Analysis Cover Sheet

DOCUMENT NO.:	REV.:	DEPARTMENT
070-1127	A	☒ Electrical Engineering (EE) ☐ Component ☒ RF ☐ Specialty ☐ Systems ☐ Guidance, Navigation & Control (GNC) ☐ Integration & Test (I&T) ☐ Mechanical Engineering (ME) ☐ DI&T ☐ PM&P ☐ Dynamics ☐ Mass Props ☐ Dynamic Environments ☐ Structural ☐ Electronics Packaging ☐ Thermal ☐ Propulsion Engineering (PE) ☐ Software Engineering (SE) ☐ Subsystems Engineering (SUB) ☐ Systems Engineering (SYS)
PROGRAM: Taurus II	MISSION: All	

QBS ☐ ELC ☐ Waiver ☐ ☒ Non-FOUO (If FOUO, Use FM52-001a)

TITLE: GPS RE-RADIATION SYSTEM CALCULATIONS, HORIZONTAL INTEGRATION FACILITY WALLOPS ISLAND	AUTHOR: Richard Blakley	DATE: 10/6/2011

OBJECTIVE: Document the calculations made in conjunction with the license applications

ASSUMPTIONS: None

RESULTS: The signal strength from the re-radiation system in Horizontal Integration Facility does not exceed the limit of -140 dBm at the distance of 100 feet (30 meters) from the exterior wall of the High Bay.

CONCLUSIONS: The calculated signal strength from the GPS booster station is in compliance with the requirements of Reference 1

REFERENCES: See Page 7

PART NUMBER(S):

ARE ADDITIONAL ANALYSES REQUIRED: ☐ YES ☒ NO DESCRIBE:	**THIS SECTION TO BE COMPLETED FOR ELC AND WAIVERS ONLY** CRITICALITY: ☐ NOT FLIGHT CRITICAL ☐ FLIGHT CRITICAL
PREPARED BY: Richard Blakley DATE: 10/6/2011 REVIEWED BY: David Twine DATE: 10/6/2011 REVIEWED BY: DATE:	APPROVED BY: DIR OF ENG: DEPT: _____ _____ DIR OF ENG: DEPT: _____ _____ PROG MANAGER: DEPT: _____ _____ FRRB REQUIRED ☐ YES ☐ NO FRRB DATE: _____

DISTRIBUTION: _____

ATTACH BODY OF ANALYSIS

FM52-001 (TM-13954)
Rev. L, 15 March 2011

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REVISION SUMMARY			
REV	DATE	CHANGE	PAGE
-	9/28/2011	INITIAL RELEASE	
A	10/6/2011	Changed heading on page and table to: 0499-EX-PL-2011	3,4

GPS Booster Station Signal Strength Calculation
NASA Wallops Island BLDG X79
Horizontal Integration Facility (HIF)
Reference file # 0499-EX-PL-2011

This GPS booster station re-radiates the GPS L1 (1575.42 MHz) and GPS L2 (1227.6 MHz) signals. Calculations are performed per Section 8.3.28 of the NTIA regulations [1]. The re-radiated power is limited by requirement 6 which states "that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building." Attenuation by the building will be neglected. The re-radiating antenna is connected to a flexible coaxial cable so it can be tripod mounted near the vehicle as required. Since the re-radiation antenna can be moved within the building only the distance from the exterior wall 30 meters out is used in the loss calculations. This worksheet shows that the re-radiated signal for BLDG X79 (Horizontal Integration Facility) location is in compliance with the NTIA requirement.

The signal strength is defined by:

$P_{sig} = P_{rec} + G_{roof} + L_{cable} + G_{lna} + G_{ant} + L_{space}$ eq. 1 [2]

Where
P_{sig} = The Re-Radiated signal strength at 30 meters from the building.
P_{rec} = The power of the received GPS signal, L1 = -130 dBm
G_{roof} = Maximum Gain of the active receiving antenna of the GPS re-rad system, 37.7 dB [3]
L_{cable} = Losses for the RF cabling of the re-rad system 200 ft @6.3 dB/100 ft = 12.6 dB [7]
L_A = Loss of coupler Box assembly = -9.0 dB (Figure 2) [5],[6].
G_{ant} = Gain of the re-radiating antenna, +5.0 dBi (on bore-sight) [4]
L_{space} = Free space loss of the re-radiated signal

The free space loss is dependent upon the distance from the re-radiating antenna to the exterior wall and from the exterior wall to the designated measurement distance, 30 meters. For these calculations the distance from the antenna to the exterior wall is zero.

$L_{space} = 20 \text{ Log}(\lambda/4\pi D)$ eq. 2 [2]

Where λ = Wavelength of the GPS signal, L1 = .190 meters, L2=.244 meters
π = Pi
D = The distance from antenna to exterior wall plus 30 meter required distance

At 30 meters from the exterior wall the re-radiated RF power level is:

a) L1, 1575.42 MHz
L_{space} = 20*Log(.1904/(4*π*(30))) = -65.92 dB
The power of the re-radiated signal at the specified distance is:

P_{sig} = -130 + 37.5 -12.6 -9.0 + 5.0 -65.92	=	-174.82 dBm
	Maximum Power	-140.00 dBm
	Margin	+34.82 dB

b) L2, 1227.6 MHz

L_{space} = 20*Log(.1904/(4*π*(30))) = -63.75 dB

The power of the re-radiated signal at the specified distance is:

P_{sig} = -130 + 38.5 -12.6 -9.0 + 5.0 -63.75 = -171.85dBm

Maximum Power -140.00 dBm

Margin +31.85 dB

GPS Booster Station (Re-Radiation System) Link Margin Evaluation

Horizontal Integration Facility

Reference # 0499-EX-PL-2011

L1 Frequency (MHz)	1227.6	1575.42	
Wavelength (m)	0.2444	0.1904	
Distance (m)	0	0	
(re-rad antenna to exterior wall)			
GPS Signal Strength	-130	-130	dBm
Roof Antenna/LNA Gain (3G1215-XN-1)	38.5	37.7	dB
RF Cable Loss (LMR-400 Ultra Flex)	-6.3	-6.3	dB
(Roof antenna to splitter box)			
Splitter Loss (LDCBS1X4-S/3.3/110)	-8.0	-8.0	dB
(typical)			
Variable attenuator loss (min attenuation) (50R-046)	-1.0	-1.0	dB
RF Cable Loss (LMR-400 Ultra Flex)	-6.3	-6.3	dB
(Splitter box to re-rad antenna)			
Re-Rad Antenna Gain (2G1215-XN-1)	5	5	dBi
(maximum)			
Space Loss to Distance	-63.75	-65.92	dB
(30.00 meters total)			
Power at Specified Distance	-171.85	-174.82	dBm
(100’ (30 meters from building)			
Specified Maximum	-140.0	-140.0	dBm
(NTIA specification)			
Margin	**31.85**	**34.82**	**dB**

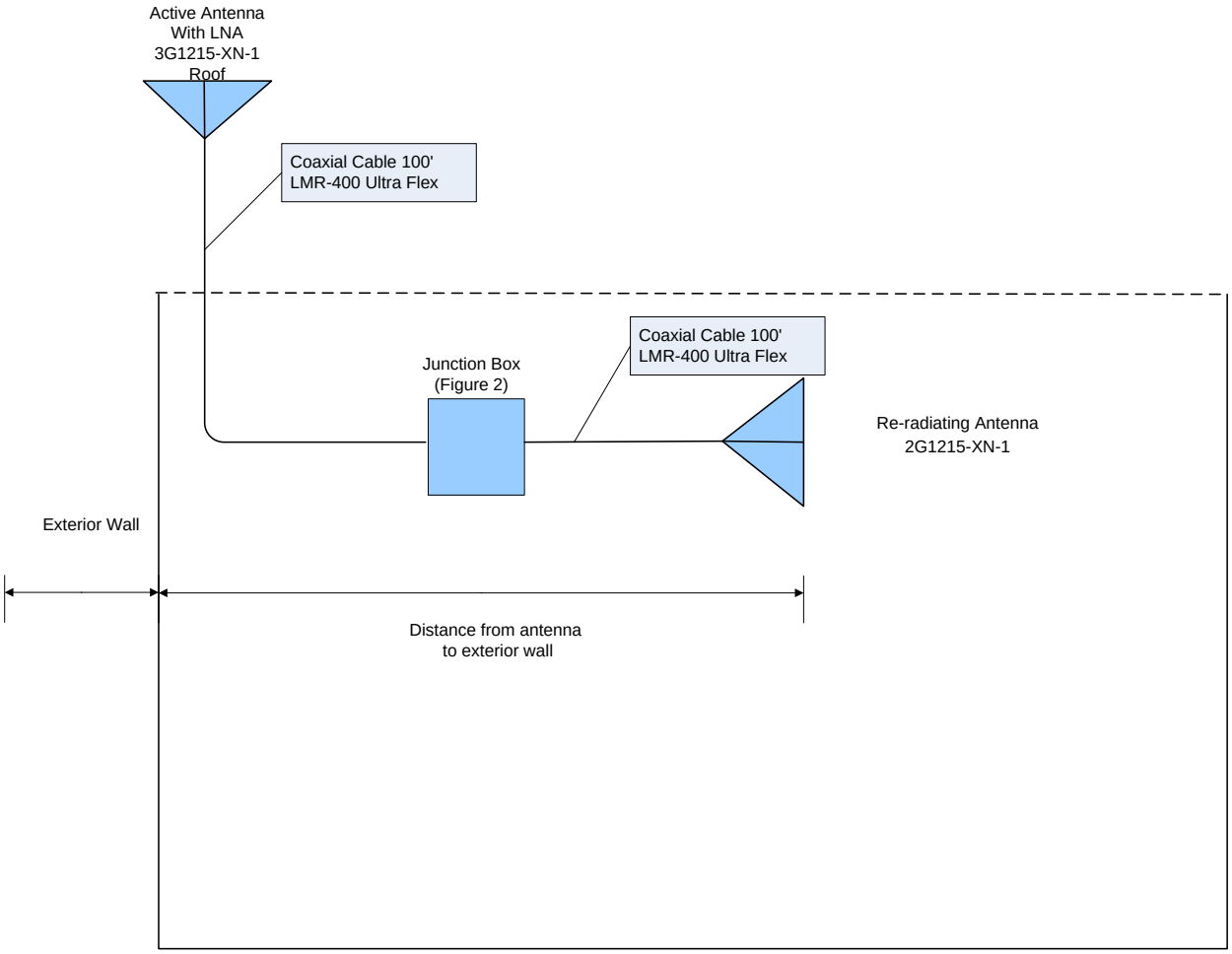

Figure 1
Horizontal Integration Facility
Re-Radiation System

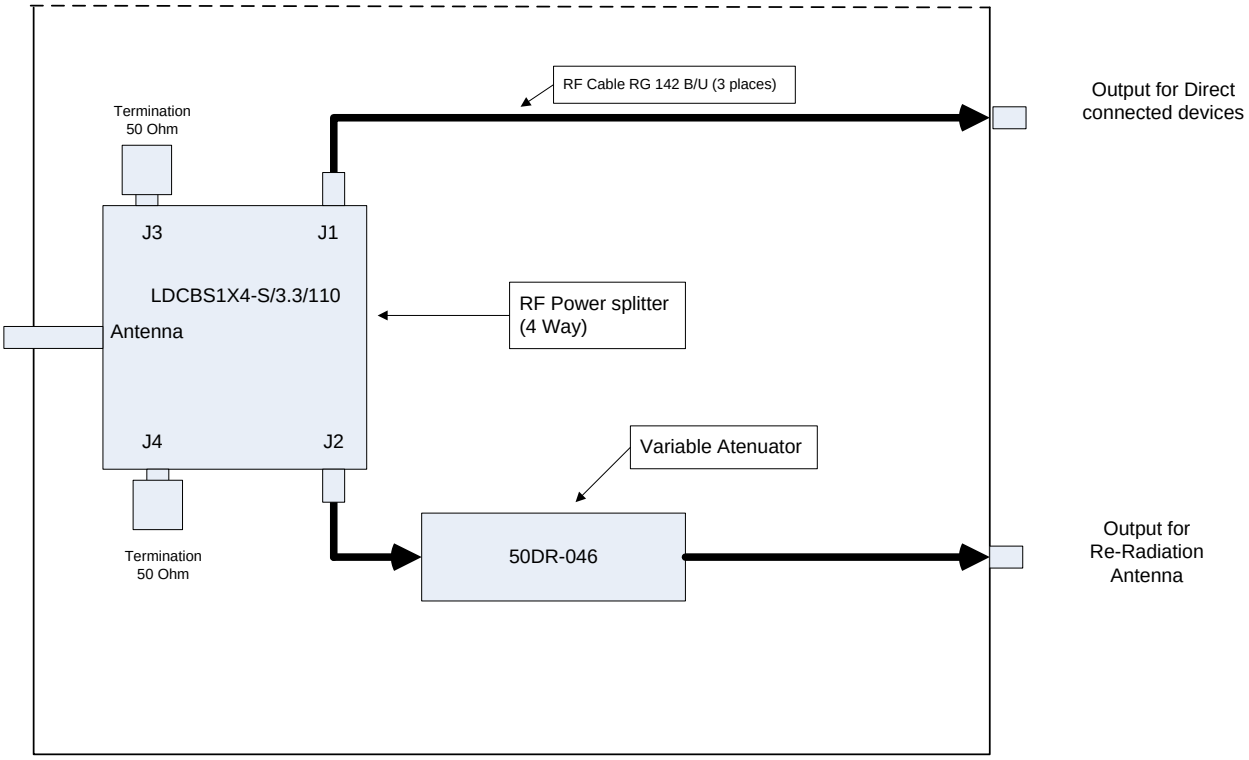

Figure 2
Junction Box

References:

1. Manual of Regulations and Procedures for Federal Radio Frequency Management, May 2008 Revision. Section 8.3.28, page 8-70.
2. Data Link Basics: The Link Budget, L3 Communications.
3. Antcom Corporation, Drawing 3G1215X-XX-X.
4. Antcom, Corporation Drawing 2G1215X-XX-X.
5. GPS Networking Inc., Technical Product Data LDCBS1X4.
6. JFW Specification Sheet 50DR-046.
7. Times Microwave Systems, LMR-400 Data Sheet.