

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:01/01/2023 - End date:31/03/2023
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q5

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:	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	Full professor	SEE
P4: Dejan Drajić	Senior 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	Assistant professor	SEE

P9: Haris Turkmanović	Teaching assistant	SEE
P10: Đorđe Sarač	Junior research 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. 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 quarter.</p> <p>In the fifth quarter, our focus was on hybrid user terminal development. More realistic channel simulators that will be used in HUT are developed. We continued the implementation of missing hardware blocks and started the implementation of software infrastructure on the RF-SoC platform. The simulation environment applicable to model the radio access network (RAN) is created, and it consists of multiple LEO satellites with desired constellations. We started the research that will explain our findings related to multiple-RAN-connections user terminals and their ability to increase information throughput, reduce the number of handovers and minimize link blockage probability. The analysis of HUT and NC interconnection is performed, because this aspect has a great impact on the final PoC demo, as well as on HUT implementation.</p> <p>Two papers are published in the international journal from the JCR list - one paper is published in the journal Mathematics (accepted in Q4, but published in January), and another paper is accepted and published in the journal Drones in February. Two papers are presented at the international conference Infoteh 2023, which was held in East Sarajevo (Jahorina) in March 2023. The project hi-STAR was also presented at the conference Infoteh 2023.</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.
<p>P3 - Zoran Čiča changed the research title in Q5. He was promoted to full professor (his previous title was an associate professor) on the 13th of February, 2023. The corresponding documentation is already sent by e-mail, and we have added the corresponding document as an attachment for this report.</p> <p>P9 - Haris Turkmanović changed the research title in Q5. He was promoted to teaching assistant (his previous title was also teaching assistant) on the 17th of January, 2023. The corresponding documentation is already sent by e-mail, and we have added the corresponding document as an attachment for this report.</p>

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	M12	Yes	
2 WP1 - Project management	D1.4 Annual project review reports	M12	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.

D1.3 - The fourth quarterly progress report is submitted, the signed document is uploaded and the hard copy of the report is timely sent to the Science Fund. The report is finally accepted, and the payment for the fifth quartal is processed. The administrative part of the report (QAR-Q4) is published on the project website (<https://histar.etf.bg.ac.rs/deliverables.html>).

D1.4 - The first annual progress report is submitted, the signed document is uploaded and the hard copy of the report is timely sent to the Science Fund. The report is finally accepted. The administrative part of the report (AAR-Q4) is published on the project website (<https://histar.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 Q5, WP1, WP2, WP3, WP4, WP5, and WP7 have been active.

WP1 - Subactivity 1.1: The fourth quarterly progress report and the first annual report are submitted, the signed documents are uploaded and the hard copy of the report is timely sent to the Science Fund. The both reports are accepted, and the administrative part of the report is published on the project website. The budget of the project is modified, according to the requirements of the Science Fund.

WP2 - Subactivity 2.1: We have finished developing the method of generating shadowed Ricean fading with desired statistical properties, which we will use to simulate the satellite-terrestrial link of the land mobile satellite (LMS) channel. This simulator will be used in WP4, to identify the corresponding attributes at the satellite-terrestrial links.

WP2 - Subactivity 2.2: We developed an analytical framework for the design and analysis of new-generation mobile networks' fronthaul/backhaul links based on the application of free-space optical (FSO) technology. Taking the receiver hardware imperfections into account, we present an efficient analytical approach to analyzing average symbol error probability. Also, we have analyzed an energy-constrained Internet of Things (IoT) system, where the collection of sensor data is realized using an unmanned aerial vehicle (UAV), which represents the aerial part of the system that enables the further transfer of collected data to the hybrid satellite/5G network.

WP3 - Subactivity 3.2: LDPC decoder is nearly completed. Implementation of other missing blocks is started with mapper and demapper for 5G NR.

WP3 - Subactivity 3.3: Implementation of software infrastructure on the ARM platform is started. The goal is to establish communication between two boards using Ethernet interface and to enable data transfer to hardware accelerators using DMA.

WP4 - Subactivity 4.1: During this quarter we mainly finished the creation of a simulation environment related to the satellite radio access network.

WP4 - Subactivity 4.2: Most of our work, related to this subactivity, was oriented to writing a conference paper, where we plan to publish our findings related to traffic management in multi radio access networks (RANs).

WP4 - Subactivity 4.3: We investigated potential architectures related to the implementation of multi-RAN user terminals.

WP5 - Subactivity 5.1: Based on conducted tests of data communication between the simulated user equipment and the core network in the OpenAirInterface environment, nFAPI protocol is identified as a protocol that should be used in the proof of concept demo for interconnecting HUT to the core network. Regarding the gateway multipath transport protocol support which is necessary for the desired HUT functionalities, two approaches have been identified: implementation of multipath support in the transport layer as a Linux module or in the application layer as part of the gateway application.

WP5 - Subactivity 5.1: Literature research has been conducted for 5G networks to identify existing state-of-the-art approaches and open issues. Also, analysis and classification of services and their requirements have been conducted because the service classes and their requirements should impact service and traffic distribution across the cells.

WP7 – Subactivity 7.1: The project website is regularly updated. Website, google analytics, and social networks KPIs are followed regularly.

WP7 – Subactivity 7.2: Journal paper accepted for publication in Q4 2022 is published and one more journal paper is published. hi-STAR project and two conference papers are presented at an international conference.

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 deviation in the payment schedule related to the timeframe of the purchasing of the Equipment. Although most pieces of equipment are delivered during the first project year, the purchase of some parts of the IoT equipment, with an estimated price of less than 1% of the total costs of the overall equipment, is not finished. It is not available for delivery in the Serbian market, and we expect the delivery of these devices during the second project year.

Personnel costs for all researchers in M15 will be paid in the first half of April, 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 (Raspberry PI) delivery delay	Primarily WP5, but also partially WP6	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 (Raspberry PI) is finished and we expect the delivery during the next year. The rest of the equipment is delivered. The equipment is planned to be used in the second half of the second year. If necessary, 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

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.

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)
The hi-STAR project team continues the implementation of missing hardware blocks. Implementation of software infrastructure on the RF-SoC platform started this quarter. During the reporting period, we created the simulation environment applicable to model the radio access network (RAN) which consists of multiple LEO satellites, with desired constellations. We started preparing a conference paper that will explain our findings related to multiple-RAN-connections user terminals and their ability to increase information

throughput, reduce the number of handovers and minimize link blockage probability. The major activity in the last three months was analysis of HUT and NC interconnection because this aspect has a great impact on the final PoC demo, as well as on HUT implementation. The next major activity was multipath transport protocol support analysis because this support is mandatory for HUT's main functionalities such as traffic switching between different radio technologies without interrupting HUT's established communication sessions.

Serbian (up to 250 words)

Hi-STAR tim nastavlja implementaciju nedostajućih hardverskih blokova. Implementacija softverske infrastrukture na RF-SoC platformi je započeta u tekućem kvartalu. U toku perioda koji je opisan u ovom izveštaju napravljen je simulacioni model, koji opisuje ponašanje korisničkog terminala sa mogućnošću konekcije preko više satelita, smeštenih u niskim orbitama. Započeto je pisanje konferencijskog rada koji će predstaviti performanse takvog korisničkog terminala sa posebnim osvrtom na povećanje informacionog protoka, smanjenje broj handover-a i minimizaciju verovatnoće otkaza linka. Glavna aktivnost u prethodna tri meseca je bilo razmatranje kako povezati HUT koji je cilj projekta i postojeći NC pošto to ima višestruki uticaj na konačni PoC demo, kao i na implementaciju HUT-a. Druga bitna aktivnost je bila razmatranje pristupa koji bi se koristio za implementaciju podrške za višestruke putanje na nivou transportnog protokola pošto je ta podrška neophodna za funkcionalnosti koje treba da ponudi HUT a koje su njegova suština poput preusmeravanja saobraćaja na drugu radio tehnologiju bez prekida uspostavljene sesije.

*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.

Two journal papers are published in the international journal from the JCR list:

[1] M. Petković, G. T. Đorđević, J. Makal, Z. Marjanović, G. V. Milovanović, "Error Probability of a Coherent M-ary PSK FSO System Influenced by Phase Noise", *Mathematics*, vol. 11, no. 1, paper no. 121, January 2023 (type of scientific publication: article in journal; journal ranking: M21a; publication status: published; Open Access: yes; web: <https://www.mdpi.com/2227-7390/11/1/121>, DOI: 10.3390/math11010121, impact factor: 2.592).

[2] A. Cvetković, V. Blagojević, J. Manojlović, "Capacity Analysis of Power Beacon-Assisted Industrial IoT System with UAV Data Collector", *Drones*, vol. 7, no. 2, paper no. 146, February 2023, (type of scientific publication: article in journal; journal ranking: M21; publication status: published; Open Access: yes; web: <https://www.mdpi.com/2504-446X/7/2/146/htm>, DOI: 10.3390/drones7020146, impact factor: 5.532).

Two papers are presented at the international conference Infotech 2023:

[3] P. Ivaniš, V. Blagojević, G. Đorđević, "The method of generating shadowed Ricean fading with desired statistical properties", 2023 22nd International Symposium INFOTEH-JAHORINA (INFOTEH 2023), East Sarajevo, Bosnia and Herzegovina, 15-17 March 2023 (type of scientific publication: publication in conference; publication status: published; Open Access: no; web: <https://ieeexplore.ieee.org/document/10094201>, DOI: 10.1109/INFOTEH57020.2023.10094201).

[4] I. Stanić, D. Drajić, Z. Čiča, "Survey of Network Selection and Vertical Handover Techniques in Heterogeneous Wireless Networks", 2023 22nd International Symposium INFOTEH-JAHORINA (INFOTEH 2023), East Sarajevo, Bosnia and Herzegovina, 15-17 March 2023 (type of scientific publication: publication in conference; publication status: published; Open Access: no; web: <https://ieeexplore.ieee.org/document/10094090>, DOI: 10.1109/INFOTEH57020.2023.10094090).

*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. Website google analytics and social networks KPIs are followed regularly.

Two papers are published in the international journal from the JCR list - one paper is published in the journal Mathematics, and another paper is published in the journal Drones. The project results are presented at the conference Infoteh 2023 (two papers).

hi-STAR project is presented at the international conference Infoteh 2023.

*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

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>15.04.2023.</u> |
| Leading SRO (stamp) | date |
| dr. Dejan Gvozdić | |
| 2. _____ | <u>15.04.2023.</u> |
| Project PI | date |
| Predrag Ivaniš | |
| 3. _____ | <u>15.04.2023.</u> |
| SRO 1 (stamp) | date |
| Prof. dr Dragan Mančić, dean | |
| 4. _____ | <u>15.04.2023.</u> |
| SRO 2 (stamp) | date |
| Ilija Radovanović, vice director | |