

# **Software Defined Radio based Global Sensor Network Architecture**

**David Haley, Linda M. Davis, André Pollok, Ying Chen, Gottfried Lechner,  
Marc Lavenant, S. Adrian Barbulescu, John Buetefuer, William G. Cowley, Alex Grant,  
Terry Kemp, Ingmar Land, Rick Luppino, Robby G. McKilliam, and Hidayat Soetiyono**

**Institute for Telecommunications Research  
University of South Australia**

**SDR-WInnComm 2014**

**March 11, 2014**





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25 years 1985 – 2010

ITR is Australia's largest university-  
based research organization  
specializing in research and  
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wireless communications

Reliable.  
Connected.  
Real Solutions.







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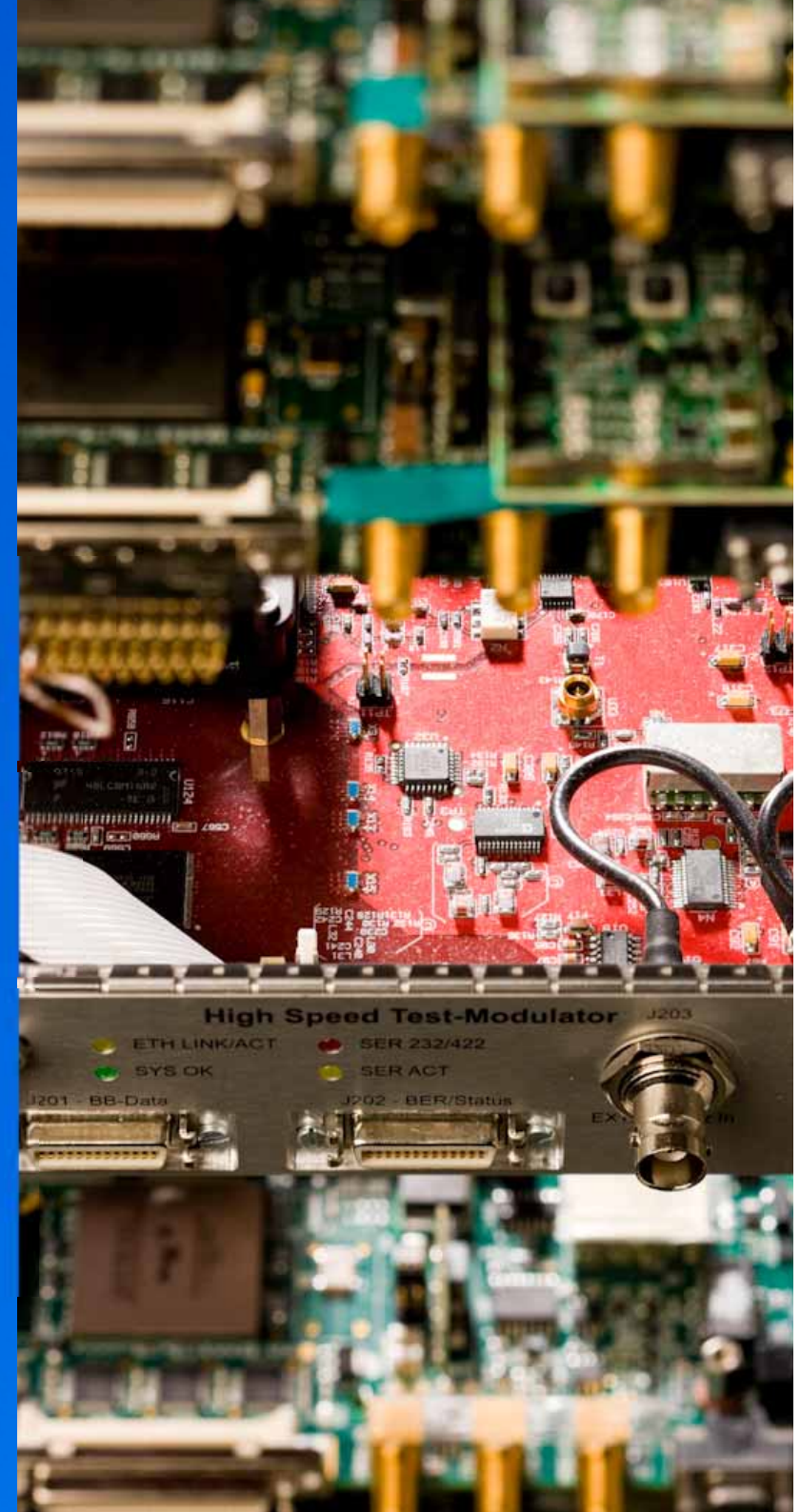
**High Speed Data**

**Flexible Radio & Networks**

**Satellite Communications**

**Computational and  
theoretical neuroscience**

Reliable.  
Connected.  
Real Solutions



# Global Sensor Network

remote sensor data gathering  
bidirectional communications  
low earth orbit satellites  
complete architecture

# Global Sensor Network

Australian Space Research Program

\$5,000,000

# Global Sensor Network

Total Project

\$12,000,000

<http://www.itr.unisa.edu.au/projects/global-sensor-network>



Institute for  
**Telecommunications  
Research**



**Australian Government**  
**Department of Defence**  
Defence Science and  
Technology Organisation



**AUSTRALIAN INSTITUTE  
OF MARINE SCIENCE**



**CSIRO**







**livestock tracking**, water/ground water chemistry, **animal and fish migration**, vessel tracking, **underwater marine ecosystems**, remote machinery/equipment, **underground seepage & melt-water**, lake and river heights and flow rates, **surface ice**, earthquakes, **surface level emissions**, acoustic phenomenon, **sub-surface parameters** (pressure, temperature, **volcanic activity etc**), micro-climates, **under-canopy forest biometrics**, surface chemical sniffers, **surface atmospheric pressure**, oil, gas and mining interests, **National Defense tracking & monitoring**, remote machinery/equipment monitoring, **machine-to-machine**, national security and defense, .....



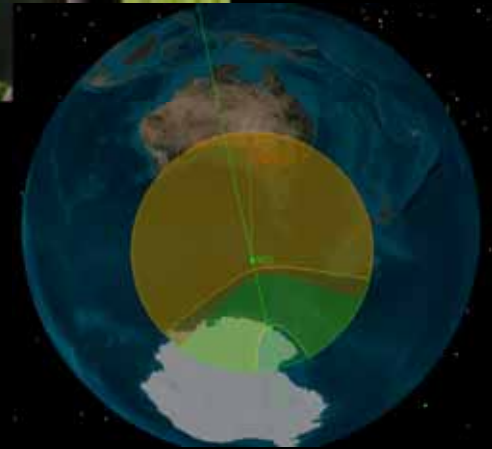
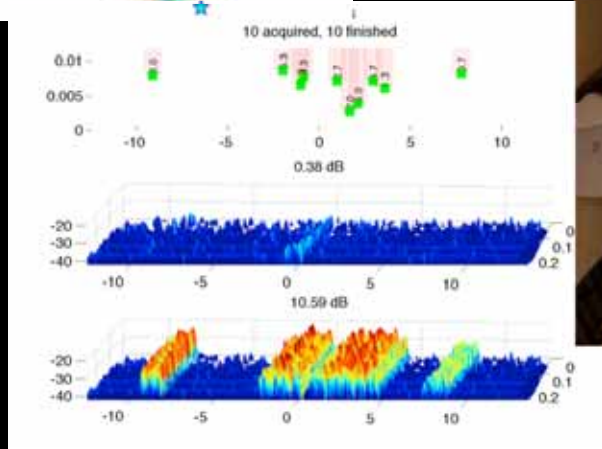
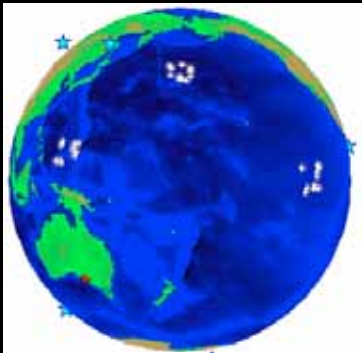
# Application Requirements

	<b>Service Type 1</b> Vessel tracking, Mobile asset tracking Marine drift sensing, Pipeline monitoring	<b>Service Type 2</b> Environmental sensing with control Remote rig monitoring and control Defense applications
<b>Number of Terminals</b>	Very Large 100,000's	Medium 100's
<b>Message Length</b>	Short (10's of bytes)	Longer (Kilobytes)
<b>Update Period</b>	1 hour	6 hours
<b>Data Path Direction</b>	Remote to Central	Bidirectional

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**from a blank sheet of paper ...**



**field proven system  
space qualified hardware  
2 years**

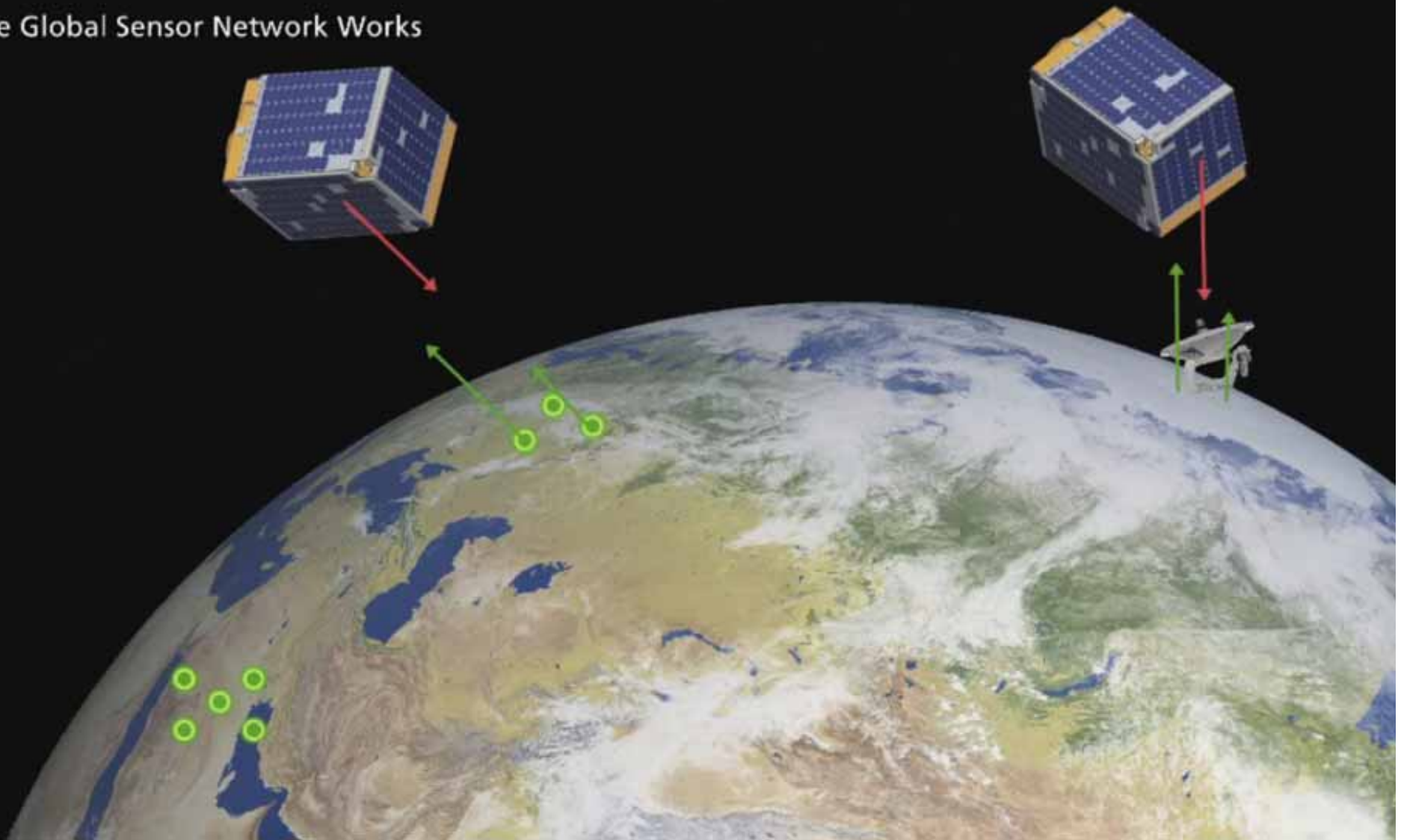


## How the Global Sensor Network Works



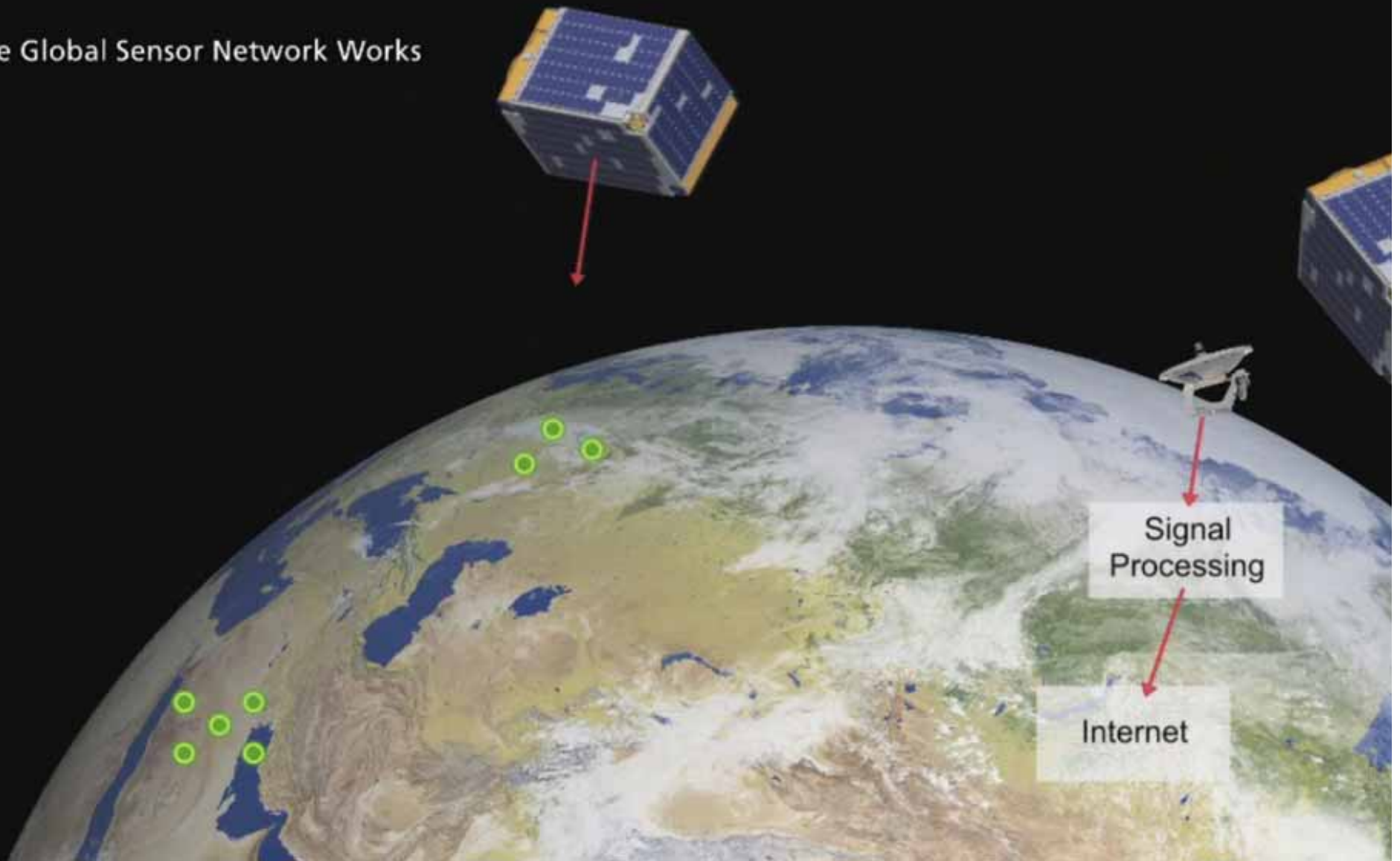
very large numbers of terminals

How the Global Sensor Network Works



bidirectional communication

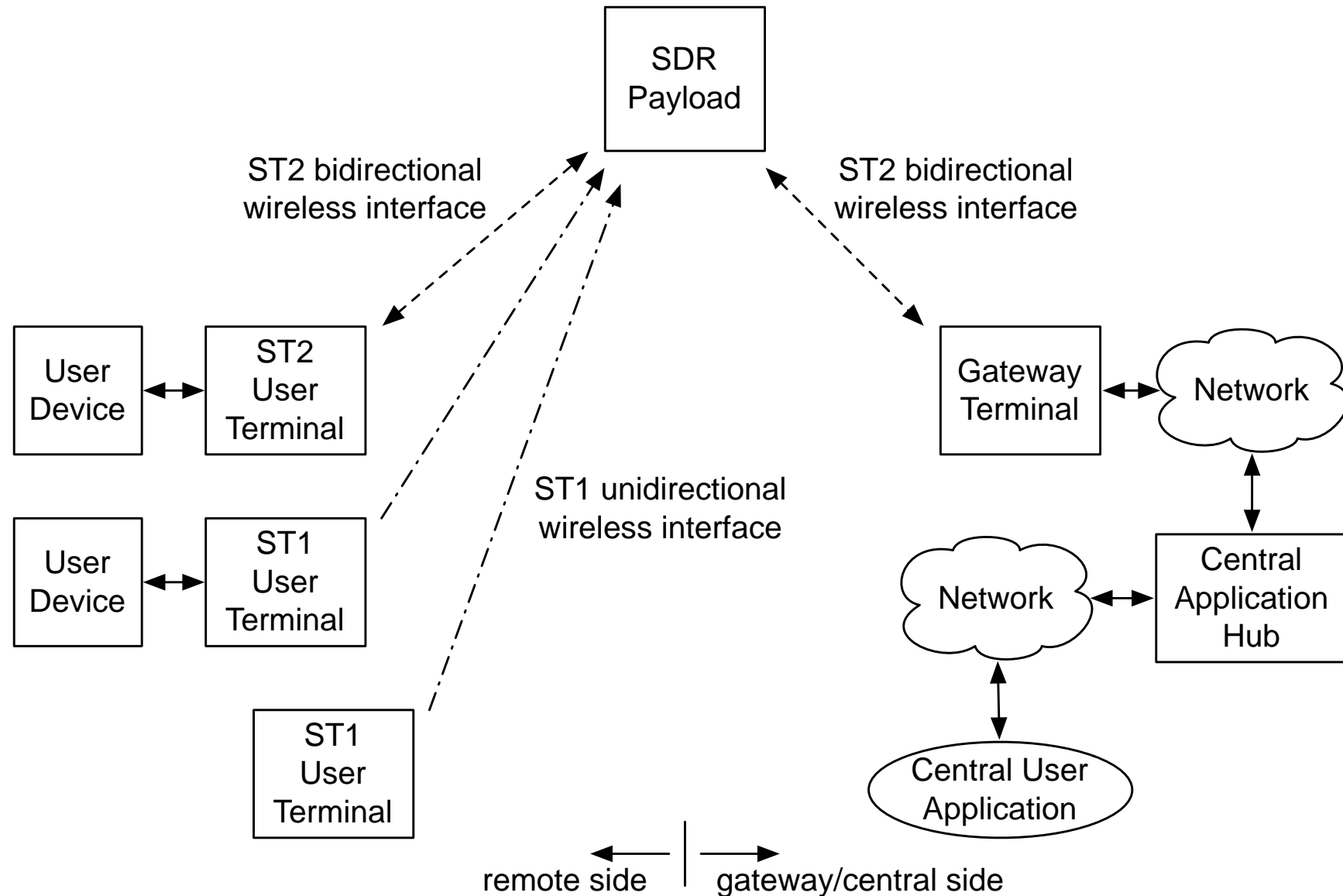
How the Global Sensor Network Works



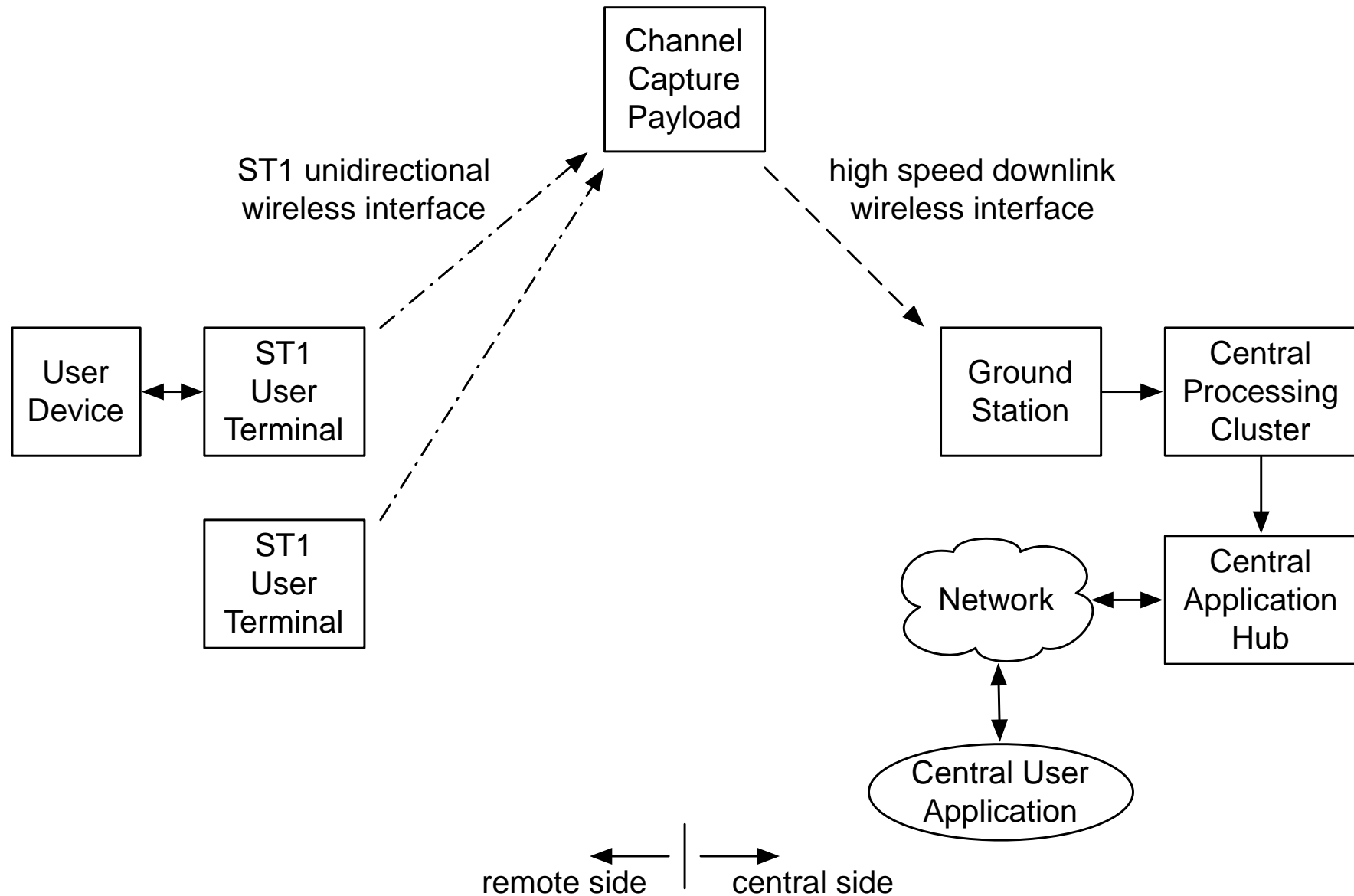
flexible and scalable system



# System Architecture: Onboard SDR



# System Architecture: Centralized



# Development Methodology

Considered Upfront

Living Reference Model

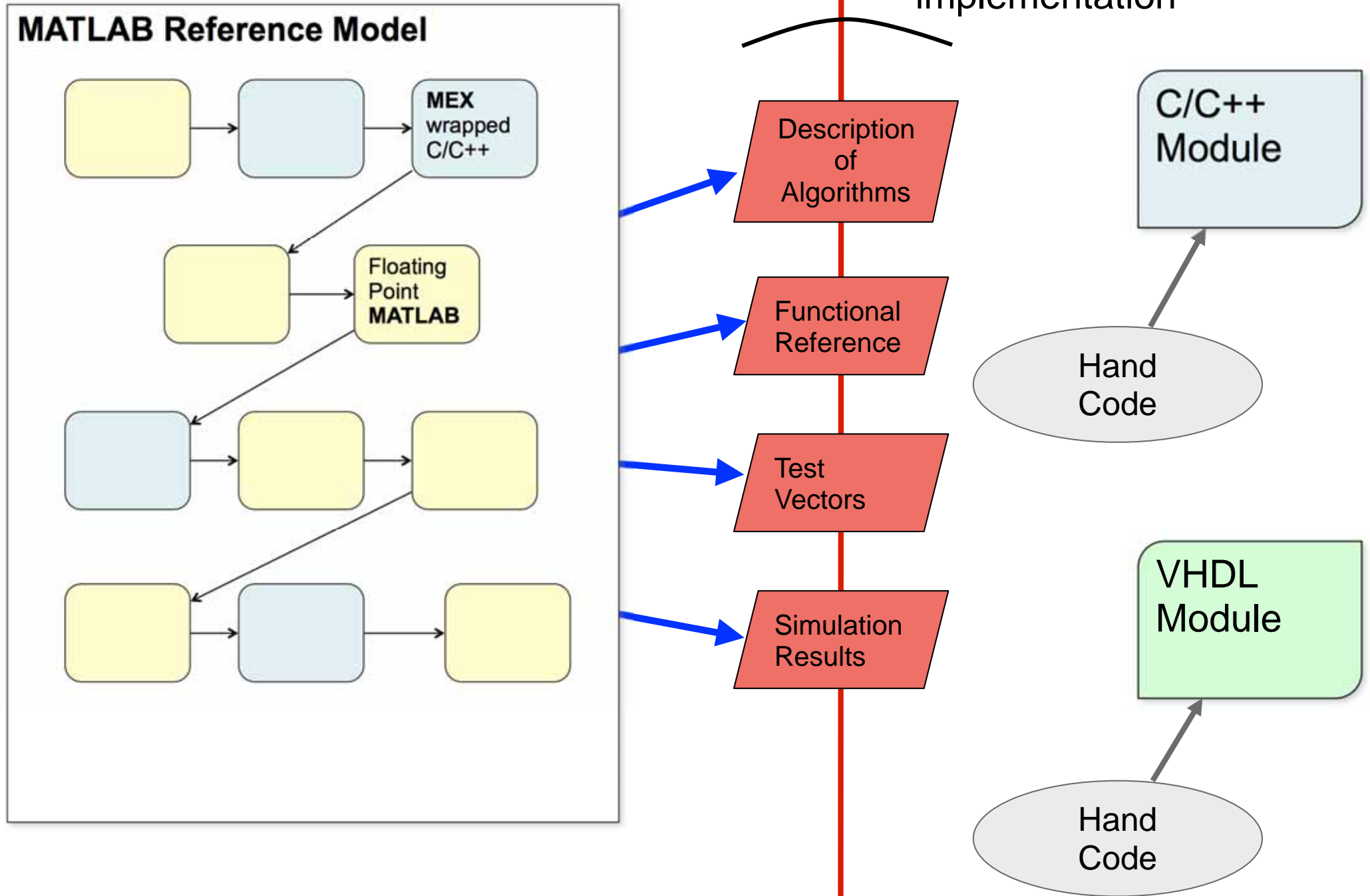
Software Defined Radio

Tightly coupled

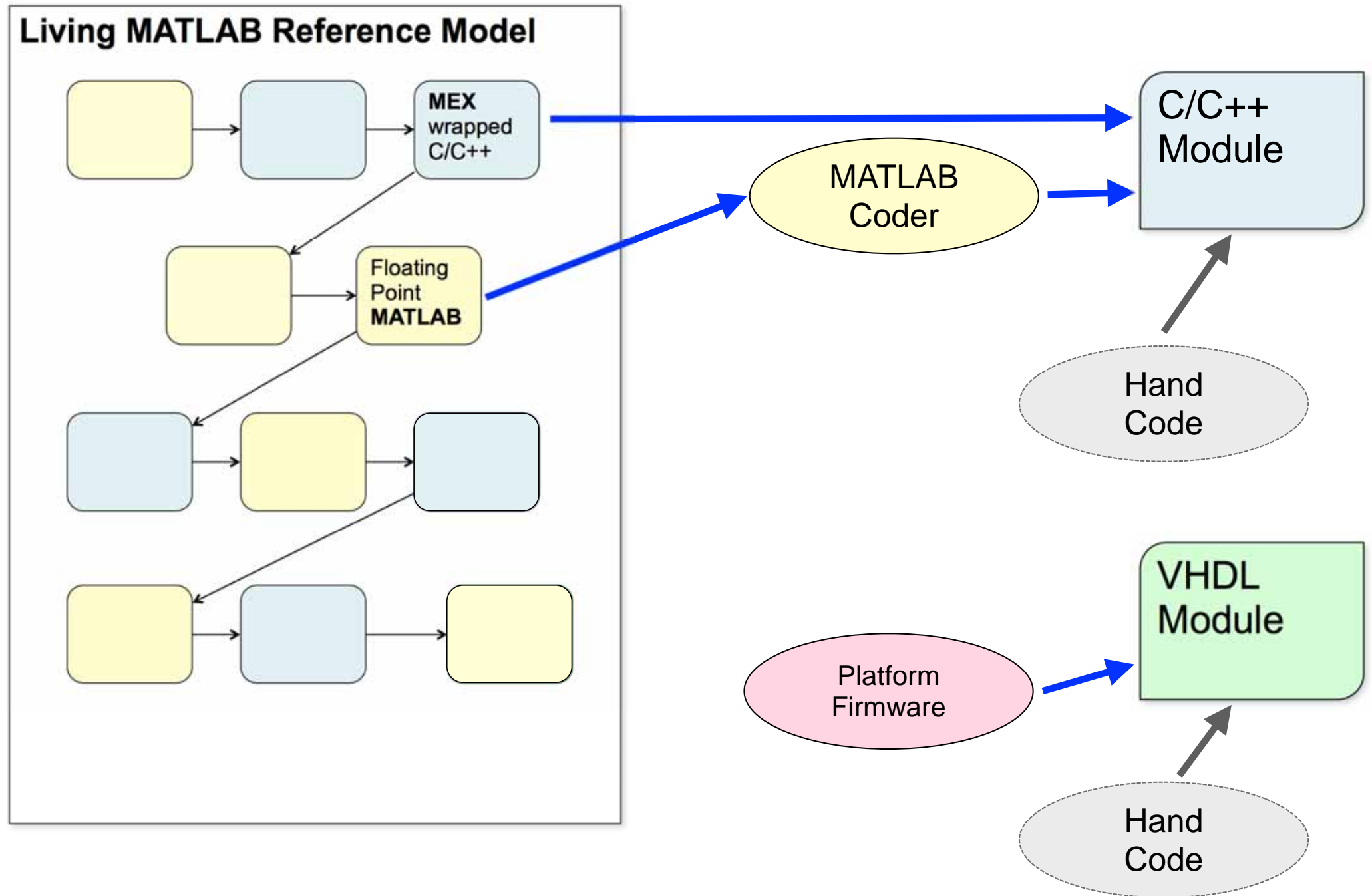
breaking the barrier between R&D



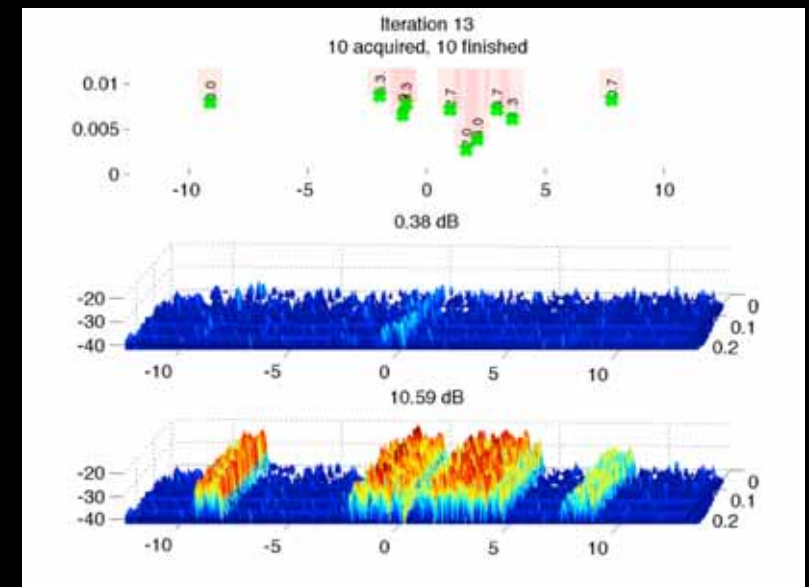
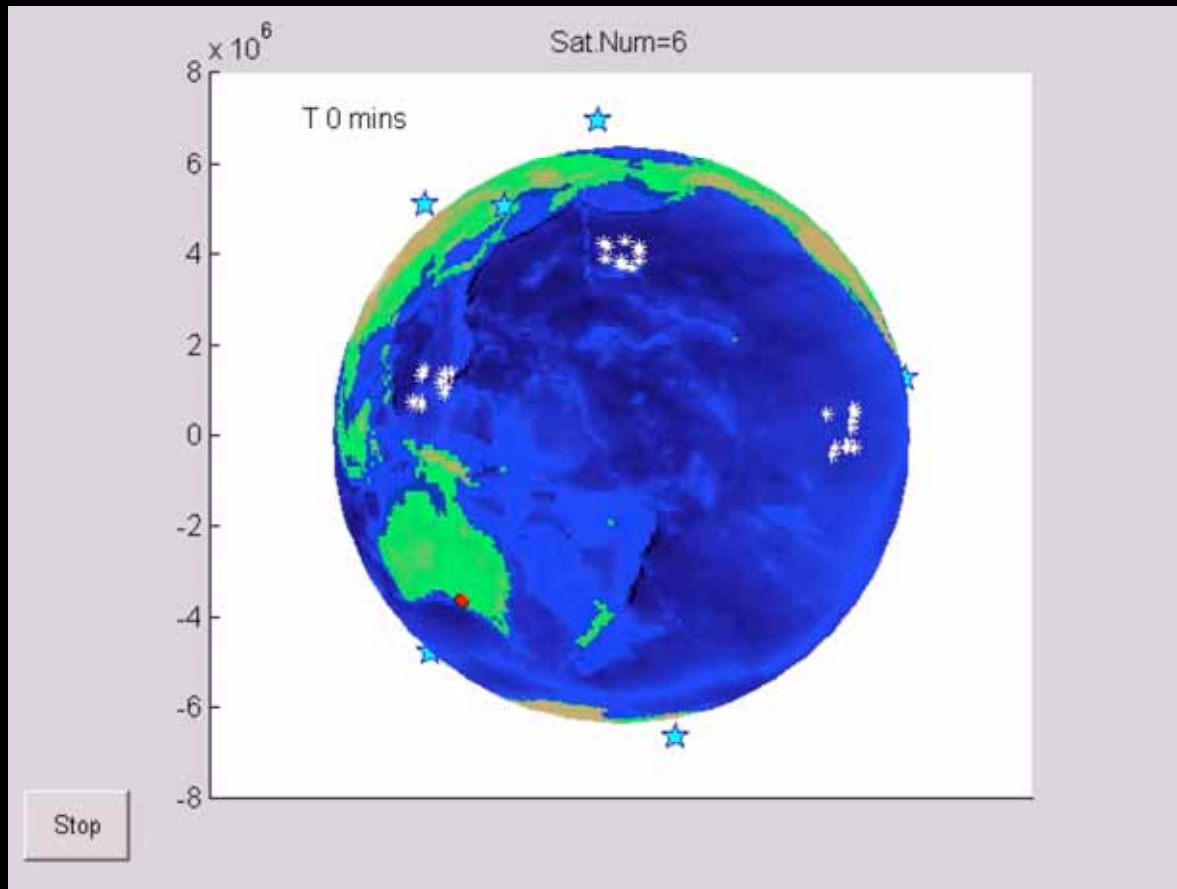
# Traditional Development



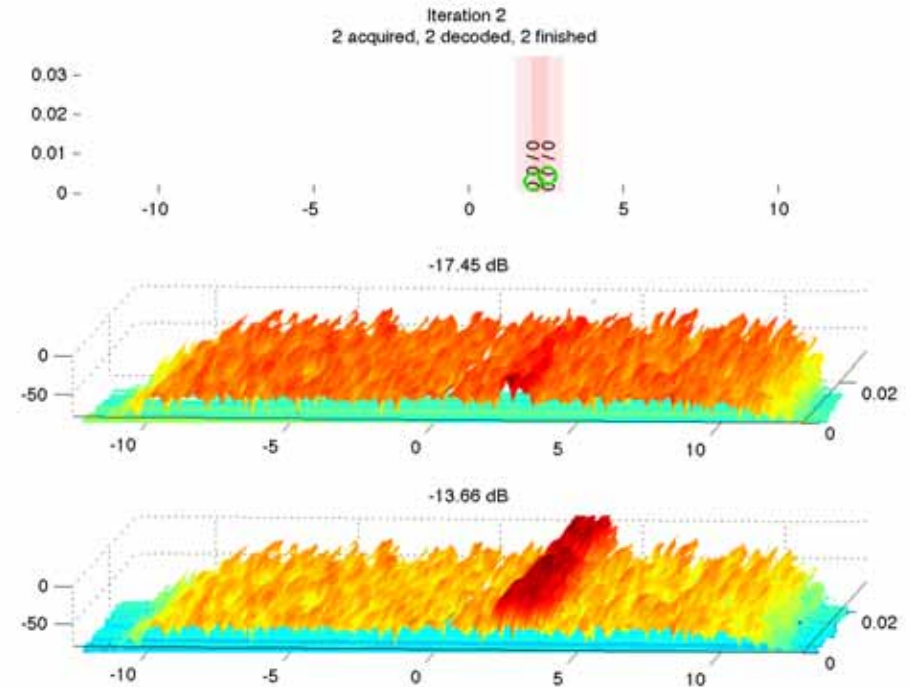
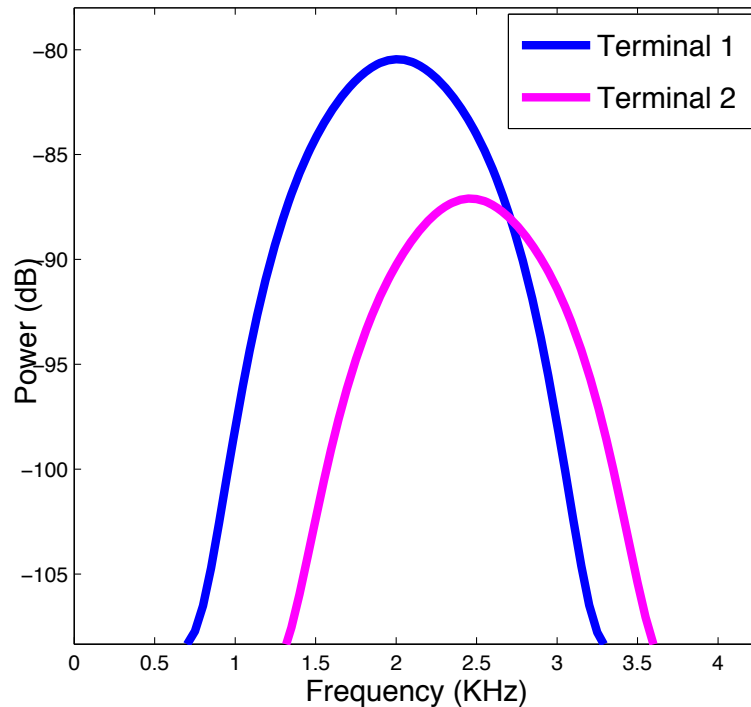
# GSN Development Methodology



# Mathematics and Simulation



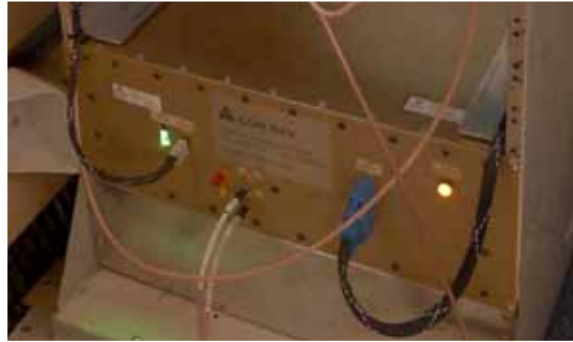
# Bench Testing



**bench proven July 2012**  
**in clean room with space hardware**

# ST1 Field Trial Communications System

## Space Qualified Channel Capture Payload



## Remote Terminals



Ettus Research USRP E110

## Compute Cluster





# ST2 Field Trial Communications System

## SDR4902 Demo Payload

### Remote Terminals



### Gateway Terminal



Ettus Research USRP E110

# ST2 Field Trial Communications System

## SDR4902 Demo Payload

### Remote Terminals



**Bidirectional**

### Gateway Terminal



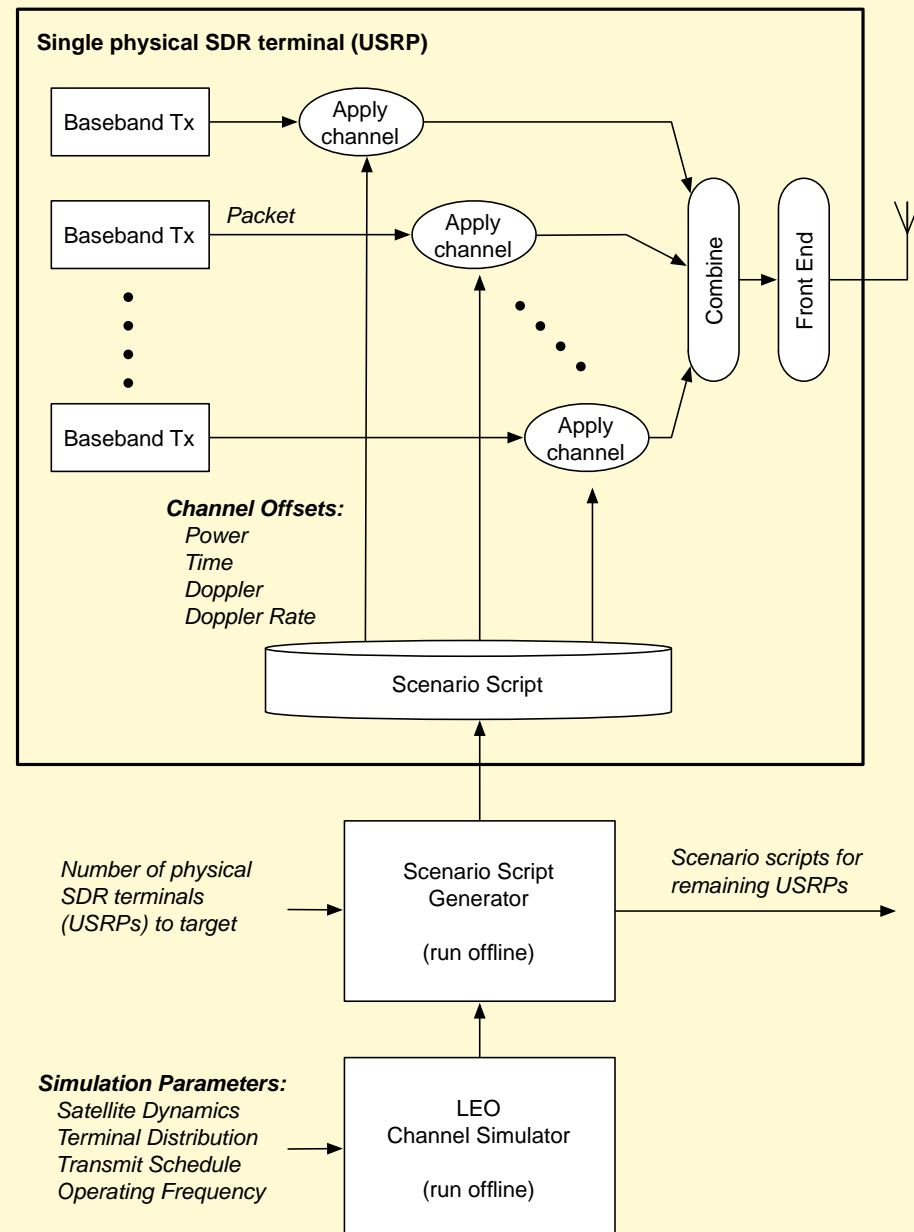
Ettus Research USRP E110

# Aircraft Trials



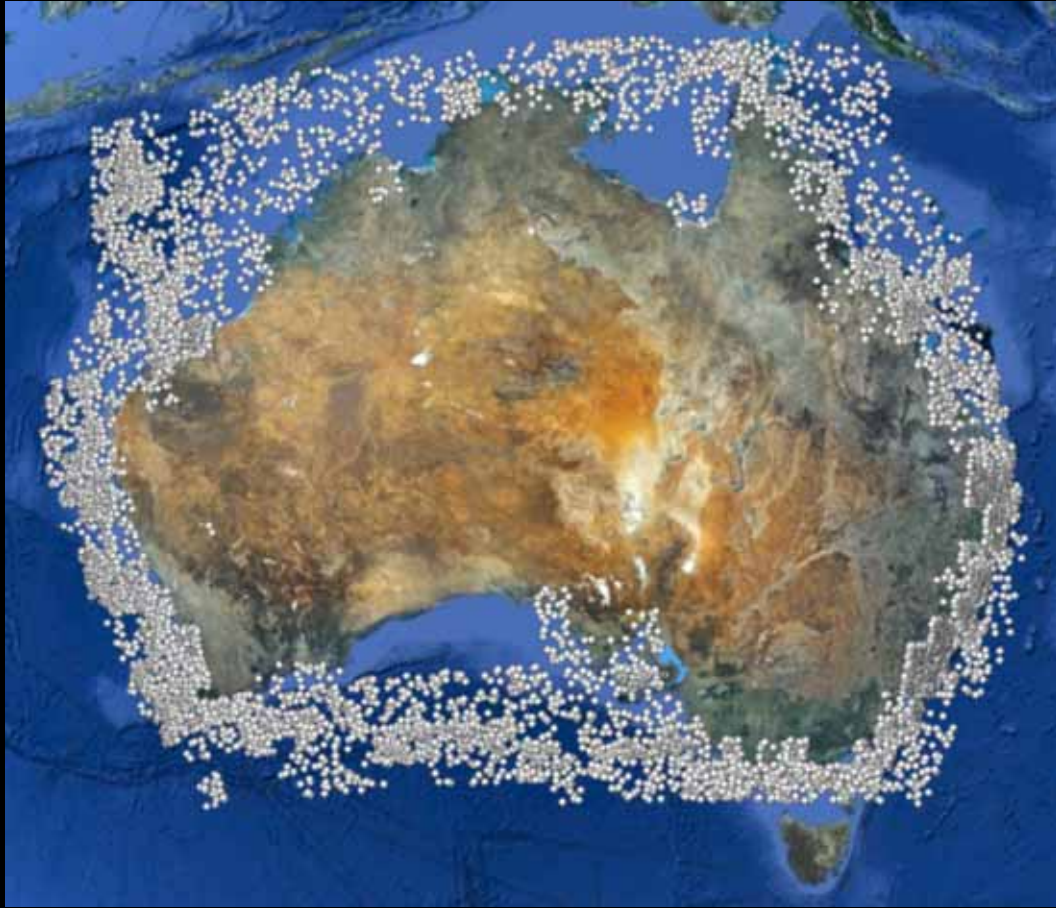
**field proven April 2013**  
**flights over South Australia**

# Advanced SDR Testbed



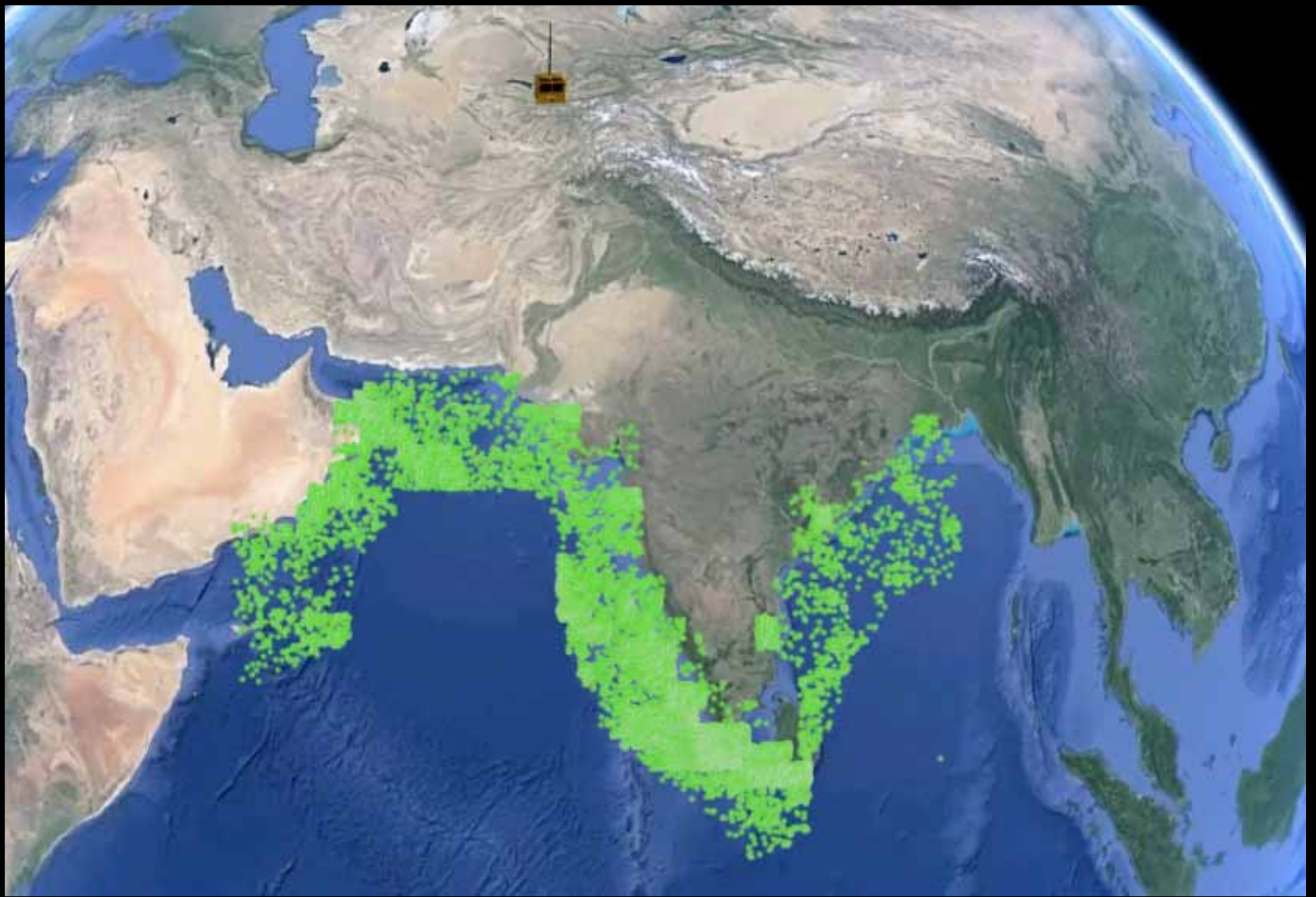


# Aircraft Trials



Looped replay of a 14 minute satellite pass  
**10,000's of terminals successfully detected**  
**single 25kHz channel**

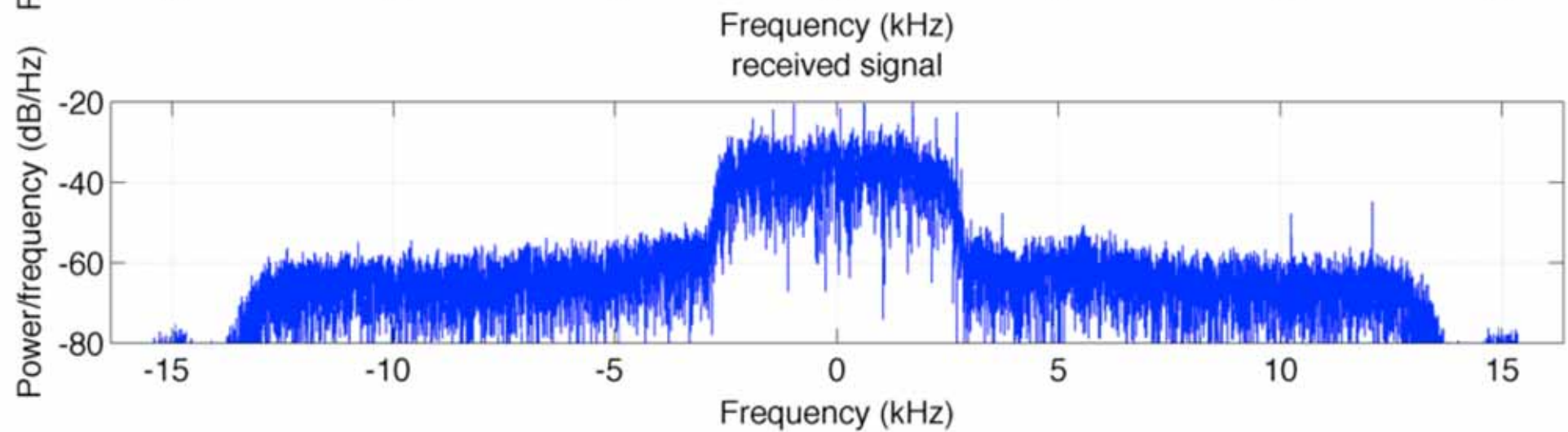
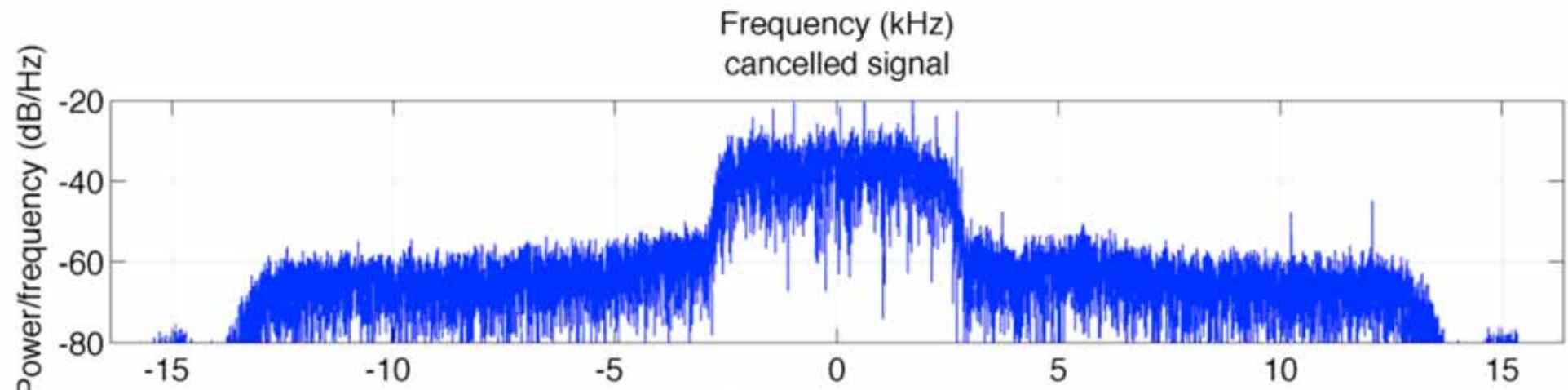
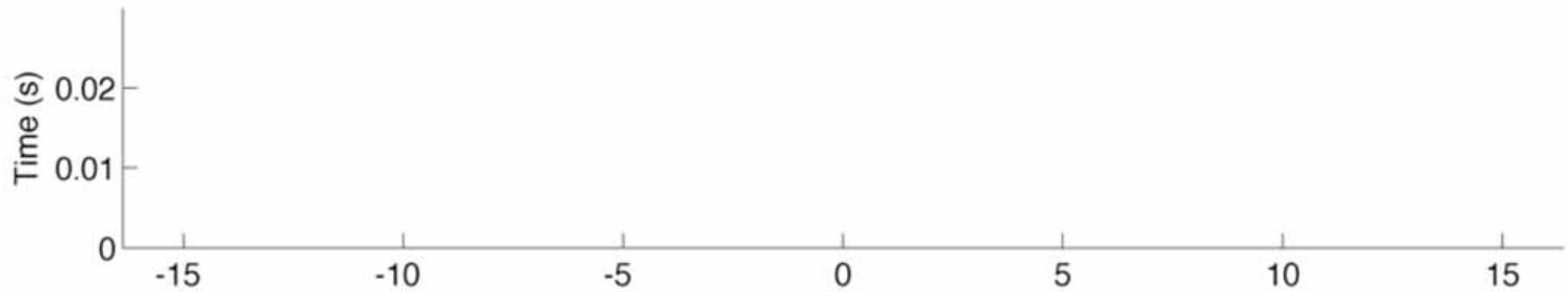




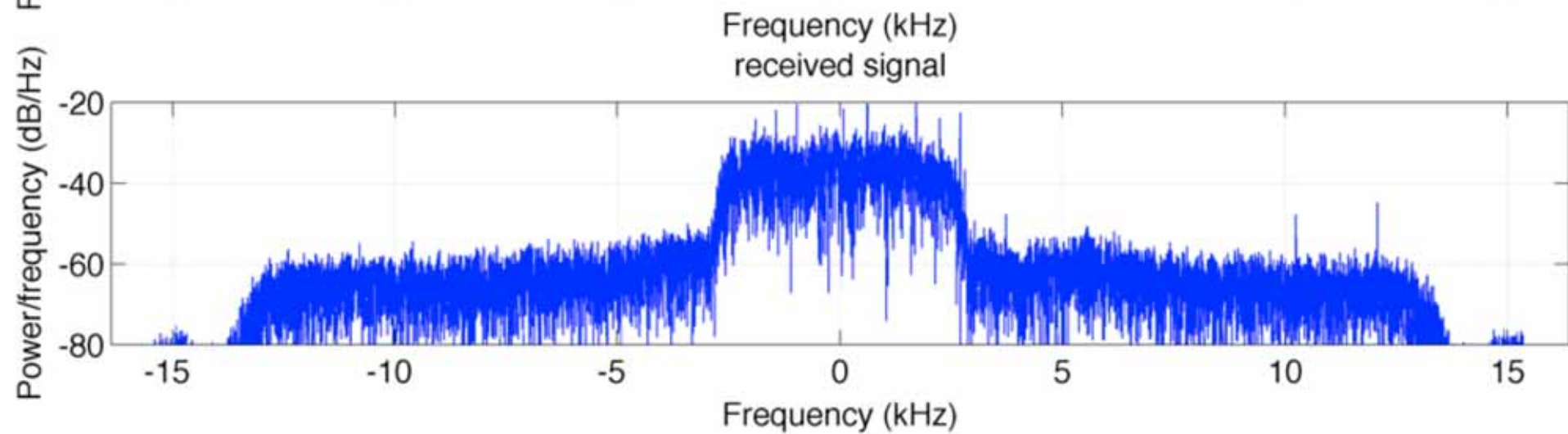
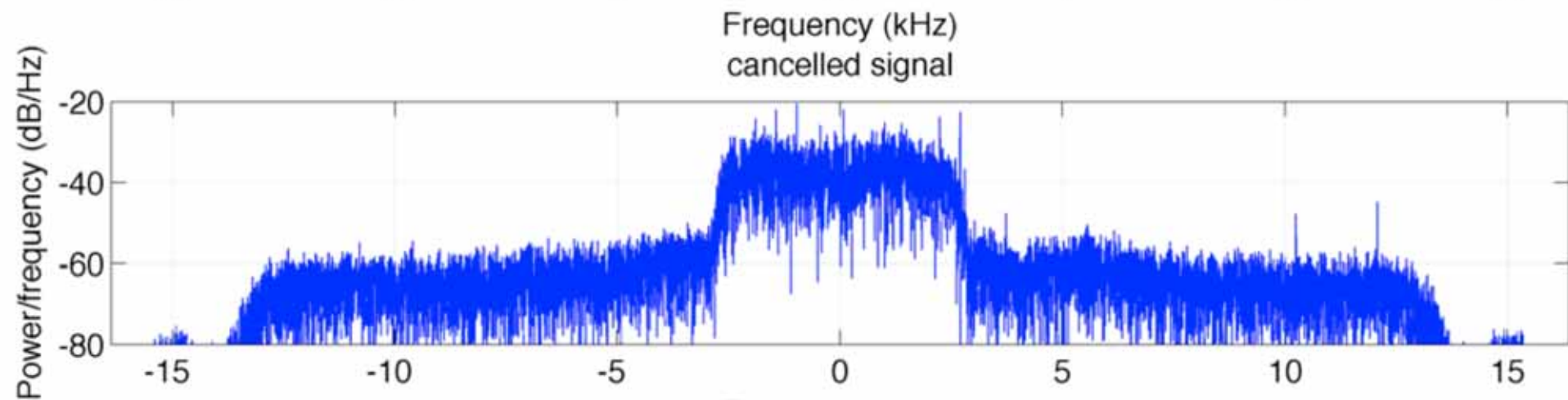
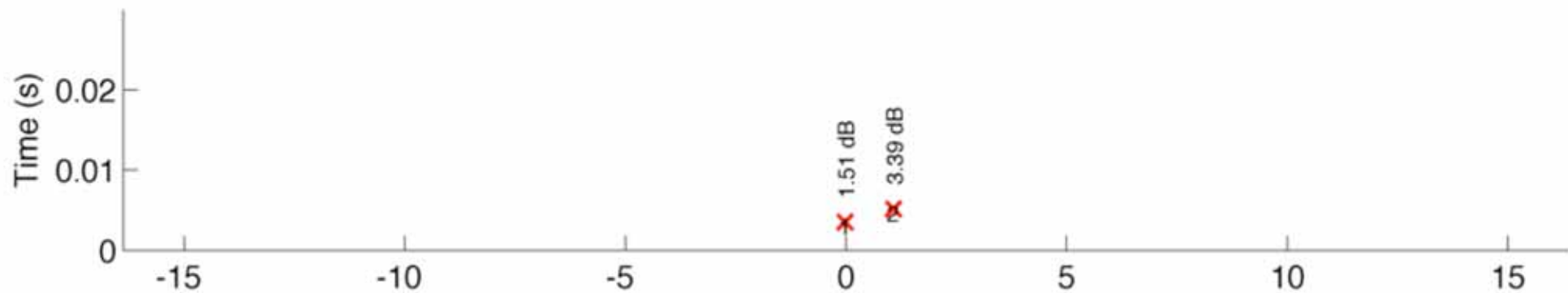
**47,299 terminals successfully detected**

# **Multuser Receiver**

Iteration 1  
0 acquired, 0 decoded, 0 finished

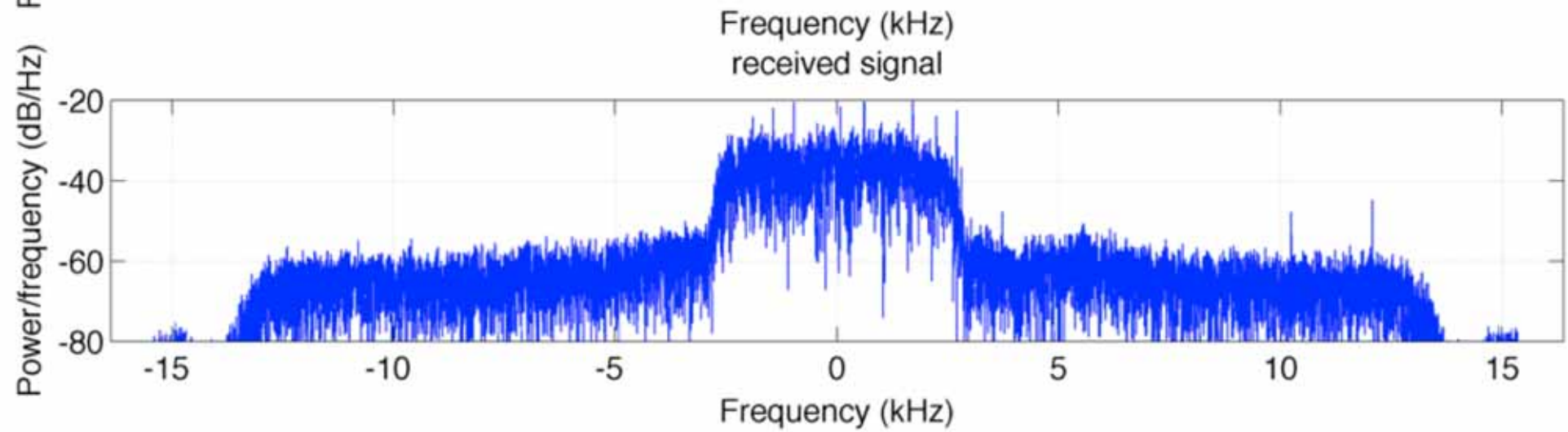
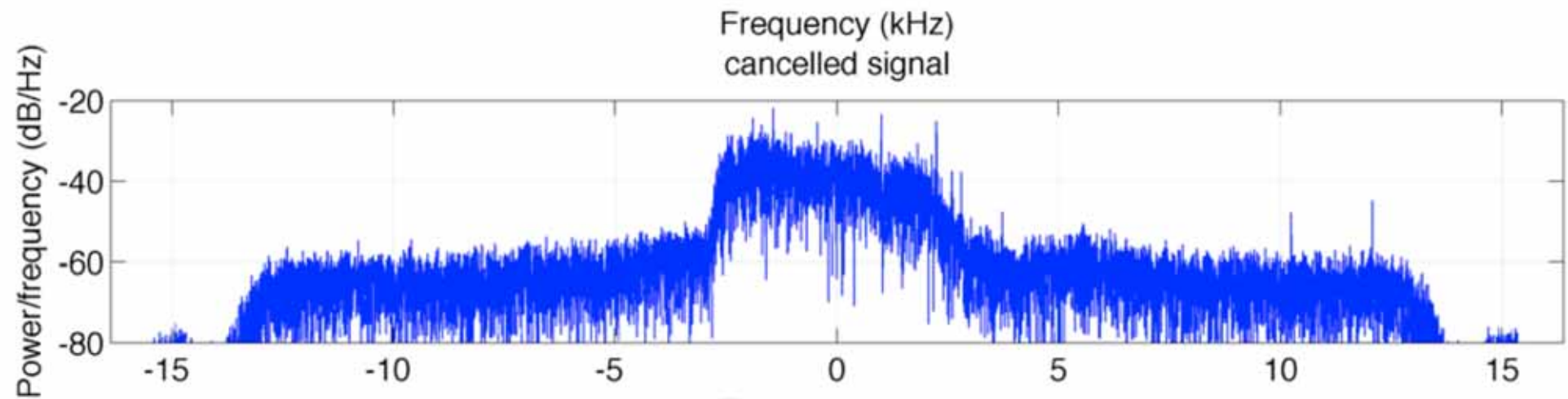
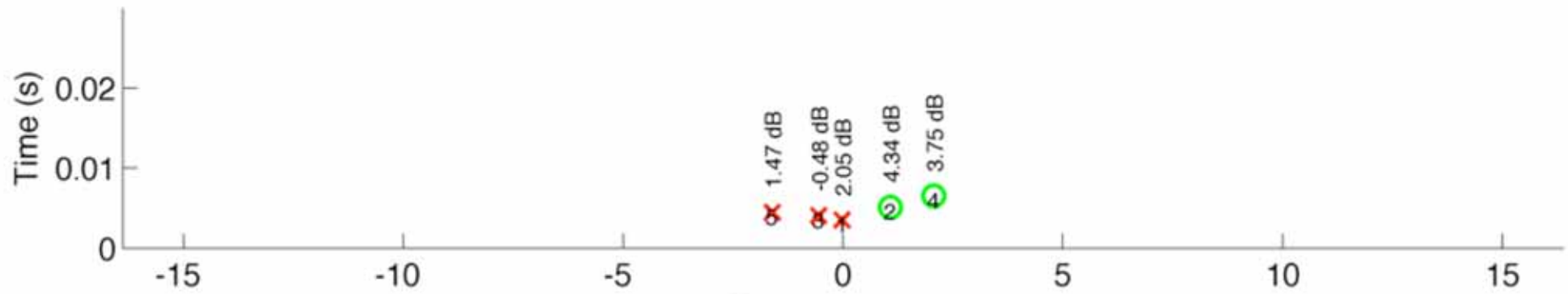


Iteration 5  
2 acquired, 0 decoded, 0 finished



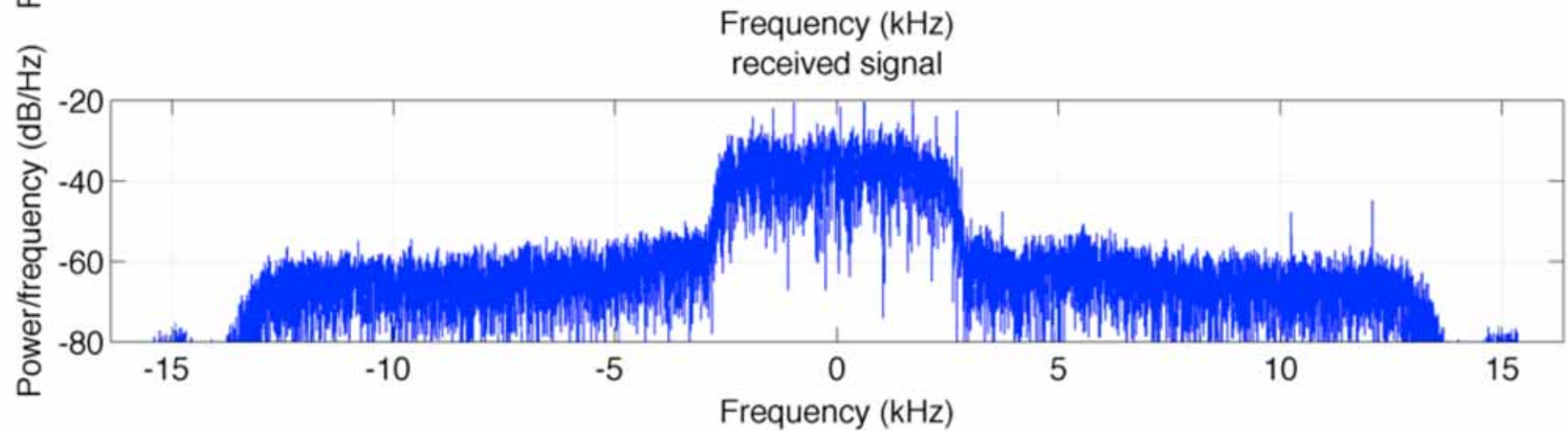
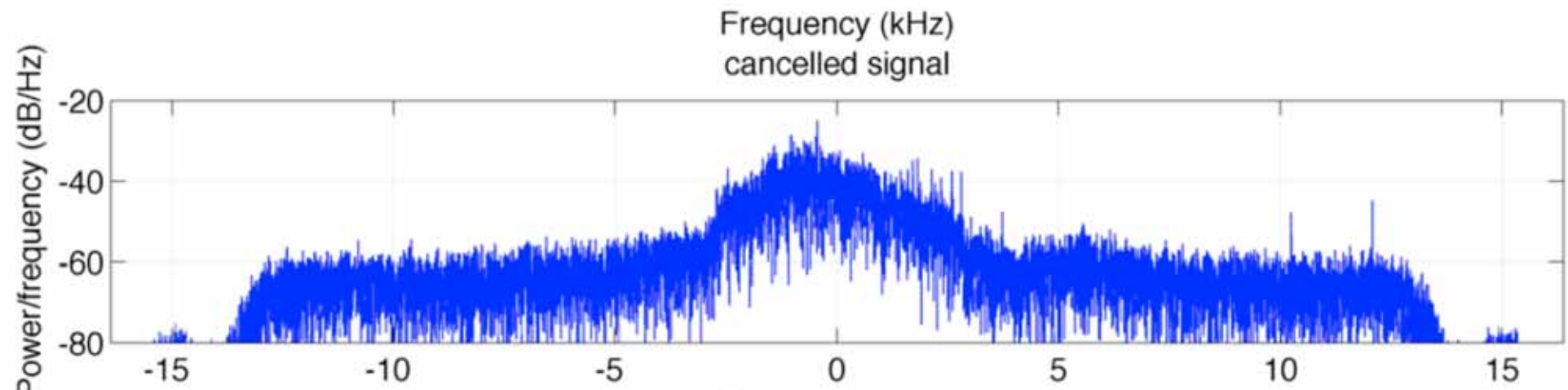
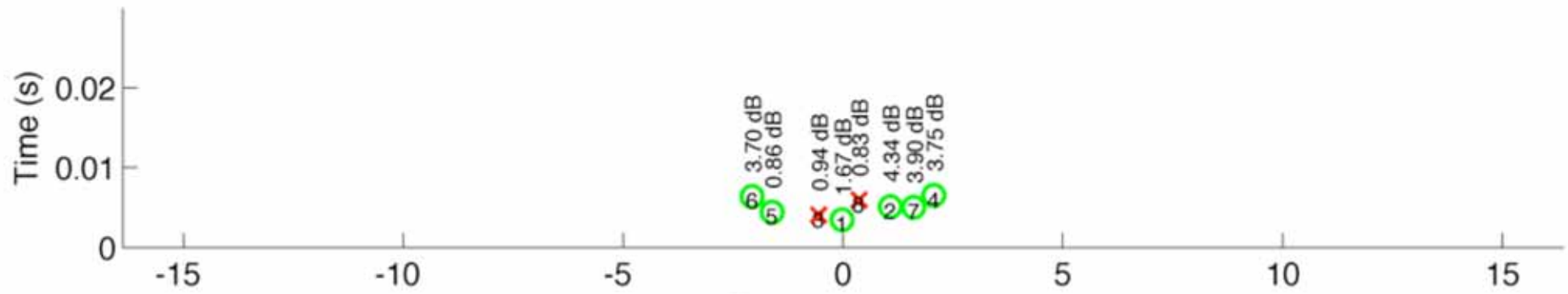


Iteration 10  
5 acquired, 2 decoded, 2 finished

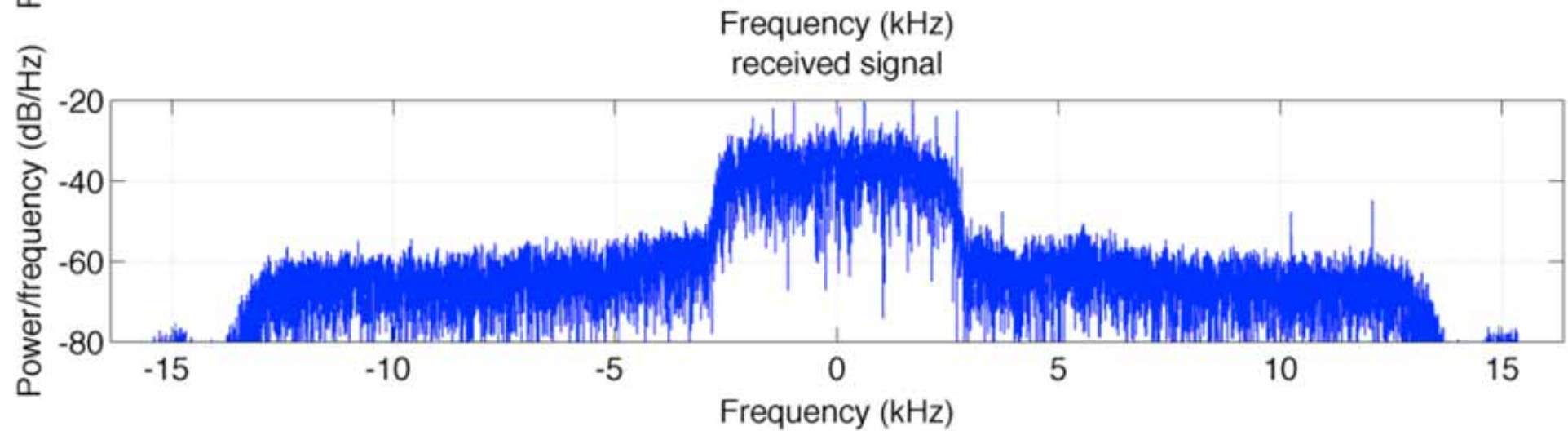
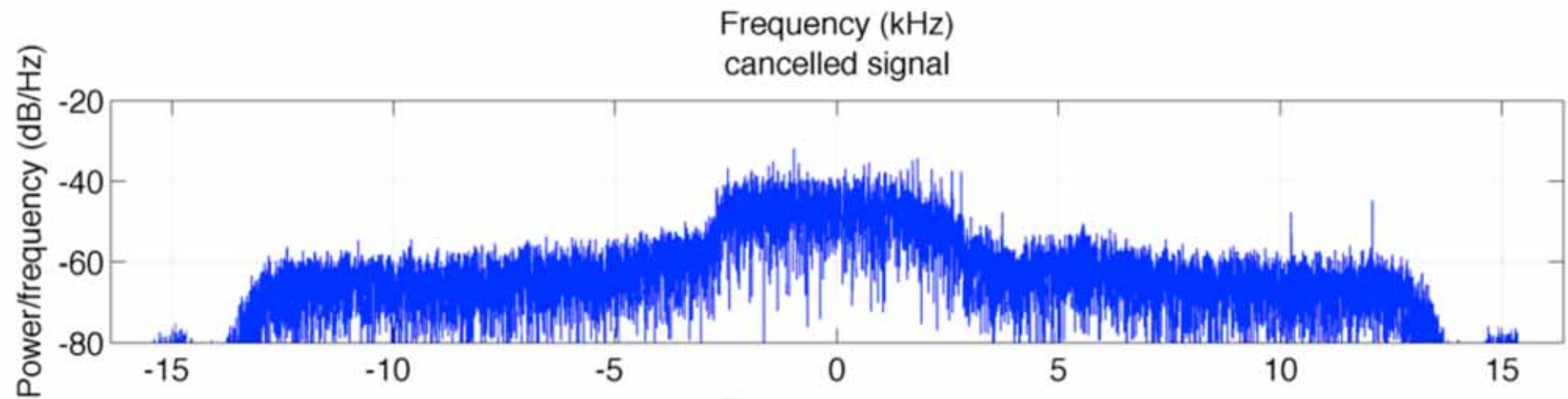
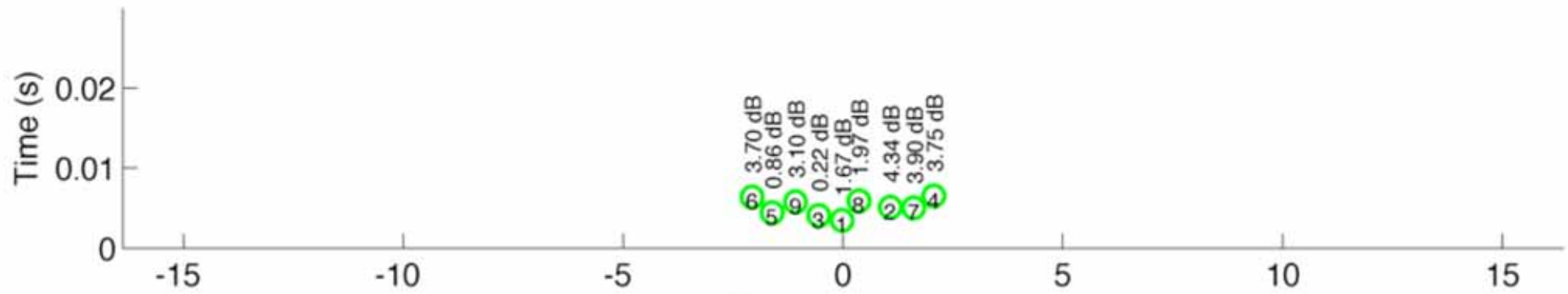




Iteration 15  
8 acquired, 6 decoded, 6 finished



Iteration 19  
9 acquired, 9 decoded, 9 finished



# Testing Under Heavy Load

9 terminals transmit

Tightly overlapped within 5kHz

45 messages in a single 25kHz channel

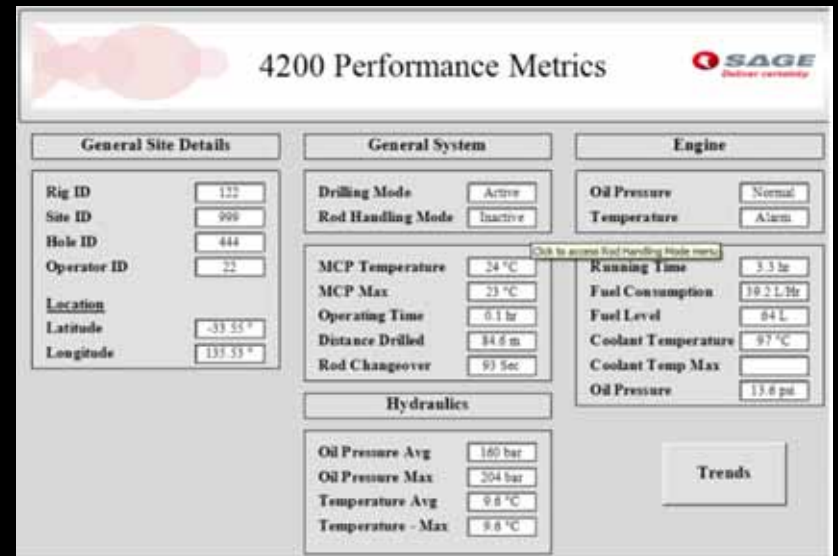
**10 minute Satellite Pass**

**More than 100,000 terminals**

# Aircraft Trials



Remote Communication Unit



## Remote Monitoring and Control

## Bidirectional communication



# Aircraft Trials



**We Found Them All**



# **Low Cost Small Form Factor Terminal**

**GSN bidirectional radio interface**

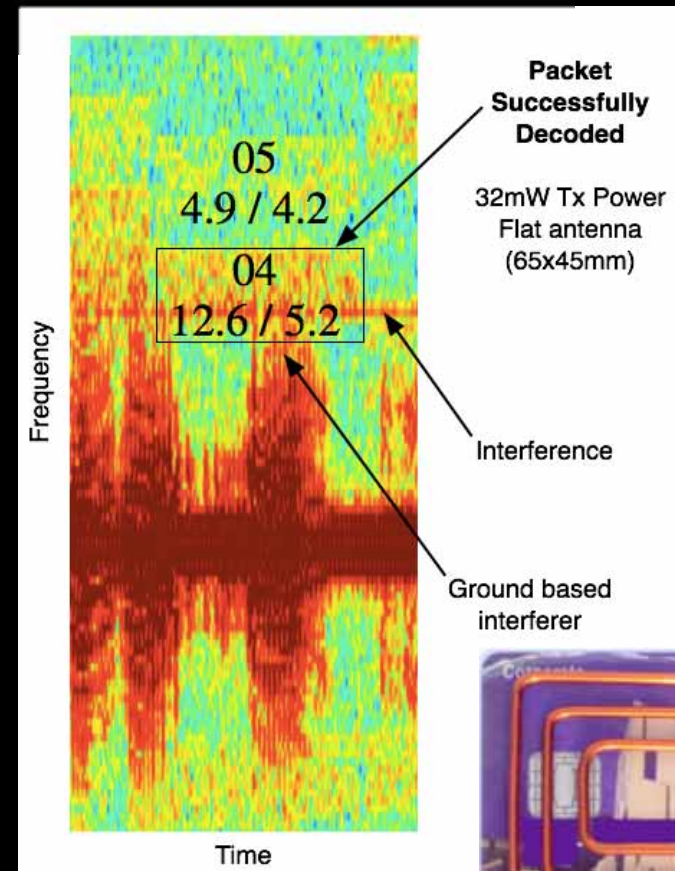
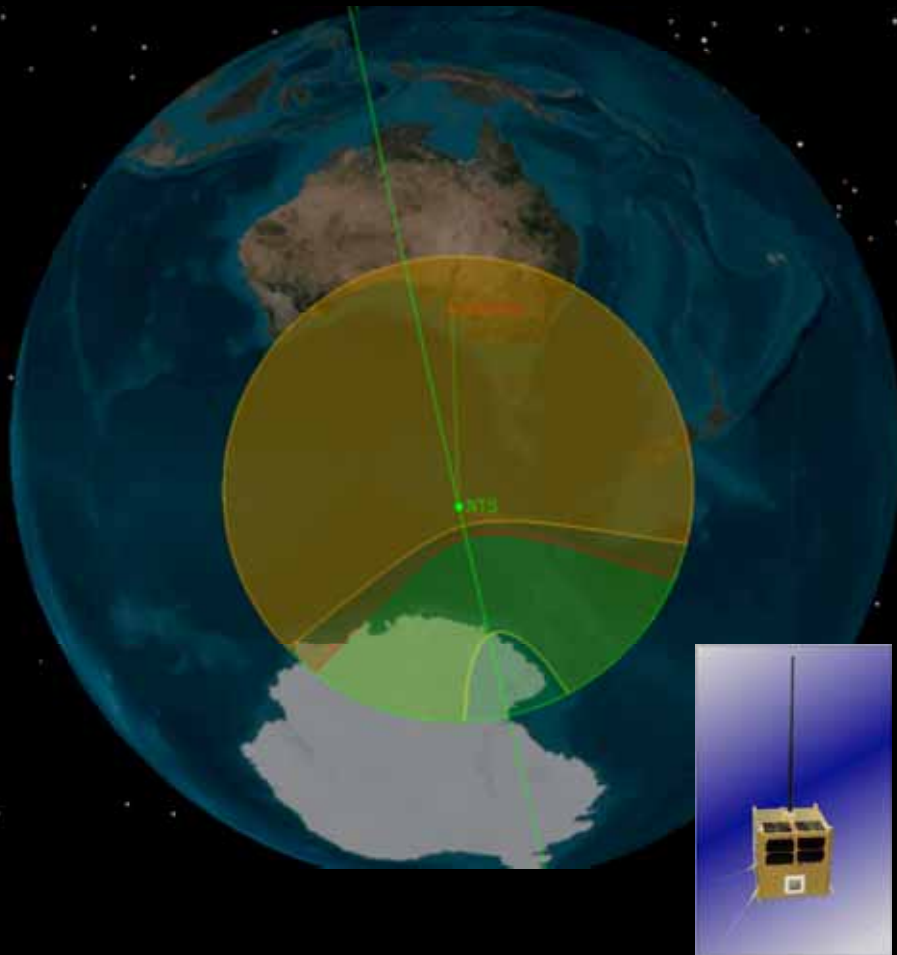
**Integrated GPS**

**USB OTG Interface**

**Credit card size (85 x 50 x 25 mm)**

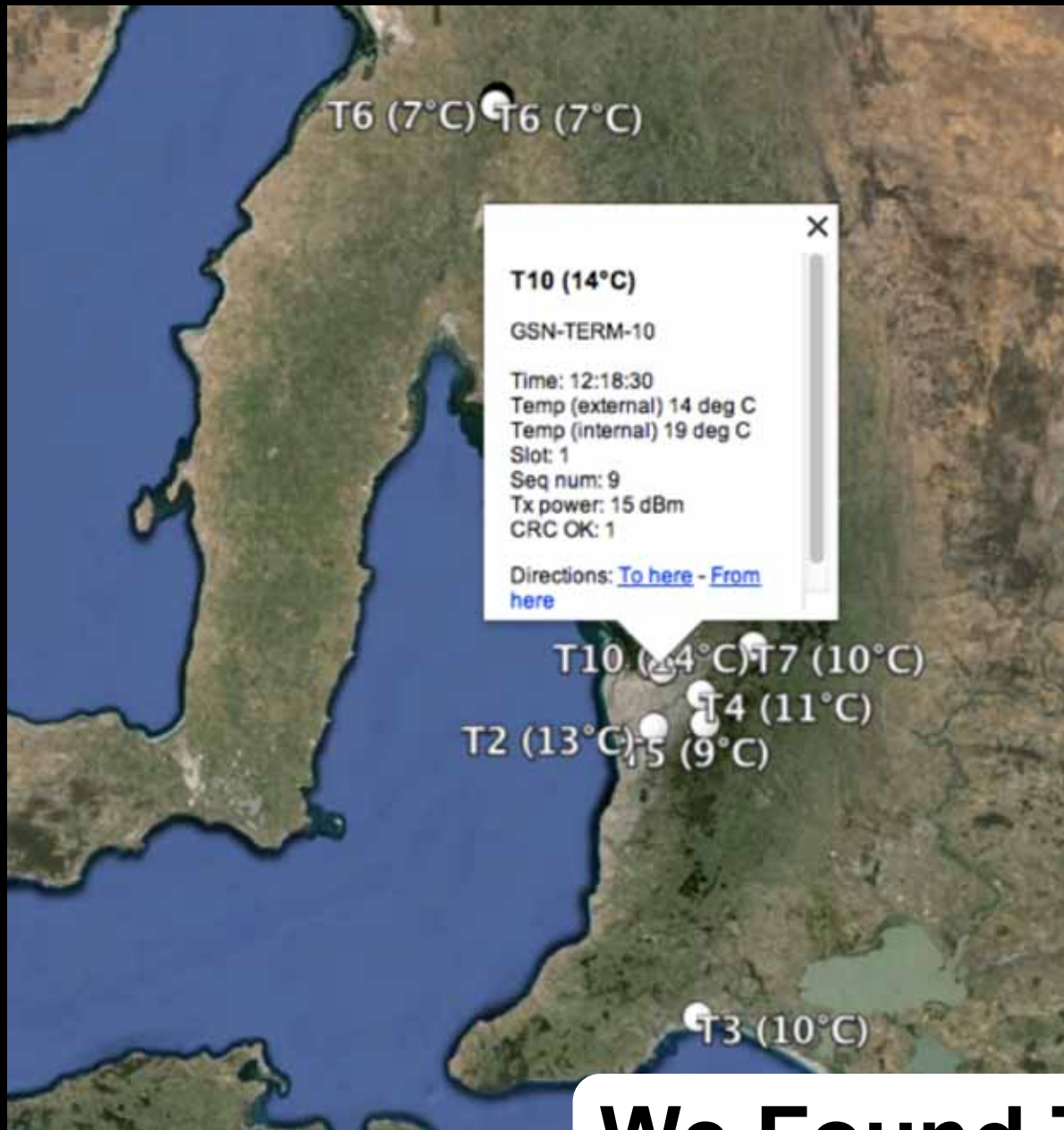
**Reprogrammable waveform processing**

# Satellite Trials



**space proven June 2013**  
**low earth orbit satellite**

# Satellite Trial - Field Deployment



Terrain testing

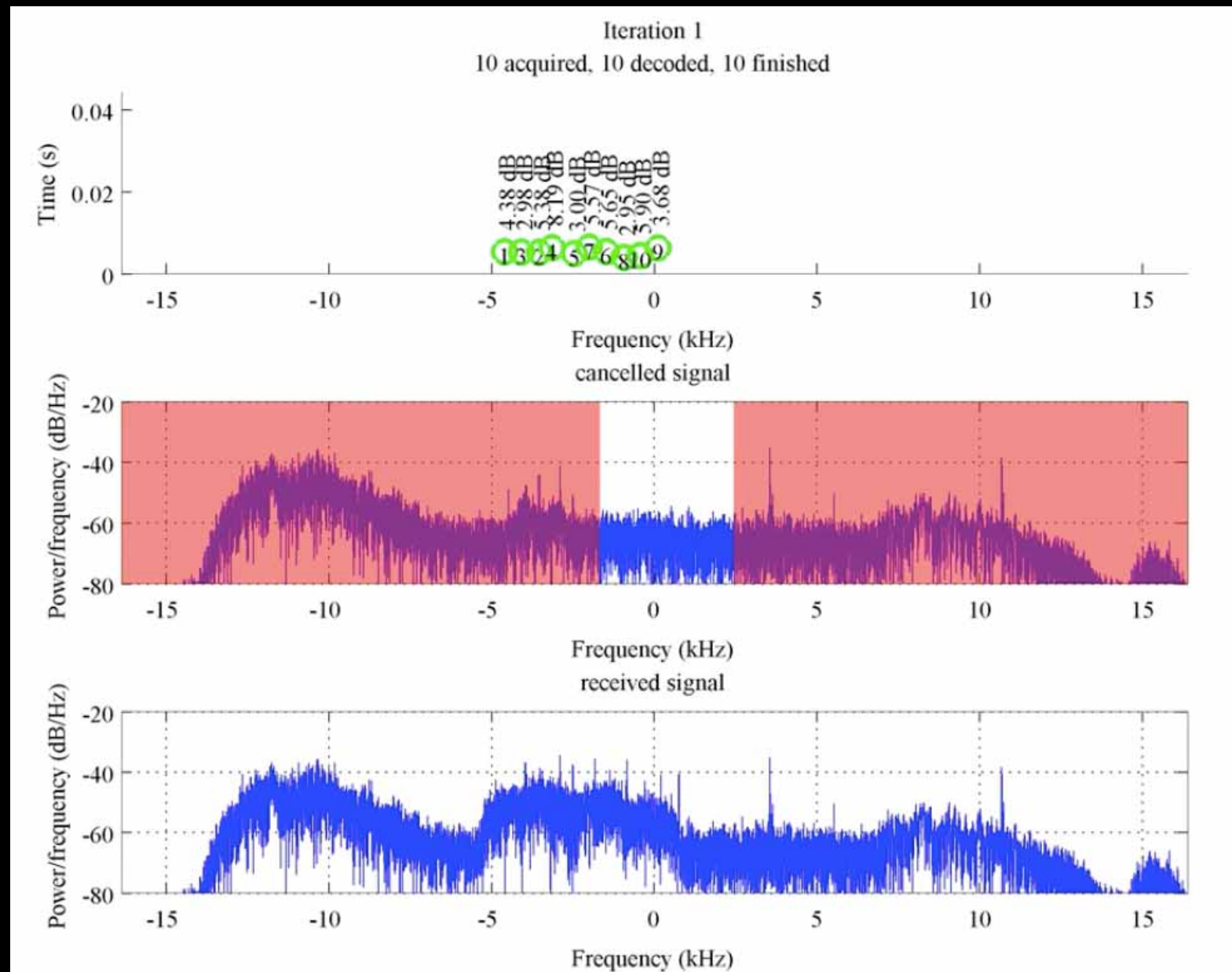
8 locations

Re-use of A/C trial sites

Temperature sensing

**We Found Them All ... Again**

# Satellite Trial - Receiver Stress Test





# **Satellite Trial - Receiver Stress Test**

10 terminals transmit tightly overlapped

Equivalent density of  
50 terminals in a single 25kHz channel

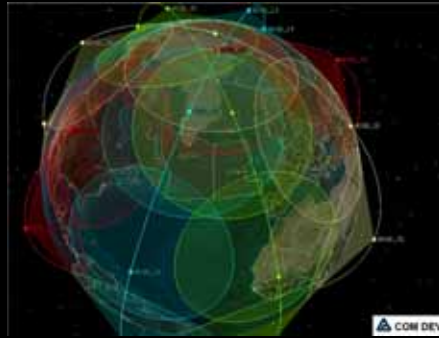
**10 minute Satellite Pass**

**120,000 terminals**

# Global Sensor Network



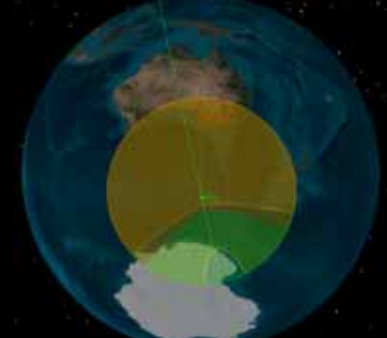
Architecture, Waveforms, Protocols



Phase A Study, Flight-  
Representative Hardware



Aircraft Trials



Satellite Trials



Initial Operational Capability



Full Operational Constellation

**logical progression**

# **Solution Differentiators**

use case driven  
greenfield design  
innovative system

flexible  
scalable  
efficient

satellite and aircraft trial proven

**Enabled by SDR**

# Global Sensor Network

Dr David Haley

[david.haley@unisa.edu.au](mailto:david.haley@unisa.edu.au)

Technical Director, GSN Program

Senior Research Fellow

ITR, University of South Australia

<http://www.itr.unisa.edu.au>

<http://www.youtube.com/watch?v=m2-VBFL6dzM>

