GPS/GNSS Interference from Iridium Data Transmitters

AGU FALL MEETING 2011 Henry Berglund, Frederick Blume, Lou Estey, Seth White
UNAVCO, Boulder, CO 80301-5553
Email: berglund@unavco.org

The Iridium satellite communication system broadcasts in the 1610 to 1626.5 MHz band. The L1 frequencies broadcast by GPS, Galileo and GLONASS satellites are 1575.42 MHz, 1575.42 MHz and 1602 MHz + n × 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 and position estimates.

In 2008, UNAVCO staff members observed that the percent of slips vs. the number of observations increased as the distance between a GPS choke ring antenna (TRM29659.00) and an Iridium antenna decreased. From those observations they suggested that Iridium antennas 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 2009 using a newer Trimble GNSS choke ring antenna (TRM59800.00) showed similar results to the previous test despite the wider frequency range of the newer antenna. More recent testing conducted to investigate the response of new receiver models to iridium transmissions has shown that many GNSS enabled models, when combined with GNSS enabled antennas, have increased sensitivity to interference when compared to older GPS-only models.

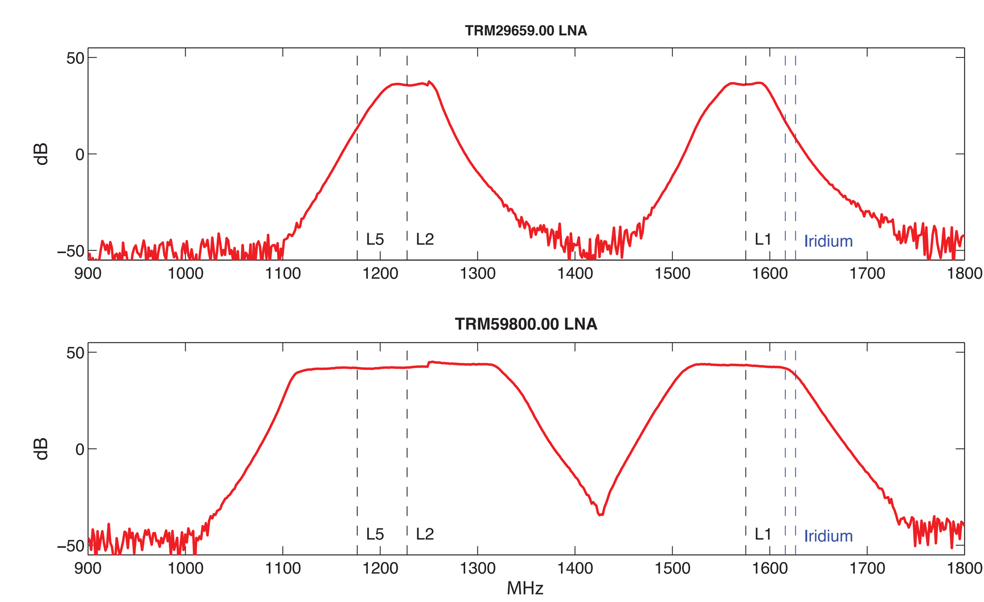
The increased bandwidth of the Low Noise Amplifiers (LNA) installed in many newer GNSS antennas can increase the impact of near-band RF interference on tracking performance. Our testing has shown that the quality of data collected at sites collocated with iridium communications is highly degraded for antenna separations exceeding 100m. Using older GPS antenna models (e.g. TRM29659.00) with newer GNSS enabled receivers can reduce this effect. To mitigate the effects that iridium data transmissions have on receiver tracking performance, we tested a custom cavity-type notch filter designed to attenuate the Iridium RF band. The filter has a >20dB rejection at 1616-1626.5 MHz. Test results when using the filter have shown excellent GPS data quality at antenna separations of ~30 m. Determining what impact the filter has on GLONASS and Galileo observations will require further testing. Future investigations will also include alternative RF mitigation methods, including RF shielding.

UNAVCO is funded by the National Science Foundation (NSF) and National Aeronautics and Space Administrations (NASA).

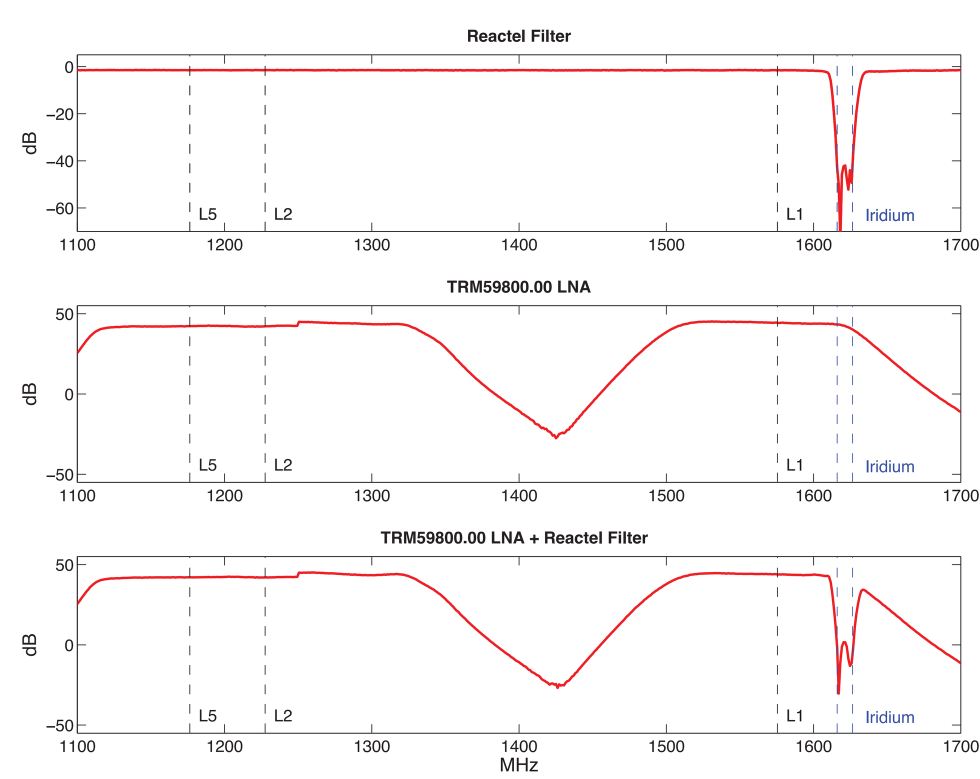
GPS/GNSS Interference from Iridium Data Transmitters

The Iridium satellite communication system uses the 1616-1626.5 MHz band to uplink with orbiting communication satellites. UNAVCO Inc. uses iridium communication links to download GPS data from remote GPS stations located at high latitudes. The L1 frequencies broadcast by GPS, Galileo and GLONASS satellites are 1575.42 MHz, 1575.42 MHz and 1602 MHz + n × 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.

The increased bandwidth of the Low Noise Amplifiers (LNA) installed in many newer GNSS receivers/antennas (shown below) can increase the impact of near-band RF interference on GPS tracking performance. Our testing has shown that the quality of data collected at sites collocated with iridium communications is highly degraded for antenna separations exceeding 100m. Using older GPS antenna models (e.g. TRM29659.00) with newer GNSS enabled receivers can reduce this effect. To mitigate the effects that iridium data transmissions have on receiver tracking performance, we tested a custom cavity-type notch filter designed to attenuate the Iridium RF band. The filter has a >20dB rejection at 1616-1626.5 MHz. Test results when using the filter have shown excellent GPS data quality at antenna separations of ~30 m. Determining what impact the filter has on GLONASS and Galileo observations will require further testing. This filter has been deployed at several new polar sites where it was required to colocate Iridium communications with a newer GNSS enabled receiver.



Above: Gain vs. frequency for a Trimble GPS Choke Ring antenna LNA compared with a Trimble GNSS Choke Ring LNA. The bandwidth of the newer GNSS choke ring has been increased to improve the tracking of GNSS signals. **Right:** A custom cavity-type notch filter designed to mitigate the interference caused by Iridium communication transmissions.



Above: Gain (dB) vs. frequency (MHz) measurements for three different Device Under Test (DUT) combinations. 1) Reactel custom cavity-type notch filter. 2) Low Noise Amplifier (LNA) from a Trimble GNSS Choke Ring antenna. 3) Trimble LNA + the Reactel notch filter. Dashed black lines indicate the L5, L2 and L1 GPS frequencies. The dashed blue lines show the frequency band used by Iridium communications for up linking to a satellite. The notch filter has <0.5 dB insertion loss at the L1, L2 and L5 frequencies, and has a greater >20 dB rejection at 1616-1626.5 MHz.

Web sites:
http://facility.unavco.org/kb/questions/675

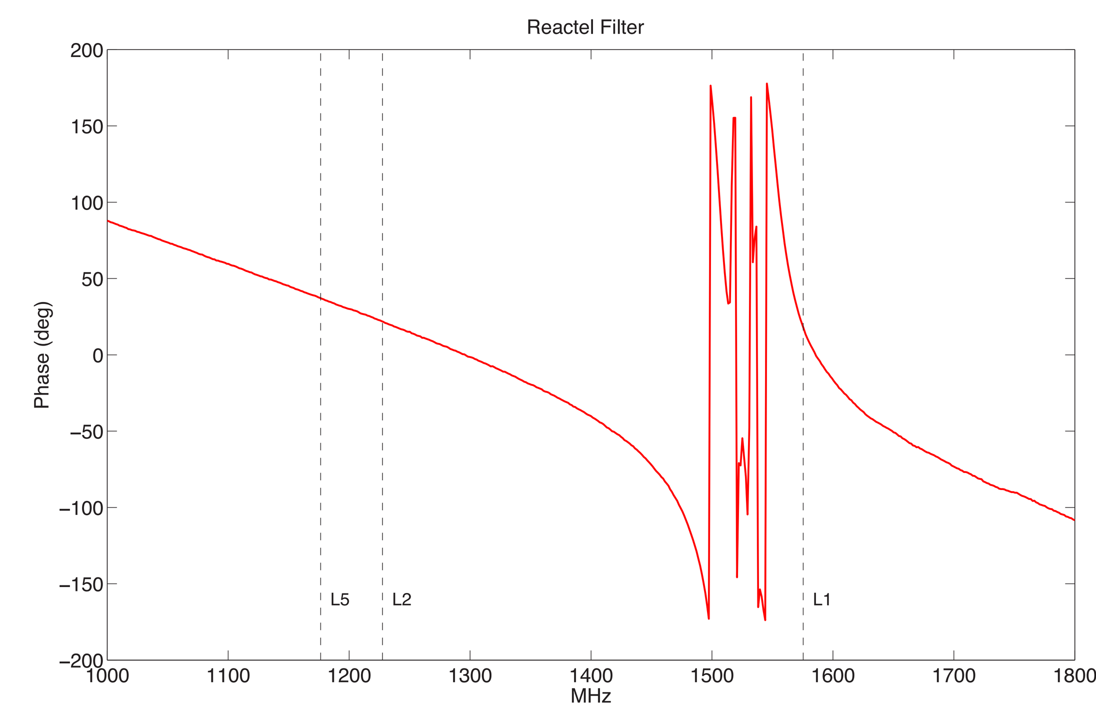
Other Sources of Potential Near-band Interference

The recent (Jan. 26, 2011) Federal Communications Commission Order and authorization giving LightSquared conditional approval to build out a ground-based cellular network may affect the quality of high-precision GPS measurements made near LightSquared's terrestrial network towers in the future. In response to this new potential source of near-band RF interference , UNAVCO has sought out testing of new RF mitigation methods for our current GNSS equipment pool. In this preliminary investigation we tested a cavity-type notch filter that is designed to have a >30dB rejection for the 1525-1535 MHz band ("The Lower Ten").

To evaluate the impact of using a cavity-type notch filter in-line between an antenna and a receiver we tried two test configurations. First, we collected a 24-hour zero-length baseline session from two receivers which share the same antenna via a splitter. The cavity-type notch filter was placed between the splitter and one of the receivers. Using TRACK, a kinematic GPS processing software, we processed the zero-length baselines. We found that no significant bias was introduced in the zero-length baseline estimates when the cavity-type notch filter was placed in-line between the receiver and the antenna.

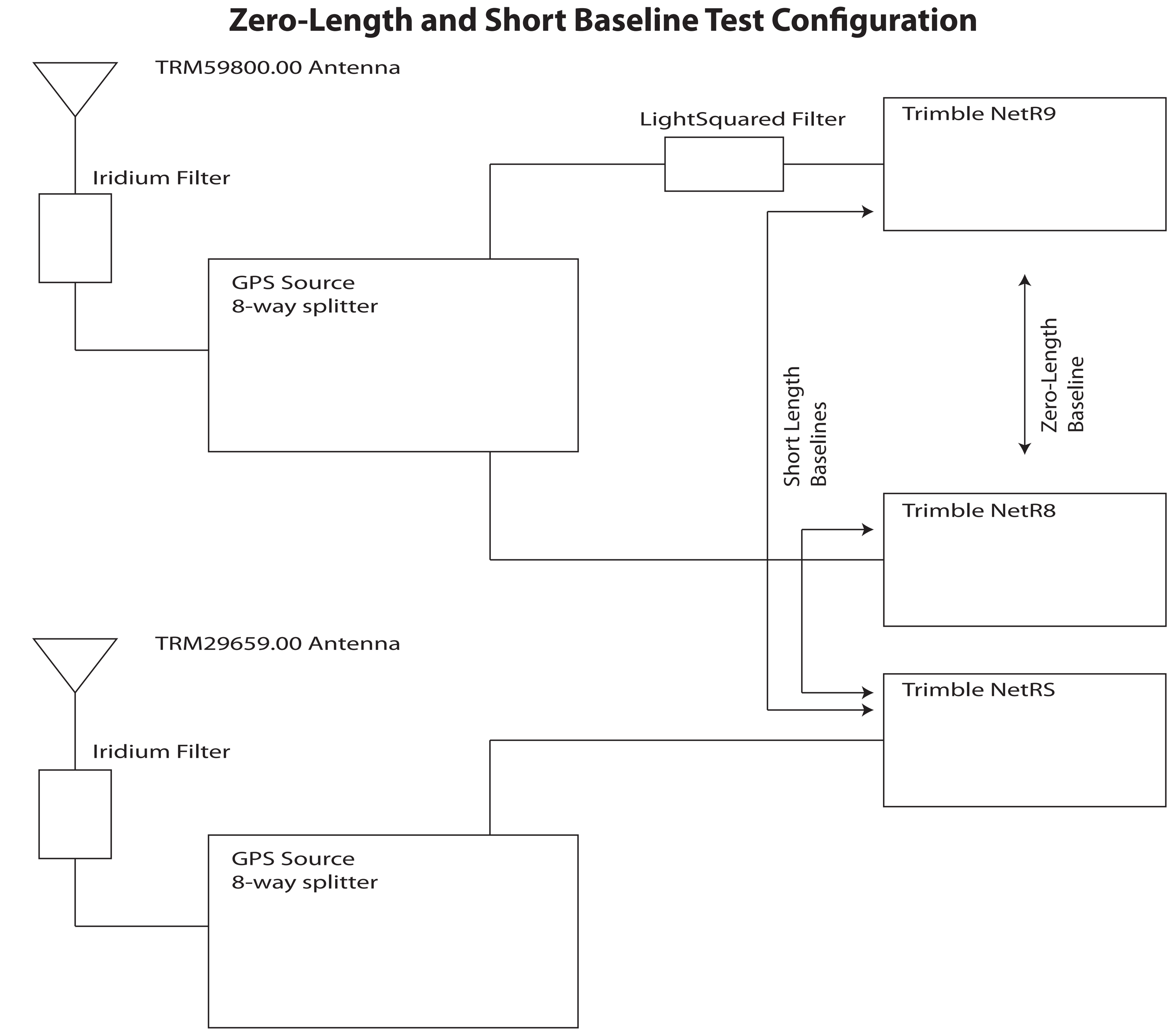
In the second test configuration, we processed multiple 24-hour short baseline sessions. We compared the estimated baselines between a reference receiver/antenna and two test receivers that shared an antenna via a splitter. Again, we found that no significant position estimate bias was introduced by inserting the notch filter between the antenna and the receiver. In future testing we intend to characterize the filters performance in the presence of LightSquared signals.

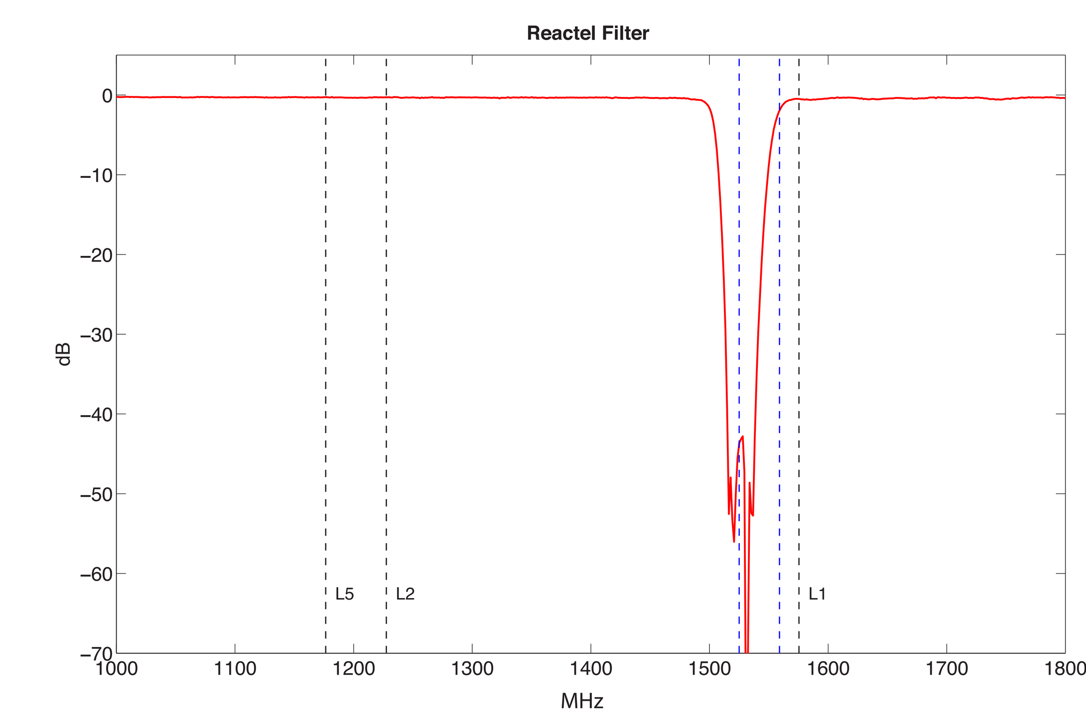
Note: Due to the presence of Iridium RF noise at our testing facility, we used a custom cavity-type notch filter designed to attenuate the Iridium RF band on all antenna outputs. Strong return reflections from a filter may interfere with proper operation of a powered splitter when placed in-line between a receiver and the splitter.



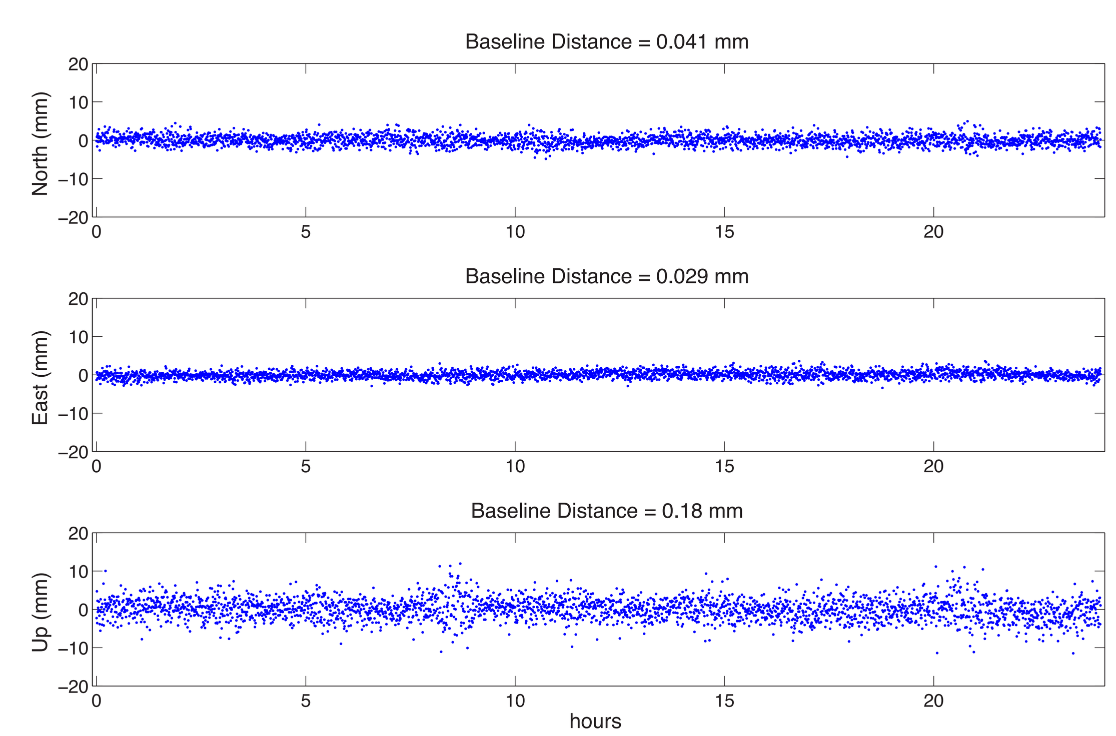
Above: Phase vs. frequency for the custom Reactel cavity-type filter. The center frequencies for L1, L2 and L5 are denoted with black dashed lines for reference.

Zero-Length and Short Baseline Test Configuration

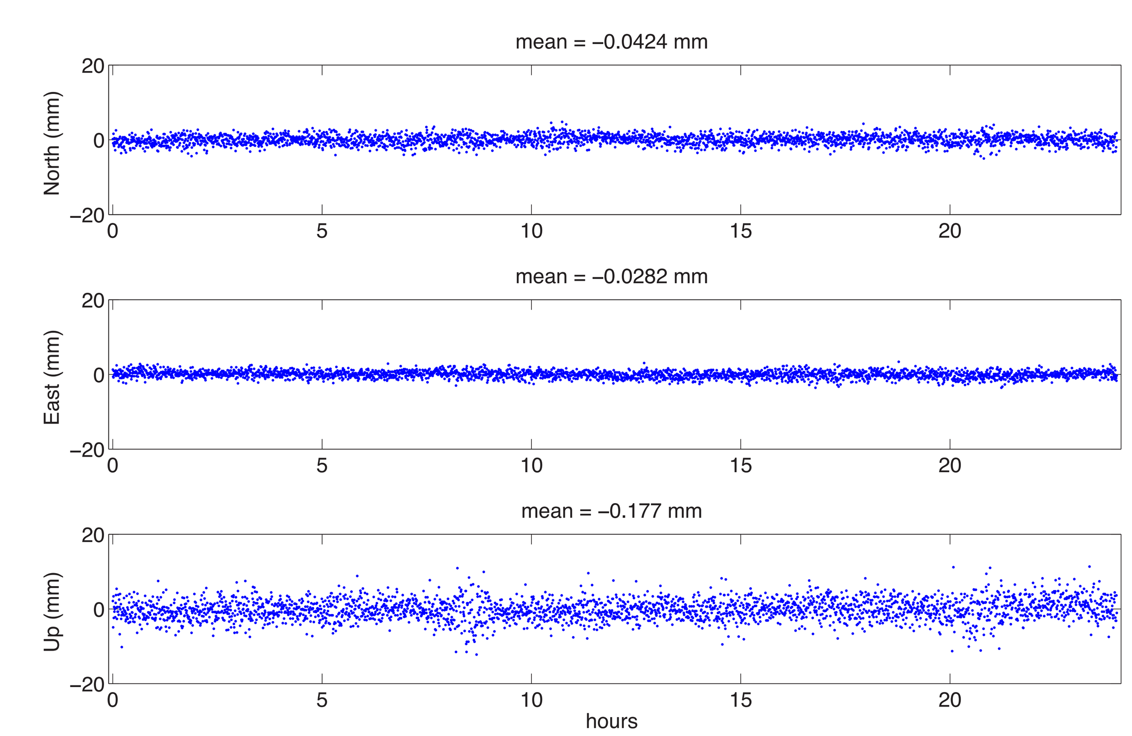




Above: Gain vs. frequency for a custom Reactel cavity-type filter. The blue dashed lines denote the frequency spectrum that would be occupied by LightSquared's ground based towers. The notch of the filter is currently aligned to attenuate the lower 10 MHz of LightSquared's spectrum. The center frequencies for L1, L2 and L5 are also shown with black dashed lines for reference.



Above: 24-hour zero-length baseline position estimates. The mean estimated position offset between receivers is <0.1 mm in the horizontal component and <0.2 mm in the vertical component. The kinematic GPS processing software TRACK was used to produce this baseline. 100% of the ambiguities were resolved.



Above: 24-hour difference between two short (<5 m) baseline estimates. The mean difference between the two baselines over this 24-hour period was <0.1 mm in the horizontal component and <0.2 mm in the vertical component.