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Increasing the value of model-assisted communication:
Modeling for understanding, exploration and verification in production line design projects

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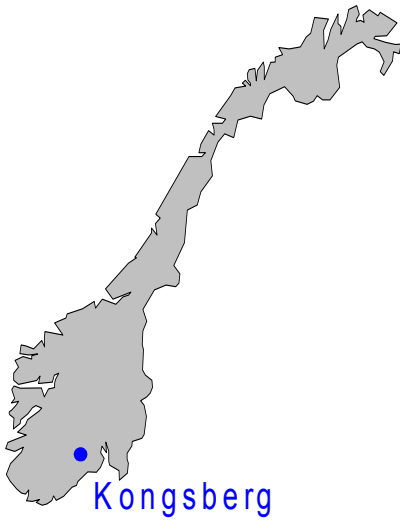


GKN Aerospace Norway

The CFM56 engine produced by SNECMA

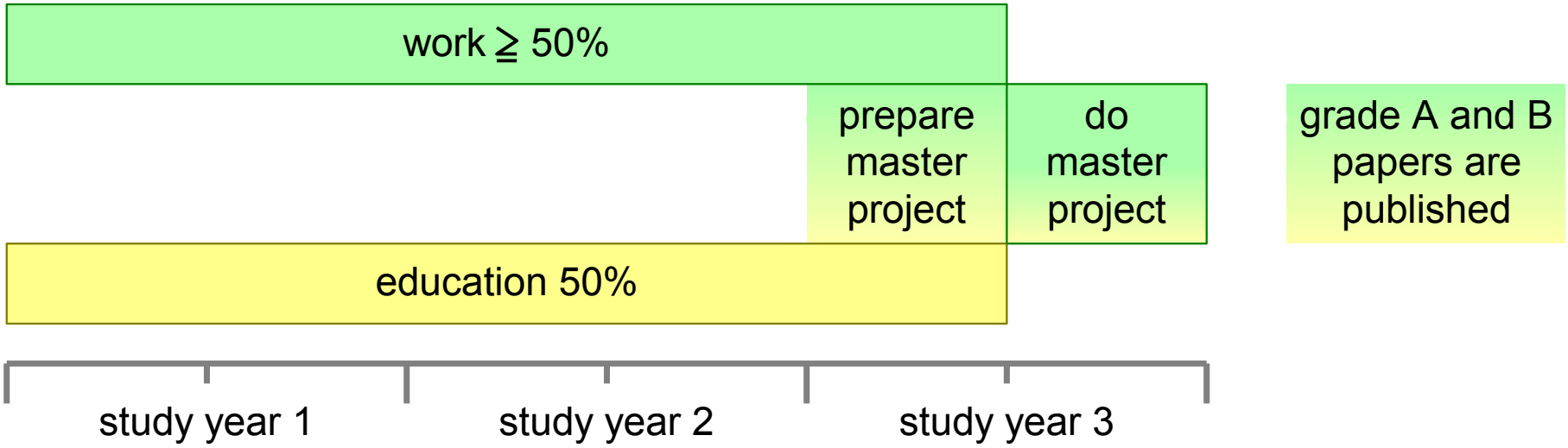
GKN Aero produces a.o. **low pressure turbine vanes**

Manufacturing of airplane engine parts
- high quality
- high precision
- lots of machining

Research Model Master Students Systems Engineering in Kongsberg, Norway

students know:
+ domain
+ SE methods and techniques

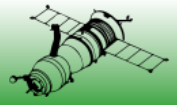
students:
+ apply
+ reflect
+ evaluate



Challenges in production line design projects

- Stakeholders pulling in different directions
- Stakeholders that do not share a common understanding of problem and goals
- Knowledge gaps between stakeholders

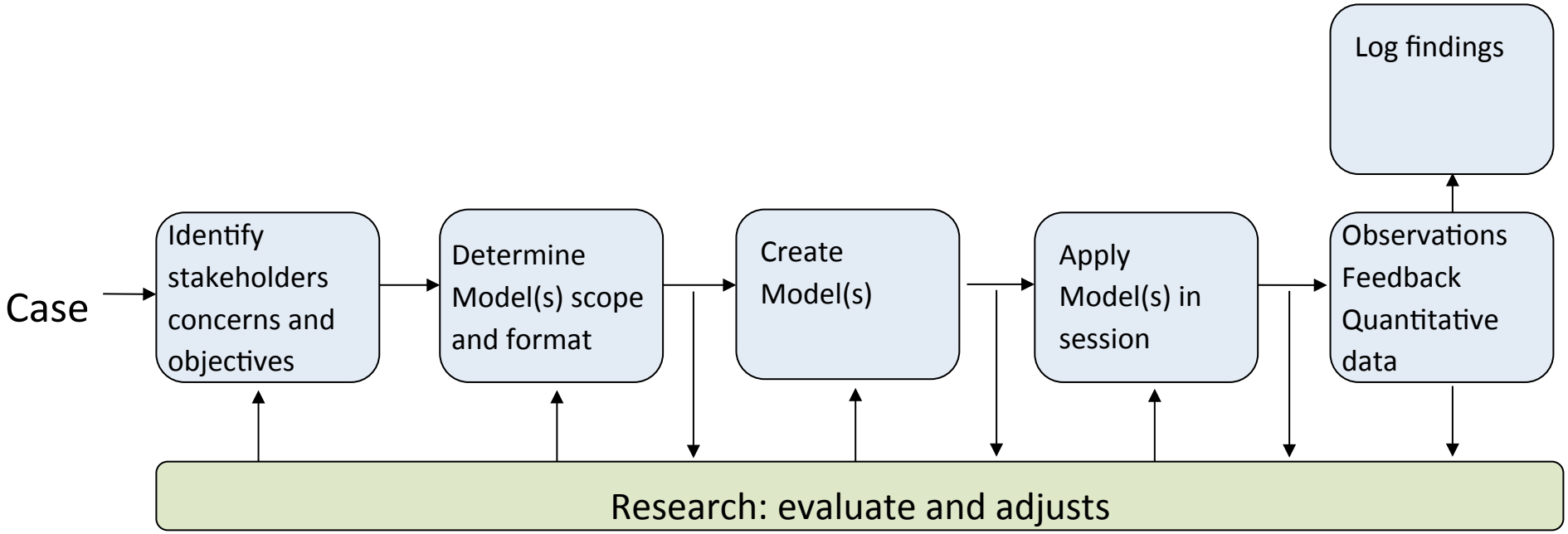
- Work sessions ending without decisions made and unclear conclusions on future work.


Building on previous Research

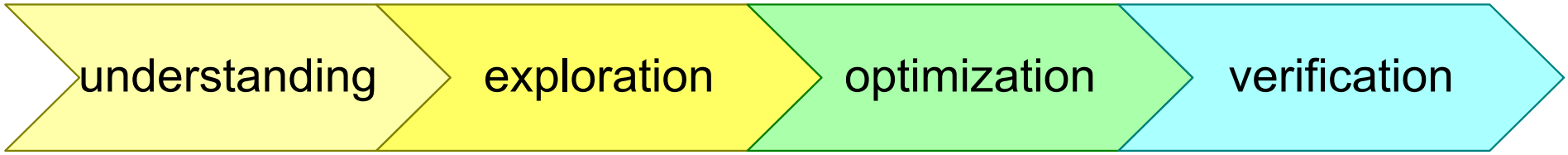
- [4] Engebakken, E., Muller, G., and Pennotti, M., 2010, *Supporting the system architect: Model–assisted communication*, Systems Research Forum, Vol. 4, No.2, 2010, p173-188
- [5] Rypdal, R., Muller, G., and Pennotti, M., 2012, *Developing the Modeling Recommendation Matrix: Model-Assisted Communication at Volvo Aero*. Proceedings INCOSE 2012 in Rome
- [6] Polanscak, 2011, *Supporting Product Development: A3-assisted Communication and Documentation*. Master Thesis, Kongsberg: Buskerud University College

Research Approach



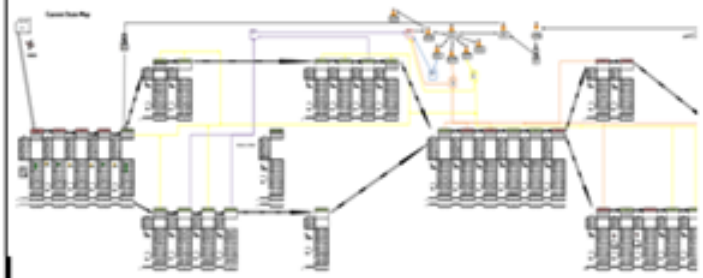
see detailed models at
http://www.gaudisite.nl/INCOSE2014figuresStalsberg.html.

Modeling Phases and Goals

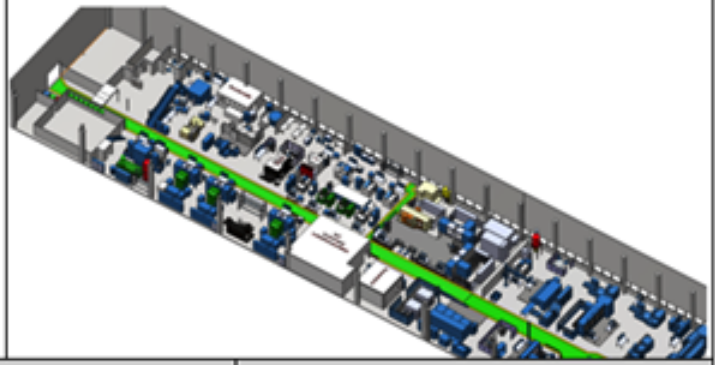


Models used in understanding phase

M1: Vane department current state VSM

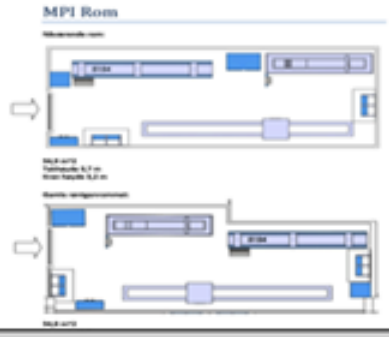


M2: Physical overview Vane department



M3: Project time line

M4: NDT room

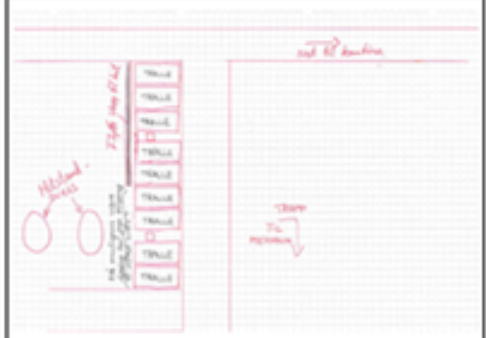


M5: Workflow grinder

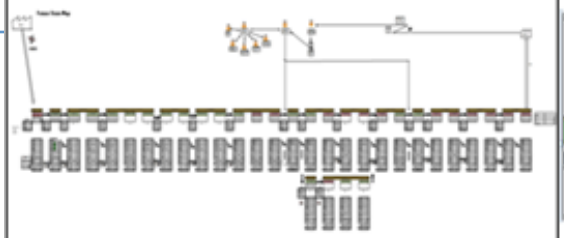
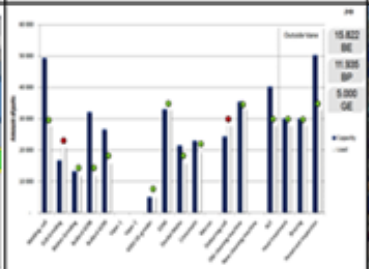
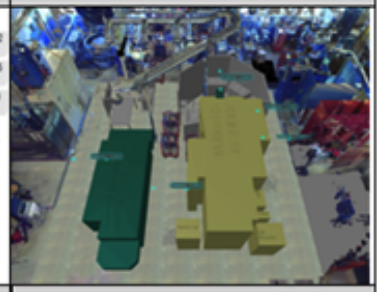
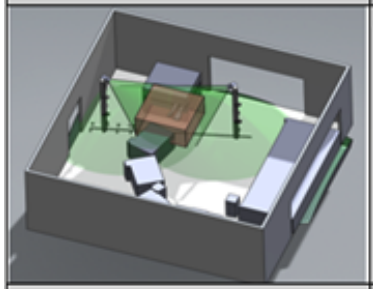
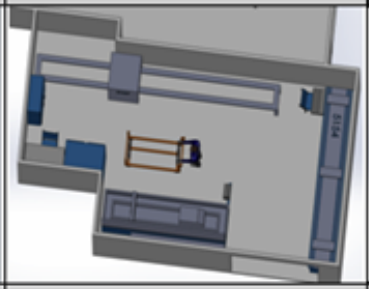
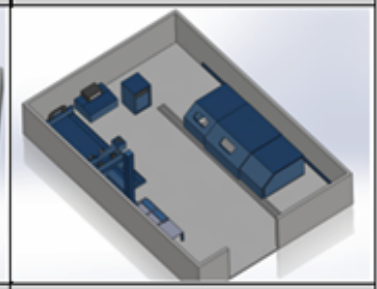
M6: Complaint process

M7: Manual work room

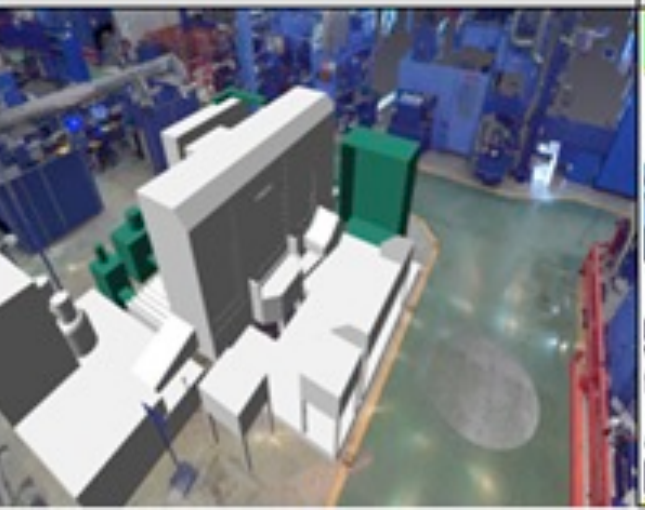
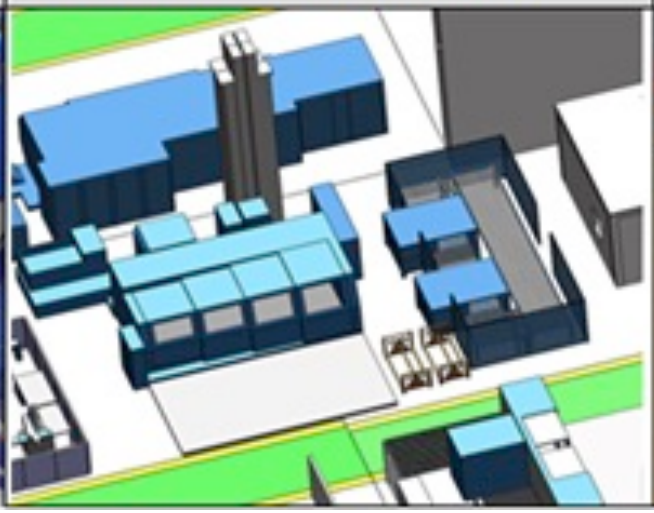
M8: Trolley placement



Models used in exploration phase

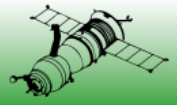
M9: Vane department future state VSM	M10: Part storage Vane	
		
M11: Production flow Vane	**M12: Capacity Vane**	**M13: Placement grinder**
		
M14: Camera position	**M15: Layout NDT room**	**M16: Layout balancing room**
		
M17: Part-loading concept	**M18: Layout manual work**	**M19: Storage improvement**
		

Models used for Verification

M20: Machine placement	M21: Machine placement	M22: Tape on floor
		

Quick facts from case examples

	Understanding Phase	Exploration Phase	Verification Phase
Number of models explored	8	11	3
Average creation time (h)	2,5	5,5	3
Average number of iterations	1,5	3	1
Average number of viewers	4	6	4
Tools used	Solid Works, Power Point, Excel, Visio	Solid Works, Auto Cad, Power Point, Excel, Point Tools	Solid Works, Point Tools


Impact factor	Effect of factor	Impact on model effectiveness	Experienced impact on resources
Close to reality	Easy to understand for stakeholder	Faster communication, less misinterpretation, increased accuracy	Increased creation time
Instant recognition	Easy to understand and accept for stakeholders	Faster communication, less misinterpretation.	Sometimes increased creation time
Personal relevance	Appeals to ownership	Increases feedback, and feedback reliability	Reduces session time
Multi-view models	Creates context for discussions	Provides right amount of information	Increased creation time
Participation	Engages stakeholder	Increases feedback, can uncover new elements	May increase session time
Assumptions	Provokes feedback	Accelerates discussions, helps to answer questions	Can increase Session time
Iterations	Evolves model over several sessions	Increases reliability	More resources involved
Format, effort and purpose	Maximizes output of model	Optimizes time and resources spent on making models in relation to model purpose	
Details	Provides right information	Accelerate discussions, increased model reliability	Increased creation time
Guidance	Focuses meeting	Accelerates discussions, channels feedback on the right topic	Reduces session time
Number of stakeholders	Involves the right number of stakeholders	Accelerate discussions, optimizes output of meeting	Reduces session time, may reduce resources involved
Intention	Focuses meeting, provides clear expectations	Accelerates discussions, channels feedback on the right topic	Reduces session time
Dynamic models	Simplifies showing functions	Communicates the right inform	

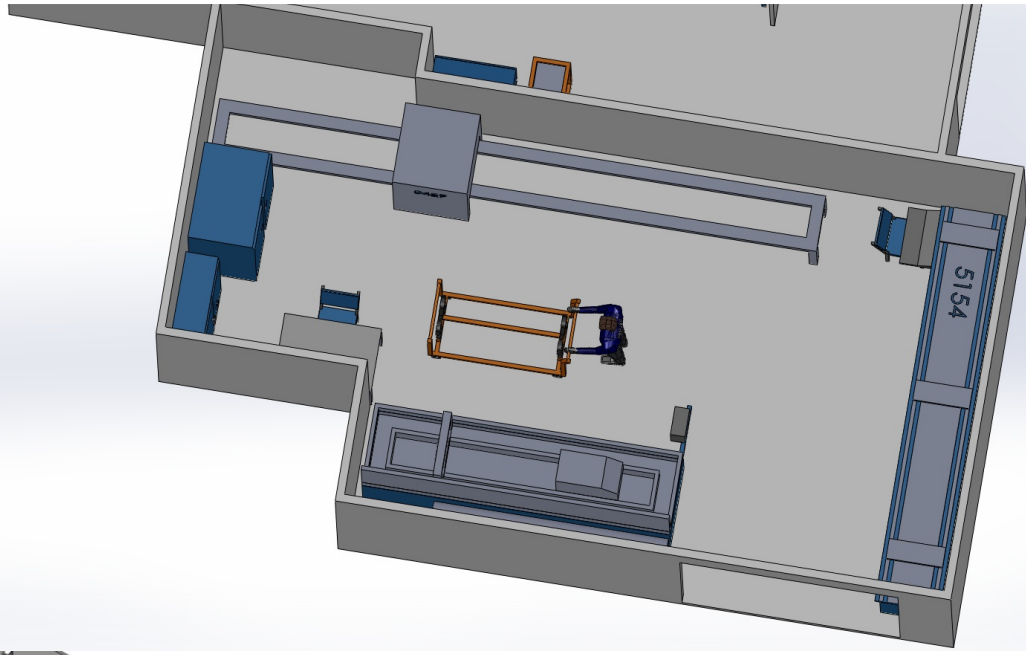
original table by Even Engebakken

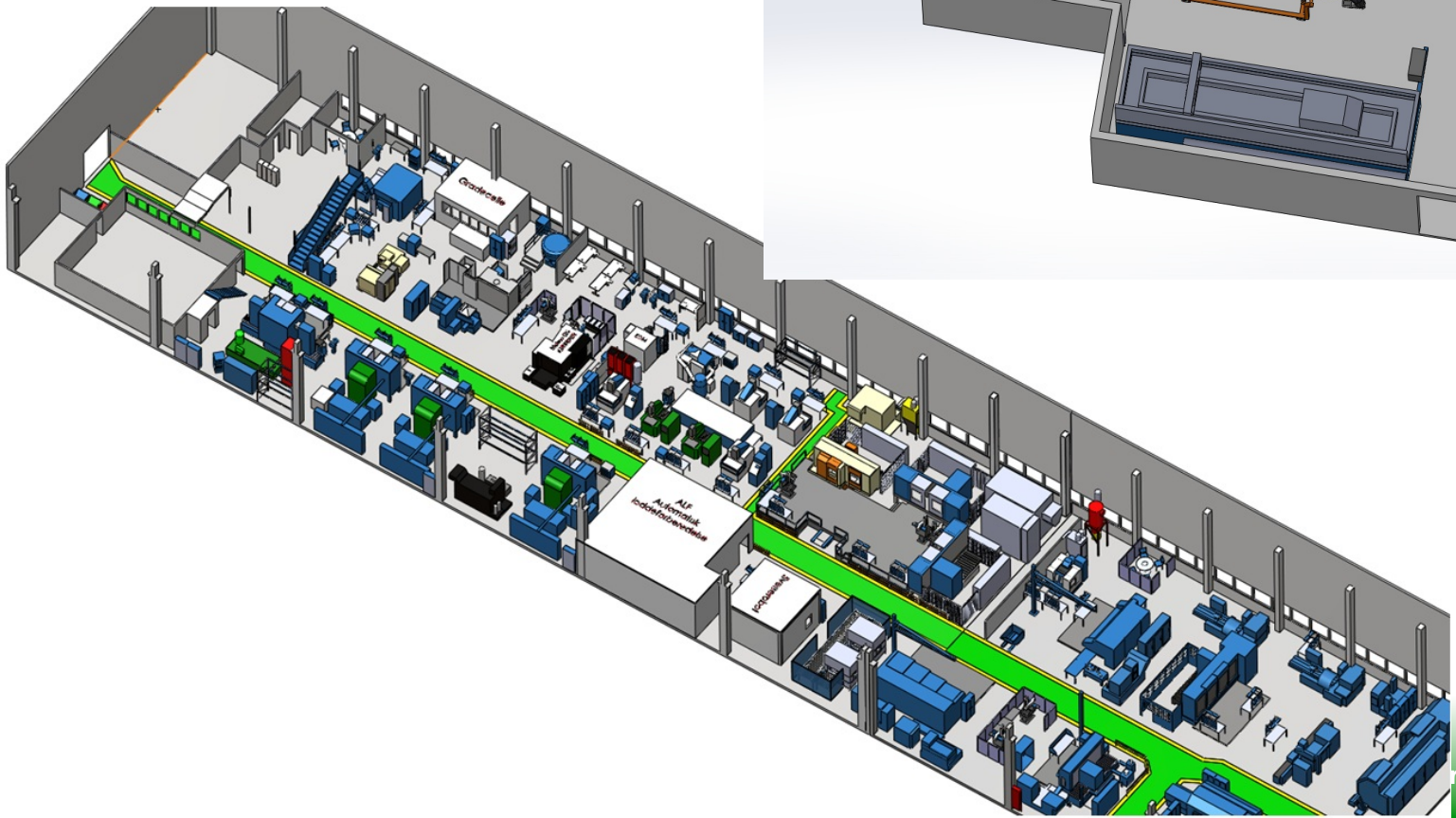
Impact factors and tensions

Impact factor	Description	Benefit	Disadvantage	Example
Visual Attributes				
Close to reality	Looks similar to the real world	Understanding, overview and engagement	Boundaries prominent prevent creative thinking, time consuming	Physical 3D overview (M2, M15)
Visibility of core message	Clear message in models	Straight to the point	Other aspects can be forgotten	Timeline (M3)
Content of model				
Level of details	Amount and type of details included in model	Credibility of model	Boundaries prominent prevent creative thinking, time consuming	Physical detailed model (M16)
Assumptions	Use of "best guess" instead of approved facts	Shorter creation time	Inaccurate model, low credibility	Process as understood (M6)
Multiple views	Showing more than one aspect of a case	Cover different aspects	Distract attention	Time and space (M3)
Personal relevance	Cases that are/ are made relevant to the stakeholder	Engage stakeholders, best solution oriented attitude	strong opinions prevent discussion, time consuming to reach conclusions	Operator workspace (M18)
Model Usage				
Active models	Models that can be instantly interacted with	Instant elaboration on ideas, ownership of ideas	Time consuming	Interactive 3D model (M17)
Guidance	Explain and clarify model	Prevent misunderstandings	Lead attention toward	All models

Close to Reality; Physical 3D overview

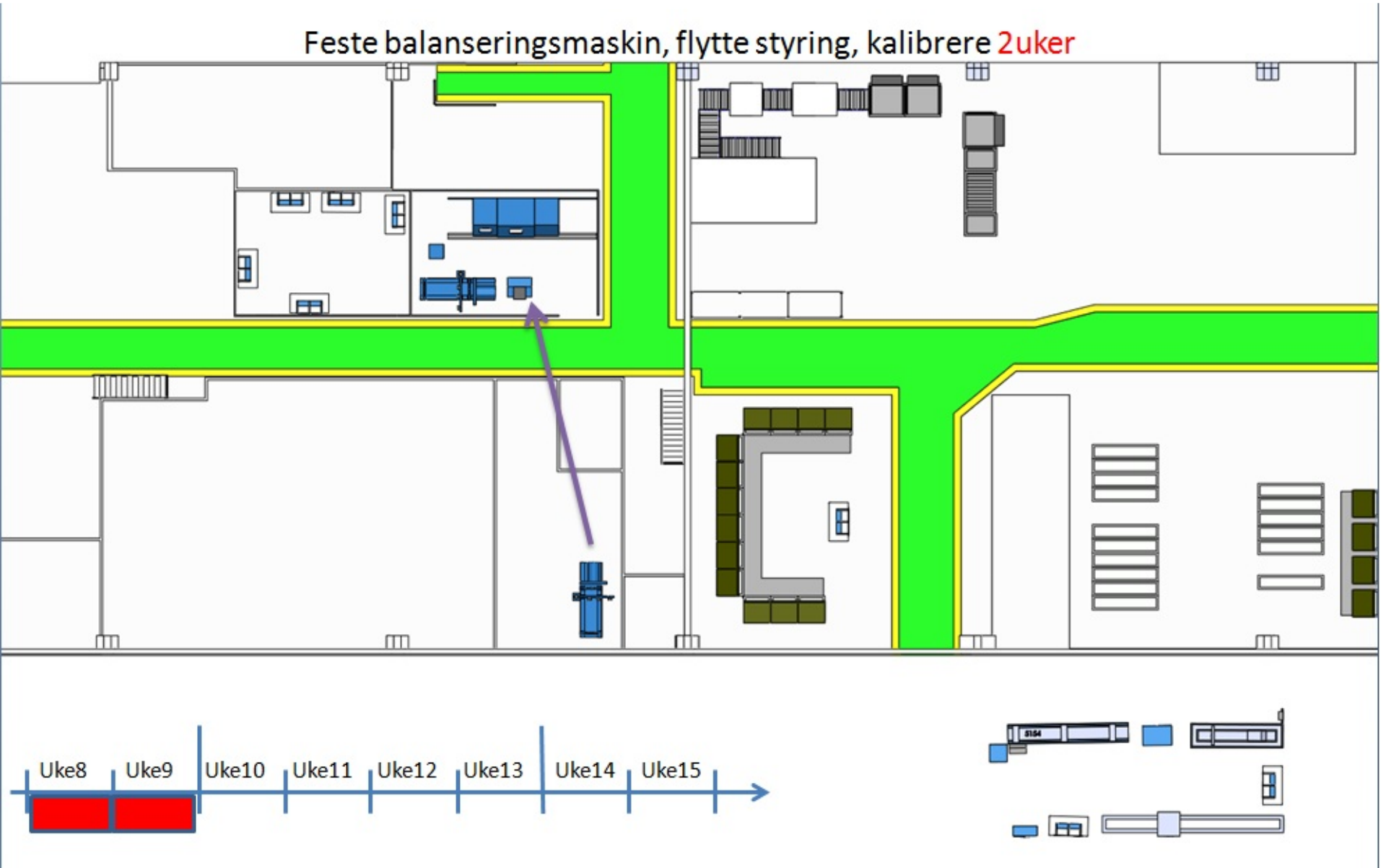
Looks similar to the real world	Understanding, overview and engagement	Boundaries prominent prevent creative thinking, time consuming





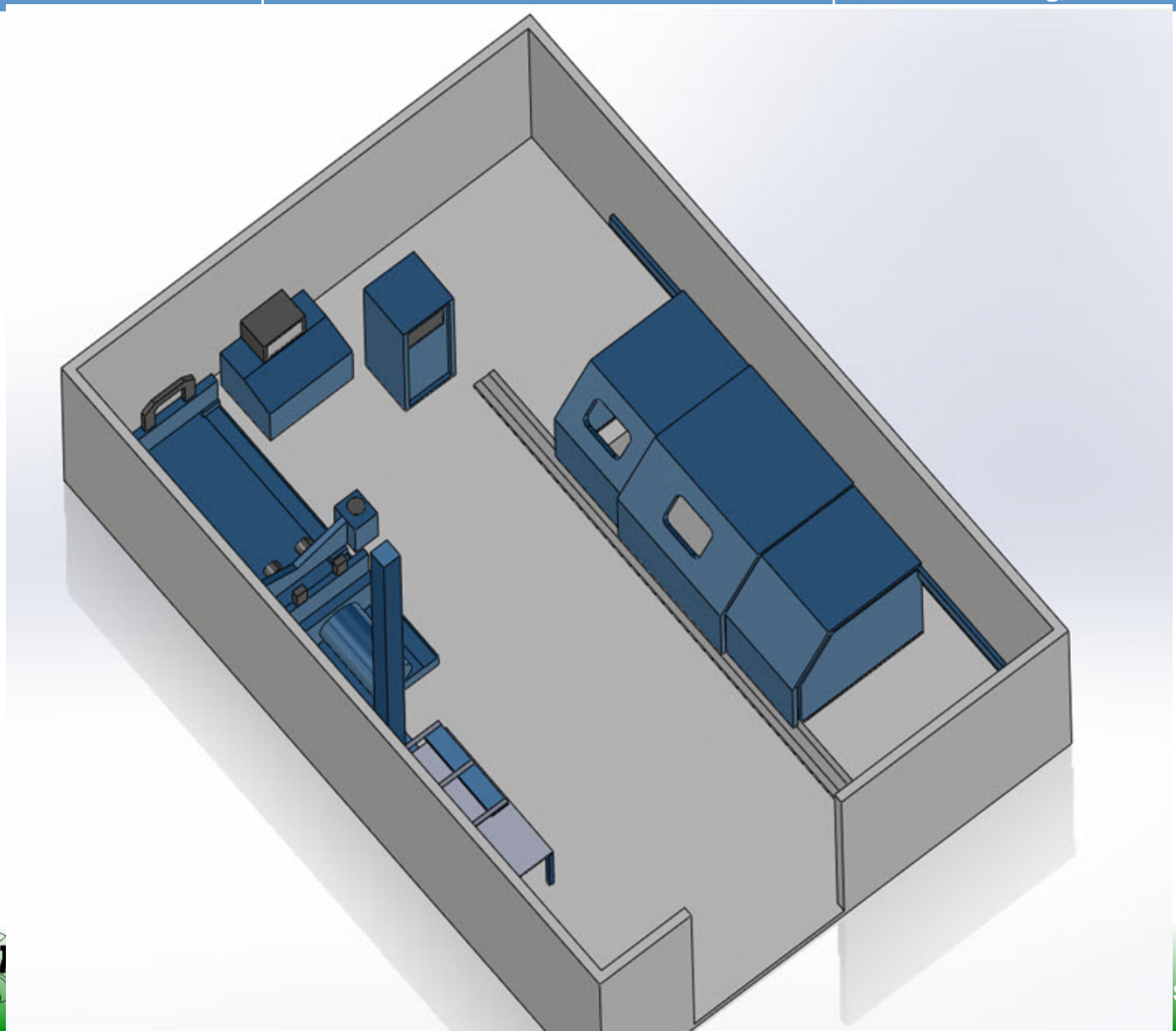
Visibility of Core Message; Time line

Clear message in models	Straight to the point	Other aspects can be forgotten



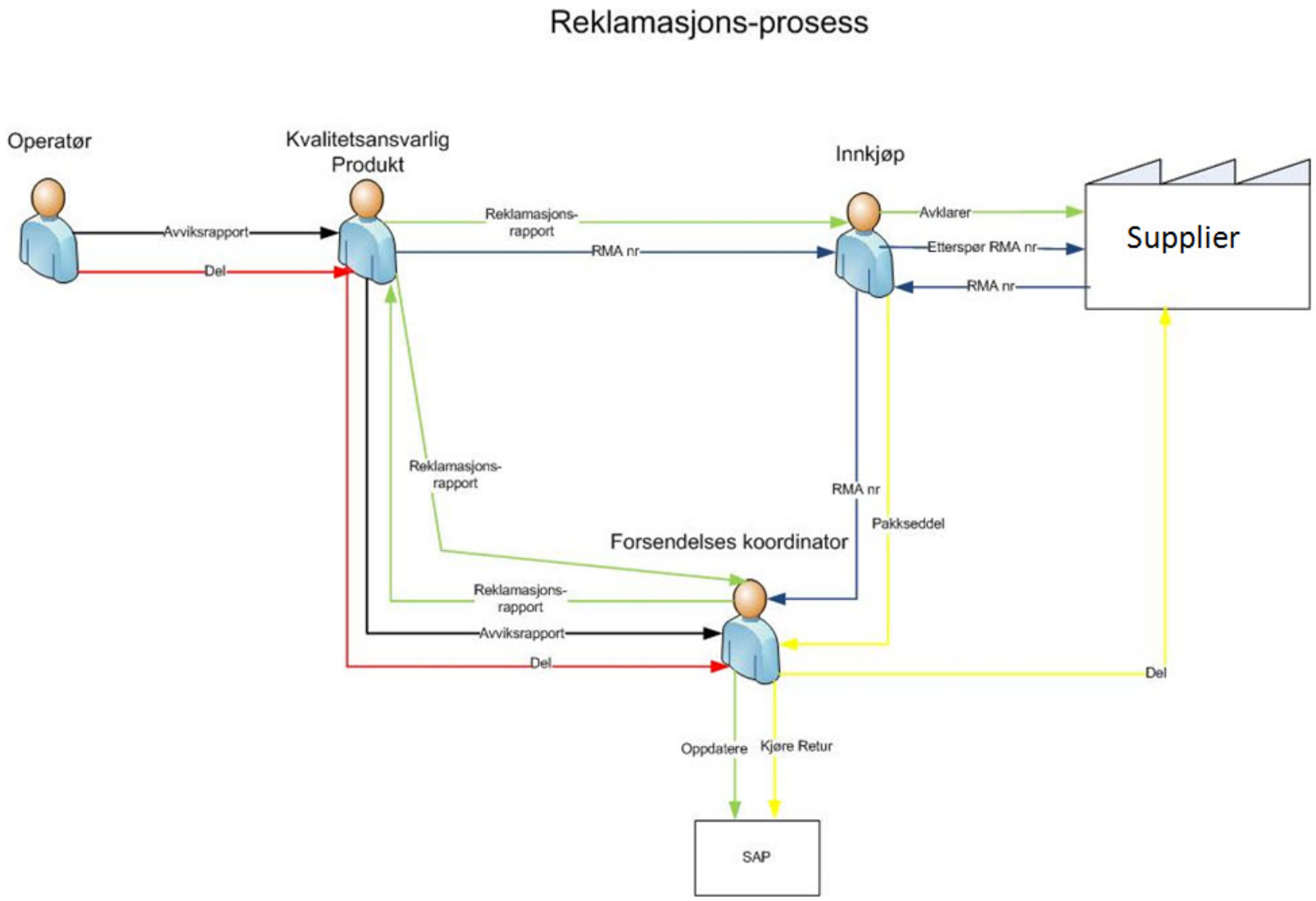
Level of Details; Physical detailed model

Amount and type of details included in model	Credibility of model	Boundaries prominent prevent creative thinking, time consuming



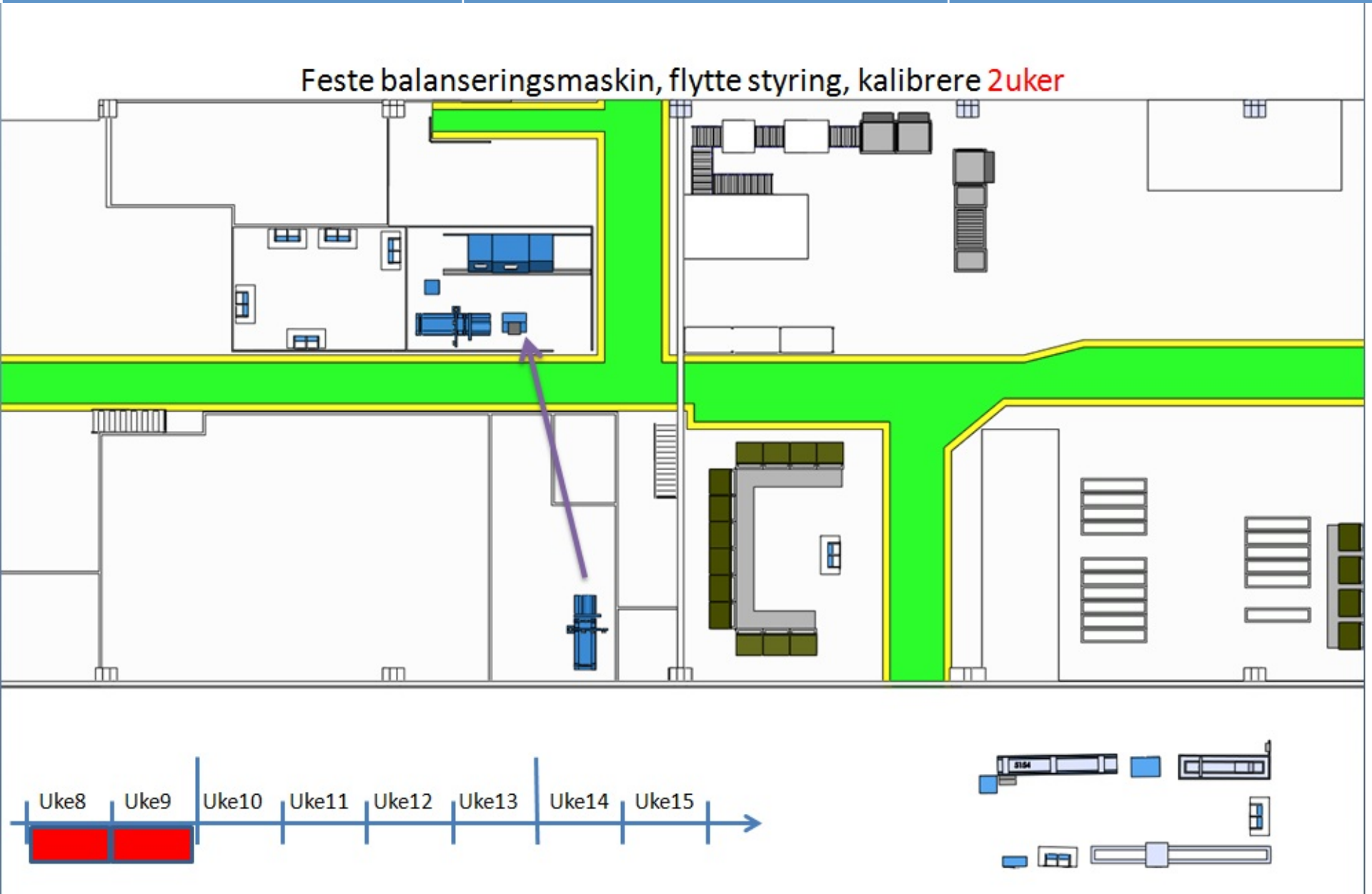
Assumptions; Process as understood

Use of “best guess” instead of approved facts	Shorter creation time	Inaccurate model, low credibility



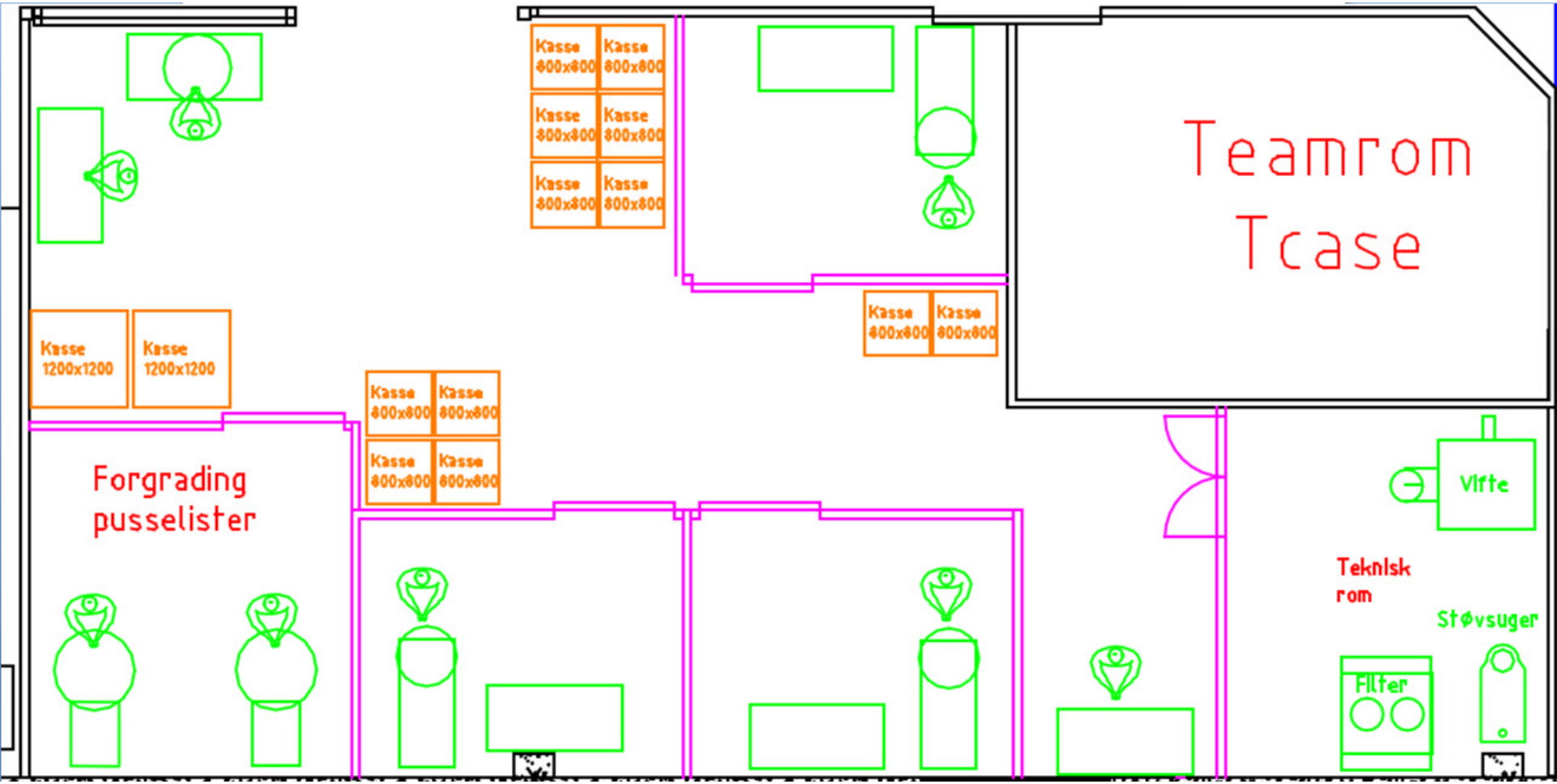
Multiple views; Time and space

Showing more than one aspect of a case	Cover different aspects	Distract attention



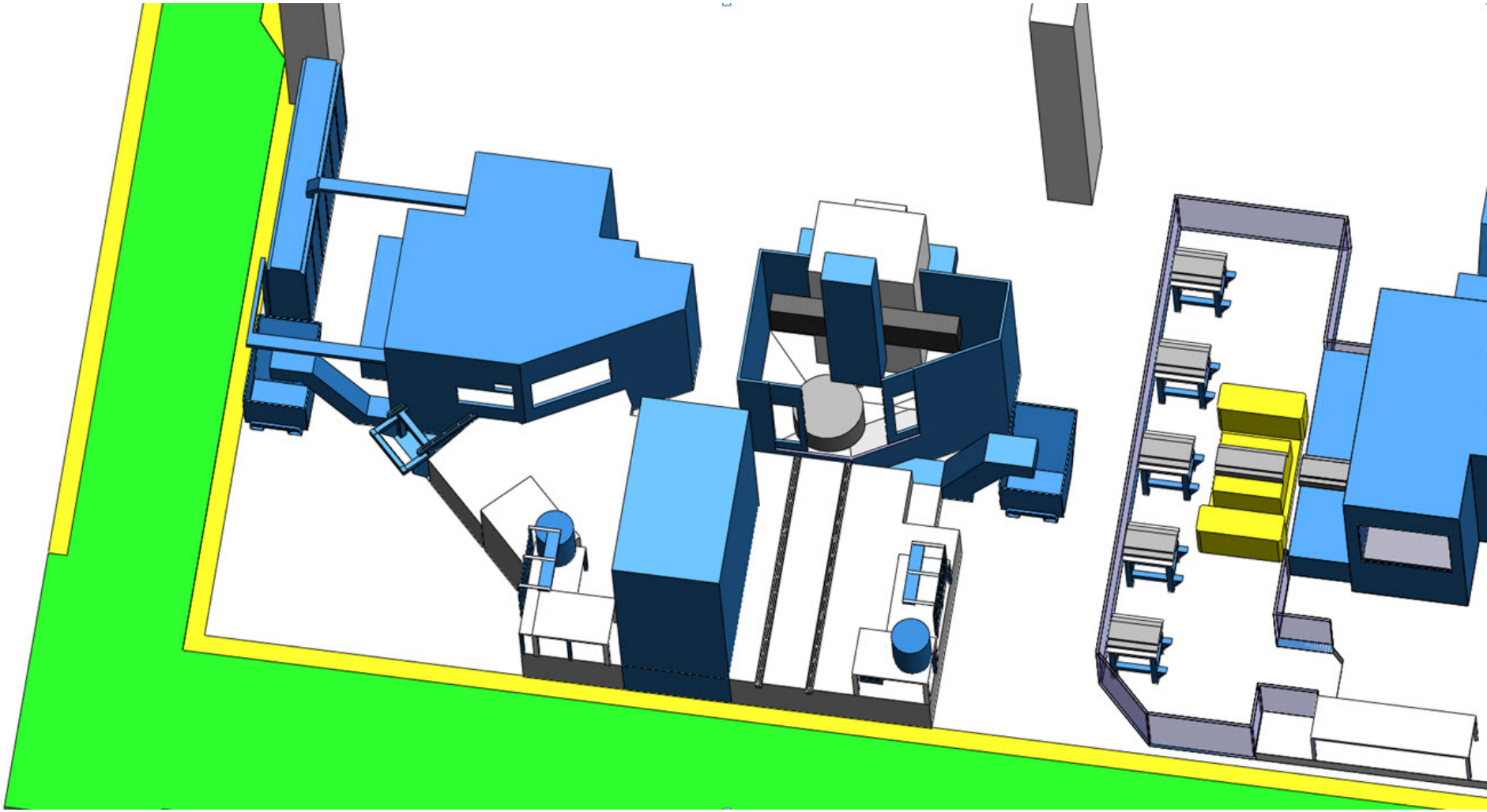
Personal Relevance; Operator workspace

Cases that are/ are made relevant to the stakeholder	Engage stakeholders, best solution oriented attitude	strong opinions prevent discussion, time consuming to reach conclusions



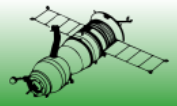
Active Models; Interactive 3D model

Models that can be instantly interacted with	Instant elaboration on ideas, ownership of ideas	Time consuming



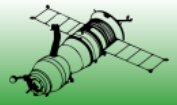
Importance of impact factors

Project phase Impact factor	Understanding Phase	Exploration Phase	Verification Phase
Visual model attributes			
Close to reality	Low	Medium	High
Visibility of core message	Low	High	High
Content of model			
Level of details	Medium	Medium	High
Assumptions	High	Low	Low
Multiple views	High	Medium	Low
Personal relevance	Medium	High	Low
Model usage			
Active models	Medium	High	Low
Guidance	High	Medium	Low

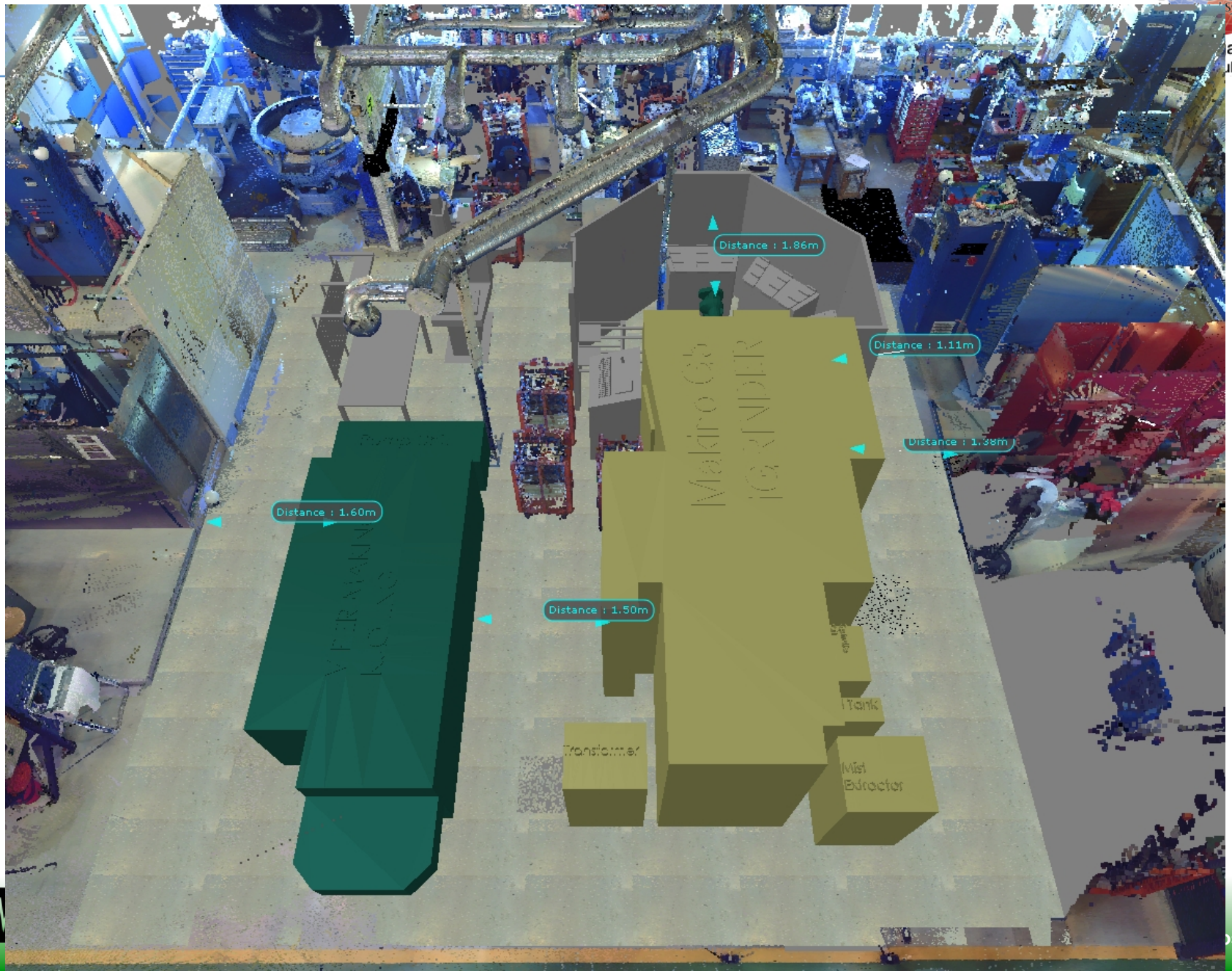




Balance

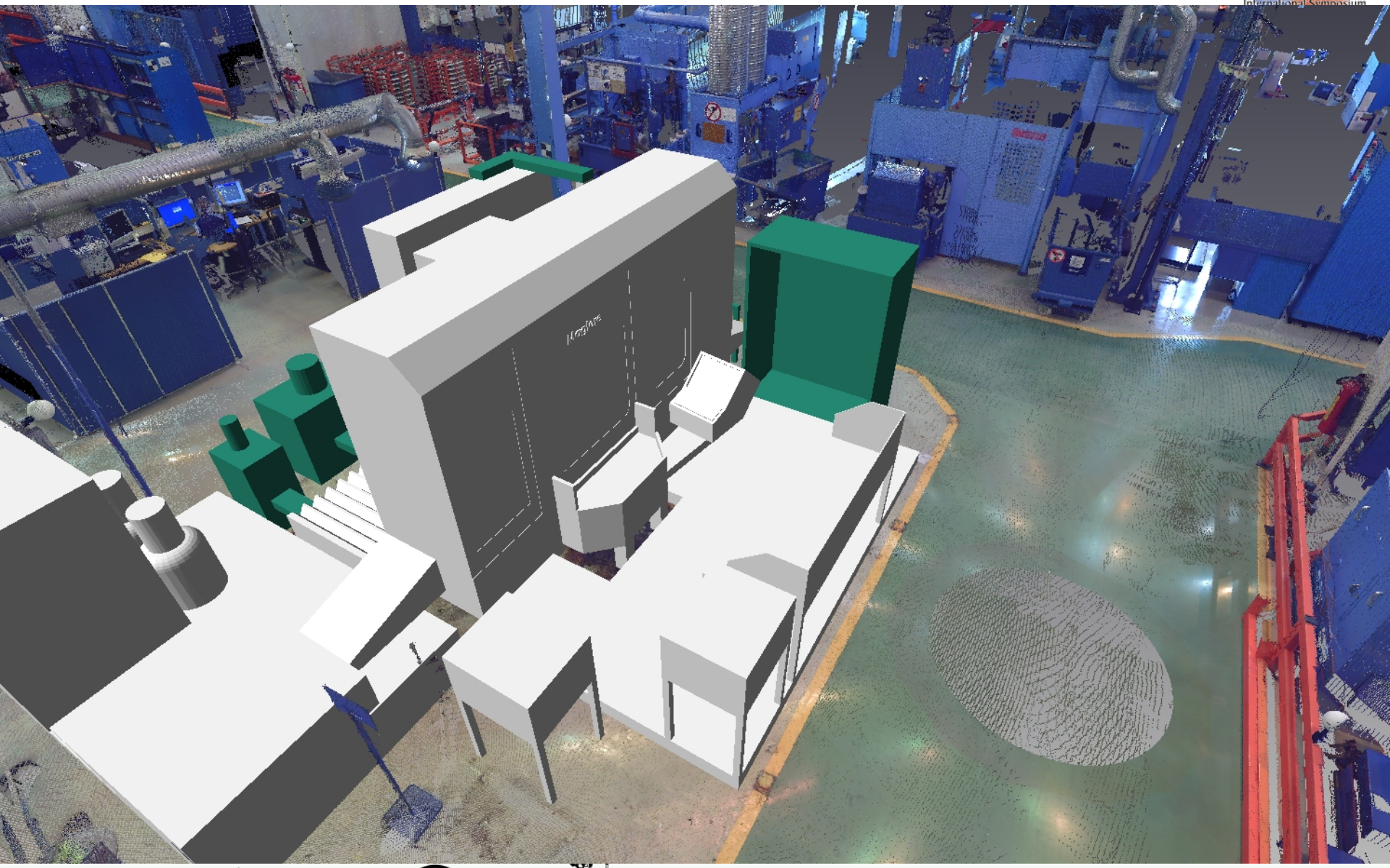
- we found that *guidance* prevented the disadvantages of *low credibility* in models high on *assumptions*, and the distraction of attention with *multiple views*.
- *Active models* we found to prevent stakeholders from being stuck in the boundaries of *high detail* models because we could *actively* remove details or rearrange the model during the meeting session.
- On a general level, we could say that the impact factors in the *model usage* category can prevent the disadvantages from the impact factors in the *visual model attributes* and *content of model* categories.


“Point Cloud” technology to get quick results



Point Cloud example 2



Cost versus value

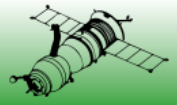
- Value: *increased understanding* of current situation and problem, *investigation* of alternatives and uncertainties reduces project risk
- Cost: should be low for understanding, may be somewhat higher for exploration

	Understanding Phase	Exploration Phase	Verification Phase
Number of models explored	8	11	3
Average creation time (h)	2,5	5,5	3
Average number of iterations	1,5	3	1

Summary and Conclusions

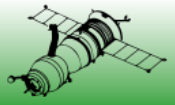
- We studied 8 impact factors
- during 9 months at GKN Aerospace
- in 22 Models

- the *visual model attributes* are more dominant towards the middle and the end of projects.
- *Model content* and *model usage* are more dominant in the start and middle of projects.

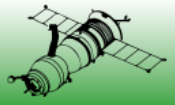

Future Research

- generalize results to other domains
- study other impact factors (see slide 13)
- study impact of stakeholders and their background
- study dynamic process models
- elaborate cost-value balance


Acknowledgements

- Ole Hoen and Even Engebakken
- The people in the technology department at GAN


Questions

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