METEOR CAMERA KIT ACTIVITY

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This activity is meant to present the main stages involved in a meteor detection and the possible consequent meteorite recovery and analysis.

EDUCATIONAL CONTEXT

AGE

11-14 years old, but adaptable to other age groups

DURATION

4-6 hours, the activity is to be divided into multiple lessons

PREREQUISITES

- General knowledge of the Solar System
- Knowledge of angles

EDUCATIONAL OBJECTIVES

WHAT DO YOU AIM FOR YOUR STUDENTS TO LEARN THROUGH THIS ACTIVITY

COGNITIVE OBJECTIVES

- Principle of triangulation to compute the distance and position of an object
- Classification of celestial objects
- Use of widgets (apps) for the analysis of scientific data
- Identification of a meteorite compared to Earth rocks

AFFECTIVE OBJECTIVES

- Active participation

PSYCHOMOTOR OBJECTIVES

- Using a goniometer and a ruler
- Using a microscope
- Taking precise measurements

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CONNECTION TO THE CURRICULA

- The Earth and the Solar System
- Triangulation principle
- Types of angles and how to measure them

INTRODUCTION

(30 minutes - 1 hour)

The activity starts with a **general introduction** of the subject matter, i.e. asteroids, meteors, and meteorites.

In order to introduce this topic to the class, it is possible to start with a **brainstorming activity**, asking the students whether or not they have ever seen a shooting star.
'Have you ever seen a shooting star? Do you know what they are?'

The teacher can then guide a **group discussion** to sum up the main ideas and illustrate the **classification of** the following **celestial objects**:

- Comet
- Asteroid
- Meteoroid
- Meteor
- Meteor Shower
- Fireball
- Bolide
- Meteorite

Suggested tools and resources:

- *Live word cloud (e.g. https://www.slido.com/)*
- *NASA's 'Eyes on Asteroids' map: https://science.nasa.gov/asteroids-comets-meteors/*
- *AMS' 'Meteor Terminology' poster: https://www.amsmeteors.org/resources/posters/*
- *StAnD Teachers' Manual: https://projectstand.eu/teachers-manual/*

DETECTION

(30 minutes - 1 hour)

The activity continues with the **presentation and explanation of fireball networks**.

In particular, the teacher can provide students with **concrete examples** of fireball networks around the world (e.g. PRISMA, StAnD, etc.) and illustrate the **scientific importance of** being able to recover **freshly fallen meteorites** using this approach.

After explaining what an all-sky camera is and how it works by means of the **StAnD Meteor Camera Kit**, the teacher can then show the class the **open source data of the StAnD all-sky cameras**.

Suggested tools and resources:

- *PRISMA website: https://www.prisma.inaf.it/*
- *StAnD website: https://projectstand.eu/*
- *StAnD Meteor Camera Kit: https://projectstand.eu/meteor-camera-kit/*
- *StAnD Meteor Camera Kit Manual: https://projectstand.eu/wp-content/uploads/2025/04/A2.2-Meteor-Camera-Kit-April2025_compressed.pdf*

TRIANGULATION

(1 hour - 2 hours)

The activity continues with an introduction and then a more in-depth explanation of the **triangulation principle**, employed by fireball networks.
*'If you extend your arm and look at your index finger, first, just with your right eye, then, just with your left one, the finger seems to have moved a little bit, even though that is not the case and you did not move your arm or index at all. Basically, your eyes, individually, count as two **different points of view** and project the object in question differently on the background. In order to know the **exact location** of your finger, you need both your eyes and your brain to **compute the information** (Figure 1)'*

In particular, students can test their skills trying to **triangulate the fall area of a meteorite**. This can be done either by using a **goniometer** to calculate the angles of a meteor in three **detection captures** of three different all-sky cameras (see the **Appendix**) or by calculating said angles and the possible **strewn field** of the meteorite via the **StAnD Meteor Camera Widget**.
'Place the ruler on a camera image and trace a straight line from the centre of the image to the position of the meteor (Figure 2). Identify with the goniometer the angle at which the meteor has been detected by the camera (Figure 3). Then, use the goniometer again to report the identified angle on the camera location on the map (Figure 4) and, with the ruler, trace a straight line from the position of the camera towards the identified angle (Figure 5). Repeat this procedure for each one of the camera images. The straight lines traced on the map, one for each camera, identify the area of probable fall of the meteorite (Figure 6 and Figure 7). In the example presented here, the three straight lines do not cross in the same point, but rather they draw a triangle. This is due to measurement errors, which are always present. The larger the errors, the larger the area within which to search in order to recover possible meteorites, so try to be as precise as possible!'


Figure 1 – An introduction to the principle of triangulation

Figure 2

Figure 3

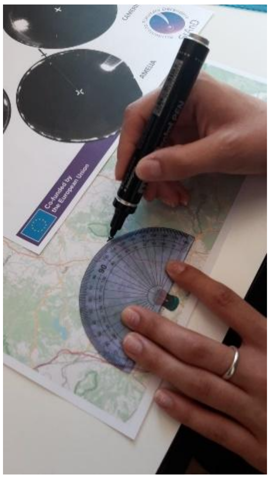


Figure 4

Figure 5

Figure 6

Figure 7

Suggested tools and resources:

- *Printed camera images and map (see the proposed example in the Appendix. It is also possible to create your own images and maps)*
- *Rulers and goniometers*
- *StAnD Meteor Camera Widget (coming soon!)*

RECOVERY

(1 hour)

Once the fall area has been identified, it is necessary to recover the meteorite. The activity therefore continues with the explanation of **how to identify a freshly fallen meteorite**.

In particular, it is possible to engage the students by presenting them a **box with compartments** (Figure 8) containing different **rock samples** and having them **guess** which one is **the meteorite** (Figure 9).
'Do you know what to look for when trying to identify a meteorite? What colour do you think it is? Do you think it presents rounded or rather sharp edges?'

Afterwards, the teacher should sum up the **main identification features of a meteorite** (see the **Appendix**), namely:

- **Black on the outside**, due to frictional heating of the meteoroid passing through the Earth's atmosphere. The cosmic body is 'burned' and a thin **fusion crust** (of order of **1 mm in thickness**) forms on the surface of the meteoroid.
- **Smooth external surface**, caused by the ablation of the body, whose external surface continuously melts losing roughness.
- **Irregular shape**, usually with faces and edges. However, the meteorite presents **rounded edges** due to the aforementioned frictional heating and abrasion.
- It may **break upon impact** with the ground, in which case it will present **sharper edges** due to the breaking. The **internal bulk** can be of **various colours** (e.g. whitish, greyish, yellowish, brownish) and the colour is **not uniform** on the inside.
- **Possibly partially buried**.
- It is **not hot** and **does not burn**.
- Generally **heavier than Earth rocks**.

These characteristics refer to rocky bodies, which are more than 90% of all meteorites. Specific meteorite types (e.g. iron meteorites, carbonaceous chondrite, HED Howardite-Eucrite-Diogenite meteorites, etc.) may show only some or even none of the characteristics listed above.

Figure 8 – Box with terrestrial rock samples and meteorite(s)

Figure 9 – Which one of these rocks is a meteorite?

Suggested tools and resources:

- *Box with compartments*
- *Rock samples (e.g. sandstone, limestone, granite, etc.), better if they are of different colours*
- *Meteorite (or cast of a meteorite, or rock sample that meets the identification requirements of a meteorite)*
- *'The Identikit of a Freshly Fallen Meteorite' of the PRISMA Network (see the Appendix)*
- *National Geographic 'Meteorite' article and video: https://education.nationalgeographic.org/resource/meteorite/*

ANALYSIS

(1 hour - optional)

The activity ends with the presentation of the **laboratory tests** that can be performed on an alleged **meteorite sample** in order to confirm its origins and to study it.

In particular, it would be possible to **show and analyse under a microscope thin sections of different meteorites** (Figures 10 and 11), highlighting the presence or absence of chondrules and other features (Figure 12). These thin sections of meteorites could then be then **compared to** those of different **Earth rocks**. Depending on the country, thin sections may be available through educational institutes, such as universities, schools, or museums. In case a microscope is not available, the activity can be carried out anyway by using images printed on transparent foils or merged in a digital presentation and a projector.

Figure 10 – Microscope showing the thin section of a meteorite

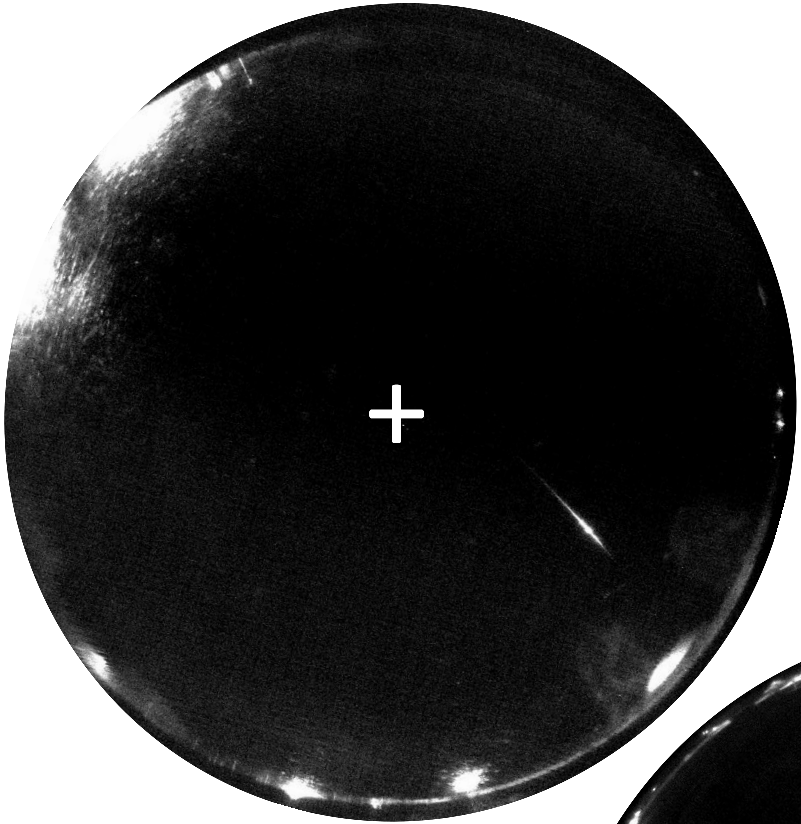
Figure 11 – Students trying to grasp details

Figure 12 – In this photo, the microscope is connected to a monitor showing a chondrule

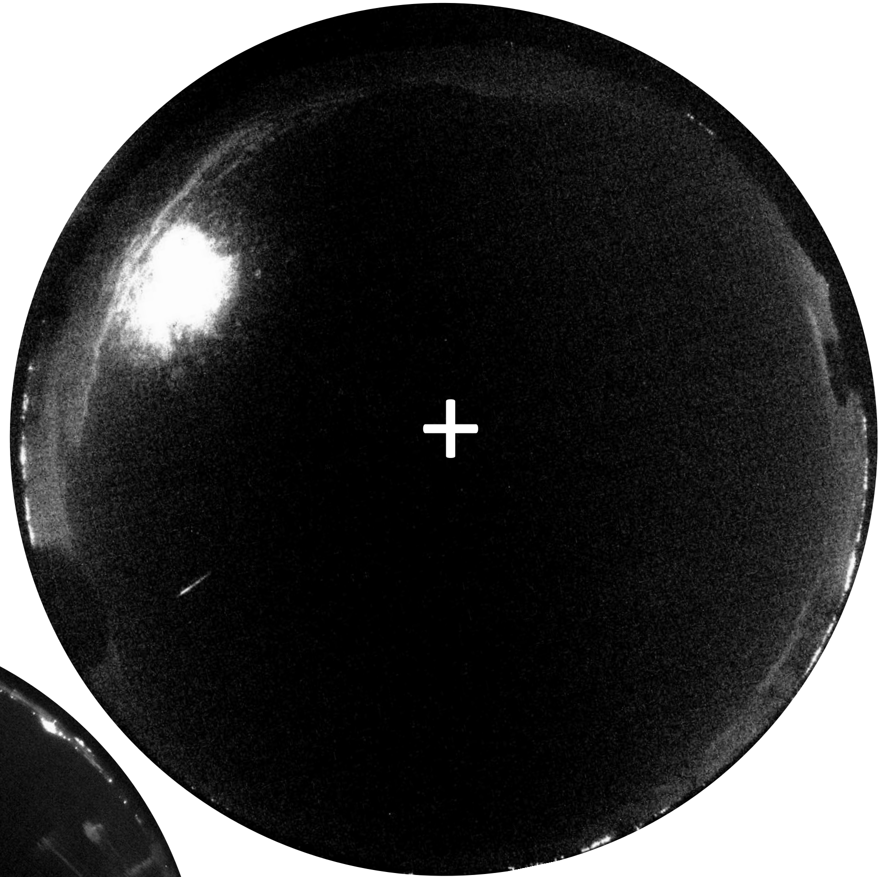
Suggested tools and resources:

- *Thin sections of meteorites*
- *Thin sections of Earth rocks*
- *Microscope*
- *'The Atlas of Meteorites in Thin Section' of the University of Pisa:* https://repositories.dst.unipi.it/documenti/Atlas_of_Meteorites_2021.06.23.pdf
- *Laboratorio Meteocert:* https://www.sma.unifi.it/index.php?module=CMpro&func=viewpage&pageid=424&newlang=ita
- *Sorvegliati spaziali:* https://sorvegliatispaziali.inaf.it/riconoscere-le-meteore-e-le-micrometeoriti/

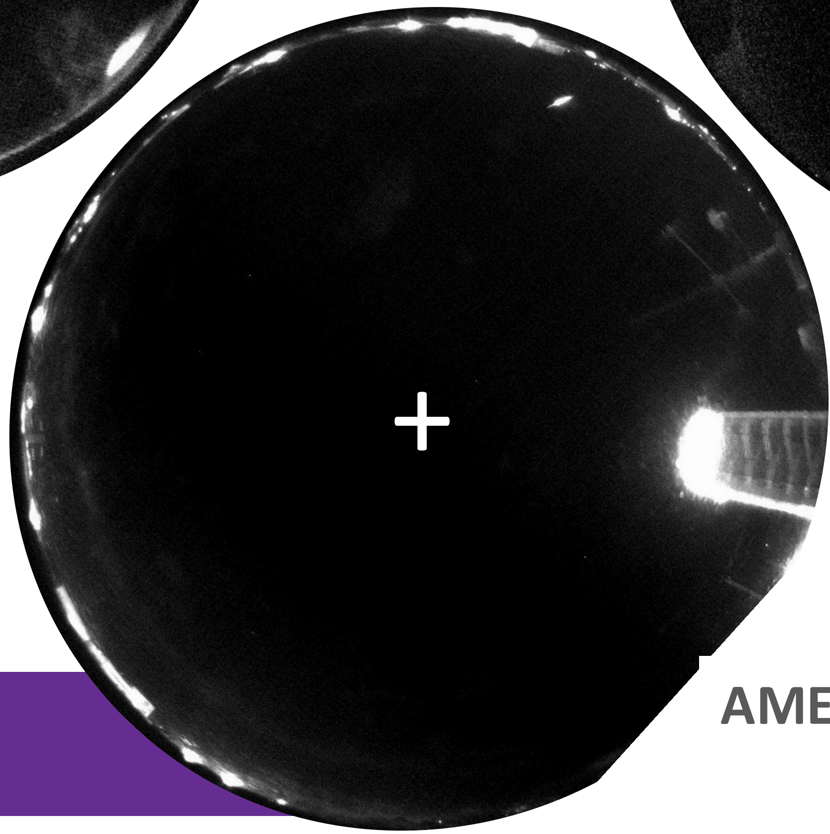
APPENDIX



PERUGIA



CAMERINO



AMELIA

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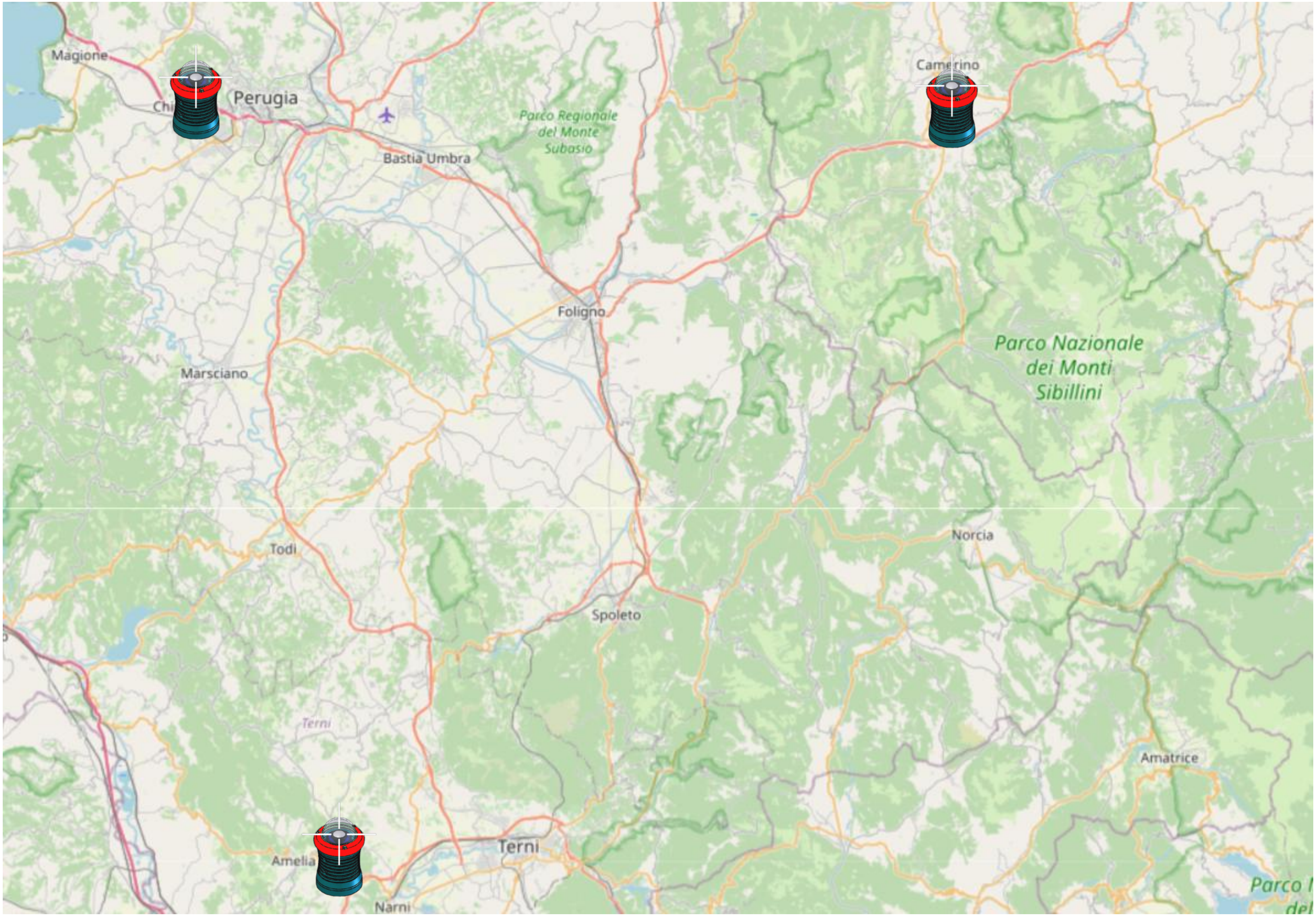
Students as Planetary Defenders
StAnD

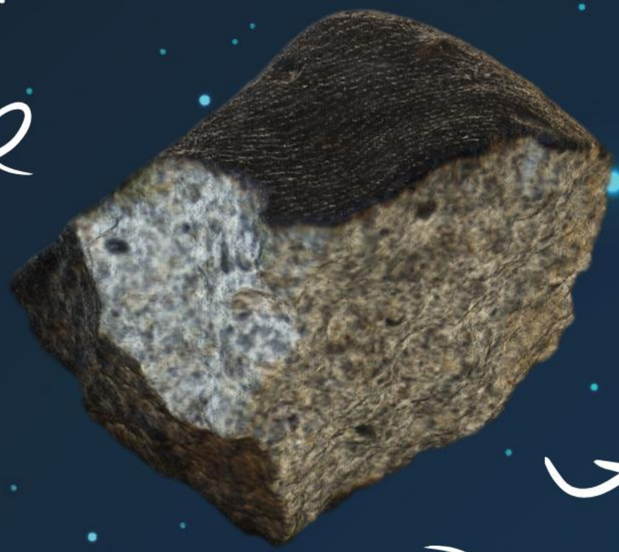

Magione
Perugia
Bastia Umbra
Parco Regionale del Monte Subasio
Camerino
Foligno
Marsciano
Parco Nazionale dei Monti Sibillini
Todi
Norcia
Spoleto
Terni
Amatrice
Amelia
Terni
Narni

The Identikit of a Freshly Fallen Meteorite

Black on the outside (fusion crust)

The fusion crust is about 1 mm thick

Smooth external surface



It could be partially buried

It is not hot and does not burn

Rounded edges

Whitish or grey on the inside

Irregular shape

The colour is not uniform on the inside

Generally heavier than Earth rocks

The photo shows a fragment of the 2020 New Year's Eve Bolide, observed on 1st January 2020. Specimens of the Cavezzo meteorite were recovered on 4th January 2020 thanks to the PRISMA network, the First Italian Network for the systematic Surveillance of Meteors and the Atmosphere.