WIRELESS ON SPACE LAUNCHER – ARIANE 5

Astrium

Space Transportation

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CANEUS / NASA « Fly-by-Wireless » workshop

27/03/2007

All the space you need

EADS astrium

Content

Astrium: a 100% subsidiary of EADS

EADS

Airbus

Military Transport Aircraft

Eurocopter

Astrium

Defence & Security Systems

Astrium's activities are based in three key areas

Astrium Space Transportation

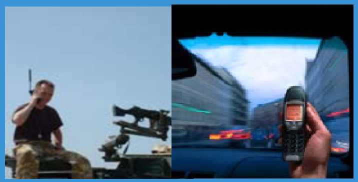
The European prime contractor for civil and military space transportation and manned space activities

Astrium Satellites

A world leader in the design and manufacture of satellite systems

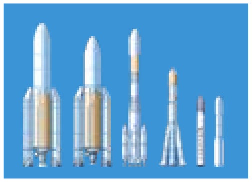
Astrium Services

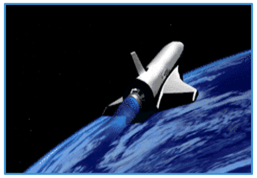
At the forefront of satellite services in the secure communications and navigation fields

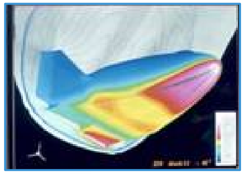


An impressive product and capability portfolio

- Launchers: Ariane, Soyuz, Rockot, Vega
- Ballistic missiles, missile defence
- Future launchers
- Orbital systems: Columbus, ATV, Operations, Atmospheric re-entry systems
- Propulsion & equipment
- System design, system integration & production






Access to space

- Europe's launcher family

Ariane 5 ESC-B	Ariane 5 ESC-A	Ariane 5	Soyuz Starsem	Rockot	Vega

GTO capability (dual launch)

12 t	10 t	6 t

LEO capability

Ariane 5	Soyuz Starsem	Rockot	Vega
> 20 t 300 km - 51°6	2.5 t / 5 t 1,400 km	1.1 t 700 km	1.5 t 700 km

Access to space

- Single Prime Contractor for Ariane 5

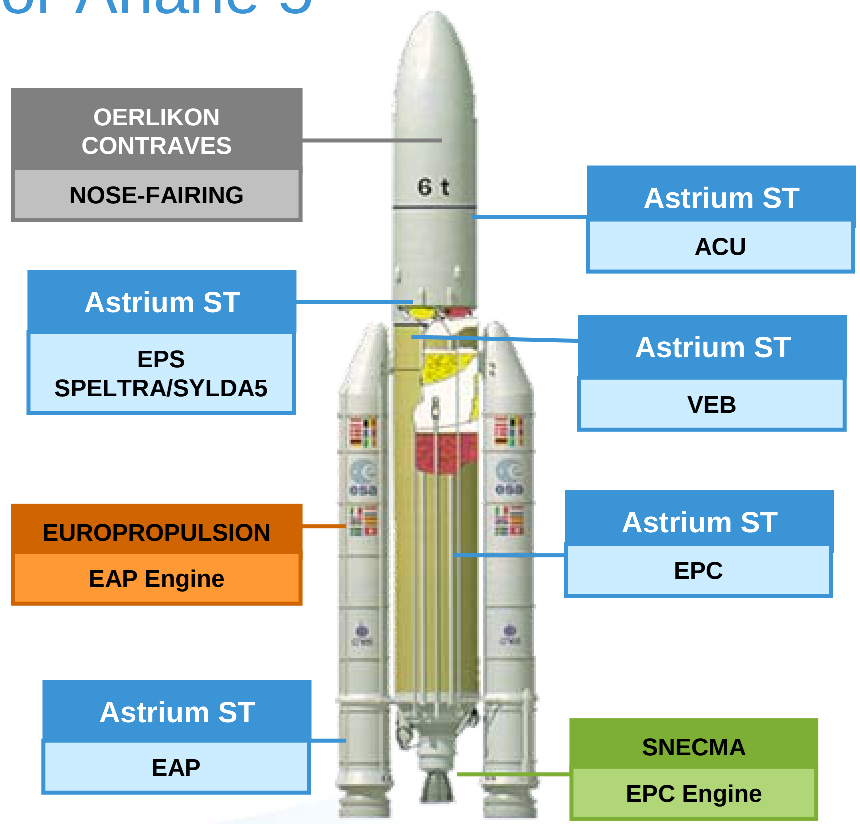
- Delivery of the fully integrated launch vehicle to Arianespace in Kourou
- Supplier of all major elements of Ariane 5 (stages, VEB, software, etc.)
- ESA’s single point of contact for future developments

Access to space

- Provider of all major elements for Ariane 5

  - EPC, EAP, EPS stages
  - Vehicle Equipment Bay
  - Flight software
  - Mission analysis
  - Sub-assemblies

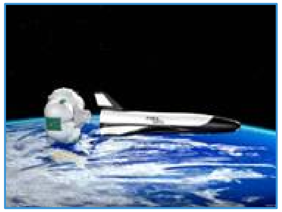
- **Performance in GTO: 5.9 to 10 t**
- **Mass at lift off: 710 t**
- **Thrust at lift off: 10,600 kN**
- **Total height: from 45 to 55.9 m**
- **Maximum diameter: 12.2 m**



Access to space

- Preparing for the new generation of launch vehicles and reducing launch costs

- System studies and stage architecture
- Research, technology, development:
  - Study of reusable, semi-reusable and expendable launch vehicle concepts
  - Company and State funding
- FLPP programme

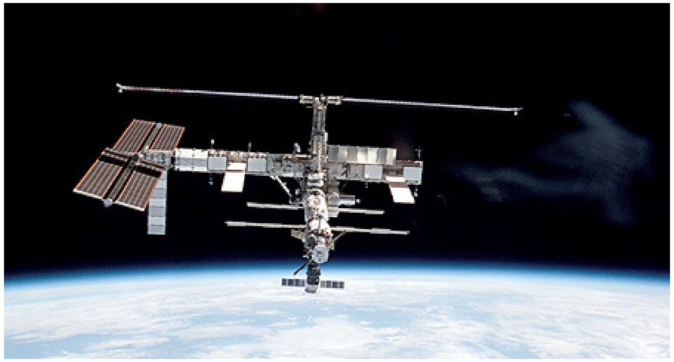


- **Technology Demonstrators**
  - Pre-X, Ares, Astra
  - Phoenix: test flight campaign in 2004

Man in space

- European contribution to the ISS: hardware elements

  - Industrial prime contractor for the core European ISS Elements:
    - Columbus research laboratory
    - Automated Transfer Vehicle (ATV)
  - Data management systems for the space station (DMS)
  - Robotic systems (ERA)
  - Experimental facilities for scientific use
  - Astronaut training and simulators for Columbus, ATV and experimental facilities



Man in space

- European contribution to the ISS: Columbus

  - ESA prime contractor for the Columbus laboratory, the European space research facility
  - Pressurised laboratory
  - Designed for microgravity research
    - Physics
    - Chemistry
    - Biology
    - Medicine
    - Human physiology
    - Space and Geosciences

Length:	8 m
Diameter:	4.5 m
Payload:	10 active payload racks
Launch mass:	12.770 tonnes
Crew:	designed for 3 crew members

Man in space

▪ European contribution to the ISS: ATV

▪ ESA prime contractor for the Automated Transfer Vehicle for logistic resupply of the International Space Station, launched on board an Ariane 5 (July-October 2007)

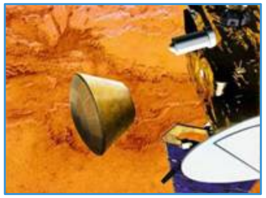
- Cargo
- Propellants
- ISS-reboost
- Waste removal

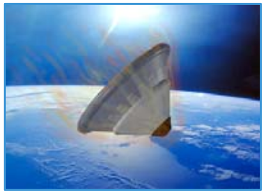
Length:	10.05 m
Diameter:	4.57 m
Payload mass:	7 tonnes net
Launch mass:	20 tonnes
Navigation:	autonomous, based on GPS data

Exploring the Universe

▪ Atmospheric re-entry systems

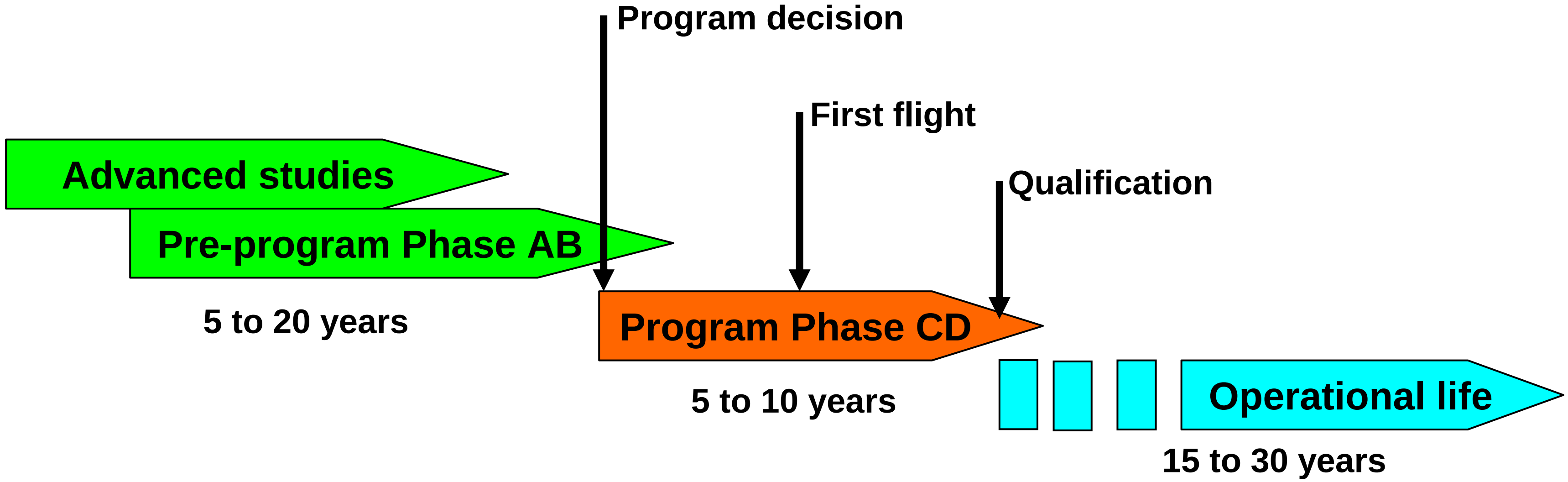
- Thermal protection systems for interplanetary probes
  - ARD: developement, integration and tests.
    Successful mission in October 1998
  - Beagle 2: Mars Express lander. Thermal protection system (2003)
  - Huygens: Titan exploration. Thermal protection system (2005)
- ISS Servicing: CARV, PARES
- Interplanetary exploration: Mars EDLS, EVD
- Expert: re-entry testbed
- NASA X-38: essential hardware and software
- IRDT: inflatable re-entry technology system





Programs characteristics (1/2)

▪ Our development programs are very long



- **Use of up to date technologies (at program decision time)**
- **Very long lifetime (treatment of obsolescence issues)**
- **Complex systems with high reliability & safety needs**
- **Functions in very harsh environments**

Programs characteristics (2/2)

- Once qualified, the configuration is difficult to modify
  - To preserve reliability
  - To optimize production flow
  - To avoid re-qualification costs

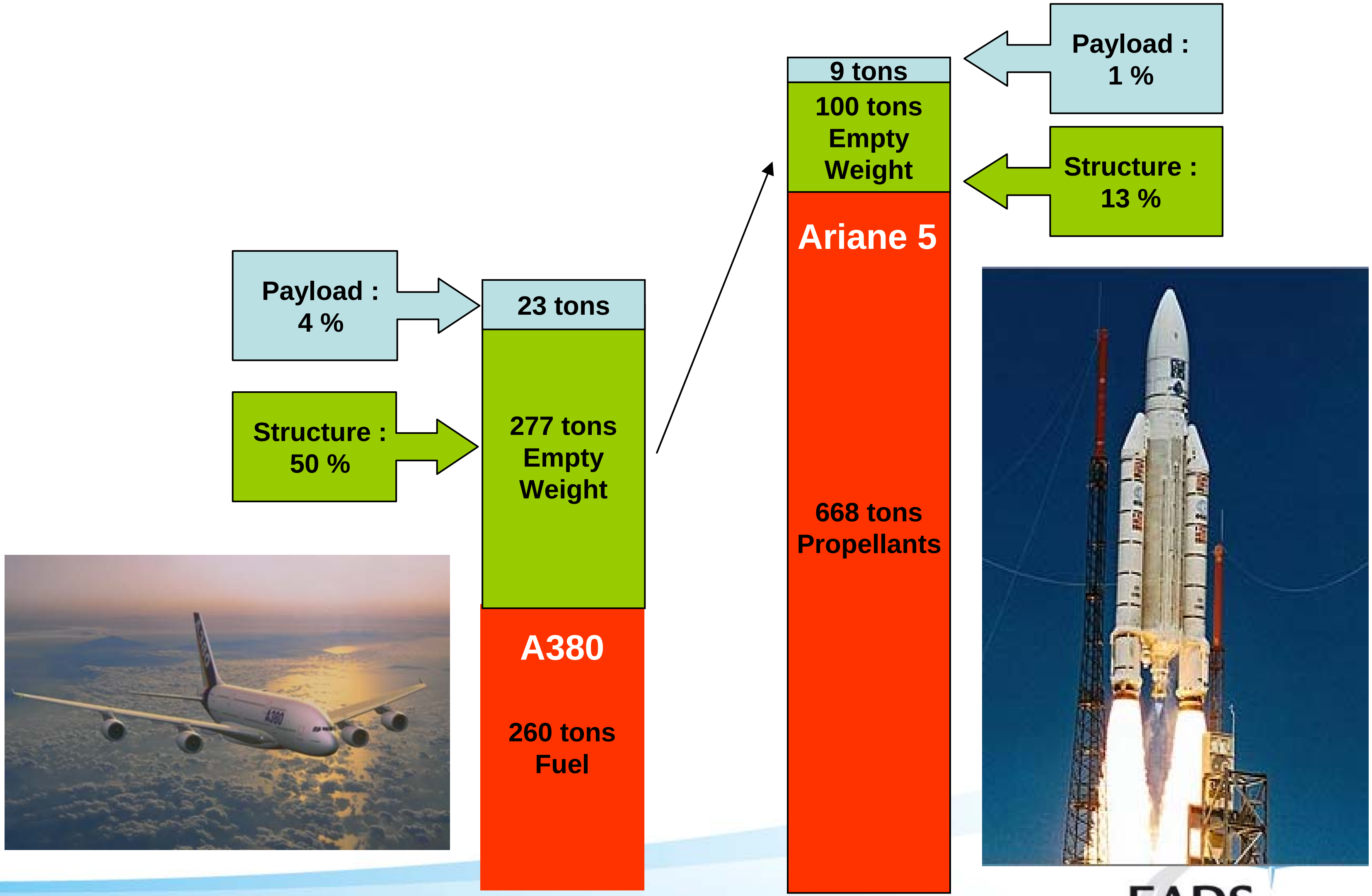
- Technology is chosen very early in the development cycle, the reasons for changing a component are generally only :
  - To solve a problem
  - To overcome obsolescence
  - To generate <u>very significant</u> savings

Our mission (1/3)

- **To give a heavy object (up to several tons) a very high speed (up to 10^4 m/s) in a short time we need :**

  - **A« big » propulsion (enough thrust and energy to counter gravity and deliver a few g's acceleration)**
  - **Tanks to contain the propellants with enough reactive mass and engines to eject it at highest possible speed**
  - **GNC (Guidance Navigation & Control) to deliver the payload on the required orbit/trajectory**
  - **Systems to monitor the vehicle health and ensure safety**

Our mission (2/3)



Our mission (3/3)

- **To do it repeatedly with high level of reliability we need :**
  - **An in depth understanding of the physical phenomena's**
  - **A correlation between the models used in the design phase and the encountered and/or induced environment**

How do MNT may be an advantage (1/4)

- Functional GNC equipment & harness

  – Miniaturization of technologies (cf Moore's law in electronics) and introduction of highly integrated electronic packaging

  – More and more unstable and flexible vehicle control (to reduce the structures mass) require more and more electronics and sensors and could be realized with MEMS

  – Use of MEMS (if space qualified) as soon as their performances are equal with bigger equipment for future developments

How do MNT may be an advantage (2/4)

- A better knowledge of actual performance may help reduce exaggerated design margins

  - Add new sensors, to map phenomena throughout the vehicle (to identify a deformation pattern or a flexible mode characteristics, to describe dynamic behavior..)
  - Introduce new wireless autonomous sensors in remote areas of the vehicle

How do MNT may be an advantage (3/4)

Telemetry and safety equipment & harness

- More than 600 different measures for any commercial Ariane flight (and much more for a qualification flight)
- New technologies (MEMS) allows « smart sensors » to reduce side equipment
- Wireless data transfer and autonomous power supply could drastically reduce the harness requirements
- RF MEMS will significantly improve the performance of the telemetry chains

How do MNT may be an advantage (4/4)

- **Combine multiple functions into structural material**

  - **Surface treatment**
  - **Surface electrical resistance**
  - **Surface thermal properties**

- **Increase the confidence before launch**

HUMS (Health and Usage Monitoring System)

Wireless communications on launchers (1/5):

Wireless : what for ?

Our envisioned applications are :

- Low rate sensor communications for versatile sensor networking

- Medium rate interstage data transmission
  - communications after stage separation
  - mechanical and electrical Interface simplification

- High rate communication on launch pad towards ground facilities : simplification on jettisonable connectors.

Wireless communications on launchers (2/5):

- First : think « Industrial process » :
  - Insensitivity to dispersion shall be proven
  - Growth potential shall be fully anticipated
  - Battery replacement shall be avoided (low consumption, low discharge rate, long stockage duration…).
- No data shall be lost, in particular last moments before critical phases
  - Strong requirements on datation : impact on the clock architecture
  - Strong requirements on data ageing : impact on the protocol
  - Real time data transmission to ground (great difference with the Shuttle Invocon application case)
- The internal RF network propagates within a Al-based alloy (or C-C composite) closed volume with low RF power dissipation.

Wireless communications on launchers (3/5):

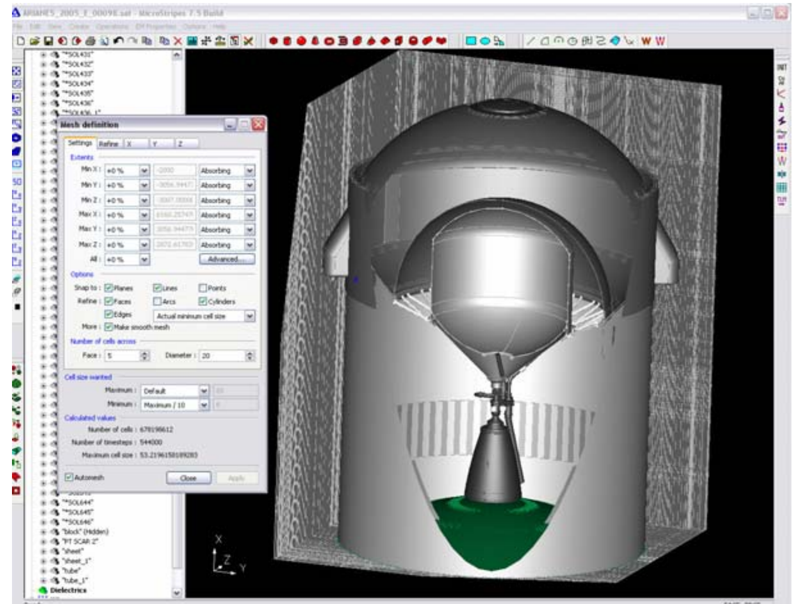
- **This leads to the following quantified requirements :**
  - Propagation simulation shall demonstrate an affordable BER : $10E^{-6}$
  - Dispertion includes :
    - geometry of the propagation volume (wire routing, equipment shapes, dilatation : shall be under $\lambda/10$ = a few mm),
    - doppler effects on reflected beams while the volume vibrates during the flight
  - Ariane5's internal diameter is over 5 m; this volume is not symmetrical, and internal details lead to a geometrical despription containing trillions of meshes for RF simulation

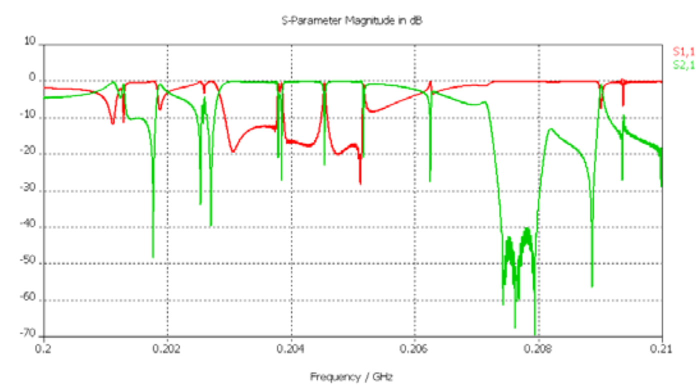
Wireless communications on launchers (4/5):

- RF simulators could possibly be used, but require very powerful machines, and despite the great quality of these tools, results remain uncertain for dispersion reasons

- Standing wave propagation regimes lead to very harsh fadings, located everywhere close to optimal reception areas, in terms of geometry as well as in term of carrier frequency : danger of link loss versus dispersion.

- Who will trust the results of the simulation outputs?





Wireless communications on launchers (5/5):

Well, what shall we do, now?

- A test campaign is planned to demonstrate the Bluetooth or Zigbee robustness to mechanical dispersion on the volume, in order to kill the « simulation-proven » paradigm.
- RF alternative for internal data transmission may be the infra Red beam mixing TDMA and Carrier Wavelength Multiplexing
- Wireless transmission is more likely to be used for free space RF propagation : EAP-EPC or Launch Pad communications.

Concluding Remarks :

« Fly-by-Wireless » could be :

- For Telemetry systems on Ariane and FLPP (Future Launchers Preparatory Programs) European launchers:
  - Add new sensors, to map phenomena throughout the vehicle (to identify a deformation pattern or a flexible mode characteristics, to describe dynamic behavior..)
  - Introduce new wireless autonomous sensors in remote areas of the vehicle
- Combine multiple functions in structural materials to Increase the confidence before launch by using ***"HUMS (Health and Usage Monitoring System)"***

- Looking for International collaborations
  - To demonstrate wireless functions
  - To do flight demonstrations

THANK YOU
MERCI !