



**I02**

**Space program  
for small science centers and NGOs**



NOESIS - Thessaloniki Science Center and Technology Museum  
2021



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## 1. STEM EDUCATION IN FORMAL AND NONFORMAL SETTINGS

Science, Technology, Engineering and Mathematics (STEM) play an important role in contemporary society. They shape an area that has transformed our lives dramatically and is continuing to evolve and determine our world building the sustainable society of the future. Our society is quickly changing into a knowledge society and new skills are needed for people to be able to function successfully in the 21st century. According to several studies the competencies needed in future society will include: computational skills, social and cultural skills, creativity, critical thinking and problem solving - together they are usually referred to as the 21st century skills.

The youngsters of today will probably have jobs that we never heard of today. Supporting our future citizens to keep up with this pace will not only benefit the citizens themselves, but the whole society.

The way to achieve this, passes through a meaningful and efficient education on STEM topics. While Schools and Universities are the main institutions, which are formally responsible for the education of youth, the nonformal sector can play a critical role as well, integrating science learning and developing 21st century skills through their programs and activities. The nonformal sector includes science research institutions, technology museums, science centers, zoos, libraries, even the media.

### 1.1. Science museums and science centers

Science museums and science centers are popular nonformal learning spaces. They are places where people can come together and explore the very mysteries that make up our world. They provide multiple opportunities for the visitors to expand and deepen their knowledge and understanding of science and technology. They offer a vast experience of the process of scientific discovery by presenting or recreating real facts and phenomena and offer opportunities for people to practice skills and acquire new abilities.

Science museums and science centers play a prime role in public engagement in science enabling people to have first-hand experience of scientific phenomena and to develop curiosity, awe, motivation, interest to know more, understanding and learning. By encouraging public understanding and engagement with science, such places serve as important platforms for the empowerment of people, enabling them to make well-informed decisions.

Promoting scientific literacy and life-long learning, science museums and science centers are exciting learning places for all ages, essential in enhancing societal capacities to adapt in the face of change. More and more the modern science centers and science museums of today have multiple functions to fulfill in society.

While the public itself values both the entertainment aspects and the opportunities for learning in such places, learning outcomes from these environments have been well studied and documented over the past forty years, each time through the prism of the latest developments in the field of teaching and learning. Research about, and understanding of,

learning in science museums and science centers has been enhanced by taking a broader perspective of the nature of learning.

In recent years, learning is seen as an active interaction of the learner with the environment and the experiences gained through it. In a science museum environment, where the personal, sociocultural and physical context, described by Falk and Dierking (2000) are the essential components in understanding the museum experience, visitors are essentially in control of their learning and can take what they need from the experience in a unique way.

Learning involves change in knowledge and understanding; capabilities and skills; ways of thinking – values, feelings and attitudes; and/or ways of acting – behaviors. It is a lifelong process that occurs in many different environments and although the learning process is the same, there are qualitative differences between formal and nonformal learning contexts that hinge on the degree of choice participants have to engage in learning activities and with whom, and whether or not there is a formal curriculum and/or assessment process.

## 1.2. Connecting schools and Science centers

School groups are among the audiences most present in the majority of science centers and museums. Therefore, much of the discussion around such nonformal places is about clarifying their role in education and their relationship with education provided by schools.

Museum visits had previously been commonly regarded by schools as an end-of-term treat, and a chance for the teacher to relax, are now considered an important learning resource, a teaching support, and a means for developing a lasting relationship between the school and its surrounding territory.

Science centers and museums are not schools, but educational institutes that offer learning experiences, without taking school's role in education. Helping students to take responsibility for their future learning is one of their major goals, while others are to facilitate students' understanding and perception toward science, to motivate them to get involved with science and technology and to change their behavior by triggering thinking and practicing skills, than presenting information and teaching in order to increase their knowledge.

Throughout the world, and for many decades, science centers and museums have provided students, teachers and families with opportunities to expand their experiences and understanding of science. They have provided a range of activities for students, which are difficult to replicate in a traditional school environment. In addition, they have offered resources and support to teachers, organizing training courses for school staff and provide services that schools for various reasons (eg lack of resources, trained staff, or financial constraints) do not have the ability to do. Science centers and museums used their equipment to support schools and thus offer a view of science and technology education not found in traditional formal educational settings.

Nowadays, the model of the modern science is characterized as multidisciplinary, and most of today's science issues are tackled by interdisciplinary teams. On the other hand, multidisciplinary or integrated science is messy and often outside a teacher's professional

expertise. Science represented by abstract canonical concepts, introduced within many textbooks, tends to lack context and, because the students themselves have to provide the synthesis that makes it meaningful, it becomes unnecessarily difficult conceptually. Science centers and museums, less attached to traditional texts and much more engaged in context-based science can and does provide for disciplinary integration and a more holistic picture of what science is really like in the world outside of school.

Conclusively, as science learning initiatives outside the classroom prove to be crucial in educating and forming next generation of researchers and innovators, an effective collaboration between schools and science centers and museums is needed. A collaboration that leads, or should lead to a learning process, that integrates the needs of the teachers and pupils, the work carried out in classroom and the experience of the museum visit.

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## 2. ASTRONOMY AND SPACE EDUCATION IN FORMAL AND NONFORMAL SECTOR

Astronomy has a natural appeal to many as it focuses on the origin of the universe, galaxies, stars, planets and even life itself. It is undoubtedly one of the sciences that enjoys intense public interest, as testified to by the very large number of popular astronomical journals, planetariums, amateur clubs and interested individuals in all countries. Astronomy is also an illustrative example of the interplay between science, culture and technology in all its historical and modern aspects. It moreover demonstrates the unity of science, gives a host of educationally useful examples of the scientific method, and may also serve as a natural stepping stone into a large number of other areas of human knowledge and activities.

The field of Space has become very important in the wake of opportunities and strategic advantages accrued from it. It has become increasingly evident that space science education is beginning to gain grounds in the 21st century and it is perceived to bring about Science, Technology, Engineering, Mathematics (STEM) awareness providing a context for teaching and learning of the subject.

Therefore, educating people on Astronomy and Space science can act as a "gateway" that opens a world of possibilities by nurturing inquisitiveness and the pursuit of knowledge using the scientific method. Moreover, as astronomical research is technology driven, astronomy and space education provide excellent opportunities to enhance different aspects of (integrated) STEM education and motivate (more) students to pursue their interests via higher education programs and STEM-oriented professional careers.

However, in most European countries, there is not a stand-alone, organized educational curriculum of astronomy and astrophysics in upper secondary level. Typically, isolated concepts related to astronomy are introduced in other disciplines like Earth Science, Physics, Geography and Chemistry. In schools a real curriculum of astronomy is still lacking.

On the other hand, in the informal / non-formal sector and especially in planetariums and science centers, the field of Astronomy and Space Science is strongly represented and remains one of the most popular topics for visitors. These places have a long history in supporting the astronomy interest for the general public but also in supporting the school curriculum of children and students. This is achieved through activities such as projections of movies, shows and live presentations on planetarium domes as well as through exhibitions, science shows and educational programs, that incorporate a variety of methods and always following the latest trends and innovative tools in education.

It becomes obvious that an effective collaboration between schools and science centers has the potential to promote and improve the education provided on Astronomy and Space science and to prove mutually beneficial for both type of organizations. Schools through their visits in such institutions can expand their students' knowledge on Space topics and their learning skills in general. Science centers and planetariums, considering the school curricula are also benefit. Research indeed reveals that the education potential of the museum increases when opportunities are offered for students to link the museum experience with

their work in the classroom; whereas such potential is lower in cases of museum visits that are not made part of a project, or of museum activities that create no links with students' school knowledge.

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### **3. A SPACE PROGRAM FOR SCIENCE CENTERS AND OTHER NONFORMAL EDUCATION ORGANIZATIONS**

#### **3.1. The Context**

The FUTURE SPACE is the EU-funded project focused on astronomy & space exploration to provide a catalyst for change in understanding and teaching STEM subjects in European educational systems. It is directed to upper secondary school students and teachers but also to non-formal educational organizations such as small science centers and NGOs.

The project aims to inspire students through space matters, increase the number of candidates for STEM studies, and introduce young people to career opportunities and further professional development in the space sector and other innovative areas. Moreover, the FUTURE SPACE is designed to build the cross-sectional and soft competencies which have significant importance on the labour market and to reduce low achievement in natural science subjects.

The two main deliverables of the FUTURE SPACE project are the Space Schools Program (SSP) and the Space Program for Science centers and other non-formal education organizations (SScSP). The first Program (SSP) includes thematic modules devoted to the 21st century's global challenges and practical solutions offered by research and exploration of the near-space environment. The modules addressed to secondary school teachers and can be adopted and implemented by them in their science classes, as an extra curricula material in astronomy and space education.

The second program for Science centers and other non-formal education organizations (SScSP) is a toolkit of 4 different activities as regards human efforts to understand and explore Space. The activities are addressed to, and can be adopted and realized by, science centers, planetariums and other nonformal education organizations that wish to enter the space education sector. During a school group visit to such an institution, the toolkit can act either independently or complementarily to SSP, offering students an out-of-school learning experience, which incorporate all the aspects of the informal science learning discussed above.

In the context of the FUTURE SPACE project, NOESIS contributes to the SScSP by developing two activities, a gamified activity entitled "Colonization of Mars - Challenges and Solutions" and an interactive planetarium activity, entitled "Wandering in the Universe".

#### **3.2. Combining educational approaches and teaching practices**

Science centers aspire to motivate students to engage in astronomy and space science, enable them to gain relative knowledge and cultivate 21st century skills. To do so, they use a variety of activities (exhibitions, educational programs, science demonstrations, live presentations, dome projections, etc.) and employ multifaceted educational methods that combine a variety of teaching / learning tools.



### **3.2.1. Inquiry based learning**

Education in 20th century focused on reading, writing and counting. In the 21st century we need to focus more on building reasoning skills early in life, and this is where inquiry-based educational approaches can play an important role.

Inquiry-Based Science Education (IBSE) is a form of science education (SE) that - unlike the traditional model where the teacher provides facts and the students learn them - gives children the opportunity to explore “hands on”, to experiment, to ask questions and to develop responses based on reasoning.

Traditionally in science education, a teacher relates facts to students, who in turn learn those facts. IBSE initiates an investigative approach to teaching and learning. It takes a more student-centered approach and puts the focus on questions and problem-solving. Students learn through reasoning and doing, through asking questions, carrying out experiments, weighing up evidence and considering alternative hypotheses. Thanks to their own curiosity and the skills of scientific inquiry they develop, students learn about the facts rather than having them presented to them as a fait accompli. The IBSE approach can thus motivate children to be interested in science and to develop scientific literacy and critical thinking skills.

There are five elements of inquiry-based learning. The five components include: Essential Questions, Student Engagement, Cooperative Interaction, Performance Evaluation, and Variety of Responses.

### **3.2.2. Collaborative learning**

Scientists and engineers work mostly in groups and less often as isolated investigators. Not only knowledge but also communication skills, leadership quality, critical thinking, and listening skills are required to achieve excellence in work.

Similarly, the education today should prepare students against all challenges they have to encounter later in life and enable them to gain experiences and skills, sharing responsibility for learning with each other. Teaching methods should not only serve the academic purpose but also develop social and cooperative skills. To serve this purpose, among all the teaching methods being followed in the world, the collaborative learning, is considered to be of great utility and wisdom.

Collaborative approaches in learning actively engage learners to process and synthesize information and concepts, rather than using rote memorization of facts and figures. Learners in groups of two or more, mutually search for understanding, solutions, or meanings, while working on projects and collaborate to understand the concepts being presented to them. They take responsibility for their team learning and succeeding, while their roles, resources, and organization is left up to them. There is no director to administer the rules of engagement, so the group itself must self-direct. Through defending their positions, reframing ideas, listening to other viewpoints and articulating their points, learners gain a more complete understanding as a group than they could as individuals.

The collaborative type of learning, presents a series of specifically elements, of which we can underline the following: students control their own knowledge acquisition process, taking on responsibilities; the teacher is only a facilitator and a guide of the students in the process; the students can make their own decisions, working together to achieve common goals.

### **3.2.3. Game based learning and Gamification**

Game based learning (GBL) is a known strategy that uses the idea of a playing games to reach specific learning objectives, whether they comprise knowledge, skills, or attitudes. GBL usually includes a game-like environment and practice of the learning content through various activities. Different GBL types can be examined along with taking into consideration the place where the game happens and the environment in which the students play. Common types of GBL are the board games and the digital games as well, where the environment is online.

In GBL, the learning experience is positive and interesting, and the learning process that comes as a result of playing the game, takes place through different and attractive scenarios and is based on overcoming different challenges. In order to create efficient game-based learning, it is essential to integrate a simulator that creates real situations, which enable students to practice skills.

Focusing in science education, in which traditional education is perceived by most students as difficult, ineffective and boring, incorporating GBL has proven highly effective because games mainly encourage students' motivation, while support the development of certain strategies and skills such as problem-solving, decision making, understanding complex systems, planning or data handling.

Today, more than ever, learners increasingly demand for innovative and motivating learning scenarios that strongly respond to their habits of using ICT and media. Moreover, technological advancements and their rapid development always create new and exciting ways to engage students learning and meet the growing needs of education.

Gamification is a technological trend and a teaching practice that has been initiated in the recent years. According to Kapp (2012) is defined as “the use of game design elements, game-play mechanics, aesthetics, and game thinking for non-game applications to motivate students.” Lately, though, gamification has focused to digitally engage students, utilizing platforms or applications with the use of digital devices like tablets, smartphones, or computers.

The implementation of gamification in education, utilizing gaming elements and aesthetics which are something familiar to students, draws their interest, enhance their motivation, reinforces skills as creative thinking, problem solving, cooperation and communication and may promote learning. Gamifying science activities by implementing gaming mechanics and elements can potentially erase the obstacles science education faces, increasing motivation, cognitive and metacognitive achievements, and students' enjoyment.

The environment of a gamified activity represents real-world problems and situations. It is carefully designed and has explicit and clear content and instructions. In this way the students do not get distracted and stray from the learning goals, which are visible and known to them from the beginning. During the activity, the students are digitally engaged, through the dedicated android application that guides the groups through the tasks and the use of the tablets.

Learning is mainly achieved indirectly, gamification's primary goal is to affect factors, such as motivation, to influence a learning-related behavior, like engagement with the educational content, and achieve a learning outcome. All gamification applications have two sets of goals, the learning goals defined by the content and the playful goals related to the user experiences they trigger, such as enjoyment and satisfaction, and are linked with the game design elements.

#### **Resources:**

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## 4. PROGRAM CONTENT

### 4.1. "Collonization of Mars - Challenges and Solutions" – Gamified activity

#### 4.1.1. Introduction

Man's plan to colonize Mars is a comprehensive effort, that includes studying and solving a variety of challenges. "Collonization of Mars - challenges and solutions" is a gamified activity for students, who are dealing with challenges and situations faced by scientists, experts and astronauts in the colonization project of Mars.

The activity, targeting at secondary school students, takes place in a properly designed and equipped room, has a duration of 90 minutes and is facilitated by 1-2 facilitators. It comprises an introduction, an experimentation phase and a reflection phase. During introduction, a short-guided discussion reveals students' ideas about human efforts to visit and colonize Mars and the facilitators explain how the activity will be implemented. During the experimentation phase, the students, in groups of five and using tablets, are guided by a dedicated android app. They are moving around five working stations and perform five different Tasks, keeping specific time limits. During the reflection phase, the students discuss in plenary their group's work and outcomes, while scientific information and up to date data from current research are given.

Developing the activity, a variety of educational approaches and tools have been combined together. Inquiry based learning is the primary method, as all the five elements of IBL (Essential Questions, Student Engagement, Cooperative Interaction, Performance Evaluation, and Variety of Responses) are present. Gamification prevails the whole activity, as the tasks determine the goals, the environment where the activity takes place represents real-world situations and the students are digitally engaged during the whole activity. In addition, as students work in small groups, taking on specific roles and trying to accomplish certain goals, share ideas, understanding, procedures and communication, the elements of collaborative learning are met as well.

The following paragraph 4.1.2. gives a complete and detailed description of the activity. It also acts as an implementation guide for anyone who would like to adopt and perform the activity on their premises. The first part, namely the "Activity's profile", is the part where the activity is briefly described (content, aims, setting, time scale), the five tasks are summarized and information about the android app, as well as guidance for the facilitators are given. The following is a detailed description of the five tasks, with complete guidelines about the setting, the experimentation and the reflection phase. The last part refers to the dedicated android app and gives all the set up instructions and the information needed to run the app and implement the activity.

#### 4.1.2. The Activity



### HUMAN COLONIZATION OF MARS – CHALLENGES AND SOLUTIONS

A gamified activity for students, who deal with challenges and situations faced by scientists, experts and astronauts in the colonization project of Mars.

Developed by



during the Erasmus+ EU  
project “Future Space”

(2019-2021)

## Activity's profile

### AT A GLANCE

Title	Human colonization of Mars – Challenges and Solutions
Age Group	13 - 18 years old (Secondary school students)
Format	Workshop for students
Duration	90 minutes
N. participants	25
N. facilitators	1-2

### OVERVIEW

Man's plan to colonize Mars is a comprehensive effort, that includes studying and solving a variety of challenges. Students, working in groups and through specific tasks, have to deal with challenges, associated with real-life situations faced by scientists, experts and astronauts involved in the planetary colonization project on Mars.

The challenges they have to deal with, and for which they have to make decisions and offer solutions, concern the preparation of the mission, the continuous communication and data transmission, the selection of the place to set the human colony on Mars, and the effective response to critical situations.

### AIMS

- Motivate students and change their attitude towards science
- Inform students about human efforts to visit and colonize Mars
- Practice 21st century skills (critical thinking/ communication and collaboration/information and technology literacy)

### THE SETTING

The activity takes place in a room where 25 students (max) can work in groups of five (max), around five working stations/tables. A computer, internet access, a projector, 5 tablets (or android smartphones) and the Android Mars app are necessary for the activity to run.

Each working station represents a Task. All the information needed to guide the group through each task is written on printed table-boards that are placed on each table. Extra materials and equipment for each task are placed on the tables, as well.

The students in groups of five, are guided by the dedicated tablet app. They are moving from station to station to perform all the Tasks, keeping specific time limits. The whole activity is being facilitated by 1-2 facilitators.

## DESCRIPTION AND TIME SCALE

### 1. Introduction/ Orientation- 15 minutes

- Short guided discussion, based on students' ideas about:
  - The missions to Mars.
  - The Colonization of Mars.
- Explanation of the activity and its implementation (context /instructions).

### 2. Experimentation- 60 minutes

Each group moves from table to table and works to accomplish the Tasks.

### 3. Reflection- 15 minutes

Discussion in plenary on each group's work and on outcomes for each Task.  
Scientific information and up to date data from current research are given.

## THE TASKS

There are five Tasks performed by each group.

Each Task travels students to a specific place and time, assigns them a specific role and sets a unique goal.

Diverse means are used to practice different students' skills.

## TASKS OVERVIEW

	Task	Date	Place	Group's role	Challenge	Task format / Skills	Means/ Materials
1	Choose the Astronauts	3 years before Mission-1 launching	Earth	The Astronaut Corps Committee that chooses the astronauts for Mission-1	Human resourcing	- Critical thinking	Printed cards
2	Load the Supplies	1 month before Mission-1 launching	Earth	A member of Mission-1 crew	Mission preparation	- Critical thinking - communication and collaboration	Android application
3	Transfer the Data	4 years before Mission-1 launching	Earth	The scientists of the Space Communications and Navigation Department	Technical competence	- hands on - problem solving	3D objects

4	Place the Colony	8 months after Mission-1 landing	Mars	The crew of Mission-1	Decision making	- information literacy - Critical thinking	Android application
5	Manage the Crisis	3 years after Mission-1 landing	Mars	The crew of Mission-1	Crisis management	- Hands on experiment - Problem solving	3D objects

## ANDROID APPLICATION

There is a dedicated Android app to the activity and a dedicated admin web page as well. The app is the guiding tool for the groups, during the experimentation phase, while the admin page is the summarizing tool for the facilitator, during the reflection phase.

In particular, the admin page:

- Is used to initialize the game settings.
- Is used to create new games and manage them.
- Allows the summarizing of all groups' work, Task by Task, during the reflection phase.

The app:

- Guides the groups through the Tasks (each task has a unique ID code), keeping track of the order they are performed and the time left for each one.
- Gives the information needed to complete each Task.
- Is used by the group to record the results of each Task.

## FACILITATION

The whole activity is facilitated by 1-2 facilitators.

Before the activity, the facilitators:

- Prepare the room, the equipment and the materials needed:
  - 5 working stations/tables (mark the tables as A, B, C, D, E).
  - 5 seats per table.
  - 5 tablets fully charged (mark the tablets as A, B, C, D, E).
- Visit the dedicated admin page and create the game.

During Introduction/Orientation phase, the facilitators:

- Welcome the school group and help students to take their seats: 5 students (max) per table.
- Start by making questions, in order to reveal and share students' ideas and knowledge:
  - Why do people plan to leave Earth?



- Why do we choose Mars as a destination?
- Why is Mars considered a “hostile” planet?
- Set the context of the activity and explains the instructions:
  - Each group has to complete 5 Tasks. In each Task the group has a unique role. The printed boards on the tables gives them all the information and instructions needed.
  - All the groups perform all the Tasks, moving from table to table, every 9 minutes.
  - The groups, using their tablets to guide them, move from Task to Task and upload their answers in the app.
- Deliver the printed table-boards and helps the groups to place them on their tables. (Board named "Task 1" is for table A, board named "Task2" is for table B etc.)
- Deliver the tablets (tablet A goes to table A, tablet B goes to table B etc.)
- Start the experimentation phase.

During the Experimentation phase, the facilitators:

- Move between tables and facilitate, where and when needed.
- Ensure that time restrictions are kept (9 minutes per Task).
- Make sure that the tables are ready to be used by the next group.

During the Reflection phase:

- Pick up the tablets and announces the end of the experimentation phase.
- Present and summarizes what all five groups have done, Task by Task (using the admin page).
- Provoke discussions in plenary on each group’s choices and outcomes.
- Give scientific information upon Tasks’ content and up to date data of the current research.

## TASK 1 - Choose the Astronauts

### AT A GLANCE

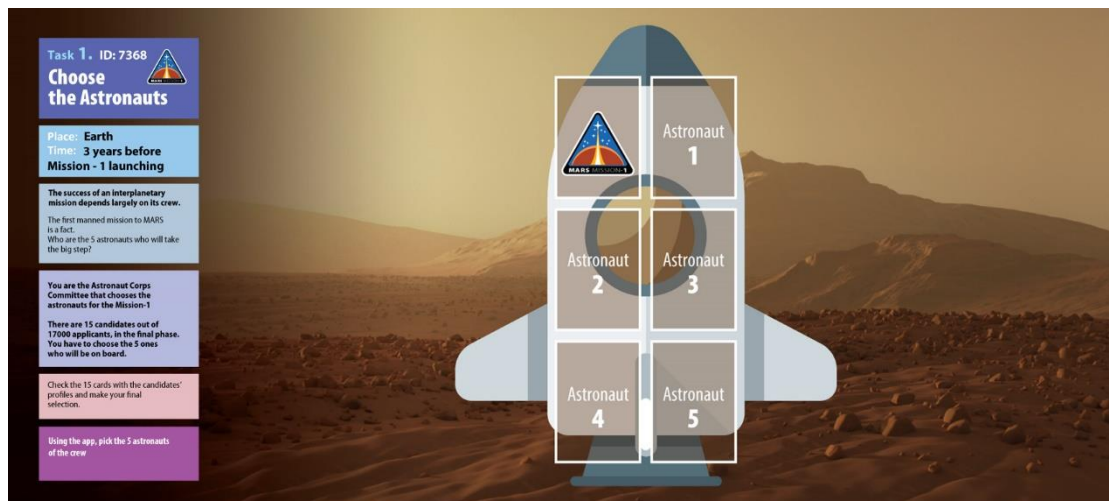
Date	Place	Group's role	Challenge	Task format / skills	Means/ Materials
3 years before Mission-1 launching	Earth	The Astronaut Corps Committee that chooses the astronauts for the Mission-1	Human resourcing	Critical thinking	Printed cards

### OVERVIEW

The success of an interplanetary mission depends largely on its crew. The first mission on Mars is a fact and the crew selection reached the final stage. The information of the final 15 (out of 17000) candidates is listed on profile cards. The team has to study the profiles and choose the 5 astronauts who will be on board.

### SETTING

#### TABLE BOARD

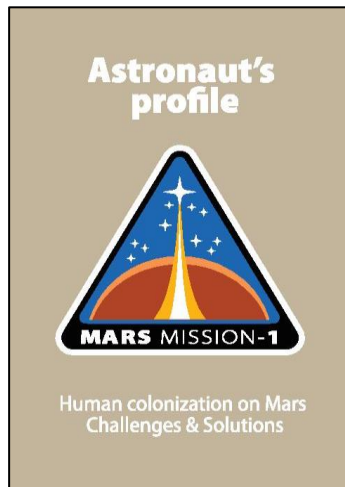


#### TASK ID


7368

#### MATERIALS

• Table board "TASK 1"
• 15 profile cards
• Tablet A



**1**  
**John Mayor**  
 Age: 48




**Education**  
 Bachelor: Mathematics  
 Master: Ocean engineering

**Experience**  
 Command of Nuclear Submarines, 100d in space

**Personal Data**  
 Married, 2 children, scuba diving, sports, reading

Example of a  
profile card  
(Card dimensions:  
8,2\*12,2 cm)

**Instructions**  
  
 Human colonization on Mars  
 Challenges & Solutions

<b>1</b> <b>John Mayor</b> Age: 48	<b>2</b> <b>Samantha Philips</b> Age: 42	<b>3</b> <b>Richard Smith</b> Age: 38
<b>Education</b> Bachelor: Mathematics Master: Ocean engineering	<b>Education</b> Bachelor: Geology Master: Geology	<b>Education</b> Bachelor: Bachelor of Engineering Master: Systems Engineering, Sea Pilot School
<b>Experience</b> Command of Nuclear Submarines, 100d in space	<b>Experience</b> Meteorology, Teaching high school sciences, 10d in space	<b>Experience</b> 100d in space, 3d combat missions
<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading
<b>4</b> <b>Raja Barak</b> Age: 36	<b>5</b> <b>Sophie Cassidy</b> Age: 37	<b>6</b> <b>Frank Marzetti</b> Age: 51
<b>Education</b> Bachelor: Physics Bachelor: Master of Science: Mechanical Engineering	<b>Education</b> Bachelor: Physics Master: M.Sc. Aerospace Engineering	<b>Education</b> Bachelor: Geophysics / Marine Geophysics, Ph.D. - Seismology
<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots
<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading
<b>8</b> <b>Kayla Watson</b> Age: 30	<b>9</b> <b>Liam Kim</b> Age: 44	<b>10</b> <b>Maria Montes</b> Age: 38
<b>Education</b> Bachelor: Biology, Master: Computational Biology Ph.D. - Molecular Biology	<b>Education</b> Bachelor: Mechanical Engineering Master: Mechanical Engineering	<b>Education</b> Bachelor: Mechanical Engineering Master: Mechanical Engineering
<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots
<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading
<b>12</b> <b>Stefan Wolowitz</b> Age: 46	<b>13</b> <b>John Wang</b> Age: 39	<b>14</b> <b>Dimitris Christou</b> Age: 43
<b>Education</b> Bachelor: Physics Master: Mechanical Engineering Ph.D. - Mechanical Engineering	<b>Education</b> Bachelor: Mechanical Engineering Master: Mechanical Engineering	<b>Education</b> Bachelor: Mechanical Engineering Master: Mechanical Engineering
<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots	<b>Experience</b> Research algorithms and software for flexible robots
<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading	<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading
<b>15</b> <b>Jeffrey Paek</b> Age: 35		
<b>Education</b> Bachelor: Mechanical Engineering Master: Mechanical Engineering		
<b>Experience</b> Research algorithms and software for flexible robots		
<b>Personal Data</b> Married, 2 children, scuba diving, sports, reading		

Profile cards'  
catalog.

**PDFs FOR PRINTING:**

- [Table board - Task 1](#)
- [Profile cards](#)

## EXPERIMENTATION

### DURATION

10 minutes

### DESCRIPTION

During the task the students have to practice their skills in critical thinking and collaboration, in order to select the crew of the first mission on Mars.

From the 17000 applications that were selected in the initial stage of the procedure, only 15 candidates reached the final stage. The profiles of the final 15, are briefly described in 15 printed cards that are placed on the table (Appendix 1).

The group has to study the profile cards and choose the 5 astronauts who will be on board.

## REFLECTION

At the end of the task each group has selected its own 5-member crew according to the priorities and preferences of their members.

Each manned space mission leads to different requirements of crew composition. For example, the Apollo 11 crew is Commander Neil Armstrong, civilian test pilot, Command Module Pilot Michael Collins and Lunar Module Pilot Edwin (Buzz) Aldrin, all of them US Air Force pilots [4].

Nowadays the missions to Mars are considered much more demanding. Studies show that the surface mission can be conducted with a minimum crew size of five, based on technical skills required. However, loss or incapacitation of one or more crew could significantly jeopardize mission success. Therefore, a minimum crew size of seven or eight may be required to address the risk issues. Currently, the reference mission is built on the assumption of a crew of six.



*Apollo 11 crew*

### *FURTHER SCIENTIFIC INFORMATION*

In the 1997 NASA reference mission, it was assumed that the crew would spend equal time in scientific work and habitation-related tasks. Three important domains of expertise have been proposed:

- Command, control, maintenance and system operations. This includes piloting, navigation, and repair.
- Scientific exploration and analysis, including planning, driving, geology, geochemistry, and reporting.
- Habitability tasks, such as operating life support systems and providing medical support.

From these domains, a list of skills has been defined. These skills are very different and it was doubtful that all of them could be possessed by a single person. After categorization, three categories of personnel have been proposed:

- A doctor
- An engineer or technician
- A geologist/biologist.

Other factors have to be considered to determine the crew size: the degree of automation, the estimated requirement of simultaneous tasks, and contingency situations, especially on the surface of Mars. For instance, if a vehicle is stuck far from the habitat with several astronauts on board, another astronaut is required to drive the rescue vehicle and still another one may have to stay in the habitat, depending on mission rules and constraints.

Concerning psychological issues, larger crews may be preferable, but a small team can also be appropriate, provided that the astronauts are selected and trained for that context and a complementary support is provided by mission control.

Another important factor is the scientific return. However, if a long surface stay is the preferred option (about 500 days on the surface), even a very small team of astronauts would have time to visit the main sites located close to the habitat. In comparison with a larger team, the main difference would be quantitative, not qualitative. All in all, a crew of six astronauts is considered the best option. According to the NASA study, there would be:

1. a mechanical engineer,
2. an electrical and electronics engineer,
3. a geologist,
4. a life scientist,
5. a physician psychologist and
6. a back-up crew.

However, this is not the minimum crew size. In the ESA (European Space Agency) reference mission, there are only three astronauts on the surface of Mars [5].

Since the 1960s, NASA has selected 350 people to train as astronaut candidates for its increasingly challenging missions to explore space [1].

The basic requirements to apply include United States citizenship and a master's degree in a STEM field, including engineering, biological science, physical science, computer science, or

mathematics, from an accredited institution. The requirement for the master's degree can also be met by:

- Two years of work toward a Ph.D. program in a related science, technology, engineering or math field;
- A completed doctor of medicine or doctor of osteopathic medicine degree;
- Completion of a nationally or internationally recognized test pilot school program.

However, if test pilot school is the only advanced degree, one must also have a bachelor's degree or higher in a STEM field.

Candidates also must have at least two years of related, progressively responsible professional experience, or at least 1,000 hours of pilot-in-command time in jet aircraft. Candidate astronauts must also be in good physical condition, have excellent eyesight and their blood pressure must not exceed 140/90 mmHg in a sitting position [1]. As part of the application process for the first time, candidates are taking a 2-hour on-line skills test.

After completing training, the new astronauts could launch on American rockets and spacecraft, developed for NASA's Commercial Crew Program, to live and work aboard the International Space Station, 250 miles above Earth. There they will take part in experiments that benefit life at home and prepare us for the Moon and Mars. They also may launch on NASA's powerful new Space Launch System rocket and Orion spacecraft, docking at the Gateway in lunar orbit before taking a new human landing system to the Moon's surface. After returning humans to the Moon in 2024, NASA plans to send astronauts to the lunar surface once per year on expeditions and establish sustainable lunar exploration by 2028. Gaining new experiences on and around the Moon will prepare NASA to send the first humans to Mars in the mid-2030s [2].

A few months prior to the mission, two crews of similar dynamics (the primary and the backup) are selected and trained simultaneously for all possible scenarios that may arise during the mission. If any problem occurs with the primary crew until a few minutes before launch, then the backup crew will take its place [3].

## RECOURCES

- [1] <https://www.nasa.gov/topics/moon-to-mars/preparing-to-go>
- [2] <https://www.nasa.gov/press-release/beanastronaut-nasa-seeks-applicants-to-explore-moon-mars>
- [3] [https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/Astronauts/Assigning\\_an\\_astronaut\\_to\\_a\\_mission](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Astronauts/Assigning_an_astronaut_to_a_mission)
- [4] [https://www.esa.int/About\\_Us/ESA\\_history/The\\_Apollo\\_11\\_crew](https://www.esa.int/About_Us/ESA_history/The_Apollo_11_crew)
- [5] [https://www.researchgate.net/publication/261710271\\_Crew\\_Size\\_Impact\\_on\\_the\\_Design\\_Risks\\_and\\_Cost\\_of\\_a\\_Human\\_Mission\\_to\\_Mars](https://www.researchgate.net/publication/261710271_Crew_Size_Impact_on_the_Design_Risks_and_Cost_of_a_Human_Mission_to_Mars)
- <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19940017410.pdf>
- [https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/Mars500/Mars500\\_study\\_overview](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Mars500/Mars500_study_overview)



## TASK 2 - Load the Supplies

### AT A GLANCE

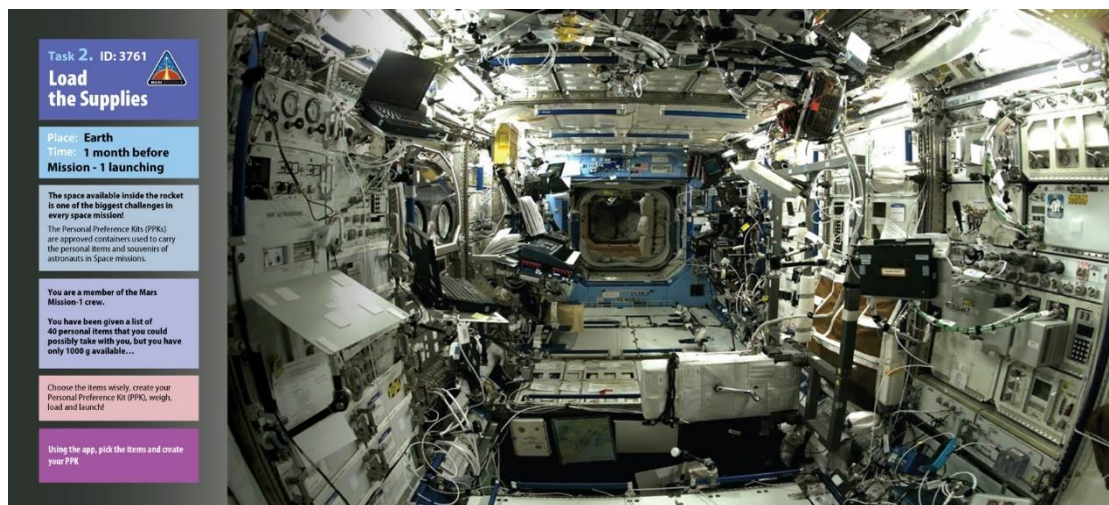
Date	Place	Group's role	Challenge	Task format / skills	Means/ Materials
1 month before Mission-1 launching	Earth	A member of the Mission-1 crew	Mission preparation	- Critical thinking - Communication and collaboration	Android application

### OVERVIEW

Space available inside the rocket is one of the biggest challenges in any space mission. PPKs (Personal Preference Kits) are approved containers used to carry the personal items and souvenirs of astronauts. The team has to choose wisely the personal items from a list of 40, for their first mission to Mars, without exceeding a total weight limit.

### SETTING

#### TABLE BOARD



**TASK ID**  
3761

#### MATERIALS

• Table board "TASK 2"
• Printed list of items
• Tablet B

Load the Supplies

	Item	Weight (gr)
1	Book big	818
2	Book light	414
3	Teddy bear	213
4	Keychain souvenir	53
5	Card postal	2
6	Family picture	2
7	Friend picture	2
8	Handheld game console	398
9	Tablet 10"	469
10	Diary	252
11	Pin souvenir	12
12	Rubik cube	346
13	Holy book	430
14	Holy symbol	15
15	Ribbon	124
16	Perfume	50
17	Ear Rings	104
18	Ring	52
19	Victory Cigar	100
20	In ear headphones	18
21	Ear cups headphones	322
22	Sunglass	230
23	Jockey	142
24	Knit cap	138
25	Scarf	151
26	T-shirt	138
27	Slippers	300
28	Socks	138
29	Harmonica	81
30	Bluetooth speaker	540
31	My feather cousin	800
32	My favourite mug	350
33	Beauty bag	100
34	Music box	250
35	Pop doll	103
36	Worry beads	155
37	Kaleidoscope	110
38	Baoding balls	410
39	Mission budes	15
40	Flag	22

Items list

#### PDFs FOR PRINTING:

- [Table board - Task 2](#)
- [Pinax of supplies](#)

#### EXPERIMENTATION

##### DURATION

10 minutes

##### DESCRIPTION

During the task the students gain insight into the human aspect of a space mission and the extreme cost of the launching as well.

The task is set up as an android application and the students select the items from the list by drag and dropping. The list includes 40 objects and the weight of each of them is given. Through the app, students see in real time the total weight of the kit, each time they add or remove an item from the list.



## REFLECTION

At the end of the task each group has formed its own PPK, which includes a different number and type of personal items. There is no such a thing as “wrong” or “right” answer, all answers are correct, as they represent personal preferences and choices.

Making the students to think and act as they are the ones who will have to live for a long time away from their homes, in an unknown and maybe hostile environment, is a way for them to understand and value the importance of the psychological dimension of a manned space mission.



*Michael Collins' PPK  
from his flight on  
Apollo 11*

Crew members on Apollo spaceflights were assigned PPKs, that were made from Beta cloth, a type of fireproof cloth that was added to Apollo/Skylab A7L space suits and used in other specialized applications. Five PPKs were carried on Apollo 11, the spaceflight that first landed humans on the Moon (20/7/1969): one for each of the three astronauts were carried on Columbia, and two were carried on Eagle Lunar Module.

## FURTHERSCIENTIFICINFORMATION

In a manned space mission, the available space inside the spacecraft is limited and each kilo that is launched costs about 20,000 euros.

According to Robert Frost, Instructor and Flight Controller at NASA, on Quora (2016): The Space Shuttle program instituted a PPK (Personal Preference Kit) that was used to carry personal belongings of each crew member. The contents of a PPK were limited to 20 separate items, with a total weight of 0.682 kilograms (1.5 pounds). The volume of a PPK must be contained in 12.82 centimeters × 20.51 centimeters × 5.13 centimeters (5"×8"×2") bag provided by NASA.

Separate from the PPK are crew care packages. These are manifested by the psychological support teams and include personal items considered to be for the wellbeing of the crewmembers, such as books, CDs, religious supplies, holiday decorations, and favorite condiments.

In addition, some personal items can be manifested under necessary supplies - for example, a crew member can have a baseball cap and/or sweatshirt from their alma mater included as part of their clothing allowance.

There is also an OFK (Official Flight Kit) in which crewmembers can put mementos for family members or their support team. For example, crewmembers sometimes fly 4"x6" personal photos of their instructors that they will take a picture of, on-orbit, and return to the instructors. The OFK also usually includes crew patches and/or pins that the astronaut will give to people, when they return.

#### RECOURCES

- [https://en.wikipedia.org/wiki/Personal\\_preference\\_kit](https://en.wikipedia.org/wiki/Personal_preference_kit)
- <https://www.forbes.com/sites/quora/2018/06/26/how-many-personal-items-can-astronauts-bring-to-space/#419bee3e3a30>
- [http://www.spaceflownartifacts.com/flown\\_ppks.html](http://www.spaceflownartifacts.com/flown_ppks.html)
- <https://www.google.com/search?sxsrf=ALeKk01OdpJBzRwIFTI4XAAOCIV3mliSrw:1585746417942&q=personal+preference+kit&tbm=isch&source=univ&client=firefox-b-d&sa=X&ved=2ahUKEwjC0cfffpcfoAhXUuHEKHYN7AoAQsAR6BAgIEAE>
- <https://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6#bottle-of-water-9100-to-43180-1>
- <https://www.reprintbrighton.com/facts/paper-weight-guide/>
- <https://www.fastbookprinting.com/useful-info-tools/weight-calculator/>

## TASK 3 – Transfer the Data

### AT A GLANCE

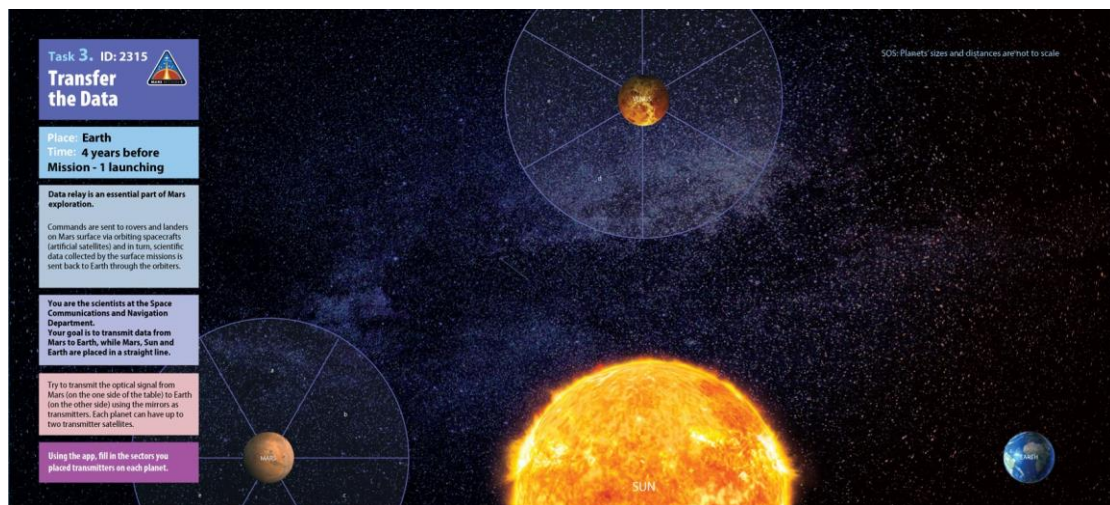
Date	Place	Group's role	Challenge	Task format / skills	Means/ Materials
4 years before Mission-1 launching	Earth	The scientists of the Space Communications and Navigation Department	Technical competence	- hands on - problem solving	3d objects

### OVERVIEW

Data needs to be constantly transmitted between Earth and Mars. In a simple, hands on simulation, the team has to "construct" a route through which an optical signal can be transferred from Mars (the one side of the table) to Earth (the other side), using mirrors as transmitters.

### SETTING

#### TABLE BOARD



**TASK ID**  
**2315**

#### MATERIALS

• Table board "TASK 3"
• Tablet C
• 3D models of Sun, Mars, Venus and Earth
• 4 mirrors on bases
• Laser source

*PDFs FOR PRINTING:*



- [Table board - Task 3](#)

*PREPARATION*

At the beginning of the experimentation phase, when the boards are placed on the table, the facilitator places the models of the planets at their spots and the mirrors on the board.

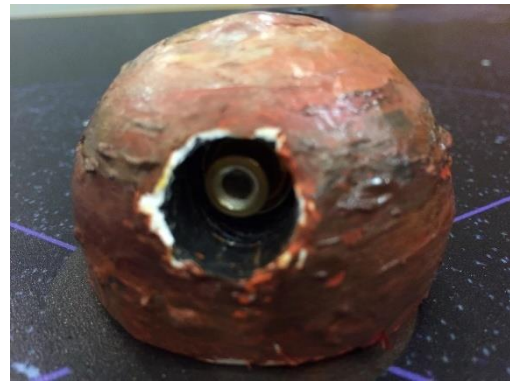
The 3D models of the Sun, Earth, Venus and Mars are constructed in order to fit in their spots, on the board.

The following table lists the specifications of the necessary objects (planet models, mirrors, laser box), along with suggestions on the materials and photos from NOESIS' version of the objects.

<p><b>Mars, Venus, Earth</b> The models of the planets are 3D solid objects. They are non-transparent, colored hemispheres, so light cannot pass through them. Diameter: 5,5 cm Suggested material: styrofoam</p> <p><b>Sun</b> The model of the Sun is a solid, non-transparent, colored quarter of a sphere, so light cannot pass through it. Diameter: 30,0 cm Suggested material: Styrofoam</p>	
<p><b>Mirrors on bases (4)</b></p> <p>Mirror's dimensions: 7,0 cm * 5,0 cm</p> <p>Base's dimensions: 7,0 cm * 7,0 cm * 3,0 cm Suggested material: wood</p>	

### **Laser**

The laser is attached inside planet's Mars model.



## **EXPERIMENTATION**

### *DURATION*

10 minutes

### *DESCRIPTION*

Through a hands-on procedure, the students simulate the process of data relay, working on the table board with 3D objects. They use the mirrors as orbiters and they try to transmit an optical signal from Mars to Earth, while Mars, Sun and Earth are placed in a straight line on the table.

Each planet is a solid, non-transparent 3D object (semi-spherical) that doesn't allow the light to pass through it, acting as a physical obstacle for the laser beam. The 6 mirrors can be placed in the drawn orbit zone of each planet. Orbit zones are divided to six sectors (named from a to f). Up to 2 mirrors can be placed in each orbit zone aiming to direct the light on the Earth's surface.

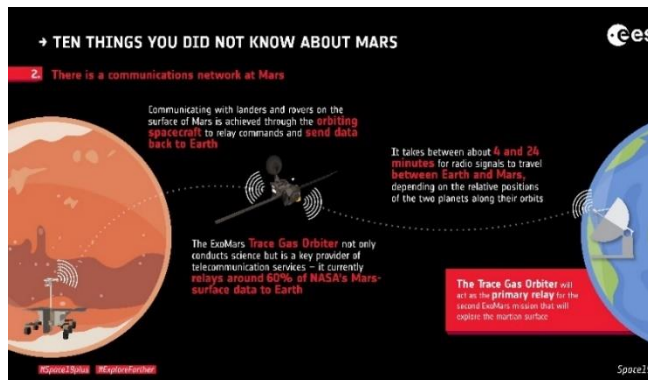
The team fills in the app, the sectors in each planet, where the mirrors are placed.

## **REFLECTION**

At the end of the task, each group has made it to transfer the laser beam from Mars to Earth's surface, or not! The "routes" that are constructed with the mirrors by each group, may differ, in the number of the mirrors that have been used and in the sectors in which they have been placed in the orbit zones as well.

Data relay is an essential part of Mars exploration, with commands sent to rovers and landers on the surface via orbiting spacecraft, and in turn, scientific data collected by the surface missions is sent back to Earth through the orbiter. It takes between about 4 and 24 minutes for radio signals to travel between Earth and Mars, depending on the relative positions of the two planets along their orbits.





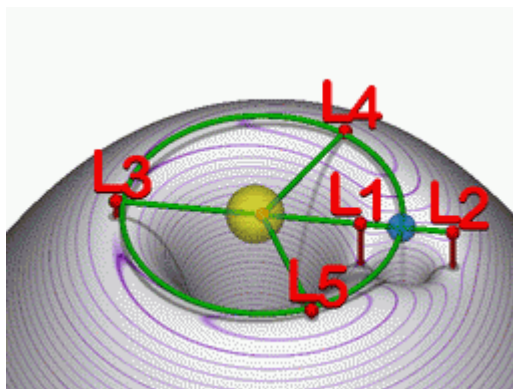
Data relay between Mars and Earth

[https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/Exploration/ExoMars/Highlights/Ten\\_things\\_about\\_Mars](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/Highlights/Ten_things_about_Mars)

In this hands-on simulation the laser beam represents the radio signals by which the data are transferred between Earth and Mars. The sizes of the planets and their distances are not to scale. The mirrors represent the orbiters and for reasons of simplification, they can be placed around Venus and Mars, in points (within permissible limits), which ensure the transmission of the visual signal. In real life, the orbiters are placed on specific points, namely Lagrange points.

#### FURTHERSCIENTIFICINFORMATION

Lagrange points are positions in space where objects sent there tend to stay put. At Lagrange points, the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them. These points in space can be used by spacecraft to reduce fuel consumption needed to remain in position.



Visualisation of the relationship between the Lagrangian points (red) of a planet (blue) orbiting a star (yellow) anticlockwise, and the effective potential in the plane containing the orbit (grey rubber-sheet model with purple contours of equal potential).

[Click for animation.](#)

[https://en.wikipedia.org/wiki/Lagrange\\_point](https://en.wikipedia.org/wiki/Lagrange_point)

For each given combination of co-orbiting planetary bodies there are five Lagrange points L1 to L5 for the Sun–Earth system, and in a similar way there are five different Lagrange points for the Earth–Moon system. Several planets have trojan satellites near their L4 and L5 points with respect to the Sun. Jupiter has more than a million of these trojans. Artificial satellites have been placed in orbits near to L1 and L2 with respect to the Sun and Earth, and with respect to the Earth and the Moon. The Lagrange points have been proposed for uses in space exploration.

## RECOURCES

- [https://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/Exploration/ExoMars/Highlights/Ten\\_things\\_about\\_Mars](https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/Highlights/Ten_things_about_Mars)
- [https://en.wikipedia.org/wiki/Solar\\_conjunction](https://en.wikipedia.org/wiki/Solar_conjunction)
- <https://mars.nasa.gov/all-about-mars/night-sky/solar-conjunction/>
- <https://mars.nasa.gov/resources/20122/mars-in-a-minute-what-happens-when-the-sun-blocks-our-signal/>
- [https://en.wikipedia.org/wiki/Lagrangian\\_point](https://en.wikipedia.org/wiki/Lagrangian_point)
- <https://solarsystem.nasa.gov/resources/754/what-is-a-lagrange-point/>
- <https://upload.wikimedia.org/wikipedia/commons/b/bf/Lagrangianpointsanimated.gif>
- <https://www.jpl.nasa.gov/news/news.php?feature=7485>
- [https://en.wikipedia.org/wiki/Colonization\\_of\\_Mars](https://en.wikipedia.org/wiki/Colonization_of_Mars)
- [https://el.wikipedia.org/wiki/%CE%A3%CE%B7%CE%BC%CE%B5%CE%AF%CE%BF\\_%CE%9B%CE%B1%CE%B3%CE%BA%CF%81%CE%AC%CE%BD%CE%B6](https://el.wikipedia.org/wiki/%CE%A3%CE%B7%CE%BC%CE%B5%CE%AF%CE%BF_%CE%9B%CE%B1%CE%B3%CE%BA%CF%81%CE%AC%CE%BD%CE%B6)

## TASK 4 – Place the Colony

### AT A GLANCE

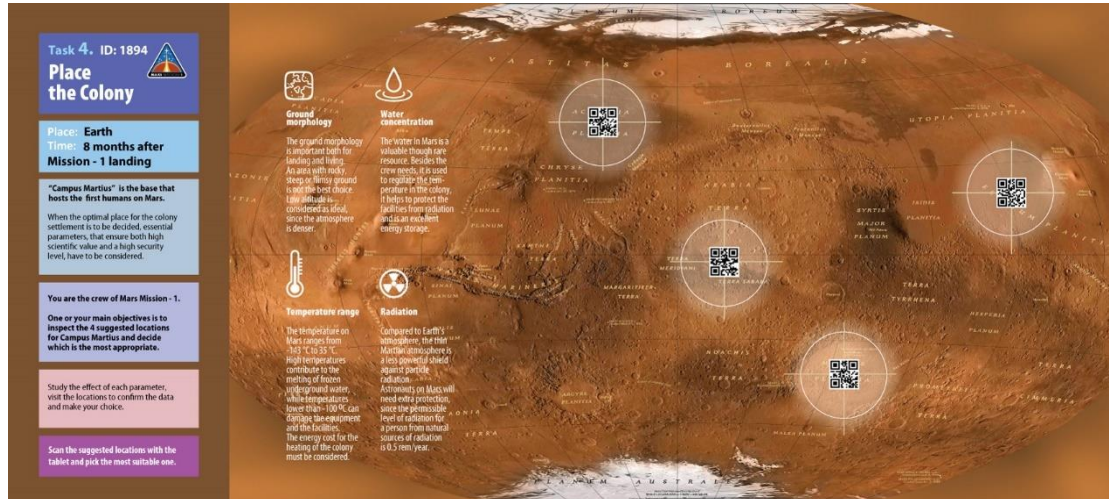
Date	Place	Group's role	Challenge	Task format / skills	Means/ Materials
8 months after Mission-1 landing	Mars	The crew of the Mission-1	Decision making	- information literacy - Critical thinking	Android application

### OVERVIEW

When the optimal setting for the first colony on Mars is to be decided, essential parameters, that ensure both high scientific value and a high security level, have to be considered. The team using a 2D-interactive Mars map has to study the effect of each parameter, visit the suggested settings to confirm the data and select the most appropriate setting.

### SETTING

#### TABLE BOARD



#### TASK ID

1894

#### MATERIALS

- Table board "TASK 4"
- Tablet D

#### PDFs FOR PRINTING:

- [Table board - Task 4](#)



## EXPERIMENTATION

### *DURATION*

10 minutes

### *DESCRIPTION*

The students stand in front of an 2D-interactive Mars map placed on the table. Their task is to select the most appropriate setting for the placement of “Campus Martius”, the first Martian colony, using the information that is written on the table and the data that they select using the android app.

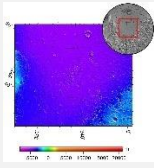
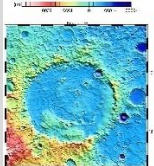
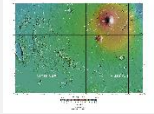
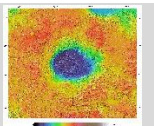
The possible areas, marked on the map, are the following 4:

- Acidalia Planitia
- Schiaparelli Crater
- Elysium Planum
- Hellas Plain

The parameters and their effects, that the students have to take into consideration, are the following 4 and they are written as information on the board:

- Ground morphology.  
(The ground morphology is important both for landing and living. An area with rocky, steep or flimsy ground is not the best choice. Low altitude is considered as ideal, since the atmosphere is denser).
- Water concentration.  
(The water In Mars is a valuable though rare resource. Besides the crew needs, it is used to regulate the temperature in the colony, it helps to protect the facilities from radiation and is an excellent energy storage).
- Temperature range.  
(The temperature on Mars ranges from  $-143^{\circ}\text{C}$  to  $35^{\circ}\text{C}$ . High temperatures contribute to the melting of frozen underground water, while temperatures lower than  $-100^{\circ}\text{C}$  can damage the equipment and the facilities. The energy cost for the heating of the colony must be considered).
- Radiation.  
(Compared to Earth’s atmosphere, the thin Martian atmosphere is a less powerful shield against particle radiation. Astronauts on Mars will need extra protection, since the permissible level of radiation for a person from natural sources of radiation is 0.5 rem/year).

The students scan with the tablet the 4 areas on the map and the data (photos and numbers) that refer to each one of the areas are revealed in the app, as shown in the table below.

Area/ parameter	Ground morphology	Water concentration	Temperature range	Radiation
Acidalia Planitia		3%	-40 °C to 17 °C	13 rem/year
Schiaparelli Crater		7%	-110 °C to 2 °C	18 rem/year
Elysium Planitia		6%	-80 °C to 6 °C	17 rem/year
Hellas Planitia		3%	-115 °C to -98°C	10 rem/year

The groups study all the information and make their case, as a real research team would have.

## REFLECTION

At the end of the task, each group ends up with a selected location on the map and there is a strong chance for the teams to pick a different location for different reasons. These choices will trigger a small debate about their suggestion. In this way, more ideas will be heard.

It is important to note that there is no right answer since scientists themselves have not definitely concluded yet. The most important part is arguing and the realization that there is not always an obvious choice, but that the final selection depends on a lot of parameters.

The 4 locations that were proposed in this task to place the colony, were selected using information from the 2019 article, titled: *GIS analysis of promising landing sites for manned flight to Mars*. The inhabitants of the Earth receive the necessary information about Mars by using probes, as an effective instrument for remote sensing. The authors of the article, analyzed the data that were selected using remote sensing devices and based on the set of 9 indicators for assessing the expedition landing, concluded that the most optimal place is the Acidalia Planitia. The results are presented in the Table below.

No	Indicator	Acidalia Planitia	Schiaparelli Crater	Elysium Planum	Hellas Plain
1	Relief (impact on landing difficulty)	2	1	0	-2
2	Gravity anomalies	2	0	-2	1

3	Magnetic field strength	1	2	0	0
4	Absorbed radiation	1	-1	-2	2
5	Rock composition	1	-1	0	2
6	The presence of volcanoes	-2	-2	2	-2
7	Daytime temperature	2	1	1	-2
8	Night temperature	1	-2	-2	-2
9	Water	0	2	2	0
	TOTAL	8	0	-1	-3

### FURTHER SCIENTIFIC INFORMATION

Landers and rovers on Mars take daily measurements of the local weather, while orbiters monitor changes in atmospheric conditions and the development of planet-wide dust storms. The ExoMars surface science platform will host a complete weather station, providing data of the ground and air temperature and on the pressure, humidity, wind, radiation and dust at the landing site.

Critical resources like water is essential to understand the potential for life on others worlds. Water-ice is present at Mars's poles. Geological evidence of a system of ancient interconnected lakes that once lay deep beneath the planet's surface. River networks show vast volumes of water once flowed across the surface. The ExoMars Trace Gas Orbiter is producing the best map of shallow sub-surface water-ice and water-rich minerals on Mars

The main concern in space is particle radiation. Energetic particles can be dangerous to humans because they pass right through the skin, depositing energy and damaging cells or DNA along the way. Earth's natural protections block all but the most energetic of these particles from reaching the surface. A huge magnetic bubble, called the magnetosphere, which deflects the vast majority of these particles, protects our planet.

Mars has no global magnetic field to deflect energetic particles, and its atmosphere is much thinner than Earth's, so they'll get only minimal protection even on the surface of Mars. Throughout the entire trip, astronauts must be protected from two sources of radiation.

The first comes from the sun, which regularly releases a steady stream of solar particles, as well as occasional larger bursts in the wake of giant explosions, such as solar flares and coronal mass ejections, on the sun. These energetic particles are almost all protons, and, though the sun releases an unfathomably large number of them, the proton energy is low enough that they can almost all be physically shielded by the structure of the spacecraft.

The second source of energetic particles is harder to shield. These particles come from galactic cosmic rays, often known as GCRs. They're particles accelerated to near the speed of light that shoot into our solar system from other stars in the Milky Way or even other galaxies. Like solar particles, galactic cosmic rays are mostly protons. However, some of them are heavier elements, ranging from helium up to the heaviest elements. These more energetic particles can knock apart atoms in the material they strike, such as in the astronaut, the metal walls of a spacecraft, habitat, or vehicle, causing sub-atomic particles to shower into the structure. This secondary radiation, as it is known, can reach a dangerous level.

## RECOURCES

- <https://mars.nasa.gov/>
- <https://www.wur.nl/en/newsarticle/The-ideal-settlement-site-on-Mars-hotspots-if-you-asked-a-crop.htm>
- <https://doi.org/10.1051/e3sconf/201913802004>
- (4)[http://www.esa.int/Science\\_Exploration/Human\\_and\\_Robotic\\_Exploration/The\\_radiation\\_showstopper\\_for\\_Mars\\_exploration](http://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/The_radiation_showstopper_for_Mars_exploration)
- (5)<https://www.nasa.gov/feature/goddard/real-martians-how-to-protect-astronauts-from-space-radiation-on-mars>
- [https://www.researchgate.net/publication/337958459\\_GIS\\_analysis\\_of\\_promising\\_landing\\_sites\\_for\\_manned\\_flight\\_to\\_Mars#pf5](https://www.researchgate.net/publication/337958459_GIS_analysis_of_promising_landing_sites_for_manned_flight_to_Mars#pf5)
- [https://en.wikipedia.org/wiki/Climate\\_of\\_Mars](https://en.wikipedia.org/wiki/Climate_of_Mars)
- <https://www.nasaspaceflight.com/2019/12/mars-colonization-new-water-map-hold-key-land/>
- <http://large.stanford.edu/courses/2017/ph240/black1/>
- <http://www.psrh.hawaii.edu/July12/water-inside-Mars.html>
- <https://www.wur.nl/en/newsarticle/The-ideal-settlement-site-on-Mars-hotspots-if-you-asked-a-crop.htm>

## TASK 5- Manage the Crisis

### AT A GLANCE

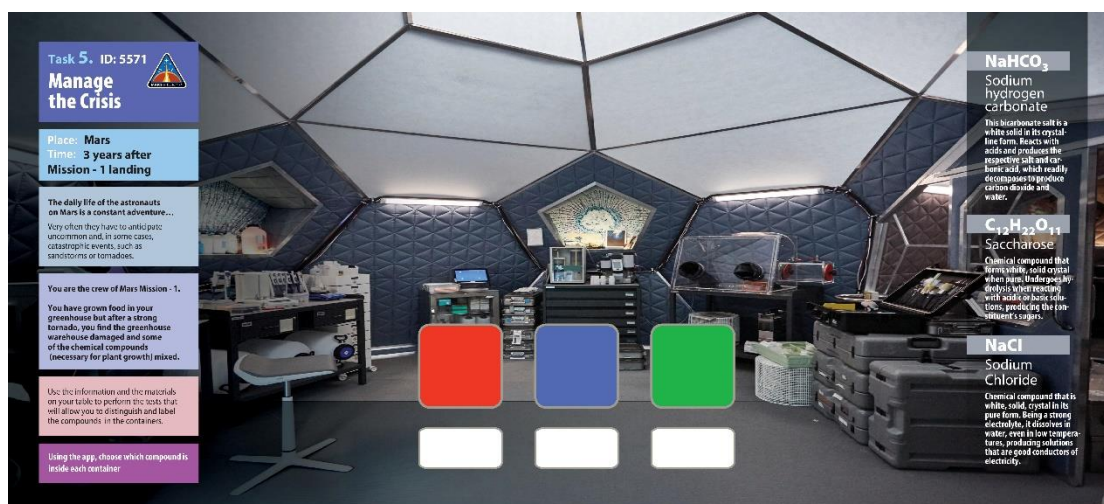
Date	Place	Group's role	Challenge	Task format / skills	Means/ Materials
3 years after Mission-1 landing	Mars	The crew of the Mission-1	Crisis management	- Hands on experiment - Problem solving	3d objects

### OVERVIEW

Daily life of astronauts on Mars is a constant adventure. Very often they have to anticipate uncommon and, in some cases, catastrophic events. The group has grown food in the greenhouse but after a strong tornado, they find the greenhouse warehouse damaged and some of the compounds (necessary for plant growth) mixed. Using information and materials available their goal is to perform tests that will allow them to distinguish and label the compounds.

### SETTING

#### TABLE BOARD



#### TASK ID

5571

#### MATERIALS


• Table board "TASK 5"
• Tablet E
• Instructions card
• Labels of the 3 compounds

• Blue container with $C_{12}H_{22}O_{11}$ (table sugar)
• Red container with $NaHCO_3$ (baking soda)
• Green container with $NaCl$ (table salt)
• Water bottle 1000ml with deionized water
• Flask with Dropper 250ml with vinegar
• Vinegar
• Simple electrical circuit: 3 wires, battery3V, led lamp, 2 leads (nails)
• 5 kits* with extra materials (one per group)

\*content of the kit:

• 3 beakers 100ml
• 3 Spoons
• Stirring rod

**Instructions**



Human colonization of Mars  
Challenges & Solutions

- 1.** In each beaker prepare an aqueous solution for each of the "unknown" compounds. (1 spoonful dissolved in 50ml of  $H_2O$  - water).
- 2.** Add  $CH_3COOH$  - vinegar to the solutions.
- 3.** Identify compound no. 1.
- 4.** Use the circuit to check the conductivity of the other two solutions. (immerse the electrodes to each beaker).
- 5.** Identify compound no. 2.

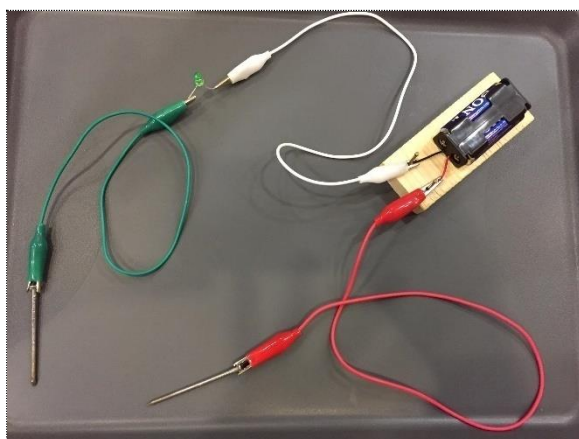
Instructions' card

**$NaHCO_3$**   
Sodium hydrogen carbonate

**$C_{12}H_{22}O_{11}$**   
Saccharose

**$NaCl$**   
Sodium Chloride

Compounds' labels



Simple series electrical circuit, consists of:

- 3 wires
- battery 3V
- led lamp
- 2 leads (nails)

### PREPARATION

Before the activity:

- The 3 white chemicals to be identified are placed in the respective containers, as follows:
  - Red container →  $\text{NaHCO}_3$  (baking soda)
  - Blue container →  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  (table sugar)
  - Green container →  $\text{NaCl}$  (table salt)
- The 5 kits are ready for the 5 groups.

When the board is placed on the table:

- The 3 containers, the deionized water, the Vinegar and the electrical circuit are on the table.
- The instruction card and the compounds' labels, are on the table.

During the experimentation phase:

- A new kit is placed on the table, each time a group moves to the table to complete the task.
- Each time a group completes the task and leaves the table, the facilitator cleans the table and replaces the kit for the next group.

PDFs FOR PRINTING:

- [Table board -Task 5](#)
- [Instructions' card](#)
- [Compounds' labels](#)

### EXPERIMENTATION

DURATION

10 minutes



## DESCRIPTION

The group is led by the task to use the printed information on the table, the instructions card and the equipment/materials on their kit, in order to perform simple chemistry experiments. The results of the experiments help the students to distinguish which of the three compounds is contained in each container.

The properties of the 3 white compounds, that are written on the board, are given below:

- $\text{NaHCO}_3$  (Sodium hydrogen carbonate) – baking soda.  
This bicarbonate salt is a white solid in its crystalline form. It reacts with acids and produces the respective salt and carbonic acid, which readily decomposes to produce carbon dioxide and water.
- $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  (Saccharose) – table sugar.  
A chemical compound that forms white, solid, crystal when pure. It undergoes hydrolysis when reacting with acidic or basic solutions, producing the constituent's sugars.
- $\text{NaCl}$  (Sodium Chloride) – table salt.  
A chemical compound that is white, solid, crystal in its pure form. Being a strong electrolyte, it dissolves in water, even in low temperatures, producing solutions that are good conductors of electricity.

## REFLECTION

At the end of the task, the groups have labeled the containers with the compounds either right, or wrong.

The facilitator, using input of the groups, indicates the right tests that allow to identify the compounds:

- By adding vinegar in each of the three solutions, only in one of them the production of carbon dioxide bubbles is observed. This happens due to the chemical reaction (neutralization) between  $\text{NaHCO}_3$  (baking soda) and acetic acid (vinegar).
- Dipping the two leads of the simple electrical circuit in each one of the solutions, the led lamp lights up. In one of them the light is a lot brighter. (If we look more closely we can observe bubbles on one lead and corrosion on the other). That solution contains  $\text{NaCl}$  (table salt). Salt is an electrolyte. By adding salt in the water, we increase the solution's electric conductivity.
- The compound that doesn't show any "reaction" in the tests (no bubbles, no light), is the  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  (table sugar).

## FURTHER SCIENTIFIC INFORMATION

It is already known from our pioneering astronauts that fresh flowers and gardens on the International Space Station create a beautiful atmosphere and let them take a little piece of Earth with them on their journeys. They're good for their psychological well-being on Earth and in space. They also are critical for keeping astronauts healthy on long-duration missions.



On the space station, astronauts receive regular shipments of a wide variety of freeze-dried and prepackaged meals to cover their dietary needs – resupply missions keep them freshly stocked. When crews venture further into space, traveling for months or years without resupply shipments, the vitamins in prepackaged form break down over time, which presents a problem for astronaut health.

NASA is looking at ways to provide astronauts with nutrients in a long-lasting, easily absorbed form—freshly grown fresh fruits and vegetables. The challenge is how to do that in a closed environment, without sunlight or Earth’s gravity.

While astronauts have successfully grown plants and vegetables aboard the International Space Station, NASA scientists at the Kennedy Space Center in Florida are collaborating with a university team to develop long-term methods that could help sustain pioneers working in deep space. The prototype involves an inflatable, deployable greenhouse to support plant and crop production for nutrition, air revitalization, water recycling and waste recycling. The process is called a bioregenerative life support system.

For the successful cultivation of plants in space, it is necessary to use fertilizers that will lead to their healthier growth. Fertilizers are generally divided into organic (containing carbon in their composition) and non-organic (do not contain carbon in their composition).

When a plant grows, it uses nine basic elements: hydrogen, oxygen, carbon, nitrogen, phosphorus, magnesium, potassium, calcium and sulfur. These elements are the basic nutrients for a plant. It also uses, in much smaller quantities, boron, chlorine, copper, manganese, zinc, iron and molybdenum. These are the secondary nutrients. From the above elements, carbon, hydrogen and oxygen are obtained from plants through the atmosphere: The plant absorbs water that has fallen to the ground as rain (source of hydrogen and oxygen) and traps carbon dioxide (carbon source) from the atmosphere. By the function of photosynthesis, it converts these components into carbohydrates (mainly glucose). The remaining elements are contained, in the form of compounds, in the soil.

## RECOURCES

- <https://www.nasa.gov/feature/lunar-martian-greenhouses-designed-to-mimic-those-on-earth>
- <https://www.nasa.gov/content/growing-plants-in-space>
- [https://en.wikipedia.org/wiki/Plants\\_in\\_space](https://en.wikipedia.org/wiki/Plants_in_space)
- [https://blogs.nasa.gov/ISS\\_Science\\_Blog/2013/09/12/sowing-the-seeds-for-space-based-agriculture-part-1/](https://blogs.nasa.gov/ISS_Science_Blog/2013/09/12/sowing-the-seeds-for-space-based-agriculture-part-1/)
- <https://blogs.nasa.gov/kennedy/2016/04/08/veg-03-plant-pillows-readied-at-kennedy-space-center-for-trip-to-space-station/>
- [https://www.nasa.gov/mission\\_pages/station/research/news/b4h-3rd/hh-plant-growth-in-iss-global-impacts](https://www.nasa.gov/mission_pages/station/research/news/b4h-3rd/hh-plant-growth-in-iss-global-impacts)
- <https://en.wikipedia.org/wiki/Fertilize>

## The android application

In order to perform the activity, an **activity's webpage**, an **android app** and a dedicated **admin page** have been developed.

The activity's webpage: <https://noesis.edu.gr/en/mars-mission1-activity> is the place, where all materials are available for downloading.

The Mars app is the guiding tool for the groups, during the experimentation phase.

In particular, the app:

- Guides the groups through the Tasks (each Task has a unique ID code), keeping track of the order they are performed and the time left for each one.
- Gives the information needed to complete each Task.
- Is used by the group to record the results of each Task.

The admin page: <https://noesis.edu.gr/mars/>

- Is used to initialize the game settings.
- Is used to create new games and manage them.
- Allows the summarizing of all groups' work, Task by Task, during the reflection phase.

In the following paragraphs, there is all the information and steps required to access the activity's webpage, to set up the admin page, to download, set up and use the Mars app and to play the game.

### 1. Access the activity's webpage and set up the admin page

**Step 1:** Submit your request sending an email at [futurespace@noesis.edu.gr](mailto:futurespace@noesis.edu.gr).

As the subject of the email use your organization's name and the activity's name: "Marsmission1". At the body of the email don't forget to introduce a contact person.

After submitting your request, you will receive an approval email with the password to enter the activity's webpage, and your account credentials for the admin page.

**Step 2:** Visit the page <https://noesis.edu.gr/mars/>.

- Click on the **Sign in** option from the home page navbar menu.



- Sign in using your credentials

**Sign In Here**
Sign Up

**Username**

**Password**

Forgot your password? [Click here](#)

☐ Remember me

**Sign In**


## 2. Set up the app

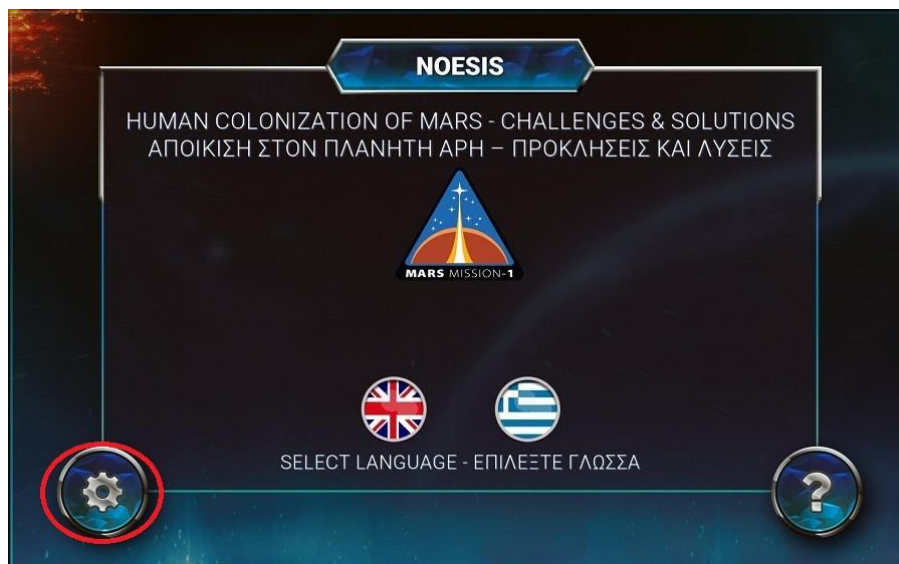
Mark the five tablets as A,B,C,D and E and follow the steps in all 5 tablets.

**Step 1:** Download the Mars.apk from the page: <https://noesis.edu.gr/mars-mission1-activity>

**Step 2:** Install the Mars app.

(Remember to enable the installation from external sources)

**Step 3:** Run the Mars app 



**Step 4:** Press the settings icon which is located on the bottom left and give the password “MARS2052” to enter the settings screen.

In the settings:

- As **server url** use: **https://noesis.edu.gr/mars**
- On the **username** and **password** fields use the credentials you received at the approval email, when your account was created.
- On **Select Group** and **Set Tasks Order** drop down menus: As each tablet (A-E) should be assigned to a group (from the available options A – E) and a unique Task order (which indicates the order by which each one of the 5 Tasks will be performed by each group) make the following settings:

For Tablet A: Select Group **A** and choose the Task Order **1→2→3→4→5**

For Tablet B: Select Group **B** and choose the Task Order **2→3→4→5→1**

For Tablet C: Select Group **C** and choose the Task Order **3→4→5→1→2**

For Tablet D: Select Group **D** and choose the Task Order **4→5→1→2→3**

For Tablet E: Select Group **E** and choose the Task Order **5→1→2→3→4**

- Tap on the **load setting from server** button.  
If your username and password are correct the tablet will load the settings from the server and you will see the values, showing up with green color. (In case you enter wrong password or username you will get an error message and the setting values will not show up. Try again).
- Tap on the Close button.

The tablets are properly set and you are ready to play the game.

### 3. Play the game

In order to implement the 90' activity in its completed form, a new game session should be created for every school group participates.

The instructions for the facilitator and for the teams are given below.

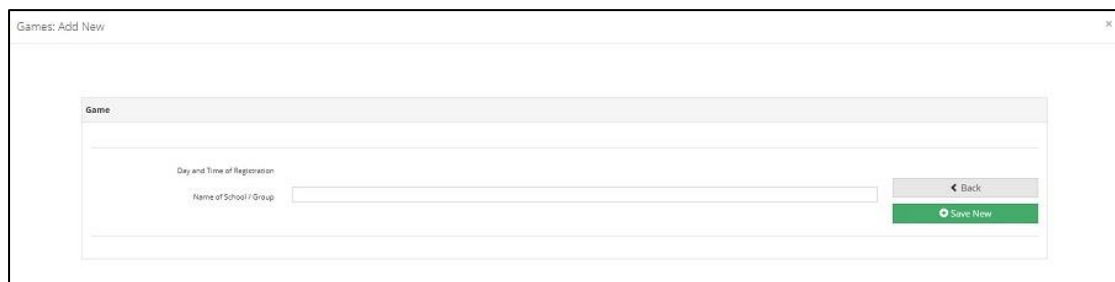
#### Instructions for the facilitator:

**Step 1:** Visit the admin page and sing in.

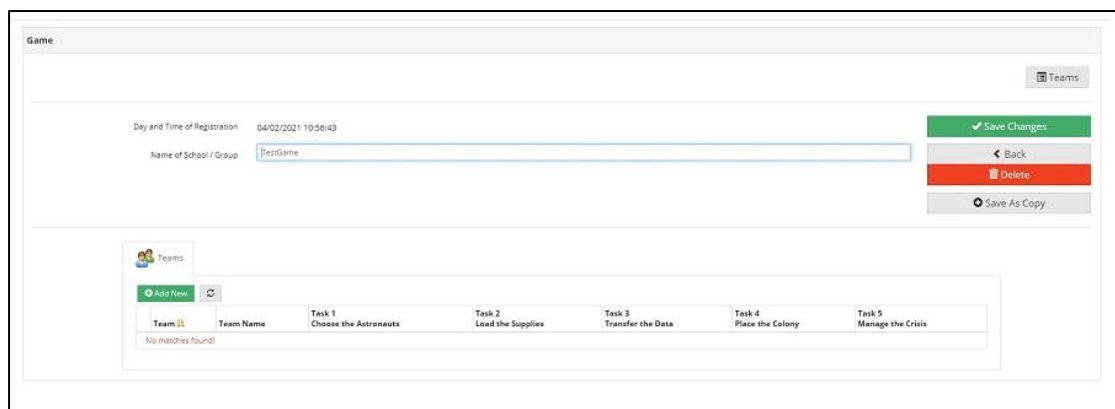
**Step 2:** Create a new game session, pressing the "+" icon on the game's toolbar.



**Step 3:** Fill in a name for the school group in the blank area and press the **save new** button.

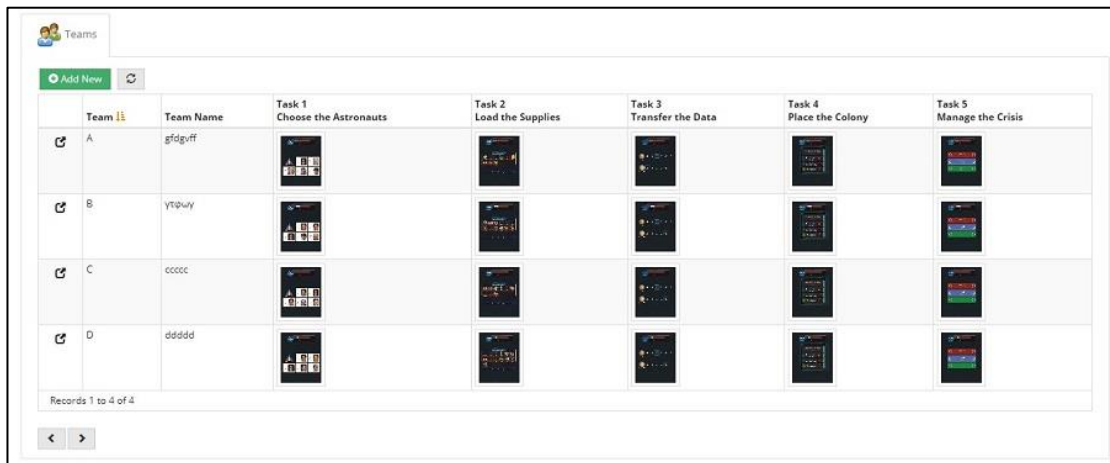


The "Teams" table with the five Tasks appear on the screen.



The game has been created and all actions made by the teams during the game, will appear on this table.

During the experimentation phase, once each Task is completed by any team, the answers/results appear at the teams tab. Using the "refresh" icon you can check the submitted results, while the game is still running.



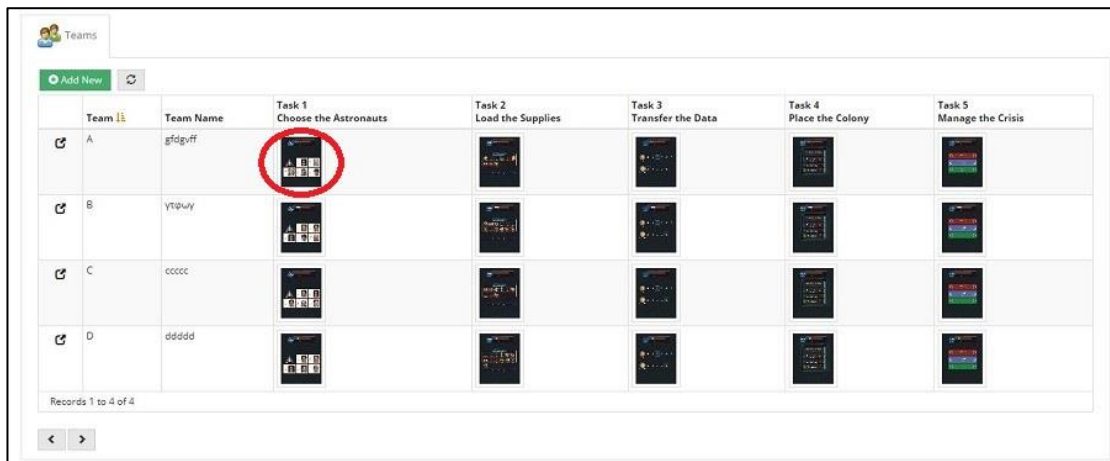
Team	Team Name	Task 1 Choose the Astronauts	Task 2 Load the Supplies	Task 3 Transfer the Data	Task 4 Place the Colony	Task 5 Manage the Crisis
A	gfdfvff					
B	ytqwyuy					
C	cccccc					
D	dddddd					

Records 1 to 4 of 4

< >

Browsing among the Tasks, the facilitator can view each team's work and answers/ results per Task.

For instance, pressing on any Task's image (e.g on Task's 1 image for the team A), the team's answer/result for this Task (Task 1) is loaded. Clicking on the **next** button (right arrow) also other teams' answers/results for the same Task are appearing as well.



Team	Team Name	Task 1 Choose the Astronauts	Task 2 Load the Supplies	Task 3 Transfer the Data	Task 4 Place the Colony	Task 5 Manage the Crisis
A	gfdfvff					
B	ytqwyuy					
C	cccccc					
D	dddddd					

Records 1 to 4 of 4

< >

Browsing among teams, pressing the buttons shown below, the facilitator can view all Tasks' answers/results per team.

Teams						
Add New						
Team ID	Team Name	Task 1 Choose the Astronauts	Task 2 Load the Supplies	Task 3 Transfer the Data	Task 4 Place the Colony	Task 5 Manage the Crisis
A	gfdgrrf					
B	ytqwy					
C	cccc					
D	dddd					

Records 1 to 4 of 4

### Instructions for the teams:

- You will be given a tablet.  
(Team A holds tablet A and starts from the table A. Team B holds tablet B and starts from the table B and so on...)
- Open the **Mars** app.
- Choose the language.



- Choose a name for the team and press **GO**.

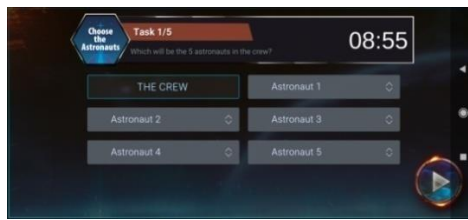


- For each Task to start, type the Task's ID (it is written on the top left corner on the table-board) and press **Enter**.



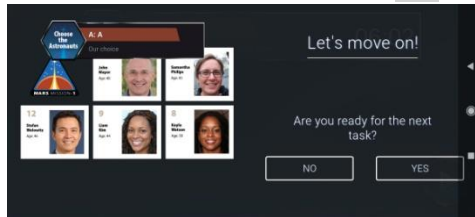
- You have 9 minutes to complete the Task.





When ready, upload your answer pressing the “play” sign.

- Move to the next Task taping on **YES**.



## 4.2. "Wandering in the Universe" - Interactive planetarium activity

### 4.2.1. Introduction

Planetariums are specially-designed theaters with a domed ceiling that is able to project a realistic image of the night sky indoors. They are unique, inspirational places, that immerse visitors in a 2D or 3D environment that evokes realism. The sight of stars appearing in a dark sky, often being lost to light pollution in many areas nowadays, immediately captures attention and evokes awe. Digital planetariums, zooming from Earth to the Moon, other planets, stars, and distant galaxies, enable the visitor to see objects from different perspectives and offer them the opportunity to understand our true place in space.

Planetariums have a long history in supporting the astronomy interest both for the public in general, but also in supporting the education of children and students. Initially used to educate about stars, planets, and constellations, planetariums today are considered as unique immersive facilities often used to support Science, Technology, Engineering, and Mathematics (STEM) learning and to cross learning disciplines into art, culture, and history.

A planetarium visit proved to be a powerful and memorable experience that can encourage learning. Immersion sparks interest and engagement and the whole experience triggers curiosity in ways that normal school classes would difficult achieve. As planetariums aim not only to educate but also to enlighten, entertain and inspire, they operate in all three realms of learning: in the thought-processing of the cognitive realm; in the psychomotor area as they offer more interactive experiences involving physical action; and in the affective realm, the realm of feelings, as they encourage greater appreciation and enjoyment of the sky and try to cultivate a sense of the adventure of science. When planetarium experience is combined with lessons and activities in classrooms before and after the visit, the effects on student's learning seem to be even greater.

The activity "Wandering in the Universe" developed by NOESIS for the Space program for science centers and other informal organizations (SScP) in the context of FUTURE SPACE EU project. It is an interactive experience, which uses the immersive environment of the planetarium, combined with ICT tools, to offer a unique journey from the Earth to the so far observable Universe.

The activity targets secondary school students and adults and lasts 45 minutes. In PART A, an interactive presentation, through a live quiz motivates visitors to answer questions using their mobile phones and to find the answers via short explanatory immersive dome videos. In PART B, the activity is completed with the projection of an 8min movie that travels visitors from Earth to the edge of the so far observable Universe.

The following paragraph 4.2.2. gives a complete and detailed description of the activity and acts as an implementation guide for those organizations, which would like to adopt and perform the activity on their premises. Its first part, namely the "Activity's profile", is the part that briefly describes the activity (content, aims, setting, time scale) and gives guidelines for those who will run it. The next part presents the elements of which the activity is comprised (interactive presentation, short full-dome explanatory videos, 8min movie). The

last part, namely "Materials for the Activity" is an index of the digital materials that have to be downloaded and prepared in order for the activity to be implemented.

### **Resources**

-International Planetarium Society Official Statement on the Role of Planetariums in Education, [www.ips-planetarium.org/page/edstatement](http://www.ips-planetarium.org/page/edstatement)

- The value of education in the planetarium: a white paper

<https://www.ips-planetarium.org/page/planetariumeducationvalue>

- **Manning, J. G. (1995).** "The Role of Planetariums in Astronomy Education." An Address to the Education Symposium of the Astronomical Society of the Pacific, June 24, 1995. Retrieved from [www.ips-planetarium.org/page/a\\_manning1995](http://www.ips-planetarium.org/page/a_manning1995).

- **Yu, K.D. (2005).** "Digital Fulldomes: The Future of Virtual Astronomy Education." *Planetarian* 34(3). pp. 6-11. <https://cdn.ymaws.com/www.ips-planetarium.org/resource/resmgr/planetarian/v34-3.pdf>

#### 4.2.2. The Activity

## Wandering in the Universe

An interactive  
planetarium presentation  
revealing the beauty  
of the so far  
observable Universe

Developed by   
during  
the Erasmus+ EU project  
"Future Space"  
(2019-2021)

## Activity's profile

### AT A GLANCE

Title	Wandering in the Universe
Age Group	Secondary school students/ adult visitors
Format	Live Interactive presentation inside the dome
Duration	45- 60 minutes
N. participants	Depends on seats available
N. facilitators	1

### OVERVIEW

The observable universe is the spherical region of the universe comprising all matter that can be observed from Earth or its space-based telescopes and exploratory probes at the present time. This is the subject of the activity takes place inside the planetarium dome.

Visitors, participating in an interactive presentation with their mobile phones are motivated through a live quiz to answer questions and to find out the answers via short explanatory dome videos. A short movie following, travels visitors through an immersive journey from our planet to the edge of the so far observable Universe and back to Earth.

### AIMS

- Helps students/visitors experience the awesome scale of the observable Universe.
- Offers students/visitors the chance to acquire knowledge on basic astronomy topics, through the entertaining experience of taking part in an online quiz inside a planetarium dome.

### MATERIALS AND SETTING

The activity comprises of a 2D interactive presentation, six short full-dome explanatory videos and an 8min planetarium movie. It is designed to take place inside a digital planetarium for a group of students/visitors participating with their mobile phones.

However, if all requirements are not met, making small or bigger adjustments, the interactive activity can be implemented inside a properly equipped room, instead of a digital planetarium, using the flat versions of the short explanatory videos. Similarly, the 8min movie can be projected as VR material for VR head-sets, using the VR version of the movie, which is also provided as an alternative choice.

## TIME SCALE

- Introduction – 2 min  
Welcome
- Part A – 30 min  
Implementation of the interactive presentation (live quiz and short full dome explanatory videos).
- Part B – 10 min  
Projection of the 8min planetarium movie.
- Closure – 2min

## FACILITATION

The activity is presented by a facilitator, who is in constant cooperation with the planetarium operator. The role of the facilitator is to guide the students/visitors through the whole activity, giving information and instructions when needed, keeping the timeline and coordinating the interaction presentation with the quiz.

A good communication between the facilitator and the planetarium operator is required during the whole activity. Especially during Part A, when the interactive presentation, that includes the quiz, appears as 2D projection on the dome, while the short explanatory videos following are projected as digital material on the planetarium dome.

In particular, the facilitator:

- Helps the group of students/visitors to enter planetarium and take their seats.
- Makes a short introduction about what is going to happen, starting with an interactive presentation with a live quiz and ending up with the projection of an 8min movie on the dome.
- Gives instructions and guides students/visitors to connect to the interactive presentation with their mobile phones.
- Starts the interactive presentation and runs the quiz, presenting the questions one by one, summarizing each time the results and moving after each explanatory video to the next question, till the end of the presentation.
- After the end of the presentation, informs students/visitors to relax in their seats and enjoy the short full-dome movie that follows.
- At the very end, thanks students/visitors for their participation and helps the group to leave the room.



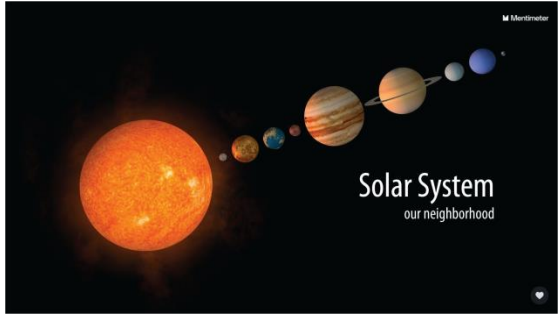
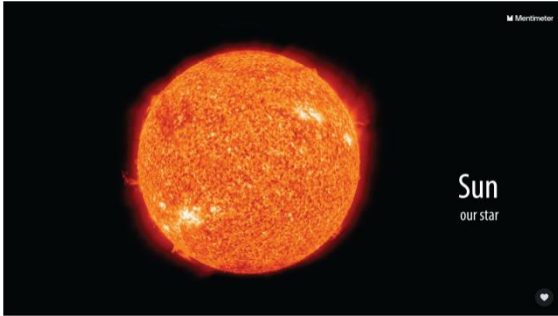

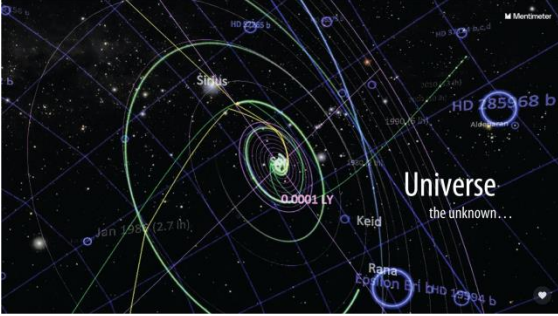
## Elements of the activity

### 1. The interactive presentation

The interactive presentation is a "six-stops iconic journey" starting from the Earth, continuing on the Moon, the Solar System, the Sun and the Milky Way and ending up in the whole Universe.

For each one of the stops, a characteristic image and one or two questions have been prepared.

The images are shown in the table below.

<p><b>Stop 1</b></p> 	<p><b>Stop 2</b></p> 
<p><b>Stop 3</b></p> 	<p><b>Stop 4</b></p> 
<p><b>Stop 5</b></p> 	<p><b>Stop 6</b></p> 



The suggested questions of the quiz per each stop, are summarized in the table below.

	Stop	Questions
1	<b>Earth - our home</b>	1. How old do you think Earth is?  2. What percentage of the Earth's surface is covered by water?
2	<b>Moon - our natural satellite</b>	1. How much do you think is the average distance between the Earth and the Moon?  2. What is the approximate duration between two successive "Full Moons"?
3	<b>Solar System - our neighborhood</b>	1. Which planet is most likely to be visited by humans in the near future?  2. Mar's atmosphere compared to Earth's atmosphere is ...
4	<b>Sun - our star</b>	1. How long does it take for light to reach the Earth from the Sun?  2. What is the energy source of the Sun?
5	<b>Milky Way - our galaxy</b>	1. What do you think is at the center of our Galaxy?
6	<b>Universe - ...the unknown</b>	1. What is the most accepted cosmological theory for the creation of the Universe?

The interactive presentation appears as a 2D projection on the planetarium dome and the visitors/students connect via their mobile phones. The questions of the quiz are appearing both on the dome and on the screens of the connected mobiles phones as well.

The questions addressed to the students/visitors, challenge them to give their answers making predictions and estimations, based on their existing knowledge and their critical thinking. Some of them are multiple choice questions, some are open questions. The students/visitors, using their mobile phones, answer the questions and their answers are appearing on the dome, in real time, as part of the presentation.

The quiz is not competitive and its aim is not to find the ones who gave the right answers or the ones who are the faster. That's why the right answer for each question is not given as an immediate feedback, but through the content of the following corresponded short explanatory video presented on the dome.

The software used to create the interactive presentation, is the free version of the *Mentimeter Interactive presentation software*. However, another similar software could be used to prepare the same or another version of the presentation, with different questions as well.

Table 1 and Table 4, in the last part of the document, summarizes the files of the images used and print screens of the whole presentation.

## **2. The short full-dome explanatory videos**

For each stop/topic of the interactive presentation, a short full-dome explanatory video (0,5 - 2,5min) has been developed.

The Uniview software for digital planetariums was mainly used to create the six videos, but some free full-dome scenes by ESO have been included in the final montage, as well.

During the interactive presentation, the short full-dome videos are projected on the planetarium dome, one by one, after participant's answer to the corresponded questions. The content of each video (visualization and narration) gives interesting information on the topic and of course the answer to the respective questions.

The short explanatory videos are available in flat versions as well. Using the flat versions, the interactive activity can be implemented inside a properly equipped room instead of the dome of a digital planetarium.

Table 2, in the last part of the document, is an index of all the files available.

## **3. The 8min planetarium movie**

An 8min full-dome production with English narration has been developed by NOESIS, using the Uniview software for digital planetariums and it is based on the idea of the AMNH production "The Known Universe".

During a journey that compresses almost 14 billion years into 8 minutes and starting from the surface of the Earth we travel through the solar system and the Milky Way stars to the realm of the galaxies and across to the edge of the observable Universe, and then back to our planet, seeing how the known Universe mapped by astronomical research looks like.

The movie is projected in the planetarium dome, right after the end of the interactive presentation, helping students/visitors realize the awesome scale of the known universe and completing the whole experience.

The 8min movie is available in dome version for digital planetariums, and in VR and flat versions as well. Using the VR version, the movie can be projected as VR material in VR head-sets, simulating the immersive experience of a planetarium. The flat version can be used as video material for any flat screen.

Table 3, in the last part of the document, is an index of all the files available.

## Materials for the Activity

All the materials that have been developed and are necessary for the adoption and implementation of the activity are summarized in the following tables.

The files are available for downloading from the activity's webpage: <https://www.noesis.edu.gr/en/eu-programs/wandering-in-the-universe/>.

To gain access to the activity's webpage, follow the next steps:

**Step 1:** Submit your request sending an email at [futurespace@noesis.edu.gr](mailto:futurespace@noesis.edu.gr).

As the subject of the email use your organization's name and the activity's name: "Wandering in the Universe". At the body of the email don't forget to introduce a contact person.

After submitting your request, you will receive an approval email with a password to enter the activity's website, where all materials needed to implement the activity are available.

**Step 2:** Visit the activity's webpage and enter the password.

**Step 3:** Download the files.

**Table 1. Files for the interactive presentation**

	Stop	Image files (jpg)	Print screens (pdf)
1	Earth	1_EARTH_image	Wandering in the Universe_ presentation_ptscr
2	Moon	2_MOON_image	
3	Solar System	3_SOLAR SYSTEM_image	
4	Sun	4_SUN_image	
5	Milky Way	5_MILKY WAY_image	
6	Universe	6_UNIVERSE_image	

**Table 2. Files for the short full-dome explanatory videos**

	Stop	Video files - Flat versions (mp4)	Video files -dome versions (jpg)	Audio files (wav)	Narration (pdf)
1	Earth	1_EARTH_flat version (1'16'')	1_EARTH_dome version	1_EARTH_audio_background 1_EARTH_audio_mixed 1_EARTH_audio_narration	Explanatory videos_ENG narration
2	Moon	2_MOON_flat version (1'49'')	2_MOON_dome version	2_MOON_audio_background 2_MOON_audio_mixed 2_MOON_audio_narration	

<b>3</b>	<b>Solar System</b>	3_SOLAR SYSTEM_flat version (2'31'')	3_SOLAR SYSTEM_dome version	3_SOLAR SYSTEM_audio_background 3_SOLAR SYSTEM_audio_mixed 3_SOLAR SYSTEM_audio_narration	
<b>4</b>	<b>Sun</b>	4_SUN_flat version (0'50'')	4_SUN_dome version	4_SUN_audio_background 4_SUN_audio_mixed 4_SUN_audio_narration	
<b>5</b>	<b>Milky Way</b>	5_MILKY WAY_flat version (2'20'')	5_MILKY WAY_dome version	5_MILKY WAY_audio_background 5_MILKY WAY_audio_mixed 5_MILKY WAY_audio_narration	
<b>6</b>	<b>Universe</b>	6_UNIVERSE_flat version (1'41'')	6_UNIVERSE_dome version	6_UNIVERSE_audio_background 6_UNIVERSE_audio_mixed 6_UNIVERSE_audio_narration	

**Table 3. Files for the short planetarium movie**

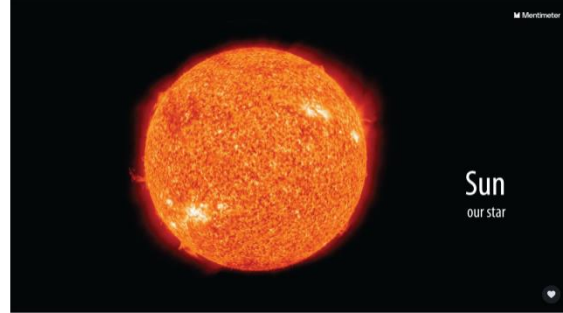
	<b>Video files - Flat version (mp4)</b>	<b>Video files - dome version (jpg)</b>	<b>Video files - VR version (mp4)</b>	<b>Audio files (wav)</b>	<b>Narration file (pdf)</b>
<b>Shot planetarium movie</b>	PLANETARIUM MOVIE_flat version	PLANETARIUM MOVIE_dome version	PLANETARIUM MOVIE_VR version	PLANETARIUM MOVIE_audio_background  PLANETARIUM MOVIE_audio_mixed  PLANETARIUM MOVIE_audio_narration	PLANETARIUM MOVIE_ENG narration

**Table 4. Print screens of the interactive presentation (mentimeter software)**

<p>Intro</p> <p>Go to <a href="http://www.menti.com">www.menti.com</a> and use the code 2428 6971</p> <p>Join us in a journey among the stars...</p> <ul style="list-style-type: none"> <li>• Use your mobile phone</li> <li>• Go to <a href="http://www.menti.com">www.menti.com</a>. Use the code given above</li> <li>• Type your name</li> <li>• Answer the questions</li> <li>• Enjoy the explanatory videos in the dome!</li> </ul>	<p>Stop 1</p> <p>Earth our home</p>
<p>Q 1</p> <p>How old do you think Earth is?</p> <p>Approx 4,5 million years old (Incorrect)</p> <p>Approx 450 million years old (Incorrect)</p> <p>Approx 4,5 billion years old (Correct)</p>	<p>Stop 2</p> <p>Moon our natural satellite</p>
<p>Q2</p> <p>What is the approximate duration between two successive "Full Moons"?</p> <p>Five</p> <p>The correct answer is: Approx 29,5 days</p>	<p>Stop 3</p> <p>Solar System our neighborhood</p>
<p>Q3</p>	<p>Stop 4</p>

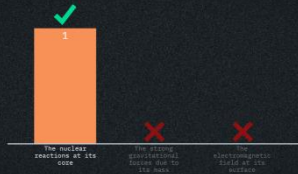
Which planet is most likely to be visited by man in the near future?

moon  
earth  
mars  
htg  
fiv



Q 4

What is the energy source of the Sun?



Stop 5



Q 5

What do you think is at the center of our Galaxy?

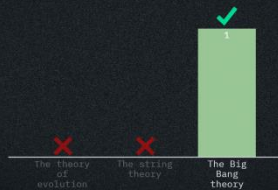


Stop 6



Q7

What is the most accepted cosmological theory for the creation of the Universe?



Closure

Is it something you would like to ask me?



No questions from the audience!

Incoming questions will show up here so that you can answer them one by one.