How to start a new Master Study in Systems Engineering?

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Abstract. Starting a new master in Systems Engineering is a challenging endeavor. This paper transforms experiences of starting such new master into a limited set of recommendations.

Introduction

This paper is based on the experiences of starting a new master in Systems Engineering at Buskerud University College in Kongsberg, Norway. Local industry identified Systems Engineering as core competence of the local industry. They started a Norwegian Centre of Expertise in Systems Engineering (NCE-SE) (Bjørnson 2007) with support of national and local government in 2005. NCE-SE identified several projects to strengthen the systems engineering competence. One of these projects was a master in systems engineering at the local university college. The master was bootstrapped by "buying" a complete master study from Stevens Institute of Technology in Hoboken, NJ; teachers from Stevens Institute flew to Kongsberg to teach courses locally. In summer 2009 the university college got accredited to deliver the master themselves. The accreditation proposal (Austenå 2008) was based on an INCOSE report (Jain 2007). The experiences of starting this master are documented in (Muller 2008, 2009, and 2012); more background material can be found at http://www.gaudisite.nl/BUCmasterSE.html.

When starting a new master education, we need to understand our main stakeholders. Typically, these are:

- Students
  - Freshmen
  - Experienced employees
- University leadership
- Staff:
  - Current staff of university
  - Future staff in systems engineering
- Current and future employers of systems engineering students
- Regulations related, e.g. accreditation and certification bodies
- Funding organizations

In the remainder of the paper we will work from the stakeholders' perspective.

Recommendations for setting up a new study in Systems Engineering

In most cases the primary driver for systems engineering education is the need of current and future employers. Employers experience a shortage of systems competence and foresee an

even larger shortage in the future.

Recommendation 1: Engage the employers closely in the set-up and evolution of the study.

Students in systems engineering can be freshmen that did a bachelor in science or engineering, or they may have several years of engineering experiences as employee. In many cases, students have been formed in engineering: How to get a reliable and accurate result for a well-defined problem. The systems engineering education has to help them in a transformation from mono-disciplinary engineer into a systems engineer. This transformation requires several essential steps:

- From mono-disciplinary to multi-disciplinary
- Connecting system internals to external stakeholders, including customers and users
- Understanding the full life cycle
- Coping with inherent uncertainties, unknowns, and heterogeneity in the system, its context, and its life cycle.

Typical master education in other disciplines consists of more knowledge and skills in the form of methods, techniques, formalisms, and tools. However, the transformation sketched above, is not achieved by conventional education. Experience and reflection plays a crucial role, see Chapter 11 of (Muller 2011).

Recommendation 2: Facilitate students in obtaining experience concurrently with their study and in connecting theory and practice by reflection.

Universities have often well-established organizations. Introducing any new study probably will hit resistance from existing staff and studies. Be aware, that a new study in first instance is perceived as competition for students and funding. Existing staff will see new studies as threat, and probably does not see the added value of something vague as systems engineering. Do not invest in converting existing staff, unless there is evidence that they are open, willing and capable to move into this world. Given such resistive environment, the support of university leadership is crucial.

Recommendation 3: Ensure support for systems engineering from university leadership.

Teaching staff in systems engineering is scarce. The main competence of systems engineers is found at employers in the practitioners themselves. The academic systems engineering is so young that few academic systems engineers exist. Unfortunately, many practitioners miss the reflective or didactic capabilities to evolve into academic teachers. Growing an educational staff in systems engineering takes time. Be aware of the cultural differences between the academic and industrial world, see (Muller 2005)

Recommendation 4: Scout at employers for potential teachers and foster potential candidates.

Gradually, systems engineering gets more defined as discipline. The curriculum of a new study in systems engineering will have to be recognized by accreditation agencies. The systems engineering curriculum will typically consist of a mandatory core and tailoring by offering a collection of electives. The whole program (core + electives) needs a balance in depth and breadth. More conventional auditors tend to look for depth, mentally equating that to rigor. The systems engineering practice may result in a very broad program.

Recommendation 5: Balance breadth and depth in the curriculum; accept that the curriculum can never have full coverage. After graduation the curriculum should facilitate masters to expand their competence.

Creating and running an education is a kind of business. Nevertheless, many universities, especially in Europe, are not used to think in business terms. When setting up such new study, there are a number of major concerns:

- How to get initial funding to build the new study (this requires an investment)?
- What is the sustainable business and operational model in the steady state?

The initial phase will take between 5 and 10 years. In these initial years, expenses precede income; the university is investing. In the steady state, there should be a healthy margin between expenses and income, such that research and courses development can be done to keep the study up-to-date. Attention should be paid to the fact that the performance in the initial years is often critical for the funding in the steady state. Hence, the business model for the steady state should be developed at the beginning, to ensure a proper build-up of trust.

Recommendation 6: Develop a business model for the systems engineering study right at the beginning.

Universities are used to a traditional teaching model, where courses are delivered a few hours per week for a semester. This teaching model does not fit well for students who are working part-time in industry. The necessity to be present every week at different times during the week introduces a lot of overhead, in traveling, but also mentally because of frequent context switches. Employers feel more constraints from this fragmented teaching model; the employee is regularly and frequently missing. By concentrating courses in a block of a few days or a week, the courses become less disruptive for employers and the overhead is reduced for the students.

Recommendation 7: Develop a teaching model that fits the needs of students and employers; creativity and perseverance will be required to get acceptance in the traditional university environment.

Conclusions

Starting a new master in systems engineering can be approached as the creation of a complex system. Starting point is the understanding of the stakeholders, their needs, and their concerns. In this paper, we have translated these in recommendations for:

- Employer relations
- Experience build-up
- Governance
- Program structure and content
- Staff
- Business model
- Teaching model

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Author Biography

Gerrit Muller.

Gerrit Muller, originally from the Netherlands, received his Master's degree in physics from the University of Amsterdam in 1979. He worked from 1980 until 1997 at Philips Medical Systems as a system architect, followed by two years at ASML as a manager of systems engineering, returning to Philips (Research) in 1999. Since 2003 he has worked as a senior research fellow at the Embedded Systems Institute in Eindhoven, focusing on developing system architecture methods and the education of new system architects, receiving his doctorate in 2004. In January 2008, he became a full professor of systems engineering at Buskerud University College in Kongsberg, Norway. He continues to work as a senior research fellow at the Embedded Systems Institute in Eindhoven in a part-time position.
All information (System Architecture articles, course material, curriculum vitae) can be found at: Gaudí systems architecting http://www.gaudisite.nl/