Engineering Knowledge Transfer Units to Increase Students' Employability and Regional Development

SOUTHEAST ASIA AUTOMOTIVE INTEREST GROUP

The driving force behind automotive ecosystems

JOINT PUBLICATION

KNOWLEDGE TRANSFER IN AUTOMOTIVE ENGINEERING

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UNITED:
Engineering Knowledge Transfer Units to Increase Students' Employability and Regional Development

Edited by:
Fairuz Izzuddin Romli
Hanna Sprenger

List of Contributors

Niwat ANGKAWISITTPAN
Himsar AMBARITA
David BANJERDPONGCHAI
Taufiq BIN NUR
Sunhapos CHANTRANUWATHANA
Prabhath DE SILVA
Thomas ESCH
Ni Putu Sri Harta MIMBA
Eva PENZ
Chonlatee PHOTONG
Natascha POTUSCHNIK
Fairuz Izzuddin ROMLI
Sanjarbek RUZIMOV
Hanna SPRENGER
Noreffendy TAMALDIN
Andrea TONOLI
I Nyoman Suprapta WINAYA

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Preface

FH JOANNEUM, as the coordinator of the UNITED project, wishes to express its big gratitude to all dedicated members of the UNITED consortium, who have been working together to reach the goals of the project:

- Establishing a sustainable network of academic experts, students and companies working and studying in the fields of automotive, mechanical, and electrical engineering – the Southeast Asia Automotive Interest Group (SAIG). The network serves as a platform for exchange of latest research activities, knowledge transfer in form of webinars and conferences, as well as connecting engineers worldwide.

- Transferring of knowledge for future developments in the fields of automotive, mechanical, and electrical engineering with the so-called Engineering Knowledge Transfer Units (EKTUs), installed at each of the Southeast Asian UNITED partner universities. The EKTUs offer trainings for engineers, academics, students and other staff related to automotive, mechanical or electrical engineering on topics related to sustainable mobility, to foster on the one hand university-business cooperation and drive the upskilling and reskilling of workforce in these areas.

Moreover, on behalf of the consortium, we would like to thank the European Union for supporting and co-funding the UNITED project and its activities under Erasmus+ Programme Capacity Building in Higher Education.

We hope that professional dialogues among researchers, engineers, experts and students will further continue beyond this UNITED project within the frame of the SAIG network and the knowledge transfer platform, and that the collaborations will prosper for many years to come.

FH-Prof. DI Dr. Kurt Steiner
Head of Institute Automotive Engineering, FH JOANNEUM
Coordinator of the project UNITED

Chapter 1

Introduction to UNITED Project

Transportation plays a big role in advancing human civilization. It is a vital element that enables greater reach in communication and networking between people, and is instrumental in creating socio-economic opportunities that have led to better living standards. In line with this perspective, the automotive industry can be seen as a primary contributor toward improvement of transportation modes, particularly for ground transportation. As the superior technologies and better vehicle designs are being developed through conducted researches in the related automotive fields, people today are able to travel much easier and faster from one place to another than they used to in the past. The progress of internal combustion engines, for instance, is an exemplary advancement that positively affects the development of ground transport vehicles (Alagumalai, 2014). At present, increasing public awareness in sustainability and also environmental effects has driven the direction of global automotive industry towards developing vehicles with higher energy efficiency and lower exhaust emission (Maurya & Agarwal, 2011).

To ensure continuous progress and growth of automotive industry, it is vital for the industrial workforce to possess proper knowledge and skills that are updated to current state-of-the-art development. One of the commonly practiced ways to accomplish this is through knowledge transfer from the experts to the industrial workers. Some

examples of knowledge transfer activities in automotive industry worldwide were documented and discussed in several publications such as Irawati and Charles (2010), Lee and Ram (2018), and also Guzman-Anaya (2019). In similar approach, the UNITED project, which is the abbreviated title for "UNITED - Engineering Knowledge Transfer Units to Increase Students' Employability and Regional Development", is initiated to increase capability and competency of local automotive workforce in Southeast Asia (SEA) region through knowledge transfer activities with European automotive experts. The SEA region becomes the focus in this UNITED project due to the substantial growth of its automotive industry over the years, though it is observed that the progress has been rather uneven throughout the region (Doner & Wad, 2014). It is believed that one of the main reasons for such uneven industrial development can be attributed to the readiness of the local automotive workforce in coping with the challenges of the changing market directions and technologies. Therefore, by transferring knowledge from the European partners of the UNITED project, the local automotive workforce in the SEA region can potentially enhance their knowledge and skills in related key areas, and become better equipped to support the progress of their local automotive industry.

The proposal work for this UNITED project began in year 2016 with the support from National Agency for Erasmus+ (OeAD) that funded travel and staff costs for personnel from coordinating institution, FH JOANNEUM, Austria to visit and also engage with future project partners in Malaysia, Indonesia and Thailand. These three countries in SEA region were selected to be the focus of this UNITED project because they have among the largest automotive industries within the region (Pavlova, 2022), as reflected by the number of vehicles production and their contribution to global automotive production. Despite the growing markets however, it was observed that there is

a notable lack of research and development (R&D) efforts for the technical automotive advancements in these three SEA countries. This becomes a primary driver for this UNITED project to empower the local automotive community in these SEA countries by filling up the identified gaps in knowledge and skills. By achieving this, the quality and competency of human capitals for automotive industry in SEA region would be enhanced and made more competitive.

UNITED project kick-off meeting at FH Joanneum, Austria

Mission and Objectives

The UNITED project officially started on the 15th January 2019 for a duration of 36 months, which was then extended for another six months due to COVID-19 pandemic, and it eventually concluded on 14th July 2022. In short, the mission of the UNITED project is to address the current lack of skilled human capitals in the areas of automotive engineering within SEA region to increase the positive impacts of automotive industry towards regional development and

internationalization. To accomplish this aim, several objectives for the project are outlined as follow:

- Capacity building by means of expert trainings at the SEA partner institutions for academic staff, students and companies interested in automotive engineering
- Setting up and operation of the Engineering Knowledge Transfer Units (EKTUs) at the SEA partner institutions to increase awareness and expertise in mechanical and automotive engineering by offering trainings to the target groups
- Fostering university-business cooperation via the EKTUs, focusing on current trends in automotive engineering and building up the UNITED network for international exchange on the topic of automotive engineering

As part of the execution of the project, it is expected that academic staff, students and also automotive industrial workforce who were trained under the project activities to disseminate their upgraded knowledge and skills further to their colleagues and co-workers. By doing so, this leads to a wider reach and multiply the impact of the transferred knowledge, which ultimately will enhance the overall competency level of general human capitals in automotive industry within the region.

Main Activities and Outputs

In line with the outlined project objectives, the activities have been essentially grouped into eight work packages. This facilitates the smooth execution of the project and helps to effectively achieve the project's aim. Target groups for majority of the project activities are

those who are working in local automotive industry; academicians, researchers and students who are in the related fields to automotive engineering; and those who are involved in student and automotive associations. A brief description of activities and outputs from each of the work packages is presented as follow.

- **Work Package 1: Comparative analysis of the automotive industry and trainings needs for the EKTUs in Indonesia, Malaysia, Thailand and the EU** – this work package involved activities such as conducting focus group interviews and desktop analysis to mainly identify the knowledge gaps and training needs for the local workforce based the future direction of the automotive market. The key outputs from this work package were the gap and comparative analysis reports, which later became the basis for the activities in the subsequent project stages.

- **Work Package 2: Capacity Building (Trainings for Trainers)** – activities in this work package included the development of training materials and the conduct of training sessions by the European partners to the members of the SEA partners based on the previously identified knowledge and skills gaps. Once the training was completed, the SEA partners were then responsible to organize their own internal training workshops to their local automotive community. By doing so, the knowledge was effectively transferred to more people apart from the project members of the SEA partners.

- **Work Package 3: Technical Instalment of the EKTUs** – in conjunction with the previously identified local automotive knowledge and skills gaps, each SEA partner came up with technical needs analysis of the required equipment for their EKTU to further support the knowledge transfer activities. This

phase of the project also included activities to purchase, install and officially launch the operation of the EKTU. At the end of this project phase, the EKTU was ready to be operated and used for the subsequent trainings to be conducted by the SEA partners.

- **Work Package 4: Operational instalment of the EKTUs** – once the installation of the EKTU was completed and ready for use, each SEA partner conducted their vocational trainings to the local automotive community in order to further enhance their competency and close their knowledge and skills gaps. Upon the completion of the vocational trainings by the SEA partners, more people had upgraded their knowledge and skills in the related areas of automotive fields through the use of the EKTUs.

- **Work Package 5: Network for National and Cross Country Exchange** – to further support knowledge dissemination activities of the project and build a much wider and long-lasting networking among the regional and international automotive community members, an automotive interest group called "Southeast Asia Automotive Interest Group" (SAIG) was established. Under this SAIG network, which is aimed to become the collaborative platform for the regional automotive community in SEA, several activities that promoted knowledge sharing and research or industrial collaborations were organized. Among others, these included international conferences, online webinars by automotive experts and also EKTU training sessions by the SEA partners. The official website for the SAIG network is https://www.saig-united.com

- **Work Package 6: Dissemination and Visibility** – for this work package, the activities were planned and carried out to promote the UNITED project to the target automotive community throughout the world. The main promotional outlets for the project are the project's official website (https://united-erasmus.usu.ac.id/en) and the project's official Facebook page (https://www.facebook.com/unitederasmus).

- **Work Package 7: Quality and Ethics Control** – in order to ensure that the implementation progress of the project was smooth and the quality of the project outputs was acceptable, several activities had been planned and executed in this work package. Among others, they included organization of quality board meetings, peer review process and evaluation of project activities by the project partners.

- **Work Package 8: Project Management** – under this work package, the activities revolved more on the management aspects of the project such as financial reporting and ensuring the completion of tasks according to the planned timeline. These included the organization of regular project management meetings and submission of project reports by each partner at certain milestones of the project.

WP1: Focus Group Study

WP2: Training-of-Trainers Workshop

WP3: Installation of EKTUs

WP4: Vocational Trainings Using EKTUs

WP5: SAIG Network Programs

WP6: Social Media

WP7: Quality Board Meetings

WP8: Project Management Meetings

Key activities of UNITED project for each work package (WP)

Project Partners

The consortium for the UNITED project is made up of 11 partners from Austria, Italy, Germany, Indonesia, Thailand and Malaysia, comprising of nine universities and two companies. Details of each partner institution and also main members for UNITED project are briefly presented as follow.

FH JOANNEUM (FHJ) is essentially one of the largest colleges of higher education in Austria and is established in 1995. It has about 5,500 total students and offers around 70 degree programs in areas of business, technology, design, media, architecture, social services and health. The Institute of Automotive Engineering is part of the Department of Engineering in FH JOANNEUM and its research has been mainly focused on innovative vehicle designs and sustainable mobility. UNITED project is one of the major international projects of the institute, where it acts as the project coordinator. Staff of the institute who worked on the UNITED project are listed as follow.

Dr. Hanna Sprenger holds a doctorate degree in natural sciences with specialization in molecular biology, as well as a certificate in project management. She has over six years of experience in national as well as European Union funded project coordination, management and implementation in the fields of imaging technologies, juridical aspects of clinical-forensic examinations and automotive engineering.

DI(FH) Thomas Lechner has a diploma in computer engineering and he is an expert for implementation of testing bays at FH JOANNEUM. In addition to that, he also conducts lectures in the field of computer engineering. He has been working for more than 20 years at the Institute for Automotive Engineering and has many experiences in Erasmus+ Capacity Building projects.

DI Dr. Karl Heinz Reisinger has a PhD degree from Technical University of Graz (Austria). He currently works at FH JOANNEUM as Associate Professor and is responsible for teaching mechatronics at the Bachelor's and Master's degree programs at the Institute of Automotive Engineering. His primary fields of interest include vehicle dynamics, control engineering and mechatronic systems engineering.

Eva Penz, BA MA holds a Bachelor degree in International Business and a Master degree in Business in Emerging Markets. She works as quality officer for the accredited testing bay for emission testing at FH JOANNEUM. In addition, she has many experiences in implementing EU funded projects and has acted as project coordinator in international projects on higher education development.

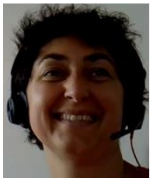
Politecnico di Torino (PTT) was founded in 1859 and is the oldest Italian technical public university. It has more than 30,000 students and offers courses in various fields of engineering, urban planning, architecture and industrial design. The Department of Mechanical and Aerospace Engineering at Politecnico di Torino has been active in promoting, coordinating and also managing basic and applied researches, trainings, technology transfer and services to the local community in engineering fields including automotive. Moreover, researchers in this department have been involved in many funded research projects by the Italian government, regional calls and also European Union, including UNITED project. The main department staff who contributed to the UNITED project are listed as follow.

Prof. Andrea Tonoli received his PhD degree in Machine Design in 1993. He currently works as a Full Professor in Department of Mechanical and Aerospace Engineering at Politecnico di Torino. His research interests include electric and hybrid vehicles and vehicle electrification, regenerative suspensions, energy recovery from exhaust gases and piezoelectric actuation systems.

Prof. Nicola Amati has a PhD degree in Machine Design and he currently works as a Full Professor in Department of Mechanical and Aerospace Engineering at Politecnico di Torino. He is active in the fields of hybrid vehicles and vehicle electrification, regenerative suspensions, energy recovery from exhaust gases, belt drive systems and driver assistance system.

Dr. Angelo Bonfitto obtained his PhD degree in Mechatronics from Politecnico di Torino in 2010. He currently works as a research fellow in the Department of Mechanical and Aerospace Engineering. His research interests include artificial intelligence for virtual sensing in automotive application, battery state of charge and health estimation, rotating machines and active magnetic bearings.

Dr. Sanjarbek Ruzimov received his PhD degree in Mechatronics in 2013. At present, he is an Associate Professor at Tashkent Turin Polytechnic University and a visiting researcher in Department of Mechanical and Aerospace Engineering, Politecnico di Torino. Among his key research areas include automotive mechatronics, hybrid and electric vehicles and intelligent transportation systems.



Cristina Casieri graduated from Turin University, Italy and presently works at Politecnico di Torino in administrative area. She has worked in various national and international projects. Among others, she has many experiences in preparation and submission of project proposals, management of project and research contracts, planning project resources allocation and project accounting.

Sonia Ragozzi provides technical support for the team of Politecnico di Torino in the UNITED project.

FH Aachen (FHA) was established in 1971 and is one of the largest universities of applied sciences in Germany. It has 10 faculties that offer around 75 educational degree programs, with total students of more than 13,000. Its automotive engineering program is offered by Faculty of Aerospace Engineering. Apart from fundamental areas of automotive, the faculty also focuses on two areas of specialization: vehicle body and interior, and drive technology and energy storage system. There are various research projects related to automotive engineering that are undertaken by staff of the faculty, including those in the framework of ERASMUS+ and also European Center for Sustainable Mobility (ECSM). For this UNITED project, key faculty staff members who have been involved are listed as follow.

Prof. Thomas Esch holds a Doctor of Engineering degree with a dissertation in the field of tribology in internal combustion engines. He is currently a Full Professor at Faculty of Aerospace Engineering in FH Aachen. His research focus covers alternative fuels like hydrogen and green propellants to reduce emissions and increase efficiency for powertrain technologies, and certification of aircraft piston engines.

Prof. Thilo Roth obtained his Doctor of Engineering degree with a dissertation on the topic of "Pedestrian Protection". He is a Full Professor and holds the post of Head of Automotive Laboratories at FH Aachen since 2001. Among his main research expertise include light weight structures (hybrid), body design and passive safety, and vehicle concepts for shared mobility.

Torsten Merkens, M.Eng graduated in 2012 with Master degree in Civil Engineering from FH Aachen. He is a research assistant and management board member of the European Center for Sustainable Mobility. He is involved in various national and international research projects in the fields of sustainable mobility, transport, infrastructure and mobility planning, implementation and evaluation.

Dipl.-Ing. Natascha Potuschnik obtained her Master degree in Mechanical Engineering from RWTH Aachen University in 2012. She worked at Technical University Aachen as a research assistant before starting her position at FH Aachen in 2019 as coordinator for the FH Aachen UNITED team. Her main tasks include organization of trainings in Southeast Asia and project quality management.

Dr.-Ing. Christian Granrath, M.Sc. received the M.Sc. degree in energy engineering in 2016 from RWTH Aachen University, Germany. From 2016 to 2021 he performed his doctoral studies at the Junior Professorship for Mechatronic Systems for Combustion Engines, Institute for Combustion Engines, RWTH

University. Since 2021, he is working as a technical specialist for systems engineering at FEV Europe GmbH. His research interests include the fields of systems engineering, agile software engineering, software architecture development and evaluation as well as simulation model development for XiL applications in automotive domain.

Sumatera Utara University (USU) was established in 1952, making it one of the oldest universities in Indonesia. It is a public university located in the city of Medan in North Sumatra, Indonesia and it is comprised of 15 faculties and a graduate school. It offers numerous undergraduate, postgraduate, professional, specialist and diploma programs, with total of more than 48,000 students. The Faculty of Engineering in Sumatera Utara University was started in 1959 and it offers teaching programs and conducts researches in many areas of engineering and technology, including automotive fields. Staff of the faculty who greatly contributed to UNITED project are listed as follow.

Prof. Dr. Eng. Himsar Ambarita holds a Doctor of Engineering degree in Production and Information System Engineering from Muroran Institute of Technology, Japan. He works as a Full Professor at Sumatera Utara University. His research interests include

numerical simulation, heat transfer, computational fluid dynamics, thermal engineering and engineering thermodynamics.

Dr. Tulus Burhanuddin Sitorus obtained his PhD degree in Mechanical Engineering from Sumatera Utara University, Indonesia in 2017. He currently works as a lecturer in Sumatera Utara University. Among others, his research interests include numerical simulation, heat transfer, internal combustion engine, thermal engineering and also engineering thermodynamics.

Dr. Eng. Taufiq Bin Nur completed his Doctor of Engineering degree at Department of Hydrogen Energy System in Kyushu University, Japan in 2015. At present, he works as a lecturer at Sumatera Utara University. His research interests include bioenergy, numerical simulation, heat transfer, fuel cell system, thermal engineering and engineering thermodynamics.

Dr.-Ing. Pramio Garson Sembiring obtained his PhD degree from Ruhr University Bochum, Germany in 2014. He currently works as a lecturer in Sumatera Utara University. Among others, his main research interests are in the fields of material, numerical simulation and heat transfer

Udayana University (UNUD) is the oldest public university in Bali, Indonesia that was officially established in 1962. It has 13 faculties, which offer about 112 different study programs, and has more than 28,000 total students. Faculty of Engineering at Udayana University was established in 1965 and since then, it has been involved in the teaching and research activities in different areas of engineering, architecture and information technology, including automotive. As partner institution for the UNITED project, several staff of Udayana University are heavily involved and they are mostly from Faculty of Engineering. The list of key staff who are involved in the project is presented as follow.

Dr. Ni Putu Sri Harta Mimba holds a PhD degree from University of Groningen, the Netherlands. She is currently the Director of Center for International Programs at Udayana University. She is actively involved in encouraging micro, small medium enterprises through strengthening their capacity building and has many experiences in managing international projects.

Prof. I Nyoman Suprapta Winaya obtained his PhD degree in Energy Conversion from Niigata University, Japan. He is a Full Professor and leads the research group on “New Renewable Energy and Energy Conservation”. His research areas include thermal

engines, co-firing on CFB boilers, and waste and biomass use for clean energy in power generation and automotive industries.

Prof. I Dewa Gede Ary Subagia completed his PhD degree at Chonbuk National University, South Korea in the field of strength and fracture mechanics of composite materials. At present, he is a Full Professor. He has conducted many research on material engineering, applied material in nanotechnology, electric vehicle structures, and phase change material for energy management of electric vehicles.

Dr. I Made Widiyarta obtained his PhD degree in 2010 from University of Newcastle, United Kingdom. He currently works as a lecturer in Faculty of Engineering, Udayana University. Among others, his current research interests are in tribology, contact mechanic, failure of surfaces, vehicle stability and machine design.

Universiti Putra Malaysia (UPM) is one of research universities in Malaysia. It has 15 faculties, 11 institutes and two schools, offering variety of educational programs at postgraduate and undergraduate levels with the research focus on agricultural sciences and related fields. The Faculty of Engineering in Universiti Putra Malaysia was established in 1975 and is now one of the largest faculties at the university, with eight engineering departments and total students of around 3,000. The faculty staff have been highly involved in many national and international research projects in engineering fields, including the UNITED project. For this project, the contributing faculty members are listed as follow.

Prof. Ir. Ts. Dr. Nor Kamariah Noordin holds a PhD degree from Universiti Putra Malaysia and currently works as a Full Professor. Her main expertise is in the fields of wireless communication and transdisciplinary areas of engineering and education. She also has many experiences in administrative, leadership and stewardship at both university and national levels.

Dr. Fairuz Izzuddin Romli received his PhD degree in Aerospace Engineering from Georgia Institute of Technology, USA. He is an Associate Professor at Department of Aerospace Engineering. His research interests include engineering design methodologies, statistical analysis, engineering optimization, air transportation system and engineering education.

Dr. Abdul Aziz Hairuddin completed his PhD degree at University of Southern Queensland, Australia in 2014. At present, he is an Associate Professor at Department of Mechanical and Manufacturing Engineering. His areas of research interest include internal combustion engine for automotive engineering, combustion modelling, computational fluid dynamics, energy and thermo-fluids.

Ir. Dr. Mohammad Yazdi Harmin graduated with a PhD degree from University of Liverpool, United Kingdom. He currently works as an Associate Professor at Department of Aerospace Engineering. Among others, his fields of expertise and research interest include aeroelasticity, swarm intelligence, structural dynamics and also experimental modal analysis.

Dr. Khairil Anas Md Rezali completed his PhD degree in the field of Sound and Vibration at University of Southampton, United Kingdom. At present, he is a lecturer in Department of Mechanical and Manufacturing Engineering and his areas of research interest include mechanical vibration, biodynamics, human vibration, vibration isolation and ergonomics.

Ir. Dr. Mohd. Khair Hassan has a PhD degree in Automotive Engineering from Universiti Putra Malaysia. He works as an Associate Professor and currently holds the post of Deputy Dean at the Faculty of Engineering. His areas of interest include control systems, automotive control, automation systems, artificial intelligence applications and electric vehicles.

Universiti Teknikal Malaysia Melaka (UTeM) is the first public technical university in Malaysia and it was established in 2000. The university is highly focused on technical fields such as engineering, information technology and also management technology. With its various offered technical degree programs, it has close to 13,000 students in total. Apart from education, the university also has good research competency in strategic areas such as green technology, systems engineering, human-technology interaction and emerging technology. Most of automotive-related research at this university are conducted under Automotive Department, which is part of the Faculty of Mechanical Engineering, including the UNITED project. The list of key personnel who worked on this project is as follow.

Prof. Ts. Dr. Noreffendy Tamaldin obtained his PhD degree from Coventry University, United Kingdom. He is currently a Full Professor. Among others, his research interest includes engine performance, emission, engine tribology, engine instrumentation and motoring, alternative fuel and EEV.

Dr. Muhd Ridzuan Mansor has a PhD degree in Mechanical Engineering from Universiti Putra Malaysia. Currently, he is an Associate Professor at Department of Automotive. His research interests include concurrent engineering, bio-composites, automotive design, manufacturing system engineering and advanced materials characterization.

Prof. Ir. Ts. Dr. Ghazali Omar completed his PhD degree in Physics at Universiti Malaya, Malaysia. He is a Full Professor and currently holds the post of Deputy Vice Chancellor (Research and Innovation) at Universiti Teknikal Malaysia Melaka. His main areas of expertise include semiconductor packaging, advanced electronic materials and material characterization.

Dr. Mohd Fadzli Abdollah graduated with a Doctor of Engineering degree from Nagoya University, Japan in 2011. He currently works as an Associate Professor and also holds the post as the Dean of Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka. His research interest includes tribology of eco-materials and surface engineering.

Dr. Ahmad Kamal Mat Yamin graduated with a PhD degree in Mechanical and Automotive Engineering from Coventry University, United Kingdom. At present, he is the Head of Automotive Department at Universiti Teknikal Malaysia Melaka. His areas of research interest include vehicle aerodynamics, automotive powertrain system, computational fluid dynamics and computer aided design.

Mahasarakham University (MSU) is a public university in Maha Sarakham province, Thailand. It gained its statutory status through the Thai Higher Education Act in 1994 and became the 22nd public university in Thailand. It has a total of 17 faculties, two colleges and two schools, which offer various educational programs to more than 40,000 of its students. The Faculty of Engineering at Mahasarakham University was established in 1999 and covers teaching and research activities in several engineering fields, including automotive. For this UNITED project, staff of the faculty under the Department of Electrical Engineering and Department of Mechanical Engineering are involved, and the list of key personnel is presented as follow.

Dr. Chonlatee Photong obtained his PhD degree from University of Nothingham, United Kingdom. He is currently an Associate Professor and the Head of Electric Automotive and Engineering Technology Research Unit. His research interests include power electronics and converters, electric vehicles, motor control and drives, and renewable energy.

Dr. Juckamas Laohavanich holds a PhD degree from Khon Kaen University. He is an Associate Professor in Department of Mechanical Engineering. His research interests include agricultural machinery and management, post-harvest technology (drying technology), and agro-process and industry.

Dr. Niwat Angkawisittpan obtained his PhD degree in Electrical Engineering from University of Massachusetts Lowell, United States in 2009. He currently works as an Assistant Professor at Faculty of Engineering. Among others, his research interests include compact microstrip devices, metamaterial applications for RF and microwave circuits, and electromagnetic material characterization.

Dr. Nattapol PoomSa-ad has a PhD degree in Energy Technology from King Mongkut's University of Technology Thonburi, Thailand. At present, he works as an Assistant Professor at Faculty of Engineering. His research interest includes thermal processing for food and agricultural product drying technology, and energy conservation and management.

Dr. Teerapat Chompookham obtained his PhD degree in Mechanical Engineering from King Mongkut's Institute of Technology Ladkrabang, Thailand in 2011. He currently works as an Assistant Professor at Faculty of Engineering. His research interests include on vortex/swirl flow in heat exchanger tube, solar air heater technology, heat pipe technology and energy conservation.

Dr. Taweesak Thongsan received his PhD degree in 2022 from Mahasarakham University, Thailand. His research interests include electrical machines, control systems, solar energy conversion and power electronics.

Dr. Lamul Wiset received her PhD from University of New South Wales, Australia in 2007. At present, she is an Assistant Professor in biological engineering in Mahasarakham University, Thailand. Her research interests include drying technology in particular quality of agricultural products such as rice, herbs, fruit and nuts.

Pakpilai Noiwimol provides administrative support for the team of Mahasrakham University in the UNITED project.

Wirun Pholchumni provides administrative support for the team of Mahasrakham University in the UNITED project.

Chulalongkorn University (CKU) is autonomous public research university in Bangkok, Thailand. It was formally established in 1917 as national university and is the oldest institute of higher education in Thailand. The university is composed of a total 19 faculties, three colleges and three schools, and they offer wide range of educational programs to a total of about 35,000 students. Faculty of Engineering at Chulalongkorn University has 12 different departments, covering

the engineering fields in its teaching and also research activities, including automotive-related fields. Several members of the faculty were greatly involved in the UNITED project and they are listed as follow.

Dr. Witaya Wannasuphoprasit obtained his PhD degree from Northwestern University, United States. He is an Associate Professor and currently serves as the Director of International School of Engineering and also Chair of the Robotics and AI Program. His research interests include collaborative robots, haptic interface, dynamics and control, innovative design and product development.

Prof. Dr. David Banjerdpongchai has a PhD degree in Electrical Engineering from Stanford University, United States. At present, he is the Head of Control Systems Research Laboratory and the Head of Intelligent Control Automation of Process Systems Research Unit. His research interests include advanced process control, robust control systems and energy management systems.

Dr. Sunhapos Chantranuwathana completed his PhD degree in Mechanical Engineering at University of Michigan, United States. He currently works as an Assistant Professor at Department of Mechanical Engineering. Among others, his research interests include dynamic systems and controls, vehicle dynamics, control theory and control applications in automotive engineering.

Dr. Nuksit Noomwongs received his PhD degree from Tokyo University of Agriculture and Technology, Japan. He is currently an Assistant Professor in Department of Mechanical Engineering. His areas of expertise include vehicle dynamics and control, hardware-in-the-loop simulator for vehicles, vehicle safety and also intelligent transport systems.

Dr. Prabhath De Silva obtained his PhD degree in Mechanical Engineering from Arizona State University, United States. He currently works as an Adjunct Professor for automotive engineering at the International School of Engineering. His areas of expertise and research interests include thermo-fluids, heating, ventilation and air conditioning, and engine cooling system.

Dr. Angkee Sripakagorn has a PhD degree from University of Washington, United States. He currently works as an Associate Professor and also holds the post of Head of the Mechanical Engineering Department. Among others, his areas of expertise and research interests include electric vehicle, engineering education, hydrogen fuel cell, energy and also smart mobility.

Dr. Surapong Suwankawin completed his PhD degree at Chulalongkorn University. At present, he is an Associate Professor and a post-doctoral researcher at Department of Electrical Engineering. He has teaching and research experiences in the fields of AC motor drives, EMI / EMC in motor drive and PV systems, converter control of battery energy storage system and building energy management.

Dr. Ronnapee Chaichaowarat obtained his PhD degree in Mechanical Engineering from Chulalongkorn University in 2015. He also received another PhD degree in Bioengineering and Robotics from Tohoku University, Japan in 2018. He currently works as a lecturer at International School of Engineering. His research interests include compliant actuation, exoskeletons and vehicle dynamics.

Fonthong Tangjitwatanakul has a Master degree in Cultural Management from Chulalongkorn University, Thailand and another Master degree in Tourism Management and Marketing from Bournemouth University, United Kingdom. At present, she works as an International Affairs officer at International School of Engineering, Faculty of Engineering, Chulalongkorn University.

DreamEDGE
Innovating the Future

DreamEdge Sdn. Bhd. is a Malaysian digital engineering services and consultancy company. It was incorporated in 2007 and has a wide portfolio in many industries including oil and gas, rail, ship-building, healthcare and automotive. It offers various services that can range from modelling and analysis in computer-aided design, engineering and manufacturing to the product design/development in a broad spectrum of areas. The company has also been involved in few automotive projects such as in new vehicle development that

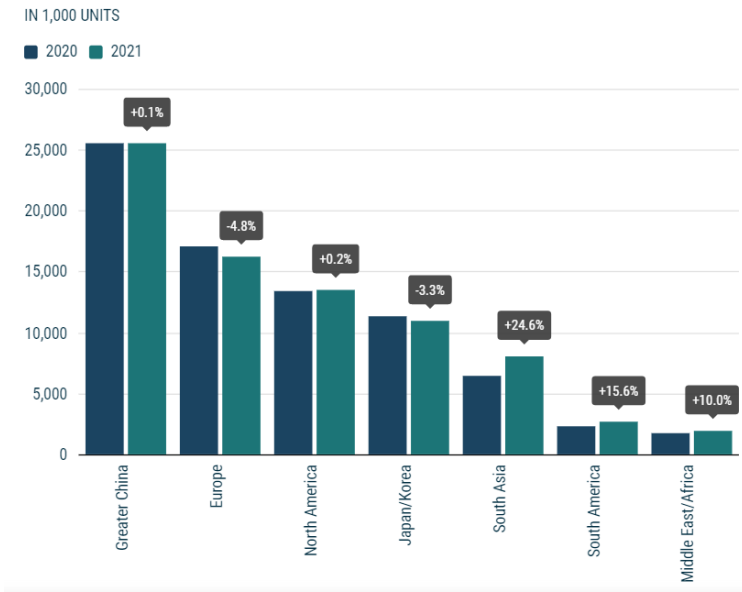
involves design, prototype development and developing systems for mass production. In the UNITED project, the DreamEdge team is led by Mr. Hisham Razuli Halim, who is currently the Head of Business Development at the company.

Atipong Motor Company was established in 1971 and it is the first company that originated and invented the local 3-wheel bikes since 1976, known as the "Skylab" or "Isan Tuk Tuk". In addition to the manufacturing the 3-wheel vehicles, the company has extended its business to having own showrooms and also service centers. The automotive products by this company have been widely utilized for numerous industries including tourism, agricultural and heavy job vehicles, and passenger vehicles. For the UNITED project, the team at Atipong Motor is headed by Mr. Pichai Opaskiatikul, who is the Executive Assistant to the company's Chief Executive Officer.

Automotive Industry in the Southeast Asia Region

The automotive industry is one of the largest and also most complex industries in the world, and it has been a main contributor towards global economics. Importance of automotive industry continues to grow as mobility progressively becomes a major part of the current lifestyle in many societies throughout the world, but this situation also makes it a demanding sector with constant need to increase productivity and also revenue (Sousa et al., 2022). In 2019, prior to COVID-19 pandemic, the global car production is recorded at more than 90 million units, which include over 67 million passenger cars and 27 million light commercial cars (Radomska & Kolotylo, 2020). Despite taking hit caused by COVID-19 pandemic situation in 2020, the global automotive industry is currently on the recovering trend as indicated in the report by European Automobile Manufacturers' Association (ACEA). The global production of motor vehicles has increased by 1.3% in 2021 in comparison to 2020, which was down by 16% from 2019 (ACEA, 2022).

A similar trend of market recovery is also observed for automotive industry in SEA region. In 2021, around 3.5 million motor vehicles were produced by the SEA countries, showing a rebound from the numbers in 2020 by 24% increment, and the vehicle sales have also improved by 300,000 units in 2021 as compared to 2020 (Gill, 2022).

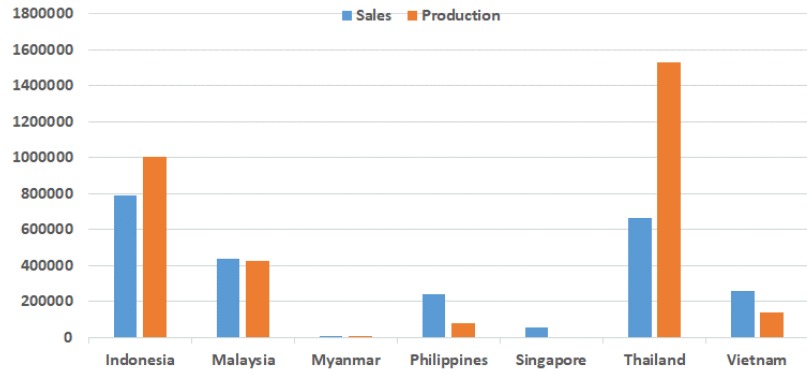


World motor vehicles production in 2020 and 2021 (https://www.acea.auto/)

The automotive industry in the SEA region remains among the attractive markets for growth and investment, and the region has the 6th largest automotive sales market and production base in the world (EU-ASEAN Business Council, 2017). It is forecasted that automotive industry in the SEA region will continue to grow rapidly until 2030. This projection is made based on the rising automotive demands that will increase the export volumes from global vehicle and parts manufacturers to countries in this region, and expected rise in transfer of production capacity by global manufacturers to this region due to comparatively cheaper labor costs.

Between all countries in the SEA region, automotive industries in Thailand, Indonesia and Malaysia are consistently in the top three, both in terms of vehicles production and also sales. This situation is reflected in the following figure, which depicts the automotive vehicles production and also sales in 2021 for countries in the SEA

region. Due to their significant roles in regional automotive market, the three countries are chosen as the focus for the UNITED project. It is believed that by enhancing the capability and competency of local automotive workforce in Thailand, Indonesia and Malaysia, it will also benefit the regional automotive community and industry as well.



Total automotive vehicles production and sales in SEA countries from January to November 2021 (Lye, 2022)

Market Overview in SEA Partner Countries

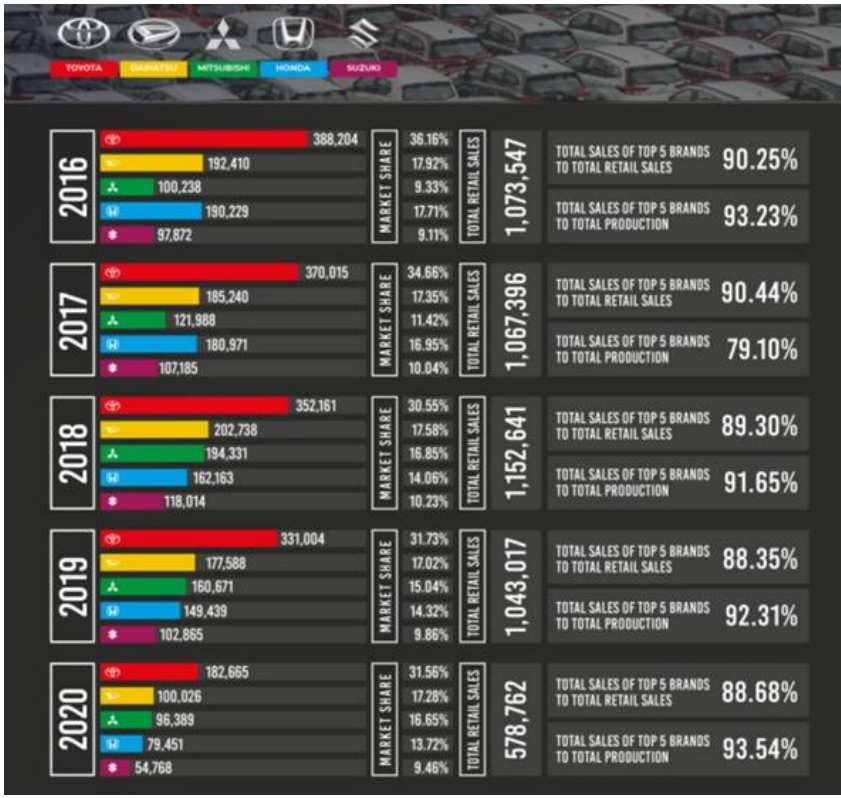
As previously indicated, the automotive industry in the SEA region is largely dominated by Indonesia, Thailand and also Malaysia. At present, Thailand is the leader in the region in terms of automotive manufacturing whereas Indonesia has the largest automotive sales market. In the meantime, Malaysia has the second largest passenger car market and the third largest vehicle manufacturer in the region (Hamzah et al., 2021). The three SEA countries capture a combined 93% of the production and 77% of the sales in regional automotive industry. A brief overview of automotive market in these countries is discussed in the following sections.

(a) Automotive Industry in Indonesia

The automotive industry in Indonesia largely benefits from its big domestic market, which is driven by its emerging middle-class. In addition, Indonesia's automotive industry is highly dependent on foreign direct investment for the establishment of their onshore car manufacturing facilities, particularly from Japan. A low per capita car ownership, cheaper labor costs and a rapidly expanding middle class are among the main factors that attracted global carmakers to heavily invest and make Indonesia their production hub. In 2019, the total foreign investment in Indonesia's automotive industry was valued at USD754 million and this had increased to USD 1.5 billion in 2021 (Kadin Indonesia, 2022). Subsequently, automotive industry has significant contribution to the gross domestic product (GDP) of Indonesia with about 4% and it is often viewed as the indicator on the economic health of the country (Reuters, 2020). The automotive market in Indonesia is overwhelmingly dominated by the Japanese carmakers with their market shares of more than 90%, led by Toyota Motor Corporation that consistently owned more than one-third of the automotive market shares from 2016 to 2020.

In terms of vehicle category, the automotive market in Indonesia is greatly skewed towards passenger cars as compared to commercial vehicles, which is not really surprising given its big population. The passenger car market in Indonesia was valued at USD15.62 billion in 2020 and was predicted to reach USD23.33 billion by 2030 (Jadhav et al., 2021). In 2021, total automotive sales in Indonesia rebounded and reached more than 850,000 units and were projected to exceed 900,000 units in 2022 (Lie, 2022). Meanwhile, the total automotive production in Indonesia was recorded as more than 1.1 million units in 2021 (Kadin Indonesia, 2022). Apart from domestic market, close to 295,000 units of vehicles were exported by Indonesia in 2021 to

more than 80 countries around the world, with Daihatsu been the top exported vehicle brand (Foong, 2022).



Top brands in Indonesia automotive market between 2016 to 2020 (https://www.idnfinancials.com)

As of early 2021, automotive industry in Indonesia was comprised of 21 major vehicle producers with a total investment of IDR71.35 trillion and a total annual production capacity of 2.35 million units, along with 38,000 employees in manufacturing sector and another 1.5 million people working in the industry's value chain (ANTARA, 2021). Therefore, the automotive industry is indeed one of the main economic contributors to Indonesia.

Location	Company	Production Capacity
Karawang	Toyota Motor Manufacturing Indonesia	250,000
Karawang	Astra Daihatsu Motor	200,000
Karawang	Isuzu Astra Motor Indonesia	80,000
Karawang	Honda Prospect Motor	200,000
Bekasi	Suzuki Indomobil Motor	270,000
Bekasi	Mitsubishi Motors Corporation	160,000
Bekasi	Wuling	120,000
Purwakarta	Nissan Motor Indonesia	250,000
Purwakarta	Hino Motor Manufacturing Indonesia	75,000
Sunter	Astra Daihatsu Motor	330,000
Sunter	Gaya Motor	40,000
Pulo Gadung	Fuso-Mitsubishi	150,000
Gunung Putri	Mercedes Benz Indonesia	20,000

Automotive factories in Indonesia
(https://www.indonesia-investments.com)

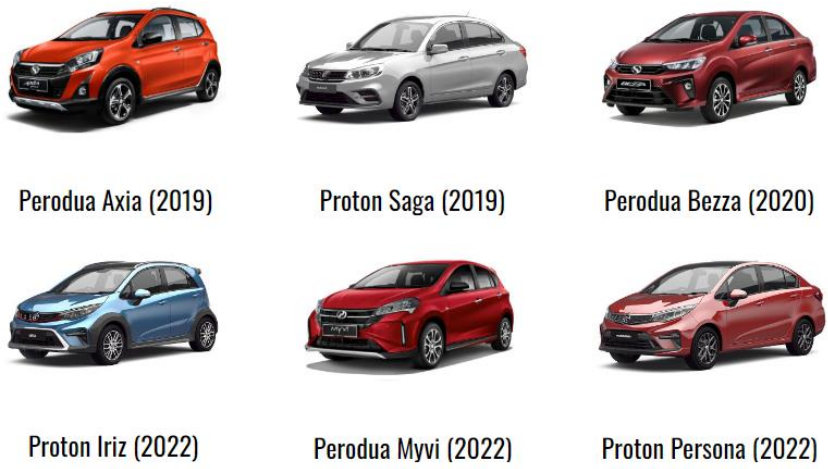
Generally, it can be observed that the Indonesian government has made a lot of efforts to turn Indonesia into a global production base for car manufacturing by attracting major car producers to establish their factories in the country and subsequently become the largest car production hub in the region. These are reflected through the policies made by the government, which were successful in getting high values of foreign investment to develop and strengthen their automotive industry, as it targeted for more industrial localization policy to support more local production in Indonesia (Suwardi et al., 2021). In 2013, with the growing interests in greener vehicles, the Indonesian government initiated few initiatives such as providing tax exemptions to manufacturers that produce more low-cost green cars (LCGCs) that meet the specified fuel efficiency targets (the cars must also contain 80% of locally-sourced parts) and purchasers of such cars. This action proved successful in solidifying their position

as major LCGC producer and exporter in the region, with estimated annual production of more than 500,000 units (Simanjuntak, 2012) and increasing domestic vehicle sales by making the prices more affordable (Medina, 2019). In 2017, the sales of LCGC in Indonesia reached 234,554 units compared to 51,180 units when this initiative was just started, clearly highlighting the resultant expansion of the local automotive market (Indonesia-Investment, 2018). Moreover, with progressive shift of the global automotive markets into electric vehicles (EVs), Indonesia has also adopted some measures to cater to the situation. Among others, they include National Master Plan for Industry 2015-2035, Presidential Regulation 55/2019 on Battery Electric Vehicle, Government Regulation 73/2019 on Luxury Tax for Automotive Products and others. In addition to promoting EVs, the Indonesian government aims to enhance related local industries, particularly battery cell manufacturing, through the requirements of more local contents in the production of EVs for the automotive manufacturers to qualify for the offered tax incentives. It should be noted that Indonesia possesses significant reserves of nickel that is used in making lithium EV battery (Schroder & Iwasaki, 2021).

(b) Automotive Industry in Malaysia

In essence, automotive sector serves as the backbone of Malaysia's industrialization planning in the 1970s and 1980s, and the country now prides itself on having two national car brands (Hamzah et al., 2021). The first national carmaker is Perusahaan Otomobil Nasional Berhad (PROTON), which began producing cars in 1985. Meanwhile, the second national car manufacturer, Perusahaan Otomobil Kedua (Perodua) was established in 1992. The establishment of these two national automotive companies successfully transformed Malaysia from car assembler into car manufacturer. Today, apart from these two main manufacturers of national car brands that hold the lion's share of the domestic automotive market, there are also other local

manufacturers of vehicles such as Malaysian Truck and Bus (MTB) that produces trucks, Industri Otomotif Komersial Malaysia Sdn. Bhd. (Inokom) that manufactures commercial vehicles and NAZA that predominantly produces passenger cars (Anazawa, 2021). The automotive industry contributed to 4.3% GDP of Malaysia in 2019 (Yean, 2021). It should be noted that domestic market in Malaysia is highly occupied by local-produced passenger cars, with PROTON and Perodua control more than half of the market shares.



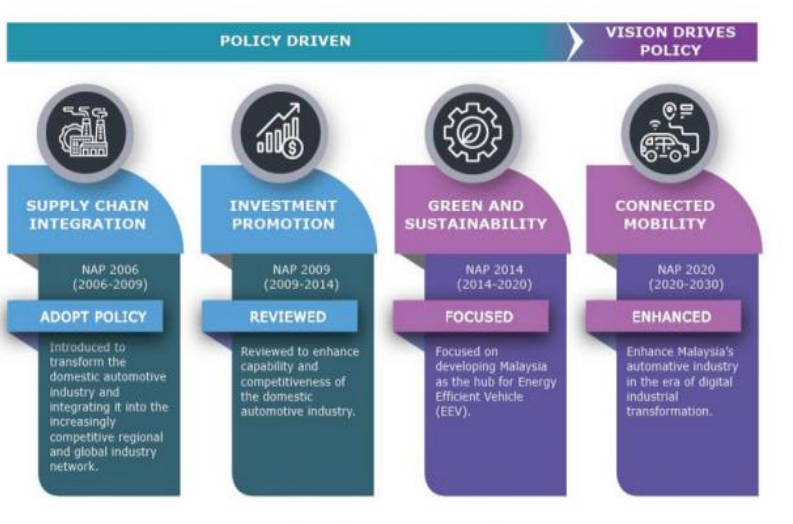
Examples of recent manufactured national cars in Malaysia (https://www.motomalaysia.com)

Passenger cars highly dominated the market in Malaysia compared to commercial vehicles. In 2021, there were 33.3 million registered vehicles in Malaysia, which exceeded the total number of its human population that was 32.6 million, and the increment trend has been about 1 million new vehicles annually (Chan, 2022). The Malaysia Automotive Association (MAA) has projected that the total vehicles production in Malaysia to increase by 6.0% in 2022, followed by an average growth of 3.1% from 2023 to 2025 (Malaysian Automotive

Association, 2021). According to the data published by MAA, total number of vehicles production and also sales in Malaysia for 2021 is 481,651 units and 508,911 units, respectively. Besides vehicles manufacturing, local automotive industry in Malaysia also consists of the automotive parts and components manufacturing. Based on statistics in 2015, the production of automotive parts industry in Malaysia was valued at more than RM24 billion with total workforce of about 50,000 people, whereby most of foreign-owned companies have higher export ratio while local parts companies are principally to support the local national cars manufacturing (Anazawa, 2021).

The direction of automotive industry in Malaysia is mainly dictated by policies made by the government. The first National Automotive Policy (NAP) was introduced in 2006 to promote a more competitive and viable domestic automotive industry, especially for national car manufacturers. Moreover, this first NAP was aimed to strengthen the competitiveness of local companies in the global market with regards to exports of automotive vehicles, parts and components (Tan, 2006). With the growing awareness on the energy issues and environmental pollution, Malaysia has taken some steps to address the matters, including for the automotive industry. The NAP was revised in 2009 and among others, the inclusion of production of hybrid and electric vehicles is among main changes in the national policy. In 2015, Malaysian Green Technology Corporation led the shift of local automotive market towards EVs through the National Electric Mobility Blueprint, which was in support of the ecological agenda put forth in NAP revision in 2014 (Hamzah et al., 2021). The revised NAP in 2014 essentially included an emphasis on the energy efficient vehicles (EEVs) with the view of making Malaysia as the leading EEV hub in the SEA region. In 2019, in line with the push for EEV, development of a third national car project was launched with DreamEDGE as the anchor company. The most recent revision

of NAP in 2020, which outlines target direction and implementation for the automotive industry in Malaysia until 2030, focuses on the Next Generation Vehicles (NxGVs), Mobility as a Service (MaaS) and Industry 4.0, and includes development in the areas of Automated, Autonomous, Connected Vehicles, lightweight material technology as well as hybrid, electric and fuel cell vehicles (Lim, 2020).



Revisions of the Malaysia's NAP throughout the years (Lim, 2020)

(c) Automotive Industry in Thailand

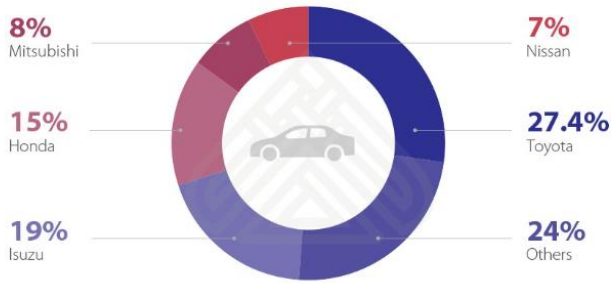
Thailand has been known as the "Detroit of Asia" due to its status as the main vehicle manufacturer among countries in SEA region and its contribution to automotive export industry. For instance, in 2018, Thailand produced 2 million units and more than half of them were exported to more than 100 countries (Medina, 2019). Despite not having their own national car, many world's leading automotive manufacturers have built factories in Thailand and they include, among others, Honda, Ford, Toyota and BMW. The government of Thailand has encouraged these foreign multinational automotive corporations to establish production bases in Thailand by offering

various privileges and protection. Such policies have been adopted ever since the emergence of automotive industry in Thailand back in early 1960s, where the enactment of the Industrial Investment Promotion Act of 1960 and its revision in 1962 proved to be fruitful in attracting foreign automotive investors from the US, Japan and Europe to set up joint ventures with the local businesses in Thailand (Fujita, 1998). For examples, Thai Motor Industry Co. Ltd. is a joint venture between Anglo-Thai Motor and Ford in United Kingdom, and also the joint venture between Siam Motors and Nissan Co. Ltd.

In line with the "Automobile Industry Export Promotion Project" by the government in 1993, the automotive manufacturing industry in Thailand started to shift more toward exports production instead of supplying for the local domestic market like it used to in the past. This move has shown to be successful in making Thailand as the leading automotive producer in SEA region. Thailand is now Asia's fourth largest automotive assembly and export hub for many of the world's largest automotive companies such as Toyota and Honda, and the industry accounts for nearly 10% of Thailand's GDP and manufacturing jobs, with 736,000 units of exports in 2020 (Sriring & Staporncharnchai, 2021). In the world, Thailand is 13th largest automotive parts exporter and the sixth largest commercial vehicle manufacturer (Rastogi, 2018). The automotive market in Thailand has been dominated by Japanese automakers that have established Thailand as their production base of one-ton pick-up trucks and eco cars for exports, but the American and European companies are also gaining ground in making Thailand as manufacturing hub for their large, luxury cars.

Commercial vehicles have larger shares than passenger cars in the automotive market of Thailand, both in terms of production and sales. Up until November, the sales and production market shares of commercial vehicles in Thailand for 2021 are roughly 58.2% and

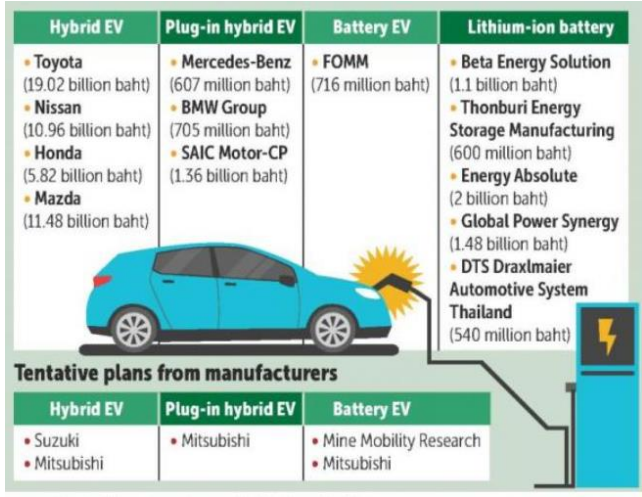
64.42%, respectively (Lye, 2022). This shows continued dominance of commercial vehicles in comparison to passenger cars in Thailand. Based on published statistics by the ASEAN Automotive Federation (AAF) on its website, the total sales of motor vehicles in Thailand for 2021 is 754,254 units whereas the total number of production is more than 1.68 million units.



Market shares of automotive industry in Thailand (Rastogi, 2018)

The success of Thailand's automotive industry is largely attributed to policies of its government. In 2007, the government in Thailand has launched its Automotive Industry Master Plan, which is aimed to make Thailand as the regional hub for exports of automotive. In general, the adopted automotive policies in Thailand, especially the Foreign Direct Investment policy, encourages foreign participation of automakers and heavily relies on foreign investment to develop their automotive industry (Tai & Ku, 2013). Moreover, Thailand has strategically targeted the vehicles production in the pick-up trucks category and became the world's top manufacturer in this category (Ariffin & Sahid, 2017). Many incentives are offered for companies to invest in the supercluster automotive zones in Thailand such as Pathum Thani, Ayutthaya, Nakhon Ratchasima, Chonburi, Prachin Buri, Chachoengsao, and Rayong, including giving tax exemptions and making it easy to obtain permanent residence permit (Rastogi,

2018). With the shifting of global automotive market towards more environmental-friendly vehicles, Thailand adapted its automotive industry to maintain its position as among the leading automotive manufacturing countries and exports in the world. Thailand started local production of eco-friendly vehicles that meet Euro 4 standard since 2007 (Schroder, 2021). As market popularity gradually grows on EVs, roadmap to promote EVs was created by the government in 2016, which also includes a tax incentive scheme for production of EVs (Rastogi, 2018). To indicate seriousness of the government for technological transition towards EVs, the National Electric Vehicle Policy Committee was established in 2020 and it has outlined short-term and long-term roadmap for EVs in Thailand, with a target that at least 30% of total vehicles production by 2030 (i.e. 750,000 units from total 2.5 million units) will be zero-emission vehicles (Hamada & Matsumoto, 2022). Thailand is aiming to be the production base for EVs within five years and expects the local domestic market for electric vehicles to rapidly grow between 2025 and 2030.



Granted incentives for manufacturers of EVs in Thailand (https://www.bangkokpost.com)

Current and Emerging Market Trends

In general, the global automotive industry has entered the period of wide-ranging and transformative change as the markets continue to shift and many environmental regulations become more prominent (Detlev et al., 2013). Among others, this situation led to the growth of global deployment of EVs and also development of more EEVs in recent years. It is expected that the global energy demands continue to rapidly increase within the next 30 years and renewable energy sources will become cheaper (Isac & Badshah, 2019). This supports the importance for automotive industry to seriously embrace the development of future EEVs. In parallel with this notion, interest in greener vehicles is also growing in the automotive industry within SEA region as briefly indicated in previous sections for Indonesia, Malaysia and Thailand. As the regional SEA automotive industry is projected to continue its growth, it becomes necessary to consider the impact this will have on the demands for fuel consumption and environmental air pollution. It must be noted that the move toward greener automotive is only restricted to EVs. In fact, by definition, EEV is a vehicle that meets a set of defined specifications in terms of carbon emission level (g/km) and fuel consumption (l/100km). Hence, in addition to EVs, the general pursuit for EEV also includes fuel-efficient vehicles and alternatively-fueled vehicles using CNG, LPG, biodiesel, ethanol, hydrogen and fuel cells, which corresponds to better vehicle system designs.

(a) Electric Vehicles (EVs)

By definition, there are several different types of EVs that include hybrid electric vehicle (HEV), battery electric vehicle (BEV), plug-in hybrid electric vehicle (PHEV) and fuel cell electric vehicle (FCEV). The SEA region emerges as the potential market and manufacturing hub for EVs, which is estimated to worth nearly USD500 million in

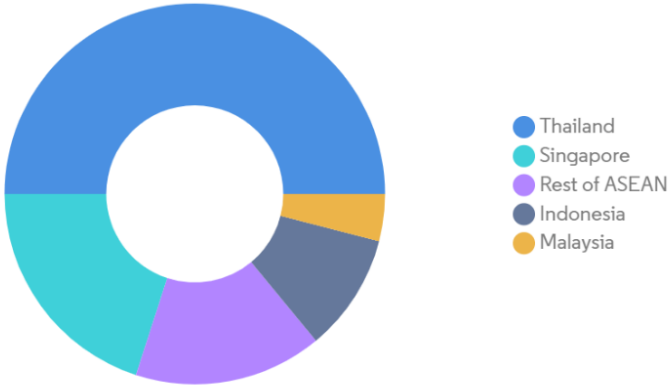
2021 and forecasted to grow to USD2.7 billion by 2027 (BIMP-EAGA, 2022). At the moment, local adoption rate of EVs in the SEA region is still considered very low despite the many incentives offered by government of SEA countries. Some of the challenges that hindered greater EV adoption in many SEA countries, apart from high price and ownership costs, include readiness of support infrastructures, charging time and driving range (Jamaludin et al., 2021). Even so, a strong commitment by the government of SEA countries towards EVs has been demonstrated through their various market policies and incentives. The Indonesian government, for instance, enacted EV support policy in December 2019 with the target of having EVs to comprise 20% of their domestic vehicle sales by 2025 (Schroder & Iwasaki, 2021). On the other hand, Malaysian government also introduced few incentives for EVs and projected 15% of domestic automotive sales to be EVs by 2030 (Malaymail, 2022). Last but not least, the government in Thailand issued EV policy in March 2017, which aims to have 1.2 million of EVs on the road by 2036 (Schroder & Iwasaki, 2021).

Country	EV definition	EV fleet (year)	EV unit target (year)	Charging stations (year)
Indonesia	HEV/PHEV/BEV	4.2 million by 2050 (proposal by National Energy Plan)	400,000 EVs + 2.1 million e-motorcycles (20 per cent locally manufactured) (2025)	479 stations 10,000 units by 2050 (proposal by National Energy Plan)
Malaysia	BEV (full EV)/HEV/PHEV (partial EV)	BEV<120 (2016)	100,000 (2020)	200 stations (309 charging points) (2020)
Thailand	HEV/PHEV/BEV	HEV: 153,184 BEV: 2,854 (2019)	1.2 million (2036)	527 (charging stations) 817 (charging points) (2019)

Summary of EV targets in Indonesia, Malaysia and Thailand (https://reglobal.co/increasing-uptake-southeast-asia-on-the-verge-of-an-ev-surge)

With regards to the automotive manufacturing of EVs, Indonesia, for instance, has outlined plans to become the primary EV hub in

the SEA region. In July 2021, a memorandum of understanding was signed with Hyundai Consortium for the establishment of first ever electric car battery factory in the region that has initial production capacity of 150,000 units, apart from Hyundai's EV manufacturing plant in Indonesia (HMG Newsroom, 2022). This highlights the big effort of the Indonesian government in pursuing and strengthening local EV manufacturing industry as a key sector for their economy. On the whole, Indonesia targets to produce 400,000 units of EV in 2025 and increases the total to 5.7 million units by 2035 (Sarmiento & Jegho, 2022). A close competitor for Indonesia to become the top EVs producer in the region is clearly Thailand. Top automakers in Thailand, namely Toyota, Nissan, Honda and also AutoAlliance that assembles Ford and Mazda vehicles, have already invested their EV manufacturing in Thailand. Moreover, other automotive companies such as Mercedes-Benz, Great Wall Motor and SAIC Motor of China have made Thailand as their EV sales market and production hub. The government of Thailand expects 30% of automotive production in Thailand will be electric by 2030, corresponds to about 750,000 units out of total production of 2.5 million units (Thailand Board of Investment, 2022). For the meantime, Malaysia has yet to reach the level of EV sales or production of both Indonesia and Thailand. It can be safely said that the EV industry in Malaysia is still at an early stage and the government made many efforts to grow this industry, which have started to show some level of success. In 2021, GCG Asia company announced their plan to set up EV battery manufacturing in Malaysia to serve the regional market (Koty, 2022). Furthermore, in line with revised NAP in 2020, Malaysia will have the production of the first locally assembled EV by Volvo in 2022 (BusinessToday, 2022).



Percentage revenue of EV market in SEA region
(https://www.mordorintelligence.com)

(b) Other Development for Energy Efficient Vehicles (EEVs)

Apart from EVs, the efforts of global automotive industry to make greener vehicles can be generalized under the development of EEVs. Instead of complete change into the electric-based vehicle designs, there are still big market and opportunities for internal combustion engine (ICE) vehicles, including HEVs. Among the research efforts to develop EEVs include system electrification and automation, and vehicle designs. For instance, the shape design of the vehicle can be improved for better aerodynamic performance characteristics and this can save the vehicle's energy consumption by as much as 8% (European Commission, 2018). Moreover, it has been demonstrated that autonomous vehicle system helps to reduce fuel consumption of the vehicles, which will make them more energy efficient (Ross & Guhathakurta, 2017). Additionally, studies are also conducted to make vehicles more energy-efficient through use of alternative fuel.

Essentially, Indonesia has started to look into development of EEVs through their successful low-cost green cars (LCGCs) initiative and policy. This has been emphasized further through the Low Carbon

Emission policy by the government in December 2021 (Kenji, 2022). As a result, local automotive market and production have increased over the years in Indonesia, creating more jobs and also research and development (R&D) works in automotive fields. In 2019, the government announced incentives for automotive manufacturers to open R&D centers and contribute to vocational education and training in Indonesia, with Astra Daihatsu Motor and Honda have already opened their R&D centers there (Sundjojo, 2019). By having these R&D centers locally, it strengthens their automotive industry and the capability of their local workforce. For instance, technology transfer in vehicle design and engineering was achieved through the establishment of R&D center by Astra Daihatsu Motor and many researches that have been done there are helping to enhance local capability to fully and independently develop new vehicle designs (Gaikindo, 2017).

Meanwhile, automotive industry in Malaysia has embarked on the journey towards EEVs since 2014 with the aim to become a regional hub for EEVs through the strategic investments. The Malaysia's EEV policy covers various vehicle segments and powertrain technologies including ICE, hybrid, electric, LNG, CNG, LPG, biodiesel as well as fuel cells. In the local context, the approach of automotive R&D in Malaysia is classified into two groups: first, design and development of vehicle and secondly, development of parts and components for the vehicle being developed (Sahari, 2014). Specifically, apart from the aesthetic design or styling, R&D on vehicle body of an EEV will focus on vehicle homologation aspects such as structural integrity, impact safety, vehicle aerodynamics and suspension system. On the other hand, the powertrain R&D is more focused on the best driving experience, fuel economy and emission quality. Presently, PROTON and Perodua have been trying to upgrade energy efficiency of ICE vehicles (Anazawa, 2021). As well, the pursuit of EEVs in Malaysia

includes autonomous vehicle research and it should be noted that a dedicated R&D center and testbed facilities for this purpose have been established (Lim, 2020).

On the other hand, Eco Car program in Thailand has been mainly focused on the development of greener vehicles and it is essentially a separate initiative than EV program. In 2017, in effort to further support EEV global trend, Thailand government has launched the Eco EV program, which effectively combines elements of both of the earlier schemes (Tan, 2019). To date, one of the big efforts towards EEV in Thailand for supporting the automotive transformation into more electrification could be seen in the research and development of smart autonomous applications (Tungsuwan et al., 2021). The Thailand Automotive Institute outlined in 2019 the official target for autonomous vehicles in Thailand, which aims to have 15% of the automotive production to be BEVs with 60% of Level-3 autonomous features by 2030 (Chollacoop et al., 2020). It is noted that the future autonomous vehicles are expected to increase the energy efficiency of vehicles by about four to 10 percent in 2050 (Prein, 2021).

Identified Gaps of Knowledge and Skills

Based on findings from the market study of automotive industry in Indonesia, Malaysia and Thailand, there are evidently opportunities and growth that can be expected in the near future. However, few challenges have also been identified for the automotive community in these SEA countries to cope with. For this UNITED project, the focus is placed on the readiness of local workforce and education institutions in partner countries to support their future emerging automotive market trends. For this purpose, it has been concluded that the followings are among the main issues to be addressed in this project.

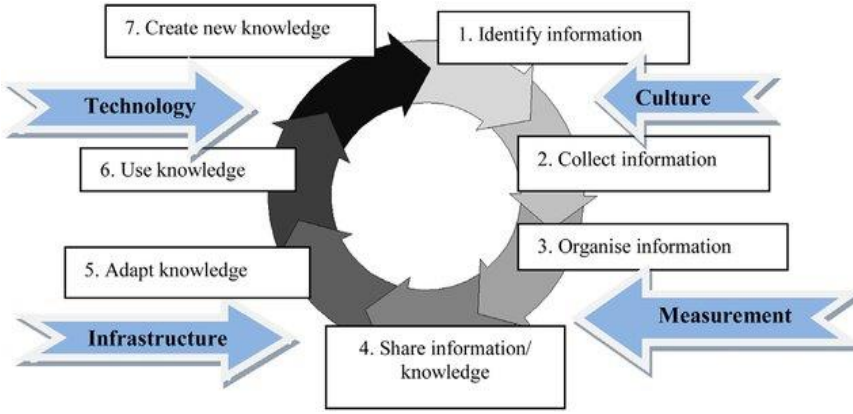
- There is a lack of capable human capitals with adequate knowledge and skills in many areas of interest for the development of EEVs in the region especially in HEVs, EVs and also vehicle system development and design.
- There is a need for local educational institutions to enhance their automotive study programs to produce capable graduates for the industrial workforce who match with the emerging market needs and future market direction.
- There is a need to improve or add new facilities in the educational institutions to make their teaching and learning activities, and also training programs more effective, especially in the lacking areas required by their local automotive industry.
- There is limited university-industry collaboration that needs to be further encouraged for the overall betterment of the automotive industry.

Chapter 3

Knowledge Transfer Activities

The central element of the UNITED project is knowledge transfer, which corresponds to activities of sharing and also disseminating knowledge from one group of people to another. This is a practical method for transitioning information or understanding of subject matters from experts to learning novices or beginners. In practice, knowledge transfer involves more than just communication but also includes circulation of ideas, information, process, documents and others. In context of this project, knowledge in automotive fields becomes the primary focus and this aligns with the main objective of this project, which is to address the current lack of skilled labors in area of automotive engineering with a view to increase positive impact of the automotive industry on regional development in the Southeast Asia (SEA).

In short, a typical knowledge transfer process framework starts with identification, collection and also organization of information for the knowledge to be transferred or shared. Once these early steps have been completed, the knowledge is shared to the target groups. Adaptation and usage of the transferred newly acquired knowledge by the target groups may be implemented to ensure that knowledge has been successfully transferred to them, which could further lead to creation or discovery of other new knowledge. It should be noted that this knowledge transfer process must include the consideration of four environmental factors: culture, measurement, technology and infrastructure. This will ensure that the methods applied for the process are properly effective and well-suited to the target groups.



Knowledge transfer process framework (Guribie & Tengan, 2019)

The UNITED project essentially follows a similar set of steps in its knowledge transfer activities. At the start, the partner institutions identified the knowledge gaps to be addressed within the execution of this project. Once these gaps have been clearly determined, the training modules were developed as tailored to the required topics. A series of capacity building training workshops were conducted to deliver the modules and transfer the knowledge. Upon completion of the trainings, the trained personnel were then asked to conduct their own trainings to disseminate and transfer the new knowledge to their local network. In addition to capacity building trainings, the knowledge transfer process was accomplished through other means such as online webinars and also organization of conferences. These activities were mostly executed under Southeast Asia Automotive Interest Group (SAIG), which is a network established as part of this UNITED project to bring together automotive community especially within the SEA region.

Capacity Building Workshops

Knowledge gaps in automotive fields that are of big interest to SEA partner institutions were identified in the early stage of the project. Each SEA partner institution conducted desktop reviews on current and projected future headings of local automotive industry in their country. Based on the findings, the necessary knowledge and skills to support such anticipated industrial progression were established. Moreover, target stakeholders for this project's knowledge transfer were engaged in the determination of the knowledge gaps through conducted focus group sessions. Among others, participants of the focus group include representatives from local automotive industry, government agencies and academic institutions. The participating stakeholders provided better insight to the required knowledge and skills for local automotive workforce in order to adequately support the projected needs of the local industry in the near future.

MSU (Thailand)

UPM (Malaysia)

USU (Indonesia)

CKU (Thailand)

UTeM (Malaysia)

UNUD (Indonesia)

Conducted focus group sessions by SEA partner institutions

Based on the findings of desktop reviews and focus group sessions, several topics in automotive fields that are of high interest to close the knowledge gaps as identified by the SEA partner institutions are

established. European partner institutions used this information to develop the modules for capacity building workshops. Overall, four capacity building workshops were successfully done by knowledge experts from the European partner institutions and each of them was attended by two or three representatives from each SEA partner institution, i.e. around a total of 20 trainees plus two to four trainers from the European partner institutions.

Capacity building workshops by European partner institutions

Training Title	Date and Venue
Electric Powertrain	 17 – 20 September 2019 (UNUD, Indonesia)
From Internal Combustion Engines to Alternative Powertrain	 4 – 8 November 2019 (UTeM, Malaysia)
Vehicle Design + Dynamics	 9 – 12 December 2019 (USU, Indonesia)
Mechatronic Systems in Automotive Engineering + Testing Bays	 10 – 13 February 2020 (MSU, Thailand)

Once all four trainings for the SEA partner institutions have been completed, they were then responsible to transfer the learned new knowledge to their local network. By doing so, this will solidify their understandings of the new learned knowledge and further assist in multiplying the knowledge dissemination to their local automotive community. Each SEA partner institution selected topics from the capacity building workshops that are most relevant to the needs of their local automotive stakeholders and did at least two workshops with the adapted training materials. It should be noted that due to COVID-19 pandemic situation that occurred throughout the world during the period of this UNITED project execution, the knowledge dissemination workshops were conducted in either physical, online and hybrid mode.

MSU (Thailand)

UPM (Malaysia)

USU (Indonesia)

CKU (Thailand)

UTeM (Malaysia)

UNUD (Indonesia)

Knowledge dissemination by SEA partner institutions

On the whole, feedback received from participants of the knowledge dissemination workshops by the SEA partner institutions have been very positive and many of them indicated that the topics of the workshops are highly relevant to their interests and fulfil the needs

for their professional development. This can be taken to indicate a successful knowledge transfer to local automotive community with the workshops' organization. Many of them also indicated interest on future trainings that were planned with engineering knowledge transfer units at each SEA partner institution, which is described in the following section.

Knowledge dissemination workshops by SEA partner institutions

SEA Partner Institution	**Workshop Topics**	**Number of Participants**
USU	Workshop 1: Challenges of internal combustion engine and hybrid/electric vehicles in automotive field, introduction to hybrid and electric vehicles, CO_2 reduced mobility: fuel cell vehicles	54
	Workshop 2: Future mobility, vehicle concepts, dynamic considerations in vehicle design, energy management	52
UNUD	Workshop 1: Internal combustion engine technology and energy management, vehicle stability and electric vehicle development	42
	Workshop 2: Future mobility and management qualities, vehicle body engineering, dynamics and vehicle model simulation, mechatronics in vehicles	104
UPM	Workshop 1: Basics in vehicle dynamics, vehicle design, modal analysis and model updating	18
	Workshop 2: System engineering approaches, future mobility, sustainable urban mobility planning	20

SEA Partner Institution	Workshop Topics	Number of Participants
UPM	Workshop 3: Virtual vehicle development program, introduction to internal combustion engine and trends, internal combustion engine characteristics, introduction to mechatronics	22
UTeM	Workshop 1: Option for CO_2 reduced mobility: fuel option for internal combustion engines, introduction and overview of internal combustion engine technology, sustainable urban mobility planning	68
	Workshop 2: Overview of advanced driver assistance systems (ADAS), vehicle mechatronics and software development, introduction to vehicle concepts development	59
	Workshop 3: Issues related to CO_2 emission, fuel options for internal combustion engines, standard fuels for engines, Fatty Acid Methyl Esters (FAME) biofuel and palm oil-based FAME biofuel	8
MSU	Workshop 1: Automotive development processes, components and design criteria of electrified powertrain, energy management, supply and storage systems, verification and validation, IT connection for automotive, introduction and overview of internal combustion engines, internal combustion and electric hybrid powertrain, energy management and storage options, battery for automotive, alternative powertrains, fuel cell powertrains	57

SEA Partner Institution	Workshop Topics	Number of Participants
MSU	Workshop 2: Introduction to automotive development, vehicle dynamics, future mobility, vehicle concepts, automotive body engineering, vehicle passive safety and crashworthiness, mechatronics and software development for automotive, test facilities for automotive laboratory, fuel consumptions, pollutant emission, automotive economical aspects	57
CKU	Workshop 1: Automotive development processes and system engineering, alternative fuels and powertrain, energy storage, electric vehicle powertrain and hybrid propulsion system, thermal management	57
	Workshop 2: Future mobility and vehicle concept, body engineering and crashworthiness, vehicle dynamics, automotive embedded system, laboratory and testing bay, thermal modeling, HVAC, aerodynamics, driving simulator	25

Engineering Knowledge Transfer Unit (EKTU)

Each SEA partner institution received allocation under the UNITED project funding to purchase and set up their Engineering Knowledge Transfer Unit (EKTU) at their facility. Selection of EKTU by each SEA partner institution was effectively made based on the identified gap of knowledge and skills for the local automotive community, which is meant to accelerate the knowledge transfer process and also make it more effective. In line with this notion, the EKTU acts as the main central tool in the development and organization of the vocational

trainings by each of the SEA partner institutions. A team of staff and students, who had gone through previous capacity building training either by the European or SEA partner institutions, is appointed to handle the operation of EKTU at each SEA partner institution. The installation of these EKTUs has generally improved available facility at the SEA partner institution and made knowledge dissemination activities more conducive and effective.

Vocational training sessions using the EKTU, which targeted local automotive community or stakeholders such as industrial workers and also academicians and students from non-partner institutions, were planned and conducted by each SEA partner institution. This further widen up the coverage of knowledge transfer process within this UNITED project and improved the quality and competencies of the local automotive workforce. The description of the EKTU and the conducted vocational trainings at each SEA partner institution is presented in the following sections.

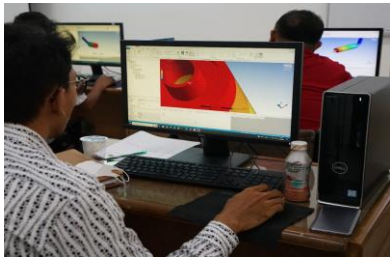
(a) Indonesia

The gap analysis study highlighted that there was strong emphasis by Indonesian government in development of electrified vehicles and number of hybrid vehicles was on increasing trend. However, there is lack of knowledge among local automotive community in Indonesia with regards to hybrid vehicles and also their designs. To address this finding, both USU and UNUD partner institutions had tailored their EKTU planning for knowledge transfer activities in these two automotive fields.

The EKTU in USU is known as “Hybrid Vehicle Training Centre and Simulation”, which comprises of a hybrid engine trainer and ANSYS software. In short, the hybrid engine trainer is aimed to be applied in vocational trainings for enhancing knowledge and skills related to the automotive hybrid engine. Among others, it is intended to

introduce the main components of a hybrid engine, demonstrate its working principles and conduct fault analysis of its system. In the meantime, the ANSYS software is a common simulation analysis tool used in automotive industry for computational fluid dynamics and finite element analysis. The capability and skills to effectively use this ANSYS software is a great value-added criterion for local automotive personnel, especially in the vehicle design applications including hybrid vehicles. The operation of this EKTU at USU had been officially launched by the USU management on 2nd June 2021.

Hybrid Engine Trainer



ANSYS Computing Facility

EKTU in USU

USU had developed two vocational training modules around their installed EKTU as follow:

- **Hybrid Cars Training** – covers the introduction of main components of hybrid engine and their functions, operational principles and performance, fault analysis and scanning, with practical demonstration and troubleshooting using the hybrid engine trainer

- **Simulation Analysis and Vehicle Design Training** – covers the introduction to static structural analysis using finite element method, design of bumper, with practical hands-on exercise using the ANSYS software

A total of 10 vocational trainings were conducted by USU using their EKTU during UNITED project duration, with more than 60 trained participants cumulatively. It should be noted that all these trainings were done in physical mode. According to received feedbacks from the participants, they stated that their knowledge on hybrid engine and ANSYS software had improved after going through the training. Inclusion of hands-on activities during the trainings had been an effective way to transfer or disseminate knowledge to participants. All in all, it can be taken that the vocational trainings had achieved the project's goal in improving the knowledge on automotive hybrid engine and enhancing computing skills of ANSYS software among automotive community in Indonesia through the use of the EKTU.

Hybrid Engine

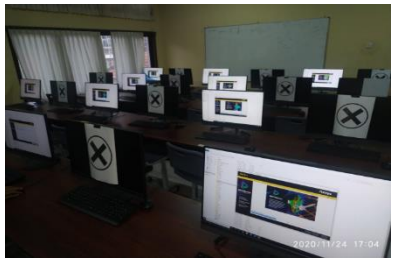
ANSYS Simulation

Conducted vocational trainings by USU using their EKTU

In similar fashion, to address the same identified knowledge gaps in Indonesia, UNUD also chose to have their EKTU to be comprised of hybrid engine trainer, Otto motor trainer and ANSYS software. The EKTU in UNUD, which is called the "Excellence Centre for Advanced Vehicle Training and Simulation", was developed under the notion that theoretical knowledge delivery must be supported by practical work, hence the equipment was used to improve the comprehension and technical skills of the trained participants by familiarizing them with hands-on tools. The focus for knowledge transfer through this

EKTU is on electric and hybrid vehicles. Among others, the hybrid engine trainer and Otto motor trainer are to increase knowledge of hybrid engine fundamentals, electrified components and also fault code analysis of the engine and electrified components. Meanwhile, ANSYS software is meant to expose participants in visualization of vehicle dynamics and analysis on vehicle components' strength.

Hybrid Engine Trainer



ANSYS Computing Facility

EKTU in UNUD

Operation of the EKTU was launched by UNUD management on 7th May 2021 and the following list of topics are among those offered by UNUD for their vocational trainings using the EKTU:

- **Electrical Vehicle Technology and Hybrid Engine** – covers the introduction to electrical renewable energy source, vehicle technology, active safety and vehicle system dynamics
- **Internal Combustion Engine and Hybrid Vehicle** – covers the introduction to internal combustion engine and hybrid vehicle, with practical demonstration using the hybrid engine trainer and Otto motor trainer
- **Battery Cell and Pack Testing of Hybrid Vehicle** – covers the different types of battery and their parameters, with

practical exercises on disassembling, examining and measuring the battery using the hybrid engine trainer

- **Simulation of Vehicle Aerodynamics** – covers the CFD simulation of vehicle aerodynamics using the ANSYS software
- **Simulation of Static Structural Analysis of Vehicle Design** – covers the construction of a vehicle design drawing and its static structural analysis using the ANSYS software
- **Battery Diagnostic and Maintenance** – covers the introduction to the battery of hybrid vehicles, its diagnostics and maintenance procedures, with practical application using the hybrid engine trainer
- **Electric Motor and Controllers of Hybrid Vehicles** – covers the introduction to the electric motors and controllers of hybrid vehicles, and their maintenance process, with practical application using the hybrid engine trainer
- **Simulation of Vehicle Dynamics** – covers the introduction of explicit dynamic analysis on vehicles, with practical application using the ANSYS software

UNUD had successfully conducted 10 vocational trainings with their EKTU in physical mode. Cumulatively, a total of about 80 people from the local automotive community were trained in the trainings. Most participants generally gave positive feedbacks on the training sessions, particularly complementing the provided practical hands-on activities in enhancing their understanding and improving their technical and computing skills with the equipment and simulation software, respectively. On the other hand, participants also noted the high relevancy of training topics to their job and professional needs.

Hybrid Engine

ANSYS Simulation

Conducted vocational trainings by UNUD using their EKTU

(b) Malaysia

According to findings from the conducted knowledge gap analysis for the local automotive community in Malaysia, a few lacking areas of knowledge had been identified as necessary to be enhanced or improved to support future direction of the industry. Among others, these identified key areas include electrified powertrains (i.e. hybrid and battery operated) and vehicle dynamics. In conjunction with this information, UPM and UTeM partner institutions had planned for their EKTU development to close these gaps and facilitate the effectiveness of the knowledge transfer process.

EKTU in UPM is known as the "Hybrid Engine Trainer and Vehicle Dynamics Simulation", which fittingly reflects on the equipment purchased and installed in their facility under the UNITED project. Their EKTU consists of two main types of equipment: the hybrid engine trainer and MSc Adams software. The hybrid engine trainer addresses the lack of knowledge or skills in electrified powertrains among local automotive stakeholders, which is used to strengthen their understanding in hybrid engine operating principle, plus the working structure of hybrid system components and diagnosis. On the other end, MSc Adams software is chosen to cater for knowledge transfer activities in areas of vehicle dynamics. This software has been widely used as one of the tools in the automotive industry to

simulate dynamic motion of vehicle components. Operational roll-out of this EKTU was officiated by the UPM management on 21st September 2021.

Hybrid Engine Trainer

MSc Adams Computing Facility

EKTU in UPM

Four vocational training modules were developed and offered by UPM with the use of this EKTU. The offered trainings are described as follow:

- **Introduction to Hybrid Engine** – covers the theoretical and practical knowledge on fundamental working principles and system components of a hybrid engine, with practical demonstration using the hybrid engine trainer
- **Safety, Troubleshooting and Electrical Measurement of Hybrid Engine** – covers the safety, hazard and risks potential of a hybrid engine, which also includes troubleshooting for potential issues computer scan and practical fault analysis activity using the hybrid engine trainer
- **Fundamentals in Dynamic Simulation of Vehicles** – covers the theoretical knowledge on the fundamental principles of

vehicle dynamics and its simulation analysis, with practical demonstration using the MSc Adams software

- **Vehicle Dynamics Simulation** – covers the theoretical and practical knowledge on simulation analysis of vehicle dynamics and its use in vehicle design process, with practical activity using the MSc Adams software

During the UNITED project, 12 vocational trainings were conducted by UPM using this EKTU and the total number of participants for all the trainings is roughly around 120 people among local automotive stakeholders. It should be noted that most of the vocational training sessions had to be conducted in online mode due to the restrictions enforced under the COVID-19 pandemic situation. Some parts of the trainings, especially those practical hands-on interactions with participants, had to be adapted into only visual demonstration. In spite of this limitation however, many participants expressed their satisfaction with the conducted online training, which raised their interest and technical knowledge in the automotive fields related to hybrid engine and vehicle dynamics. For instance, few participants indicated their intention for future advanced training and academic collaborations with UPM using the EKTU. In fact, one participant from a local company requested for advanced training for his other colleagues. On the other hand, participants of vocational training session that was conducted in physical mode were relatively more satisfied and had better comprehension with the included practical hands-on activities when it comes to the learning of MSc Adams software. This is not surprising since it is certainly more effective to demonstrate and learn to use computing software through practical examples and hands-on activities. Overall, the EKTU installed in UPM is successful in supporting the knowledge transfer activities to local automotive community in Malaysia in the areas of automotive hybrid engine and vehicle dynamics simulation.

Hybrid Engine

Vehicle Dynamics Simulation

Conducted vocational trainings by UPM using their EKTU

In the meantime, another partner institution from Malaysia, UTeM chose to focus their EKTU on bridging the identified knowledge gap in hybrid engine, particularly in the fuel management system. Their EKTU, which is called "UTeM Future Fuel Design Training Centre", is made of two primary equipment: fuel injection trainer and data acquisition software for advanced fuel injection system. The fuel injection trainer is utilized to facilitate in transferring knowledge of operating principles and strategies of fuel injection for the hybrid engine, working structure and diagnosis of the injection system for hybrid components. To complement the fuel injection trainer, the data acquisition software allows training on fuel injection strategies and system analysis. The official operational roll-out of this EKTU in UTeM was done by the UTeM management on 4th May 2021.

With this EKTU, UTeM has developed two training modules at three different levels of difficulty depending on the background of the participants. The basic level is designed for the industrial workforce who have no engineering knowledge or background. Moreover, the advanced level 1 training is developed for participants with at least bachelor degree level of knowledge in either automotive technology or mechanical engineering whereas the advanced level 2 training has been developed for participants with qualifications of master's

degree and above in related fields to automotive. The two offered training modules are tentatively described as follow:

- **Fundamental of Fuel Injection System (Basic Level)** – covers the theoretical and fundamental knowledge of automotive fuel delivery system, basic components in fuel delivery system and fuel injection system, working principle of fuel injection system, with practical demonstration using the fuel injection trainer
- **Automotive Fuel Injection (Advanced Level 1 and 2)** – covers the functions of a diesel fuel injection system, injection timing control, atomization, bulk mixing and air utilization, injection quality control, advanced injector behavioral analysis (for advanced level 2), with practical demonstration using the fuel injection trainer and data acquisition software

EKTU in UTeM

UTeM conducted 10 vocational trainings with the EKTU throughout the duration of UNITED project, with a total number of 56 trained

participants among the local automotive industry workforce. These vocational trainings were conducted in the physical mode and all of the participants were able to experience hands-on practical exercise with the EKTU. It was noted that, since the training topics were in a niche area of automotive fuel injection system, prior knowledge and background of participants should be known first before conducting the training in order to effectively adapt the delivery methods to better suit with the participants. Nonetheless, based on feedbacks received from the participants, it is concluded that the vocational training had successfully accomplished its goal in supporting and facilitating knowledge transfer of the automotive fuel management system in hybrid engine to the automotive community in Malaysia. Many participants acknowledged that their understanding of the automotive fuel injection system and its emerging technologies was much improved after underwent the training and they were happy to have practical hands-on session with the EKTU.


Conducted vocational trainings by UTeM using their EKTU

(c) Thailand

In line with the identified areas of knowledge gaps for Indonesia and Malaysia, it was found that similar topics of hybrid and also electric vehicles were lacking and required enhancement among the local automotive community in Thailand. Among others, specific fields of knowledge and skills to be focused on include system design and

components of the electrified and hybrid powertrains, engine fault analysis and diagnostics, energy management system and battery technology. Based on this obtained information, both MSU and CKU partner institutions planned the development and instalment of the EKTU at their facility.

The EKTU in MSU, named “Electric Vehicle and Energy Technology Development and Transfer Unit” consists of training equipment for electrical motor drive and battery management system, automotive scanning analyzer and also a learning management system. In brief, the electrical vehicle training equipment is to train for theoretical and practical knowledge on the electric car drive motor, new energy sources in automotive engineering and also battery management system. Meanwhile, the automotive scanning analyzer is intended for transferring or disseminating knowledge on the engine scanning and diagnostics whereas the learning management system is used for creating suitable simulation experiments, which is designed as working stations with a dedicated software to run for the technical analyses related to the automotive vehicle system on programming languages such as C, C++, LabView and Simulink. The EKTU in MSU was officially launched by the management of MSU on 6th July 2021.

EKTU in MSU

Using their EKTU, MSU conducted 10 vocational trainings, which involved local automotive companies or organizations. Within the duration of the UNITED project, an estimated total of more than 70 people from the local automotive community were trained by MSU. Four different core modules were developed for vocational trainings and they are described as follow:

- **Automotive Technology: Components, Design and Concepts (Part 1)** – covers introduction to automotive development and processes, components and design criteria of electrified powertrains, energy management, supply and storage systems, information technology (IT) connection for automotive, introduction to internal combustion engine (ICE) technology, ICE/electric hybrid powertrains, battery for automotive, alternative powertrains, fuel cell powertrains

- **Automotive Technology: Components, Design and Concepts (Part 2)** – covers vehicle dynamics, automotive future mobility, vehicle concepts, automotive body engineering, vehicle passive safety and crashworthiness, mechatronics and software development for automotive, test facilities for automotive laboratory, fuel consumption, pollutant emission, automotive economical aspects

- **Practical Electric Vehicle (EV): Components and Drives** – covers practical measurements of motor internal resistance, battery capacity and battery voltage, experimental analysis of battery discharge and high voltage motor drive control devices, experimental measurements of automotive instrument display, battery pack disassembly, adjustable voltage charging, gear position control, accelerator control, motor speed system, key switch, brake switch and DC-to-DC device

- **Practical Electric Vehicle (EV): Battery and Diagnosis** – covers practical measurements of battery internal resistance and battery capacity, experimental analysis of battery discharge, constant voltage discharge, battery management system, motor voltage, motor speed, high-voltage motor drive controller, high-voltage motor drive operation wave, electrical appliance power discharge, accelerator pedal, oscilloscope, wire connection, constant voltage charging and constant current charging, EV diagnose using scanner analyzer


Conducted vocational trainings by MSU using their EKTU

Based on feedbacks from participants of the trainings, most of them were happy with training and acknowledged that they had increased their knowledge on the trained topics. Many of them also indicated relevancy of training topics to their career development or to their company. Furthermore, as evident from the conducted training, the use of learning management system had made the training easier to follow by participants since they can individually study the training materials. For many practical exercises during training, distribution of prepared lab sheets containing fundamental descriptions of the training topics seemed to improve understanding of participants, especially when they did not have the basic background knowledge of the topics prior to the trainings.

Meanwhile, CKU named its EKTU as “Chulalongkorn Engineering Knowledge Transfer Unit”. Development of this EKTU was tailored to address the lack of knowledge and skills of the local automotive workforce in areas of hybrid and electric vehicles. In line with this aim, the EKTU in CKU is mainly comprised of equipment for real-time simulation system for operation of typical hybrid and electric vehicles. Among others, they include electric drives, converters, on-board vehicle networks and optical data buses. The use of this EKTU is targeted to enhance understanding of state-of-the-art simulation and testing techniques in modern automotive technology, mainly in system development and testing of hybrid and electric vehicles. Official operation of this EKTU was launched by the management of CKU on 26th March 2021.

EKTU in CKU

Five vocational training modules were developed by CKU based on their EKTU. Three of the modules are designed for physical hands-on training while the other two are offered in online mode. The brief descriptions of the training modules are as follow:

- **Module A** – covers interlock in hybrid and all-electric vehicles, battery disconnect unit in hybrid and all-electric vehicles, and safe handling of hybrid vehicle systems

- **Module B** – covers fundamentals of DC-AC conversion in vehicles, DC-DC step-up converters in hybrid and all-electric vehicles, and DC-DC step-down converters in hybrid and all-electric vehicles

- **Module C** – covers PWM signals in automotive engineering, electric automotive drives, and 48V onboard electric system in motor vehicles

- **Module L1: Introduction to Hybrid Vehicles (Online)** – covers the future trends, pros and cons, hybrid powertrain classification, hybrid system architecture, thermal management and hybrid vehicles

- **Module L2: Introduction to Electric Powertrain Sizing (Online)** – covers classification of electrified powertrains, system level modeling, system requirements, thermal modeling

Within the timeframe of the UNITED project, CKU had successfully conducted 10 vocational trainings with their EKTU. A cumulative total of more than 140 people were trained through the vocational trainings, which were conducted in either online or physical mode due to the COVID-19 pandemic situation. It should be noted that the participants' feedback regarding the trainings had been mostly positive and they were satisfied with the new knowledge that they had gained through the conducted trainings. In hindsight, it could be seen that the trainings would be effective when the number of participants was limited to only two people per equipment station. Moreover, due to their different levels of background knowledge on

the training topics, a short introductory lecture can be delivered at the beginning of training before any practical hands-on activities are conducted. All in all, the vocational trainings were successful and helped to bridge the knowledge gap among local automotive community in areas of hybrid and all-electric vehicles.

Conducted vocational trainings by CKU using their EKTU

Southeast Asia Automotive Interest Group (SAIG)

Another avenue for knowledge transfer activities under the UNITED project is through the establishment of Southeast Asia Automotive Interest Group (SAIG). With the motto “The Driving Force Behind Automotive Ecosystems”, SAIG aims to become a platform for the automotive community to share ideas and knowledge in the related automotive fields, with a particular attention on the industry and regional development in Southeast Asia countries. In other words, its establishment is envisioned to act as a catalyst and outlet for potential collaborations between the members of the automotive community within SEA region and worldwide. To further support

the achievement of the goals of UNITED project, this SAIG network has been actively utilized as a channel for knowledge transfer and dissemination activities.

The official logo of the SAIG network aptly reflects on its mission, vision and objectives. In short, the symbolic car illustration is an homage to the official logo of the UNITED project, which this SAIG network is developed for, and also indicates that the main interest of the network is in the automotive field. The color red signifies the great passion of this network to drive the future development and technology advancement in automotive industry within SEA region. In the meantime, the green color corresponds to the fundamental principles of sustainability that underlines efforts of the network to ensure that the industry remains relevant in years ahead amid new market changes and challenges.

Official logo of SAIG network

The following are among the objectives of the SAIG network:

- To provide a common networking platform for the different stakeholders within the automotive ecosystem in the Southeast Asian region and Europe, with a strong focus on increasing university-business cooperation
- To provide a platform for information exchange and professional development opportunities among the members

of the Southeast Asian regional automotive community, hence leading to increased employability of students

- To promote knowledge sharing and discussions of current developments related to the automotive field, especially towards CO2-reduced mobility
- To produce and disseminate essential information regarding general issues as well as hot topics in the automotive field, to serve as a knowledge transfer platform for interested engineers and experts all over the world
- To organize activities related to automotive and mechanical engineering, such as research collaborations, professional consultations, academic conferences, trainings and competitions, to strengthen cooperation
- To encourage more communications and discussions among the members of the network

To date, there are around 550 registered members of SAIG network from various countries around the world including India, Pakistan, Australia, Indonesia, Malaysia, Thailand, Germany, Austria, Italy, Philippines, Uzbekistan, Kuwait, Nigeria, Iraq and Belgium. This goes to highlight the success of the SAIG network in reaching out to the members of the automotive community all over the world and effectively becomes the platform for sharing and/or disseminating new knowledge, and encouraging collaborations in the automotive fields. It can thus be taken that the establishment of SAIG network has brought positive impacts to automotive community, especially in SEA region. Through its conducted activities, the network has helped to increase exchange of ideas and also discussions among academic institutions and automotive industries, either nationally

or internationally. Moreover, by becoming a platform for knowledge transfer and dissemination activities, the network has facilitated in improving technical and practical knowledge among the members of the network, leading to a more competitive and competent local automotive workforce in the region. Last but not least, through its conducted activities as well, the SAIG network managed to promote national and international participants and collaborations, both in academic and research cooperation. Among the major activities of the SAIG network that helped it to achieve abovementioned impacts to automotive community in SEA and also worldwide include EKTU training workshops, cross-border conferences and online webinars.

(a) EKTU Training Workshops for SAIG

In conjunction with the successful installation of EKTU at each SEA partner institution, one training workshop was conducted by each of them as part of the knowledge transfer and dissemination activity under the UNITED project. Organization of this workshop also acted as a promotion for the EKTUs to the local automotive community, especially among the members of SAIG network. By doing this, it helped to encourage potential collaborations through the use of the EKTU between the institutions or companies of the participants and the SEA partner institutions. It should be noted that the coverage of these training workshops was not in great depth as the vocational trainings with the EKTU since the primary goal was to promote and increase awareness of the EKTU especially among local automotive community.

Overall, it is concluded that the organization of these EKTU training workshops within SAIG network had achieved the goal of promoting and also increasing awareness of the EKTU, and in some ways also transferring and disseminating basic knowledge in the automotive topics related to each EKTU. From the general feedbacks given by

the participants, many of them indicated their interest to join the more extensive vocational training in the future to further enhance their knowledge and improve their hands-on practical skills using the available EKTU.

EKTU training by SEA partner institutions for SAIG network

Partner Institutions EKTU Training Titles		Number of Participants
	**USU** Flow Simulation and Static Structural Analysis	6
	**UNUD** Hybrid Vehicle Battery Test and Diagnostics	6
	**UPM** Introduction and Demonstration of MSc Adams Software and Hybrid Engine Trainer	16
	**UTeM** Fuel Injection Management System	10

Partner Institutions EKTU Training Titles		Number of Participants
	**MSU** Automotive Technology: Components, Design and Concepts	15
	**CKU** Academic Training and Demonstration of EKTU	13

(b) Cross-border Conferences

Under the UNITED project, the SAIG network managed to organize two cross-border conferences. The conference is meant to become a regular flagship program for the SAIG network, which acts as an effective platform for the automotive community to share current state-of-the-art knowledge, development and technologies in areas including sustainable mobility, manufacturing, policies, education and training in fields of automotive engineering. This conference series, aptly titled as the "UNITED-SAIG International Conference", was first organized by CKU in Bangkok, Thailand on 21st to 22nd April 2021 in full-online mode due to COVID-19 pandemic. Second edition of the conference was then organized in Putrajaya, Malaysia by UPM in the following year on 23rd to 24th May 2022, which was conducted in hybrid mode.

The theme for the first conference was "International Collaboration Towards Sustainable and Green Automotive Technology". On top of the scientific presentations, the conference program also included four keynote speakers, promotional session for UNITED project and

SAIG network, and a special forum on topic of "University-Business Cooperation from Industry Perspective". The four keynote speakers and the titles of their keynote address are listed as follow:

- **Achieving the Autonomous Driving in Future Mobility: Thailand's Perspective** – Dr. Pasan Kulvanit from Thailand's Ministry of Higher Education, Science, Research and Innovation
- **CO_2-Neutral Powertrain** – Dr.-Ing. Ralf Marquard from LHP Europe GmbH, Germany
- **Retrofitting Electric Vehicle: The IIUM Journey – Achievements, Challenges and Moving Forward** – Assoc. Prof. Dr. Sany Ihsan from International Islamic University Malaysia
- **Challenges in the Transport Industry in Europe Towards CO_2 Emission** – Prof. DI Dr. Josef Affenzeller from AVL List GmbH, Austria

In total, 17 scientific papers were presented at the conference in few focused areas of automotive engineering, which are alternative or sustainable powertrain, materials, vehicle dynamics and also new business models and automotive evaluation. The conference also managed to attract approximately 200 total participants during its two-day program from many countries such as Thailand, Malaysia, Germany, Austria, Italy, Indonesia and Uzbekistan. All in all, it can be taken that this first UNITED-SAIG International Conference had achieved its objectives, both in promoting the UNITED project and SAIG network, and in sharing and disseminating new knowledge in automotive fields particularly to the local automotive community within the SEA region.

Online 1st UNITED-SAIG International Conference

In the meantime, "Green and Future Mobility Concepts" was chosen as the conference theme for the second edition of the UNITED-SAIG International Conference. Overall, a total of more than 200 people participated in the conference during its two-day program either in physical or online mode. The conference program was comprised of scientific presentations, four keynote sessions and one session for EKTU promotion by the SEA partner institutions. The four keynote speakers and the titles of their keynote address are listed as follow:

- **Future of Internal Combustion Engines Beyond the Year 2030** – Ir. Azmi Osman from PROTON, Malaysia
- **System Level Optimization of Hybrid Vehicle Components** – Mr. Gianluca Cariccia from Dayco, Italy
- **Impact of Green Mobility Solutions as Part of the Environmental, Social and Governance (ESG) Agenda in Malaysia** – Mr. Hisham Razuli Halim from DreamEDGE, Malaysia

- **Towards Climate Neutral Mobility: Case of Austria 2040** – Dr. Gerfried Jungmeier from Joanneum Research, Austria

On the whole, 32 scientific research works were presented during the conference with researchers from various countries throughout the world including Malaysia, Indonesia, India, Austria, Germany and Thailand. The outreach of the participants for this conference also covered other countries including Iraq, Pakistan, Philippines, Nigeria, Cameroon, Morocco, Ethiopia, Mozambique, Bangladesh and Italy. Based on this, it is easily deduced that the conference was successful in widening up the networking of SAIG to members of automotive community beyond the countries of partner institutions in the UNITED project. By achieving this situation, the knowledge sharing and dissemination activities for the SAIG network become more inclusive and beneficial to further improve the competencies of the regional automotive workforce as it involves contribution and also participation of a wider worldwide community.

2nd UNITED-SAIG International Conference

(c) Online Webinars

Another primary outlet for SAIG network to disseminate knowledge and encourage sharing of expertise is through the organization of the online webinars. These online webinars enabled the coverage of knowledge for more specific or niche automotive topics to be shared or disseminate to the local automotive community within the SEA region. Each partner institution in UNITED project, either from SEA or Europe, took turns to deliver the online webinar on automotive related topics that were of high interest for the SAIG network. To date, SAIG network organized nine online webinars and they were participated by people from various countries worldwide.

It can be observed that wide range of topics was essentially covered by the organized webinars and all of them were delivered by expert speakers. Through the webinars, knowledge transfer process to the participating members of automotive community was achieved in the presentation delivery by the experts and technical discussions among participants during the webinar session. The responses from the participants had been positive and many of them had indicated that the topics delivered were current and highly relevant to them.

FHJ (Austria)

Virtual Tour through the FH Joanneum Test Bed Area

UPM (Malaysia)

Development of Load Segmentation Strategy for Electric Vehicle

UTeM (Malaysia)

Sustainable Biofuel Technology for Internal Combustion Engine

FHA (Germany)

Introduction to Fuel Cell System Technologies

USU (Indonesia)

Future of Hybrid Mobility

UNUD (Indonesia)

Mobility for Future

MSU (Thailand)

Practical Implementation of MSU-EKTU to Local Automotive Companies: Case Study of Atipong Motor

CKU (Thailand)

Progression of Autonomous Vehicle Deployment in Thailand

PTT (Italy)

Recent Advances in HEV Energy Management Systems and Battery Technologies

Online webinars by the SAIG network

Main Project Outcomes

Two main tangible outputs from UNITED project are installation of EKTUs at each SEA partner institution and establishment of SAIG network. The impact of this project is therefore closely tied to the operation of the EKTUs and the conducted activities under the SAIG network. In general, the project outcomes can be categorized into several levels according to extent of the impacts and also the groups of automotive community or stakeholders involved.

Impact at Institutional Level for SEA Partners

The purchase and installation of EKTUs at each of the SEA partner institutions was funded under UNITED project's budget. The EKTUs essentially enhance the existing facility at each partner institution, which enables improvement in the quality of teaching and learning activities for students in the related knowledge fields of the EKTUs. By having the EKTUs, various physical hands-on activities could be included into the course delivery instead of just theoretical lectures and this helps to further increase the students' understanding of the subject matters. Subsequently, the quality of graduates from each SEA partner institution is increased and they are more prepared in terms of required knowledge and skills to competently work within automotive industry. In addition to students, these EKTUs can also be used to train academic and technical staff of the institution and increase their competency through attainment of new knowledge and skills. Furthermore, the EKTUs help to increase visibility of the

institution to local automotive community and become the catalyst in fostering inter-university or university-industry collaboration. This is evident during the operational roll-out event of the EKTUs at each SEA partner institution where the automotive stakeholders attended and showed their interest with the EKTUs. More specific impact for each SEA partner institution is discussed in the following sections.

(a) Sumatera Utara University (USU)

For USU, a new dedicated laboratory facility called Hybrid Vehicle Training Centre and Simulation was established with installation of their EKTU. The new facility focuses on training activities in areas of hybrid and electric vehicles. Additionally, a new research group was created to work with the new facility. Teaching and learning activities of the students have also improved through the use of the hybrid engine trainer and ANSYS simulation software in related course deliveries, and new courses on electric and hybrid vehicles are being developed to be offered in the future study program. All things considered, this certainly improves the quality of graduates from automotive-related programs at USU.

Establishment of new laboratory facility at USU for their EKTUs

(b) Udayana University (UNUD)

Improved facilities at UNUD with their EKTU have enabled better teaching and learning activities for their students. This is achieved by including some practical sessions with the EKTUs in few related

course delivery, especially for courses with topics on the design and system analysis of hybrid and electric cars. As the result, the quality of future graduates from UNUD is also enhanced for employment in automotive industry. Furthermore, the EKTU is also aimed to assist UNUD in developing their own hybrid or electric vehicle design in future by upgrading their staff's knowledge and skill, strengthening the image of UNUD as one of the leading institutions in automotive.

(c) Universiti Putra Malaysia (UPM)

As a university that does not offer specific program in automotive fields, installation of their EKTU enhances teaching capabilities of UPM, or specifically Faculty of Engineering, in fields of automotive engineering. The EKTU essentially offers the facility to effectively deliver topics related to vehicle dynamics and hybrid or electric engines that are covered in several current mechanical engineering courses. In future, with availability of the EKTU, more topics and/or specialized courses related to automotive engineering can possibly be developed and included into the offered undergraduate and also postgraduate engineering study programs by the faculty. In the meantime, the EKTU also provides the means and opportunities for more scientific studies to be conducted at the faculty in automotive fields, especially for the postgraduate study. It should be noted that several academic and technical staff had also joined and obtained transferred knowledge and skills during trainings and workshops of the UNITED project, hence increasing the general capability of the faculty in teaching and doing research in many areas of automotive engineering. This is a crucial progress to further encourage more involvement of the faculty in automotive fields and build a positive overall impression of UPM in terms of its staff's competency and available facilities to support and engage with the local and also international automotive community.

(d) Universiti Teknikal Malaysia Melaka (UTeM)

As a university with focused study programs and also specialized technical capabilities in automotive areas in Malaysia, installation of EKTU from UNITED project further enhances UTeM's strength in delivering teaching and research activities in automotive field. The EKTU in UTeM has improved their existing automotive facilities and enables them to extend their capability into exploring the areas of sustainable fuel and fuel management for automotive applications. A dedicated new training center called the Advanced Future Fuel Design Training Centre was developed around the EKTU in UTeM. Moreover, the EKTU also benefits the offered educational programs in UTeM whereby the existing academic curriculum for automotive-related programs in UTeM is expected to be improved with inclusion of the EKTU to increase competitiveness of their future graduates in automotive. These programs include undergraduate automotive engineering and automotive technology, and Master in Mechanical (Automotive).

Official launching of the new EKTU training center in UTeM

(e) Mahasarakham University (MSU)

The EKTU at MSU improved the available facility, particularly for teaching and training activities in areas of electric vehicles. To this effect, several new courses and a new undergraduate program on electric vehicles are under development at MSU with the use of the EKTU. In terms of improving the current study program, the EKTU was already used in more than 50 senior projects by their students. Meanwhile, a new research unit specifically for electric vehicles has been established at MSU, along with the hiring of two new lecturers in this area of study. Moreover, use of the EKTU has strengthened the position of MSU as one of leading institutions in the areas of electric vehicles in Thailand, especially through accomplishments achieved from the use of the EKTU such as having five presented international research papers and also receiving four awards related to electric vehicles.

Use of EKTU at MSU by their students

(f) Chulalongkorn University (CKU)

Similar to other SEA partner institutions, EKTU obtained by CKU through the UNITED project is a valuable addition to their available

teaching and research equipment. Installation of the EKTU leads to the creation of new laboratory space that is dedicated for teaching and training activities in areas of hybrid and electric vehicles. The EKTU is now utilized regularly in several related current academic courses, improving delivery methods to students. The automotive engineering curriculum at CKU will also be enhanced in future with inclusion of more usage of their EKTU.

Impact at National Level of SEA Partner Countries

The impact of the UNITED project at national level for the three SEA partner countries is mostly contributed to the conducted workshops and vocational trainings by the SEA partner institutions, especially through their EKTUs. In general, competency and capability of local automotive workforce is enhanced by the transfer of new knowledge and upgraded skills, which helps to support the national agenda for automotive industry in each particular country. Furthermore, this situation also helps to strengthen the industry. On the other hand, another major impact of the UNITED project for local automotive community at each of the SEA partner countries is seen in aspect of collaboration and engagement between the partner institution and the local automotive organizations or companies. Such relationship can help to strengthen national industry in the long run, especially in development of new technologies and competent human capital. More detailed discussion on the contribution of UNITED project to each partner country is presented in the following sections.

(a) Indonesia

In essence, the direction of the automotive industry in Indonesia is heading towards the hybrid and electric vehicles, and various efforts have been made by its government to realize this aspiration (Yusuf

et al., 2021). Through UNITED project, both USU and UNUD have also supported this national automotive agenda with the conducted trainings with their EKTUs. The EKTU in USU is actually the first simulation tool of hybrid vehicle that is available in North Sumatra province. Hence conducted trainings using their EKTU has certainly empowered local automotive community, especially in interested areas of hybrid and electric vehicles, and better preparing them to support the achievement of national agenda. Trainings conducted by USU were attended by academicians and students from various universities and technical vocational schools, and also engineers in several automotive companies in North Sumatra. In the meantime, UNUD also conducted their EKTU trainings on the topics of hybrid and electric vehicles to people from multiple local companies such as PT Auto 2000 Sanur, Makara EV, Sumber Jaya Agung Motor, Dellin's Motor, Arsa Nadi, NGP Otomotif, and also local academic institutions including Politeknik Transportasi Darat, Politeknik Negeri Bali, Universitas Pendidikan Ganesha and Team Weimana Udayana Bali. On the whole, it is concluded that the UNITED project has improved the general capability of local automotive workforce in Indonesia in pursuing their national automotive industrial goal to be among the world's leader in development and manufacturing of hybrid and electric vehicles.

(b) Malaysia

The conducted EKTU trainings and also workshops by both UPM and UTeM have generally enhanced the local automotive workforce in Malaysia in areas of hybrid engines, fuel management system and vehicle dynamics. This is parallel with the needs to prepare capable human capital to effectively support the future direction of national automotive industry that is moving towards sustainable and energy efficient vehicles (Veza et al., 2021). The EKTU in UPM assists to address identified gap in knowledge and skills for hybrid engines

and vehicle dynamics, while the EKTU in UTeM has done the same for automotive fuel management. Collectively, participants in the conducted trainings and workshops by both UPM and UTeM were mostly from various automotive companies, government agencies and academic institutions, therefore increasing competency across different stakeholders of local automotive community in Malaysia. In addition, the UNITED project has also assisted in encouraging more inter-university and university-industry collaborations at the national level. For instance, by attending one of the EKTU online trainings conducted by UPM, a local company has requested similar training for their other employees to increase their knowledge and skills of MSc ADAMS software. During the requested training, the company expressed their interest in engaging experts in UPM for future engagements of training and research. Through the UNITED project as well, UPM has strengthened their relation with the local partner company of the project, DreamEDGE in other collaboration projects. A similar situation also occurred with other local academic institutions whereby their academicians and postgraduate students attended the trainings by UPM and indicated possible research and academic collaborations between them with UPM. On the other hand, UTeM has solidified their relationships and fostered several new collaborations with local automotive-related companies and agencies through the activities of UNITED project. Each of their vocational trainings was specifically targeted to particular company and government agency, resulting in much closer partnership and engagement in terms of future training and research collaborations. All in all, it could be taken that automotive community in Malaysia has generally benefitted from UNITED project through improved quality of manpower or human capital in supporting the national automotive agenda and a stronger inter-university and university-industry relationships that can help to spur valuable development and research findings in automotive fields.

Green Energy Sdn. Bhd.

Proton ESS

PESB Energy Sdn. Bhd.

KMZ Energy Sdn. Bhd.

Fostering stronger university-industry relationships in Malaysia through EKTU trainings by UTeM

(c) Thailand

In similar manner, UNITED project has also improved the overall competency and also capability of local automotive community in Thailand. The automotive industry in Thailand is moving towards electric vehicles and autonomous driving (Intarakumnerd, 2021), and the EKTUs installed at both MSU and CKU greatly support this national agenda by offering knowledge transfer and upgraded skills through conducted trainings. In general, the trained participants among local automotive community are now better equipped with the required knowledge and skills to assist successful achievement of this national automotive agenda. For instance, the EKTU training conducted by CKU involved many people from automotive industry, including manufacturers, vendors and also academia-government

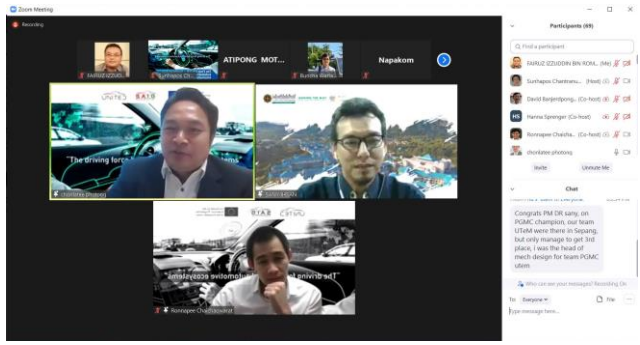
institutions, like Toyota Daihatsu Engineering and Manufacturing (TDEM), Inoue Rubber (IRC), Honda, Tri Petch Isuzu Sales, Denso, Continental, Bosch, Somboon Advance Technology (SAT), AVL, IRCT, CTMS, RMUTT, KMUTNB, TuKorea, TGGS, KMITL, NSTDA, Petroleum Authority of Thailand (PTT), TuKorea, TGGS, KMITL, RSU, Electricity Generating Authority of Thailand (EGAT), Thailand Industrial Standard (TIS) and Thai Automotive Industry Association (TAIA). In addition, several local automotive entities contacted CKU for potential collaborations with regards to the autonomous vehicle research after their online webinar event under the UNITED project. This highlights how the UNITED project help to strengthen inter-university and university-industry relation in Thailand, which in turn assists further advancement of their automotive industry.

Autonomous vehicle study in CKU is also supported by their EKTU

Impact at Regional/International Level

At regional or international level, contributions from the UNITED project can be linked to activities of SAIG network. At present, there are more than 550 registered members of the SAIG network from various countries throughout the world including India, Pakistan,

Australia, Indonesia, Malaysia, Thailand, Germany, Austria, Italy, Belgium, Philippines, Uzbekistan, Kuwait, Nigeria and Iraq. This indicates that most activities of the SAIG network are participated by automotive community throughout the world and therefore, the impact from the UNITED project is also spread not just to the SEA region but also worldwide. In hindsight, the COVID-19 pandemic forced many activities under the UNITED project to be conducted in online mode. While this was a challenge for the project partners, it also brought advantages in term of accessibility and wider outreach of the project's knowledge transfer activities beyond the local and regional automotive community. For instance, the EKTU trainings by UPM were constantly participated by few people from outside of Malaysia, some even from outside of SEA region, and this further increased the effect of knowledge transfer activities through use of the EKTU and better promoted the EKTU and UPM itself to a wider automotive community. Moreover, organized online webinars and conferences under SAIG network for UNITED project were joined by worldwide participants and this situation benefits in supporting the knowledge dissemination and making it more impactful while also encourages future collaborations and discussions between partner institutions and worldwide community in niche areas of automotive technology and development.



Online SAIG conference had worldwide participation

Meanwhile, another aspect of the impact from the execution of the UNITED project at regional and international level is the fostered collaborations or engagements between project partner institutions beyond the scope of the project. For instance, UTeM in Malaysia has entered into further academic and research cooperation with FH Aachen in Germany. Furthermore, MSU in Thailand has obtained another international project grant with FH JOANNEUM, Austria while UPM in Malaysia has initiated potential future collaboration with MSU in Thailand for possible academic and research activities. This situation aptly reflects on the big contribution of the UNITED project as the catalyst for regional or international relationships for the advancement of the automotive fields.

Memorandum of Understanding (MoU) signing between UTeM and FH Aachen for further academic and research collaborations

Sustainability of Project Outputs

After the conclusion of the UNITED project, it is important that the main project outputs continue to benefit the local and also regional automotive community. In view of this, several steps are taken by

the project partners to ensure that installed EKTUs at their facility can be sustained in long run and relevancy of the established SAIG network is maintained. These measures are essentially discussed in the following sections.

(a) Operation of the EKTUs

It is imperative that the EKTUs continue to be effectively operated in order for knowledge dissemination and upskilling process from its use to be carried out beyond the duration of UNITED project. To ensure that operation of their EKTUs is reasonably sustainable, the SEA partner institutions have taken some measures, which include the following:

- The use of the EKTUs can be embedded into the curriculum of offered academic programs at their institution. This will ensure continuous usage of the EKTUs in knowledge dissemination and capacity building activities, and also allocation of maintenance budget from their institution to maintain the equipment.

- The EKTUs can be offered for use in paid trainings or research applications to any interested external parties from automotive companies, and also academicians and researchers from other institutions. This will help to generate the funding necessary to maintain the equipment.

- Paid training sessions can be regularly conducted by the EKTU team to automotive workforce, academicians, researchers and students, either in online or physical mode, to generate the funding necessary to maintain the equipment.

- Collaborations with other UNITED partner institutions, government agencies, automotive companies and other academic or training institutions can be done to promote the

EKTUs and also their trainings to a wider coverage of interested parties. This can help to generate the funding to maintain the equipment from paid fees.

- The EKTUs can be positioned or registered under established research center at their institutions such that the maintenance cost has been included under the center's annual budget.

Regular paid trainings can be conducted by the EKTU team to fund its operation and maintenance costs

(b) Continuation and Relevancy of the SAIG Network

Meanwhile, some measures are taken by SAIG management board to ensure that the network maintains its relevancy and effectively play its role as the platform for regional or international automotive community to share and discuss new knowledge. These steps are discussed in details as follow:

- All SEA partner institutions in the UNITED project have pledged their commitment to ensure their continued involvement in the SAIG network. Thus far, under the UNITED project duration, the management of SAIG network was

primarily under the responsibility of UPM. At present, the chairmanship and management of the network has been passed on to MSU for next two years. This rotation of SAIG network chairmanship will continue for all SEA partner institutions, which will ensure the continuation of the SAIG network's activities for years to come.

- Several successful activities of the SAIG network have been made into its flagship activities that will be continued to be organized periodically. Among others, these include the online webinar series and also the international conference, which have been very effective in accomplishing the vision and mission of the network to the automotive community worldwide. These activities can also tackle topics on recent development and progress in automotive fields that will maintain the relevancy of the SAIG network.

- Apart from the committed UNITED project partners in activities of the SAIG network, the current registered members of the SAIG network are also from other entities throughout the world and they have different backgrounds and expertise in the automotive fields. In order to maintain the relevancy and also effectiveness of the network, these members will gradually be involved into the management board and organization committees of activities for the network. This will ensure a wider participation from them and maintain the relevancy of the network.

- In addition to the flagship activities, other more diverse activities have been planned to increase the participation and memberships from different types of stakeholders in the automotive community. Among others, these include

competitions for students or researchers and also forums to discuss current happenings in the automotive industry.

- The social media outlets for the SAIG network will also be maintained as the primary means of communication and knowledge transfer platform among the members. In addition, the Facebook page of the UNITED project will also be continued by the SAIG network to signify the continued contribution of the project beyond its conclusion.

UNITED Facebook page is taken over by SAIG management

Lessons Learned and Way Forward

In conclusion, the UNITED project has successfully accomplished all its objectives, particularly in increasing the level of competency and capability of the local automotive workforce in the SEA region through knowledge transfer and upskilling activities in the relevant areas for the SEA partner countries. This includes increasing the quality of graduates from SEA partner institutions such that they have better employability criteria and become the driving force of

future development in automotive industry both locally and in the SEA region. Meanwhile, there are indeed some lessons learned from the experiences during the execution of this UNITED project that can be referred to by all partner institutions in similar international projects in future. These include some aspects of the project that went well and also some that might need improvements.

The following is the listing of several key positive lessons that could be taken from this UNITED project:

- A good involvement and engagement of various stakeholders in the project activities has helped to make the project outputs more relevant to the automotive industry and contributed to the success of the project. Their participation in the project activities also became the catalyst in generating interests and fostering collaborations with the partner institutions.

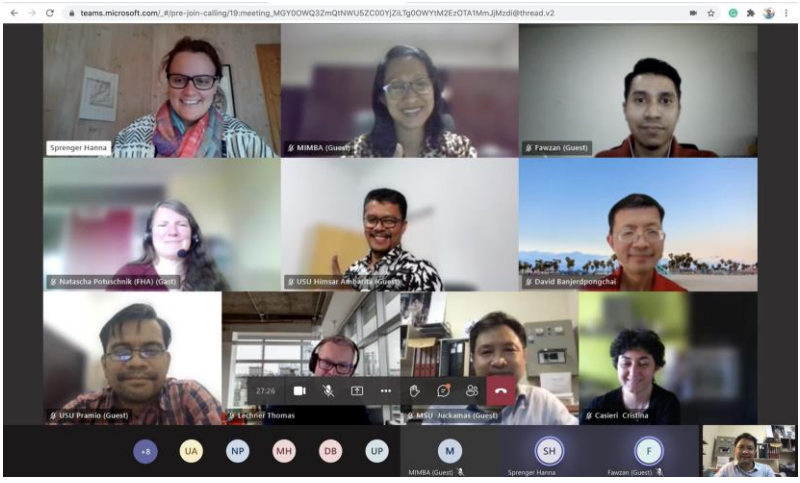
- The conducted trainings are very useful for the local automotive community, especially in transferring the new knowledge and upgrading their skills in relevant areas that cater to the needs of the local industry. Practical hands-on trainings are often preferred but the flexibility of online training sessions also has the advantage of enabling a wider audience.

- The installation of EKTUs at each SEA partner institutions definitely improves their available facility for teaching and training purposes, which also enhance the effectiveness of the knowledge dissemination process of the UNITED project. Several new academic programs and revised courses are being carried out by the SEA partner institutions to strengthen their offered programs with the inclusion of the EKTU application.

- Having the liaison partnership pairing between each SEA partner institution and one of the European partner institutions certainly helps in better planning for the installation and operation of their respective EKTU, particularly through the sharing of expertise and experiences.

- By establishing the SAIG network, it creates a very effective platform or avenue to bring the members of the regional or worldwide automotive community together. As a result, it promotes greater knowledge sharing and closer cooperation or collaboration between them in advancing the automotive fields.

- Great communication is key to ensure that all project partners are progressing at the right track and pace. To this effect, regular project management meetings and updates by the project coordinator have been an important part in ensuring the successful completion of this UNITED project.



Regular project management meeting is crucial to the successful completion of the UNITED project

On the other hand, few improvements to the project execution that can be considered are summarized as follow:

- More intensive participation of the local automotive stakeholders can be included at the start of the project to better capture their current market needs and interests, which helps to smooth out the project execution in subsequent stages and make it more effective.

- Better documentation of training materials and development of assisting media such as short video demonstration can be prepared and made available online to the participants in order to effectively improve the knowledge dissemination process of the conducted workshops or trainings.

- Different institutions have different procedures for project management and financial process. It is therefore probably good to include at least one representative of the institution management into the team to ensure easier and faster project execution.

- A wider coverage of participants for the project activities, either with the EKTUs or under the SAIG network, can be achieved through full applications of current social media platforms such as live streaming on YouTube and Facebook.

- The inclusion of peer review process of the project outputs from each partner institution was very good to ensure that the project was running in the expected pace and the quality of the outcomes was satisfactory. However, the execution of the process can be made more effective through better planning and communication.

Moving forward, the main outputs from this UNITED project can be further applied in several extended ventures. Future projects can be explored to further strengthen the usage of the EKTUs such as in development of specific course curriculum and training modules including Massive Open Online Course (MOOC), advanced research in related fields, and more dissemination programs to the local or regional automotive stakeholders. In addition, SAIG network can be utilized as a primary platform for future knowledge dissemination projects throughout the region, strengthening its role in providing effective avenue for knowledge sharing and fostering collaboration.

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