

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:01/01/2024 - End date:31/03/2024
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q9

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	Research assistant	ICEF
P12: Goran Marković	Associate professor	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.

<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>Regarding 5G/Sat transceivers, coding and decoding accelerators are implemented and tested. Other elements of transceivers will be implemented in the software. Integration of accelerator components is stalled and the current focus is on the implementation of complete functional HUT based on Linux application. Developed accelerators will be eventually used in the later stages after the entire HUT communication chain is established. The work regarding task 4.3 was conducted in order to develop the management of data traffic steering and switching logic on the RFSoc platform. The software was upgraded to accommodate multiple parallel TCP/UDP servers and client connections, which are responsible for efficient data traffic steering. Moreover, the existing software's data control logic was expanded to enable the periodic transmission of channel statistics to the main gateway machine, where the core logic for the HUT is situated. To facilitate traffic switching, the HUT logic core implemented on the gateway machine in the form of a GUI application was extended to support the reception and analysis of data statistics. Work on test environment design to measure the impact of latency and packet loss rate for various combinations of their values to optimally define multipath transport protocol setting for different parameter values.</p> <p>Performed throughput measurements for different link parameter combinations for multipath transmission control protocol (MP-TCP). In order to examine the performance of HUT, channel conditions in terrestrial and land-satellite channels need to be emulated. Channel models are described by probability density functions and autocorrelation functions and both of these functions need to be appropriately emulated. For the land-satellite communication, a shadowed-Rician channel model is used, which is composed of scattering and shadowing components - independently modeled by Nakagami-m and Rayleigh distributions. Nakagami-m and Rayleigh distributed processes can be emulated by a modified Jakes model, or in a two-step approach 1) first model uncorrelated Nakagami-m and Rayleigh samples and then 2) use autoregressive moving average (ARMA) model to insert desired level of correlation among them. The second modeling approach is chosen due to easier implementation: it requires CORDIC blocks for sample generation and FIR and IIR filters for ARMA block. The terrestrial channel model is called TWDP (two-wave with diffuse power) fading model and it is emulated in similar fashion: first, uncorrelated samples are generated and then the ARMA block is used for final sample shaping.</p> <p>One paper was submitted to the international journal indexed in the JCR list. One paper was submitted in the international conference CSNDSP 2024.</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>

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)
1	M3.2 Integrated 5G/Sat high-throughput transceiver	M24	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	D 1.3 - Quarterly progress reports	M24	Yes	
2	WP1	D 1.4 - Annual progress reports	M25	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.	
N/A	

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 Q8, WP1, WP3, WP4, WP5, and WP7 were active.

WP1 - Subactivity 1.1: The eighth quarterly progress report and the annual progress report for the second year were submitted, the signed documents were uploaded, and the hard copy of the report was sent to the Science Fund. The reports were accepted, and the administrative part of the report was published on the project website. The modified budget was approved, the signed documents were uploaded, and the hard copy of the report was sent to the Science Fund.

WP3 - Subactivity 3.2: Regarding 5G/Sat transceivers, coding and decoding accelerators are implemented and tested. Other elements of transceivers will be implemented in the software.

WP3 - Subactivity 3.3: Integration of accelerator components is stalled and the current focus is on the implementation of complete functional HUT based on Linux application. Developed accelerators will be eventually used in the later stages after the entire HUT communication chain is established.

WP4 - Subactivity 4.3: The software was upgraded to accommodate multiple parallel TCP/UDP servers and client connections, which are responsible for efficient data traffic steering. Moreover, the existing software's data control logic was expanded to enable the periodic transmission of channel statistics to the main gateway machine, where the core logic for the HUT is situated. To facilitate traffic switching, the HUT logic core implemented on the gateway machine in the form of a GUI application was extended to support the reception and analysis of data statistics.

WP5 - Subactivity 5.2: Work on test environment design to measure the impact of latency and packet loss rate for various combinations of their values to optimally define multipath transport protocol setting for different parameter values. Performed throughput measurements for different link parameter combinations for multipath transmission control protocol (MP-TCP).

WP5 - Subactivity 5.3: Start of preparation of deliverable D5.3 based on previously conducted analyses.

WP6 - Subactivity 6.1: To examine the performance of HUT, channel conditions in terrestrial and land-satellite channels need to be emulated.

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 paper was submitted to the international journal Entropy, indexed in the JCR list. One paper was submitted in the international conference CSNDSP 2024 (Rome).

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

Personnel costs for all researchers in M27 will be paid in the first half of April 2024, 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)

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.

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 development of functional HUT is continued by adapting current applications on RF-SoC platforms to support additional communication streams. Channel models are analyzed and a two-step approach is adopted enabling simpler hardware architecture of the emulator module. During the reporting period, we were mostly oriented on writing the journal paper, where we plan to publish our findings related to handover procedures executed based on the machine learning models. Technical work was oriented toward developing a set of functionalities necessary for supporting the complete integration of the HUT into the RF-SoC platform. The major activity was multipath transport protocol performance measurements for different parameter combinations of links. Possibilities to include link state information in transport protocol were considered to improve reaction speed to link state variations. Work on deliverable D5.3, related to use cases and business models of hybrid user access, has been started.
Serbian (up to 250 words) Razvoj funkcionalnog HUT-a je nastavljen prilagođavanjem aplikacije na RF-SoC platformama kako bi podržala dodatne komunikacione tokove podaka. Analizirani su modeli kanala i usvojen je dvostepeni pristup

kojim se omogućava jednostavnija hardverska arhitektura emulatora. U toku prethodnog tromesečnog perioda rad na WP4 je bio usmeren na pripremu rada u časopisu koji bi sadržao rezultate istraživanja vezane za procenu performansi HUT modula. Tehnički rad u tom periodu uključivao je razvoj softverskih funkcionalnosti potrebnih za integraciju HUT modula na RF-SoC platformu. Glavna aktivnost je bila merenje performansi transportnog protokola sa podrškom za višestruke putanje za različite kombinacije parametara linkova. Razmatrane su mogućnosti za uključenje informacija o stanju linka u protokol radi poboljšanja brzine reakcije na promene stanja linka. Započet je rad na izveštaju D5.3 vezan za poslovne modele i najadekvatnije primene hibridnog korisničkog pristupa.

*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 papers are submitted in Q9:

[1] G. T. Djordjevic, P. Ivanis, D. Milic, J. Makal, V. Kafedziski, A Method for Generating Random Process Having Given First- and Second-Order Statistics over FSO Channel, submitted to 2024 14th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP 2024), Rome, Italy.

[2] P. Ivaniš, J. Milojković, V. Blagojević, S. Brkić, Capacity Analysis of Hybrid Satellite-Terrestrial Systems with Selection Relaying, submitted to Entropy journal.

*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*

During Q9 two papers were submitted, and no other dissemination actions were performed.

*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>16.04.2024.</u> |
| Leading SRO (stamp) | date |
| dr. Dejan Gvozdić | |
| 2. _____ | <u>16.04.2024.</u> |
| Project PI | date |
| Predrag Ivaniš | |
| 3. _____ | <u>16.04.2024.</u> |
| SRO 1 (stamp) | date |
| Prof. dr Dragan Mančić, dean | |
| 4. _____ | <u>16.04.2024.</u> |
| SRO 2 (stamp) | date |
| Ilija Radovanović, vice director | |