Abstract

The Systems Engineering Master education in Kongsberg requires from students that they work part-time. This document describes ideas behind the educational model with the part-time job where students build up engineering experience. This experience helps to appreciate Systems Engineering teaching, it facilitates their further personal development in becoming broader engineers.
The objective of the industry master in systems engineering is to **accelerate** the **competence development** of new systems engineers, from e.g. 10..20 years in the past to 5..10 years.

Core of the acceleration is **experiential learning**, where offering **theory** and building up **experience** happens **concurrently** and is used to **reinforce learning**.
Evolution from Engineer to Systems Engineer

tradionally systems engineers "grow" in decades

depth of knowledge

breadth of knowledge

all-round engineer

aspect systems engineer

systems engineer

mono-disciplinary root knowledge to be maintained

mono-disciplinary

system

legend
Intended growth of Industry Master students

- Bachelor
- Master
- On the job training
- Systems engineer
- Theory
- Practice
- Depth of knowledge
- Breadth of knowledge
- Time
- Mono-disciplinary root knowledge to be maintained

Legend:
- System
- Mono-disciplinary
Mandatory Core of the Program

theory oriented (with practice woven in)

SEFS Fundamentals of Systems Engineering
SEAD Architecture and Design
SEPM Project Management of Complex Systems
SESI Systems Integration

facilitating experiential learning

SERP Reflective Practice (9 workshops over 3 years)
SEMP Master Project (6 month full-time)
Master programme in Systems Engineering 120 ECTS
- Mandatory courses 7.5 ECTS each*
  - SEFS 6102 - Fundamentals of Systems Engineering
  - SEAD 6102 - System Architecture and Design
  - SEPM 6102 - Project Management of Complex Systems
  - SSI 6202 - Systems Integration
  - SEMP 6301 - Master project (*30 ECTS)
  - SERP 6102 - Reflective Practices

Elective courses
52.5 ECTS in elective courses:
1: Minimum 22.5 ECTS in Systems Engineering courses = 3 courses
2: Maximum 30 ECTS from *Depth courses *industrial domain courses *business and management courses = 4 courses

Systems Engineering courses:
  - SERE 6302 – Robust Engineering
  - SEMA 6202 – System Modeling and Analysis
  - SESL 6202 – System Supportability and Logistics
  - SESA 6202 – Advanced System Architecting
  - SELD 6202 – Lean Product Development
  - SEKD 6202 – Knowledge Management
  - SEHF 6202 – Human Centered Systems Design

Industrial Domain courses:
  - SSOP 6202 – Production Technology & Application
  - SSAS 6202 – Production Systems Architecture
  - SSTS 6202 – Production System Technical Safety (TBC)
  - SEEM 6202 – Electric and Hybrid Vehicles Systems

Stevens Institute of Technology - Course choice pack = 30 ECTS:
  - Systems Engineering Courses - Systems Engineering
  - Business and management Courses - Management and Leadership
  - Industrial Domain Courses - Manufacturing
  - Industrial Domain Courses - Maritime Systems
  - Depth Courses - Data Exploration & Visualization for Risk & Decision Making
  - Depth Courses - Embedded Systems
  - Depth Courses - Robotics and Controls
  - Depth Courses - Modeling and Optimization

Depth courses:
  - SEPD 6202 – Advanced Materials
  - SEAM 6202 – Advanced Mechanical Engineering
  - Courses from the Embedded Systems Program – see website for details.
  - Courses from the Industrial IT and Automation Program – see website for details.

Business and management courses:
Courses chosen from the Systems Engineering with Industrial Economy Programme – see website for details.
*Please note that courses from both the Embedded Systems and Industrial Economy programmes are presented over a whole semester.

For electives from other universities or for a course program deviating from our standard requirements – permission is required from the Institute. Please contact Beate Calleja for more information. bc@usn.no
### Typical Industry Master Program Time Line

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Semester 2</th>
<th>Semester 3</th>
<th>Semester 4</th>
<th>Semester 5</th>
<th>Semester 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEFS</td>
<td>SEAD</td>
<td>SEPM</td>
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<td>SEMP</td>
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</tbody>
</table>

**Industry Master in Systems Engineering**

Gerrit Muller

version: 0

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IMSEstandardIMprogramTimeline
## Typical Course Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>SERE Robust Engineering</td>
</tr>
<tr>
<td>5</td>
<td>SEAM Advanced Mechanical Engineering</td>
</tr>
<tr>
<td>6</td>
<td>SEAD Architecture and Design</td>
</tr>
<tr>
<td>7</td>
<td>SSSA Subsea Production System Architecture</td>
</tr>
<tr>
<td>8</td>
<td>SESA Advanced Architecting</td>
</tr>
<tr>
<td>9</td>
<td>SERP Reflective Practice</td>
</tr>
<tr>
<td>11</td>
<td>SESL System Supportability and Logistics</td>
</tr>
<tr>
<td>12</td>
<td>SEAD Architecture and Design</td>
</tr>
<tr>
<td>15</td>
<td>SEHF Human Centered Design</td>
</tr>
<tr>
<td>16</td>
<td>SEEM Electric and Hybrid Vehicles Systems</td>
</tr>
<tr>
<td>22</td>
<td>SEST Systems Thinking</td>
</tr>
<tr>
<td>24</td>
<td>SEMP Master Project preparation</td>
</tr>
<tr>
<td>33</td>
<td>SERP Reflective Practice</td>
</tr>
<tr>
<td>33</td>
<td>SEMP Master Project preparation</td>
</tr>
<tr>
<td>35</td>
<td>SESI Systems Integration</td>
</tr>
<tr>
<td>36</td>
<td>SEFS Fundamentals of Systems Engineering</td>
</tr>
<tr>
<td>37</td>
<td>SEMA Architectural Reasoning Using Conceptual Modeling</td>
</tr>
<tr>
<td>37</td>
<td>SEMP Master Project preparation</td>
</tr>
<tr>
<td>38</td>
<td>SESI Systems Integration</td>
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<tr>
<td>39</td>
<td>SELD Lean product Development</td>
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<tr>
<td>41</td>
<td>SEFS Fundamentals of Systems Engineering</td>
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<tr>
<td>41</td>
<td>SEKD Systems Engineering Knowledge Management</td>
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<tr>
<td>42</td>
<td>SEPM Project Management of Complex Systems</td>
</tr>
<tr>
<td>44</td>
<td>SSTS System Technical Safety</td>
</tr>
<tr>
<td>47</td>
<td>SERP Reflective Practice</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Skills</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The candidate...</td>
<td>The candidate...</td>
</tr>
<tr>
<td>- has advanced knowledge within the academic field and specialized insight in a limited area</td>
<td>- can analyze and deal critically with various sources of information and use them to structure and formulate scholarly arguments</td>
</tr>
<tr>
<td>- has thorough knowledge of the scholarly or artistic theories and methods in the field</td>
<td>- can analyze existing theories, methods and interpretations in the field and work independently on practical and theoretical problems</td>
</tr>
<tr>
<td>- can apply knowledge to new areas within the academic field</td>
<td>- can use relevant methods for research and scholarly and/or artistic development work in an independent manner</td>
</tr>
<tr>
<td>- can analyze academic problems on the basis of the history, traditions, distinctive character and place in society of the academic field</td>
<td>- can carry out an independent, limited research or development project under supervision and in accordance with applicable norms for research ethics</td>
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</table>
## Industry Master Program Learning Outcomes

### Knowledge

The candidate...

- has advanced knowledge within the interdisciplinary field of systems engineering and specialized insight in engineering, and innovation management and leadership
- has thorough knowledge of Systems Engineering and detailed knowledge of methods, techniques, and tools according to international standards and professional societies of systems engineering.
- can apply systems engineering methods and techniques to new areas within innovation and systems development
- has knowledge of fitness-for-purpose, stakeholders satisfaction, and mindset of holistic view, human-centered, and continuous improvement
- has knowledge of relevant methods for research of the innovation and systems engineering body of knowledge

### Skills

The candidate...

- can analyze and deal critically with various sources of information and use them to structure and formulate Systems Engineering arguments
- can analyze existing theories, methods and interpretations in the interdisciplinary field of systems engineering and work independently on practical and theoretical problems
- can apply theoretical knowledge of Systems Engineering to problems encountered in his work independently and as part of an engineering team
- can use Systems Engineering methods and techniques to make system designs with fitness-for-purpose and stakeholders satisfaction
- can carry out an independent, limited research of the systems engineering body of knowledge or innovation and systems development project under supervision and in accordance with applicable norms for research ethics
- can apply the mindset of holistic view, human-centered, continuous improvement and leadership in systems development

### General Competence

The candidate...

- can analyze and synthesize systems engineering problems in the broader social, ethical, economical, industrial context
- can apply his/her knowledge and skills in new areas in order to carry out advanced innovation and systems development assignments and projects
- can communicate extensive independent work and master's language and terminology of the interdisciplinary field of systems engineering
- can communicate, as a broad technical engineer, systems engineering related issues, analyses and conclusions with a broad variety of stakeholders
- can contribute to new thinking and innovation processes in innovation and systems development
- can use his insights in the fields of ethics, work-life, business, market, applications, processes, and organizations
- can develop into a full systems engineer within five to ten years.
- can be qualified to embark on the road to becoming a highly qualified systems engineer, with the capability of supervising complex endeavors in private or public enterprises.
Overload of Impressions for Fresh Bachelors

1. **Project**
   - Cost pressure
   - Time pressure

2. **Finance**
   - EBITA
   - RONA
   - ROI
   - NRE
   - Sales price
   - Margin
   - Cost

3. **Business Functions**
   - Quality assurance
   - Logistics
   - Production
   - Sales
   - Service

4. **Customer Life Cycle**
   - Legacy
   - Installed base
   - Problems

5. **Process/Organization**
   - Processes
   - Procedures
   - Tools
   - Organization
   - Requirements
   - Engineering
   - Testing
   - Documentation
   - Changes

6. **Systems Engineering**
   - Components
   - Technology
   - Functions
   - Products
   - Systems

7. **Humans**
   - CEO
   - CFO
   - Other disciplines
   - Managers
   - Colleagues
   - Project leader

8. **Tools**

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IMWEcontextExperience
What is Competence?

<table>
<thead>
<tr>
<th>Attitude (perseverance, faith, critical, constructive, etc.)</th>
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*train*

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<thead>
<tr>
<th>Ability (know when to use what skill and knowledge)</th>
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</table>

*apply/use often, experience*

<table>
<thead>
<tr>
<th>Skills (calculate missing angle, calculate hypothenusa)</th>
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</table>

*exercise*

<table>
<thead>
<tr>
<th>Knowledge (triangle has 3 corners, sum of angles is 180 degrees, Pythagoras $c^2 = a^2 + b^2$)</th>
</tr>
</thead>
</table>

*learn*

Competence = Knowledge + Skills + Ability + Attitude
Competence Program Partitioning

- **what**
  - Attitude
  - Ability
  - Skills
  - Knowledge

- **how**
  - Lecturing
  - Exercises
  - Assignments
  - Practice
  - Coaching
  - Reflection

- **who**
  - Participant
  - Teacher/coach

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AACLcompetenceProgram
Reflective Practice

School (Theory)
- SE courses

Work (Practice)
- work in company

Master Project
- last half year of study

Workshops during first years of study