Real-Time Wireless Data Acquisition System

RF Health Node & SensorNet (RSN)

March 28, 2007

POC: Emilio Valencia, KT-C (321) 861-9074 J.Emilio.Valencia@nasa.gov
POC: Jose Perotti, NE-E8 (321) 867-6746 Jose.M.Perotti@nasa.gov
Presented by: Richard Birr, KT-C (321) 876-6301 Richard.B.Birr@nasa.gov

Purpose

- Present KSC's wireless sensing technology development efforts that provide new instrumentation capabilities

How RFHN came about

- Commercially available micro-wireless sensors developed by Invocon, Inc. were installed into the Orbiter to meet new instrumentation requirements
- Developed RFHN prototype to interface with the micro-wireless sensors
- RFHN was to communicate with the Orbiter's installed base of micro-wireless sensors in addition to provide remote access to sensors from the control center
- RFHN did not fly on Shuttle due to funding issues
- 1st flight test of RFHN on-board a sounding rocket in Sept 2004
- 2nd flight test of RFHN on-board a sounding rocket scheduled for Q4 2007 (with KSC SensorNet technology)

How SensorNet came about

- SensorNet was developed to increase efficiency during ground operations
- An operational SensorNet system is currently installed at Pad A
- Design has been optimized for use in aerospace applications (miniaturization, power consumption, etc.)
- 2nd generation wireless sensor prototype (optimized version) has been designed and implemented
- SensorNet transceiver board has been designed and implemented

RFHN Capabilities

- Current Capabilities
  - Interface to SensorNet
  - Support temperature, pressure, hydrogen, etc sensors
  - Ethernet and serial interfaces
  - Data storage
  - Timestamp (NTP)

- Future Capabilities
  - Preprocess data
    - health monitoring, trending, limit checking, etc…
  - Perform data fusion (i.e. data reduction)
  - Time interface (IRIG)

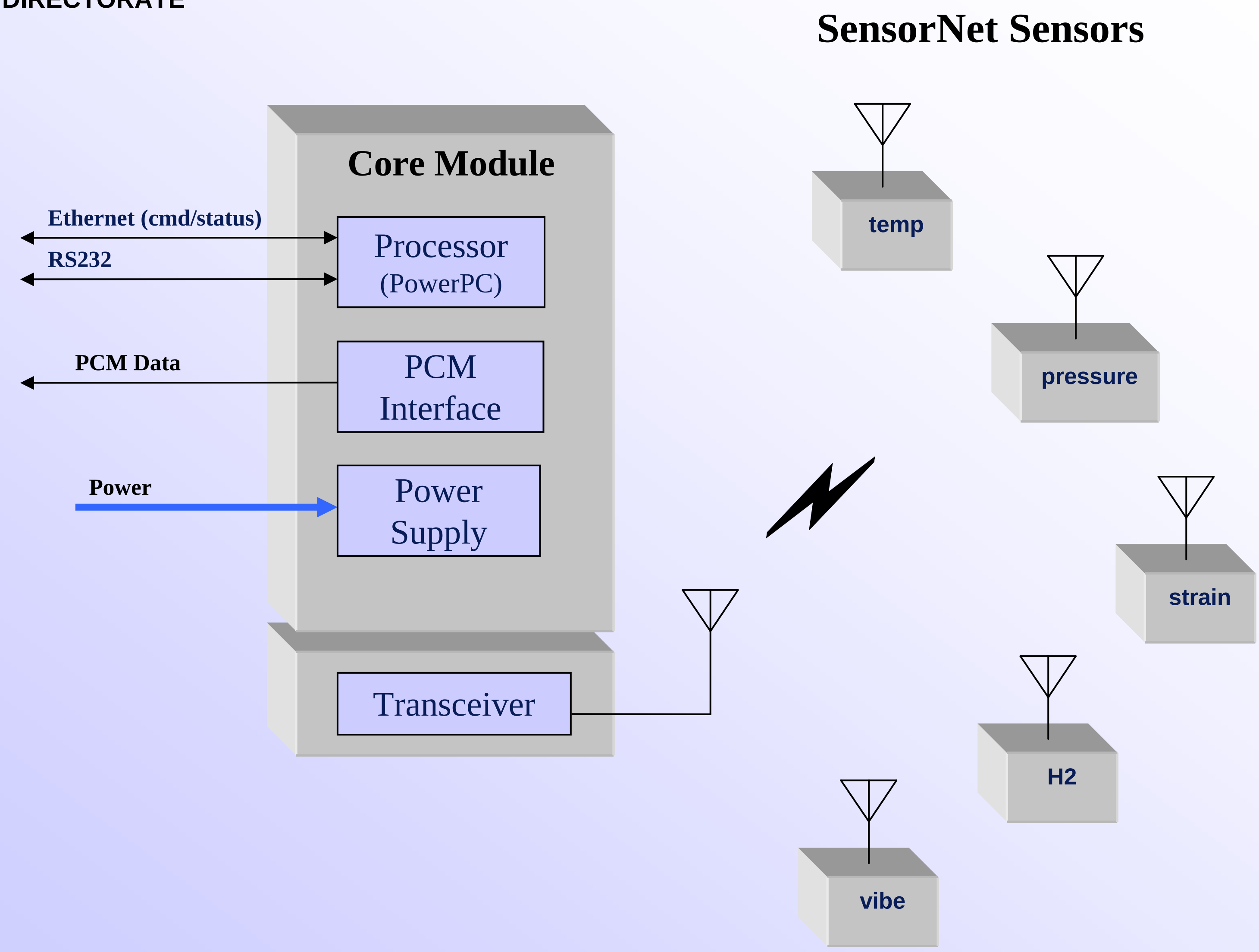
RFHN Implementation

- COTS Circuit Boards (PC104+ standard)
  - Processor with Ethernet and Disk-On-Chip (DOC)
  - PCM Encoder Card
  - Power Supply
- Custom Circuit Board
  - Transceiver designed and built by KSC
- Software written in C
- VxWorks Real-time OS

Operations Concept

- RFHN installed in the vehicle along with SensorNet sensors
- Temp, pressure, hydrogen, etc. wireless sensors installed in the vehicle where needed
- Spacecraft: ethernet interface from the RFHN to the control room via the vehicle's umbilical
- Aircraft: ethernet interface from the RFHN to the aircraft's computer
- Spacecraft: Command, control and data monitoring of the wireless sensors from the control room
- Aircraft: Data monitoring of the wireless sensors from the cockpit (manual command & control from the cockpit for maintenance)

RFHN/SensorNet (RSN) Block Diagram



RFHN Flight Test

- Launch Date: Sept 23, 2004
- Location: White Sands Missile Range, New Mexico
- Flight Vehicle: Two-stage sounding rocket (Terrier/Orion)

RFHN

RFHN Flight Test (cont)

- Approximately 15,000 packets transmitted from wireless sensors to the RFHN during flight out of a possible 20,000 packets (107 bytes per packet)

- Data throughput rate = 20.6 Kbps

- Average number of retransmissions per packet = 1.15

- **Flight Test Conclusion:**

  Flight environment did not degrade the reliability of the wireless link

  (reliability during flight was compared to reliability during ground testing under nominal conditions)

Wireless SensorNet

SensorNet System Features

- Information processing at Sensor level
  - Processor at each remote station enables for real-time analysis of data validity. Flexible modular architecture allows for additional embedded complex data processing at Remote Stations
  -
- Low power requirements
  - Embedded smart power management algorithms allow for extended life of battery-powered remote stations while reducing size, weight, and cost of batteries
- RF High reliability
  - SensorNet has point-to-point, multi-point and relay mode communication capabilities. Provides autonomous self-diagnosis of communications links. Automatically reconfigures upon RF failure detection, establishing new communication paths. Automatically and autonomously selects best communication paths based on the existing operating environment.

SensorNet System Features (cont)

- Improved data Availability
  - SensorNet is a real-time, deterministic data acquisition system. Capability of buffering time-stamped data at remote stations ensures data availability and integrity if temporary communications losses occur
- Scalability
  - Remote Stations' flexible modular architecture accommodates to most sensing technologies and facilitates easily reconfiguration to any application
  -
- Speed
  - Typical latency time between central station request for data and receipt of data from remote station is 10 ms
  -
- Low cost
  - Generic modules are common to remote and central stations

SensorNet System Requirements & Performance

System Requirements

- No source of interference to other systems
- Portable and self-sustained (power, communication, intelligence)
- Operate and survive harsh environments (flight & launch area)
- Highly reliable, assure data integrity and availability
- Capable to self-diagnose and self-heal the communication links
- Capable of embedded complex data processing

System Performance

- Low RF output power ($\leq$10 mW) to minimize interferences
- Battery-operated with embedded power management algorithms to maximize battery life
- Self-contained system with signal conditioning, data acquisition, data manipulation and data transmission capability
- Capability to perform complex data operations (DSP module)
- Modular flexible architecture reconfigurable to accommodate to most sensing technologies

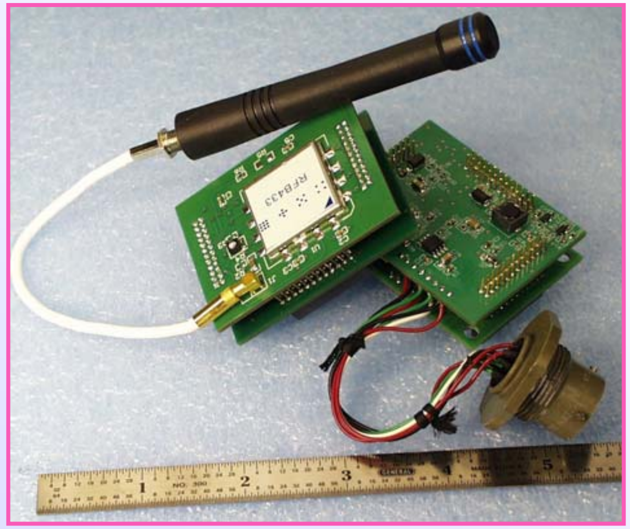
SensorNet System Configuration

- Wireless SensorNet System is composed of:
  - One or more Central Stations
    - Different physical configurations depending on application
      - Industrial computer for ground support (Wireless VJ System)
      - Hand-held device for portable applications (Orbiter Wireless Inclinometer)
      - PC-104 format for flight applications (RFHN)
      - Others

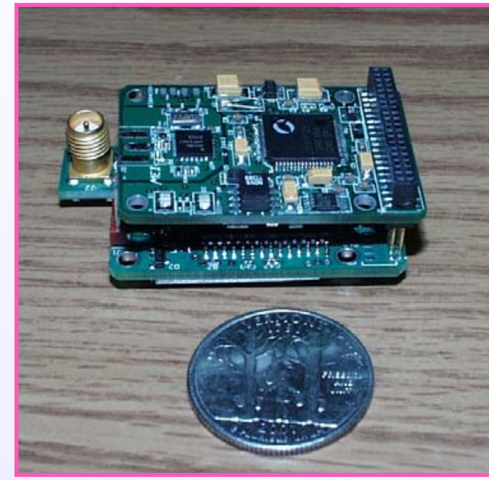
  - Many remote stations
    - Remote station → sensor point in the network
    - Up to 256 remote stations capability for present design
    - Modular, self-contained, self powered architecture

Wireless SensorNet Products

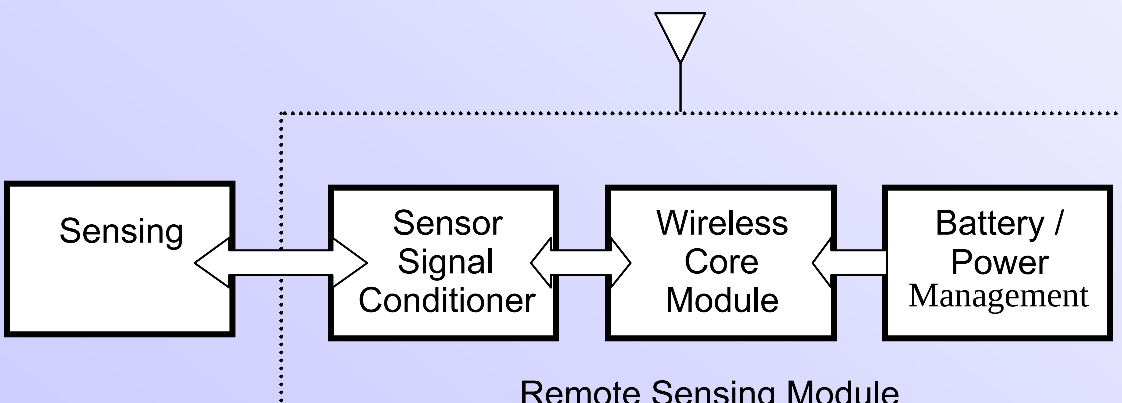
RFHN



Example of Remote Station used for vacuum jacket
(sensor not shown)



Example of Remote Station for H2
(sensor not shown)



Backup Charts

RFHN Electrical/RF Interfaces

- Command & data
  - Ethernet - 10/100Mbps
  - RS232
- Data (PCM)
  - RS422
  - IRIG 106-01
  - Simplex
- Power
  - 28VDC
  - 28 Watts
- RF
  - Proprietary protocol (Invocon, Inc.)
  - 916 MHz - frequency
  - 50 Kbps - bandwidth
  - 1 mW - power

Micro-Wireless Sensors per Mission

Mission	*Vehicle*	*Month*	*Year*	*WIS*	*Rec*	*TAU*	*SGU*	*ELMWIS*	*WBTAU*	*Notes*	*Total Sensors*
STS-95	103	10	1998		4						4
STS-88	105	12	1998								0
STS-96	103	5	1999		4					IVHM HTD(4)	4
STS-93	102	7	1999								0
STS-103	103	12	1999								0
STS-99	105	2	2000								0
STS-101	104	5	2000	12	6					First flight of HTD1403 (ECLSS)	18
STS-106	104	9	2000	12	10					ARS (6R), ECLSS (12T), SHOSH (4R)	22
STS-92	103	10	2000	12	6					ARS (6R), ECLSS (12T)	18
STS-97	105	11	2000	12	20					FRCS(14R), ARS (6R), ECLSS (12T)	32
STS-98	104	2	2001								0
STS-102	103	3	2001								0
STS-100	104	4	2001	12	14					ECLSS(12T), FRCS(14R)	26
STS-104	104	7	2001	9						Airlock(5), HPGA(4)	9
STS-105	103	8	2001								0
STS-108	105	12	2001		14	8	11			FRCS(14R), MPLM TAU(6), MACH1TAU(2), SGU(11)	33
STS-109	102	3	2002				11			SGU(11)	11
STS-110	104	4	2002				12			SGU(12)	12
STS-111	105	6	2002			6	12			MPLM TAU(6), SGU(12)	18
STS-112	104	10	2002				12			SGU(12)	12
STS-113	105	11	2002				13			SGUon Thrust Struct.(12), SGU on OMS Pod(1)	13
STS-107	102	1	2003				12			SGU(12)	12
STS-114	103	6	2005			6	12		64	Feedlines(5), WBTAU Thust struct(6), SGU(12), WLE(44), ECLSS(8)	82