IP For Responsive Microsats, A Practical Approach

Space Internet Workshop 5, 2006

Assi Friedman & Jeffrey Janicik
Innoflight Inc.

Innoflight

Presentation Abstract

Using Internet Protocols on smallsats started as a grass roots effort to take advantage of commercial hardware and software and save development time, money, and reduce risk. These premises are still exist today within the community. In addition, even though the primary users of microsats nowadays are government customers (in the U.S.) the motivation for fast responsive microsats is consistent with the original premises.

There are many spacecraft tracking stations available for government and commercial networks in the U.S. yet only few can support IP operations as a standard feature. Capitalizing on the benefits that IP can provide to us will come into play only if we can establish an operational baseline that is cost effective and easy for spacecraft designers to implement. Using protocol on protocol or unique and proprietary encoding methods defeats the point as it is as efficient as designing your own in-house system.

Innoflight has been working on a number of microsat IP technology solutions that will enable spacecraft builders to purchase COTS IP enabled hardware and software package for both the ground and flight segments. This presentation will describe how Innoflight integrated traditional IP/HDLC with CCSDS standards, and Type-1 encryption to provide users with secure, high performance IP link between the spacecraft LAN and the ground segment

Innoflight

Who is Innoflight?

The Innovative Implementation of COTS-Based Solutions for Affordable and Responsive Commercial and Aerospace Systems

Communications

- ✓ **Secure TCP/IP link engineering, integration, and hardware fabrication**
- ✓ Analog (FM) and digital (GMSK/BPSK/ QPSK) RF engineering
  - Experienced in VHF thru X-band
- ✓ Portable and fixed ground-based stations
- ✓ Miniature and non-traditional flight systems

Flight Hardware

- ✓ In-house concept-to-product capability
- ✓ Skilled at low power, light weight designs and qualifying them for extreme environments
- ✓ High efficiency power systems
- ✓ Embedded systems
  - On-board-computers
  - Controllers
  - Command decoders
- ✓ High reliability supervisory circuits

Small Sats

- ✓ Experts in systems design, engineering, integration, test and operations
- ✓ Hands-on experience
- ✓ Network of vendors
- ✓ SEIT "best practices" for low-budget, quick-response programs

Innoflight

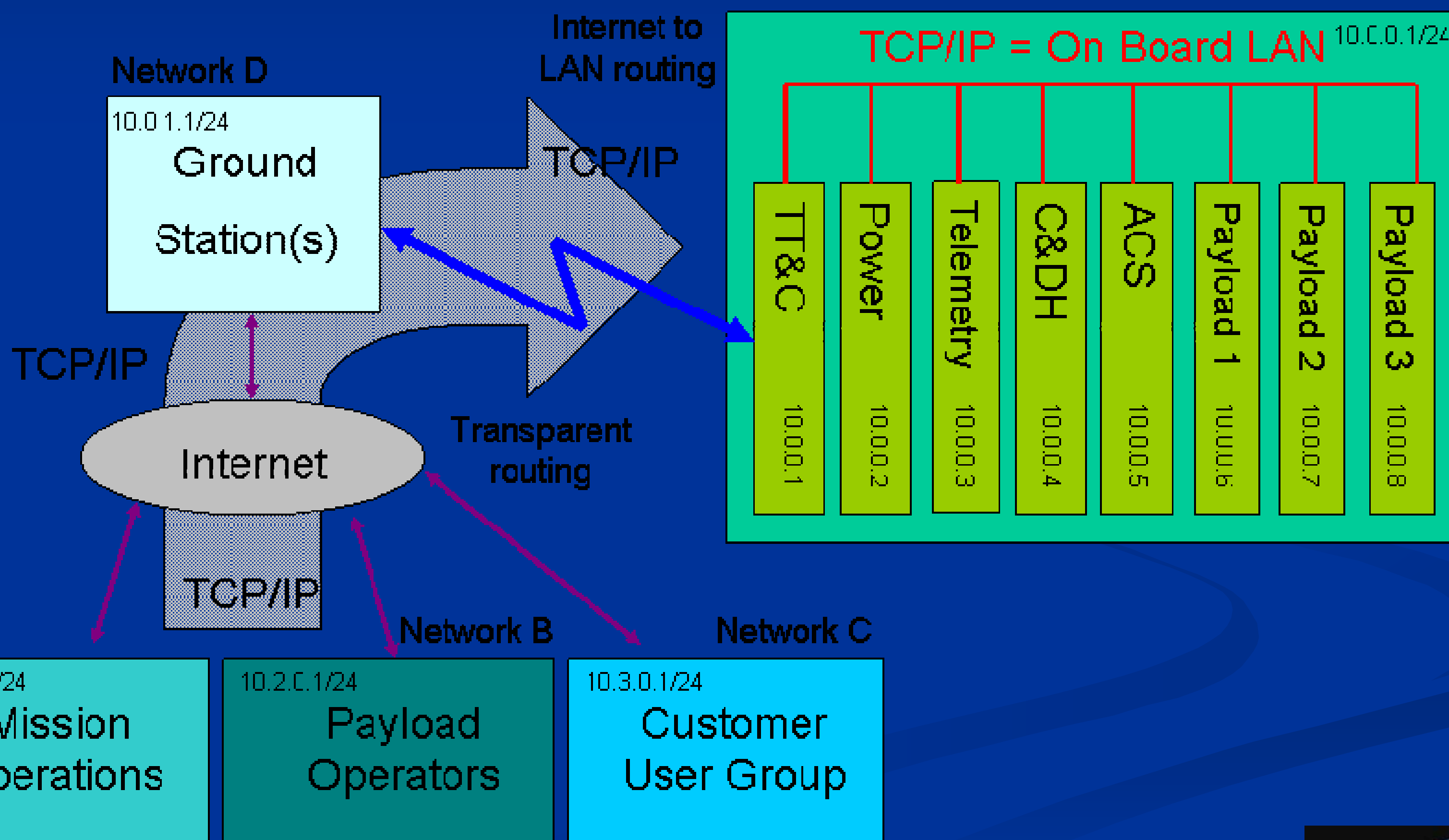
Motivation for Work

- IP is an Enabler
  - Ground Segment
    - Enables creation of virtual mission operations centers tied by private and public IP networks
    - Enables widest range of connectivity physical layers (Serial, Ethernet, PTP, Wireless, Dialup, ADSL, Cable, Satellite, etc…)
    - Enables use of COTS platforms for user, and network hardware
  - Space Segment
    - Transforms C&DH and subsystems into a LAN of subsystem hosts
    - Enables use of commercial and industrial IP stacks
  - Overall System
    - Reduce engineering time spent on transport and increases time put towards actual mission implementation

Innoflight

The Responsive Space Network

- IP in space is worthless if not implemented as a system!



Innoflight

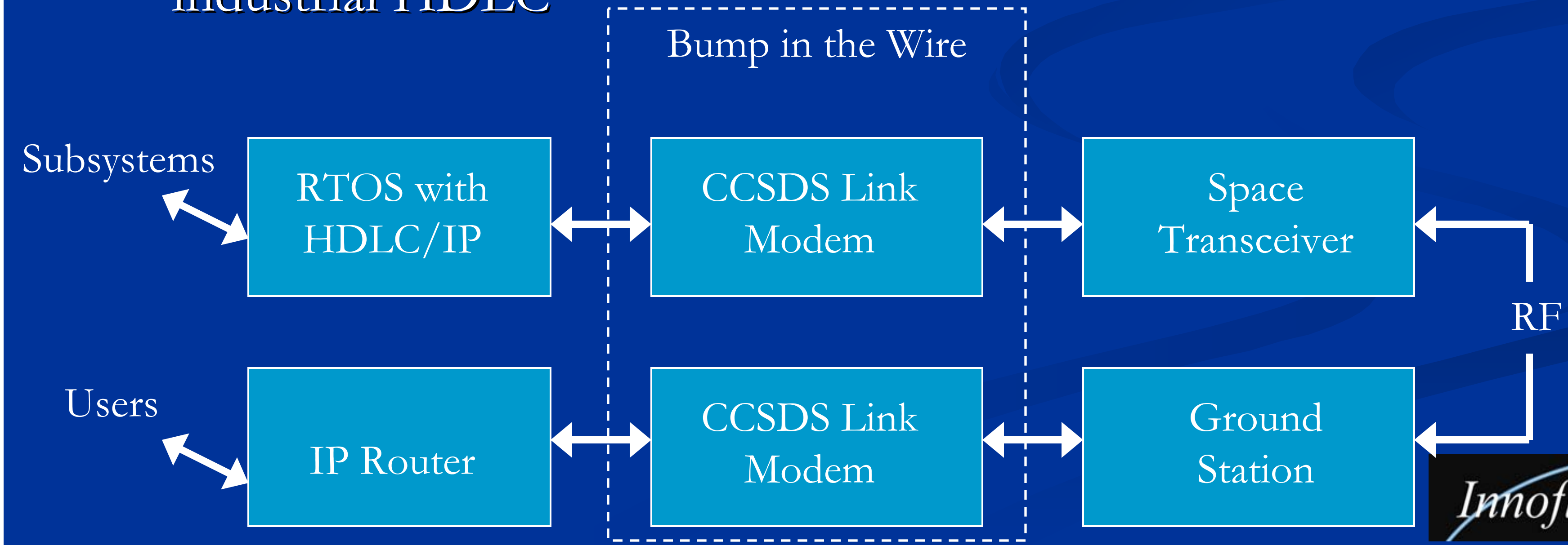
On-Orbit Missions

- Practical IP implementation has been ad-hoc and non standard – as any good evolutionary process is!
- DMC-UK
  - HDLC based with SSTL style physical link encoding
- CHIPSat
  - HDLC based with in-house link encoding
- Previous missions lack the powerful link characteristics of standard CCSDS encoding
- To the best of our knowledge IP over CCSDS hasn't been implemented and isn't available commercially

Innoflight

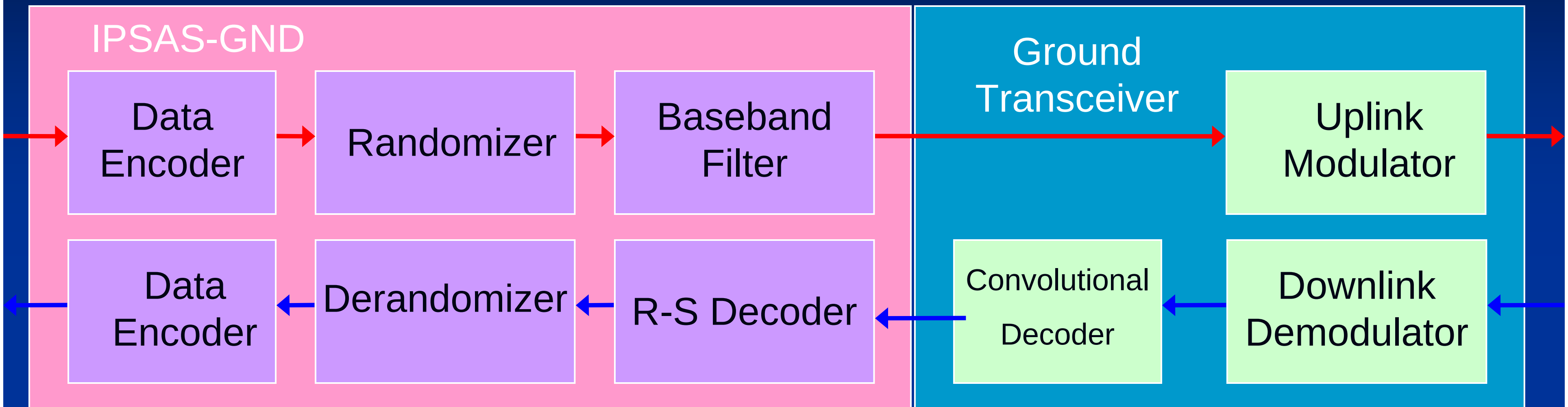
A Practical Approach to IP

- Granted that HDLC is supported by most RTOS's and has been the focus of experimentation with IP in space
- CCSDC 131 offers powerful link encoding methods
- *Bump in the wire* approach allows combinations of powerful CCSDS standards with the reliability of commercial and industrial HDLC



Innoflight

Ground IP Satellite Access System



Uplink

- No utility in FEC due to high link margins
- FEC processing on spacecraft is power consuming
- Data encoder
  - NRZ/NRZI
- Randomizer
  - CCSDS
- Baseband filter
  - GMSK
  - Raised Cosine

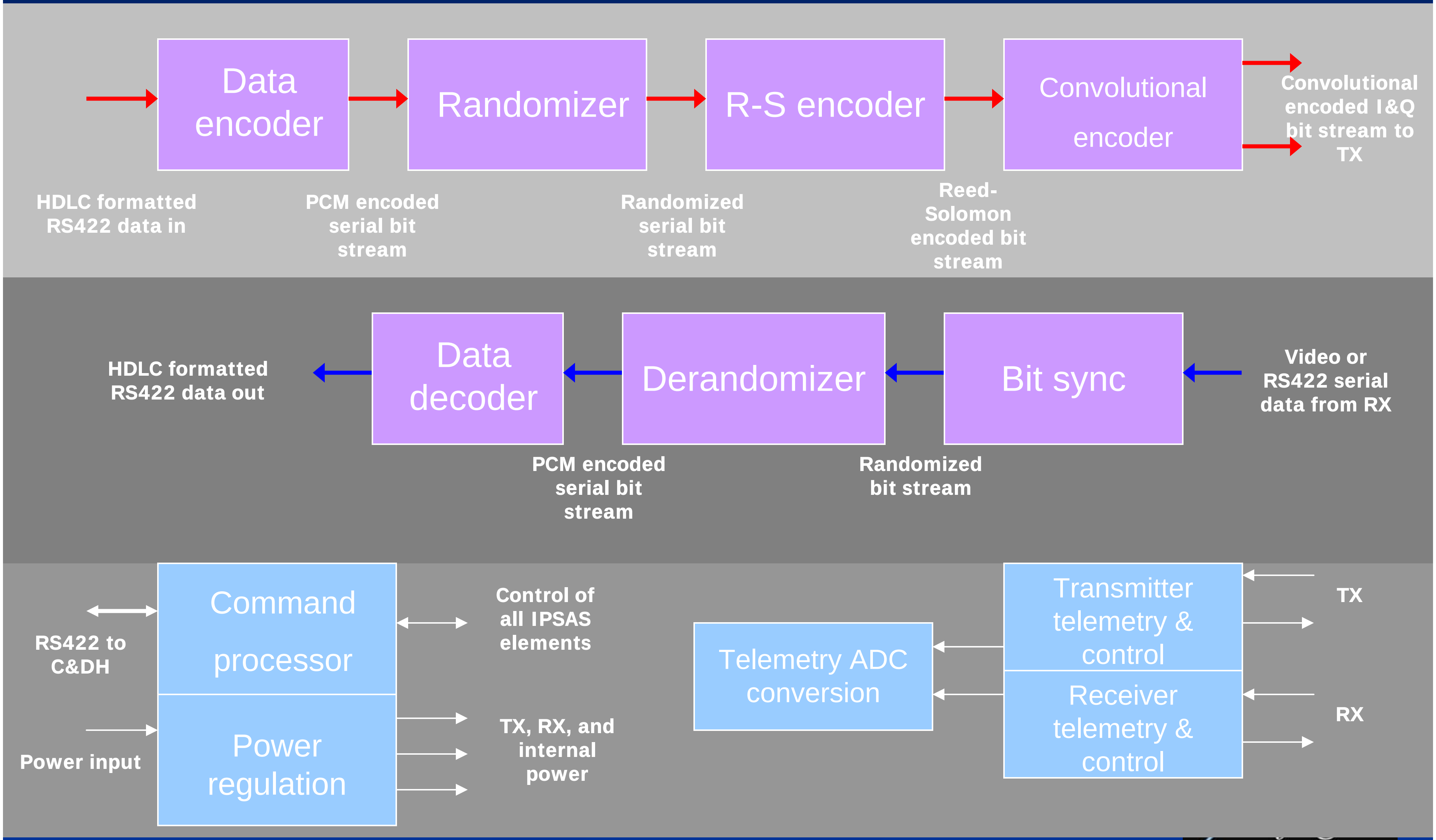
Downlink

- QPSK
  - With CCSDS convolutional decoder
- BPSK: no convolutional decoder
- Reed Solomon block decoder
  - CCSDS
- Derandomizer
  - CCSDS
- Data encoder
  - NRZ/NRZI

IPSAS™ = (Industry Standard TCP/IP) + (Aerospace Link Encoding)

Innoflight

Flight IP Satellite Access System



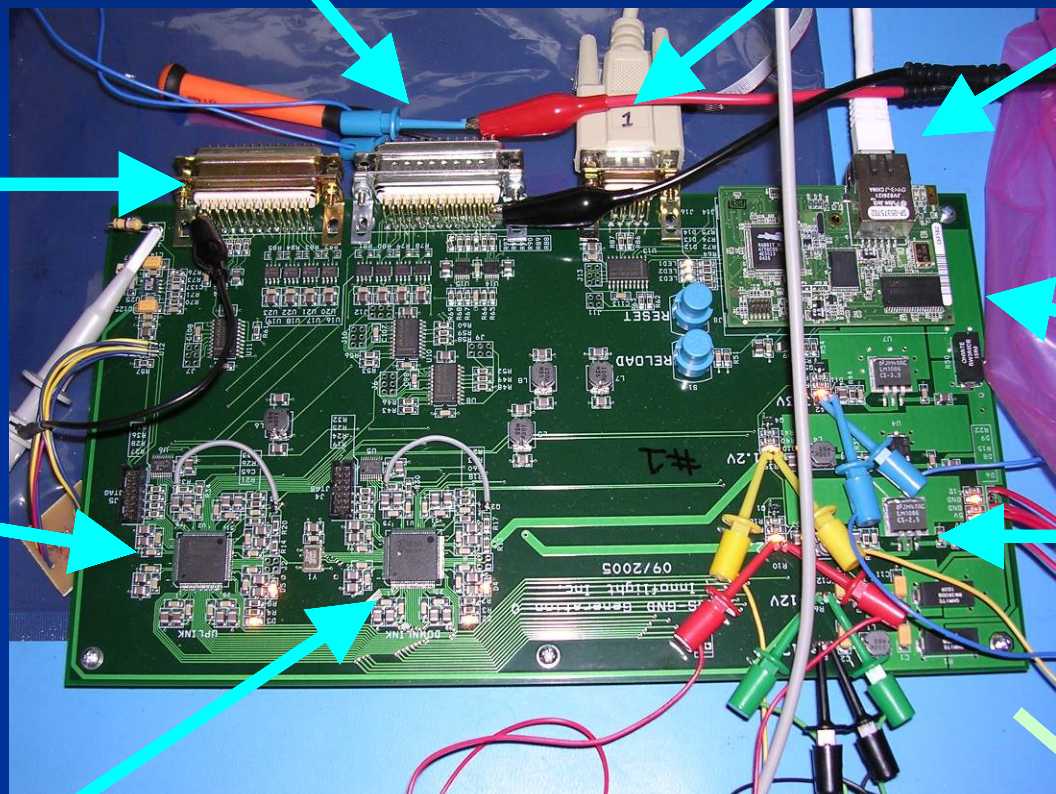
IPSAS-GND Prototype

Router Interface

RS232 Interface

Ethernet Interface

Transceiver Interface



Control Processor

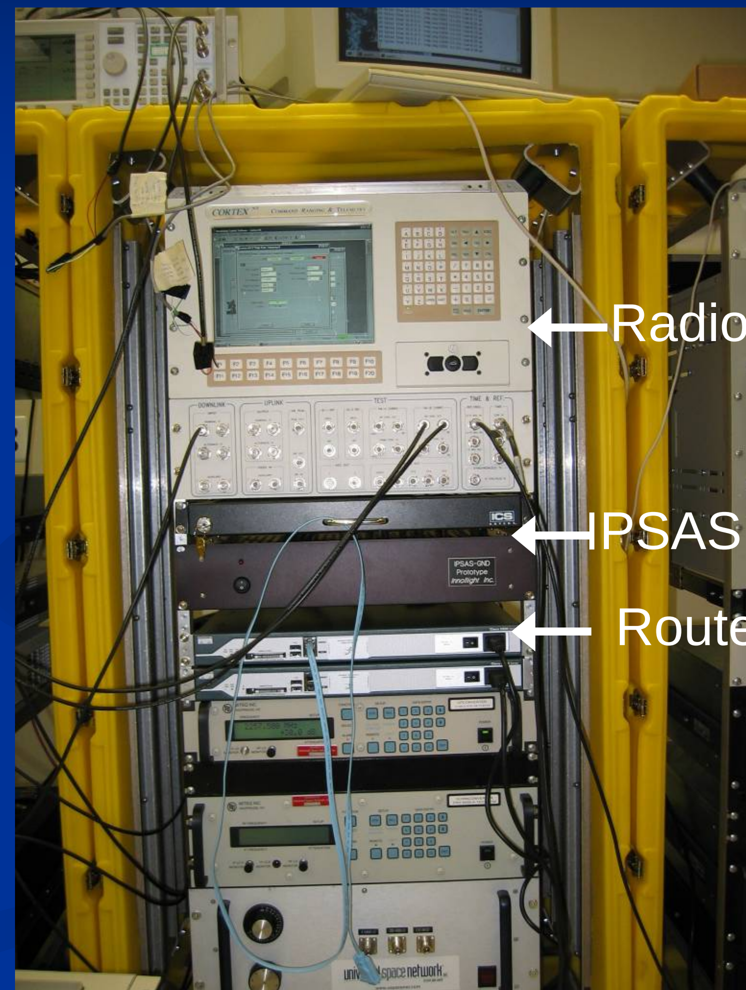
Uplink FPGA Processor

Power Regulation

Downlink FPGA Processor

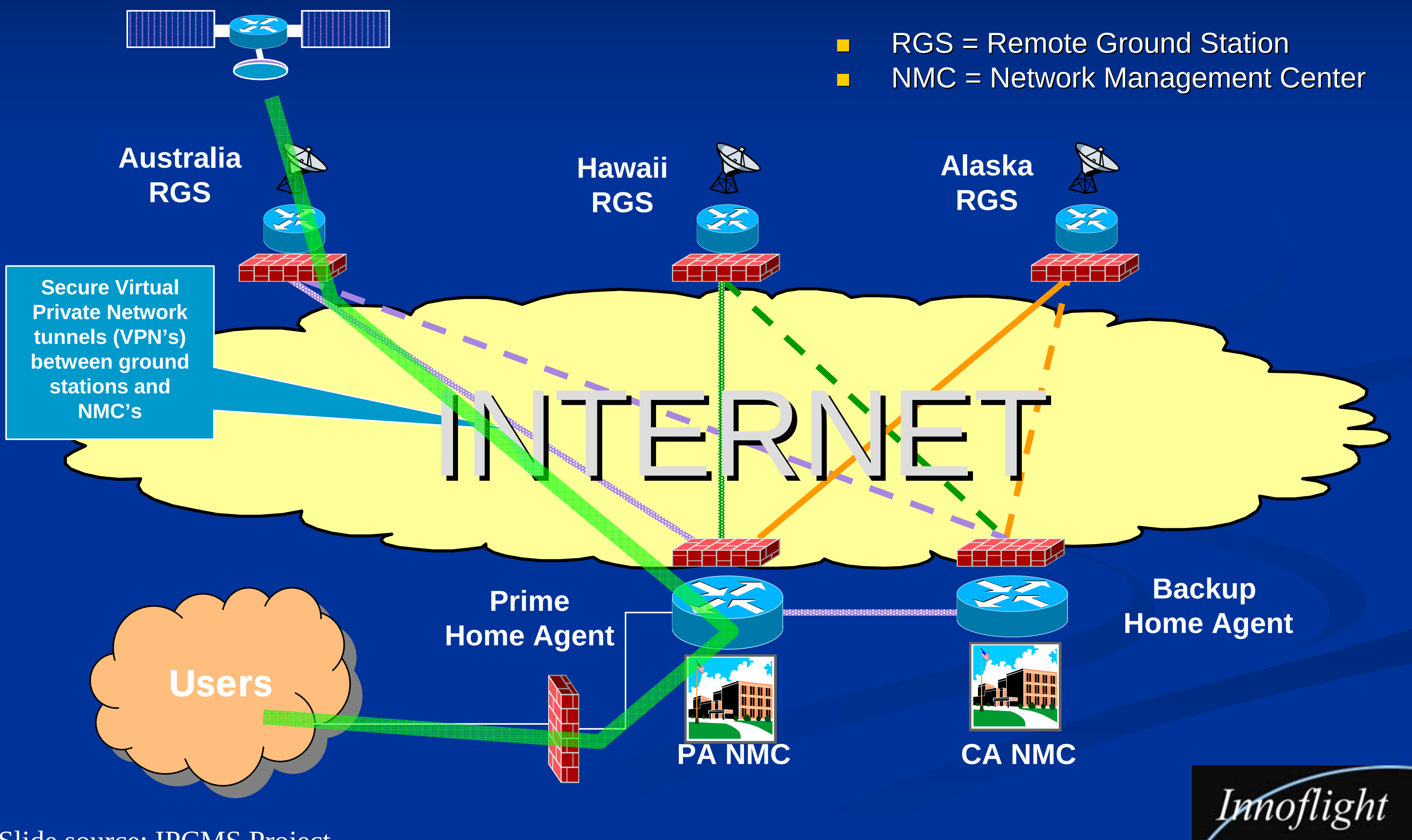
IPSAS Operational at USN

- IPSAS was deployed to USN in November 2005
- System tested with Innoflight's full spacecraft simulator
- IPSAS supports two operational on - orbit spacecraft
- Currently working on introducing support in additional ground station networks



Innoflight

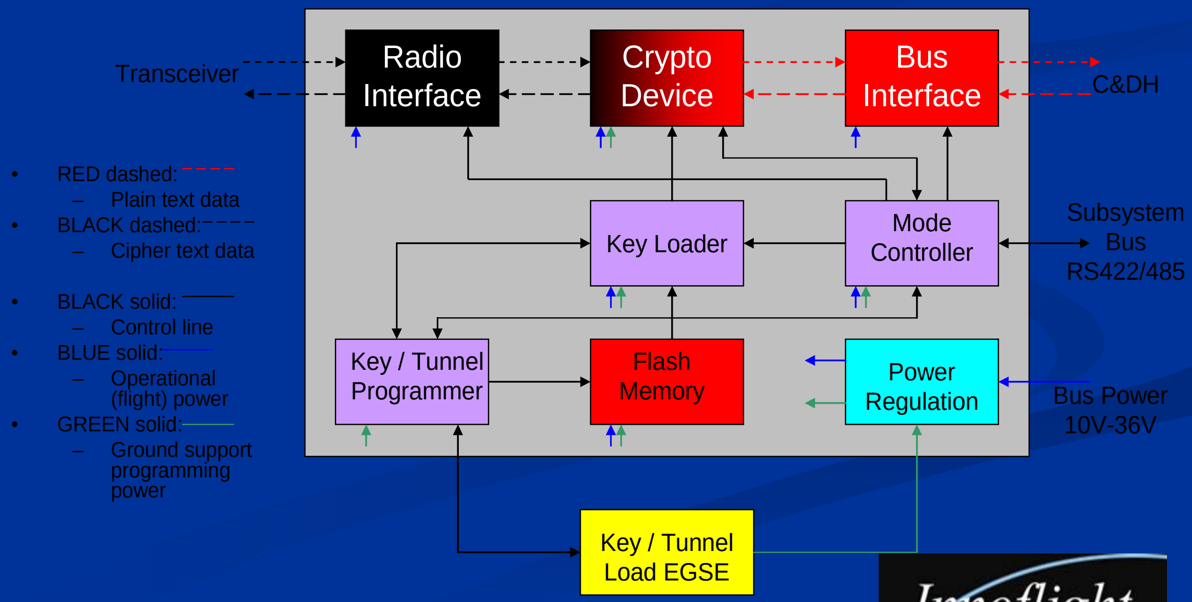
TCP/IP Network Implementation w/USN



Slide source: IPCMS Project

Microsat Encryption Unit

- Bump in the wire approach allows additional relevant
- HQ0006-05-C-7289, Phase 2 STTR with Missile Defense Agency
- TASK: Design and build an NSA certified, type-1 encryption device that is suitable for use on government microsats and supports TCP/IP communications protocols.
- Research Partner: Southwest Research Institute (SwRI)
- Gov't Assist: NSA



Innoflight

Contact Information

- Assi Friedman – Principal Engineer
  Email: afriedman@innoflight.com
  Tel: (858) 638-1580 ext. 13
- Jeffrey Janicik – CEO & President
  Email: jjanicik@innoflight.com
  Tel: (858) 638-1580 ext. 12
- Innoflight Inc.
  5850 Oberlin Dr.
  Suite 340
  San Diego, CA 92121
  http://www.innoflight.com
  Fax: (858) 638-1581

Questions anyone?

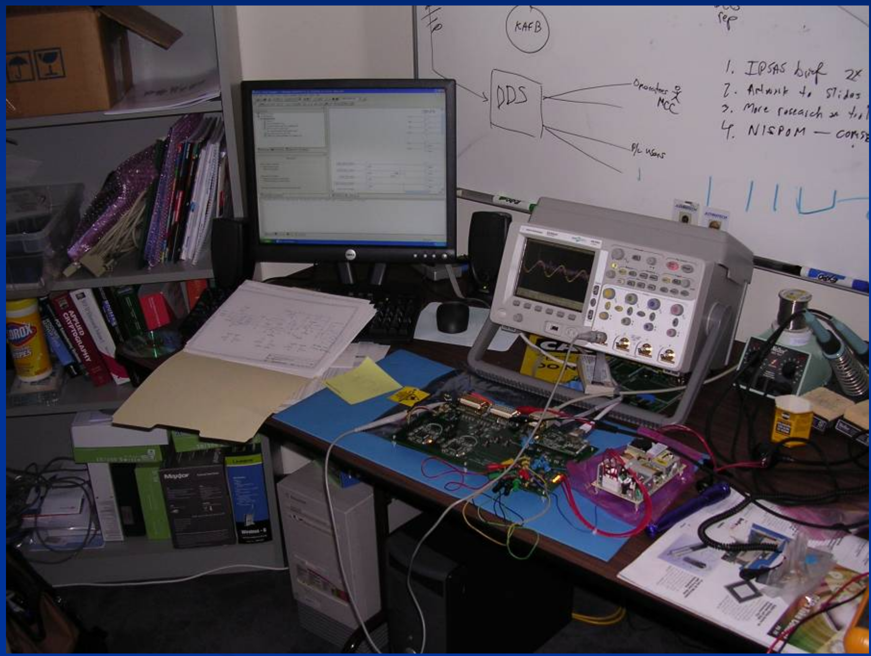
Innoflight

Backup Materials

Innoflight

IPSAS-GND Specifications

- Input Power
  - Standard 110VAC
  - Power < 10W
- Mechanical Form Factor
  - Standard 19” rack, 2U height, 8” deep
- User Interface
  - Remote configuration using
    - Ethernet 10/100 Mbps
      - TCP/IP Telnet (port 23)
      - Simple ASCII protocol
  - Local configuration
    - RS232
    - Front panel aliveness status LED
  - Non volatile memory for configuration storage
- Quality and Reliability
  - Prototype Level



First IPSAS-GND Prototype Under Test

Innoflight

IPSAS-GND Demonstration Specifications

Downlink:

- Input:
  - RS232
  - RS422
  - LVTTL
  - Data & clock (invert capable)
  - Data rate: up to10Mbps
- Descrambler:
  - ITU V35 / Intelsat
  - CCSDS (modified)
  - HAM
- Decoder:
  - NRZ / NRZI
  - FM0 / FM1
- Output:
  - RS232
  - RS422
  - LVTTL
  - Data & Clock (invert capable)

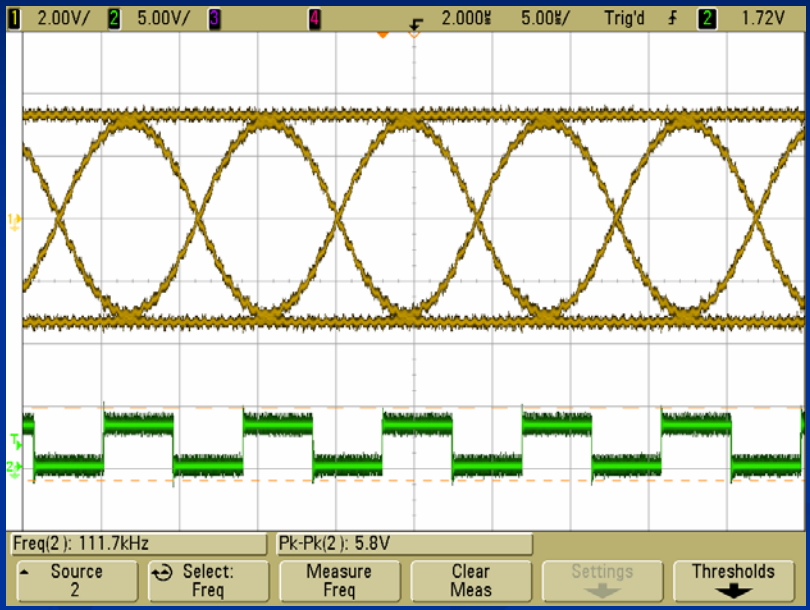
Uplink:

- Input:
  - RS232
  - RS422
  - LVTTL
  - Data & clock (invert capable)
  - Data rate: up to100,000bps
- Encoder:
  - NRZ / NRZI
  - FM0 / FM1
- Scrambler:
  - Ham Radio
  - CCSDS (modified)
- Output
  - RS232
  - RS422
  - LVTTL
  - Data & clock (invert capable)
  - Analog
    - GMSK 0.5 BT
    - Raised cosine
    - DC coupled

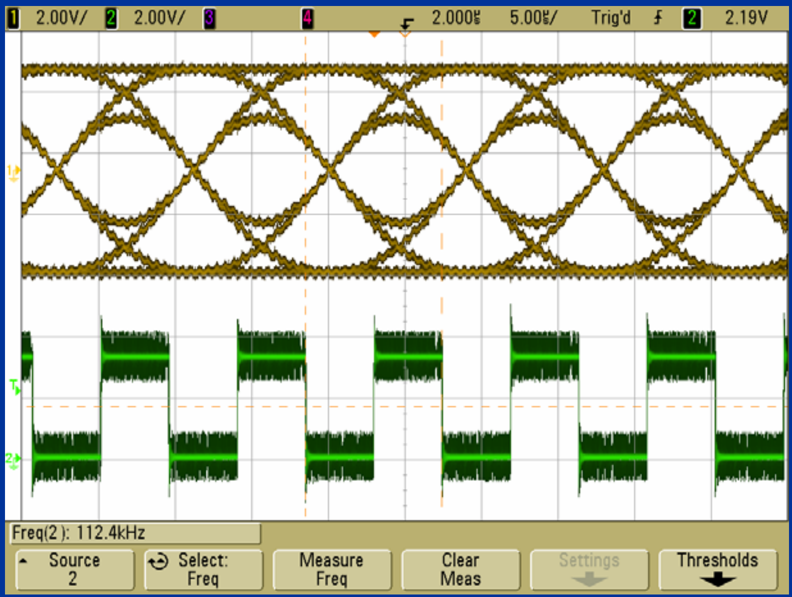
Innoflight

Analog Filter Options – User Configured

- Two selectable analog out filters
- Data rate up to 100kbps
- 1.4 Vp-p into 50 Ohm load



Gaussian, BT=0.5 (GMSK)



Raised Cosine

Innoflight