

## 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:01/10/2022 - End date:31/12/2022
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q4

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	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	Assistant professor	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.

<b>2.4. Project team performance</b>
<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 fourth quarter, our focus was on developing more realistic channel simulators and hardware implementation of the error correction decoders. The simulator of the satellite-terrestrial link is improved and we evaluated the statistical parameters of the signal envelope over the terrestrial mm-Wave channel. HDL design of the standalone BCH decoder is completed while LDPC is still under development. The focus of this activity besides hardware implementation is on porting 5G NR chain to the Xilinx development platform. We continued work related to examining handover techniques based on the MADM and reinforced learning applicable to hybrid radio network access. This quarter we were mainly focused on the LEO/GEO satellite networks and we discussed the potential of doing horizontal handover within the satellite access networks. Further analysis steps were conducted regarding the choice between OpenAirInterface 5G-core network and free5GC solutions that have been selected and initially analyzed in the research done in the previous quarter (OpenAirInterface will be in focus regarding the 5G network core, but the free5GC user element emulation will be used for initial tests). Also, gateway design and gateway connection to considered 5G network core solutions have been analyzed.</p> <p>Two papers are published in the international journal from the JCR list - one paper is published in IEEE Communications Letters (accepted in Q3, but published in October), and another paper is accepted and published in the journal Axioms in October. One paper is presented at the international conference TELFOR 2022, which was held in Belgrade in November 2022. Also, one paper is finally accepted for publication in the international journal Mathematics, indexed on the JCR list.</p> <p>The most important and the most expensive parts of the equipment are delivered to the SROs (two RF-SoC boards, a spectrum analyzer, some parts of IoT equipment, power splitters, and cables). The rest of the equipment (with an estimated price of less than 1% of the total costs of the equipment) is currently not available in the market, and we believe that it should be delivered during the next year.</p> <p>A new laboratory, entitled Laboratory for the Intelligent Communications and Information Theory is established at the School of Electrical Engineering, University of Belgrade.</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>P4 - Dejan Drajić changed the research title in Q4. He was promoted to Senior research associate (his previous title was Research associate) on the 26th of October, 2022. The corresponding documentation is already sent by e-mail, and we have added the corresponding document as an attachment for this report.</p>

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

<b>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.</b>
N/A. No milestones are planned in the second quartal.

<b>3.3. Deliverables - Short description of deliverables achieved during the reporting period, with reference to the Project Description A and Gantt Chart.</b>				
<b>Tasks/activities*</b>	<b>Deliverable name**</b>	<b>Delivery month (Mx) from Gantt Chart</b>	<b>Achieved Deliverable</b>	<b>If not achieved, enter estimated delivery month (Mx)</b>
1 WP1 - Project management	D1.3. Quarterly progress reports	M09	Yes	
2 WP2 - System architecture and attributes selection	D2.1. Hybrid 5G/Sat network architecture	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).

<b>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.</b>
D1.3 - The third 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 accepted, and the payment for the fourth quartal is processed. The administrative part of the report (QAR-Q3) is published on the project website ( <a href="https://hi-star.etf.bg.ac.rs/deliverables.html">https://hi-star.etf.bg.ac.rs/deliverables.html</a> ).
D 2.1 - The report is finished and it is published on the project website.

**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 Q4, WP1, WP2, WP3, WP4, WP5, and WP7 have been active.

WP1 - Subactivity 1.1: The third 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.

WP2 - Subactivity 2.1: As the channel model for the satellite-terrestrial link is mostly developed, we concentrated on the evaluation of the probability density function and cumulative distribution function of the signal envelope over terrestrial mm-Wave channel. We also analyzed necessary terms in the infinite summation under the condition of achieving a given accuracy for typical values of channel parameters.

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 the average symbol error probability of the coherent FSO system, in the case when the optical signal transmission is influenced by pointing errors and atmospheric turbulence.

WP3 - Subactivity 3.2: HDL design of standalone BCH decoder is completed while LDPC is still under development. The focus of this activity besides hardware implementation is on porting 5G NR chain to the Xilinx development platform.

WP4 - Subactivity 4.1: We continued work on the development of a Matlab-oriented simulation environment that will be able to support stationary as well as moving users with dual connectivity. For the development of the simulator, we will use propagation models for the terrestrial and satellite channels developed in WP2.

WP4 - Subactivity 4.2: We continued work related to examining handover techniques based on the MADM and reinforced learning applicable to hybrid radio network access. This quarter we were mainly focused on the LEO/GEO satellite networks and we discussed the potential of doing horizontal handover within the satellite access networks.

WP5 - Subactivity 5.1: Further analysis steps were conducted regarding the choice between OpenAirInterface 5G-core network and free5GC solutions that have been selected and initially analyzed in the research done in the previous quarter (OpenAirInterface will be in focus regarding the 5G network core, but the free5GC user element emulation will be used for initial tests). Also, gateway design and gateway connection to considered 5G network core solutions have been analyzed (a few approaches for connecting have been identified, and one of them will be selected that suits the best hybrid user terminal).

WP7 – Subactivity 7.1: The project website is regularly updated. Two journal papers are published, and one additional journal paper is accepted for publication and is available for early access. One conference paper is presented at international conference. Project factsheet and poster/roll-up are created. Website google analytics and social networks KPIs are followed regularly.

**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. 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 (some parts of the IoT equipment, with an estimated price of less than 1% of the total costs of the overall equipment) is finished in Q2, but it is not available for delivery in the Serbian market. We expect the delivery during the next year.  
 Personnel costs for all researchers in M12 will be paid in the first half of January, 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 has developed a hardware module for the BCH decoder. LDPC decoder is still under development. The next step will be the integration of these blocks into the DVB-S2X framework. Several state-of-the-art handover methods were analyzed and discussed, while simultaneously we are improving our custom-made simulation environment. From the two recognized candidates for the 5G core network platform (OpenAirInterface 5G-core network and free5GC), OpenAirInterface 5G-core network is selected and will be in focus in the remainder of the subactivity 5.1 and other project activities that include 5G network core. Also, the initial gateway design analysis points that the gateway will be implemented as a merge point (in form of a virtual machine) to which the 5G and satellite access networks will connect via IP connection. This merging point will provide continuous connection in case of switching the traffic between the 5G and satellite accesses as well as the merged traffic in case of traffic splitting between both access networks.

**Serbian** (up to 250 words)

Projektni tim projekta hi - STAR razvio je hardverski modul za BCH dekodera, dok je LDPC dekodera još uvek u fazi razvoja. Sledeći korak je integracija navedenih blokova u DVB - S2X okruženje. Nekoliko standardnih metoda hendovera su razmotreni i detaljno analizirani, a istovremeno razvijamo i sopstveno simulaciono okruženje. Od dva prepoznata kandidata za platformu jezgra 5G mreže (OpenAirInterface 5G core network i free5GC), izabran je OpenAirInterface 5G core network i u nastavku rada ova platforma će biti korišćena u narednim zadacima u okviru podaktivnosti 5.1, kao i u okviru drugih projektnih aktivnosti koje uključuju 5G mrežno jezgro. Inicijalna analiza pokazuje da je optimalno da se gateway implementira pomoću virtualne mašine (kao merging point), gde će 5G i satelitska pristupna mreža spajati IP saobraćaj. Na ovaj način će biti obezbeđena neprekidna povezanost korisnika u slučaju preusmeravanja saobraćaja sa 5G na satelitsku mrežu (ili obrnuto), kao i spajanje saobraćaja u slučaju kada je deo saobraćaja bio usmeren preko jedne, a deo preko druge mreže.

\*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] S. Brkić, P. Ivaniš, and B. Vasić, "Adaptive Gradient Descent Bit-Flipping Diversity Decoding," IEEE Communication Letters, vol. 26, no. 10, pp: 2257-2261, October 2022 (web: <https://ieeexplore.ieee.org/abstract/document/9844740>, DOI: 10.1109/LCOMM.2022.3195026, impact factor: 3.553)

[2] Z. Marjanović, D. N. Milić, and G. T. Đorđević, "Estimation of Truncation Error in Statistical Description of Communication Signals over mm-Wave Channels," Axioms, vol. 11, no. 10: 569, October 2022 (web: <https://www.mdpi.com/2075-1680/11/10/569>, DOI: 10.3390/axioms11100569, impact factor: 1.824).

One paper is presented at the international conference TELFOR 2022:

[3] H. Turkmanović, D. El Mezeni, V. L. Petrović, L. Saranovac, "Profiling of GNU Radio DVB-S2X transmitter using multi-core CPU and hardware accelerators", 2022 30th Telecommunications Forum (TELFOR 2022), November 15-16, 2022, Belgrade, Serbia, pp. 1-4, <https://ieeexplore.ieee.org/document/9983695>.

One journal paper is accepted for publication in the international journal from the JCR list, and it is available for download from the Early Access section of the corresponding web page:

[4] 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 (web: <https://www.mdpi.com/2227-7390/11/1/121>, DOI: 10.3390/math11010121, impact factor: 2.592).

\*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.

Two papers are published in the international journal from the JCR list - one paper is published in IEEE Communications Letters, and another paper is published in the journal Axioms. The project results are presented at the conference TELFOR 2022 (one paper), and one paper is accepted for publication in the journal Mathematics.

Project factsheet and poster/roll-up are created. Website google analytics and social networks KPIs are followed regularly.

A new laboratory, entitled Laboratory for the Intelligent Communications and Information Theory is established at the School of Electrical Engineering. This activity is related to the expected impact of the project, and the corresponding document is attached.

\*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>15.01.2023.</u> |
| <b>Leading SRO (stamp)</b>              | <b>date</b>        |
| <b>dr. Dejan Gvozdić</b>                |                    |
| 2. _____                                | <u>15.01.2023.</u> |
| <b>Project PI</b>                       | <b>date</b>        |
| <b>Predrag Ivaniš</b>                   |                    |
| 3. _____                                | <u>15.01.2023.</u> |
| <b>SRO 1 (stamp)</b>                    | <b>date</b>        |
| <b>Prof. dr Dragan Mančić, dean</b>     |                    |
| 4. _____                                | <u>15.01.2023.</u> |
| <b>SRO 2 (stamp)</b>                    | <b>date</b>        |
| <b>Ilija Radovanović, vice director</b> |                    |