

## 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:01/10/2023 - End date:31/12/2023
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q8

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:	<b>Faculty of Electronic Engineering, University of Niš (FEE-UNI)</b>
SRO authorized person (legal representative) name and last name:	<b>Prof. dr Dragan Mančić, dean</b>
SRO name:	<b>Innovation Center, School of Electrical Engineering, University of Belgrade (ICEF)</b>
SRO authorized person (legal representative) name and last name:	<b>Ilija Radovanović, vice director</b>

\*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

\*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.

<b>2.4. Project team performance</b>
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 eighth quarter, our focus was on WP3, WP4, and WP5. In the reporting period, the project team has improved the developed software application to enable better control of data flow. Integration of developed IP blocks is in progress. During the reporting period, we tested and verified our handover execution method and compared our solution with state-of-the-art machine learning (ML) techniques that can be alternatively used for the prediction of the communication channel. We only considered a low-complexity ML solution, given that the handover method is placed in the end-user terminal, which prohibits the use of complex optimization methods. One of the major activities was related to completing deliverable D5.1 related to functional gateway design for use in the PoC demo. As well, a milestone regarding the functional 5G network core was reached. Based on detected open research problems regarding asymmetric links in multipath transport protocols we have defined scenarios for testing various combinations of link parameters such as latency, packet losses, and bandwidth. Milestones M4.2 and M5.1 were reached. We inspected two open source environments - OpenAirInterface and free5GC, both are working according to 5G standards and both can be used as a network core in PoC demo (part of the results regarding this milestone was published at the conference IcETRAN 2023 and the paper was awarded in Telecommunications section - Best young researcher's paper).</p> <p>Two conference papers were presented at important international conferences (one paper is an invited paper). Our paper, published in the Sensors journal, was selected as the best paper in the area of Telecommunications, published in an international scientific journal in the year 2022/2023.</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.
No

<b>3. Progress on implementation and results achieved</b>				
<b>3.1. Milestones</b> - Short description of milestones achieved during the reporting period, with reference to the Project Description and Gantt Chart.				
	<b>Milestones title</b> – insert milestone name*	<b>Delivery month (Mx)</b> from Gantt Chart	<b>Milestone reached</b>	<b>If not reached, enter estimated month (Mx)</b>
1	M3.2 Integrated 5G/Sat high-throughput transceiver	M24	No	M27
2	M4.1 HUT algorithm verification	M24	Yes	
3	M5.1 Network core support implementation and verification	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).

<b>3.2. If a milestone is not reached, please explain</b> – 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.
M3.1: Due to the complexity of implementation, it is expected that the development of the integrated 5G/Sat high-throughput transceiver will be finished in M27.

<b>3.3. Deliverables</b> - Short description of deliverables achieved during the reporting period, with reference to the Project Description A and Gantt Chart.					
	<b>Tasks/activities*</b>	<b>Deliverable name**</b>	<b>Delivery month (Mx)</b> from Gantt Chart	<b>Achieved Deliverable</b>	<b>If not achieved, enter estimated delivery month (Mx)</b>
1	WP2, Subactivity 2.2	D2.3. Reliability analysis of 5G/Sat hybrid network	M24	Yes	
2	WP3, Subactivity 3.2	D3.2. FPGA-based accelerators for high-performance 5G/Sat transceivers	M24	Yes	
3	WP4, Subactivity 4.2	D4.2. Simulation and verification of the TCU module	M24	Yes	
4	WP5, Subactivity 5.1	D5.1. Functional network core gateway for PoC	M24	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).

<b>3.4. If a deliverable is not reached, please explain</b> – 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, WP2, WP3, WP4, WP5, and WP7 were active.

WP1 - Subactivity 1.1: The seventh quarterly progress report was submitted, the signed documents were uploaded, and the hard copy of the report was sent to the Science Fund. The report was 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.

WP2 - Subactivity 2.1: The performance analysis of UAV-assisted wirelessly powered network applicable for industrial IoT and emergency applications was performed

WP2 - Subactivity 2.2: Further generalizations of the adaptive diversity gradient-descent bit flipping decoder were considered. While the original AD-GDBF decoder was designed for the binary symmetric channel and used mostly to decode regular LDPC, the generalized algorithm incorporates several improvements that make it eligible for the additive white Gaussian channel and decoding of arbitrary linear block code.

WP3 - Subactivity 3.2: The previously created application was further improved in terms of functionality to support the reception and forwarding of both control and status messages between the computer and the two FPGA boards. Also, within the PC application, a mechanism was added that allows tracking the flow of packets between the device and the PC. This mechanism can be used for quantification of the achieved performance in the following stages.

WP3 - Subactivity 3.3: Integration of developed accelerators into developed software infrastructure using DMA controllers has been started in this quarter.

WP4 - Subactivity 4.2: We compared our handover algorithm, placed in ITCU (Intelligent Traffic Control unit), with several state-of-the-art prediction techniques like the Support vector machine and k nearest neighbor method and verified its superiority.

WP4 - Subactivity 4.3: We also started the handover algorithm software-hardware decomposition.

WP5 - Subactivity 5.1: We performed the functional design of the gateway with multipath TCP support that resulted in Deliverable D5.1.

WP5 - Subactivity 5.2: We worked 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 settings for different parameter values.

WP5 - Subactivity 5.3: We continued business analysis of use cases that would benefit from hybrid access.

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

WP7 – Subactivity 7.2: Two conference papers are presented 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 have been executed fully according to the Project proposal (Annex 1 of the Contract on the Project financing).

Personnel costs for all researchers in M24 will be paid in the first half of January 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 project team improved the developed software application to enable better control of data flow. Integration of developed IP blocks is in progress. During the reporting period, we tested and verified our handover execution method and compared our solution with state-of-the-art machine learning (ML) techniques that can be alternatively used for the prediction of the communication channel. We only considered a low-complexity ML solution, given that the handover method is placed in the end-user terminal, which prohibits the use of complex optimization methods. One of the major activities was related to completing deliverable D5.1 related to functional gateway design for use in the PoC demo. As well, a milestone regarding the functional 5G network core has been reached. Also, based on detected open research problems regarding asymmetric links in multipath transport protocols we defined scenarios for testing various combinations of link parameters such as latency, packet losses, and bandwidth.

**Serbian** (up to 250 words)

Projektni tim je unapredio razvijenu softversku aplikaciju čime je omogućena bolja kontrola toka podataka. U toku je integracija razvijenih IP blokova. U toku vremenskog perioda obuhvaćenog izveštajem, izvršeno je testiranje predloženog ITCU modula i njegova verifikacija u pogledu ostvarenih performansi. Izvršeno je poređenje sa nekoliko značajnih algoritama mašinskog učenja, pri čemu su izabrani najznačajniji algoritmi koji imaju malu kompleksnost i primereni su implementacijama u korisničkom terminalu. Jedna od glavnih aktivnosti je bila kompletiranje izveštaja D5.1 vezanog za funkcionalni dizajn gejtujeja za PoC demo. Dodatno dostignut je milestone vezan za postavljanje funkcionalnog mrežnog jezgra za 5G deo. Takođe, na osnovu detektovanih otvorenih problema vezanih za asimetrične linkove kod transportnih protokola sa podrškom za višestruke putanje definisani su scenariji za testiranje različitih kombinacija parametara linka od interesa (kašnjenje, gubici paketa, protok).

\*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 conference papers were presented at important international conferences (paper [1] is an invited paper):

[1] I. Stanić, D. Drajić, Z. Čiča, "Overview of Network Selection and Vertical Handover Approaches and Simulation Tools in Heterogeneous Wireless Networks", in Proc. 16th International Conference on Advanced Technologies, Systems and Services in Telecommunications (TELSIKS 2023), Niš, Serbia, October 25-17, 2023, pp. 133-142.

[2] J. Milojković, S. Brkić, P. Ivaniš, Z. Čiča, "Performance of Handover Execution in Satellite Networks with Shadowed-Rician Fading", in Proc. 16th International Conference on Advanced Technologies, Systems and Services in Telecommunications (TELSIKS 2023), Niš, Serbia, October 25-27, 2023, pp. 155-158.

\*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\*

hi-STAR project is presented at the TELSIXS 2023, Niš, at a special session "IoT Applications in Modern and Emerging Technologies".

hi-STAR project is presented at the workshop in Christian Doppler Laboratory "Digital Twin assisted AI for sustainable RAN", TUV, Vienna, Austria

Our paper, published in the Sensors journal:

A. Cvetković, V. Blagojević, J. Anastasov, N. T. Pavlović, and M. Milošević, "Outage Analysis of Unmanned-Aerial-Vehicle-Assisted Simultaneous Wireless Information and Power Transfer System for Industrial Emergency Applications", Sensors vol. 23, no. 18, paper no. 7779, September 2023, was selected as the best paper in the area of Telecommunications, published in a scientific journal in the year 2022/2023 in Serbia. One of the authors, Vesna Blagojevic is the project team member, and the paper has the acknowledgement of the project hi-STAR.

\*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

- |   |                    |
|---|--------------------|
| 1. _____                                | <u>15.01.2024.</u> |
| <b>Leading SRO (stamp)</b>              | <b>date</b>        |
| <b>dr. Dejan Gvozdić</b>                |                    |
| 2. _____                                | <u>15.01.2024.</u> |
| <b>Project PI</b>                       | <b>date</b>        |
| <b>Predrag Ivaniš</b>                   |                    |
| 3. _____                                | <u>15.01.2024.</u> |
| <b>SRO 1 (stamp)</b>                    | <b>date</b>        |
| <b>Prof. dr Dragan Mančić, dean</b>     |                    |
| 4. _____                                | <u>15.01.2024.</u> |
| <b>SRO 2 (stamp)</b>                    | <b>date</b>        |
| <b>Ilija Radovanović, vice director</b> |                    |