RT LOGIC
an Integral Systems Company

Testing the Test Range without Flights
Progress Update

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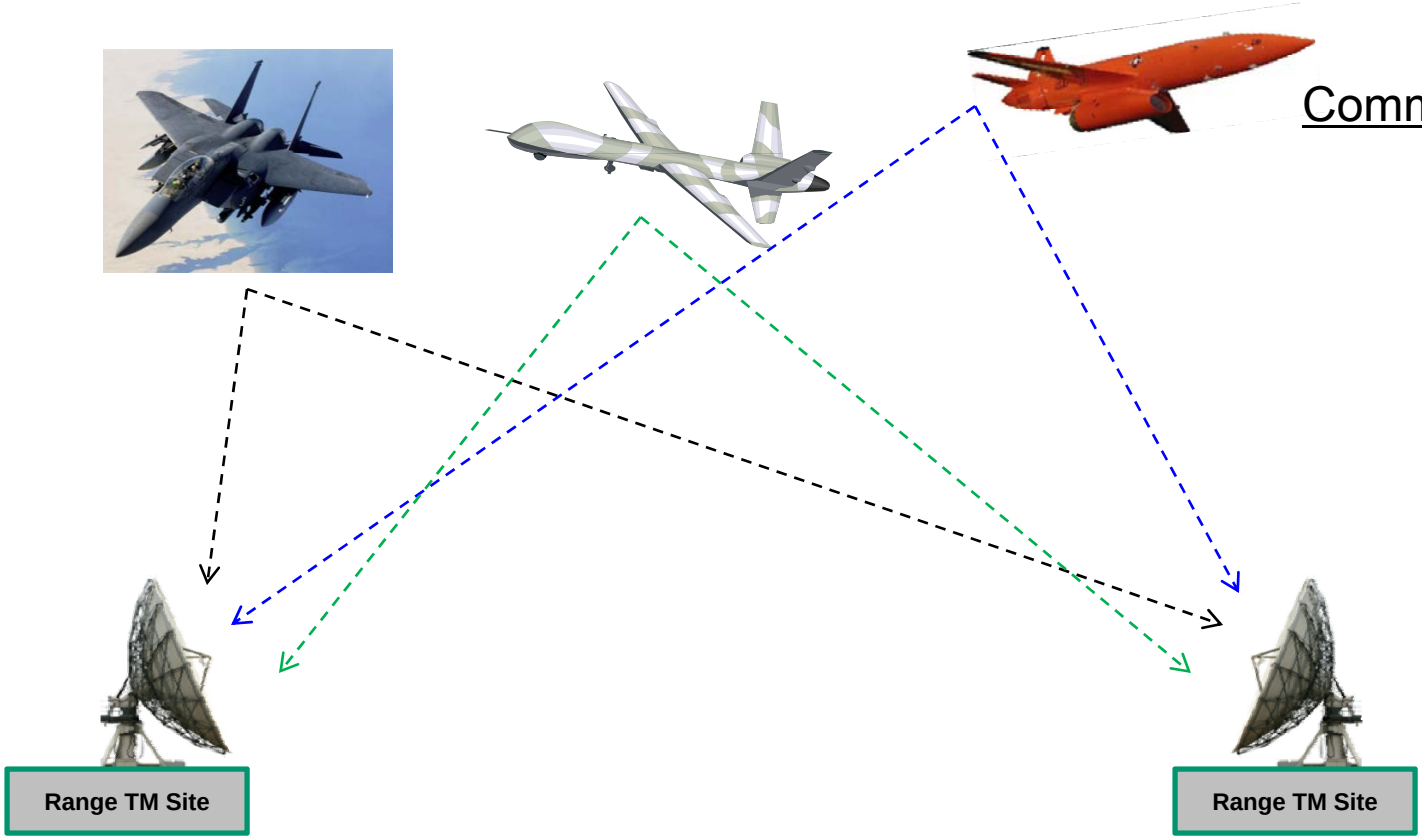
20 October, 2010

Whenever transmitters and receivers are in motion with respect to each other, RF link perturbations occur.

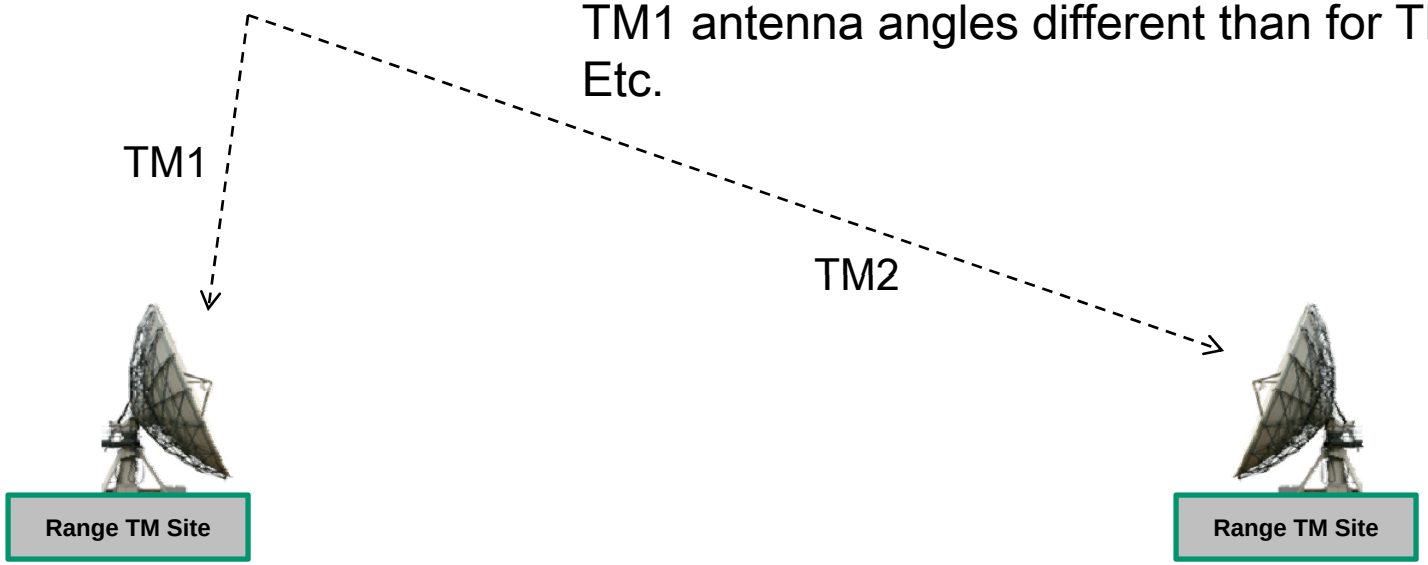


Common Perturbations
Signal Strength
Delay
Doppler shift
Noise
Interference
Terrain Blockage
Body shielding
Weather
Multipath
Ducting
Etc.

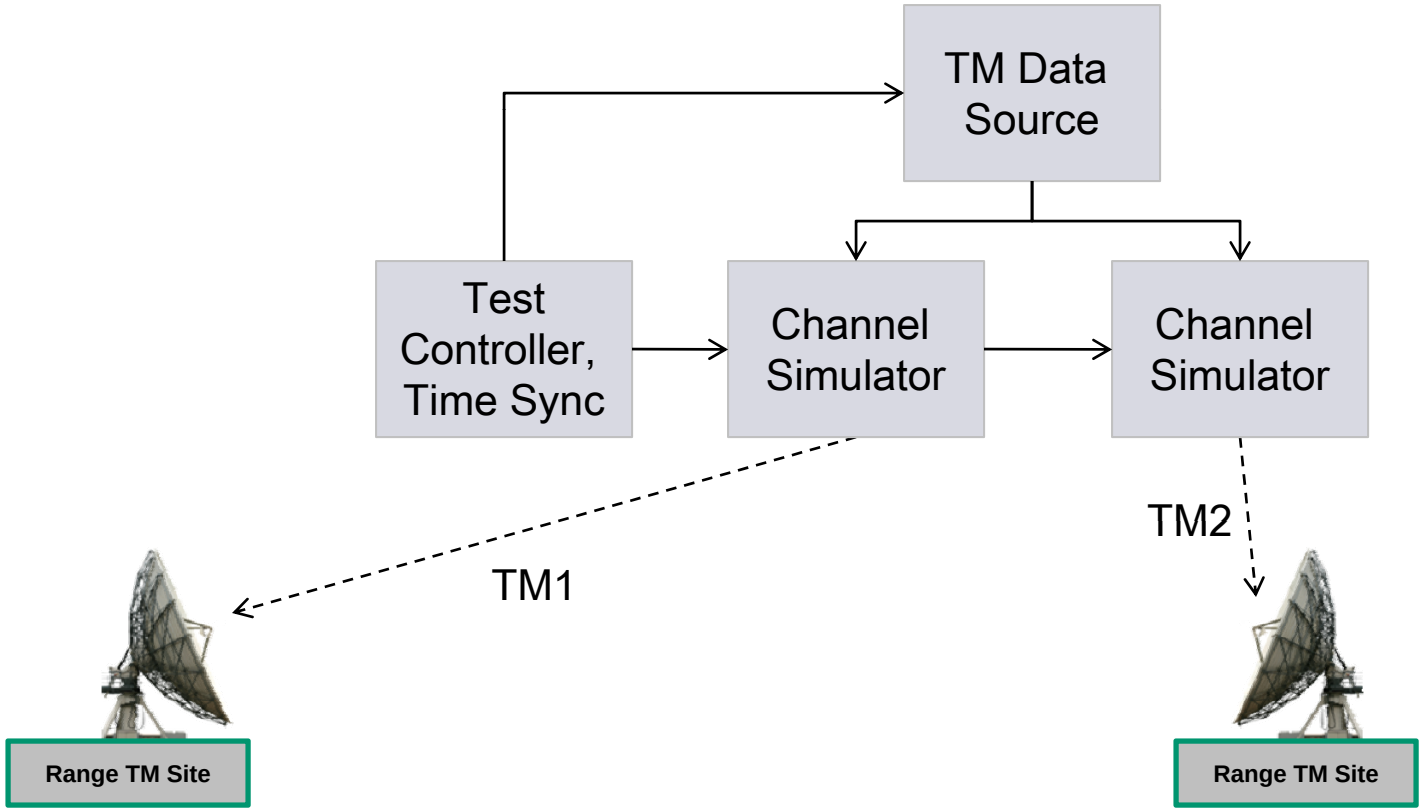
Signals TM1 and TM2 are transmitted from the same transmitter, so the data on each is the same, but the signals can look dramatically different from each other at receiving TM sites.

Examples

- TM1 delay shorter than TM2
- TM1 signal strength higher than TM2
- TM1 affected by more Doppler shift than TM2
- TM1 affected by different terrain than TM2
- TM1 antenna angles different than for TM2
- Etc.



A method for testing the Test Range without flights is to supply signals from a central fixed location to the TM sites that have these same signal characteristics.



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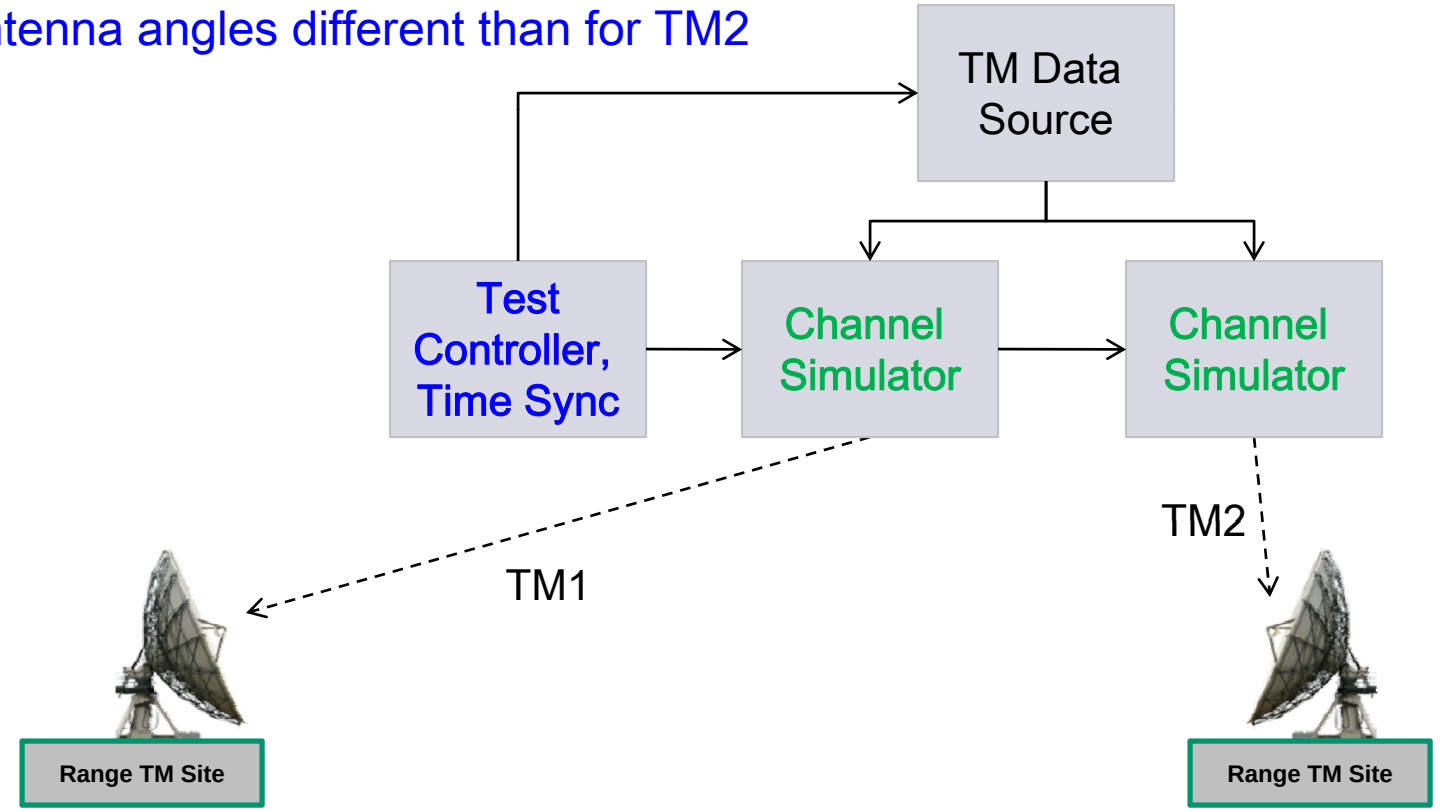
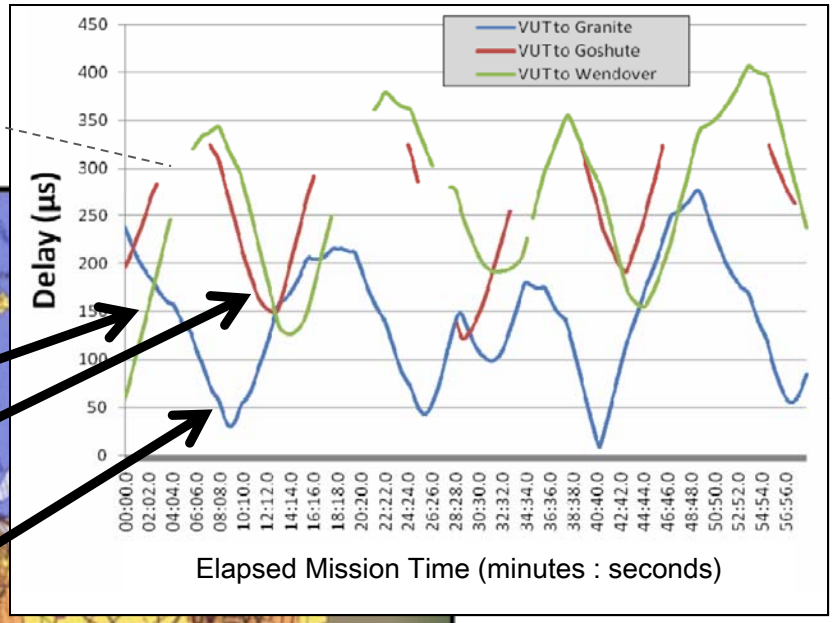
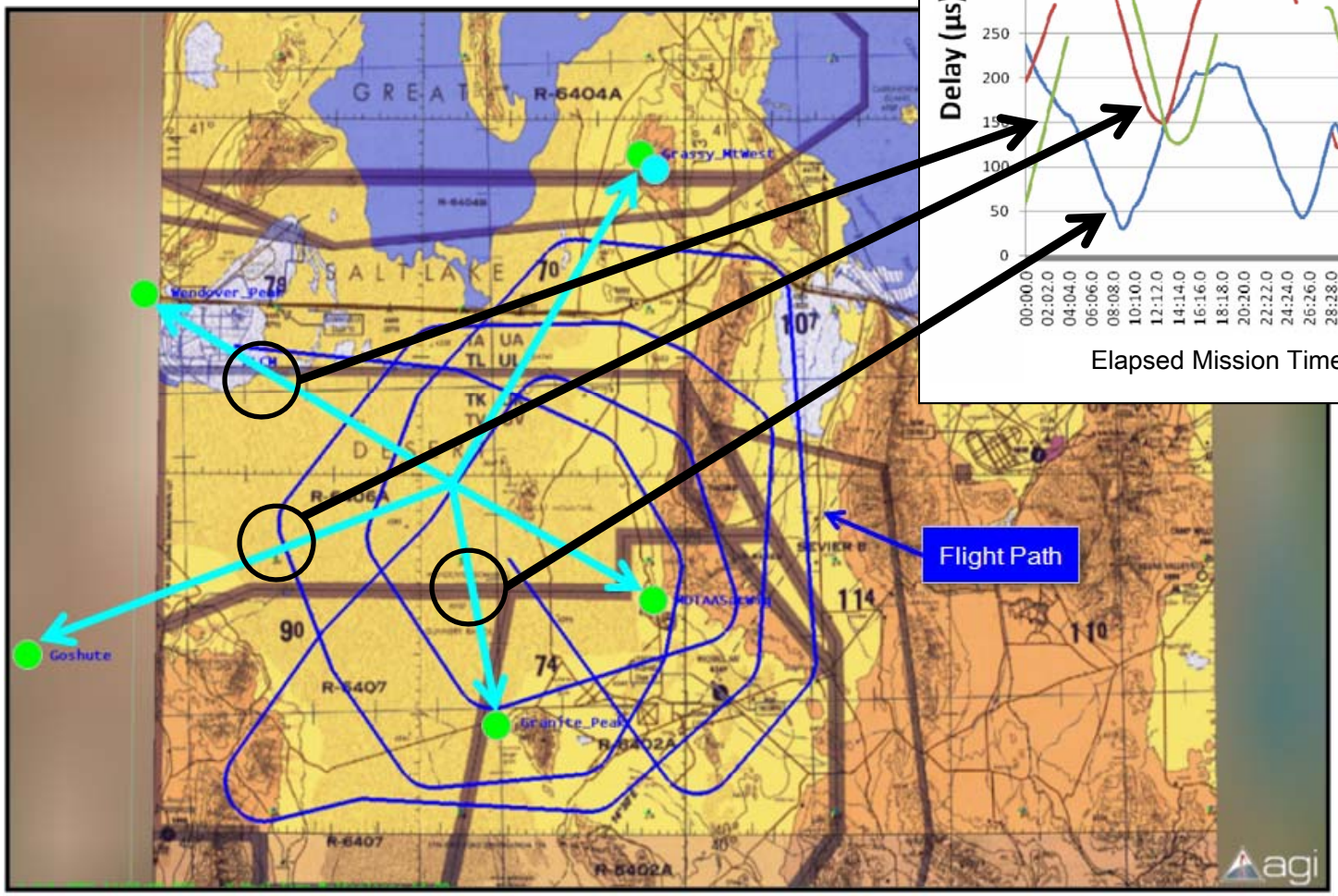


Signal Delay Variance Through Flight

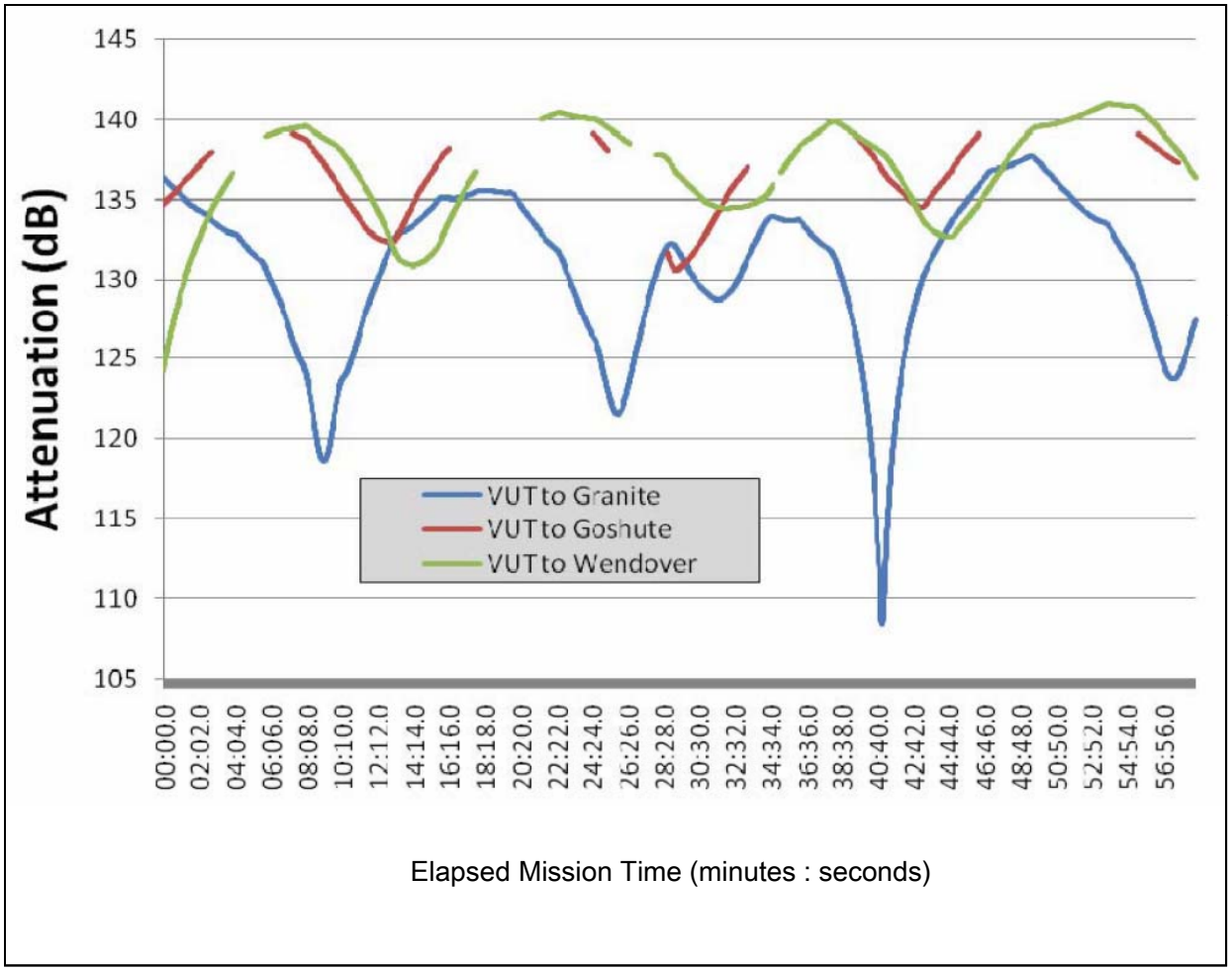
Gaps are terrain, link budget, and/or body shielding drop-outs





RF signals are received at each TM site at slightly different times due to the dynamic distance between the flight platform and the TM site location.

Attenuation (Loss) Variance Through Flight

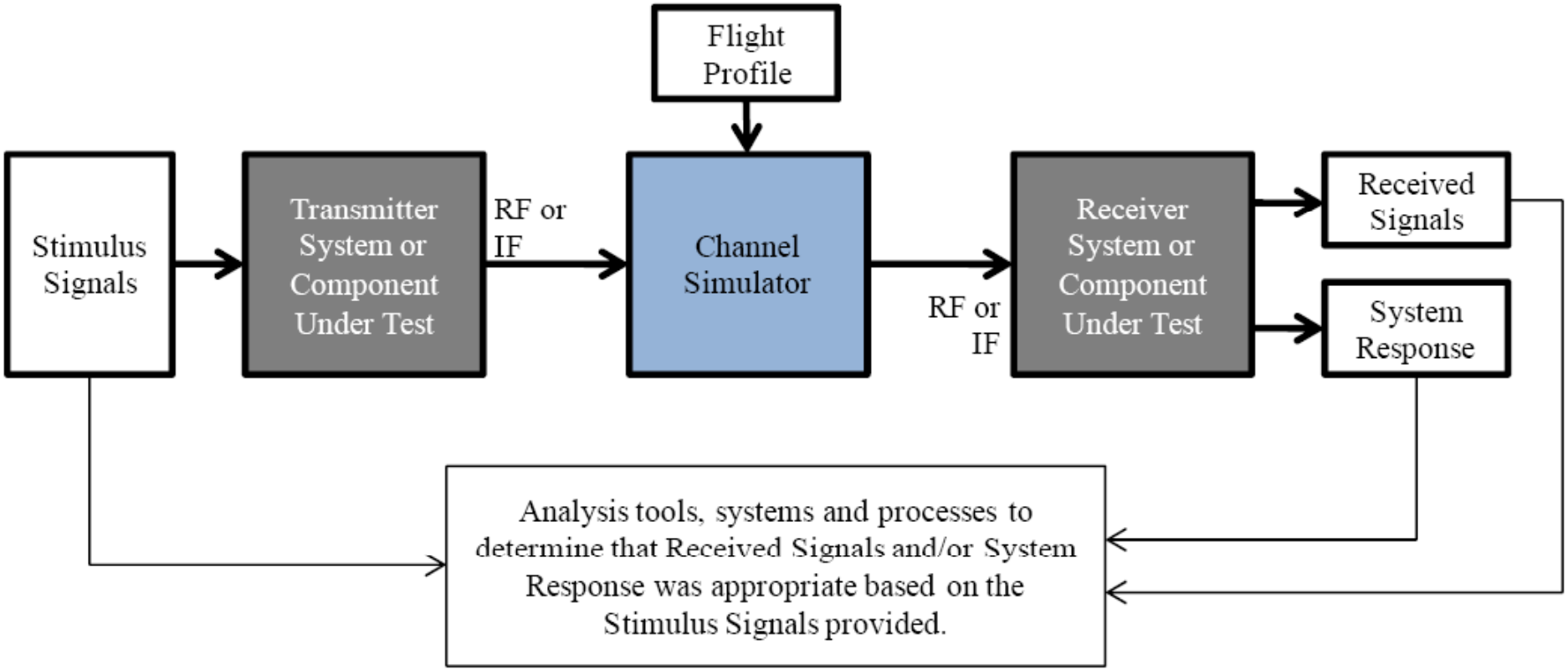


RF signals are received with differing power levels at each TM site at due to the dynamic distance between the flight platform and the TM site location.

Other dynamic attenuation factors include antenna patterns, body shielding, foliage, frequency selection, etc.

- Testing possibilities
  - TM Site as a whole
  - TM Site RF hardware elements
  - TM Site signal processing hardware elements
  - TM Site firmware, software, algorithms or processes
  - Entire Test Range, including BSS, Range Control Center Displays and final data creation/processing
- Training possibilities
  - TM Site Operators — Nominal conditions
  - Range Operators — Worst-case conditions
- Up-front range capability proof to customer
- Range mission readiness proof to range personnel and customer

- Theory is sound
- And, Channel Simulators do exist
  - But usually used in the lab for testing flight/ground hardware, SW, FW, etc.
  - Flight/Ground systems: Satellites, UAVs, Targets, Aircraft, Missiles, etc.



- Channel Simulators haven't been used in this manner in the past. Will they be useful for Range Testing?
  - With high power amplifiers and antennas
  - With complex flight profiles and flight/ground antenna models

- Needed to find a Test Range and a flight capability that was interested in helping validate the concept.
  - UTTR, Summer, 2009
    - Use of a Channel Simulator to pre-distort signals and transmit at RF to a TM site to validate received signal quality and Doppler, delay, loss and noise expectations.
  - Pax River and Airtec, Sept 28-29, 2010
    - Expanded test of entire concept…

- Test Process utilized at Pax River
  1. Perform Test Flight
     - Transmitting simple, known, unclassified BER TM
     - Close range and long range → signal fading, BER
     - High speed, close passes → Doppler shift
     - Various turn maneuvers → body shielding
     - Horizon → terrain masking
     - Record as-transmitted TM and TSPI on aircraft (truth data)
       - Also captured at Pax TM sites
     - Record TM & and signal characteristics at two TM sites
       - St. Mary's Airport
       - On Pax River

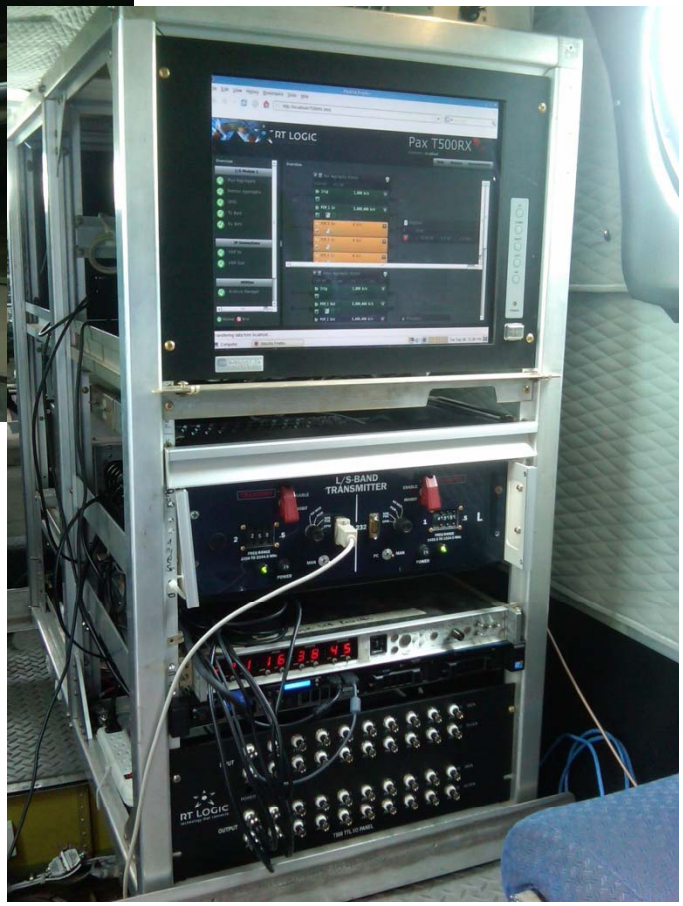
2. Process flight TSPI data to create Channel Simulator control model that mirrored the actual flight.
   - Latitude, Longitude, Altitude, Yaw, Pitch and Roll
   - Incorporate previously constructed
     - Aircraft body model
     - Aircraft antenna/transmitter model
     - TM site antenna/receiver model

   } RF Model

3. Use Channel Simulators to transmit to 2 TM sites.
   - Input signal = BER TM pattern as recorded on aircraft during flight
   - Use TSPI and RF model constructed in #2 above
   - Record TM & signal characteristics at two TM sites

4. Compare TM & signal characteristics from actual flight (step #1) and the simulated (step #3) flight.

Airtec Beach A-100 King Air

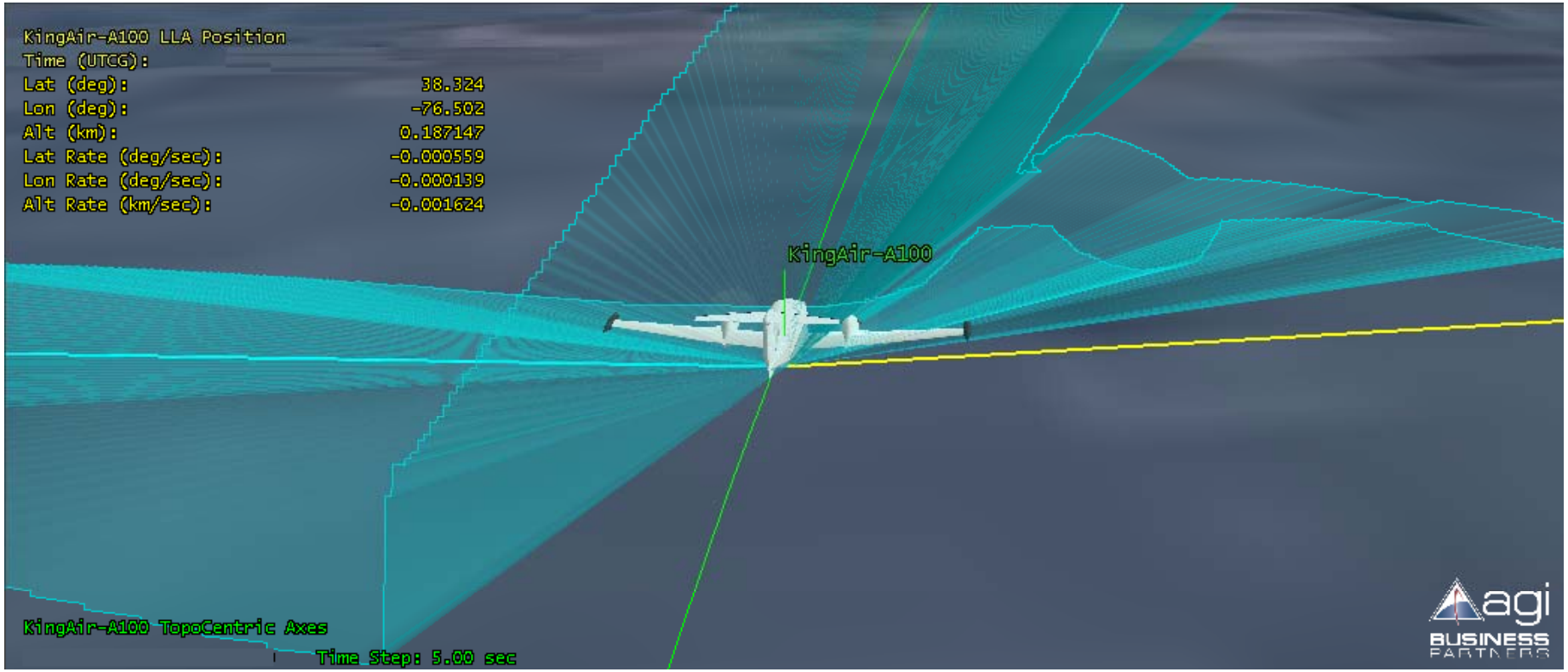


On board equipment rack
GPS / IRIG Time
BER / TM Data Generator
S-Band Transmitter

[Novatel ARDS Pod](#)
For acquiring recording and transmitting TSPI data

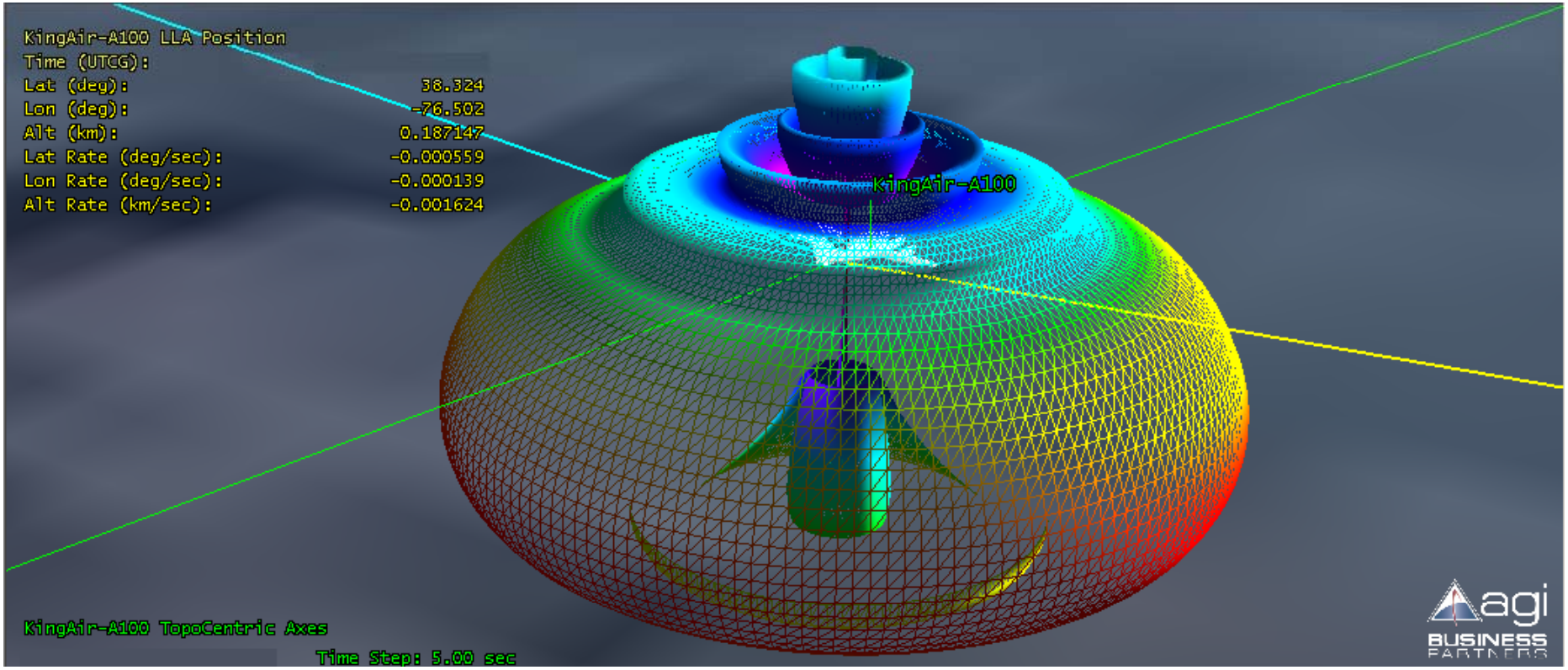
S-Band Antenna
This was used for transmitting our test BER TM.

A separate antenna was used for transmitting from the ARDS pod.

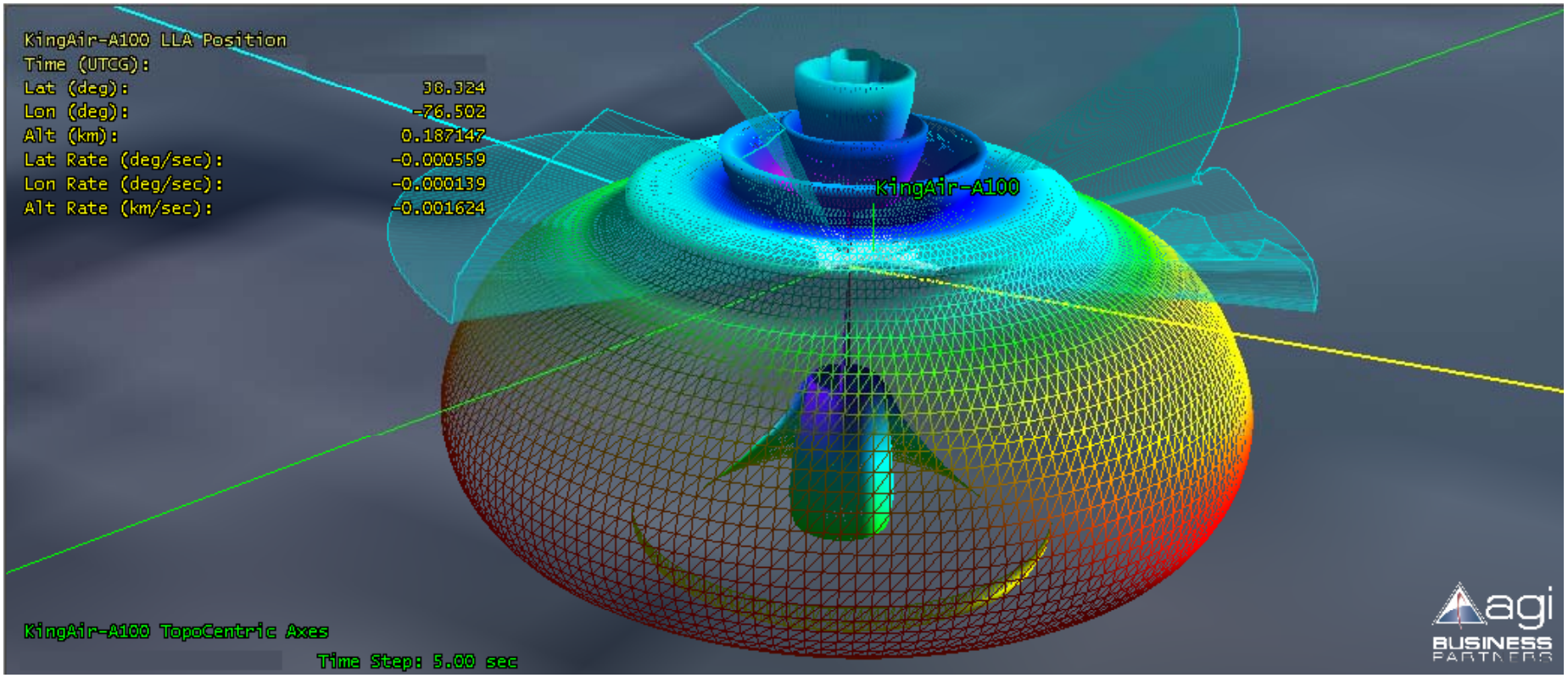


Antenna Body Shielding Mask

Based on mounting location of antenna. Modeled in AGI STK, which is used for Channel Simulator control.



Antenna Radiation Pattern
Based on antenna characteristics.

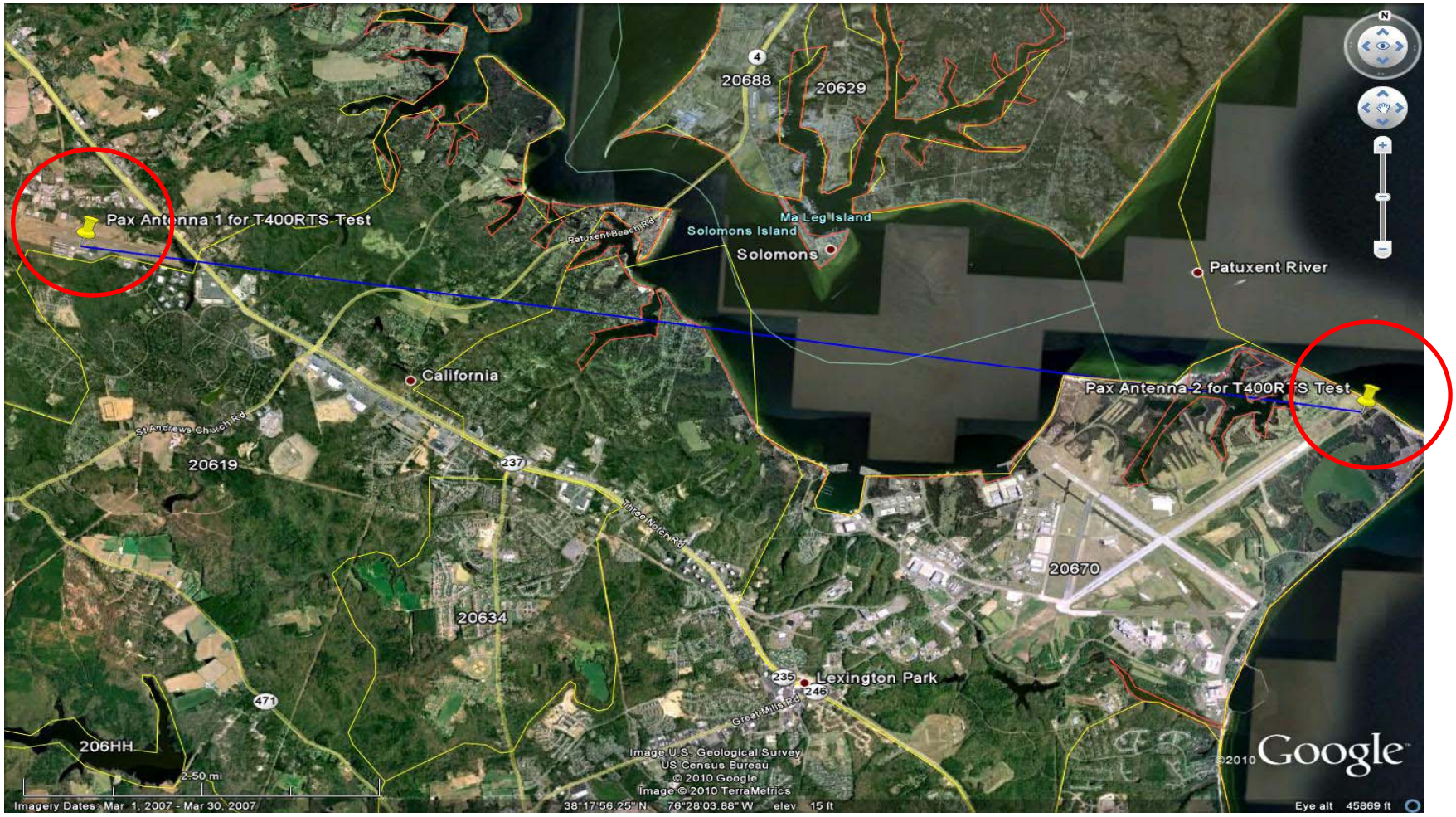


Antenna Radiation Pattern and Body Shielding Mask
Based on antenna characteristics and mounting location.

TM Sites
This was the mobile site used at St. Mary's Airport

Very similar system used at Pax River site.

- TM Site locations for test flight



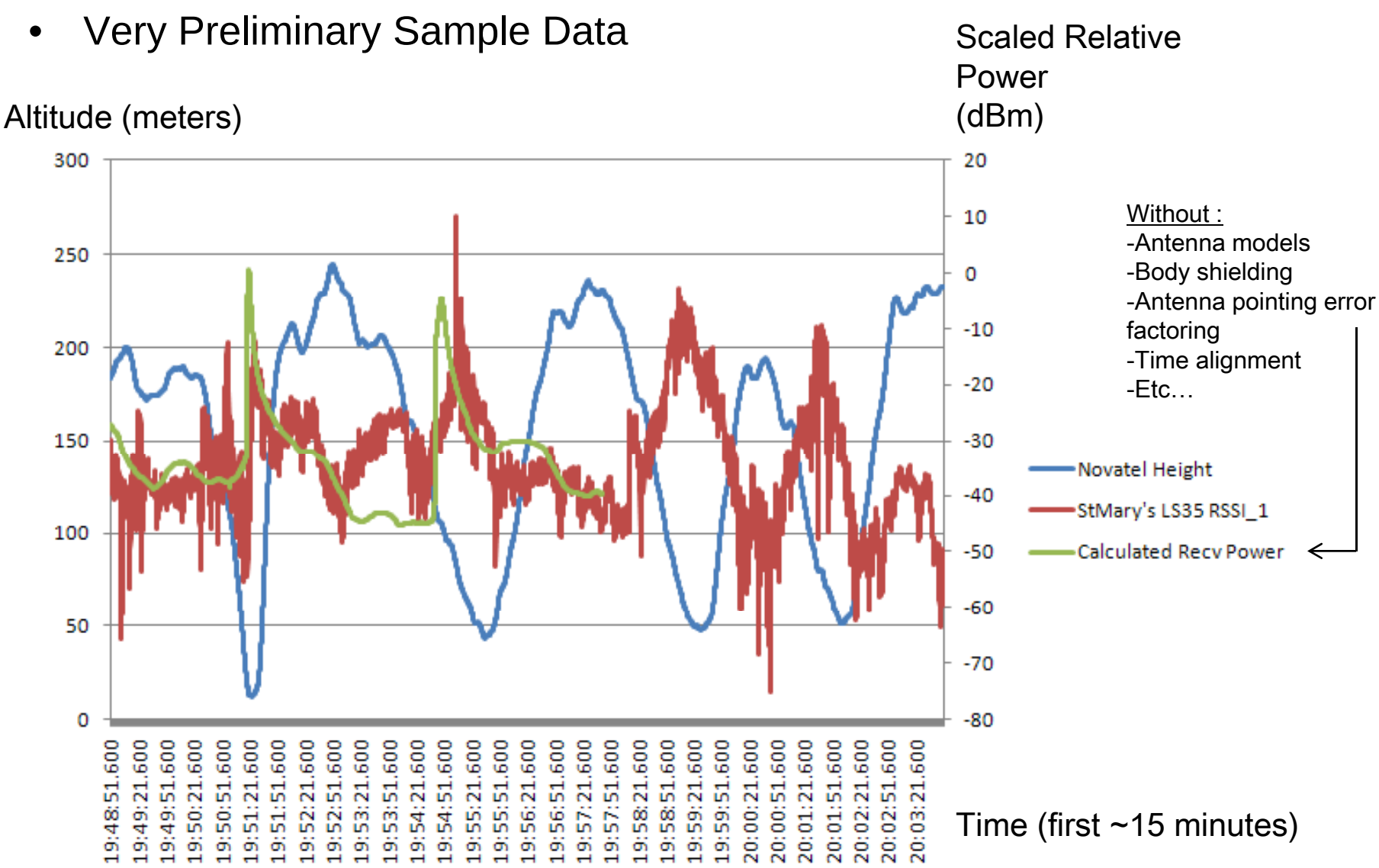
- Test Flight, Pax River, 28 Sept, 2010

- Flight Simulation, Pax River, 29 Sept, 2010

Telemetry Van
Channel Simulators, Amplifiers and control elements.
Two S-Band cone antennas pointed at 2 TM sites.

Primary Channel Simulation Equipment

- Very Preliminary Sample Data



- Near term next steps
  - Continued data analysis
  - Refine aircraft model, body masking and RF models
  - Rerun test simulations in lab using collected TM data
  - In-depth review of final results with Pax River
  - Develop and implement recommendations
    - Another test flight
    - Retransmit to Pax TM sites
    - Channel Simulator functionality modifications (e.g. multipath)
    - Etc.

- Summary
  - Verification efforts continue, but…
  - Channel Simulators can be used to verify Test Range operation as a whole, or in part, and can be dual-purposed for Test Range operations training.
  - Such testing/training is faster, more economical and more complete than testing/training with actual flights, since the limits of scenario development are virtually boundless.

- Acknowledgement
  - RT Logic would like to express it's sincere gratitude to Mr. Bob Myers and his NAVAIR team at Pax River for their enthusiastic support and valued assistance in conducting these tests.

- For further information and/or a copy of the final report
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  - Booth #315, NDIA Targets, UAVs and Range Operations Symposium.