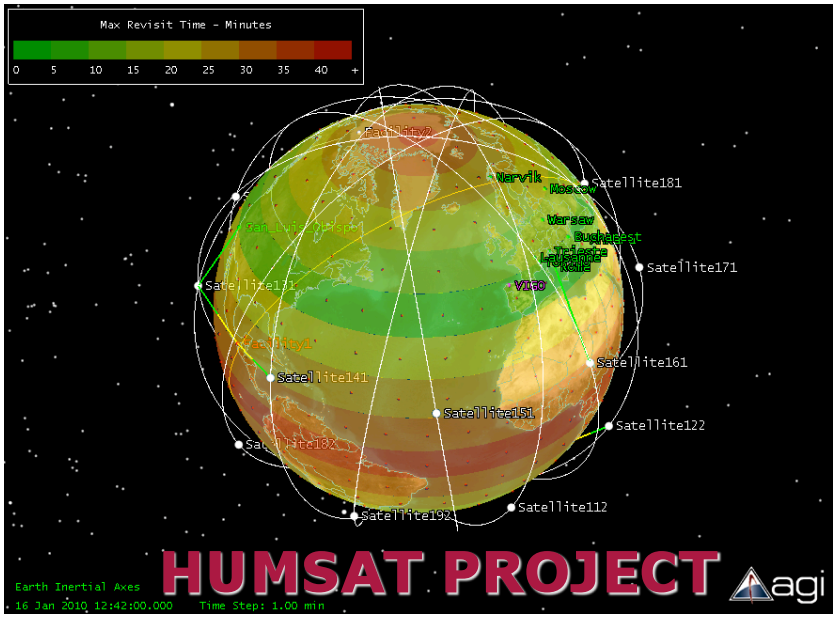
HUMSAT



The HUMSAT CONSTELLATION

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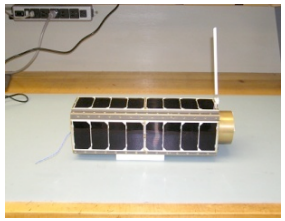
IAC 2010

Project Definition

- HUMSAT is an international educational initiative for building a constellation of nano-satellites providing communication capabilities to areas without infrastructure.
  - Based on the CubeSat standard and using GENSO as ground segment.
- HUMSAT is meant to provide data-relay services (storage and forward concept) for transfer of data like for example:
  - In-situ Environmental information (uni-directional)
  - Humanitarian (Simple bi-directional data)
  - Possible secondary specific payloads.



- GEOID initiative will be a GENSO testbed trough HUMSAT compatible nanosats that ESA will launch in support of the project and for educational purposes:
  - Constellation of 9 CubeSats

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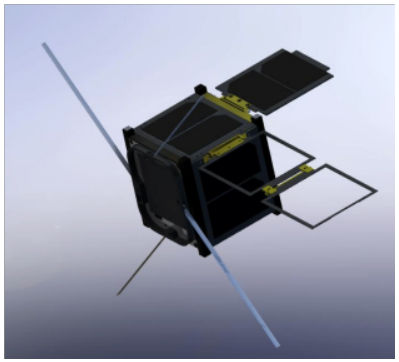
Project Initiators



- Concept definition and initiators:
  - University of Vigo (Spain)
    - Xatcobeo
    - European GENSO Operations Node
  - California Polytechnic State University (USA)
    - CubeSat standard definition
    - P-POD development
    - Future US/American GENSO Operations Node
  - Universidad Nacional Autonoma Mexico (Mexico)
    - CubeSat development for HUMSAT
    - Follow up trough SATEX2 project
  - CRECTEALC: Regional Centre for Space Science and Technology Education for Latin America and the Caribbean. Affiliated to the United Nations.

Supporting Organizations

The system is supported by a number of international organizations and countries:

- UNOOSA
  - HUMSAT discussed at UN Symposium on Small Satellites organized in Graz in September 2009 and 2010.
  - HUMSAT to be considered under the United Nations Basic Space Technology Initiative (UNBSTI, http://www.unoosa.org/oosa/en/SAP/bsti/index.html).
- ESA
  - Optional Educational Initiative for State and Cooperating Members
  - GENSO development and operations node selected.
  - Leading the implementation of the test-bed of GENSO with HUMSAT compatibles satellites via GEOID.
  - Call for proposal: http://www.esa.int/SPECIALS/Education/SEMXA9HONDG_0.html
  - Deadline: 17th October 2010.
- NASA
  - Educational program to launch US/CubeSats.
  - Use of GENSO for their CubeSat projects.
  - Selection of the US/American GENSO node.
- IAF
  - Promoting the HUMSAT idea with the Heads of Agencies in the world to allocate regular access to space on a rotating bases for humanitarian nanosats.

University and Country Organizations

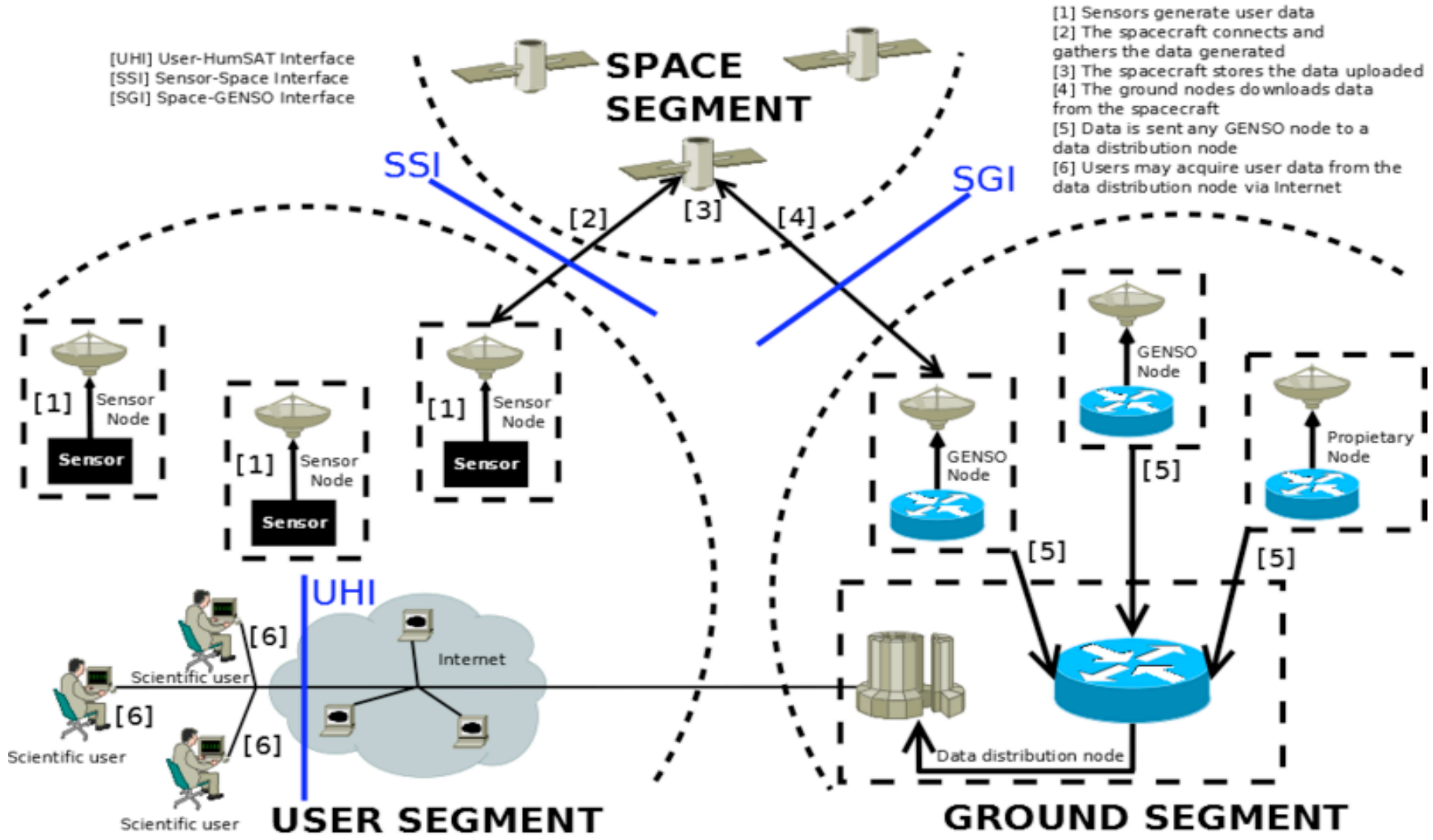
- **ESA**: Educational Program of the European Space Agency to launch 9 nanosatellite.
  - Call for proposal
- **California Polytechnic University**
  - Coordinates the US participation.

- **UNOOSA** (Through Regional Centers: i.e. CRECTEALC) :
  - Central and South America:
    - Mexico (2 satellites)
    - Colombia (Sequoia Space)
    - Brazil
    - Chile
    - ….
  - India
  - Russia
  - South Africa
  - Nigeria
  - Egypt
  - Vietnam
- Many other countries have expressed interest.
- **Open for all interested participants.**

Educational Objectives

- Provide hands-on-project experience on a space project for engineering/science students.
  - Covering all design, implementation and operations phases.
  - Covering all technical aspects of a space development
- Get students familiarized with ESA project management, standards and procedures for space projects.
- Hands-on experience with universities, institutions and space agencies at worldwide scale.
- Promote international cooperation between universities, space agencies and countries in space.
- Sharing experience with universities/institutions of developing countries.

HUMSAT Mission Concept



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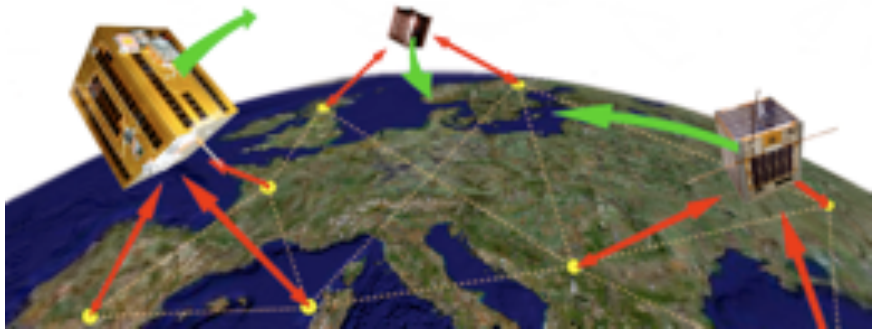
HUMSAT Architecture

- **Space segment** is based on nano-satellites, according to the **CubeSat** standards as baseline, but open for other standards.
- **Ground Segment** is based on the GENSO network (near worldwide coverage).
- **User segment** based in low-cost ground sensors:
  - **Up-linking** key information for further release to users,
  - Providing **bi-directional** communication capabilities between users in remote locations.



System Design Details

- Constellation of CubeSats, approx. 1.3 to 4.5 Kg. (Open for non-Cube Standards)
- Low Earth orbits, ~600 km.
- User time gap in visibility for any s/c in the constellation < 2 hours.
- GENSO ground station worldwide network used for data downloading and TTC, providing almost continuous visibility on the CubeSats.
- Possible user ground sensors (applications):
  - Public health: providing communication means from remote locations.
  - Monitoring and prevention of natural disasters through a worldwide sensor network.
  - Sensor networks for climate monitoring.
  - Monitoring of environmental pollution: wells, lakes, areas with difficult access, seas…
  - Use of nano- and micro-technology for the sensors.

User Data Distribution

- Sensor interface to the constellation is currently available at ESA Education web site.
- Every user can define its own monitoring sensors and locations.
- Once a sensor has sent their data to the s/c, this user data is downloaded through one of the GENSO ground stations and transported to the Data Distribution Center(s) using the Internet.
- Users will need to register and authenticate in order to access their data.
- Access is provided via the Internet to the data collected.
- No proprietary tools required for the access.

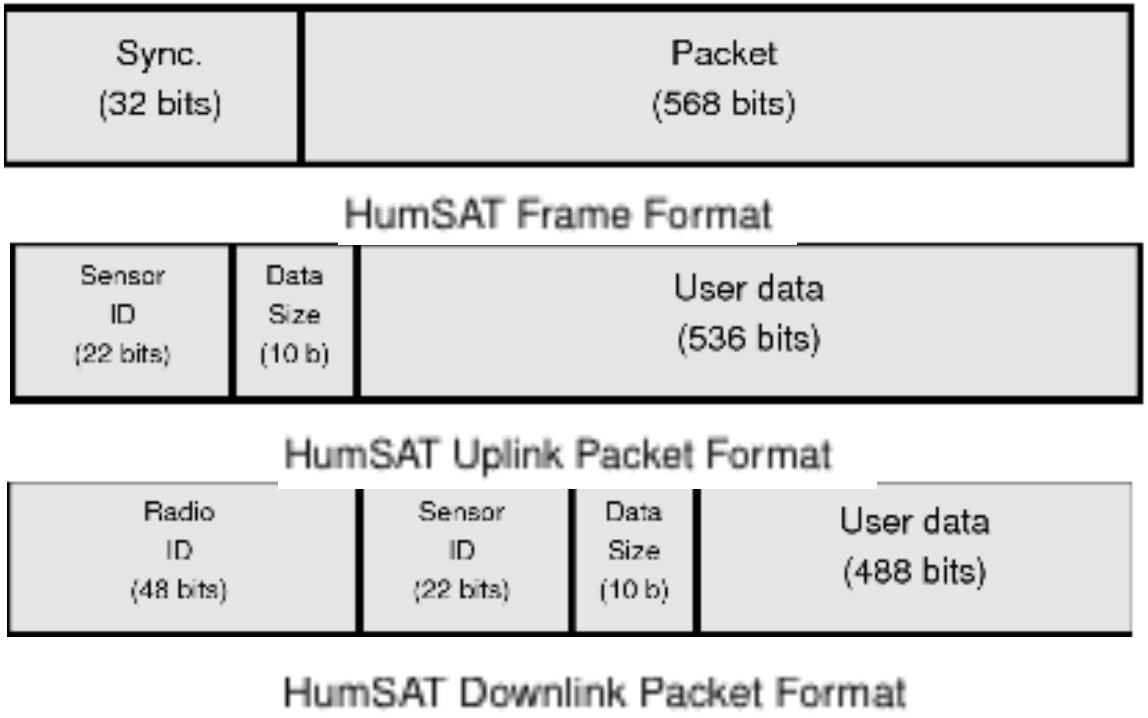
Sensor to Space Interface (SSI) (TBC)

Sensor to Space Interface (SSI)	UPLINK (Sensor-SC)	DOWNLINK (SC-Sensor)
Frequency Allocation	• UHF Radio Amateur • Specific frequency (401-402 MHz)	• UHF Radio Amateur • Specific frequency (401-402 MHz)
EIRP	1 W	1 W
Modulation	BPSK	BPSK
Data Rate	1200 bps	1200 bps
Modulation BW	1.2 KHz	1.2 KHz
Message Duration	Up to 500 ms.	Up to 500 ms.
MAC	Aloha with random message repetition	Immediate SC response after uplink message.
Polarization	Lineal	Circular
Receiver sensitivity	Better than -120 dBm	Better than -120 dBm
Doppler compensation	On Satellite	On Satellite

Sensor Target Price: few $

- **DISCLAIMER This is not the final version of the SSI. The HUMSAT system is currently under design and the present data may undergo modifications. <u>This version of THE DATA IS NOT VALID FOR IMPLEMENTATION.</u>**

Data Frame Format(TBC)



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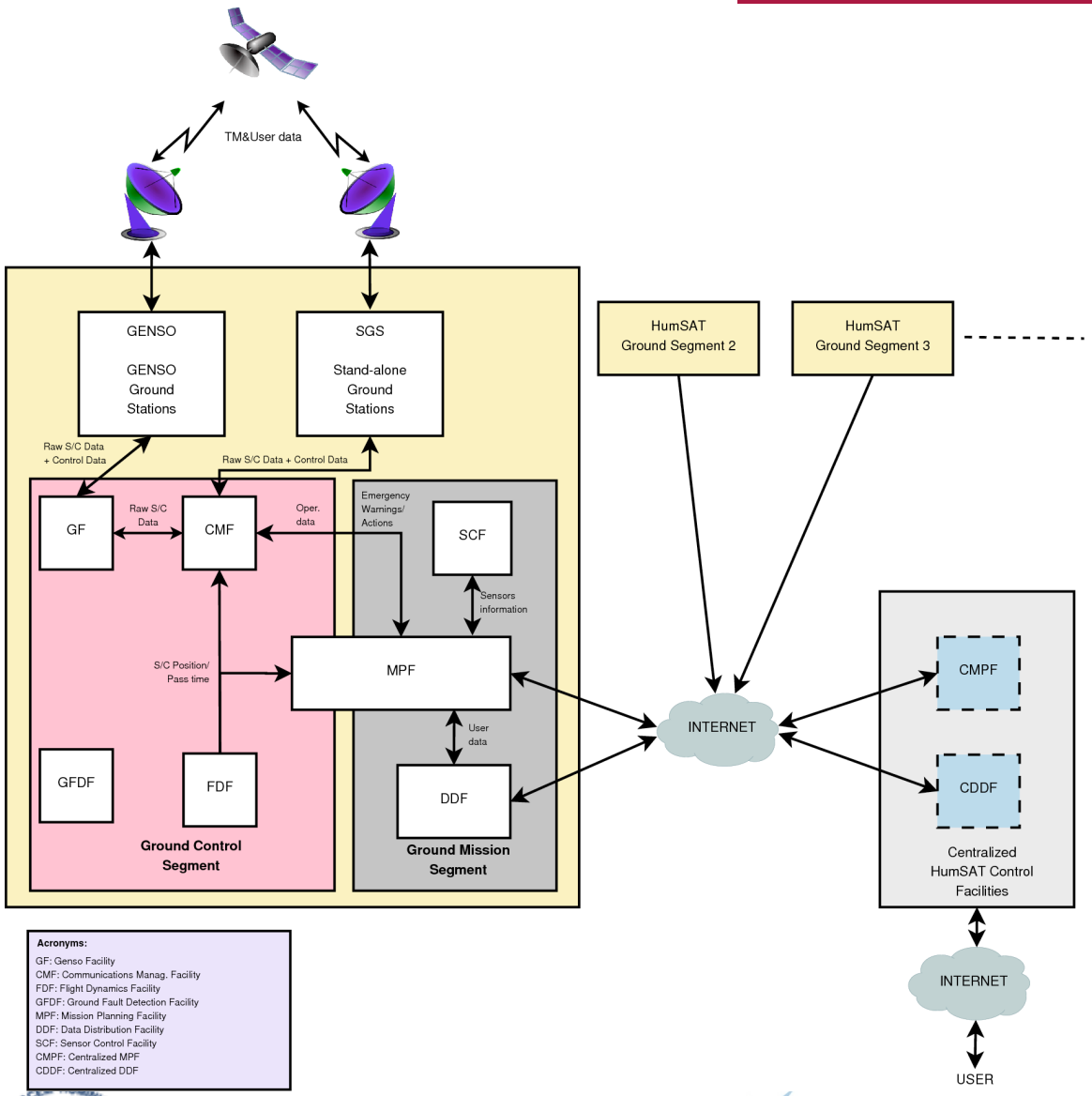
All the parameters are TBC

Doppler Shift Compensation

- Used in current systems as Argos, WEOS …
- All the sensor transmits at the same nominal frequency.
- The received frequency varies in function of the relative location of the sensor and satellite (less than ±10 KHz Doppler UHF – Radio Amateur Band for a 600 Km LEO).
- Use the different Doppler Frequency shifts to improve the overall system performance allowing simultaneous arrival of different sensor signals.
  - Doppler-shift based Frequency Division Multiple Access.
  - Location Sensors trough Doppler shifts.
- Transceiver possible implementations:
  - Simple receiver without parallel reception.
  - Radio-software including parallel reception.
- Similar technical challenges: AIS satellite receivers with STDMA access protocol.

Ground Segment



HUMSAT Satellite Constellation

- Current situation:
  - Use the orbit provided by launchers.
  - Very difficult to have dedicated launch opportunities.
  - Typical 600-70 SSO orbits
- Ad-hoc Satellite Constellation.
- Possibility to include passive mechanisms to distribute as best as possible the satellites in the orbit (RESEARCH).
- Include new satellites in HUMSAT will improve the overall performance of the system.
  - Temporization of the HUMSAT satellites.
- Possibility to include HUMSAT in any Cubesat/Nanosat/Mictro as:
  - Primary Payload
  - Secondary Payload

HUMSAT Animation

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Sensor Philosophy

- BPSK selected for the SSI due to the large availability of COTS BPSK chips with very low cost.
- Not synchronization required between the different sensors.
  - Easy to implement – Aloha protocol
  - Very cheap – Target: a few $ per sensor
  - Reduce the performance/number of users of the system.
  - No Doppler compensation in the sensor.
  - Low power.

HUMSAT: Project Management and Schedule

- **Central, South America and Caribbean Countries**: CRECTEALC (Regional Centre for Space Science and Technology Education for Latin America and the Caribbean affiliated to the United Nations and UNAM/ AEXA coordination
- **Africa**: UNOOSA coordination with the support of the promoter group, IAF and the rest of the Space Agencies
- **Asia Pacific**: UNOOSA coordination with the support of the promoter group, IAF and the rest of the Space Agencies.

HUMSAT: Project Management and Schedule. Global concept.

- Plan:
  - System design activities are undergoing at present.
  - Release of the first system documentation for participants expected by end 2010.
  - Possibility to undertake efforts in three areas:
    - Develop a CubeSat
    - Develop the hand-set and sensors for communication with the constellation
    - Join the GENSO network which will provide the ground infrastructure for data relay
- Highly recommended the use of a tailored version of the different SPACE QUALITY Standards (e.g. ECSS in the case of Europe, ….)
- Debris mitigation.

GEOID: Project Management and Schedule. (European Contribution)

- GEOID, the HUMSAT test-bed that ESA Education Office will develop is a 3-4 years project
  - (http://www.esa.int/SPECIALS/Education/SEMXA9HONDG_0.html)
- Purpose: build the European component of the Global constellation
- Promote the concept of HUMSAT through international cooperation with other space Agencies.
- Plan:
  - System design activities are undergoing at present.
  - Call for participation and release of the basic system documentation for participants 16th September 2010.
  - Possibility to undertake efforts in three areas:
    - Develop a CubeSat
    - Develop the hand-set and sensors for communication with the constellation
    - Join the GENSO network which will provide the ground infrastructure for data relay
- The System Engineering activities will be led in Europe by University of Vigo which is one of the promoter of the HUMSAT concept under ESA management control.

CONCLUSIONS

- HUMSAT - Active support and participation by Space agencies and highly recognized International Organizations.
- Goals: Educational, Research, Humanitarian, Climate monitoring, Non Commercial.
- HUMSAT payload could be primary or secondary payload in any mission.
- UNOOSA: United Nations Basic Space Technology Initiative (UNBSTI).
- ESA: GEOID initiative for testing GENSO trough HUMSAT compatibles satellites.
- Any country could join the project in different levels:
  - Nanosatellite development
  - GENSO Ground Segment.
  - Specific User Segment (sensor)
- Capability to design Space Segment (secondary payloads) and Sensors specifically for the local/regional needs.
- Worldwide coverage.
- Open standard.
- Free access to the data through internet.
- WIN-WIN Approach: share satellites, GS, information, ….

Contact Points

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