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Orbital Views: defying gravity

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Abstract

The *Orbital Views* program brings virtual reality in true weightless and partial weight environments, in preparation for real space missions in orbit and on the surface of other planets. It opens opportunities for the training of astronauts on critical tasks that can only be trained in reduced-weight environments such as parabolic flights. With appropriate installations, *Orbital Views* also allows modern space tourists to experience the sights, sounds, and proprioceptive feelings of space without actually going there.

1 Introduction

Space has become a salient aspect of culture and collective imagination. The view of Earth from orbit has become an iconic sight in the last decades. However, until recently, only astronauts could live a complete space experience and contemplate this view in true weightlessness or reduced gravity. Originally operating for missions in extreme environments, the *Orbital Views* program now offers to the public an access to the experience of space.

2 Rationale

I.C.E.B.E.R.G. (Isolated and Confined Environments Behavior and Emotions Research Group) initiated the Orbital Views project in order to sustain the technical requirements of a prior project: EVE, for "Exercise in Extreme Environments" [1]. The EVE project was built on the expert opinion [2,3] that crews living and working in isolated and confined environments -such as submarines, polar outposts and space stations- could alleviate part of their psychological stress with the help of virtual reality.

In long-haul nuclear submarines, no communications are allowed with the outside world and large crews are confined in a limited space with no windows and no other sight than the metal hull of the boat, only yielding a few meters visible range. Even in the relatively less stressful context of Low Earth Orbit (*International Space Station*) and Antarctica (especially scientific continental stations like *South Pole* and *Concordia* stations), most of our usual environmental assets are missing: 24-hours day/night cycles; wild flora and fauna; interactions with large, renewed and heterogeneous social groups; rich and diverse perceptions; and last but not least, privacy and intimacy [4].

The EVE project makes use of daily physical exercise sessions in isolated and confined environments (2.5 hours on the International Space Station) to re-introduce perceptions of terrestrial biomes and their respective flora and fauna: desert, jungle, mountains, etc. A proof of concept prototype was demonstrated to the Medical Operations teams of the European Astronauts Center in 2014, using an *Oculus Development Kit 2*, and a bicycle ergometer.

Figure 1. “Exercise in Virtual Environments” proof-of-concept prototype (© I.C.E.B.E.R.G. 2014)

A similar prototype was demonstrated in Antarctica, to 20 crewmembers of the 2014 *Concordia* and *Dumont d’Urville* scientific winter-over missions. Feedback from operational space and polar staff was positive, and underlined the importance of maintaining rich and diverse perceptions while living and working in extreme settings.

However, extreme environments such as space, subsea and Antarctica are not suitable for traditional Virtual Reality systems, even modern ones. For instance, the reduction of weight and geomagnetic signals can strongly interfere with micro-electro-mechanical systems (MEMS) used in head tracking, to the point where MEMS-based virtual reality systems cannot be trusted (Table 1).

Through cutting-edge iterative research and field-testing, I.C.E.B.E.R.G. achieved the first step of its *Orbital Views* program: solving the technical obstacles preventing the use of virtual reality in extreme environments, where crews live and work for extended periods of time.

Thanks to the *Orbital Views* research and development program, virtual reality can now be used to help alleviate the stressful effects of extended isolation, confinement, monotony and danger.

Context	Acceleration	Geomagnetism
Nominal	+	+
Polar	+	-
Subsea	+/-	-
Space	-	-

Table 1. Reliability of MEMS sensors in off-nominal contexts

3 Experiences

The results of the *Orbital Views* program were first displayed in October 2016, during a public flight of the Novespace A310-ZEROG aircraft, with a group of users experiencing two different conditions: a Moon landscape in true lunar 1/6th weight environment, and a low-Earth orbital scene in true weightlessness (i.e. no perceived weight).

Thanks to specific flight maneuvers known as *parabola*, parabolic flights can temporarily reduce the weight of objects and passengers inside the aircraft for periods of 20 to 25 seconds, thus achieved weightlessness, the same exact feeling that astronauts experience throughout their missions in orbit.

Weightlessness is useful to simulate orbital operations (e.g. in Low Earth Orbit), while partial weight conditions allow for the simulation of surface operations (e.g. Moon, Mars, asteroids). When used for space tourism purposes, parabolic flights allow passengers to experience the sights, sounds and true proprioceptive feelings of space and other planets.

Figure 2. First public demonstration of the Orbital Views moonwalk experience in true lunar 1/6th weight environment (© I.C.E.B.E.R.G. & Novespace 2016)

Mixing parabolic flights and virtual reality provides strong opportunities for astronauts to train on critical weightless-based tasks, e.g. fire suppression in weightlessness. It can also be used in real space missions to train and maintain specific competencies like depth perception and piloting skills that become critical in later segments of the mission (e.g. preparing for a Mars landing that will happen many months after the beginning of the mission).

Figure 3. First public demonstration of the Orbital Views spacewalk experience in an authentic weightless environment (© I.C.E.B.E.R.G. & Novespace 2016)

In public parabolic flights, the *Orbital Views* program also opens opportunities for space tourism and astronomical awareness. Clients can now experience high-fidelity space scenes in reduced weight and total weightlessness, a very thorough space simulation. Our virtual reality approach in this setting combines audiovisual perceptions with full-body proprioceptive cues in room-scale environments, generating a very strong sense of presence [5].

Such experiences can even trigger the *overview effect* [6], a well-documented psychological aspect of human missions in space: when looking down at the Earth from orbit, astronauts report that the beauty and fragility of our planet become obvious. Contemplating a large number of stars, nebulae and galaxies against the black background of space can also trigger what Romain Rolland casually named the *oceanic feeling*: the sensation of being one with the universe. In the case of space, this paradoxically encompasses feelings of vastness and emptiness.

In order to offer similar experiences to the broadest public, I.C.E.B.E.R.G. is also developing ground-based *Orbital Views* experiences using virtual reality and weight-reducing devices.

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