Fostering Opportunities Towards Slovak Excellence in Advanced Control for Smart Industries

D2.3. Report on short- and long-term scientific exchanges

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Abstract	The project aims at increasing the research and academic prospects of 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 RU Bochum, Germany (RUB) and Pisa University, Italy (UNIPI). The specific goals of the action are to reinforce 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 management toolbox, - Research efforts aiming at the continued creation of high-quality research results 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, - Organising 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;

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	Embedded systems in automation and control.

Document Revision History

Version	Date	Description of change	List of contributors

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PARTNERS

The consortium of FrontSeat consists of 3 partners, as presented here below.

STUBA

Slovak University of Technology in Bratislava

RUB

Ruhr University Bochum

UNIPI

University of Pisa

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EXECUTIVE SUMMARY

This document constitutes Deliverable 2.3 „Report on short- and long-term scientific exchanges“ of the FrontSeat Project, funded by the European Union´s Horizon Europe research and innovation programme under the action number 101079342. Primary goal of the exchanges was to sustain and foster collaborative research between the partners, with a focus on data- and model-based optimal control. The approach centered on aligning the expertise of experienced researchers with the research topics of ESRs, aiming at publishing joint conference contributions.

The purpose of this report is to collect and summarize all long- and short-term exchanges that took place within the frame of the project. The report provides a comprehensive overview of the key metrics and outcomes across all exchanges. It covers a year-by-year breakdown of individual exchanges, including detailed information and hyperlinks to corresponding blog entries published on the FrontSeat website. In addition, all joint publications are summarized to highlight the success of the exchanges, followed by a conclusion.

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ABBREVIATIONS

Abbreviation	**Expanded Version**
SR	Senior Researcher
ESR	Early-Stage Researcher
Tba	To be announced

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OBJECTIVES

Work Package 2, „Promoting Excellence in Automatic Control Research“, corresponding to this deliverable, has multiple objectives. The main aim is to develop collaborative research activities in the field of advanced automatic control. This goal is set to be reached by enhancement of the research capabilities of the STUBA group, the development of software tools and the preparation and submission of joint research projects. A fundamental part to achieve these goals are the short- and long-term exchanges of SRs and ESRs. Exchanges last up to 6 months for ESRs and up to 1 month for SRs. The principle is to match the expertise of the SRs with the research topics of the ESRs. Research will be focused on data- and model-based optimal control. Results will be treated as a case study for future successful projects.

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SUMMARY OF EXCHANGES

The corresponding WP2 started at M1 of the project, by planning all exchanges for the upcoming three project years. The exchange program is structured in phases. In the first phase, exchanges serve as an introduction, with each exchange not lasting longer than two weeks. The focus is on the introduction of participating SRs and ESRs and specifying joint research topics. This preparation allows for more efficient and productive collaboration during the long-term exchanges of the ESRs, which are scheduled for the exchange phase that takes place in the second and the beginning of the third project year. The long-term exchanges are dedicated to conducting research and preparing joint publications. Shorter exchanges from the SRs complement the long-term exchanges, enabling more frequent in-person discussions and ongoing support for the research. All exchanges conclude with an optional short visit at the end of the third project year, intended to finalize ongoing research and joint publications. Throughout the project, each exchange was accompanied by either a pedagogical or scientific lecture, to further enhance STUBA's research capabilties and to increase knowledge transfer between the partners.

In total, 48 exchanges were conducted, accounting for more than 900 days of exchange activity. 31 researchers participated in the exchanges, including 16 ESRs and 15 SRs. All key performance indicators were met, as the project required 5 short-term and 6 long-term exchanges, involving 15 ESRs and 3 SRs. The following section provides a detailed overview of all exchanges, including information on the participating researchers, the partners involved, the specific dates of the exchanges, and the respective objectives. In addition, each exchange is supplemented by a hyperlink to the corresponding blog entry on the FrontSeat Website, giving a more in-depth perspective on each exchange.

The color coding used in the list of exchanges is as follows: A blue background indicates exchanges that were carried out as planned and fully funded by the FrontSeat project. An orange background indicates exchanges that took place within the frame of FrontSeat but were only partially funded by the project, with additional financial support provided through additional grants. A yellow background highlights planned exchanges that have not been implemented by M33 of the project.

Year 1 (12.22 – 10.23)

The first project year included a total of 15 exchanges, each lasting approximately one week, resulting in a cumulative 68 days spent abroad. The initial exchanges primarily focused on introducing SRs and ESRs to one another and identifying potential joint research topics. The scientific lectures helped as an introduction to match the expertise of the researchers.

Name:	Status:	From:	To:	Date:	Objective:	Results:
Boldocky, Jan	ESR	STUBA	RUB	06.02-09.02	Mentoring scheme, Introduction	Blog post
Gulan, Martin	SR	STUBA	RUB	06.02-09.02	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Balla, Michal	ESR	STUBA	RUB	06.02-09.02	Mentoring scheme, Introduction	Blog post
Pribis, Rudolf	SR	STUBA	RUB	06.02-09.02	Scientific/Pedagogical lectures, Outline possible joint research	Blog post
Haffner, Oto	SR	STUBA	RUB	06.02-09.02	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Kucera, Erik	SR	STUBA	RUB	06.02-09.02	Scientific/Pedagogical lectures, Work on joint research projects	Blog post

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Dyrska, Raphael	ESR	RUB	STUBA	27.02-03.03	Scientific lectures, Work on joint research projects	Blog post
Pannocchia, Gabriele	SR	UNIPI	STUBA	08.03-10.03	Scientific lecture, Shape joint research projects	Blog post
Faber, Ratislav	ESR	STUBA	UNIPI	18.03-25.03	Mentoring scheme, Introduction	Blog post
Paulen, Radoslav	SR	STUBA	UNIPI	18.03-25.03	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Pannocchia, Gabriele	SR	UNIPI	STUBA	05.06-10.06	Attendance of Conference, Work on joint research projects	Blog post
Müller, David	ESR	RUB	STUBA	21.08-25.08	Introduction, Work on joint research projects	Blog post
Mönnigmann, Martin	SR	RUB	STUBA	22.08-24.08	Pedagogical lectures, Work on joint research projects	Blog post
Vaccari, Marco	SR	UNIPI	STUBA	11.09-15.09	Lecture at Summer School, Work on joint research projects	Blog post
Bacci di Capaci, Riccardo	SR	UNIPI	STUBA	18.09-22.09	Scientific/Pedagogical lectures, Work on joint research projects	Blog post

Year 2 (10.23 – 10.24)

The second project year focused heavily on the long-term exchanges of the ESRs, which resulted in numerous successful outcomes. These exchanges significantly strengthened collaboration, particularly among the younger researchers, building relationships that extend beyond the scope of research activities. A total of 18 exchanges were conducted during the second project year, comprising over 500 days of exchange. The duration of individual exchanges extended up to four months. Project year 2 paved the way for numerous joint publications, which were either completed and published by the end of the year or finalized during subsequent exchanges in the third project year.

Name:	Status:	From:	To:	Date:	Objective:	Results:
Čorňák, Marek	ESR	STUBA	RUB	15.09-15.10	Scientific lectures, Work on joint research projects	Blog post
Sekaj, Ivan	SR	STUBA	RUB	06.10-10.10	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Klaučo, Martin	SR	STUBA	RUB	07.10-10.10	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Bacci di Capaci, Riccardo	SR	UNIPI	STUBA	07.10-10.10	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Leonow, Sebastian	SR	RUB	STUBA	13.11-17.11	Pedagogical lectures, Work on joint research projects	Blog post
Dyrska, Raphael	ESR	RUB	STUBA	13.11-24.11	Scientific lectures, Work on joint research projects	Blog post
Müller, David	ESR	RUB	STUBA	08.01-12.01	Work on joint research projects	Blog post

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Mönnigmann, Martin	SR	RUB	STUBA	08.01-12.01	Work on joint research projects	Blog post
Dzurková, Diana	ESR	STUBA	RUB	22.01-01.03	Scientific lectures, Work on joint research projects	Blog post
Fáber, Rastislav	ESR	STUBA	UNIPI	01.02-31.05	Mentoring scheme, Work on joint research projects	Blog post
Boldocký, Ján	ESR	STUBA	RUB	15.02-15.06	Mentoring scheme, Work on joint research projects	Blog post
Horváth, Dušan	ESR	STUBA	UNIPI	01.05-31.05	Work on joint research projects	Blog post
Lindner, Nora	ESR	RUB	STUBA	10.06-05.07	Scientific lectures, Work on joint research projects	Blog post
Pannocchia, Gabriele	SR	UNIPI	STUBA	19.06-21.06	Pedagogical lectures, Work on joint research projects	Blog post
Müller, David	ESR	RUB	STUBA	22.07-17.08	Scientific lectures, Work on joint research projects	Blog post
Okienková, Kristína	ESR	STUBA	UNIPI	01.09-01.11	Work on joint research projects	Blog post
Vaccari, Marco	SR	UNIPI	STUBA	07.10-11.10	Scientific/Pedagogical lectures, Work on joint research projects	Blog post
Bacci di Capaci, Riccardo	SR	UNIPI	STUBA	07.10-11.10	Scientific/Pedagogical lectures, Work on joint research projects	Blog post

Year 3 (10.24 – 07.25)

The third project year again included a large number of exchanges. In total, an additional 15 exchanges were conducted, encompassing more than 360 days of exchange. The final exchanges were focused on finishing joint research projects and submitting joint publications. It is important to highlight the two exchanges marked in red, as they extended beyond the scope of FrontSeat funding and were facilitated through additional grant support. These exchanges exemplify the strong collaboration and partnership that has developed over the years, enabling joint research beyond the scope of the FrontSeat project.

Name:	Status:	From:	To:	Date:	Objective:	Results:
Oravec, Juraj	SR	STUBA	RUB	21.10-25.10	Scientific lectures, Work on joint research projects	Blog post
Holaza, Juraj	SR	STUBA	RUB	21.10-25.10	Scientific lectures, Work on joint research projects	Blog post
Fikar, Miroslav	SR	STUBA	RUB	20.11-22.11	Scientific lectures, PhD defence, Work on joint research projects	Blog post
Boldocky, Jan	ESR	STUBA	RUB	06.01-21.03	Mentoring scheme, Work on joint research projects	Tba
Málik, Róbert	ESR	STUBA	UNIPI	13.01-15.03	Work on joint research projects	Blog post
Wadinger, Marek	ESR	STUBA	UNIPI	07.02-07.03	Work on joint research projects	Blog post

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Lindner, Nora	ESR	RUB	STUBA	17.02-28.02	Work on joint research projects	Blog post
Mönnigmann, Martin	SR	RUB	STUBA	26.02-28.02	Work on joint research projects	Blog post
Valábek, Patrik	ESR	STUBA	UNIPI	01.03-31.05	Work on joint research projects	Blog post
Lindner, Nora	ESR	RUB	STUBA	24.03-04.04	Scientific lectures, Work on joint research projects	Blog post
Pavlovičová, Erika	ESR	STUBA	UNIPI	10.03-11.04	Scientific lectures, Work on joint research projects	Blog post
Fikar, Miroslav	SR	STUBA	UNIPI	01.05-09.05	Pedagogical lectures, Work on joint research projects	Tba
Vargan, Jozef	ESR	STUBA	UNIPI	01.05-23.05	Work on joint research projects	Tba
Pannocchia, Gabriele	SR	UNIPI	STUBA	26.05-27.05	Pedagogical lectures, Work on joint research projects	Blog post
Müller, David	ESR	RUB	STUBA	09.06-13.06	Scientific lectures, Work on joint research projects	Tba
Lotti, Francesco	ESR	UNIPI	STUBA	Tba	Work on joint research projects	Tba
Gori, Pietro	ESR	UNIPI	STUBA	Tba	Work on joint research projects	Tba
Bacci di Capaci, Riccardo	SR	UNIPI	STUBA	Tba	Scientific lectures, Work on joint research projects	Tba
Vaccari, Marco	SR	UNIPI	STUBA	Tba	Scientific/Pedagogical lectures, Work on joint research projects	Tba
Mönnigmann, Martin	SR	RUB	STUBA	Tba	Scientific lectures, Work on joint research projects	Tba
Leonow, Sebastian	SR	RUB	STUBA	Tba	Scientific lectures, Work on joint research projects	Tba
Tba	ESR	RUB	STUBA	Tba	Scientific lectures, Work on joint research projects	Tba

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JOINT PUBLICATIONS

Beside the number of exchanges and the strong partnerships established, joint publications serve as a measurable key metric for evaluating the success of the exchanges. According to the key performance indicators, the project aimed for at least 10 joint conference contributions. The number of publications successfully exceeded the key performance indicators, with 11 joint conference contributions submitted and accepted. In addition, 2 joint poster presentations and 3 joint journal publications were submitted and accepted. The 3 joint journal publications surpassed expectations and were initally not considered an achievable results within the three project years. The number and quality of joint publications clearly demonstrate that the partnerships are not only well established but also highly productive and impactful. The partners' expertises were ideally matched during the exchanges, contributing significantly to the success of the collaborations.

The complete list of joint publications is provided below, including the title of each publication, the partners involved, and the type of publication. Note that this list only contains joint publications and does not account for publications produced independently by one of the partners within the project. The full list of all publications, containing both joint and non-joint publications can be found on Zenodo.

Publication:	Partners involved:	Type:
Heat exchanger control using model predictive control with constraint removal	RUB, STUBA	Journal
Exploiting symmetries in active set enumeration for constrained linear–quadratic optimal control	RUB, STUBA	Journal
Simple Controller Tuning for Unmanned Aerial Vehicles using Governors	RUB, STUBA	Conference
Simple Tuning of Arbitrary Controllers using Governors	STUBA, RUB	Conference
A Feasibility Condition for the Governor-based Tuning of Explicit MPC: Application to a Hydraulic Plant	RUB, STUBA	Conference
Improved Neural Ordinary Differential Equation-based Reduced Model for Impinging Jet using Wall Shear Stress	RUB, STUBA	Journal
Symbolic dynamics for active sets of a class of constrained nonlinear optimal control and MPC problems	RUB, UNIPI	Conference
Quadcopter altitude control using model predictive control with online constraint removal	RUB, STUBA	Conference
Integrating Levelled-Homomorphic Encryption in a Secure Process Control Application	RUB, STUBA	Poster
Learning to Solve Parametric Mixed-Integer Optimal Control Problems via Differentiable Predictive Control	RUB, STUBA	Conference
Integrated Testing of Model Predictive Control on Industrial PLC	STUBA, UNIPI	Conference
Offset-free Model Predictive Control of the Van de Vusse Reaction	STUBA, UNIPI	Conference
Improving Process Monitoring Via Dynamic Multi-Fidelity Modeling	STUBA, UNIPI	Conference

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Soft-Sensor-Enhanced Monitoring of an Alkylation Unit via Multi-Fidelity Model Correction	STUBA, UNIPI	Conference
Integrated Data Analytics and Regression Techniques for Real-time Anomaly Detection in Industrial Processes	STUBA, UNIPI	Conference
Multi-fidelity Modeling for Process Optimization in Refinery Operations	STUBA, UNIPI	Poster

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CONCLUSION

The short- and long-term exchanges of SRs and ESRs have been a full success. The number of exchanges and researchers involved significantly exceeded the targets that would already have been considered a success, fostering a strong and deep relationship among all partners. As a result, the collaborative research activities in the field of automatic control at the STUBA group were not only maintained but also significantly enhanced. This is also reflected by the number of joint publications, which exceeded the expected output by far. The groups even managed to successfully publish joint journal articles before the end of the project, further boosting STUBA's visibility in the field of automatic control.

With additional exchanges already planned beyond the officially scheduled timeframe, the partners are set to continue the successful collaboration established through the FrontSeat project. The complete impact of the exchanges is likely to unfold after the project ends, as several publications are still underway. These outcomes will provide a solid base for future joint research projects and thus long-term collaboration among the partners.

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