

Quarterly Administrative Report

1. Program and Project information	
Name of the Program:	IDEAS - Engineering and Technological Sciences
Name of the Project:	Hybrid Integrated Satellite and Terrestrial Access Network
The Project acronym:	hi-STAR
Project realization period (from dd/mm/yyyy to dd/mm/yyyy):	Start date:01/04/2022 - End date:30/06/2022
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q2

2. Project participants information	
2.1. Principal Investigator (PI) and Lead Science and Research Organization (SRO)	
Name and last name of the PI:	Predrag Ivaniš
Academic and research title of the PI:	Full professor
SRO name:	School of Electrical Engineering, University of Belgrade (SEE)
SRO authorized person (legal representative) name and last name:	Prof. dr Dejan Gvozdić

2.2.* Project Partners - Science and Research Organizations (SRO)	
SRO name:	Faculty of Electronic Engineering, University of Niš (FEE-UNI)
SRO authorized person (legal representative) name and last name:	Prof. dr Dragan Mančić, dean
SRO name:	Innovation Center, School of Electrical Engineering, University of Belgrade (ICEF)
SRO authorized person (legal representative) name and last name:	Ilija Radovanović, vice director

*Copy this table as needed to provide information about all Partner SROs.

2.3. Members of the project team		
Name, last name	Academic and research title*	Science and Research Organization (SRO) Acronym
PI: Predrag Ivaniš	Full professor	SEE
P1: Goran Đorđević	Full professor	FEE-UNI
P2: Lazar Saranovac	Full professor	SEE
P3: Zoran Čiča	Associate professor	SEE
P4: Dejan Drajić	Research associate	ICEF
P5: Srđan Brkić	Assistant professor	SEE
P6: Dragomir El Mezeni	Assistant professor	SEE
P7: Vesna Blagojević	Associate professor	SEE

P8: Vladimir Petrović	Teaching assistant	SEE
P9: Haris Turkmanović	Teaching assistant	SEE
P10: Đorđe Sarač	Junior teaching assistant	SEE

*In case of any changes in the status of academic and research titles of team members, submit the appropriate decision on acquiring academic and research title of the team member(s) in question, justifying the change of the status.

2.4. Project team performance
Are the project team members performing their roles and tasks in line with the approved Project Proposal (as presented in the Project Description A, Gantt Chart, Budget and other project documentation)? Is the cooperation between team members adequate? If NO, elaborate.
<p>Project team members are performing roles and tasks fully in line with the approved Project Proposal. In the second quartal our focus was on the creation of an adequate simulation environment that describes the propagation in satellite and 5G communication links. Three papers are presented at the international conference IcETRAN, and one of these papers is selected as the best paper presented in the Section of Telecommunications. Also, one paper is presented at the international conference ICEST, and two papers are finally accepted for presentation at the conference CSNDSP, which will be held in Porto in July this year. A detailed analysis of the GNU radio SDR framework is completed, and the SW architecture for DVB-S2x physical layer implementation is defined. The cooperation between team members is adequate, and the obtained results represent a good starting point for the synergy of the project team in the next quartal.</p> <p>Important parts of the equipment are delivered to the SROs. For the rest of the equipment, that should be delivered to SEE, the public procurement procedure is in the final stage.</p>
During the reporting period, were there any unforeseen circumstances requiring a change in any of the team members, including the PI? (This includes a change of job or contract of a team member, or a change in the research or academic title, longer-term absence like parental leave, inability to work or any other relevant change.) If YES, elaborate.
N/A

3. Progress on implementation and results achieved			
3.1. Milestones - Short description of milestones achieved during the reporting period, with reference to the Project Description and Gantt Chart.			
Milestones title – insert milestone name*	Delivery month (Mx) from Gantt Chart	Milestone reached	If not reached, enter estimated month (Mx)

*Based on milestones planned in Table 3.2d in the Project Description A (Approved Project Proposal - Project Description, in accordance with the Decision of the Managing Board) and Gantt Chart (Annex 3 of the Contract on the Project financing).

3.2. If a milestone is not reached, please explain – based on milestones planned in Table 3.2d in the Project Description A (Approved Project Proposal - Project Description, in accordance with the Decision of the Managing Board) and Gantt Chart (Annex 3 of the Contract on the Project financing). If a milestone is reached, enter N/A.
N/A. No milestones are planned in the second quartal.

3.3. Deliverables - Short description of deliverables achieved during the reporting period, with reference to the Project Description A and Gantt Chart.

Tasks/activities*	Deliverable name**	Delivery month (Mx) from Gantt Chart	Achieved Deliverable	If not achieved, enter estimated delivery month (Mx)
1 WP1 – Project management	D1.3. Quarterly progress reports	M03	Yes	

*Based on tasks presented in Table 3.2c in the Project Description A (Approved Project Proposal - Project Description, in accordance with the Decision of the Managing Board) and Gantt Chart (Annex 3 of the Contract on the Project financing).

**Based on deliverables presented in Table 3.2c in the Project Description A (Approved Project Proposal - Project Description, in accordance with the Decision of the Managing Board) and Gantt Chart (Annex 3 of the Contract on the Project financing).

3.4. If a deliverable is not reached, please explain – based on deliverables presented in Table 3.2c in the Project Description A (Approved Project Proposal - Project Description, in accordance with the Decision of the Managing Board) and Gantt Chart (Annex 3 of the Contract on the Project financing). If a deliverable is reached, enter N/A.

The first quarterly progress report is submitted, conditionally accepted, the signed document is uploaded and the hard copy of the report is timely sent to the Science Fond.
Based on the first quarterly progress report, the payment for the second quartal is processed.
The administrative part of the report (QAR-Q1) is published on the project website (<https://hi-star.etf.bg.ac.rs/deliverables.html>).

3.5. Project results (recommended up to 250 words) – brief summary of the Project progress (briefly describe performed project tasks, activities and results relevant for the current reporting period).

The project progresses as scheduled.

In Q1, WP1, WP2, WP3, WP4, and WP7 have been active.

1.WP1 - Subactivity 1.1: The first quarterly progress report is submitted, conditionally accepted, the signed document is uploaded and the hard copy of the report is timely sent to the Science Fond. The administrative part of the report is published on the project website. Modification of the project budget is proposed and accepted.

2.WP2 - Subactivity 2.1: The analytical models of the 5G communication channels for millimeter waves are analyzed, and used to determine communication system performances. We have made an overview of channel models in hybrid satellite-terrestrial systems. We started to develop our source files for modeling these channels for application in Monte-Carlo simulations, as well as effective mathematical models that helped us in the analytical approach to the study of these systems.

3.WP2 - Subactivity 2.2: We finished a reliability analysis of satellite links subjected to deep fades, modeled as burst erasure channels. This analysis is presented at the conference IcETRAN, and the corresponding paper is chosen as the best paper in the Telecommunications section. We evaluated the outage probability of mixed satellite RF - terrestrial FSO cooperative systems. We identified the effects of different channel parameters on outage probability. We focused on physical layer security over satellite-to-ground station links.

4.WP3 - Subactivity 3.1: We completed a detailed analysis of the GNU radio SDR framework and defined the SW architecture for DVB-S2x physical layer implementation. In parallel, we started analyzing 5G NR SDR frameworks and identified Open Air Interface as the only publicly available framework that has the most necessary features and the most commonly used framework in the community.

5.WP3 - Subactivity 3.2: Since GNU radio has been chosen for satellite link SDR framework, we have managed to obtain preliminary code profiling results and confirmed that throughput bottlenecks are LDPC and BCH decoders and encoders. We started hardware implementation of DVB-S2X LDPC decoder and system analysis of BCH decoder.

6.WP4 – Subactivity 4.1: During this quarter, we examined the possibility to use state-of-the-art network simulators like NS-3 to model physical channel variation and handover exactions. Although such simulators are detailed and have many functionalities at this stage it was decided to continue the work on our own simulator that will be able to capture the essence of the problem that we are solving, without introducing unnecessary functionalities.

7.WP4 – Subactivity 4.2: Based on the simulator of the satellite link, that we designed in the previous three—month time period, we examined the influence of the handover execution on the achieved information rate. We obtained bounds after which there is no need to increase the number of links that are used for the handover.

8.WP7 – Subactivity 7.1: The project website is regularly updated. One journal paper is published, four conference papers are presented and two papers are accepted for presentation at international conferences.

3.6. Project deviations (recommended up to 250 words) – In case of any deviation/discrepancy from the Project Description A, briefly describe reasons for its occurrence and appropriate further steps. In case of no deviations/discrepancies, enter N/A.

Project activities are executed fully according to the Project proposal (Annex 1 of the Contract on the Project financing).

There is a significant deviation in the payment schedule related to the timeframe of the purchasing of the Equipment. All pieces of equipment were scheduled for purchase in Q1 of the hi-STAR project. However, due to the need for public procurement of the planned equipment, the procedure of the modification of the public procurement plan has been executed at the leading SRO.

Public procurement for the part of the equipment (Spectral Analyzer, RF connectivity components, and some parts of the IoT equipment) is finished in Q2 and now we expect the delivery of the equipment. For the rest of the equipment (RF-SoC boards and two desktop computers), the public procurement procedure is in the final stage, and we expect the public procurement decisions in the first month of Q3, and the delivery of the equipment in the near future.

Personnel costs for all researchers M6 will be paid in the first half of July, according to a general payment schedule.

3.7. Project risks

3.7.1.a. Foreseen risks - the risks identified in Table 3.3 in the Project Description A – for the current reporting period.

Risk No.	Risk title	Description of risk	Work Packages/Tasks concerned	Risk-mitigation measures (as in Project Description A)
1	Procurement	The procured equipment (RF-SoC development board) delivery delay	Primarily WP3, but also partially WP4	Use similar equipment available at School of Electrical Engineering; lease equipment from third-party company

3.7.1.b. Status of risk mitigation measures				
Risk No.	Risk Title	Did the risk occur?	Did you apply risk mitigation measures?	If the risk still applies, describe the next steps for risk mitigation.
1	Procurement	Yes	No	In this phase of the project, the application of all risk mitigation measures is still not necessary. Public procurement for the part of the equipment (Spectral Analyzer, RF connectivity components, and some parts of the IoT equipment) is finished and we expect the delivery of the equipment. For the rest of the equipment (RF-SoC boards and computer equipment), the public procurement procedure is in the final stage, and we expect the delivery in the next quartal. In the meantime, we will use similar equipment available at School of Electrical Engineering.

3.7.2.a. Unforeseen Risks - describe all the additional risks that were NOT initially identified in Table 3.3 in the Project Description A.				
Risk No.	Risk title	Description of risk	Work Packages/Tasks concerned	Proposed risk-mitigation measures
1	Procurement	WP3	Rapid variation of the exchange rates for USD.	We did not propose any measures, as the risk was not identified in the project proposal.

3.7.1.b. Status of risk mitigation measures (for unforeseen risks)				
Risk No.	Risk Title	Did the risk occur?	Did you apply risk mitigation measures?	If the risk still applies, describe the next steps for risk mitigation.
1	Procurement	Yes	No	RF-SoC boards are the most expensive part of the equipment, that is approved in the budget. It is manufactured by US company Xilinx, and the price is given in US Dollars (USD). In the moment when the previous budget modification was accepted (February 21st) the exchange rate for USD was 1 USD =103.44 RSD. The public procurement procedure is started in April, and a company that could deliver this type of equipment gave the offer in May 15th. In that moment, the exchange rate was 1 USD = 113.08 RSD. As the exchange rate increase of 9.5% prevent us to buy three RFSoc boards, we propose the buget modification (we will buy 2 RFSoc boards and 2 desktop computers instead). The budget modification is accepted at May 20th, and after the completing the related documentaion we started the new public procurement procudeure. In this moment, it is visible at the Public Procurement portal, and we expect the offers in the next ten days.

3.8. Publishable summary* – description (up to 250 words) of the activities and significant results achieved by the project in the reporting period in both English and Serbian.

English (up to 250 words)

In this reporting period, we analyzed separately mmWave terrestrial links, links between satellites and earth stations, and we also considered mixed satellite/terrestrial cooperative systems. We evaluated the performances of the communications systems for the case when hardware imperfections of the receiver are present, and we analyzed the improvement of the error probability due to the application of LDPC codes. The hi-STAR project team has completed the DVB-S2x physical layer software profiling and identified functionalities with the highest processing complexity. The team has started hardware implementation of these bottleneck functionalities in order to achieve higher throughput. In addition to that, 5G NR software frameworks for the physical layer have been analyzed and compared. During the second quarter of the project, our work was also directed to analyze the handover execution in satellite networks with simple but accurate decision metrics. We created the simulation environment that contains different complex propagation conditions and made the first step in designing a handover algorithm that chooses the best radio access network based on the instantaneous signal-to-noise ratio and second-order fading statistics like signal level crossing rate. At this stage of the project, we are focused on the handover algorithms that use a small number of attributes, due to implementation reasons.

Serbian (up to 250 words)

U prethodnom tromesečnom periodu posebno smo analizirali zemaljske linkove sa milimetarskim talasima, linkove između satelita i zemaljskih stanica, kao i kooperativne sisteme koji uključuju i satelitske i zemaljske linkove. Izvršena je procena performansi telekomunikacionih sistema u slučaju kada su u prijemniku prisutne hardverske nesavršenosti, a zatim je analizirana mogućnost smanjenja verovatnoće greške primenom LDPC kodova. Tim hi-STAR projekta je kompletirao softversko profilisanje fizičkog sloja DVB-S2x sistema i identifikovao funkcionalnosti sa najvećom kompleksnošću obrade. Tim je započeo hardversku implementaciju ovih kritičnih funkcionalnosti, u cilju postizanja većeg protoka. Pored toga, obavljena je analiza i poređenje dostupnih softverskih rešenja za fizički nivo 5G NR sistema. Tokom drugog kvartala rada na projektu, naši napori su bili usmereni na analizu izvršavanja hendovera u satelitskim mrežama, koristeći jednostavnu ali preciznu metriku za odlučivanje. Kreirali smo simulaciono okruženje koje može opisati različite složene propagacione scenarije i napravili prve korake u dizajniranju algoritma hendovera koji bira najbolju pristupnu radio mrežu na osnovu trenutnog odnosa signal-šum i statistika drugog reda, kao što je broj preseka zadatog nivoa u jedinici vremena. U ovoj fazi projekta, fokusirani smo na hendover algoritme koji koriste mali broj atributa, usled implementacionih ograničenja.

*This summary should clearly explain the key features of the Project to a non-scientific audience. The Publishable summary for the current reporting period should not consist of more than 250 words. It should focus on achievements to date and how these will generate impact. The Publishable summary can be used by the Science Fund of the Republic of Serbia for promoting and demonstrating the value and impact of the Project.

4. Dissemination*

4.1. Scientific publications – Insert the full reference with the link of the publication: article in journal, publication in conference/workshop, book/monograph, book chapter etc.

In Q2 one journal paper and four conference papers were accepted and published:

[1] P. Ivaniš, S. Brkić, and B. Vasić, "Suspicion Distillation Gradient Descent Bit-Flipping Algorithm," *Entropy* 24, no. 4: 558, April 2022 (web: <https://www.mdpi.com/1099-4300/24/4/558#cite>, DOI: <https://doi.org/10.3390/e24040558>, impact factor: 2.738).

[2] S. Brkić, Z. Čiča, A. Radošević, Đ. Sarač, P. Ivaniš, "Reliability of Earth - Space Links under Deep Fades with Interleaved Reed - Solomon Codes," in *Proc 9th IcETRAN 2022*, TEI 1.5, Novi Pazar, Serbia, 6-9 June 2022, <https://www.etrans.rs/2022/en/proceedings/> (selected as the best paper presented in the Section of Telecommunications).

- [3] J. Milojković, S. Brkić, J. Čertić, "On Pulse Shaping for Generalized Faster than Nyquist Signaling with and without Equalization," in *Proc 9th IcETRAN 2022*, TEI 1.1, Novi Pazar, Serbia, 6-9 June 2022, <https://www.etrans.rs/2022/en/proceedings/>.
- [4] G. T. Djordjevic, J. Makal, B. Vasic, and B. Vasic, "Effect of Phase Noise on Error Probability of MPSK Receiver over TWDP Channel - Simulation Study," in *Proc. 9th IcETRAN 2022*, TEI 1.6, Novi Pazar, Serbia, 6-9 June 2022, <https://www.etrans.rs/2022/en/proceedings/>.
- [5] G. Djordjevic, N. Milosevic, J. Makal, and D Milic, "Outage Probability of Mixed Satellite RF / Terrestrial FSO Cooperative System", in *Proc 57th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST 2022)*, Ohrid, North Macedonia, 16-18 June 2022, https://icestconf.org/wp-content/uploads/2022/06/ICEST2022_PROGRAM.pdf.

Also, two papers are finally accepted, but not published or presented in Q2 (will be presented in Q3):

- [6] G. T. Djordjevic, I. B. Djordjevic, "Multidimensional LDPC-coded signal transmission over TWDP fading channel," status: accepted for presentation at conference *13th IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP2022)*, Porto, Portugal, 20-22 July (<https://csndsp2022.av.it.pt/>).
- [7] J. Anastasov, P. Ivanis, J. Makal, G. Djordjevic, D. Milic, "On the Secrecy Analysis of Satellite-Terrestrial Communication Link over Gamma-Shadowed Ricean Fading Channels", status: accepted for presentation at conference *13th IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP2022)*, Porto, Portugal, 20-22 July (<https://csndsp2022.av.it.pt/>).

*Please keep in mind that only activities that are properly labelled according to promotion, publicity and visibility rules as stated in the Contract of the Project financing will be accepted as Project results. As additional documentation, please submit a copy of the main pages of all publications.

4.2. Type of dissemination and communication activities*

The website of the project <https://hi-star.etf.bg.ac.rs/> is updated.
The project results are presented at conferences IcETRAN and ICEST, as well as in the journal Entropy.
One of the papers presented at the IcETRAN conference is selected as the best paper presented in the Section of Telecommunications.

*List only activities directly linked to the Project like organization of a conference, workshop, press release, website, social media, training etc. Provide the website/social media link for this reporting period. As additional documentation, please submit visibility activities supporting documentation (e.g. workshop materials, pictures, promotion materials etc.).

5. Ethical approvals (if applicable)

No.	Ethical approval*	Period covered by the ethical approval	Issuing authority	State which SRO is covered by the ethical approval	State which work package/task is covered by the ethical approval

*List all documentation (approvals, decisions etc.) required by relevant laws.

5.1. If the ethical approval has not been obtained, please elaborate.

N/A.
Ethical approval is not required for this project.

6.1 Environment - Please indicate if your research involves use of potentially hazardous or harmful elements for the environment (such as chemicals, polluting substances etc.). In case your answer is yes, please elaborate how do you ensure environment protection in compliance with the official standards in Serbia. Please list official protocols or permissions obtained by the public authorities you follow, if any.

N/A

6.2 Health and Safety - Please indicate if your research involves activities potentially hazardous for the workers' health (e.g. field work in dangerous terrain, laboratory work etc.). In case your answer is yes, please elaborate safety measures you undertake prior to, and during those activities in compliance with the official standards in Serbia. Please list official protocols you follow, if any.

N/A

7. Additional information relevant for Project implementation (if needed)

N/A

8. Date and signature

We hereby confirm that all information in the Quarterly Administrative Report is accurate.

Name and last name of the authorized person

- | | |
|---|--------------------|
| 1. _____ | <u>15.07.2022.</u> |
| Leading SRO (stamp) | date |
| Prof. Milo Tomašević | |
| 2. _____ | <u>15.07.2022.</u> |
| Project PI | date |
| Predrag Ivaniš | |
| 3. _____ | <u>15.07.2022.</u> |
| SRO 1 (stamp) | date |
| Prof. dr Dragan Mančić, dean | |
| 4. _____ | <u>15.07.2022.</u> |
| SRO 2 (stamp) | date |
| Ilija Radovanović, vice director | |