# Education and Training for Automation 4.0 in Thailand - ETAT

Christian Madritsch
Engineering and IT
Carinthia University of Applied Sciences
Villach, Austria
c.madritsch@cuas.at

Reinhard Langmann
Edunet World Association e.V.

Blomberg, Germany
langmann@ccad.eu

***Abstract*—This paper describes the ERASMUS+ project ETAT: Education and Training for Automation 4.0 in Thailand. First, the current situation in Thailand in relation to the shift in national strategy is depicted. Here, the main project objectives and goals are also stated. Next, the lab equipment ETAT Smart Lab is described in detail. It begins with the general concept, continues with the components structure, and concludes with a part on teaching and training. The chapter Technological Models describes the additional hardware components used which are specific to the key area of each partner university. At the end, a chapter Summary and Conclusion is ending this paper.**

***Keywords—Automation 4.0, Thailand, Curricula Development, Smart Lab***

## I. Introduction

Thailand has undergone a shift in its national strategic positioning. From agriculture over light manufacturing to heavy industries, Thailand is moving towards a digitized integrated business and social system and an advanced infrastructure – as well as a modernization of industrial automation. In this context, the East Economic Corridor (EEC) project, supported by the government in Thailand, aims to expand the entire region southeast of Bangkok into a modern industrial region over the next years (Thailand 4.0). An essential basis for the implementation of the EEC project is the availability of highly qualified professionals who can develop, operate, and maintain the relevant production, manufacturing, and logistics technologies. Thereby, the educational institutions in the EEC, especially the universities, play an important role. Currently, the Higher Educational Institution (HEI) sector in the EEC is lacking the skills and knowledge to teach and train students in the field of Automation 4.0.

The ETAT project (Erasmus+ program) will enable the training and education of future Thai trainers in the EEC for automation engineers, maintenance engineers, process workers and students using non-classic teaching methods such as learning by doing, remote and mobile teaching with innovative technologies as well as LLL and the experience of several European universities [1].

The general aim of ETAT is to enhance the employability of university graduates and Life-Long Learning (LLL) in the field of Industry 4.0 and industrial automation by the introduction of European standards of education through practical examples.

The ETAT project aims to create exemplary Education & Training Centres in the field of engineering education at participating Universities that are able to support as education hubs for industry-related education and training for engineers and young specialists.

The following objectives will be achieved with the ETAT project:

- Modernization of Higher Education in Thailand based on the experience of European countries,
- Increase the employment rate of university graduates and implement the concept of Life-Long learning with the help of special training modules in the field of industrial automation,
- Development of partnerships with enterprises,
- Improve the quality and relevance of Higher Education in Thailand in the field of industrial automation,
- Establishment of six certified ETAT Training Centres at partner universities, which will be equipped with 24 special training places (respectively 4 ETAT Smart Labs per Thai university),
- Establishment of a platform for distance learning and cooperation between the partners for providing E-Learning & Cloud-based learning courses and for exchange of didactical documents and information.

This paper is organized in the following way: the chapter *ETAT Smart Labs – ESL*, describes the general concept as well as the component structure of the ESL. Moreover, this chapter gives an overview about the learning and teaching possibilities with the ESL.

The next chapter *Technological Models* lists the real-world demonstrators and lab-equipment used at the individual universities in Thailand. These Models are derived from the focus areas of the institutions involved and will be used in combination with the ESL in the ETAT project.

The last chapter *Summary and Conclusions* will elaborate on the current state of the project, briefly discuss the Curricula Development efforts so far and the planned ETAT training centers.

## II. ETAT Smart Labs – ESL

### *A. General Concept*

The term *Smart Lab* has been used around the world for various areas of application and with different contents. With the increasing digitization of production, the use of cyber-physical systems (CPS) and the concept of Industry 4.0, the term *smart* is often used as a synonym for modern automation

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of technical processes. For example, the *Smart Factory* is a core element of Industry 4.0.

In order to qualify the specialists for the development, operation and maintenance of a Smart Factory, appropriately equipped laboratories are required in the educational institutions that map the basic principles, methods and objects of such a Smart Factory in a realistic and practice-oriented manner for learning and teaching purposes. For this reason, appropriately equipped laboratories are increasingly being set up as *Smart Automation Labs* at professional and academic educational institutions around the world. Examples of this can be found in [2], [3], [4], among others.

The well-known Smart Automation Labs are larger investment projects that are neither reproducible nor available as a product. Neither didactic concepts nor didactic documents are available to the public or on the market.

There are some efforts by manufacturers of teaching equipment to market at least the electromechanical system components (stations) as Smart Lab systems, e.g. CP Factory from Festo Didactic (DE) as a Smart Factory kit, systems for Smart Grid technology from EDIBON (ES) or Smart House Training Bench from Shouldshine (CH). The marketing strategy is based on the sale of expensive electromechanical modules (stations). For educational institutions, this means high costs, since existing stations cannot be used.

But, if appropriately equipped with modern automation components, a Smart Lab can also be built from available systems and system parts. Electromechanics are not smart, but intelligent electronics, information technology (IT) and networking can be combined to create a Smart Lab.

The *ETAT Smart Lab (ESL)* is an educational solution that provides a modular and flexible option to implement the new educational requirements in the age of Industry 4.0 for the digitization of production in a cost-effective and reproducible manner. The ESL concentrates on the provision of the automation and information technology components that are required for a Smart Automation Lab.

All ESL modules are set up as DIN A4 learning boards and come from the didactic model range *Eduline modular* of Phoenix Contact. Fig. 1 illustrates this equipment with a few examples.

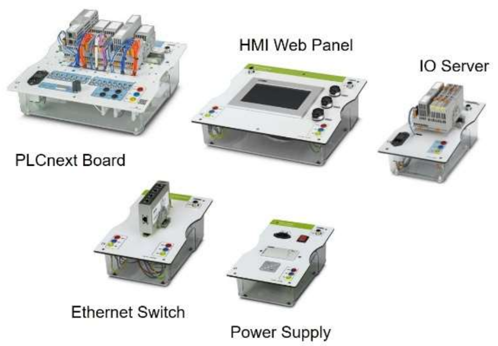


Fig. 1. ELS modules assembled as DIN A4 learning board

Electromechanical systems or system parts (conveyor lines, workpiece storage, processing stations, robots, etc.) that already exist in the educational institutions (if necessary, also be combined with new stations) can used together with the ESL in order to implement an industrial-related Smart Factory for training and education. Capital investments in educational institutions are limited and you can concentrate on the core automation components of a Smart Automation Lab in training and teaching.

## B. Component structure

The ESL provides all automation and information technology components that are required for setting up a Smart Factory in the laboratory (Smart Factory Lab). These include e.g. as hardware components (see also Fig. 1):

- *PLCnext Board*: Training board with a powerful PLC controller.
- *HMI Web Panel*: Operation and visualization of the technical process.
- *IO Server*: Extension of the basic system with classic fieldbus systems and/or Ethernet-based bus systems (e.g. PROFINET, Modbus/TCP, Ethernet/IP) and intelligent peripheral interfaces (e.g. IO-Link).

Fig. 2 illustrates the example configuration of an ESL for a Smart Factory of smaller complexity. With the configuration according to Fig. 2, e.g. a system structure (technological model) for a Smart Factory Lab can be set up in which 48 digital and 10 analog IO process signals as well as 16 IO-Link process signals from sensors/actuators can be processed.

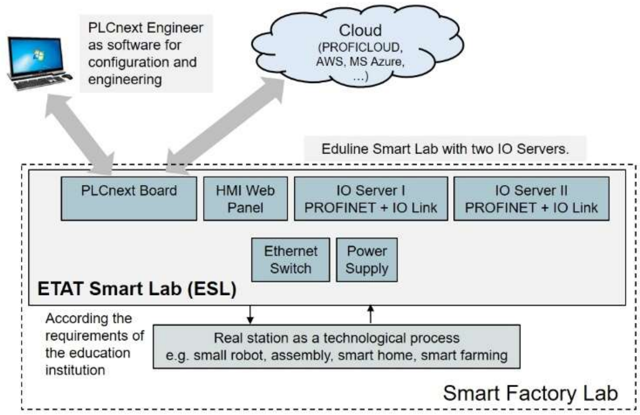


Fig. 2. ETAT Smart Lab for setting up a Smart Factory of smaller complexity

With a corresponding scaling, extensive systems of a Smart Factory can also be operated via the ESL.

## C. Teaching and training with the ESL

In addition to the hardware, important components for the ESL are the didactic documents for conveying the core automation topics of Industry 4.0. These documents are currently being developed in the project by the project partners. The subject areas deal with classic and advanced topics in automation technology and are based on the Reference Architecture Model for Industry 4.0 (RAMI 4.0). The subject areas are structured as follows:

- *Control and feedback control systems*: The basis of every automation solution for a Smart Factory is a powerful, open and standardized PLC (PLC – Programmable Logic Controller). Training topics are the installation and configuration of PLC, the basics of PLC programming according to IEC 61131 and the integration of high-level programming languages (C++, C#) in PLC programs as a supplementary topic.

- *Operating & monitoring*: Human Machine Interfaces (HMI) for process and production automation are increasingly working on the basis of web technologies and use the web browser as stationary or mobile operator terminals.

  Learning content in this subject area is the basics of Human-Machine Communication, project planning and implementation of operating interfaces for a control system, and the visualization of process data.

- *Communication at the field level*: For the communication and networking of distributed sensors and actuators at the field level or in the factory, Ethernet-based real-time bus systems are increasingly used, supplemented with intelligent peripheral interfaces.

  Topics for the training include the basics of communication with PROFINET, Modbus/TCP and EtherNet/IP at the field level as well as project planning, configuration and commissioning of industrial communication networks.

- *Vertical networking*: For the digitization of production in the sense of Industry 4.0, the networking issue plays a key role for the automation of an entire value chain across vertical automation levels up to global networking.
  The learning content includes the basics and global networking with OPC UA and MQTT, the use of cloud gateways, networking with the RESTful HTTP protocol and the use of a PLC as a cyber-physical system.

- *Cloud Computing*: In connection with Industry 4.0, Cyber-Physical Production Systems (CPPS), Industrial Internet of Things and Cloud Computing is a topic that is strongly in focus in industrial automation. In CPPS, data, services and functions are stored, accessed, and executed where they have the greatest advantage in terms of flexible production.

  The training content in this subject area therefore focuses on the fundamentals of Cloud Computing for industrial automation as well as data analysis and visualization in the cloud,

The ESL is structured as an expandable Smart Lab based on hardware components and subject areas and can be used flexibly depending on requirements (Bachelor, Master or industrial training). Tab. 1 lists the hardware components required in each case for the corresponding configuration level.

The possible subject areas that can be taught and learned in the respective configuration level can be found in Tab. 2.

TABLE I. CONFIGURATION LEVELS FOR THE ETAT SMART LAB

| Configuration level | ETAT Smart Lab components | | | | |
|---|---|---|---|---|---|
| | *PLCnext Board* | *HMI Panel* | *IO Server* | *Switch* | *Power Supply* |
| Primary | X | | | | |
| Basic | X | X | | | |
| Standard | X | X | X | | X |
| Advanced | X | X | X | X | X |

TABLE II. SUBJECTS OF EDUCATION FOR THE ESL CONFIGURATION LEVELS

| Subjects of education | Configuration level | | | |
|---|---|---|---|---|
| | *Primary* | *Basic* | *Standard* | *Advanced* |
| Control and feedback control systems | X | X | X | X |
| Operating&Monitoring | | X | X | X |
| Communication in the field level | | | X | X |
| Vertical Networking | | | | X |
| Cloud Computing | | | | X |

Since the didactic subject areas of the ESL are not based on industrial branches, but on the basics and principles of automation and information technology, the ETAT Smart Lab and the associated training documents can also be used for Smart Home Labs, Smart Grid Labs, Smart Farming Labs, etc.

Based on the configuration levels and subjects of education for the ESL, a course concept was developed that takes into account the content of the planned study courses and at the same time ensures high efficiency and quality in course development and use. The concept is based on the following core features:

- 8 didactic modules listed in Tab. III were developed, which individually or in combination contain all the necessary teaching content for the new or updated study courses in the Thai universities on the subject of Automation 4.0.
- For each didactic module there is a responsible leader as well as one or more contributors and one or more interested parties from among the ETAT Thai universities.
- Each Thai university is responsible for determining which didactic module is used in which study course for which level of study.

In principle, all didactic modules can be used in study programs for Bachelor's or Master's degree.

TABLE III. DIDACTICAL MODULES FOR THE NEW OR UPDATED ETAT STUDY COURSES IN THE PARTICIPATING THAI PARTNER UNIVERSITIES

| No. | Description | Theory [Hours] | Practice [Hours] |
|---|---|---|---|
| M1 | HMI/SCADA systems | 12 | 9 |
| M2 | IEC 61131 programming | 5 | 9 |
| M3 | Industrial communication | 6 | 10 |
| M4 | IoT and cloud technology | 11 | 10 |
| M5 | Node RED programming | 3 | 5 |
| M6 | Python programming | 8 | 10 |
| M7 | Robotics/ROS programming | 9 | 8 |
| M8 | Big data analysis and pattern recognition | 21 | 18 |

With the didactic modules listed in Tab. III, a total of 23 study courses in 18 study programs of the 6 participating Thai universities will be updated or newly created.

## III. TECHNOLOGICAL MODELS

The ESL components allow the connection to external hardware – Technological Models – by means of Digital I/O, Analog I/O, and IO-Link. Each partner university has its own unique research and development focus. In order to extend the teaching capabilities from Industry 4.0 to real-world applications, each university extends the ESL concept by adding their own expertise. The following subsections describe briefly the planned Technological Models.

### A. *Factory Automation - Burapah University (BUU)*

BUU plans to extend the ESL with components from Fischertechnik. The *Factory Simulation* Model (see Fig. 3) combines the models *Sorting Line With Color Detection*, *Multi Processing Station With Oven*, *Automated High-Bay Warehouse*, and *Vacuum Gripper Robot*. It allows for a self-contained material cycle: workpieces are retrieved from the *Automated High-Bay Warehouse*, processed in the *Multi Processing Station With Oven*, then sorted by color in the *Sorting Line With Color Detection* and finally stored in the *Automated High-Bay Warehouse* again [5].

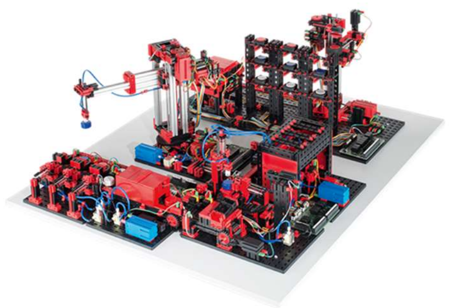

Fig. 3. Factory Simulation by Fischertechnik

### B. *Machine Vision with Robotics - Rajamangala University of Technology Tawan-ok (RMUTTO)*

For RMUTTO, machine vision and robotics will be combined into one technological model for the ESL (see Fig. 4). An industrial camera connects to a microprocessor via USB, the microprocessor is linked to a router via Ethernet. The connection is used to interface into different Cloud based data storage services. Additionally, a Mini Robot is connected to the ESL via Digital I/O.

This setup can be used for applications like Automated Optical Quality Inspection, Robot Control, Cloud based data storage, etc.

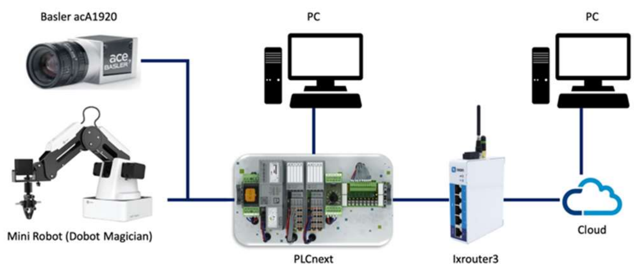


Fig. 4. Machine Vision and Robotics

### C. *Agriculture – Smart Farming - Rajabhat Rajanagarindra University (RRU)*

One of the focus areas of RRU is Smart Farming and Agriculture. Several ESL components will be interfacing a Greenhouse Model (see Fig. 5). The Greenhouse Model is equipped with a variety of sensors: light, color, temperature, humidity, soil moisture, air-pressure, CO2, electric conductivity. Additionally, to control, a set of actuators is used: water spray system, light-control, dripping water system, and fan system.

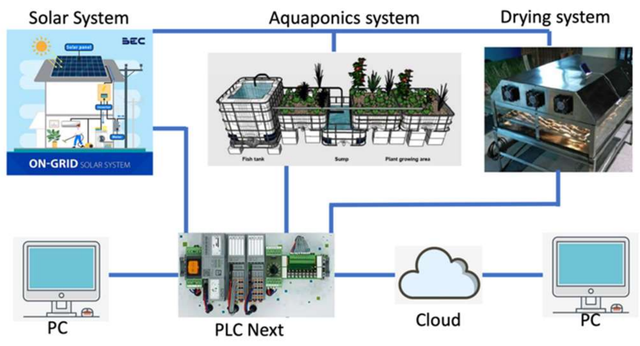


Fig. 5. Smart Farming – Agriculture

### D. *Automated Sorting Conveyor Simulation System - Kasetsart University (KU)*

In KUs setup, a variety of different technologies is combined into one Technological Model (see Fig. 6). The ESL is interfacing a variety of different sensors, is connected via a power amplifier to a conveyor belt (including pneumatic components), uses the HMI for user-feedback and control. Additionally, the ESL is connected, via Ethernet, to a Raspberry Pi and IP cameras. One possible application is also an Automated Optical Inspection Module with HMI and Cloud connect.

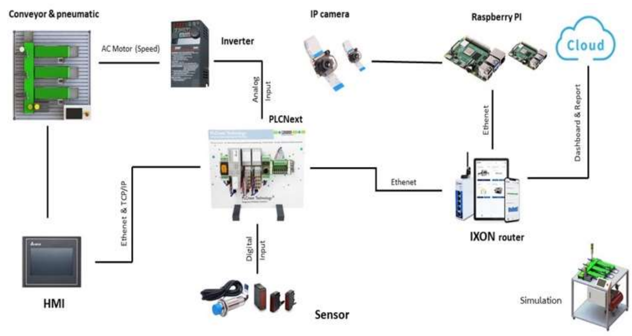


Fig. 6. Automated Sorting Conveyor Simulation System

### E. *Building Automation - King Mongkut's Institute of Technology Ladkrabang (KMITL)*

KMITL will develop several different technological models. One example is the Building Automation System (see Fig. 7). Using face and temperature detection, persons will be sensed for access control in a room of a building. The detector will snap faces and record their temperatures, then send this data to the ESL. Inside the controlled room, the motion sensor will control lights (switch on and off). In the case of an emergency situation, a smoke detector or PM 2.5 sensors will detect the problem and send a warning message via cloud for data analytics. Additionally, an alarm light will be automatically turned on.

The other models from KMITL are: Automated Parking Lot Detection System and Flood Warning System.

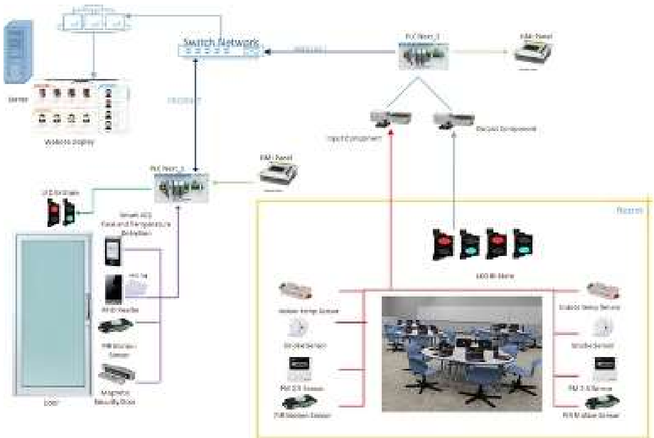


Fig. 7. Building Automation System

### F. *Railway Operation and Control - King Mongkut´s University of Technology North Bangkok (KMUTNB)*

The idea behind KMUTNBs model is to demonstrate modern automation technology in vehicles as well as automatic traffic/logistic solutions. Each railway setup consists of two model railways with tracks/crossings/junctions, light signaling, train-block detection, and several sensing systems. The train control and operation can be displayed either with HMI or a PC monitor.

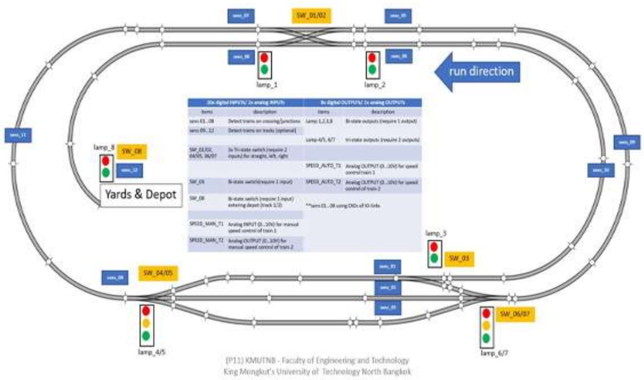


Fig. 8. Railway Operation and Control

So far, the choice on the technological models per partner university has been made and the compatibility with ESL was ensured. When all components will be available, lecture material, lab exercises, and eventually a study-book will be developed.

## IV. Summary and Conclusions

Due to the corona situation, there are considerable delays in the project, especially when carrying out the planned face-to-face training and workshops. So far, not a single face-to-face event could be held in the project since the start of the project in January 2020.

In spite of this, at least the entire equipment (24 ETAT Smart Labs) for establishment of training centers at the Thai universities has been successfully procured and the first learning documents have been developed.

Some workshops on theoretical topics have already been held online. However, training directly at the ESLs proves to be problematic. For this, face-to-face training is required, which hopefully can be carried out in 2022.

Due to Corona, an extension of 12 months is planned in the project, so that it is currently assumed that the ETAT Training Centers in the universities will be operational in 2022/23 and can be used for student education and industrial training.

## Acknowledgment

The authors would like to thank all project partners in the ETAT project who are very interested and committed to ensuring that the project can be carried out successfully even under the adverse Corona conditions.

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