Cover page

Bando PrIN 2019

Title of the program:

VIRTUAL REALITY AND AUGMENTED REALITY FOR SCIENCE, EDUCATION AND OUTREACH

Carattere del programma: DIV

National Scientific Coordinator:

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INAF Structures participating in the program:

1. Palermo OA
2. Palermo IASF
3. Bologna OAS
4. Catania OA
5. Osservatorio d'Abruzzo
6. OA Capodimonte
7. Trieste OA
8. Arcetri OA
9. OA Roma

Program summary

Virtual Reality and Augmented Reality hold enormous potential for science, education and outreach, and for the fruition of cultural heritage and knowledge transfer and the use of VR and AR in education has many benefits, such us visualizing the invisible, improving the learners' sense of presence, immediacy, and immersion, increasing content understanding and motivation.

VR allows scientists to navigate and interact with their own virtual environments and multiple representations can help to experience phenomena like magnetic fields or spatial scales, thus facilitating the exploration of the universe. Furthermore, the use of these instruments bridges formal and informal learning and the ease of portability of devices like Oculus or smartphone enables to set up AR and VR experiences at various events, festivals and in classrooms.

Nevertheless, despite the broad proliferation of VR and AR tools in consumer culture, only a small minority of institutions currently uses these technologies.

The digital shift has had a profound impact on the way cultural content is produced, disseminated and accessed, thus we ask for funds to face the challenges posed by ICT, in order to improve the growth and competitiveness of INAF also in the field of innovation both in the creation of science contents and in knowledge tranfer.

We intend to share the experiences and the activities related to virtual and augmented reality that have been carried on in many INAF structures, take up new technologies and develop new models and exhibitions, that can be used in VR and AR to explore the world of astronomy, thus making people visualise abstract concepts, promoting the understanding of even the most complex topics and demonstrating the usefulness and the beauty of science.

Since today's students are accustomed to high levels of interactivity and games, they easily become disengaged when teachers use traditional methods. Thus, the use of ICT in education and outreach is really effective to engage also teen agers and young people.

The project aims to bring together researchers from different INAF sites and instil a mindset of innovation and collaboration through the sharing of experiences, data and knowledge which should arouse more innovation and the technological development.

The project aims to:

- Start the creation of an INAF national Virtual Lab to experiment and test innovative ways to create 3D simulations of astrophysical phenomena, create virtual environments of INAF facilities and museums, create learning classes of research topics through VR, find low-cost solutions for VR and AR, in order to reach a broader audience, investigate AR experiences with the use of smartphones and Google VPS (Visual Positioning Service) for educational purposes.

- The INAF Virtual Lab will be provided with a variety of cutting-edge equipment and will also conduct innovative experimental research to deliver effectively immersive experiences for education, outreach and for Cultural Heritage.
- This lab will serve as a training school to share the acquired competences to all the INAF researchers and technologists involved in education and public outreach, so that they can create their own visualization tools or understand the better ways to use VR and AR for outreach, education and communication purposes.
- Acquire the hardware and the software needed and develop AR/VR products and exhibitions for science, education, outreach, and for the fruition of Cultural Heritage
- Us
- Activate collaborations with scientists and software engineers with related skills, in order to develop the aforementioned technologies
- Develop AR/VR astro-tourism contents to support the "astronomical routes" of the INAF pilot project on the astro-tourism plan in Florence and Palermo, which has already developed astronomical itineraries in the cities
- Organize at least 3 events of public outreach per site per year where to show VR and AR exhibits
- Participate in international meetings to present the outcome of our VR/AR tools and acquire knowledge on the newest products and solutions on the VR/AR field and ICT at large.
- Organize an international workshop before the end of the two years program to put together all the experiences learned by the participants and showcase their results within the INAF community and to experts from all over the world.

In summary, the proposed project promotes scientific excellence in strategically relevant areas and represents a coordinated national effort to mark a new real step into the innovation and improvement of the outreach experiences INAF has been carrying on in the last years. The project will benefit all the INAF structures and it will give more attractiveness and potential in outreach and educational efforts.

Contesto scientifico generale, nazionale e internazionale del programma (max. 4 pagine, incluse figure e referenze bibliografiche).

The future of our country rests on inspiring and training the next generation of scientist and citizens. For this reason the public outreach and education team at the National Institute of Astronomy (INAF) works as a national community from the IYA2009 to promote the INAF mission, communicating astronomical discoveries and achievements to the public, engaging the general public in astronomy and training and inspiring students to consider a career in STEM research areas.

To share cutting-edge scientific discoveries and knowledge of the universe in a way that inspire, excites, challenges and informs a vast audience, throughout the years we have organized a very significant number of public events, exhibits and displays, managed visits and activities at the observatories museums, facilities and science institutes, set up websites, published multimedia and video contents.

We made large use of social media, printed brochures, books, astronomical guides and a range of other printed products, organized theater performances, made experiments of astro-tourism and interdisciplinary activities, like science and art events, developed internet-based activities and didactical games.

Moreover, we have carried on formal education projects, classroom lessons, curriculum development, after-school programs, classroom visits and taken care of the professional education of teachers, graduate students and post-docs. We have also contributed to programs engaging people with disabilities.

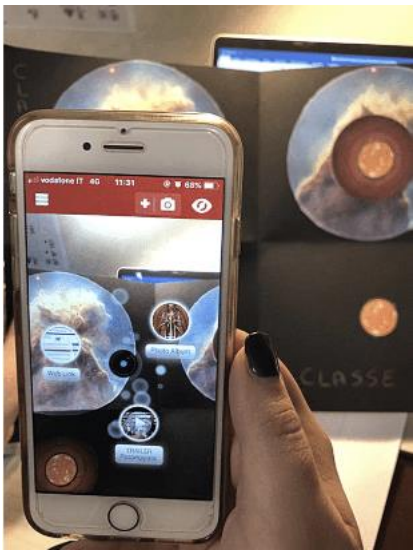
Furthermore, we have participated to international, national, regional, and local meetings, science fairs, exhibits, and events that provide opportunities to interact with other experts and to connect with diverse audiences.

These programs offered great potential for public education and outreach at all levels and for different target audiences: school-age children and their families, college students, young adults, teachers and science professionals, and more generally informal learners, that may have some general awareness of astronomy and its long and rich cultural heritage.

Increasing the awareness of current scientific research in the youngest segments of the citizenry is particularly important to us and our outreach efforts to investigate continuously new opportunities of promoting science among teen agers and young people, exploring new ways to communicate complex topics, making people visualise abstract concepts and demonstrating the usefulness and the beauty of seemingly distant science.

Among the major challenges schools are facing in teaching science, the first is to keep today's students engaged as they are learning about science. Today's students are so accustomed to high levels of interactivity and games that they easily lose their interest when teachers use traditional

methods. Moreover, because of the high costs and lack of resources, many schools are unable to provide their students with adequate access to science facilities such as laboratories. As a result, students may lack the opportunity to learn practical science, which is an essential part of education.
In a society in which many people, even young children, have access to high resolution smart phones and highly realistic video games, it is important to leverage on cutting-edge technology to intrigue young and old minds alike. Virtual and Augmented Reality allow for powerful learning experiences, adding the "wow" factor that encourages children and adults who attend our events to learn more about astronomy and can increase students interest in STEM fields, particularly physics and math. The use of AR in education has many benefits, such us increased content understanding and student motivation.



Among the factors influencing the learning process, sounds, narrating voices, visual representation and animation can be crafted in many ways to present the narrative of a given concept or phenomenon being these the most effective means to target different audiences. Multiple representations can facilitate students' ability to experience phenomena that are otherwise impossible or infeasible, understanding spatial scales in the Solar System, or visualizing the structure of a magnetic field. Furthermore, by allowing the learner to physically enact the abstract educational concepts through gestures, their understanding can be greatly improved (Radu, 2014). Wu et al. (2013) emphasized that AR systems can support learners in visualizing abstract science concepts or unobservable phenomena, thanks to the following specific features:

• learning content in 3D perspective
• ubiquitous, collaborative and situated learning
• learners' sense of presence, immediacy, and immersion
• visualizing the invisible
• bridging formal and informal learning.

Virtual reality technology is poised to revolutionize science education by increasing access to practical science.

To engage actively the learners for interacting with science, and increase their access to practical scientific education, the developement of fully interactive virtual laboratories complete by gamification elements such as an immersive 3D universe, or a storytelling dynamics, is a successful solution.

In particular highly immersive experience provided by virtual reality headsets like Oculus increases engagement and the rate of transfer of knowledge. They offer interactive sensorial experience which can easily carry complex topics to the learners about astronomical environments and phenomena. Furthermore, the ease of portability enables to set up Virtual Reality experiences at various events, festivals, and even in classrooms.

The future of VR for scientific purposes in astrophysics resides most likely in the development of a robust, generic application devoted to the exploration and visualization of 3D observational datasets.

In the last few years, many INAF structures have experienced virtual reality and augmented reality in different fields; just to quote some experiences:

Oculus and other visors have been used for public outreach and education in Palermo, Bologna, Naples, Cagliari, Trieste and Teramo with excellent feedback.

The Palermo and Teramo museums have enhanced their collections and improved some exhibits using QR codes and/or Zappar codes.

Some INAF structures have recently developed VR experiences for the SKA and CTA outreach package.

Many sites are creating virtual tour of their museums and facilities with touchble hotspots.

The INAF – Osservatorio Astronomico di Trieste uses "Samsung Gear VR" visors connected to smartphones and the Virtours platform (http://www.virtours.com) to develop contents. Thanks to the Virtours platform, visors can be used both individually or controlled by a tablet, for a guided

experience. Moreover, it is possible to follow the tour also for people who do not wear the visors, since the contents are also visible on an external screen.

INAF - OATs VR tours have been presented to the public during many events such as the “Guido Horn’s telescope” exibhition and “Trieste NEXT” science festival, involving several thousands of people. The INAF-OATs experience on VR has been presented at the International Virtual Observatory Alliance interoperability meeting in Paris (May 2019).

As an example, the Trieste NEXT VR 360° tour is available at: http://bit.ly/next2019inaf.

The tour starts with a starry Piazza Unità d'Italia, then it moves to the Basovizza observing station and from there it jumps into a 360 degrees sky, which will is explored as from a spaceship that left the Earth. Then the tour comes back on our planet on the Chilean Andes where the largest telescopes of the world survey the deep sky.

The INAF - Osservatorio Astronomico D'Abruzzo developed “Mundus Coeli Vastus”, a sort of virtual planetarium, that represents models of ancient cosmologies, developed using Unity and Oculus Rift with many different 3D models, as for example a model of the solar system, to enrich the museum exhibit. In addition, the researchers experimented augmented reality application with Unity and Vuforia that use the camera of a tablet to recognize an element of the solar system and a virtual reality application (a game), developed with Unity, with the use of the Oculus Rift that allows a player to rebuild the solar system, interacting directly with its elements.

The MuSA - Museum of Astronomical Instruments of the Capodimonte Astronomical Observatory has created a virtual tour with Google Street View technology to visit and admire its collections freely (https://www.media.inaf.it/2016/07/07/realta-virtuale-napoli/).

The MUVISS - VIrtual MUseum of Space Sciences of the IAPS is an experimental prototype of a virtual reality system that allows the realization of new forms of communication, dissemination and teaching of scientific contents such as navigation in the Solar System and space. It is composed of different systems related to virtual reality and / or experiences in 3D, such as an integrated 3D planet simulator, an immersive virtual reality system, lessons with smartphone viewers

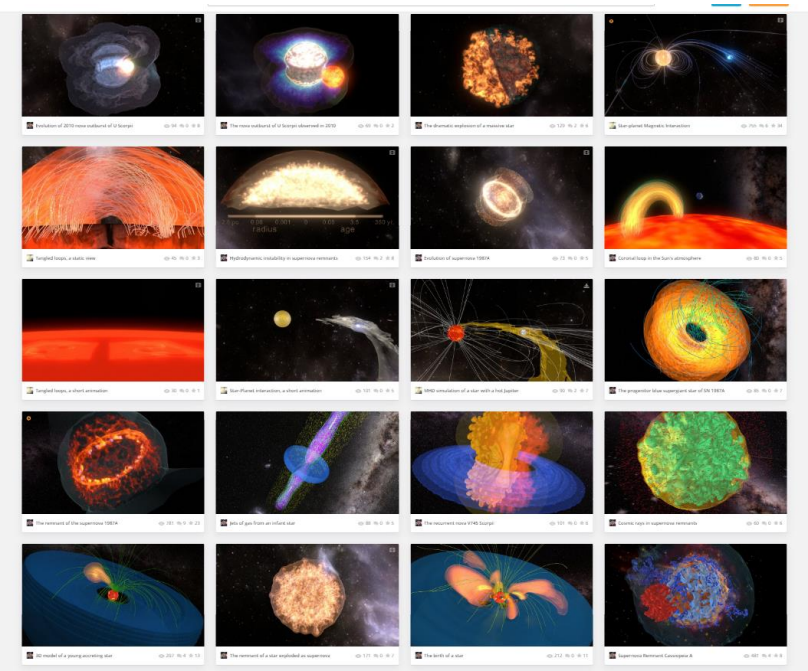
(http://www.iaps.inaf.it/ufficio.comunicazione/per-il-pubblico/muviss-museo-virtuale-di-scienze-spaziali/).

In the last few years OACT-ICT has started to develop VR Application (using Unity as Game Engine and Oculus Rift as Virtual Reality Headset) as knowledge-transfer activities in the framework of the Italian Ministry of Education, Universities and Research project named "Agreement University of Milan Bicocca – Consortium Cometa for the evaluation of leading-edge interactive technologies for improving teaching and popularization of science" (http://www.argo3d.unimib.it/) and as part of the 3DTeLC project funded through the Erasmus+ Key Action 2 Strategic Partnerships for Higher Education scheme (http://3dtelc.lmv.uca.fr/). The VR application is aimed at giving the possibility of teaching and disseminate Earth Sciences and geo-hazards navigating into a 3D geological environment, where it is possible to observe in detail and measure objects of interest.

INAF-OACT has also starded a collaboration (https://www.media.inaf.it/2019/09/04/ska-vr-inaf-idia/) with IDIA - South African Inter-University Institute for Data Intensive Astronomy to develop VR applicaton for the analysis of data coming from the Meerkat SKA precursor. See also https://www.youtube.com/watch?v=IR-wJuH8sK4&t=34s

Even if fully 3D simulations of astrophysical phenomena represent a challenge in visualizing standard data for scientific purposes, because of the amount of processed data and the wealth of scientific information they contain, the routinely scientific use of VR environments is still in its infancy. In 2019 the INAF Palermo Observatory launched 3DMAP-VR (3D Modeling of Astrophysical Phenomena in Virtual Reality), a project for visualizing 3D MHD models of astrophysical simulations, made with FLASH or the PLUTO MHD codes, and elaborated with software like Paraview for a graphical rendition of the results available also using VR equipments (https://www.media.inaf.it/2019/05/02/supernova-realta-virtuale/). Recently the astrophysicists of the INAF Palermo Observatory have uploaded on the Sketchfab portal some of their models in the collection “Universe in hands” with great feedback

https://sketchfab.com/sorlando/collections/universe-in-hands



Other models are in the gallery “The art of astrophysical phenomena” available at the link https://skfb.ly/6OzCU.

The collections show the results of (magneto-)hydrodynamical models of different astrophysical phenomena.

These 3D models have attracted the interest of many research institutions and universities and even the NASA contacted our astronomers for using them!

It is worth noting that scientific visualizations and materials INAF researchers produce allow the public to directly interact with current scientific data and visualize complex processes. In addition, the study and the use of virtual reality has stimulated great sinergies between the outreach team and the astronomers and between researchers and the public.

Other science public institutions in Italy, like INFN and CNR, have VR facilities to support research, education and oureach activities (http://www.roma3.infn.it/vr/). In particular:

- the **CNR** group Enterprise Engineering and Virtual Applications (EVA) has experience in the use and application of technologies capable of involving the user in an interactive digital environment; EVA uses video cameras and tracking systems to acquire in real time data related to the user and to the environment. CNR has also developed GIOVE (Graphics and Interaction for OpenGL-based Virtual Environments), a set of tools created for the development of collaborative virtual reality environments.

- **CINECA** has a Visual Information Technology Laboratory (VIS.IT LAB) which has been operating for years in the field of scientific visualization, for Cultural Heritage and Big Data, according to an ecosystem vision and promoting the understanding of complex research activities, thanks to image synthesis. VIS.IT LAB favours the creation of open source frameworks with a cross-media approach, working with multidisciplinary project teams.

- The **INFN** section of Roma Tre has a laboratory that, through different Virtual Reality systems, supports research, teaching and dissemination activities. The main application in use at the laboratory is BELLE II VR http://www.roma3.infn.it/en/vr/

There are many institutions in the rest of the world, like ESA, NASA, etc. exploiting the potential of VR and AR for research visualization, education and outreach events, planetariums, museums, creating 360º videos, software for Oculus and visors, virtual environments. Some examples are:

- The Astrophysical Big Bang Laboratory at RIKEN, Japan

https://arxiv.org/abs/1811.01542

https://ithems.riken.jp/ja/news/engaging-the-public-with-supernova-and-supernova-remnant-research-using-virtual-reality

- NASA

https://jcom.sissa.it/archive/18/04/JCOM_1804_2019_A01

https://informal.jpl.nasa.gov/museum/360-video

https://www.nasa.gov/feature/jpl/mars-virtual-reality-software-wins-nasa-award

https://www.ibtimes.com/nasa-creating-virtual-reality-space-movie-spacex-dragon-set-return-footage-2818237

- Pardue University

https://boilerlink.purdue.edu/organization/vr

https://www.rcac.purdue.edu/news/1297

- ESO

http://snr2019.astro.noa.gr/wp-content/uploads/2019/08/S9.6-Vogt-poster.pdf

https://www.eso.org/public/italy/videos/Mars-The-Red-Planet-VR/

https://www.eso.org/public/announcements/ann17079/

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Salvatore Orlando, Ignazio Pillitteri, Fabrizio Bocchino, Laura Daricello and Laura Leonardi*: 3DMAP-VR, A Project to Visualize 3-Dimensional Models of Astrophysical Phenomena in Virtual Reality*, AAS21348 -RNAAS Research Notes of the AAS (2019) https://iopscience.iop.org/article/10.3847/2515-5172/ab5966#rnaasab5966fn1

Osborne, J. & Hennessy, S. (2006). *Literature review in science education and the role of ICT: promise,*
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Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, *18*(6), 1533–1543.

Wu, H., Lee, S.W., Chang, H. & Liang, J. (2013). Current status, opportunities and challenges of augmented
reality in education. *Computers & Education*, *62*, 41-49

Workflows for virtual reality visualisation and navigation scenarios in earth sciences

Immersive virtual reality for earth sciences

Obiettivi che il programma si prefigge di raggiungere con specificato il ruolo dei partecipanti (max. 2 pagine).

The project intends to start the building up of an INAF national VR facility (that currently is not present within our institution) to support research, education and oureach activities, taking advantage of digital technologies and facing the challenges posed by ICT, in order to improve the growth and competitiveness of INAF also in the field of innovation both in the creation of science contents and in knowledge tranfer.

Many science public institutions in Italy and all over the world have VR laboratories operating in the field of scientific visualization, that, through different Virtual Reality systems, support research, teaching and dissemination activities and promote the understanding of even complex research activities.

These laboratories exploit the potential of VR and AR for research visualization, education and outreach, for Cultural Heritage and Big Data and for the development of collaborative virtual reality environments (see 3. Contest). And that is exactly our goal. The future of VR in astrophysics resides most likely in the development of applications devoted to the exploration and visualization of 3D observational datasets.

As a first step, we intend to share the experiences and the activities related to virtual and augmented reality that have been carried on in many INAF structures.

After having taken up new a variety of cutting-edge equipment to build up the INAF Virtual Lab, we will conduct innovative experimental research in the study of VR/AR technologies and in the development of collaborative virtual reality environments.

We intend to develop new models and exhibitions, that can be used in VR and AR to explore the world of astronomy, thus making people visualise abstract concepts, promoting the understanding of even the most complex topics and demonstrating the usefulness and the beauty of science.

The developement of fully interactive virtual laboratories completed by gamification elements such as an immersive 3D universe and storytelling dynamics, is indeed a solution to actively engage the learners for interacting with science, and increase their access to practical scientific education.

The project represents a coordinated national effort to mark a new real step into the innovation and to promote INAF scientific excellence in a strategically relevant area like Virtual Reality technology, which is poised to revolutionize science, education and outreach by increasing access to practical science.

Summarizing, the project aims to:

• Start the building up of an INAF national Virtual Lab

•Develop AR/VR products and exhibitions for science, education, outreach, and for the fruition of Cultural Heritage (including the development of vitual environments and the use of Google VPS) and upload to the edu.inaf platform all the contents and software developed in order to effectively share them with other researchers and with non academic people

•Develop AR astro-tourism contents to support the "astronomical routes" of the INAF pilot project on the astro-tourism plan in Florence and Palermo, which has already developed astronomical itineraries in the cities

•Organize at least 3 events of public outreach per site per year where to show VR and AR exhibits

•Participate in international meetings to present the outcome of our VR/AR tools and acquire knowledge on the newest products and solutions on the VR/AR field and ICT at large.

•Organize an international workshop before the end of the two years program to put together all the experiences learned by the participants and showcase their results within the INAF community and to experts from all over the world.

The work project will be composed of the following work packages (WPs):

WP0 - Project management and dissemination (months 1-24):

At the beginning of the project, we plan to organize a kick off meeting to make a survey of the experiences and the activities related to virtual and augmented reality that have been carried on in the last years and exchange information on the hardware/software used. Immediately afterwards the project will enter its operative phase.

The proposers will have a continuous tracking of all actions involved in this project (tasks, deliverables, financial assets) and will take all the necessary actions to guarantee its successful evolution and finalization. A conference call per month among the participants will assure the smooth conduct of the project as well as the desired interaction and feedback among the researchers.

An international workshop, close to the end of the project, will give visibility to our results.

The proposers will be engaged to communicate the results of the project, with talks/posters, events.

WP Responsible: L. Daricello; participants: all participants

WP1 – creation of an INAF Virtual Lab to exploit the potential of VR and AR for science visualization, education and outreach to share cutting-edge scientific discoveries and knowledge of the universe in a way that inspire, excites, challenges and informs the vast audience. The first step will be the purchase of the hardware and software to built up this Lab, as GoPro Omni to create 360-degree training simulation content, Oculus Quest Virtual Reality Headsets to deliver virtual reality simulations, Microsoft HoloLens for augmented reality training simulations.

Then, the researchers involved in the project will find the best solutions to create VR/AR simulations, models and exhibits. They will also study how to develop collaborative virtual reality environments and investigate experiences of AR/VR, which use smartphone and Google VPS. They will also create

learning classes of research topics through virtual reality and think about low-cost options for VR and AR, such as cardboard or other devices, in order to reach a broader audience, and will, for educational purposes. This WP includes a training school to share the acquired competences to all the INAF researchers and technologists involved in education and public outreach. *WP Responsible: M.G. Guarcello; participants: all participants*

WP2 - Development of VR contents: This WP has 3 sub-WPs. All the contents will be upload to the edu.inaf platform

WP2.1 **- realization of contents for science visualization**. *WP Responsible: M.G. Guarcello; participants: L. Daricello, L. Leonardi, G. Iafrate, M. Ramella, G. Cutispoto, T. Mineo, P. Sangiorgi, V. La Parola, A. La Barbera*

WP2.2 - realization of exhibits and contents for education and outreach *WP Responsible: G. Valentini; participants: all participants*

WP2.3 – development of vitual environments and the use of Google VPS: *WP Responsible: M.G. Guarcello; participants, L. Daricello, L. Leonardi, G. Cutispoto, G. Iafrate, M. Ramella, T. Mineo, P. Sangiorgi, V. La Parola, A. La Barbera, A. Rifatto*

WP3 - Development of AR contents: This WP has 3 sub-WPs. All the contents will be upload to the edu.inaf platform

WP3.1 **- realization of *AR* contents museums and INAF facilities**. *WP Responsible: V. La Parola; participants: all participants*

WP3.2 - realization of *AR* exhibits and contents for education and outreach *WP Responsible: A. La Barbera; participants: all participants*

WP3.3 - realization of astro-tourism *AR* contents and a game using also Google VPS: The INAF - OAPa has worked with Arcetri and Padua in the INAF pilot project on the astro-tourism plan to develop astronomical itineraries in the cities, that is going to be completed with the realization of the guide "Palermo. Second star on the right" ed. Bas Bleu. INAF - OAPa intends to develop AR astroturism contents to support the “astronomical routes” in the city. *WP Responsible: L. Daricello; participants: L. Leonardi, F. Tribioli*

WP4 - Organization of events of public outreach with VR and AR: *WP Responsible: F. D’Alessio; participants: all participants*

Here is a table with the of the project with the intermediate and final check points.

Month/s	Description	Deliverable
1-24	Continuous tracking of all actions involved in this project (WP0)	Project Status Report every 3 months
1-2	Kick off meeting (WP0)	Report

1-5	Purchase of the hardware and software (WP1)	Verification or testing report from the RUP
1-24	Realization of VR contents for science visualization (WP2.1)	Simulations
13-24	Experimenting ways to create virtual environments (WP1)	Creation of a virtual environment
6-24	Studies on how to create VR learning interactive classes (WP1)	Report, publications
6-24	Training of the INAF colleagues involved in the project (WP1)	Classes, summary of the lessons
1-5	Find low-cost solutions for VR and AR (WP1)	Report on the solutions tested
5-24	The study of the use of AR with phones and Google VPS (WP1, WP2 and WP3)	Report on the solutions tested
1-24	Development of VR products and exhibitions (WP2.2)	VR products and exhibitions
1-24	Development of AR products and exhibitions (WP3.2)	AR products and exhibitions
1-24	Realization of AR contents museums and INAF facilities (WP3.1)	AR products and exhibitions
2-24	Upload of contents to the edu.inaf platform (WP2 e WP3)	Contents uploaded
13-24	Activation of a research grant (WP1)	Contract and report on the activities
6-24	Development of AR astro-tourism contents (WP3.3)	Contents available for web and smartphones
12-24	Development of vitual environments (WP2.3)	Exhibit using vitual environments
6-24	Organization of events of public outreach with VR and AR (WP4)	Events, printed or digital materials
6-24	Participation in international meetings (WP0)	Publications
20-24	Organization of an international workshop (WP0)	Publications

Impegno di personale di ruolo dedicato al programma (in FTE), **distinto per qualifica e ruolo all'interno del programma e suddiviso per strutture di ricerca** (per il personale Associato vale la Struttura presso la quale si è associati).

INAF Structures participating in the program:
Palermo OA
Palermo IASF
Bologna OAS
Catania OA
Osservatorio d'Abruzzo
OA Capodimonte
Trieste OA
Arcetri OA
OA Roma

People involved in each structure and main tasks

Affiliation	Name	Status	Months	Main Tasks
OA Palermo	Laura Daricello	Technologist	0.5+0.5	- Creation of the Virtual Lab and 3D Modeling of Astrophysical Phenomena in Virtual Reality - Development of VR and AR apps and programs for research, education, outreach and cultural heritage - experiments of Astro-tourism with AR - organization of events - participation in the meetings
	Mario Giuseppe Guarcello	Researcher	0.3+0.3	
	Filippo Salemi	Technologist	0.3+0.3	
	Laura Leonardi	Research fellow	0.3+0	
OAS Bologna	Sandro Bardelli	Astronomer Researcher	0.3+0.3	

	Elena Zucca	Astronomer Researcher	0.3+0.3	- Content development for AR and VR and realization of exhibits - organization of events
Palermo IASF	Teresa Mineo	Senior Researcher	0.3+0.3	- Content development for AR and VR and realization of exhibits - organization of events
	Pierluca Sangiorgi	Technologist	0.3+0.3	
	Valentina La Parola	Researcher	0.3+0.3	
	Antonino La Barbera	Researcher	0.3+0.3	
Trieste OA	Giulia Iafrate	Technologist	0.3+0.3	- Content development for AR and VR and realization of exhibits - organization of events
	Massimo Ramella	Associate Astronomer	0.3+0.3	
Osservatorio D'Abruzzo	Matteo Di Carlo	Technologist	0.3	- Content development for AR and VR and realization of exhibits - organization of events
	Buonanno Roberto	Full professor	0.3+0.3	
	Elisa Di Carlo	Researcher	0.3+0.3	
	Gaetano Valentini	Researcher	0.4+0.4	
OA Catania	Giuseppe Cutispoto	Associate astronomer	0.3+0.3	- Content development for AR and VR and realization of exhibits - organization of events
OA Capodimonte	Agatino Rifatto	Astronomer Researcher	0.3+0.3	- Content development for AR and VR and realization of exhibits - organization of events
	Luciano Terranegra	Astronomer Researcher	0.3+0.3	
	Dario Mancini	Full Professor	0.3+0.3	
	Maurizio Oliviero	Astronomer Researcher	0.3+0.3	
OA Arcetri	Francesco Tribioli	Technologist	0.3+0.3	- Content development for AR and VR and realization of exhibits

				- organization of events - experiments of Astro-tourism with AR
OA Roma	Francesco D'Alessio	Astronomer Researcher	0.5 + 0.5	- Content development for AR and VR and realization of exhibits - organization of events
	Maria Teresa Menna	Researcher	0.5 + 0.5	

The project will also take advantage of the expertise of some technical staff within INAF.

Costi del programma (limitatamente ai fondi richiesti ad INAF) **suddivisi per macro-voci** (investimento, consumo, calcolo, missioni, spese per assegni di ricerca, borse di studio e personale a Tempo Determinato, spese per pubblicazioni).

We are asking 100 Keuro to:

1. buy the hardware and the software needed
2. activate collaborations with specialized personnel to develop some technologies
3. Develop VR and AR exhibits for science, education, outreach, and for the fruition of Cultural Heritage
4. Organize at least 3 events for the public per seat per year and test our VR and AR exhibit
5. Participate in international meetings to present our research and keep ourselves up to date on ICT

Estimated costs for the Project:

Item	Cost (keuro)
Personnel	24
Equipment	51
Travels	17
Consumables	8
TOT.	100

Financial request per UOL

OA Palermo	Detailed description of the requested items	Request (keuro)
Personnel	Activation of a research grant for 1 year	24 keuro
Equipment	GoPro Omni to create 360-degree training simulation content (or similar)	6
	4 Oculus Quest Virtual Reality Headsets to deliver virtual reality simulations	2
	Microsoft HoloLens for augmented reality training simulations (or similar)	6
Travels	Participations in international meetings to share the results of the project	3
	TOTALE	**41**

OAS Bologna	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software	4
Travels		1
Consumables		1
	TOTALE	**6**

Osservatorio D'Abruzzo	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software	4
Travels		3
Consumables		2
	TOTALE	**9**

Trieste OA	Detailed description of the requested items	Request (keuro)
Equipment	Virtours licence + device renewal + 360° panorama (images and videos) editing software	7
Travels		3
Consumables		1
	TOTALE	**11**

Arcetri OA	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software + equipment for AR	5
Travels		2
	TOTALE	**7**

IASF Palermo	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software + equipment for AR	5
Travels		2
Consumables		1
	TOTALE	**8**

OA Capodimonte	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software	4
Travels		1
Consumables		1
	TOTALE	**6**

OA Catania	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software	4
Travels		1
Consumables		1
	TOTALE	**6**

OA Roma	Detailed description of the requested items	Request (keuro)
Equipment	Kit Oculus + Software	4
Travels		1
Consumables		1
	TOTALE	**6**

Risorse strumentali ed eventualmente finanziarie messe a disposizione dalle Strutture di ricerca INAF ed eventuali altre fonti di finanziamento esterne.

Among the instrumental resources, high performance computing facilities with which we usually work (e.g. CINECA, Bologna, Italy), our researchers data analysis, the visualization applications we already have to realize navigable 3D graphics of the astrophysical simulations, the equipment for education and outreach of the involved INAF structures, like Oculus visors and laptops.
More specifically:
- 3DMAP-VR (3-D Modeling of Astrophysical Phenomena in Virtual Reality), a tool for visualizing 3D MHD models, using virtual reality equipments (http://cerere.astropa.unipa.it/progetti_ricerca/HPC/3dmap_vr.htm). The workflow combines: accurate 3D HD/MHD simulations performed with the parallel numerical codes available, the software (e.g. ParaView, MeshLab, MeshMixer) to realize the scenes and quickly have a VR representation of the models, the upload of the models on Sketchfab (the largest platform to publish and share 3D virtual reality and augmented reality contents), and two Oculus Rift VR equipments and dedicated computers with advanced graphics cards to visualize the models in VR. The laboratory is used to analyze the numerical results in an immersive fashion, integrating the traditional screen displays, and for public outreach and education (see the INAF-OAPA gallery on Sketchfab https://skfb.ly/6NooE).Laboratorio 3DMAP-VR per la preparazione di contenuti VR, corredato di oculus e computer dedicati (anche qui puoi dare un'occhiata a cosa ho scritto io nel mio PRIN)
- Software for post-processing, visualization and presentation of the results (e.g. IDL, ParaView, Visit, MeshLab, MeshMixer, etc.); tools for the visualization of MHD simulations in virtual reality (oculus rift); ~ 20 TB disk storage are also available to the group within the computer network of INAF/Oss. Astronomico di Palermo to store and analyze the numerical data acquired in the framework of the PRACE Large Computational Program (Award N. 2016153460).
- Public outreach resources published on edu.inaf and astrokids.inaf.it and other educational contents produced by the observatories in the last 20 years.

Dichiarazione, datata e firmata, di accettazione da parte del Direttore della Struttura INAF di afferenza del Coordinatore Scientifico Nazionale e nulla osta da parte dei Direttori di Struttura dei partecipanti al programma.

Assenso del Coordinatore Scientifico Nazionale alla diffusione via Internet delle informazioni relative ai progetti finanziati e alla diffusione presso gli eventuali valutatori esterni, all'esclusivo scopo della valutazione stessa, delle informazioni riguardanti i progetti presentati; dichiarazione ai sensi del D. Lgs. n. 196/2003 di consenso al trattamento dei dati sensibili e non.

Data 27.11.2019

Firma del Coordinatore Scientifico Nazionale

Dott.ssa Laura Daricello

Firma del Direttore dell'INAF Osservatorio Astronomico di Palermo

Dott. Fabrizio Bocchino