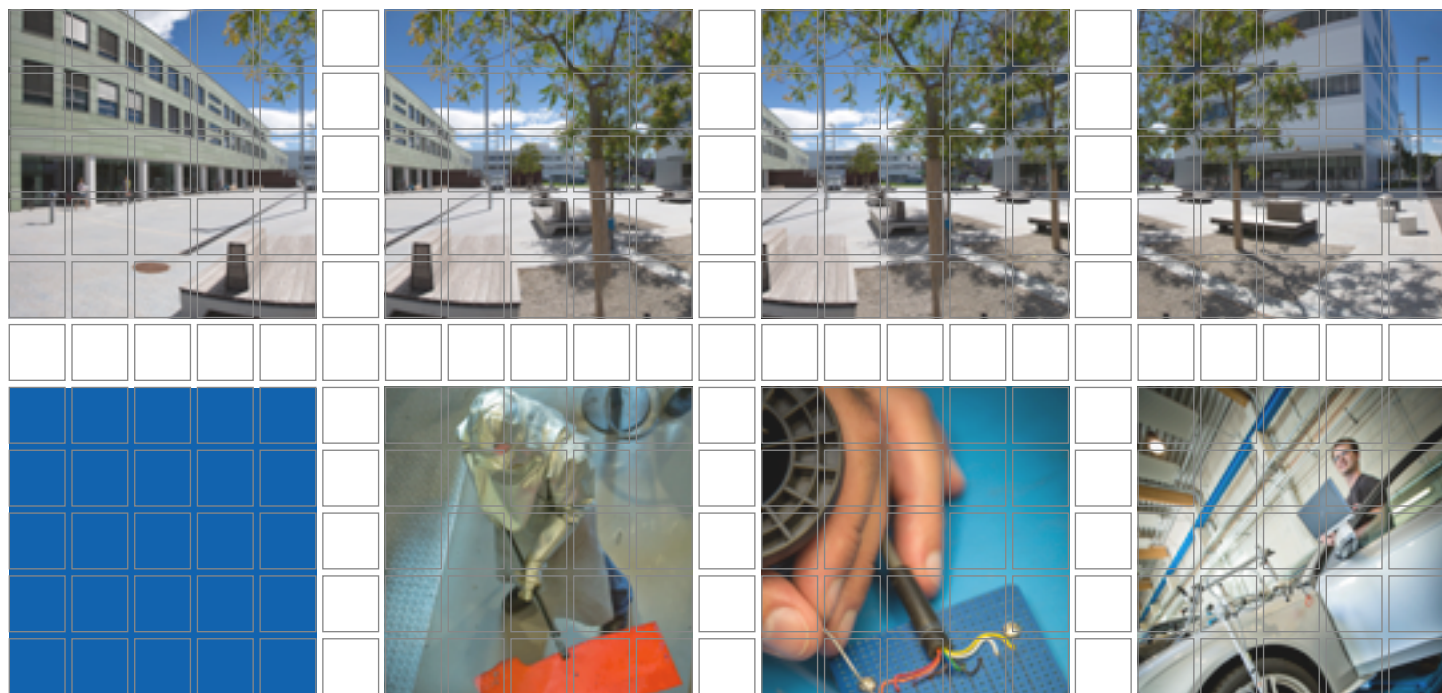


[FSI]



Annual Report 2016 Activity Report

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PREFACE



Andrea Hoffmann
Vice Rector Finance and Human Resources



Horst Bischof
Vice Rector Research

The FSI Activity Report of 2016 sums up and accentuates the important role of the FSI with its three Institutes within Mobility & Production – one of the 5 Fields of Expertise of Graz University of Technology.

The FSI has developed into a unique center of excellence for European vehicle technology, thus generating a “win-win-win-situation” where Magna, TU Graz and students benefit from the established close cooperation:

- Magna is able to lead research activities with high-qualified scientific partners from TU Graz and to have direct contact to qualified students.
- The Institutes at TU Graz conduct their research activities with Magna as a strong industrial partner for projects in their research field.
- The students at TU Graz benefit from direct contacts to the Magna Group worldwide and to other important car manufacturers or suppliers, primarily for internships as part of their studies but also for their future job position.

In 2016 TU Graz decided to integrate the Institute of Tools & Forming and the Institute of Production Science Management as departments of existing

institutes of the Faculty of Mechanical Engineering and Economic Sciences in order to get a leaner organizational structure.

In the course of this consolidation the institutes were renamed:

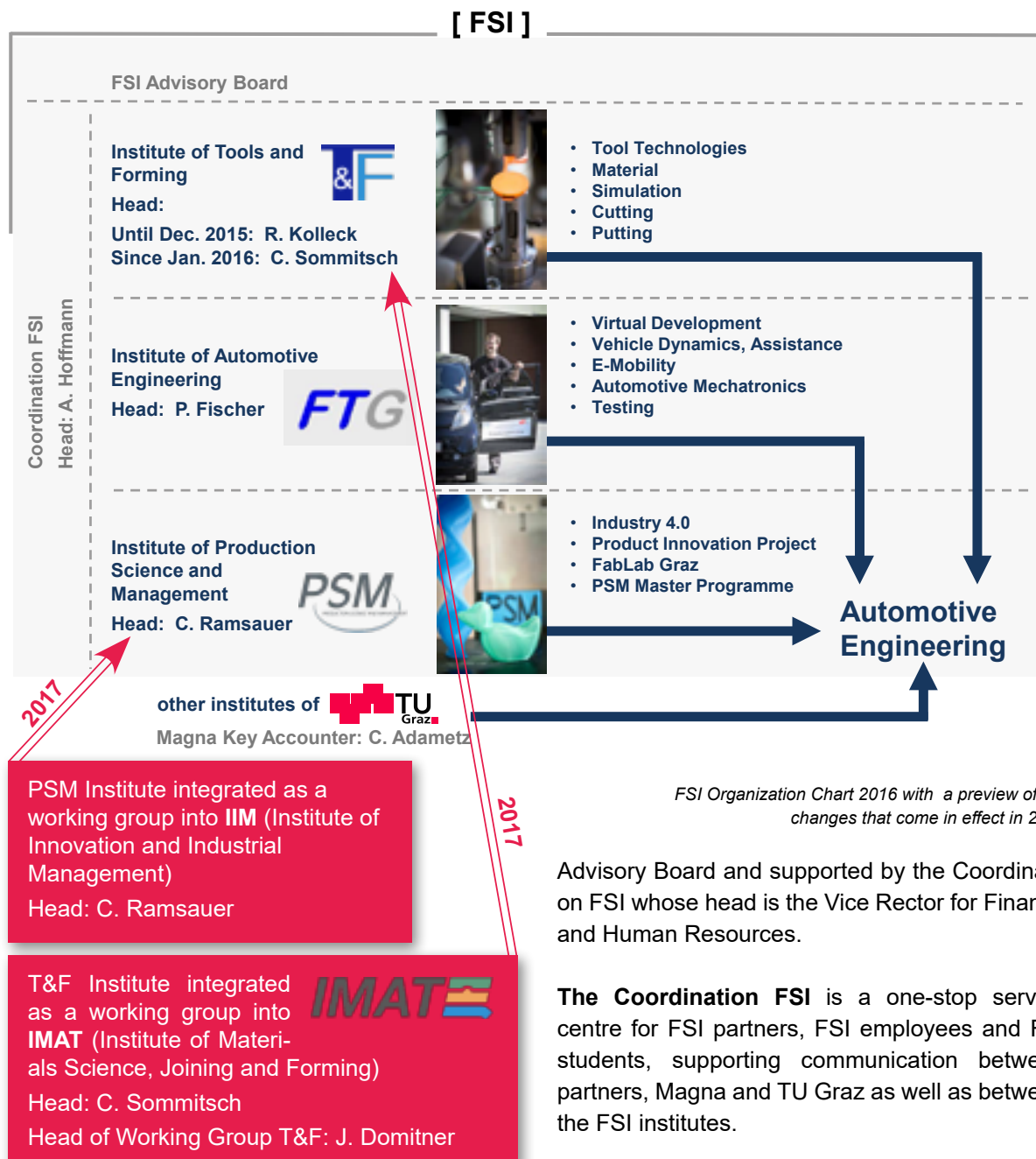
The Institute Tools and Forming which had to stand the unexpected death and loss of Prof. Ralph Kolleck is now a working group at the **Institute of Materials Science, Joining and Forming** (formerly Institute of Materials Science and Welding).

The Institute of Production Science Management is now a department of the **Institute of Innovation and Industrial Management**.

These changes are effective as of 1st January, 2017.

In the following, the report shows a summary of activities and events at FSI in 2016. Since the beginning of the cooperation **teaching activities and research projects** have been the main pillars of the cooperation and remain the core business at FSI. The extension of the FSI building is planned for 2017 in order to improve the positive development and achievements of FSI.

FSI ORGANIZATION



FSI Organization Chart 2016 with a preview of the changes that come in effect in 2017

Advisory Board and supported by the Coordination FSI whose head is the Vice Rector for Finance and Human Resources.

The Coordination FSI is a one-stop service centre for FSI partners, FSI employees and FSI students, supporting communication between partners, Magna and TU Graz as well as between the FSI institutes.

The FSI is an independent academic institution integrated into the Faculty of Mechanical Engineering and Economic Sciences at TU Graz. Its three institutes – FTG, T&F, and PSM – pursue their own special research and teaching interests. They are guided by the FSI

The Coordination FSI prepares the Advisory Board meetings, supervises the FSI Scholarships, organizes guest lectures and visits at FSI. The main tasks of the Coordination FSI are: reporting, budgeting, budgetary control of the FSI budget and the ongoing administration of the FSI website www.fsi.tugraz.at

FSI ORGANIZATION

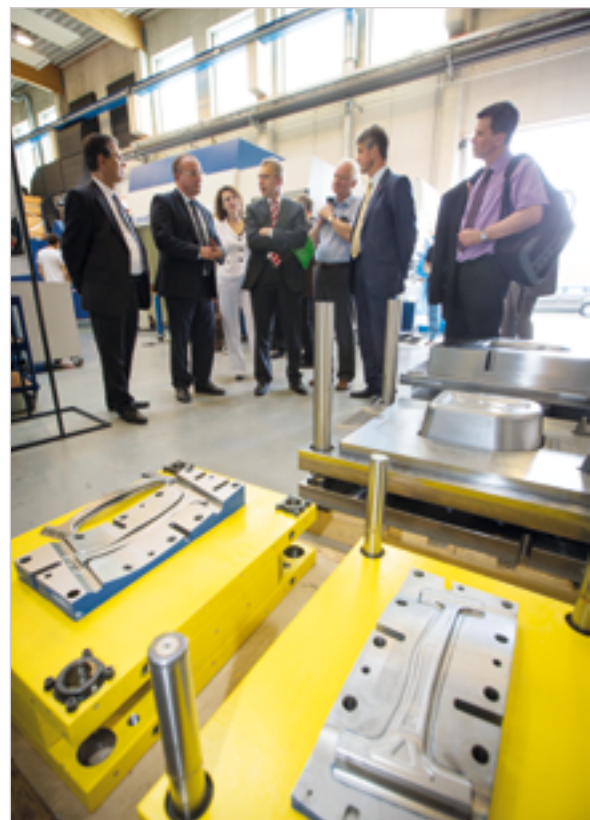


FSI Advisory Board Members

The FSI Advisory Board is composed of respectively three representatives of Magna and TU Graz.

In 2016 three regular meetings took place at the FSI in January, July and November. In these meetings the Advisory Board performed their main duties and responsibilities including:

- the definition and monitoring of common research areas
- reporting and evaluation of scientific results
- budgeting and budgetary control of the FSI budget
- defining the selection criteria as well as selecting the students for the hearing and awarding of the FSI Scholarships for qualified students



SUCCESSFUL REORGANIZATION: IIM

PSM Institute integrated as working group in the IIM Institute

Since January 2017 the Institute of Production Science and Management (PSM) is part of the Institute of Innovation and Industrial Management (IIM) and is headed by Prof. Dr. Christian Ramsauer. Now it is possible to take even more advantage of the synergies between these two institutes. The four initiatives and six research areas of the new institute are presented in the next paragraphs.

The initiative of the Institute of Innovation and Industrial Management (IIM) are:

- **FabLab Graz** – The makerspace at the FSI building will be expanded and will provide space for students, teaching, research, start-ups, SMEs, and also large enterprises. The objective is to increase creativity and innovation capabilities of all stakeholders. (<http://fablab.tugraz.at>)



- **Product Innovation Project** – International and interdisciplinary student teams work within one academic year on new product concepts, business plans, and working prototypes. The task and the budget are provided directly from industry partners. Eight projects started in October 2016 and the results will be presented on 29th of May 2017 at 5 p.m. at Old Campus of TU Graz. The industrial partners of this academic year are Magna Powertrain, Remus Sebring, Porsche Holding, Energie Graz, Andritz, LogicData, Ventrex, and Palfinger. (<http://www.product-innovation.at>)
- **IIM LeanLab** – The learning factory at the New Campus of TU Graz is used for teaching, research, and executive education in the areas of lean production, industry 4.0, and industrial engineering. The objective is to gain practical experience by applying different tools and methods and by working in an assembly line of the learning factory. (<http://industrie40.tugraz.at>)
- **Harvard Case Study Teaching** – A room, which is a duplicate of the lecture rooms at Harvard Business School, located at TU Graz is used to teach the Case Study Teaching method of Harvard Business School. Real case studies of companies are used to discuss real-life examples. This participant-centered method is used for teaching and executive education. (<http://iim.tugraz.at>)

SUCCESSFUL REORGANIZATION: IIM



The IIM LeanLab – A learning factory for teaching, research and executive education

Additionally, the Institute of Innovation and Industrial Management is active in six main research areas:

- **Maker Movement** – The main idea is to provide production technologies in an easy and fast way. Therefore, it is possible to realize ideas in working prototypes. This research area is connected to FabLab Graz.
- **Product Design** – How can innovation processes be managed and how to increase creativity? Different concepts are tested in the Product Innovation Project.
- **Agile Production** – How do companies deal with an increased volatility and uncertainty in operations? A proactive preparation, a monitor system and a governance system are necessary to react faster on demand and product mix changes.
- **Ramp-Up Management** – How to decrease time, effort and costs in the phase between developed prototypes and a serial production.
- **Industry 4.0** – Information and communication technologies are changing the way how operations in industrial companies are done in future. The IIM LeanLab is used to test new technologies and to do research in this field.
- **Lean Production** – Lean Production is still an important topic in production. Avoiding waste and increasing efficiency are two main aspects.

Further information and contact details can be found online. (<http://iim.tugraz.at>)

FSI ACTIVITIES AND EVENTS 2016

FSI RECRUITING DAY

After the successful Recruiting Event 2015 the FSI Coordination organized the Recruiting Day 2016 on 20 January. More than 150 students joined the invitation to this all-day recruiting and networking event. Representatives of the partner companies such as AVL, Mahle, Miba and Magna – represented by Magna Powertrain, Magna Steyr, Magna Steyr Fahrzeugtechnik and Cosma – came into contact with the highly interested students. The IAESTE, an international student organization, provided information about internships and practical trainings abroad.

The program of the Recruiting Day included company presentations and in the course of a panel discussion in the lecture room the representatives of the Human Resources Departments and Technical Departments of the companies gave practical tips for career paths. Besides the recruiting possibilities a CV check – in collaboration with Ms. Sigrid Maxl-Strudler of the Career Center of the University of Graz (<https://careercenter.uni-graz.at/>) – and a photoshooting for application photos were offered to the students.

During this networking event also many internships – in particular for PSM Internship applicants – and summer jobs were offered and could be arranged.

Because of the good response and positive feedback about this event from all participants, the Recruiting Day is planned again for 2017.



Top: Panel discussion on „Career Paths - Practical Tipps“

Middle: Students at the Magna exhibition stand

Bottom: Photoshooting

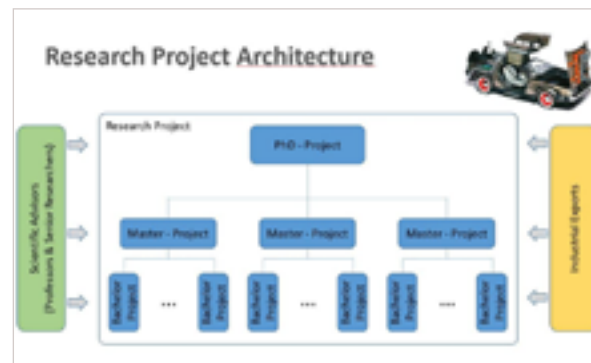


FSI ACTIVITIES AND EVENTS 2016

INTED – MAY 2016

Mario Hirz – Assoc. Professor at FTG – attended the INTED 2016 (International Technology, Education and Development Conference) in Valencia.

More than 650 delegates from 70 different countries came together and shared experiences in the fields of Education, Technology and Development. Mario Hirz gave a talk about the FSI – an example for successful University-Industry collaboration.



Reference: Hirz, M., Pointner, A., & Deketele, A. (2016). The FSI – an Example for Successful University – Industry Collaboration. In *INTED Conference 2016*.

FSI VISITORS in 2016



In December 2016 the HTL Zeltweg visited the FSI

Visits of Secondary Schools

Going to university is a big decision – school visits at the FSI help exploring the options and gives a short but practical insight into studying at FSI.

FSI offers special guided tours for pupils of secondary schools through the institutes with their interesting labors and workshops. Hereby tools,

products and research topics are explained to the pupils and teachers. These presentations give pupils an important stimulus to opt for a FSI related study at the TU Graz, where young scientists are very welcomed and promoted. The cooperation with Magna provides students at TU Graz direct contact to the Magna Group worldwide and to other important car manufacturers or suppliers, not only for internships as part of their studies but also for future job positions.

TEACHING AT FSI

MECHATRONICS ACADEMY

Mechatronics systems have increasingly share in automotive applications, e.g. in infotainment and driver assistance functions, comfort and safety, and of course in propulsion technology.

The development and production of mechatronics systems requires deep knowledge and understanding of the wide ranging integration of mechanical, electrics/electronics and software domains. A key factor for success plays the knowledge of staff involved into the entire product development and production chain. In a close co-operation with MA-GNA Powertrain, FTG developed and conducted a training programme for more than 150 employees at international locations. The courses include an introduction of structures and functions of automotive mechatronics systems and focus on the integration of the domains mechanics, electrics and electronics including software. In addition development processes are introduced and discussed in terms of their application and optimization for MA-GNA products. A specific focus is put on electric motors for auxiliary devices in internal combustion engines, and their integration into formerly mechanical systems. The course gives also insights into simulation methods and software development, as well as different automotive standards and product verification and quality procedures.



TOOLS AND FORMING

The teaching focus is on providing a basic knowledge of forming technology and non-cutting manufacturing. A variety of technical services and consulting are also offered to industry.

Research focuses include tool technology, materials, simulation, cutting and joining. Among other things, the (former) Institute of Tools and Forming developed and built the prototype of an induction furnace for the automobile industry. The induction furnace was meant to speed up the production of component parts with ultra-high strength properties and considerably reduce energy expenditure.



TEACHING AT FSI

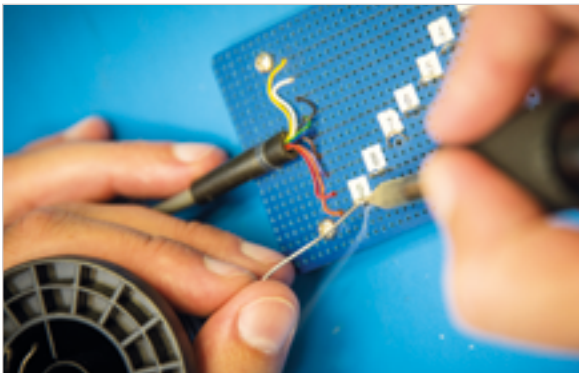
PRODUCTION SCIENCE AND MANAGEMENT

Since many years, the topic of production has gained a higher importance in Europe and North America. Industrial companies have to compete with low-cost countries around the globe. To keep production and therefore jobs in Europe and North America, companies have to increase efficiency and have to deal with new production technologies on a regular basis.

The master's program Production Science and Management is reacting to this trend. It deals with the topics of production management, production technology, and social economics. Additionally, experts from industry are employed as lecturers to discuss real life challenges and new trends in production.

The master's program Production Science and Management has been offered since 2007 at TU Graz. All courses are held in English language to prepare students for international careers. In the winter semester 2016/17, 131 students were registered for the program and the number of students is raising every year.

The master's program is supported by the Working Group (former Institute) of Production Science and Management, which is now part of the Institute of Innovation and Industrial Management, led by Prof. Dr. Christian Ramsauer. The idea for the master's program Production Science and Management is to prepare students for the challenges of industrial companies.



Master's program Production Science and Management

Duration of study: 4 semesters

ECTS credit points: 120

Academic degree: „Diplom-Ingenieurin“ or „Diplom-Ingenieur (Dipl.Ing. oder DI)“, equivalent to the Master of Science (MSc)

Content

- Deepen fundamental knowledge in production science and the economic sciences
- Understand current theories, principles and methods of production science and apply these in practice
- Combine technical knowledge with economic capabilities and social as well as international competence skills
- Gain knowledge about building up industrial production: product development, planning, procurement, production, sales and marketing
- Conduct independent research and application-oriented projects
- Prepare and present results of work effectively and using modern tools
- Write scientific reports
- Develop and hone social skills such as teamwork, team leadership and negotiation strategies
- Improve English terminology and gain international experience through subsidized stays abroad

Specialization Subjects

- Advanced Technologies or
- Management and Social Economics.

For more information please visit:

fsi.tugraz.at/studying

FABLAB GRAZ



FabLab Graz will transform to a product development hub for students, startups and industrial partners

The team around FabLab Graz at the Institute of Innovation and Industrial Management (IIM) received a research grant in 2016, which makes a new positioning of the current initiative possible. The new FabLab Graz will not only offer state of the art digital production equipment for prototyping and small batch size production, but also infrastructure for co-working, product testing and demonstration. The new mandate is to assist all users – students, startups and industrial partners - with support and solutions along the product development process from idea generation to market launch.

FabLab Graz was launched as the first Austrian university based FabLab in 2014. Neil Gershenfeld from the Massachusetts Institute of Technology (MIT) set up the first FabLab (Fabrication Laboratory) worldwide in 2002. The basic idea of this global network is to offer possibilities for every individual to invent and build hardware products themselves by having easy access to capabilities for designing, manufacturing, distributing and knowledge. At the current FabLab Graz you can find machines like a laser cutter, CNC milling machine and various 3D printers. Moreover, tools for traditional manufacturing activities such as metalworking, woodworking and electronics pro-

tototyping are provided. FabLab Graz is planned to be expanded in 2018 to 800m².

Prof. Christian Ramsauer, Head of the Institute of Innovation and Industrial Management, has a strong focus on teaching practical skills and applying them creatively. Therefore, he heavily encourages students to invent and prototype - not only in the offered course "Product Innovation Project". Open to inventors, entrepreneurs and creatives, FabLab Graz is a place for learning, prototyping and idea exchange to foster product innovation.

For more information visit fablab.tugraz.at

RESEARCH HIGHLIGHTS 2016

INSTITUTE OF AUTOMOTIVE ENGINEERING, DEPARTMENT FOR AUTOMOTIVE MECHATRONICS



Research project: Automated robot-based charging system for electric vehicles

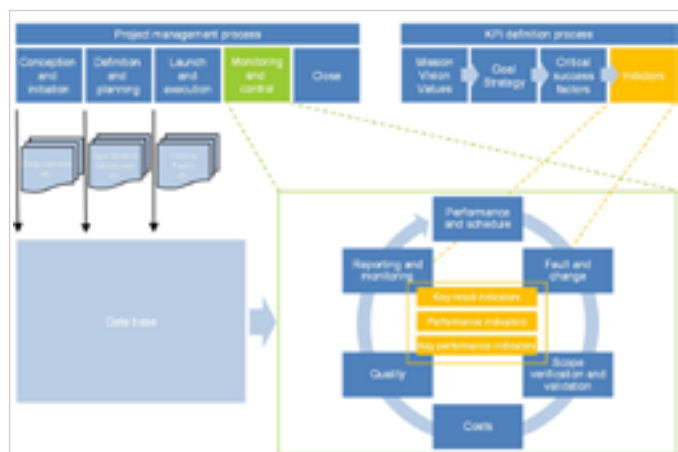
With the rising number of electric and hybrid vehicles the demand for customer-friendly and innovative solutions for the charging infrastructure is growing steadily.

Furthermore, future autonomous driving and parking vehicles are calling for new approaches regarding to battery charging. Nowadays electric vehicles have to be charged by hand. In other words, someone has to connect the charging cable with the charging socket of the vehicle. The research project “Automated robot-based charging system for electric vehicles” is a part of a FFG-funded joint project with the project partners Magna Steyr, BMW, KEBA, and FTG. Project target is the evaluation of technologies for automated charging systems for electric vehicles. In addition, the project includes the concept development of an automated charging station and its realization as technology demonstrator.

Research project: Development and manufacturing process optimization of mechatronics products by key performance indicators

The increasing complexity of mechatronics systems challenges both product- and production development. In this context, new methods have to be developed to support failure detection and -reduction by improving quality management and development processes.

Innovative analysis methods show the capability to control process and reliability during the whole product life cycle by using key process/performance indicators (KPIs). As result of comprehensive analysis and evaluation, these metrics have to be introduced as soon as possible during product layout, development and manufacturing engineering. The research project aims at finding new approaches for process analysis and evaluation to support quality assessment and risk analysis during different stages of the life cycle of automotive mechatronics systems. In co-operation with Magna Powertrain, new methods for tracking development processes and procedures for continuously quality control and improvement are introduced.



RESEARCH HIGHLIGHTS 2016

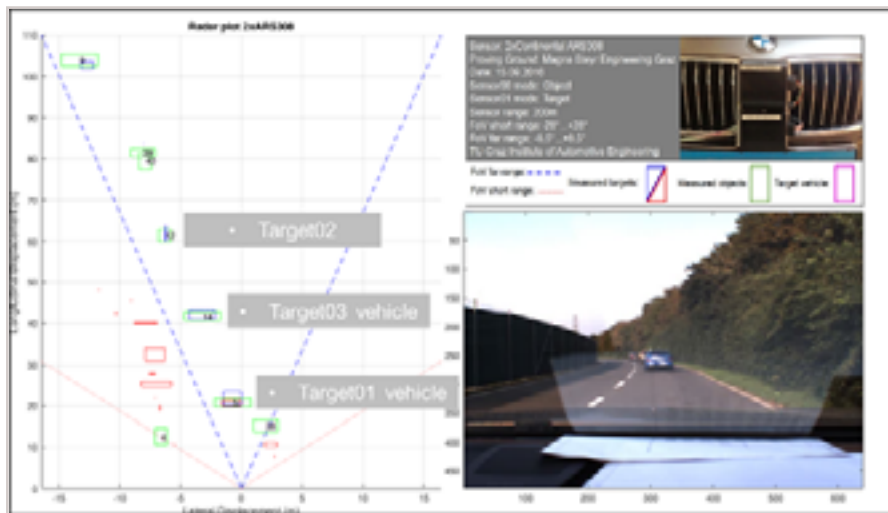


Fig. 1: Visualization of recorded object lists of automotive near and long range radar sensors

Automotive Engineering

In May 2016, the Institute of Automotive Engineering joined the large scale European project Enable-S3. The consortium has 71 Partners from 16 countries of European Union, leader of the consortium is AVL.

The objective of ENABLE-S3 is to establish cost-efficient cross-domain virtual and semi-virtual V&V platforms and methods for Advanced Cyber Physical systems in the domains Aerospace, Automotive, Farming, Health, Maritime and Rail.

The Institute of Automotive Engineering as well as Magna Steyr Engineering is engaged in the Automotive domain, working on V&V methods for **automated driving**. The contributions of FTG are

1. **Virtual sensor models** (RADAR, LIDAR, camera) for virtual validation of automated driving as well as their implementation in Hardware-in-the-loop test benches,
2. Demonstration of the use case “**Traffic Jam Assist** with car-to-car communication based vehicle platooning”

Figure 1 shows the main contribution of FTG to the first activity. Many different on-road tests in urban, rural and highway scenarios with test vehicles equipped with high-precision reference measurement systems to record vehicle trajectories as well

as with different sensors with open data interfaces to measure the output of these are performed. The measured data will serve as a basis to validate virtual sensor models in the project.

Figure 2 shows the application of the Traffic Jam Assist in the AD SG (Automated Driving Simulator Graz) of the institute. The goal is to develop V&V platforms that enable to test the traffic jam platooning in different scenarios as well as fail safe operation of the system in case of faulty car-to-car communication. In the driving simulator especially the human driver acceptance when using this automated driving function and developing objective methods for subjective human evaluation is examined.



Fig. 2: Experiment of a volunteer driver in a dense traffic on a highway. The driving simulator is an open platform to integrated automated driving and test the human-machine interaction in a reproducible way.

SELECTED PROJECTS 2016

INSTITUTE OF TOOLS & FORMING

Investigations on self-piercing riveting of aluminum blanks in the automotive sector

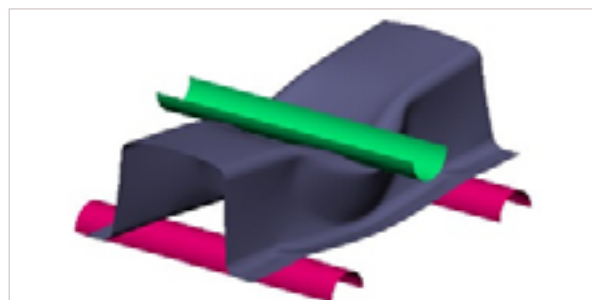


In order to reduce the weight of modern vehicles, new materials and processes are being developed in very short time periods. The trend in vehicle engineering is to use aluminum alloys due to their good mechanical properties and significant weight advantages. However, the joining of aluminum parts causes some difficulties, because the application of thermal joining technologies such as spot-welding is often restricted. The advantages of the self-piercing riveting process are its high automation potential, the good mechanical properties of the joints and there is no heat introduced into the parts to be joined. In this project carried out with Magna Steyr the DoE method was used to investigate the mechanical properties and the process parameters influencing the joints. Tools for the manufacturing of the KS2 specimens were designed, built and tested and a force-displacement measuring system to monitor the setting process was developed. The results out of the cross-tension and shear-tension tests were analysed statistically and the influences of the different parameters were determined. With the results of these tests the simulation model is validated which is used to improve the process stability of industrial self-piercing riveting processes.

Springback compensation in deep drawing of advanced high strength steels

Steel manufacturers are striving for the implementation of advanced high strength steels (AHSS) in the automotive industry in order to reduce the mass and to improve the structural performance of the vehicles.

However, defining optimal and cost effective processes as well as solutions for introducing complex steel products in cold forming are quite challenging, because the application of AHSS often causes formability problems such as springback. The stress relaxation through the targeted heating of materials in the radius area after the deep drawing process is a promising approach for minimizing springback. Thus, a hybrid concept of deep drawing dies combined with local induction heat treatment is introduced in this work. The influence of different heating temperatures on the springback of formed U-shaped parts is investigated. The results of the first numerical investigations show that local heating can decrease the springback without reducing the strength significantly. Sheet metal forming experiments will be conducted on AHSS including twinning induced plasticity (TWIP) and dual phase (DP) steels. Finally, the mechanical properties of the parts formed with and without local heat treatment will be compared using numerical simulations and three-point bending experiments.



FSI SCHOLARSHIPS



Top: Harald Kainz, Dave Pascoe, Andrea Hoffmann, Andreas Ramsauer, Martin Leitner, Hans Peter Schnöll, Santiago Rinon Arrese, Florian Hönsch, Christoph Krammer, Shadi d'Amelj (April)

Bottom: Markus Salchner, Andrea Hoffmann, Christian Rabitsch, Jens Gächter, Horst Bischof, Marina Kofler, Franz Heitmeir, Shadi d'Amelj, Gerhard Krachler (July)

Magna and TU Graz have the intention of supporting excellent performances of diploma and doctoral students at FSI within the framework of the cooperation. Therefore, a FSI-grant has been set up which is regularly granted to especially qualified students of the TU Graz.

Talented students who write their final papers at the FSI (diploma, master's or doctoral thesis) are eligible for the merit-based scholarship awarded by Magna.

Requirements and application modalities for students can be found under:

www.tugraz.at/kooperationen/fsi/about-fsi/scholarships/



FSI SCHOLARSHIPS



Harald Kainz, Franz Heitmeir, Michael Machhammer, Andrea Hoffmann, Philipp Berner, René Nagl, Shadi d'Amelj, Gerhard Krachler, Dave Pascoe, Horst Bischof (November)

Scholarships were granted for:

Schnöll, Hans Peter, IBL, PhD: *Integrated Product Development. A process model for the context-sensitive design of the product development process of components made of fiber-reinforced plastics*

Leitner, Martin, FTG, Master: *48 Volt Mild-Hybridization and its Impacts on CO2 Emissions*

Rinon Arrese, Santiago, T&F, Master: *State-of-the-Art Springback prediction during Cold Forming of AHSS parts in the Automotive Industry*

Hönsch, Florian, T&F, Master: *Implementation of a Design of Experiments method in the field of half-hollow riveting of aluminium parts in automotive engineering*

Ramsauer, Andreas, FTG, Master: *Drivability Optimisation of Hybrid Electric Vehicles*

Ernst, Markus, FTG, PhD: *Integrated Development Process for Automotive Mechatronic Systems*

Rabitsch, Christian, PSM, PhD: *Management approach for implementing agility in the manufacturing industry*

Salchner, Markus, FTG, PhD: *Knowledge-based Design Methods in Multi-CAD Environment*

Kofler, Marina, T&F, PhD: *Evaluation of New Materials for Forming Applications*

Gächter, Jens, FTG, PhD: *Evaluation of rotor position sensor characteristics and impact on control quality of permanent synchronous machines (PMSM)*

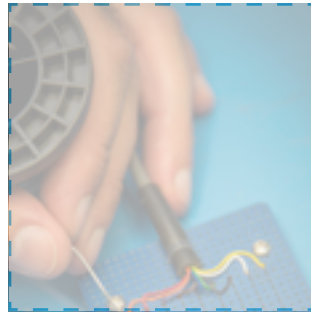
Machhammer, Michael, T&F, PhD: *Study into the usage of partial tempered aluminum alloys in the sheet metal forming process for automotive applications.*

Berner, Philipp, IBL, Master: *Technology Screening – Development of a Structured Approach for the Early Identification of Arising Technologies and Startups*



FSI COOPERATIONS with third-party companies





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