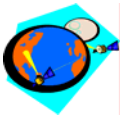
--------------Unit Two--------------

THE GPS AND GPRS SYSTEMS

There are two systems that the ***Prism TM2*** uses outside of the Teletrac system. One is the Global Positioning System, more commonly called GPS and the other is the General Packet Radio System otherwise known as GPRS. The following pages will give you a basic introduction to where these systems came from as well as how they work. At the end of this section will be a summary of how Teletrac uses these two systems together to get the location of a vehicle.

GLOBAL POSITIONING SYSTEMS (GPS)

The following information was taken from information posted to the Teletrac Intranet. Included here is the abridged version of GPS. The full text appears in Appendix A at the end of this Information Guide.



AN INTRODUCTION TO GLOBAL POSITIONING SATELLITE SYSTEMS

Global Positioning Systems

GPS uses "man-made stars" or satellites as reference points to calculate positions on Earth accurate to within meters. In fact, with advanced forms of GPS you can make measurements to better than a centimeter. In a sense, it's like giving every square meter on the planet a unique address.

Since GPS receivers have been miniaturized to just a few integrated circuits and have become very economical, the technology has become increasingly accessible.

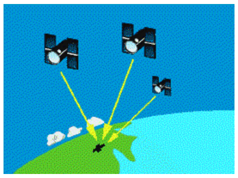
Here's how GPS works in five logical steps:

Here is a summary of each of the steps involved with GPS in order to determine a location. This is the first part of Teletrac finding the locations of vehicles using a ***Prism TM2***. Once a location is determined then it is sent via another system. We'll explain each of the following points in the next five sections.

1. The basis of GPS is "triangulation" from satellites.
2. To "triangulate," a GPS receiver measures distance using the travel time of radio signals.
3. To measure travel time GPS needs very accurate timing, which it achieves with some tricks.

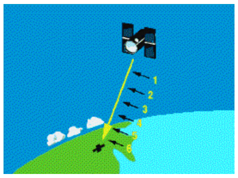
4. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.
5. Finally you must correct for any delays the signal experiences as it travels through the aTM2osphere.

Step 1: Triangulating from Satellites



Improbable as it may seem, the whole idea behind GPS is to use satellites in space as reference points for locations here on earth. That's right, by very, very accurately measuring our distance from three satellites we can "triangulate" our position anywhere on earth.

Step 2: Measuring Distance from a Satellite



But how can you measure the distance to something that's floating around in space? We do it by timing how long it takes for a signal sent from the satellite to arrive at our receiver.

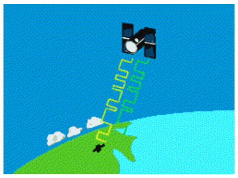
The Big Idea, Mathematically

In a sense, the whole thing boils down to those "velocity times travel time" math problems we did in high school. Remember the old: "If a car goes 60 miles per hour for two hours, how far does it travel.?"

Velocity (60 mph) x Time (2 hours) = Distance (120 miles)

In the case of GPS we're measuring a radio signal so the velocity is going to be the speed of light, or roughly 186,000 miles per second.

Step 3: Getting Perfect Timing



If measuring the travel time of a radio signal is the key to GPS, then our stop watches had better be darn good because if their timing is off by just a thousandth of a second, at the speed of light, that translates into almost 200 miles of error!

The secret to perfect timing is to make an extra satellite measurement.

That's right, if three perfect measurements can locate a point in 3-dimensional space, then four imperfect measurements can do the same thing.

EXTRA MEASUREMENT CURES TIMING OFFSET

If everything were perfect (i.e. if our receiver's clocks were perfect) then all of our satellite ranges would intersect at a single point (which is our position). But with imperfect clocks, a fourth measurement, done as a cross-check, will NOT intersect with the first three.

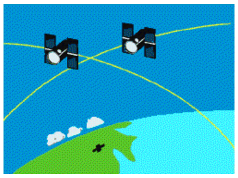
So the receiver's computer says "Uh-oh! There is a discrepancy in my measurements. I must not be perfectly synced with universal time."

Since any offset from universal time will affect all of our measurements, the receiver looks for a single correction factor that it can subtract from all its timing measurements that would cause them all to intersect at a single point.

That correction brings the receiver's clock back into sync with universal time, and bingo! - you've got atomic accuracy time right in the palm of your hand.

Once it has that correction it applies to all the rest of its measurements, and now we've got precise positioning.

Step 4: Knowing Where a Satellite is in Space



On the ground all GPS receivers have an almanac programmed into their computers that tells them where in the sky each satellite is, moment by moment.

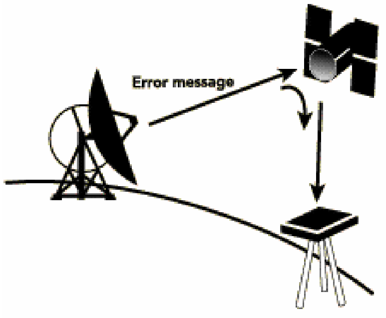
CONSTANT MONITORING ADDS PRECISION

The basic orbits are quite exact but just to make things perfect, the GPS satellites are constantly monitored by the DeparTM2ent of Defense.

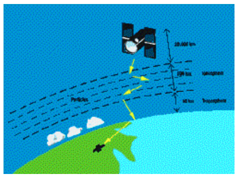
They use very precise radar to check each satellite's exact altitude, position and speed.

Getting the Message Out

Once the DoD has measured a satellite's exact position, they relay that information back up to the satellite itself. The satellite then includes this new corrected position information in the timing signals it's broadcasting.



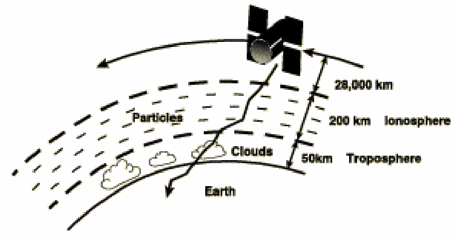
Step 5: Correcting Errors



Rough Trip through the ATM2osphere

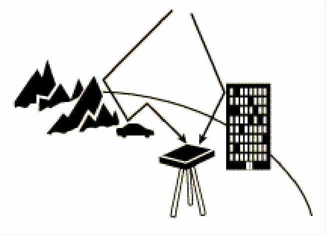
First, one of the basic assumptions we've been using throughout this tutorial is not exactly true. We've been saying that you calculate distance to a satellite by multiplying a signal's travel time by the speed of light. But the speed of light is only constant in a vacuum.

As a GPS signal passes through the charged particles of the ionosphere and then through the water vapor in the troposphere it gets slowed down a bit, and this creates the same kind of error as bad clocks.



ROUGH TRIP ON THE GROUND

Trouble for the GPS signal doesn't end when it gets down to the ground. The signal may bounce off various local obstructions before it gets to our receiver.



This is called multipath error and is similar to the ghosting you might see on a TV. Good receivers use sophisticated signal rejection techniques to minimize this problem.

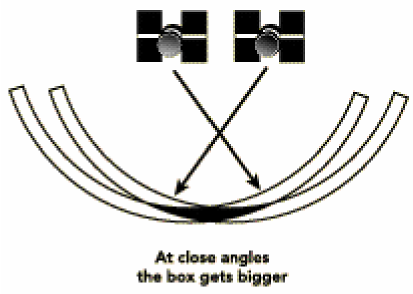
PROBLEMS AT THE SATELLITE

The atomic clocks they use are very, very precise but they're not perfect. Minute discrepancies can occur, and these translate into travel time measurement errors.

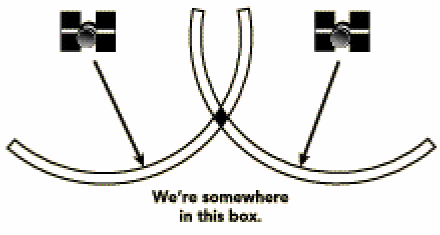
SOME ANGLES ARE BETTER THAN OTHERS

There are usually more satellites available than a receiver needs to fix a position, so the receiver picks a few and ignores the rest.

If it picks satellites that are close together in the sky the intersecting circles that define a position will cross at very shallow angles. That increases the gray area, or error margin, around a position. Commonly refered to as HDOP.



If it picks satellites that are widely separated, the circles intersect at almost right angles and that minimizes the error region.



Intentional Errors!

As hard as it may be to believe, the same government that spent $12 billion to develop the most accurate navigation system in the world can cause errors by intentionally degrading its accuracy. The policy is called "Selective Availability" or "SA" and the idea behind it is to make sure that no hostile force or terrorist group can use GPS to make accurate weapons.

Basically the DoD introduces some "noise" into the satellite's clock data which, in turn, adds noise (or inaccuracy) into position calculations. The DoD may also be sending slightly erroneous orbital data to the satellites which they transmit back to receivers on the ground as part of a status message.

Together these factors make SA the biggest single source of inaccuracy in the system. Military receivers use a decryption key to remove the SA errors and so they're much more accurate.

Note: As of Spring 2000, the DoD eliminated the intentional error in the calculation, however, this may come back at any time.

The Bottom Line

Fortunately, all of these inaccuracies still don't add up to much of an error, and a form of GPS called "Differential GPS" can significantly reduce these problems.

GPRS

The second system used by the ***Prism TM2*** is the General Packet Radio System, more commonly called GPRS. This system is meant to be an invisible link from a mobile unit, such as a wireless modem, to land line systems. The next few pages will give you an introduction to GPRS and how it works to transmit information.

The following information was taken from information posted to
http://www.rysavy.com/Articles/GPRS2/gprs2.hTM2l and
http://www.geocities.com/mobile4g/gprs.hTM2l.

AN INTRODUCTION TO GENERAL PACKET RADIO SERVICE

What is GPRS?

GPRS offers packet-switched connections to data networks via mobile technology. It is designed to allow faster and easier Internet access with continuous connectivity, and enables applications including multimedia messaging, wireless corporate intranet, remote control and maintenance of appliances. It is also considered part of the migration to third generation (3G) mobile networks. The advantages of GPRS technology allows users to stay connected to the Internet by using packet switching technology, providing faster downloads as no time is spent attempting to access a dial-up connection.

How does GPRS work?

GPRS transports packets between mobile devices and packet networks. Packets can be IP or X.25, though with the Internet's popularity, operators and device vendors will probably emphasize IP. Mobile devices will have an IP address, either static or dynamic, and, once on the network, IP packets can originate from mobile devices and travel to external networks, such as the Internet or privately connected intranets. IP packets from external networks will reach mobile devices, even when moving. GPRS doesn't care what protocols operate above IP. This indifference enables all standard Internet protocols to operate, including TCP, UDP, HTTP, Secure Sockets Layer (SSL), and IPSec.

GPRS uses two essential new infrastructure elements, the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). The SGSN, which connects to base-station controllers, tracks the mobile station's location and sends data packets to and from the mobile station. It forwards packets using a tunneling protocol to the GGSN, which acts as a gateway to external networks, such as the Internet or private intranets. An operator will have multiple SGSNs for different service areas, but needs only one GGSN for each external network it interconnects with. The GGSN assigns IP addresses to mobile stations, and IP packets from external networks route to the GGSN, which tunnels them to the appropriate SGSN for delivery to the mobile station.

Architecture and protocols are fine, but how do users actually connect to the network and send data, and how does the network keep track of users as they move around? When users turn on the GPRS device (GPRS PC Card modem) in a GPRS coverage area, the device first registers with the network and then requests a Packet Data Protocol (PDP) context. The PDP context activates an IP address for the device, generally a dynamic address assigned by the GGSN. At this stage the device can send and receive data.

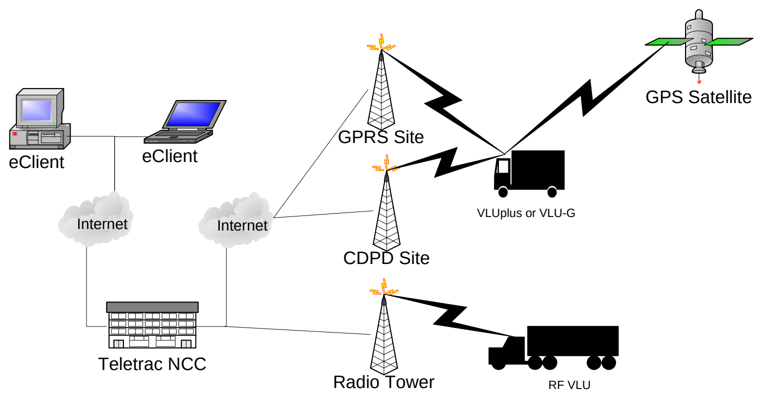
To actually send a packet of data, the device makes requests using a packet random-access channel. Channels are logical data paths consisting of predefined time slots in select GPRS radio channels, and are the primary mechanism in the MAC layer. The network responds by assigning a data-traffic channel for a temporary period sufficient to send the data packet. GPRS networks use 200KHz radio channels, with each channel divided into eight time slots. Each time slot can support 13Kbits/sec of throughput in today's networks (though options exist to increase data rates to over 20Kbits/sec), and so actual user throughput will depend on the number of time slots a user's device can handle and the particular service options from the carrier.

To support mobility, the GPRS device informs the SGSN when it's within a new base station's coverage range. If the user travels out of one SGSN's coverage to another, then the old SGSN and the new SGSN must collaborate and inform the GGSN of the user's new location. Users will also be able to roam into networks operated by other GPRS carriers.

THE OVERALL TELETRAC PICTURE

Now that you have an understanding of GPS and GPRS, let’s talk about how Teletrac uses these systems in order to provide location and messaging services to our customers. In Unit One we talked about the components that make up the ***Prism TM2***, now let’s talk about how those components work together.

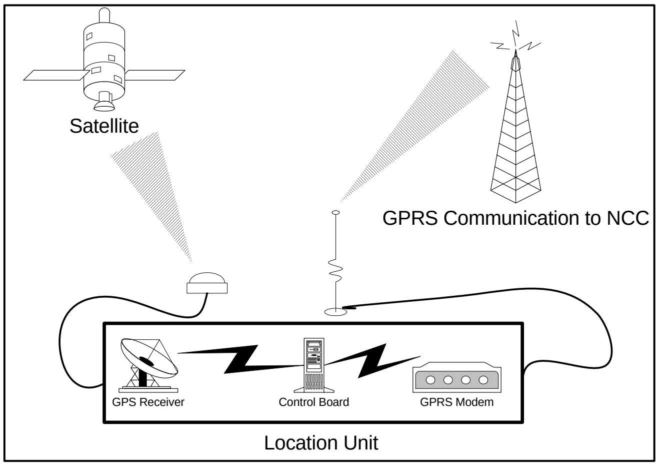
As shown in the diagram, a computer running eClient connects to the Teletrac NCC via the Internet. The NCC is where all the customer databases are stored and where customer location requests are processed. From there, the NCC contacts the customer’s vehicles via the Internet. The vehicles that use



The three types of location systems Teletrac uses

GPS to determine their location send that information directly to the NCC and it is in turn sent back to the eClient workstation.

The GPS receiver built into the ***Prism TM2*** works to determine the location of itself. As long as the receiver is able to see enough satellites it can tell the ***Prism TM2*** where it is. If a vehicle drives into an underground garage, inside a warehouse or even under an overpass, the receiver may not be able to see enough, if any, satellites to determine it's location. Since the signals coming from the satellites to the receiver are very low they can easily be blocked, even dense cloud cover can reduce the actual signal.



The GPS receiver will determine its location every few seconds and store the information. When the ***Prism TM2*** Controller is contacted through the GPRS modem, the Controller contacts the GPS receiver and a request is made for its location at a certain time. Once the Controller receives the location information from the GPS receiver, it relays the locate to the Teletrac NCC via the GPRS modem. Even if the GPRS modem cannot be contacted by the NCC, the GPS receiver is still collecting the information on where it is located. When the GPRS modem is able to communicate with the NCC, the ***Prism TM2*** will download the location information that the GPS receiver has been providing.

Now, lets say your driver is taking a lunch break under the awning of a drive-up restaurant. In this location the GPS receiver probably cannot see enough satellites to determine it's location. In this event, when the controller requests a locate from the GPS receiver, the last known location will be used. Since the receiver takes it's own readings every few seconds the last known location is probably just outside the restaurant awning. When it's time to send in a locate to the NCC, the ***Prism TM2*** can still "pick up" the GPRS modem and contact the NCC. But, the only location that will be returned is the last known location reported to the ***Prism TM2*** Controller, which was probably just outside the awning. This location will be reported as a poor quality locate and display as the last known location.

Even though the GPS receiver is blocked, a dispatcher can still send messages to a driver. Since the messages travel over the GPRS system they will be sent to the ***Prism TM2*** and simply a poor locate (last known location) will be returned to the dispatcher.

Lastly, the ***Prism TM2*** can be set up to store events such as ignition on/off, messages and location information when the GPRS modem is out of it's coverage area. The events, messages and locations can be stored in a memory buffer and later transmitted once the modem is able to communicate. See the following chart to help explain what happens when each system is able to operate or is blocked.