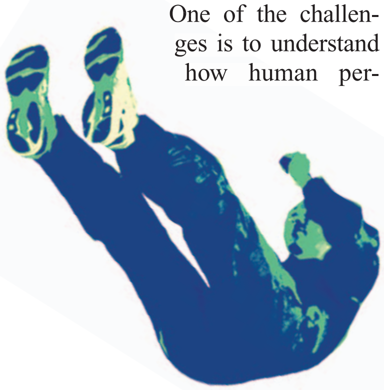
Parabolic Flight Experiment

By **Dario Schor (IEEE Member), Alix Dudley, Trisha Randazzo, Kathleen Samoil, Joshua Nelson, Dr. Angie Bukley, and Dr. Gilles Clement**

Space agencies across the world are preparing for a return manned mission to Mars in the next 20 years. Such a mission would require at least six months to reach the surface, then provide astronauts some time to perform experiments on Mars, and finally embarking on the long return journey to Earth. This ambitious goal poses many technological, biological, and psychological challenges for all stakeholders. One of the challenges is to understand how human performance is impacted by reduced gravity conditions where the signals from the central nervous system are in conflict with the surrounding visual cues. In order to train future astronauts and develop counter-measures to help them during these long duration missions, a team of students from the International Space University (ISU) devised some experiments to characterize the adaptation process and provide insight into the problem. The experiment was accepted for two parabolic flight campaigns from ESA and CNES in 2014 from Bordeaux, France. The results from these experiments are being reviewed for publications. This article describes the experience and lessons learned from the design of the software components for the flights.



Motivation

Terrestrial gravity shapes the signals used by our central nervous system for orientation and to perform tasks requiring hand-eye coordination. Signals originating from our inner ear give us a sense of balance and orientation – our vestibular sense. We gauge movements and position with what are called proprioceptive feedback. Combining visual cues with these signals allows us to perform sensorimotor tasks like pointing and grasping objects.

In microgravity, the perceived signals are different due to the change in gravitational reference, thus visual cues can become a dominant system for determining spatial orientation. Although other parts of the body are affected, the sensorimotor tasks are still relatively easy in microgravity conditions.

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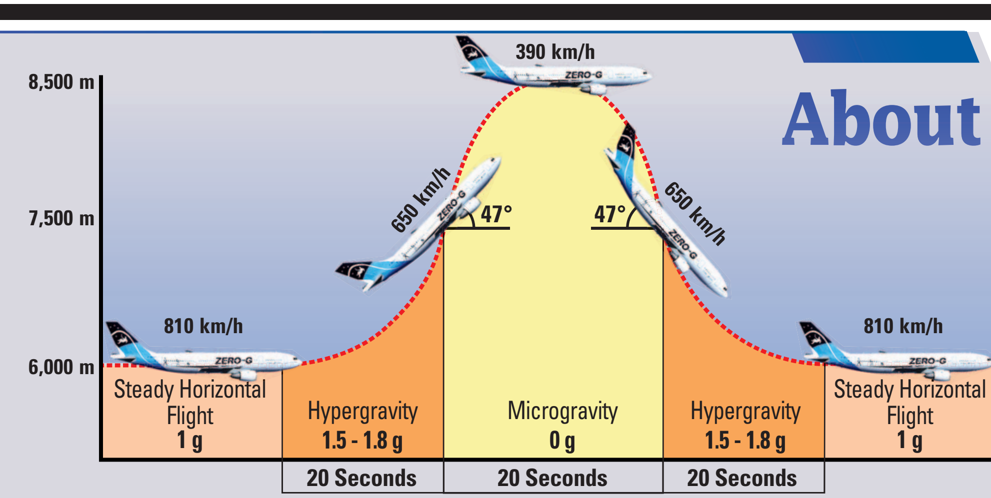

Figure 1: Parabolic Flight

About Parabolic Flights

A parabolic flight is an airplane flight that utilizes specially configured airplanes to execute a maneuver called a parabola that provides 18-22 seconds of microgravity (0 G). In order to get to that state, the aircraft climbs at a steep 47 degree angle with respect to the horizon while experiencing increased gravity forces (1.8 G), then reduces its speed to complete the weightless phase at the apex of the parabola, and finally speeds

Personal Experience During the Flight

By **Dario Schor**

I acted as an operator on the first parabolic flight of the September 2014 campaign and I was both excited and nervous beforehand. I followed all the dietary recommendations and limited my breakfast in case I got sick. Before the first parabola, I tightened straps over my feet to avoid flying out of control while trying to run the experiment.

When the "30 seconds for the first parabola" was heard on the intercom, I braced for the transition from 1 G to 1.8 G. We could see that almost everyone else was lying down on the floor, as we stood for our experiment. Then, there was a sudden transition and everything felt heavier. I stood very still and did not move my head as recommended in the training. I felt a little light-headed, but nothing out of the ordinary.

The transition from 1.8 G to 0 G was very sudden and felt like someone magically removed the floor from underneath your feet. Everyone on the flight started acting like a child as they floated next to their experiments. Looking around, you could see people posing for pictures or leaving things to float in front of them. Even with the straps, it felt very loose and simple arm movements were not a struggle. Partway through the parabola, one of the test subjects reported the screen went black, so we immediately started addressing the problem. It turned out he was wearing inversion goggles and accidentally hit the power button on the monitor.

The transition back to 1.6 G and then 1 G was less exciting. The key was to always aim our feet toward the ground to avoid falling onto the experiment directly behind us. We annotated the anomaly and prepared for the next parabola.

After a few parabolas, the experiment was running smoothly, I felt more comfortable, and I began loosening the straps on my feet so that I could float while operating the experiment. On a couple of instances I purposely let a pen or my camera float in front of me for a short time during the experiment and then grabbed them before starting the descent. After all the readings about human performance in space, I felt compelled to try moving in different ways during the 0 G and 1.8 G phases to see how my body reacted. The worst experience was tilting my head up and down during the 1.8 G phase, but never to the point where I felt sick.

We spent the last two parabolas in the fun zone at the back of the aircraft. During the first one, I let loose, flipped upside down, and had to get one of the aircraft crew members help me flip back before the end of the 0 G phase. On the second parabola, I held onto a strap and floated while watching Prof. Clement turn and float upside down while wearing inversion goggles. At the end, I felt very tired and thirsty. It is not obvious during the flight, but your body does a lot of work during the hypergravity phases and while it adjusts after each transition.

Overall, a fantastic experience. This was the best 2.5 hour roller coaster in the world. ■

Credit: ESA/Anneke Le'Floch

To go to Mars, we need to understand how human performance is impacted by reduced gravity ...

up in a steep descent to (1.6 G) to complete one parabola. The whole process takes roughly 1 minute as shown in Fig 1. The microgravity phase can achieve a low gravity in the order of 10^{-2} g.

These types of flights are primarily used for research purposes, preparation for long-duration missions, and astronaut training. The main benefits of parabolic flight campaigns are that they can be scheduled with short lead times and provide researchers the capability of interacting with their experiment during and in between flights. In recent years, parabolic flights have also been used in other industries like the film *Apollo 13* and can even be booked by private citizens to experience microgravity.

The European Space Agency executes 31 parabolas per flight. The first parabola, #0, is the test parabola, then the aircraft executes sets of 5 consecutive parabolas with 5-8 minute breaks in between sets. In total, one experiences over 10 minutes of microgravity, which is roughly equivalent to riding the Disney Tower of Terror 250 times. Each research campaign consists of three flights on consecutive days, thus totaling 93 parabolas to obtain more than 30 minutes of microgravity.

The Novespace Airbus A300 aircraft was the third A300 produced, and thus still has a number of additional sensors linked to a control panel inside the aircraft for real-time telemetry. Airbus often sends representatives to sit on the aircraft and collect data during these flights as it provides valuable information about the performance over time - especially when performing atypical

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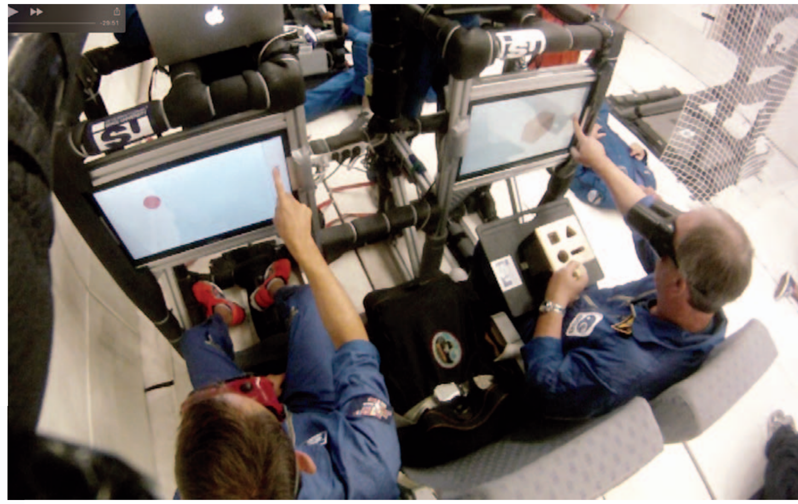


The purpose of this study is to evaluate what happens when visual cues are altered under different gravity conditions. The hypothesis is that when introducing altered visual cues, the difficulty for sensorimotor tasks will increase with increased gravity levels. The results of this research help in our

Under normal gravity levels (1 G), it can take a person more than 7-8 days to get used to the inversion goggles.

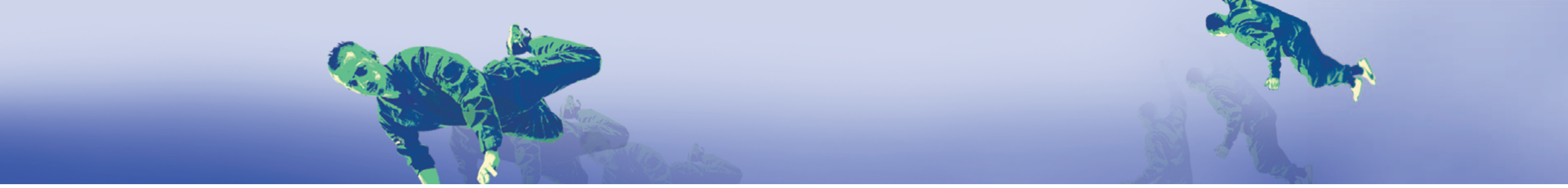
maneuvers for these experiments. In addition, this aircraft does not have restrooms or the traditional food and beverage service. The washroom stalls are available, but passengers must use special receptacles. Finally, it is worth noting that there are no windows in the laboratory portion of the aircraft to prevent changes in lighting in the cabin or passengers getting sick as a result of noticing the angle at which the aircraft is climbing. The windows located by the seats at the front of the airplane are all shut off with Velcro strips so that they do not move too much during the parabolas.

Many experiments are designed to run for fewer than the maximum number of parabolas. This gives teams flexibility if a problem is encountered that requires some time to be reset or fixed in flight and also allows first-time flyers to relax and enjoy the experience. During this time, it is not recommended to do pirouettes any-

Company/Agency	Aircraft
Canadian Space Agency (CSA) / National Research Council (NRC)	1. Falcon 20
National Aeronautics and Space Administration (NASA)	1. C-131 Samaritan 2. KC-135A 3. KC-135B 4. McDonnell Douglas C-9B 5. Skytrain II
European Space Agency (ESA) / Centre National d'Études Spatiales (CNES)	1. Caravelle 2. Airbus A300 3. Airbus A310
Ecuadorian Civilian Space Agency / Ecuadorian Air Force	1. T-39 Sabreliner
Russia	1. Ilyushin Il-76
Zero Gravity Corporation (ZERO-G)	1. Boeing 727-200
Integrated Spaceflight Services / Swiss Space Systems	1. Airbus A340
Japan Space Exploration Agency (JAXA) / Diamond Air Service	1. Mitsubishi MU-300 2. Glufstream-II

Table 1: Aircraft used for Parabolic Flight Laboratories.

where as one could bump into other passengers or experiments in progress. For this, the Airbus aircraft has a dedicated "fun-zone" area where up to three passengers at a time can go and let loose. In our experiment, we accounted for two such parabolas.



understanding of (i) the roles and weights associated with these three sources of signals, (ii) enable us to characterize the adaptation process, and ultimately (iii) apply this for astronaut training and countermeasures for future long duration missions.

Experiment Overview

The proposed experiment consists of two different tasks to be performed on a parabolic flight to obtain the different gravity levels. The visual cues are altered by using a pair of inversion goggles that use prisms to flip the image upside-down. Under normal gravity levels (1 G), it can take a person over 7-8 days to get used to the inversion goggles, thus getting subjects with little to no experience with them can help understand the initial adaptation phase. Since the inversion goggles restrict the peripheral vision, a pair of osculating goggles was designed to mimic the restricted field of view without inverting the image, thus forcing test subjects to move their head in similar ways for both inverted and non-inverted tests.

The two tasks to be performed in flight are pointing and grasping. The pointing task measures the reaction time, action time, and accuracy with which a test subject can identify and click on a target presented in a touchscreen monitor. The grasping task utilizes a toy shape sorter and interactions through a touchscreen monitor to measure the reaction and action times. Both experiments are designed to be executed by a test subject while an operator monitors the progress.

Microgravity Laboratories

There are four major types of laboratories for microgravity experiments: (i) drop towers, (ii) parabolic flights, (iii) sounding rockets, and (iv) the space station. Drop towers date back to the 1700s (then known as shot towers) and offer a cost effective means of experiencing free-fall for 4-5 seconds of microgravity. These towers are ideal for short duration, small automated experiments, but cannot accommodate human performance experiments. Parabolic flights were proposed in the 1950s and have been in use for medical research and astronaut training since the NASA Mercury program. Sounding rockets also follow a parabolic trajectory with a much higher altitude, thus providing longer exposures of roughly 15 minutes of microgravity, but are only suitable for automated physical sciences experiments. This technology has also been around since the 1950s with Canada playing a major role through its Black Brant program that first launched out of Churchill, Manitoba in 1959. Finally, the International Space Station (and its various predecessors) is a venue for long exposure experiments. This is the most expensive microgravity platform that requires specialized equipment and training.

Experimental Setup

The setup, shown in Fig. 2, consists of a row of three airplane seats where the two test subjects sit on the window and aisle seats such that they can move freely without bumping into their neighbour. In front of the seats, there is a custom aluminium structure connected to the rails holding the seats in place.

The operators for the experiment stand behind the structure facing the test subject. The structure holds a 22-inch ViewSonic TD2220 touchscreen monitor in front of each subject and a laptop for operators to control the experiment. The monitor provides a 5 ms response time that meets the requirements based on the expected response time of subjects during the experiment.

In addition, a 3-axis accelerometer was attached to the structure to log data for post analysis and a power bar with breaker protection was installed to connect to the aircraft power supply.

Figure 2: Experimental Setup on the flight

Credit: ESA/Anneke Le'Floch

A Dell Latitude E5410 running Windows 7 is used to control the experiment while the touchscreen acts as a second monitor for the test subject. The custom software is written in C++ using Microsoft Visual Studio implementing the MFC libraries for the graphical user interface. The commercially available drivers from ViewSonic were used to interface with the touchscreen as a single touch input.

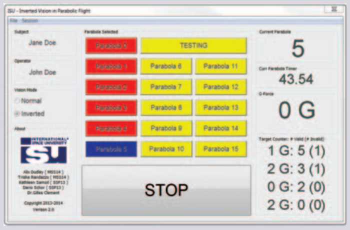


Figure 3: The interface screen

The software interface consists of a main window each for operators and subjects. See Figure 3 above for the operator interface.

The subject screen is displayed in the touch screen monitor in fullscreen mode and consists of an experiment panel and a right navigation panel with two buttons; see Figures 4 and 5.

Before each parabola, the experiment panel displays instructions and serves as the main area for

Pointing experiment

In the pointing experiment, a target is displayed at a random location in the screen. The user must then use their index finger to point to the target. In order to obtain metrics to evaluate the performance, a home button is used in between trials to reset the timers. Once the user presses the target, the home button switches colors and text throughout the trial to indicate the state of the trial and expected user response. This is repeated as many times as possible from 30 seconds before the first parabola in 1 G, through the various phases of the parabola, until returning to 1 G again.

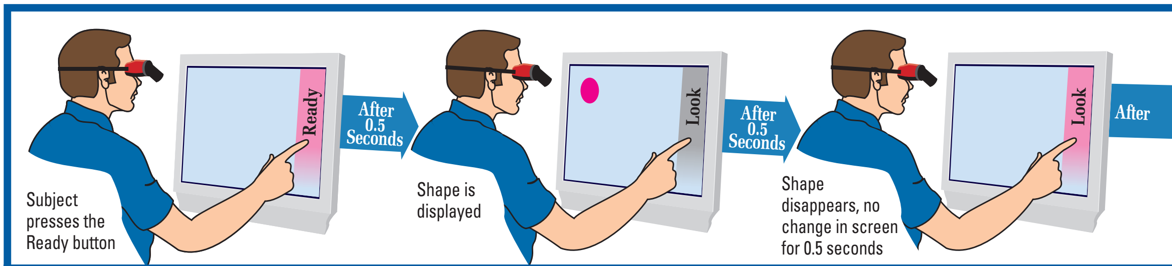


Figure 4: Sequence for Pointing Experiment

The sequence for one trial is shown in Fig. 4. The user begins by pressing and holding the home button labeled “READY”. Once pressed, there is a 0.5 second delay, followed by a 0.5 second period where the shape is displayed on the screen, and finally another 0.5 second delay before the next user interaction. The delays surrounding the appearance and disappearance of the target are used to (i) pace the users through the trials, and (ii) force the user to remember the perceived location instead of using the target as visual feedback to compensate for their movements and attempt a higher accuracy. After the shape disappears, the home button switches to “GO” and the timer for the reaction time starts ticking until the user releases the home button. A new timer is started to measure the time from the release until the perceived location of the target is hit or the user aborts the test. The accuracy is measured as the Euclidean distance between the center of the target location and the position where the user touched the screen. The raw trial interactions during the pointing experiment. The subject navigation panel is two inches wide and is filled with two buttons that allow the subject to step through the experiment trials. The main button, known as the home button, is used to control the timing measurements and occupies the majority of the area as it is used very frequently during the flight. The text and background color for this button changes throughout the experiment as described below.

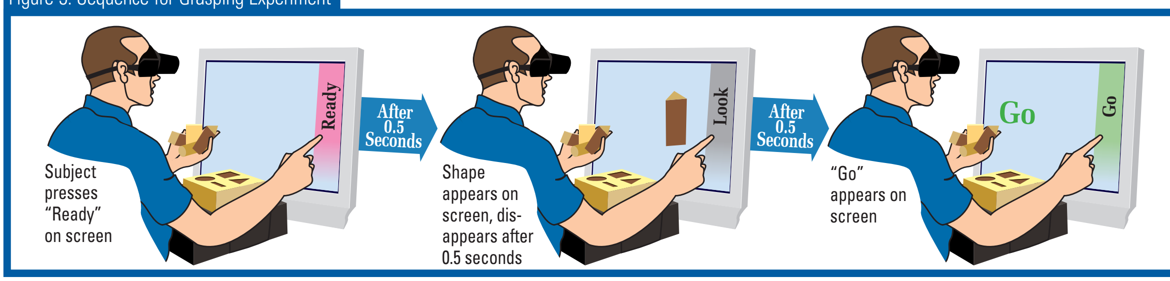


Figure 5: Sequence for Grasping Experiment

The second button is much smaller and allows the user to terminate a current trial if either they made a mistake in the procedure or felt something would have skewed the results. If the skip button is pressed, the data is still logged, but it is flagged as invalid so that it can be excluded from the analysis.

The operator screen has (i) a menu to select normal or inverted vision, (ii) buttons to select the current parabola, and (iii) a start/stop button to log information during each parabola. In addition, the screen has displays for timers for each parabola and statistics on the number of trials completed or skipped in each parabola. All text and buttons used large fonts to prevent operator error during the flight.

Since the touchscreen drivers configure touch responses as mouse clicks, the subject and operator can create conflicts for each other if clicking on different parts of the screen. To mitigate that, all the operator activities are accessible through keyboard shortcuts so that the subject controls the mouse focus during a parabola.

The software generates two archives during the flight. The first one logs information on each trial completed for the given experiment into a comma-separated file for easy post-processing. The second file is an event log that tracks every interaction with the software from either the operator or test subject. The events include autonomous functions from the software, keystrokes, mouse clicks, and touchscreen interactions. Depending on the action, different parameters are logged to help recreate the events that take place during the flight during post-processing.

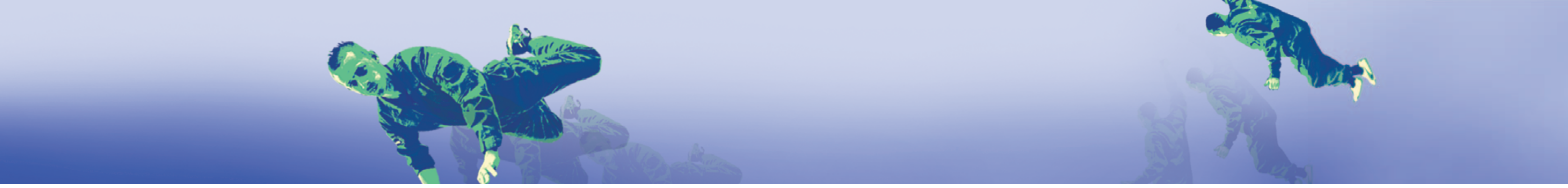
In addition to the data logged by the software, two GoPro cameras are used to record what the subjects and operators are doing. This helps remove bad data for scenarios where something happens outside the software that goes against the experiment protocol, such as a test subject using their left arm to support their right arm when pointing to the screen in the 1.8 G phase.

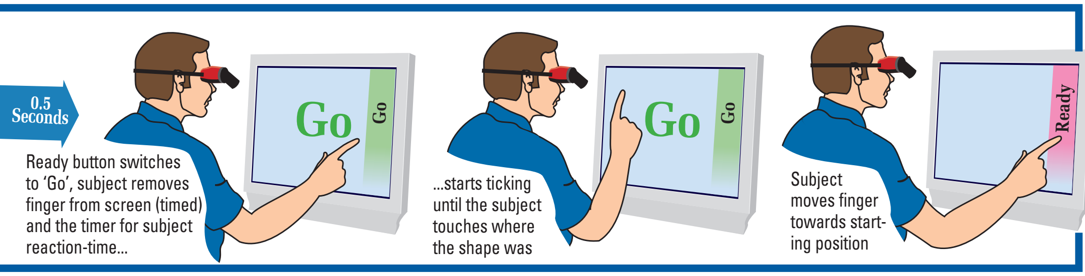
The Flight Campaign

The following sections describe the major stages of the parabolic flight campaign. The experiences described are specific to the ESA and CNES campaigns, but the high-level concepts can be applied to other organizations. Depending on the experiment, one may get a dedicated flight or share the flight with other researchers. In the case of the ESA campaign in September 2014, there were 11 research teams from different parts of Europe testing different experiments in many fields including cognitive science, human performance, and physical sciences.

Design Process and Major Milestones

For our particular experiment, the design was carried out by a





coordinates are used to estimate patterns in overshooting and undershooting the target.

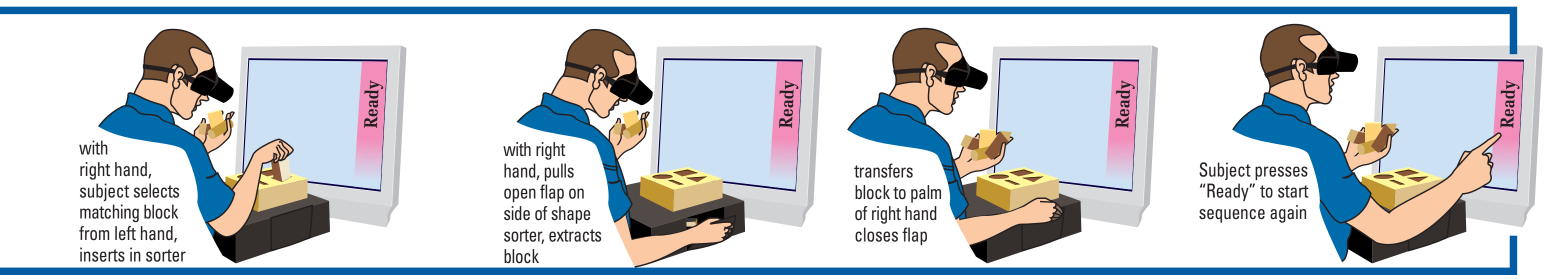
Preliminary Results

The experiment showed consistent results for all gravity levels with normal vision. In normal vision, there were noticeable differences in the target pointing accuracy for 0 G compared to 1 G, while there were only small variations for 1.8 G. However, we did not observe a systematic undershooting in 0 G, as shown in previous experiments on board the Space Shuttle. Thus, the data is in agreement for the hypothesis for hypergravity conditions, but does not follow the pattern for reduced gravity cases.

Grasping experiment

The grasping experiment evaluates the timing required to take a wooden shape and put it through one of the holes of a toy shape sorter. This mimics actions for using tools to fix components in space. The overall physical setup of the airplane seat and screen are reused. For this experiment, the subject holds a tray with a shape sorter with four shapes: a circle, triangle, rectangle, and square.

In order to prevent pieces flying out during portions of the parabola, the tray is secured using backpack-like clips around the test subject's legs and the shape sorter is glued onto the tray. Furthermore, the open faces of the shape sorter are covered



team of International Space University (ISU) students under the direction of Prof. Gilles Clement that included participants from the nine-week intensive graduate level Space Studies Program (SSP) and year-long Masters of Space Studies (MSS) program. The tasks for the project were divided amongst participants. All the structural components were designed and built in Strasbourg, France so that it would be easy and relatively inexpensive to transport them to Bordeaux for the flight. In parallel, the software was designed in Winnipeg, Canada with many online meetings and emails to discuss functionality, user interfaces, and various project management elements.

The preliminary designs were completed by January 2014, when the team held a design review teleconference with two engineers from Magellan Aerospace, Winnipeg who had worked on PMDIS-TRAC and VCF for shuttle mission STS-90. The feedback was incorporated into the design early enough to permit ground-based tests conducted in Strasbourg to test the system and experiment protocols. During this phase, there were different versions of the software released incorporating changes to pace subjects through the experiment and ways to identify invalid test cases.

The next iteration came after another design review held in Montreal, Canada during the SSP 2014 program. At this point, the sequence for the experiment as described in Fig. 4 and Fig. 5 was finalized while also incorporating many of the keyboard shortcuts. Much of this meeting was spent recreating a typical parabola, purposely ignoring the protocol, and testing recovery methods in case something went wrong during the flight.

Medical Checks and Insurance

Once the experiment was accepted and a date confirmed for the flight, the team identified a number of test subjects consisting of ISU classmates including people from Canada, US, France, Germany, Italy, Netherlands, Spain, and Austria. Because of insurance purposes, only European citizens would be allowed to be test subjects, while those from North America would have to act as operators. Each participant received a package of forms to receive clearance to work at the facilities, medical forms to be filled out by their physician, and insurance forms.

Individuals visited their family doctor for a physical equivalent to that of an aircraft pilot - a basic physical and an electrocardiogram. Although there are few conditions that would make someone ineligible to participate, the assessment informs the medical team on board the aircraft about their passengers in case of an emergency.

Setup, Inspection, and Training

The week leading up to the flight, the team arrived in Bordeaux, France and met at the Novespace facility. After completing facility training, the team loaded the experiment onto the Airbus A300 and mounted the seats and aluminium structure to the rails on the plane. After installing the circuit breaker and performing a power-on test, the structure was covered in protective padding. The padding protects individuals and the equipment during the flight as objects shift during parabolas.

Once the setup is complete, it is common to go through the flight protocol a few times and simulate

with a Velcro flap so that the shapes can be removed in a controlled fashion after each trial. The subject holds the shapes in their left hand throughout the trial and uses their right hand to place shapes and interact with the screen.

The sequence is similar to the pointing experiment as shown in Fig. 5. The subject presses the "READY" button, waits 0.5 seconds, a shape appears for 0.5 seconds, and then disappears for another 0.5 seconds before instructing the user to "GO" and start the action. The reaction time is measured from the time they are instructed to "GO" until they release the button. The video captures are used to confirm the handling of the shapes before pressing the "READY" button to complete the trial and stop the action timer. The shape selection is random and has only one restriction to prevent the same shape from appearing in successive trials. The pictures of the shapes were taken on three different angles to remove biases from seeing the shape in a position that is easier to place in the shape sorter.

It is possible that although the vestibular and proprioceptive signals were weaker in microgravity, visual cues throughout the airplane provided subjects with a relative orientation to their bodies.

Fly Your Thesis!

The Education Office from the European Space Agency (ESA) runs an annual program called "Fly Your Thesis!" that offers graduate students opportunities to conduct microgravity experiments directly related to their thesis in a parabolic flight campaign. The program is open to science and engineering students from ESA Member States. Canada is an ESA Associate Member, thus students in Canadian institutions qualify for these opportunities.

The program uses a two-step selection process to accelerate the timeline from proposal to flight. The first step consists of an annual call for proposals inviting students to submit an idea for an experiment to be conducted in microgravity. A single student or a team of students may complete the proposals, where at least one student utilizes the results for their thesis. The proposal consists of a high level description of the experiment, methodology, equipment, timeline, and budget to demonstrate both the scientific and management elements required to succeed in such projects.

The top 15 teams expand their proposals and are invited to a workshop at the European Space Research and Technology Centre (ESTEC) in the Netherlands. At the end of the workshop, all the teams present their work to a Review Board who selects the top four experiments to fly on board the Novespace Airbus 310 Zero-G aircraft in the fall of the following year. ESA covers the cost of the flight, parts of the experimental hardware, and provides some support for travel and accommodations.

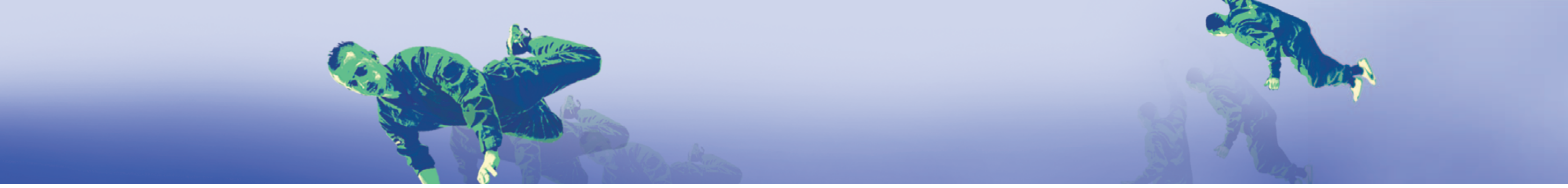
For more information visit: http://www.esa.int/Education/Fly_Your_Thesis

a few parabolas to ensure that both operators and test subjects know what to do. A team member uses a stopwatch to call out phases of the parabola while the team that will fly the experiment performs their corresponding tasks. In addition, during this time, one can simulate a few fault scenarios to practice recovery protocols to reduce the down time if something goes wrong.

These runs serve as a pre-flight specialized training while the airplane is on the runway for both operators and test subjects. For some experiments not involving human subjects, this is an opportunity to collect some controlled data under normal gravity conditions, however, for our experiment, the controlled data was collected during the 1 G phases of the parabolas in flight, thus maintaining the same environmental conditions including noise, temperature, subject medication across all gravity levels.

After completing the setup, a team of 6 engineers and flight personnel from Novespace reviewed the configuration to ensure it was safe. There are two reviews, an informal and a formal review that are conducted a few days apart. The formal review takes place the day before the first flight. Fail to complete that milestone, and the experiment would be removed from the flight. Some of the checks include that (i) there is sufficient padding on all corners and edges of the structure, (ii) the cables for the monitors and laptops are properly secured with zip ties to prevent power losses during the experiment, (iii) that laptops and other tools used during the flight are secured, and (iv) that the emergency switch to power off all equipment is operational. In addition, the team asks lots of questions to ensure there are mitigation procedures in place for many what-if scenarios such as shape sorter pieces getting loose and flying away during a parabola.

Once all the teams complete the inspection, Novespace offers a training session to go over safety procedures for the flight. The training session includes presentations from the aircraft pilot, the medical team on board, and the cabin crew. This session can be thought of as an extended version of the safety video on most commercial flights. The core portion of the presentation focuses on safety recommendations for anyone flying that includes: refraining from certain foods before the flight, avoiding rapid head movements during the hypergravity portion of the flight as they may cause dizziness, and what to do if one feels sick. Finally, after completing the safety discussions, each research team present is introduced and presents a short summary of their experiment so that everyone is aware of what is happening during the flight.



The experiment showed consistent results for all gravity levels with normal vision. We did not see significant differences for different gravity levels in the overall duration of the task. The measured action times decrease with increased gravity levels. Conceivably, the subjects learned the orientation and relative position of the shapes for the sorter box, thus after getting instructions from the screen, they could grab and rotate the shape in one motion, thus reducing the impact of different gravity levels.

General conclusions from both experiments

The preliminary results from both experiments indicate that subjects strongly relied on visual feedback for performing the head-eye coordination tasks, despite that vestibular and proprioceptive signals were weaker in 0 G and stronger in 1.8 G. Relatively small changes were observed in inverted vision compared to normal vision for the various levels of gravity. Further analysis of the data and reviews of the videos are needed to confirm these conclusions.

Canadian Reduced Gravity Experiment Design Challenge

In 2016, the Students for the Exploration and Development of Space (SEDS) group launched the Canadian Reduced Gravity Experiment Design Challenge (CAN-RGX). In this competition, Canadian post-secondary student teams will be selected to design, implement, and test an experiment over 12 consecutive parabolas on board the Falcon-20 aircraft from the National Research Council (NRC), which has been modified for this purpose by the Canadian Space Agency (CSA). The competition enables students to develop technical and project management skills, conduct an experiment in microgravity, and, ultimately, have a direct impact in space exploration and development in Canada.

Teams interested in participating submit a letter of intent in September and a full proposal by the end of November. The four teams selected are notified in December of the same year. Those selected experience the typical space-industry project phases and must submit documents for each major milestone;preliminary designs, critical designs, and an integration and testing plan.

The CAN-RGX selection criterion includes the technical description, scientific merit, budget and funding plans, and outreach plans. The competition funds most of the costs associated with the flight except for $2500 per team and experiment fees, thus teams are encouraged to apply for university grants and seek corporate sponsorship. Finally, the outreach component includes disseminating the experience through both social media and presentations to a variety of audiences.

For more information visit http://www.seds.ca/projects/canrgx

After completing the formal training, all test subjects meet one-on-one with the flight doctor. This gives each individual a chance to review the hazards and risks associated with the particular experiment, and then sign the informed consent for participating in the test. For this experiment, inversion goggles are considered a hazard that can make subjects dizzy in normal gravity conditions. Thus, when combined with the parabolic flight, they can increase the risk of getting sick during the flight.

The Flight

On the day of the flight, the team meets at the Novespace facility before 7:30 am. Those flying that day put on their flight suits and head over to see the medical staff for a last check up before takeoff. Individuals have the option of getting a shot of scopolamine to prevent motion sickness. First-time flyers are encouraged to receive the medication, while experienced flyers sometimes opt-out as they know how to prepare their bodies for the effects of the flight.

Meanwhile, team members not flying that day will go to the aircraft to go through a pre-flight checklist that includes testing all equipment and confirming all parts are in designated spots. This includes carrying writing utensils, screen cleaners for the touchscreen monitors, hard candies or mints to combat the dry mouth side effect of the scopolamine, and other tools for fixing the experimental setup if needed during the flight.

Credit: ESA

At 8:45 am, the team members flying will board the plane and sit in the front of the cabin for takeoff. Unlike commercial flights, there are no security checks, boarding passes, baggage, or assigned seats. All experiments are powered off for takeoff. The plane takes off at 9:30 am and once it reaches 10,000 feet, the seatbelt light is turned off, power is provided to all experiments, and the fun begins. Although the airplane is still climbing and travelling to a designated airspace, the passengers get up, move toward the back of the cabin, and begin powering on their equipment. This allows teams to perform one last check of the setup before the first parabola.

The plan is to perform parabola #0 as a test where experiments are first tested in microgravity. Then, there is a short couple min-

Canadian Space Summit

By Dario Schor (IEEE Member) and Wayne Ellis

The Canadian Space Summit is a two-day conference attracting stakeholders from all disciplines in the space community including industry, academia, government, military, and many space enthusiasts. With over 150 attendees annually, the summit is an excellent place to learn about the latest Canadian space projects and network with industry professionals.

The summit is organized by the Canadian Space Society – a non-profit/charitable organization composed of both professionals and enthusiast volunteers interested in the development of Canada's space industry.

Each year, the summit features a group of renowned keynote speakers, thematic sessions, and public events geared to all audiences. The themes for the sessions highlight the diversity of Canada's contributions to space:

Life Sciences – Studying human health, physiological, and cognitive behaviors related to space exploration and discoveries from space-based research.

Education and Outreach – Discussing projects from elementary, secondary, and post-secondary programs and their participation in space missions such as the Canadian Satellite Design Challenge.

Astronomy – Focusing current and conceptual designs for space telescope structures, detectors, receivers, and optics.

Space Applications – Covering topics related to satellite missions, space debris, on-orbit servicing, and space situational awareness.

Space Commercialization – Pitching ideas and opportunities for commercial enterprises and discussing trends on the future of the Canadian space industry.

Planetary Exploration – Combining remote sensing technologies for Earth and other planets, as well as robotic and human exploration of the Solar System.

Lunar Exploration – Narrowing the scope of planetary exploration to focus on the Moon, our nearest neighbour, as a platform to develop technologies for further exploration.

Law and Policy – Presenting legal issues surrounding exploration, exploitation, habitation, cooperation, and liability in space.

Art and Culture – Examining the links between space art and technology to explain how space art continues to evolve and inspire the next generation of explorers.

The 15th annual Canadian Space Summit will be hosted in Winnipeg, Manitoba from November 13-15, 2016 at the Inn at the Forks. The theme for this year is "At the Centre of It All" which highlights many of Manitoba's contributions to space from the launch of the first Black Brant suborbital rocket from Churchill, Manitoba in 1959 through the development of components for Mars rovers and buses for the RADARSAT Constellation Mission. The public events will include, among other things, industry tours and hands-on workshops for pre-university students. Please see the website for more details: **http://www.css.ca/**

IEEE Canada is proud to be one of the sponsors for the 15th Canadian Space Summit in Winnipeg, MB.

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utes before commencing six sets of five parabolas each (totaling 31 parabolas in one flight). The sets are separated by 5-8 minute breaks where experiments can be reset or configured to evaluate other variables.

The crew makes announcements over the intercom leading up to each phase of the parabola:

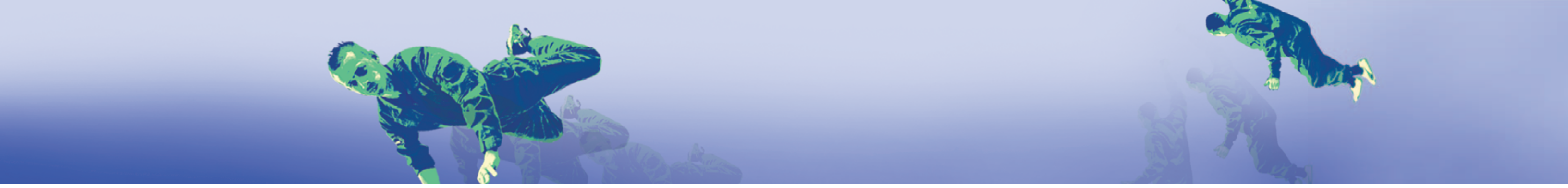
- The warning "30 seconds to next parabola" is heard to set the experiments on and brace for the next parabola.
- "3, 2, 1, pull-up" announced before starting the climb where one experiences 1.8 G. At this point, there is a sudden transition from 1 G to 1.8 G where most passengers lay on the floor and avoid making any sudden head movements that could make them feel dizzy. The operators for our experiment stayed standing and would brace themselves over the structure to support their bodies while still being able to operate the software as needed.
- The countdown to the 0 G phase is done in terms of angles with respect to the horizon, "20 degrees, 30 degrees, 40 degrees, 3, 2, 1, injection!" This is the most difficult transition as we go from 1.8 G to 0 G in a fraction of a second.
- After roughly 20 seconds, the reverse countdown starts "40 degrees, 30 degrees, 20 degrees" and a quick force pulls all passengers to the ground. It is important to hold onto something before this transition to prevent injuries from the fall.
- Finally, no announcement is made after returning to 1 G.

After completing all 31 parabolas, the experiments are powered off, and there are a few minutes to relax while flying back towards the airport. At this point, the aircraft crew handed out water bottles and chocolate bars to all passengers. During this time, we backed up all the results into memory sticks and took down some notes on key things to improve for the next day. The airplane lands around 12:30 pm and preparations start for the next flight.

Post-Flight

After landing, the passengers get off the plane and proceed back to the Novespace facilities where the ground crew is waiting with lunch. The team discusses the key observations, any issues during the flight, and performs a preliminary assessment of the data to see how many of the 31 parabolas were successful at collecting the necessary data. Possible losses of data could be attributed to either equipment failure or a team member getting sick during the flight.

The summary of the experiment is presented at a post-flight briefing with all the research teams and aircraft crew. During this time, special requests for the next day can be made if one group needs a few more seconds between parabolas or sets of parabolas to reset their test. ■



Concluding Remarks

The campaign was able to provide a large interdisciplinary and international team an opportunity to collaborate together to further our understanding of the human body for space exploration. The technical and non-technical lessons learned are applicable in all aspects of our future careers and included being able to experience the full design process from the experiment design, building the various components, ground tests, design reviews, testing in flight, and finally analyzing and interpreting the results. One of the highlights was working within a multidisciplinary team that included engineers, physicist, nurses, neuroscientists, lawyers, and others, thus being able to discuss all aspects of the projects from multiple perspectives. Finally, for a group of aspiring space professionals, this was a first-hand exposure to working in microgravity that provided us with a better understanding of what astronauts experience, a greater appreciation for the accomplishments in space flight, and a source of motivation to help advance technology for humanity. ■

Back row left to right: Olivier Renard, Nathan Wong, Alix Dudley, Dario Schor, Angie Bukley, Gilles Clement, Trisha Randazzo, Joshua Nelson, Anja Schuster, Gabriele Librandi
Front row left to right: Kathleen Samoil and Valentina Boccia

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About the Authors

Dario Schor completed his B.Sc. and M.Sc. in Computer Engineering at the U. of Manitoba in 2008 and 2013 respectively. Shortly thereafter, he attended the nine-week Space Studies Program from the International Space University in Strasbourg, France. Currently, he works as a Software Engineer for Magellan Aerospace on flight software, ground tools, and testing for the RADARSAT Constellation Mission and as a Seasonal Instructor for the UofM Computer Science Department. He volunteers with IEEE Winnipeg, the Space Generation Advisory Council, and other organizations. Email: schor@ieee.org

Alix Dudley's primary expertise is in life and health sciences research. She has a B.Sc. in Honours Physiology and a M.Sc. in Neuroscience (McGill University), and a M.Sc. in Space Studies (International Space University). Currently, she is the Senior Science Officer at Brain Canada.

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Kathleen Samoil, is a Registered Nurse in the Emergency Department in Calgary Alberta. She holds a BSc from the University of Alberta and is completing an MSc in patient safety. Kathleen's interest in simulation and remote healthcare drew her to International Space University's SSP 2013.

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Gilles Clement, PhD, is Emeritus Faculty at the International Space University. His research focuses on the effects of changes in gravitational input on spatial orientation. In addition to parabolic flights, he has flown experiments on Salyut, Mir, the Space Shuttle, and the International Space Station.