

Fostering Opportunities Towards Slovak Excellence in Advanced Control for Smart Industries

D2.1. Report on research audit and research-intensification activities

Date by 30.09.2023 v.1



Project: 101079342 — FrontSeat — HORIZON-WIDERA-2021-ACCESS-03



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DELIVERABLE INFORMATION

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Abstract	The project aims at increasing the research and academic prospects of the Slovak University of Technology in Bratislava, Slovakia (STUBA) and at initiating the evolution of STUBA into a modern, reputed excellent institution that performs high-quality research in advanced automatic control, educates top-quality scholars and industrial practitioners, and is successful in active dissemination and exploitation of its research and innovation efforts. For this purpose, STUBA teams up with two renowned research groups in automatic control from Ruhr University Bochum, Germany (RUB) and Pisa University, Italy (UNIPI). The specific goals of the action are to reinforce the collaboration with the two research groups from Western Europe, to intensify research in advanced automatic control, to open up new collaboration channels through academic and industrial networking, to train excellent young/senior researchers and project managers, and to effectively disseminate and exploit the research results of STUBA. The unique features of the project are: - Adoption/amendment of internal research project-related rules and procedures and develop project managers and research (junior and software tools, - Establishment of a series of guest scientific and academic lectures, - Exchanges and training of project managers and research (junior and senior) personnel, - Organization of conferences and invited sessions, seminars with industry, and annual summer schools, - Preparation and implementation of a new PhD curriculum at STUBA, - Establishment of an academic-industrial research and innovation cluster.
Keywords	Control theory and optimization; Sensor networks, embedded systems, hardware platforms; Embedded systems; Monitoring and control systems;





Embedded systems in automation and control.

Document Revision History

Version	Date	Description of change	List of contributors
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The consortium of FrontSeat consists of 3 partners, as presented here below.



STUBA

Slovak University of Technology in Bratislava



RUB

Ruhr University Bochum



UNIVERSITÀ DI PISA

UNIPI

University of Pisa





EXECUTIVE SUMMARY

This document constitutes Deliverable 2.1 "Research Audit" of the FrontSeat Project, funded by the European Union's Horizon Europe research and innovation programme under the action number 101079342. It is the purpose of the Research Audit to assess the current state of all major processes and measures in action at STUBA towards research capabilities and their output. The audit proceeded by reviewing the state of the facilities at STUBA, the current research topics and the workflows within and across research groups at STUBA and to both industrial and academic research partners outside of STUBA. In light of the diverse research topics covered at STUBA today, the audit is focused on the core topic covered by the FrontSeat projects, specifically automatic control applications relevant to smart industry needs. The Faculty of Chemical and Food Technology was chosen as the starting point and representative for all topics. The audit was guided by questions proposed by the participating research groups at UNIPI and RUB, where STUBA had the opportunity to suggest additional questions. The audit took place from the 21st to the 24th of August 2023.





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Abbreviation	Expanded Version
WoS	Web of Science





How do the new research trends penetrate the research at STUBA?

New research trends reach STUBA in two ways. One of them is hiring new researchers who, through their own expertise, incorporate new research directions. The other one being cooperations with other research groups who are focusing on different core topics or are approaching problems differently.

To increase the penetration of new research trends of research and STUBA, UNIPI and RUB propose several measures with the aim of ensuring long-term relevance and competitiveness. The research groups of STUBA are encouraged to be more sensitive and active in leveraging their strengths and identifying new research trends when attending conferences, and subsequently process them in the form of scientific papers or journal articles. It is deeded to be valuable to attend conferences that go beyond the topic of automation control in order to not only establish a link to other subject areas but also to be able to derive research trends of other research areas and transfer these to STUBA. Another way for deriving and become involved with new research trends is the attendance of international and renowned seminars. This gives an additional opportunity to catch excellent presentations while discussing and exchanging ideas with other researchers. Attending these international seminars became a lot easier due to the pandemic since many seminars switched to online presentations using the common web conference platforms. The third measure to monitor new research trends is through the continuous review of new grant calls, which often propose new long-term research questions or research directions.

How many operational laboratories for experiments exist?

At the examined faculty of chemical and food technology there are currently 5 operational laboratories with 14 experiments covering topics in chemical engineering, mechanical engineering, and thermal engineering. The number of laboratories and experiments is adequate in light of the number of researchers. All laboratories are in good condition; about one half of them are continuously renewed in order to create even better research opportunities. All of the laboratories are currently being used in research or teaching.

The number of operational laboratories is not a limiting factor in terms of the actuality of research and the research output generated at STUBA.

How many experiments that generate research-relevant data are currently being conducted?

At present five experiments are being conducted at the Faculty of Chemical and food Technology at STUBA. Specifically, a heat exchanger, a three-tank system, a distillation column, a rotary pendulum, and a membrane-based separation unit.

a. How many additional labs are currently planned?

Several new labs are currently being set up. The two most important are a green house and a photovoltaic test rig. The faculty is currently building multiple frames for green houses of different sizes, to do research on optimal control of plant growth. Simultaneously, the faculty is also building a test rig for researching on control of photovoltaic systems and their power output. For setting up such new experiments access to several high-quality 3D-printers was crucial in endeavours like these in the last 5 years. Both the quality of the experiment and the time-to-setup of new experiments were improved tremendously.

The access to labs and the ability to constantly renew labs is not a limiting factor for generating research-relevant data. STUBA should maintain the planning of new experiments in order to be able to generate research-relevant data in the long term.





b. How many publications are based on lab data generated at STUBA?

The audit revealed that the connection of publications to labs is not tracked currently. The audit also showed that STUBA already operates a very sophisticated publication database, but the database focuses on quality control of the publications and recording citations. UNIPI and RUB is recommended to also include information on the relation of publications to experimental data generated in the STUBA labs.

c. Does more experimental data lead to more publications?

Especially in the research field of machine learning, large sets of data are mandatory for generating publications. STUBA also reports high-quality experimental data is key to publications in high-ranking journals.

UNIPI and RUB encourage STUBA to consider a higher level of data acquisition automation. This would increase the data as such and is likely to increase the data quality. The labs themselves are not a limiting factor in the opinion of UNIPI and RUB, but they are in excellent condition and already use electronic data acquisition to a large extent.

On average, how many publications are generated per project?

STUBA participates in multiple projects, which are funded by various institutions. The most important projects are the EU-projects, the VEGA-projects, and the APVV-projects. In their largest project STUBA generated 25 publications per project year with 25 researchers being involved. This leads to one publication per project year per researcher which is an excellent result. From a broader perspective, the examined research group only generated 29 high ranking papers and articles in the last 5 years, which were published in Quartile 1 (Q1) or Quartile 2 (Q2) journals according to WoS, which is also an excellent result. The access to and ability to acquire third-party funding is not a limiting factor.

How good are the journals in which the articles are published?

STUBA's research groups review their publications and research results annually. This assessment is part of a university intern benchmarking process on which the distribution of university funds is based. Currently, 65 % of the money is distributed based on the number of publications, 25 % is distributed as internal matching funds for grants, and 10 % are distributed based on citations.

Keeping track of the number and quality of publications is also necessary to keep the teaching accreditation, which is required in Slovakia to teach courses in the related subject at universities.

The measures in place at STUBA encourage high-quality publications. In order to get the accreditation, one researcher has to generate a large set of publications, which fulfil another set of constraints. The research groups therefore publish in mostly good journals across all researchers with only a minor part being published in average journals. To get a better sense of international comparison, the performance of other non-Slovak universities is also included in the annual report. This is intended to help STUBA to be internationally competitive and to identify further potential for optimization.





	PSE	OIRP	PSE:OIRP	
	11 people	11 people	1	
2015	8 x Q1, 15	7 x Q1, 10	Q1: 1, 1.5	
2016	5 x Q1, 9	4 x Q1, 5	Q1: 1, 2	
2017	4 x Q1, 7	7 x Q1, 8	Q1: 0.5, 1	
2018	6 x Q1, 12	5 x Q1, 4	Q1: 1, 4	
2019	6 x Q1, 15	7 x Q1, 10	Q1: 1, 1.5	
2020	4 x Q1, 11	5 x Q1, 6	Q1: 1, 2	
2021	4 x Q1, 15	2 x Q1, 6	Q1: 2, 2	
total	37 x Q1, 84	37 x Q1, 49	Q1: 1, 1.5	

Comparison with NTNU / ChemEng / PSE

Figure 1: Comparison of the ratio between the number of publications and scientists between the department of Information Engineering and Process Control (ORIP) at STUBA and the department of Process Systems Engineering (PSE) at faculty of Chemical Engineering at NTNU (Norway)

UNIPI and RUB consider the annual assessment appropriate and up-to-date and suggest exploring only minor modifications. The number of publications has currently the highest impact, which may encourage to optimize output towards a larger number of publications while being tempted to accept compromises with respect to quality. A larger weight on citations, and a larger weight on journal quality by quartile (as reported by Scopus and Web of Science) could mitigate this problem. Moreover, Web of Science recently introduced an automated assignment of citations to categories that distinguish, for example, whether a publication is cited as general background information, or because it provides an essential result. In addition to evaluating the quality of STUBA's publications based on journal quartiles and number of citations, the importance of citations can be assessed with these services in the future.

In the sequel, some results of the last STUBA assessment of publication quality pertinent to this report are listed.

a. How do the journals rank officially?

STUBA publishes most of their articles in journals which rank in the second-best quartile (Q2) according to WoS or Scopus. More than 25 % of the articles are published in journals which rank in the best Quartile (Q1) according to WoS or Scopus. In UNIPI and RUB's opinion, this is a very good result.





OIRP CC publications 2015-2021 with "best" quartiles



Figure 2: Excerpt from STUBA annual report on publications

b. How high are the reputation of the journal and the publisher?

STUBA publications reach the highest-quality journals in the field (such as IFAC Automatica in the field of Automation and Control). The audit revealed that some of the targeted top journals are indeed high-ranking (e.g., belong to the 1st or 2nd quartile according to WoS), but sometimes they are high-ranking in a subject category that is not the immediate target of the publishing group (e.g., Applied Thermal Engineering for Automation and Control).

Is there open data and open software supporting the publications?

STUBA offers various software tools that support their publications. Most prominently, the Multi Parametric Toolbox (MPT) has over 35000 downloads and is used internationally in education and industry. This is extended by the upcoming MPT+, which adds useful features to the MPT in Matlab. Other internationally used software is the TBX Manager, a Matlab-based package manager, and MUNUM, a Matlab toolbox for universal numbers (number format). Both are used in education and industry.

STUBA also provides dedicated software for industrial partners. This encompasses around 15 different software applications (e.g., HSYDEL, OPTIPLAN, piddesign and mup) that are typically based on Matlab.

STUBA's software has proven to support cooperations and citations. STUBA is encouraged to continue focusing on supporting software.

How are publications by Ph.D. students reviewed internally before submission?

Before completing Ph.D. degrees, Ph.D. students must prove to be capable to publish in international peer-reviewed proceedings and journals. Ph.D. students are supervised by assistant, associate or full professors on a daily to weekly basis and encouraged to write research papers whenever their results permit. Research papers are first reviewed internally by the advising professor and co-authors. This process repeats up to three times as required. On average it takes up to one month until an article is ready for submission. Communication and collaborative writing are based on git repositories.

The internal review structure before publishing an article at STUBA is similar to that in place at UNIPI and RUB. Internal review processes occur fast and are not an obstacle for the Ph.D. students. STUBA is encouraged to continue with the established process and should maintain the use of git repositories as it has many advantages for collaborative working and long-term storage.





Does the hardware-setup at STUBA affect research and publication times?

The hardware-setup at STUBA is up to date. This includes all computers at the workplaces and the related peripherals, as well as all experiments with their additional hardware-setup. All the hardware can run the latest engineering software applications. Git repositories are used as an additional storage and are also up to date.

Where can publications like articles and papers be found in the long-term?

In Slovakia, it is a nationwide requirement to report the performance of the individual research groups working at universities. STUBA operates a self-written, sophisticated content-management system that tracks all publications related to the faculties and brings together all information relevant to the publications. In addition to typical information such as author names or group names, the database also includes information like project names or citation counts. This enables detailed searches in the system, which allows precise filtering of all publication-relevant information. The software was developed and is currently managed by an associate professor at STUBA. Database updates are carried out individually by each researcher at the beginning of every year. This also includes the number of citations, which is determined by entering the actual citing citations by hand and checked for duplication by the software. Because they are evaluated based on their publications, researchers and research groups are intrinsically motivated to keep their records up to date.



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2015	Engell S.; Paulen R.; Reniers M.; S Thompson H.	Sonntag C.;	Core Re	esearch and Innovati	ion Areas in Cyber-Physica	al Systems of Systems		33	Citations
2015	Martí R.; Lucia S.; Sarabia D.; Pau Prada C.	ilen R.; Engell S.; d	le Improvir	ng scenario decomp	osition algorithms for robus	st nonlinear model predic	tive control	31	Citations
2015	Chachuat B.; Houska B.; Paulen F Rajyaguru J.; Villanueva M.	a.; Peric N.;	Set-The	oretic Approaches ir	n Analysis, Estimation and	Control of Nonlinear Sys	tems	30	Citations
2017	Gottu Mukkula A. R.; Paulen R.		Model-b guarant	eased design of optir eed parameter estim	nal experiments for nonline nation	ear systems in the contex	tt of	26	Citations
2018	Thangavel S.; Lucia S.; Paulen R.;	Engell S.	Dual rob	oust nonlinear mode	I predictive control: A multi-	-stage approach		23	Citations
2014	Lucia S.; Paulen R.		Robust Optimal	Nonlinear Model Pre Experiment Design	edictive Control with Reduc	tion of Uncertainty Via R	obust	20	Citations
2012	Paulen R.; Fikar M.; Foley G.; Kov	acs Z.; Czermak P.	Optimal	feeding strategy of	diafiltration buffer in batch	membrane processes		18	Citations
2011	Paulen R.; Foley G.; Fikar M.; Kov	acs Z.; Czermak P.	Minimiz	ing the process time	for ultrafiltration/diafiltratio	n under gel polarization	conditions	14	Citations
2019	Tran T. B. L.; Törngren M.; Nguyer Gleason N. W.; Duong T. H.	H. D.; Paulen R.;	Trends i	n preparing cyber-p	hysical systems engineers			13	Citations
2016	Paulen R.; Fikar M.		Optimal	Operation of Batch	Membrane Processes			13	Citations
2016	Wenzel S.; Paulen R.; Stojanovski Beisheim B.; Engell S.	G.; Krämer S.;	Optimal pricing	resource allocation	in industrial complexes by	distributed optimization a	and dynamic	12	Citations
2016	Paulen R.; Villanueva M.; Chachua	at B.	Guarant techniqu	teed parameter estinues with domain and	nation of non-linear dynam I CPU-time reduction strate	ic systems using high-or gles	der bounding	12	Citations
2016	Jelemenský M.; Sharma A.; Paule	n R.; Fikar M.	Time-op	timal control of diafi	Itration processes in the pr	esence of membrane fou	ıling	12	Citations
2011	Paulen R.; Fikar M.; Kovacs Z.; Cz	ermak P.	Process producti	optimization of diaf	iltration with time-depende	nt water adding for albun	nin	12	Citations
2018	Peric N.; Paulen R.; Villanueva M.;	Chachuat B.	Set-mer	mbership nonlinear r	egression approach to par	ameter estimation		9	Citations
2015	Paulen R.; Jelemenský M.; Kovacs	s Z.; Fikar M.	Econom	nically optimal batch	diafiltration via analytical n	nulti-objective optimal co	ntrol	9	Citations
2013	Paulen R.; Villanueva M.; Fikar M.	; Chachuat B.	Guarant Techniq	teed Parameter Estin ues	nation in Nonlinear Dynam	nic Systems using Improv	ed Bounding	9	Citations
2020	Kusumo K.; Gomoescu L.; Paulen Pantelides C. C.; Shah N.; Chachu	R.; García Muñoz s Jat B.	S.; Bayesia Strategy	n Approach to Proba	abilistic Design Space Cha	racterization: A Nested S	Sampling	8	Citations
2015	Jelemenský M.; Paulen R.; Fikar N	1.; Kovacs Z.	Time-O	ptimal Operation of I	Multi-Component Batch Dia	afiltration		8	Citations
2014	Lucia S.; Paulen R.; Engell S.		Multi-sta	age Nonlinear Mode	Predictive Control with Ve	rified Robust Constraint	Satisfaction	8	Citations
2013	Paulen R.; Jelemenský M.; Fikar N	1.; Kovacs Z.	Optimal limiting	balancing of tempo flux conditions	ral and buffer costs for ultra	afiltration/diafiltration prod	cesses under	8	Citations

Figure 3: Overview publications sorted by number of citations

Publication information are automatically linked to each researcher's individual website, which does not only support visibility but also assists in verifying the fulfilment of requirements by Ph-D. students for their graduation. This establishes a natural encouragement for keeping everything up to date as young researchers are reporting the data for their own benefit. All the publications and the related data is also available in various forms and collections in Scopus, WoS and google scholar (see Figs. 3 and 4).





Creating & editing citations

List of publications

Publication

R. Martí – S. Lucia – D. Sarabia – R. Paulen – S. Engell – C. de Prada: Improving scenario decomposition algorithms for robust nonlinear model predictive control. Computers & Chemical Engineering, vol. 79, pp. 30–45, 2015.

Add citation

Citations

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Year 🛓	Citation	Type (FCHPT)	Type (Wold)	Inserted $\prescript{0}$	Type OLD ∲	Source OLD	
2015	Zhang, Runfan – Chen, Diyi – Ma, Xiaoyi: Nonlinear Predictive Control of a Hydropower System Model. <i>Entropy</i> , no. 9, vol. 17 , pp. 6129-6149, 2015.	SCI(f)	SCI	2017-10-15 17:24:36	SCI(f)	WoS	Edit Delete
2016	Gros, Sebastien – Fredriksson, Jonas – Dahl, John – Klintberg, Emil: An improved dual Newton strategy for scenario-tree MPC. In 2016 IEEE 55th Conference on Decision and Control (CDC), pp. 3675-3681, 2016.	SCI(f)	Other	2017-10-15 17:24:36	Other(f)	WoS	Edit Delete
2016	Madsen, Henrik – Poulsen, Niels Kjolstad – Mahmoudi, Zeinab – Hagdrup, Morten – Boiroux, Dimitri – Jorgensen, John Bagterp: An Ensemble Nonlinear Model Predictive Control Algorithm in an Artificial Pancreas for People with Type 1 Diabetes. In 2016 European Control Conference (ECC), pp. 2115-2120, 2016.	SCI(f)	Other	2017-10-15 17:24:36	Other(f)	WoS	Edit Delete
2017	Dinesh Krishnamoorthy – Bjarne Foss – Sigurd Skogestad: Gas Lift Optimization under Uncertainty. In <i>Computer Aided Chemical Engineering, vol. 40</i> , pp. 1753-1758, 2017.	SCI(f)	Other	2018-04-08 11:10:13	Other(f)	WoS	Edit Delete
2017	Oberdleck, Richard Heinrich: Theoretical and algorithmic advances in multi-parametric optimization and control, Imperial College London, 2017.	Other(f)	Other	2017-11-03 09:41:04	Other(f)	Google Scholar	Edit Delete
2017	Klintberg, Emil – Gros, Sebastien: A Parallelizable Interior Point Method for Two-Stage Robust MPC. IEEE Transactions on Control Systems Technology, no. 6, vol. 25, pp. 2087-2097, 2017.	SCI(f)	SCI	2017-11-03 09:40:26	SCI(f)	WoS	Edit Delete
2018	Krishnamoorthy,D. – Suwartadi,E. – Foss,B. – Skogestad,S. – Jaschke,J.: Improving Scenario Decomposition for Multistage MPC Using a Sensitivity-Based Path-Following Algorithm. <i>IEEE</i> <i>Control Systems Letters</i> , no. 4, vol. 2, pp. 581-586, 2018.	SCI(f)	Other	2019-05-02 10:33:55	SCI(f)	WoS	Edit Delete
2018	Han,X – Feng,Y. – Dong,N. – Wu,A: An improved model-free adaptive predictive control algorithm for nonlinear systems with large time delay. In <i>Proceedings of 2018 IEEE 7th Data</i> <i>Driven Control and Learning Systems Conference, DDCLS 2018</i> , pp. 60-64, 2018.	SCI(f)	Other	2018-12-04 08:14:59	Other(f)	WoS	Edit Delete
2018	Jäschke,J. – Krishnamoorthy,D. – Thombre,M. – Skogestad,S.: Data-driven Scenario Selection for Multistage Robust Model Predictive Control*. <i>IFAC-PapersOnLine</i> , no. 20, vol. 51 , pp. 462-468, 2018.	SCI(f)	Other	2018-12-01 17:29:33	Other(f)	WoS	Edit Delete
2018	Krishnamoorthy, Dinesh – Foss, Bjarne – Skogestad, Sigurd: A Distributed Algorithm for Scenario- based Model Predictive Control using Primal Decomposition. <i>Ifac Papersonline</i> , no. 18, vol. 51 , pp. 351-356, 2018.	SCI(f)	Other	2018-10-18 07:38:36	Other(f)	WoS	Edit Delete
2018	Kouzoupis, D. – Klintberg, E. – Diehl, M. – Gros, S.: A dual Newton strategy for scenario decomposition in robust multistage MPC. International Journal of Robust and Nonlinear Control, no. 6, vol. 28, pp. 2340-2355, 2018.	SCI(f)	SCI	2018-05-09 23:21:11	SCI(f)	WoS	Edit Delete

Figure 4: Creating and editing of citations

UNIPI and RUB believe STUBA already offers a very well-structured database for publications that collects the full text papers with their comprehensive information, which can be a point of reference for other universities. Currently, the database is limited by the fact that it is only operated in Slovak. UNIPI and RUB encourage STUBA to operate the database in English as well to simplify use for international researchers at STUBA.

In which author constellations are articles published?

c. Does STUBA cooperate with industrial partners?

STUBA cooperates rarely with industrial partners. There exist collaborations, e.g. with Slovnaft, which operates the largest oil refinery just outside Bratislava. In general, industrial collaborations appear to be more rare than at UNIPI and RUB. If such cooperations take place, they do typically not lead to joint publications. Industrial





partners appear not to be interested in publications and often do not want to be named as co-authors.

Companies in Bratislava need to learn to recognize the benefits of research for their business. UNIPI und RUB propose to use the high-quality experimental setups at STUBA to promote industrial cooperations showing the potential for different businesses.

d. Does STUBA cooperate with international co-authors?

Collaborations with international co-authors have helped STUBA a lot to establish a large research network and to gain recognition. The term international here encompasses both the European and the extended international level. Two good examples are the collaboration between STUBA and the university of Shanghai and between the three partners within the FrontSeat project. In both cases, the cooperations result in several joint publications per year.

While STUBA already cooperates with many international co-authors, UNIPI and RUB propose to foster additional collaborations to broaden the perspective and to increase international visibility.

Are early-stage researchers involved in publications (for example the further development of student work)?

Ph.D. students are required to publish as described above. Bachelor and master students are invited to contribute to conference papers if their results permit to do so. STUBA has started to consider incentives for bachelor and master students to develop their work into a scientific publication and to attract them to a research career. It is currently difficult to integrate students below the Ph.D. student level because no dedicated funds exist for this purpose. UNIPI and RUB encourage STUBA to continue promoting exceptionally good students as early as possible but acknowledge that wider support is not possible due to lack of funding for this particular purpose.

Are research results incorporated into the teaching process? How are they incorporated?

According to the interviews conducted at STUBA, research results are only incorporated into the teaching process in rare cases. In the case that they are incorporated, they are not a main component of the teaching process but rather appear as a side node.

UNIPI and RUB both incorporate research results into their teaching material more frequently and can report that students appreciate these efforts. Research results do not only make the lectures more appealing but also provide a better understanding of certain problems since control problems can be very abstract, in particular when advanced numerical methods are involved. Researchers with teaching accreditations should be encouraged to revise their lectures and incorporate more research data into the teaching process.

What are the requirements for a Ph.D. student to get the Ph.D. degree?

To be able to start the Ph.D. program at STUBA, the student is required to already have a bachelor's and master's degree in a to the Ph.D. program comparable subject. The Ph.D. program is designed to take four years. The process is split into two separate parts, taking courses with written exams, and writing publications and the thesis. The first part takes one and half years and is setup like a master's degree. Ph.D. students need to collect a certain amount of Credit Points (CP), which add up to a workload between 1500 and 2000 hours a year. Successful completion of the first part is a requirement for admission to the mid-term-exam and to continue with the research part of the Ph.D. programme. Courses are split into topics regarding automation control with an exam at the end of the semester and generic skill courses at the Faculty of Chemical and Food Technology. Generic courses cover the procedure from reading and understanding a scientific publication to writing and submitting the first paper step by





step. After passing all courses and the mid-term exam, the Ph.D. students spend two and half years on researching for a specific scientific topic and writing their doctoral thesis. Every student is assigned to one professor, who typically supervises only one Ph.D. student. While researching, every Ph.D. student needs to publish either one article in a Quartile 1 journal with no coauthor besides the advisor, or two articles with one in a Quartile 1 journal and one in a Quartile 2 or 3 journal, where coauthors are admitted. Only after publishing the required number of articles, the Ph.D. student is allowed to submit his doctoral thesis. After revision of the thesis, the Ph.D. student is admitted to his defence, which is the last step of getting the Ph.D. degree.

This Ph.D. curriculum exists because the Ph.D. degree must comply with the guidelines of the ECTS system. STUBA is currently remodelling the Ph.D. program to reduce the course load and to increase the time for research. RUB and UNIPI encourage STUBA to do so, since the Ph.D. students at STUBA already enter with a master's degree that involved a course program very similar to the one currently required in STUBA's Ph.D. program. RUB and UNIPI also propose to simplify the requirements necessary to get the Ph.D. degree. Specifically, co-authorships should be encouraged.



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The results of the audit show that STUBA is already operating on a very high level in regard to research output. This holds for both the quantity and the quality of the scientific output. In addition to classical research output forms such as books, book chapters and research papers, STUBA has continuously been publishing specialist software, which has been acclaimed internationally. The operated laboratories as well as the conducted and planned experiments generate high quality data and thus will continue to provide opportunities for high-level publications. The internal review and self-benchmarking processes implemented at STUBA are up-to-date and efficient. Annual reports exist that monitor publications by person thus ensuring that STUBA can continue operating at a very high scientific level.

As a result of the audit, UNIPI and RUB encourage STUBA to increase sensitivity for new research trends. Measures towards this goal are, for example, strengthening international cooperations across all units of STUBA, increased participation at international conferences of members of all units of STUBA, and invitations of high-ranking guest lecturers. Furthermore, RUB and UNIPI encourage STUBA to continue their work on remodelling the current Ph.D. curriculum towards an increased time for research, and to simply the requirements necessary to get the Ph.D. degree.

