



Mid-term evaluation

Title of the programme: **Building blocks, tools and systems for factories of the future**

Acronym of the programme: **GOSTOP**

S4 priority area: **Factories of the future**

Evaluator:

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1. Introduction

The GOSTOP project (www.gostop.si) is the largest of its kind in the *Factories of the future* category in Slovenia jointly supported by the Ministry of Education, Science and Sport, the European Union, the European Regional Development Fund and the Slovenian industry. Therefore, it is obviously pretty difficult to follow the progress in every detail. Nevertheless, a very informative overview was provided beforehand and at the well-organized midterm evaluation on the progress in the 8 Objectives of GOSTOP. Beyond the previously supplied Progress report, presentations of the sub-project representatives and on-site visits in laboratories offered a rather complex picture facilitating the compilation of this report.

2. Basic data on the project and mid-term evaluation

On March 27, 2019 the review meeting took place from 14:00- 17:55 at the prestigious Jožef Stefan Institute just celebrating its 70th anniversary. The meeting with R&D leaders in the presence of some of the industrial representatives was followed by on-site visits at four laboratories of IJS. This guided tour was meant to elucidate the fundamental research results to build on in the GOSTOP endeavour.

On March 28, 2019 from 9:00- 14:00 the progress achieved in the integration of the results obtained in the 8 objectives of the individual pillars could be assessed in the presence of the researchers and the representatives of the tentative beneficiaries of GOSTOP. This meeting with several demonstrations, some with the involvement of the collaborating industry, was held at the Faculty of Mechanical Engineering of the University of Ljubljana.

At both institutions the leadership (Advisor to the Director of *IJS* and the Dean of Faculty) gave an introduction about the host's capabilities and *stressed the importance they assign to*



GOSTOP and the established new collaborations both R&D and industrial enabled by this 9.4 Million€ programme.

The presentations and laboratory visits were very well scheduled, thanks to the *very disciplined and skilful leadership of the project coordinator, Ass. Prof. Igor Kovač*. Sufficient time was allocated both for oral presentations and demonstrations, as well as for questions and answers for the reviewer. Thanks to the balanced scheduling and timely interventions of the coordinator in the laboratories even most of the participants could be introduced. The lab-visits reflected an overall smooth cooperation, and supported the complex positive impression about the progress.

3. Assessment of the progress made with regard to the objectives outlined in the project proposal

The project proposal was built upon the skills and strengths of the Slovenian R&D and industry, being also the *main elements of smart specialisation in the key and enabling technologies*. A proper selection of such areas and focussing of resources is essential in such a relatively small economy, like Slovenia. In this regard the timely proposal of the *collaboration of 13 industrial partners and 6 research institutions* was meant to result in breakthrough technologies for new products of SMEs, and to optimise throughput and quality of production at large Slovenian companies by developing *the Factories of the Future concept*. The proposed co-operation focussed on 4 specific areas, where on the medium term breakthroughs can be expected in Slovenia: *control technologies, tooling, robotics, and photonics*.

3.1. General observations with regard to mid-term report and visit

The identification of the most promising R&D competences to be integrated for the TRL 3-6 development in order to form the added value in the products of the participating companies is a core element of the success in enhancing the competitiveness. The management of the project in its whole complexity was facilitated by this grouping of the topics in the four subprojects - called pillars, each with dedicated sub-coordinators. Their reports on the progress in in the 8 Objectives reflected an intensive cooperation not only among the researchers but involving the industrial partners at the early research stage already.

The development of such a concept and the daily co-ordination of this huge concerted effort is a formidable task. At this point I have to stress the *pivotal role of the project coordinator*, who is the brain, and the driving force behind the synthesis of the diverse efforts to lead to a synergetic result. Igor Kovač is a very experienced coordinator with the proven ability to motivate and at the same time to control the work of a huge team. This was felt throughout the review.

3.2. Key highlights: which achievements stand out in your opinion

Besides the appreciation for the fact of ability to conduct such an effort, based upon the subjective impression of the evaluator some highlights were observed. The progress in the realisation of Objective 3, 5 and 8 was particularly eye-catching. In this regard the carefully selected laboratory visits both at JSI and the Faculty were the most conclusive.



In the **Control Pillar** (Dr. V. Jovan) the existing extensive competence on essential elements for automatic control technologies was further developed and demonstrated. The fact that the *Competence centre for advanced control has 17 members, the Clusters for System and control technology has 30 members* in Slovenia ensured, that in the competition for GOSTOP membership only the best contenders could be selected.

Especially the progress in development of the *digital twin concept* is to highlight. A distributed decision making model was introduced for manufacturing environment. Several other targeted developments serve the need of participating SME's. The direction of *Automatic product quality control*, which uses the IoT capabilities of all kinds of different sensors (even remotely, centrally supervised) has certainly a large market potential. The added value is particularly large for SME's.

In the **Tooling Pillar** (Dr. A. Hančič) the extensive tool supply industry (world's second highest number of toolmakers/capita behind Japan only!), and the large traditions of tool-making in Slovenia demand to address the needs in the digital world. Specific robotised applications are envisaged with a variety of customized tools for e.g. injection moulding, where special knowledge of IJS in materials science can be made use of to manufacture wear- and corrosion-resistant coatings on 3D structures with specified surface properties for better tooling results in high throughput production. Albeit not listed in the Robotics Pillar, several fancy gripping tool solutions were demonstrated for custom designed handling robots as well.

In the **Robotics Pillar** (Dr. A. Ude, 4 activities) the advantages of digitalisation are becoming really obvious. The reviewer was highly impressed by the information that in the smart specialisation call for Slovenia 50 interested partners could be identified in 2014 already. Obviously, also industrial participation is most intensive in this GOSTOP subproject (Kolektor, Yaskawa, and family company Podkrižnik), as the expected benefits are here the highest.

Especially the activity of Kolektor is exceeding the originally planned staff effort, which even led to two new H2020 projects with IJS+Kolektor as main partners. Automatic reconfiguration capability was developed with an investment of over 100mio € for the visual inspection of a number of products for their own captive market at Kolektor, for an intended commercialization later.

Most impressive result for the reviewer reflecting the real benefits of GOSTOP was the introduction of the demonstration platform of the virtual factory presented by Dr. Herakovič and his co-workers at the Faculty of Mechanical Engineering of UL. The development of a complex universal framework with distributed agents for control of production from demand-to delivery contains all elements needed for a customized solution for each end-user. It is visualized by hands-on-experience that integration and digitalization (AI, deep-learning, IoT, cloud computing, etc.) brings enormous benefits. This »slow motion« operation is the way to persuade decision making managers of production companies to invest in automated production management and control for efficient mass production of improved quality and throughput using the concept.

The **Photonics Pillar** (Dr. Janez Štrancar) is somewhat different from the others, in that the activities start from the fundamental investigation a.o. of fibre-lasers (TRL1-2) based on the traditionally high level of research in this field in Slovenia. Also the domestic photonics industry



is well developed (ISKRA, OPTOTEK, FOTONA), consequently the domestic demand for new concepts is also rather high.

The industrial partners, potential end-users participate in the research phase of laser applications for measurement and medical (theranostic) purposes already, as it was demonstrated at JSI.

Still very advanced, well established production applications of laser technology were demonstrated, too, in the LASIM and LASTEH part presented at the Faculty. After all it became clear, why the Photonics Pillar is an essential tool for robotized production technology in the FoF concept of GOSTOP.

3.3. Changes

There were no particular modifications or major changes needed in the workplan with 8 Objectives. Only minor adjustments were revealed, required by particular needs of the industrial partners. They were efficiently handled as part of the development, though. No delays, extra costs or inconsistencies were generated by any changes effected in course of the project.

3.4. Work plan till the end of the project

The program commenced by November 1, 2016. In the Midterm report thus the results of the last two years were mainly summarized. In the remaining one year until the project's completion by April 30, 2020, the full execution of the workplan seems not at all in jeopardy. Its implementation is deemed to be fully realistic, no critical bottlenecks or hampering factors could be detected.

4. Role of the partners in the project

Of course it is unrealistic in such an overall assessment to accurately weigh the role and performance of all partners. It can be said with certainty, however, that all partners delivered and contributed to the current status according to their assigned share. Some of them even started individual, independent collaborative projects outside GOSTOP, but inspired by GOSTOP. Generally, *the cross-fertilization and push-pull inspiration effect of the R&D programme is obvious* at this stage already.

Throughout the evaluation process I felt the *enthusiasm and pride of the industrial partners and the researchers alike* that they can be part of this *excellent initiative*, as they put it. They were convinced that the *substantial critical mass could be gathered and mobilized for the GOSTOP targets only by this proportionally generous support*. Therefore, to harvest the economical results of this large scale advancement in competitive production technology, following the TRL 3-6 phase a continuation of combined financing to TRL7-9 is essential. I am convinced that the decision makers will recognize the added benefits and understand the need of supporting the full exploration of the accelerating effect achievable in GOSTOP.



5. Internal (between the project partners) and external communication

The subdivision into four pillars also made the internal communication between interested partners easier, while the coordinator held an almost daily contact with the pillar and activity leaders. An annual GOSTOP meeting is also organised for complex information dissemination and team-building, while this Midterm evaluation is also used to inform all 19 collaborating partner institutions and companies about the achieved progress. Internal dissemination and networking is thus primarily within the pillar- participants.

The coordinator provided evidence and indicator figures for the dissemination measures during the introduction of GOSTOP. Admittedly, the information of the public can always be improved, although several innovative actions (school visits, demonstrations) are already implemented in their arsenal. *A pilot-demonstration line would be a great step to publicize the GOSTOP results. Raising the awareness of the taxpayers to the societal-economic impact of such large projects, like GOSTOP helps to enable the transition to Industry 4.0 and beyond by the extensive use of automation.*

6. Assessment of dissemination & exploitation of project results in the phase TRL7-9.

Some of the obtained results of GOSTOP, relatively minor topics mainly, were already taken up by SMEs and even potential end-users for in house exploitation (TRL 7-9). This was evident from the reports and demonstrations e.g. in Objectives 4 and 6.

As mentioned previously, the real benefits of GOSTOP could become evident in a successor project of TRL 7-9, which obviously requires an even larger funding from the stakeholders. The exploitation of the GOSTOP results, however, cannot be expected without a large-scale TRL 7-9 effort.

7. Assessment of quality of main scientific achievements

The scientific excellence of the participating teams was proven by the indicators, which are well beyond the previously projected figures. At this level scientific publications can only be allowed after securing IPR. The high number of publications shown (150) exceeds 5-times the planned indicator, while the number of innovations and patents exceeds already the figure projected for the whole project. The high level of fibre-laser related scientific research results was striking. The scientific excellence all in all is in line with planned impact.

8. Cooperation between public and private partners

The cooperation proved to be not a question of a decision, but the result of a learning process. GOSTOP appeared to be an excellent example that appetite comes with eating. The private



partners, as soon as realized the real potential of the newly developed technologies for their own products and processes, immediately increased their staff efforts and contribution to the project.

They also showed increasing interest in the developments outside of their own original targets. The private investment in R&D was unexpectedly doubled compared to the originally planned amount, just like the number of new processes and products based upon the GOSTOP results. The collaboration among public research and private production partners was particularly enhanced by the networking within the Pillars, i.e. among partners of similar interests, and even competitors. The synergetic effect is thus rather high and adds to the final success.

9. Concluding remarks and recommendations

The initiative Factories of the Future drastically improves the collaboration among shareholders in the most promising focus areas in R&D with an eye on fast return on investment. Albeit maintaining the freedom of selection of scientific research topics is a justified demand, the responsible financing, the proper allocation of funding for R&D needs corner-stones to adjust the limited resource distribution for best utilisation of the scientific outcome in the economy.

In conclusion the reviewer agreed with the project coordinator's statement that *nothing can be copied for Factory of the Future*, it has to be developed according to the specific needs of the country using the GOSTOP results. It has to be remarked that during the whole institute visits hardly any lady-researcher was seen. The full male-orientation of GOSTOP was, however, well compensated by the completely female governmental administration and supervision of the project.

In summary: Congratulations to the co-ordinator and the whole GOSTOP staff for the achieved, excellently presented performance! *The final recommendation can only be: continue in this fashion, and try to further improve the information of the public opinion*, how well the taxpayers' money is spent for the benefit of society. In order to spread the elaborated technology to even smaller industries, *a turn-key pilot line and a company has to be set up with governmental support to market the own Slovenian knowledge obtained a.o. by GOSTOP*. This is what the stakeholders lead by the excellent coordinator are asking for and expecting together with the evaluator.