Characterization of Complex Geographic Terrain to Support Testing of Autonomous Systems

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Presentation Outline

Generate awareness of science-based methods and strategies to identify and characterize critical natural environmental parameters that may impact development and testing of military equipment (sensors, robotics, etc.)

- Natural environment impacts to military equipment
- What we know about the environment – then and now?
- How do we apply environmental characterization to the science of test?:
  - An example: RF propagation and soil interference

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Natural Environment Impacts on Individual Weapons

- Troops report multiple malfunctions of the M16 and M4
- Exposure to dust appears to be part of the problem
- DRI and USMA analysis shows jamming due to chemical reaction between dust and gun lubricants

Natural Environment Impacts on Aircraft and Vehicles

Desert dust impacts to

- Rotorcraft blades
- Avionics
- Visibility
- Engine life
- Weapon system malfunctions
- Electronic and physical functionality

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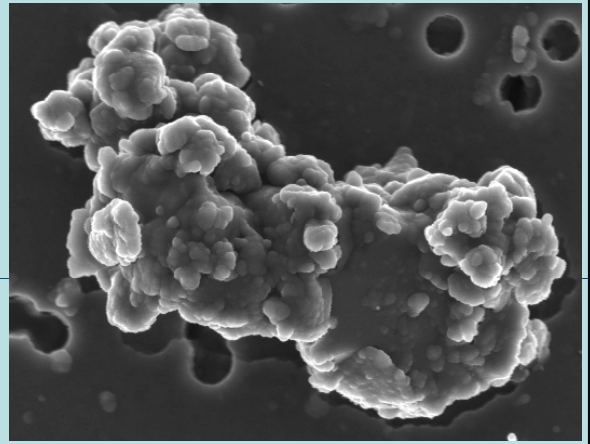
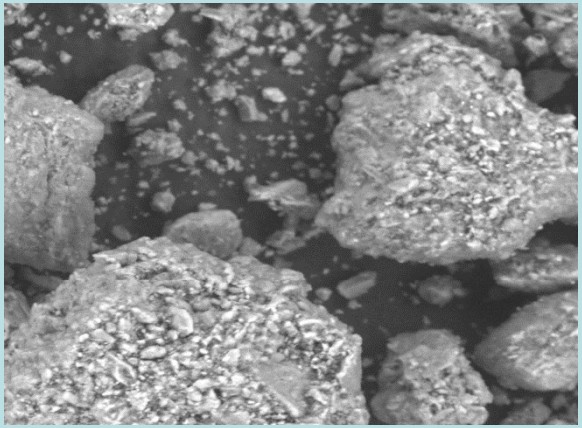
Testing for the Effect of Dust?

- Standard chamber testing uses ground silica sand (silica flour)
  - Ground silica is abrasive, “clean”, and not reactive



Desert dust particles coated with reactive compounds



Desert dust is “dirty” - abrasive and corrosive
- Includes reactive compounds: salts, carbonates, iron oxides, clays

Lessons Learned
- The properties of dust –
  - are well known in the scientific community
  - are critical to military operations

  But
  - limited use in the RDT&E community

Need:
- Identify & characterize the factors of the environment critical to operations
- Use the scientific knowledge of the natural environment during RDT&E

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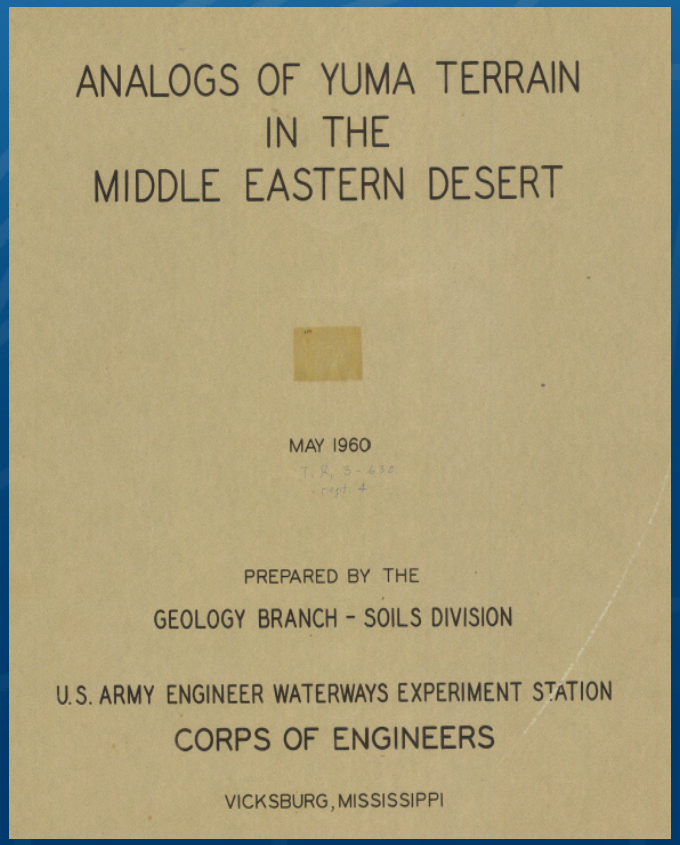
What we know about the environment – then

DoD References and Regulations about the Natural Environment



ANALOGS OF YUMA TERRAIN
IN THE
MIDDLE EASTERN DESERT

MAY 1960

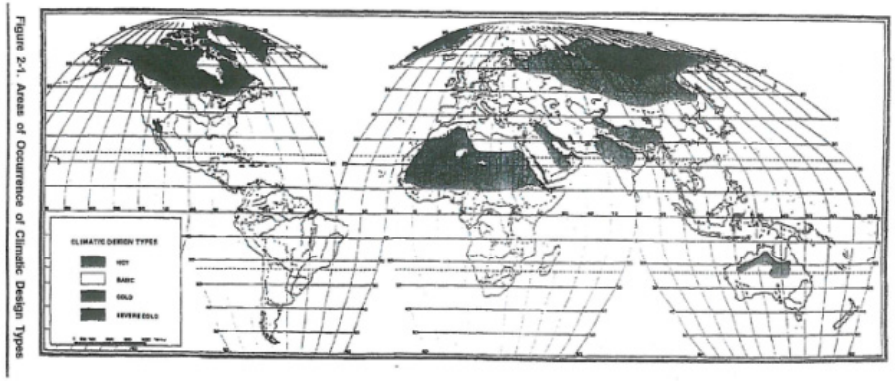
PREPARED BY THE
GEOLOGY BRANCH - SOILS DIVISION

U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS

VICKSBURG, MISSISSIPPI

- **Commonly predate 1990, often 1970**
- **Have limited environmental data**
- **Have little digital data**
- **Lacks geospatial reference**
- **Do not address impact on modern equipment**
- **Do not apply or adapt to high-tempo warfare**

From Current 1979 Version of AR 70-38



The dark areas are considered "Extreme" climates, full performance is not required, testing may be waived outside the "Basic" areas, or simulated in environmental chambers (Ref. MIL-STD-810)

Simple, black and white, clean, and on paper

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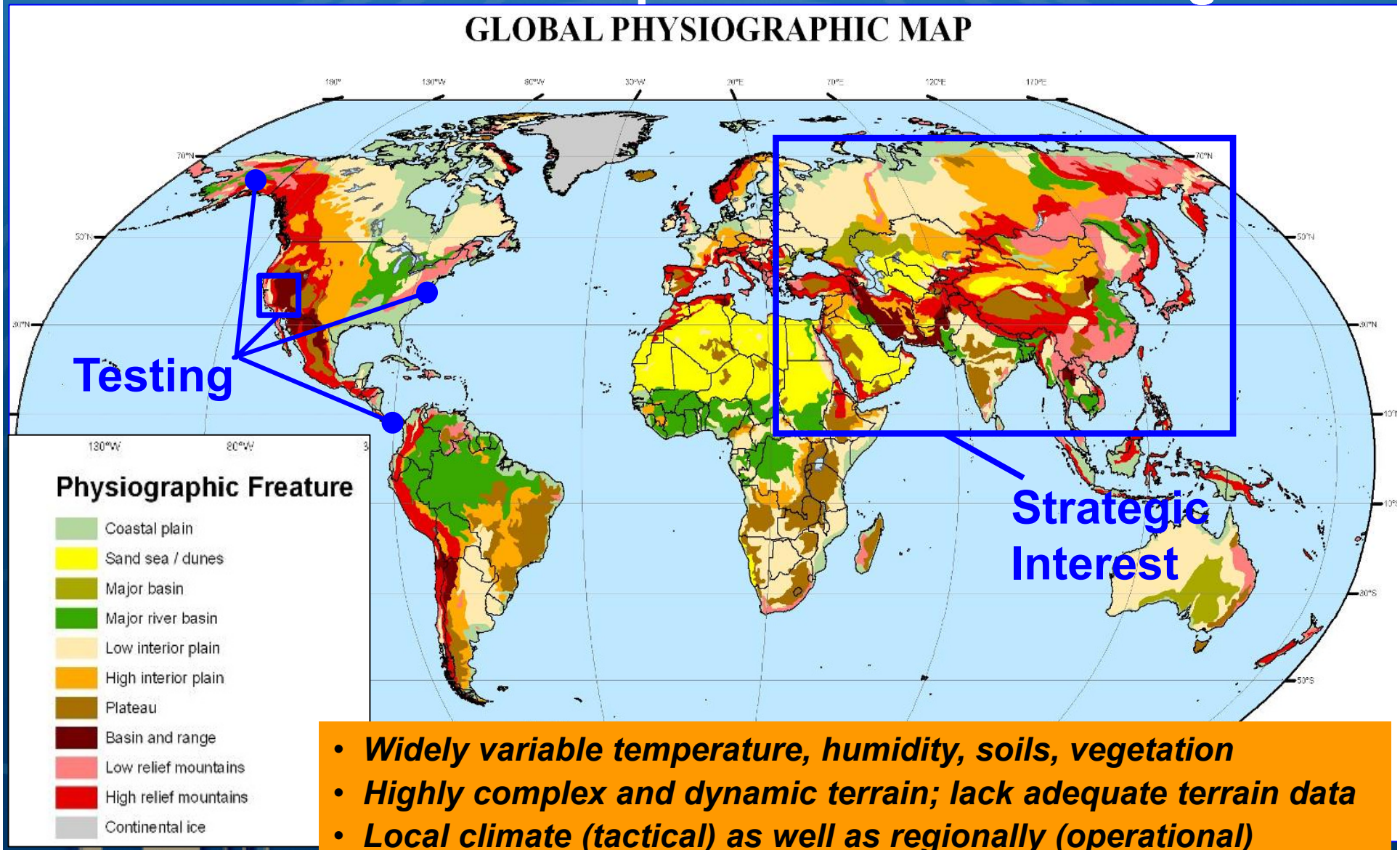
How do we design test for diverse geographic areas? Do our test facilities provide realistic analogs?



- ***Widely variable temperature, humidity, soils, vegetation***
- ***Highly complex and dynamic terrain; lack adequate terrain data***
- ***Local climate (tactical) as well as regionally (operational)***

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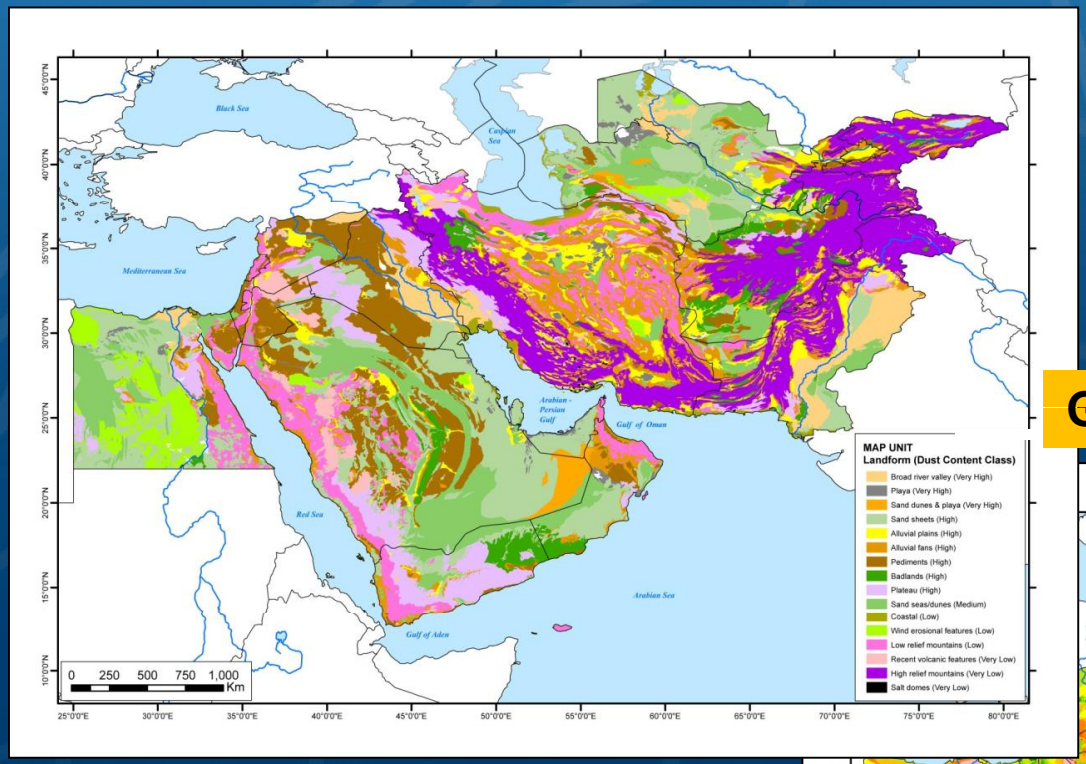
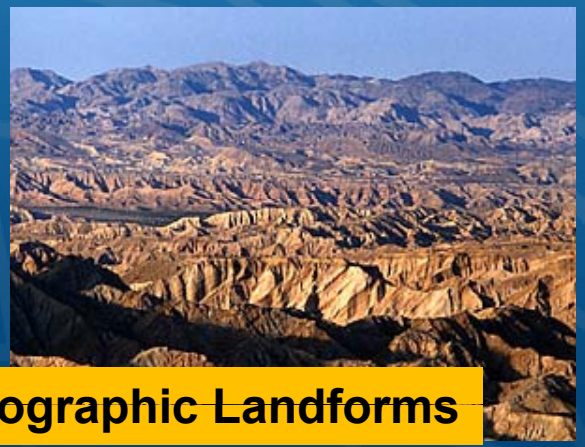
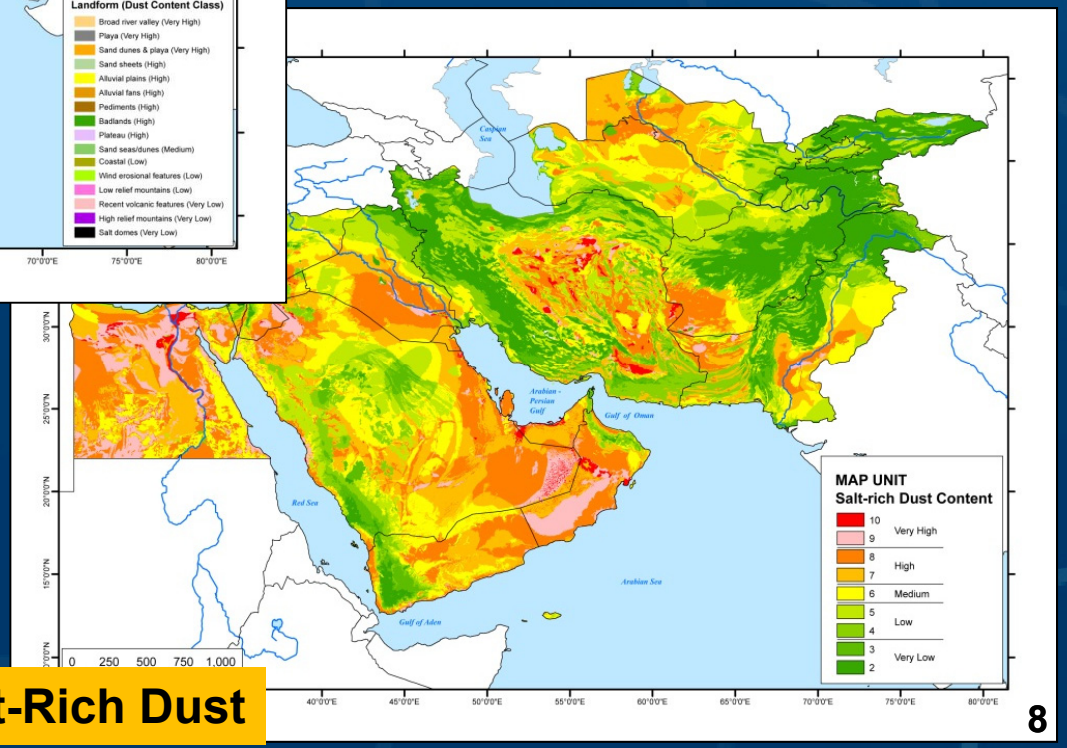
How we can make better use of what we know

Digital Products: Catalog of Major Terrain Properties





Geographic Landforms



Source of Salt-Rich Dust

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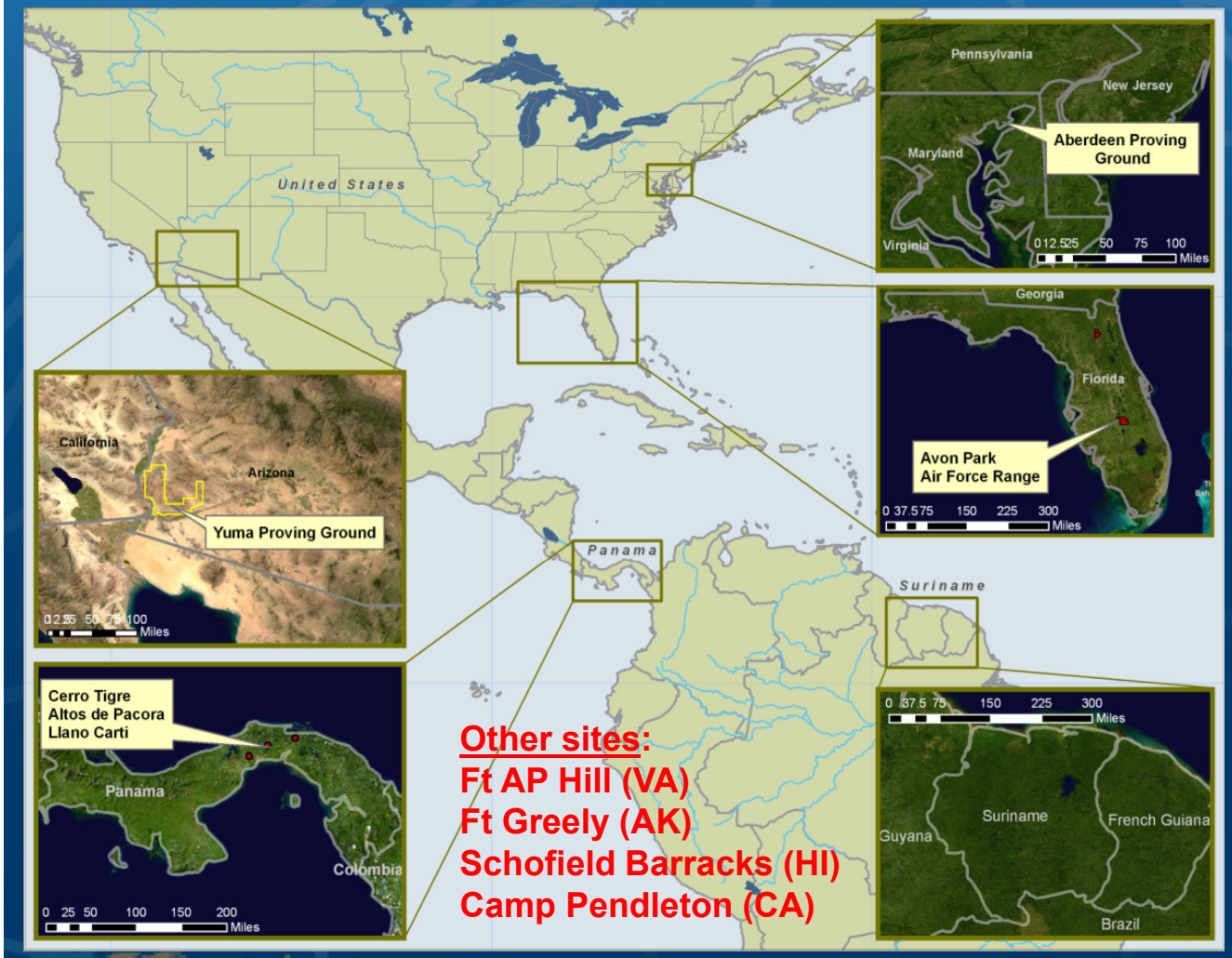
How we can make better use of what we know

Proposed Master Environmental Reference Sites (MERS)

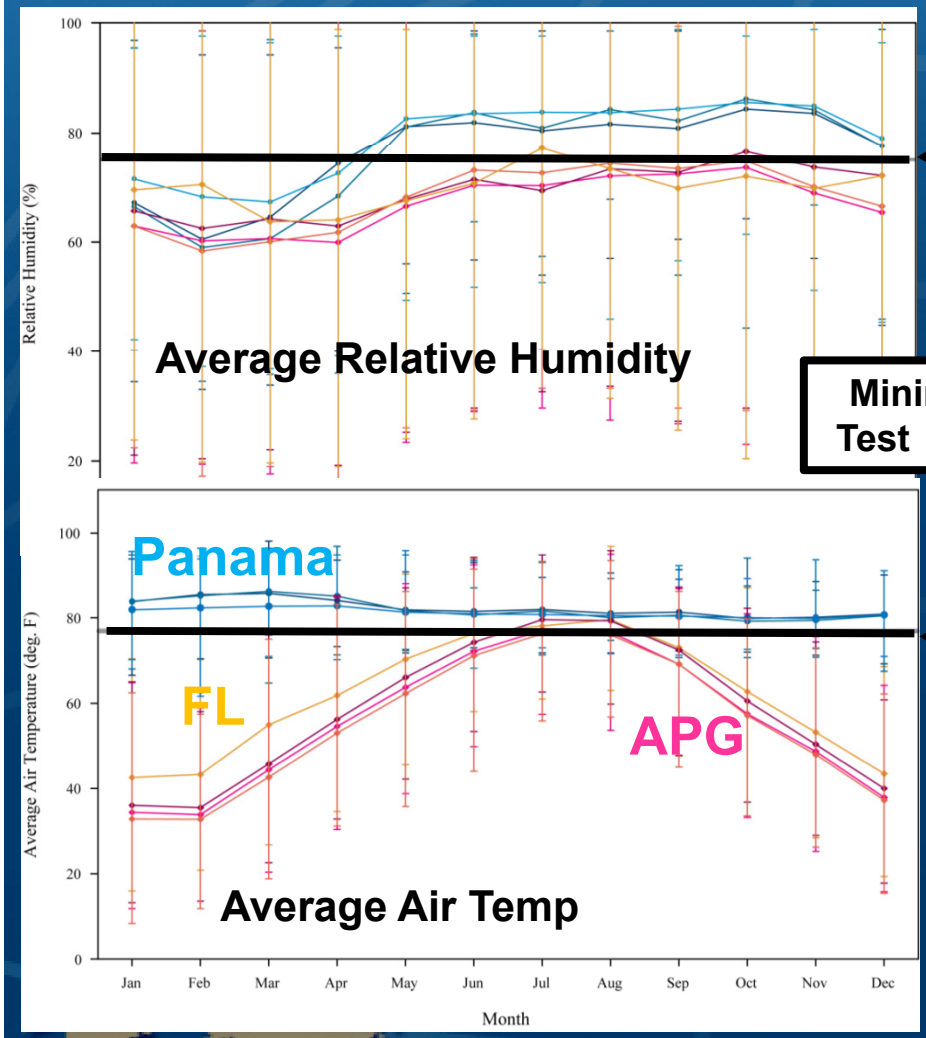


Other sites:
Ft AP Hill (VA)
Ft Greely (AK)
Schofield Barracks (HI)
Camp Pendleton (CA)

- Comprehensive soil characterization
- Energy/mass balance monitoring
- On-line (in future)
- Location to test, validate sensor technology

How we can make better use of what we know

Climate Analysis for Test & Evaluation



- Comparison among potential test areas
- Parameters for chamber testing
- Seasonal variations

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How do we apply environmental characterization

Example: Soil Impacts to RF Propagation

- Collect data on Radio Frequency (RF) propagation in the environment of interest along with soil and climatic properties.
  - COTS-based specialized instrumentation.
  - Multiple locations and scenarios in order to maximize the variations of propagation due to soil structures and geo-location of instrumentation.
  - Locations at Yuma Proving Ground where data was collected:
    - Site 1: Crushed Granite Road
    - Site 2: Desert Pavement
    - Site 3: Sand
    - Site 4: Gypsum
- Each of these sites has unique soil and terrain properties
  - Specific environmental parameters measured
  - Goal: to characterize RF propagation as a function of soil and climate.

Soil & Weather Instrumentation

Hydra Probe - Soil Parameters: Temperature, Moisture, an Dielectric permittivity

The DUALEM-21 measures soil conductivity, magnetic susceptibility, and can detect buried metal

Campbell Instruments: Surface temperature, air temperature, soil moisture, relative humidity

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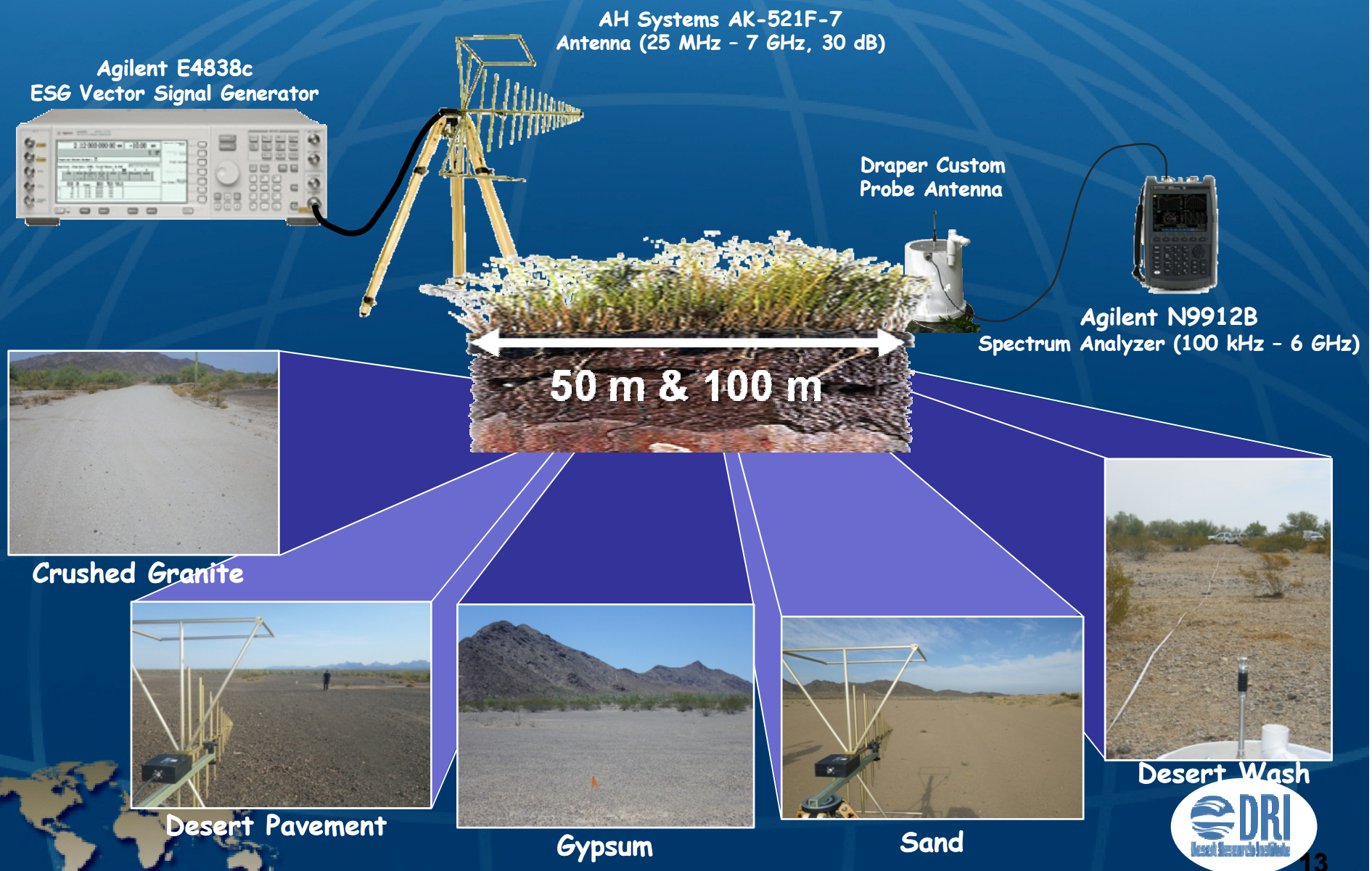
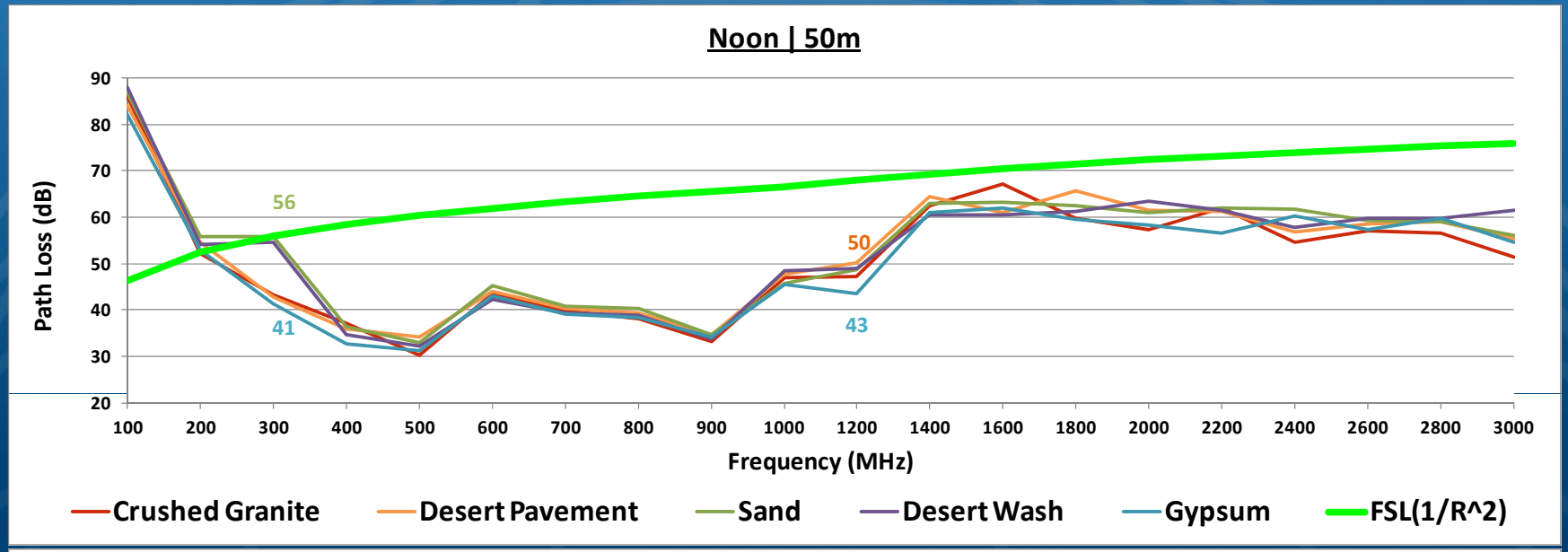
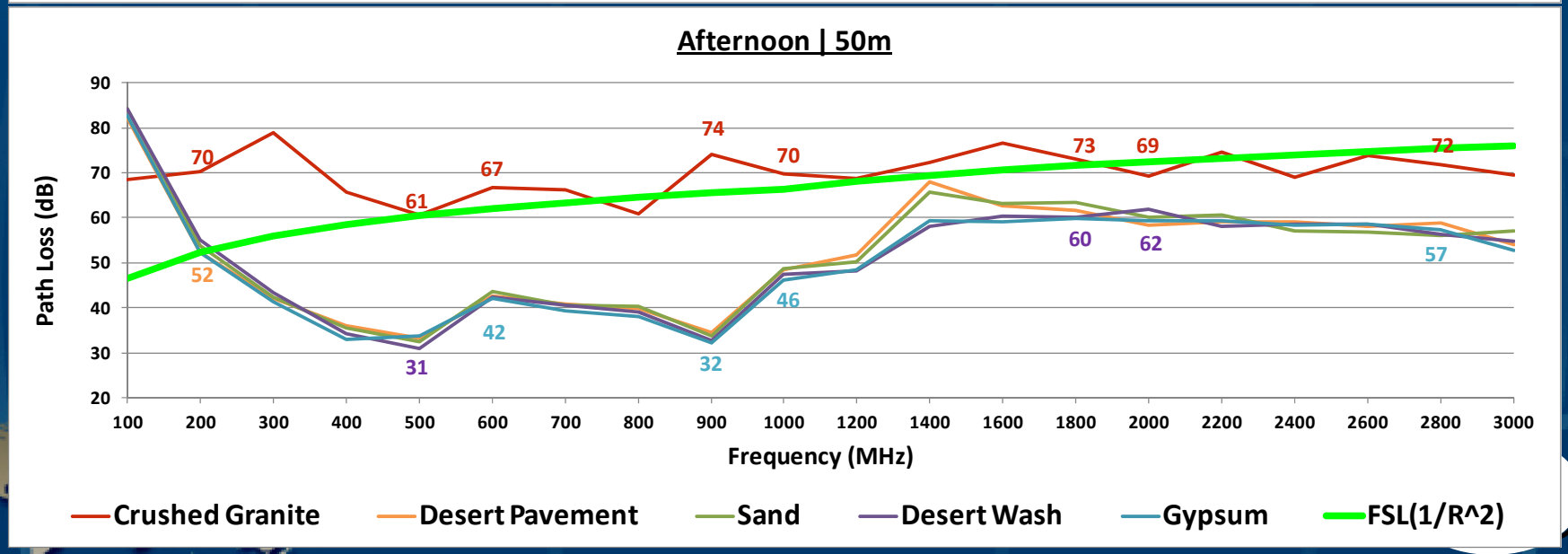
RF Instrumentation & Setup



RF Propagation Results: Site to Site @ 50m





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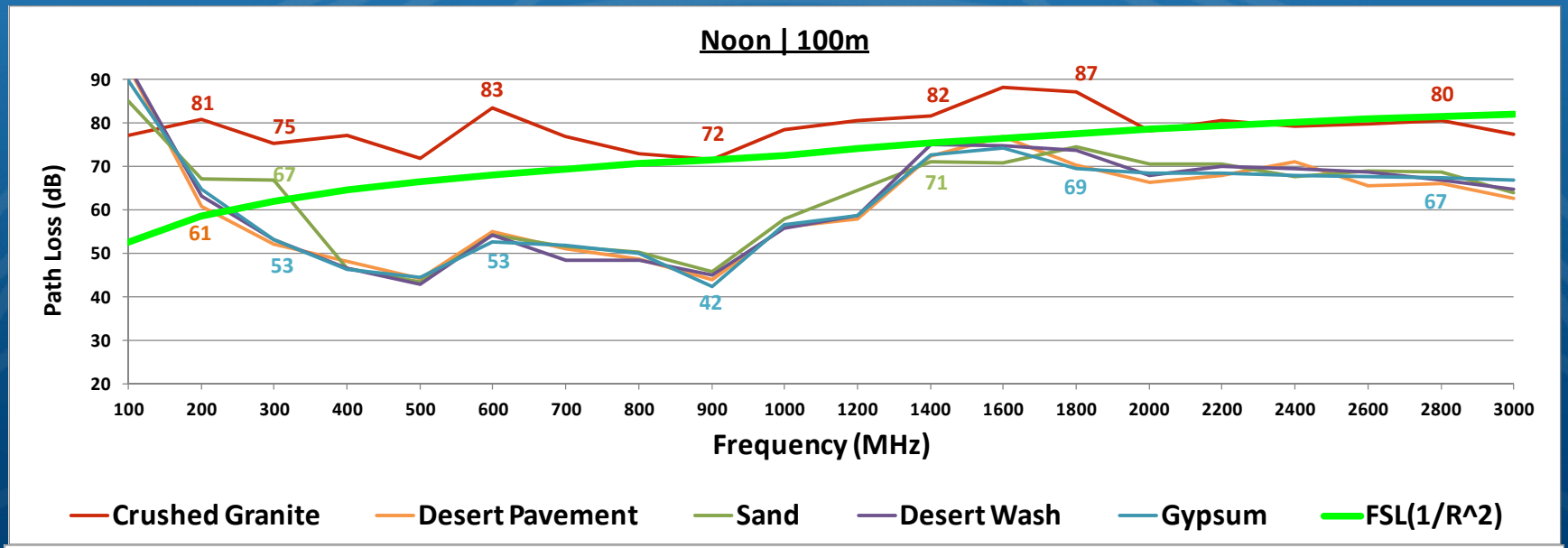
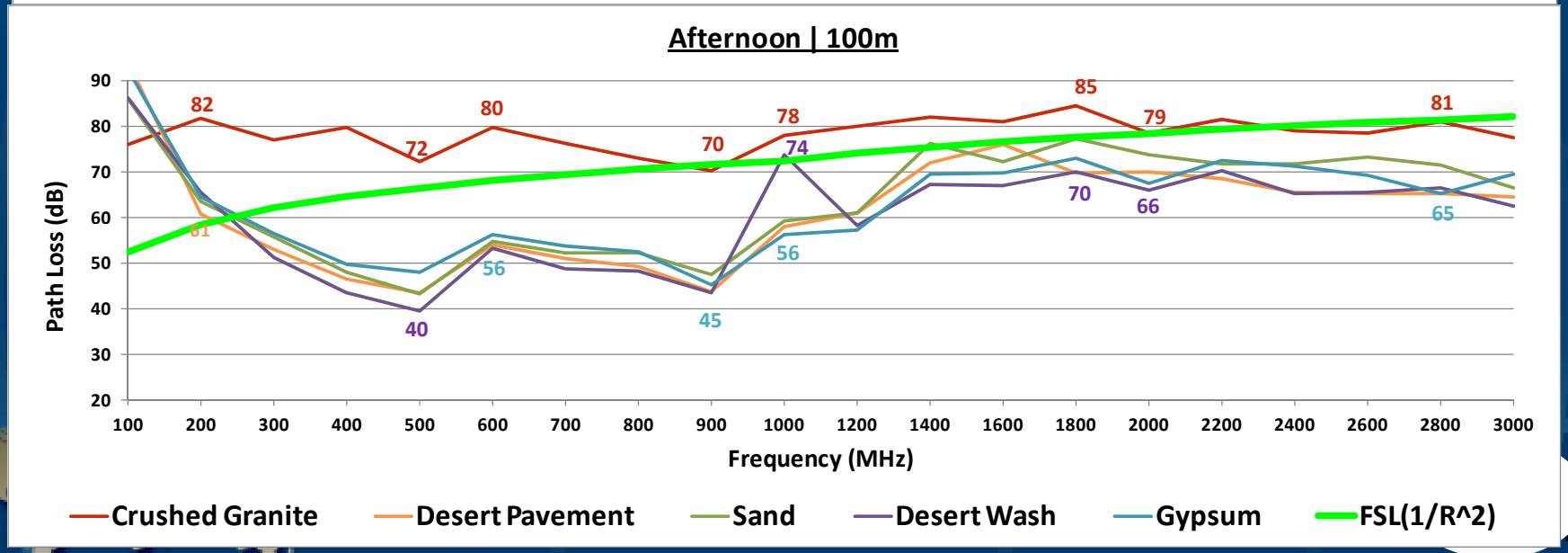
RF Propagation Results: Site to Site @ 100m





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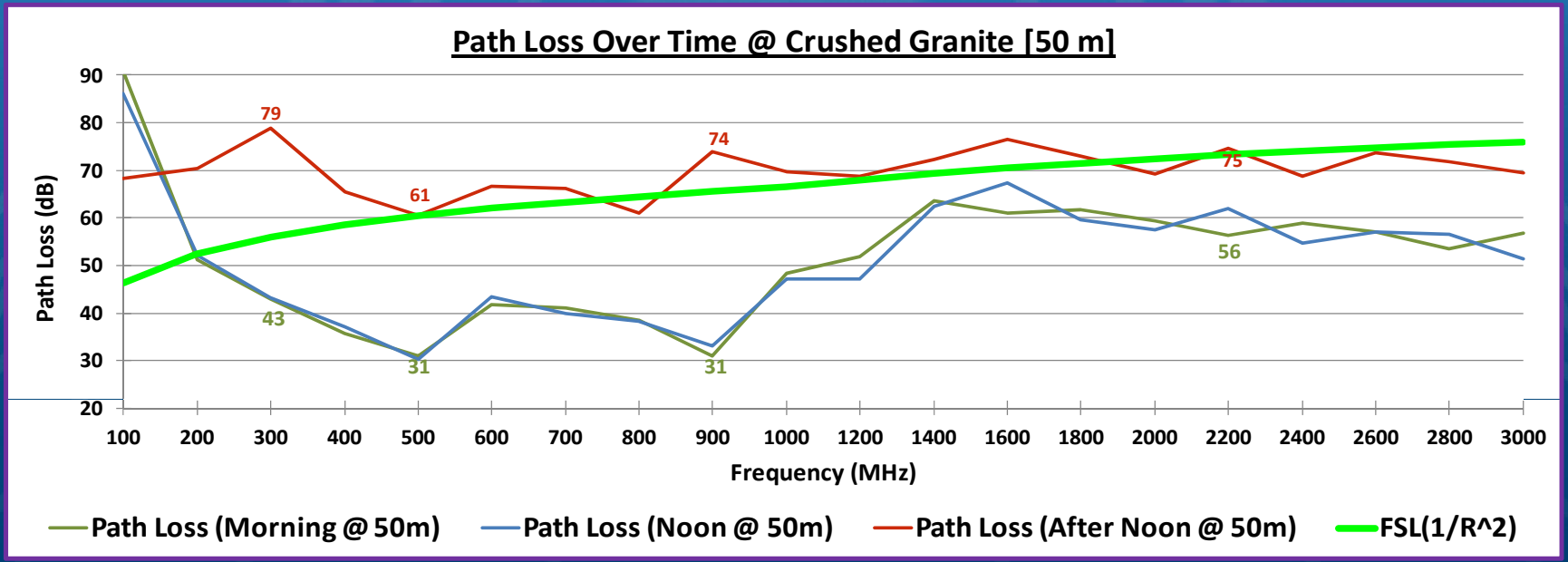
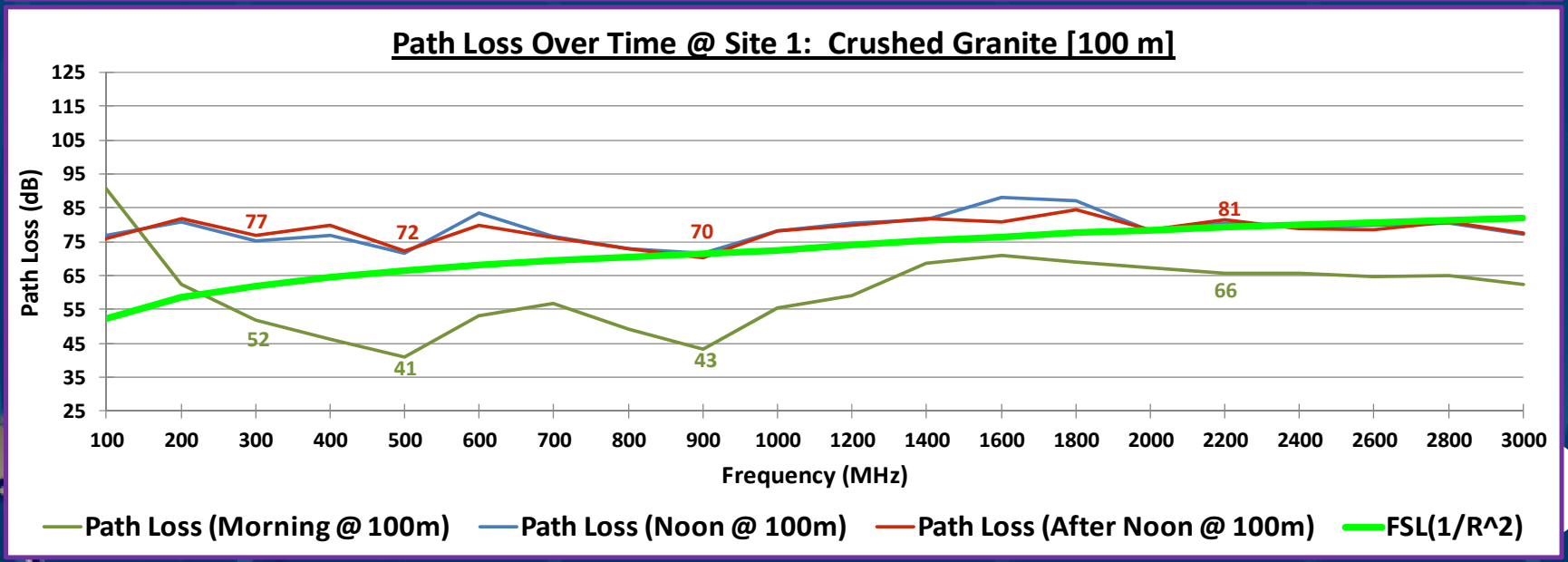
RF Propagation Results: Crushed Granite





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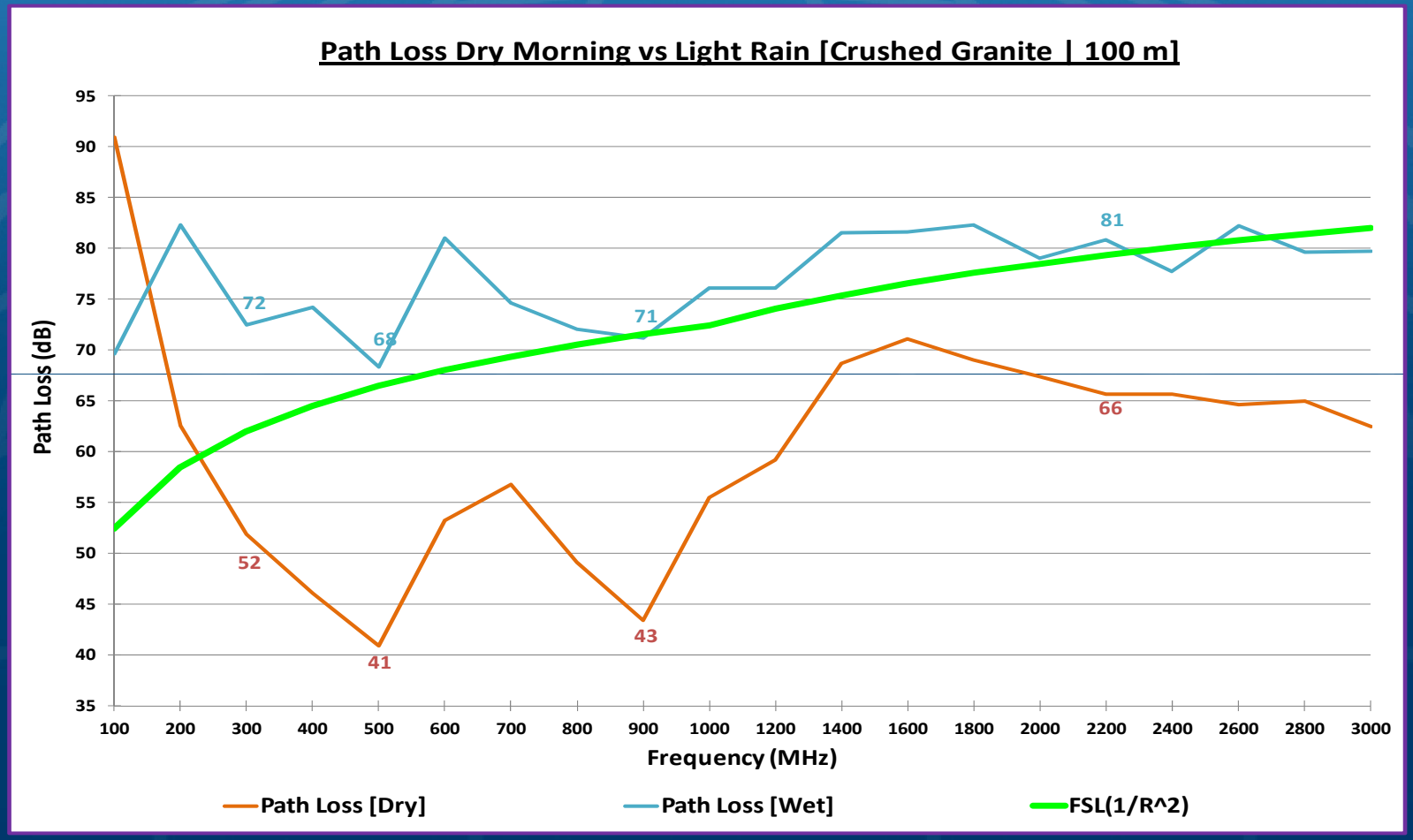
RF Propagation Results: Dry vs. Light Rain



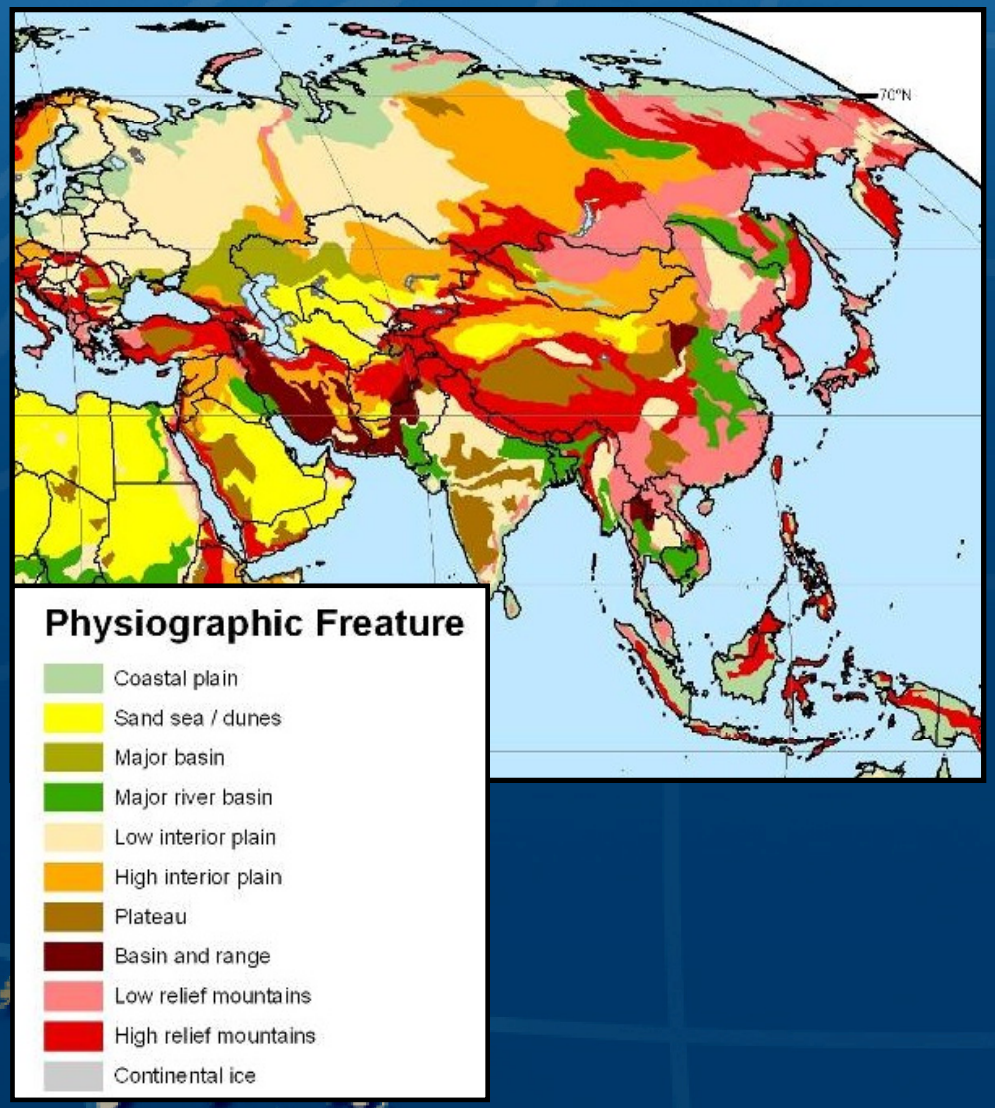
Note: Other sites did not show change from dry to light rain.

Summary: RF Propagation

- Soil/weather data: work is in progress to assess impacts to RF.
- Anomalies at specific frequencies at specific sites require further investigation. For example:
  - Desert Wash attenuation increased from noon to afternoon (~1600) by 18 dB @ 1000MHz
  - Desert Wash attenuation decreases from morning to afternoon by 10 dB @ 1400 MHz
- The data collected is a short snapshot of time, however, it does expose some areas of interest that should be assessed with data collection of longer durations (days/months).
- We were fortunate to have a slight rain after collecting data in a hot dry condition. The rain drastically affected propagation on the Crushed Granite road and only a select number of frequencies at Sand and the Desert Wash.
  - Note: No data for Gypsum soil in morning due to location from other sites.
- Recommendation: establish methodology and instrumentation to collect data over long term to asses how changes in weather conditions affects propagation at specific sites.

Concluding Remarks:

The Science of Test and Future Areas of Strategic Interest.....



- What are the effects of environmental and terrain conditions on current or future military equipment, especially sensors, robotics, RF?
- Need to ID and incorporate all military operating environment data into Test & Evaluation strategies
- Tools exist to link science-based knowledge of global terrain with developing of effective Test and Evaluation procedures

DRAPER LABORATORY

WEST POINT
United States Military Academy

DRI