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Improved risk assessments

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Contents

- The typical QRA?
  - Typical comments
  - How the QRA relates to the engineering timeline
- Expectations
- Alternative approach
  - Early review and screening
  - Simplified studies in early phase
  - (Continuous evaluation)
  - (Detailed studies)
- Experience
  - From engineering projects
  - From risk analysis in operation phase
- Summary

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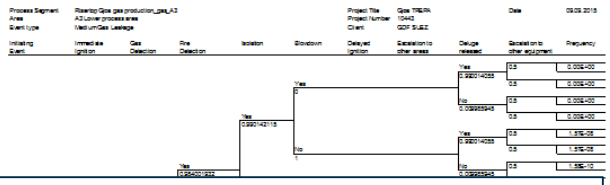
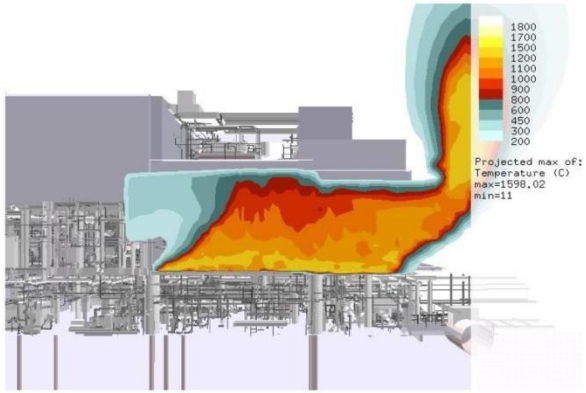
The typical QRA

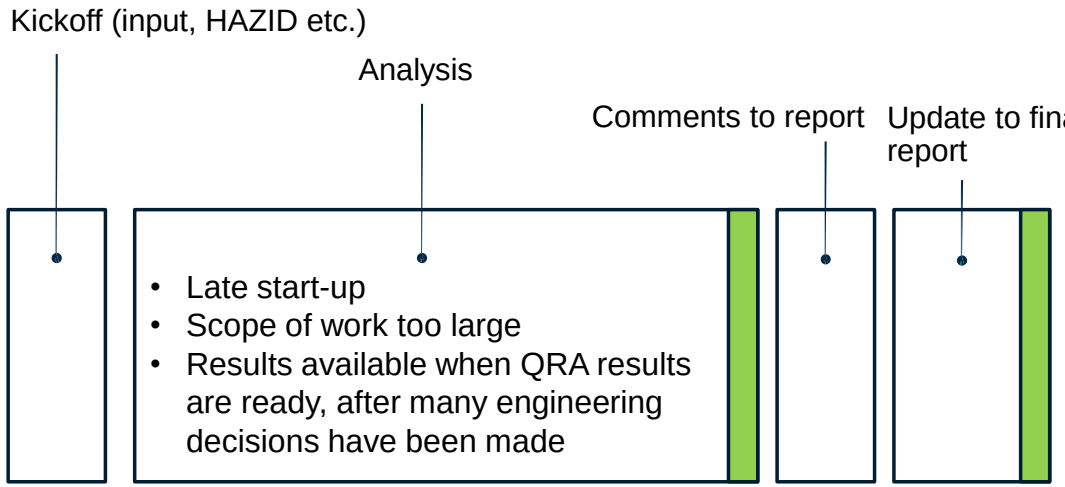




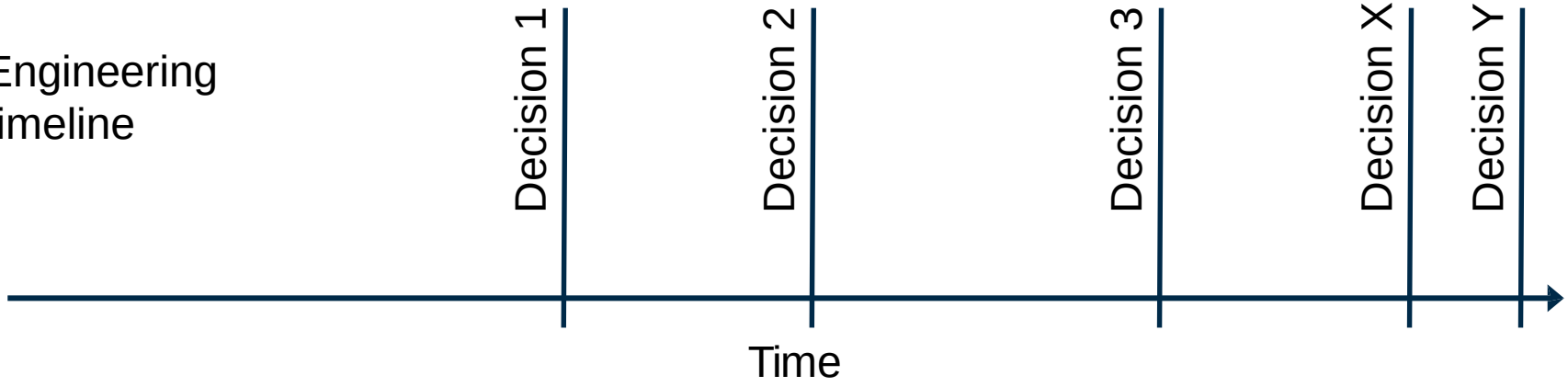
- What parts of the QRA are typically used in the design phases of an installation?
- How can we adapt the risk analysis to the engineering timeline?
  - Can we remove parts of the QRA?
  - Do we have to increase the amount of information on some topics?
  - And/or do we have to change the way we present certain results?
- What has already been done?
- Cooperation with ConocoPhillips

Engineering timeline and the typical QRA

QRA process



Engineering timeline



Typical comments

- Too costly and requires a lot of follow-up
- Results come too late
- Too complex
- Not enough information (not the right information)
- Results are not used

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Expectations

Time

Cost

Information

- Demand for early input to design accidental loads: relatively detailed, before a significant amount of specific analyses have been performed.
- Deliver better, more detailed results faster, and at the same time support the projects' cost focus, demanding cheaper, more flexible solutions

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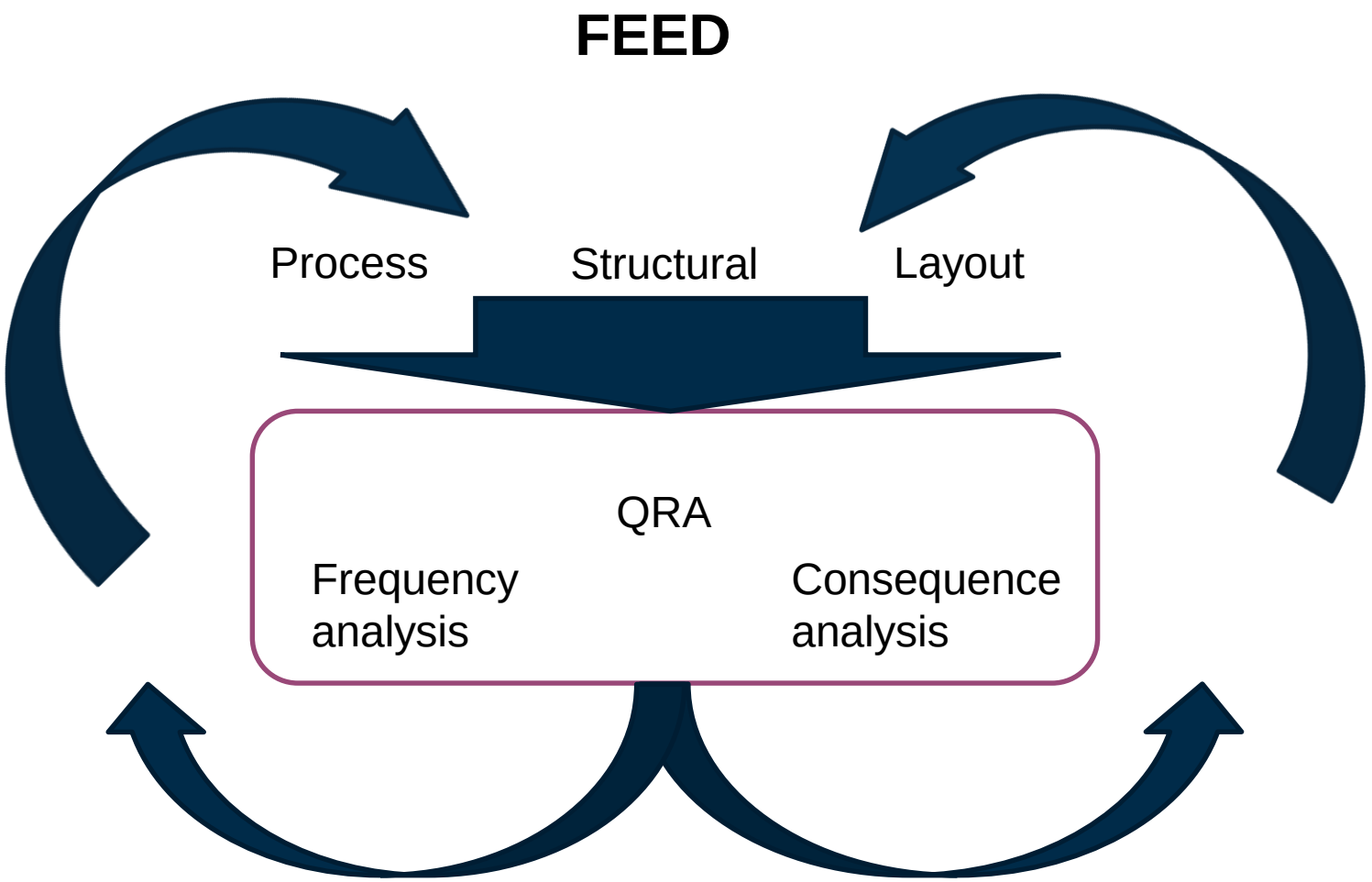
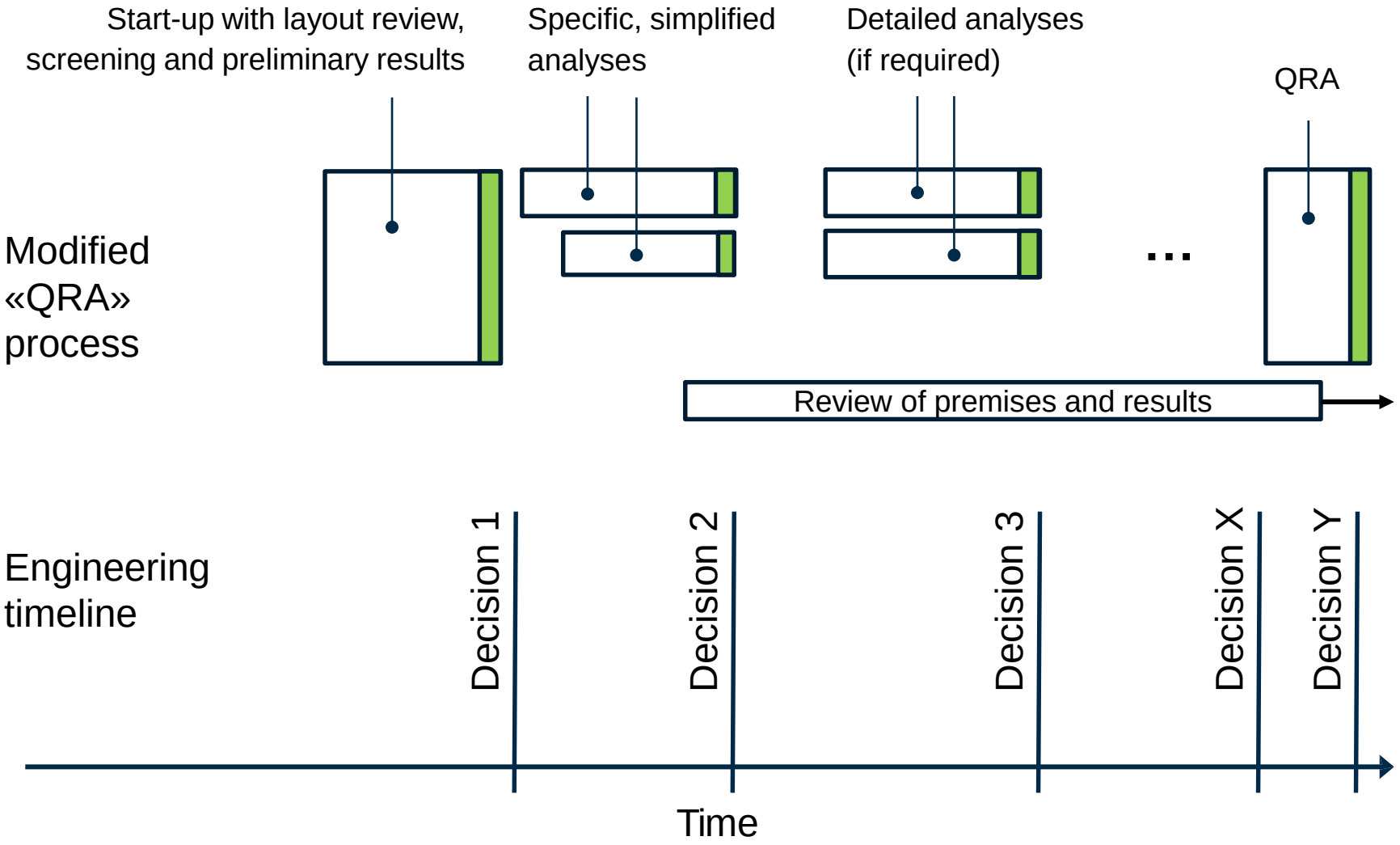
«The only thing I want to know is how strong I have to make it»

The engineering process – the dilemma

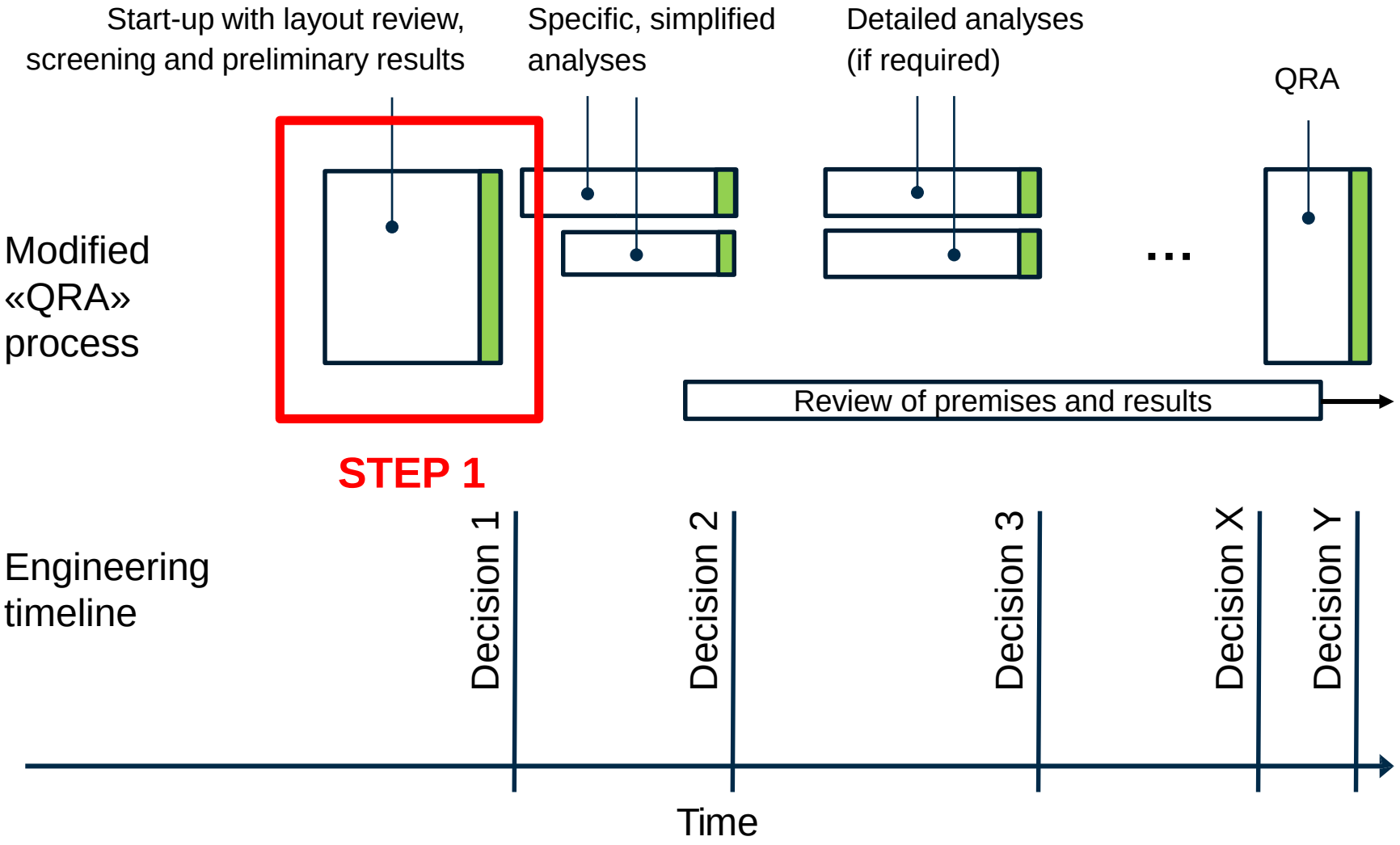


Preliminary input to DAL, based on limited site specific information is conservative in the specified loads, but not overly so, since a too conservative solution drives the cost up.

Engineering timeline and alternative RA approach



Engineering timeline and alternative RA approach



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Step 1: Concept or early FEED input

- Screening
  - Hazard identification (major accident events) and barriers
  - What is installation specific?
  - Where can risk analyses contribute to design?
  - Which analyses are required?
- Review of preliminary design
  - Expected leak durations and fire loads
  - Expected explosion loads
  - Escape routes
  - …
- How?
  - Early integration in projects enables early identification of risk drivers (while design can be changed)
  - Experience from similar installations
  - Guidelines/standards

Screening of critical areas - fire

- The selection of layout and process layout is governing with respect to inherent risk of the facility
- Screening workshop or layout review as part of layout optimization:

Inventories with potential for long duration leakages identified

Risk by probability and escalation potential

	M720			M310	M510	M330	M210	M110	N219	N110	
Offloading	Escape tunnel				Escape tunnel			Escape tunnel			LQ
	Oil metering module		Future	Process support module	Dehydration and PW module	Future module	Oil separation module	Manifold module (CH)	Turret ;WS)	Work Shop Module (Turret)	
Flare stack	KO Module	Power generation module (hooded)	Lay down module	WI module	HP compression (hooded)	HP compression (hooded)	Oil stabilisation module	Chemical injection module (Turret)		Primary lay down area (turret)	
F130	M710	M730	M630	M530	M430	M410	M2130	CM130		N130	

- Critical areas/modules to be identified early – follow up in detailed analyses

Screening of critical areas - explosion

- The selection of layout and process layout is governing with respect to inherent risk of the facility
- Screening workshop or layout review as part of layout optimization:

Inventories with potential for large gas releases identified

Risk by probability and escalation potential

	M720			M310	M510	M330	M210	M110	N219	N110	
Offloading	Escape tunnel				Escape tunnel			Escape tunnel			LQ
	Oil metering module		Future	Process support module	Dehydration and PW module	Future module	Oil separation module	Manifold module (CH)	Turret ,WS)	Work Shop Module (Turret)	
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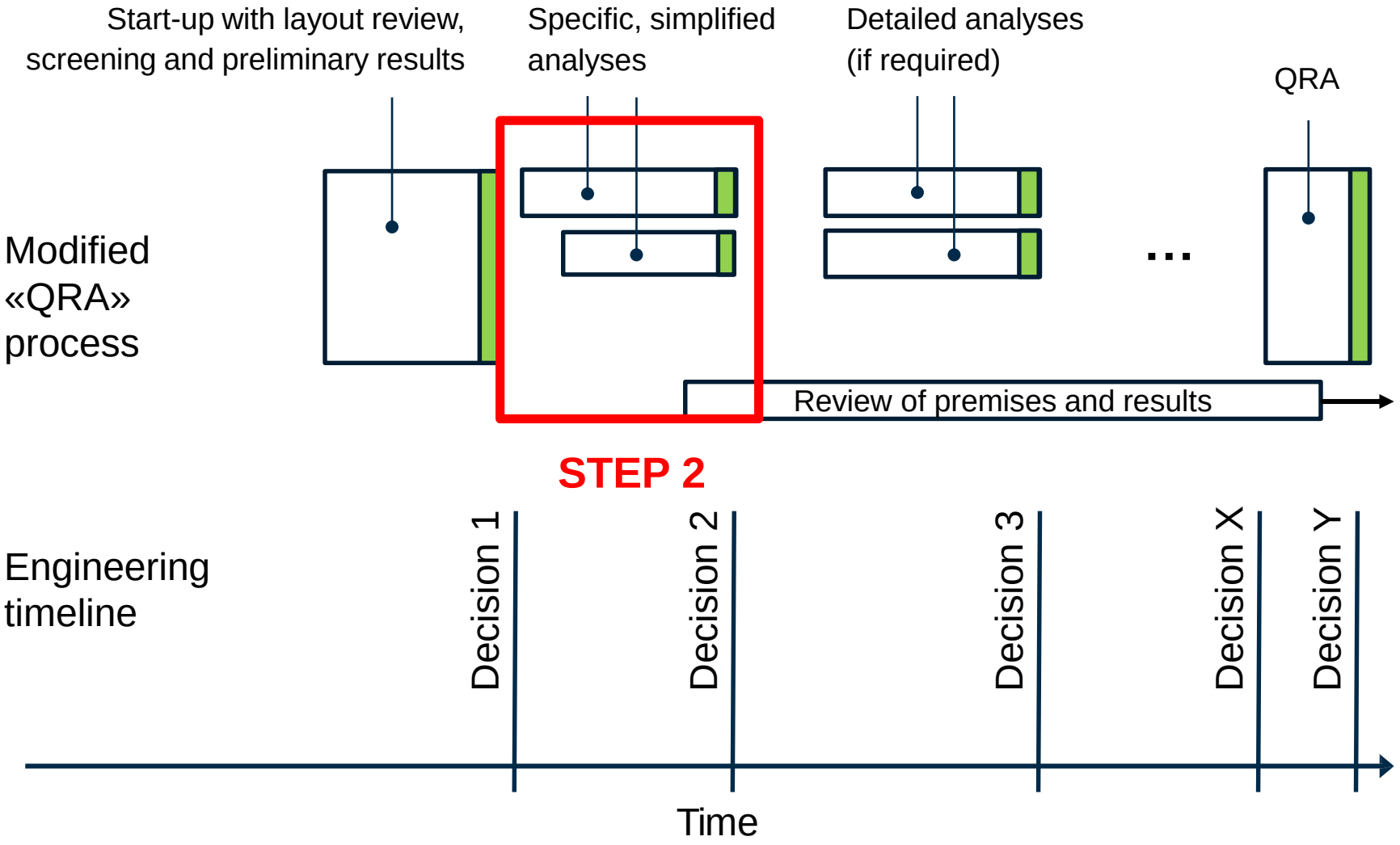
- Critical areas/modules to be identified early – follow up in detailed analyses

Engineering timeline and alternative RA approach



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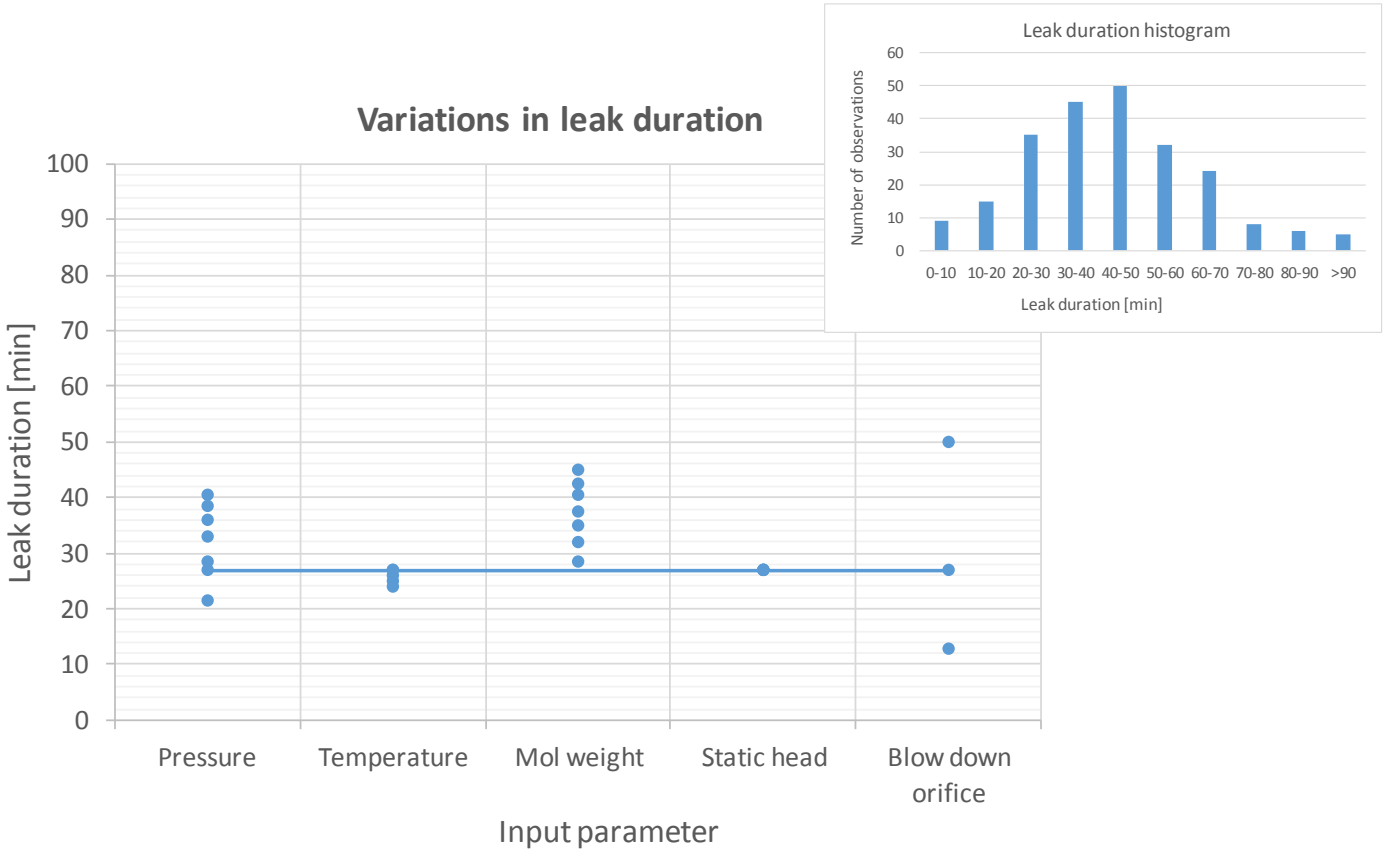
Step 2: Early FEED

- Simplified, specific analyses
  - Typically establish fire and explosion loads
    - Leak duration calculations for representative process equipment
    - CFD explosion simulations
  - Sensitivity and uncertainty must be discussed
  - Enable evaluation of relevant input parameters and results in subsequent design phases, operation and barrier management

- How?
  - Establish base case and perform sensitivities
  - Use experience from as-built models and installations
  - Willingness not to require risk numbers for all areas / accident events (in this phase)
  - Flexibility in budget to take on ‘unforeseen’ tasks / sensitivities
  - Standardization of input to analysis?

Establish potential fire durations

- Leak duration calculations

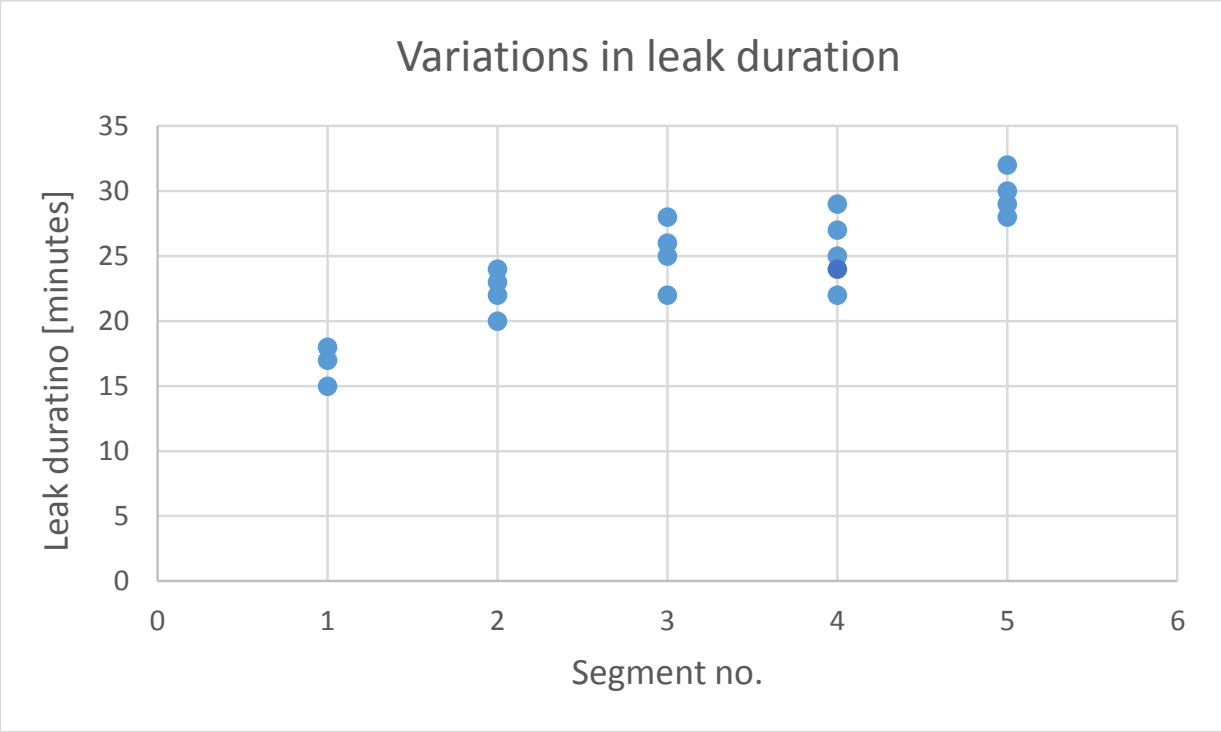


Leak duration calculations are quick to perform – heat loads can be based on e.g. NORSOK S-001

- Establish base case and perform sensitivities

Establish potential fire durations cont.

Leak duration calculations are quick to perform – heat loads can be based on e.g. NORSOK S-001



‘Dimensioning loads’ established based on current knowledge of the installation combined with sensitivities (expected as-built/future) → choice

Establish explosion loads

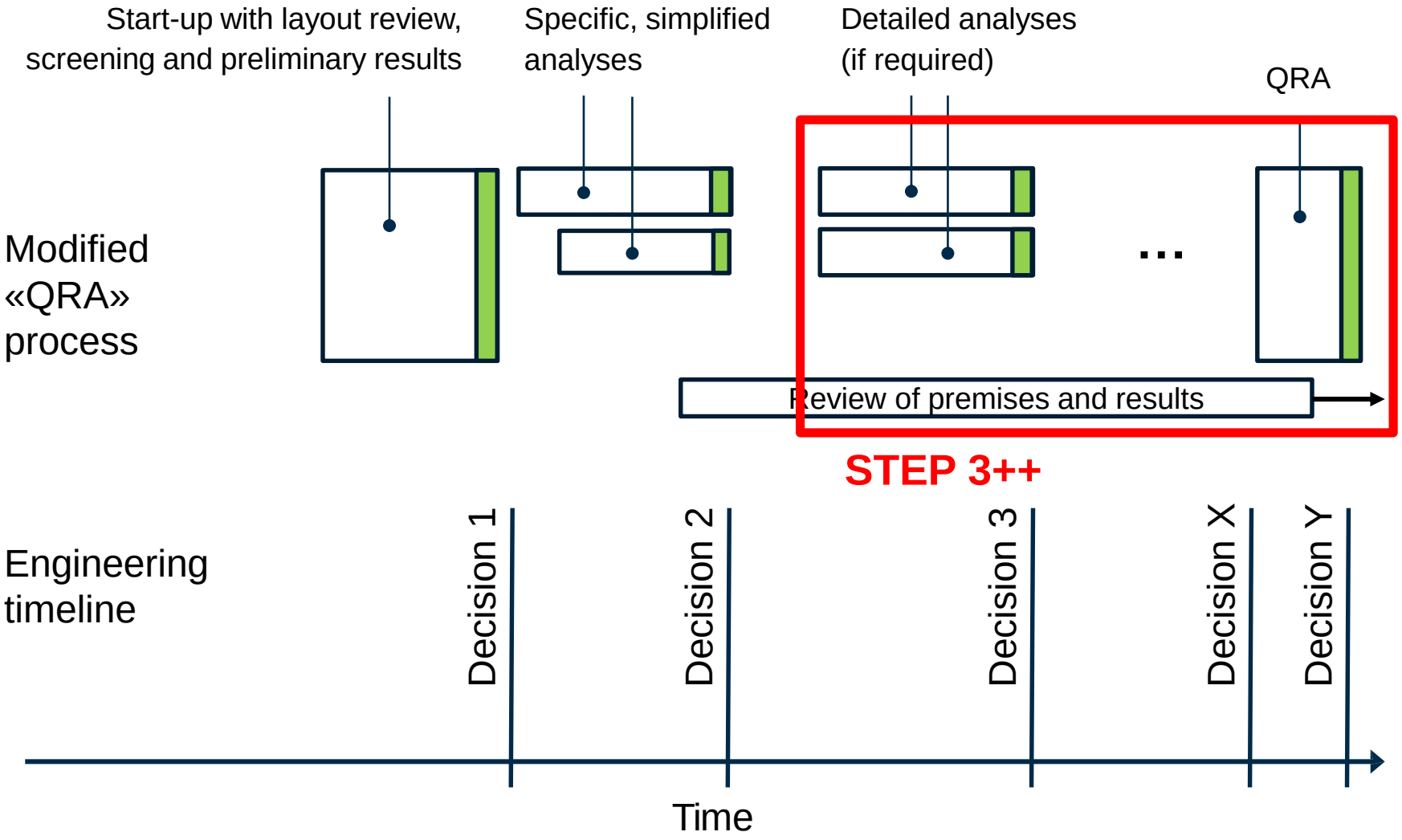
- CFD simulations on ‘as built model’:

Cloud size [%]	Ignition point									
	0	1	2	3	4	5	6	7	8	9
2	0.1	0.05	0.1	0.05	0.15	0.05	0	0.1	0.1	0.05
5	0.15	0.2	0.25	0.15	0.3	0.15	0.15	0.3	0.35	0.15
10	0.3	0.45	0.5	0.45	0.5	0.3	0.3	0.55	0.5	0.3
15	0.5	0.7	0.9	0.6	0.7	0.5	0.5	0.7	0.65	0.5
20	0.65	0.9	1	0.8	0.9	0.75	0.65	0.9	0.85	0.7
30	0.85	1.1	1.3	1.2	1	1.2	0.9	1.1	1.25	1
50	1.2	1.5	1.4	1.7	1.3	1.6	1.1	1.6	1.8	1.6

Explosion simulations are quick to perform – but requires an ‘as built model’ to give representative loads

‘Dimensioning loads’ established based on experience (cloud size for specific area and expected as-built/future geometry) and expected capacity of walls and structure → choice

Engineering timeline and alternative RA approach



Further steps

- Basis established
  - Adapted to the iterative engineering process
  - Continous evaluation of input parameters and results for subsequent design phases, operation and barrier management
- Evaluate the need for more detailed analyses
  - In case of «problem areas»
  - Not required if design is well-known?
  - Assessments of worst credible event
  - Probabilistic analyses
  - Structural response analyses
  - Full QRA

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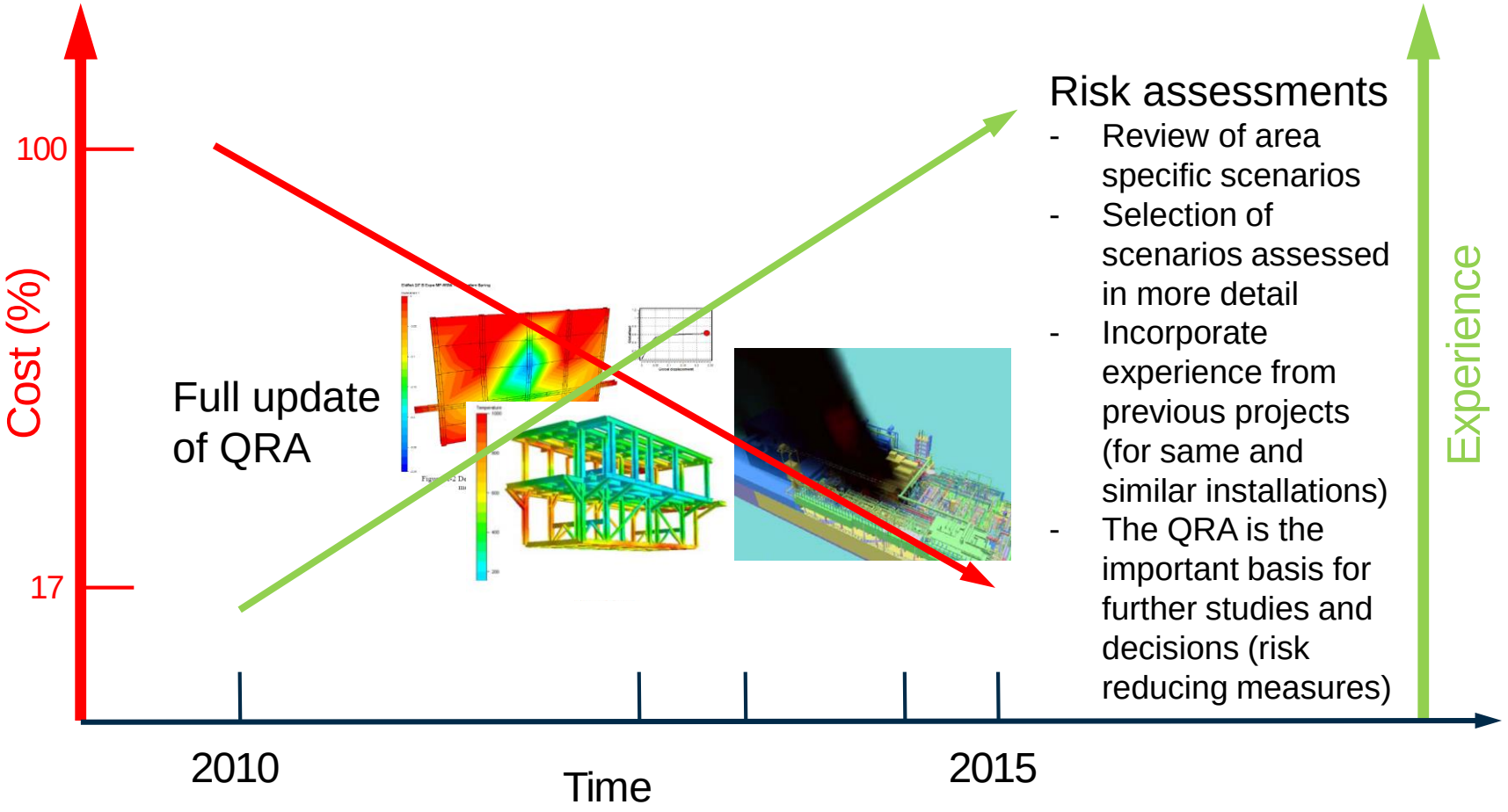
Experiences from engineering projects

- Early integration in engineering projects
- Close dialogue and co-location of safety consultant and engineering disciplines
- Risk analysis represented in discipline meetings (Layout/process/ structure/technical safety)
- Budget to include sensitivities / ‘un-foreseen’ tasks
- Active use of CFD – ‘as-built’ model established early (artificial congestion/ equipment included)
- Experience-based early definition of dimensioning loads
- ‘All’ activities to be run in parallel (‘the dilemma’)

Experience from risk analyses in operation



(Q)RA – before and now (?)

Before

- Large analyses that cover ‘everything’
- Non-specific studies – ‘generic’ answers
- Unclear scope – analysis for all (i.e. no-one?)
- General answers on risk level

Now

- Shorter, time-limited analyses
- Specific studies
- Clear scope and expectations
- Increased level of detail in some areas (but reduced in some areas)
- Recommendations to be given up-front – final results/report in later stage

Summary of alternative approach

- Step 1
  - Early hazard identification and layout review
  - Screening of which analyses to perform
  - Preliminary results
- Step 2
  - Simplified analyses, typically fire and explosion
  - Review the need for more detailed analyses
- Step 3
  - More detailed, probabilistic analyses (if required)
  - Review of early phase premises and results
  - Review the need for more analyses
- Step 4
  - The complete QRA (if required)
  - Review of early phase premises and results
- Step 5
  - Review of premises and results for the operation phase and barrier management

Summary

- QRA (and the results hidden inside) is an important basis for decisions in design/engineering – but other ways of presenting results and additional analyses are often needed
- Usually a ‘full QRA’ is not needed to provide sufficient basis for design – limited analyses may provide 80% of the answers
- Re-use / standardization of QRA results

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Thank you

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