The Ups and Downs of Zero G

A team of physicists from the Unversity of Leicester undertook some experiments in zero gravity. But not all went according to plan, as **Dave Gray** explains.

The pilot announces the angle of the airliner as its nose climbs towards the sky. "20 degrees, 30, 40, injection". As a modified Airbus begins the first of 93 micro-gravity parabolas it will fly that week, two Leicester students experience weightlessness for the first time, and inside a 20cm clear plastic box, the seed of a small planet is formed.

Leicester has a long history of successfully participating in the Student Parabolic Flight Campaigns also called 'Fly Your Thesis'. This is partly because the initial kit taken on that campaign (a platform that vibrates with controllable frequency) had proved reliable, adaptable and safe.

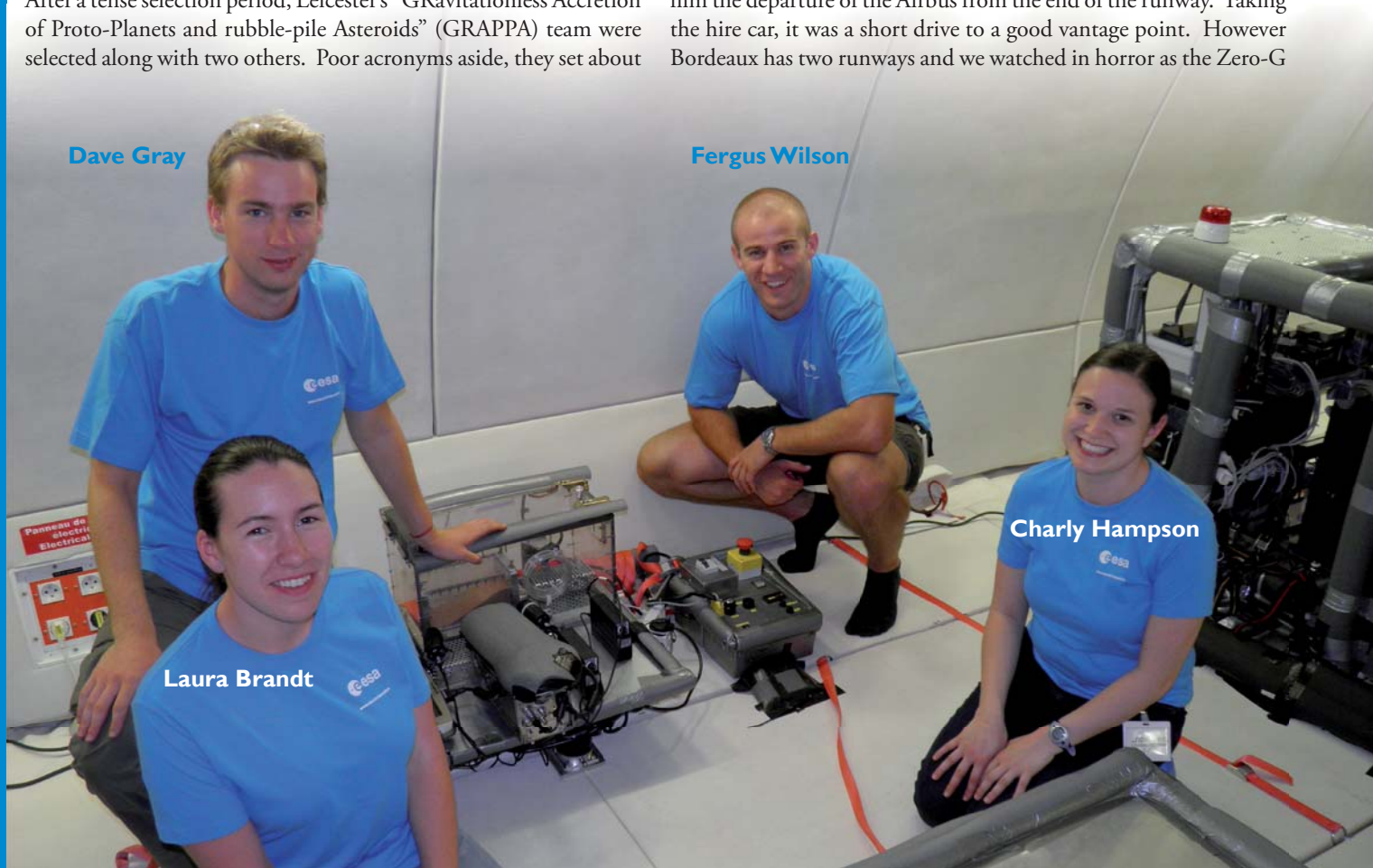
For the 2011 campaign, three postgraduates and an undergraduate from the physics department submitted a project based on planet formation. The team would look for the critical properties needed for a loose collection of objects to form a cluster in micro-gravity, by shaking different materials (ball bearings and sand) at different frequencies. Objects colliding slowly in micro-gravity tend to stick to each other due to friction and electro-static charging. Those properties could then be compared to the conditions in the early solar system, when the Sun was surrounded by a dusty proto-planetary disc.

After a tense selection period, Leicester's "GRavitationless Accretion of Proto-Planets and rubble-pile Asteroids" (GRAPPA) team were selected along with two others. Poor acronyms aside, they set about extensively modifying their equipment to suit the new experiment with the €10,000 funding granted by the European Space Agency (ESA).

At the same time as the volcano Eyjafjallajökull was causing the biggest European shutdown of air traffic since World War II, two of the Leicester team were to meet the engineers from Novespace who operate the Zero-G plane. Two days later - and £1000 poorer - the team were no closer to a finished experiment, and time was running out. Worse still, two team members graduated. One moved to London and the other to the United States, with both planning on returning for the campaign.

The following months were an intense period of designing components, reporting to Novespace, ordering materials and building the equipment. A delay in the campaign start date eased the pressure, but upon arriving in Bordeaux further changes were requested. After a week of final preparations and a strenuous few days mounting and testing the kit in the aircraft, everything was ready for the first flight. Ten samples would be taken, and the first two Leicester students to fly donned flight suits and were waved off by those left behind.

With nothing else to do but wait around the airport, we decided to film the departure of the Airbus from the end of the runway. Taking the hire car, it was a short drive to a good vantage point. However Bordeaux has two runways and we watched in horror as the Zero-G



Getting our shots: Dave and Fergus get injections prior to the flight

aircraft began taxiing to the second strip. We jumped into the car and, leaving a large dust cloud behind, sped off down the country lane to the end of the other runway. At the last moment we saw a good spot and swerved over, skidding to a halt across the gravel. Jumping out and onto the roof of the car we were just in time to film the takeoff!

"the rig's broken. It's dead; it's all dead"

Having gotten our adrenaline fix for the day, we had high hopes for our two team mates soon to be on a four hundred mile an hour roller coaster over the Bay of Biscay. When the plane returned, we rushed to the stairs to hear the good news but were greeted with two very gloomy looking scientists, saying, "the rig's broken. It's dead; it's all dead". Stunned silence followed.

The vibration motor had stopped working after only a few parabolas, and the High Speed Camera had failed to record at all. The team member who had stayed in Leicester spent the majority of the flight feeling incredibly ill and the other had only just returned from the US. Thankfully, the problems were fixable and the rig was soon back in working order, but this had not been possible in the air as the two most technically capable of the team had not been on the flight.

The next day was my turn to fly. Following a sleepless night, we were issued our flight suits. Next was an injection of an anti-sickness drug, with a bizarre side-effect of causing a really dry mouth, so most people were chewing gum, which helped. Everything in the aircraft had been set up the night before, so we strapped in and felt the excitement build as the aircraft started to taxi out. It had only gone twenty meters when it stopped, turned around, and parked.

Unbelievably, the aircraft had developed a technical problem and there would be no flight that day. By now there were just two days left of the campaign, with one team mate who had flown leaving before the last day and another already flying home for her ▶

Getting down to work: Setting up and monitoring the rig during the parabolic flight

wedding! Furthermore, if bad weather aborted another flight there may only have been one more chance. This raised another problem as there were four in the Leicester team and only two places per flight. To ensure that everyone flew at least once, the two who had not flown that day should have been on the next flight, but this would mean that the team member leaving early would only fly once for certain. The following team discussions would mark the lowest point of the campaign.

The next day's flight was equally plagued with problems, as again, the motor stopped working mid-flight, with no obvious fix. The High Speed Camera continued to work so the team carried on testing samples, using the vibration of the aircraft to stimulate the materials. Upon landing, the High Speed Camera footage was saved and the kit inspected. After futile hours searching for a solution, ESA officials called the team aside to discuss the next flight. Places on the Zero-G don't come cheap, and there were others who were waiting to take the team's place if Leicester couldn't conduct science.

> "The situation was saved by redefining what we were looking for"

Needless to say, having not flown yet, I was worried. The situation was saved by redefining what we were looking for. We still had the High Speed Camera and samples. Furthermore, the flight that day had proved that the samples did interesting things even without the motor. To everyone's great relief, we were given the go ahead.

Once again, we got our flight suits, got our injections and strapped in. I was allowed to sit up front for the first parabola so I squeezed into the tight cockpit and clipped into the spare seat. I tucked a sick bag under my leg, as I could have no idea how I would react to being weightless and didn't think the pilots would appreciate me throwing up over their instruments! The flight engineer pointed this out to the rest of the crew much to their amusement. There were three flight officers – one controlling the pitch, one the roll and one the throttle. All three have to work together to maintain micro-gravity.

The pilot called "Pull Up" and the g force increased to 2g as the nose began to rise. With nothing but blue sky through the window he made the angle call until we reached 53 degrees and 'injection'. Then zero-g. It feels like you've taken a massive breath in, like a heavy towel has been lifted off you, or like all your clothes have disappeared. Your arms and legs have no weight and it almost feels like they too aren't there. Up and over the parabola I could see the horizon rise in the window as sky was replaced by the sea. It kept going as the plane pitched further and further forward. Through the narrow windows I had no notion of how steep our dive was, but it felt near vertical! Finally the pilot called "Pull Out" and the 2g came back on.

The next thirty parabolas would be taken up changing samples and recording information, with a single parabola each to go to the 'play-pen'. This was a netted off area where you could spin upside down and enjoy zero-g without hurting anyone. Samples of plastic and metal ball bearings up to one centimetre in size and boxes filled with sand were filmed. Sand moves as a fluid in zero-g, splashing against the container walls in waves. Plastic balls bounce off each other without losing energy, and combinations of the two form clusters. Steel ball bearings form a soft solid as each ball is partially magnetised.

At first, we were lying down during the 2g entry and exit phases of each parabola, and staying vertical during the twenty seconds of micro-gravity in between. This way, you don't feel ill and don't land too heavily during pull out. Soon, however, we found we could move in 2g and float in any orientation when weightless. Not everyone mastered this. I saw someone fall one meter from free floating horizontally down onto the aircraft floor!

The last flight of the campaign provided the last of the data the team needed. By the end all the samples had been tested despite the problems. The data showed sixteen distinct effects caused by inter-particle and particle-wall collisions and is still being analysed. The rig was packed up ready to be shipped back to the UK, and the last two of the Leicester team took off from Bordeaux to fly home - this time without the ups and downs. ■

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