Iridium & GPS/GNSS Inteference from Iridium Data Transmitters

Update: GPS/GNSS Interference From Iridium Data Transmissions

The Iridium satellite communication system broadcasts in the 1610 to 1626.5 MHz band. UNAVCO Inc. uses iridium communication links to download GPS data from remote GPS stations. The L1 frequencies broadcast by GPS, Galileo and GLONASS satellites are 1575.42 MHz, 1575.42 MHz and 1602 MHz + nÃ— 0.5625 MHz, respectively (each GLONASS satellite uses a unique frequency). The proximity of the Iridium frequency band with the L1 frequencies of the GPS, Galileo and GLONASS systems leaves GNSS receivers susceptible to interference from Iridium data transmissions. Interference from Iridium transmissions can cause cycle slips and loss of lock on the carrier and code phases, thereby degrading the quality of GNSS observations. In 2008, UNAVCO staff members observed that the % of slips/# of observations increased as the distance between a Trimble GPS choke ring antenna (TRM29659.00) and an Iridium antenna decreased. From those observations they suggested that Iridium and GPS antennas should be separated by >30 m to minimize cycle slips caused by the interference from Iridium data transmissions.

A second test conducted in 2/09 using a newer Trimble GNSS choke ring antenna (TRM59800.00) and a Trimble NetRS receiver showed similar results to the previous test despite the wider frequency range of the newer antenna. Cycle slips were observed to be decreasing as the GPS antenna was placed further away from a bank of Iridium antennas. Cycle slips decreased to zero over an hour-long session when the GPS antenna position was a distance of 15 m from the bank of Iridium antennas.

The purpose of this update is to present new observations showing GNSS tracking interference from Iridium data transmissions. These results show that two Galileo enabled receiver models (Leica GR10 and Trimble NetR9), when connected to GNSS compatible antennas, have increased sensitivity to interference from Iridium transmissions compared to older receivers (NetRS, NetR5, NetR8, etc.). Frequent loss of lock indicators and ionospheric delay slips were detected by UNAVCOâ€™s pre-processing software, TEQC, with both the GR10 and NetR9 receivers. The distance between the Iridium transmission source and the GNSS antenna was ~35 m for all of the observations. Our results indicate that the old recommendation of a >30m antenna separation will not prevent interference from occurring with newer Galileo enabled receiver designs. Future testing will be necessary to determine the minimum antenna separation distance to prevent Iridium interference from degrading the quality of GNSS observations. We will also need to search for alternates to antenna separation for mitigating the RF interference, as large separation distances may be impractical in the field.

Equipment Used

1. Iridium Antennas: A mix of ~10 iridium antennas (green stick, puck and marine antenna). These antennas are transmitting data all of the time.
2. GNSS Antennas Tested: Trimble GNSS choke (IGS #: TRM59800.00); Trimble choke (IGS #: TRM29659.00); Trimble Zephyr GNSS (IGS #: TRM57971.00); Trimble Zephyr (IGS #: TRM41249.00); Leica AR-10
3. Receivers Tested: Trimble NetRS; Trimble NetR5; Trimble NetR9; Leica GR10 (Rev 2)
4. GPS Source 8-way GPS Splitter
5. 20dB Attenuator

Testing Location

The observations used in this report were collected on the roof of the UNAVCO facility. The GNSS antenna test location is shown below with a red circle. The approximate location of the Iridium antenna bank is indicated with a yellow circle. The separation of the antennas is ~35 m.

GPS Data Processing

The GNSS data in this report were processed using TEQC. Leica files were translated from the Leica .m00 format to RINEX using TEQC. Trimble data must first be translated using the Trimble translator program runpkr00 before being translated to RINEX using TEQC. Navigation files were extracted from the data using the +nav flag. We used the +qc flag to quality check each RINEX file. For this report we only use the TEQC summary file with the .10S filename extension. We use two pieces of information from the summary file to detect possible iridium interference in our GNSS data, the â€œqc plotâ€ and the obs/slip number.

All of the receivers in this report were set with 0 degree elevation mask. Both the number of sessions and the frequency of the data vary from receiver to receiver. Although, there were primarily 15 sec, 1 Hz and 5 Hz sessions recorded.

Results

Iridium Off vs. On

Iridium: Turned on at approximately 22:30:00

Receiver Type: Trimble NetR9

Antenna Type: Trimble GNSS Choke

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version: teqc  2010Oct11

SV+|------------|------------|------------|------------|------------|------------| SV
13|AALLL_LL++++LL+L++LL++^L^L+LL+++L++LLL_LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL| 13
31|+++++++++++++LL+LL+++L++LLLL++++LLLLLLLLLLLLLLLLLL_____| 31
12|~~~~~~~~~~~~~I~~~~~~~~~~~~~~~~~~~~~~~~IIIIIIIIILIIIIIII~IIII~IIIIIIIILI~I| 12
29|~~~I~~~~~~~~~~~~~I~~~~~~~~~~~~I~~~LILLIIIIIIIIIIIIIIIIIII~LIIIIIIII~III| 29
 2|oooooooooooooooooooooooooooooooooLLLLLLLLLLLLLLIIIILLoLLLLLIILLIIoLLIL| 2
30|oooLoooooooooooooLoooooooooooLoooLLLLLLoLLILLLoILIIILLILLoIILLLLLLLLLIo| 30
10|oooooooooooooooooooooooooooooooL ILLLLLLLLILLILILILLLLLIILLIILLLL| 10
25|~~~I~~~~~~~~~~~~~~~~~~~~~~~~~~~~LIIILL~II~III~IIIIIIIII~II~~~III~III~| 25
 4|oooIoooooooooLooooLoooooooIIoooLLooLIILLILIIIIILILILLLLLLLLLLLLLLLL| 4
 5|~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~I~ILLI~IIIIII~LIIIIIIII~LI~IIIIIIIII| 5
21|             _____LAAALLLLLLLLLLLLLLLLLLLLLLLLLLTILLLL-LLLLTII| 21
26|             _____LLLLLLLLLLLLLLLL| 26
R 8|*****************II*1*111***11*I****IIIL*IIIIIIL*IIIIIIIL*LILI      |R 8
R 2|****************************L*II[****]IIII]******I****II**I*|R 2
R23|****************11*I2*2*************IIIIILIIIII*IIIIIIIIIILIIILLI I     |R23
R15|*************III***[1**********II***IIILILLIIIII*IILLI1ILI**LIILLIIIIILL*|R15
R16|*****************II[**********II*I***IIILII*IIIIIIIIIIII I***IILII II*III|R16
R 1|************************************IIIIIIII***II1**IIIIIIII|R 1
R17|***********************************I*I1LIIIII*IIIII IL*II***III*III*II*|R17
R24|******************************L****IIIIIIIIII***II**IIIII*II|R24
R14|**************IL                               |R14
R18|        L*1*LIIIIIIIIIII*LI*IIIIII**IIIL*I I*LIIII|R18
R 9|                   LLIIII1ILL*|R 9
-dn|+++++ ++    +    +++++  ++++++++ +++ +++++ ++++ ++++++++++++++ ++  |-dn
+dn|++++        +++    +++++    ++    +  +++ +     |+dn
+10|8888888888888888888888888888888888888888888888887777788888888888888888|+10
Pos|ooooo ooooooooooooooooooooooooooooooooo. oooooooooooooooooooooooooooooo|Pos
Clk|                                  |Clk
  +|------------|------------|------------|------------|------------|------------+
22:00:00.000                                          22:59:59.000
2010 Oct 21                                           2010 Oct 21

***********************
QC of RINEX  file(s) : DEV1294_22.10o
input RnxNAV file(s) : DEV1294_22.10n
                       DEV1294_22.10r
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This quality check plot from TEQC shows a large increase in both ionospheric delay (phase) slips (I) and loss of lock indicators (L) after the Iridium system was turned on at ~22:30:00. This is from a 1 Hour session with a 5 Hz measurement interval. Both GLONASS and GPS signals were affected. TEQC results from a Leica GR10 receiver sharing the same antenna via a splitter showed a similar increase in ionospheric delay slips and loss of lock indicators after the Iridium system was turned on.

Testing Antenna Types

Iridium: Was transmitting for the duration of this session

Receiver Type: Leica GR10

Antenna Type: Trimble Zephyr Geodetic 2 -> Trimble Zephyr Geodetic

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SV+|-----------|-----------|-----------|-----------|-----------|-----------+ SV
 2|                                            | 2
 3|                                            | 3
 4|                           _____LL++++++L_L++| 4
 5|                                            | 5
 6|                                            | 6
 7|IIIII~~~I~~II~I-IIIII~~~I~~IIIIII~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~I~~| 7
 8|IooII-IooooIIIIIIIIIoIoIoIIIIooooooooooooooooooooooooooooooooooooo| 8
 9|                           _____L++| 9
10|                                            | 10
11|IIIIIooIooIoIII-oIIIIoIIIoIIooIoooooooooooooooooooooooooooooooooooo| 11
12|                                            | 12
13|                                            | 13
14|                                            | 14
15|-IIIIIIII~~IIII-IIIIII~~I-I-IIII-I~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~| 15
16|                                            | 16
17|II~III~~~I~~IIIII~~IIII~III-II~~I~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~| 17
18|                                            | 18
19|IIII-II-IoLL+LLL++LLLL+++L+_____     | 19
20|                                            | 20
21|                                            | 21
22|                                            | 22
23|                                            | 23
24|IIIIIIIIooI-IIIIIIIIIoIIIIIooIoooooooooooIoooooooIoI2o-I+L+++++++++LL+L+| 24
25|                                            | 25
26|IIIIIooIooIooIIIIIIIIooIIoooII-Iooooooooooooooooooooooooooooooooooo| 26
27|_____^L^___^LL_L+L+L+-III-Iooooooooo0IIooooooooooIoooooooooooooIooooo| 27
28|IoIII-IIooIIIIIIIIIooII-IoooI2ooooooooooooooooooooooooooooooooooooo| 28
29|                                            | 29
30|                                            | 30
31|                                            | 31
32|                                            | 32
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We tested several antenna models commonly used by UNAVCO to determine which are more susceptible to interference from Iridium signals. We observed a significant decrease in both loss of lock indicators (L) and ionospheric delay slip indicators (I) for tracked GPS satellites when we changed the antenna from a L5 and Galileo enabled Trimble Zephyr Geodetic 2 to the older Trimble Zephyr Geodetic antenna. This decrease occurred in recorded observables from both the GR10 and NetR9 receivers. Other antenna/receiver combinations were also tested and those tests are summarized in Table 1.

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R13|LLIIIIII~IIII.LIIIIII~III~II.I-IIII~~~I~~I~~~.III~L~~I~IIIII~~~I~~I~II~I~|R13
R23|I..LII.I~~~I.I~LI.I~LI~III~IILILII~LI~IIIIIIIIIIIIII~IIIIIIIIII~III~IIILII|R23
R22|ILcILILI~~~ILI~IIII~LL~I~~~~IILILIIII~~~I~~I~II~I~IIII~LII2LII~~III~IIIII~|R22
S38|ILcLLLLLcc.cccLLLLLLcccLccLcLLL.cccccccccccccccccccccccccccccccccccccccc|S38
S35|LLcLLLLLccLcccLLLLcLcccLccccLLL.cccccccccccccccccccccccccccccccccccccccc|S35
R12|IIIIIILLI~III~IIIIIII~~~~I~~IILILIIII~~~~~~II~I.I~~III~I.IIIIII~~~I~~~IIII.|R12
R21|IL..LIII~IIIILLILLLIIL.        -                                          |R21
R11|ILLILLL.IILIIILILLLIIIILLLLII- I                                         |R11
R24|    LLL LIIIIILLLLIIIILILLLII-IIIIILLLLLIIIILIIIIIIIIIILIL LIIIIIIIIIII|R24
R14|        II LI-I    I~I~~ILIILIIILIIIIIILIIIIIIIIIIIIII~I|R14
-dn|     +++++ +++  +++ + +                           +++++    +++++ |-dn
+dn|64466435  64475545654 26547553-3    12      1 2 11      1  1  |+dn
+10|9999999999988888888888888888888999999999999999999999999999988888888888888|+10
Pos|0000000000000   0  000000.                           000000000.000|Pos
Clk|                        ^                                         |Clk
  +|-----------|-----------|-----------|-----------|-----------|-----------+
16:00:00.000                                              16:59:59.000
2010 Oct 22                                                2010 Oct 22
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Loss of lock and ionospheric delay slip indicators in the GLONASS observables did not decrease as significantly from the antenna change. We suspect that the proximity of the GLONASS L1 frequency to the Iridium frequency band makes it more susceptible to interference, even when using an older narrower band antenna.

Conclusions

1. A 30 m distance between a Galileo and L5 enabled receiver/antenna and an Iridium antenna is not â€œsafeâ€ and the GNSS data may be significantly degraded by the RF interference.
2. A new â€œsafeâ€ distance must be determined for Galileo/ L5 enabled receiver/antenna combinations when they are near an Iridium transmitter to prevent adverse effects to the data.
3. We suspect that the newer Galileo/L5 enabled receivers/antennas have a much wider bandwidth making them more susceptible to interference from other communication bands.
4. An inline notch-type filter that rejects 1616-1626.5 MHz will reduce interference from Iridium transmissions. However, this may reduce the receiverâ€™s ability to track certain GNSS signals (e.g. GLONASS).
5. Using an older non-Galileo/L5 antenna in combination with a Galileo and L5 enabled receiver significantly reduces the interference from Iridium transmissions in the GPS data. It does not; however, significantly reduce interference from Iridium transmissions in the GLONASS data.
6. We suspect the improvement in the GPS data when using an older antenna is due to the narrower bandwidth of older antennas.
7. Using a 20 dB attenuator does not reduce interference from Iridium transmissions.
8. Other receiver brands and models may need to be tested for susceptibility to interference from Iridium signals. It is likely that any Galileo/L5 enabled receiver may be susceptible to increased interference from Iridium transmissions.

Summary Table

This table shows receiver/antenna combinations with known increased sensitivity to interference from Iridium Transmissions. A distance of 30 m between iridium and GNSS antennas with these combinations will **not** prevent the degradation of GNSS data.

Table 1.

	Leica AR10	Trimble GNSS Choke TRM59800.00	Trimble Choke TRM29659.00	Trimble Zephyr Geodetic 2 TRM57971.00	Trimble Zephyr Geodetic TRM41249.00
Leica GR10 (Rev 2 board)	Yes	Yes		Yes	
Trimble NetRS					
Trimble NetR8					
Trimble NetR9	Yes	Yes		Yes	

Further testing of additional receiver models and mitigation techniques is ongoing.

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http://kb.unavco.org/kb/questions/110/Iridium+%26+GPS+Antenna+Interference+Test+(2008)