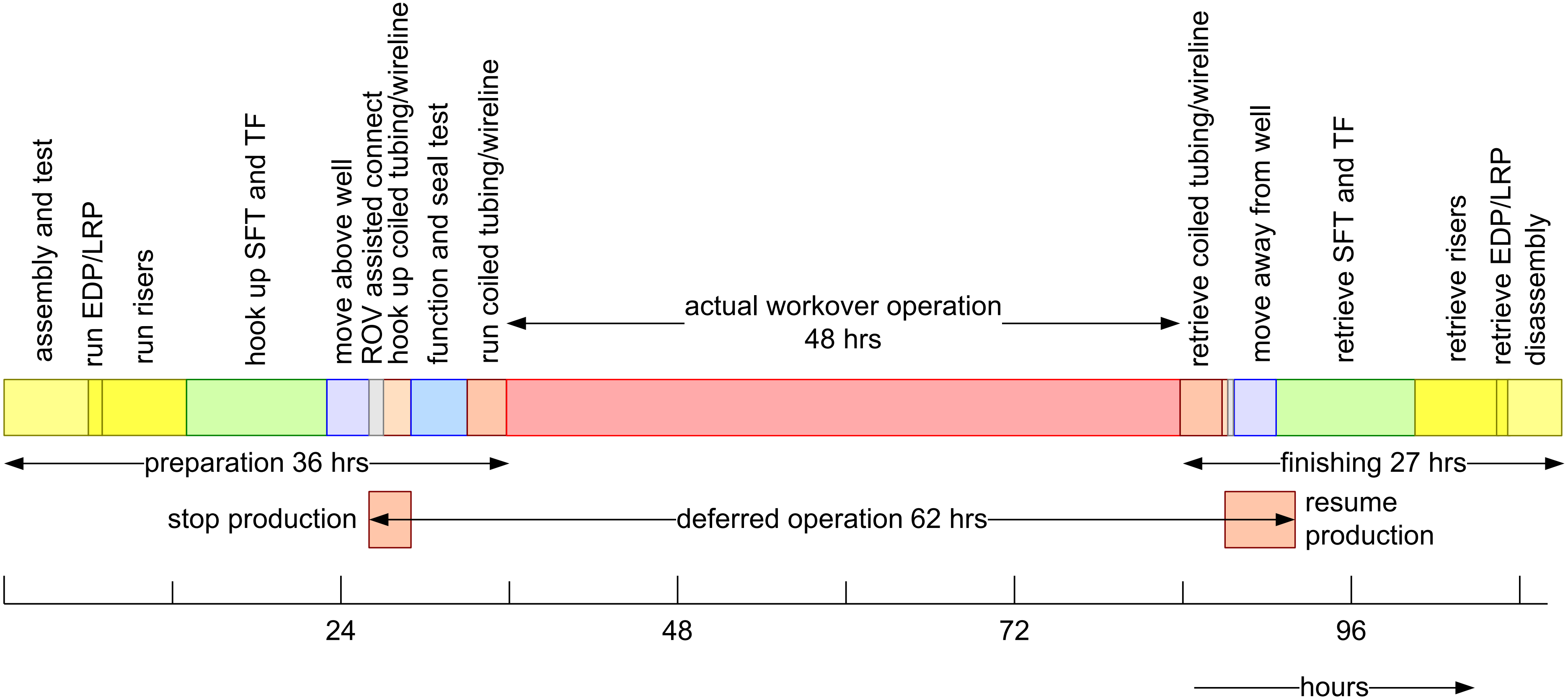
Typical Workover Operation on Timeline

assumptions:

running and retrieving risers: 50m/hr

running and retrieving coiled tubing/wireline: 100m/hr

depth: 300m



assembly and test

run EDP/LRP

run risers

hook up SFT and TF

move above well

ROV assisted connect

hook up coiled tubing/wireline

function and seal test

run coiled tubing/wireline

actual workover operation
48 hrs

retrieve coiled tubing/wireline

move away from well

retrieve SFT and TF

retrieve risers

retrieve EDP/LRP

disassembly

preparation 36 hrs

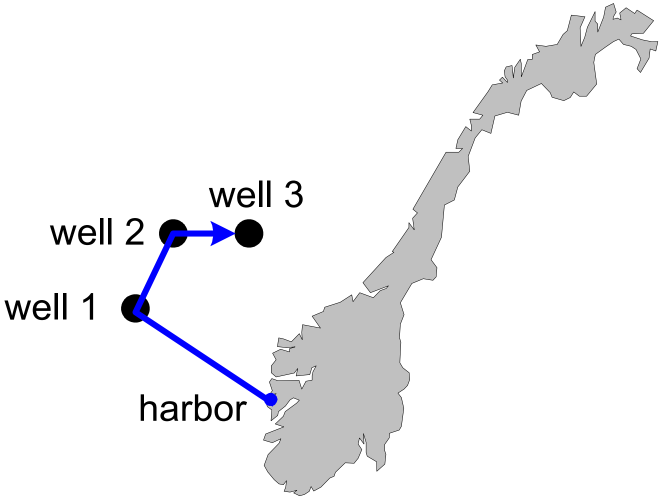
finishing 27 hrs

stop production

deferred operation 62 hrs

resume production

Typical Workover Operation Context

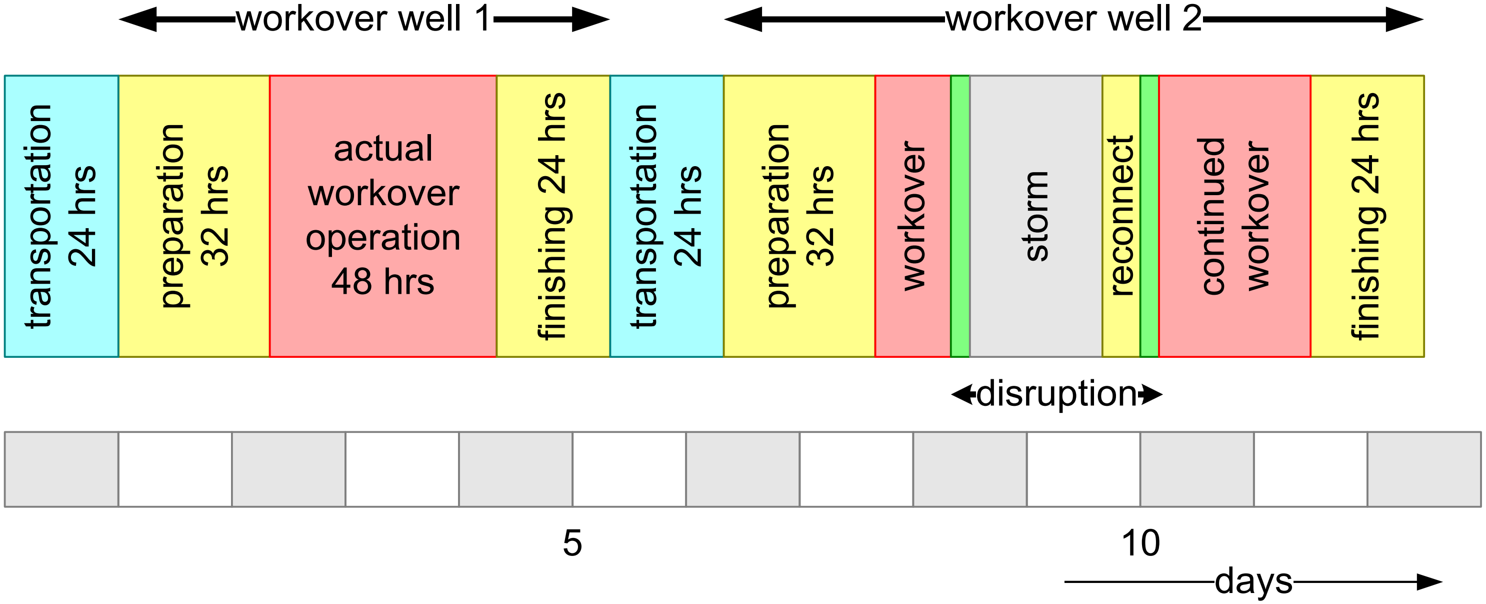


zero order model

$$t_{workover} = t_{transportation} + t_{preparation} + t_{workover} + t_{finishing}$$

first order model

$$t_{workover} = t_{transportation} + t_{preparation} + t_{workover} + t_{disruption} + t_{finishing}$$



workover well 1

workover well 2

transportation 24 hrs

preparation 32 hrs

actual workover operation 48 hrs

finishing 24 hrs

transportation 24 hrs

preparation 32 hrs

workover

storm

reconnect

continued workover

finishing 24 hrs

disruption

5

10

days

0-order Cost Model Workover Operation

workover cost per day	*assumed cost (MNoK)*
platform, rig	2
equipment	0.2
crew	0.1
total	2.3 MNoK/day

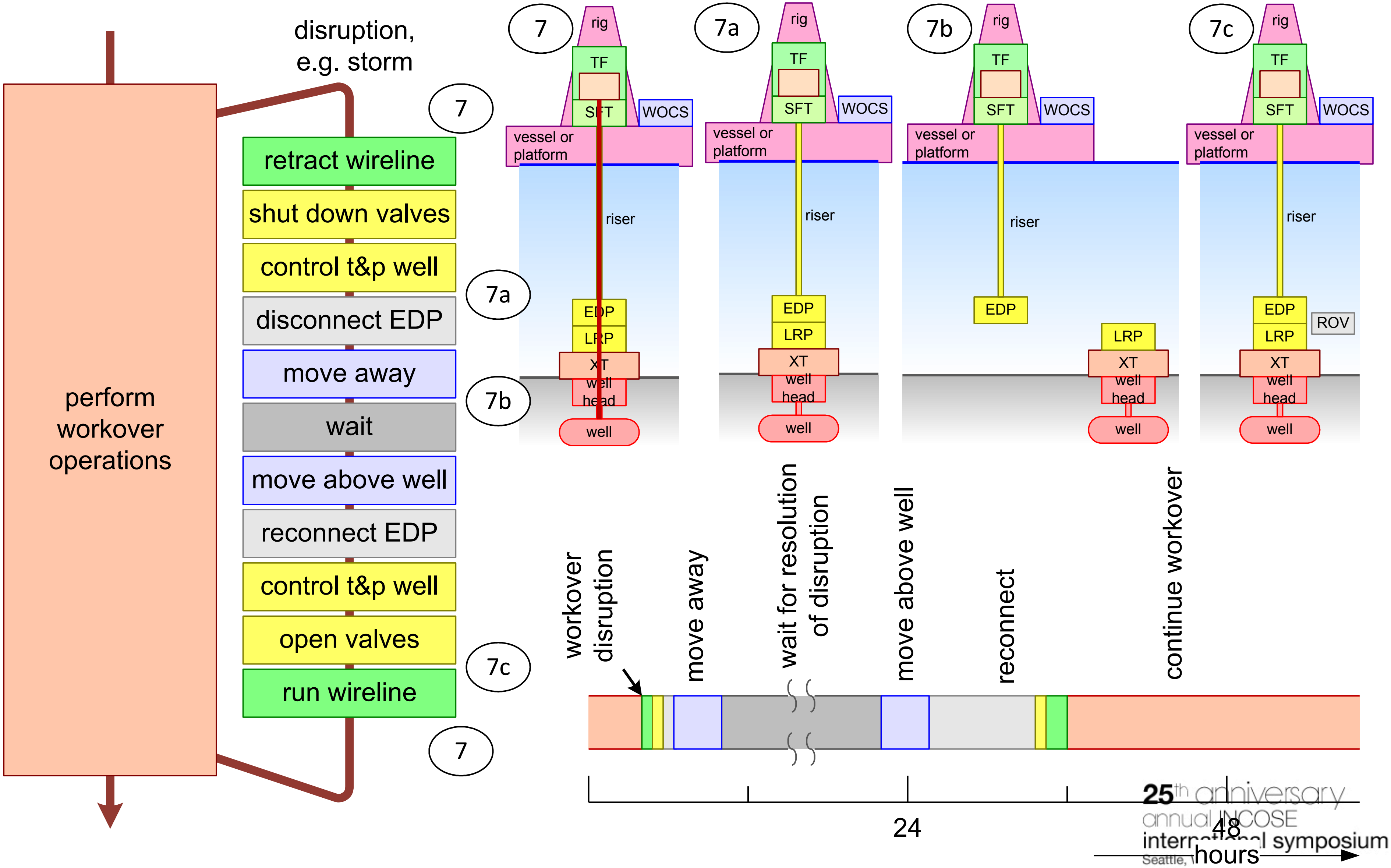
deferred operation per day	*assumed cost (MNoK)*
production delay	0.1
ongoing cost operation	0.2
total	0.3 MNoK/day

workover duration	*estimated duration (hours)*	*production loss*
transportation	24	
preparation	36	6
workover	48	48
finishing	27	8
total	135 (5.6 days)	62 (2.6 days)

$$\text{cost} = \text{cost}_{\text{workover/day}} * t_{\text{workover}} + \text{cost}_{\text{deferred op./day}} * t_{\text{deferred op.}}$$

$$\sim= 2.3 * 5.6 + 0.3 * 2.6 \sim= 14 \text{ MNoK / workover}$$

Disruption Workover Operation



perform workover operations

disruption, e.g. storm

- retract wireline
- shut down valves
- control t&p well
- disconnect EDP
- move away
- wait
- move above well
- reconnect EDP
- control t&p well
- open valves
- run wireline

1st order Cost Model Workover Operation

workover cost per day	*assumed cost (MNoK)*
platform, rig	2
equipment	0.2
crew	0.1
total	2.3 MNoK/day

deferred operation per day	*assumed cost (MNoK)*
production delay	0.1
ongoing cost operation	0.2
total	0.3 MNoK/day

workover duration	*estimated duration (hours)*	*production loss*
workover 0-order	135 (5.6 days)	62 (2.6 days)
average disruption		
duration	72	
overhead	11	
disruption frequency	0.3	
1st order disruption correction	83*0.3= 27	27
total	162 (6.7 days)	89 (3.7 days)

$$1^{st} \text{ order cost} = \text{cost}_{\text{workover/day}} * t_{\text{workover}} + \text{cost}_{\text{deferred op./day}} * t_{\text{deferred op.}}$$

~= 2.3 * 6.7 + 0.3 * 3.7 ~= 16.5 MNoK / workover

0-order cost ~= 14 MNoK ; disruption cost ~= 2.5 MNoK

Workover operation; architecture overview

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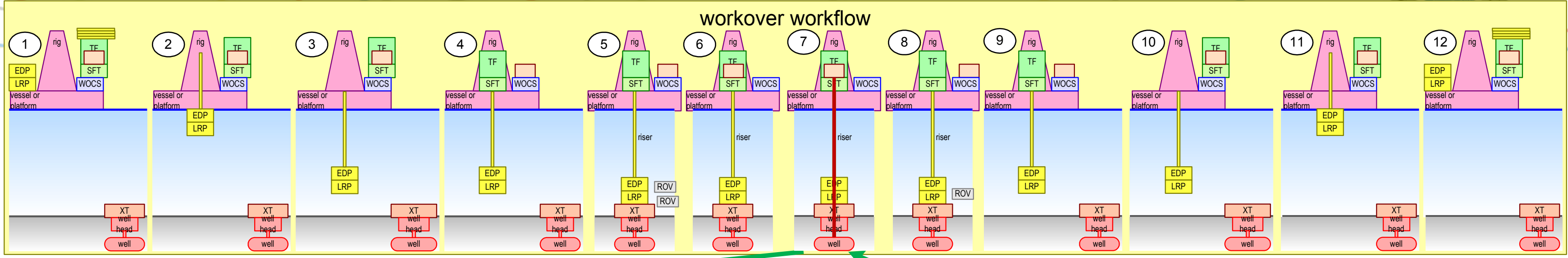
version 2.2 Gerrit Muller

workover workflow

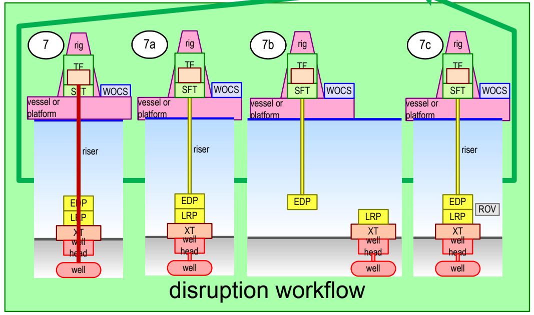
- assembly, functional test
- 1
- run EDP/LRP
- 2
- run risers
- 3
- hook up SFT and TF
- 4
- move above well
- 5
- ROV assisted connect
- hook up coil tubing and wireline BOP
- 6
- system function and connection seal test
- run coil tubing and wireline
- 7
- perform workover operations
- 7
- retrieve coil tubing and wireline BOP
- unhook coil tubing and wireline BOP
- 8
- ROV assisted disconnect
- move away from well
- 9
- retrieve SFT and TF
- 10
- retrieve risers
- 11
- retrieve EDP/LRP
- 12
- disassembly

workover workflow

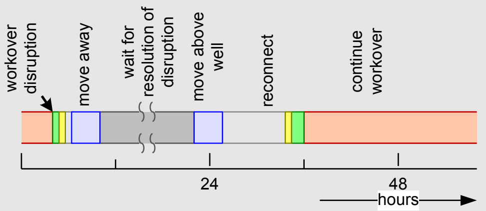


disruption workflow

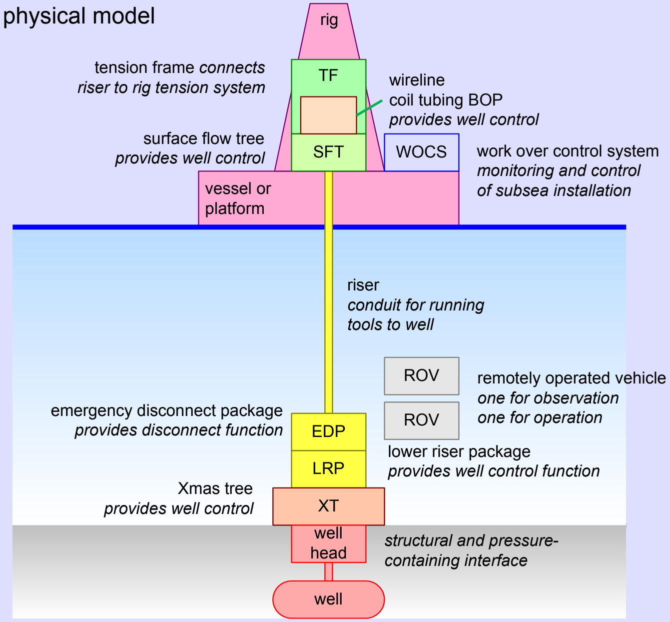
- retract wireline
- shut down valves
- control t&p well
- 7a
- disconnect EDP
- move away
- 7b
- wait
- move above well
- reconnect EDP
- control t&p well
- open valves
- 7c
- run wireline



disruption timeline



physical model



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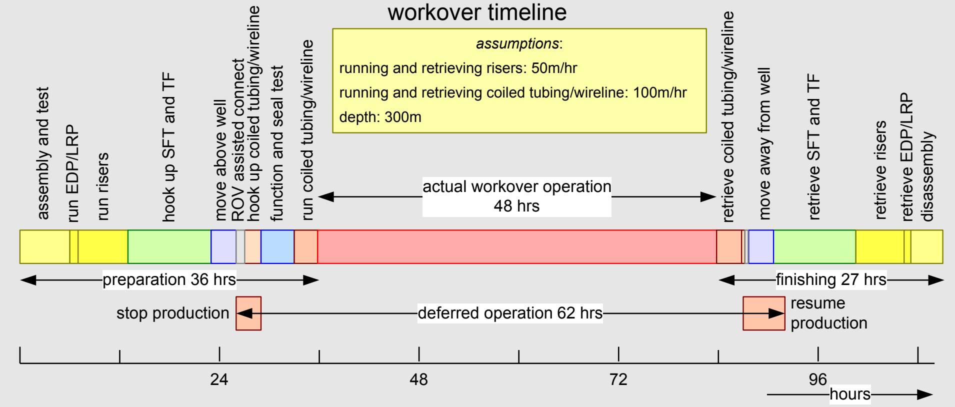

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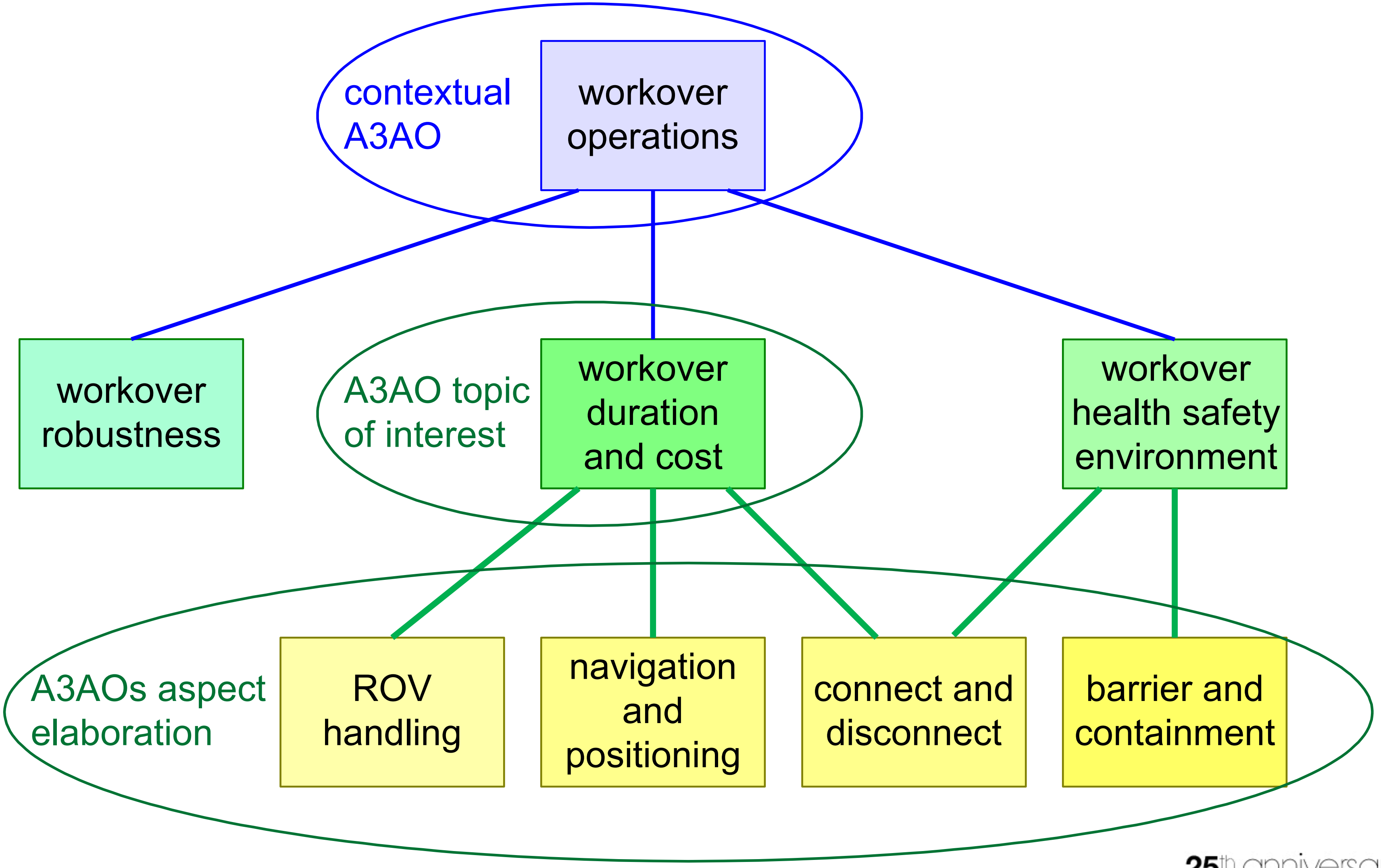
Levels of A3s



contextual A3AO

workover operations

A3AO topic of interest

workover robustness

workover duration and cost

workover health safety environment

A3AOs aspect elaboration

ROV handling

navigation and positioning

connect and disconnect

barrier and containment