



# RF Channel Simulation: Realistic Test and Training for Targets, UAVs and Ranges

Steve Williams

Manager, Signals Instrumentation

[swilliams@rtlogic.com](mailto:swilliams@rtlogic.com)

719-884-6269

3 Oct 2012



**RT LOGIC**

A **KRATOS** Company

# Communications Environment



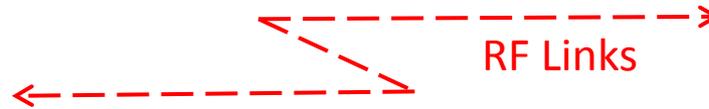
**Dynamic**  
Doppler Shift  
Delay  
Path Loss  
Noise  
Interference

**Dynamic**  
Flight Profiles  
Body Masking  
Antenna Pointing  
Antenna Patterns  
Multipath  
Terrain  
Weather

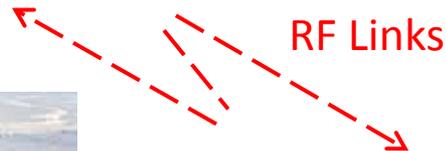


Targets and Platforms  
under Test

Range Telemetry  
Monitoring Assets



Ground Control  
Systems



Test Requirements and Training Requirements are Implied

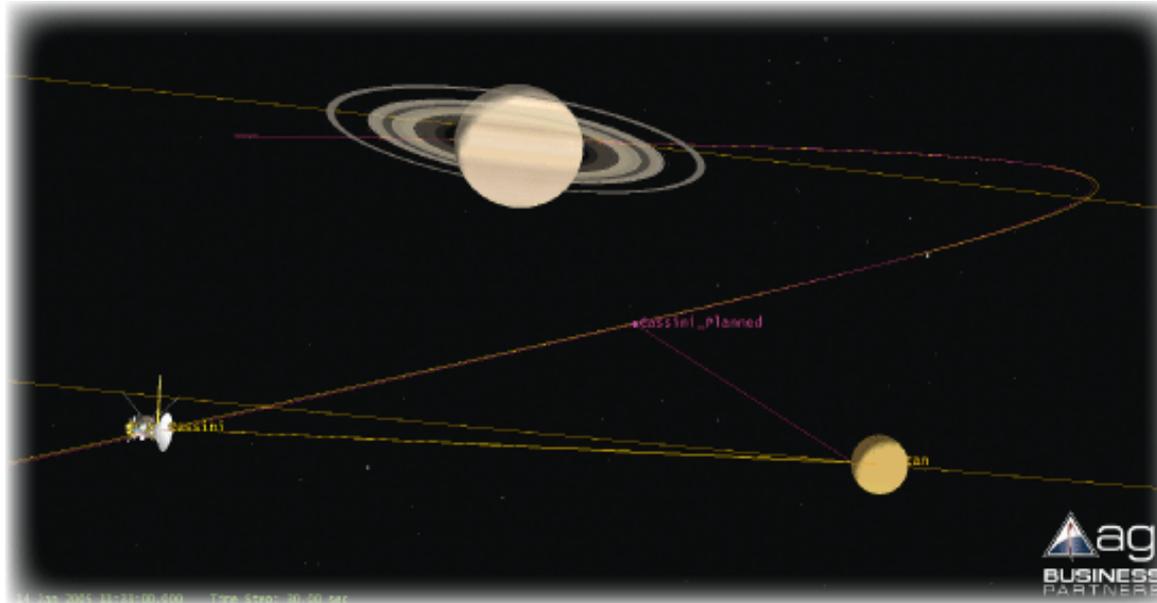
# Two Stunning Examples of Testing and/or Training Failures

## RQ-170 Incident / 4 Dec 2011



- What happened here?
  - Simple COMMS Jamming?
  - Sophisticated EW techniques as Iran claims?
  - Something else?
  - **Testing and/or training didn't cover whatever caused the loss**
  - **Disastrous Loss**

# Cassini-Huygens Mission / 2005



- What happened here?
  - Doppler shift causes Data Rate changes
  - In-flight analysis: Data tracking loop won't handle the data rate change
  - **Testing didn't cover this dynamic issue**
  - Flight path altered, mid-mission, to decrease separation velocity
  - **Mission was successful.**

- Many other examples, large and small
  - Blue-on-blue interference
  - Red-on-blue interference
  - Radios that don't work in foliage
  - Navy SATCOM disrupted by purposeful EMI
  - Etc.
  
- The Future of Testing and Training
  - We've got to do go deeper in the labs
  - Save money and time at later testing stages
  - Need Intelligent Instrumentation
    - SW/FW definable
    - Built into fielded systems for automatic test, remote test and training, self-healing
    - Usable for both test and training

# Communications Environment



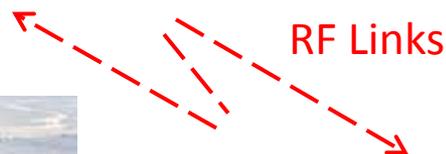
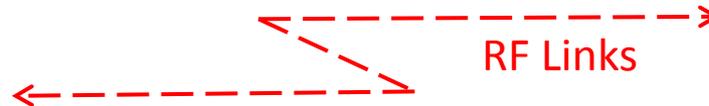
**Dynamic**  
Doppler Shift  
Delay  
Path Loss  
Noise  
Interference

**Dynamic**  
Flight Profiles  
Body Masking  
Antenna Pointing  
Antenna Patterns  
Multipath  
Terrain  
Weather



Targets and Platforms  
under Test

Range Telemetry  
Monitoring Assets



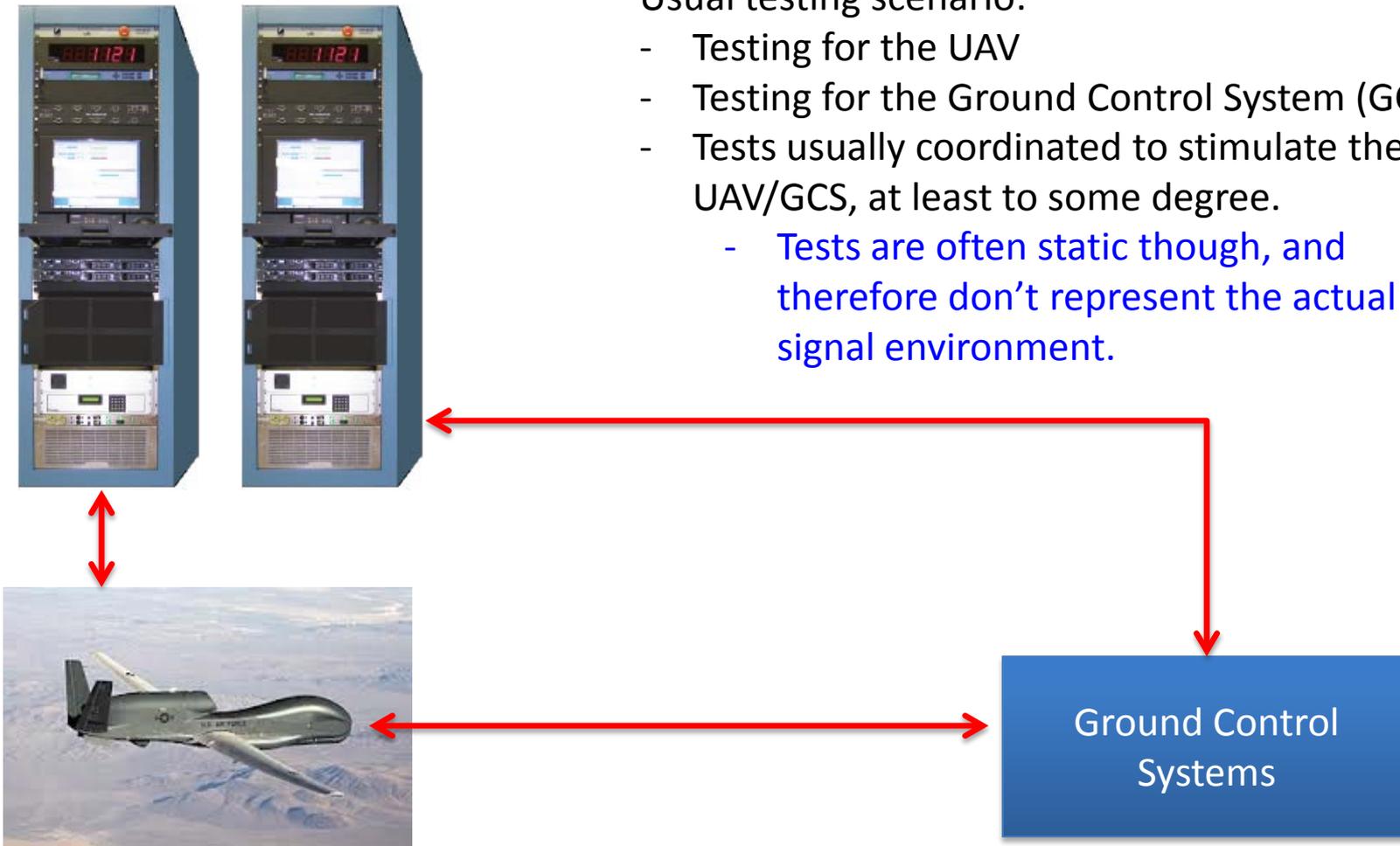
Ground Control  
Systems



- UAV/Target and Ground Control System **Designers**
  - Must conduct thorough test in absolute worst case conditions
    - Test against the very worst that could happen
    - Think outside the box!
  - Comprehensive regression test when modifying HW, SW or FW
  
- UAV/Target and Ground Control System **Operators**
  - Training: Prepare operators to detect, characterize & mitigate
  - Planning: Can the system handle the mission?
  - Pre-mission Test: Is the range fully ready to go right now?
  - Regression: Does the system still work after HW, FW, SW upgrades and updates?

Usual testing scenario:

- Testing for the UAV
- Testing for the Ground Control System (GCS)
- Tests usually coordinated to stimulate the UAV/GCS, at least to some degree.
  - Tests are often static though, and therefore don't represent the actual RF signal environment.





Utilize dynamic tests that do represent RF signal propagation, and other matters that will impact the signals.



- | <u>Dynamic</u> | <u>Dynamic</u>   |
|----------------|------------------|
| Doppler Shift  | Flight Profiles  |
| Delay          | Body Masking     |
| Path Loss      | Antenna Pointing |
| Noise          | Antenna Patterns |
| Interference   | Multipath        |
|                | Terrain          |
|                | Weather          |



*RF/IF Channel Simulator*



Ground Control Systems

- Supplies the “next step” from simulation to actual hardware test
- From an RF perspective, recreates →
- Substitutes for dangerous tests, expensive tests, tests on different battle fronts, tests that can’t usually be created (WX).
- Inserted into the RF/IF signal path
- Physics compliant
- Cost sensitive
- The same equipment for test as training.

**Dynamic**  
**Doppler Shift**  
**Delay**  
**Path Loss**  
**Noise**  
**Interference**

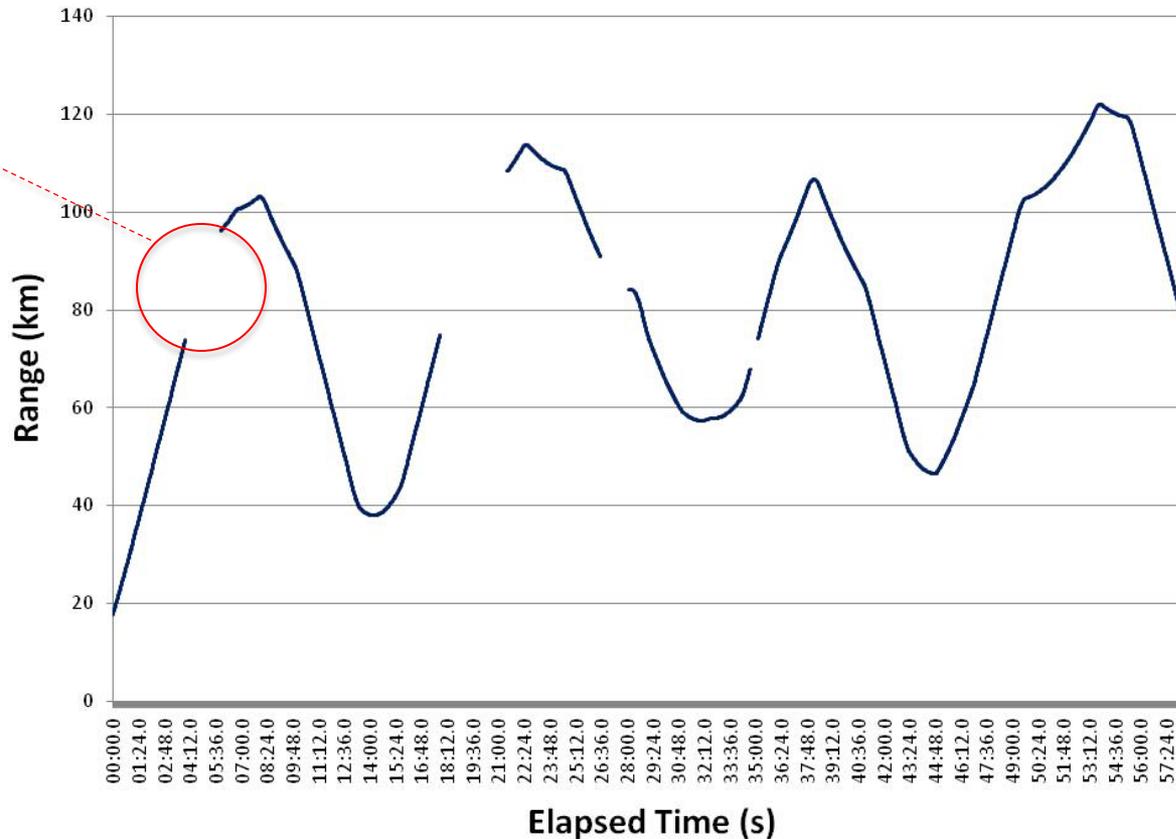
**Dynamic**  
**Flight Profiles**  
**Body Masking**  
**Antenna Pointing**  
**Antenna Patterns**  
**Multipath**  
**Terrain**  
**Weather**



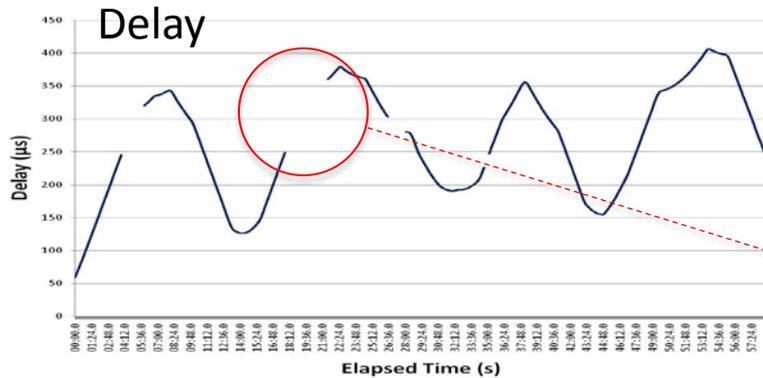
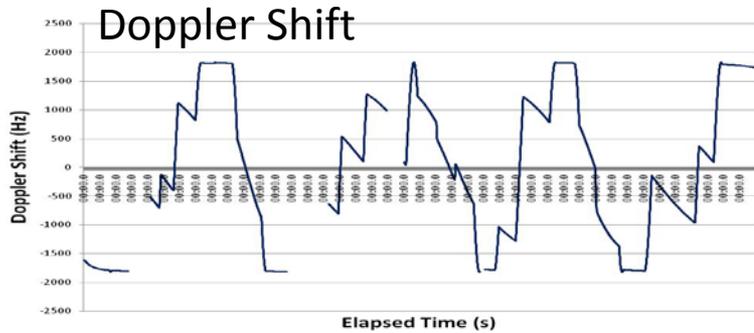
# Dynamic RF Channel Simulation

- Range vs. Time between a UAV and a control station

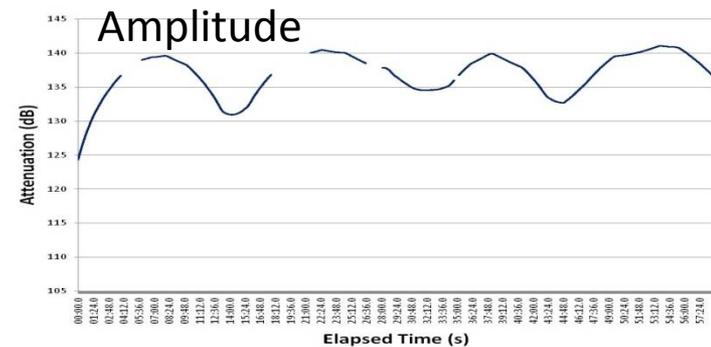
Range not determined due to terrain-related signal dropout



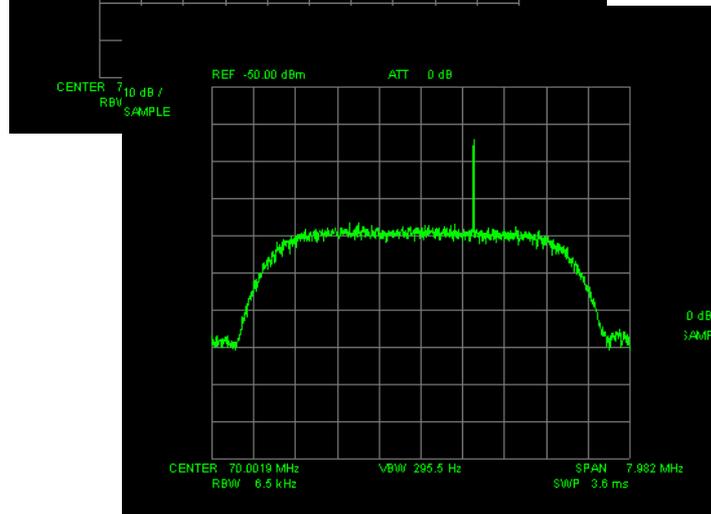
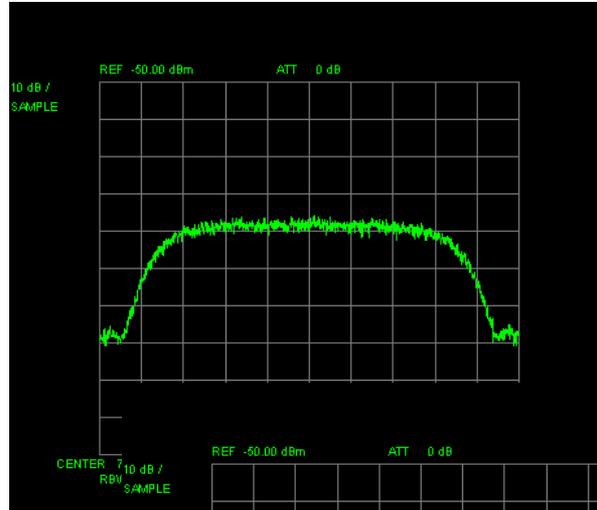
# Dynamic RF Channel Simulation



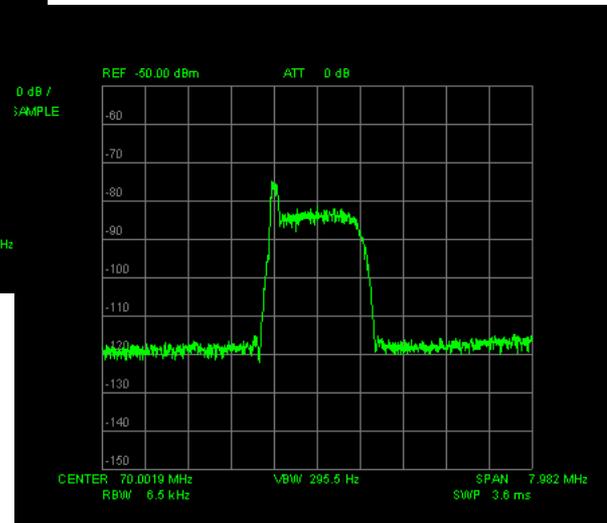
Signal dropouts due to terrain



# Dynamic RF Channel Simulation

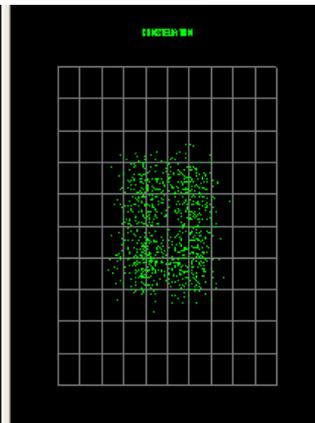
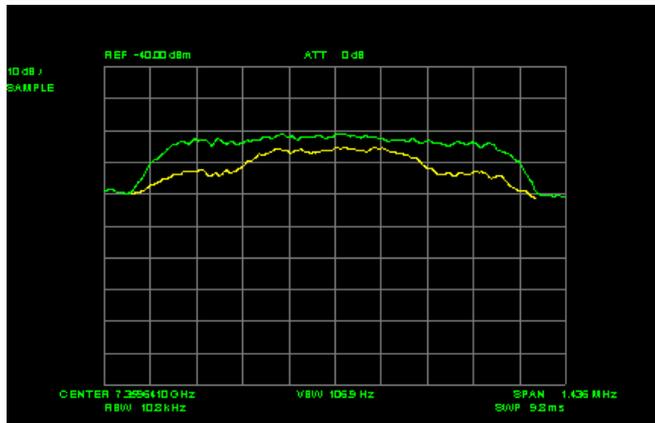
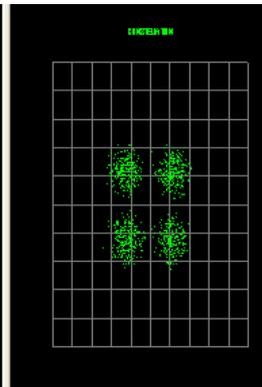
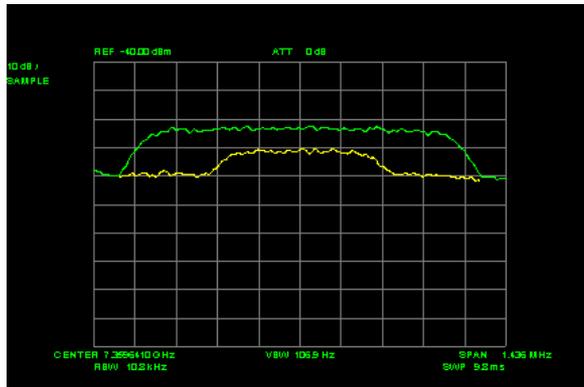
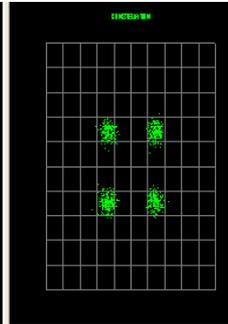
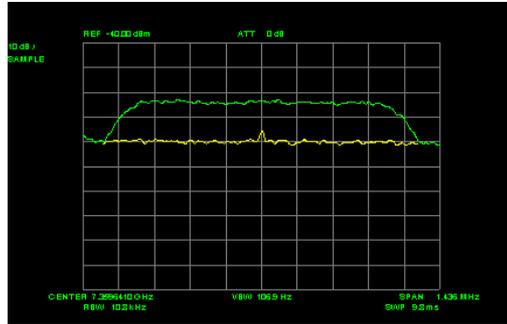


Different types of overt EMI.



Ground Control Systems

# Dynamic RF Channel Simulation



Increasing levels of covert EMI



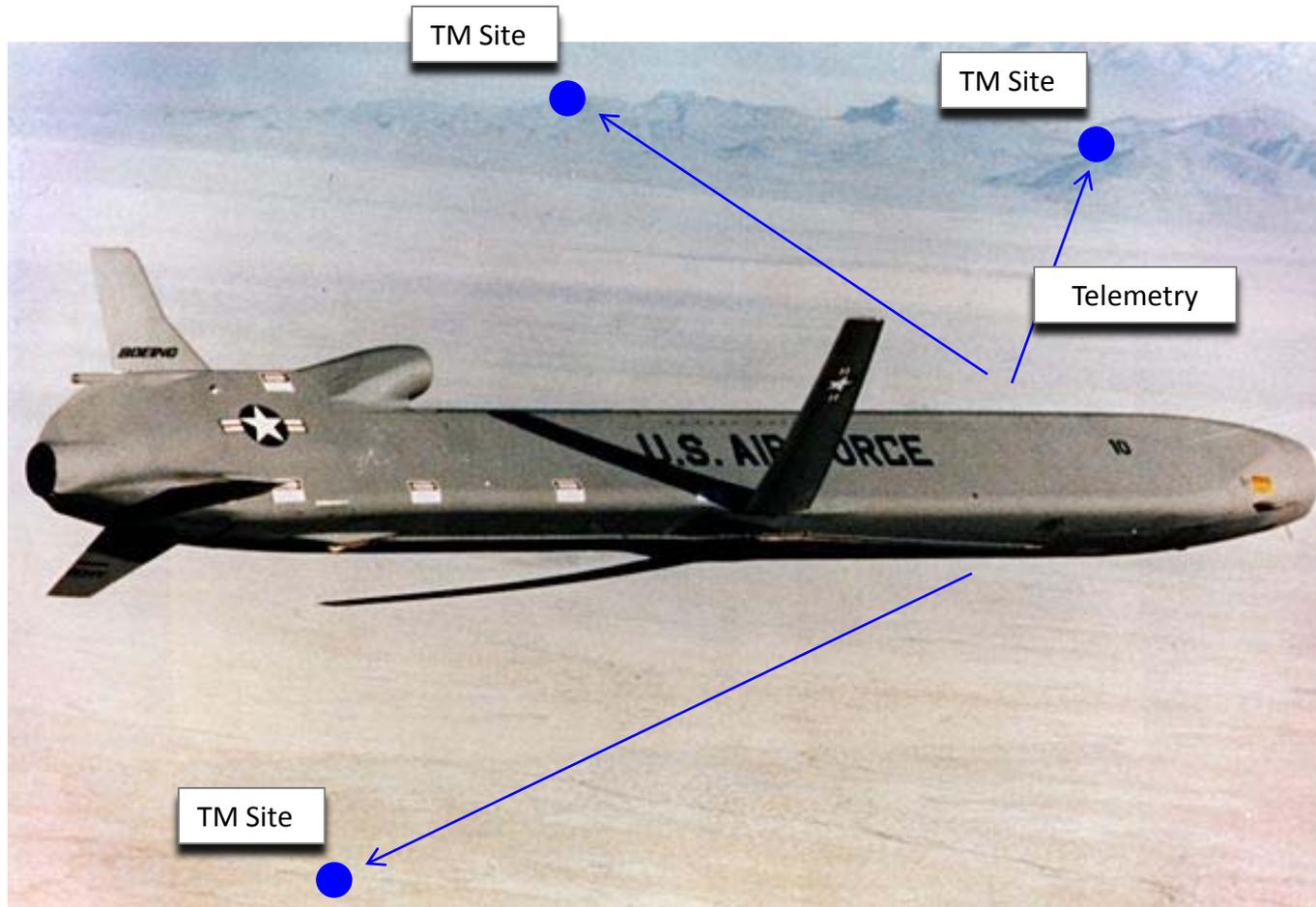
# Dynamic RF Channel Simulation

- Test under any conditions imaginable
- Harden the UAV and Ground Station HW, SW and FW
  - Natural RF Physics
  - Signal Threats
    - Blue-on-blue interference
    - Red-on-blue interference
    - Operator error
    - Equipment faults
    - Single threats / multiple threats
- These tests become the basis for Ground Station Operator training scenarios, with the same equipment.



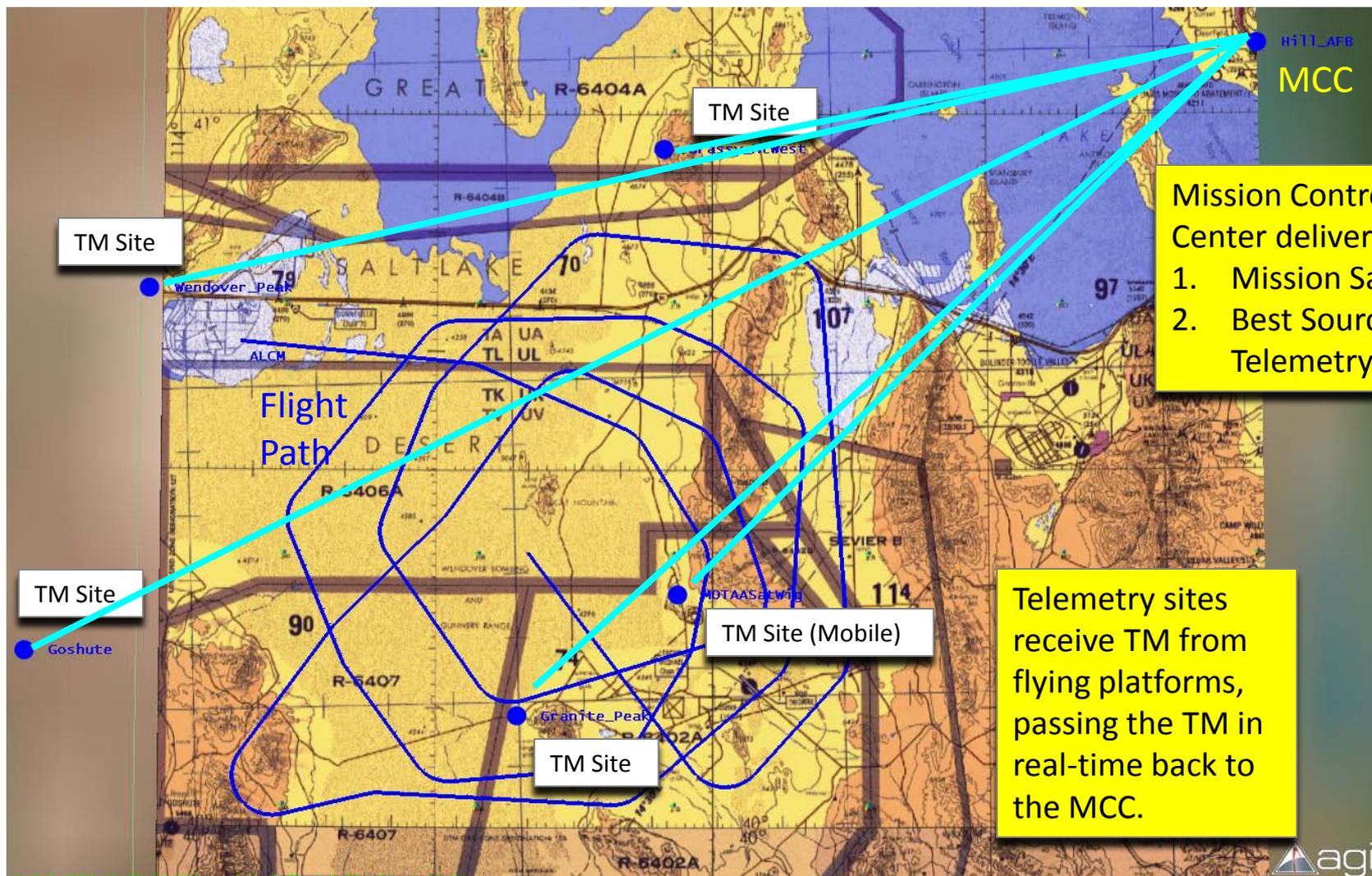
- UAV/Target, Ground Control System, Range Operators
  - Assure mission safety
  - Assure mission success
    - Range operators
    - Customers
  - Validate equipment functioning, pre-mission
  - Validate equipment after upgrades and updates
  - Calibrate equipment
  - Training

# Testing the Test Range



Boeing Photo

# Testing the Test Range



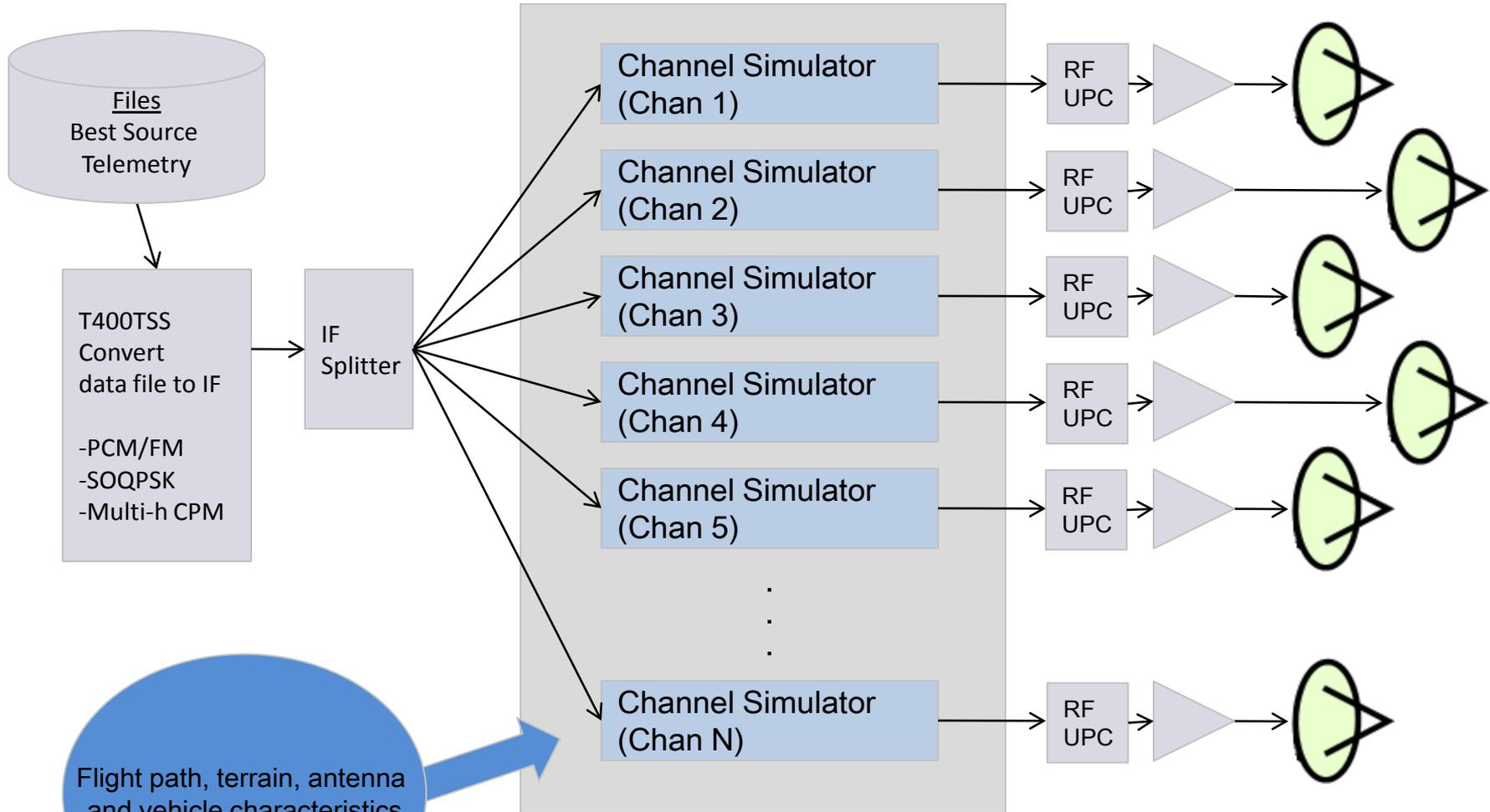
Mission Control Center delivers:

1. Mission Safety
2. Best Source Telemetry

Telemetry sites receive TM from flying platforms, passing the TM in real-time back to the MCC.



# Testing the Test Range



Time-synchronized and driven by AGI STK software.



Antennas pointed at telemetry stations. Alternatively, connect networked Ch Sims at each TM site.

- RF Channel Simulation
  - Essential step from pure simulation, when the systems must be tested with actual signals
  - Stimulates systems with physics compliant RF signals
    - Doppler shift, Delay, Attenuation, Noise
    - Interference
    - Antenna pointing, antenna patterns
    - Terrain, weather, overhead obscuration
  - Decreases test costs, while simultaneously increasing depth
- Critical test instrument and a vital training instrument in one
- Contact Information
  - Steve Williams
  - [swilliams@rtlogic.com](mailto:swilliams@rtlogic.com)
  - 719-884-6269