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Development of Education System for System Safety Engineers in Nagaoka University of Technology

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***Abstract*— The education system of system safety engineers developed by Nagaoka University of Technology(NUT) has been introduced in the paper. Since safety much be achieved by "The state of the art" technology, career-long education is important. Two education system introduced here, department of system safety and qualification system of "System Safety Engineers", organize the career-long education. It has been also discussed an application of system safety to service robot safety. Since service robot safety involves many safety factors, not only technical but also user diversity, system safety engineers may play a key role for its development.**

***Keywords*— system safety, international standards, design, management, career-long education, service robot**

I. Introduction

"System safety" refers to the integrated application of safety technologies and management skills to achieve the reasonably highest safety in practice based on technical standards and laws. Though related international standards, e.g., ISO 12100[1] for safety design and risk assessment, had been developed since around the year of 2000, the concept of system safety have not been well utilized in Japanese society. For example, a report claims that 80% of all the accidents in Japan could have been prevented with suitable "system safety" measures taken[2]. To overcome this situation, Nagaoka University of Technology(NUT)[3] had established the department of system safety in the professional degree course, where the associated technologies and management have been taught harmonized with international safety standards.

In addition, lifelong education is also important for system safety professionals, because safety should be utilized based on "the state of the art" technology and management. In order to integrate this continuous education into his/her professional carrier, a new qualification system called "System Safety Engineer[4]" is also provided by NUT.

Such transversal knowledge and integration skill of system safety into each application can be a basement of new industry in Japan, e.g., service robot(ISO 13482[5]). The overview of the education system will be presented in the paper.

II. Department of System Safety in NUT

A. Outline

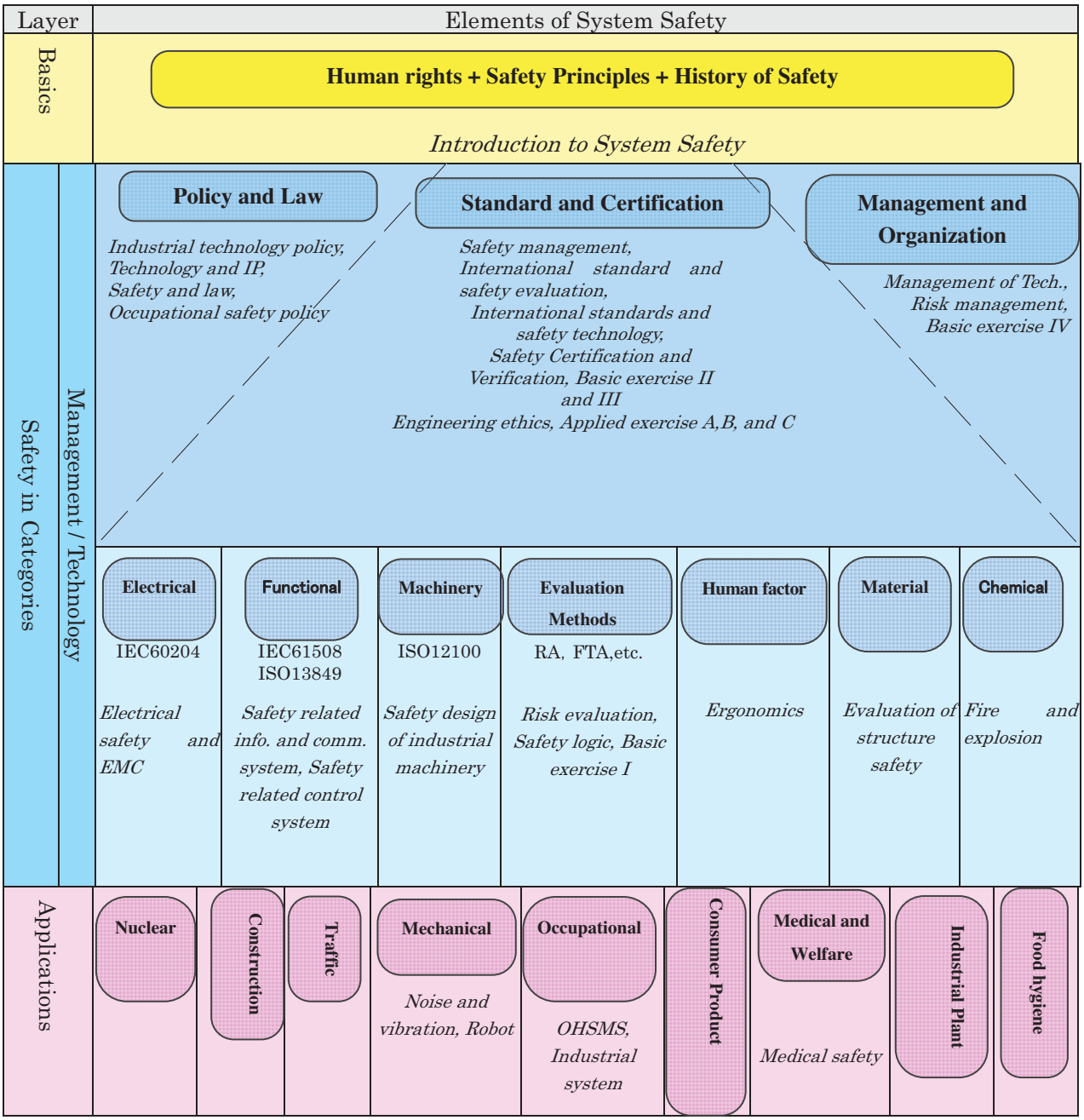
The new education system, department of system safety in NUT, is the first and the only graduate course in the field of system safety in Japan at this moment. The education system originated in the concept of "safety of machinery", of which representative standard is ISO 12100, and now extended to functional safety (IEC 61508), occupational safety, information security, and so on. Table 1 summarises a historical development of the department. Table 2 shows the knowledge system of system safety, which are originally developed by the department, and the corresponding classes(*italic* in the table) of it. According to Table 2, one could understand how the knowledge of both technology and management in system safety is integrated in the department curriculum.

TABLE I
DEVELOPMENT OF DEPT. OF SYSTEM SAFETY IN NUT AND RELATED TOPICS(*MINISTRY OF HEALTH, LABOUR AND WELFARE. ** MINISTRY OF ECONOMY, TRADE AND INDUSTRY)

Year	In NUT	In Japan
2001	Estab. of endowed chair of safety of machinery in Dept. Mech. Eng.	Guideline of comprehensive safety standard for machinery(MHLW*)
2002	Estab. of endowed master degree course of safety of machinery in Dept. Mech. Eng.	
2003		-ISO 12100 -Food Safety Basic Act
2004	First graduation of the safety of machinery course	JIS B 9700(Japanese ver. of ISO 12100)
2005		Revision of Industrial Safety and Health Act(requirement of risk assessment)(MHLW*)
2006	Estab. of Dept. of System Safety	Revision of Consumer Products Safety Act(METI**)
2007		

Year	In NUT	In Japan
2008	-First graduation of Dept. of System Safety -Estab. of research center of Safe and Secure Society -Estab. of doctor degree course of system safety	Estab. Of Consumer Affairs Agency(METI**)
2009	First visiting researcher in the center	
2010	-Estab. of Qualification system of System Safety Engineer -First research report of the center	
2011	Second research report of the center	Great East Japan earthquake and Fukushima nuclear power plant accident
2012	Estab. of Dept. of Nuclear System Safety Engineering	

TABLE II
KNOWLEDGE SYSTEM OF SYSTEM SAFETY(*ITALIC* INDICATES THE CLASSES IN DEPT. OF SYSTEM SAFETY IN NUT)



B. Features

The department is aiming to educate system safety professionals while in office who can contribute in practical situation, e.g., occupational safety, safety design of products, and safety authorities in government sectors. Therefore, it belongs to the professional graduate school in NUT and the enrolled students must be university graduates(or equivalent) and require two year (or more) working records. System safety covers various industries and types of job, the enrolled students have various personal records. See Table III.

TABLE III
DISTRIBUTION OF ENROLLED STUDENTS DURING 2006-2011

Years

20's	30's	40's	50's	60's	Total
7	28	29	21	6	91

Affiliation

Mech.	Elec.	Chem. Food.	Auto-mobile	Con-struction
19	19	6	5	7
Other indust.	Public sector	Education	Medical	Others
12	10	6	3	4

Residential area

Tohoku (North of Japan)	Niigata (Local)	Kanto (around Tokyo)	Tokai-Hokuriku (Middle)	Kansai (West)
1	24	52	10	4

In order to educate the students with diversity in an effective way while in office, the department has the following features:

- Study support
  - Most of the classes are intensive courses held in the weekends.
  - Some classes are provided in E-learning.
  - Tokyo extension campus
  - Library books can be rented through postal mail without charge.
  - University condo can be used with fare price(1500yen/night).
- Lectures
  - Oversee/domestic internship in certification organizations(voluntary)
  - Half year research project based on individual job theme(mandatory).
  - Most of lectures have job records in safety business.

Another interesting feature is student's relationship; Most of students while in office are already experts in individual organizations. Therefore, once they know each other, they start self-learning through their communication. Their job sectors and types are different, but they have the same knowledge of system safety, which can unify the differences and leads to beneficial discussion in an effective way.

III. SYSTEM SAFETY ENGINEER[4]

Safety must be achieved by "The state of the art" principle, where the latest knowledge of safety must be used. Therefore, carrer-long development is important for safety professionals. In order to support such lifelong learning, a new safety qualification system has been launched at Nagaoka University of Technology in 2010.

A. Qualification System Structure

The new system is organised and operated by a newly-created board with the support of Nagaoka University of Technology (hereinafter called the University). As shown in Figure 1, an independent board, the Board of System Safety Engineers, will provide the accreditation program, organize examinations and award certificates to qualified experts. The Examination Committee draws up the examinations for entry and for renewal, and acts as interviewer. The organisational duties are carried out by the Administration Committee, which is set up at the University.

This system of organization, combining the independence of the accreditation board and the transparency of operation, is crucial to safety in the modern world. The Board of System Safety Engineers (Chairman: Prof. Mukaidono, Meiji University) consists of leading authorities on safety, and it is independent of the University. Implementation conditions for the qualification system are conferred by the board and concluded as agreement.

B. Qualifications and their requirements

System Safety Engineer qualifications consist of three levels: System Safety Engineer in the middle and System Safety Expert and System Safety Sub-engineer above and below it respectively as shown in Figure 2. Qualification as a System Safety Engineer affirms a deep knowledge of system safety and the practical abilities of safety management, risk assessment and safety design, certifying safety managers in administration, or safety engineers and assessors for industries. System Safety Expert certifies the ability, in addition to

System Safety Engineer credentials, to carry out safety assessment as a third party and System Safety Sub-engineer the basic knowledge and abilities for System Safety Engineer.

Requirements for System Safety Engineer application are a bachelor's degree and more than four years professional experience or the equivalents, and entry examinations of seven subject areas with a problem solving approach and a general technical paper in the form of essay as well as an interview are set. With regard to System Safety Expert and System Safety Sub-engineer, detailed qualification application requirements are not fixed at the moment as System Safety Engineer has started this year, earlier than those two qualifications. In a few years the precise application requirements for them are to be announced. Especially, in the case of the System Safety Sub-engineer, the extension and enhancement of safety engineering education at Technological Colleges is expected, and in this context the application requirements for the Sub-engineer should be conferred with Technological Colleges.

The special features of this new qualification system are worth mentioning. The qualification is not valid forever, but has a three-year renewal requirement involving active participation. In this way, the latest knowledge can be discussed and disseminated, and the credentials and skills enhanced. The opportunities for this process are provided by the University. It is also noteworthy that the new system will be open to all in 2011. The entry process to System Safety Engineer described above is aimed at graduates of the Department of System Safety of the University, and they are joined by any other suitable applicants who are successful in a preliminary exam.

C. Examinations

As described above, the examinations for System Safety Engineer cover seven subject areas. Concretely, the seven areas are:

a. Basic Safety Engineering
b. International Safety Standards
c. Safety of Control Systems
d. Safety of Electrical Equipment
e. Safety of Machinery
f. Risk Assessment
g. Safety Management including Engineer Ethics.

In addition to this, essay examinations on safety matters and an interview are set. The criterion to pass each examination subject is a mark of 60% or better, and the qualification requires a pass or better in all subjects.

In March of 2010 the first System Safety Engineer Qualification examination was held. In spite of the limitations of the preparation time for the new qualification system, twelve applicants, who were all graduates of the Department of System Safety or its former course, challenged the exams and eventually eleven engineers passed. The number of applicants to the qualification is limited as the quota of the Department of System Safety is fifteen. When the qualification is, however, open to all beyond the limitation of Department of System Safety, an increase in applications is anticipated.

IV. Application to Service Robot Safety

Service robots, which are working not in factory but in our daily life space with direct contact to a person, are expected to be a next industry in Japan. Typical examples are a mobile cleaning robot and a person carrier robot. The corresponding safety standard is ISO 13482[5] which is an extension of industrial robot safety(ISO 10218). ISO 13482 will be published in 2012 and the following standards are main references; ISO 12100:2010(safety of machinery), IEC 60204(electrical safety), ISO 13849(control system safety) and IEC 62061(computer system safety).

In addition to these, the service robot used in our daily life must have reasonably comparable safety as the general consumer products, e.g., an electrical fan. Consumer product safety requires to consider child and elder people, where corresponding safety standards are ISO/IEC Guide 50(child safety) and ISO/IEC Guide 71(elder people safety).

Comparing to industrial robot safety(ISO 10218), service robot safety(ISO 13482) requires wider consideration of safety, and this means system safety plays a key role to utilize ISO 13482. We are expecting our education system can contribute for establishing the service robot industry, and the detailed curriculum is under development.

V. Conclusions

The education system of system safety engineers developed by Nagaoka University of Technology(NUT) has been introduced in the paper. Since safety much be achieved by "The state of the art" technology, career-long education is important. Two education system introduced here, department of system safety and qualification system of "System Safety Engineers", will organize the career-long education.

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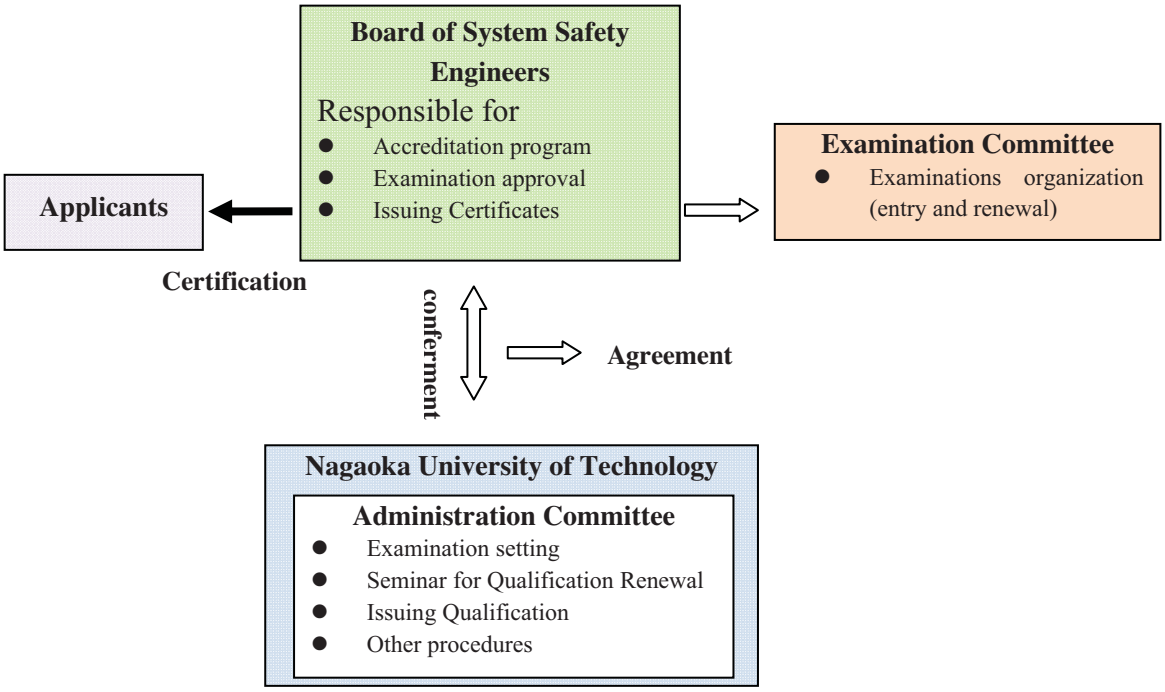

Figure 1.Organizations for qualification

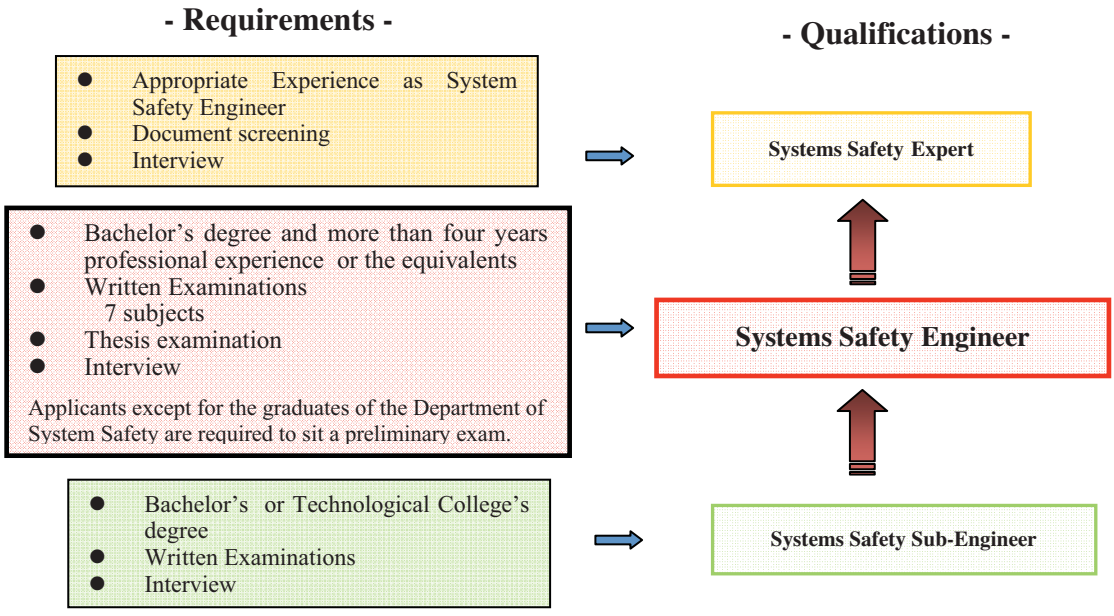

Figure 2. Requirements for qualification