

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:01/07/2022 - End date:30/09/2022
Reporting period (insert Q1, Q2, Q3, Q4, ..., Q8):	Q3

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	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.

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.</p> <p>In the third quarter, our focus was on algorithms that could increase the reliability of low-latency links, HDL implementation of basic modem functions, and identifying handover algorithms that use a small number of attributes. We have proposed the adaptation method based on the genetic optimization algorithm that is incorporated into a state-of-the-art decoding algorithm, resulting in a low-complexity LDPC decoder with superior performance. Also, we have optimized DVB-S2X physical layer software implementation to achieve better usage of processing resources, and we have almost completed HDL implementation of the most critical blocks for DVB-S2x hw/sw codesign: LDPC and BCH decoders.</p> <p>Two papers are presented at the international conference CSNDSP 2022, which was held in Porto in July this year, and one paper is finally accepted for publication in the journal IEEE Communications Letters.</p> <p>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>Important parts of the equipment are delivered to the SROs (two desktop computers, and some parts of IoT equipment). For the rest of the equipment, that should be delivered to SEE, the public procurement procedure is finished and we wait for the equipment delivery.</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>P8 - Vladimir Petrović changed the research title in Q1, and we have added this comment in QAR for Q1. However, the data in the corresponding table is still unchanged. He was promoted to Assistant Professor (his previous title was Teaching Assistant) on the 14th of March, 2022. The corresponding documentation is already sent by e-mail on April 21, 2022, 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)
1	M3.1 Unified 5G/Sat framework verification	M08	No	M12

*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.

This milestone is not accomplished because of changes in the concept of the final demonstrator. Instead of having one unified SDR framework, SatCom and 5G physical layers will be implemented on separate development boards. This approach was necessary since OAI and GNU Radio cannot be efficiently merged into a unified solution. Nevertheless, higher communication layers will use a unified API to access both physical layers.

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	M06	Yes	
2	WP3 - Satellite and terrestrial modems implementation, Subactivity 3.1. Analysis of existing SDR frameworks for DVB-S2X and 5G	D3.1 Unified SDR framework for DVB-S2X and 5G modems	M08	Yes	M08

*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 second quarterly progress report is submitted, the signed document is uploaded and the hard copy of the report is timely sent to the Science Fond. The report is accepted, and the payment for the second quartal is processed. The administrative part of the report (QAR-Q2) is published on the project website (<https://hi-star.etf.bg.ac.rs/deliverables.html>).

D 3.1 - 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 Q3, WP1, WP2, WP3, WP4, WP5, and WP7 have been active.

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

WP2 - Subactivity 2.1: We continue developing our source files for modeling terrestrial and satellite channels for application in Monte Carlo simulations. An analytical approach is applied for the analysis of 5G millimeter links, and the corresponding analytical expressions are derived in closed form.

WP2 - Subactivity 2.2: We proposed a novel framework that can be applied to increase the reliability of earth or satellite links that requires low latency. Its key component is the adaptation method based on the genetic optimization algorithm that is incorporated into the recently proposed Gradient Descent Bit-Flipping Decoding with Momentum (GDBF-w/M). We have shown that the resulting decoder outperforms all state-of-the-art probabilistic bit-flipping decoders, and additionally, it can be trained to perform beyond BP decoding, which is verified by numerical examples that include codes used in the 5G standard.

WP3 - Subactivity 3.1: We have analyzed different architectures of GNU radio DVB-S2X transceivers to maximize throughput for a given processing platform and confirmed that it is necessary to implement additional blocks in SW to complete the entire PHY chain (part of SA 3.2). GNU Radio and Open Air Interface will be used as separate entities and merged at higher layers since the scheduling mechanisms of the two are fundamentally different.

WP3 - Subactivity 3.2: Software architecture was optimized for the best use of processing resources, where the most critical parts are offloaded to hardware. In addition, accelerating architectures were analyzed. The focus of this activity is still on the hardware implementation of BCH and LDPC decoders, for which software reference models have been developed and HDL design is almost completed.

WP4 - Subactivity 4.1: A comparison study, that includes several publically available network simulators, was performed. We examined the feasibility of NS-3, OMNeT++, OpenAirInterface, and Matlab frameworks. It was finally concluded that we will continue to develop our own simulation environment for handover executions by using Matlab packet, given the limited time frame and the fact that, to develop our environment, we need to implement only a small portion of functionalities that are included in NS-3, OMNeT++, OpenAirInterface frameworks.

WP4 - Subactivity 4.2: We conducted a simulation study to compare the performance of different handover execution techniques, used on the user side to choose the best LEO (Low Earth Orbit) satellite for the upstream communication stream. We compared the MADM (Multi-Attribute Decision Making) algorithm called TOPSIS and the technique that is based on the reinforced learning principle.

WP5 - Subactivity 5.1: Research of available open-source code solutions for network core functions was conducted, and the two most prominent candidates were further analyzed - OpenAirInterface 5G-core network and free5GC. Both candidates support the core functions of interest, but initial research and analysis show that OpenAirInterface 5G platform might be a better choice (more suitable) for interconnecting to HUT in the later stages of the project.

WP7 – Subactivity 7.1: The project website is regularly updated. One journal paper is accepted for publication and is available for early access, 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 are executed fully according to the Project proposal (Annex 1 of the Contract on the Project financing).

There is a significant 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 (RF-SoC boards, Spectral Analyzer, RF connectivity components, and some parts of the IoT equipment) is finished in Q2 and we expect the delivery of the equipment in Q4.

Personal costs for Dejan Drajic for months M07, M08 and M09 will be paid at the moment when Science Fund transfer the payment for Q2 (as a necessary condition, ICEF has to open a new bank account, according to the requirements from Science Fund). Personnel costs for all other researchers in M09 will be paid in the first half of October, 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 (RF-SoC development board) delivery delay	Primarily WP3, but also partially WP4	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 (RF-SoC boards, Spectral Analyzer, RF connectivity components, and some parts of the IoT equipment) is finished and we expect the delivery of the equipment in Q4. The rest of the equipment is delivered. In the meantime, 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)
In this reporting period, we were focused on algorithms that could increase the reliability of low-latency links, HDL implementation of basic modem functions, and identifying handover algorithms that use a small number of attributes. In WP2, we have proposed the adaptation method based on the genetic optimization algorithm that is incorporated into the recently proposed Gradient Descent Bit-Flipping Decoding with Momentum (GDBF-w/M), resulting in low-complexity LDPC decoder with superior performance. The hi-STAR project team has optimized DVB-S2X physical layer software implementation to achieve better usage of processing resources. In WP3, the team has almost completed HDL implementation of the most critical blocks for DVB-S2x hw/sw codesign: LDPC and BCH decoders. The main activities in WP4 included work on the development of custom-based simulation environment and comparison of different handover strategies used in LEO-based satellite communications. We are currently in a process of developing our own handover execution strategy that will combine different existing strategies. The main goal of the initial research conducted in WP5 was to find the 5G core network platform that would be most suitable for working with HUT. Currently, two promising candidates have been found. Both of them are open-source and support the relevant 5G core functions necessary for the hi-STAR project and further analysis will determine which platform is more suitable for all the planned goals of the hi-STAR project.
Serbian (up to 250 words)
U prethodnom tromesečnom periodu posebno smo razmatrali algoritme koji treba da obezbede veliku pouzdanost linkova koji zahtevaju mala kašnjenja, HDL implementaciju osnovnih modemskih funkcija i identifikaciju algoritama hendovera koji koriste mali broj atributa. U paketu WP2 predložili smo novi metod za adaptaciju baziran na genetskom algoritmu, koji se može direktno primeniti na nedavno predloženi bit-flipping dekođer sa gradijentnim spustom sa momentumom (Gradient Descent Bit-Flipping Decoding with Momentum, GDBF w/M). Ovo rešenje obezbeđuje malu kompleksnost odgovarajućeg dekodera, uz izuzetno dobre performanse. Projektni tim je optimizovao fizički sloj DVB S2X sistema, sa ciljem efikasnijeg korišćenja resursa. Tim angažovan na aktivnostima u okviru paketa WP3 je skoro potpuno završio implementaciju najkritičnijih blokova u DVB S2x hw/sw: LDPC i BCH dekodera. Glavne aktivnosti u okviru paketa WP4 uključuju rad na razvoju adekvatnog simulacionog okruženja i poređenje raznih strategija hendovera koje se koriste u LEO satelitskim sistemima. Trenutno smo u fazi razvoja sopstvene hendover strategije koja će kombinovati više postojećih strategija. Cilj početnih istraživanja u okviru paketa WP5 je određivanje platforme za jezgro 5G mreže koje bi bilo najadekvatnije za rad sa HUT. U ovom trenutku su identifikovana dva kandidata, pri čemu su oba zasnovana na principu otvorenog koda i podržavaju relevantne funkcije jezgra 5G mreže koja su potrebna za uspešnu realizaciju hi-STAR projekta. Dalja analiza će pokazati koja platforma je pogodnija za ostvarivanje svih planiranih ciljeva hi-STAR projekta.

*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 presented at the international conference CSNDSP 2022:

[1] G. T. Djordjevic, I.B. Djordjevic, "Multidimensional LDPC-coded signal transmission over TWDP fading channel," in Proc. 13th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP 2022), July 20-22, 2022, Porto, Portugal, pp. 219-222, DOI: 10.1109/CSNDSP54353.2022.9907966, <https://ieeexplore.ieee.org/document/9907966>.

[2] J. Anastasov, P. Ivanis, J. Makal, G. T. Djordjevic, D. Milic, "On the Secrecy Analysis of Satellite-Terrestrial Communication Link over Gamma-shadowed Ricean Fading Channels," in Proc 13th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP 2022), July 20-22, 2022, Porto, Portugal, pp 179-184, DOI: 10.1109/CSNDSP54353.2022.9908002, <https://ieeexplore.ieee.org/document/9908002>.

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

[3] S. Brkić, P. Ivaniš, B. Vasić, "Adaptive Gradient Descent Bit-Flipping Diversity Decoding," IEEE Communication Letters (Early Access), DOI: 10.1109/LCOMM.2022.3195026, <https://ieeexplore.ieee.org/abstract/document/9844740>.

One paper is submitted at the international conference TELFOR 2022:

[4] H. Turkmanović, D. El Mezeni, V. L. Petrović, L. Saranovac, "Profiling of GNU Radio DVB-S2X transmitter using multi-core CPU and hardware accelerators", Telfor 2022, Belgrade, Serbia

*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.

The project results are presented at the conference CSNDSP 2022 (two papers), and one paper is accepted for publication in the journal IEEE Communications Letters.

A short update about the project results is presented at the meeting of the COST action "European NETWork on Future Generation Optical Wireless Communication Technologies (NEWFOCUS)", which was organized in Porto at the same time as the conference CSNDSP 2022.

*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. _____
Leading SRO (stamp)
dr. Dejan Gvozdić | <u>13.10.2022.</u>
date |
| 2. _____
Project PI
Predrag Ivaniš | <u>13.10.2022.</u>
date |
| 3. _____
SRO 1 (stamp)
Prof. dr Dragan Mančić, dean | <u>13.10.2022.</u>
date |
| 4. _____
SRO 2 (stamp)
Ilija Radovanović, vice director | <u>13.10.2022.</u>
date |