La missione ESMO
European Student Moon Orbiter
e il Radiometro a Microonde MiWaRS
proposto dalle Università di Roma "La Sapienza" e di L’Aquila

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• Che cosa è SSETI

• Descrizione della missione ESMO

• Il radiometro a microonde quale payload scientifico

• Un possibile contributo della comunità dei radioamatori
The main objective of the Student Space Exploration and Technology Initiative is to create a network of students, educational institutions and organisations across Europe in order to design, construct and launch micro satellites and other spacecraft. This, by nature, distributed task can be handled by using available internet tools.

This objective is reached when a spacecraft is designed, built and launched by a significant number of European students in a highly distributed way. The completion of this project objective is independent of a mission success or failure.

The complexity of this task leads to a necessary kind of missions to reach the goal by the participating students and professors with the support of the European Space Agency and Arianespace.
Objective
- to actively involve European students in real space missions
- to give students practical hands-on experience
- to enhance their motivation to work in the fields of space technology and science
- to ensure the availability of a suitable and talented workforce for the future

Participation
- Started in 2000 for European students
- Hands-on project on a real space mission
- Over 350 students actively involved
- 28 universities in 15 European countries (+ Canada)

Projects
- SSETI Express: 62 Kg, launched 27 October 2005 into LEO(*)&
- ESEO: 120 kg, planned for launch in 2008 into GTO
- ESMO: planned for launch 2011

(*) carrying an Amateur Radio Transponder
In March 2006, the Education Department of the European Space Agency approved the European Student Moon Orbiter (ESMO) mission proposed by the Student Space Exploration & Technology Initiative (SSETI) association for a Phase A Feasibility Study. If found to be feasible, ESMO will be the third mission to be designed, built and operated by European students through the SSETI association, and would join many other contemporary missions to the Moon such as ESA’s SMART-1, the Chinese Chang’e-1, the Indian Chandrayaan, JAXA’s SELENE and Lunar-A, and NASA’s Lunar Reconnaissance Orbiter.

Italy has taken part in the project with:
• Università di Roma “La Sapienza”
• Politecnico di Milano
• Università di Napoli “Federico II”
• Università di L’Aquila
**ESA provides:**
- AO, payload & subsystem selection, selection of student teams
- Full-time project, risk & system engineering management
- Quality/Product assurance support from ESA experts to ensure compliance with ECSS
- Organisation and sponsorship of regular student workshops
- Technical advice to student teams via controlled interaction with ESA experts
- Formal project reviews of documentation during all phases
- Support and facilities for AIV of student payload/subsystem at ESTEC
- The launch opportunity

**SSETI Association provides:**
- Agreements with universities on student team participation
- Infrastructure for use by project managers,
- public relations to promote SSETI and its projects

**Student teams provide:**
- System engineering/ Technical management functions,
  Payload experiments, Spacecraft subsystem hardware,
  Onboard software, Ground segment, Mission operation
The ESMO mission objectives are summarised as follows:

- **Education**: prepare students for careers in future projects of the European space exploration and space science programmes by providing valuable hands-on experience on a relevant & demanding project.

- **Outreach**: acquire images of the Moon and transmit them back to Earth for public relations and education outreach purposes.

- **Science**: perform new scientific measurements relevant to lunar science & the future human exploration of the Moon, in complement with past, present and future lunar missions.

- **Engineering**: provide flight demonstration of innovative space technologies developed under university research activities.
The ESMO spacecraft would be launched in 2011 as an auxiliary payload into a highly elliptical, low inclination Geostationary Transfer Orbit (GTO) on the new Arianespace Support for Auxiliary Payloads (ASAP) by either Ariane 5 or Soyuz from Kourou.

From GTO, the 200 kg spacecraft would use its on-board propulsion system for lunar transfer, lunar orbit insertion and orbit transfer to its final low altitude polar orbit around the Moon.

A 10 kg miniaturised suite of scientific instruments (also to be provided by student teams) would perform measurements during the lunar transfer and lunar orbit phases over the period of a few months, according to highly focussed science objectives. The core payload would be a high-resolution narrow angle CCD camera for optical imaging of lunar surface characteristics and a Cubesat subsatellite for precision gravity field mapping via accurate ranging of the subsatellite from the main spacecraft. Optional payload items being considered include a Microwave Radiometer and a LIDAR.
Le missioni scientifiche sulla Luna
Le missioni più famose del passato
ESMO Project Organisation

Project Manager
R. Walker (ESA)

Technical Manager
R. Walker (ESA)

TM Team
R. Mayne, X. Alabart

Programmatics
Politecnico di Milano

System Engineering Manager
R. Walker (ESA)

Avionics
R. Schlambusch

Energetics
C. Taccelli, G. Curti

Science/Payload
S. Forsman

Platform 1
TBD Student

Platform 2
TBD Student

Ground Segment 1
R. Dall’Aria

Ground Segment 2
G. Mezzana

OBDH
Porto University
TU Munich

ADCS
Naval University
Lisbon Uni.
SUPAERO

Power
Sherbrooke Uni.

Camera
Liege University

Structure/Config
Southampton Uni

Mechanisms
Porto University

Harness
TBD Student Team

Ground Stations
TU Munich

Mission Control
Rome La Sapienza

Flight Dynamics
TBD Student Team

Mission Analysis
Glasgow University

Simulation
TBD Student Team

Comms
Virginia University

Elec Propulsion
Southampton/Warwick

Backup
Open University
Rome La Sapienza

Chem Propulsion
Milano / Napoli

Thermal
Rome La Sapienza
Obiettivi scientifici del radiometro a microonde

- Global mapping of the surface and sub-surface temperature.
- Global mapping of the lunar microwave emissivity.
- Estimate of the lunar soil thickness and properties.
- Estimate of the lunar sub-surface thermal conductivity.

Proposed F = 3 GHz & 10 GHz
Radiometer payload

1. Anenna Efficiency: $\eta_A$
2. Main lobe Efficiency: $\eta_{ML}$
3. HPBW: $\theta_{ADB}$
4. Calibration Reference: $T_{ref}$
5. Beam width $B$
6. Gain $G$
7. Noise Figure $F$
8. Power gain Variation: $\Delta G/G$
9. Integration time: $\tau$
10. Number of bit $n_b$
11. Predetection receiver
12. Low pass filter (integrator)
13. A/D converter

Moon Soil characteristics retrieval techniques

- Channel 1
- Channel 2

Noise generator
Circulator
Detector
Switch

Antenna: $T_b$

Moon soil

rock

$T_1$

$T_2$

$H$

$d$

20 cm

$20$ cm

Microwave side
Possible antenna types for MiWaRS

Patch antenna
≈ 23 × 15 cm

Short Backfire antenna (SBFA)

2λ < 20 cm
Conical horn @ 10 GHz

\[ a = 4.74 \text{ cm} \]

\[ L = 10 \text{ cm} \]
Un possibile contributo dei Radioamatori alla missione MiWaRS di ESMO:

consentire al sensore di operare come RADAR PASSIVO

per ottenere mappe di riflettività bistatica e diffusività lunare
Modalità RADIOMETRO
Modalità RADAR PASSIVO

Osservazione contributo specularre
Incidenza normale

una o più stazioni EME
“illuminano” la Luna a 10 GHz

Disturbo alla modalità RADIOMETRO? L’attività EME si svolge essenzialmente nei weekend.
Il radiometro ESMO potrebbe avere un sistema di selezione della banda
Modalità RADAR PASSIVO

Osservazione contributo speculare
Incidenza obliqua
Modalità **RADIOMETRO** (assenza di illuminazione)
Il radiometro, opportunamente calibrato, misura una $T_a = 300 K$.
La potenza raccolta dal radiometro è $K T_{sys B} = -125.6 \text{ dBW}$

Modalità **RADAR PASSIVO** - contributo specular (presenza di illuminazione)
In questo caso la potenza ricevuta è la somma di quella termica, prima calcolata, e di quella dovuta al segnale che illumina la Luna.
La potenza totale misurata è: $K T_{sys B} + \Delta P$ dove $\Delta P = -142 \text{ dBW}$ Ma $\Delta P$ rappresenta un incremento, letto sulla scala delle temperature misurate dal radiometro, che è pari a 9.16 K.

**EIRP TX**: 77 dBW (antenna 7 metri, TX 150 W, come da IQ4DF di Bagnara)

$R = 370\ 000\ \text{km}$, $F = 10\ \text{GHz}$

Luna supposta con riflettività -12 dB (valore di letteratura)

Radiometro "total power" $B = 50\ \text{MHz}$ (banda equivalente di rumore)

$T_{sys} = T_a + T_{rec} = 300K + 100K = 400\ K$; $\tau = 1\ s$ (tempo di integrazione)

Risoluzione radiometrica $\Delta T = 0.06\ K$

Guadagno d'antenna 16 dBi
La stazione EME di Bagnara di Romagna
Modalità RADAR PASSIVO

Osservazione contributo diffuso

In questo caso $\Delta P$ è più piccolo!

Una modalità "coerente" dovrebbe consentire un certo guadagno di processo. ESMO, opportunamente comandato, campiona il segnale con un ritmo adeguato e lo trasferisce a Terra, dove la comunità dei radioamatori provvede a correlarlo con la copia del segnale trasmesso.
In questo caso “estremo” il satellite rimane nella posizione d’interesse per un tempo breve. Tale tempo potrebbe essere insufficiente per ottenere il guadagno di processo richiesto. Si può pensare di coinvolgere stazioni di Terra con maggiore EIRP (stazioni scientifiche?).
Thanks for your attention

http://www.die.uniroma1.it/esmo-urm/