Case Study

The Infini.to planetarium: One tool, many ways to make the most of it!

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Infini.to is a science center devoted to astronomy and space that contains a digital planetarium. Since its opening in September 2007, the planetarium has been one of the most essential tools for audience engagement and science communication at Infini.to. After more than fifteen years of trial and error, we have learned many lessons and identified several best practices, which we relay in this article.

Introduction: Infini.to, a brief presentation

Infini.to is the first pioneering Italian science centre devoted to Astronomy and Space, thanks to the visionary idea of its first President and Founder, Professor Attilio Ferrari. It was inaugurated in September 2007 on top of the panoramic hills surrounding the city of Turin, next to the Astrophysical Observatory (Figure 1), with the mission of communicating the most advanced results of scientific research on astronomical topics. The participating institutions of Infini.to are the National Institute of Astrophysics, the University of Turin, the National Institute of Nuclear Physics, the Piedmont Region, the Metropolitan City of Turin, and the Township of Pino Torinese.

Infini.to combines one of the most technologically advanced planetariums with a 1,000-square-metre exhibition area and more than 40 interactive exhibits. Infini.to has hosted more than 600,000 visitors and students, not only from the neighbouring cities of the Piedmont Region but also from Italy and abroad. Infini.to offers guided tours, laboratory activities, shows in the planetarium, conferences, seminars, workshops for educators and teachers, and stargazing events aimed at its many visitors.

In 2020, with the start of the Covid- 19 crisis, Infini.to launched Infini.to@home, a digital project to enrich educational programmes. With this, Infini.to opened up new opportunities to reach out to and engage with audiences, increasing the visibility of its multimedia digital assets for edutainment. The new offering considers current transformations in formal education, in which new learning models are overcoming the boundaries of traditional schooling.

In this panorama, Infini.to will be an instrumental part of the learning ecosystem – a bridge between formal, non-formal and informal learning. Recognising digital technologies as part of the museum's educational mission will strengthen its public value by providing inspiring and engaging lifelong learning opportunities for all, as well as empowering culture in society with a particular focus on youth.

Infini.to has gathered a strategic network of partners and collaborators to help it achieve its goals. These include scientific institutions,

Figure 1: *Infini.to entrance.*

space agencies, aerospace corporations, educational institutions, philanthropic organisations, publishing partners, and other science centres and planetariums.

The importance of a dedicated production team for content creation

Planetariums can be a powerful visualisation tool. However, their effectiveness relies heavily on the contents displayed and how they are presented. Today, hundreds of great shows are on the market, covering a variety of topics. Even so, we felt the need to tell our stories and to tell them in our way.

To achieve this, we built a dedicated content creation team of physicists and astrophysicists with computer graphics and storytelling expertise. The team began creating planetarium shows in 2008, less than a year after the opening. However, in a small-to-medium-sized planetarium such as the one at Infini.to, it is not always possible to have resources dedicated solely to content creators. This means the content creation team also serves as part of the explainer team, conducting guided tours inside the museum and as planetarians under the dome. This constraint turned out to be a strength. Creating your own show and immediately testing it with the audience as a planetarian is a valuable tool and can speed up the refinement process. Live audience feedback during and after shows helped us make critical improvements, leading to fast and efficient development along the entire content creation pipeline.

Moreover, producing custom content enabled us to develop a personal style: a trademark that differentiates our planetarium from others.

The process has been gradual. Initially, we started exploring the planetarium's capabilities regarding objects, databases and pre-built scripts. In this way, we encourage our visitors to engage in the same learning by engaging in processes we employ in our content creation.

There is an excellent community of planetariums, and many resources are available online, including cloud-based databases that facilitate learning from the community. After some time, we started to create our own 3D models, 2D graphics and animations. In this way, we have found that learning from the experiences of others, modifying existing materials, and challenging yourself with complex tasks is an efficient way to learn.

As pre-rendered shows require a significant amount of rendering time, the Infini.to planetarium typically uses the real-time engine already used by the system. There are some limitations typical of many real-time engines, but the gain in speed and flexibility is massive – both of which are particularly important for a small team. These limitations must be well understood to produce the best possible products and get both good performance and visual effects.

The market also offers many different solutions for software, both for 3D modelling, 2D graphics rendering, and video editing. Many great open-source software are available and cover all the necessary aspects of content creation. This is an excellent option for a small team with a low budget. As with any new software, the learning curve can be steep. However, investing time in learning and developing new skills is an opportunity for growth and progress in the future.

A planetarium's audience can be diverse, from schools of any order to families, amateur astronomers and casual visitors. By creating custom shows dedicated to specific topics or peculiar events and specific audience targets, we can meet many of the audience's needs and peculiarities. Throughout our more than 15 years of operation, many shows have been produced at Infini.to, some of them are for a particular audience or topic, and others are more flexible and can be used for general audiences. Moreover, a considerable fraction of the guests may be frequent visitors who visit the planetarium several times yearly, hoping to have a unique experience each time. Our planetarium stories are constantly evolving as discoveries and challenges step onto the horizon.

Real-time interaction and the active audience

All the shows produced internally are live shows. By interacting with the audience, we can create a unique experience at each show, accommodating the scenes according to the visitors' needs. In this way, we can answer questions, foster ongoing dialogue, and create an engaging environment for the visitors, who often continue the conversation after the show has ended.

Additionally, this interactive and friendly show creates a more relaxed environment where everyone can feel free to express themselves, transforming the traditional passive experience into an active one.

Open and real-time shows built on demand

In addition to our pre-scripted shows, we have had success in giving the audience drive the show according to their preferences and curiosity. To this end, we have special events for which we rely entirely on the visitors' requests, building the show in real-time.

These kinds of improvised shows need a lot of preparation, both from a technical and astronomical point of view. In order to be able to fly to any location requested by the audience, we have created many custom button boxes. These allow the planetarium operators to quickly load models, images, sounds, visual effects and more while maintaining a smooth narrative. Content creators must pay special attention to building scripts open enough for use in many different situations but can still achieve the desired result. Our custom-built archive of scripts, organised in buttons and pages, is constantly growing. When we began producing real-time shows, we needed two planetarium operators to run the show: one flying and the other talking, collecting requests and answering questions. Now, with more experienced staff and a more streamlined and refined system, our planetarians can run these shows individually.

Although there are some downsides to this show style, such as not being able to use a proper soundtrack synchronised to what is shown, building the show together with the audience is a unique experience, both for the planetarium operators and for the guests. Visitors feel more engaged and perceive the planetarium as welcoming, attentive, and capable of creating a unique show every time.

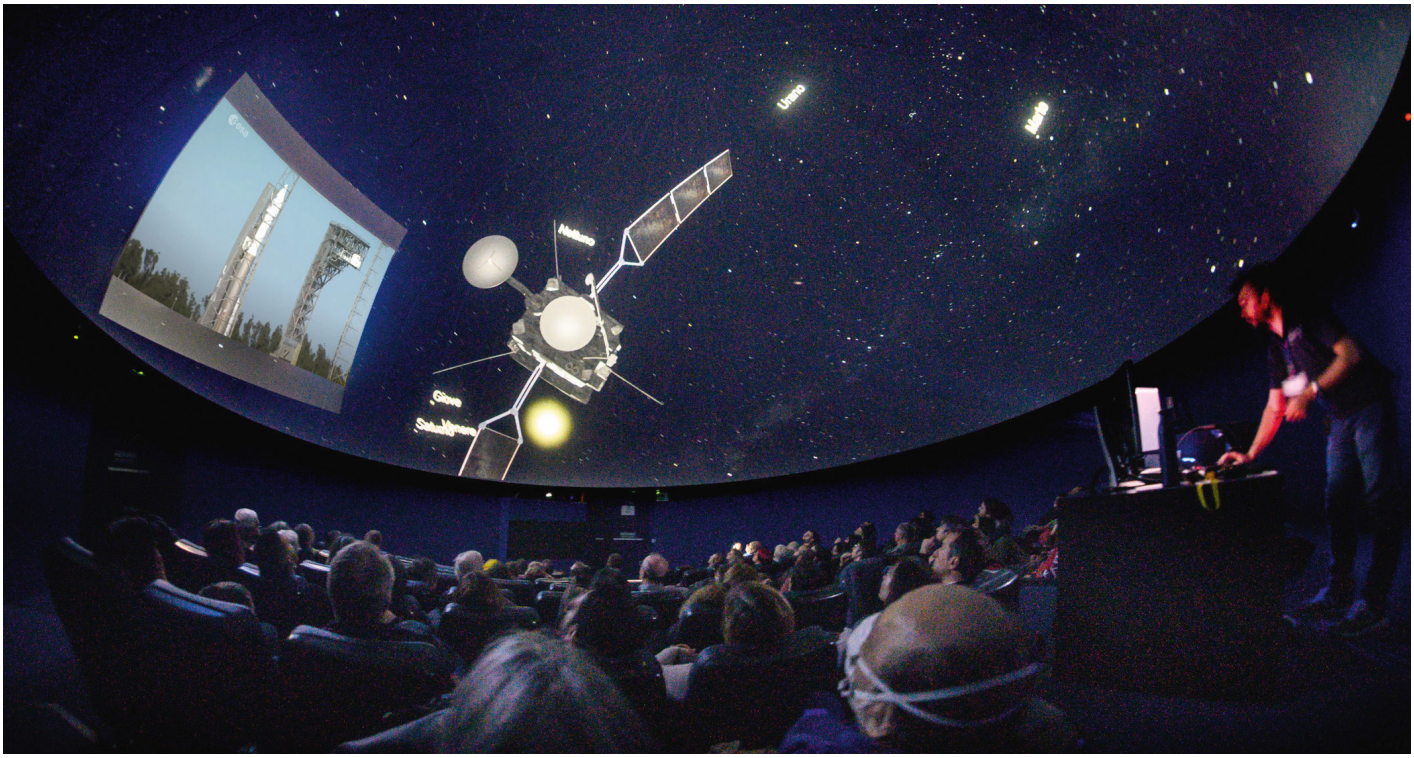

Figure 2: *A dedicated show on the ESA Solar Orbiter launch. Image Credit: Infini.to*

Create dedicated shows for current astronomy events

Astronomy is a living science. We have discoveries, publications and news almost every week – many of which make it to the public's attention. Keeping pace with these publications can be an incredible advantage, and planetariums are an excellent tool to bring these discoveries to life.

To achieve this result, we have many custom-made events during the year. Some are preprogrammed, such as commemorating a spacecraft launch (e.g., Figure 2); others are scheduled to run if a discovery arises. The expertise earned from the live events enables us to quickly create small shows for each event. Sometimes, a new spacecraft or object is featured in the news, and a 3D model does not already exist in the planetarium library. In that case, we construct a custom 3D model with dedicated textures that can be imported inside the real-time engine. To display trajectories correctly, real data is downloaded from dedicated web archives, such as JPL or ESA datacentres, and, if necessary, converted and rewritten in a readable format to be displayed and used under the dome.

Teacher training using the dome

The planetarium is a powerful educational tool, representing the sky and offering a model that is difficult to reproduce in a school environment. It is not an accessory but rather complementary to traditional teaching tools. Through its representation of the sky, the planetarium is an effective resource that allows students to change their perspective and have sensory experiences that may be difficult to replicate in real life or within a school setting.

For this reason, Infini.to has implemented several teacher trainings using the dome. Almost yearly since 2014, Infini.to has hosted a workshop on astronomy and science, reaching about 450 teachers globally. Though astronomy is not mandatory in Italy, it is part of the national science curriculum, and due to students' typical fascination with astronomy, it is a great way to introduce many other scientific disciplines, such as chemistry, physics, math, and coding. For this reason, the dome has been used not only to train teachers on specific topics and update them about astronomical discoveries but also to spread the beauty of space and share hints on how to use it in their classrooms.

Researchers under the dome

Infini.to is proud to be part of a network of scientific institutions with important technological partners. As part of this network, we invite researchers and engineers under the dome to showcase the latest discoveries and milestones in the space industry. These "Astrotalks" take place at least once a month. The idea is to use the planetarium to support the talk, giving a powerful visualisation tool to the speaker and an immersive experience to the audience. Working with the planetarium operators, the speaker has freedom of movement inside the digital universe projected on the dome. Custom 3D models, images and videos are prepared in advance and can be pulled anytime during the talk. This flexibility is fundamental to engaging the audience as they interact with engineers and researchers, asking questions and requesting more information. These events are for the general audience and usually occur on Saturday afternoons. We developed a similar format for schools, called "Ask it to the astronomer", in which all interactive elements of the original are maintained. Still, the complexity of the talk is adjusted to fit the audience's age.

Visualising scientific data sets for a general audience and researchers

The amount of scientific data coming from the research world is constantly increasing. So, too, is the frontier of space probes, and their journies are monitored continuously. Much of this data, regarding both science and the technology of the instruments used, are open source. Although the data can be challenging to visualise, the planetarium is a powerful tool for visualising this data in a virtual 3D space.

One of Infini.to's significant efforts in research and development activities has been to bridge the gap between data and the full-dome projection system of the planetarium. To achieve this, we have developed and experimented with software for data processing that can collect, filter, reprocess, and convert data from external databases into a format understood by the software that manages the planetarium projection. These software are continuously updated and improved, enabling us to visualise raw and filtered data from current and past space missions and immerse them in the 3D space of the digital planetarium. Our ongoing research and development allow Infini.to to propose cutting-edge themes, working closely with researchers in the field to create planetarium shows that benefit general audiences. In addition, through our many programmes at the planetarium, we provide unique opportunities for data visualisation and analysis for professional astronomers.

Artistic collaborations with music, visual arts and theatrical performances

Planetariums are places dedicated to astronomy, space and science in general. However, the planetarium can also showcase works and collaborations with non-STEM fields. In Infini.to's fifteen years, we have hosted many different art forms under the dome. For example, in 2015, we created a summer live music festival under the dome called "Songs for Stars" (Figure 3). During this event, now scheduled every year, the beauty of music and the wonders of the Universe play together to create a visual and acoustic immersive experience. Typically, we ask the performer to improvise their music while we, as planetarians, improvise the flight. We do not give astronomical explanations during the show: visitors are free to enjoy the beauty and fascination of the sky, driven by the live soundtrack. The interaction between musician and planetarian is unique: sometimes we follow the music, and at other times, the musician gets inspiration from the sky, steering their compositions accordingly.

Figure 3: *"Songs for stars": live music under the dome with real-time travel through the Universe.*

In addition, planetariums can be a suitable venue for theatrical performances. The dome can become the show's scenery, and a new set of interactions between actors and the dome can be explored. Since 2010, we have tested this format at Infini.to, adapting existing shows to be performed under the dome and even creating and producing our own show, "Cosmic Snapshot". Special attention must be dedicated to the lighting setup: the dome works better in darkness, but the actors need light. To accommodate these opposing requirements, we adopted a custom lighting system which can be controlled in real-time from the planetarium control panel.

Finally, as a visual system, the planetarium naturally lends itself to the digital arts. In 2016, we hosted "Words and Stars", a collaboration between the artist Grazia Toderi and the Nobel Prize for Literature recipient Orhan Pamuk. The dome became a drawing board for images and poetry inspired by the starry sky over Istanbul.

We have found that such events are ideal for meeting different audiences, fostering their creativity and imagination.

Planetarium design for all

As astronomers heavily rely on light to gather information, planetarium shows mainly consist of visual displays. Unfortunately, this can make standard shows less accessible for individuals with blindness or low vision. At Infini.to, we recognise this challenge and have been actively working to design and develop shows that everyone can enjoy, regardless of their abilities.

"Un cielo per tutti" (A sky for all) is an Infini.to project aimed at improving museum accessibility and promoting inclusion and equal participation in astronomy for people with disabilities, including those with blindness or low vision, Deaf or hard of hearing people, and those with cognitive disabilities. The project was co-funded by the Fondo di Sviluppo e Coesione PAR FSC 2007- 2013 and supported by Fondazione Compagnia di San Paolo. It was launched in 2016 to find innovative strategies and solutions to make astronomy

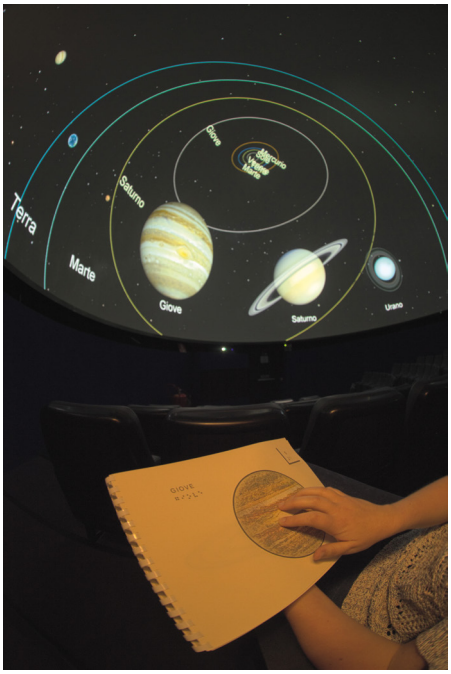

Figure 4: *The tactile book developed by Infini.to for people with blindness and low vision to use as a storyboard during planetarium shows.*

more accessible to people with disabilities and to address the challenges they face in enjoying museum exhibits and the planetarium. The project was the result of collaborative work that involved several institutions in different phases, including the Fondazione Nazionale delle Istituzioni Pro Ciechi, Servizi per Disabili Sensoriali della Città di Torino, and Unione Ciechi di Torino. Through collaboration with the scientific communicators at Infini.to, we developed a suite of flexible and modular activities and tools (consisting of physical materials) that enable customised visits and workshops for different audiences and disabilities. We preferentially focused on tools rather than standard-issued objects to help autonomous equipment production and to modify or update production on demand.

The outcomes of "Un cielo per tutti" are numerous. For example, shows for the planetarium were explicitly created for blind and low-vision visitors, featuring tactile tables that act as storyboards and allow the public to follow live talks about the sky in the planetarium (Figure 4). Some of the planetarium shows were also subtitled for Deaf and hard-of-hearing visitors. We conducted several educational activities using tactile materials and 3D models for different disabilities. Additionally, we developed SpazioApp, an application to support visits to the museum that integrates geolocation and virtual reality and allows the user to zoom in and vocalise text. This app provides a digital guide that enables visitors, including those with disabilities, to easily move around the exhibition space and enjoy the museum content. Although the project has concluded its pilot phase, it continues to evolve and improve every day. Groups and individual participants can contribute their experiences, evaluations, and feedback to promote continuous improvement for future visitors.

Building on the experience gained through "Un cielo per tutti" (A sky for all), in 2022, Infini.to was awarded a grant from the Italian Ministry of Culture to further improve accessibility. The approved project named "OPEN SKY", currently being implemented, includes interventions to enhance access to the museum structure and significant actions to make the planetarium experience more inclusive. Thanks to commercially available software, planetarium shows will feature audio descriptions for those with blindness and low vision and shows in multiple languages to cater to non-Italian speakers.

Conclusions

In many years of astronomy and science dissemination using the dome, we have learned some good practices worth sharing that we will summarise here.

- It's essential to communicate and to know how to communicate. That's why it's helpful to create custom content, tune them for each specific audience, and use them as a tool to engage. The dome can be a place for dialogue, not only monologues.
- While doing so, it is also important to create a community as large and diverse as possible. A planetarium can be a place for students, teachers, researchers, artists, and more. We can foster mutual influence by inviting this wide variety of experience and expertise under the dome. This flexibility and creativity have been vital to expanding our reach.
- Different audiences also include other ways of perceiving the Universe. By providing opportunities to explore the Universe with more senses than just sight, we build an inclusive and rewarding environment for our visitors. We are now developing shows for everyone, including tactile and sound experiences, to offer a show for everyone.

Planetariums will increasingly focus on fostering active engagement with their audiences. Recent years have shown that, for our visitors, live shows conducted by engaging and interactive experts are the most popular, and this mode of presentation should be developed and expanded as much as possible. In this context, we are exploring new ways to involve audiences, such as participatory planetarium experiences that leverage technology to create immersive and interactive environments.

Biographies

Marco Brusa is a Physicist of Advanced Technologies and has been working at Infini.to since 2007. He is the coordinator of the Multimedia Office, which deals with planning educational activities, workshops and training courses for the general public and teacher training. In addition, Marco creates shows for the planetarium and develops virtual environments to disseminate astronomy and science.

Eleonora Monge is an astrophysicist and science communicator. Since 2014, She has been the Director of Infini.to, responsible for managing activities and coordinating the staff. She coordinates and directs institutional activities and contributes to developing and implementing programmatic and strategic plans in agreement with the President and the Board of Directors.

Emanuele Balboni is an astrophysicist and has worked as a science communicator at Infini.to since 2008. As Planetarium Coordinator, he creates shows for the digital planetarium. He has combined his passions for astrophysics and photography in the blog *Cosmos and Surroundings*, where he publishes his suggestive shots and deals with scientific dissemination.

Simona Romaniello is an astrophysicist and science communicator and has been the Education Manager of Infini.to since 2014, where she is responsible for managing and projecting educational activities.