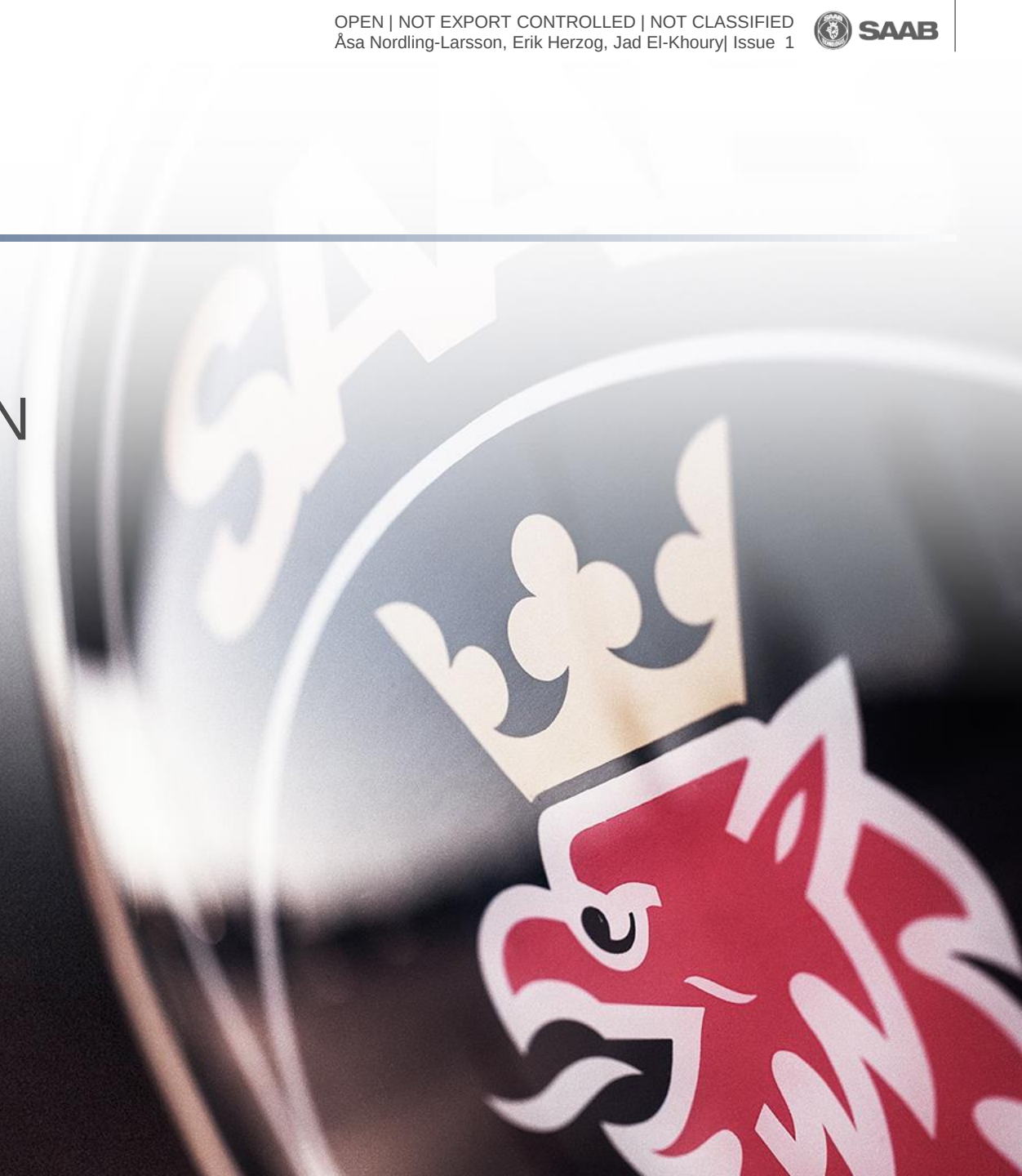
EXPERIENCE FROM INTRODUCING SYSTEMS ENGINEERING IN AN ACADEMIC ENVIRONMENT USING AN INDUSTRY TRAINING COURSE

MODPROD 2018



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AGENDA

- What is a SAAB?
- What is the challenge in development of complex systems?
- Student competence mismatch
  - From the SAAB perspective
- Opportunities for introducing Systems Engineering in the Swedish educational system
- Experience from an initial experiment at KTH
- Conclusions

SAAB - THE DOMAIN

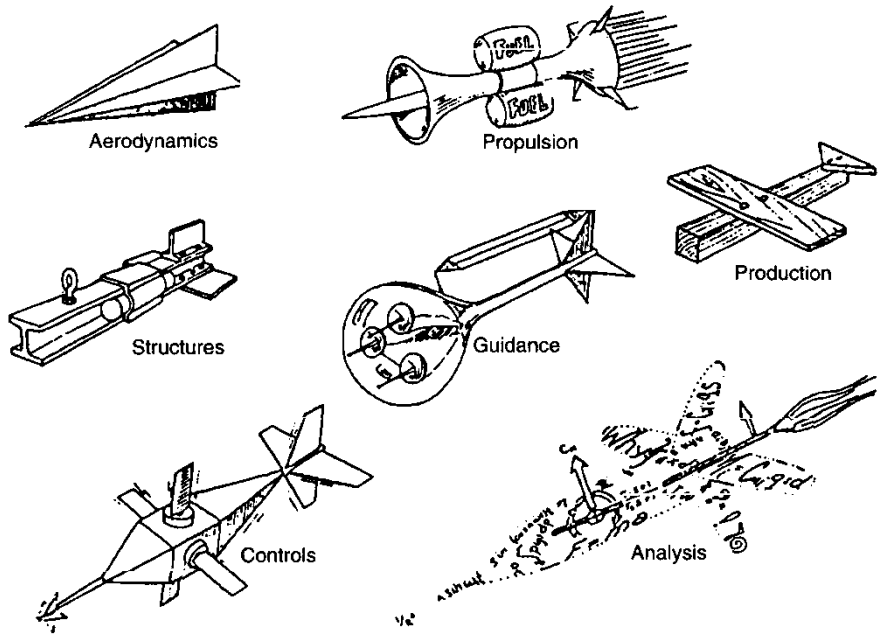






WHAT IS THE CHALLENGE?

- Formal models, simulations results, proofs matter little if we aren't in agreement on what we are building
- Safety analyses, no matter how elaborate, of a system we do not intend to build has little value
- Parts designed and built, but not compatible in the intended configuration has little utility even though they may be fully verified
- The merit of the design solution is low if it not sufficiently safe or if it can not be maintained
- **Optimising the whole – not the parts**
  - **Mastering development is not about improving domain engineering methods but methodology for understanding and communicating system design**



COMPLEXITY DRIVERS

RCS

Fuel consumption

Center of Gravity

Safety

Availability

Operational cost

Payload

Service life

Flight envelope

Fuel capacity

Weight

Environmental impact

Range

Supportability

Development Cost

Maintenance interval

Security

THE SITUATION FACING OUR NEW RECRUITS

Lifecycle management
Verification & Validation of heterogeneous systems
System of systems
Requirements management
Systems thinking
System integration
Systems architecting and design
Reliability, Availability & Maintainability
Systems engineering
System safety
Operations analysis
System modelling & simulation
Multi-disciplinary trade studies
Configuration management
Development of heterogeneous systems
Human system integration

Computer Science
Machine design
Electronics engineering
Engineering management
Material sciences
…
…
…
Logistics
Aeronautical engineering

Ecomics, HR, Law, …




CONTINUOUS COMPETENCE DEVELOPMENT

- Internal training programs
- General Systems Engineering courses
  - 6-20h introductions
  - INCOSE CSEP preparation courses
    - 20 students/year
- Dedicated courses in
  - Safety
  - ILS
  - Architecture
  - …

Can such an introduction be valuable to students?

IDEA AND EXECUTION

- Test whether the standard SAAB Systems Engineering introduction course will make sense to senior engineering students
- Minimal modification to course contents
  - SAAB specific details removed
- Course given at the Mechatronics Master's program at KTH
  - Spring term, year 4
- Given for 60 students
- An opportunity to communicate industrial challenges to students and faculty

THE SETUP

Engineering Design Programme 2017-19
Mechatronics Track

<table>
<tr><th colspan="4">Year 1 (60 hp credits)</th><th colspan="4">Year 2 (60 hp credits)</th></tr>
<tr><th colspan="2">Fall 2017</th><th colspan="2">Spring 2018</th><th colspan="2">Fall 2018</th><th colspan="2">Spring 2019</th></tr>
<tr><th>P1</th><th>P2</th><th>P3</th><th>P4</th><th>P1</th><th>P2</th><th>P3</th><th>P4</th></tr>
<tr><td colspan="2">MF2095 C Programming for Embedded Systems (3hp)</td><td colspan="2">MF2042 Embedded Systems I (6hp)</td><td colspan="2">free electives (6hp)</td><td colspan="2">MF2071 Research Methodology in Mechatronics (4.5hp)</td><td rowspan="3">Master thesis project in Mechatronics (30hp)

MF214X
(CivIng students only)
MF224X
(MSc students only)</td></tr>
<tr><td colspan="2">MF2030 Mechatronics Basic course (6hp)</td><td rowspan="2">free electives (9hp)</td><td>MF2007 Dynamics and Motion Control (9hp)</td><td>MF2044 Embedded Systems II (6hp)</td><td colspan="2">free electives (10.5hp)</td><td colspan="2">MF2059 Mechatronics Advanced Course part 2 (15hp)

OR
MF2091 Engineering Design Research Project (15hp)</td></tr>
<tr><td colspan="2">MF2043 Robust Mechatronics (6hp)</td><td colspan="2">MF2058 Mechatronics Advanced Course part 1 (9hp)</td><td colspan="2"></td><td colspan="2"></td></tr>
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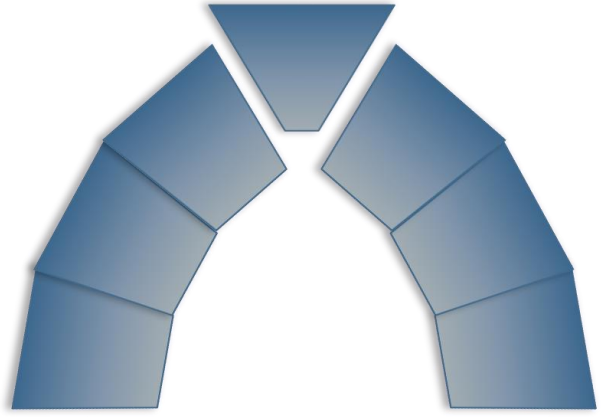
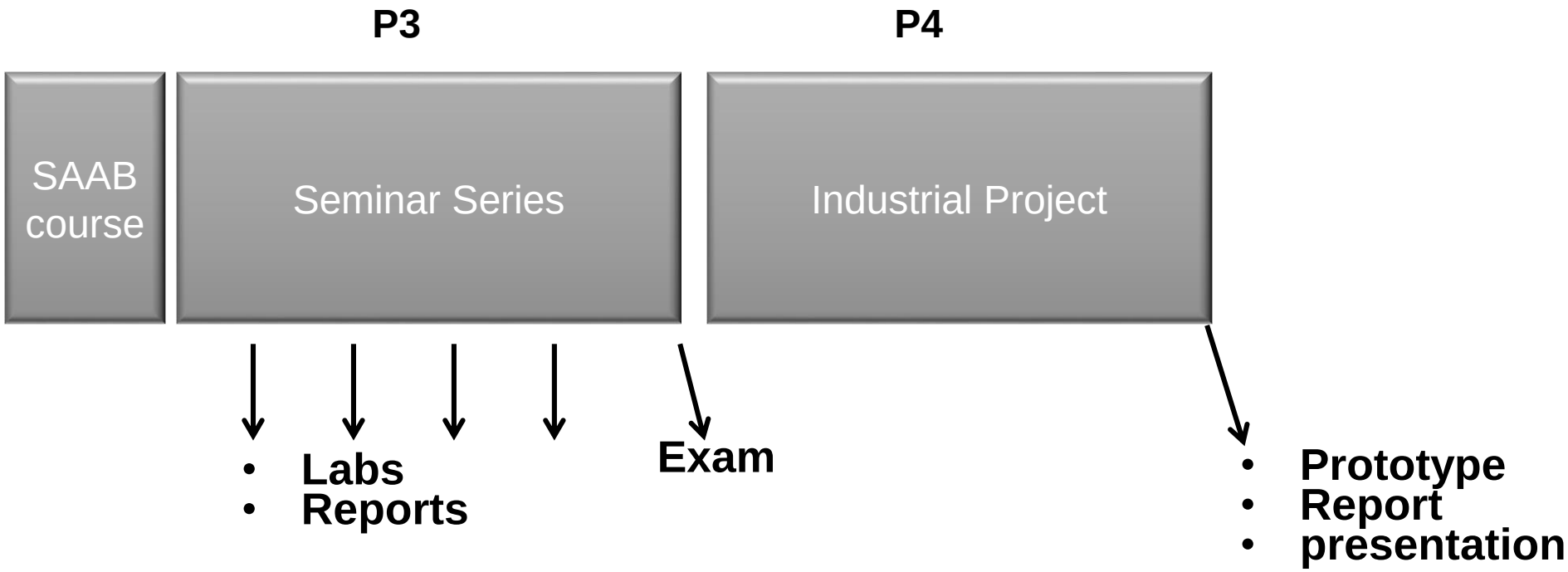
Capstone course

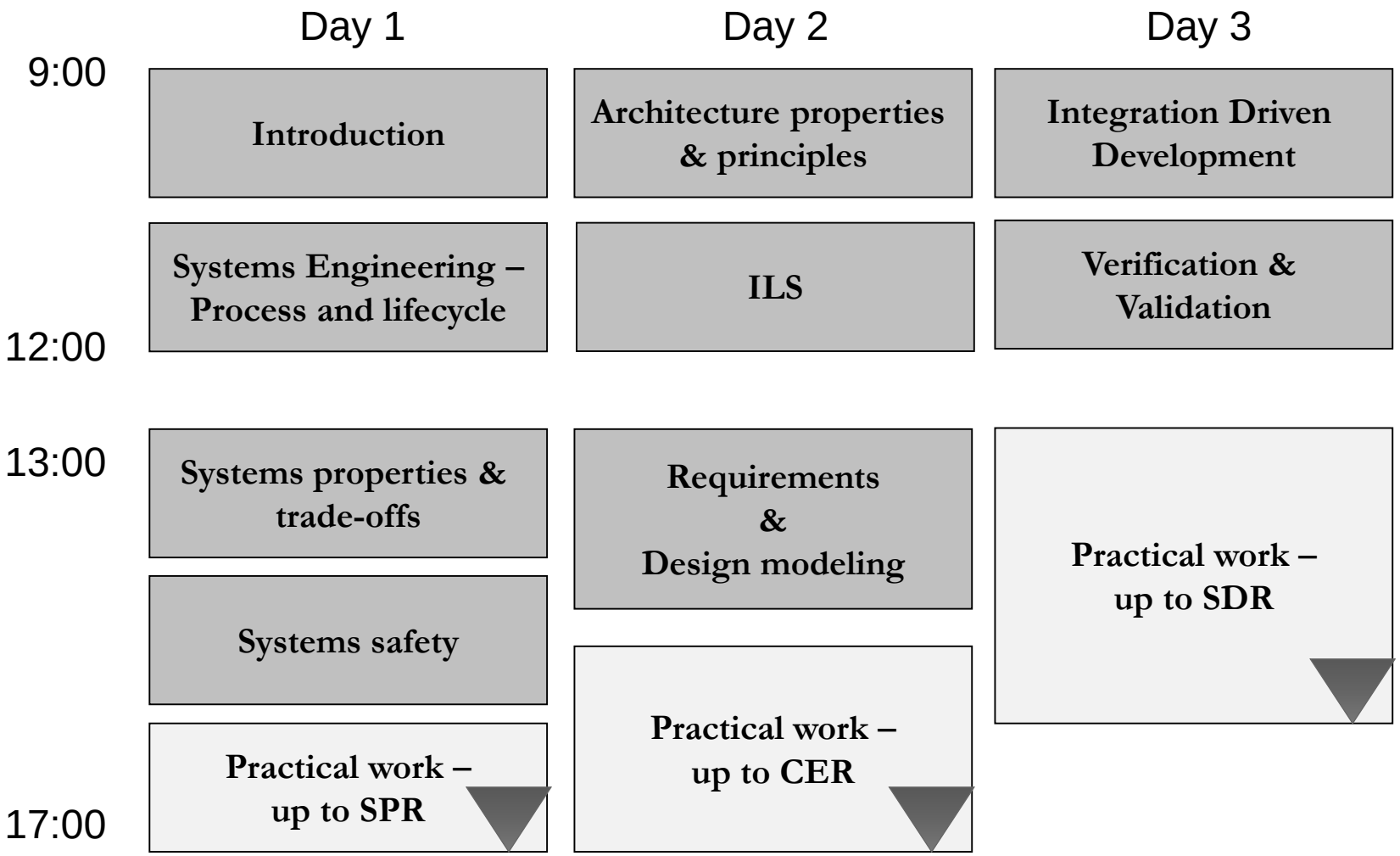


Designed to allow students to show that they can apply knowledge they have acquired on real projects

MF2058 MECHATRONICS ADVANCED COURSE, PART I



SAAB COURSE SETUP

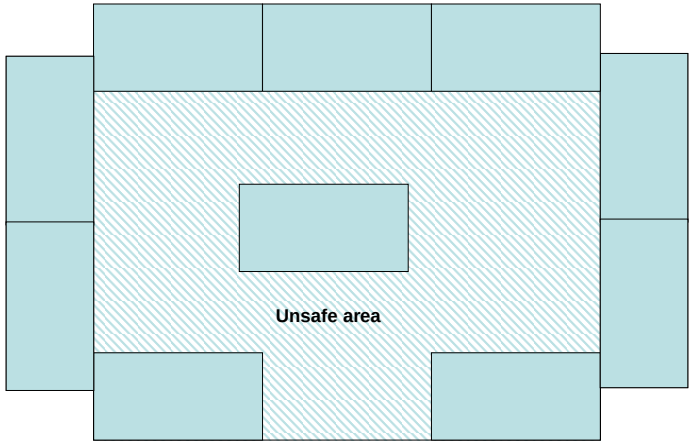


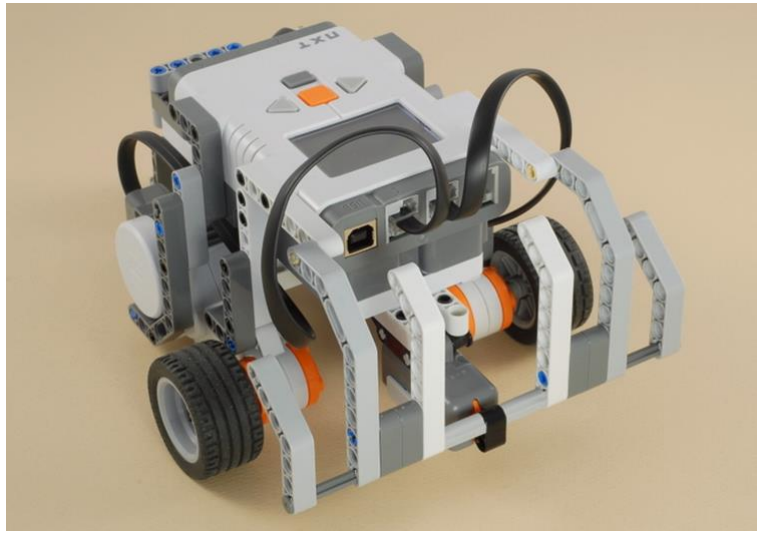
Course objectives

- Multi-domain example
  - Time pressure
- Process
- Importance of Planning
  - Follow the plan
- Non-functional properties
  - Safety!

THE PRACTICAL PART

- Extracting valuable objects from unsafe building
- Autonomous vehicle, must not move the walls of the building
  - Safety is an issue here
- Based on LEGO Mindstorms
- Reliability information for all LEGO sensors have been produced
- The task in to exercise the Engineering process
  - Requirements
  - Design
  - Integration
  - Verification and Validation
  - Technical reviews
- For the students the tricky part of the exercise are
  - to realise that a proper safety analysis is required
  - To properly plan for all activities that have to be performed

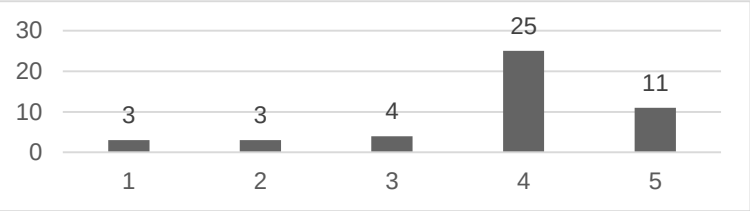




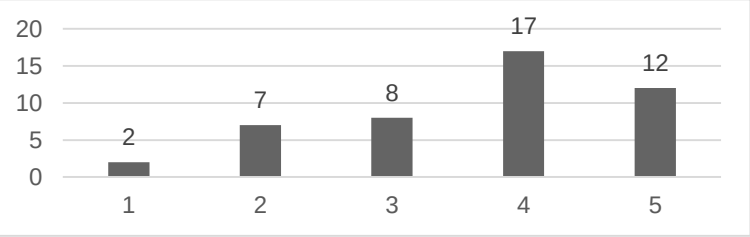
EVALUATION 2017

- Generally positive feedback
- First encounter for students for topics like
  - Systems Engineering
  - Safety
  - Reliability, Availability, Maintainablity
  - Integration
  - Verifcation and Validation
- In the practical exercise many students complained that the task was unclear
  - This is a feature designed in on purpose on the exercise
  - Need to understand the problem, before trying to solve it
- Once the challenges was understood we saw an extraordinary level of creativity
  - Students compained that there was not sufficient time to fully implement their practical solution
- For SAAB, an excellent communication opportunity
  - Meeting the senior students that will soon be available for thesis work

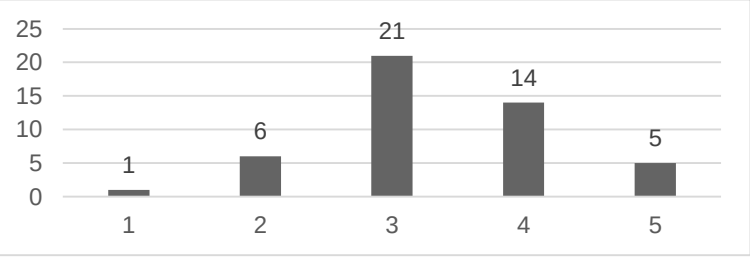
Coupling to course objectives – 5 optimal



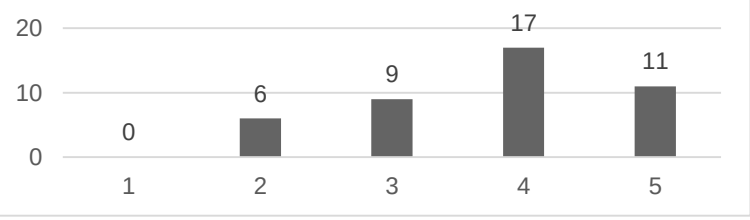
Theory practise mixture – 5 optimal



Course length – 3 optimal



Course element integration – 5 optimal

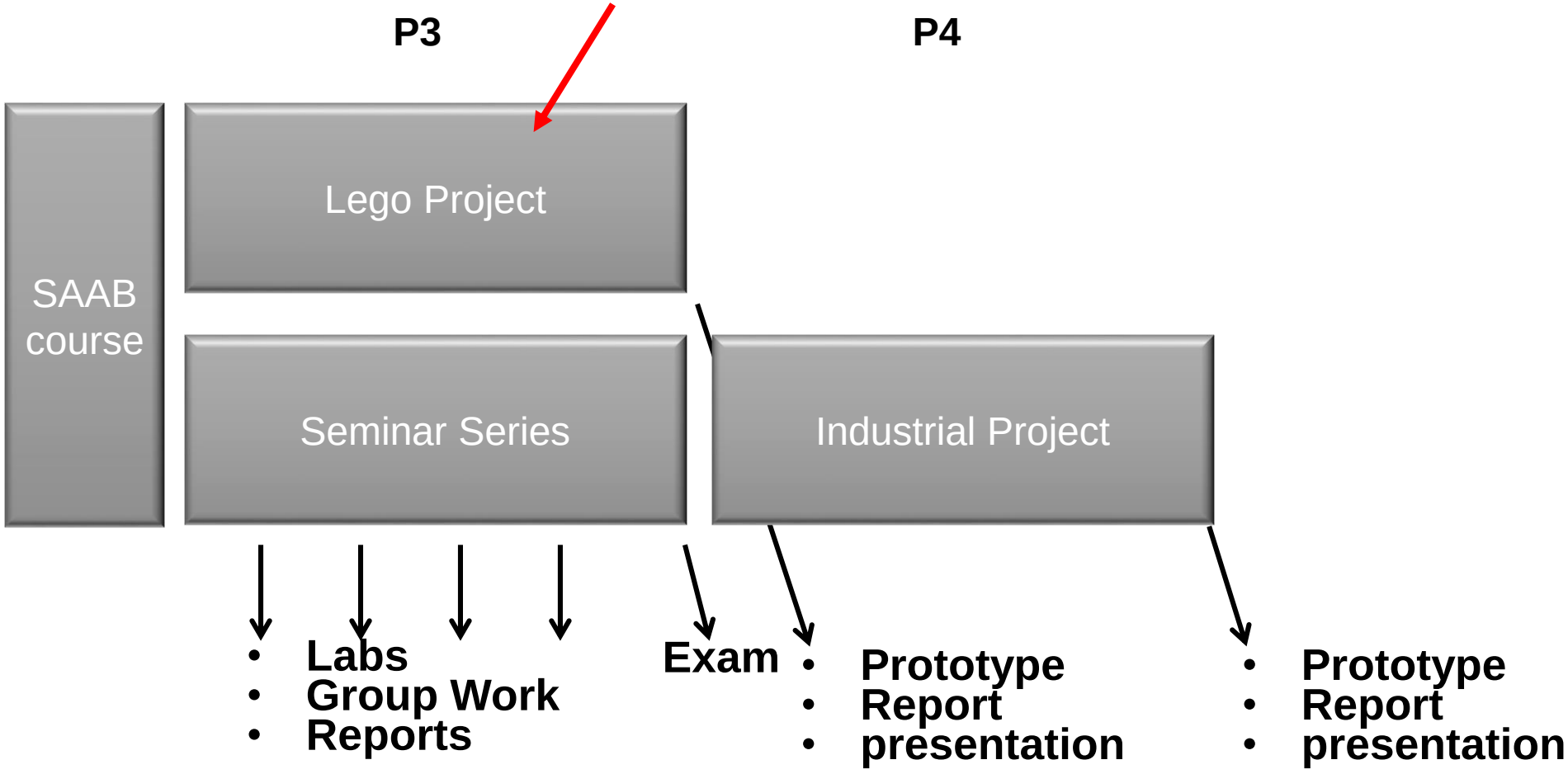


CONCLUSIONS AND WAY AHEAD

- Value added to the KTH course and students
  - Real world perspective from credible people
  - Real world large scale examples
- Lecturing to students does add value for SAAB lecturers
  - Need to focus the message in concise way
  - Early recruitment opportunity
- Need to strengthen the integration with the rest of the KTH course
  - Students requested a full implementation project to practise the application of Systems Engineering

2018 COURSE SETUP

Collaboration between 2 lego mindstorms robots to extract an object from an enclosed area



SUMMARY

- Can Systems Engineering be taught to students?
  - Absolutely, preferably coupled with a practical project!
- Standard internal course
  - Minimal investment
  - Course content is tailored and simplified in order to not overwhelm the audience
- Energy boost for the lecturers
  - Meet young, interested and creative students
- A good investment in SAAB’s future!