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UNITED

Engineering Knowledge Transfer Units to Increase Student´s Employability and Regional Development

Work Package 1 – Comparative analysis of the automotive industry and trainings needs for the engineering knowledge transfer units in Indonesia, Malaysia, Thailand and the EU

1.3 UNITED Comparative Report

1.3 Comparative Report, v5 final

WP 1

The Comparative report summarizes the Status-quo and Gap Reports in one document to provide a guide on how the differently strong and working automotive industries and efforts/investments in the development can be compared when aiming to have an increase of awareness about the respective topics among the target groups and an enhancement in regional development.

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Amendment History

Version	Revision	Date	Pages	Author	Modification
V1	Internal	25/04/2020	20	Tonoli, Ruzimov, Casieri	First draft of the Comparative Report, Title page were added
V2	FHJ	05/05/2020	33	Tonoli, Ruzimov, Casieri	Table 1, Table 4, Table 5 and Table 6 were added
V3	SEA partners	05/06/2020	33	Tonoli, Ruzimov, Casieri	Feedbacks from SEA partners
V4	Peer review of FHA	15/11/2020	35	Tonoli, Ruzimov, Casieri	Peer review of the report - Amendment history, Introduction, Summary added
V5	Final check	04/07/2022	35	Tonoli, Ruzimov, Casieri	New disclaimer is added, Automatic numeration issues are fixed

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1. Introduction

UNITED project aims in enhancing university-business cooperation, improving teaching quality and skill-level to address the labour market and strengthening accessibility & collaboration between the EU and SEA partners. The comparative report is the first important outcome of the UNITED project. It summarizes two documents: the status-quo of the development and the future aims for the automotive industry, and the GAP analysis. The report draws recommendations to define the topics and the content of the capacity building trainings in the field of automotive and mechanical engineering. Furthermore, it contains the list of recommended equipment for testing bays, identified in the basis of needs of the industries and proposed training topics. The feedbacks from SEA partners are collected to complete the final version of the report.

2. Aims & Objectives of the Comparative report

The objective is to produce a comprehensive report on the status-quo of the development and the future aims for the automotive industry and the GAP analysis in one piece, and provide a guide on how the differently strong and working automotive industries and efforts/investments in the development can be compared when aiming to have an increase of awareness about the respective topics among the target groups and an enhancement in regional development. Further, this report is also going to give some recommendations and key performance indicators in terms of successful future developments in the automotive industry to increase regional development and university business cooperation as well as the internationalization in this field. This part is very essential for the UNITED work package 2 when it comes to the development of capacity building trainings in the field of automotive and mechanical engineering (AE / ME), forming the basis for the content of the trainings. The comparative report is the first important outcome of the project and will therefore be disseminated among the target groups of the project with the support of all partners (HEIs and company and supporting partners).

3. Description of Methodology

The aim of this report is to compare the findings out of completed national and institutional research in order to uncover possible gaps and needs which are important to be discussed before the development of the training curriculum.

Therefore, the methodology is as follows:

1) Reviewing and combining the results of UNITED WP 1.1 (Status-quo analysis and focus group interviews) and WP 1.2 (Gap analysis)

2) Elaboration of guidelines for the development and internationalization of automotive engineering and university-business cooperation through the implementation of engineering knowledge transfer units (EKTUs) in SEA countries

3) Draw recommendations and key performance indicators for automotive engineering and testing bays

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4) Draw recommendations for capacity building trainings in the UNITED project

The report contains information on the current state of development of automotive industry, education in AE and ME, testing bays and university-business cooperation in EU and SEA countries. The critical comparison of the information is performed to draw the guidelines and recommendations for further improvement of the critical aspects. It is very important for the consortium to mention that the findings are value-free and just a review of the current situation – this is an essential fact as the project should not judge on the participating countries in terms of their efforts taken.

4. Development of Automotive Industry in European and SEA countries

4.1. Development of AE industry in European countries ["what is"]

Italy

Automotive Industry in **ITALY** accounts for more than 100 bn euros of industry turnover, i.e. with 4.3 % of GDP of Italy. More than 1.2 m people are employed in Automotive Industry related companies. The industry exported product equal to 45 bn euros in 2017. Annual investment in R&D accounts approximately 1.8 bn euros, i.e. 12.7% of R&D spending of manufacturing sector in Italy. Around 5700 companies are involved in production of automotive related components and parts.

Germany

Automotive Industry in **GERMANY** accounts for more than 423 bn euros of industry turnover. More than 820,000 people are employed in Automotive Industry related companies. The industry is export oriented with 78% of products exported in 2017. Annual investment in R&D account approximately 22 bn euros in 2017. R&D personnel accounts around 114,000 people. Around 945 companies are involved in production of automotive related components and parts.

SOURCE: https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/industry-overview-automotive-industry-en.pdf

Austria

Automotive Industry in **AUSTRIA** accounts for more than 19 bn euros of industry turnover, i.e. 5.16% of Austrian GDP. Approximately 35,000 people are employed in Automotive Industry related companies. The industry is export oriented with 88% of export quota. Annual investment in R&D account approximately 1 bn euros. Around 222 companies are involved in production of automotive related components and parts.

4.2. Development of AE industry in SEA countries ["what is"]

Indonesia

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Automotive Industry in Indonesia was started since 1970 by using conventional engine (2W and 4W). Today, Indonesia automotive is known as the biggest market in ASEAN Country. Automotive Industry in INDONESIA accounts for more than 10% of Indonesian GDP (which is around 1 trillion euros). Approximately 1.2 m units of vehicles are produced in Indonesia, including joint companies with seven Japanese car makers. The industry produces vehicles and components for mainly local market, only small portion is exported. Around 42,000 companies are involved in production of automotive related components and parts.

The total sales in 2017 was 1,079,534 followed by Thailand with 871,650 total sales. However, the biggest producer in this region is Thailand with car production of 1,988,823 and followed by Indonesia 1,216,615 (Data of 2017). The present condition of automotive industry in Indonesia can be summarized as follows:

Over the next five years, the passenger vehicle segment will remain very attractive, while growth of the commercial vehicle segment will be slower. Passenger vehicle (PV) growth is estimated at Compound Annual growth rate (CAGR) 6.8% until 2020, motorcycle (MC) growth is estimated at CAGR 4.8% to 2020, truck growth is estimated at CAGR 3.5% to 2020, bus growth is estimated at CAGR 1.9% to 2020. Greater Jakarta will remain the key region driving PV and CV growth, while demand from medium and smaller-sized cities is expected to increase over the next decade. In the PV segment, the low-cost green car segment (LCGC) is expected to experience the fastest growth at CAGR 8.1% to 2020. In the truck segment, the gasoline light-duty truck segment (GLDT) is expected to experience the fastest growth at CAGR 4.6% to 2020. In the bus segment, the medium-duty bus segment (MDB) is expected to experience the fastest growth at CAGR 3.2% to 2020. These facts show that Indonesia automotive market is still growing. The national increasing market due to increasing middle class. Along with national market, the export market is also increasing. The expansion in export will leverage the quality and the quantity. However, Indonesia's export competitiveness is still low.

Malaysia

Malaysia has become one of the emerging car manufacturers since an inauguration of the first national car, PROTON in 1983 followed by PERODUA in 1993. Through the formation of these companies, it has enabled the country to significantly develop its automotive capabilities in research and development, prototyping, testing and manufacturing. Automotive Industry in MALAYSIA accounts for more than 8 bn euros of industry turnover, i.e. 4 % of Malaysian GDP. Approximately 800,000 people are employed in 667 Automotive Industry related companies. Around 1 m vehicles are produced in the country, from which approximately 20,000 were exported (2%). Annual investment in AE R&D account more than 1.6 bn euros. Around 641 companies are involved in production of automotive related components and parts. Several Governmental initiatives are ongoing to support the R&D in AE industry.

Apart from that, the Malaysian automotive industry includes a joint venture with foreign car company to set up an assembly line capability for complementing the imported complete knock down (CKD) kits. As a result, the industry has able to create a number of job opportunities mainly in engineering field, as well as business opportunity in vehicle service and repair, and component supply.

With the latest review of National Automotive Policy (NAP) in 2014 since its inception in 2006, the future direction of automotive industry in Malaysia is focusing into a holistic development of green technology and human capital, including enhancement in automotive industrial ecosystem and market expansion. This policy is headed by the government agency under the Ministry of International Trade and Industry (MITI) in order to ensure the Malaysian automotive industry to stay competitive in both domestic and global market. MITI

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has established Malaysia Automotive, Robotics and IoT Institute (MARii) to provide assistance in ensuring the growth of Malaysia Automotive Industry. From the data gathered by MARii, the export of the parts and components has been gradually increasing from RM9.8 bn in 2015 to RM12.10 bn in 2018 with increments of almost 25%. Meanwhile, the export of (Complete Built-Up) CBU vehicles increases from RM1.2 bn in 2015 to RM2.08 bn in 2018. In terms of the energy efficient vehicle (EEV), it has been recorded that more than 50% market penetration of new vehicles has been sold in Malaysia. Therefore, since the announcement of NAP 2014, the key objectives as stated in the policy has been well undertaken and the revised NAP should be expected in this near time.

Thailand

Automotive Industry in **THAILAND** is the biggest among SEA countries and accounts for more than 26 bn euros of industry turnover, i.e. around 6-10 % of GDP of Thailand. Nine OEMs are operating in AE industry and more than 2 million cars produced in 2018. Annual investment in R&D account approximately 1 m euros.

The global automotive industry is shifting focus towards electric vehicles (EVs), partly due to tightening regulations as tougher emission duty guidelines are set in major economies like the US, Europe and China. Several countries including Germany, Norway and India, are planning to phase out sales of diesel and gasoline powered vehicles. While oil price in 2019 is expected to linger at a relatively high level, government bodies are encouraging EV production via incentives and tax reductions.

In alignment with this wave, the Thai Finance Ministry reduced excise tax rates for EV cars since 2017, driving domestic sales of hybrid electric vehicles (HEVs), battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). This trend will likely continue into 2019 despite the expected decline in the overall domestic automotive sales. Figure 1 shows Thailand's domestic automotive market between 2018 – 2019.

Domestic automotive market — 2019 projections

	2018		2019	
Vehicle types	Sales Volume (vehicles)	%yoy	Sales Volume (vehicles)	%yoy
EV	21,000	75%	37,000 - 38,500	76% - 83%
- HEV	12,200	270%	25,100 - 26,050	106% - 114%
- PHEV	8,745	1%	11,500 - 12,000	32% - 37%
- BEV	55	104%	400 - 450	627% - 718%
Eco Cars (ICE)	171,000	37%	152,000 - 157,000	(-11%) - (-8%)
Others	838,000	14%	791,000 - 814,500	(-6%) - (-3%)
Total domestic automotive sales	1,030,000	18%	980,000 - 1,010,000	(-5%) - (-2%)

Figure 1. Thailand's domestic automotive market [Credit: kasikornbank 2019, [1]]

In 2019, Thailand's domestic automotive market was expected to contract by 2% to 5% while EV sales growth is projected to remain impressive between 76%-83%. Reasons for the market contraction include high household debt and stricter credit policy set by financial institutions to tackle higher non-performing car loans. Uptrend in policy rates and the delay in general election may also slow down demand to purchase vehicles. However, high growth in the EV segment, particularly the PHEVs and HEVs, will continue to support the industry.

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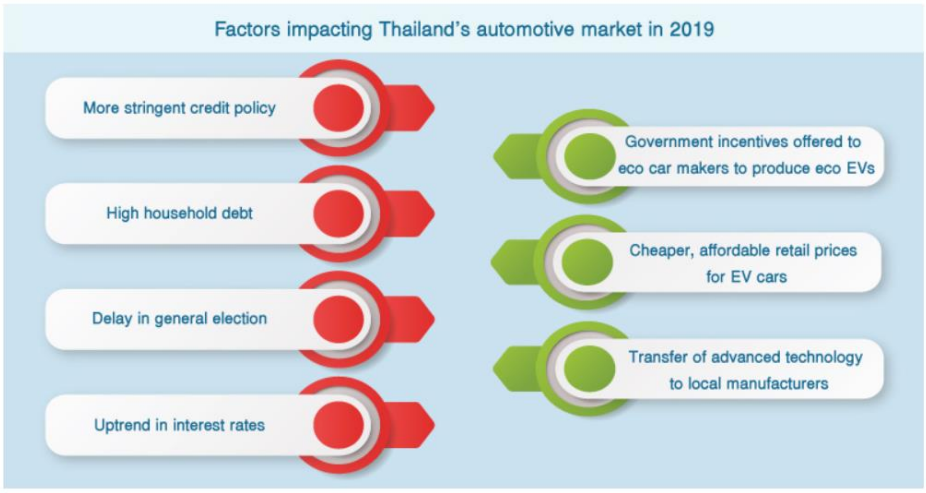

Figure 2. Factors impacting Thailand's automotive market in 2019 (positive vs negative points of view) [Credit: kasikornbank 2019, [1]]

In 2019, the government also tried to incentivize eco car makers to launch more eco EVs, especially the hybrid type. These eco EVs will also get excise tax reduction like other EV models, making retail prices more affordable. Meanwhile, PBEV and BEV eco cars are unlikely to take off soon due to high lithium battery costs. Another driver for EV production is attributed to more transfer of advanced technology to local manufacturers from forming joint ventures with overseas manufacturers.

Thailand's auto export growth has outpaced domestic sales, making up approximately 60% of Thai automotive sales. In 2019, Thailand's auto export volume growth is projected to grow gradually by 1-4% pressured by global economic slowdown and relocation of production base to countries in Europe. However, auto export volume to Vietnam is expected to grow notably by 14-22% in 2019, spurred from high demand for Thai automobiles and it is considered a high potential market in 2019 due to:

- The ease of import restricting regulation imposed under Decree 116
- Relocation of passenger cars manufacturing base into
- Thailand for auto products to be re-exported back to Vietnam
- Higher average income among the Vietnamese population
- More affordable small engine eco cars, amid high oil price in Vietnam.

On the contrary, Thai auto export to Europe will be pressured by the relocation of production bases to countries in the region, nearer to end consumers, in an effort to reduce logistics and transportation costs. These include countries like Hungary, Netherlands, France and Finland, for instance. Emission controls in Europe will also contribute to the reduction in Thai auto exports to the region. Lastly, the United States-Mexico-Canada Agreement (USMCA) will come into effect from 2020 onwards, which will tighten control over where the vehicles are originally manufactured from. This would potentially slow down Thai auto export to the membership countries. Thailand can limit the negative impacts by ramping up production and exporting EVs to Europe and USMA member countries, which heavily promotes EV adoption.

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Automotive export market — 2019 projections

Countries	2018 Sales Volume (vehicles)	2018 %yoy	2019 Sales Volume (vehicles)	2019 %yoy
Vietnam	53,400	44%	61,000 - 65,000	14% - 22%
Europe	123,000	-14%	118,000 - 123,000	(-4%) - (0%)
Overall	1,135,000	-1%	1,150,000 - 1,180,000	1% - 4%

Figure 3. Automotive export market -2019 projections [Credit: kasikornbank 2019, [1]]

Car (units)	Production	Domestic Sales	Export
Passenger Cars	60,077	35,086	25,673
Commercial Vehicles	94,011	44,213	49,512
Total	154,088	79,299	75,185

Motorcycle (units)	Production	Domestic Sales	Export
	171,799	135,458	31,277

Figure 4. Thailand Automotive Statistics in November 2019 [credit: www.taia.or.th/, [2]]

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Table 1: SWOT Analysis of the SEA automotive industry

Malaysia	
STRENGTHS - R&D expertise - Manufacturing capability - Malaysia owns two national car producers - Strong OEM supporting industries, Tier II	**WEAKNESSES** - Testing facilities - High-tech skilled workers - After sales - Low quality parts - Investment - Technology gap - University-industry networking is weak
OPPORTUNITIES - Affordable expertise - Low manufacturing costs - Sustainable governmental policies - Global branding	**THREATS** - Low part cost from China - Imported cars - Technology maturity is too fast
Thailand	
STRENGTHS - Long tradition of car manufacturing in the country - Big group of auto suppliers - Big domestic market	**WEAKNESSES** - Traffic congestion - Air pollution
OPPORTUNITIES - Economic growth increases demand for cars - XEV industry	**THREATS** - Change from ICE to XEV - Behavior change of customers
Indonesia	
STRENGTH - Huge domestic market - The domestic market is growing - Have a strong support from the government - Significant contribution to national GDP - Abundant labour	**WEAKNESS** - Export competitiveness is still low - Supporting industry is still weak - Low competency of labour
OPPORTUNITY - Big export market in the region - Growing economy in the region	**THREATS** - Shifting technology from internal combustion to electricity - Growing of competitor in the region

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4.3. Differences between the development of AE industry in European and SEA countries

AE industry in European countries includes mainly local companies, whereas SEA countries have the joint companies established with other foreign countries. The European companies are mainly export oriented and includes all the stages of production process (starting from raw material to complete automobile). High percentage of investments on R&D of AE related products can be highlighted. Instead, in SEA countries the AE industry is based on a vehicle assembling with relatively high component production localization. The AE industry produces vehicles for local markets, with low percentage of exports to SEA countries, mainly. Based on Status-Quo Analysis, it seems that the R&D in product development and innovation is relatively high in Malaysia.

5. Education in Automotive and Mechanical Engineering in European and SEA countries

5.1. Education in AE and ME in European countries ["what is"]

Politecnico di Torino (PTT)

PTT offers an Automotive Engineering degree for both BS and MS level students. In total 567 BS and 434 MS students are currently enrolled in courses offered by AE degree program. More than 10 full time and 11 part-time professors and researchers teach the courses. More than 100 researchers are involved in different research projects in AE field. Most of the topics mentioned in the GAP analysis are covered in the courses, however some topics related to ADAS and Connected vehicles currently are not covered (planned to be covered partially in the master degree program in ICT For Smart Societies). The extensive research in all the mentioned topics are carried out by different research groups of PTT with vast of experience and competence in the field.

FH Aachen (FHA)

FHA offers an Automotive Engineering degree for both BS and MS level students. In total 387 BS and 93 MS students are currently enrolled in courses offered by AE degree program. 14 full time and 8 part-time professors and researchers teach the courses. 5 researchers are involved in different research projects in AE field. All the topics mentioned in the GAP analysis are covered in the courses. The extensive research in all the mentioned topics are carried out, therefore researchers have vast experience and competence in the field.

FH Joanneum (FHJ)

FHJ offers an Automotive Engineering degree for both BS and MS level students. In total 190 BS and 86 MS students are currently enrolled in courses offered by AE degree program. 18 full time and 24 part-time professors and researchers teach the courses. More than 20 researchers are involved in different research projects in AE field. Most of the topics mentioned in the GAP analysis are covered in the courses, however some topics related to Industrial processes (powertrain production, Industry 4.0) are not covered. The

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extensive research in all the mentioned topics are carried out, therefore researchers have vast experience and competence in the field.

5.2. Education in AE and ME in SEA countries ["what is"]

Indonesia

In Indonesia, the education system starts from elementary school, to junior high school, senior high school, and higher education. The senior high school can be divided into general and vocational one. In the vocational one the automotive study program is offered, where graduate students are expected to fulfil the automotive labour market's needs. They are projected to become junior mechanics in automotive industry. The higher education is also divided into general and vocational one. In the general higher education, the automotive study program is not provided. Instead, mechanical engineering study program is the closest study program that supports the automotive industry. In addition, vocational higher education is also offering an automotive study program. The graduates are expected to become senior mechanics in automotive industry.

The partner universities in Indonesia do not offer AE degree programs separately. Limited teaching offer on AE related topics are covered within the ME program courses. The topics related to Vehicle dynamics and electrified powertrains (HEV and EV), ADAS and Connected vehicles are not covered. Topics related to Industrial processes (i.e. production processes, Industry 4.0 and production plans) are not fully covered, as well.

The automotive industry expects that higher education system can support and develop the industry mainly in the following domains:

- Development of electric and hybrid vehicles
- Development of biofuel mandatory vehicles
- Development of fuel cell vehicles
- To produce all of the vehicle components locally

Malaysia

Now, there is no specific degree program for automotive engineering that is offered at both UPM and UTeM. Nonetheless, automotive engineering topics are also taught as part of the Mechanical Engineering degree program: Bachelor of Mechanical Engineering with Honors (UPM) and Bachelor of Mechanical Engineering Technology (Automotive Technology) (UTeM). In addition, the field of automotive engineering study is also offered for Master degree by research at both universities. It should be noted that UTeM is planning to offer a specific degree program in automotive engineering in future (expected to start in September 2019).

The numbers of students, academic staff and researchers in the field of mechanical engineering and/or automotive engineering at both UPM and UTeM are tabulated in the following Table 1.

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Institution	Students	Academic Staff	Researcher
UPM	211	29	29
UTeM	60	135	135

Table 2. The number of students, academic staff and researchers in the field of ME and AE in UPM and UTeM

Based on the collected data from the desktop research, the level of competencies and skills among the current professors and students at UPM and UTeM in certain areas of automotive engineering can be summarized as tabulated in Table 2.

Automotive Engineering Topic	**Level of Competencies**	
	Professors	Students
Vehicle Design	Middle to Strong	Middle
Control System & Autonomous Vehicles	Middle to Strong	Middle
Industrial Processes	Middle	Middle
Testing Laboratories	Middle to Strong	Middle

Table 3 The level of competencies and skills among the current professors and students at UPM and UTeM in specific AE areas

Automotive industry in Malaysia has several great attributes and has a big potential for future growth, not only in areas of manufacturing and assembly but also in areas of R&D and innovation. A career in the automotive industry can be very diverse, with opportunities for a range of skill sets from sales to accounting to engineering. This means that the industry attracts diverse groups of people, creating a rather interesting work ecosystem. Narrowing on engineering employment, the technological changes in automotive engineering system can be quite complex and they involve a lot of fundamental area of development or knowledge that can be subsequently in other industries like rails, defence, aerospace and others. Furthermore, since transportation industry can be considered as one of the current necessities to enable human mobility from one place to another, there are lot of innovations can be seen to be coming into realization such as flying car, autonomous vehicles and electric vehicles. Hence, apart from the excitement of working on something that will directly benefit the society, automotive industry also remains as one of the attractive industries to have a working career due to its interesting evolutionary nature. Along with changes in the industry, the skill sets that are expected for engineers to work in automotive industry have also evolved. Apart from necessary technical engineering knowledge, many employers have also considered some essential soft skills in the hiring process. Among others, these include good problem-solving skills, technical reporting, project planning and management, practical hands-on skills and information technology skills. However, as indicated by many employers, they believe that many graduates still lack those soft skills and this situation can make it difficult for them to fulfil the current work demands and professional expectations from the industry, particularly for R&D works. Some of the possible reasons for this situation include lack of self-initiative of the graduates to explore new set of skills or new emerging technologies, and the lack of hands-on activities during their study. To tackle this issue, the universities have started vast cooperation with

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few automotive companies and regional municipalities for the establishment of new educational facilities and laboratory centres, and also for the development of educational study programs that are created to simulate real production to enable students to learn under real conditions and hence prepared practically for real life in companies. It is noted that the hands-on exposure to the students within their degree program will depend on the type of university that they are studying at. For a research-based university such as UPM, the undergraduate students are only exposed to the related hands-on skills through integrated laboratory testing as part of the theoretical courses. In contrast, for technical university like UTeM, more hands-on contents are adequately incorporated into their curriculum in comparison to the conventional university. In general, most universities in Malaysia have a good relationship with the industries. While a number of collaborations exist, there is still an ongoing need to have more collaborations between universities and business entities in areas such as contract internship for graduates, industrial training placements and also joint researches. To have a better partnering between the university and the industry, several things have to be considered. One of the primary aspects to be taken into account is the mismatched expectations between the university and the industry partner within a collaborative project. Secondly, there is also an issue of trust that acts as a stumbling block for potential cooperation and collaboration, especially in relation to development of new invention or intellectual property. Further initiatives are needed in order to bring both parties to a common understanding for mutual benefits. On a positive note, encouraging feedbacks have been obtained from the representative participants who have been involved in the focus group regarding the readiness of their institution or organization to support and cooperate with the activities within this UNITED Erasmus+ project.

The topics related to Vehicle dynamics and electrified powertrains (HEV and EV), ADAS and Connected vehicles are not covered. Topics related to Industrial processes (i.e. production processes, Industry 4.0 and production plans) are not fully covered, as well.

Thailand

The partner universities in Thailand offer Mechanical and Automotive Engineering programs for BS and MS students (CKU offers Automotive Engineering and MSU offers Mechanical engineering courses). Vehicle design part of the AE courses is offered in both universities. Professors of two universities have advanced knowledge and experience in the part of Control Systems & ADAS and interconnected vehicles. However, the teaching of the topics of included in this part is not foreseen in teaching plans. Topics related to Industrial processes (i.e. production processes, Industry 4.0 and production plans) are covered in CKU, but the topics are not foreseen in teaching plans for MSU students.

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Table 4 SWOT Analysis of SEA automotive education

Indonesia	
STRENGTHS - Professors with high interest in AE - High interest of new students in automotive engineering	**WEAKNESSES** - Professor with specific knowledge on AE is absence - Automotive industry is only branches - Students lacking skills in course of development of automotive engineering - Students lacking basic skills on automotive training course
OPPORTUNITIES - Interest for AE in student population is increasing - Interest of government for green transportation is increasing - Interest of public for buying new vehicles is steadily increasing	**THREATS** - International education institutions offer specific courses in AE - Fulfilment of automotive science need for millennial generation - Scenario of usage of hybrid and electrical vehicle
Malaysia	
STRENGTHS - Curriculum design aligned with local automotive industry needs. - Academics staff with professional qualification (C.Eng. Ir, Ts) & >50 % with industry experience, fully accredited program - comply Washington accord - Strong financial support for TVET agenda- Malaysia to setup facilities & capabilities in Automotive program. - Strong networking with 2 national car industry (Proton & Perodua) - Collaboration with automotive related association, MARii, MIROS, MPOB - Lecturers in materials, vehicle design, powertrain and internal combustion engine - Connection with SAE and industry related to automotive -	**WEAKNESSES** - Relatively young Tech Univ (16 yrs) Automotive capability not matured - Lacking of technical support from industry/gap - Mismatch of expectation between academics & industry needs - Lack of facilities - Limited support staff - Lack of automotive focus in current curriculum

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OPPORTUNITIES	THREATS
- Involvement in National Automotive Policy 2018 - National Biodiesel Roadmap - Existing 2 national car manufacturer - IR4.0 in automotive industry - M'sian Gov strong initiative in implementing national automotive industries- 3rd national car project in the pipeline - Geographical locations in the centre of Malaysia: easy access - Students' interest in automotive, also through Master by research	- Competition among local universities, implemented similar automotive program- creating competitive disadvantages - Very dynamics governmental policy- negative impact on setting up capabilities - Students are lacking basic skills for the engineering courses (automotive) - Lack of funding - Highly focused automotive programs in other HEIs

Thailand

STRENGTHS	WEAKNESSES
- Professors trained in automotive engineering - Some professors with industrial experience - Well aware of Thai automotive policies and current situation - No. of experts in both ME & EE - No. of partners from industries/government agencies	- Not enough professors - Don't have enough testing facilities - Low no. of practical equipment - High work load
OPPORTUNITIES	**THREATS**
- Automotive interest in the country is growing - Much encouragement for start-up companies - Supported by government (Thailand 4.0 Cluster) - Increasing of SMEs/MMEs	- Some students are lacking basic skills for the engineering courses - Some students change the major after graduation - Students are lacking basic skills for the engineering courses 'internationally' - Limit in budget supported from university

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5.3. Differences between the education in AE and ME in European and SEA countries

In all three EU partner universities the AE degree program is offered separately from ME, instead in SEA partner universities AE degree programs are not run separately. The topics listed in the GAP analysis form are partially offered within ME degree program courses. In some SEA universities, a lack of competences in Vehicle dynamics and Electrified powertrains (HEV and EV) can be highlighted. While competences in ADAS, connected vehicles and current trends in Industrial processes seems to be lacking in all the partner SEA universities.

6. Implementation of laboratory concepts / testing bays in European and SEA countries

6.1. Implementation of laboratory concepts / testing bays in European countries ["what is"]

Politecnico di Torino

In PPT several testing bays related to AE are currently running to provide hands-on learning for students. The testing bays include such test beds like: Front Engine Accessory Drive test bed for testing the Mild and Micro HEV, Virtual Test Simulator for ADAS, Engine test beds, Shaker test stand, Transmission test beds, Brake test beds, Vehicle dyno, Dynamic testing machine for ICE and others. From 2020, the university is seeking to establish new test bays to enhance research and education in Connected Cars and Advanced Driver Assistance Systems, electrified and alternative powertrains. Such test bays will allow performing experimental tests of complete vehicles and the experimental characterization of HEV/EV powertrain components. Racing teams of different completions like Formula Student HEV, Electric, Alternative Powertrain and Formula Student ADAS allow students to have more hands-on learning of the offered courses.

FH Aachen

In FHA different testing bays related to AE are running to provide hands-on learning for students. Battery test stand, Climate test stand, Shaker test stand, Crash-Sledge Facility, Vehicle Assembly Area, Quasi-Static crusher and Chassis dyno 2WD are some of the test bays currently present in the university. The universities test bays are planned to be equipped with 4WD chassis dyno with emission measurement device EU6d conform and portable emission measurement system (PEMS) starting from 2020. Racing teams composed of students allows them to enhance hands-on training.

FH Joanneum

In FHJ, there are 14 testing bays, used for Student's project and thesis work, cooperation with companies and universities' R&D. The test beds include Acoustics laboratory, drive train test beds, Engine test beds, Chassis Dyno and others. The university is seeking to cover alternative powertrain development through the testing bays. Internships, Project works (group of 3-4 students) and Racing teams are used to enhance hands-on training of the students.

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6.2. Implementation of laboratory concepts / testing bays in SEA countries ["what is"]

Indonesia

The testing bays in USU and UNUD are limited to internal combustion engine test bench. The universities are seeking to cover conventional and electric vehicle testing through the testing bays in future.

Malaysia

The testing bays level in UTeM and UPM differ substantially. In general, the universities have engine test cells, gas analysers and different types testing equipment's for testing the material properties. The universities are seeking to cover conventional and electric vehicles, ADAS and vehicle impact tests through the testing bays. Based on the currently available equipment and testing bays structures in UPM and UTeM, it can be said that the facilities are partially complete. There is a few essential equipment needed to better conduct hands-on training for the students with regards to automotive study. The laboratory or hands-on training activities are now only partially done as part of several courses within the curriculum.

Thailand

The testing bays in MSU and CKU include Engine test cells, where students can learn the engine control systems. The universities are seeking to cover conventional and electric vehicles (including agricultural vehicles for MSU) tests through the testing bays.

6.3. Different approaches regarding the implementation of laboratory concepts / testing bays between European and SEA countries

The range of the equipment in the testing bays in EU and SEA countries differ substantially. The testing bays in EU partner universities is sufficient to cover most of the AE related laboratories. SEA partner universities have testing bays mainly limited to Engine test cells (except UTeM, which has a vast list of the lab equipment in AE related fields).

The universities in SEA are seeking to cover Electrified powertrain, Connected Vehicles and Autonomous driving research and education through the testing bays in future. In addition, the partner universities seem to be lacking the competence of managing the test bays.

7. University / business cooperation and employability in Europe and SEA countries

7.1. University / business cooperation and employability in Europe ["what is"]

Politecnico di Torino

PTT has good cooperation with AE industry. The Master level courses offered in PTT are co-led by industrial engineers. Furthermore, the Master thesis works can be co-supervised by the company engineers or done directly in the companies like FCA, CRF, Dayco, Magneti Marelli. The students can have stage/internship in

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the AE related companies. FCA group and other industrial partners support the Formula Student Team to enhance the cooperation between university and the company. Automotive engineering program was initially established in Partnership between FCA group and the university. Industrial research projects, partnerships (like one with FCA - Polito), University Alumni and Seminar led by AE professionals helps to strengthen cooperation between PTT and Industry in AE research and education. The university is involved in wide range of clusters and associations. PTT has high employability rate of the students, with 88.6% of Master's graduates can find jobs in their field of study. They are occupied in the field of Vehicle and component design and testing, Powertrain development and testing, engine control system and Process engineering. The University supports the students to increase the employability by updating the course contents frequently to meet the new industrial challenges based on the results of the projects, by spending stages in companies, by involving the students in industrial projects. Working on Thesis work under co-supervision of specialist from companies, participating in student racing teams and Hands-on trainings, additional knowledge of CAE tools used in AE, studying interdisciplinary degree and having soft skills (language and report writing) are key success factors for graduates to be employed in good companies.

FH Aachen

FHA has practical works organized in companies included in the study plan of the BS and MS students. Project works, BS and MS thesis of the students can be carried out in companies (Ford, Porsche, FEV, etc). Industrial research projects, public funded projects by federal or German ministries, Network and cooperation contracts are used as alternative channels to improve the cooperation between the University and business. FHA is a member of 7 top universities of Applied Sciences in Germany (HAW7). 90 % of graduates of FHA can find jobs within 3 months. Most of the graduates are employed in Automotive Industry (40% directly at OEM, 40% at Engineering Companies, 20% rest like TÜV and non-automotive). Adjust the curriculum in close alignment with industry needs (e.g. Industriebeirat) seems to be key success factor for graduates to be employed.

FH Joanneum

FHJ has good cooperation with the AE industry related companies. Students have to do internships in industry (BS – min 450 hours and MS – min 350 hours). Furthermore, Formula student racing teams are supported by major AE companies. The university has wide cooperation with national and international clusters and bodies. Different projects with industrial partners, involving academic and scientific staff, as well as students are used as additional channels to cooperate with companies. Lecture series in AE by invited guest speakers from companies are organized to enhance the cooperation. More than 98 % of graduates can find jobs within three months, which are mainly occupied in AE related fields, such as Powertrain development, Control Systems, Technical Design, Drivetrains simulation and E-Technique. University supports student's employability by adapting their competences to industrial needs, by merging scientific and industrial teaching, by inviting lecturers working for automotive companies to teach the courses and by promoting internships with partners. Key success factors for graduates of FHJ to be employed are: Working on final thesis in cooperation with companies, having business & linguistic additional skills, participating in formula student projects, invitation of professionals from companies as lecturers, combination of mechatronic degree focusing on automotive engineering and frequent hands-on training during studies.

7.2. University / business cooperation and employability in SEA countries ["what is"]

Indonesia

In USU and UNUD send the students to companies for having some internships in companies or to work on minor projects (usually related to final project). The faculties of the universities cooperate with the national clusters and associations related to AE, like BP2TD and Land Transportation Education and Training Agency.

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In average, more than 50 % of graduates can find jobs within three months. The main field of occupation of the graduates is related to the maintenance and sales of the vehicles. Job fairs are organized to support the employability of the students. Key success factors which help graduates to be employed are having soft skills, language proficiency and additional certificates.

Malaysia

In UPM and UTeM industrial training/internship (10 weeks) is compulsory for the students. Industrial experts are invited to train/teach students and also examine the engineering programs. Technical talks and consultations projects are organized to allow students to work on industrial projects and research. The faculties of the universities cooperate with the international and national clusters and associations related to AE, Society of Automotive Engineers (SAE), Malaysia Automotive, Robotics and IoT Institute (MARii) and Malaysia Institute of Road Safety Research (MIROS) are being some of them. In average, more than 80 % of graduates can find jobs within three months. The main field of occupation of the graduates is related to the AE and to manufacturing sector in general. Job fairs are organized to support the employability of the students. Key success factors for graduates to be employed are: having practical skills, soft skills and having curricula aligned with AE industry needs. Furthermore, involvement of stakeholders in the university life is an additional factor.

The current level of cooperation between the universities and industrial companies and government agencies in local automotive industry can be considered as good, as stakeholders in the educational degree program, representatives from the automotive industry and related governmental institutions are continuously engaged in improving the program curriculum.

Thailand

In CKU and MSU have different levels of cooperation with the companies. In CKU 7 weeks of industrial training is mandatory for the students. Industrial experts are invited to train/teach students. Feedbacks from the industry are also taken into account in the development or update of the curriculum. The faculties of the universities cooperate with the clusters and associations related to AE. More than 80 % of graduates can find jobs within three months. The main field of occupation of the graduates is related to the AE, however includes field of sales and warranty services of vehicles as well. Job fairs are organized to support the employability of the students. Key success factors for graduates to be employed are: having practical skills, hardworking, soft skills including English proficiency and ability to work under high pressure.

7.3. Differences between university / business cooperation in European and SEA countries

The European universities have high-level cooperation with the AE industries. Universities in SEA countries have limited cooperation with companies. In the EU universities the organization of racing teams, spending stage/internships in the companies and having industrial project related research topics for the students are main reasons to have good cooperation between universities. In SEA universities, spending stage/internships in the company is the main way of cooperation between universities and industries. The high majority of graduates of the European universities can find jobs within short time in AE related fields of occupation. Even though the employability rate of the graduates of SEA universities is high, the graduates are not mainly occupied in the field of their study. The key factors for graduates of European universities is having practical oriented curriculum aligned with the needs of the industry, whereas for the universities from SEA countries having soft skills (language proficiency, communication) is the main factor to find job in short time.

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Table 5: Gap analysis in SEA regarding automotive engineering education

Country	Item	Current Status	Desired Status	GAP	Action / Training needed	Improvement
Indonesia	degree programs / main focus	ME: BS and MS	Development of dedicated AE track. Strengthen the teaching offer in specific fields of AE	AE degree programs are not run separately from ME. Limited teaching offer on AE related topics as described below according to the needs of the industry.	Support of activation of dedicated AE program, organize trainings to setup new courses	Dedicated training addressed to specific needs coming from industry.
Malaysia	degree programs / main focus	ME: BS and MS	Development of dedicated AE track. Strengthen the teaching offer in specific fields of AE	AE degree programs are not run separately from ME. Limited teaching offer on AE related topics as described below according to the needs of the industry.(Planned from the upcoming Academic year)	Support of activation of dedicated AE program, organize trainings to setup new courses	Dedicated training addressed to specific needs coming from industry.
Thailand	degree programs / main focus	AE: BS and MS	Development of dedicated AE track. Strengthen the teaching offer in specific fields of AE	Missing the teaching offer in specific fields of AE.	Support of activation of dedicated AE program, organize trainings to setup new courses	Dedicated training addressed to specific needs coming from industry.
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	competences & skills - vehicle design (professors / students)	professors: middle to strong (depending on the university) students: low	strong	Lack of competences in vehicle dynamics and electrified powertrains (HEV and EV)	UNITED training on vehicle dynamics (longitudinal, lateral) and Electrified powertrains	universities can offer course on vehicle dynamics and electrified powertrains to students
Malaysia	competences & skills - vehicle design (professors / students)	professors: middle to strong students: middle	strong	Lack of competences in Vehicle dynamics, electrified powertrains (HEV and EV)	UNITED training on Electrified powertrains	Universities can offer more Hands on training for students in Vehicle dynamics and offer a course in electrified powertrains
Thailand	competences & skills - vehicle design (professors / students)	professors: middle to strong students: middle	strong	Lack of competences in Crashworthiness, electrified powertrains (HEV and EV)	UNITED training on Crashworthiness, Electrified powertrains	Universities can offer more Hands on training for students in Vehicle dynamics, Crashworthiness and in electrified powertrains
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	competences & skills - control systems & autonomous and connected vehicles	[strong / middle / low] professors: middle to strong students: low	strong	Lack of competences in ADAS and connected vehicles	UNITED training on Autonomous and Connected vehicles	universities can offer course on Autonomous and connected vehicles to students

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	(professors / students)					
Malaysia	competences & skills - control systems & autonomous and connected vehicles (professors / students)	[strong / middle / low] professors: middle to strong students: middle	strong	Lack of competences in ADAS and connected vehicles	UNITED training on Autonomous and Connected vehicles	universities can offer hands on courses on Autonomous and connected vehicles to students
Thailand	competences & skills - control systems & autonomous and connected vehicles (professors / students)	[strong / middle / low] professors: middle to strong students: middle	strong	Lack of competences in ADAS and connected vehicles	UNITED training on Autonomous and Connected vehicles	universities can offer hands on courses on Autonomous and connected vehicles to students
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	competences & skills - industrial processes (professors / students)	[strong / middle / low] professors: middle students: low	strong	Lack of competences in current trends in Industrial processes education	UNITED training on Industry 4.0 and production plants	Universities can offer courses on Industry 4.0 basics for Automotive Industry production process organization
Malaysia	competences & skills - industrial processes (professors / students)	[strong / middle / low] professors: middle students: middle	strong	Lack of competences in current trends in Industrial processes education	UNITED training on Industry 4.0 and production plants	Universities can offer courses on Industry 4.0 basics for Automotive Industry production process organization
Thailand	competences & skills - industrial processes (professors / students)	[strong / middle / low] professors: middle students: middle	strong	Lack of competences in current trends in Industrial processes education	UNITED training on Industry 4.0 and production plants	Universities can offer courses on Industry 4.0 basics for Automotive Industry production process organization
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	availability of testing bays at universities	availability: partial	full		UNITED development of list of test equipment for purchasing. Training in using the test equipment and managing the test bays	Universities can improve the teaching of the courses with more experimental skills
Malaysia	availability of testing bays at universities	availability: partial	full	Testing bays in the field of Electrified powertrain, Connected Vehicles and Autonomous driving lab equipment are needed. Lack of competence of managing the test bays.	UNITED hands on training in electrified powertrain, connected vehicles and Autonomous driving	Universities can offer practical lessons in electrified powertrain, connected vehicles and Autonomous driving

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Thailand	availability of testing bays at universities	availability: partial	full	Testing bays in the field of Electrified powertrain, Connected Vehicles and Autonomous driving lab equipment are needed. Lack of competence of managing the test bays.	UNITED hands on training in electrified powertrain, connected vehicles and Autonomous driving	Universities can offer practical lessons in electrified powertrain, connected vehicles and Autonomous driving
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	hands-on trainings for students	availability: partial	full	Lectures are not supported by hands on trainings.	UNITED can help in setting up multidisciplinary projects to link different AE courses in one study case (Numerical or Experimental + Numerical). These projects could be inspired by industrial partners.	Universities can enhance the students' competences in handling practical/ real world problems.
Malaysia	hands-on trainings for students	availability: partial	full	Limited number of topics are supported by hands on trainings.	UNITED can help in setting up multidisciplinary projects to link different AE courses in one study case (Numerical or Experimental + Numerical). These projects could be inspired by industrial partners.	Universities can enhance the students' competences in handling practical/ real world problems.
Thailand	hands-on trainings for students	availability: partial	full	Limited number of topics are supported by hands on trainings.	UNITED can help in setting up multidisciplinary projects to link different AE courses in one study case (Numerical or Experimental + Numerical). These projects could be inspired by industrial partners.	Universities can enhance the students' competences in handling practical/ real world problems.
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	university - business cooperation	low to middle	strong	UNUD - has good cooperation with the companies. USU has limited cooperation with the companies. This is probably due to low level of cooperation of students with the companies.	UNITED help organizing seminars, stages involving local industrial partners for further improvement of the University-Company cooperation. To foster a research cooperation UNITED could show example of cooperation projects between University and companies.	Strengthen the link between Universities and Companies. Improve course contents with topics of interest for the industry. Wider involvement of students in industrial projects.
Malaysia	university - business cooperation	middle	strong	UTeM and UPM have good cooperation with the companies.	UNITED help organizing seminars, stages involving local industrial partners for	Strengthen the link between Universities and Companies. Improve

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					further improvement of the University-Company cooperation. To foster a research cooperation UNITED could show example of cooperation projects between University and companies.	course contents with topics of interest for the industry. Wider involvement of students in industrial projects.
Thailand	university - business cooperation	middle	strong	CKU - has good cooperation with the companies. MSU has limited cooperation with the companies. This is probably due to low level of cooperation of students with the companies.	UNITED help organizing seminars, stages involving local industrial partners for further improvement of the University-Company cooperation. To foster a research cooperation UNITED could show example of cooperation projects between University and companies.	Strengthen the link between Universities and Companies. Improve course contents with topics of interest for the industry. Wider involvement of students in industrial projects.
Country	**Item**	**Current Status**	**Desired Status**	**GAP**	**Action / Training needed**	**Improvement**
Indonesia	employability of graduates	average	high	Limited teaching activity in Product Engineering, especially, in emerging trends of automotive fields. Some of Automotive Engineers do not find a job in Automotive industry.	Stages, cooperation projects, study cases proposed by the industry. Organizing Career days and Company days.	Improve job placement of students.
Malaysia	employability of graduates	average to high	high	Limited teaching activity in emerging trends of automotive fields, such as vehicle electrifications, autonomous and connected vehicles.	UNITED can organize the training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles	The job placement of students appears already to be high. The proposed actions could keep this level also considering new trends and fast changes affecting Automotive industry today
Thailand	employability of graduates	average to high	high	Limited teaching activity in emerging trends of automotive fields, such as vehicle electrifications, autonomous and connected vehicles, product life cycle management.	UNITED can organize the training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles	The job placement of students appears already to be high. The proposed actions could keep this level also considering new trends and fast changes affecting Automotive industry today

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Country	Item	Current Status	Desired Status	GAP	Action / Training needed	Improvement
Indonesia	trends in AE, offer / response of university	High production capacity, but limited Product engineering	Industries and Universities capable of keeping pace in current trends in AE	Limited development of Small segment Green/Electric cars	UNITED can organize the training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles	Help companies to keep or improve their market position also considering new trends and fast changes affecting Automotive industry today. Help university to improve their position in perspective of AE new trends.
Malaysia	trends in AE, offer / response of university	High level of development of alternative fuels for the vehicles	Industries and Universities capable of keeping pace in current trends in AE	Limited development of Electrified powertrains, Autonomous and connected vehicles, and Sustainable production using elements of Industry 4.0	UNITED can organize the training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles	Help companies to keep or improve their market position also considering new trends and fast changes affecting Automotive industry today. Help university to improve their position in perspective of AE new trends.
Thailand	trends in AE, offer / response of university	Strong electronics industry, but with limited interaction with Automotive industries	Industries and Universities capable of keeping pace in current trends in AE	Limited development of new trends of Sustainable Automotive industry like electrification, autonomous and connected vehicles.	UNITED can organize the training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles	Help companies to keep or improve their market position also considering new trends and fast changes affecting Automotive industry today. Help university to improve their position in perspective of AE new trends.

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8. Guidelines for the development of automotive engineering education and testing bays in SEA countries

This section describes how automotive engineering and testing bays could be improved, based on the data acquired during the status-quo analysis and the gap analysis in the SEA countries. Input from automotive and mechanical engineering experts on regional development and university-business cooperation, as well as regarding needs of improvements was given during the focus group interviews and is considered herein regarding the training topics of the UNITED capacity building trainings.
Further, recommendations and key performance indicators in terms of successful future developments in the automotive industry to increase regional development and university-business cooperation as well as internationalization and suggestions for training topics are described in this section.

8.1. Existing gaps between EU and SEA universities on AE education and testing bays

Following gaps were identified, based on the comparison of the status-quo of AE education and available testing bays in the universities and needs of the industries in the corresponding countries

- AE degree programs do not run separately from ME and limited teaching is offered on AE related topics.
- All SEA universities have lack of competences in vehicle dynamics, electrified powertrains (HEV and EV), crashworthiness, ADAS and connected vehicles, as well as and industrial process education.
- The universities lack testing bays in the field of electrified powertrain, connected vehicles and autonomous driving labs. Lack of competence of managing the test bays can be highlighted as well.
- Limited number of topics are supported by hands-on trainings in all the universities.
- The universities have limited to good level of cooperation with the companies. This probably might be due to the limited interest of the companies to accept students during the final project or thesis, as well as to start research in cooperation with the universities.
- High employability rate of graduates can be mentioned as a very positive aspect.
- The universities have limited development in new trends of sustainable automotive industry like electrification, autonomous and connected vehicles.
- The car manufacturers in SEA countries are aligned with the current trend on powertrain electrification and aiming to produce electrified vehicles in near future.

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TRAINING TOPICS	COMMENTS FROM INDUSTRY EXPERTS REGARDING TRAINING TOPICS
Electrified powertrains, Hybrid/Alternative Powertrain, Vehicle Design and Vehicle Dynamics, Mechatronic Systems in Automotive Engineering + Testing Bays	- fuel cells will be the most important driving power in the next 20 years - light e-mobility will gain stronger popularity in megacities, (48V for e-scooters, cargo bicycles, rickshaw or three-wheeled passenger cars) - Modular 48V system for rickshaw might become a highly popular type of powertrain for transport in Southeast Asia (SEA) - Electrified powertrain component design - During the last five years, the trend in automotive industry was to electrify the vehicle powertrain due to regulations and higher sensitivity of costumers to environmental issues. Most of the cars designed in these years were mainly hybrid or pure electric vehicles. - new sustainable fuel such as PtG (power-to-gas e-fuels) in combination with solar energy should be a main part of this topic) - Towns will change, more radical new mobility concepts will change the urban layouts. - Conventional IC will get out of urban areas more and more. Sustainability in products and processes will start having a significant influence, safety will happen more due to infrastructure (smart cities) but still crashworthiness will play a major role in the design of vehicles. - Vehicle Design + Dynamics topic is important especially in the case of special regional vehicles. For large OEMs it not that relevant, because the one and only "world cars" does not exist anymore. - Additive manufacturing and Industry 4.0 concepts are bringing radical changes to the product manufacturing. - CASE (connected, autonomous, shared, electric), flexible vehicle platforms, Production Strategies in combination with flexible product placement, new steel and aluminium materials and production technologies, major focus on steel due to cost, active safety systems and crashworthiness will increase further - The training on Mechatronic Systems and IT in Automotive Engineering is considered as important while it strongly contributes to the volume of sales in automotive industry. - Testing bays are important for combination of university research (e.g. PhD education) and services / contract research for industry. By this way network to industry can be built up. Test bays are a strong link to the industry for a university. - The usage / implementation of testing bays always depends on the needs of the institution.

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	- Focus on bays where local companies have a need for testing to set up corporations with local industry However some of the possible testing machines that can be suggested: - Tension-Compression-Machine (measurement of material properties) - Drop Tower (Crash) - Drive train test rig - Virtual reality equipment - Test track if possible, e.g. to show students special vehicle driving scenarios - Test track for ADAS (mini smart city) - Material testing (important for virtual development process)

Table 6: Proposed training topics and some of the suggested testing bay equipment by experts from industries interviewed during the UNITED Focus Groups

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8.2. Guidelines for the development of automotive engineering education in the universities

The car manufacturers in SEA countries are aligned with the current trend on powertrain electrification and aiming to produce electrified vehicles in near future. To handle specific needs coming from AE industry activation of dedicated AE programs and organization of trainings to setup new courses are needed. To increase the university – business cooperation and increase the employability of the graduates, universities must try to satisfy the needs of the industries by increasing the competences of their graduates in current automotive engineering trends.

In general, the topics related to vehicle dynamics and electrified powertrains (HEV and EV), ADAS and connected vehicles and industrial processes (i.e. production processes, Industry 4.0 and production plans) should be covered to close the gap between needs of the industries and the courses offered by the universities.

Summarizing the needs of the industries, the topics suggested for the trainings to be conducted under the UNITED Erasmus+ project can be divided into following trainings sessions and topics:

Training session title	Main topics
Training 1: Electrified powertrains	Electric/Electrified powertrain concepts and system layout Electric/Electrified powertrain embedded software systems IT connectivity in modern vehicles
Training 2: Moving from ICE to Alternative Powertrain	Sustainable urban mobility planning (SUMP) Low CO2 ICE efficiency Hybrid and alternative fuels:
Training 3: Vehicle Design and Vehicle Dynamics	Future Mobility / Vehicle concepts / Body Design / Safety Vehicle Dynamics
Training 4: Mechatronic Systems in Automotive Engineering + Testing Bays	Development process for mechatronic systems Testing Bays

Table 7: Proposed training topics based on the needs of the SEA universities and the provided expertise by the European partners in the UNITED project

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Furthermore, to foster the university-business (academic and research) cooperation, universities might:

- organize seminars, stages, study cases and cooperation projects involving local industrial partners in the UNITED EKTUs;
- use best practice example of European universities for cooperation projects between university and companies;
- organize career days and company days to improve the employability of the graduates as part of the UNITED network;
- organize training courses, as well as cooperation projects in vehicle electrification and autonomous vehicles in the UNITED EKTUs;
- set up multidisciplinary projects to link different AE courses in one study case (Numerical or Experimental + Numerical). This can help to link the university and industries by addressing the needs of latter. These projects could be inspired by industrial partners.

8.3. Guidelines for the development of automotive engineering testing bays

For further increase of university-business cooperation, testing bays in universities can be enhanced with modern equipment (hardware and software) to carry on the proposed training topics and adapt to the needs of the industry in the future. Therefore, this section describes the equipment that might be purchased within the UNITED project to run the training sessions in the EKTUs and also beyond the time frame of the project, to further upgrade the EKTUs and testing bays at universities.

The installation of testing bays could serve the industry in many ways such as

- crash test,
- research on engine performance,
- development of vehicle subsystem,
- component testing according to standards,
- emission standard testing and many others.

Among the services that are currently needed by local automotive industries include powertrain testing facilities, engineering service and development, testing facilities and reliability as well as durability testing.

Furthermore, some of the expected benefits from having the test bays at the universities to the students are:

- improvement of the knowledge related to automotive engineering,
- creation of more competent talents,
- increased practical skills,
- provision of hands-on experience related to vehicle examination and
- opening of new research topics to the university researchers that will improve in-class teaching with relevant examples taken from the research projects.

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The list of test equipment to accomplish hands-on lessons needs to be generated and purchased based on the allocated budget to each partner university. Training in using the test equipment and managing the test bays should be organized, which is extensively planned in WP3 and WP4.

Example of some hardware and software used in specific area of automotive engineering research, education and consultancy in partner universities in EU is summarized in the following table. Obviously, the equipment names and manufacturers are given for reference reason only and is not limited to this list. The SEA universities will decide on the equipment based on available budget, regional availability of these or alternative products, and other conveniences.

Training session title	Proposed equipment and software for testing bays
Training 1: Electrified powertrains	To understand the component and energy management strategies of the Electric/Electrified powertrain concepts and ADAS systems following hardware and software could be suggested: Hardware: ● Demo/training units of the electrified powertrain overall systems ● Demo/training units of the electrified powertrain components (electric motor, battery management system, inverters, cabling, control boards) ● EV drive unit demonstrators ● ADAS (Advanced Driver Assistance Systems) simulators ● Battery emulators Software: ● AVL Cruise, IPG Carmaker, CarSim, MSC Adams etc. (Including toolbox for ADAS-Advanced Driver Assistance Systems) ● Matlab/Simulink ● Siemens Amesim
Training 2: Moving from ICE to Alternative Powertrain	Simulation tools software for internal combustion engine combustion, fuel consumption and efficiency modelling, virtual development and alternative fuelled vehicle modelling: Hardware: ● AVL fuel cell test systems ● Engine test cells ● Load cells, torque meters, Fuel flow meters, pressure and temperature sensors for engine characterization Software:

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	• GT Power • AVL BOOST™, AVL FIRE™ and AVL CRUISE • Matlab/Simulink
Training 3: Vehicle Design and Vehicle Dynamics	Hardware and Software used in Automotive body engineering, Vehicle safety & crashworthiness and Vehicle dynamics testing: Hardware: • AVL, RaceLogic, Kistler Vehicle dynamics testing equipment • 3D Printers for rapid prototyping of the car body Software: • AVL VSM – (Vehicle Simulation Model), Matlab/Simulink, MSC ADAMS, CarSim, IPG Carmaker • Ansys, Comsol, Altair, NX Nastran (a more generic software useful for different applications) • Matlab/Simulink
Training 4: Mechatronic Systems in Automotive Engineering + Testing Bays	Development process for mechatronic systems, Hardware in the loop systems Testing Bays/Hardware: • Engine control units from AVL, Bosch, NewEagle, Siemens and others • D-Space (Autobox, MicroAutobox), National Instruments (CompaqRIO, CompaqDAQ) data acquisitions systems • AVL E-Drive Test Systems (however, existing ICE dyno can be adapted to this specific need) • AVL DiTest Exhaust gas measurements Software: • Universal tool for this kind application is Matlab/Simulink • The specific tools to operate with chosen hardware should be purchased bundled (DSpace Control desk, NI Labview and others)
Generic for all Engineering Knowledge Transfer Units	Following equipment can be considered generic for all cases: • Workstation desktops to run the computationally and graphically demanding software and to plugin hardware. • Projectors • Smartboards • etc

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Table 8: Proposed equipment for testing bays in the UNITED SEA universities, for example as part of the Engineering Knowledge Transfer Units

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9. Summary

The comparative report summarizes the actions, recommendations and key performance indicators to increase regional development and university business cooperation in the field of Automotive Engineering. Based on the suggestions of the focus groups and the needs of SEA universities the topics and general contents for four trainings are identified. Furthermore, the list of recommended equipment for running the trainings in EKTU's and establishing testing bays is proposed. The equipment list contains some of hardware and software widely used in Automotive and Mechanical Engineering education in EU universities.

10. References:

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