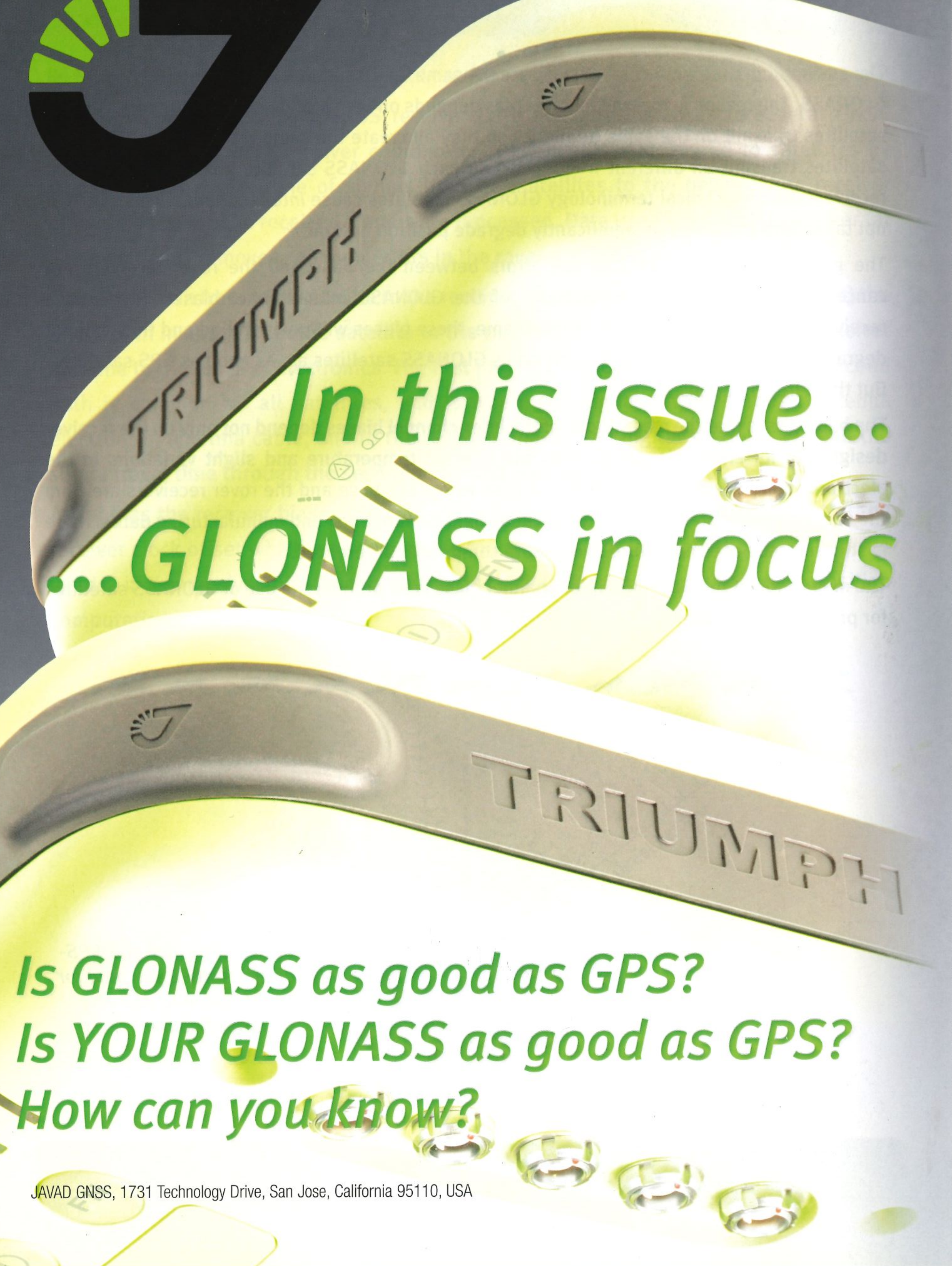


In this issue...

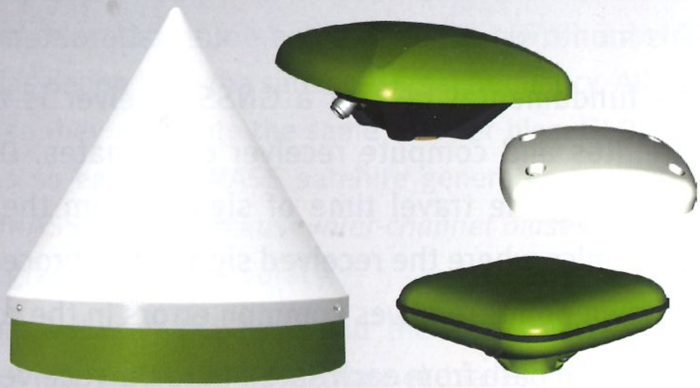
...GLONASS in focus

Is GLONASS as good as GPS?
Is YOUR GLONASS as good as GPS?
How can you know?

JAVAD GNSS, 1731 Technology Drive, San Jose, California 95110, USA

In Focus

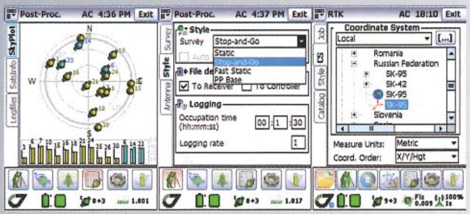
TRIUMPH-4X



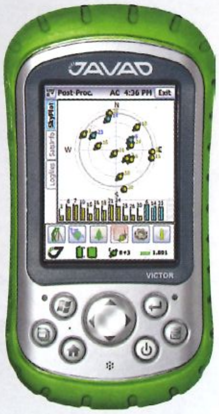
GrAnt, TriAnt, RingAnt,
GyrAnt,TyrAnt, AirAnt,

Modems

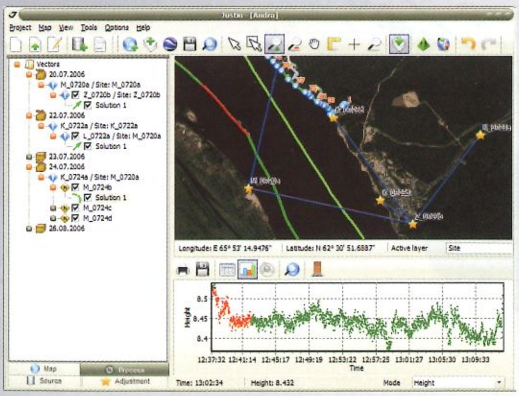
RTK Caddy and Umbrella



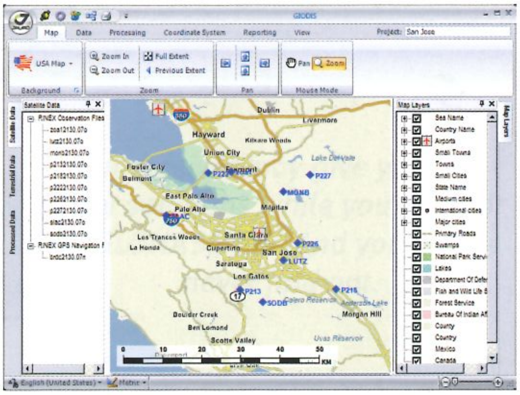
Tracy



Victor



Justin



Giodis

in the next issues

OEM Boards

We offer 7 OEM boards to cover the entire spectrum of precision applications and budgets. Each board is based on our TRIUMPH Technology implemented in our TRIUMPH Chip. For the first time in the GNSS history we offer up to 100 Hz RTK.

Each board includes the true Galileo option. We offer a FREE Galileo option for one year.

The on-board power supply on every OEM board accepts any voltage from +4.5 to +40 volts and delivers clean filtered voltage where needed. This eliminates the risk of power contamination (ripples) that can be created when clean power is generated elsewhere and delivered to the board via cables.

The CAN interfaces in each board are complete with all associated hardware and firmware, not just the CAN bus. The same is true with all the serial RS232/RS422 ports in our boards.

Each board also comes with large amount of flash for data storage. Each board also includes drivers for four LEDs, ON/OFF and function button controllers. Simply stated, additional functions are not need to incorporate any of our OEM boards.

In addition to timing strobes and event markers, each OEM boards also include the option of complete IRIG timing system.

We have been able to achieve tremendous advances in technology while reducing costs substantially. In the table below, we have summarized our features to allow you make a comparison. Simple features like 1-PPS and serial ports are not included in the table below but are present in all of our boards. In the table below, G2 means GPS+Galileo, G3 means GPS+Galileo+GLONASS, and the trailing T means triple frequency.

Features/Boards	TR-G2	TR-G3	TR-G2T	TR-G3T	TRE-G2T	TRE-G3T	TRE-G3TAJ
GPS L1	16	16	16	16	16	16	16
GPS L2/L2C	--	--	16	16	16	16	16
GPS L5	--	--	16	16	16	16	16
Galileo E1	16	16	16	16	16	16	16
Galileo E5A	--	--	16	16	16	16	16
GLONASS L1	--	16	--	16	--	16	16
GLONASS L2	--	--	--	16	--	16	16
SBAS	4	4	4	4	4	4	4
IBIR	--	--	--	--	--	--	Yes
Fast acquisition channels	110K	110K	110K	110K	110K	110K	110K
Ethernet	--	--	--	--	Yes	Yes	Yes
Complete CAN	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Button/LED support	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IRIG timing system	Yes	Yes	Yes	Yes	Yes	Yes	Yes
On-board Flash (MB)	128	128	128	256	4,000	4,000	4,000
4.5-to-40V Power supply	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hardware Viterbi	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size (mm)	40x55	57x66	57x66	57x88	100x80	100x80	100x80

Duo and Quattro... The Two- and The Four-in-One Boards

Quattro-G3D is a 100x160 mm Euro-card board that accepts inputs from up to four antennas. It is equivalent of four receivers which operate synchronously with a common oscillator and central processor to coordinate all communications and other activities. One of the receivers (the main) tracks 14 each of GPS L1/L2, GLONASS L1/L2 and Galileo E1. This receiver can perform long baseline RTK in conjunction with a base. The other three receivers each track 14 each of GPS L1/L2, and Galileo E1 and along with the main one can provide attitude (orientation) solutions.

Dual frequency GPS alone can provide very fast and reliable orientation solutions due to very short antenna separations (about one meter) and the fact that typical applications are in open fields. The main GPS+GLONASS L1/L2 unit can help in providing long baseline RTK solution.

Duo-G2D is a 100x80 mm half Euro-card board that accepts inputs from up to two antennas. It is equivalent of two receivers which operate synchronously with a common oscillator and central processor to coordinate all communications and other activities, and is ideal for heading applications. Each of the two receivers track 14 each of GPS L1, GPS L2, and Galileo E1.

100 Hz RTK, Duo, Quattro

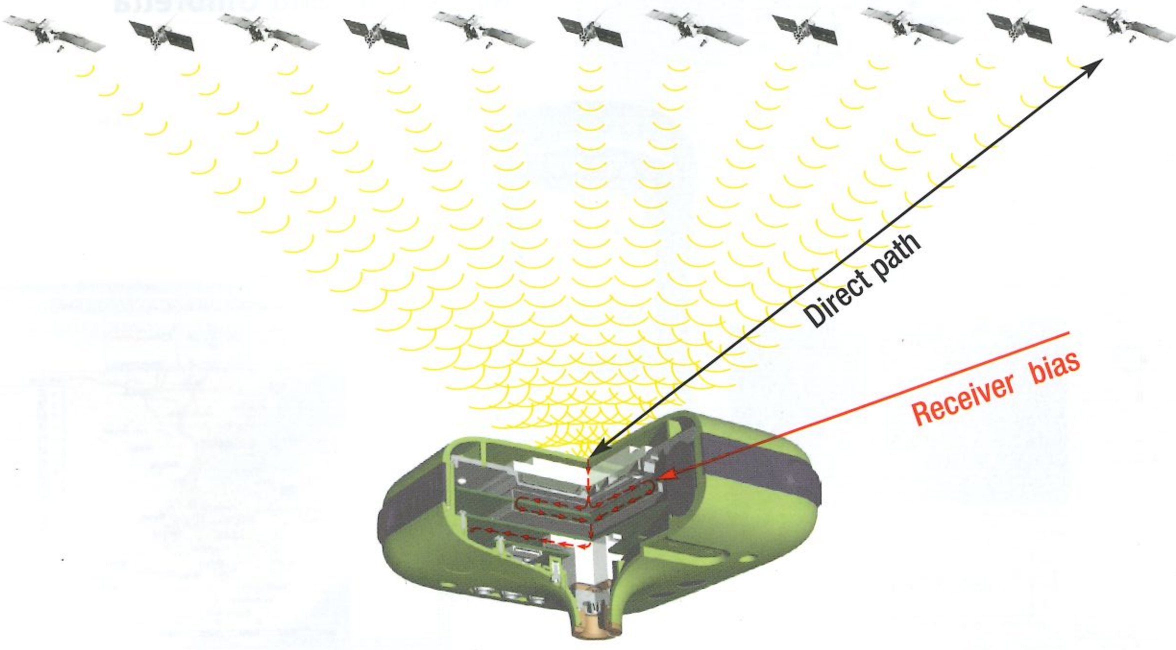
RECEIVER BIASES

This month we will examine a potential problem with GPS + GLONASS receivers.

The fundamental task of a GNSS receiver is to measure distances to several GNSS satellites and compute receiver coordinates. Distances are measured to satellites by measuring the travel time of signals from the satellites to the heart of the receiver electronics where the received signals are processed. Data used from a base receiver (at a known point) removes common errors in the rover and yields accurate results.

The signal path from each satellite to the receiver electronics consists of two parts: **1) the direct path in space from the satellite to the receiver antenna,** and **2) from the receiver antenna to the receiver electronics**. The first path is unique to each satellite. The second path is common for all satellites, and is where the signal travels through antenna electronics, antenna cable, and to the receiver analog and digital sections. **We call the signal travel time through the second path "the receiver bias."**

As long as the receiver bias is the same for all satellites, it acts as a component of the receiver clock offset which we solve as the fourth unknown (along with x, y, z). In other words, if the receiver bias is the same for all satellites it does not impact position computations.



FROM ANTENNA TO INSIDE RECEIVER

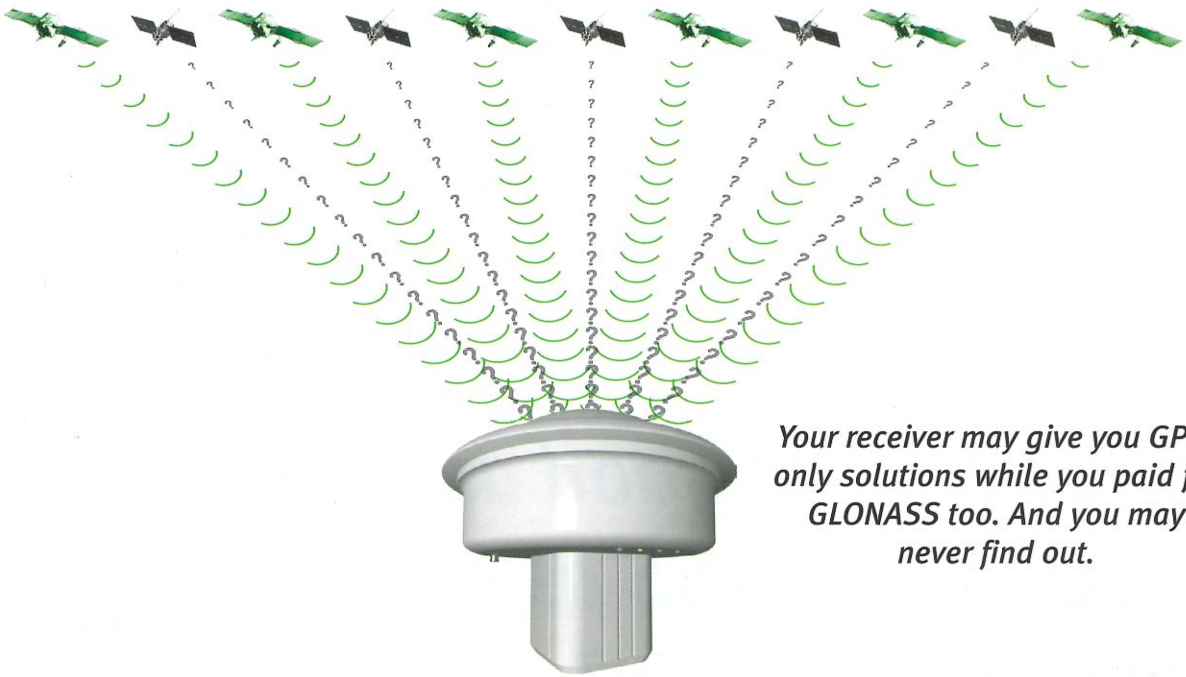
GLONASS INTER-CHANNEL BIASES

The assumption that the receiver biases are the same for all satellites is true for GPS but not for GLONASS. The reason is that the receiver bias depends on the satellite signal frequency. All GPS satellites transmit on the same frequency so they all create the same receiver bias. GLONASS satellites transmit on different frequencies so each GLONASS satellite generates a different receiver bias. In technical terminology GLONASS satellites cause *inter-channel biases* which, if not taken into account, can significantly degrade position accuracy.

The good news is that all common errors between the base and the rover receivers are cancelled. Therefore, if the magnitudes of the GLONASS inter-channel biases in the base receiver and in the rover receiver are the same, these biases will be cancelled and they will not degrade the position accuracy. In such cases GLONASS satellites act as good as GPS satellites. But this rarely happens.

The bad news is that the magnitudes of the inter-channel biases depend not only on the receiver design and its electronic components but also on temperature and slight variations in the electronic components. Even in the best case where the base and the rover receivers are from the same manufacturer and have identical design, components, and manufacturing dates, there is still the issue of temperature and minute component differences.

The magnitude of the GLONASS inter-channel biases can prohibit the use of GLONASS satellites for precision applications.



Your receiver may give you GPS-only solutions while you paid for GLONASS too. And you may never find out.

A CHALLENGE, NOT A PROBLEM

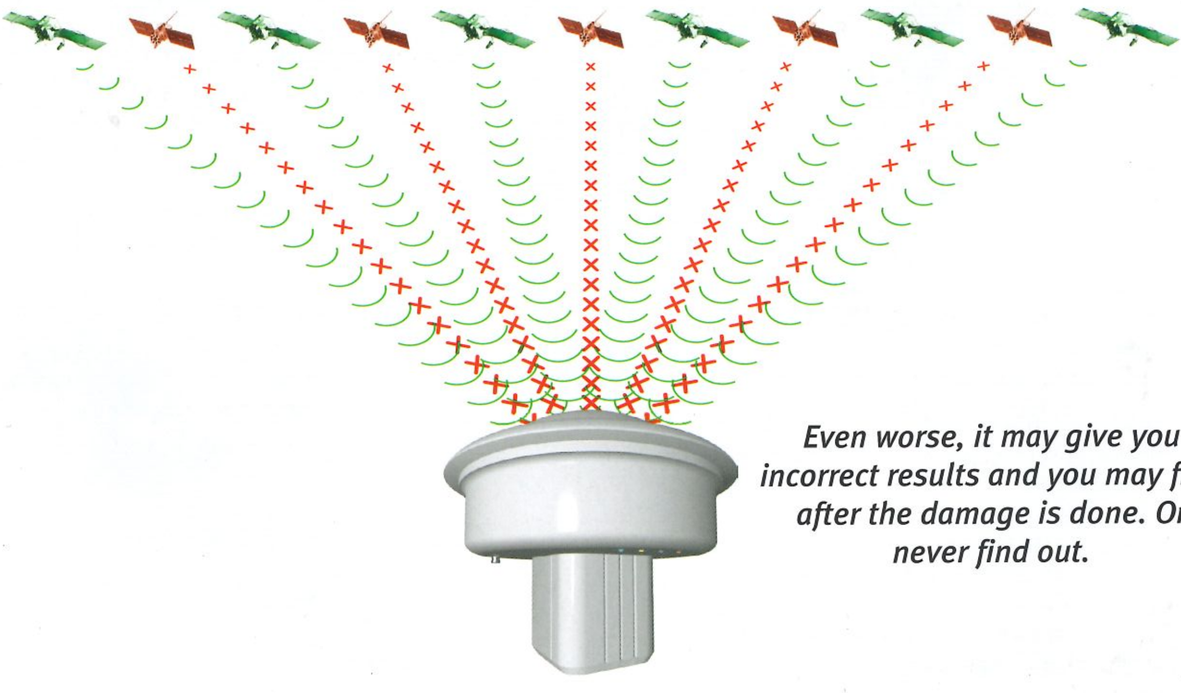
DEALING WITH GLONASS BIASES

When the objective is to achieve centimeter and sub-centimeter accuracy, dealing with GLONASS inter-channel biases is not an easy task. This may be the reason why, until recently, most manufacturers had avoided GLONASS for so many years.

Currently, **some manufacturers simply ignore the GLONASS inter-channel biases** and assume that customers use identical receivers as base and rover. In the early years we did the same and since we were the only GPS + GLONASS manufacturer, all receivers had similar inter-channel biases. When the inter-channel biases were noticeable we used GPS + GLONASS to resolve ambiguities (fix the integers) and then ignored GLONASS measurements or significantly de-weighted them. Even in such cases we found significant improvement over the GPS-only usage.

With some receivers, when the inter-channel biases between the base and the rover become intolerable, the receiver firmware ignores the GLONASS satellites and provides solutions based on GPS satellites only! Dealing with the problem in this manner does not allow the customer to know why his GPS+GLONASS receiver does not show any improvement over GPS-only receivers. Such receivers are still in use. When the receiver firmware cannot isolate the GLONASS satellites with high inter-channel biases it provides inaccurate results. This is a serious problem which causes the user to accept faulty results as the truth.

Some manufacturers try to measure the GLONASS inter-channel biases in a sample of pre-production receivers and hardcode these biases into the firmware. This is a positive step forward but by no means can cure the problem because there are still differences between electronic components and their characteristic vary by temperature and time.



Even worse, it may give you incorrect results and you may find after the damage is done. Or never find out.

ALL GLONASS RECEIVERS ARE NOT THE SAME

CONTINUOUS GLONASS CALIBRATION

We calibrate all GLONASS inter-channel biases in every receiver continuously and in real-time with an accuracy of ±0.1 millimeter. We have designed and implemented special patent-pending hardware inside the TRIUMPH chip to achieve this. This real-time calibration is done in the background without any impact on the normal use of the receiver.

The bottom line is that we have made GLONASS as good as GPS and offer you a lot more satellites to do your job faster and more accurately, even in adverse conditions. Our TRIUMPH receiver has 216 channels to track all GPS, GLONASS, and Galileo signals and to cover your needs now and well into the future.

Is your GLONASS as good as GPS? Ask the manufacturer of your receiver how this is handled. It might impact past or future observations. And as you know, many times past observations (e.g. construction) cannot be re-made. GLONASS and GPS, with tens of billions of dollars of investment, is up there for free. Used in combination wisely, they can provide a real advantage and improve your bottom line.

With 0.1 millimeter automatic, real-time self calibration, now we offer you 44 (more later) GPS-like satellites instead of 30.

OUR GLONASS IS AS GOOD AS GPS

The future is not what it used to be

A few decades ago, companies like AT&T, Ford, IBM, General Electric, Standard Oil, Pan American, J.P. Morgan, and others were making five, ten, even twenty-year plans. The future was predictable. But now companies adjust their plans several times a year and still get shocking surprises. The future is not what it used to be. In many respects, it is no longer predictable.

To transmit signals, GPS uses CDMA (Code Division Multiple Access) and GLONASS uses FDMA (Frequency Division Multiple Access). Simply put, all GPS satellites use the same frequency while broadcasting different codes, while GLONASS satellites use the same code but on different frequencies. In previous pages we explained how we had to work harder to make GLONASS as good as GPS for precision applications. Why such a drastic difference between GPS and GLONASS? The answer is that the difference was not drastic until surveyors showed up! When GPS and GLONASS were on the drawing boards, no one had a clue that these systems could be used for millimeter-level accuracy and that the precise community would be potential users. With GPS we just got lucky. With GLONASS we have had to work harder to achieve comparable accuracies.

Don't feel bad. More than 90% of today's users were not part of the intended user-crowd. Even then the future for the satellite usage was not predictable. Cell phones did not exist and car navigation was not on the horizon. Well after the initial GPS satellites were launched, scientists at JPL thought of using the GPS carrier phase for accurate measurements. Before then, accuracy of ±ten meters was the best that could be hoped for and even that was reserved for military applications. In 1983, at an Institute of Navigation conference, I presented a paper — along with a homemade video clip — showing that GPS could be used for street navigation. A senior vice president of Rockwell borrowed the clip to show to the U.S. Congress and in return I got a tour of the fabulous Rockwell rocket facilities.

In early proposals, thought was given to applying a user-fee to each piece of GPS equipment. Later, it was decided that the cost of collecting user fees would be more than the actual money collected. Even today I am eager to see the calculations for this conclusion! With hindsight, we see today that the number of users are in the hundreds of millions and the companies from which to collect the user-fees number less than 100.

Don't worry, it is too late to change the user-fee policy, and with GPS being free Galileo will not be able to charge either!

In such a volatile and unpredictable world we should salute all those who gave the FREE gift of GPS to the world, which after 30 years, is still a marvel. Equally, we should be thankful to the creators of GLONASS, and we should encourage the Galileo authorities to follow the same well-proven and beneficial path.

There are many rumors regarding the "relationship" between GPS and GLONASS. One says that the Russians "copied" the U.S. GPS and Space Shuttle programs. We all know that in the 1950s the Russians jumped ahead of U.S. in space by launching "Sputnik", the first satellite. When following the location of Sputnik from known locations, U.S. scientists quickly realized that satellites could be used in the reverse role: if the orbit of the satellite was known the location of the user could be determined. Another rumor says Russian scientists were well aware of the use of satellites for navigation but could not get funding from their military because, according to Russian intelligence, there was not such a program in the US military at that time! Whether these rumors are true or not, the fact is that today the cooperation of bright minds is helping users all around the world.

Back to the CDMA vs. FDMA discussion. The Russians are seriously considering employing CDMA techniques for future generations of GLONASS satellites. I have been privileged to participate in some of the discussions between Russian and U.S. scientists to make both systems more interoperable. Many people on both sides of the globe are working hard to make this happen. I do not wish to give false hope; if such a switch happens, the operational GLONASS CDMA satellites will not appear any time soon. And meanwhile, we have found a perfect solution for handling GLONASS biases while keeping the clear advantage of more satellites in the sky.

Until the next issue
Regards,
Javad

Javad Ashjaee