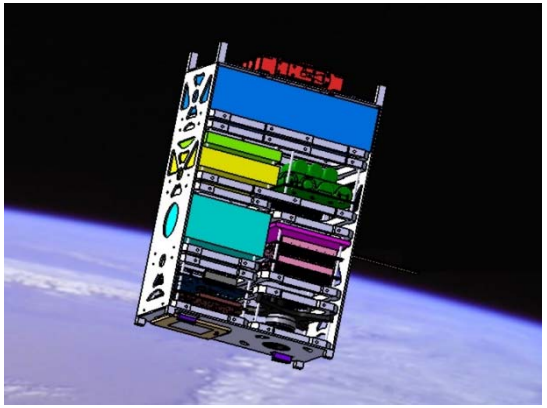
Committee on the Peaceful Uses of Outer Space, 59th session
Wien, 15th June 2016

IKUNS: a University NanoSatellite in support of Italian-Kenyan cooperation in space activities

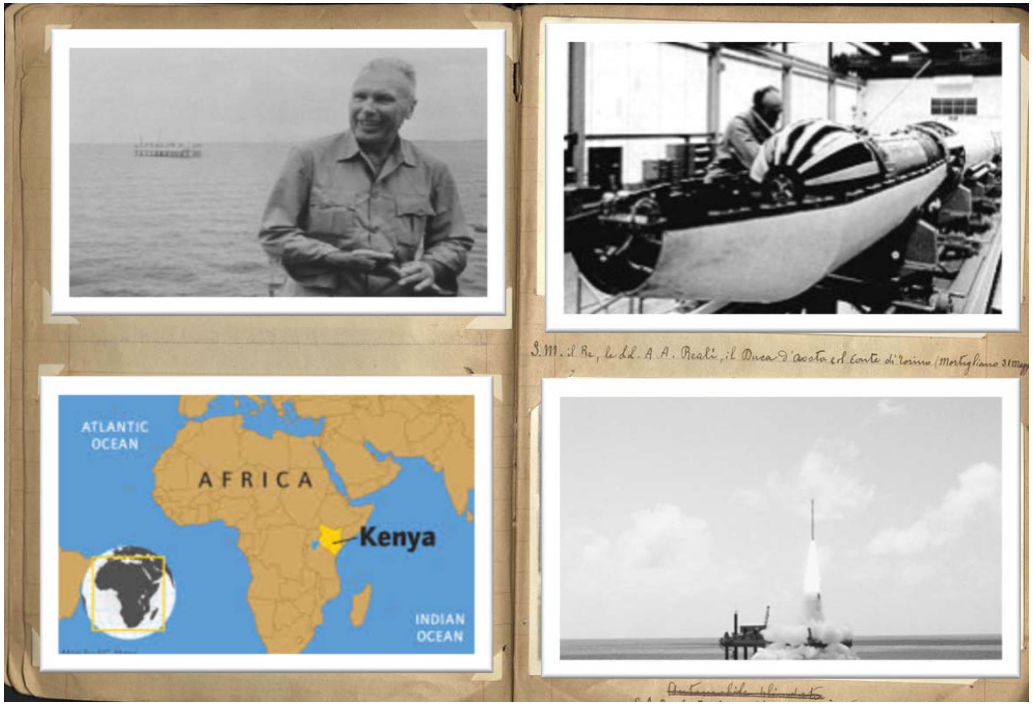


Simone Pirrotta (Italian Space Agency – ASI)

Fabrizio Piergentili, Fabio Santoni (University of Rome «La Sapienza»)

Mwangi Mbuthia, Heywood Ouma, Vitalice Oduol (University of Nairobi)

Italy and Kenya, long-term cooperation



San Marco 1, launched on Dec 1964: Italy became the first European country to deploy and operate its own satellite with a national team
27 successful launches from San Marco base in Malindi, Kenya

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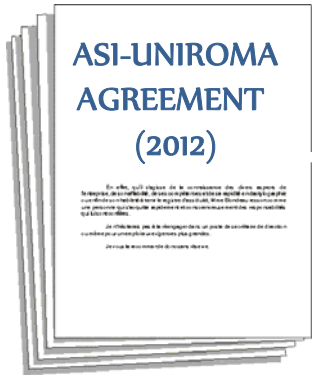
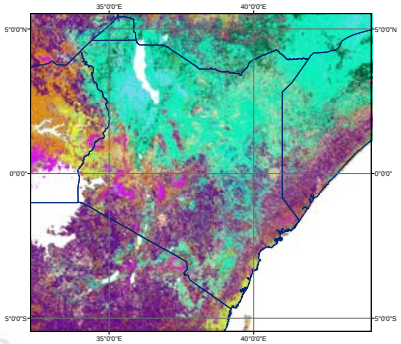
Today, the Broglio Space Centre is the main reference in East Africa for TT&C and scientific data comms services (main partners: ESA, NASA, CLTC)

ASI and La Sapienza, joint research at BSC

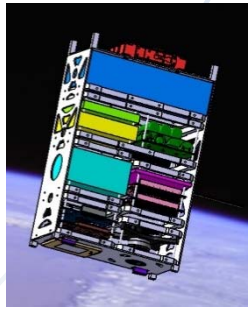


EQUO: EQUatorial Italian Observatory

SBAM: Satellite Based Agricultural Monitoring



IKUNS: Italian--Kenyan University NanoSatellite



Development of a nanosatellite for Earth Observation applications, by a joint team of Italian and Kenyan University students

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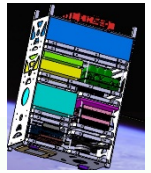
The «IKUNS system»

ITALIAN SPACE AGENCY

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



UNIROMA «La Sapienza»

- Project implementation: cubesat design, development and testing

UNINAIROBI

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

The IKUNS goals

Data acquisition and In Orbit Demonstration

- Scientific experiment

Technologies development and testing

Common Data Exploitation

First direct experience on Flight and Ground space hardware

- International cooperation

- Education and training

Joined Postgraduate Course in "Space Mission Design and Management"

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Assessment study at ASI CEF (1)

The preliminary mission study has been performed during fall 2015 by the students of "Spacecraft Design" course, (taught in the Space and Astronautical Engineering MSc Course of "La Sapienza" University) at ASI Concurrent Engineering Facility (CEF), in Rome.
ASI CEF provides a common and virtual environment and tools to support a group of experts in different disciplines in the exploitation of a space mission feasibility study.

ASI CEF Disciplines:

- System,
- Mission analysis,
- Payload,
- Attitude and Determination Control System,
- On Board Data Handling,
- Configuration and Structures,
- Power,
- Thermal control,
- Communications,
- Ground Segment,
- Costs, Programmatics and Risks

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Assessment study at ASI CEF (2)

MISSION OBJECTIVES

- East Africa land observation from space
- Support cooperation between Italy and Africa in Space activities

MISSION REQUIREMENTS

CUBESAT standard satellite

Nominal mass < 10 kg

Optical payload in visual band

Target Area: East Africa and Italy

10 images of area of interest per day

Ground Resolution < 150 x 150 [m]

DESIGN DRIVERS

Modular bus to host multiple payloads

Adequate reliability level: maximize the use of Commercial Devices certificated for Space

Readiness for launch in 2 years

Ground Stations:

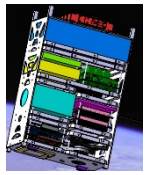
- New antenna at Broglio Space Center (Malindi, Kenya)
- Existing antenna at "La Sapienza" University (Rome, Italy)

Preliminary Design: Comms architecture

S – Band Antenna 3 m (Rome)

Downlink (2500 MHz):

- Gain = 29.2 dBi
- SNT = 18.73 dBK
- G/T = 10.57 dB/K



VHF/UHF Antenna (Rome & Malindi)

Uplink VHF (146 MHz):

- Gain = 13.2 dBi
- SNT = 24.73 dBK
- EIRP = 12.95 dBW

Downlink UHF (438 MHz):

- Gain = 16.3 dBi
- G/T = -8.43 dB/K

S – Band Antenna 10m (Malindi)

Downlink (2500 MHz):

- Gain = 45dBi
- SNT = 18.73dBK
- G/T = 26.27 dB/K

Preliminary design: Payload and AOCS

REQUIREMENT	IMPLEMENTATION
Passive optical sensor	Nanocam C1U
Ground resolution < 150 m	47 m @ 500 km
Ten images over Africa per day	1600x1200 , JPEG compression factor 0.5 Data Volume (10 Images): 12 MB
Max 2U allocated for P/L	91.7 x 86.0 x 57.8 mm

Primary payload: commercial NanoCamera for imaging (TRL8). Secondary payload: deorbiting sail, trasponder

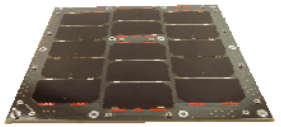
Sensors	Producer
Star Tracker	Hyperion Tech.
Sun Sensors (x2)	SOLARMEMS
Magnetometer	SSBV
Gyros (x3)	-
GPS	(TBD)

Actuators	Producer
Reaction Wheels (x3)	Hyperion Tech.
Torque Rods (x3)	Hyperion Tech.

Attitude control with 3-axes stabilization for good pointing accuracy

Preliminary Design: Data Handling, Comms, Power

- Microcontroller:
  - High performance, low power 32-bit ARM Cortex-M3 based MCU
  - 4-48MHz @ 1.25 DMPIS/MHz
  - Integrated Real-Time-Clock
  - Internal + External Watchdog for added reliability
- Communication:
  - 2 x I2C interface with multi-master capabilities
  - 1 x Debug UART interfqce on eternal header
  - 1 x CAN up to 1Mbps.



1x 6U Solar Array 3J
2x 3U Solar Arrays 3J
1x 6U Solar Array (Silicon)

1x Lithium Polymers Battery
1x NiCd battery pack
1x 3rd Generation EPS
2x 12W BUCK BCRs

Sizing of the subsystems, in order to support the "choice from the shelf"

PAYLOAD DATA

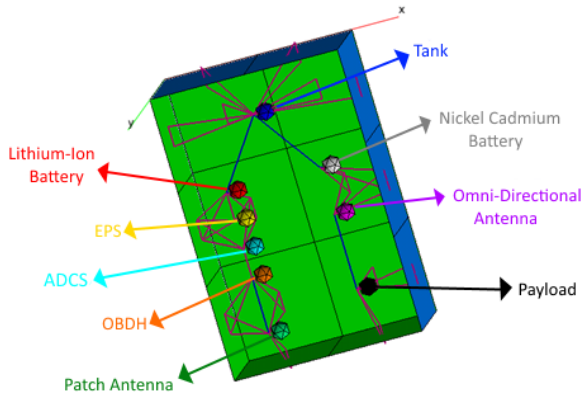
DOWNLINK
BER:10^-5 Eb/N0: 9,6
Modulation: BPSK Margin: 3 dB
Bit rate for Rome: up to 692,16 kbps
Bit rate for Malindi: up to 25,72 Mbps
Maximum data rate selectable from the transmitter: **100 kbps**

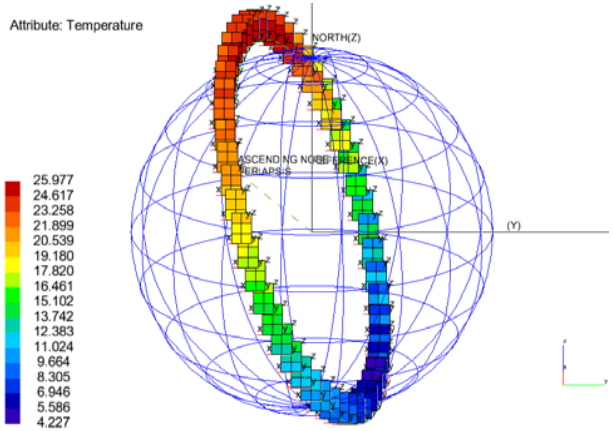
TELEMETRY AND COMMAND

UPLINK
BER:10^-6 Eb/N0: 14
Modulation: FSK Margin: 3 dB
Bit rate for Rome: up to 95,76 kbps
Bit rate for Malindi: up to 95,76 kbps

DOWNLINK
BER:10^-6 Eb/N0: 10,5
Modulation: BPSK Margin: 3 dB
Bit rate for Rome: up to 75,82 kbps
Bit rate for Malindi: up to 75,82 kbps
Data rate selected: **9,6 kbps**

Preliminary Design: Structure and Thermal control





Thermal analyses showed no need for active thermal control

The structure will be optimized to be produced by innovative techniques, e.g. Additive Manufacturing

FIRST NATURAL FREQUENCIES	LAUNCH VEHICLE SPECIFICATION
LONGITUDINAL AXIS	20 Hz ≤ f ≤ 45 Hz or ≥ 60 Hz
LATERAL AXIS	≥ 15 Hz

```
Finite element program ADINA, response range type mode-shape:
Listing for zone WHOLE_MODEL:
   MODE        NATURAL
  NUMBER      FREQUENCY

        1   6.69441E+01
        2   1.41200E+02
        3   3.21259E+02
        4   5.20907E+02
        5   6.05914E+02

*** End of list.
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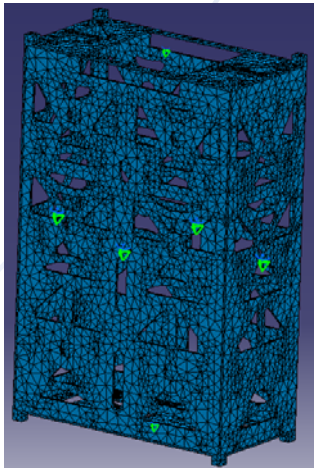

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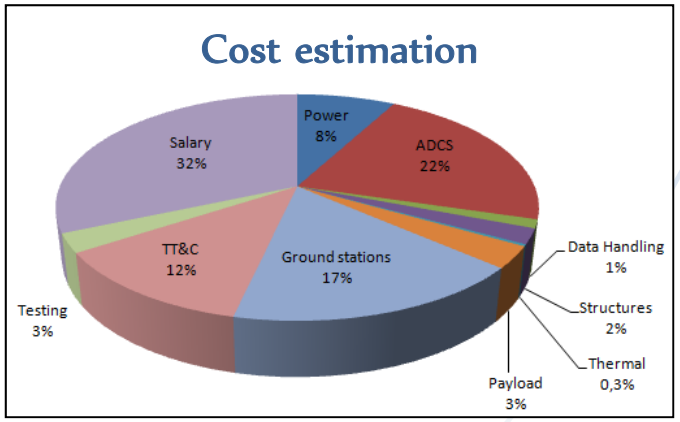
Preliminary Design: high level results

Subsystems	Allocated [kg]	Actual [kg]	Margin [%]
Primary Payload	*0.5*	*0.17*	*5*
Power	*2*	*1.5*	*10*
TT&C	*0.4*	*0.4*	*5*
Structure	*2*	*1.96*	*20*
OBDH	*0.1*	*0.08*	*5*
ACDS	*1*	*0.4*	*5*
Secondary Payload	*3*	*1.5*	*50*
Harness	*0.6*	*0.2*	*50*
Drag Sail	*0.4*	*0.25*	*5*

TOTAL MASS [kg]	
Allocated	10,00
Actual (without margin)	6,46
Actual (with SS margin)	7,92
Actual (with 20% Sys margin)	9,38

Mass budget

Cost estimation

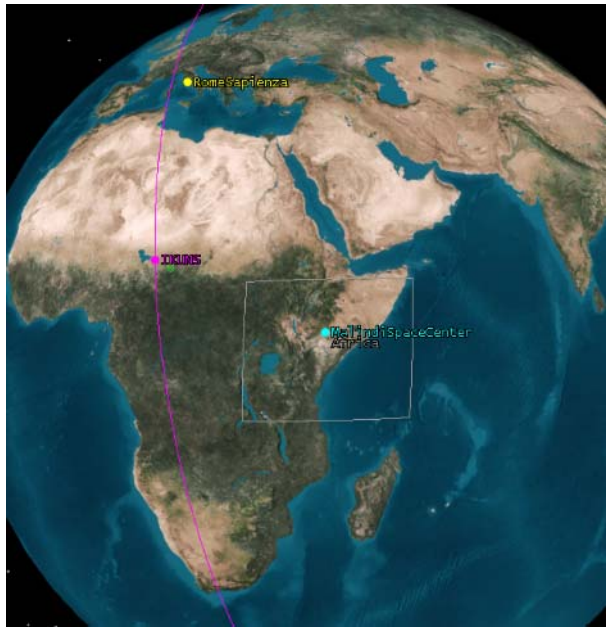


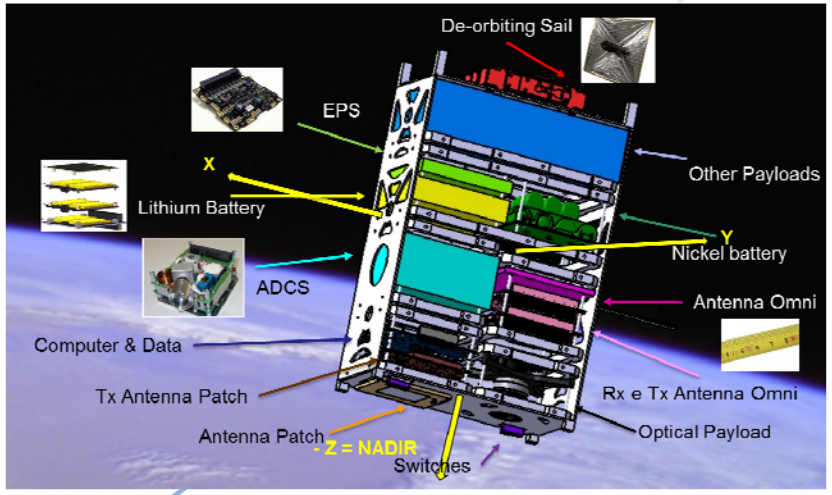
Planning

	PDR			CDR			QR/AR	
	1/16	04/16	07/16	10/16	1/17	4/17	7/17	10/17
Management								
Design								
Testing								
Procurement								
Integration								

IKUNS baseline

- Mission duration: 2 years
- Orbit: Circular Sun-synchronous LEO
  (Height: 500 km, Inclination: 97.4°, LTAN: 0:30:00)
- Size 6U : 300 (h) x 200 (l) x 100 (w) mm
- Mass: 9,38 kg (including margins)
- Main Payload: NANOCAM 1U
- Nominal Attitude: Sun-Pointing
  (Nadir pointing during data acquisition)
- Solar Panels: Body Mounted
- Uplink Band: VHF (Command and tracking)
- Downlink Band: UHF (Telemetry) – S (Payload data)
- Baseline launcher: VEGA
- Drag Sail for deorbiting





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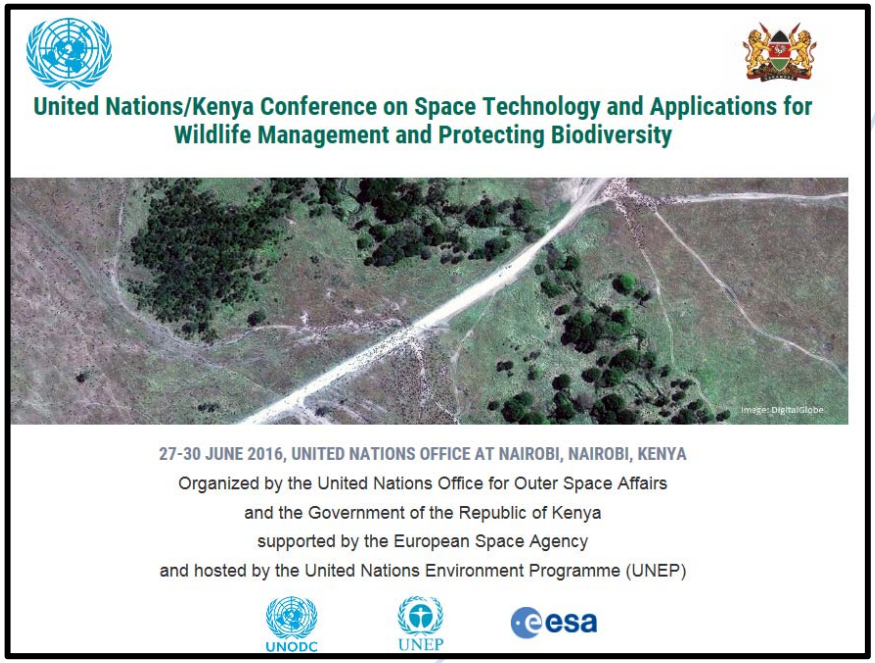
Possible future applications

Small satellite in support of Protecting biodiversity is one of the challenges for the future (as stated in the Resolution adopted by the United Nations General Assembly on 25 September 2015: "Transforming our world: the 2030 Agenda for Sustainable Development", specifically addresses this as the Goal 15).

Possible future application for IKUNS: the paper «Capacity building in space technology by experimental nanosatellite for wildlife monitoring», to be presented in Nairobi at the conference ->



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Conclusions

- Italian Space Agency ASI promotes international cooperation between Italy and Kenya in space sector, starting from academic level
- IKUNS NanoSatellite is a multipurpose program, with fine scientific and technological goals but also strong educational impacts
- A preliminary mission assessment has been implemented at ASI Concurrent Engineering Facility, by the first student team of La Sapienza;
- Preliminary Design Review is expected in July 2016; possible mission baseline update will be performed by joined team.

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Thank you

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

simone.pirrotta@asi.it

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