How applying models in work group sessions can help to retrieve information for making FTA and FMECA analysis.

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Research by Levi Vigdal, master project student at Dresser-Rand





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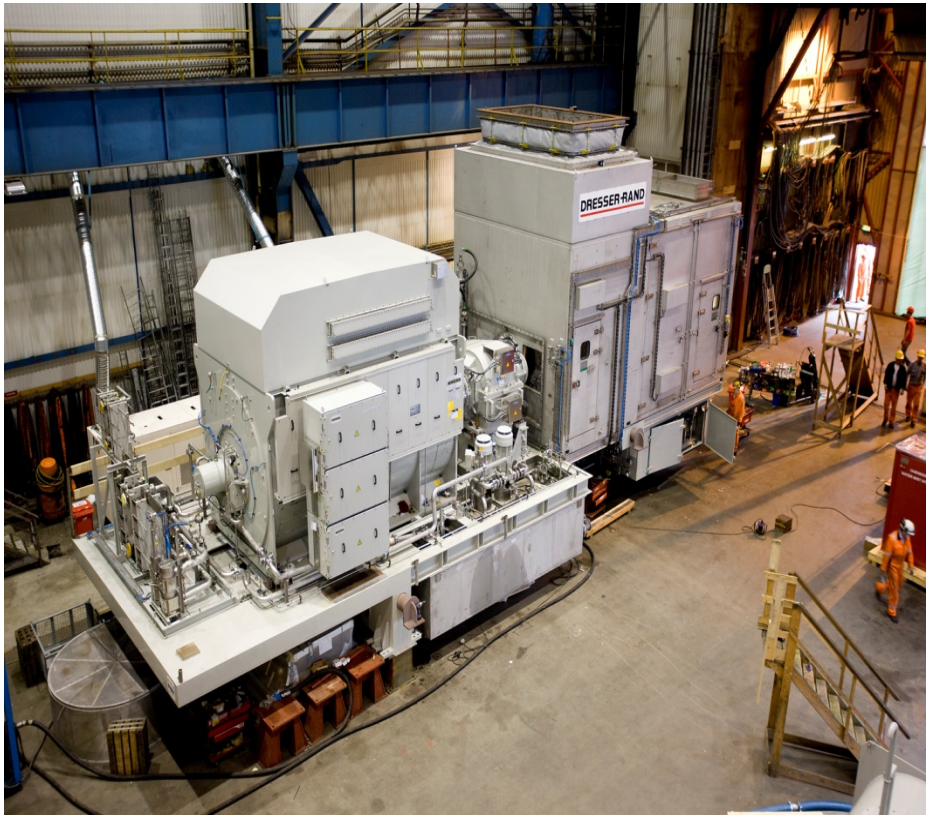
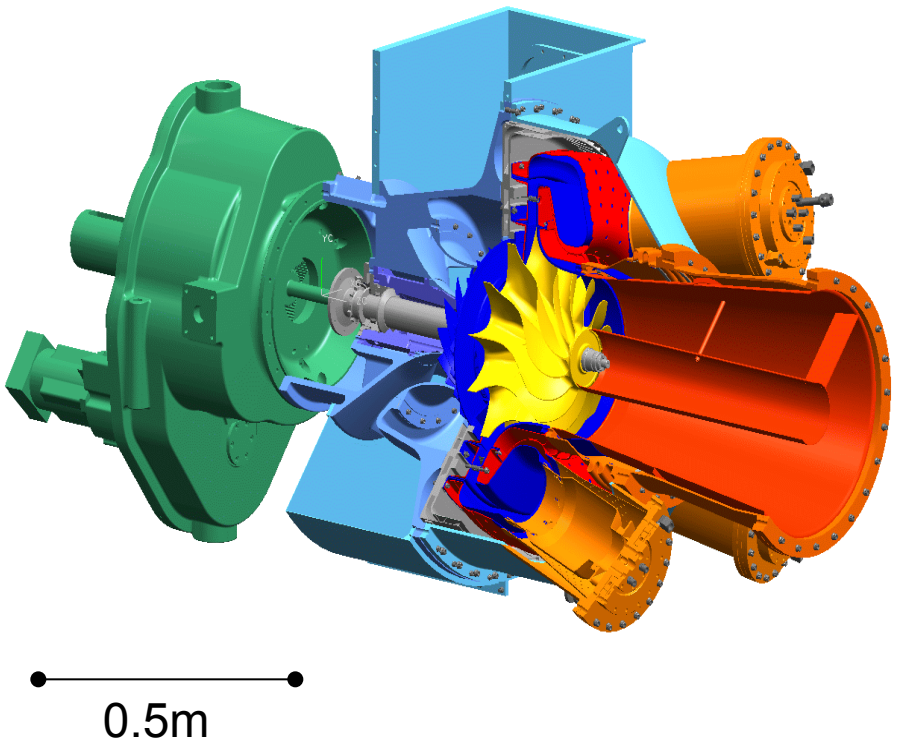
Small, but complex topside services

- Limited space
- Need stable power and process heat
- Large consumers w/step-loads
- Limited gas supply, but want to use what is available
- Unmanned
- Remote

Project Metrics for Large (>75 MW) Power Systems

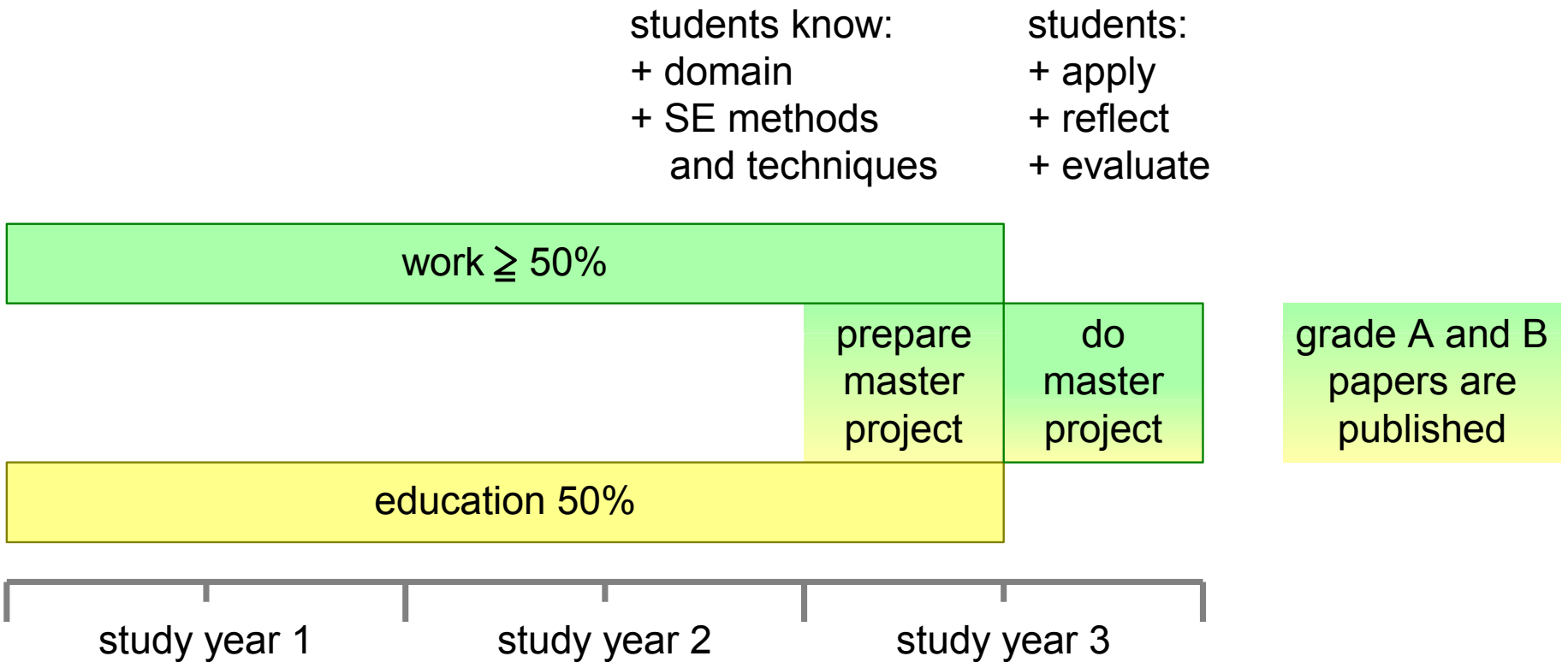


- Meet Specifications (Quality)
- On Time Delivery
- Documentation flow on time
- Not exceeding weight (penalty)
- Frequency and Voltage stability
- Material to meet life>25 years
- High efficiency
- Provide enough process heat for the platform in all operation cases
- No or limited number of punch items at time of delivery
- Neutral cash low by meeting payment milestone conditions
- Meet cost target

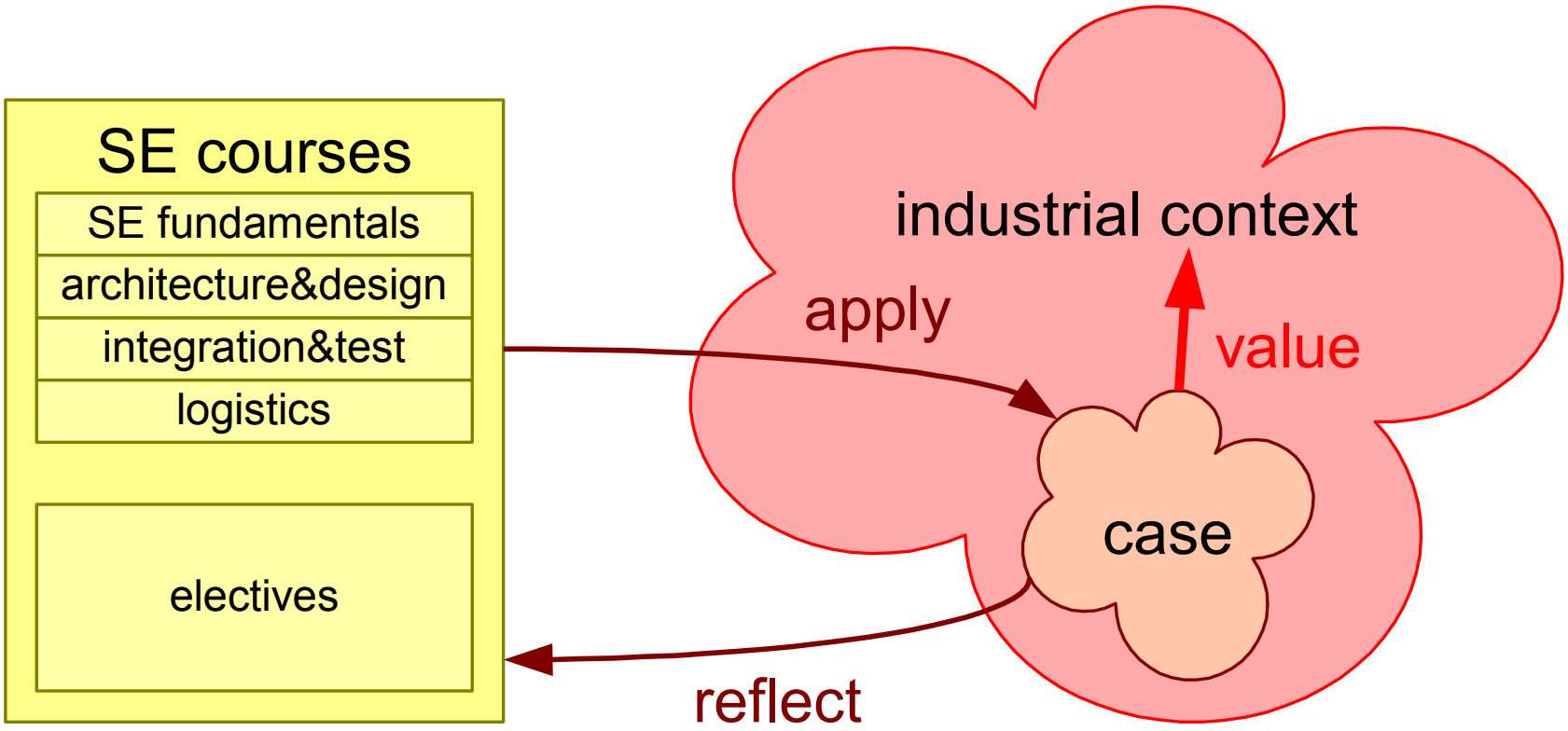


- Dresser Rand is mostly packaging Gas Turbines
- A new more efficient gas turbine is being developed 25 years later
- Knowledge and experience resides in older employees
- Levi Vigdal was asked to prepare the integration and test phase
- Looking into FMECA and FTA

Research Model Master Students

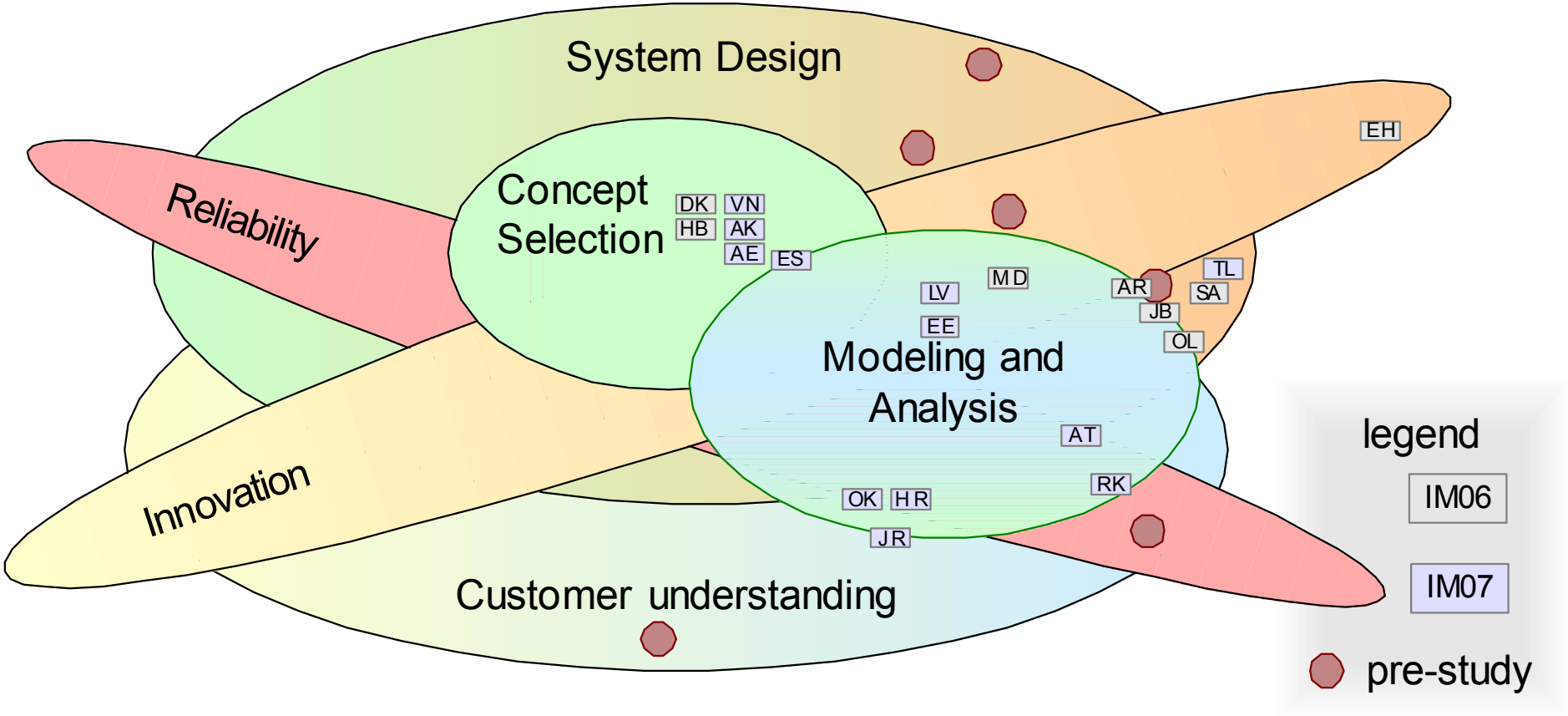


Master Project Objectives

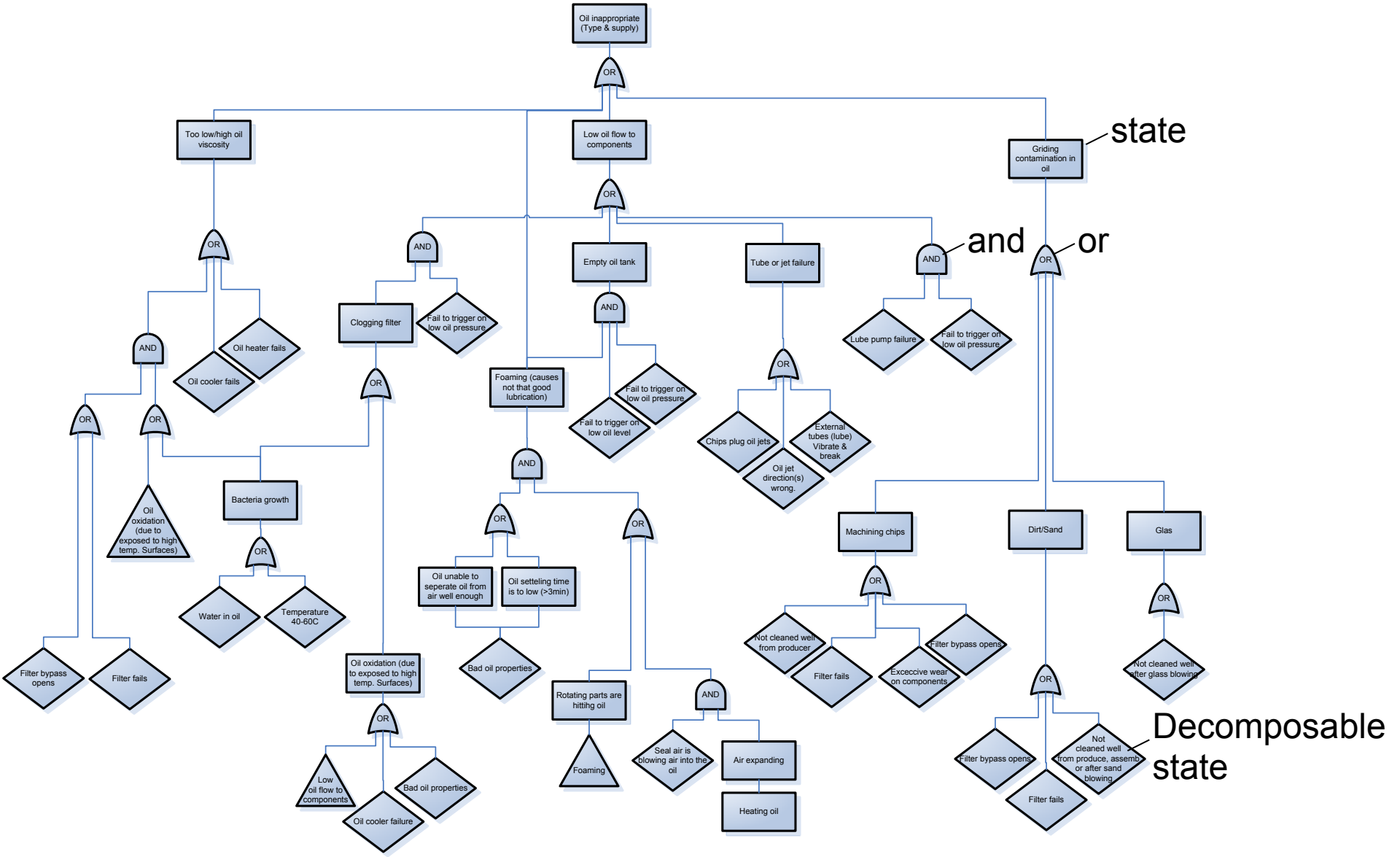


Apply SE methods, techniques, and concepts in practice and reflect on its application, while providing value to the industrial sponsor

Research 2008-2010



Fault Tree Analysis



FMEA

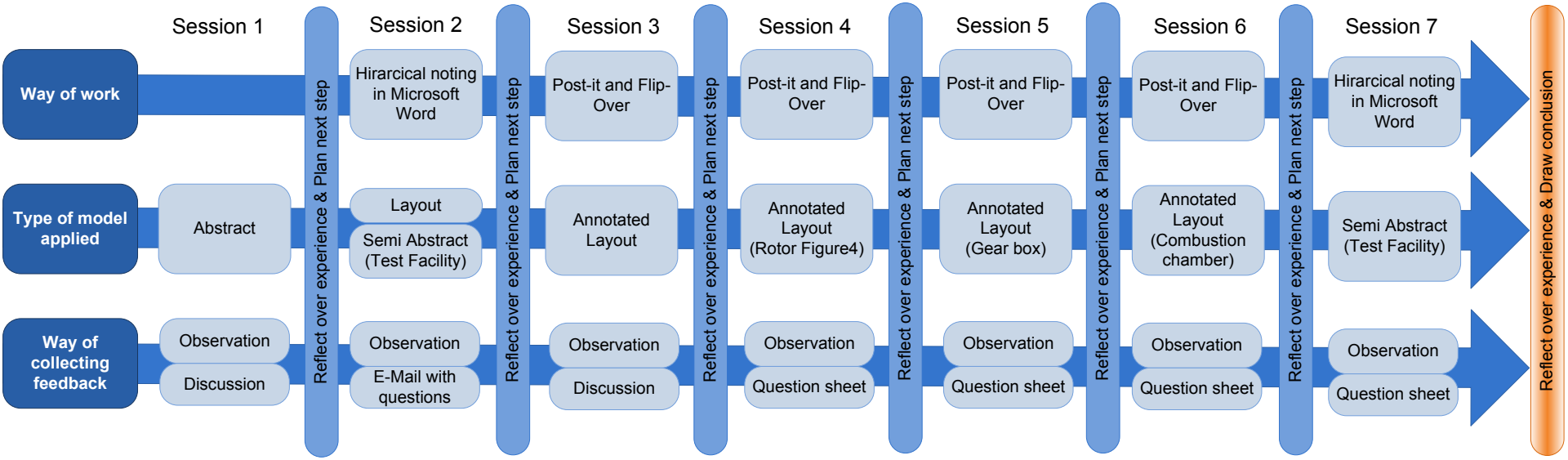
Occurrence (O)
Severity (S)
Likelihood (D)
Risk Priority =
O * S * D

Description of unit			Description of failure			Effect of failure						
ID	Function	Operational mode	Failure mode	Failure cause or mechanism	Detection of failure	On the subsystem	On the system function	O	S	D	RPN	Corrective actions
1	Generate torque	Full load	Blade break	Damper joint is not damping blade vibrations causing resonance	Terrible noise when blades fall off	Causing blades to fall off on both Exducer and impeller. This leads to total failure of rotor assy	Total failure of system function.	2	8	3	48	Checking damper pre load and contact area.
2	Generate torque	Full load	Blade break	The blade has a natural frequency outside what expected	Terrible noise when blades fall off	Causing blades to fall off on both exducer and impeller. This leads to total failure of rotor assy	Total failure of system function.	3	8	2.5	60	Doing a frequency test on each blade
3	Generate torque	Full load	Blade break	Uneven shroud leads to blades rubbing on certain areas inducing a resonance.	Terrible noise when blades fall off	Causing blades to fall off on both Exducer and impeller. This leads to total failure of rotor assy	Total failure of system function.	1	8	3	24	Measuring the Shroud surface
4	Generate torque	Full load	Blade break	A foreign object falls into the turbine	Terrible noise when blades fall off	Causing blades to fall off on both Exducer and impeller. This leads to total failure of rotor assy	Total failure of system function.	1.5	7	2	21	Assuring that all upstream components are surly fastened. And that they are not subjected to higher load than designed for

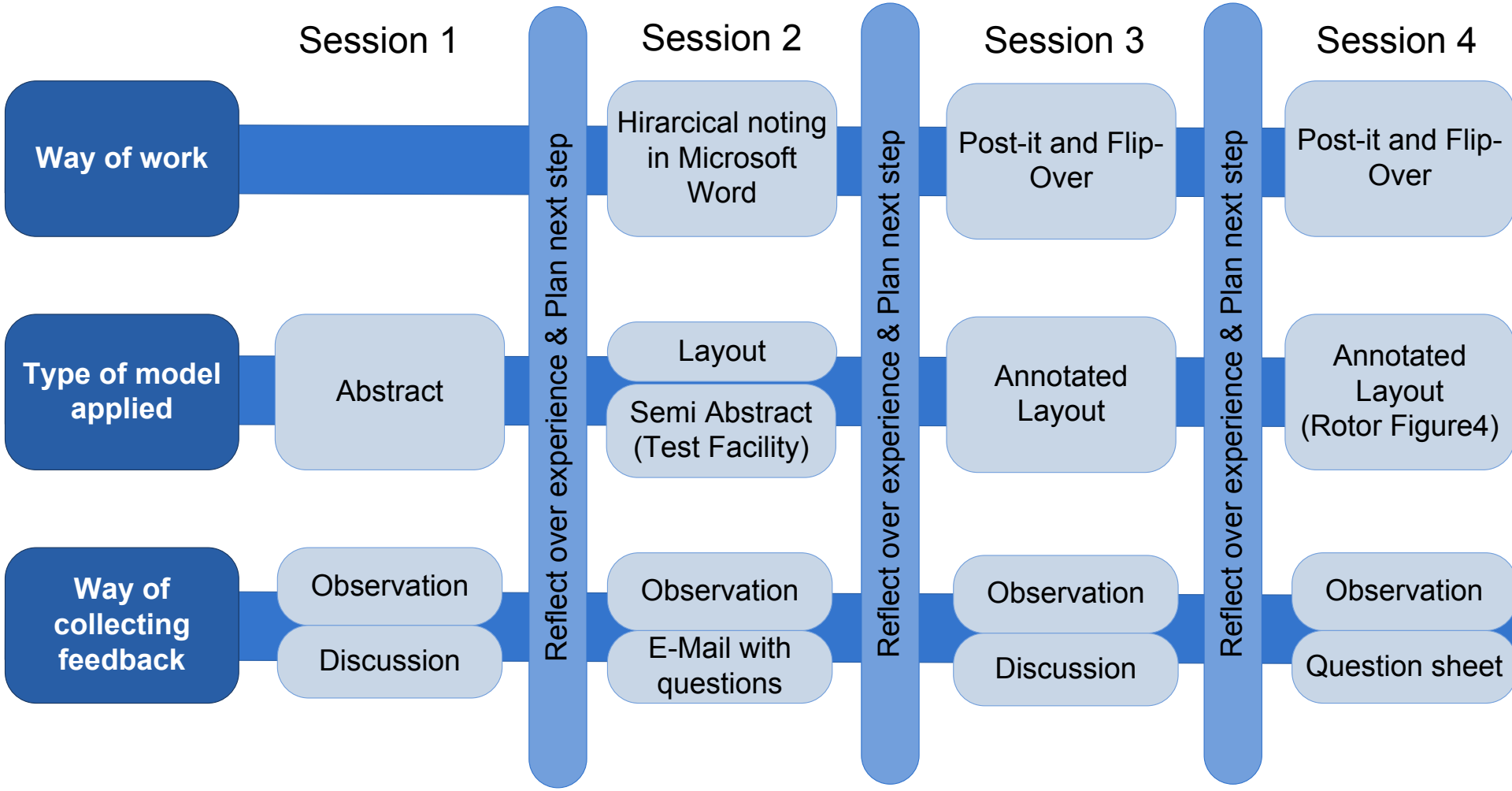
Main Challenge, Research Hypothesis

- How to get the interaction going as junior engineer with 5 engineers with ~40 years of experience each?
- H1: *Working with flipchart and Post-It encourages a more* ***active participation*** *than working towards a shared document projected onto a large screen. When having a group session it is important to have a work process that encourages participation and discussion.*
- H2: *When presented with a model, people respond better if the model has elements that they* ***recognize****.*
- H3: *Using models that reflect the meeting theme helps in enforcing* ***creativity*** *and* ***discussion*** *around a failure mode causes and effects for a FTA and FMEA analysis. As the models help enforcing creativity and discussion, it also help the engineers to think of failure modes they did not view as critical or did not know at all.*

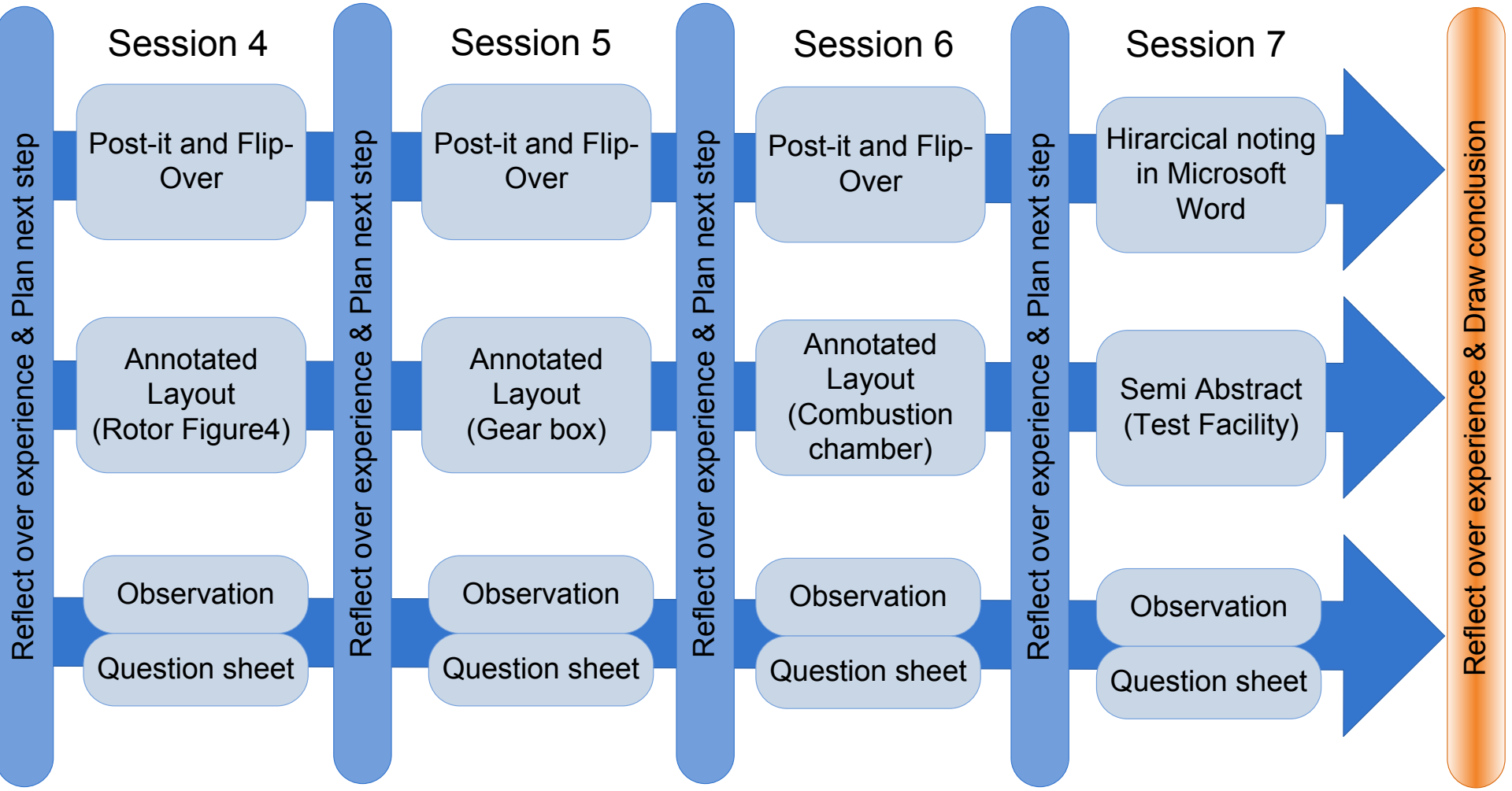
Research Approach



Research Approach



Research Approach



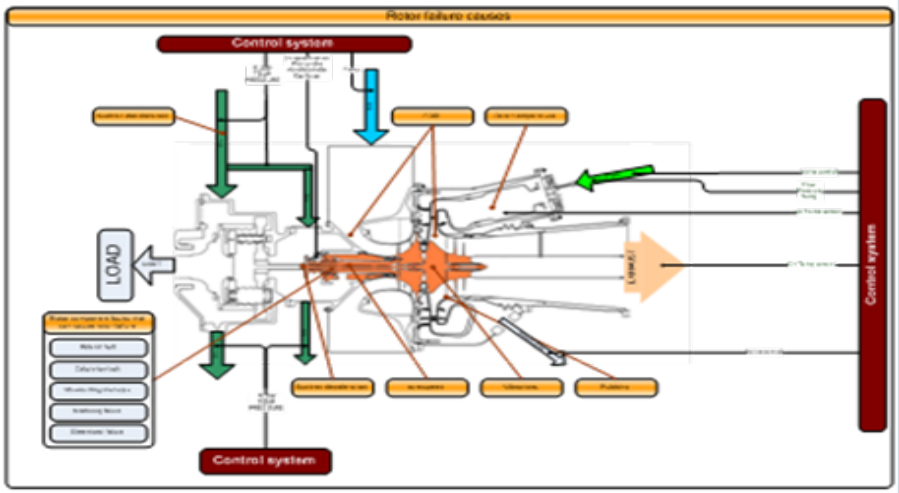
Findings step 1, way of working

- Central facilitation by shared electronic document:
  - Side tracking: spelling, description, structure i.s.o. failure modes
  - Passive behavior
- Flipchart and post-it notes:
  - Process needs explanation at beginning
  - Engineers tend to write down root cause i.s.o. chain of events
  - More active engagement
    - Mental and physical
    - Reshuffling of Post-its
    - More creativity building on previous work

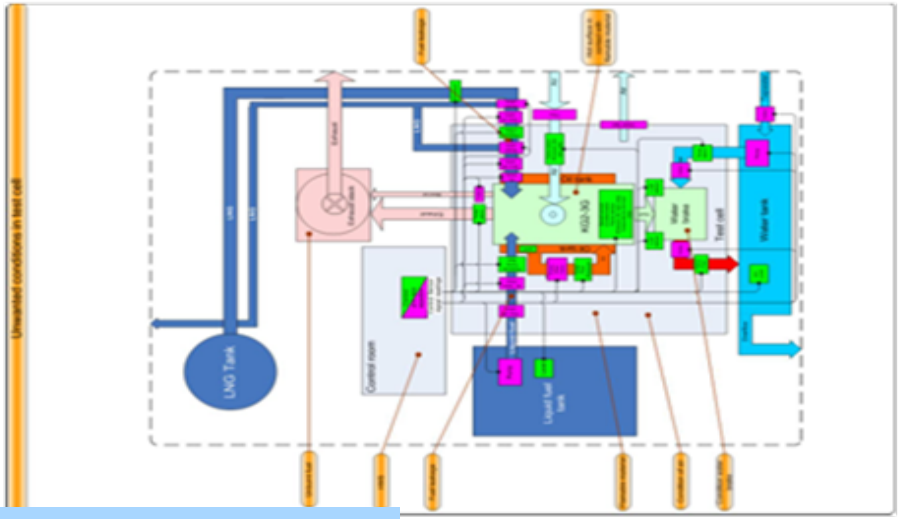
Grading Table for Type of Model

Observation	Grade 1-6 where 6 is high grade of statement and 1 is low
Looking at model	
Pointing at model	
Referring to the model	
Noting and adding things on/to the model	
Participant engagement	
Discussion follows model theme	
Model is self explaining	

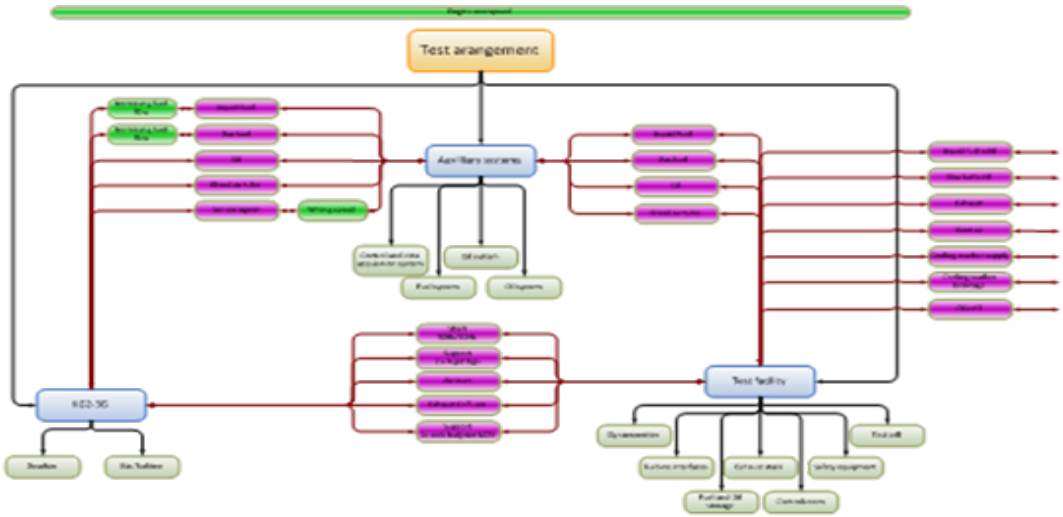
Annotated diagram



Semi abstract model of test arrangement



Abstract physical decomposition



Results of model gradding

Observation	Physical decomposition	Semi abstract model	Clean layout	Layout with annotations 1	Layout with annotations 2
Looking at model	5	4.5	4.5	5	4
Pointing at model	3	2	2	2	2
Referring to the model	2	2	2	2	1.5
Noting and adding things on/to the model	1	1	2.5	1	1
Participant engagement	3	4	3.5	4	5
Discussion follows model theme	3	4.5	3	5	5
Model is self explaining	2	6	6	6	6
Sum	**19**	**24**	**23.5**	**25**	**24.5**

Interview questions

- *What do you think is the advantage of having these kinds of models?*
- *What do you think is the disadvantage of having these kinds of models?*
- *Did the models help you think of new issues?*
- *Did the meeting help you think of new issues (things you knew of but did not view as an issue?)*
- *If you could change something, what would you change?*

Conclusions

- Engineers appreciated models
- But not too abstract…
- Keywords work as trigger for brainstorm
- Are issues detected because of model, meeting or attendees?
- Physical hardware might trigger even more?
- Active meeting format (flipcharts, Post-it notes, preprinted models) engages the audience.