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Atmospheric Measurement Techniques Discussions

Interactive comment on "Potential radio frequency interference with the GPS L5 band for radio occultation measurements" *by* A. M. Wolff et al.

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General: Very interesting paper which is quite relevant to the coming use of L5 signals for RO. This paper also has information which is useful for planning future RO instruments. As discussed below, the level of RFI power from DME/TACAN should be compared with thermal noise, not with the signal power. Also, there should not be receiver front-end saturation at the RFI power levels discussed. Consider mention of other satellite navigation signals at L5 such as from Beidou, Galileo, QZSS and IRNSS.

I would like to see all the assumptions (antenna gains, satellite orbits, etc) spelled out including worst-case settings for DME/TACAN power and pulse timing among transmitters and the inclusion of more typical cases. Of course, those could be tasks for future

papers.

Most of my following comments are based on an interest in digging more information out of this very interesting experiment/analysis.

Specific comments Page/line 4530/12 One should qualify the statement that RTK "results confirmed". The link calculation portion seems to be confirmed by its comparison to a published result for RFI to an aircraft. This would be stronger if the assumptions used for both calculations (power, ant gains, range, etc) were described.

4532/22 Change to S(N+I)R, and make use of this ratio instead of the I/S ratio. As mentioned in General Comments above, I believe the RFI should be discussed in relation to the noise, not the signal. This equation can be used to compare the loss of SNR from interference (I) which is the ratio S/(N+I) to S/N, which is a factor of N/(N+I). So, when the pulse is active, the loss of SNR is 10*Log(N/(N+I)). Notice the signal power is not in the equation.

4534/19 change "the directive orientation of the receiver antenna pattern aboard a RO satellite with respect to a DME station increases the received power level from a DME station as well as increases the total number of DME stations effectively witnessed by the receiver." to "the high-gain RO antenna toward a DME station increases the received power level from a station in its beam but decreases the total number of DME stations received." Why: Basic antenna property is the gain and beam solid angle are inversely proportional. High-Gain means a smaller solid angle is within the beam.

4534/4 What is the peak gain of the DME antenna? What is its 3 dB beamwidth in elevation? [I think +9 dBi linear and >6 deg per manufacturer specs]

Fig 2: Gain of helical antenna is? [I'd guess +9 dBic for a 2-turn helix] Estimated noise floor at L5 is ___ K, (or dBm/Hz)? Hump in noise is due to filter shape, or?? Vertical scale is ___ dBm/MHz Resolution BW is? Is this averaged over many pulses or is it taken from a short dwell while the pulse is ON? Can you estimate the EIRP from each

station?

Fig 4 and 5: Please describe what is plotted. For example, is it the voltage of the signal + noise + interference after some amount of amplification?

4535/22 What is the estimated noise floor? What are the respective gains (approximate) of the choke ring and helix toward Denver?

4535/24 Change from “high gain directive antenna that’s energy is focused on the limb of the earth” to “high gain directive antenna whose gain is focused on the limb of the earth” Why change: RO antenna is receiving, not transmitting.

4535/24 “Therefore, it is consistent that GPS RO receiver will witness interference comparable to that seen by the helical test“ This remains to be shown. One could say it is possible, if the higher gain of the RO antenna and the fact there are more DME/TACAN transmitters in view compensate for the additional range from the RO geometry. (The typical range from LEO to the earth limb is 3,000 km while the range from Pikes Peak to the Denver airport is 118 km, a difference of -28 dB. The gain of the COSMIC RO antenna is similar to a 2-turn helix, and the worst-case (all 76 stations transmitting at the same times) factor with 76 DME stations in the beam at the same time is +19 dB. I’d guess the COSMIC RO case would show, worst case, about 9 dB lower RFI from DME.)

Section 4: The assumptions used for the STK and reference calculations are not described in this text, and so the similar result from the toolkit is not convincing. If the toolkit link calculation needs verification, that can be done by numerical calculation in a few lines. Otherwise please describe the range, gains, etc. used to calculate the link. The parentheses are missing a square in formula 1.

4536/7 Mention the gain of the DME transmit antenna is +9dBi with vertical linear polarization. (also, vertical FWHM is >= 6 degrees) Both taken from the manufacturer’s website.

What is the gain of the aircraft antenna toward the boresight of a ground antenna aimed at +4 degrees elevation? What range was used?

4537/19 What satellite height and RO gain were used? At 4 deg el, Satellite at 800 km altitude, Pt = 1000W, Gt = +9 dBil, I get R = 2878 km, and Pr at L5 with a +10 dBic RO antenna [The COSMIC antenna was about +10 dBic, but was L1 + L2] to be -117 dBW. [That is close enough to the STK -123 dBW value.]

4538/2 Why -125 dBW? Perhaps a somewhat arbitrary dividing line, which is fine.

4538/8 Must specify which code and the receive antenna gain for if you give a typical received GPS signal power. Also, the ratio of RFI power to signal power is not the best comparison. One should compare RFI to the noise floor. (See comment 4532/22)

4538/10-16 I suggest this be re-written. Even if all DME pulses occur simultaneously, the received power is < -123 dBW + 10*log(76) = -104 dBW. A typical receiver saturation level is well above that.

Does the result shown in Fig. 8 assume random pulse timing among DME sites? Is this timing known to be random or is it coordinated among sites?

4538/23 I think you mean “experiment” instead of “simulation”.

4538/23 Change “Specific antenna patterns. . .” to “Uncertainties in specific antenna patterns. . .” By the way, these parameters are known for the COSMIC-2 mission, which has L5-capable receiver hardware. The parameters can be obtained from UCAR or JPL.

4538/24 Why is the transmitter noise figure of interest? Is “receiver noise figure” meant?

4539/5 Change “at any point in time” to “at some point in time”.

4539/10 Very true! Most high accuracy receivers have relatively slowly increasing filter rejection outside the signal bands, and will admit nearby RFI.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 4529, 2014.