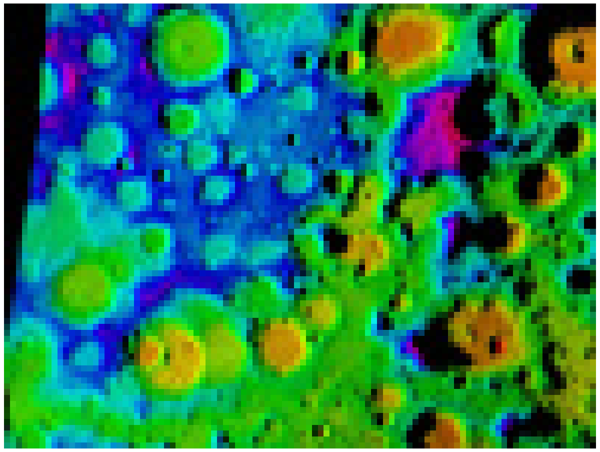
SPACOMM 2009
PANEL

Challenges and Hopes in Space Navigation and Communication: From Nano- to Macro-satellites

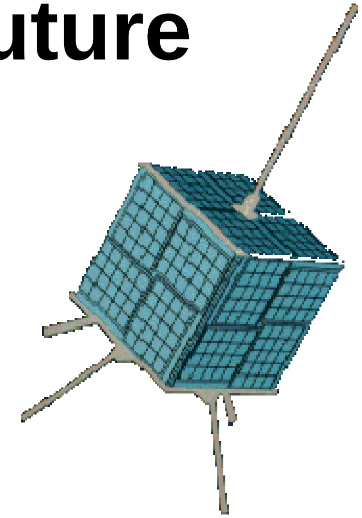
Lunar Reconnaissance Orbiter (LRO): NASA's mission to map the lunar surface

- Landing on the Moon

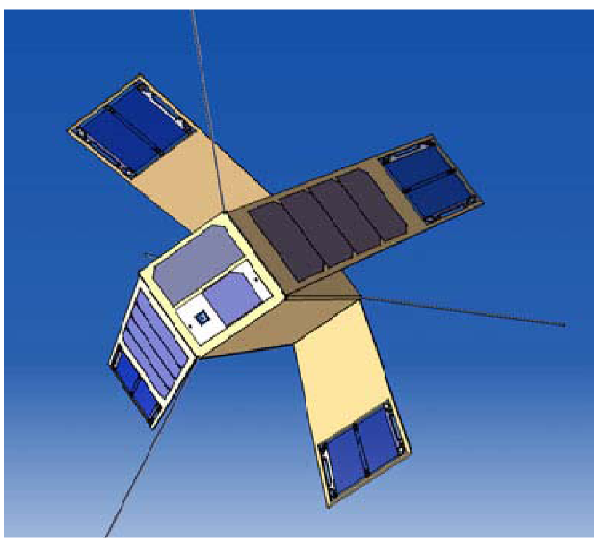


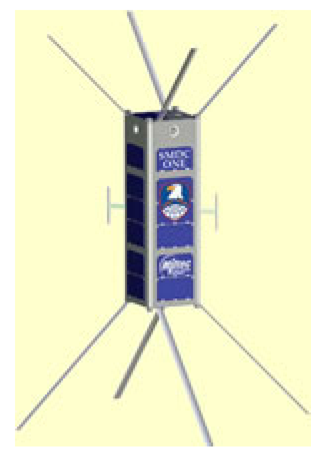
Nano & Pico-satellites, leading to Femto-satellites

- **Nano-Satellites – Future of the Future**
- http://www.russia-ic.com/education_science/science/science_overview/578/



- **Spatial sensors?**





Guests

- **Moderator:**
  Petre Dini, IARIA / Concordia University, Canada
- **Expert Panelists:**
  Igor Bisio, University of Genoa, Italy, Italy
  David Evans, ESA/ESOC, Germany
  Freddy Pranajaya, UTIAS Space Flight Laboratory, Canada
  Ross M. Jones, Jet Propulsion Laboratory, USA

Satellite Communications and Networking Laboratory

Towards a Reliable and Efficient Interplanetary Internet

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The Research Challenge

- The IPN Internet is a network infrastructure for communications among the Earth, planets, moons, space probes and spacecrafts through satellites, which operate as network nodes allowing transmissions over deep space channels.

- The main problems concern: extremely long and variable propagation delays; asymmetrical forward and reverse link capacities; high error probability; intermittent link connectivity (due to satellites eclipses and common link failures); attenuation of the transmitted signals due to distances; power, mass and size of communications hardware and costs, both in terms of hardware and protocols' complexity; backward compatibility.

- These problems strongly compromise the reliability and the efficiency of a communications process over an IPN network and, as a consequence, the minimization of their impact on the communications represents a research challenge.

The Research Goals

- The research purpose is to propose new deep space communications solutions that allow matching the vision of the IPN Internet: the reliable and efficient communication process to support space missions, to connect scientists and their remote instruments, and also to involve the public via common web interfaces.

- To reach the aim, the scientific goals are two-fold: the definition of the complete architecture of the IPN network and the design of innovative communications and networking solutions suited to be employed in each node of the network.

Possible Solutions – The IPN Internet Architecture

- The first aforementioned scientific goal is to optimize the complete architecture, defining the number and type of the required satellites and ground stations and their location.

- This optimization will consider a combination of the average duration of the link unavailability and the average propagation delay and it will deal with the orbital parameters of each satellite included in the IPN architecture.

- The idea is to design a planetary satellite constellation network and a set of ground stations such that the availability of communication links is maximized, by simultaneously fixing the maximum number of satellites adopted, in order to limit costs.

Possible Solutions – Communications and Networking

- TCP/IP systems are poorly suited for adoption in IPN networks where links operate intermittently and over extremely long propagation delay.
- This consideration leads to exploit a network architecture based on an independent middleware, the Bundle Layer, which is the main element of the Delay/Disrupt Tolerant Network (DTN) paradigm.
- It is not sufficient to offer reliable and efficient transmission over the IPN Internet, because of the dynamics of the environment under investigation. A more insightful approach is needed.
- The key idea for future research is the automatic reconfiguration capacity of the IPN protocol stack obtained by adopting innovative control strategies.
- In this perspective, the idea explicitly fills the control gap in the currently employed communications and networking solutions for IPN networks.

UTIAS SFL Space Flight Laboratory

Building Canada's Future In Space

Improving Data Throughput from a Nanosatellite

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Nanosatellite

Cost-effective, advanced spacecraft

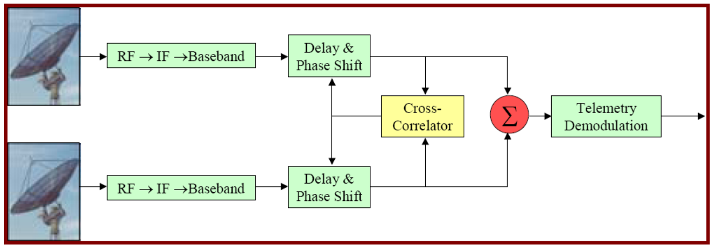
- For operational mission and technology demonstration
- Mass up to 15 kg
- Volume up to 20 by 20 by 40 cm

Data throughput defines the operational duty cycle

- **How to improve data throughput from a nanosatellite?**

Current Efforts

- 1 Mbps demonstrated from orbit
  - 3.5 kg nanosatellite (500 mW RF output, 2.2 GHz)
  - 2.1 m Ground Station dish
- ~13.5 MB per day
  - Daily operations using max 256 kbps into 2.1 m dish
- Scalable data rate
  - 32 to 256 kbps, into 2.1 m dish (primary station)
  - 256 kbps, into 9.1 m dish (secondary station)
- Research on ground station antenna array
  - Improve link condition and data rate
  - Long baseline communication (higher orbit, deep space)
- Global Ground Station Network
  - Improves contact time



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Limitation

- TX power vs. Spacecraft Power
- TX antenna vs. Spacecraft Exterior
- Modulation vs. Bandwidth
- Frequency Allocation
- Overall mission cost

Challenge

- Modulation vs. Complexity
- Higher bands (C, X, …) vs Complexity
- Frequency allocation across multiple jurisdiction

PANEL SPACOMM

Ross Jones

"Challenges and Hopes in Space Navigation and Communication: From Nano- to Macro-satellites"

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- Nano-satellites, perhaps many Nano-spacecraft

  => Scalability

  - Mechanisms we use to manage communications among them will have to scale up to large numbers and complex configurations.

    => Automation

USING THE MARGIN

David Evans ESA/ESOC
SPACOMM 09
15/07/2009

USING THE MARGIN – The Rationale

The traditional design approach to space communications is very conservative

- We imagine the worst case for every line of a link budget
- We imagine the worst weather
- We imagine the worst station and spacecraft geometry
- We imagine the maximum possible data rates required

And then we add 3dB as a link margin!

This means for the majority of time in real-world cases we have much more margin than we need. Experience bears this out (some missions rarely lose a frame)

USING THE MARGIN – The challenge

A cost-effective way to increase data return and/or reduce costs would be to use this real world margin. The disadvantage is that the amount of margin is variable (e.g. weather, geometry dependant). Using it requires changes onboard and in the ground:

- Systems on-board and ground that can measure and adapt their downlink strategy accordingly.
- Delivery protocols that enable a higher acceptable error rate. This enables the system to use more of the margin.
- Active ground/space feedback loops to facilitate these strategies

USING THE MARGIN – Exploitation

On a simple level we can use this to increase data return or reduce ground station time. However in the real world we have to book ground stations and make downlink plans in advance so a variable resource cannot be exploited without a concept change:

- Fly secondary payloads or have secondary datasets that are only guaranteed to be downloaded statistically. We know that sometime extra margin will become available to provide this service and the longer we wait the more likely it is we will achieve it.

- Operate a network, either on the ground or in space. By spreading a varying resource across a network we can sure that statistically we will achieve the goal.