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Dissemination level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

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Abstract: Europlanet 2020 RI has developed pilot outreach tools for use in formal and informal settings based around two of Europlanet's core science themes: planetary analogues and comparative planetology. The project, "Planet P.I." challenges students to compare climate data on Earth with data from the Rover Environmental Monitoring Station (REMS) instrument on the Curiosity Rover, which has been exploring the Gale Crater on Mars since August 2012. "Planet P.I." has been designed to allow different levels of engagement by schools or groups and at different age ranges. Older students (13-18) can build their own climate sensors based on the Raspberry Pi single board computer. A suite of sensors has been identified and issued to a group of experienced teachers for piloting. Students can use the kit to collect their own data and compare it with data collected using the same sensors by scientists during planetary analogue field trips supported through Europlanet's JRA/TA programme. School groups that do not want to build the kit but still participate in the project can access archive data online and process this to complete investigations. A project has also been developed for younger students (9-13 years) to compare online data from REMS and data from weather stations around the world. Schools will access Planet P.I. projects via the GlobalLab platform (https://globallab.org/en/). Draft projects* on GlobalLabs (investigations and teaching resources) have been developed linked to key topics in school curricula (e.g. ideal gas equation, climate, seasons, position of planets within the solar system, conditions for life etc). These projects are currently being piloted with teachers and will be available via the GlobalLab platform once the final version is published in spring 2018.

*NB The two projects will only be visible on the GlobalLab site once the projects have been published. Links to the draft projects are included in Section 8.

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1 Introduction and aims

Studies have shown that young people find it hard to engage with science until they can experience how it relates to their own lives, and that scientific literacy increases when the student co-constructs knowledge through a vigorous exchange of questions and ideas with other students[1]. Current research has also indicated that a positive Science-Technology-Engineering-Mathematics (STEM) experience prior to high school correlates strongly with a student's choice of career in STEM[2].

Planet P.I. is a pilot educational outreach project for young people to build a custom, hand-held measuring device, collect Earth planetary climate data in their local regions and compare it with data from other locations on Earth and with data collected by the Curiosity Rover on Mars.

Equipped with a device for collecting environmental data, groups of young citizen scientists (students) can discover that measurable quantities follow a scientific logic – formulas – and that these mathematical formulas have an expression in each young person's everyday experience.

Development and piloting of the Planet P.I. project have taken place in collaboration with Europlanet's JRA and TA field trips to the Danakil Depression in Ethiopia and to Lake Tirez and Rio Tinto in Spain, with researchers on the field trips using the Planet P.I. device for collecting data on environmental parameters in these exotic locations. Datasets have also been collected in Latvia and Madrid at various times of the year. In addition, data from the REMS instrument on the Curiosity Rover on Mars has been made available for comparison. All these datasets are available online for students to use in addition to the data they acquire using the devices that they build themselves. The online archives also enable students to participate in the project if they don't wish to undertake the construction of the sensor. Students can use the data to calculate derived quantities, share their findings with other classes and students and learn science with real-world experience.

A project aimed at secondary school students introduces the Ideal Gas Law and enables students to compare the atmosphere at different locations on Mars and Earth using the archive data, as well as any data that they collect themselves. Students learn how to apply

[1] (1) Peter Labudde (, (University of Applied Sciences Northwest Switzerland) invited speaker: `The Challenge of Teaching Physics', May 30, 2013, University of Latvia.

[2] (2) George, P., Stevenson, C., Thomason, J., & Beane, J. (1992). *The middle school and beyond*. Association for Supervision and Curriculum Development. Alexandria, VA.

the same climate science to different locations on Earth and on other planetary bodies, and to understand the narrow range of climate in which humans can live.

To extend the age range of students that can participate in Planet P.I, a project aimed at primary schools has also been developed based on graphs of archive maximum and minimum air temperature data from REMS and from a global network of weather stations (WeatherOnline), which schools can access over the internet.

Planet P.I. has been developed by Dr Amara Graps from the University of Latvia, Dr Felipe Gómez Gómez of the Center for Astrobiology (CAB-INTA) in Spain and Anita Heward of Science Office in Portugal, with support from a number of teachers that have volunteered time and expertise to assist with piloting the project.

2 Name and branding

We gave a great deal of time and discussion to finding an appropriate name for the project. We rejected the original working title, “Space Climate Detectives”, due to similarities with unrelated educational projects called “Space Detectives” in Portugal and the UK. However, we felt that it was important that the name retained the sense of investigation and mystery evoked by the word *detectives*. “Planet Sleuths” was considered but rejected as not being accessible to students and teachers for whom English is not a first language.

We finally selected the project name “Planet P.I.”, as P.I. has the triple meaning of:

- a “Principal Investigator” of an instrument for a space mission
- a “Private Investigator” or detective
- “Pi” relating to Raspberry-Pi

The design team at Science Office has produced a logo that references the enquiry and engineering aspects of the project, as well as the link to planetary science. This logo is available in a range of formats:

3 Project timeline

September 2015 – February 2016	Development of the initial prototype by Dr Amara Graps in Riga, Latvia
February 2016	Shipment of prototype to Dr Felipe Gomez at CAB-INTA, Madrid, Spain
April 2016	First field test of prototype device at the Dankil Depression, Ethiopia
May 2016-October 2017	Refining sensor selection. Further field testing.
September – December 2017	Investigation of online platforms for schools’ access
October 2017	Ordering of components for pilot kits for teachers

October - November 2017	Development of branding for the Planet P.I. project
January 2018	Further field tests
January – February 2018	Development and piloting of investigations and teaching resources.

4 Development of kit

The development of the Planet P.I. kit has been led by Dr Amara Graps. Dr Graps was responsible for building the initial prototype of the device, and has also overseen development of educational resources for the project, with support from Dr Felipe Gómez Gómez and Anita Heward.

Dr Gómez has led the field testing of the prototypes and refining the selection of sensors to be included in the Planet P.I. kits.

The original prototype comprised the following:

- Raspberry Pi 3 Model B
- Case
- 32GB MicroSD Card with Adapter Preloaded with NOOBS
- 2.5A Power Supply
- Heatsinks
- GPIO Breakout Board
- T-shape Cobbler Breakout Board
- 40 Pin Ribbon Cable
- Male-Male Jumper Wires
- Male-Female Jumper Wires
- Tie In Point Breadboard
- Resistors
- Buttons

The following sensors were considered:

- Adafruit ID1980 High Dynamic Range Digital Light Sensor TSL2591
- Adafruit ID1918 Analog UV Sensor 240-370nm GUVA
- Watterott 20150173 BME280 Humidity & Pressure Sensor
- Adafruit ID2651 BMP280 Pressure & Temperature Sensor

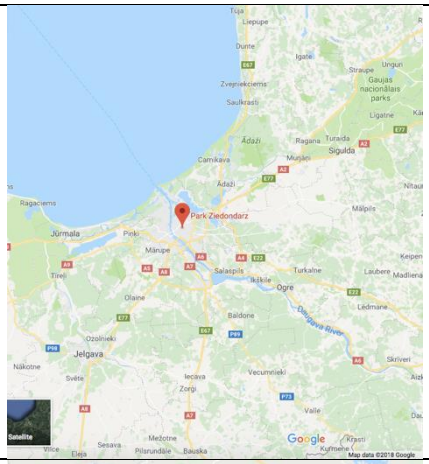
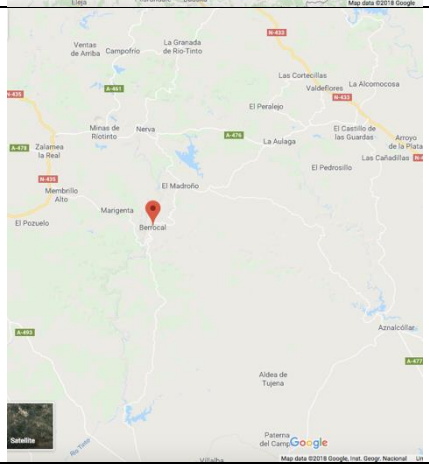
- Adafruit ID1085 ADS1115 16-Bit ADC+PGA
- Adafruit ID1083 ADS1015 12-Bit ADC+PGA
- Adafruit ID3295 RealTime Clock BreakoutBoard PFC8523
- Adafruit ID1400 Pushbutton Powerswitch

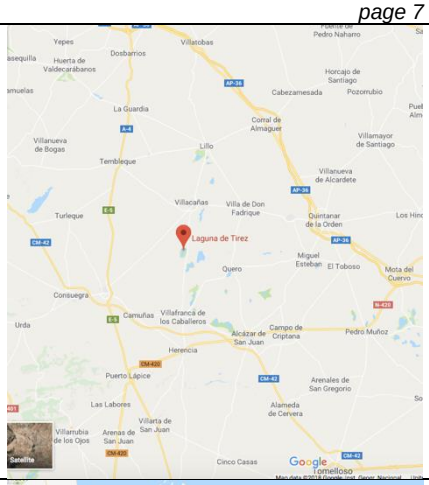
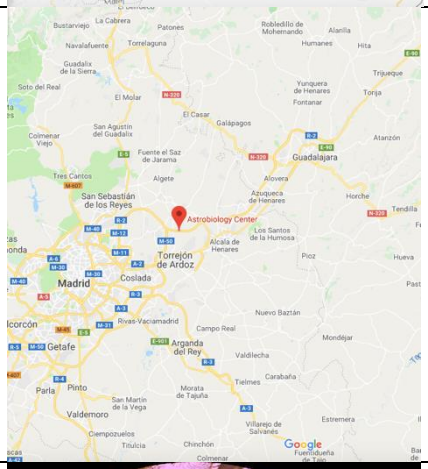
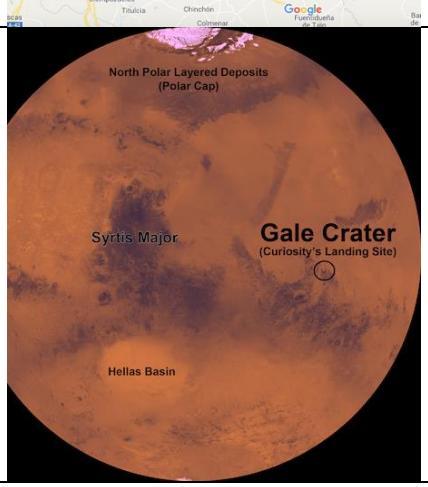
The Planet P.I. kits trialled in the field and currently being piloted in schools include the following sensors:

- Pressure. Altitude is derived on the chip from the Pressure value.
- Temperature

5 Piloting in the field

Data has been collected in the following locations:

Date, location, link to data files	Image of location	Map of location
February 2016 **Ziedondarz Park, Riga** **Log 18** **Log 19**		
June 2017 **Berrocal, Rio Tinto, Spain** **Log 40**		

September 2017 **Tirez Lake, Spain** **Log 21** **Log 22** **Log 23**		
January 2018, Dallol, Ethiopia **Log 33** **Log 34** **Log 35**		
February 2018 **CAB-INTA, Madrid** **Log 52**		
September 2012 - February 2018 Mars REMS data		

6 Piloting with teachers

In January 2018, the following teachers were sent Planet P.I. kits for pilot testing:

- Javier Pérez - Spain
- Diana González – Spain
- Javier Fernández - Spain
- Francois Ravetta - France
- Anni Maattanen - France
- Robert Coombes - UK
- Artur Coelho - Portugal
- Anica Trickovic - Serbia

The pilot kits included a Raspberry Pi, a suite of sensors (pressure+altitude, temperature) and building instructions from the sensor suppliers. The main objective of this piloting exercise is to test and evaluate the Planet P.I. kit and the accompanying educational resources in a classroom environment. The teachers selected are very experienced in using Raspberry Pi and other electronic systems and are able to advise and trouble-shoot on potential issues, as well as suggest/develop protocols for managing data reduction and graphic representations.

The team at CAB-INTA is providing technical and scientific support for the teachers, who have been asked to fill in a questionnaire to gather feedback on:

- Assembly instructions
- Where and when they plan to use the Planet P.I. climate sensors
- How they plan to manage data storage (transfer data from the climate sensor to a PC via a USB, use a USB to transfer data to an external hard drive, or have the kit directly connected to a PC)
- How they plan to manage data reduction (use an existing protocol, modify an existing protocol or develop a new protocol)
- How they plan to manage data graphic representation (use an existing protocol, modify an existing protocol or develop a new protocol)
- Whether they would like to see other sensors added, such as humidity, wind or albedo
- Whether they are planning to use Ethernet, WiFi, Bluetooth or other to communicate remotely with the device, and how they will communicate results.

Feedback to date has been positive from the pilot group. The teachers have described the assembly instructions of kit as “Easy to follow”. However, it should be noted that all these teachers are very experienced in building this kind of system. As we expand the group of teachers involved we will continue to evaluate and monitor responses to ensure that those with less experience are fully supported.

All the teachers from the pilot sample that have responded to the questionnaire will be using the kit outdoors during limited periods every day to gather data. They will be using a USB pen drive to transfer data from Planet P.I. kit to a PC, although some are planning to implement a WiFi connection. They will modify pre-existing data reduction and graphic representation protocols to fit the needs of this project.

The teachers opportunities to modify and augment the initial sensors in the kit: some are planning to develop a wind sensor and an albedo sensor, and some are planning to use a humidity sensor. Some are planning to add other relevant sensors that they already own. The teachers are planning to create their own webpages for the project.

7 Educational interface

We consulted the Galileo Teacher Training Project to help us find the best interface for schools to access the learning resources for Planet P.I. projects and share their data. After

some research, we selected GlobalLab, an online platform that facilitates collaborative student projects using crowdsourcing.

The following description from the GlobalLab website explains how the platform works:

- Each project participant completes a small experiment or study comparable in difficulty to regular lab work or an individual school project
- The results of the experiment or study are then entered into a shared database.
- Based on the data sent in by student participants from all over the world, the cumulative results are displayed as various infographic widgets, including maps, diagrams, galleries, tag clouds and more.
- The cumulative results can be used for the value of the new knowledge they present, serve as a discussion topic or a jumping-off point for new projects

Each project has a protocol page, which describes the investigation, a report page, in which students can upload their data, and a findings page, in which students can compare their results with other students around the world. We have currently set up two pilot projects on the GlobalLab platform: **"Atmospheric Investigators",** aimed at Secondary Students, and **"Comparing Planets**", aimed at Primary Students, and these are currently undergoing a pilot phase of testing with teachers prior to publication and the formal launch of the project, planned for spring 2018.

8 Teaching resources

Teaching resources and the GlobalLab projects have been prepared in collaboration with the Gail Renaud, a specialist science teacher at the Independent Bonn International School (IBIS) in Germany. She has piloted the draft GlobalLabs projects with Year 6- 8 students (aged 10-13) at the school in February 2018.

Initial curriculum links in mathematics, science and geography have been identified. A more detailed curriculum mapping process will take place in the next phase of the project.

Links to Planet P.I. teaching resources:
Europlanet Planet P.I. webpage
The Case of the Contrasting Planets
The GlobalLab projects are private until published, but we have downloaded pdf files of the current versions of the project pages for this Deliverable Report:
Draft GlobalLab Primary Project "Contrasting Planets" Protocol Page
Draft GlobalLab Primary Project "Contrasting Planets" Investigation Page
Draft GlobalLab Primary Project "Contrasting Planets" Findings Page
Draft GlobalLab Secondary Project "Atmospheric Investigators" Protocol Page
Draft GlobalLab Secondary Project "Atmospheric Investigators" Investigation Page

Build instructions for Planet P.I. Climate Sensors:
Adafruit BMP280 Barometric Pressure + Temperature Sensor Breakout (from AdaFruit Learning System)
Adding a Real Time Clock to Raspberry Pi (from AdaFruit Learning System)
Adafruit 4-Channel ADC Breakouts (from AdaFruit Learning System)
Arduino and GUVA-S12SD UV Sensor (from Arduino Learning)

9 Data Management

Most schools participating in Planet P.I. will register and upload data through the GloblalLab platform, so Europlanet will not collect data directly. For any other cases, including data collected during piloting and analogue field trips, we are following procedures set out in Europlanet's Data Management Plan for Transnational Access projects (see Europlanet 2020 RI Deliverable 1.18).

10 Next Steps

- Feedback from the piloting exercise will be used to optimise the sensors and build-instructions for the kits and the project pages and learning resources on the GlobalLab platforms.

- Final versions of the kits will then be distributed to schools and details of how to acquire the sensors will be added to the project site.

- The GlobalLab projects for primary and secondary schools will be launched in spring 2018 and advertised through relevant channels and partner organisations (Galileo Teacher Training Programme, Hands On Universe, EU Space Awareness, European Schoolnet, Ecsite etc).

- Statistics on usage and feedback from teachers will be collected via the GlobalLab platform.

- LMT, the Latvian Mobile Telephone company, has expressed interest in developing a Planet P.I. project based on assessment of air quality. Dr Graps will follow this up in spring 2018.

11 Acknowledgements

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