Estimate of Interference From AeroVironment Aeronautical Mobile to Goldstone Radio Astronomy Stations at 4.9 GHz

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Background

- FCC has allocated the 4.9 GHz band to public safety telecom services. This frequency had been allocated to Radio Astronomy Services (RAS)
- AeroVironment is proposing to conduct air mobile experiment at two test sites separately using small aircraft flying at altitudes of less than 400 ft (122 m) above the ground at the frequency band of 4.94-4.99 GHz
- The airborne area proposed is within 1 km of two ground stations: Simi Valley (34.3112°N, 118.8022°W) and Camp Roberts (35.7693°N, 120.8003°W)

Background (cont'd)

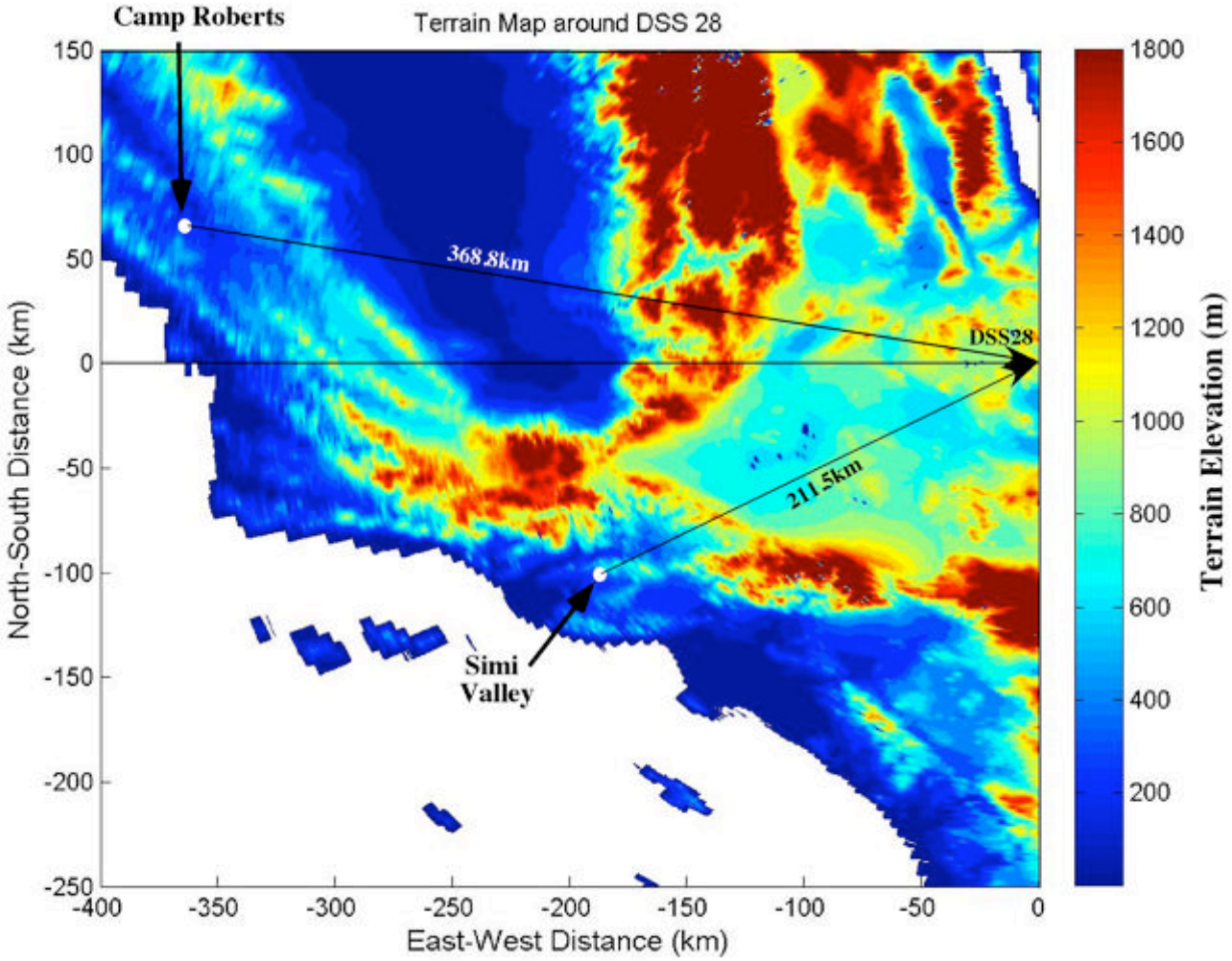
- The aircraft transmitter has 23 dBm of output power, a 3 dBi omni-directional antenna and occupies 20.0 MHz of bandwidth
- The EIRP of the transmitting system is -4.0 dBW (26 dBm). The resulting EIRP spectral density is -77 dBW/Hz
- The problem of potential RFI from the airborne transmitter to the radio astronomy stations at Goldstone and the necessary coordination area need to be evaluated

RAS at Goldstone and Its Protection Requirements

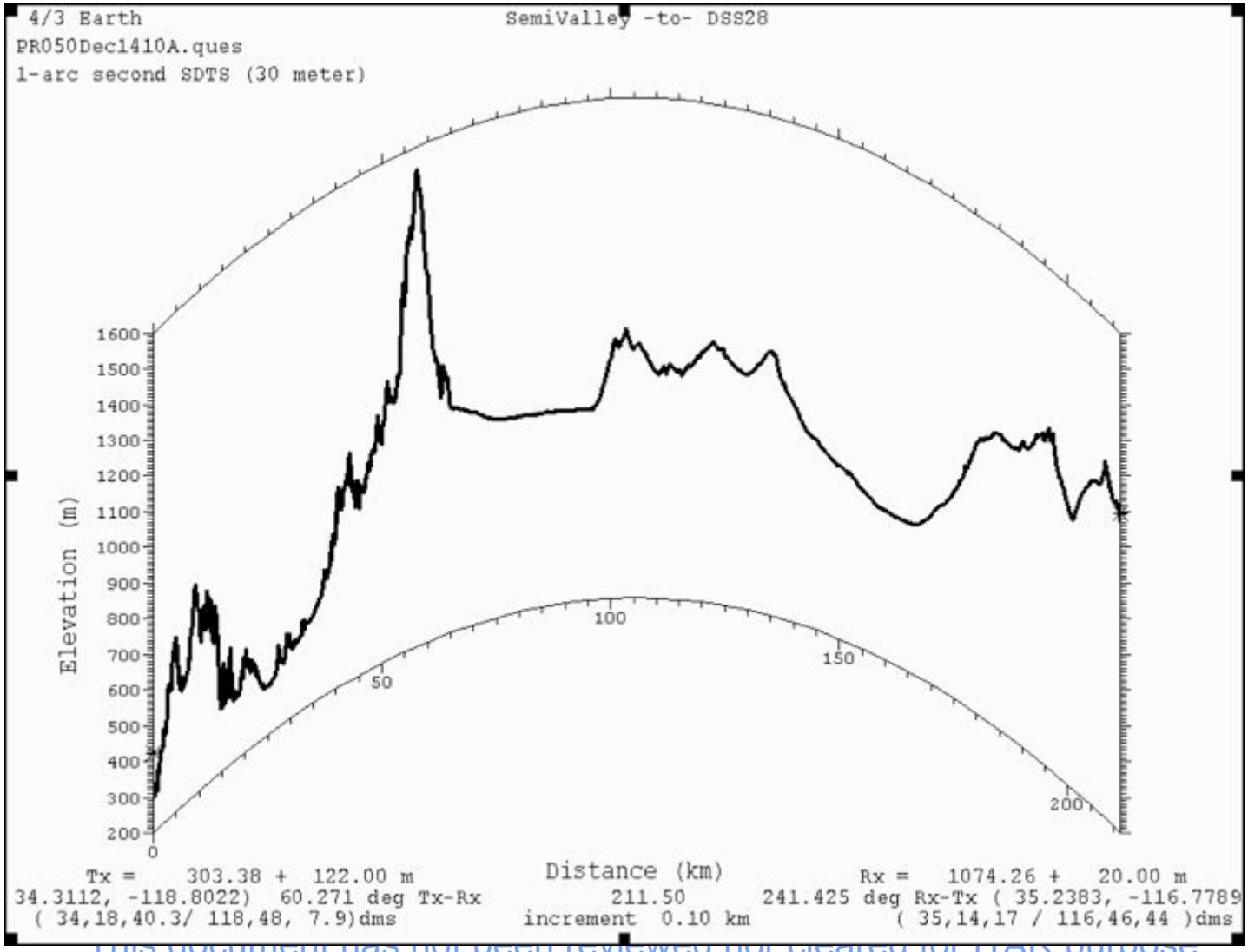
- NASA will primarily use DSS 28 for radio astronomy services, but may also use other stations
- The station will track sources all over the sky from as low as 10° elevation angle to the zenith
- The maximum acceptable interference level is -241 dBW/m^{2}Hz (ITU-R Rec. RA.769)
- The maximum allowable loss of observation time for RAS is 5% from all interference sources, and 2% from a single source (ITU-R Rec. RA.769)
- Since the public safety aeronautical mobile will operate with a low duty cycle, we have used 5% time in this study to determine the coordination distance and propagation loss

RAS DSS 28 with 34 m Dish Antenna

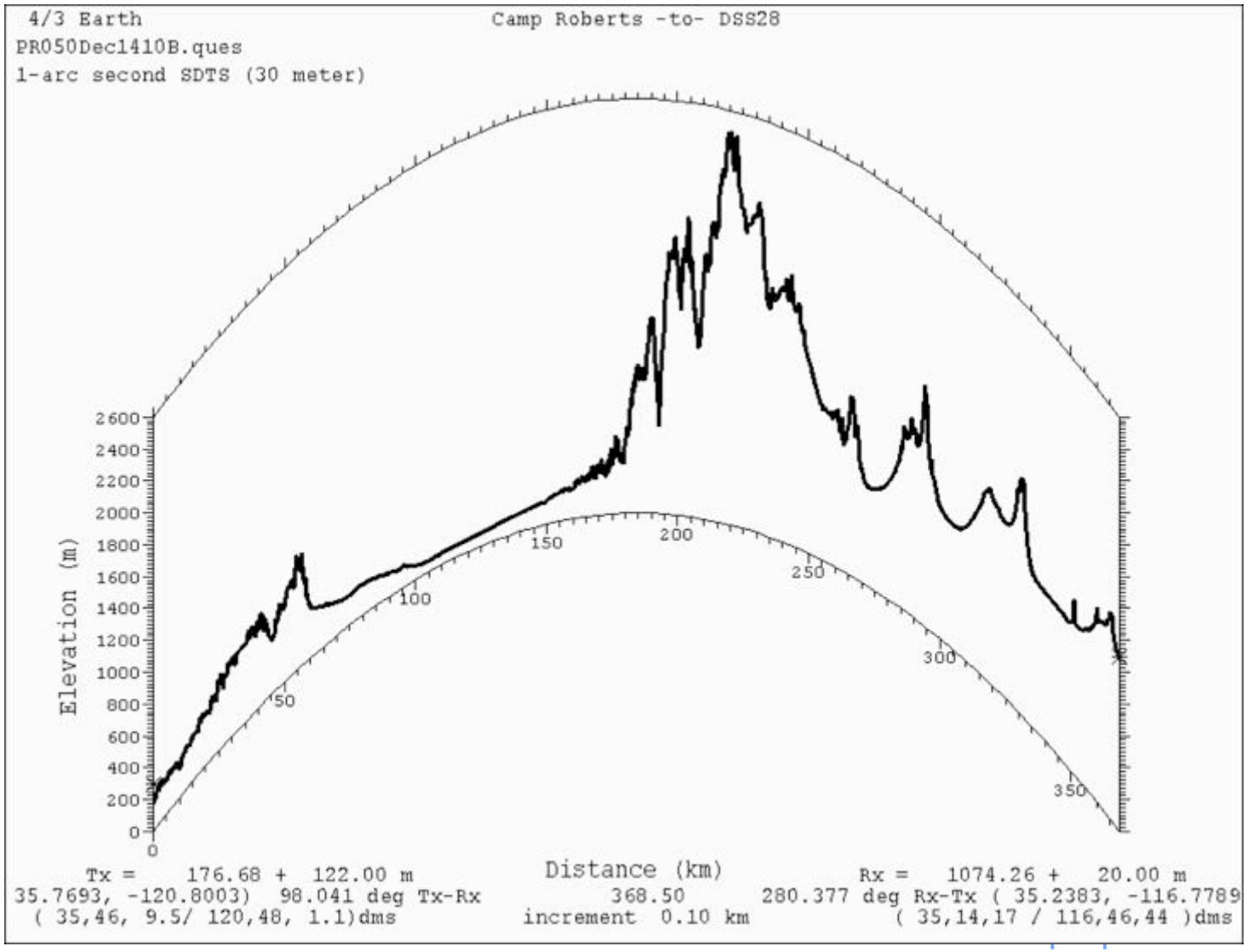
Terrain between Two Test Sites and Goldstone DSS 28



Terrain Profile between Simi Valley and Goldstone DSS 28



Terrain Profile between Camp Roberts and Goldstone DSS 28



Trans-Horizon Propagation Loss

- In addition to possible line of sight links, there are also non-line-of sight links due to several anomalous propagation modes which can propagate trans-horizontally for a very small percentage of time
- These models include: Terrain diffraction, tropospheric scatter, and ducting, etc
- Propagation losses through these anomalous modes are dependent on terrain elevation, transmitter height, distance, signal frequency, and percent of time
- Propagation losses and interference powers are calculated assuming
  - 0 dBi receiving antenna gain for the RAS station (ITU-R Rec. RA.769)
  - The airborne transmitter antenna points to the victim station

Propagation Loss Calculation

- For this calculation we have used the Trans-Horizon Interference Propagation Loss (TRIPL) software based on ITU-R Rec. P. 452 and high resolution (30m) terrain data

- The following parameters are used in this calculation

Frequency = 4.99 GHz	Transmitter bandwidth = 20 MHz
Percent of Time = 5.0%	Receiver Height = 37 m
Transmitter Height = 400ft (121.9m) above terrain	Receiver antenna gain = 0 dBi
Transmitter antenna gain = 3 dBi	Refractivity = 330 N
Transmitter Power = 23 dBm W	Refractivity Gradient = 45 N

Required Minimum Propagation Loss

- Acceptable RFI Level for RAS at 4.9 GHz (Rec. 769):
  - Power spectral flux density $\boldsymbol{P_{sfd}}$ = **-241** (dBW/m^{2}Hz)
- The corresponding received power spectral density P_{sd} (dBW/Hz) at DSS 28 is

$$P_{sd}(W/Hz) = A_{eff}(m^2) \times P_{sfd}(W/m^2 Hz) = \frac{EIRP_{sd}(W/Hz) \times G_r}{L}$$

$$= \frac{EIRP_{sd}(W/Hz) \times 4\pi A_{eff}(m^2)}{\lambda^2(m^2) L} \qquad where \quad G_r = \frac{4\pi A_{eff}}{\lambda^2}$$

- Expressed in dB: $P_{sfd} = EIRP_{sd} - L + 10\log(\frac{4\pi}{\lambda^2})$

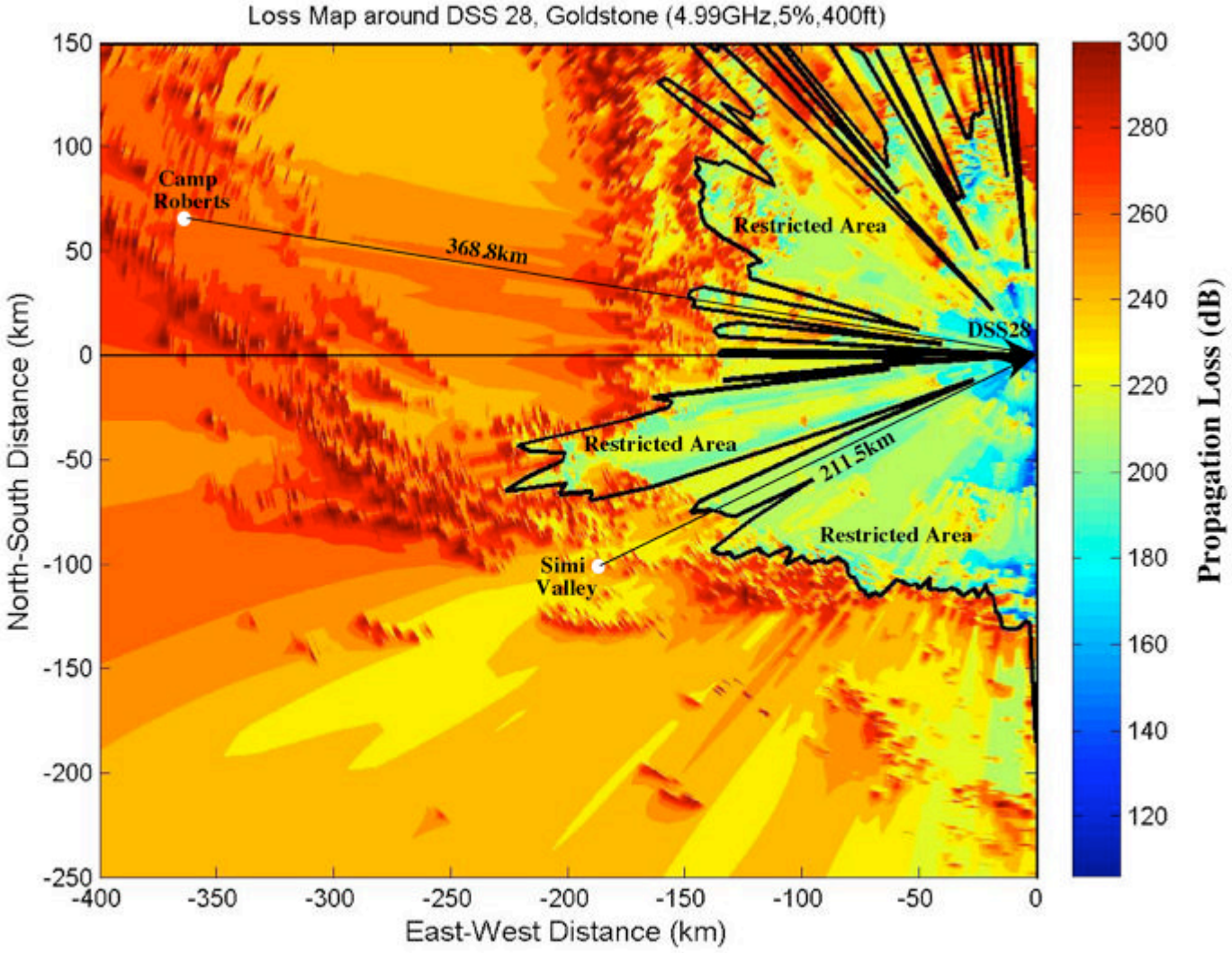
$$L = EIRP_{sd} - P_{sfd} + 35.4 \quad dB$$

where: $EIRP_{sd} = P_t + G_t - B = -7 + 3 - 10\log(20 \times 10^6) = -77.0 \quad dBW/Hz$

- The minimum total loss required:

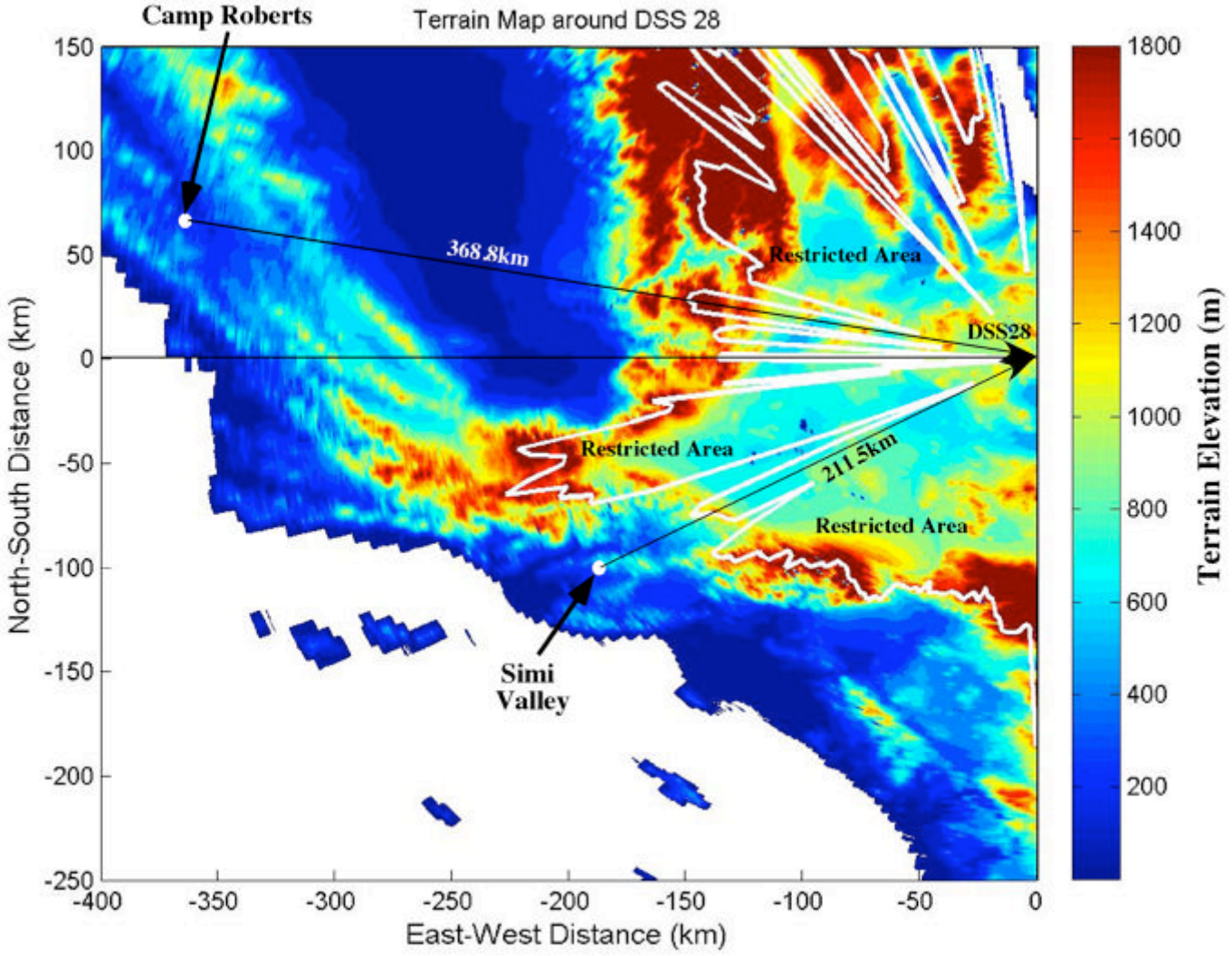
$$L_{req} = -77.0 + 241 + 35.4 = 199.4 \quad dB$$

Propagation Loss Map - 400ft Height, 5% of Time



Spectrum Engineering

Two Testing Sites and Restricted Area Around DSS 28



Summary

- Simi Valley testing site is 211.5 km away from Goldstone DSS 28 (RAS) site, while Camp Roberts is 368.9 km away.
- Using a link analysis, the minimum loss required to meet the RAS protection criteria is determined. This loss is plotted on the propagation loss map generated using ITU-R Recommendation P.452 and the link parameters. A restricted area around DSS 28 is defined.
- We find that two testing sites are located outside the restricted area defined in this study around DSS 28. Thus the aircraft transmissions within the 1 km airborne area around the two experiment sites proposed by the AeroVironment will not cause interference to the RAS stations at Goldstone