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Federated Union of Telecommunications Research
Facilities for an EU-Brazil Open Laboratory

D3.3: Outreach, extension and sustainability plan

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Abstract	This deliverable reports the outreach, extensions and sustainability actions and plans for FUTEBOL to outlive its initial funding.
Keywords	Outreach, extension, sustainability



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EXECUTIVE SUMMARY

This deliverable reports the outreach, extensions, and sustainability actions and plans for FUTEBOL to outlive its initial funding. It is based on the T3.5 (Outreach, extension, and sustainability of FUTEBOL), which develops mechanisms for amplifying the impact of FUTEBOL and ensure its long-term sustainability. The task encompasses three aspects: extension, outreach and sustainability.

The deliverable discusses possible funding models to keep the system alive after the project as well as means to manage to get more people using the project testbeds and technologies.



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ABBREVIATIONS

3GPP	3rd Generation Partnership Project
4G	Fourth generation
5G	Fifth generation
5GINFIRE	Evolving FIRE into a 5G-Oriented Experimental Playground for Vertical Industries
5GTN+	5G Test Network
ANACOM	Autoridade Nacional de Comunicações
ANATEL	Agência Nacional de Telecomunicações
CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
CapEx	capital expenses
CGI.br	Comitê Gestor da Internet no Brasil
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
COPA	
E-AWARE	
EC	European Commission
eMBB	Enhanced Mobile Broadband
EMBRAPII	Empresa Brasileira de Pesquisa e Inovação Industrial
E2E	End-to-End
EU-BR	European Union-Brazil
EVI	Experimental Vertical Instance
eWINE	Elastic Wireless Networking Experimentation
Fapemig	Fundação de Amparo à Pesquisa do Estado de Minas Gerais
FAPES	Fundação de Amparo à Pesquisa e Inovação do Espírito Santo
FAPESP	Fundação de Amparo à Pesquisa do Estado de São Paulo
Fed4FIRE+	Federation for Future Internet Research and Experimentation
FIBRE	Future Internet Brazilian Environment for Experimentation
FORGE	Forging Online Education through FIRE
FUTEBOL	Federated Union of Telecommunications Research Facilities for An Eu-Brazil Open Laboratory
GUI	Graphic User Interface
IEEE	Institute of Electrical and Electronics Engineers



IFES	Instituto Federal do Espírito Santo
IoT	Internet of Things
IPR	Intellectual Property Right
LSA	Licensed Shared Access
LTE	Long Term Evolution
mMTC	Massive Machine-Type-Communication
NECOS	Novel Enablers for Cloud Slicing
NERDS	Núcleo Emergente em Redes Definidas por Software
NFV	Network Function Virtualization
O2CMF	OpenStack and OpenFlow Control and Management Framework
OpEx	Operational expenses
ORCA	Orchestration and Reconfigurable Control Architecture
PON	Passive Optical Network
R&D	Research and Development
RNP	Rede Nacional de Ensino e Pesquisa
RSPEC	Request Specification
SDN	Software-Defined Network
SDR	Software-Defined Radio
SME	Small and Medium Enterprise
srsLTE	software radio systems LTE
TCD	Trinity College Dublin (FUTEBOL partner)
UFES	Universidade Federal do Espírito Santo (FUTEBOL partner)
UFMG	Universidade Federal de Minas Gerais (FUTEBOL partner)
UFRGS	Universidade Federal do Rio Grande Do Sul (FUTEBOL partner)
UK	United Kingdom
UNICAMP	Universidade de Campinas (FUTEBOL partner)
UNIVBRIS	University of Bristol (FUTEBOL partner)
urLLC	Ultra Reliable Low Latency Communication
USRP	Universal Software Radio Peripheral
VTT	VTT Technical Research Centre of Finland (FUTEBOL partner)
WINS-5G	Wireless Network Slicing Functionality for 5G



WISHFUL **Wireless Software and Hardware platforms for Flexible and Unified radio and network control**



1 INTRODUCTION

This deliverable describes the plans for outreach, extension and sustainability that will be carried out after the funding for FUTEBOL has officially ended. The objective of this plan is:

- ensure that the testbeds are still operational after the official funding of the project, providing benefit to the academic and industrial communities;
- increase the number of users and institutions using the FUTEBOL testbeds;
- improve the current offering of equipment and tools, in order to allow experimentation in current and future telecommunication technologies.

Outreach and dissemination activities that were performed during the three years of the project are not listed in this deliverable. Readers interested in those activities are referred to deliverable D6.3. Regarding extensions, this deliverable presents current activities as well as the plan for future ones, since this topic is not covered in other deliverables.

Finally, this deliverable presents current activities as well as future plans for further extensions of the research infrastructures of the project consortium members.



2 EXTENSION OF RESEARCH INFRASTRUCTURE

This section details the plans of the FUTEBOL testbed owners for the extension of the research infrastructure once the project has ended. Based on the feedback from the reviewers as well as the experience obtained during the project, we foresee two main axis of actions, namely an more advanced specialization of the testbeds, and an improved ease of use.

The first axis, **specialization**, aims to provide unique functionalities to each of the testbeds. Given the fact that many open testbeds are already available for the community at large, FUTEBOL testbeds will focus on how to differentiate from others. One example is the UFES testbed, which is already positioning itself as a testbed for robotics and ultra-reliable low latency communication. Another example is VTT testbed, which will focus its offer on cellular communication for 5G. Table 1 shows the main offerings of each of the testbeds, which we plan to refine and extend in the future.

UFES	Intelligent space: Cloud Robotics real time control using Wireless URLLC.
VTT	Wireless experimentation with LTE base stations. LSA.
UFMG	Last mile wireless: Packet-wireless network programmability, indoor IoT, 4G.
UFRGS	Wireless experimentation with software-defined radio, IEEE 802.15, LoRa, and Wi-Fi platforms, allowing dynamic creation of heterogeneous scenarios, e.g., 4G/5G, IoT. Radio-over-fiber setups connecting indoor and outdoor sensors (Unicamp extensions).
UNIVBRIS	Cross-layer orchestration: optical-wireless-cloud integration.
Iris TCD	Software-defined radio and passive optical network (PON) testbed enabling reconfigurable management of spectral, processing, and transport network resources.

Table 1 - Specific offerings of each of the FUTEBOL testbeds.

Iris TCD - the reconfigurable radio testbed at Trinity College Dublin (TCD) provides virtualized radio hardware, Cloud-RAN, Network Functions Virtualisation (NFV), and Software Defined Networking (SDN) technologies to support the experimental investigation of the interplay between legacy technologies, 5G radio and future networks. We offer the radio resources including 20 USRP N210s and 2 USRP X310s ceiling mounted nodes all equipped with SBX daughterboards, reaching frequencies between 40 MHz and 4 GHz. These platforms are connected to a computational cloud, allowing us to deploy an array of computational environments, accessible through Fed4FIRE. To expose the functionality of these platforms for a variety of applications, we employ a variety of radio hypervisors that freely enable prototyping of wireless systems, as exemplified by GNURadio, srsLTE (an open-source 3GPP 4G stack from the Irish company Software Radio Systems), etc.

UNIVBRIS - The main focus at UNIVBRIS is to provide optical-packet orchestration, through a newer optical solution on an SDN-enabled network, and a virtualized infrastructure overlaid in an optical-packet path, which enables the experimental investigation using cross-layer algorithms that could be involved in 5G network research. Furthermore, experimenters can define physical parameters in an optical resource (BV-ROADM) and create an end-to-end (E2E) path using optical-packet mapped by a tuple of ports and wavelengths. We deploy our infrastructure using OpenStack, ABNO and proprietary optical solutions from UNIVBRIS. s

UFES - The UFES testbed in light of the new generation of robotics as a service (e.g, robot localization



and navigation, assistive robotics), has been built to support the requirements of real-time remote control of robots over a wireless-optical SDN-enabled network. It explores the field of cloud robotics control with the aid of computer vision that requires novel orchestration features offered by the FUTEBOL Control Framework (CF) such as i) flexible innovative vertical auto-scaling providing elasticity of Virtual Network Functions (VNF) using Openstack ii) orchestrating wireless, packet and optical networks to meet simultaneously low E2E latency and high bandwidth requirements, aiming to study and overcome the bottlenecks in the cloud-fiber-wireless domain, involving cyber-physical systems use cases with stringent requirements. Our target are production processes environments that need to test wireless control of industrial manufacturing, where URLLC communication services are expected, especially in the context of the Industry 4.0 (also known as Industrial IoT) vertical.

UFMG - UFMG's focus is on wireless experimentation, and how wireless technologies interact with cloud, packet and optical networks. As such, the UFMG testbed provides resources for experimentation of the so-called last mile technologies, that is, the technologies that connect the end-users to the core networks, using standards for both licensed (4G) and unlicensed (WiFi, ZigBee, Bluetooth) bands. The resources of the testbed allow the experimenters to program the network on layers 1 and 2 of the wireless protocol stack using USRP, while the implemented SDN protocols and NFV functionality provide programmability at layers 2 and above. Further, the testbed provides resources for IoT experimentation in an indoor environment.

UFRGS - The testbed is focused on devices for wireless research, Internet of things, sensor networks and optical-wireless convergence. With wireless experimentation (WiFi, 3G, 4G, 5G) including new protocols and technologies over programmable radio platforms (i.e., SDR), the testbed also provides optical-wireless convergence experimentation with its radio-over-fiber arrangement, where it's possible to create networks (up to the layer 2) using USRP through optical infrastructure.

VTT - The VTT testbed provides means for research and development by experimentation of wireless communication. The testbed may be enhanced by adding new hardware, for example targeted at 5G research. The testbed focus area is mainly shared spectrum access, LSA (Licensed Shared Access) being the current implemented and tested software, and SAS (Spectrum Access System) as a possible future improvement.

Regarding the second axis, **ease of use**, the testbeds will work on simplifying the usage of their resources so that less experienced users will be able to devise, set-up and operate experiments of their interest. So far, FUTEBOL has supported ease of use by making available to experiments a number of pre-installed images for software functionalities that are most requested. For example, the UFMG testbed provides images for video servers as well as images for the 4G core and eNodeBs. Those images come pre-configured, including for example the fine-tuning of antennas and the appropriate carrier settings. Another useful available functionality is COPA, a Graphic User Interface (GUI) for the migration of virtual resources. Other software, e.g. for the orchestration or for the low-level control of the parameters of the resource, are envisioned as expansions of the infrastructure of the UFMG testbed.

Further, a number of ongoing extension activities can be outlined in both sides of the Atlantic. Those activities include the improvement of the connectivity as well as the extension of the capabilities of the testbeds, and are detailed below.

Further, a number of ongoing extension activities can be outlined in both sides of the Atlantic. Those activities include the improvement of the connectivity as well as the extension of the capabilities of the testbed, and are detailed below.

1. FUTEBOL is already in talks with RNP to integrate its facilities with FIBRE. The FUTEBOL testbed owners are participating in initiatives together with FIBRE to further fund both FIBRE and FUTEBOL testbeds from 2019 onwards. In July of 2018, FUTEBOL participated in the writing of a proposal for the Science and Telecommunications Ministry for the next phase of FIBRE's testbed. Further, we have participated in the writing of a proposal for FAPESP/CGI.br to fund the integration of FIBRE and FUTEBOL.
2. Due to the strong ties with FIBRE, FUTEBOL testbeds are planned to receive a faster link with the planned upgrade of FIBRENET 10 Gbps links. this upgrade will increase the speed of the links among FUTEBOL and FIBRE testbeds. This upgrade is currently under definition and the



testbeds chosen for receiving these new types of equipment will be defined according to the budget received by RNP.

3. Intelligent space in IFES will replicate the intelligent space existent in UFES worked on under the Experiment 2.2, using cameras to acquire robot position and wireless indoor setup to provide the robot control communication. The application processing algorithms will be running in a virtual cloud remote setup in UFES with support of O2CMF.
4. FUTEBOL is in talks with the NECOS project to extend experimentation and researching by aggregating facilities from both projects, together with RNP's infrastructure. This integration aims to merge network and infrastructure slicing to demonstrate in a large-scale real-world experiment how cloud computing and network slicing may support telecommunications applications and services.
5. FUTEBOL and E-AWARE partnership extended the testbed at UFRGS with new sensors and wireless nodes. This partnership allows FUTEBOL experimenters to reserve and use in their experiments an IEEE 802.15.4 gateway, in which several sensor nodes from the E-AWARE's testing environment are connected. The information collected from the sensors is forwarded to the gateway, which is controlled by the experimenter, and can be used to test different IoT applications in a realistic environment.
6. The FUTEBOL control framework was a fundamental component for the Iris testbed's recent success in a 5GINFIRE (Grant Agreement 732497) open call for new infrastructures. The project, called Wireless Network Slicing Functionality for 5G (WINS-5G), integrates the COPA control framework into the 5GINFIRE infrastructure, in addition to providing dynamically instantiated radio slicing and virtualisation across Experimental Vertical Instances (EVIs) at the Iris testbed. COPA 5GINFIRE functionality can monitor all instantiated virtual network functions (VNFs), visualise activities via a centralised GUI, and support end-user configuration of radio parameters across mMTC, eMBB, and URLLC use cases.
7. FUTEBOL testbeds have already been extended beyond the testbeds promised features set at the time of the project submission. Unicamp resources are available in jFed via UFRGS. Unicamp is specialising in optical/wireless testbeds for wireless sensor networks and smart cities.
8. UNIVBRIS has worked cooperatively with UFES in order to create an intelligent space inside its research laboratory (<https://goo.gl/zvGwsV>). It has been an effort between the universities to create a consistent framework and intelligent space that could be able to provide a real use case application like gesture recognition deployed as one kind of application to be used on 5G networks (<https://goo.gl/qbxwuC>).

Although the focus for future expansions is not at adding new locations to the FUTEBOL testbeds, Unicamp's example indicates that new testbeds could leverage FUTEBOL's experience. Instead of pursuing the entire jFed federation process as a new island, Unicamp has sped up the process by using UFRGS as a proxy. This allowed Unicamp to federate their resources in less time than other partners, in a model that could be pursued by other institutions willing to link to Fed4Fire.



3 OUTREACH AND ENGAGEMENT OF EXTERNAL ENTITIES

This section describes the planned outreach and engagement activities in order to engage cooperation with other institutions as well as to increase the usage of the testbeds.

Besides the actions described below, the testbed owners understand that high impact research using the testbeds is key to increasing the visibility of the testbeds. Hence, the testbed owners will attempt to publish papers in prestigious conferences and journals, in order to emphasize the usefulness of the FUTEBOL testbeds.

3.1 Short courses in events

One important form to engage the academic community is to present short courses on conferences and events focused at academic results related to experimental research, and to provide the course material online on the FUTEBOL website. One successful example is the PhantomNet testbed (<https://www.phantomnet.org/>) at the university of Utah. The testbed owners have presented a short course on how to use their testbeds for 4G and 5G experimentation in a number of conferences (<https://www.phantomnet.org/tutorials.php>). Those activities increase the visibility of the testbed, and provide a first hands-on contact with the testbed.

Further, in Brazil many universities organise summer schools or internal conferences, in which presenters from other institutions are invited to speak about their research. FUTEBOL tutorials could be presented in those events, since they provide free access to resources that usually are not available for the students and researchers of smaller universities.

It is worth mentioning that educational activities using the testbeds facilities for teaching students or even training companies have the potential to create a demand for regular use of the testbeds.

3.2 Tutorial and testbed usage guides

Online tutorials and user guides are an important tool for outreach, since they are available to a wider audience 24/7. During the FUTEBOL project, tutorials and testbed usage guides were prepared for both novice and advanced users. Each testbed has provided a user guide, and links for those user guides are available in the FUTEBOL website at <http://www.ict-futebol.org.br/index.php/infrastructure/tutorials/>. FUTEBOL partners plan to maintain those tutorials and user guides, improving them when new features are added.

Further, it is important for experimenters to have access to basic experiments on which to build on. Researchers on the FUTEBOL institutions will be encouraged to provide links to RSPECS and source code of their experiments in the FUTEBOL public repository available in Gitlab at <https://gitlab.com/futebol>. As an example, the scripts for experiment 3.2 are already provided in this repository. Code and RSPECS will be provided on a case by case basis, depending on issues such as timing (e.g. to ensure that others do not use the code before publishing the results) and IP protection (in case of plans to file patents or use the code for innovation purposes).

3.3 Outreach to regulators and standardization bodies

So far, UFC had several meetings with ANATEL (the Brazilian regulator) either with the local branch in Fortaleza or with the engineers from the headquarters in Brasilia. In fact, one member of ANATEL was in the FUTEBOL's plenary meeting in Fortaleza, presenting their vision about 5G and the regulatory and coexistence challenges that need to be overcome in Brazil. Moreover, a representative from ANACOM (the Portuguese regulator) was invited by IT and was presented in the plenary meeting of Lisbon. Also, Intel had a meeting with Ofcom (the UK regulator). In all of these meetings, regulators had the opportunity to know better the FUTEBOL project, and from their side, the consortium heard



what are the main local challenges that regulators face. These discussions were very helpful in shaping our possible contributions to regulation.

Concerning standardization, FUTEBOL was presented in the 77th 3GPP SA1 meeting in the Jeju Island in South Korea. Also, more recently INTEL had the chance to present the project in ETSI RRS#45 meeting in Biel/Bienne in Switzerland. While the first presentation was about the FUTEBOL's use cases, the latter focused in the SAS trials using the VTT testbed and the challenge of the 3.5GHz band with LTE and TV satellite receivers in Brazil. As an outcome, both presentations raised the attention of some delegates from companies (e.g., Nokia) to regulators (e.g., BAKOM/UFCOM/OFCOM, the Switzerland regulator) and future interactions are possible.

In this manner, even after the FUTEBOL ends, the UFC plan is to keep the communication with ANATEL open, for example, by promoting F2F meetings, organize workshops related with spectrum regulation, promote collaborative works that may result in joint publications, or participate in any public consultation for the regulatory framework in Brazil.

3.4 Outreach to Small and Medium Enterprises

Some Small and Medium Enterprises (SME) showed interest in the FUTEBOL testbeds and access to experimental resources. In particular the following ones asked for more information and will follow up along 2019 to check on what their area of business can benefit from the FUTEBOL proposition.

- WINGS (Greek SME based in Athens, working on 5G system and communication)
- Incelligent (Greek SME based in Athens, working on proactive network management)
- MOTIUS (German SME working for several key partners like BMW and Siemens)
- Allbesmart
- E-Aware



4 SUSTAINABILITY OF THE FUTEBOL PLATFORM

This chapter describes the sustainability through opportunities for technical, infrastructural, service-related, business and organizational collaborations that advance the economic viability of the FUTEBOL platform. In short, it describes actions and plans for FUTEBOL to outlive its initial funding.

First, it includes a description how each testbed owner has planned to finance the testbed in the future. Costs are used as a base for cost benefit evaluation, as well as in analysing different tariff schemes for customers using FUTEBOL research infrastructure. Tariff schemes may be based on usage or subscription, related with capacity, duration of the test, used technology, based on the targeted user (e.g. academic versus industrial, etc). Analysis will be performed to clarify several relevant parameters, such as, the number of users, costs, policies and usage profiles. Finally, the section also describes the service level agreements and access policies for FUTEBOL.

4.1 Access policies

FUTEBOL testbeds will have two types of access models: (1) best effort experimenters & (2) premium external experimenters.

4.1.1 Best effort service for experimenters

This best effort service is for non-commercial experimentation only, such as personal use by PhD students, occasional use by academic institutes and ad-hoc use by research projects. Access to infrastructure is constrained: limited resource usage (on peak, over a longer period), not all equipment might be accessible, no/limited advance reservation of resources, no guarantee on availability, lowest priority compared to other reservations, fair use policy. Basic support is accessible for the experimenters: the FUTEBOL portal, guidelines and handbooks or other information (e.g. specific training sessions or public demonstrations) made available by the individual testbed infrastructures. More detailed or individual technical support is not included in this service. For such usage scenario, the service is provided for free. However, in return, the FUTEBOL project demands some feedback on the experiment: the project should be mentioned in publications when results are obtained using the testbed, and feedback on the experience should be reported.

4.1.2 Premium use for experimenters

The premium use service focuses on more advanced use of the testbed infrastructure with guarantees on resource usage and support. Commercial and non-commercial experiments are targeted, such as:

- Use in academic research that is aligned to the testbed owner's research goals. Given the interest of the testbed owners on a certain research (e.g. alignments of the research interest, to foster future corporations), the operators of the testbed may provide a more complete support in order to speed up the advancement of the experimenters.
- Commissioned projects from industry.
- Experimenters selected in funded or unfunded open calls, e.g. future projects financing the expansion of the testbeds.

4.1 Tariff schemes

Table 2 depicts our proposed tariff model. For FUTEBOL consortium partners, for the entities that applied for open calls, and for the experimenters making use of the best effort service, the cost for using the FUTEBOL infrastructure is free, under the constraints described above. For premium users, the tariff shall be cost based.

For software components, a distinction between open source and dedicated software components shall be made. For open source components, the additional developed components shall be published under open source licencing terms. For dedicated software components, they can be used for free / fair use for



FUTEBOL core partners and open call partners, and the experimenters making use of the best effort service (however upon discussion, case by case specific). For premium use experimenters a case-by-case evaluation shall be made per each testbed owner.

Operational costs are free for FUTEBOL partners, for the open call partners and for the best effort service experimenters, and cost based for premium use experimenters.

	Best effort service	Premium use
Hardware (including investment cost, continuous cost of operation, maintenance and repairs)	Free	Cost based model
Open source software (including software updates)	Additional developed components to be published under open source licensing terms	
Dedicated software components (including software updates)	Components can be used for free / fair use - upon discussion, case by case specifics	Componentes can be used upon discussion, case by case specifics
Operational costs (including provisioning and management services, support, pricing and billing, marketing, others)	Free service provisioning and management	Cost based model

Table 2 - Tariff model overview.

4.2 Future plans for funding

This section presents the plans for funding the testbeds after the FUTEBOL project end, taking into account the costs and policies described in the previous sections. Since the realities of European and Brazilian funding are very different, we start by describing the overall plans for funding in both sides of the Atlantic, mentioning some of the opportunities that have already been explored. Further, we describe how each testbed plans to fund its own infrastructure, based on its competences, local legal framework and specific testbed-related aspects and constraints.

General in Brazil: RNP plans to continue funding FIBRE, planning to propose an extension for the FIBRE testbed until 2022 with funding from the Brazilian Ministry of Science, Technology, and Innovation (the same that funds the EU-BR calls FUTEBOL successfully applied to). This plan includes incorporating Brazilian FUTEBOL facilities into FIBRE. This is considered in the sustainability plans for FUTEBOL. To that end, RNP leads the submission of a project to the FAPESP call (financed by the money of domain registrations in Brazil from CGI.br - Comit  Gestor da Internet) in order to maintain the testbed for the next five years. UFES, UFRGS and UFMG also submitted a second project to the same FAPESP call to maintain the FUTEBOL facilities.

Finally, Brazilian partners will be able to explore the new innovation law, which allows universities to provide their infrastructure for companies under a fee, in order to improve the testbeds. In such a model, industry can be billed for the usage of the testbed as one indirect cost of the project.

General in Europe: European partners will continue to submit projects to national funding agencies as



well as to the European Commission calls, which are specific to testbeds development. Those calls will allow the European partners to expand the resources and functionalities of each testbed. Other national and EC projects will contribute to maintain the testbeds, with funds made available for personnel and maintenance costs. Due to the strong links of SMEs and industry with the university, the partners will also explore commissioned projects and fees to maintain their testbeds.

Individual testbeds have different plans for covering the costs. The most common funding models for testbeds are:

- **National funding**, from either national- or state-wide governmental funding agencies.
- **International funding**, e.g. EC projects and EC-sponsored open calls, joint Brazil-EU, Brazil-US and other such international calls.
- **Member fees**, in which an institution pays early/monthly fees to access the testbed with a more dedicated support in their experiments.
- **Commissioned projects**, in which the industry contracts the academic partners to execute a certain research and/or development project.
- **SME Access**. In the case of SME that may not have enough budget to fund the usage and the support provided by the testbed partners, special agreements can be reached to eliminate or cover the costs of the usage of the testbed.

Each FUTEBOL testbed has estimated the relevance of each funding model in the context of its testbed, as described in the sections below.

4.2.1 VTT testbed

- VTT will continue the development of the base station controller, which the LSA controller uses for giving commands to the base station (e.g. lock, un-lock, change channel, change transmission power), under the scheme of the ASCENT-project (Demonstrator of license assisted spectrum access satellite networks,
- <https://artes.esa.int/projects/ascent>, commercial project). In that project, the LSA controller will be developed by a Finnish SME called Fairspectrum. The VTT FUTEBOL testbed will be used in other project demos also in the future. For instance, it was recently used in the final demo of the CORNET-project (Critical Operations over Regular Networks, <https://www oulu.fi/cornet/>).
- VTT testbed related parts are also related to 5G Test Network (5GTN, <https://5gtn.fi/>), which brings together VTT, University of Oulu and over 20 industry partners.

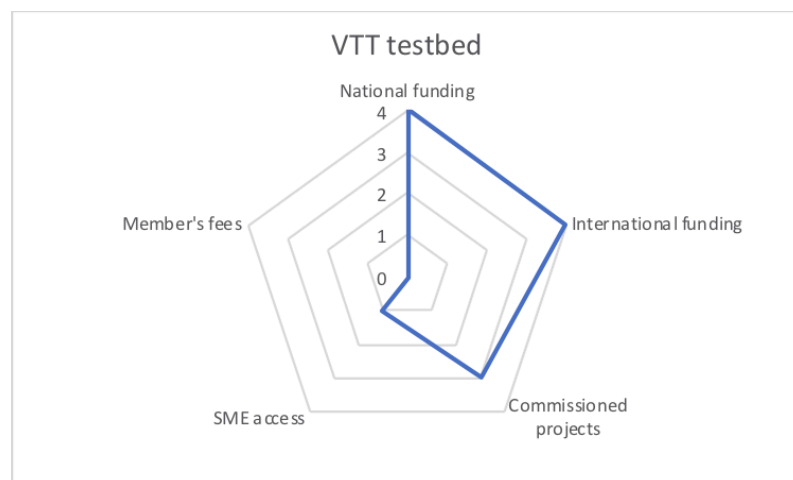


Figure 1- Radar plot of VTT's planned funding effort.



4.2.2 TCD testbed

- A large percentage of the Iris TCD testbed funding comes directly from governmental funding agencies such as the Science Foundation Ireland Research Centres Programme and the European Regional Development Funds and indirectly from industry partners such as large multinationals, SMEs and start-ups based on collaborative research agreements. These funds support indirect costs, equipment purchase, and operational staff salaries.
- Funded H2020 and Horizon Europe projects contribute indirectly to testbed maintenance and support. Iris has also received open call funding from EU projects to upgrade the testbed, such as from 5GINFIRE, and to support SMEs and academic institutions with wireless research and experimentation. Notable projects to date include: Fed4FIRE+, ORCA, WISHFUL, FORGE, eWINE, etc.

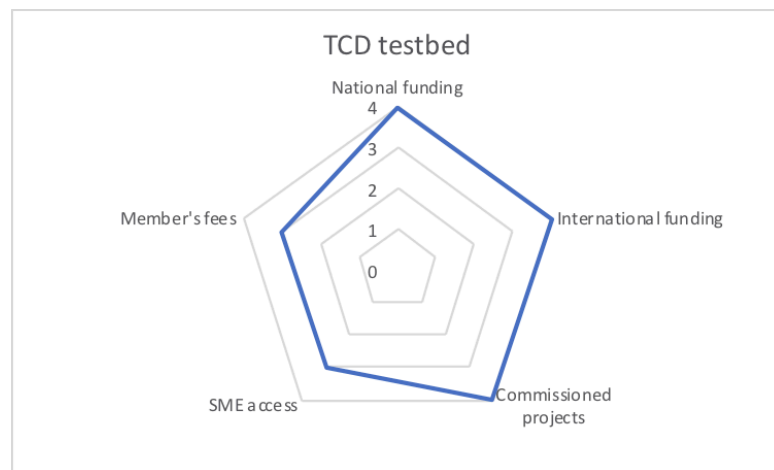


Figure 2- Radar plot of TCD's planned funding effort.

4.2.3 UNIVBRIS testbed

- UNIVBRIS is still working on novelty optical solutions on its testbed and keeps to provide it using the federation. The UNIVBRIS Testbed is able to be used as an infrastructure capable to evaluate cross-layer orchestration and/or optimization algorithms.
- UNIVBRIS has plans to use testbed resources and local expertise for R&D projects in partnership with industry related with 5G environments, and also for using in other projects that will be useful for maintaining and expand our cloud and optical solution in the testbed. UNIVBRIS has also received fundings from EU projects to upgrade the testbed, such as from 5GINFIRE, and to support academic institutions with optical-wireless-cloud research and experimentation.

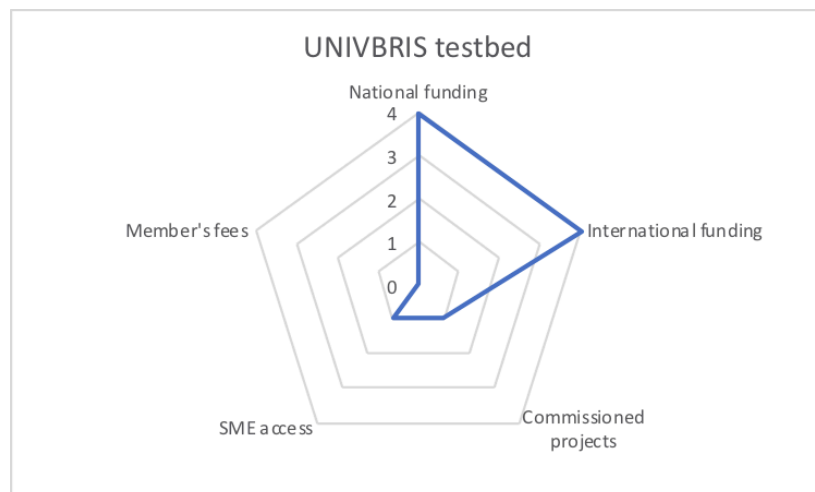




Figure 3- Radar plot of UNIVBRIS's planned funding effort.

4.2.4 UFMG testbed

- The main focus of the UFMG team will be towards ensure further funding, mainly coming from national agencies, such as CNPq, Fapemig, CAPES and RNP. Moreover, since the testbed is a tool for the research carried out in UFMG, funding from such agencies will be used to increase the existing hardware resources.
- UFMG also plans to use testbed hardware and local expertise for R&D projects in partnership with industry. Those projects can be funded in a number of ways (e.g. innovation law, informatics law, EMBRAPII, funds from the companies themselves). A percentage of the budget (in the order of 1-5%, varying depending on the nature of the funds) of such projects will be allocated to maintain and expand the testbed.
- Course on 5G using FUTEBOL's resources (in partnership with UFES) - We are finalizing a 5G course, which will use the FUTEBOL testbeds for practical assignments. A percentage of the funds will be directed towards the maintenance of the testbed.

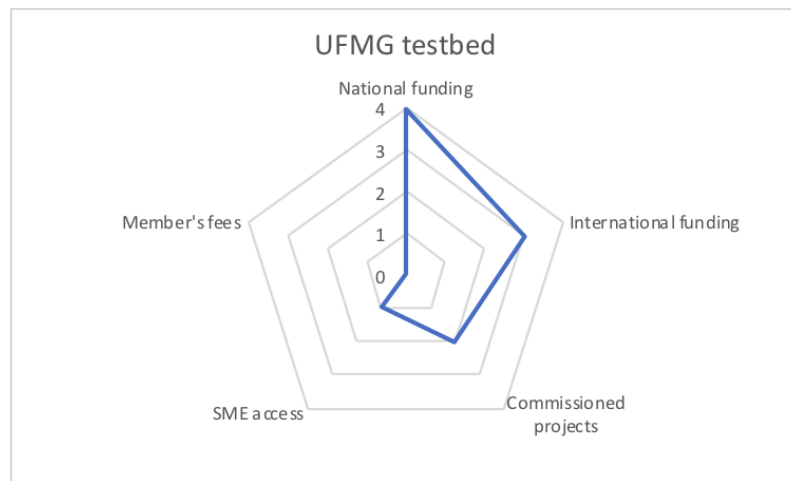


Figure 4 - Radar plot of UFMG's planned funding effort.

4.2.5 UFES testbed

- UFES plans to use testbed hardware and local expertise for R&D projects in partnership with industry. In terms of government funding, there was a research agency call by CNPq-Fapes that has been approved to fund emergent research groups (NERDS¹). This is a follow up initiative to fund the UFES testbed (see Lab-NERDS webpage <http://nerds.ufes.br/>).
- Initial arrangements were made with R&D facility of *ArcelorMittal* in Brazil for using UFES testbed as a prototyping pilot system for planning an automating steel production process in their plants around the world. In those plants, computer vision integrated with cloud-robotics is a key technology for steel production process automation due to the high temperatures and aggressive environments. That allows envisioning a clear use of FUTEBOL testbed at UFES for prototyping specific algorithms for: i) designing a multi-camera 3D detection and localization; ii) designing robot automatic control while interacting with the cameras; and iii) evaluating the impact of network constraints while using remote cloud computing facilities.
- Advanced discussions are being conducted between UFES and a SME called *Atman systems*². UFES testbed will be used for testing a cyber-physical system combined with vehicle to infrastructure (V2I) employing computer vision and smart road intersection for smart cities.

¹https://fapes.es.gov.br/Media/fapes/Importacao/Arquivos/EditaisResultados/Edital_05-2017_PRONEM_SelecaoHomologado_21dez2017_Instrucoes.PDF

²<http://www.atmansystems.com/>



- Another potential user of UFES testbed is *Vixsystem*³. They require a large set of resources to run their application, in particular, a combination of cloud-computing and computer vision in the UFES testbed. They are currently facing challenges regarding both indoor localization and improving processing capabilities (avoiding embedding power-hungry hardware) of their prototypes for *Lysa*⁴, a robotic guide dog for the blind and visually impaired.

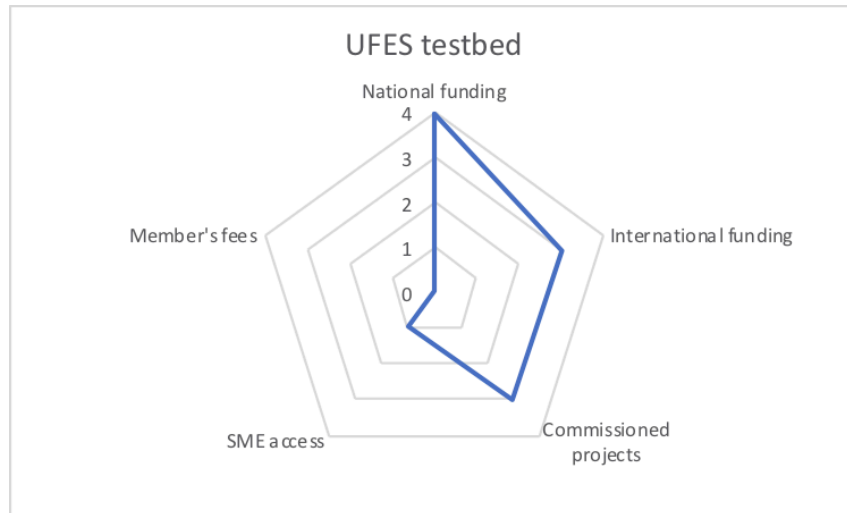


Figure 5 - Radar plot of UFES's planned funding effort.

4.2.6 UFRGS testbed

- The computer networks group at UFRGS will continue working on experimental research in topics like 5G, IoT, Industry 4.0, etc, thus we will be constantly seeking for funding from the main state and federal government agencies, such as CNPq, CAPES, FAPERGS, and RNP (a couple proposals are already under consideration).
- We are currently running research projects in areas related to network management, network functions virtualization, and security, to name a few, with national and international funding that will use the facilities deployed by FUTEBOL beyond the lifetime of the project and help maintaining and expanding the testbed.
- We have been in contact with SMEs currently incubated in the *Centro de Empreendimentos em Informática* (CEI) at UFRGS that are potential candidates to use the testbed. We have actually partnered already with a company called E-Aware to expand the testbed capabilities, and we will keep looking for further opportunities.
- We have a long history of industry projects as well, partnering with local companies and now with the testbed facilities deployed we have more tools to propose realistic prototype implementations. Therefore we will approach industry partners to assess the possibility of new partnership projects to use and help fund the testbed.

³ <https://www.vixsystem.com.br/>

⁴ <https://www.youtube.com/watch?v=0jkLAG1sKHk&authuser=0>

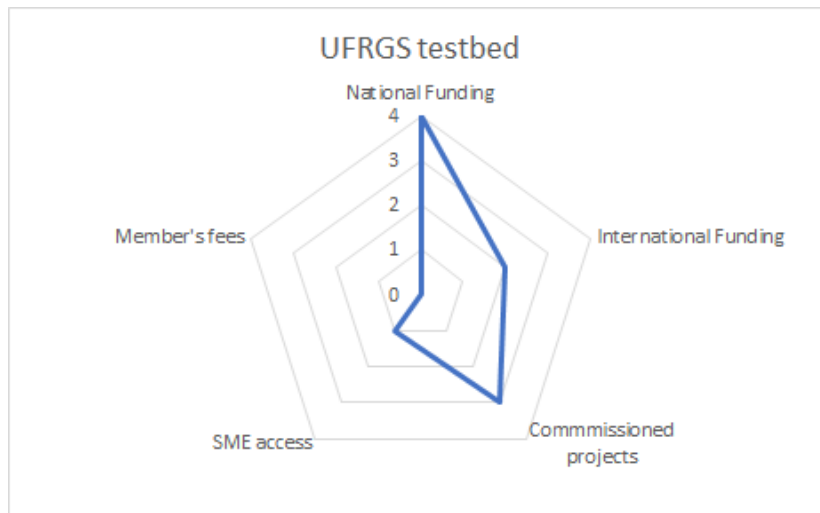


Figure 6 - Radar plot of UFRGS's planned funding effort.



5 CONCLUSIONS

This deliverable describes the FUTEBOL plans for outreach, extension and sustainability beyond the period of coverage of the EU-BR funding. This plan will be used by the FUTEBOL partners as a guideline for future actions regarding the FUTEBOL testbeds.

Concerning extensions, FUTEBOL partners will work towards adding new functionalities to their testbeds, namely to differentiate themselves with regards to other Fed4Fire+ testbeds, and towards providing new features that speed up or simplify the experimental process.

With regards to outreach, the testbeds will continue to attract more users, and will allow high impact research thanks to the testbeds capabilities. Besides those activities, we plan to keep improving the user guides and to use the testbeds' infrastructure for courses and teaching.

Funding is critical for the upkeep of testbeds, so we have outlined the funds that have already been secured, as well as the projects that have already been submitted. Furthermore, we have also outlined the importance of many different paths for funding (national and international projects, commissioned projects, etc) for each testbed, based on the opportunities and expertise of each partner.



REFERENCES

- [1] http://www.5gensure.eu/sites/default/files/5G-ENSURE_D4.5%20Testbed%20Extension%20and%20Operation%20Plan.pdf