A Survey of Mechatronics Education in the Nordic and Baltic Countries

M. Ottestad[1,a], G. Hovland[1,b], S. Persson[1,c], K.G. Robbersmyr[1,d], J. Pohl[1,e]

[11]Agder University College, Faculty of Engineering and Science, Grimstad, Norway

{[a]morten.ottestad, [b]geir.hovland, [c]sara.persson, [d]kjell.g.robbersmyr, [e]jochen.pohl }@hia.no

Keywords: Mechatronics education.

Abstract. This paper describes mechatronics education programs in terms of the extent to which mechatronic courses are developed and their course content emphasis (i.e., electrical/computer engineering vs mechanical engineering and system courses vs analytical courses). A selective survey of some mechatronics education programs in the Nordic and Baltic countries is presented and the programs are compared. The survey revealed that the investigated universities have self-contained mechatronic departments with research activity and their programs are optimized from a mechatronics point of view. The small universities focus their education towards the local industry, while the larger universities' programs are more general.

1.0 Introduction

The term mechatronics came originally from Japan in the late 60s, see for example [1] and has since spread all over the world. Over the past decade, there has been a significant growth internationally in the provision of postgraduate, undergraduate and other courses in mechatronics [2]. This paper surveys some of the new providers of mechatronic education in the Nordic and Baltic countries. There have been other similar surveys in the past, for example [3] for the UK, but to our knowledge this paper is the first surveying the Nordic and Baltic countries.

A challenge in mechatronics as a study discipline is to find the right organization and focus between courses in mechanical, electrical and computer engineering. At Agder University College (AUC) we have categorized mechatronics study plans at different universities into four levels shown in Table 1.

Level	Description
Level 1	Existing courses from other departments are integrated into a study plan in a mechanical or electrical engineering department.
Level 2	A new mechatronics study program is created within existing mechanical, electrical and/or computer engineering departments. The study program is a combination of existing and newly developed courses and one or more persons coordinate the study program.
Level 3a	A separate mechatronics department is created at the same level as other departments in mechanical and electrical engineering. The study program structure and contents are optimized from a mechatronics point of view and the department conducts research and has PhD students.
Level 3b	Same as level 3a, but with an adaptation of the study program towards a local industry.

Table 1: Four different levels of mechatronics education programs.

In the survey we have made an attempt to categorize the surveyed mechatronics study programs into the four levels shown in Table 1. However, this categorization is difficult and in some cases we have had to make a qualified estimation based on public available information. The number of

students in Table 1 are based on the number of students studying a specialization in mechatronics, e.g., in a general MSc program in Systems or Control Engineering.

Another way to categorize a mechatronics education is illustrated in Figure 1. This figure has two axes, where the horizontal axis distinguishes between mechanical and electrical engineering, while the vertical axis distinguishes between system courses and methods/analysis courses. The organizers of mechatronics study programs in Levels 3a and 3b described in Table 1 have often made a conscious decision where they want to position their study program according to the categories in Figure 1. The mechatronics study programs at the different universities included in this survey are placed according to the two axes in Figure 1. Except for the two circles for AUC (BSc and MSc), an accurate placement of the other study programs is a difficult exercise and is mainly based on the perception of the authors.

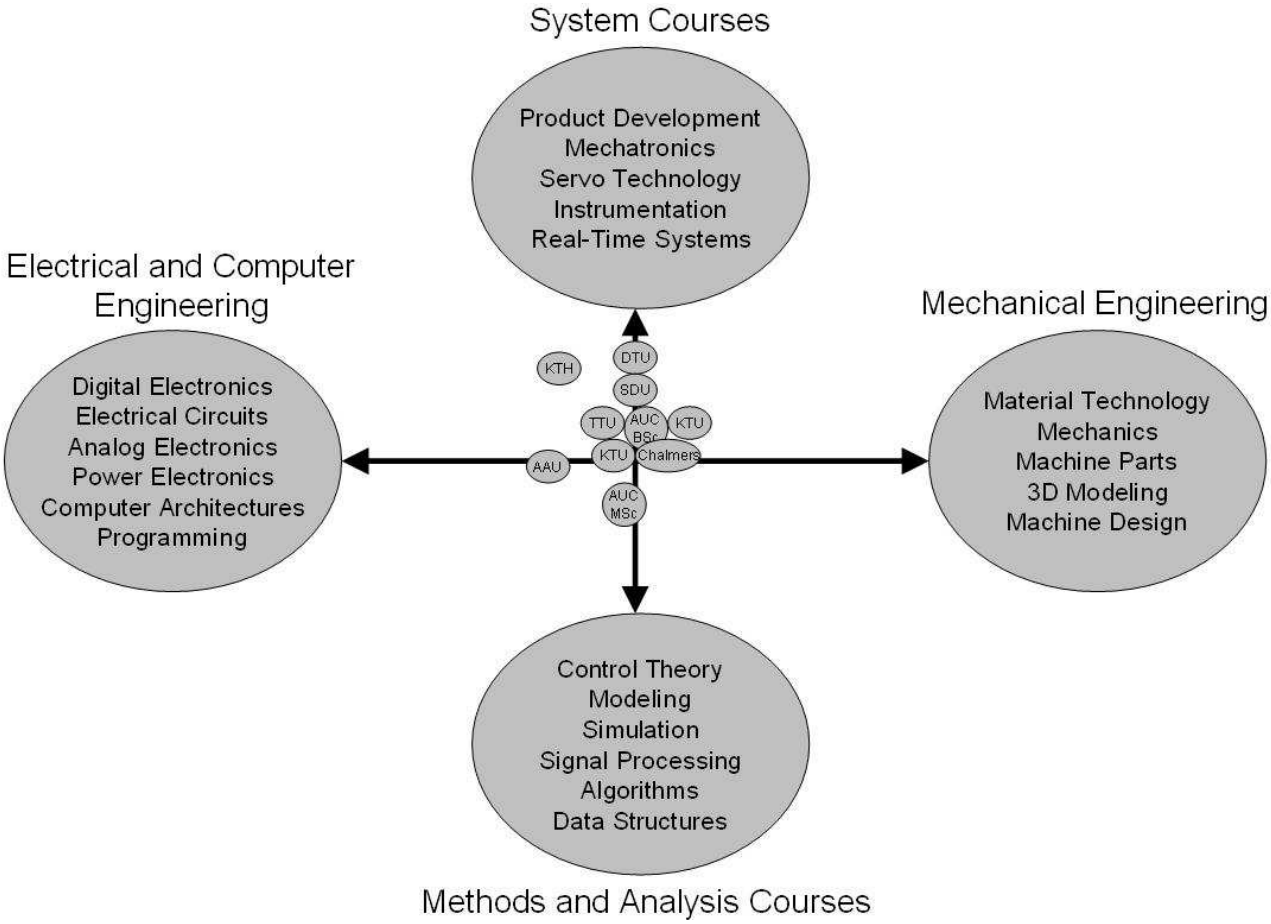

Figure 1: Categorization of Mechatronics Study Program.

2.0 Survey

This section describes some statistics about a few selected mechatronic education providers in the Nordic and Baltic countries. First, Table 2 shows the statistics and then a paragraph is written about each participant in the survey.

Institution	Level	First Program Started	Bachelor students per year	Masters students per year	PhD students per year
AUC - Norway	3b	1988	60 - 90	15 – 30	1 - 3
TTU - Estonia	3b	2003	39 – 45	19 - 25	1 - 2
DTU – Denmark	3a	1996	50 - 60	20 - 25	1 - 3
SDU – Denmark	3b	1999	40	40	1 - 3
Aalborg – Denmark	3b	2001	15 - 20	15 - 20	1 - 2
Chalmers – Sweden	3a	2000	50	30	2 - 4
KTU – Lithuania	3b	1997	10 - 15	5 - 8	1 - 3

Table 2: Statistics from the survey participants.

2.1 Tallin University of Technology (TTU) – Estonia
Estonia is a relatively small country with a population of 1.3 million. Small-to-medium enterprises (SMEs) are dominating in industry and the economic growth is currently extremely fast. The keywords for the mechatronic industry in Estonia are fast development, wide coverage and flexibility. TTU collaborates with Elcoteq (producer of Ericsson and Nokia subassemblies), ABB, JOT Estonia (producer of mobile phone assembly robots), but SMEs are dominating and the education is focused on rapid prototyping towards the SMEs.

2.2 Technical University of Denmark, Aalborg University and the University of Southern Denmark - Denmark: Mechatronics is taught as a study discipline mainly at three Danish universities, Technical University of Denmark (DTU), Aalborg University (AAU) and The University of Southern Denmark (SDU). Academics from these three institutions also founded the Mechatronics Association (Mekatronisk Selskab, MS) in 2001. MS is an international association which organizes annual meetings. At DTU mechatronics is one of seven study disciplines in the Institute of Mechanics, Energy and Construction. This institute has its roots back to 1952 when the section for construction and product development was founded. In 1996 the institute merged with the two institutes for mechanics and control technologies. In this paper we have defined the year 1996 as the initial year for mechatronics education at DTU. SDU is a relatively young university which was founded in 1998. The Bachelor and Masters education programs in mechatronics are taught in the city of Sønderborg. The PhD education at SDU is shared with the Mads Clausen Institute (MCI). MCI aims at assisting small and medium-sized enterprises with technical know-how and product development. At Aalborg University (AAU) the mechatronics study program is called Electro-Mechanical System Design and is taught by the Institute of Energy Technology. The study program at AAU has a relatively high focus on hydraulic system design and also on problem-based learning and was established as a strategic collaboration between AAU and the company Danfoss.

2.3 Chalmers University of Technology – Sweden
The BSc in Mechatronics at Chalmers started in 2000 on demands from industry. The goal is to educate engineers with a broad knowledge base and who can function as a bridge between the classical engineering disciplines, machine design, electronics and computing. Unique to their education is the possibility to study a work-integrated-learning (co-op) program where 21 weeks of

paid work practice is part of the program together with theoretical courses. Currently, 20 students are enrolled in the general program and 30 students in the co-op program. The courses offered (in both the general and co-op program) are in mechanical engineering, electrical and computing engineering, general courses (quality, economy and organization, environment and energy, and English), basic courses (mathematics, and statistics) and mechatronics (control theory and projects, mechatronic projects, sensors and actuators, and final year thesis).

Similar to the BSc in Mechatronics, the MSc in Systems, Control and Mechatronics at Chalmers starts in 2007, aims at offering an education resulting in a broad, general knowledge base and proficiency without specialization in application or industry business area. Compulsory courses include modeling and simulation, discrete event systems, digital control and real-time control systems. Parallel to the compulsory courses, courses in different areas of specialization is offered. The specialization areas are automation, control systems and mechatronics. The mechatronics specialization includes courses in applied mechatronics, rigid body dynamics and computer based simulation.

The Royal Institute of Technology (KTH), Sweden, offers specializations in Mechatronics for students in BSc Mechanical Engineering and BSc Electrical Engineering. Students in MSc Mechanical Engineering are also offered a specialization in Mechatronics. The mechatronics specialisation at KTH contains mainly electrical engineering courses, possibly because the study program is targeted mainly at mechanical engineering students. For this reason we have not included the KTH study program in Table 1. However, academics at KTH are active in mechatronics research and education, see for example [4]. The authors at KTH strongly argue for a problem and project-based mechatronics education.

2.4 Kaunas University of Technology – Lithuania

The Mechatronics educational program at Kaunas University of Technology (KTU) was started in autumn of 1997 and the first BSc students graduated in spring of 2001. The department of Mechatronics was created as a mechatronics department from the beginning and did not grow out of a mechanical or electrical engineering department. However, the department is closely linked with mechanical engineering, and the PhD students graduate with a degree in mechanical engineering. The education program is targeted towards the local manufacturing, medical and electronics industries.

3.0 Mechatronics at Agder University College - Norway

Agder University College, Faculty of Engineering and Science was established in Grimstad in 1968 with the purpose of educating mechanical engineers with specializations in construction and production technologies. The study programs of electrical and civil engineering were established the year after. In 1986-7 academics from AUC visited the University of Dundee, which was the first university in the UK to appoint a professor in mechatronics, see [3]. As a result of the visit to Dundee, it was decided to establish a study program in mechatronics and the first students enrolled in 1988. In the beginning existing courses from mechanical and electrical engineering were used, but these were gradually replaced by separate mechatronics courses with the focus towards the local industry.

Figure 2 illustrates the BSc and MSc study programs at AUC. The colour coding in the figure distinguishes between courses in mechatronics, mechanical and electrical engineering, science and electives. As for most mechatronics programs there is an overweight of science courses in the beginning and an overweight of mechatronics courses at the end.

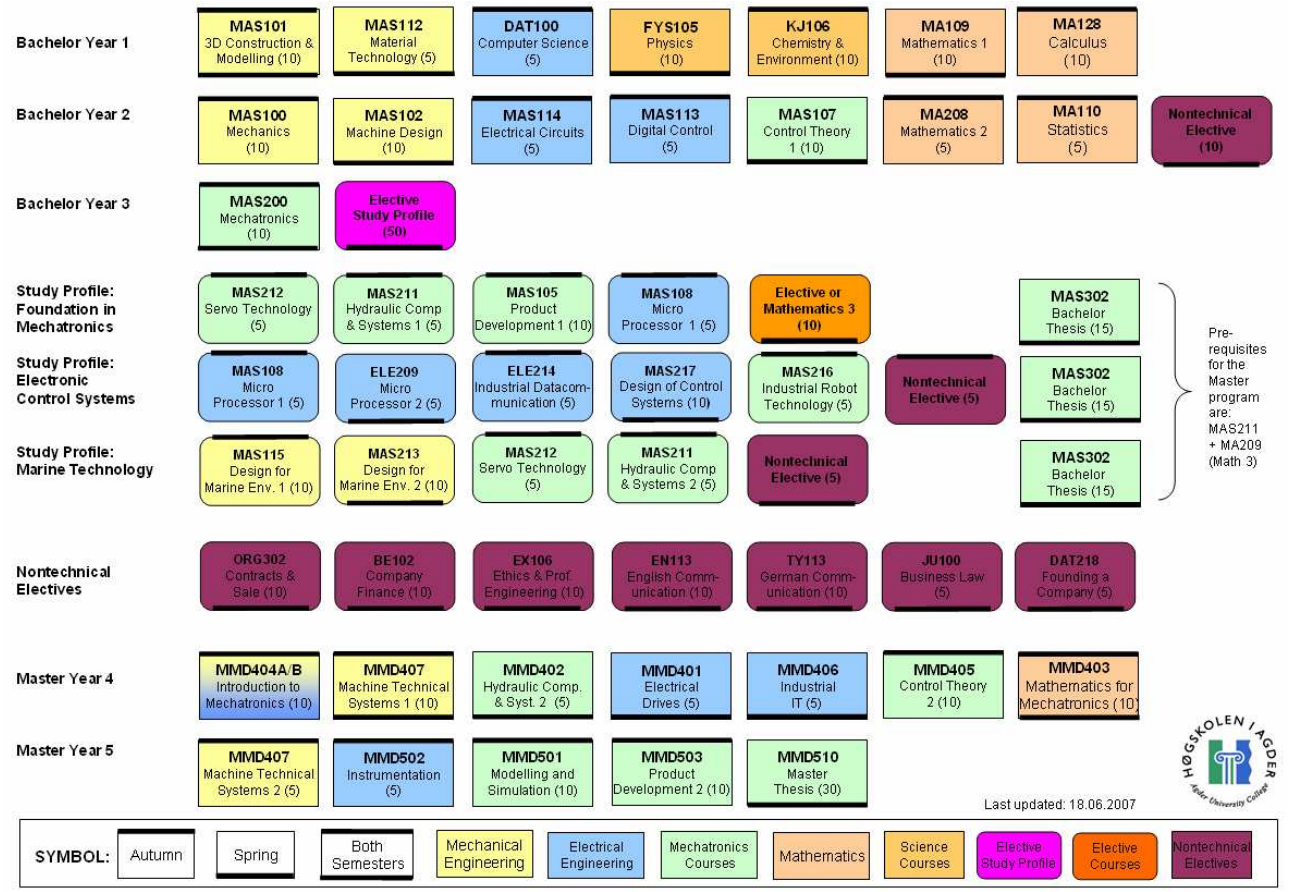

Figure 2: Overview of BSc and MSc Mechatronics study program at AUC.

At the BSc level the students have an option between three study profiles in the final year. The study profile Foundation in Mechatronics is the classical profile based on the original third year of the program. The new study profile Electronic Control Systems has an increased focus towards electronics, micro processors, design of industrial control systems, industrial communication and industrial robot technology. A typical company interested in Mechatronics engineer with such a background is XStrata Nickel in Kristiansand. The third study profile is Marine Technology. Two important courses in this profile are Design for Marine Environments 1 and 2. This study profile is focused towards the large group of companies in Southern Norway which manufacture and deliver equipment to the offshore oil and gas industry.

While the BSc program has a slight overweight of mechanical engineering and system-type courses as illustrated in Figure 1, the MSc program has a neutral balance between mechanical and electrical engineering and has more method-type courses, for example Control Theory 2 and Modelling and Simulation. All the mechatronics courses at the MSc level are separated from the BSc courses. Students who enter with a BSc in mechatronics, will have no courses in common with the Bachelor students. Students without a mechatronics background will have only one (repetition) course in common with the BSc students.

The BSc program at AUC follows the Bologna model for education in the EU countries. This means that after completing a 3-year bachelor degree at AUC in mechatronics, a student can continue with a Masters degree at any university in the EU which also follows the Bologna model. Of the graduating students from AUC approximately 65% enter the workforce, while 35% continue with further studies at the MSc level. In addition to the mechatronics MSc at AUC, other popular MSc programs in Norway are Engineering Cybernetics and Product Development and Material Technology at the Norwegian National University of Science and Technology. Other popular

national MSc programs are Petroleum Technology at the University of Stavanger and Process Automation at Telemark University College.

The local industry in Southern Norway is world-leading in the design and production of specialized offshore drilling equipment. Tough requirements on health and safety of workers have led to the development of large hydraulic robots for handling heavy equipment on offshore oil platforms and production vessels. Typical products are roughnecks and torque masters, which assemble and disassemble the drilling equipment during operation. The largest companies in this segment are Aker Kvaerner MH, National Oilwell and Wellquip. Other companies are Advanced Production and Loading, Aker Kvaerner Pusnes, NYMO, Sevan Marine and Nexus Floating Production. Typical products from this group of companies are automated anchor systems as well as complete solutions for design, manufacture and operation of production platforms.

4.0 Conclusions

This paper has presented a selective survey of different providers of mechatronics education in the Nordic and Baltic countries. All the Nordic and Baltic countries are included, except Finland and Latvia, due to the difficulty of obtaining confirmed information about mechatronic study programs in these two countries. Examples of mechatronics education providers in Finland and Latvia are University of Oulu and Riga Technical University.

Our analysis shows that all the surveyed mechatronics education providers have a focus towards a local industry, except DTU in Copenhagen and Chalmers in Gothenburg (Table 1). The more general education in Copenhagen could be explained by the fact that the city is larger and not dominated by a few large industry groups, which is the case for example at Agder University College in Norway. Another explanation could be the fact that DTU and Chalmers are older and well-established institutions with a higher academic focus in general and which have a broader recruitment base for students.

Since mechatronics education is relatively young as a separate discipline, the research activities in the discipline are still relatively small. Most of the surveyed participants recruit small numbers, from 1 to 3 new PhD students per year.

The survey has found that the majority of mechatronics education providers in the Nordic and Baltic countries have started their study programs during the last decade and that the majority also have decided to focus the study programs towards topics relevant for a local industry group. Today, nearly every university in the Nordic and Baltic countries offers at least individual courses or study programs in mechatronics.

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