Detriti spaziali e realizzazione di nanosatelliti

Fabrizio Piergentili

Attività Principali

❖ **Sorveglianza Spaziale**

- Gestione campagne osservative
- Analisi dati
- Determinazione di orbita e assetto
- Sistemi di mitigazione/rimozione

❖ **Satelliti**

- Progetti in corso:
  - URSA MAIOR
  - IKUNS→1KUNS
  - Eaglet
  - LedSat

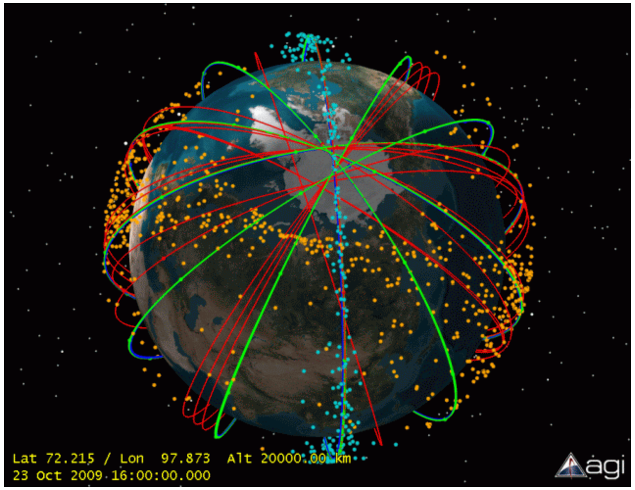
❖ **Sistemi Aerospaziali**

- Impianti di bordo di aeromobili
- Torre di controllo vitrtuale

❖ **Didattica**

- Esperimenti razzi e palloni stratosferici
- CanSat

Sorveglianza spaziale



I Detriti Spaziali

*"Space debris are all **man-made objects**, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are **non-functional** with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be author"*

(Technical Report on Space Debris in 1999 by
UN/COPUOS/STSC
United Nations Committee on the Peaceful Uses of Outer Space)

Debris size and effect on spacecraft can be grouped into the following categories:

(1) Debris less than 0.01cm - Causes surface pitting and erosion, which may have significant effect on the spacecraft after long exposures.

(2) Debris 0.01cm to 1cm - Causes significant impact damage, which can be serious depending on spacecraft system design.

(3) Debris larger than 1cm - Causes significant damage and may cause the catastrophic loss of the spacecraft.

(4) Larger Debris can hit ground

[NSTCC 1995]The National Science and Technology Council Committee on Transportation Research & Development, " Interagency Report on Orbital Debris 1995

Rientri

“The likelihood of getting hit by one of those fragments is much lower than being hit by lightning.”

Rientro satellite UARS

LA STAMPA.it BLOG DEI GIORNAL

ATTUALITÀ | OPINIONI | ECONOMIA | SPORT | TORINO | CULTURA | SPETTACOLI | MOTORI | DONNA | CUCINA

HOME | POLITICA | ESTERI | CRONACHE | COSTUME | TECNOLOGIA | SCIENZA | AMBIENTE | LAZAMPA | I

ME NE VADO NELLO SPAZIO

Roberto Giovannini

Consiglia 318 · Tweet 15 · +1 1

21/9/2011 - CONVOCATA UNA RIUNIONE TRA PROTEZIONE CIVILE E AGENZIA SPAZIALE ITALIANA

UARS, satellite in rientro a Terra Qualche frammento sull'Italia?

MEDIASET TGCOM 24

HOME | CRONACA | POLITICA | MONDO | ECO

Casa | Assicurazioni | Mutui | Pres...

MONDO ORA PER ORA

LE NOTIZIE DEL GIORNO

Protesi Pip, rilasciato produttore
27.1.2012 - ore 08.30

Attentato a Baghdad, 28 morti
27.1.2012 - ore 10.31

Siria, Unicef: 384 bambini uccisi
27.1.2012 - ore 14.19

22.9.2011

Satellite Nasa verso la terra: forse frammenti pioveranno anche sulle regioni del Nord Italia

Uars entrerà nell'atmofera venerdì e l'impatto con il nostro pianeta è previsto in serata

FOTO AP/LAPRESSE

22:42 - I frammenti del vecchio satellite della Nasa, che venerdì entrerà nell'atmosfera terrestre, potrebbero cadere sulle regioni del nord d'Italia. Secondo le simulazioni degli scienziati che stanno analizzando la traiettoria del satellite, l'impatto potrebbe avvenire tra le 21.25 e le 22.03 di venerdì.

Il vecchio satellite della Nasa si distruggerà nel momento in cui entrerà a contatto con l'atmosfera del nostro pianeta. La zona di caduta viene individuata in un'area di 200 chilometri che sarà via via ristretta con il passare delle ore.

Analogamente, per l'Italia le probabilità di caduta dei frammenti spaziali si sono ridotte dallo 0,9% allo 0,6%, lasciando aperta una sola "finestra" temporale possibile (inizialmente erano due), tra le 21.25 e le 22.03 di venerdì.

CORRELATI

PROTEZIONECIVILE.IT quotidiano on-line indipendente

Home » Attualità

Rientro del satellite UARS: continua il monitoraggio

Tutte le Regioni interessate hanno attivato le proprie strutture operative. La previsione di rientro è centrata intorno alle 19:20 di questa sera; a rischio (anche se la probabilità è molto bassa) il Nord Italia

Articoli correlati

Giovedì 22 Settembre 2011

Rientro del satellite UARS: le indicazioni della ProCiv

tutti gli articoli »

Venerdì 23 Settembre 2011 - Attualità -

Continuano ad arrivare informazioni sul **rientro del satellite UARS della NASA.** Nell'aggiornamento di ieri sera, il Comitato tecnico scientifico ha modificato lo scenario prospettato precedentemente: sulla base degli ultimi dati disponibili sia sullo stato orbitale che sull'attività solare prevista - spiega il Dipartimento in una nota - **la previsione di rientro è centrata intorno alle 19:20 di questa sera, con una finestra di incertezza che si apre alle 14 di oggi e si chiude alle 3 del 24 settembre.**

All'interno di questo arco temporale **non è ancora possibile escludere la remota possibilità (aumentata fino all'1,5%) che uno o più frammenti del satellite possano cadere sul territorio italiano.** Una novità nell'aggiornamento di ieri sera riguarda la traiettoria che potrà interessare l'Italia, in due finestre temporali: la prima compresa **tra le 21:25 e le 22:03**, la seconda **tra le 3:34 e le 4:12** L'area a rischio è stata ridotta, e riguarda le regioni Piemonte, Valle d'Aosta, Liguria e Lombardia, le Province Autonome di Trento e Bolzano, parzialmente l'Emilia Romagna (Parma e Piacenza), il Veneto (Verona, Vicenza, Belluno, Treviso) e il Friuli Venezia Giulia (Pordenone e Udine).

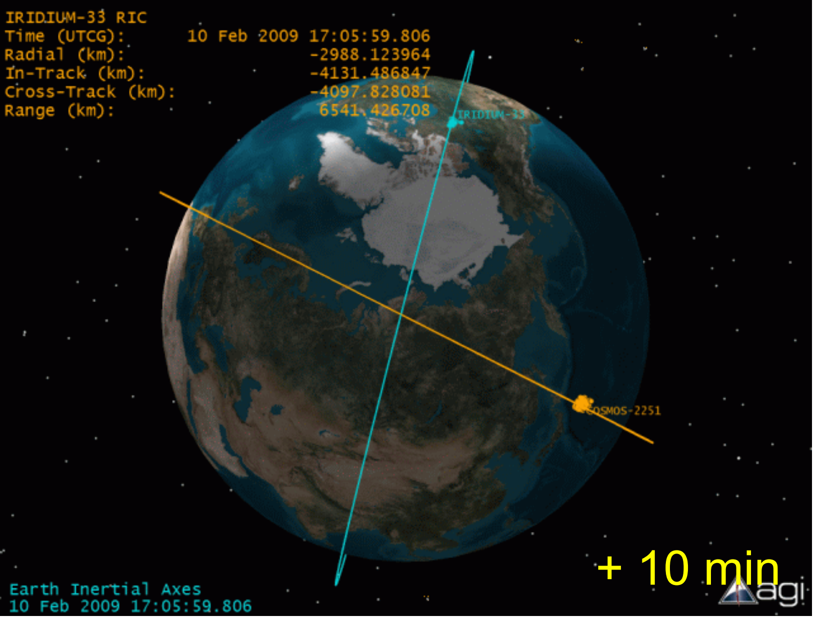
Collisioni ed esplosio

Table 1. Top 10 Breakups, January 2016

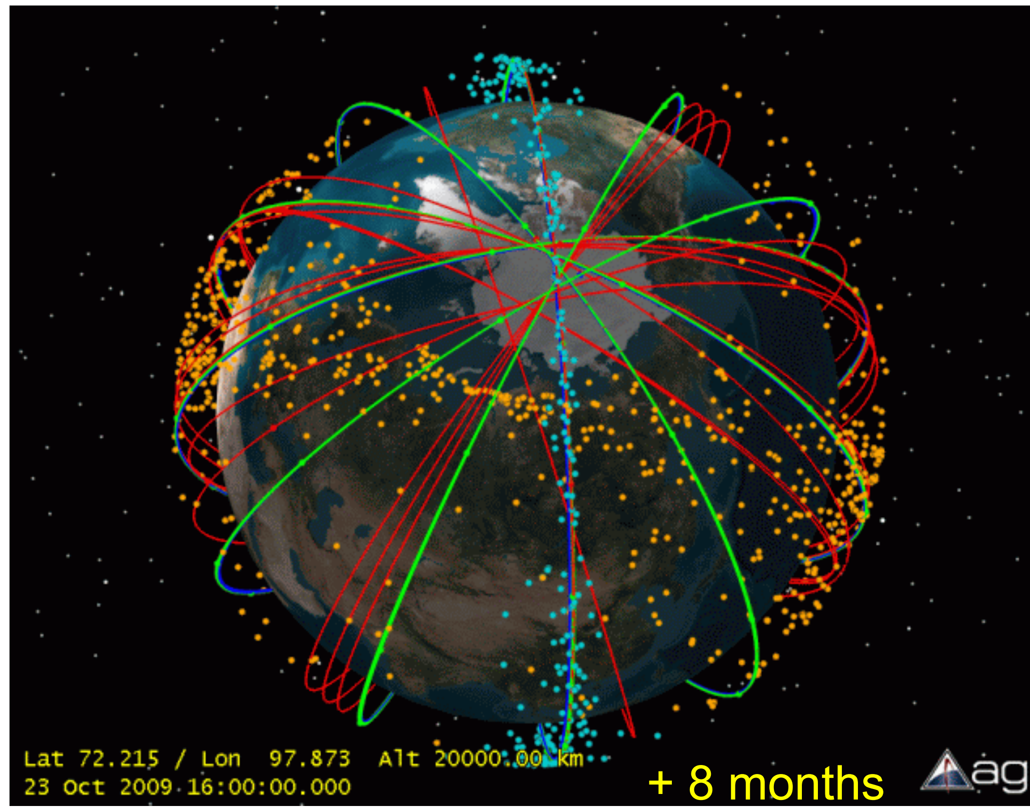
Rank	International Designator		Common Name	Year of Breakup	Altitude of Breakup	Cataloged Debris	Debris in Orbit	Assessed Cause of Breakup
1	1999	25	Fengyun-1C	2007	850	3428	2880	intentional collision
2	1993	36	Cosmos 2251	2009	790	1668	1141	accidental collision
3	1994	29	STEP-2 Rocket Body	1996	625	754	84	accidental explosion
4	1997	51	Iridium 33	2009	790	628	364	accidental collision
5	2006	26	Cosmos 2421	2008	410	509	0	unknown
6	1986	19	SPOT-1 Rocket Body	1986	805	498	32	accidental explosion
7	1965	82	OV2-1 / LCS 2 Rocket Body	1965	740	473	33	accidental explosion
8	1999	57	CBERS 1 / SACI 1 Rocket Body	2000	740	431	210	accidental explosion
9	1970	25	Nimbus 4 Rocket Body	1970	1075	376	235	accidental explosion
10	2001	49	TES Rocket Body	2001	670	372	80	accidental explosion
						9137	**5059**	

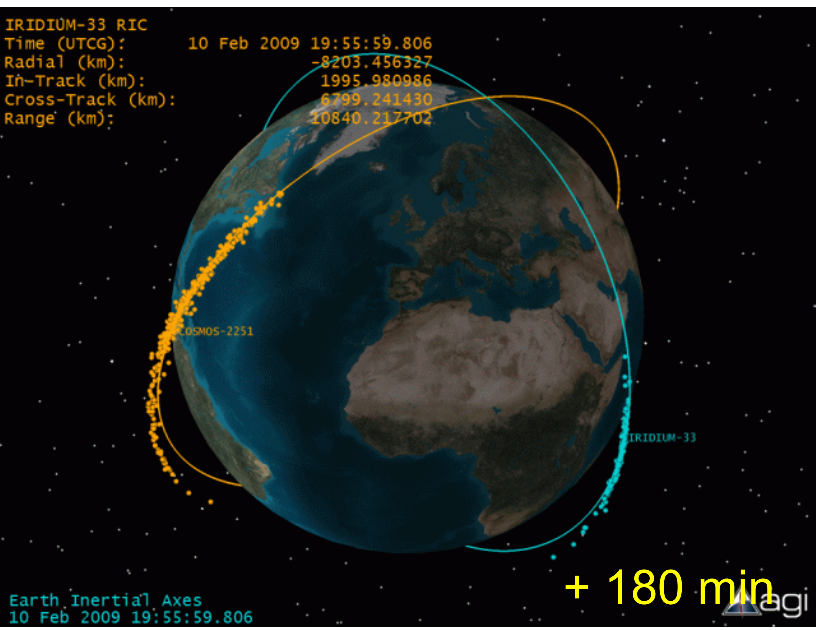
* as of 04 January 2016

Orbital Debris Quarterly News, Vol. 20, Issues 1&2, April 2016

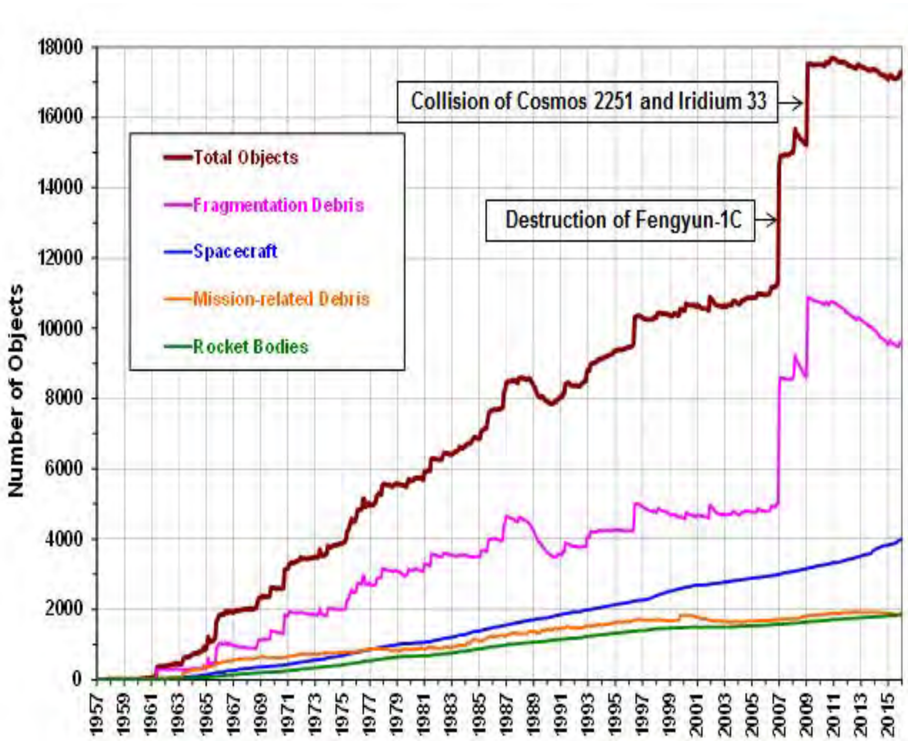


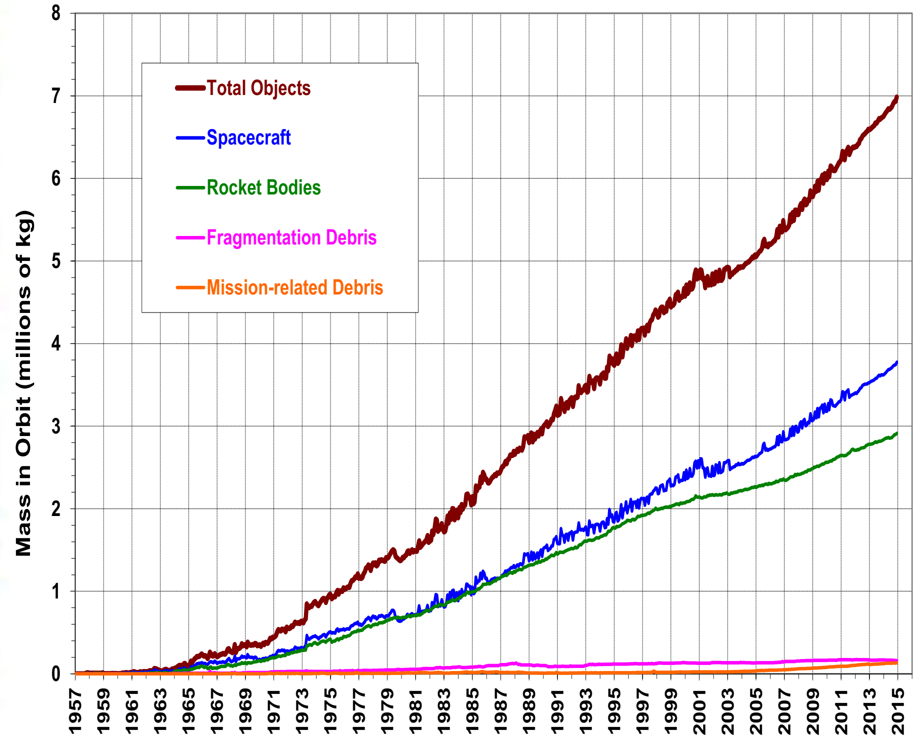
Cosmos Iridium collision





Presente e Futuro dei detriti spaziali





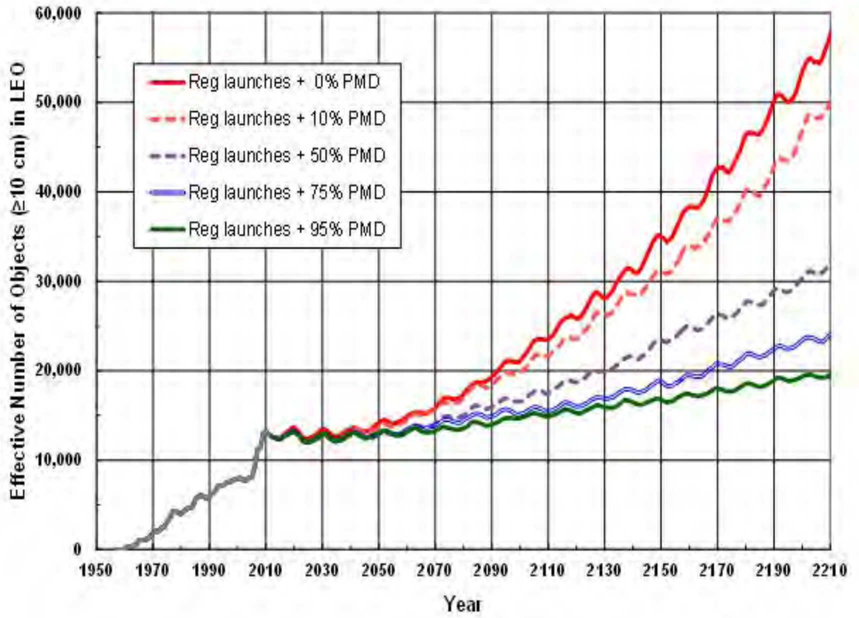
C. R. Englerta, J. T. Baysb, K. D. Marrc, C. M. Browna, A. C. Nicholasa, T. T. Finnea, Optical orbital debris spotter, Acta Astronautica, Volume 104, Issue 1, November 2014, Pages 99–105

The **Kessler syndrome**, proposed by the NASA scientist Donald J. Kessler in 1978, is a scenario in which the density of objects in low Earth orbit (LEO) is high enough that collisions between objects could cause a cascade—each collision generating space debris which increases the likelihood of further collisions. One implication is that the distribution of debris in orbit could render space exploration, and even the use of satellites, unfeasible for many generations.

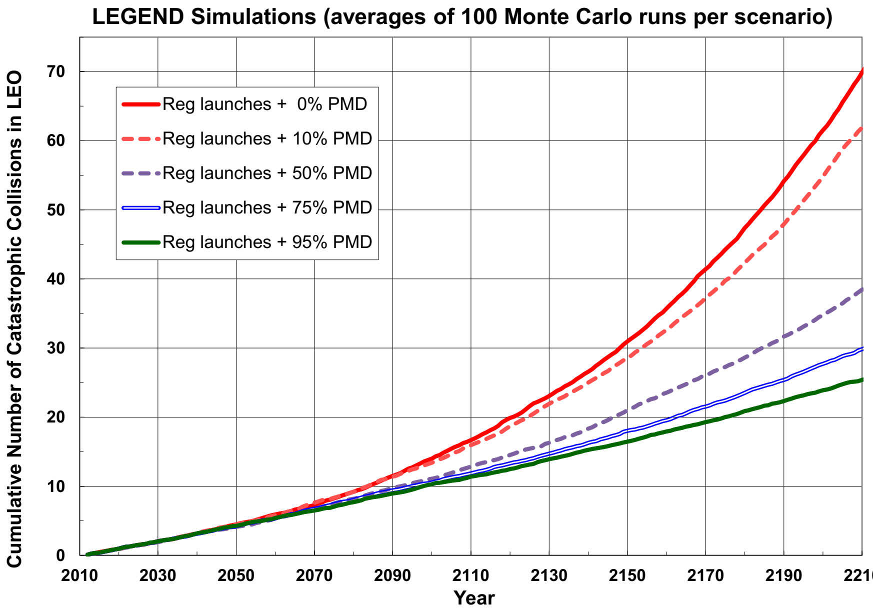
Long-Term Sustainability of Activities in Outer Space

Has the current debris population in the LEO region reached the point where the **environment is unstable** and collisions will become the most dominant debris-generating mechanism in the future?

The answer is yes. Even without new launches, collisions will continue to occur in LEO over the next 200 years, primarily driven by the high collision activities in the region between 900 and 1000 km altitudes, and force the debris



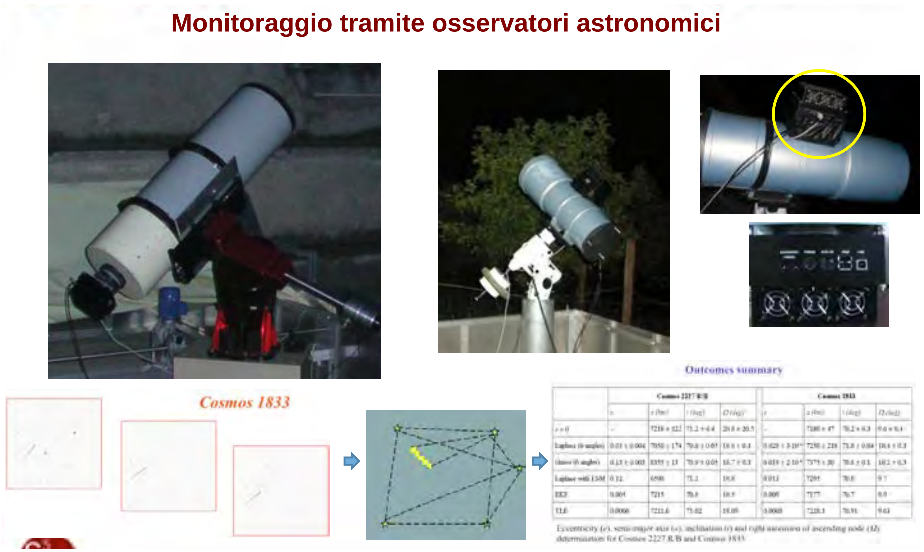
Effective Number of Objects ≥10 cm in LEO vs. year (NASA LEGEND model simulations average of 100 Monte Carlo runs per scenario). The periodic variations on the projection region are due to the solar cycle

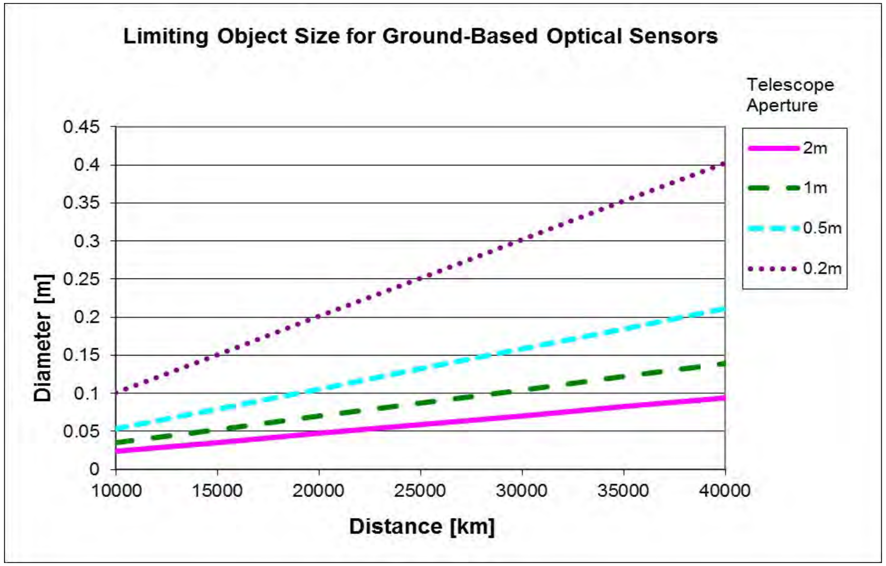


Cumulative number of Catastrophic Collisions (E>40 J/gr) as a function of time (NASA LEGEND model simulations averaged of 100 Monte Carlo runs per scenario).

Contromisure:

- Linee Guida mitigazione (disposal, Mission related objects,…)
- Missioni di rimozione attiva
- <u>*Sorveglianza e collision avoidance*</u>



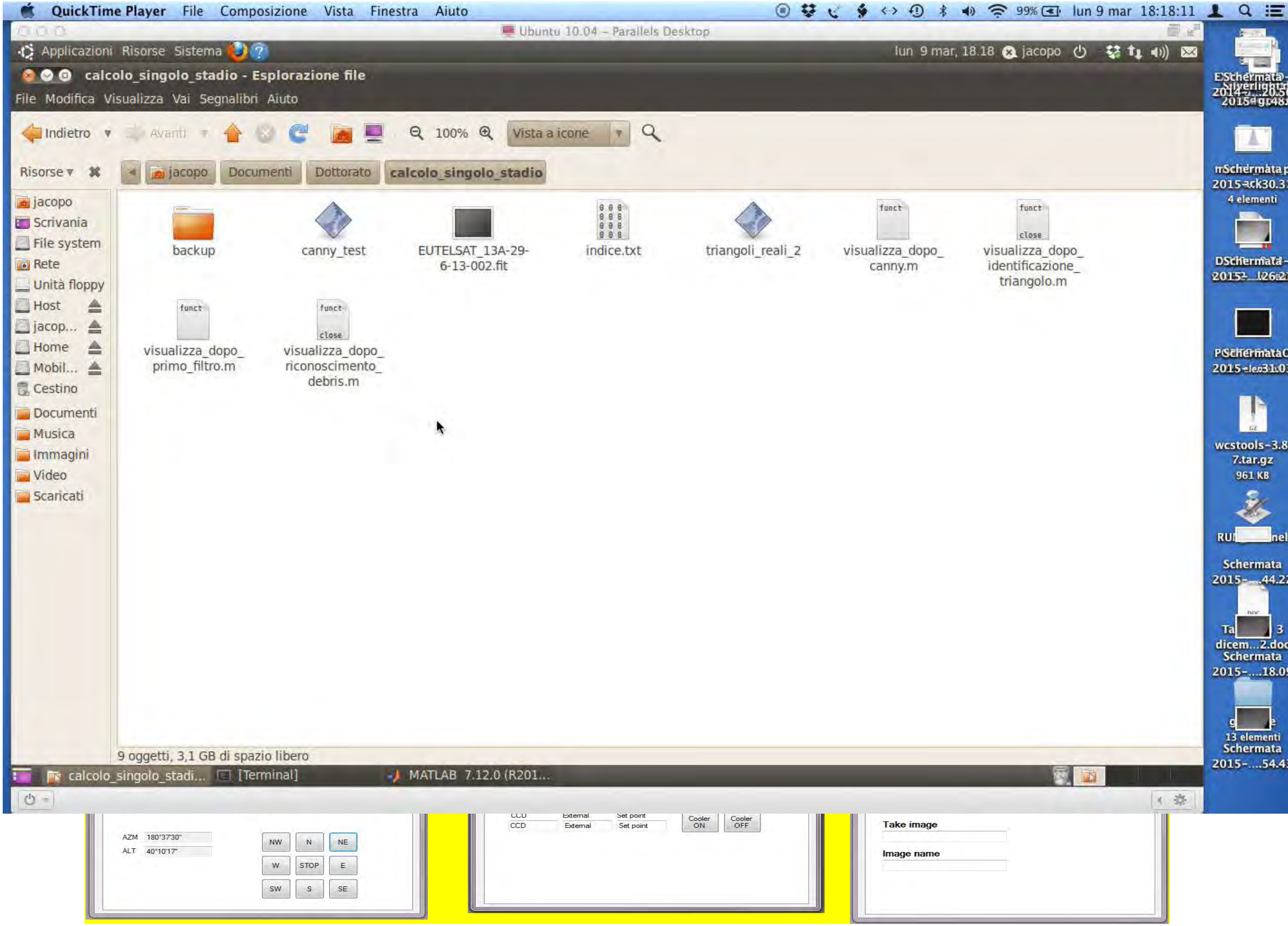


IAA- SG 5-14 Situation Report on Space Debris
Compilation of inputs on September 18th , 2016

Network osservatori

Attività di ricerca nel campo dei detriti spaziali al DIMA:

- **Sviluppo di sistemi per la gestione delle campagne osservative (ASI-INAF, ESA)**
- **Progettazione strumentazione per osservazione e mitigazione (NPC-Spacemind)**
- **Fotometria, Spettrometria, Ricostruzione dell'assetto di oggetti in orbita da misure fotometriche (University of Michigan, Inter Agency Space Debris Committee)**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Ubuntu 10.04 – Parallels Desktop
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9 oggetti, 3,1 GB di spazio libero
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[Terminal]
MATLAB 7.12.0 (R201...
wcstools-3.8.7.tar.gz
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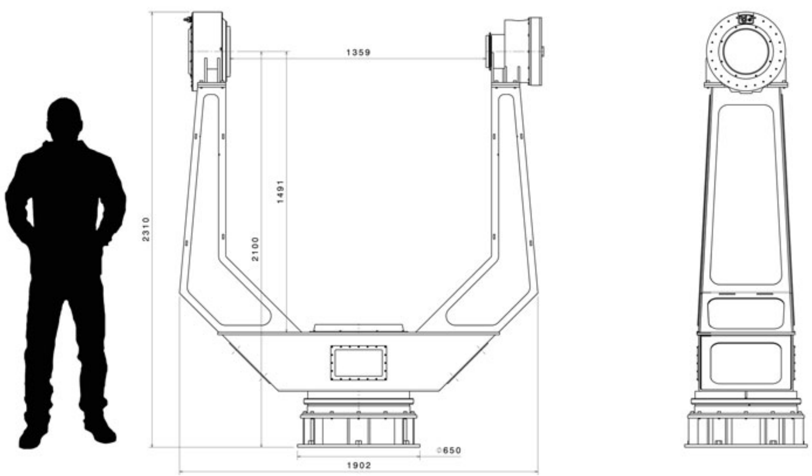
CCD External Set point
Cooler ON
Cooler OFF
Take image
Image name

Progettazione strumentazione per osservazione e mitigazione (NPC-Spacemind)

MORAL

1 m class Alt-Az mount

Maximum telescope weight: 500 kg
Ultimate telescope weight: 1000 kg
Distance between support plates: 1410 mm
Lightweight: overall weight 700 kg
Maximum speed: >30° deg/sec (up to 45 deg/sec currently tested)
Angle measurement resolution directly on the axes: 0,01 arcsec
High torque direct drive motors
ASCOM compliant communication protocol
First quality industrial standard components
Unlimited rotation in azimuth
Optimized design using aerospace derived analysis methods



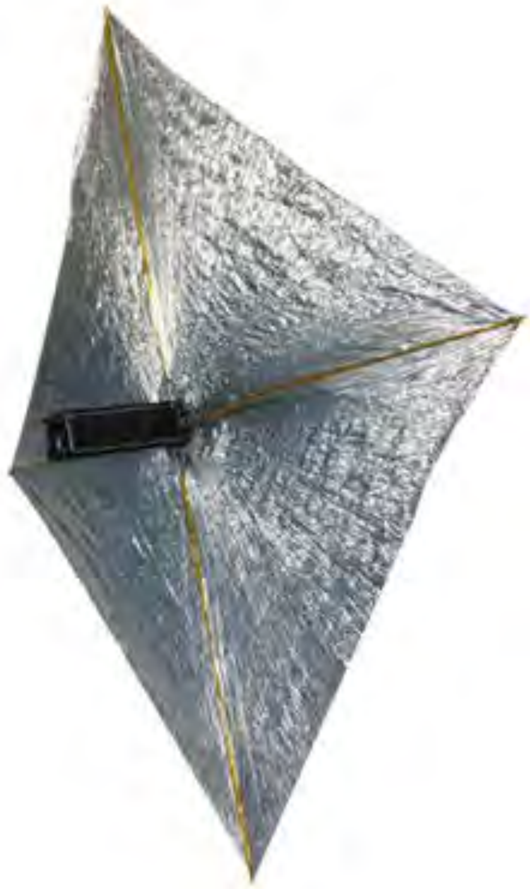
Progettazione strumentazione per osservazione e mitigazione (NPC-Spacemind)

ARTICA

(Aerodynamic Reentry Technology In Cubesat Application) is a deorbiting system based on a deployable

ARTICA spec:

2,1 m2 drag sail
25 years IADC guidelines respected for all common Cubesat orbits
Stand alone Plug&Play system
Low mass, low volume device (0,3U)
Sustainable for 1U
Easy adaptable structural interface
Autonomous kill switches integrated
Autonomous RBF integrated
Autonomous PWR supply /temporized circuit
External redundant opening signal redundancy
External redundant opening connector: power peak 2W @ max 30 sec.



Fotometria, Spettrometria, Ricostruzione dell'assetto di oggetti in orbita da misure fotometriche
(University of Michigan, Inter Agency Space Debris Committee)

- Instruments used to collect data:
  - 0.6-m MODEST (Chile)
  - 6.5-m Magellan (Chile)
  - 1.5-m Loiano Observatory (Italy)
- **Photometry and spectrometry** as possible indication origin of the debris
- Study of **brightness variability** as possible indication of rapid changes in attitude of GEO object, performed analysis to process data of GEO object trailed across the field of view
- **Attitude reconstruction** using joint photometric measurements.

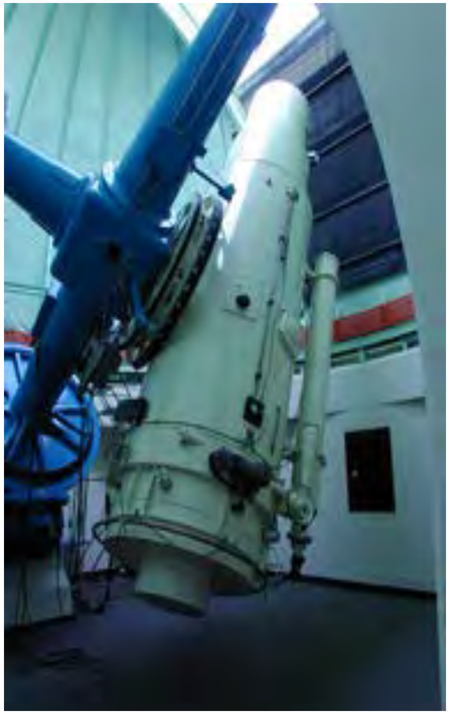
Campagne di identificazione oggetti High Area to Mass Ratio (University of Bern, Michigan University, ISON, Applied Defense)

Objects with high area-to-mass ratios (HAMR) in high-altitude orbits were first discovered in 2004. The orbits of these objects had semimajor axes near the nominal value of geosynchronous objects but eccentricities considerably different from zero [*Schildknecht et al. . Optical observations of space debris in high-altitude orbits, "Proceedings of the Fourth European Conference on Space Debris", 2005*]

↓

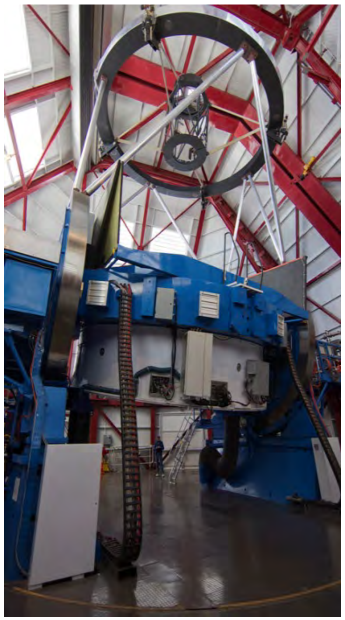
Analisi spettrofotometrica di oggetti in GEO per la determinazione delle caratteristiche fisiche di tali oggetti
[*Cardona, Seitzer, Rossi, Piergentili, Santoni BVRI Photometric Observations and Light-Curve Analysis of GEO Objects, Article in Advances in Space Research 58(4) · May 2016]*

0.6-m MODEST (Chile)



Detector	Single E2V thinned backside illuminated
Array	4112x4096 pixels
Quantum Efficiency	90% @ 650 nm
Pixel size	15 micron
Pixel scale	1.45 arc-sec/pixel
Field of View	1.6°x1.6°
Read-out time	16 sec

6.5-m Magellan (Chile)



Detector	LDSS-3
Array	2600x2600 pixels
Quantum Efficiency	93% @ 650 nm
Pixel size	15 micron
Pixel scale	0.189 arc-sec/pixel
Field of View	8.3’x8.3°
Read-out time	16 sec
Operating	

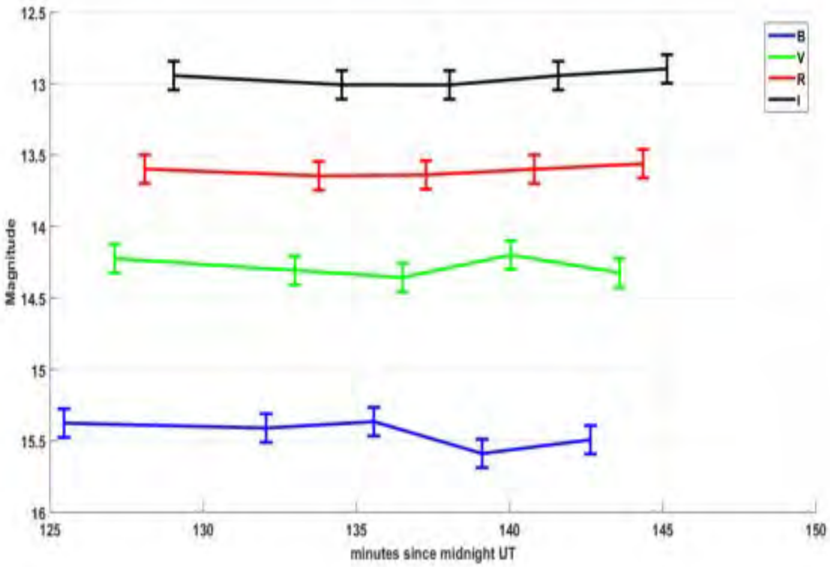
1.5-m Loiano Observatory (Italy)

Detector	EEV LN/1300-EB/1
Array	1300x1340 pixels
Quantum Efficiency	80% @ 500 nm 32% @ 900 nm >50% @ 300 nm
Pixel size	20x20 micron
Pixel scale	0.58 arc-sec/pixel
Field of View	13'x12.6'
Read-out time	18 sec @ 100 KHz

Photometry

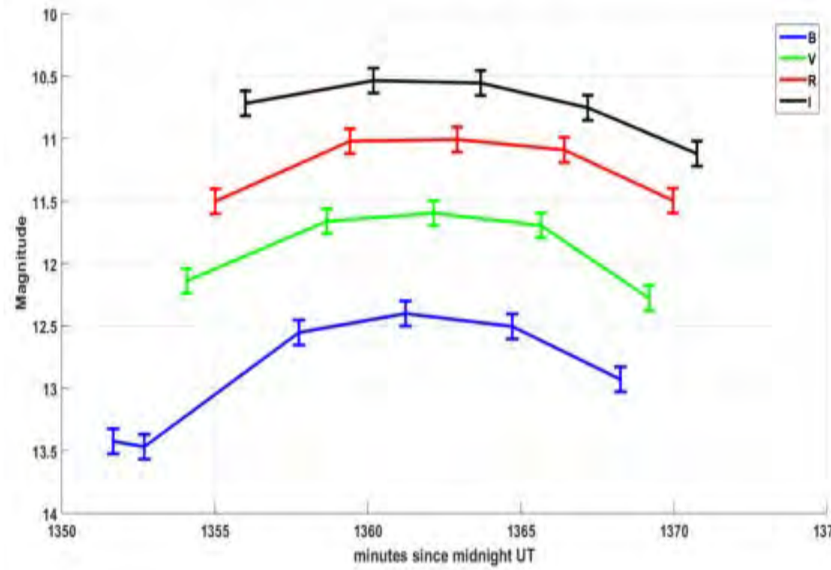
- The most fundamental information we can measure about orbiting objects is the amount of energy (flux), in the form of electromagnetic radiation, that is reflected by orbiting object.
- Orbital debris do not have a constant brightness, they give off flashes at typically regular times caused by the **tumbling motion of the object**.
- The metallic surfaces act as mirrors for the sun (specular reflection).
- By using BVRI photometric observations of objects at GEO, **give information on the surface characteristics and attitudes of the targets**.
    - Comparing photometry data with laboratory sample results gives **hints on the physical composition** of the GEO targets and hence, possibly the origin of the targets.

Photometry



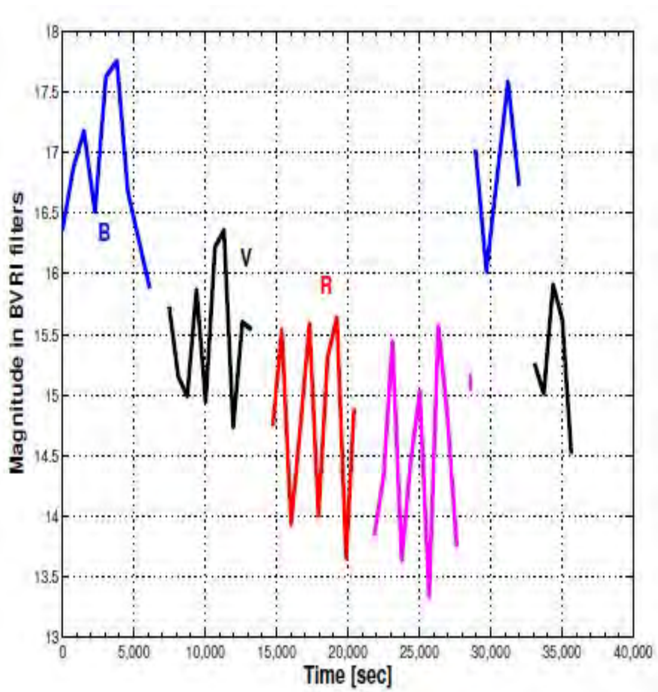
Meteosat8 (SSN 27509)

SL-12 R/B (SSN 38104)



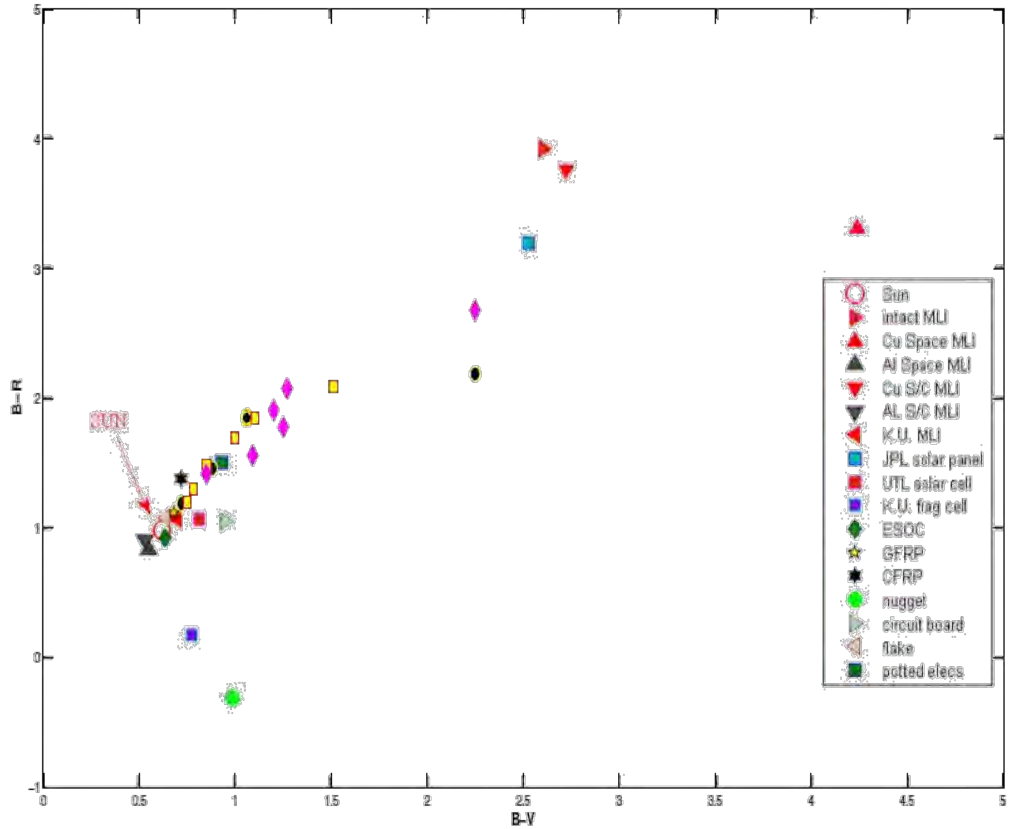
Cardona, T., Seitzer, P., Rossi, A., Piergentili, F., & Santoni, F. (2015). BVRI photometric observations and light-curve analysis of GEO objects. Advances in Space Research. DOI: 10.1016/j.asr.2016.05.025

Photometry



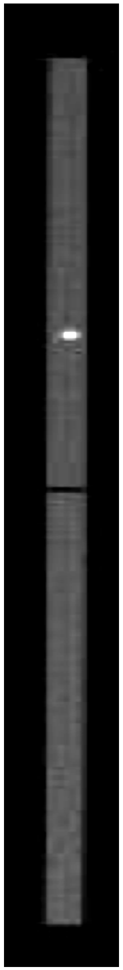
HAMR object

Comparison between real data ♦ and laboratory analysis



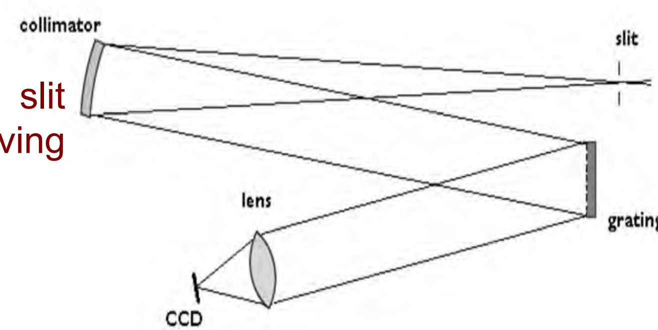
** A. Rossi, S. Marinoni,* ***T. Cardona****, E. Dotto, F. Santoni, F. Piergentili, "Physical characterization of objects in the GEO region with the Loiano 1.5m telescope", 6th European Conference on Space Debris, ESA/ESOC, Darmastad/Germany, 22 April 2013.*

Spectrometry

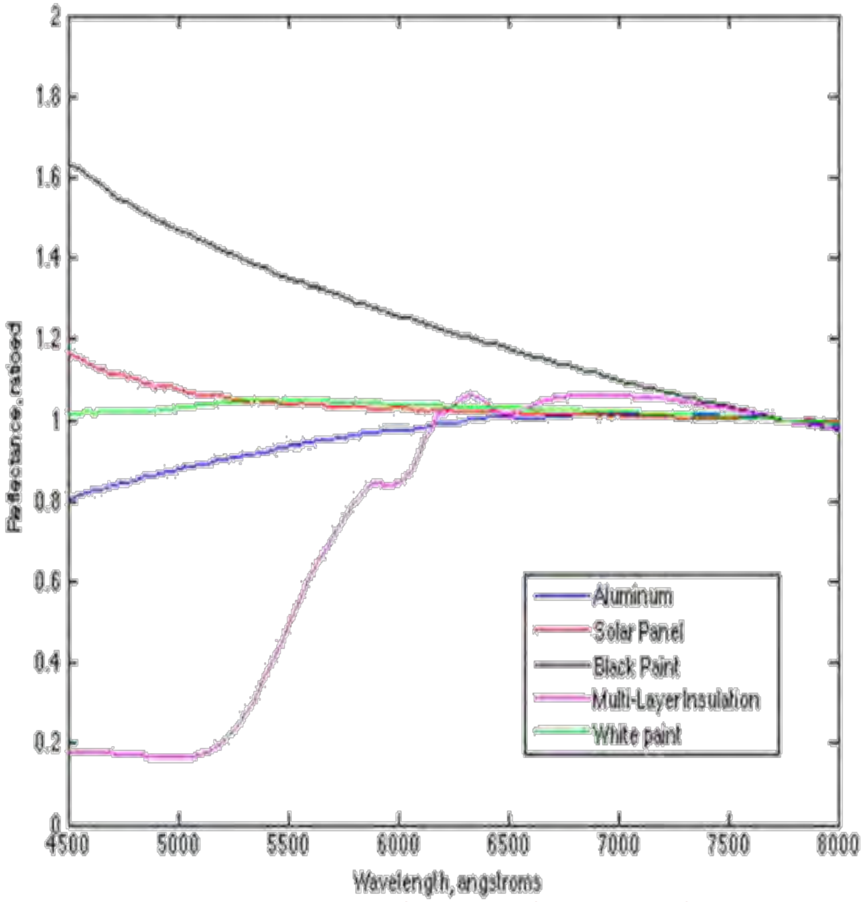


- Permits to determine the chemical compositions, physical properties, and radial velocities of astronomical sources.
- If we can measure the flux in small wavelength intervals, we start to see that the flux is quite irregular on small wavelength scales.
- This is connected to the interaction of light with the atoms and molecules in the object. By studying these “bumps and wiggles” in the flux as a function of wavelength, **it is possible to understand what the object is made of**.

- It is mandatory to keep the object inside the slit (widest 2 arcsec) for at least 4 minutes, by moving the telescope with Non Sidereal Tracking.



Spectrometry



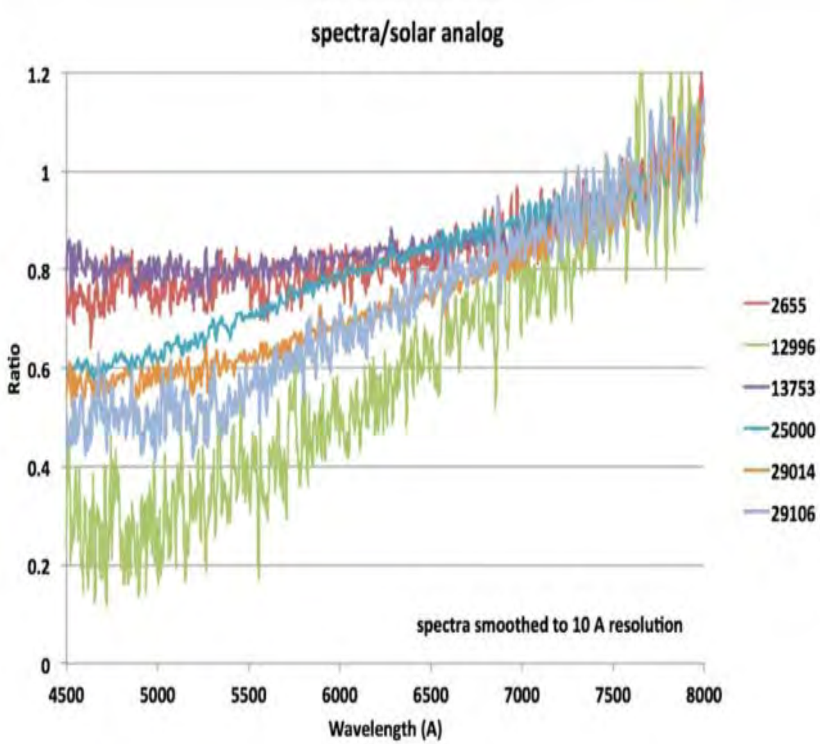
Sample materials are analyzed in laboratory in order to obtain a value to compare the obtained data.

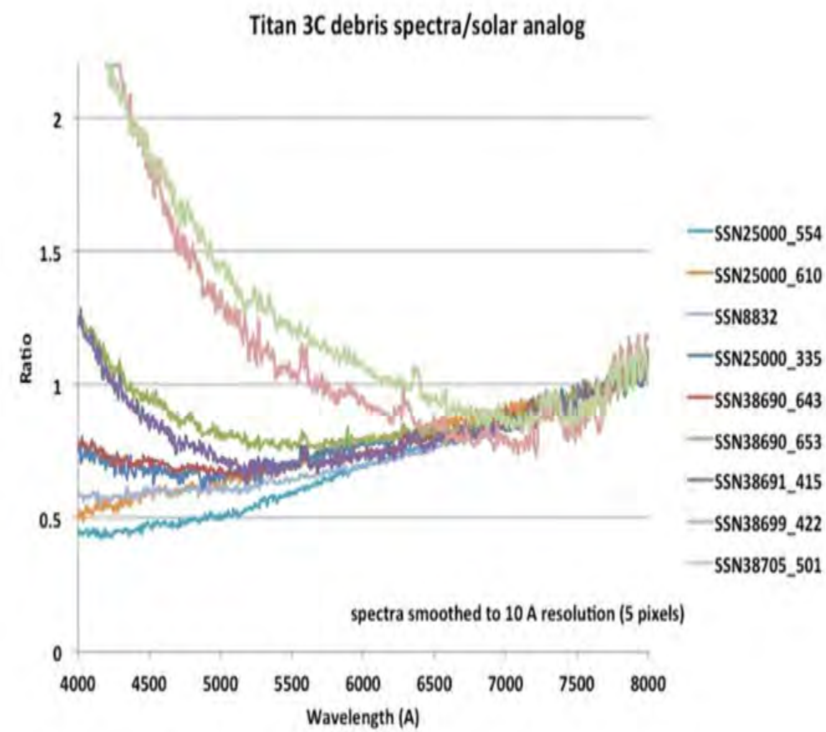
Several problems:

- During exposures of we are seeing complex structures and not a simple surface during our 30 second exposure
- The object is rapidly tumbling and presenting multiple surfaces towards us during the exposure
- Phase angle differences discussed above
- Space weathering effects of surfaces with time

K. J. Abercromby, J. Rapp, D. Bedard, P. Seitzer, T. Cardona, H. Cowardin, E. Barker, S. Lederer, “Comparisons of a Constrained Least Squares Model versus Human-in-the-loop for Spectral Unmixing to Determine Material Type of GEO Debris”, Sixth European Conference on Space Debris, Darmstadt- Germany 22-25 April 2013

Spectrometry





P. Seitzer, T. Cardona, S. M. Lederer, H. Cowardin, K. J. Abercromby, E S. Barker, D. Bedard, “Optical Reflection Spectroscopy of GEO Objects”, 64rd International Astronautical Conference: 23-27 September 2013 Beijing, China

Brightness variability of GEO objects

Active satellites at GEO are typically attitude controlled. This control ceases in the case of loss of control, or when the satellite is moved to a graveyard orbit, and decommissioned. When one of these occurs, how does the attitude change with time?

- **Rapid changes in brightness are investigated as possible implication of rapid changes in attitude.**
- Observations are obtained while the **telescope is tracking at the sidereal rate**, and the **GEO object is trailed across the field of view**.
- Analysis of intensity changes along the trail reveals the primary frequencies of the object's brightness variations on time scales of a second or less.
- Minimum change : (seeing disk/rate) ~ 2 arcsec FWHM/15"/sec ~ 0.13 seconds ~ 7 Hz
- Maximum change: MODEST ~ 0.03 Hz - Loiano ~ 0.05 Hz

Ricostruzione dell'assetto di oggetti in orbita da misure fotometriche (University of Michigan, Inter Agency Space Debris Committee)

- The used observatory are:
  - MODEST
  - 1.3-m U.S. Naval Observatory Flagstaff Observatory (Arizona, USA)
- The target: GSAT3

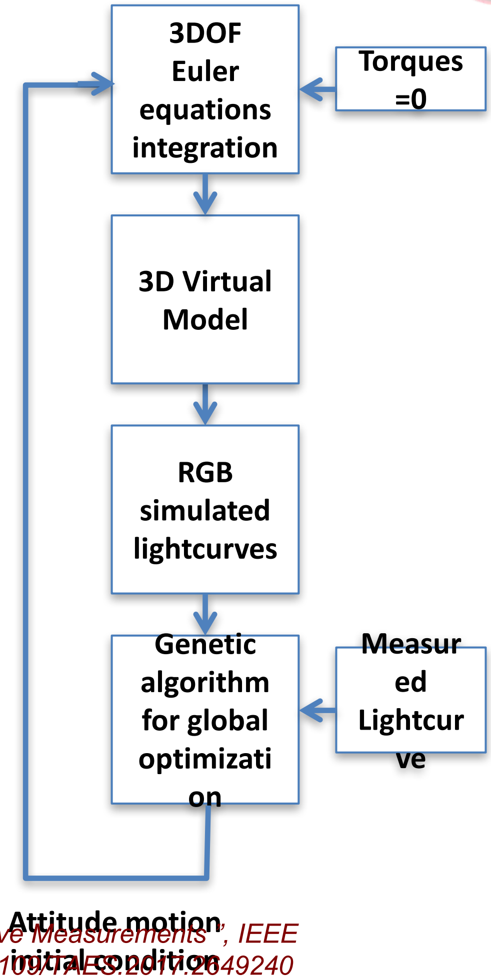
Nation:	India
Type / Application:	Experimental Communication
Configuration:	I-2K bus
Propulsion:	LAM
Power:	2 deployable solar arrays, batteries
Lifetime:	7 years (launch date 20.09.2004)
Mass:	1950 kg (820 kg dry)
Orbit:	GEO

Piergentili, F., Santoni, F., Seitzer, P., "Attitude Determination of Orbiting Objects from Lightcurve Measurements ", IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

Satellite motion analysis through virtual model

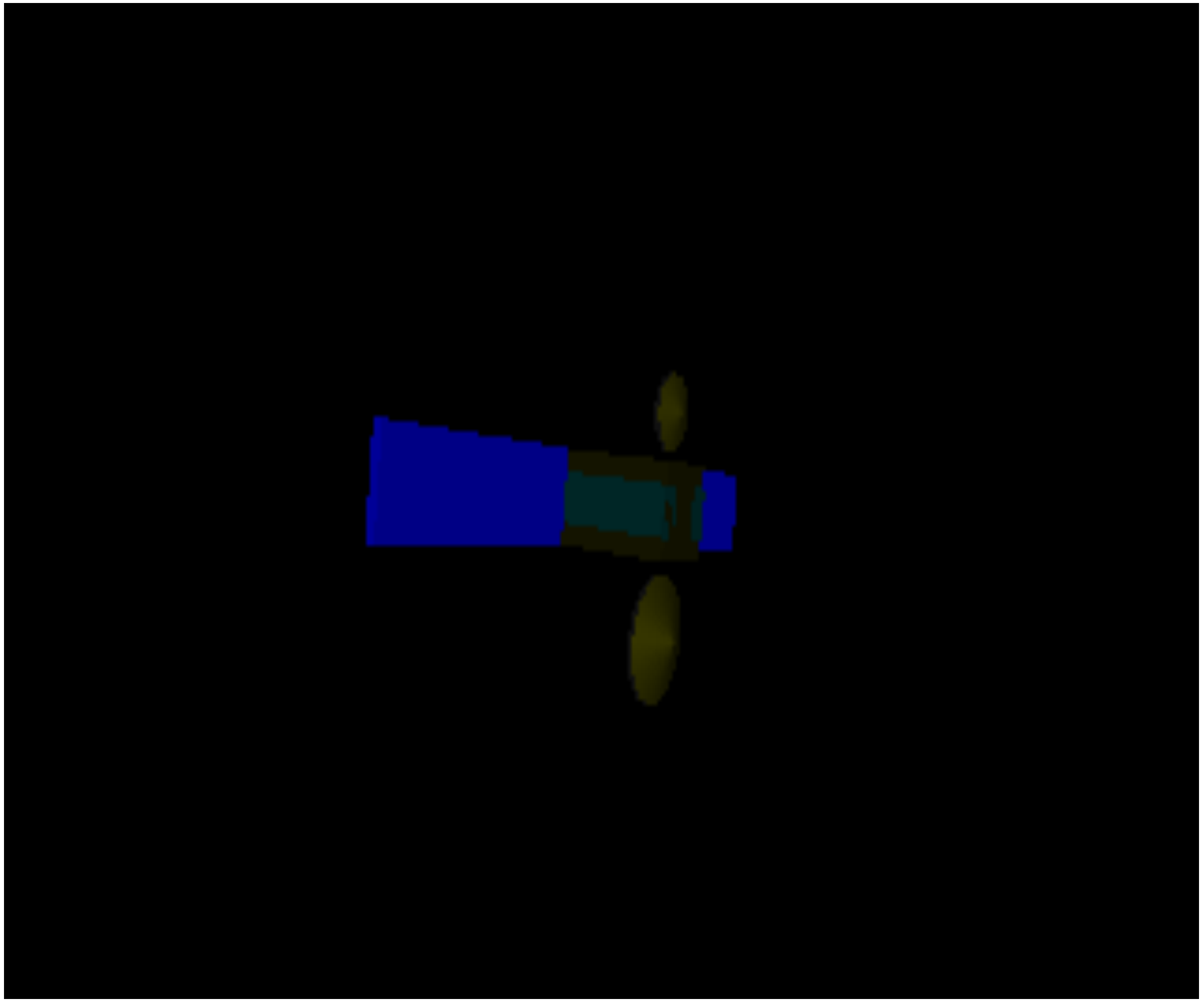
The three main parts of the system are:

- 3D virtual world which permits to simulate the satellite and to reproduce its lightcurve based on effective observation geometry (observer, satellite, Sun)
- Attitude motion propagator which implements the free rigid body rotation on the basis of initial conditions
- Minimization of residuals, obtained comparing the real and simulated lightcurve, through a global optimization tool based on genetic algorithms



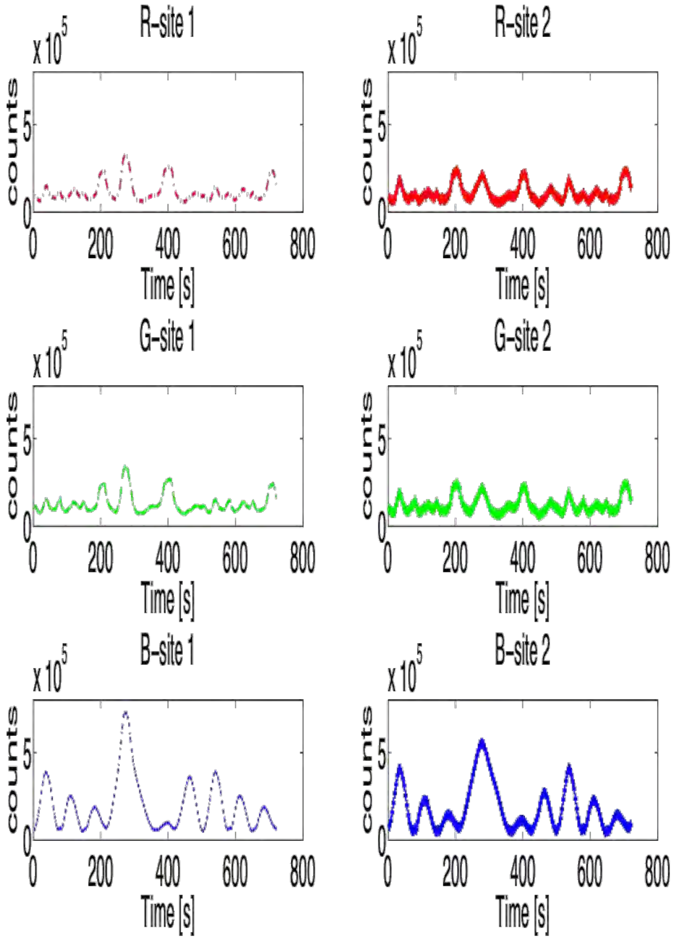
Piergentili, F., Santoni, F., Seitzer, P., "Attitude Determination of Orbiting Objects from Lightcurve Measurements", IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

The GSAT 3 model



Piergentili, F., Santoni, F., Seitzer, P., “Attitude Determination of Orbiting Objects from Lightcurve Measurements ”, IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

Simulated RGB lightcurves

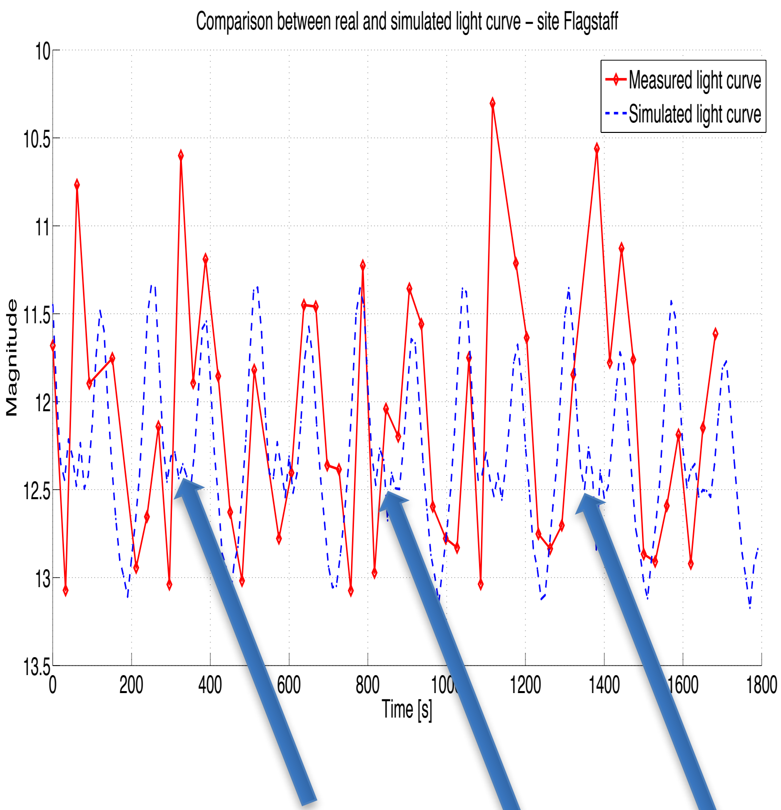


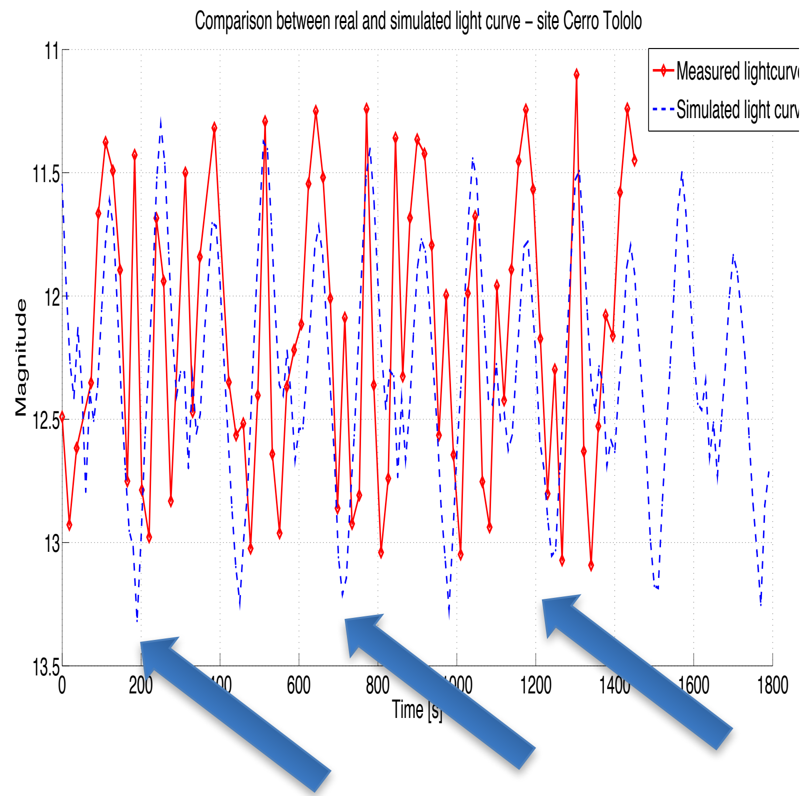
With a rotation rate of about 0.5° /s for every axes, lightcurves have been simulated in RGB from Flagstaff and Cerro Tololo

Table 2 - GSAT3 identified initial conditions	
Initial parameter	*Value*
Pitch [rad]	3.9495
Roll [rad]	0.1881
Yaw [rad]	1.0916
P [rad/s]	0.00028
q [rad/s]	0.01454
r [rad/s]	0.01876

Piergentili, F., Santoni, F., Seitzer, P., "Attitude Determination of Orbiting Objects from Lightcurve Measurements ", IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

Light-curves comparison



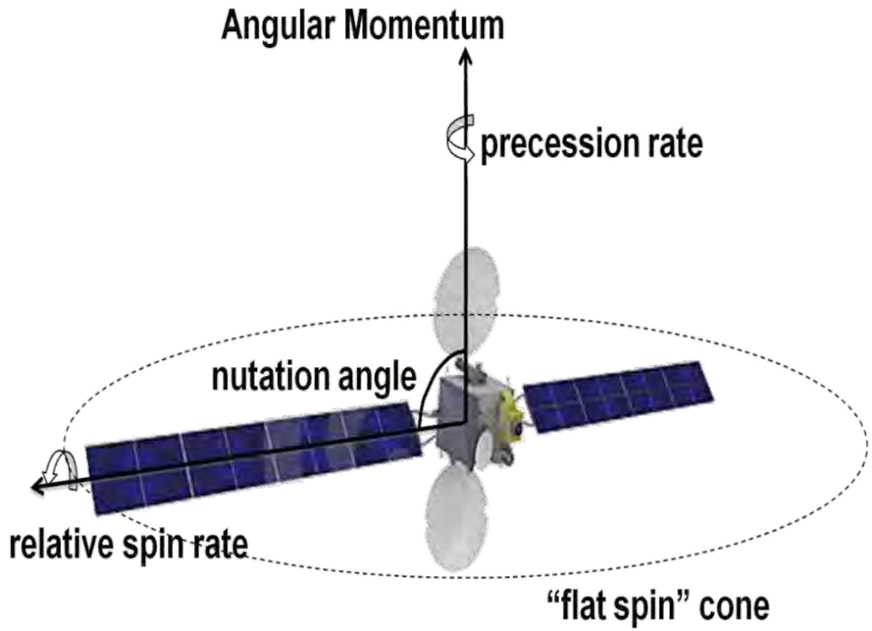


Cyclic discrepancies

Piergentili, F., Santoni, F., Seitzer, P., "Attitude Determination of Orbiting Objects from Lightcurve Measurements ", IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

Dynamical interpretation of the GSAT-3 reconstructed "free-body" attitude motion

- Nutation angle: 89.6 deg
- Precession rate: 1.36 deg/sec (0.23rpm)
- Relative spin rate: 8e-3 deg/sec(1.3e-3 rpm)
- Angular momentum unit vector components in J2000:
  [- 0.69 0.18 - 0.70]
- Angular momentum RA: 166 deg
- Angular momentum DEC: -44 deg



Piergentili, F., Santoni, F., Seitzer, P., "Attitude Determination of Orbiting Objects from Lightcurve Measurements ", IEEE Transactions on Aerospace and Electronic Systems (Volume: PP, Issue: 99), 2017, DOI: 10.1109/TAES.2017.2649240

Estensione a UAV

Attività di ricerca nel campo dei detriti spaziali al DIMA:

Punti di forza:

- Possibilità di accedere ad ogni punto della filiera dalla concezione della campagna di misura all'analisi dei dati
- Capacità di interazione hardware/software, capacità progettuali (cupola, montatura, automazione)
- Possibilità di unire competenze nel campo della realizzazione dei satelliti (assetto, materiali…) e progettazione software (realtà virtuale, AG)
- Interazione con gruppi internazionali operanti nel settore (Inter Agency Space Debris Committee)
- Interazione con gruppi nazionali operanti nel settore (AD, CNR, INAF)

Punti di debolezza:

- Poca possibilità di accesso a grandi osservatori (space debris poco considerati nella comunità degli astronomi/astrofisici)
- Mancanza di continuità nelle operazioni

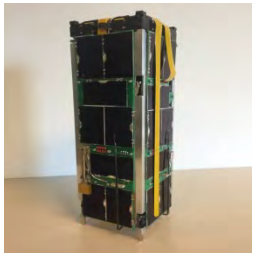
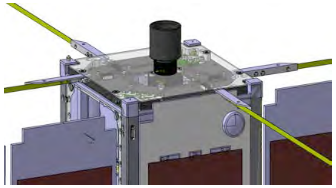
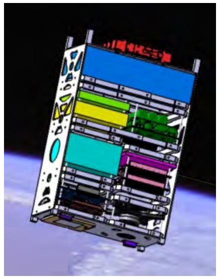
Sviluppi futuri nella ricerca in ambito space debris

- Ricostruzione dell'assetto e delle caratteristiche fisiche sarà nuovo campo di ricerca (fotometria e spettrometria)
- Estensione di misure ottiche ad orbita LEO come controparte alle misure radar grazie a nuovi sistemi a largo campo di vista
- Utilizzo di sistemi in orbita per l'osservazione ottica (star tracker)
- Esportazione delle tecniche di analisi ad altri campi di ricerca: UAV, analisi moto coordinato stormi o sciami

Terza missione

- Progettazione strumentazione e movimentazione→ Spin off
- Validazione misure di osservatori usati in ambito Space Situational Awareness (contratto ESA-E-geos)
- Condivisione database o gestione siti (Applied Defense)

Realizzazione di satelliti all’Università di Roma “La Sapienza”

Approccio alla didattica

“**Hands-on activities** let the students' minds grow and learn based on the experiences and the environment they are exposed to. They learn while discussing, investigating, creating, and discovering with other students. As the students become familiar with the subject they are learning, they begin to make decisions, requiring less teacher support and allowing more interactive learning experiences to occur”

(Cooperstein & Kocevar-Weidinger, 2004).

Satelliti Universitari?

- È un **veicolo spaziale funzionante**, o uno strumento, un payload o un componente. Deve operare nello spazio con i propri mezzi indipendenti di comunicazione e di comando

- **Personale non qualificato** (cioè studenti) hanno partecipato ad una frazione significativa di decisioni chiave di progettazione, integrazione e test, e delle operazioni di volo

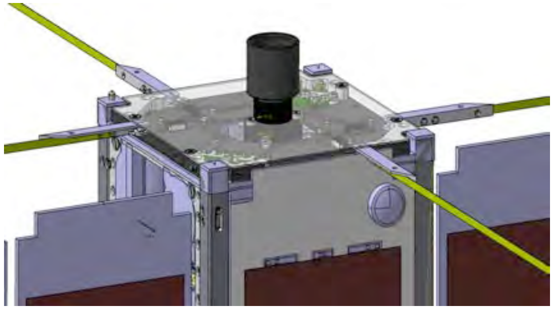
- La **formazione di queste persone** è importante quanto (se non più importante) la "missione" del satellite stesso

Satelliti Universitari
PRO e CONTRO

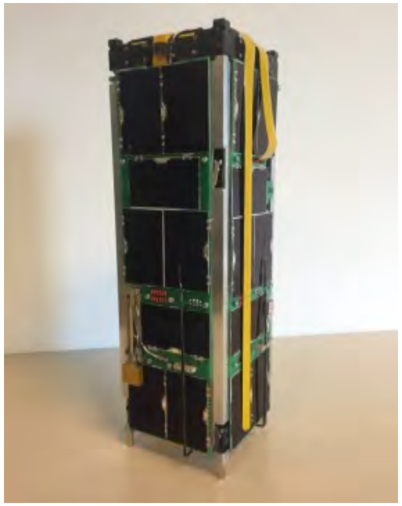
- <u>PRO</u>
  - Corta vita operativa è OK
  - Concetti nuovi e componenti terrestri possono essere provati
  - Si assume un alto rischio (il fallimento è un opzione)
  - Piccoli gruppi perchè lo sforzo organizzativo e di gestione è minimo

- <u>CONTRO</u>
  - E' coinvolto personale senza esperienza
  - Frequenti ritardi dovuti ad errori tecnici e di pianificazione

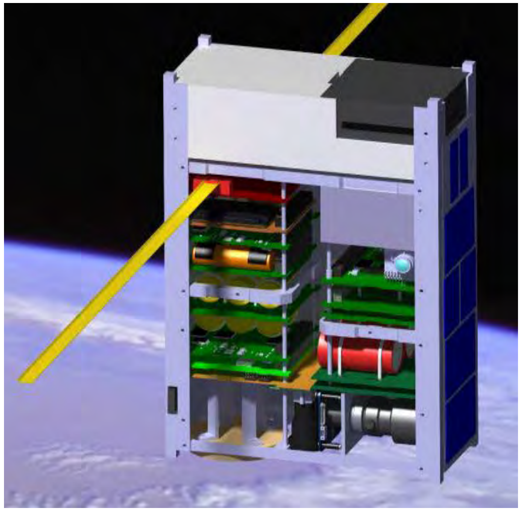
Progetti in corso



EAGLET (OHB Italia)



URSA MAIOR
(QB50-H2020, ASI)

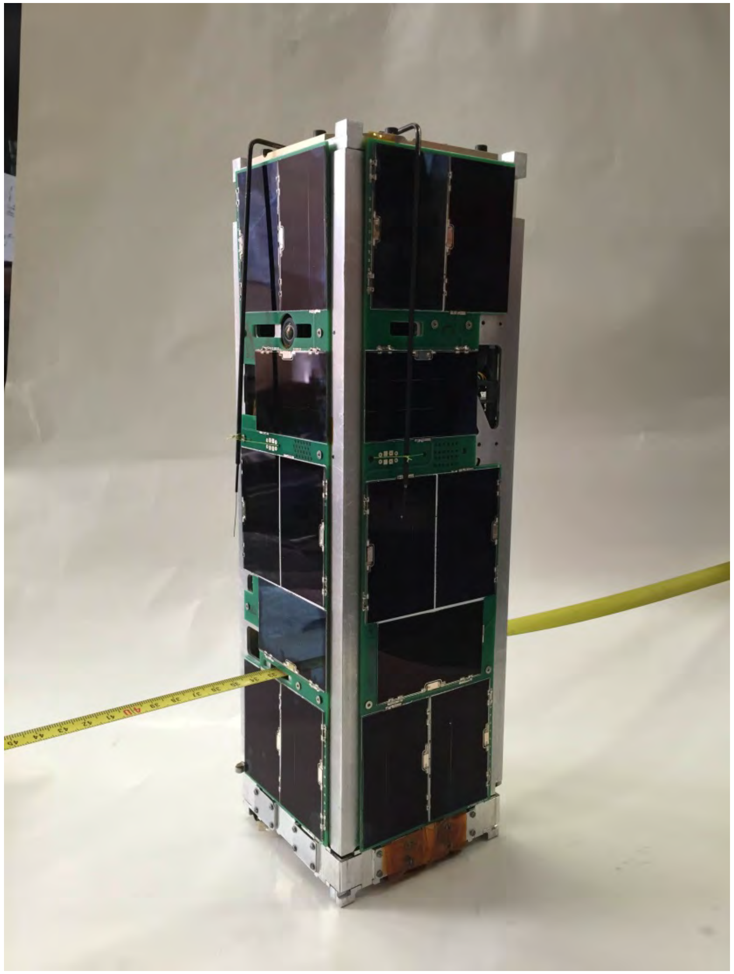


IKUNS (ASI, Kenya, United Nations)

LEDSAT
??

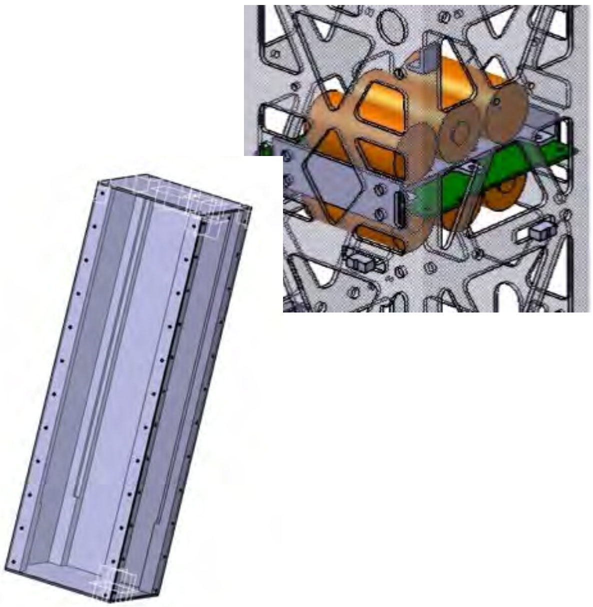
SVILUPPO DI UN NANOSATELLITE

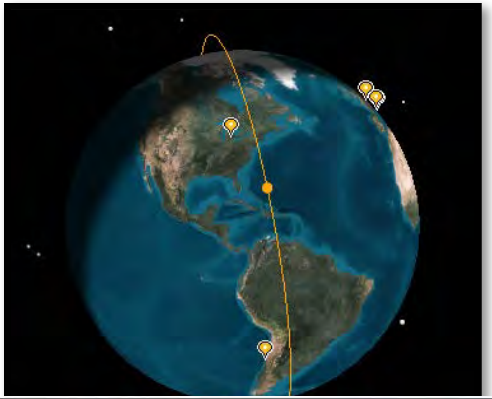
- Progetto
- Costruzione
- Test

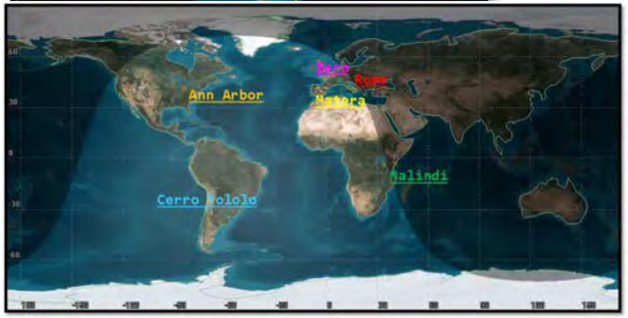


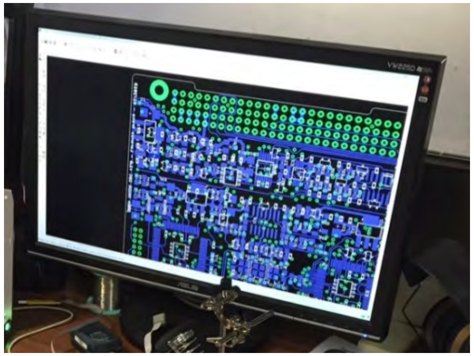
PROGETTO

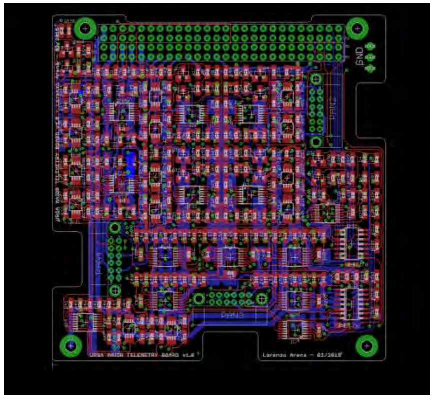
- **Procedure di progetto di sistemi spaziali**
- **Programmi CAD per elettronica e struttura**
- **Analisi di Missione**











PROGETTO

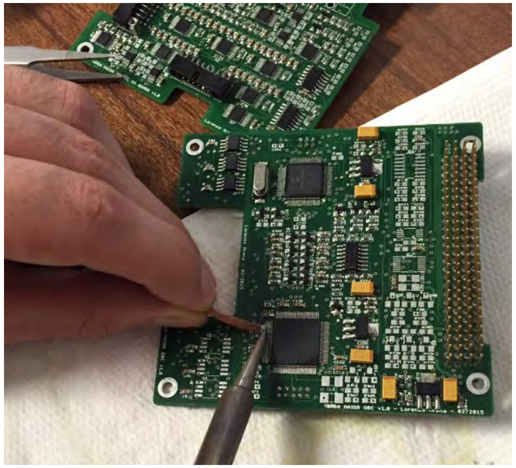
Obiettivi educativi:

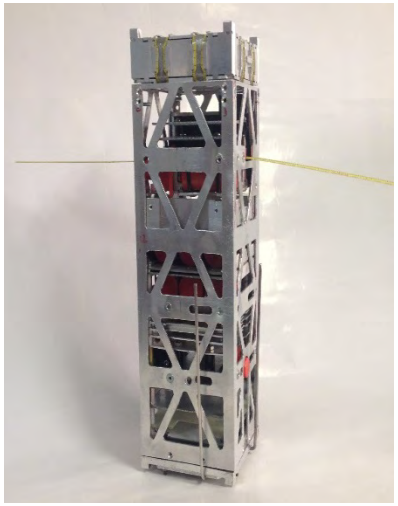
- **Imparare a gestire la documentazione tecnica di un programma spaziale**
- **Sviluppare la capacità di lavorare in gruppo: gestione dei conflitti, budget, tempo.**

PROTOTIPI E TEST

Far volare componenti commerciali a basso costo

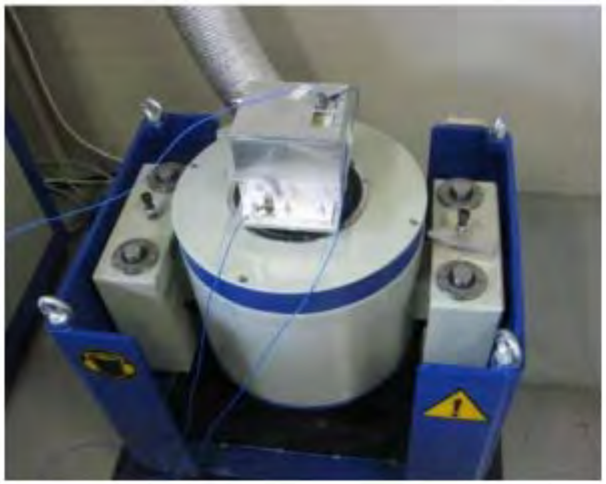
Sviluppo rapido: Iniziare subito con prototipi per evidanziare criticità

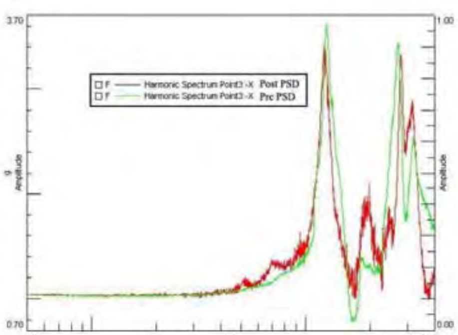




TEST

- **Vibrazioni**
- **Termovuoto**





1U Cubesat structure vibration test results

LABORATORY FACILITIES

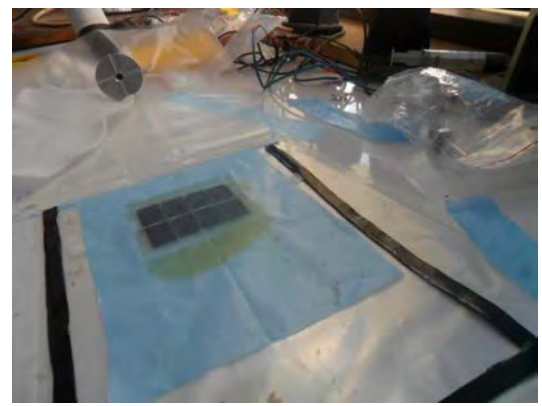
Laboratory vacuum chamber

Electronics development facility

Laboratory milling machine

Remotely controlled space debris Observatory

Magnetic Field Simulator



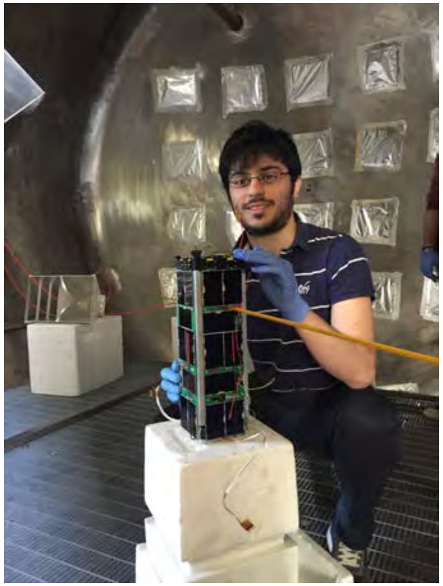
Solar panel manufacturing

URSA MAIOR

Lancio Aprile 2017

QB50 PROJECT

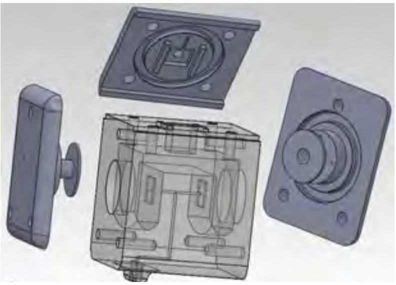
QB50 si pone l'obiettivo di studiare i parametri della bassa termosfera in-situ (90-320 km) con una costellazione di 50 CubeSats



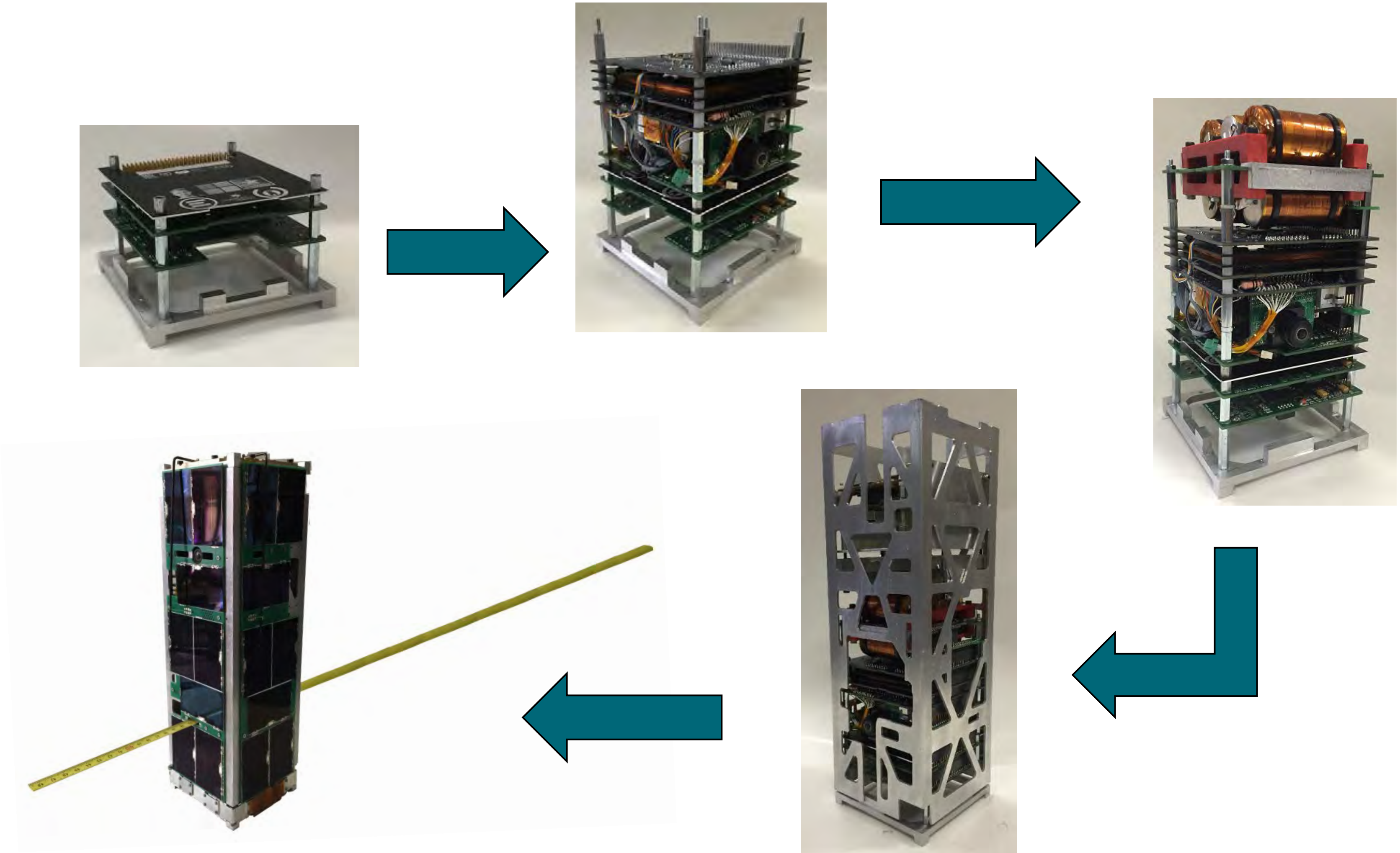
URSA MAIOR: ESPERIMENTI

1. Una vela per deorbiting

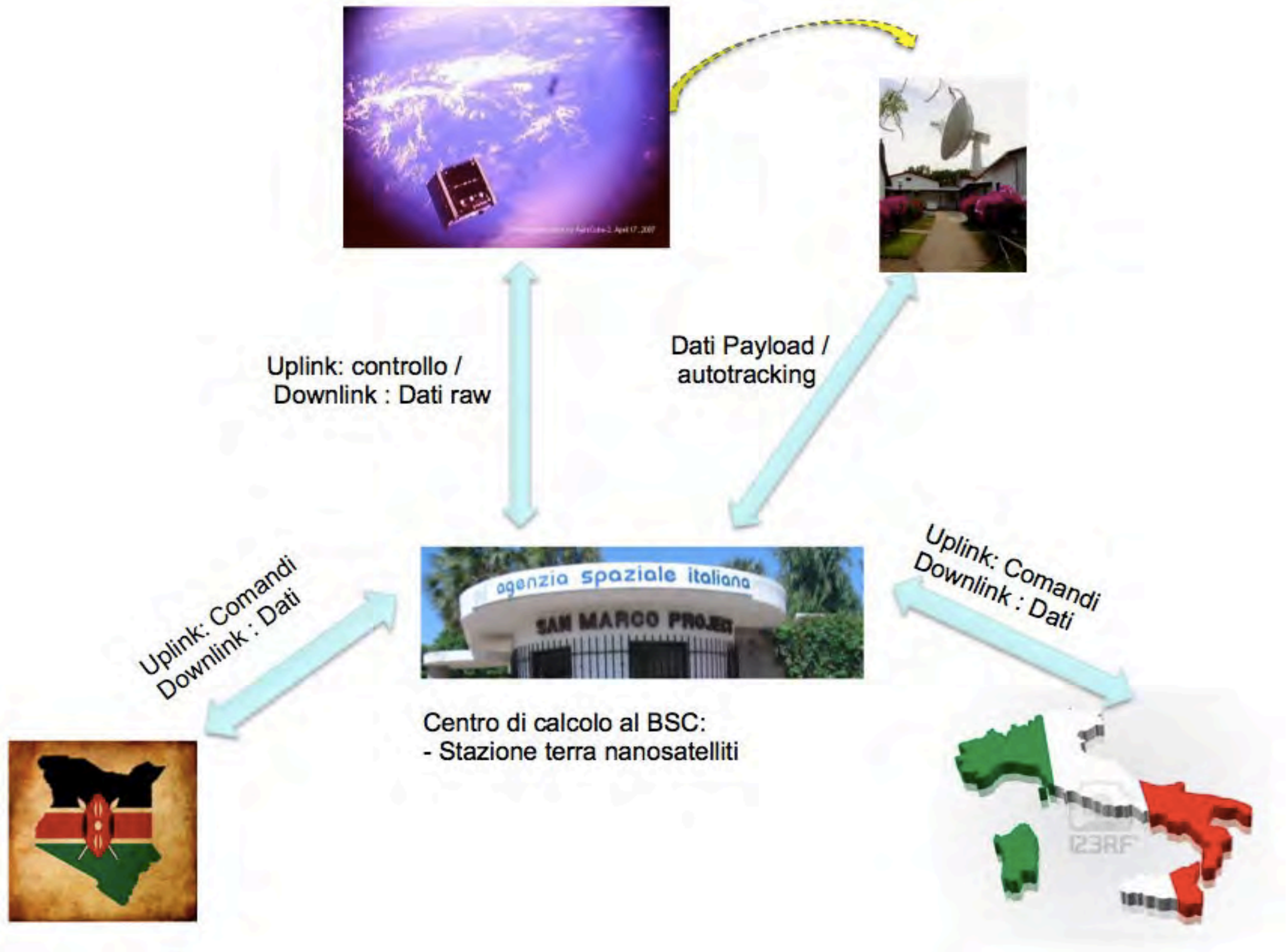
2. MEMS MicroPropulsori (MEMIT)



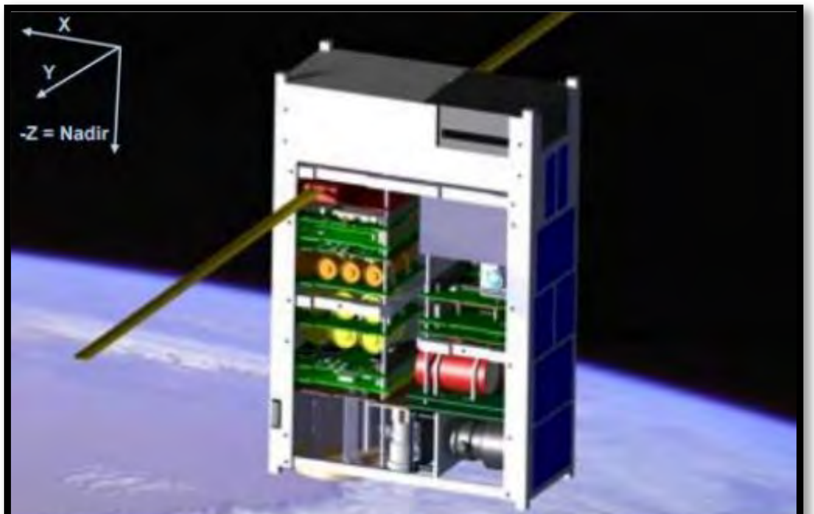
URSA MAIOR



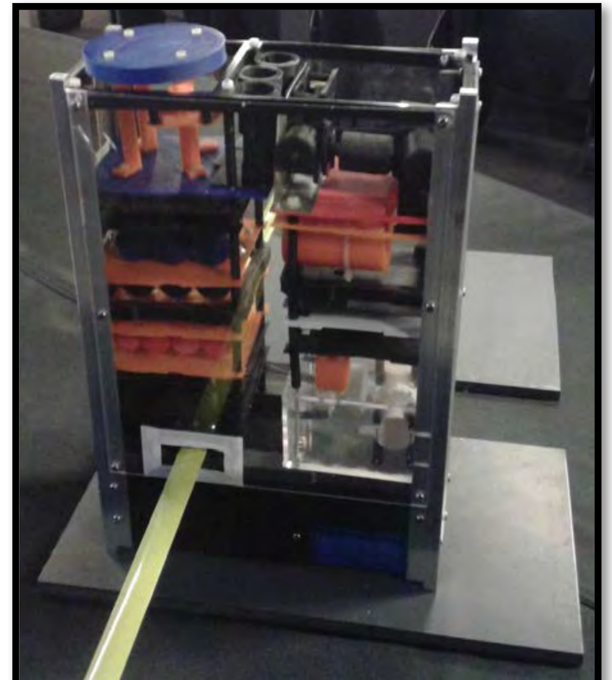
Cubesat IKUNS:
Italian-Kenyan University NanoSatellite



CubeSat Team: IKUNS 6U CubeSat

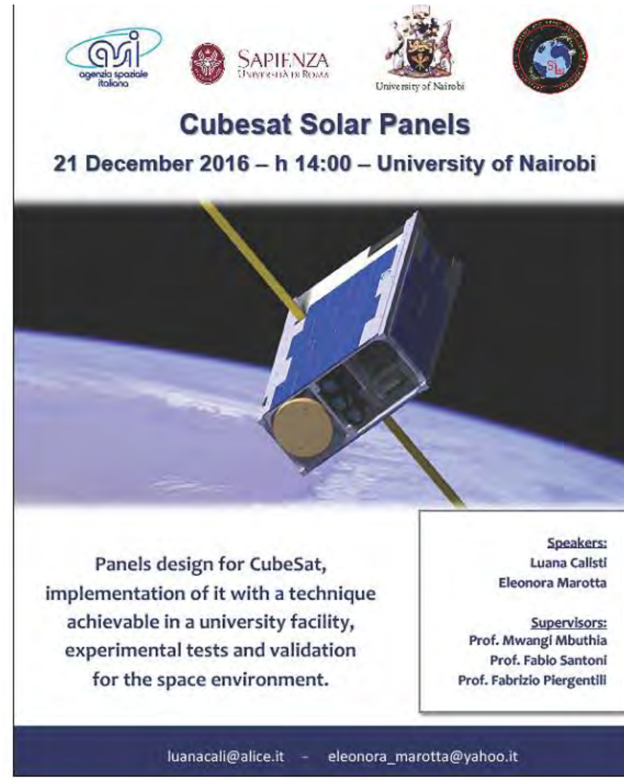


University nanosatellite developed in support of the **Italian-Kenyan cooperation in space activities**, part of an agreement between Sapienza – University of Rome and the Italian and ASI



3D-printed Mock-Up

Activity at Nairobi University: IKUNS



Da IKUNS ad 1KUNS

Lancio Previsto 2018

UNIVERSITY OF NAIROBI
Office of the Vice-Chancellor

Prof. Peter M. F. Mbithi, IOM, EBS, MKVC (Surgery), MKIM, BVM, MSc., (Nbi), MVSc. (Sask), PhD, (Nbi)

Fax: +254-20-2212604/2216030
Email: vc@uonbi.ac.ke
Website: www.uonbi.ac.ke

Tel: +254-20-3318262, +254 732 020 207
P.O. Box 30197 - 00100 - GPO
Nairobi, Kenya

March 31, 2016

United Nations Office for Outer Space Affairs
Vienna International Centre
P.O. Box 500, A 1400
VIENNA, AUSTRIA

ENDORSEMENT FOR THE APPLICATION

The University of Nairobi based in Nairobi Kenya, and University of Rome (Sapienza) based in Rome Italy, have signed a cooperation agreement. The two main projects to be implemented under this agreement are:

1. IKUNS-PF: 1st Kenyan University Nano Satellite Precursor Flight will be realized in collaboration with University of Rome "La Sapienza" in the framework of the IKUNS ASI-Sapienza program that is part of the cooperation agreement. The1KUNS-PF satellite team will have at its disposal the facilities of University of Rome, including S5Lab (Sapienza Space Systems and Space Surveillance Laboratory) and SasLab.

In this framework, the University of Rome will provide support in terms of contribution to design and development, test and integration facilities and manpower through students, PhD and researchers that will be involved in 1KUNS-PF project, fostering

UNITED NATIONS
Office for Outer Space Affairs

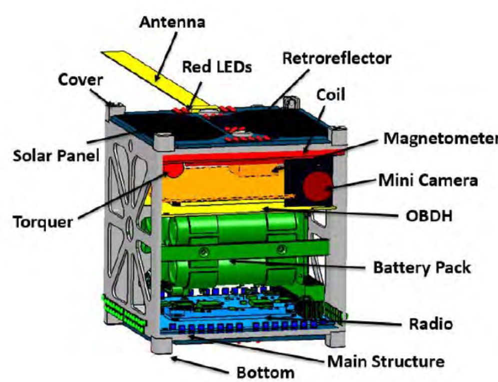
5 August 2016

Dear Mr. Mbuthia,

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

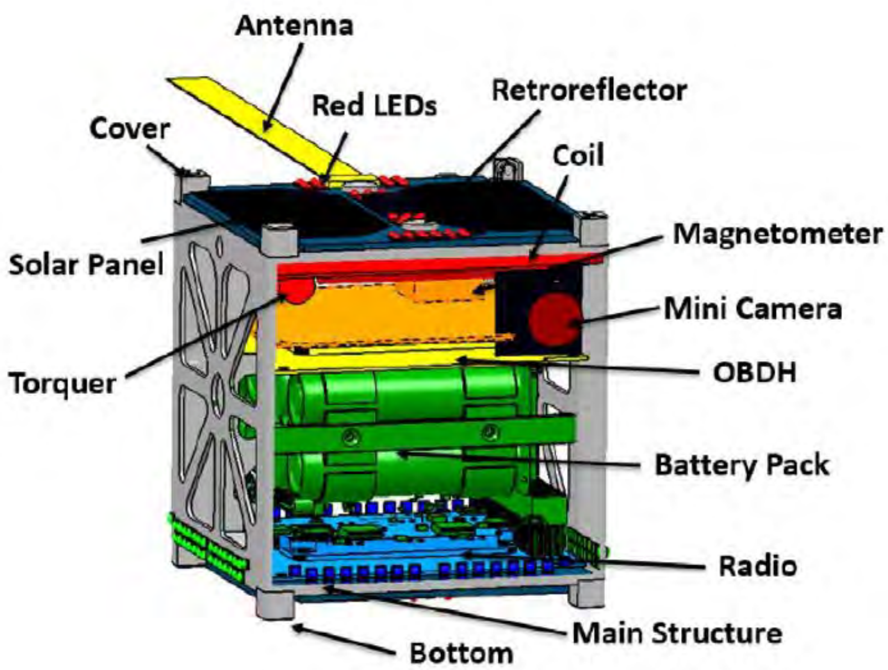
On behalf of the United Nations Office for Outer Space Affairs (OOSA) and the Japan Aerospace Exploration Agency (JAXA), we are pleased to inform you that the proposal ("1KUNS") that you have submitted in response to the Announcement of Opportunity of the United Nations/Japan Cooperation Programme on 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).



Da IKUNS ad 1KUNS

Lancio Previsto 2018 da ISS



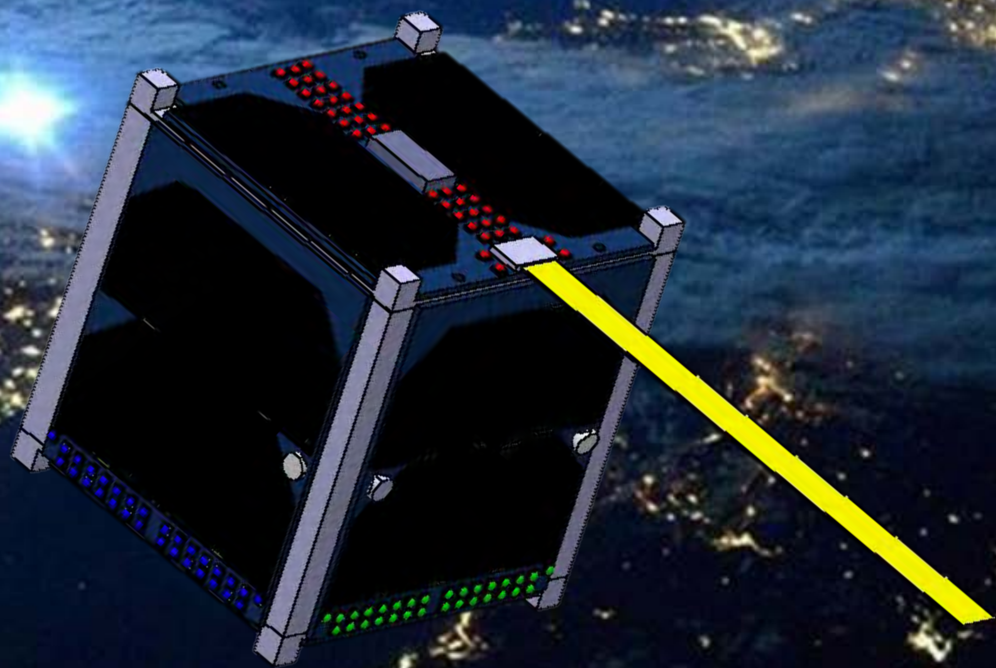
1KUNS sarà un volo precursore di IKUNS:

- Test tecnologie critiche sottosistemi di bordo
- Test di payload kenyani (microcamera, pannelli solari)

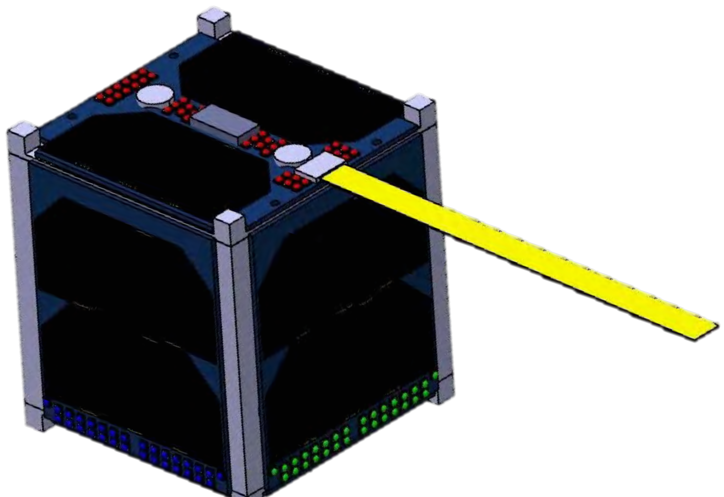
EAGLET (OHB Italia)

LedSat

Design of a 1U CubeSat equipped with a led-based technology



LedSat 1U CubeSat



In-orbit testing of led-based technology for satellite orbital and attitude determination and telecommunication by means of optical measurements

Attività di ricerca nel campo dei nanosatelliti universitari al DIMA:

Punti di forza:

- **Possibilità di accedere ad ogni punto della filiera dalla concezione del satellite al lancio**
- **Capacità di progettazione hardware/software**
- **Interazione con la didattica, visione sistemistica**
- **Collaborazioni internazionali, stato dell'arte rispetto alle altre università nel mondo**

Punti di debolezza:

- **Ricerca richiede ingenti finanziamenti**
- **Attività ad alto rischio (risultati in orbita difficili da ottenere a causa dell'alta mortalità di questiotipi di satelliti)**

Sviluppi futuri nella ricerca in ambito nanosatelliti

- **LEDSAT (sinergia tra nanosatelliti e space debris)**
- **Studi su megacostellazioni**
- **Supporto a paesi emergenti nello sviluppo di un loro piano spaziale nazionale**

Terza missione

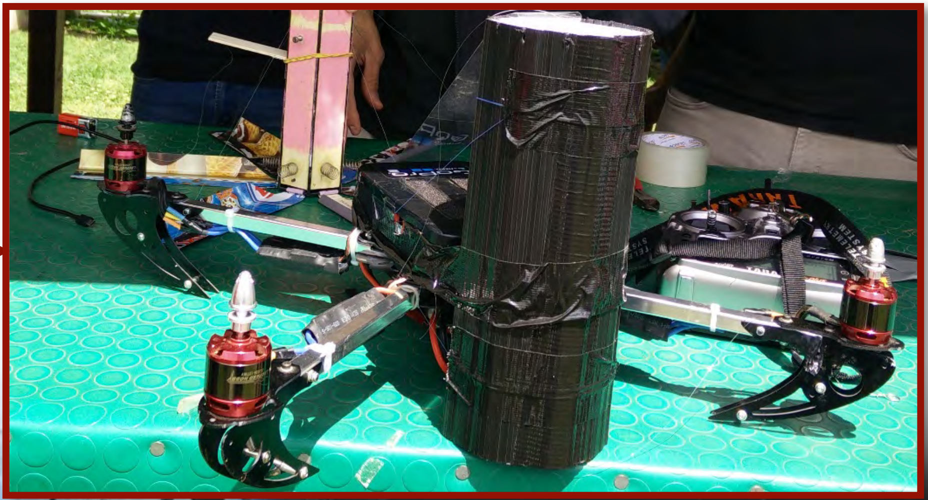
- **Progettazione per aziende esterne di sottosistemi o integrazione**
- **Servizi per aziende esterne (progettazione di bus multi-pourpose)**

Attività Didattiche / gare internazionali

CANSAT Team

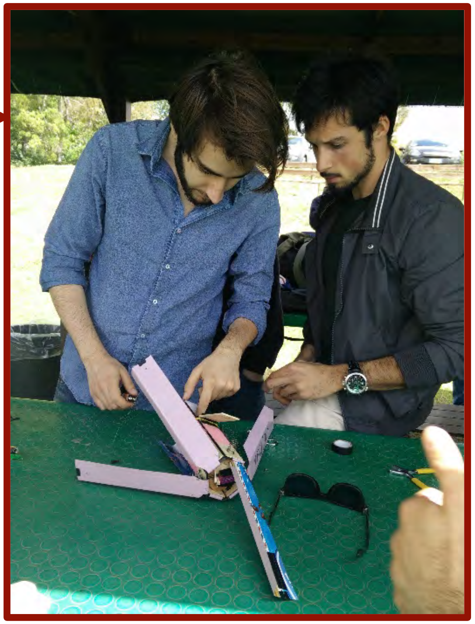
DESIGN

DEVELOPMENT



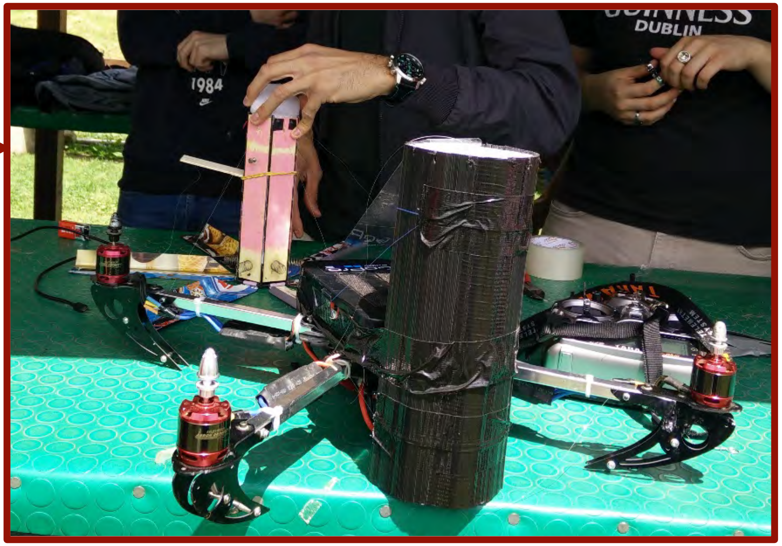
CANSAT Team

LAUNCH



CANSAT Team

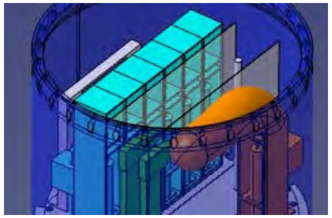
LAUNCH



REXUS/BEXUS
roots

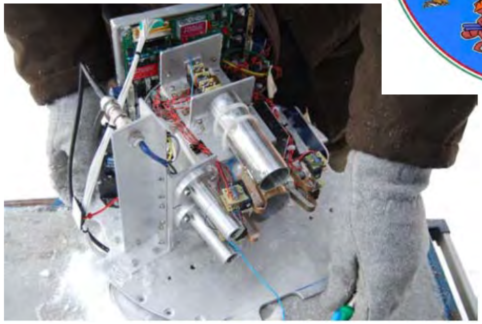
AURORA, Bexus 7

REDEMPTION, Rexus 12



COMPASS, Bexus 9

BUGS, Rexus 7



STRATONAV

STRATOspheric NAVigation experiment

STRATONAV

BEXUS 22/23

STVDIVM VRBIS

ALMA MATER STUDIORUM

A.D. 1088

esa

EuroLaunch

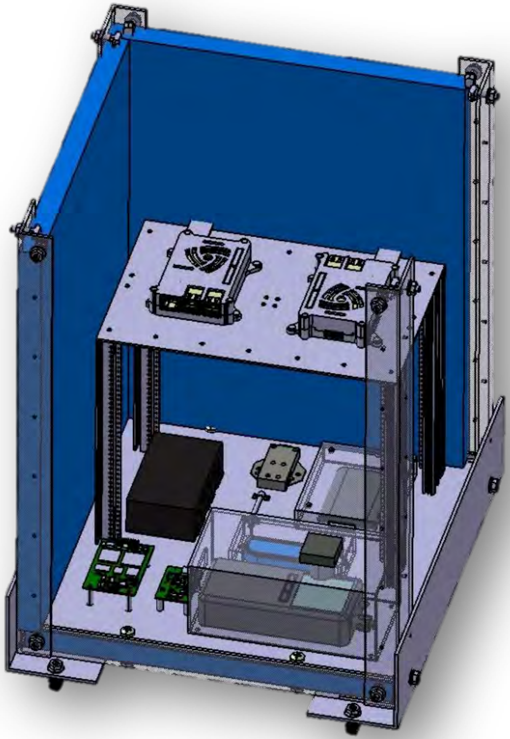
ZARM

SSC

DLR

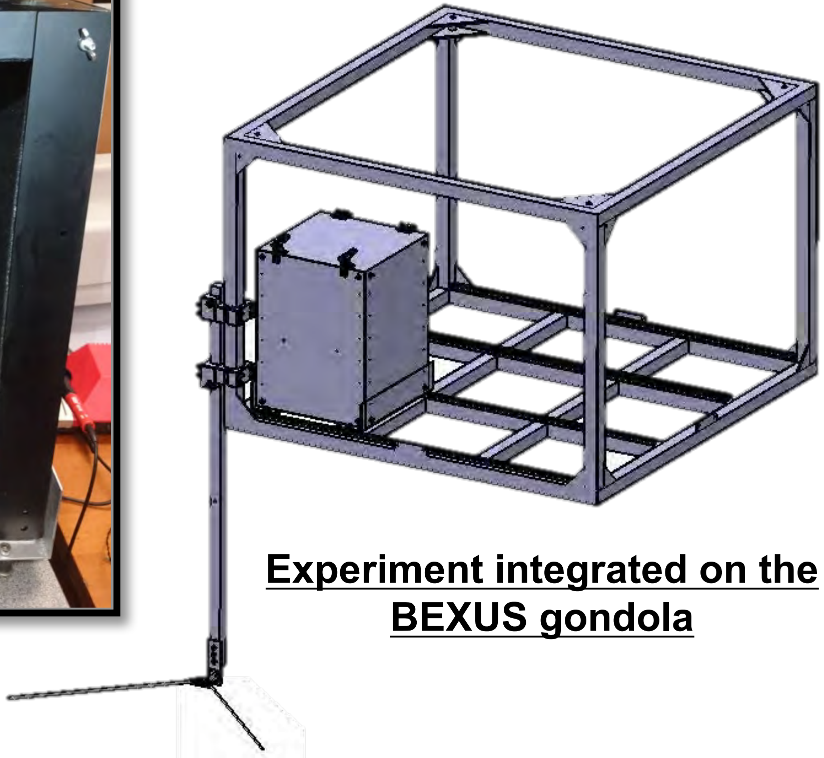
RYMDSTYRELSEN
Swedish National Space Board

BEXUS Team: STRATONAV Experiment



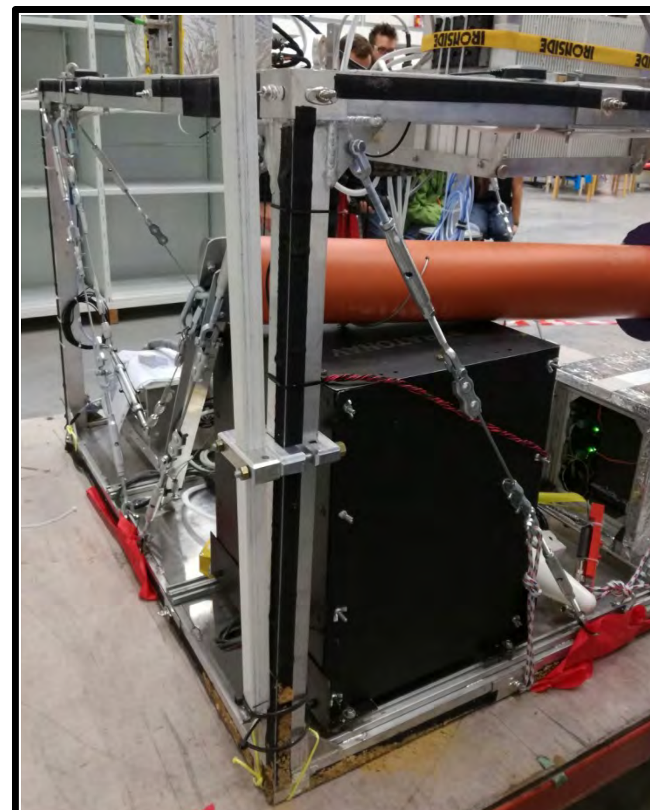
CAD Model

Flight Model



Experiment integrated on the BEXUS gondola

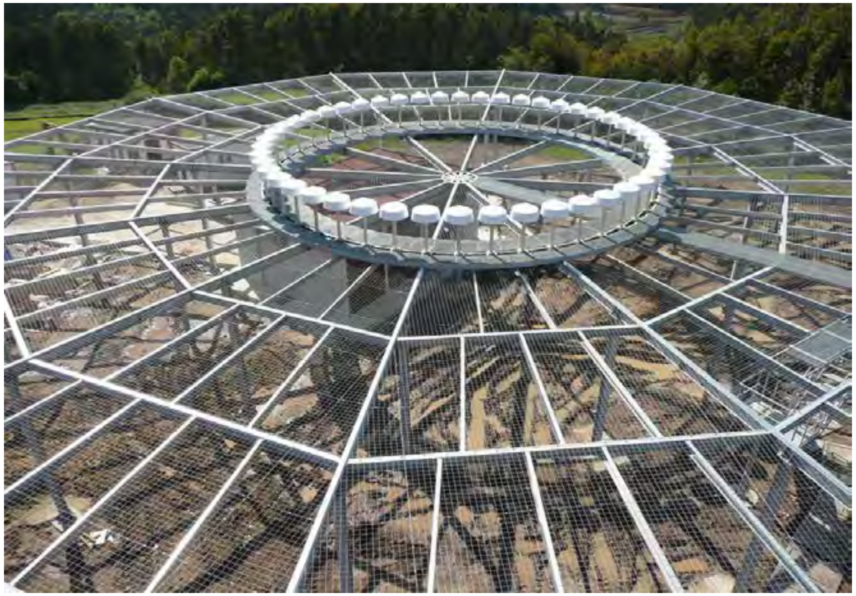
BEXUS Team: STRATONAV Experiment



VOR (VHF Omnidirectional Range)

VOR service volume limit

AVAILABLE DATA

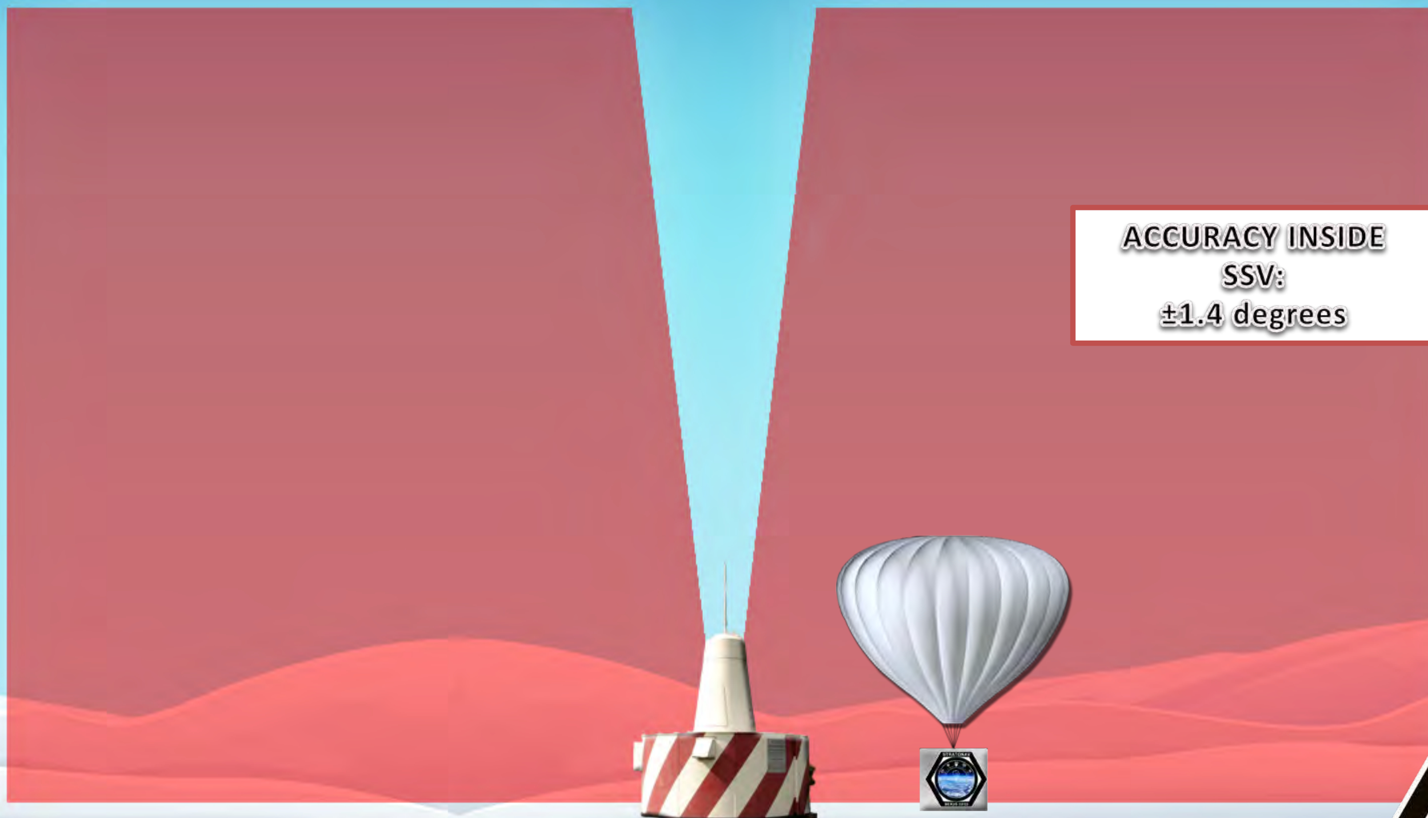


RADIATED POWER RATES

STRATOSPHERIC FLIGHT HERITAGE

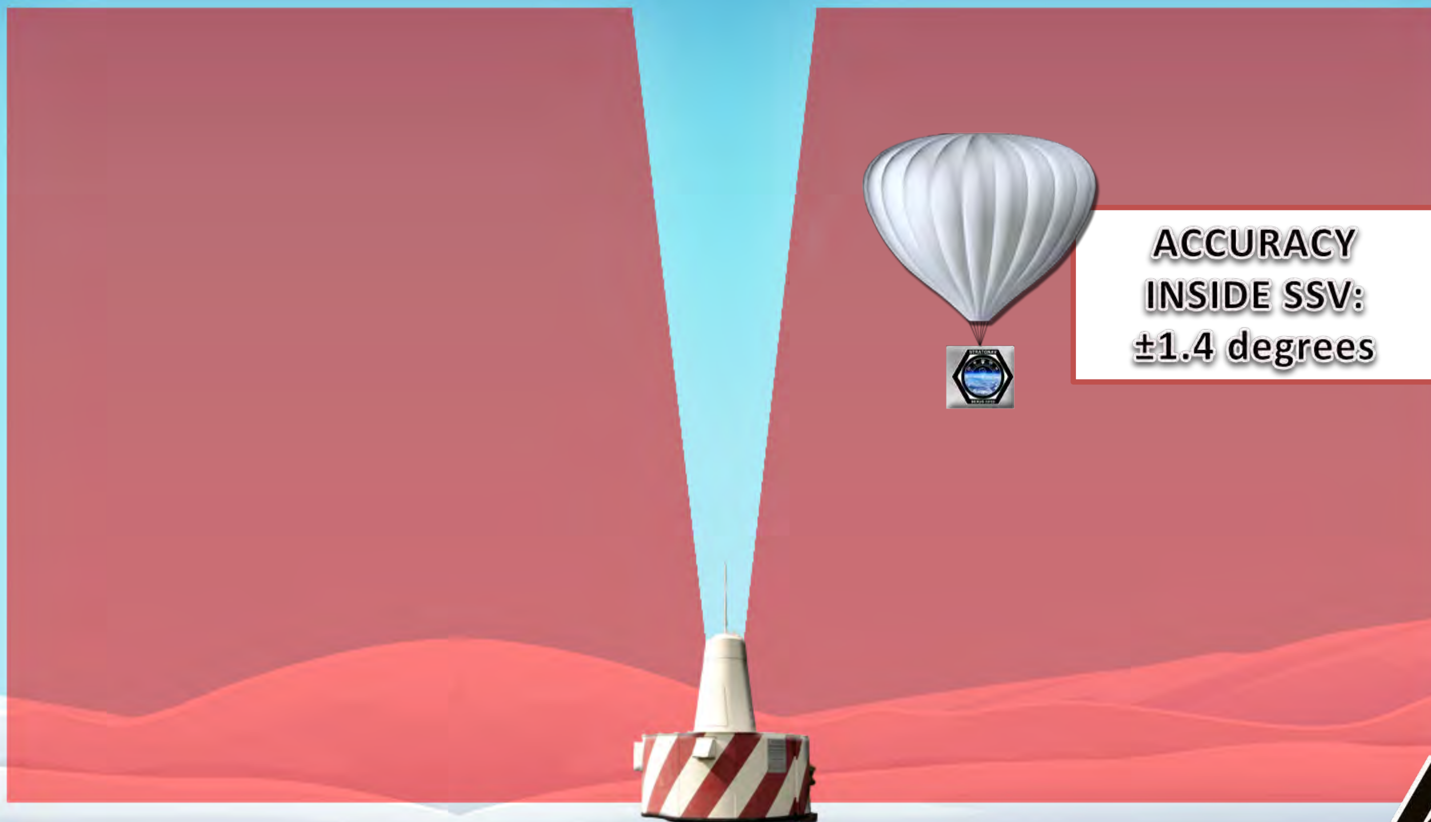

VOR
Standard Service
Volume
(SSV)

EXPECTED RESULTS



EXPECTED RESULTS

ACCURACY OUTSIDE SSV:
±4 degrees



International Environment

IMPIANTI AERONAUTICI

System level analysis with emphasis on critical components

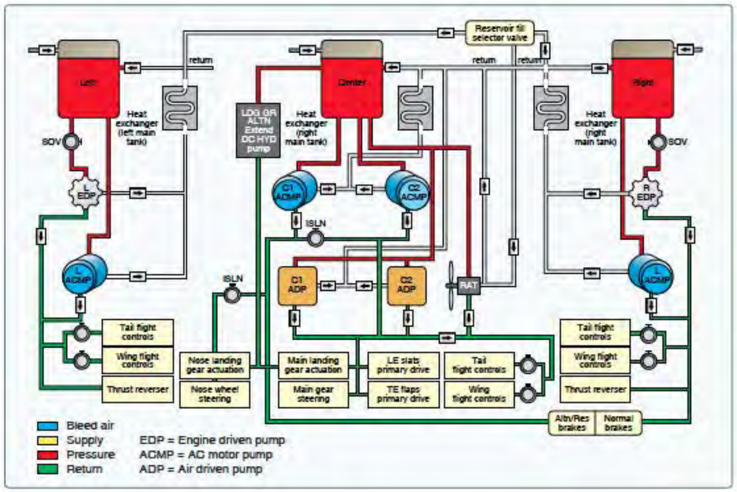
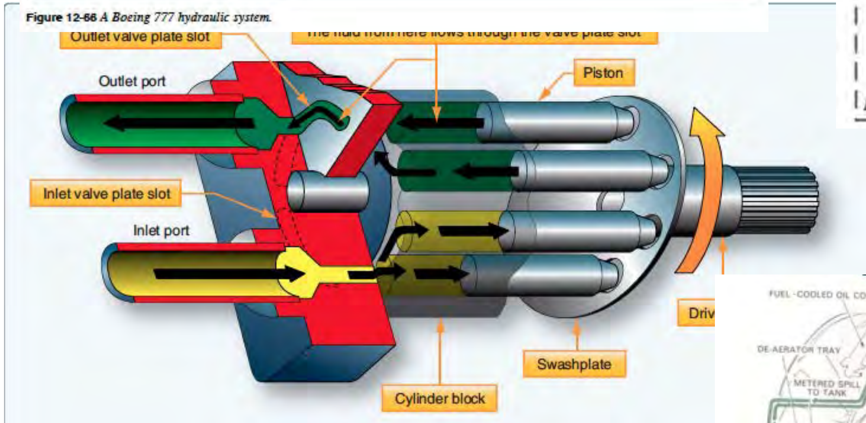
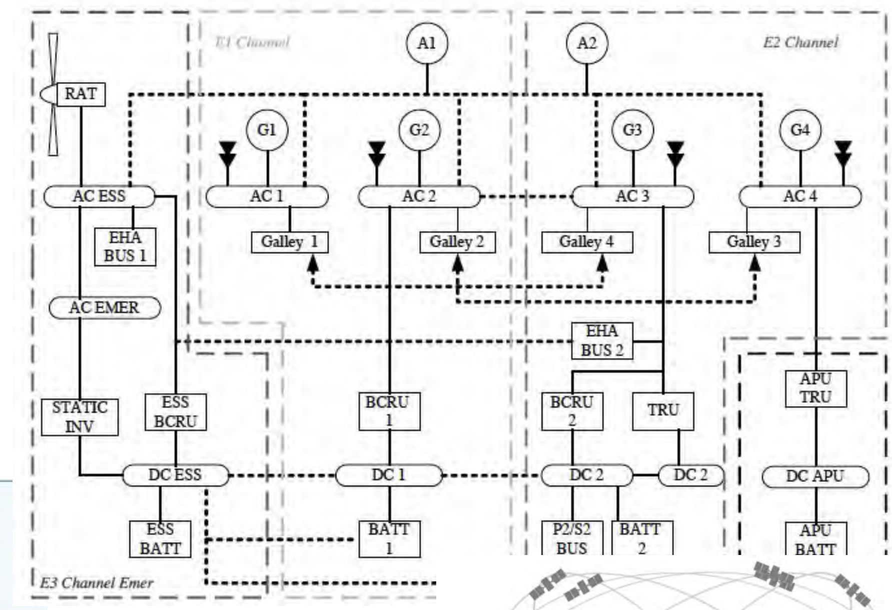
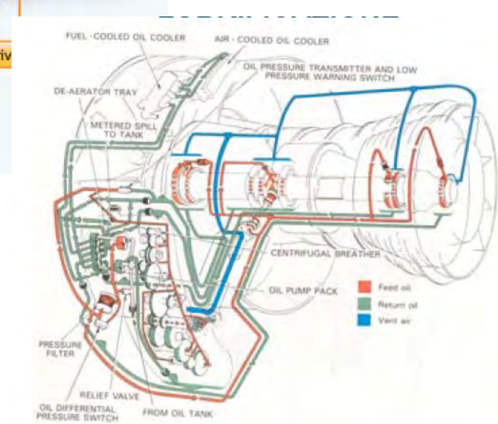
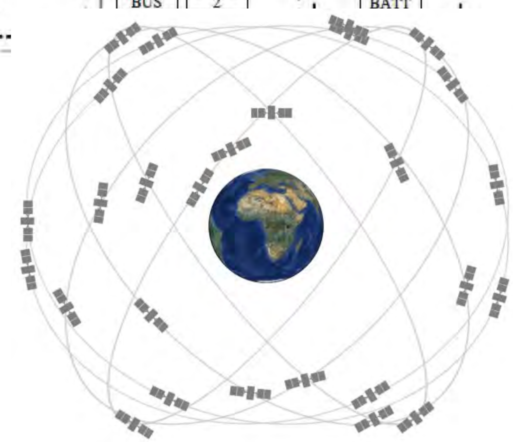


Figure 12-66 *A Boeing 777 hydraulic system.*

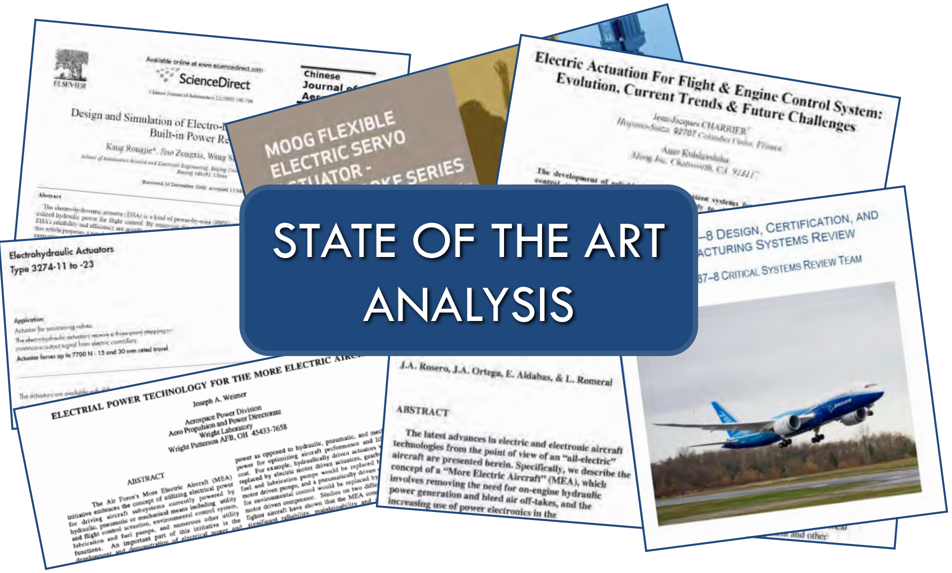




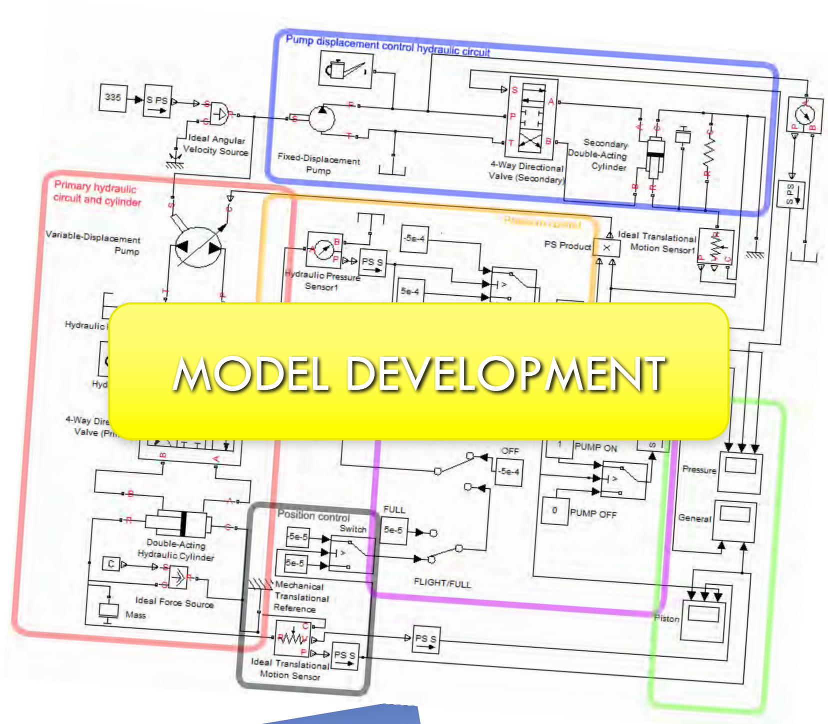




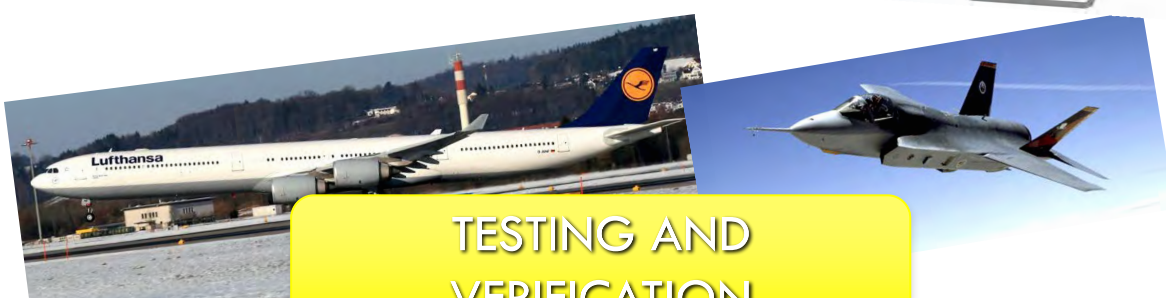
Power-by-Wire – Analysis of an Electro-Hydrostatic Actuator



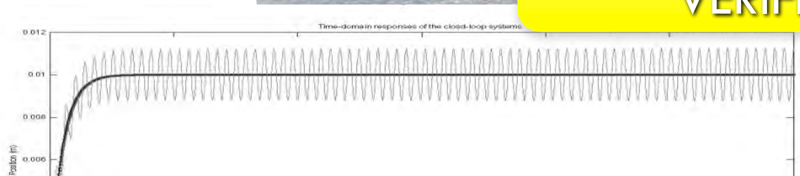
STATE OF THE ART ANALYSIS



MODEL DEVELOPMENT



TESTING AND VERIFICATION

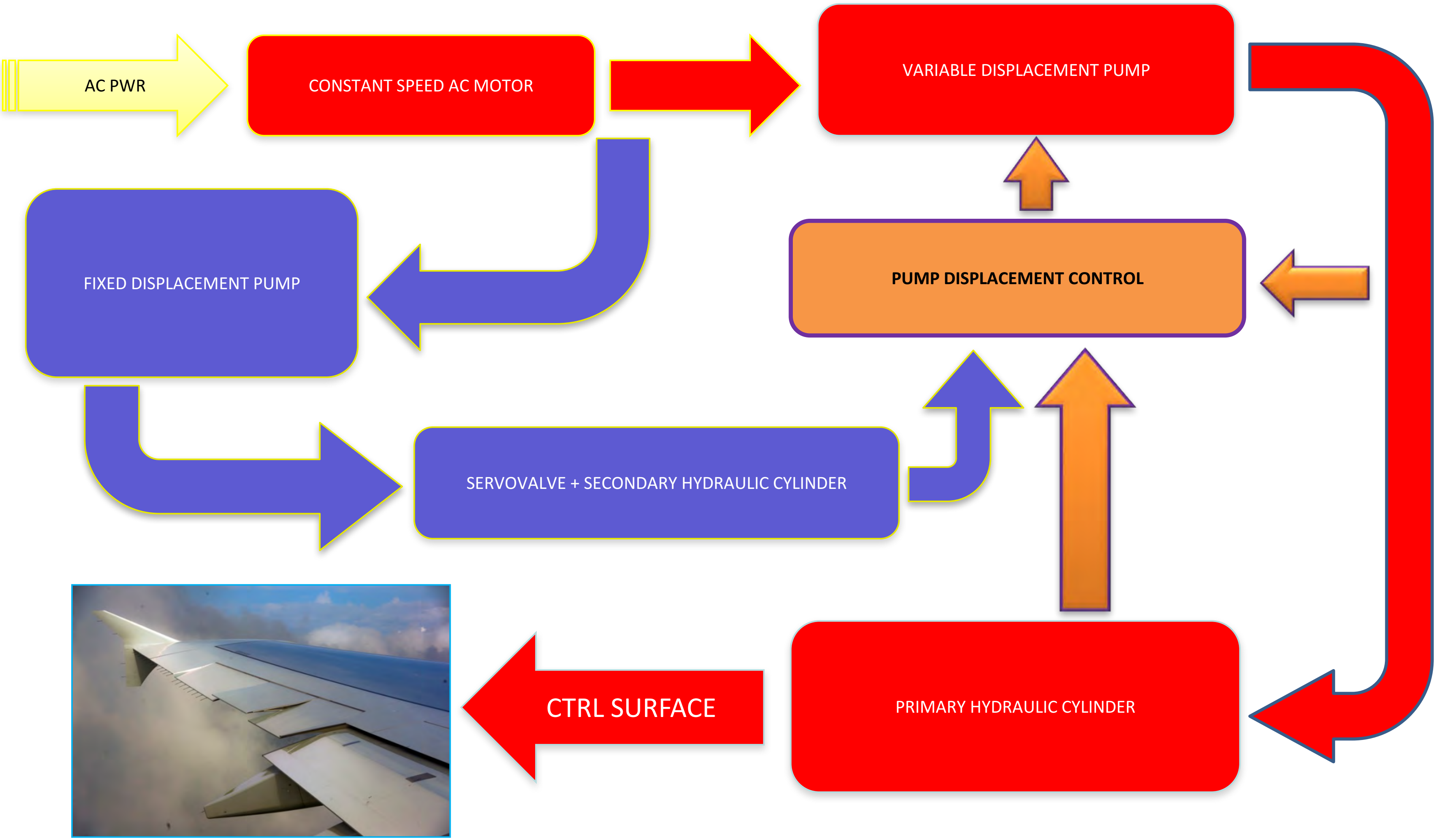


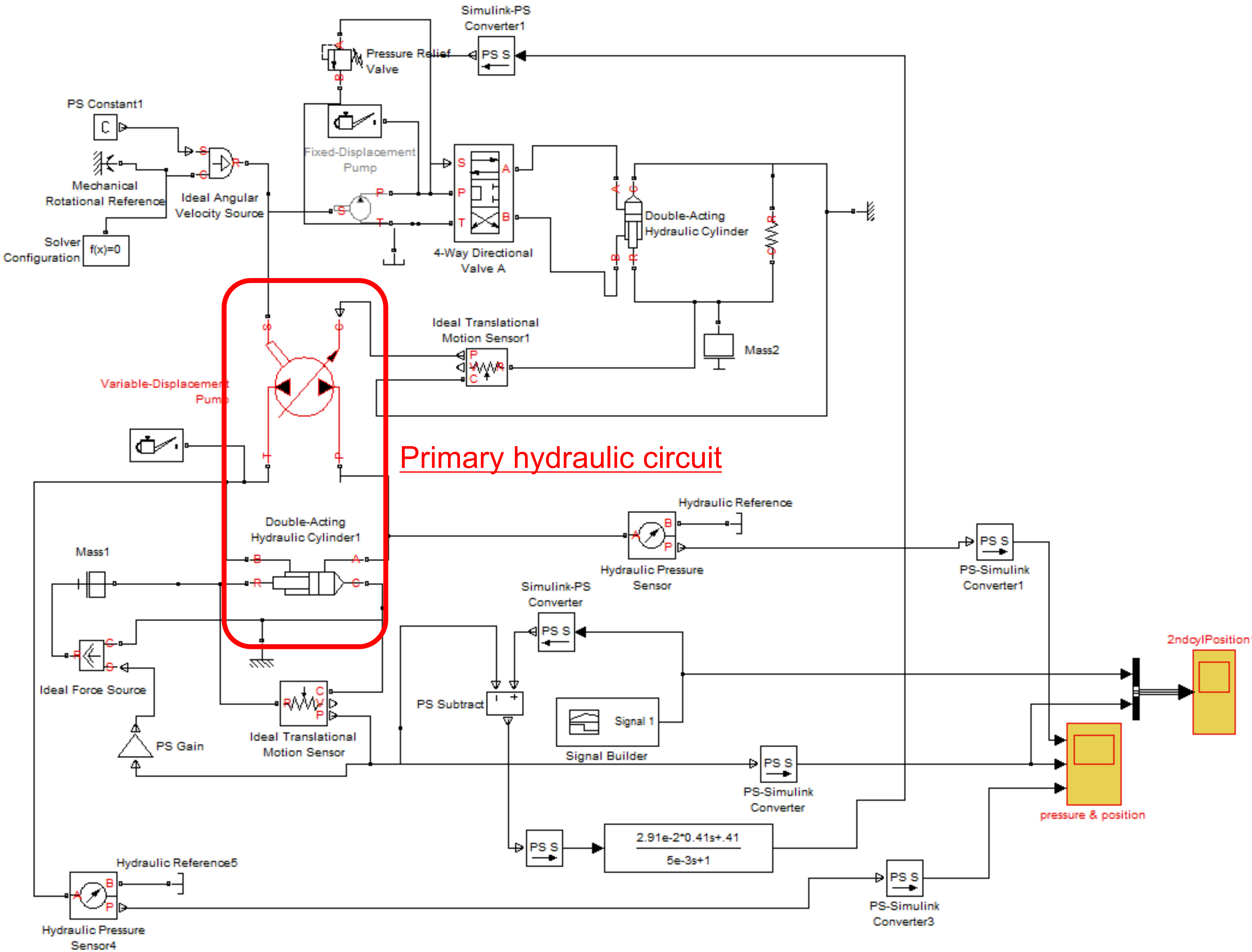
Electro-Hydrostatic Actuators (EHAs) analysis and modeling

- Electro-Hydrostatic Actuators (EHAs) are one of the technologic innovations of Power-by-Wire actuation (in the More-Electric Aircraft concept framework), aimed to remove the aircraft hydraulic system and to replace it with electric power buses;

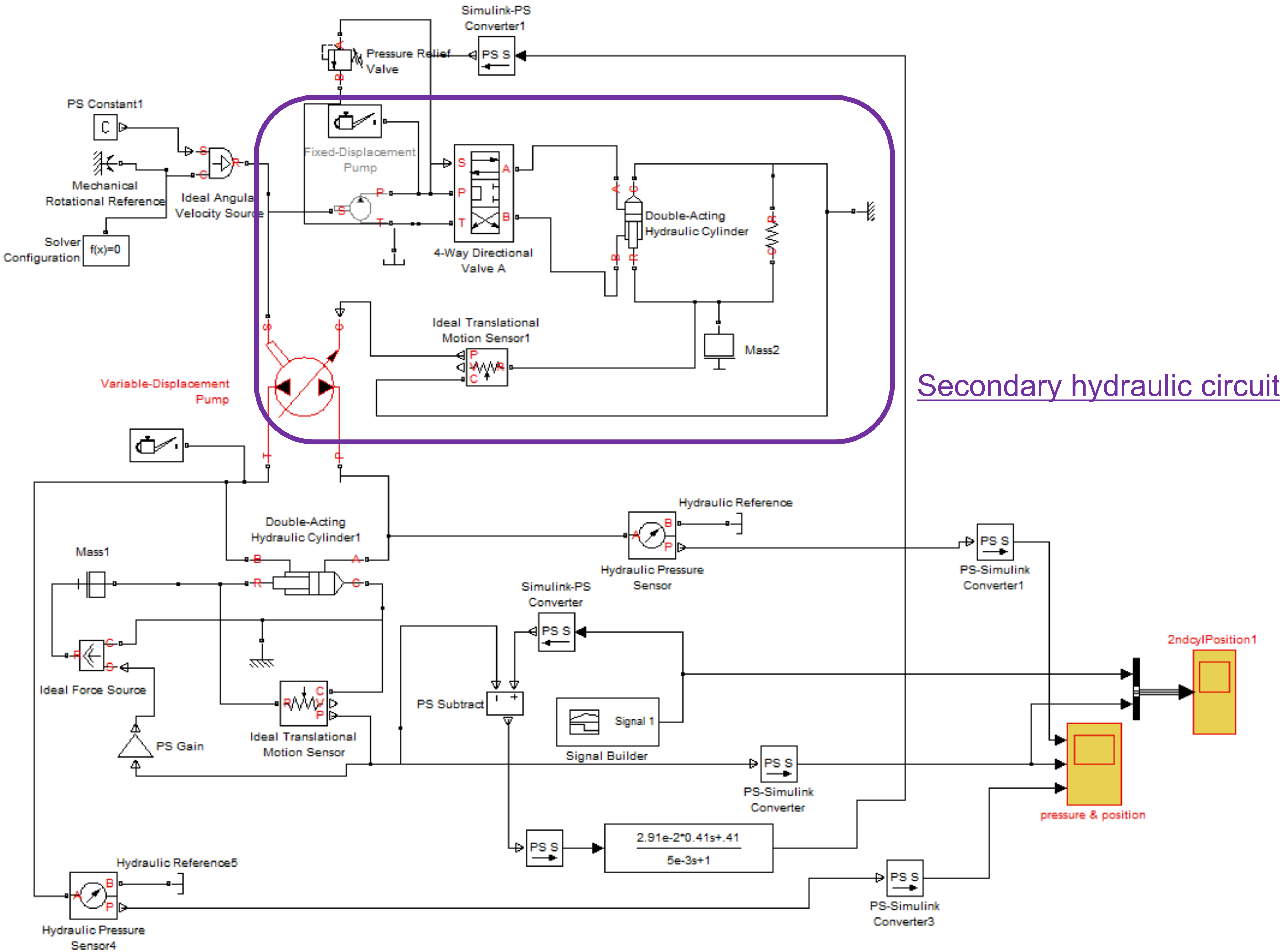
- An EHA can combine improved performance with an overall reliability increase and weight savings.

Electro-Hydrostatic Actuator: principle of operations





Simulink-PS Converter1
Pressure Relief Valve
PS Constant1
Fixed-Displacement Pump
Mechanical Rotational Reference
Ideal Angular Velocity Source
Solver Configuration
f(x)=0
4-Way Directional Valve A
Double-Acting Hydraulic Cylinder
Ideal Translational Motion Sensor1
Mass2
Variable-Displacement Pump
Primary hydraulic circuit
Hydraulic Reference
Double-Acting Hydraulic Cylinder1
Mass1
Hydraulic Pressure Sensor
PS-Simulink Converter1
Simulink-PS Converter
Ideal Force Source
PS Subtract
Signal 1
Signal Builder
Ideal Translational Motion Sensor
2ndcylPosition1
PS Gain
PS-Simulink Converter
pressure & position
2.91e-2*0.41s+.41
5e-3s+1
Hydraulic Reference5
PS-Simulink Converter3
Hydraulic Pressure Sensor4


Simulink-PS Converter1
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PS S
PS Constant1
Mechanical Rotational Reference
Ideal Angular Velocity Source
Solver Configuration
f(x)=0
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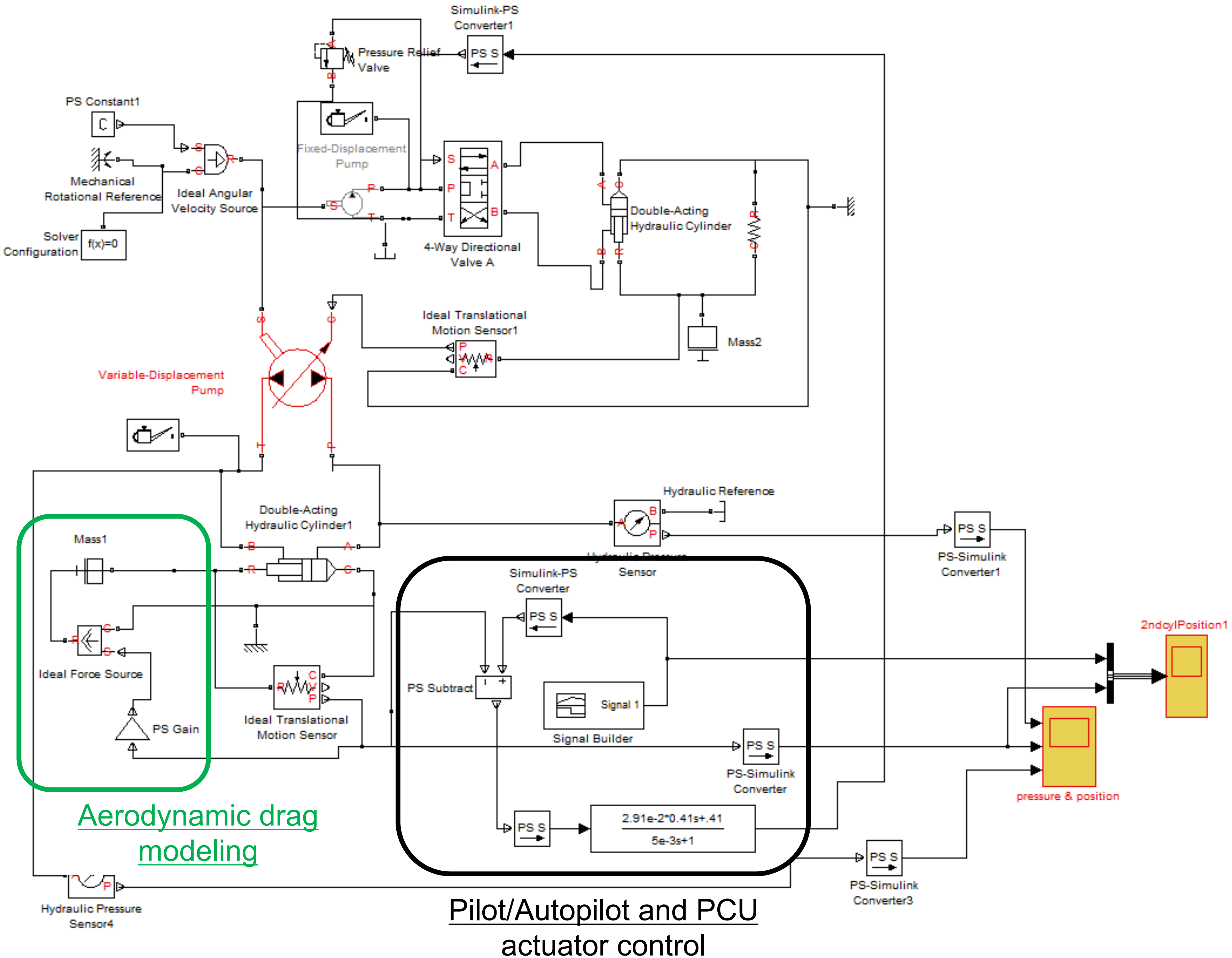
4-Way Directional Valve A
Double-Acting Hydraulic Cylinder
Ideal Translational Motion Sensor1
Mass2
Variable-Displacement Pump
Secondary hydraulic circuit
Hydraulic Reference
Double-Acting Hydraulic Cylinder1
Mass1
Hydraulic Pressure Sensor
PS-Simulink Converter1
Simulink-PS Converter
Ideal Force Source
PS Subtract
Signal 1
Signal Builder
PS Gain
Ideal Translational Motion Sensor
PS-Simulink Converter
2ndcylPosition1
pressure & position
2.91e-2*0.41s+.41
5e-3s+1
Hydraulic Reference5
Hydraulic Pressure Sensor4
PS-Simulink Converter3



Simulink-PS Converter1
Pressure Relief Valve
PS Constant1
Fixed-Displacement Pump
Mechanical Rotational Reference
Ideal Angular Velocity Source
4-Way Directional Valve A
Double-Acting Hydraulic Cylinder
Solver Configuration
f(x)=0
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Mass2
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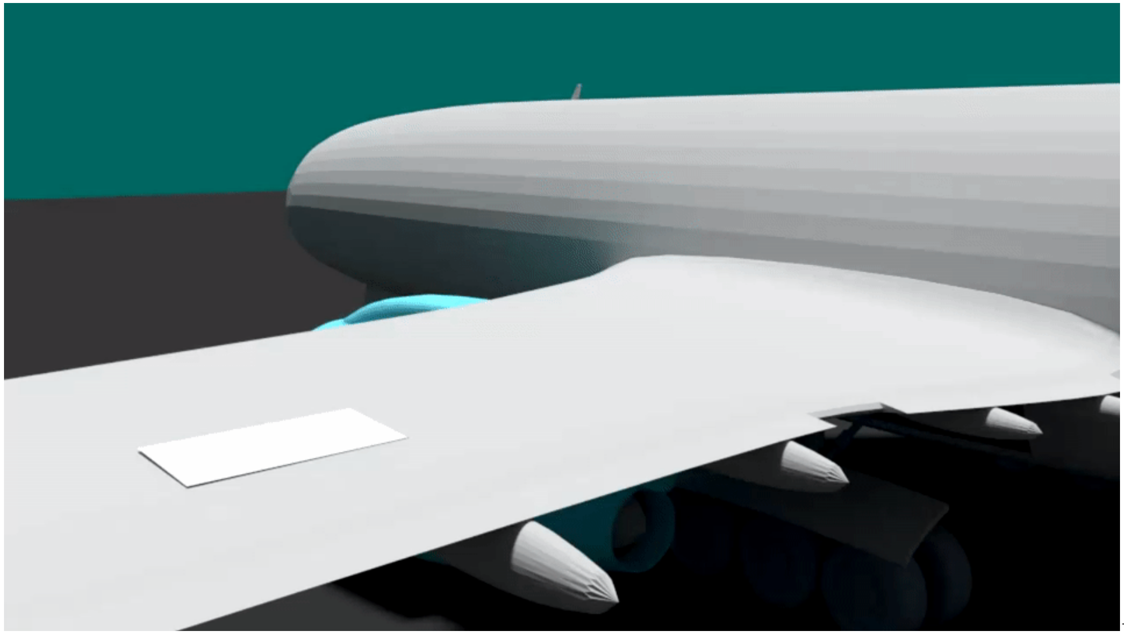
Hydraulic Reference
Double-Acting Hydraulic Cylinder1
Mass1
Hydraulic Pressure Sensor
Simulink-PS Converter
PS-Simulink Converter1
2ndcylPosition1
Ideal Force Source
PS Subtract
Signal 1
Signal Builder
PS Gain
Ideal Translational Motion Sensor
PS-Simulink Converter
pressure & position
2.91e-2*0.41s+.41
5e-3s+1
Aerodynamic drag modeling
Hydraulic Pressure Sensor4
PS-Simulink Converter3
Pilot/Autopilot and PCU actuator control

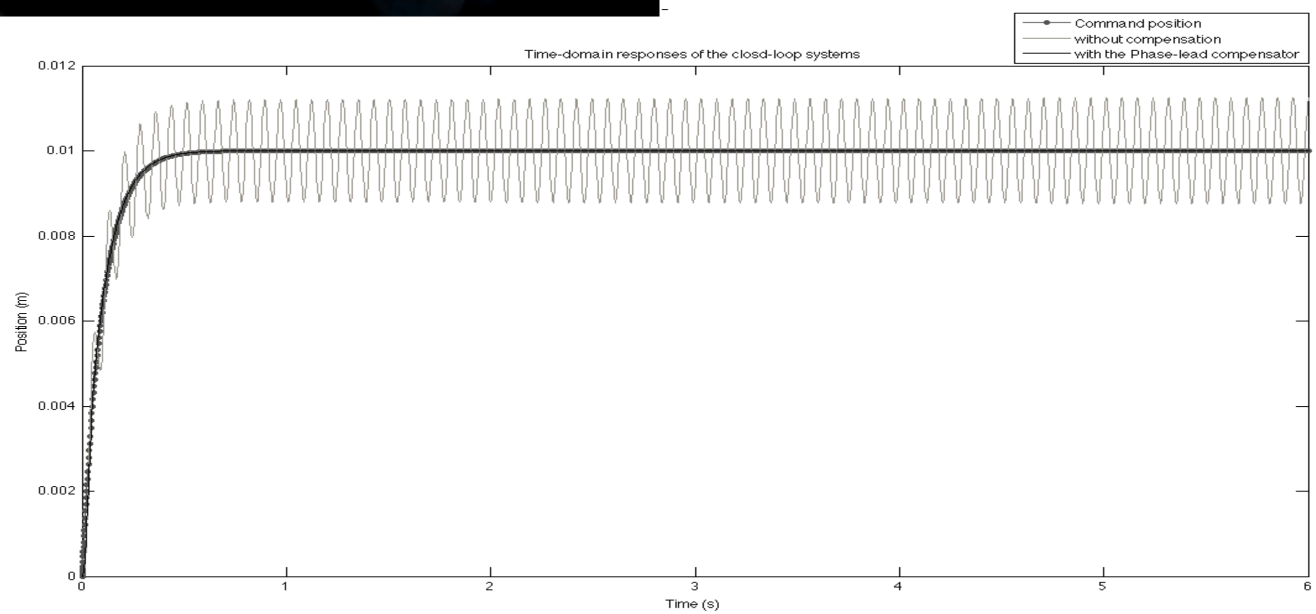
MODEL CONFIGURATION

RUDDER ACTUATOR	A340-600	F35-JSF
Actuator type	FAIL SAFE 2/3	TANDEM
Actuator stroke, m	± 0.0546	± 0.0335
Chamber diameter, m	0.083	0.050
[illegible]	[illegible]	[illegible]

Simulation results



- Stabilized behaviour
- The actuator is de-pressurized when not in use
- The same actuator could be used in different applications (even in different vehicles) only by changing the main cylinder
- The results have been verified by comparison with the F35 rudder EHA build-up and testing campaign

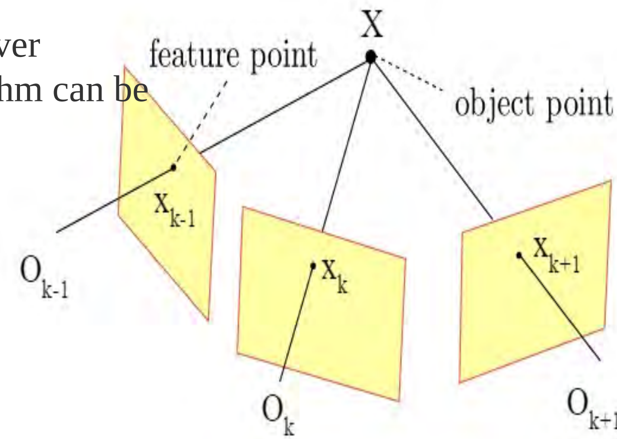


Virtual Control Tower:

Approaching flight object
Automatic Trajectory
Reconstruction

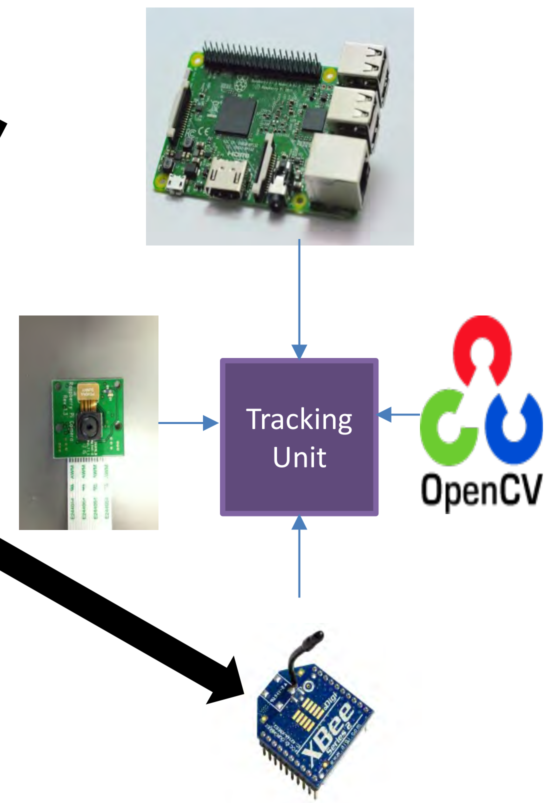
Tracking Units

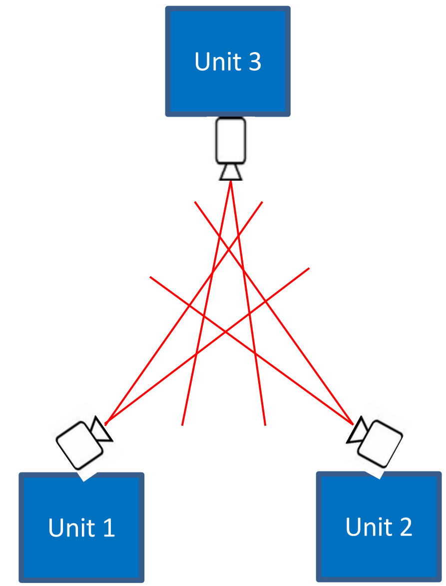
The system can be applied from two to n views so that there are more equations to over determine the linear system. In such case, the Direct Linear Transform (DLT) algorithm can be applied



Main components:

- Microprocessor
- Microcamera
- Micro transmitter
- Algorithms and software for image analysis and trajectory reconstruction





Direct Linear Transformation

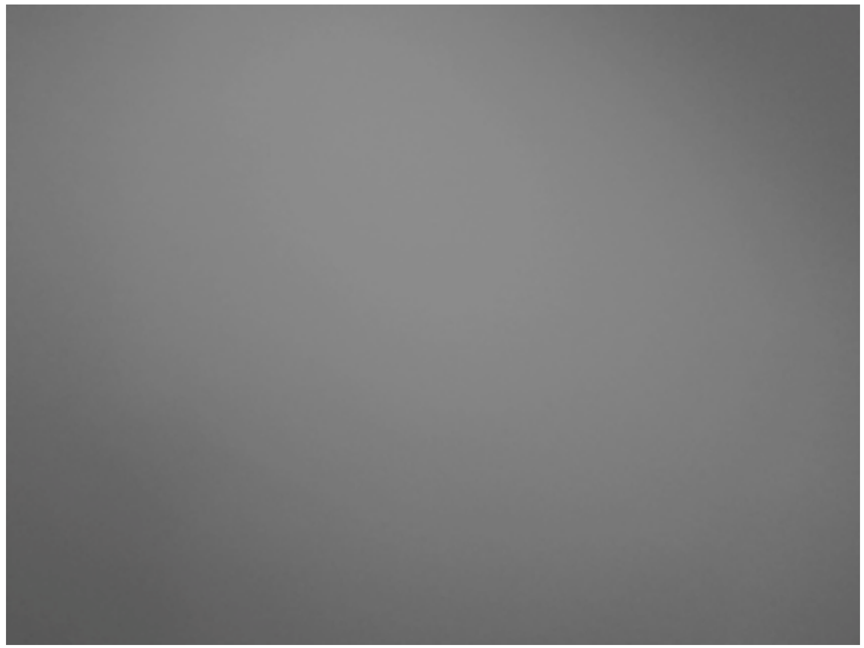
- Direct linear transformation (DLT) is a method of determining the three dimensional location of an object (or points on an object) in space using views of the object.
- Calibration is achieved by solving for each view the projection matrix:

Combining the projection matrices, the 3D world coordinates are found by
Solving:

$$\begin{matrix}\text{Point 1}\\ \\ \text{Point 2}\\ \\ \\ \text{Point } N \\ \\ \end{matrix}\underbrace{\begin{bmatrix} x_1 & y_1 & z_1 & 1 & 0 & 0 & 0 & 0 & -u_{L1}x_1 & -u_{L1}y_1 & -u_{L1}z_1 \\ 0 & 0 & 0 & 0 & x_1 & y_1 & z_1 & 1 & -v_{L1}x_1 & -v_{L1}y_1 & -v_{L1}z_1 \\ x_2 & y_2 & z_2 & 1 & 0 & 0 & 0 & 0 & -u_{L2}x_2 & -u_{L2}y_2 & -u_{L2}z_2 \\ 0 & 0 & 0 & 0 & x_2 & y_2 & z_2 & 1 & -v_{L2}x_2 & -v_{L2}y_2 & -v_{L2}z_2 \\ & & & & & \vdots & & & & & \\ x_N & y_N & z_N & 1 & 0 & 0 & 0 & 0 & -u_{LN}x_N & -u_{LN}y_N & -u_{LN}z_N \\ 0 & 0 & 0 & 0 & x_N & x_N & x_N & 1 & -v_{LN}x_N & -v_{LN}y_N & -v_{LN}z_N \end{bmatrix}}_{2N \times 11} \underbrace{\begin{bmatrix} L_1 \\ L_2 \\ L_3 \\ L_4 \\ L_5 \\ L_6 \\ L_7 \\ L_8 \\ L_9 \\ L_{10} \\ L_{11} \end{bmatrix}}_{11 \times 1} = \underbrace{\begin{bmatrix} u_{L1} \\ v_{L1} \\ u_{L2} \\ v_{L2} \\ \vdots \\ u_{LN} \\ v_{LN} \end{bmatrix}}_{2N \times 1}.$$

$$\begin{bmatrix} L_1 - L_9 u_L & L_2 - L_{10} u_L & L_3 - L_{11} u_L \\ L_5 - L_9 v_L & L_6 - L_{10} v_L & L_7 - L_{11} v_L \\ R_1 - R_9 u_R & R_2 - R_{10} u_R & R_3 - R_{11} u_R \\ R_5 - R_9 v_R & R_6 - R_{10} v_R & R_7 - R_{11} v_R \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} u_L - L_4 \\ v_L - L_8 \\ u_R - R_4 \\ v_R - R_8 \end{bmatrix}. \longrightarrow \mathbf{Q}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \mathbf{q}, \longrightarrow \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \left(\mathbf{Q}^T\mathbf{Q}\right)^{-1}\mathbf{Q}^T\mathbf{q}.$$

Application to UAV



Camera Rig Calibration and 3D Reconstruction

- DLT algorithm calculates the Projection Matrix for each view (3D to 2D correspondence)
- Given the projection matrix pixels can be projected to the word coordinates system