

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:01/04/2023 - End date:30/06/2023
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q6

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
P11: Ivan Vajs	Junior research assistant	ICEF

*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.

<p>2.4. Project team performance</p>
<p>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>
<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 sixth quarter, our focus was on WP2, WP3, and WP4. In the reporting period, we have created and tested the simulation environment that incorporates the shadowed-Rician propagation model, for the satellite communication channels and a two-wave with diffuse-power channel model for the terrestrial communication. Also, we have proposed and tested an initial TCM (traffic control module) and verified the improvements in terms of achievable spectral efficiency and data loss rate. LDPC and BCH encoder and decoder accelerators for SATCOM are completed, and these accelerators support all standard codes from the DVB-S2X communication standard. Communication between RF-SoC boards and one PC host using an Ethernet interface is established using Linux OS. The initial version of the GUI application is developed to enable easier communication control.</p> <p>One paper is published in the international journal from the JCR list, in the journal Sensors (published in May). Three papers are presented at the international conference IcETRAN 2023, which was held in East Sarajevo in June 2023. Our paper, presented at the IcETRAN 2023 conference, was selected as the best paper presented in the Section of Telecommunications. Our other paper was selected as the best paper of the young author presented in the same section. The hi-STAR project is presented at the Second ICEF workshop - Presentation of scientific research work.</p>
<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>
<p>P10 - Đorđe Sarač is not engaged in the project starting from May 25th. His research title (Junior research assistant) expired on May 24th. The corresponding documentation is already sent by e-mail, and a new version of the application info document, gant chart, budget, and payment schedule was filled and approved by the Science Fund.</p> <p>P11 - Ivan Vajs is engaged in the project starting from May 25th, as a replacement for Đorđe Sarač. His research title is Junior research assistant. The corresponding documentation is already sent by e-mail, and a new version of the application info document, gant chart, budget, and payment schedule was filled and approved by the Science Fund.</p>

<p>3. Progress on implementation and results achieved</p>
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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)
1	M2.1 Integrated 5G/Sat network architecture proposal	M18	Yes	

*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				

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	M18	Yes	
2	WP2 - System architecture and attributes selection	D2.2. HUT architecture	M18	Yes	
3	WP4 - Hybrid user terminal development	D4.1. Traffic control unit based on deep neural network learning	M18	Yes	
4	WP7 - Dissemination and communication activities	D7.2. Mid-term report on dissemination and communication activities	M18	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 fifth 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 quarter is processed. The administrative part of the report (QAR-Q5) is published on the project website				

(<https://hi-star.etf.bg.ac.rs/deliverables.html>).

D2.2 - The deliverable is published on the project website (<https://hi-star.etf.bg.ac.rs/deliverables.html>).

D4.1 - The deliverable is published on the project website (<https://hi-star.etf.bg.ac.rs/deliverables.html>).

D7.2 - The deliverable 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 Q5, WP1, WP2, WP3, WP4, WP5, and WP7 have been active.

WP1 - Subactivity 1.1: The fifth quarterly progress report is submitted, the signed documents are uploaded, and the hard copy of the report is timely sent to the Science Fund. The report is accepted, and the administrative part of the report is published on the project website.

WP1 - Subactivity 1.2: Junior research assistant Ivan Vajs (P11) was engaged in the project starting from May 25th, as a replacement for the researcher Đorđe Sarač (P10). The corresponding documentation is already sent by e-mail, and a new version of the application info document, gant chart, budget, and payment schedule was filled and approved by the Science Fund.

WP2 - Subactivity 2.1: We have performed the outage probability analysis of the hybrid integrated satellite-terrestrial communication systems, where the reliability of the system is increased by using the cooperative relay. The closed-form expression of the outage probability is derived for the case when the propagation of the satellite-terrestrial links is described by using the shadowed Ricean fading model and the propagation of the terrestrial links is described by using the Nakagami fading model, both with integer-valued fading parameters. The analysis takes into account the system geometry and realistic channel parameters.

WP2 - Subactivity 2.2: We consider the inclusion of Low-Earth-Orbit (LEO) satellites in the terrestrial mobile network. We study the transmission of information from an LEO satellite to a mobile terminal on the surface of the Earth. Signal transmission is performed with the help of a relay on Earth that applies a decode-and-forward (DF) strategy. For the channel from the satellite to the relay, a channel model is used that includes multipath propagation, where there is one dominant and many non-dominant components, where both the dominant and non-dominant components are under the influence of the shadow effect. After decoding in the relay and amplification, the signal is further transmitted in the millimeter range to the mobile terminal. A numerical procedure for calculating the outage probability is developed, and then an analysis of the influence of the parameters of both channels on the outage probability is performed.

WP3 - Subactivity 3.2: LDPC and BCH encoder and decoder accelerators for SATCOM are completed. These accelerators support all standard codes from the DVB-S2X communication standard.

WP3 - Subactivity 3.3: Communication between RF-SoC boards and one PC host using an Ethernet interface is established using Linux OS. The initial version of the GUI application is developed to enable easier communication control.

WP4 - Subactivity 4.1: In the reporting period we have created and tested the simulation environment that incorporates the shadowed-Rician propagation model, for the satellite communication channels and a two-wave with diffuse-power channel model for the terrestrial communication

WP4 - Subactivity 4.2: We have proposed and tested an initial TCM (traffic control module), according to Subactivity 4.2, and verified the improvements in terms of achievable spectral efficiency and data loss rate.

WP4 - Subactivity 4.3: We have made an initial analysis related to the hardware resources needed to implement TCM in FPGA chips.

WP5 - Subactivity 5.1: Gateway multipath transport protocol support approaches for PoC (Proof of Concept) demo have been analyzed. Application layer implementation has been selected because it offers greater flexibility regarding implementation and performance testing which are important aspects in the developing stage of the solution that will be used in PoC.

WP5 - Subactivity 5.2: Service classes have been identified and default settings regarding their traffic steering and splitting have been analyzed. Based on service requirements, analysis of relevant traffic parameters is undertaken to identify the most important ones for optimizing traffic distribution between the cells.

WP7 – Subactivity 7.1: The project website is regularly updated. Website, Google Analytics, and social networks KPIs are monitored regularly.

WP7 – Subactivity 7.2: One Journal paper is published and three conference papers are presented at an international conference. hi-STAR project is presented at the Second ICEF workshop - Presentation of scientific research work.

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 M18 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 (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	Did you apply risk	If the risk still applies, describe the next steps for risk mitigation.
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		occur?	mitigation measures?	
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)

hi-STAR project team completed the required hardware accelerators supporting the satellite communication channel. Software infrastructure enabling communication between RF-SoC boards and PC is developed using an Ethernet interface. In the reporting period, we have finished the multi-RAN simulator that is used to verify the performance of TCM units. We have also tested our TCM unit and verified the benefits of establishing multi-RAN connections and performing user-centric handover operations. An important activity was related to the selection of an implementation approach for multipath transport protocol support because this has a major impact on the end-point design (gateway and user side). The application layer approach has been selected because this approach provides better flexibility in testing various designs and the possibility to work in different environments which are major aspects in the initial development stage. Also, an analysis of nFAP messages has been conducted because these messages will be used in the PoC demo. The website of the project <https://hi-star.etf.bg.ac.rs/> is updated. Website Google Analytics and social networks KPIs are followed regularly. One journal paper is published in the international journal from the JCR list (MDPI Sensors), and three conference papers are published at the IcETRAN conference. Our paper, presented at the IcETRAN 2023 conference, was selected as the best paper presented in the Section of Telecommunications. Our other paper was selected as the best paper of the young author presented in the same section. hi-STAR project is presented at the Second ICEF workshop - Presentation of scientific research work.

Serbian (up to 250 words)

hi-STAR tim je kompletirao razvoj akceleratora neophodnih za realizaciju satelitske komunikacije. Softverska infrastruktura koja omogućava međusobnu komunikaciju RF-SoC ploča i PC-a je razvijena korišćenjem Ethernet interfejsa. U toku prethodna tri meseca završen je rad na simulatoru procene performansi korisničke komunikacije preko više pristupnih mreža. Testiran je dizajnirani modul za upravljanjem saobraćajem i kvantifikovane su prednosti višestrukog pristupa i adaptivnog odabira pristupne mreže. Važna aktivnost je bila vezana za izbor implementacionog pristupa podrške za višestruke putanje

transportnih protokola pošto to utiče na dizajn krajnjih tačaka u PoC (gejtveja i korisničke strane). Izabrana je implementacija na aplikacionom sloju iz razloga fleksibilnosti testiranja različitih pristupa i mogućnosti rada u različitim okruženjima što je bitno za inicijalni razvoj. Takođe je urađena analiza poruka nFAPI protokola pošto će te poruke biti korištene kada se bude razvio PoC demo. Web sajt projekta <https://hi-star.etf.bg.ac.rs/> se redovno ažurira, a KPIevi Google analitike veb-sajta i društvenih mreža se redovno prate. Objavljen je dan rad u međunarodnom časopisu sa JCR liste i tri rada na međunarodnoj konferenciji IcETTRAN 2023 proglašen je za najbolji rad u sekciji Telekomunikacije, dok je drugi naš rad proglašen za najbolji rad mladog autora u istoj sekciji. Jedan naš rad, prezentovan na konferenciji hi-STAR projekat je predstavljen na Drugoj ICEF radionici - Prezentacija naučnoistraživačkog rada.

*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.

One journal paper is published in the international journal from the JCR list:

[1] N. Kozić, V. Blagojević, A. Cvetković, P. Ivaniš, "Performance Analysis of Wirelessly Powered Cognitive Radio Network with Statistical CSI and Random Mobility," Sensors, vol. 23, no. 9, paper no. 4518, May 2023

(type of scientific publication: article in journal; journal ranking: M21; publication status: published; Open Access: yes; web: <https://www.mdpi.com/1424-8220/23/9/4518>, DOI: 10.3390/s23094518, impact factor: 3.847).

Three papers are presented at the international conference IcETTRAN 2023:

[1] J. Milojković, P. Ivaniš, V. Blagojević, S. Brkić, "Performance analysis of land mobile satellite-terrestrial systems with selection relaying", in Proc. 10th IcETTRAN 2023, TEI 1.2, East Sarajevo, Bosnia and Herzegovina, June 5-8, 2023 (type of scientific publication: publication in conference; publication status: published; Open Access: no; temporary link on the web: https://www.etrans.rs/2023/E_PROCEEDINGS_ICETTRAN_2023/IcETTRAN23_RADОВI/TEI1.2.pdf, permanent link will be available soon at <https://ieeexplore.ieee.org/Xplore/home.jsp>). This paper was selected as the best paper presented in the Section of Telecommunications (<https://www.etf.bg.ac.rs/en/news/2023/06/participation-of-etf-in-the-oldest-conference-etrans>).

[2] G. Djordjevic, N. Milosevic, J. Makal, B. Vasic, P. Ivanis, "Outage Performance of Mixed Shadowed Ricean/TWDP Relayed Assisted Link", in Proc. 10th IcETTRAN 2023, TEI 1.7, East Sarajevo, Bosnia and Herzegovina, June 5-8, 2023 (type of scientific publication: publication in conference; publication status: published; Open Access: no; temporary link on the web: https://www.etrans.rs/2023/E_PROCEEDINGS_ICETTRAN_2023/IcETTRAN23_RADОВI/TEI1.7.pdf, permanent link will be available soon at <https://ieeexplore.ieee.org/Xplore/home.jsp>).

[3] B. Živkovic, Z. Čica, "Network Traffic Capturing in Open-Source 5G Core Network Platform", in Proc. 10th IcETTRAN 2023, TEI 1.8, East Sarajevo, Bosnia and Herzegovina, June 5-8, 2023, (type of scientific publication: publication in conference; publication status: published; Open Access: no; temporary link on the web: https://www.etrans.rs/2023/E_PROCEEDINGS_ICETTRAN_2023/IcETTRAN23_RADОВI/TEI1.8.pdf, permanent link will be available soon at <https://ieeexplore.ieee.org/Xplore/home.jsp>). This paper was selected as the best paper of the young author presented in the Section of Telecommunications (<https://www.etf.bg.ac.rs/en/news/2023/06/participation-of-etf-in-the-oldest-conference-etrans>).

*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.
One journal paper is published in the international journal from the JCR list (MDPI Sensors), and three conference papers are published at the IcETRAN conference.
Our paper, presented at the IcETRAN 2023 conference, was selected as the best paper presented in the Section of Telecommunications. Our other paper was selected as the best paper of the young author presented in the same section.
hi-STAR project is presented at the Second ICEF workshop - Presentation of scientific research work.

*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.

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.

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.

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

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

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|---|--------------------|
| 1. _____ | <u>11.07.2023.</u> |
| Leading SRO (stamp) | date |
| dr. Dejan Gvozdić | |
| 2. _____ | <u>11.07.2023.</u> |
| Project PI | date |
| Predrag Ivaniš | |
| 3. _____ | <u>11.07.2023.</u> |
| SRO 1 (stamp) | date |
| Prof. dr Dragan Mančić, dean | |
| 4. _____ | <u>11.07.2023.</u> |
| SRO 2 (stamp) | date |
| Ilija Radovanović, vice director | |