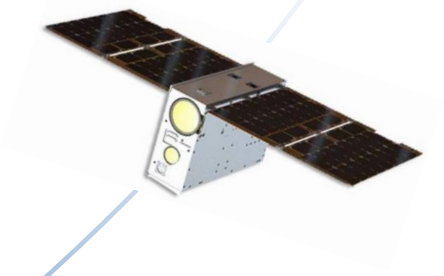
ArgoMoon and LICIACube: Italian cubesats for international cooperation

Simone Pirrotta
Exploration and Observation of the Universe - EOS dept.
Italian Space Agency



Committee on the Peaceful Uses of Outer Space,
62nd session
Wien, 17th June 2019

Small devices for large opportunities

- Space science is one of the areas where cubesats can be used to complement the investigations performed by traditional probes. Modularity, standardization, large use of state-of-the art COTS technologies allow to manage cheaper missions in shorter periods of time.
- The limited financial effort required makes missions affordable for a wider group of potential space actors, so enabling the participation of small or emerging countries in big endeavors and fostering the international cooperation at different levels of involvement.

- The Italian Space Agency (ASI) is currently implementing several projects for cubesats development within international frameworks.

The «IKUNS system»

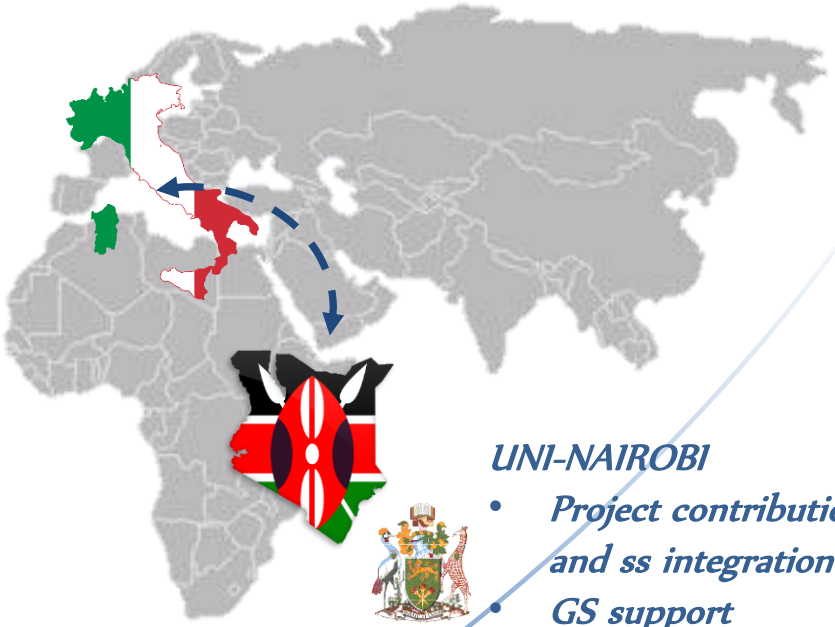
"IKUNS - Italian-Kenyan University NanoSatellite" coordinated by ASI with the support of the Kenya Space Agency and jointly developed by Sapienza University and the University of Nairobi, aiming the development of cubesats for Earth Observation, also with training and educational goals.

ITALIAN SPACE AGENCY

- *Project coordination and management*
- *Financial and Institutional coverage*
- *BSC Comms support*

UNI-ROMA «La Sapienza»

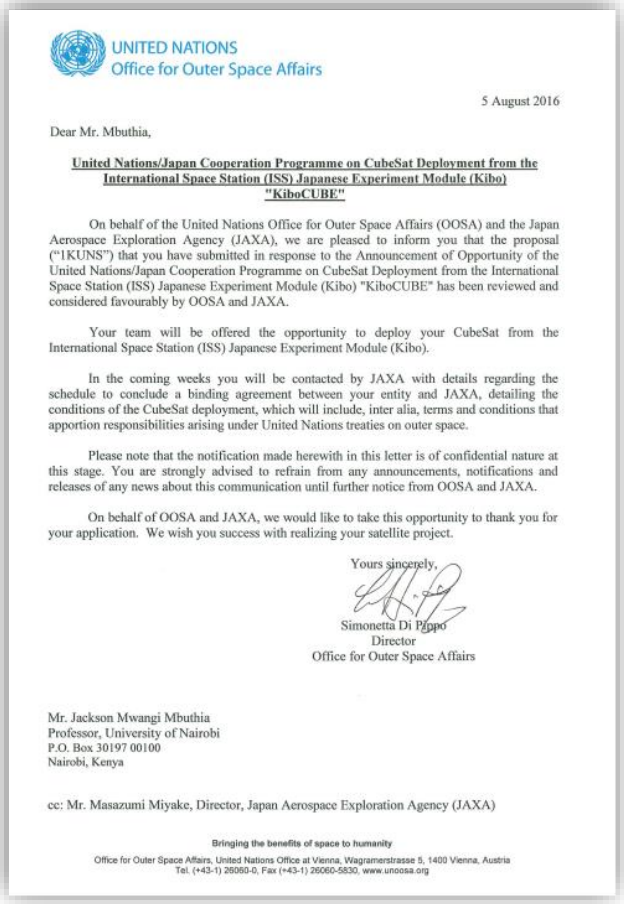
- *Project implementation: cubesat design, development and testing*



UNI-NAIROBI

- *Project contribution: payload and ss integration and testing,*
- *GS support*

KiboCube: precursor flight opportunity



UNITED NATIONS
Office for Outer Space Affairs

5 August 2016

Dear Mr. Mbuthia,

United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE"

On behalf of the United Nations Office for Outer Space Affairs (OOSA) and the Japan Aerospace Exploration Agency (JAXA), we are pleased to inform you that the proposal ("1KUNS") that you have submitted in response to the Announcement of Opportunity of the United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE" has been reviewed and considered favourably by OOSA and JAXA.

Your team will be offered the opportunity to deploy your CubeSat from the International Space Station (ISS) Japanese Experiment Module (Kibo).

In the coming weeks you will be contacted by JAXA with details regarding the schedule to conclude a binding agreement between your entity and JAXA, detailing the conditions of the CubeSat deployment, which will include, inter alia, terms and conditions that apportion responsibilities arising under United Nations treaties on outer space.

Please note that the notification made herewith in this letter is of confidential nature at this stage. You are strongly advised to refrain from any announcements, notifications and releases of any news about this communication until further notice from OOSA and JAXA.

On behalf of OOSA and JAXA, we would like to take this opportunity to thank you for your application. We wish you success with realizing your satellite project.

Yours sincerely,

Simonetta Di Pippo
Director
Office for Outer Space Affairs

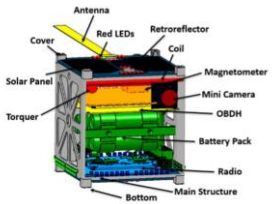
Mr. Jackson Mwangi Mbuthia
Professor, University of Nairobi
P.O. Box 30197 00100
Nairobi, Kenya

cc: Mr. Masazumi Miyake, Director, Japan Aerospace Exploration Agency (JAXA)

Bringing the benefits of space to humanity

Office for Outer Space Affairs, United Nations Office at Vienna, Wagramerstrasse 5, 1400 Vienna, Austria
Tel. (+43-1) 26060-0, Fax (+43-1) 26060-5830, www.unoosa.org

The first product, **1KUNS - 1st Kenyan University NanoSatellite - Precursor Flight**, has been proposed by Nairobi University and selected by the Japanese Space Agency (JAXA) and the United Nations Office for Outer Space Affairs (UNOOSA) to be launched by the Japanese "Kibo" module of the International Space Station (ISS), as part of the **"KiboCube" program**, devoted to emerging countries.

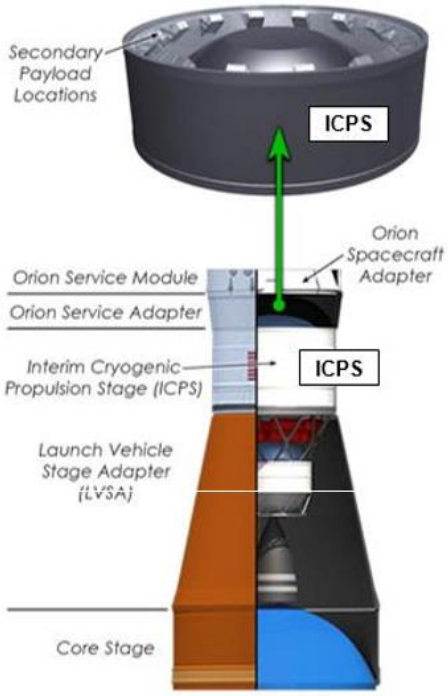


Achievements of the 1KUNS partnership

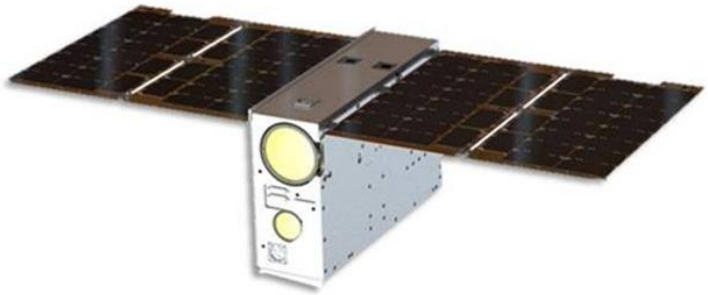
The 1KUNS 1U cubesat has been deployed form ISS on 11th May 2018 and it is fully operational, capturing interesting pictures of the Earth surface (see the mission's official website at http://1kuns-pf.ns0.it/)

NASA SLS EM1 – cooperation opportunities

In the frame of NASA Space Launch System (SLS), NASA HQ Exploration Systems Directorate (ESD) has directed the SLS Program to accommodate Secondary Payloads of the Cubesat Class, to increase the scientific and exploration capabilities, allowing international community for access to much higher orbits than are currently available for small payloads

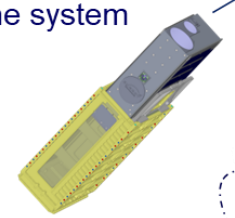


In 2016, the ASI-proposed "Argomoon" mission has ben selected as European contribution to EM1 mission.



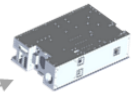
Argomoon on board of NASA SLS EM1

T_0 : deployment
Closure of the separation switches: power to the system



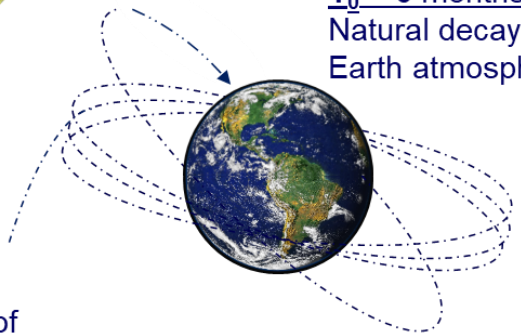
T_0 + 15 sec

ATTITUDE reconstruction

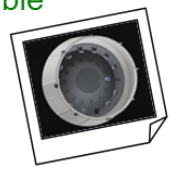


Pointing Cameras towards ICPS

T_0 + 6 months
Natural decay into Earth atmosphere

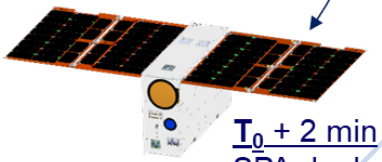


1st picture possible



T_0 + 1 min
ICPS Targeted: Tracking Mode

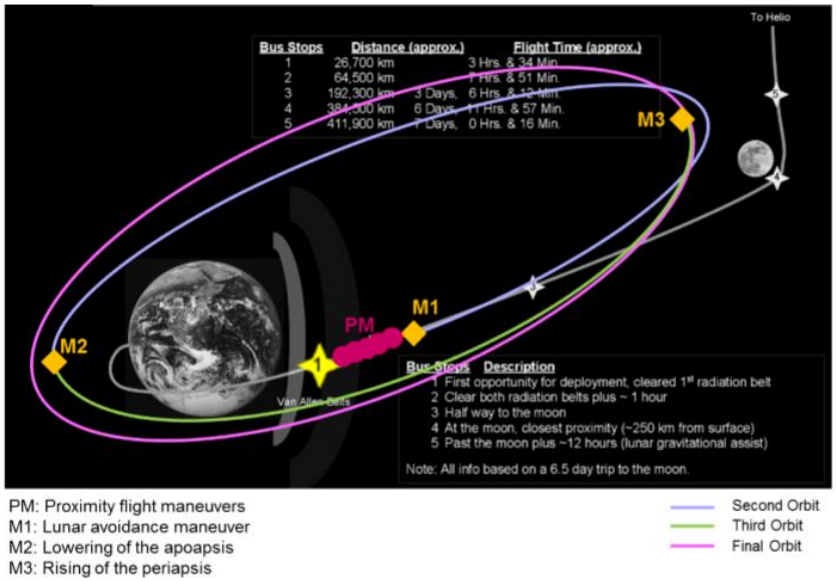
T_0 + 8 hr
Burn to enter a Geocentric orbit to take pictures of Earth and the Moon and validate the on-board technology



T_0 + 2 min
SPA deployment

ArgoMoon is a 6U satellite that aims at taking significant photographs of the EM-1 mission and validate new technologies in deep space.

Argomoon mission profile

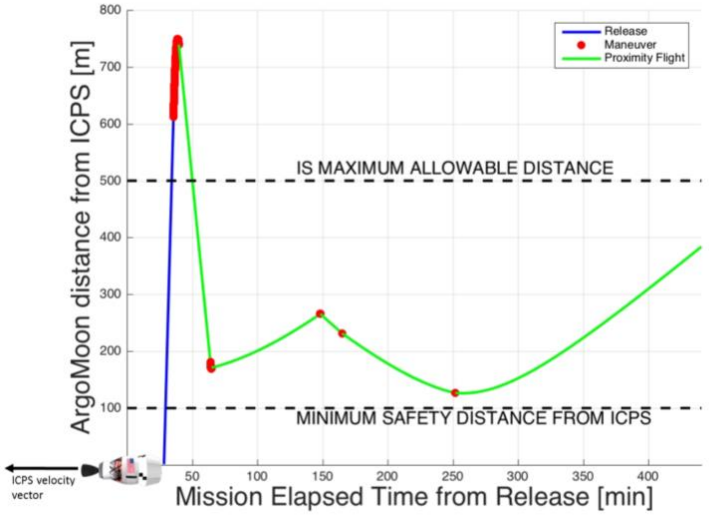


PM: Proximity flight maneuvers
M1: Lunar avoidance maneuver
M2: Lowering of the apoapsis
M3: Rising of the periapsis

Second Orbit
Third Orbit
Final Orbit

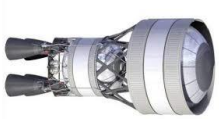
Orbital maneuvers will inject the cubesat into a geocentric orbit with high apogee, so allowing several moon flyby and imaging.

After separation, ArgoMoon will autonomously perform proximity navigation, based on processing of optical data from on board cameras



Argomoon mission timeline and ojectives

Launch (≈3 hours)



Commisssioning (≈17 minutes)

Disposal

First Phase (≈ 10 hours)

SLS EM1 support:

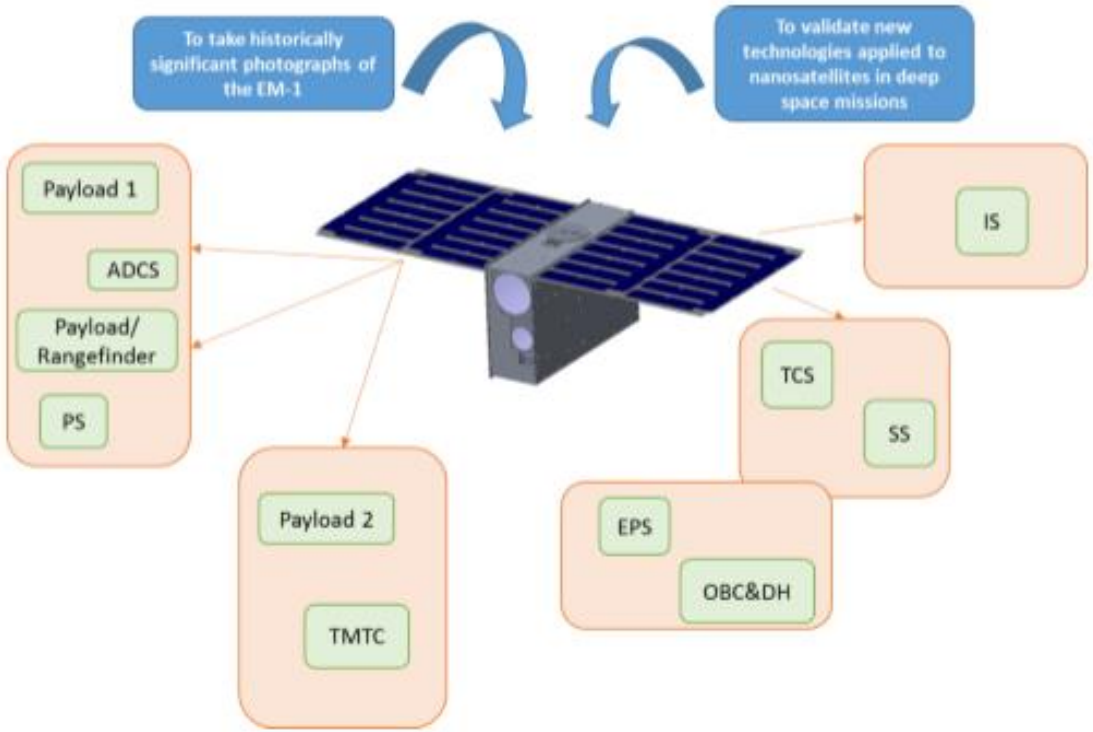
- providing information regarding status of payloads deployment;
- visually inspect the condition of the SLS second stage
- enhance public outreach

Second phase (≈ 6 months)

In-orbit Operations

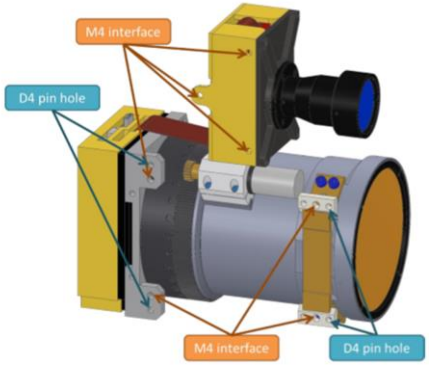
- collect Moon's images with scientific purpose
- validate small satellite's new technologies in deep space:
  - Targeting system based on optical recognition
  - Develop or Increase TRL of miniaturized subsystems (e.g. power distribution, data acquisition and processing)

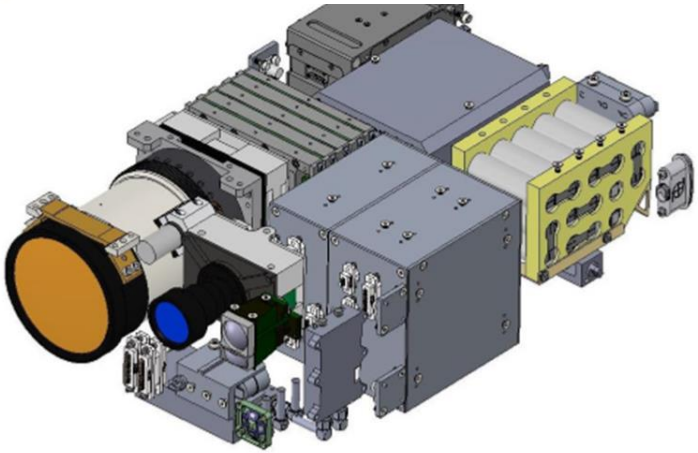
Argomoon baseline design



Payload:

- Optical-1+Electronic
- Optical-2+Electronic
- Range Finder

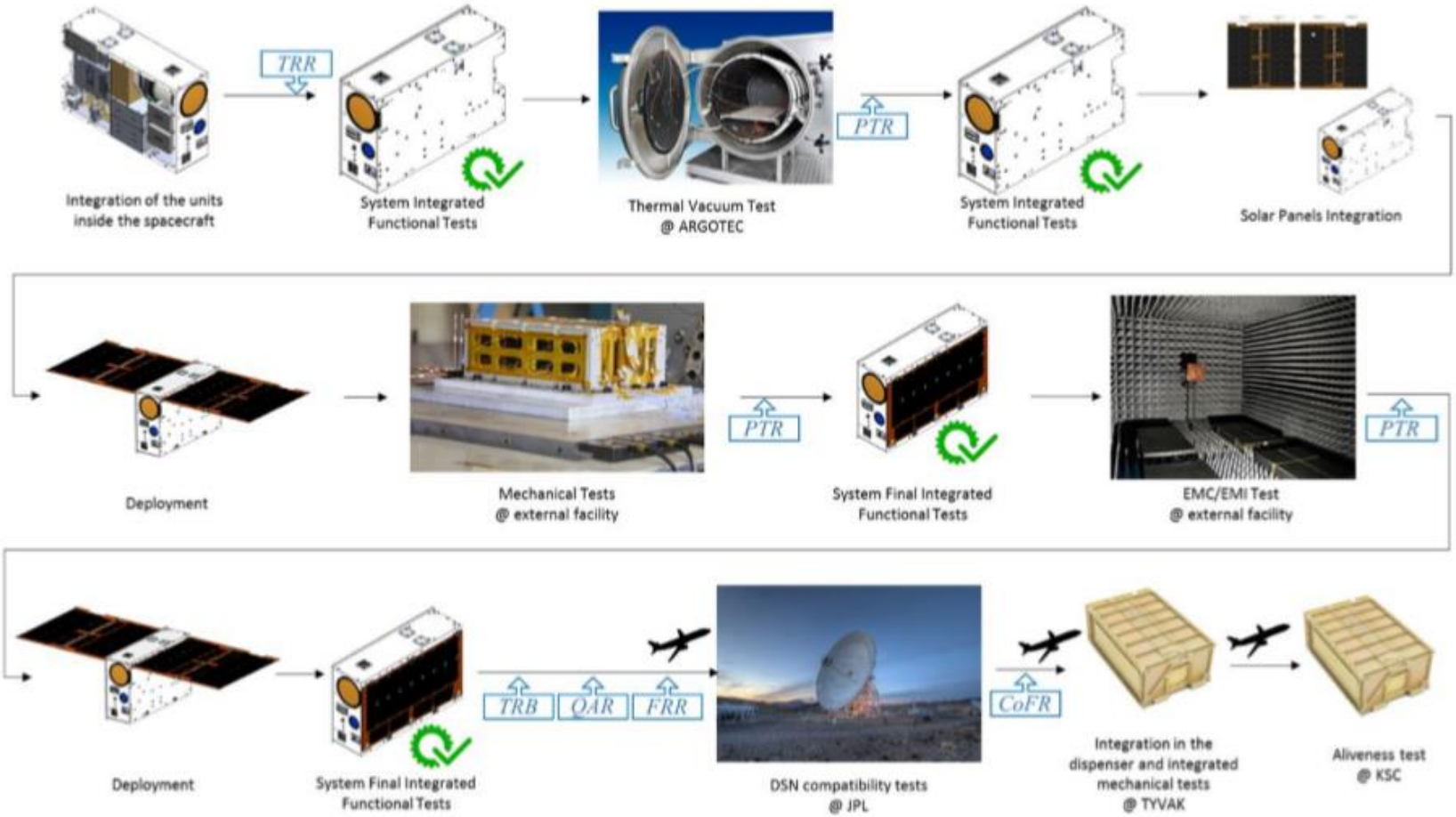




Platform:

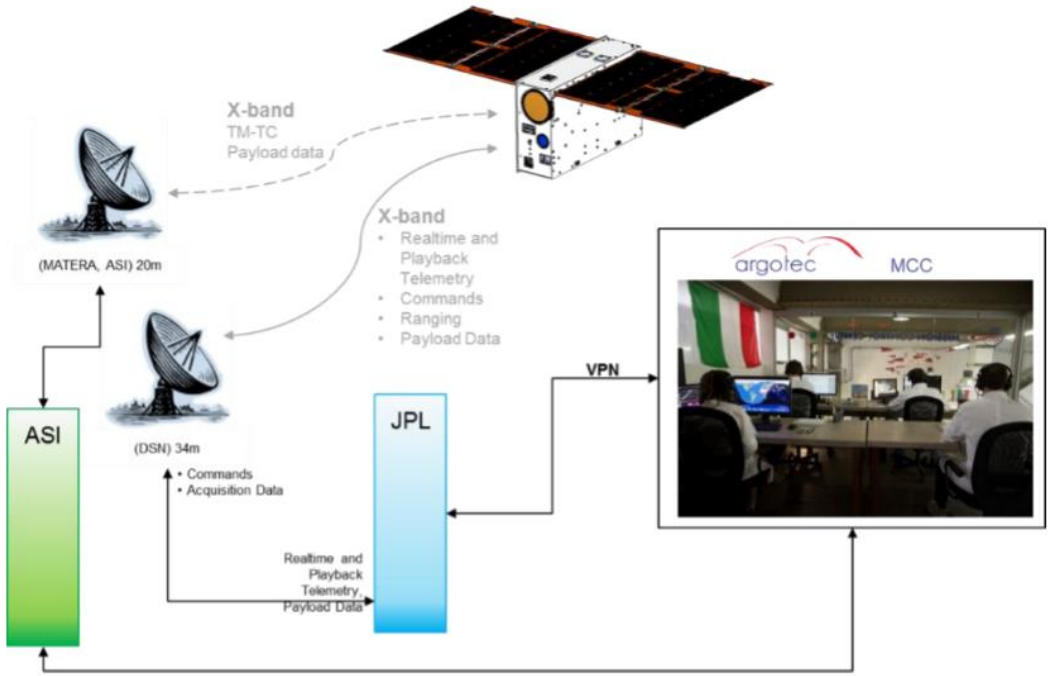
- On Board Computer
- EPS (Solar Panels, Battery, EPS board)
- TMTC (Radio, Antenna)
- Attitude, Dtermination, Control System
- Propulsion System

Argomoon AIV

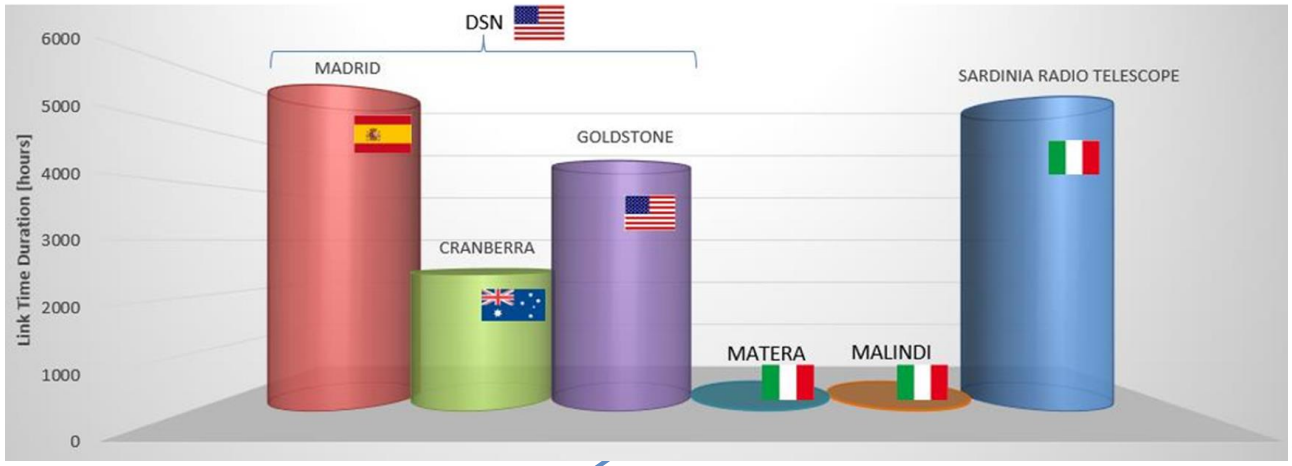


Proto-flight approach is implemented, before the delivery to Tyvak and integration in the dispenser.

Argomoon Comms architecture



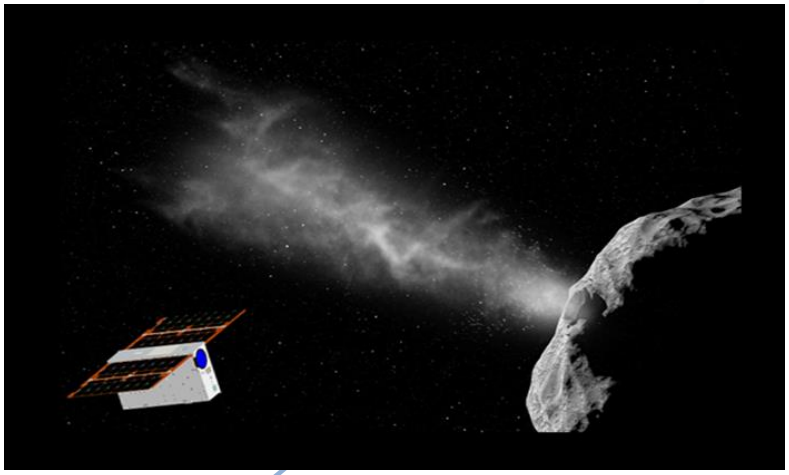
Communications based on X-band up and downlinks, with support of NASA DSN antennas and Italian facilities involvement, like the Sardinia Deep Space Antenna



The asteroid imager: LICIACube

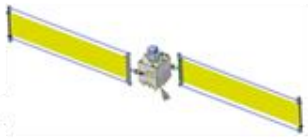
The Light Italian Cubesat for imaging of Asteroids - LICIACube will fly as piggyback of the NASA-APL DART probe towards the Didymos binary asteroid system, and will then be released to witness the impact effects of the American probe on the secondary Didymoon, in order to test trajectory deflection method by kinetic impact for Planetary Defense.

During a quick fly-by, LICIAcube will perform target tracking and imaging of the asteroid surface, including the rear side, and of the ejected plume of surface materials. Possible additional investigations allowed by captured pictures and radio-science will be additional mission achievements.



LICIACube scheme for cooperation

DART TEAM



NASA HQ Science Mission Directorate
Planetary Science Division –
Planetary Defense Office

- DART mission responsibility
- Leading of US team
- Technical/programmatic management
- Int. relations (LICIA) management

Implementing Arrangement

ICD

Management
Science
Engineering

Communication

JHU Applied Physics Laboratory

- Mission Implementation
- Technical IF management

Jet Propulsion Laboratory – Deep Space Network

- TT&C and Navigation Services

NASA Goddard Space Flight Centre
NASA Johnson Space Centre

LICIACube TEAM

Agenzia Spaziale Italiana:

- LICIACube mission responsible
- Leading of Italian team
- Technical/programmatic management
- Int. relations (DART) management

Phase B/C1 contract (KickOff – Dec 2018)

Argotec srl: LICIACube Contractor

- Support to programmatics
- Technical interface

INAF Istituto Nazionale di Astrofisica

- Payload performances definition
- Scientific investigation

Politecnico di Milano

- Mission analysis e trajectory optimization

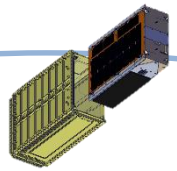
Università di Bologna

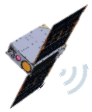
- Orbit Determination and Deep Space Navigation - Radioscience

LICIACube mission timeline

LICIACUBE DEPLOYMENT
DART S/C TRIGGER THE LICIACUBE DEPLOYMENT 120 HOURS BEFORE THE IMPACT

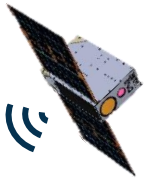
PIGGYBACK CRUISE PHASE
LICIACUBE IS CARRIED BY DART **S/C**



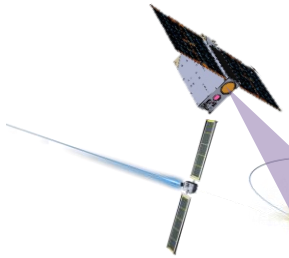


APPROACHING PHASE
LICIACUBE ESTABLISHES A LINK W/DSN TO PERFORM THE SATELLITE TRACKING AND THE ORBIT DETERMINATION

LAUNCH

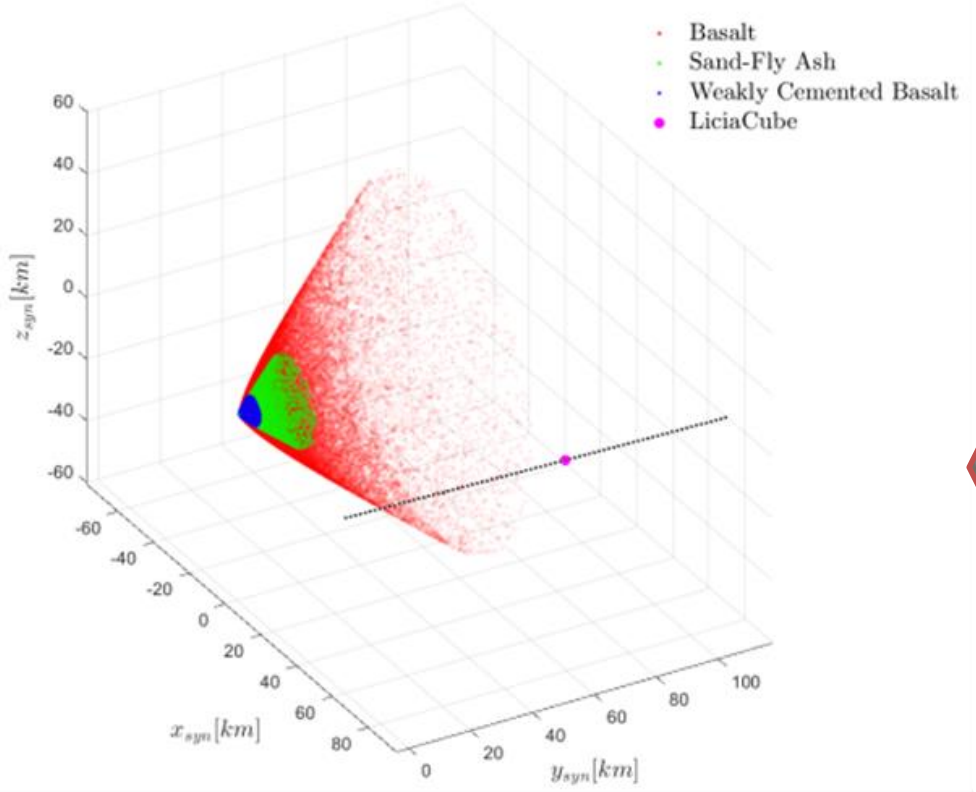


SCIENCE
DOWNLINK OF ACQUIRED SCIENTIFIC DATA FOR 6 MONTHS



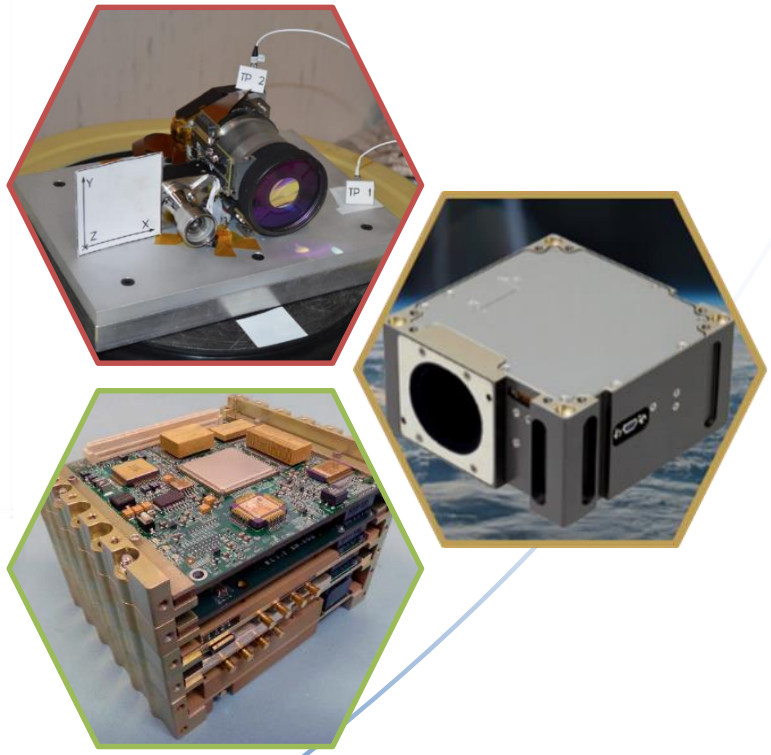
SCIENCE
LICIACUBE PERFORMS SEPARATION MAENUVERS AND ACQUIRES PICTURES OF DIDYMOS B AND PLUME GENERATED BY THE DART S/C IMPACT

LICIACube challenges and solutions



Accurate mission design for precise trajectory optimization.

ArgoMoon-like design, with improvements in ADCS, Propulsion, Payloads.



Conclusions

- IKUNS is a joint Italian-Kenyan project, with relevant scientific and technological goals but also strong educational impacts.
- ASI will contribute to NASA exploration program with the Argomoon 6U cubesat, to be launched during the EM1 mission aboard the US heavy launcher SLS, in mid-2020.
- LICIACube will fly as NASA/APL DART piggyback to Didymos asteroid binary system, to support primary probe mission with imaging of impact effects.

- Small satellites confirm to be powerful tools to promote and push international cooperation in space.
- The ASI cubesat-based missions reinforce the importance of small satellites as space mission elements in an global scenario.

Thank you

Simone Pirrotta, PhD
Exploration and Observation of the Universe - EOS dept.
Italian Space Agency ASI

simone.pirrotta@asi.it