Austrian
Research Promotion Agency

# → SUMMER SCHOOL ALPBACH 2018

## Sample return from small solar system bodies

July 17–26, Alpbach/Tyrol – Austria

Details and further information: **www.summerschoolalpbach.at**


INTERNATIONAL SPACE SCIENCE INSTITUTE

AUSTROSPACE

# SAMPLE RETURN FROM SMALL SOLAR SYSTEM BODIES

The purpose of the Summer School is to foster the practical application of knowledge derived from lectures, to develop organisational and team-work skills and to encourage creativity. The teams themselves are responsible for the selection of the subject of the project and for the team structure and working methods.

## ALPBACH STUDENTS WILL BE REQUESTED TO:

- define the requirements that a space mission must fulfil to meet the scientific objectives identified as the mission goals
- design a space mission: spacecraft, payload, mission (launch vehicle, orbits) and operations including observation strategies
- prepare a written 10 page report of the above tasks
- prepare and present a 1 hour oral presentation to an expert review panel

# The Workshops and Student Project Teams:

Beyond the Sun, its eight planets, and their larger moons, the solar system is home to a myriad of other, smaller bodies, including dwarf planets, asteroids, trojans, centaurs, and comets, all the way down to interplanetary dust particles. The size and spatial distributions of these families, along with their orbital properties, composition, and internal structure play a key role in our understanding of the formation and evolution of the solar system. Collisions between some of these objects and the larger planets and moons have likely played a part in delivering volatiles and organics to them, and in their geological and biological evolution. A major collision may yet cause the extinction of humankind in case of an event similar to that at the end of the Cretaceous which brought about the demise of the dinosaurs.

The majority of the roughly 800,000 small solar system bodies known today are confined to the asteroid belt between Mars and Jupiter. But others are found closer to Earth, in Earth-crossing orbits, or in gravitationally-favourable locations such as the trojans located at Lagrange points associated with various planets. It is also thought that some of the more irregular moons in the solar system, including Phobos and Deimos around Mars, may be captured asteroids. And recent discoveries even suggest that we may occasionally be visited by asteroid-like objects coming in from interstellar space. Conversely, while the number of comets known today totals just a few thousand, they originate in two main reservoirs containing up to a trillion such objects, namely the Kuiper Belt in the ecliptic beyond Neptune and the Oort Cloud, uniformly distributed around the solar system at large distances, perhaps stretching halfway to our nearest stellar neighbours. ‘Dead comets’ as well as active asteroids may also be found in the asteroid belt.

Remote telescopic observations can reveal much about these various families of objects via imaging and spectroscopic surveys, while meteorites provide physical samples that have fallen through the Earth’s atmosphere, whether primordial chondritic material or more processed achondritic and metallic objects as fragments of shattered asteroids.

But there is no substitute for studying the solar system’s small bodies directly in situ with spacecraft and, ideally, returning samples to earth. The latter would enable the most detailed possible analysis, providing a crucial link with remote spectroscopic observations and the compositions of meteorites in order to develop a much wider understanding of these small bodies, their properties, and what they can tell us about the evolution of the solar system. In addition, samples returned to earth can be analysed in the future with instrumentation not available today. This is illustrated by the detection of traces of water in samples from the moon in 2008, ~40 years after they were retrieved by the Apollo missions. Beyond these academic questions, there are also more practical issues related to the possible commercial exploitation of resources from asteroids and comets, and to potential approaches towards protecting the Earth from major extinction-level impact events in the future.

More than 50% of the time spent in Alpbach will be dedicated to the workshops. Four student teams will be set up to define the scientific objectives of a space mission and a preliminary end-to-end mission design including the spacecraft, scientific instruments, mission, and science operations capable of meeting the stated objectives. During these workshops, each of the four teams of about 15 students will define, study and design a scientific satellite mission using imaginative concepts.

The results of the projects will be delivered as short “mission studies” to be presented by each team during the final workshop day to an expert review panel and all other teams, tutors and lecturers .

Four student teams will be set up. The teams will be supported by tutors who are experts in the scientific aspects of the summer school topic and in space mission design. Each team has two tutors, one covering the scientific aspects and one covering the engineering aspects. In addition roving tutors will provide advice on scientific, engineering and programmatic aspects to all teams. The Head Tutor will coordinate the support provided during the Workshops.

The teams select a mission concept within the topic of the Summer School based on the information provided in the lectures and their own knowledge of the topic. They then define the scientific objectives of their proposed space mission and provide a preliminary end-to-end mission concept including launcher, spacecraft, scientific instruments as well as mission and science operations that will meet their stated mission objectives.

By the end of the workshop, the teams will have considered not only the scientific instrumentation, which can meet the chosen scientific requirements, but also the mission design (launch, transfer and orbit), the spacecraft design with all required subsystems, the ground segment, development schedule, risk and rough-order-of-magnitude mission cost.

The lectures present the current knowledge and gaps in our understanding to enable the students to select and formulate objectives for new space missions. The offered lectures will cover existing and planned space missions, space mission design, and the principles of instrumentation for the required observations, including remote observations/measurements. The lectures will provide the students with the scientific and technical background needed for defining and elaborating innovative asteroid return space missions.

Plentiful of scientific and background material and the support and advice of tutors and lecturers will assist the students to carry out successfully their challenging task of designing their space missions.

Students will come to understand how the general constraints of operations in space, launcher capability and, as a driving constraint, the availability of the required technologies will impact on the achievement of these goals. Students will learn how to form an international team to tackle the many issues connected with space mission design, and how to achieve the goals by working together as a team under pressure. These requirements are exactly those that arise in all space missions, and so the workshop is a good preparation for a career in space.

In order to monitor the progress of the project, three reviews have been introduced in the programme of the Workshops. Each team will undergo the following reviews:

- Objectives and Requirements Review on July 20
- Preliminary Design Review on July 23
- Final Design Review on July 24

These reviews are separately to each team; lecturers and tutors will attend and contribute advice, although the teams themselves will need, in the first place, to learn from the reviews and improve on eventual shortcomings.

Each team will prepare and give a one-hour presentation on their completed mission concept and submit a written report. A jury of experts will evaluate the mission concepts according to the scientific case, the technical feasibility, the innovative nature and competitiveness, and quality of presentation. The jury will evaluate the proposed concepts in each of these four categories and will give feedback to the teams. Each mission concept will be published on the web following the Summer School.

## The Workshops:
## Organisation, support and practical advice

The four student teams, red, blue, green, and orange, will prepare its own structure and organisation. The election of spokespersons is essential, as they will be asked to report briefly on the team's progress on a daily basis. In most cases a small planning group of two or three people may also prove useful to determine and allocate tasks to the team. It is important that each member of the team contributes to the work according to his or her ability and enthusiasm, knowledge, training and experience. It is equally important that all team members should be kept informed of activities, undertaken by specific team members or small subgroups.

The student teams will be supported by **Team Tutors** who will be dedicated to the team and provide expert advice on the project. **Roving Tutors**, who will not be attached to a particular team, will provide help and advice to the student teams on general aspects of mission design. A **Head Tutor** will coordinate the support provided to the students during the workshops.

Many of the lecturers will remain in Alpbach for the duration of the school and all will be available to help students with advice on relevant aspects of their mission. In addition, any tutor or lecturer is available to help any team, in his or her area of expertise.

Access to the internet will be possible during the Summer School, either through fixed laptops allocated to each team, or through personal laptops using wireless access. Supporting material (books, reports, internet address lists, dedicated server with supporting material) will be centrally available for the use by the students.

Joint evening dinners will be organised at the Fichtensaal of the Hotel Böglerhof for the entire Summer School team including lecturers, tutors, students and accompanying persons to provide a good atmosphere for informal discussions.

The workshop is a unique opportunity for the Alpbach students to explore new objectives and mission concepts in a realistic context and with the support of professional space scientists and space engineers. Teams are therefore encouraged to be as innovative and visionary as possible; of course they have to be able to justify the scientific objectives and requirements, and they also have to show their understanding of questions related to the technical and programmatic feasibility of the chosen mission. To achieve the expected standard of mission design, the teams collectively, and the students individually should make full use of the resources of the Alpbach Summer School, lecturers, and tutors and, in a demonstration of cooperative teamwork, equal share of each other's' experiences and knowledge.

Since the time available for the projects is limited, students should:

- Elect the team spokesman or spokeswoman and establish the team organisation, latest on day 2 (Wednesday, July 18).
- Establish the project essentials (scientific objective, target object, mission scope), as soon as possible, latest on day 4 to prepare the Objectives and Requirements Review (scheduled for Friday July 20)
- Plan the work sensibly, identifying which decisions need to be taken early and the various tasks to be done and distributed within the team
- Identify as early as possible the main questions and problem areas related to the selected mission concept and start gathering information, solutions from the tutors, lecturers, the internet and books.
- Iterate frequently within the whole team, so that completion of tasks can be monitored, progress and status reviewed, unproductive paths abandoned and that every team member can contribute effectively to the overall goals.
- Prepare for the Preliminary and Final Design Reviews (Monday and Tuesday, 23 and 24 of July, respectively) and use these as milestones in the scheduling of all the tasks
- Collaborate within the team; let (and make sure) that each team member contributes; once decisions are taken get behind the chosen course of action, even if it was not your choice
- Use all the resources of the Summer School; ask tutors and lecturers for advice and help — it is what they are there for
- Remember that the report and presentation take time to prepare, start early on the organisation of this part of the activity, preferably at the start of the second week of the Summer School.

# Role of students, tasks and goals

- **Plan the work sensibly**, identifying **decisions to be taken** and **tasks to be done**
- Identify as early as possible **main questions and problem areas** related to the selected mission concept and start gathering information, solutions from the tutors, lecturers, and the internet
- **Use all the resources** of the Summer School; ask tutors and lecturers for advice and help — it is what they are there for
- **Come to all lectures and listen carefully** – ask questions, ask for advice
- **Iterate frequently within the whole team**, so that completion of tasks can be monitored, progress and status reviewed, unproductive paths abandoned
- **Collaborate within the team**: let each member contribute; once decisions are taken get behind the chosen course of action, even if it was not your personal choice
- Remember that the **report and presentation take time to prepare**, start early on the organisation of this part of the activity, preferably at the start of the second week of the Summer School

# Evaluation Guidelines

The team projects will be evaluated by a Jury according to the following criteria:

## A. The science case for the mission

- The overall importance of the mission objectives in the scientific topic of the Summer School
- Statement of scientific requirements to meet the stated objectives
- How much the expected results from the proposed mission advance the field

## B. The technical case for the mission

- The suitability of the proposed payload to meet the mission objective(s) (matching of payload and instruments to the science requirements)
- The technical feasibility of the proposed payload, including accommodation and other spacecraft resource requirements such as mass, power and telemetry
- Presentation of the Technical Readiness Level(s) of the mission components and the identification of enabling technologies
- The technical feasibility of the whole mission concept, including launch and orbit requirements and launcher constraints
- The feasibility of the operational concept and its matching to the mission objectives

## C. The competitiveness of the mission

- How well the mission competes with, or complements other missions (approved or planned) and with remote observations/measurements (where relevant) in the scientific topic of the Summer School
- The value for money of the mission; the quality and breadth of the contribution compared with the expected cost category of the mission
- The identification of descoping options and their impacts on the scientific capability of the mission

## D. The Quality of

- The presentation of the Team
- The final written report
- The answers of the students to questions of the Jury