Bharathidasan University

Tiruchirappalli, Tamil Nadu

Programme: M. Tech Geoinformatics

Course: Global Navigation Satellite System (GNSS)

Title: GNSS Applications

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GNSS Applications

Application:-

It is impossible to describe all GNSS applications. While we will highlight some consumer applications of this technology, our focus will be on commercial applications in various industries, including:

- Transportation
- Machine Control
- Surveying
- Port Automation

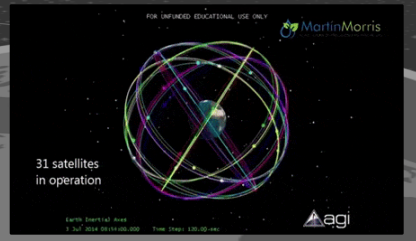
GNSS receivers are now routinely integrated into mobile communications equipment, to support applications that display maps showing the location of and best route to stores and restaurants.

Portable navigation devices can give drivers directions on road or off.

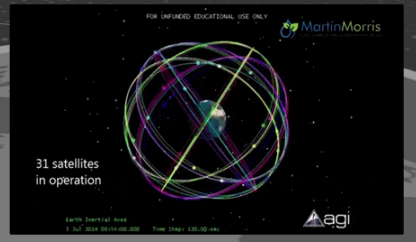
Geocaching is an outdoor activity in which participants use a GNSS receiver to hide and seek containers (called “geocaches” or “caches”) around the world.

Currently, most GNSS consumer products are based on GPS, but this will change as more GNSS constellations are implemented.

TRANSPORTATION



In rail transportation, GNSS is used in conjunction with other technologies, to track the location of locomotives and rail cars, maintenance vehicles and wayside equipment, for display at central monitoring consoles. Knowing the precise location of rail equipment reduces accidents, delays, and operating costs, enhancing safety, track capacity, and customer service.

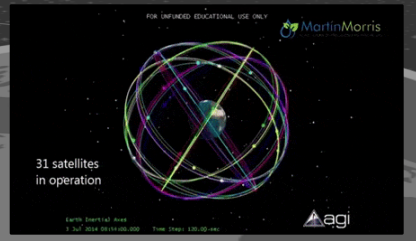


In aviation, GNSS is being used for aircraft navigation from departure, en route, to landing. GNSS facilitates aircraft navigation in remote areas that are not well served by ground-based navigation aids, and it is a significant component of collision-avoidance systems, and of systems used to improve approaches to airport runways.

Refer to “Wide Area Augmentation System (WAAS)”, US system that delivers GPS corrections and a certified level of integrity to the US aviation industry, enabling aircraft to conduct varying levels of precision approach to airports.

In marine transportation, GNSS is being used to accurately determine the position of ships.

MACHINE CONTROL



GNSS technology is being integrated into equipment such as bulldozers, excavators, graders, pavers and farm machinery to enhance productivity in the real-time operation of this equipment, and to provide situational awareness information to the equipment operator. The adoption of GNSS-based machine control is similar in its impact to the earlier adoption of hydraulics technology in machinery, which has had a profound effect on productivity and reliability.

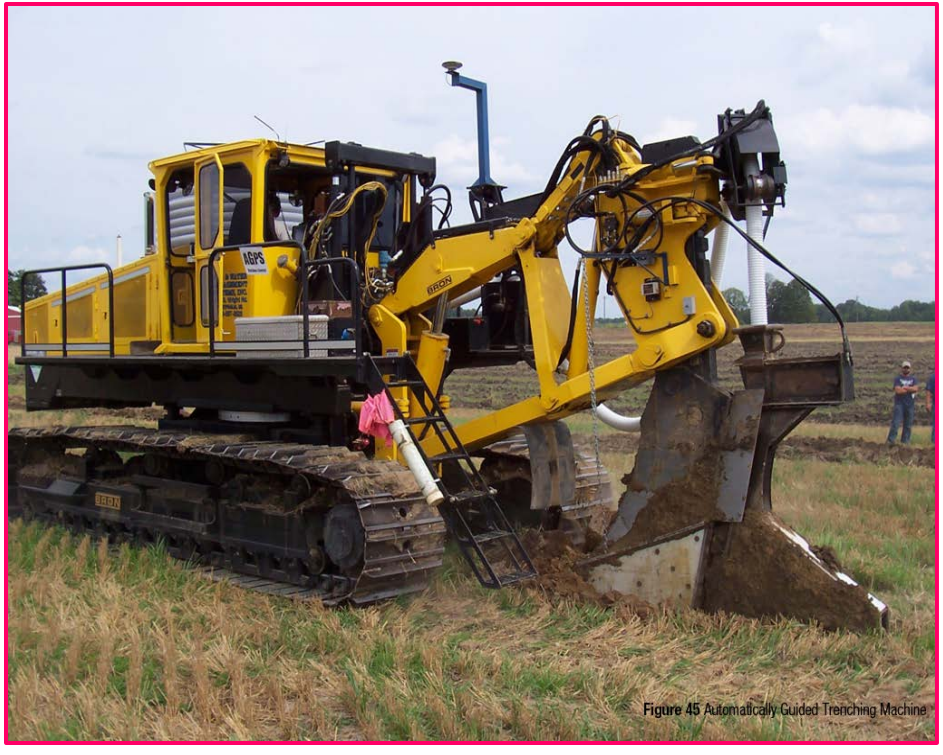
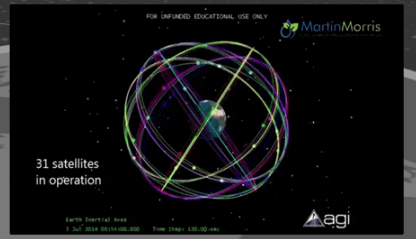


Figure 45 Automatically Guided Trenching Machine

AGRICULTURE

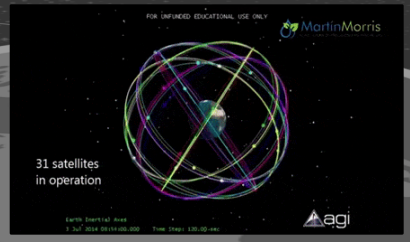


Many companies have recognized the significant challenges of farming and have developed sophisticated GNSS applications to make farming easier and more efficient.

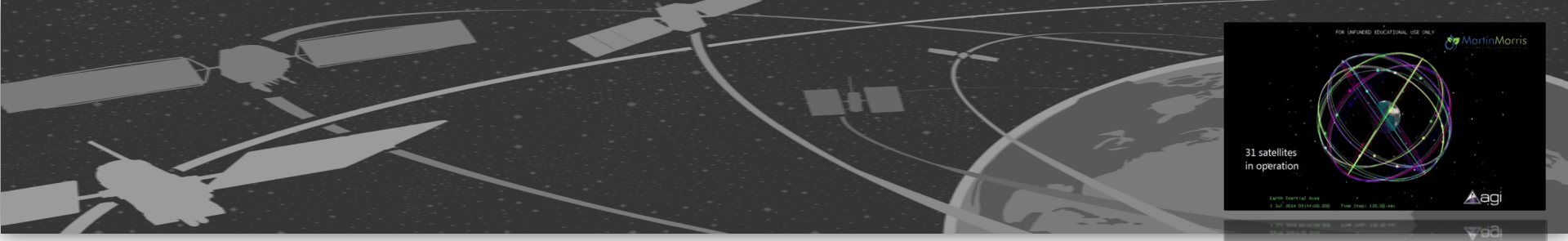
In precision agriculture, GNSS-based applications are used to support farm planning, field mapping, soil sampling, tractor guidance, and crop assessment. More precise application of fertilizers, pesticides and herbicides reduces cost and environmental impact. GNSS applications can automatically guide farm implements along the contours of the earth in a manner that controls erosion and maximizes the effectiveness of irrigation systems.

Figure 46 Precisely Aligned Crop Rows Planted by GNSS-guided Machinery

CONSTRUCTION

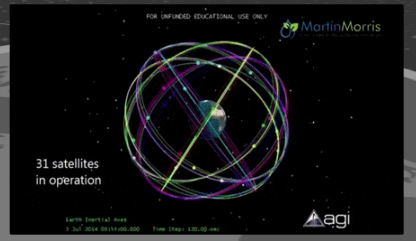


GNSS information can be used to position the cutting edge of a blade (on a bulldozer or grader, for example) or a bucket (excavator), and to compare this position against a 3D digital design to compute cut/fill amounts.



1. “Indicate systems” provide the operator with visual cut/fill information, via a display or light bar, and the operator manually moves the machine's blade or bucket to get to grade.
2. Automatic systems for bulldozers/graders use the cut/fill information to drive the hydraulic controls of the machine to automatically move the machine's blade to grade.
3. Use of 3D machine control dramatically reduces the number of survey stakes required on a job site (each stake costs time and money).
4. Productivity studies have repeatedly shown that the use of 3D machine control results in work being completed faster, more accurately and with significantly less rework than conventional construction methods.

MARINE APPLICATIONS

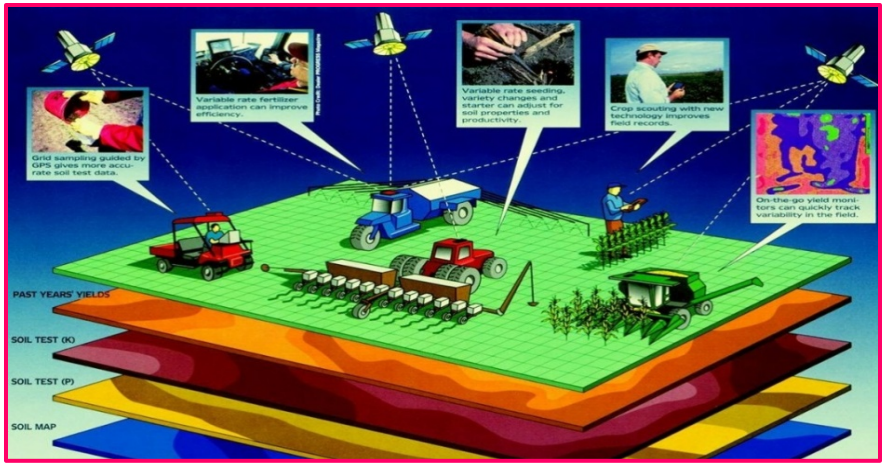


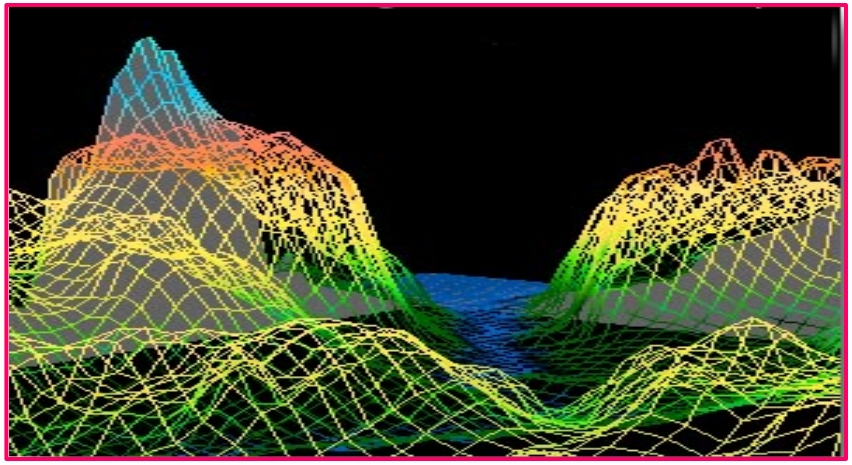
In the Foreword, we discussed the challenges that early explorers had determining their position when at sea. With the advent of GNSS, these problems have largely disappeared.

In addition to dramatically improving marine navigation, GNSS is also being applied to a broad range of marine applications, such as oilrig positioning, underwater cable and pipeline installation and inspection, rescue and recovery, and the dredging of ports and waterways.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

A geospatial information system (GIS) captures, stores, analyzes, manages, and presents data that is linked to location. The data may consist of, for example, environmental or resource data. GIS is also used to map attributes for insurance companies, municipal planning, utility companies, and others. The positions associated with the data can be provided from a GNSS receiver. GIS applications can generate detailed contour maps from the data and present these maps in a digital form.



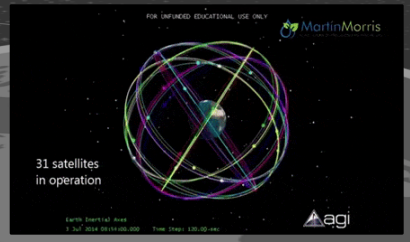


DEFENCE

The defence sector makes broad use of GNSS technology, including:

• Navigation: Using GNSS receivers, soldiers and pilots can navigate unfamiliar terrain or conduct nighttime operations. Most foot soldiers now carry handheld GNSS receivers.

• Search and Rescue: If a plane crashes and that plane has a search and rescue beacon that is equipped with a GNSS receiver, it may be possible to more quickly locate it.

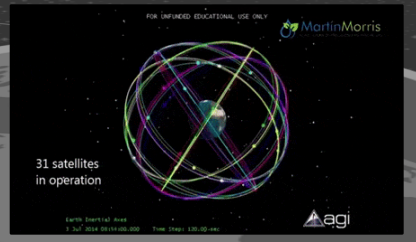


1. Reconnaissance and Map Creation: The military uses GNSS to create maps of uncharted or enemy territory. They can also mark reconnaissance points using GNSS.

2. Unmanned Vehicles: Unmanned vehicles are used primarily for reconnaissance, but they can also be used for logistics, target and decoy, and research and development.

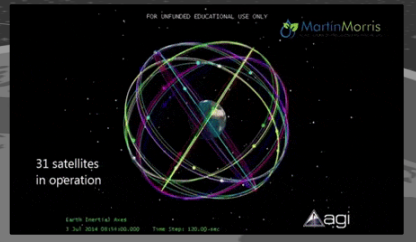
3. human control, whether radio controlled or automatically guided by a GNSS-based application. UAVs can be used to scout territory in unsecured airspace and in contaminated areas. Mission coordinates may be predefined and corrections may be sent to keep the UAV on a specific tack

TIMING



1. In addition to longitude, latitude, and altitude, the GNSS provides a critical fourth dimension – time. Each GNSS satellite contains multiple atomic clocks that contribute very precise time data to the GPS signals.
2. GNSS receivers decode these signals, effectively synchronizing each receiver to the atomic clocks. This enables users to determine the time to within 100 billionths of a second, without the cost of owning and operating atomic clocks.
3. Precise time is crucial to a variety of economic activities around the world. Communication systems, electrical power grids, and financial networks all rely on precision timing for synchronization and operational efficiency. The free availability of GPS time has enabled cost savings for companies that depend on precise time and has led to significant advances in capability.
4. For example, wireless telephone and data networks use GPS time to keep all of their base stations in perfect synchronization. This allows mobile handsets to share limited radio spectrum more efficiently.

MISUSES OF GPS



1. A Global Positioning System (GPS) is a network of satellites that provides location information to many common devices such as smartphones, car navigation systems, and laptop computers.
2. The satellite information allows these devices to be located on a map. There are many different types of devices that use GPS technology and GPS can be extremely useful for tasks like finding nearby establishments or getting directions to an unknown location.
3. For all of the positive uses of GPS, the expanded use of GPS-enabled devices has also increased the inappropriate use of technology to monitor or track a person's location.
4. GPS monitoring can also lawfully be used in many ways – for example, a parent may monitor the whereabouts of a minor child or a judge may order that someone on probation be monitored through a GPS device.
5. However, as GPS technology has become cheaper and more advanced, small and easily hidden devices can include GPS technology and make it harder to know which devices have tracking capabilities, enabling abusers to misuse the technology to track your location. For example, nearly all cellphones now have GPS technology that could be misused by an abuser to gain access to information about where you are and where you have been.

How can an abuser misuse GPS technology?

1. Because domestic violence is about one person seeking power and control over another person, an abuser may misuse GPS technology to try to gain or keep control over you.
2. For example, an abuser could use GPS to learn where you have been, and then misuse this information against you. Because GPS-enabled devices can be so small and easily hidden, an abuser could hide a device in your belongings or car.
3. The GPS in your phone could also be used to track you. Your location information through the GPS in your phone is not automatically available to another person, but there are a variety of ways that an abuser could get that information. Some examples of how that information could be accessed is if an abuser shares a cell phone plan with you, if s/he can access your cell phone account, or if s/he has another way of accessing your information, such as through spyware, downloaded apps, or when your devices are synced to the "cloud" or your computer.
4. An abuser may use this technology as a way to stalk you or to maintain power and control over you by not allowing you to have any privacy or autonomy.

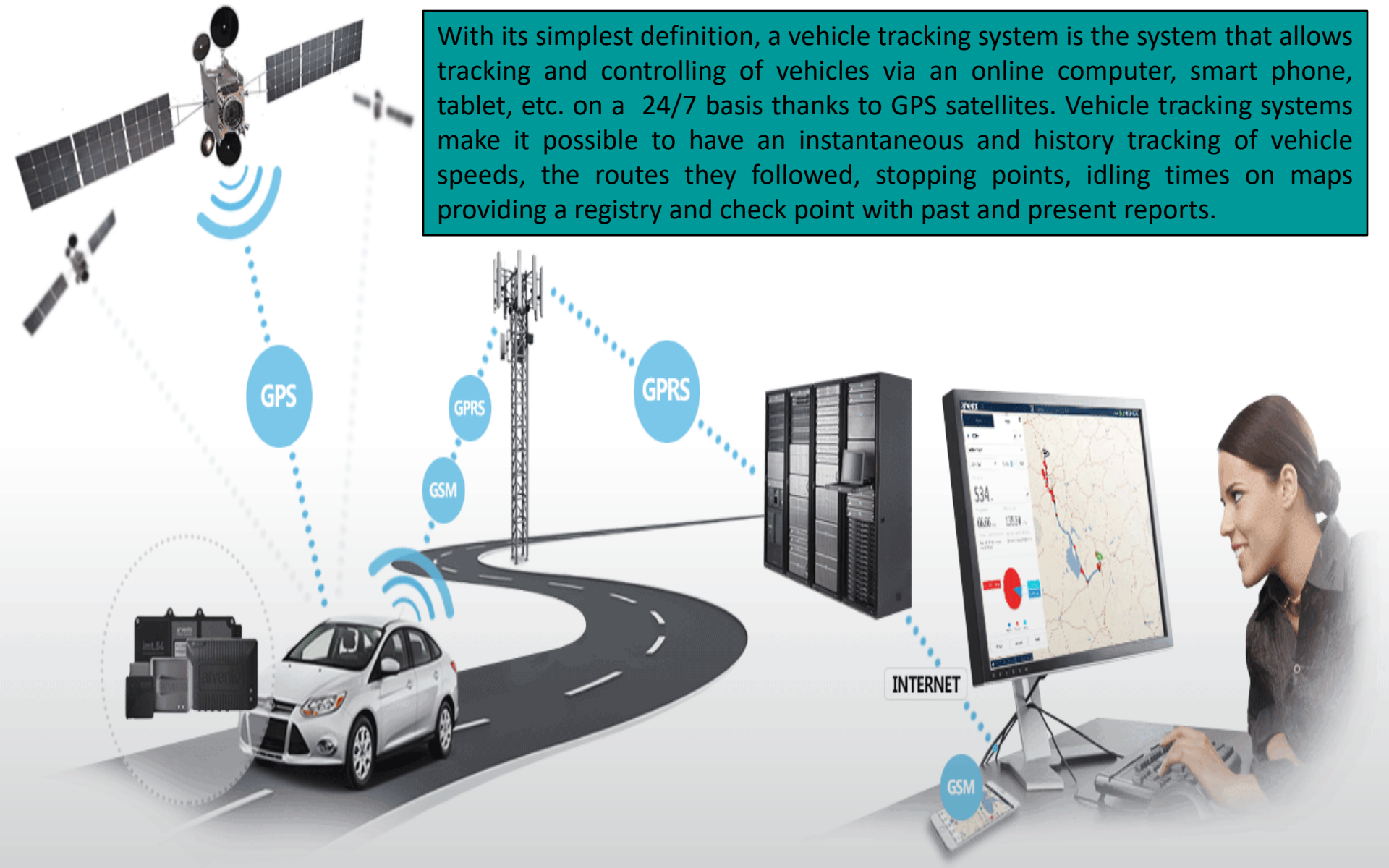
What laws can protect me from GPS monitoring?

1. Some states may have laws that specifically protect you from having a tracking device installed on your property without your consent. If the abuser tampered with your personal technology devices (e.g., cell phone, tablet, etc.), there may also be state laws that protect you, such as interference or tampering with an electronic communications device.
2. Depending on the language of your state's laws, stalking, harassment, or cyberstalking laws may protect you from this behavior as well.
3. Additionally, electronic surveillance laws may also apply to a situation where an abuser is monitoring or tracking you. Many of these laws are not specifically focused on domestic violence, so when speaking to the police, an advocate, or an attorney, it may be a good idea to suggest that they look at the computer crimes or privacy laws within your state.

How A GPS Vehicle Tracking System Can Help Prevent Misuse of Your Movable Assets

1. A GPS tracking device is a simple solution that you can use to prevent any kind of misuse on your car or vehicle.
2. A recent survey has revealed a startling fact – cars are often misused by third-party drivers without any knowledge of the owner. With a help of a tracker, you can avoid any misuse of your vehicle and also bring about a reduction in extra expenditures.
3. The device will help you – the owner – to track the speed, location, as well as the idle status of your movable assets day and night apart from giving you insights into a number of other details.
4. A GPS vehicle tracking solution will give you numerous benefits in terms of helping track driver behavior, saving money, and improving the overall vehicle life.
5. Drivers tend to be more careful and punctual when they are aware that a vehicle is fitted with a tracker. And when your driver is careful in all respects on the road, it can only help you save money in the long run!

With its simplest definition, a vehicle tracking system is the system that allows tracking and controlling of vehicles via an online computer, smart phone, tablet, etc. on a 24/7 basis thanks to GPS satellites. Vehicle tracking systems make it possible to have an instantaneous and history tracking of vehicle speeds, the routes they followed, stopping points, idling times on maps providing a registry and check point with past and present reports.



How does the Vehicle Tracking System work?

1. Basically, the vehicle tracking systems work in a loop of GPS, GSM/GPRS, digital maps and special software.
2. Mobile data devices mounted on vehicles transmit two pieces of information they get from satellites – real-time when the satellite information was transmitted and position of the satellite in orbit at the time of transmission - and transmit telemetric information such as temperature to control and communication centers via the GSM/GPRS network.
3. Information received as such are then compiled to special software and recorded in a databank on servers.
4. On the user side, vehicles can be tracked on their instantaneous and history records via a computer or a smartphone/tablet by using special software making it possible to visualize all information from vehicles, and to modify alarms and program statuses of vehicles. This structure forms the basis for functioning of the vehicle tracking

Type:

Cruise Missile
Ballistic Missile

Launch Mode:

Surface-to-Surface Missile
Surface-to-Air Missile
Surface (Coast)-to-Sea Missile
Air-to-Air Missile
Air-to-Surface Missile
Sea-to-Sea Missile
Sea-to-Surface (Coast) Missile
Anti-Tank Missile

Range:

Short Range Missile
Medium Range Missile
Intermediate Range Ballistic Missile
Intercontinental Ballistic Missile

Propulsion:

Solid Propulsion
Liquid Propulsion
Hybrid Propulsion
Ramjet
Scramjet
Cryogenic

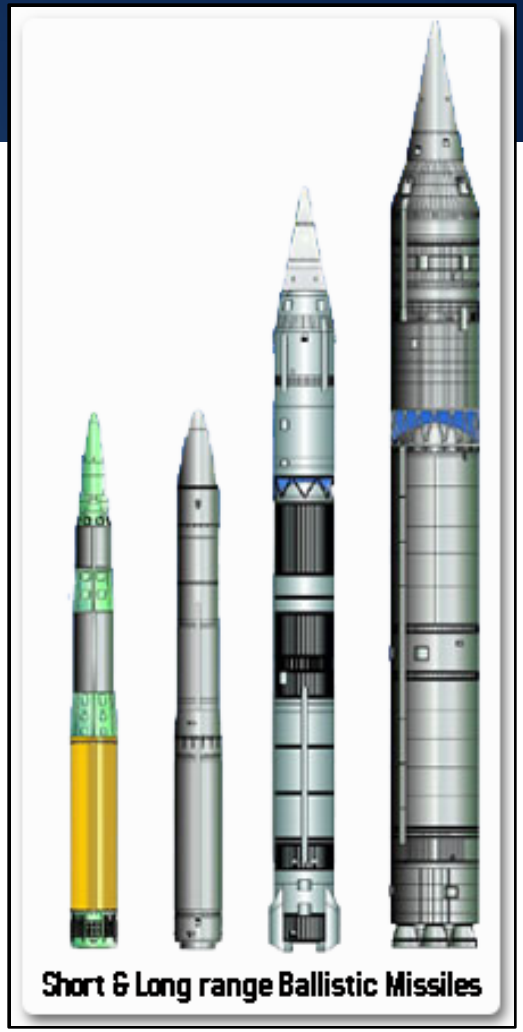
Missiles are generally classified on the basis of their Type, Launch Mode, Range, Propulsion, Warhead and Guidance Systems.

Warhead:

Conventional
Strategic

Guidance Systems:

Wire Guidance
Command Guidance
Terrain Comparison Guidance
Terrestrial Guidance
Inertial Guidance
Beam Rider Guidance
Laser Guidance
RF and GPS Reference


Short & Long range Ballistic Missiles

On the basis of Launch Mode:

(i) Surface-to-Surface Missile: A surface-to-surface missile is a guided projectile launched from a hand-held, vehicle mounted, trailer mounted or fixed installation. It is often powered by a rocket motor or sometimes fired by an explosive charge since the launch platform is stationary.

(ii) Surface-to-Air Missile: A surface-to-air missile is designed for launch from the ground to destroy aerial targets like aircrafts, helicopters and even ballistic missiles. These missiles are generally called air defence systems as they defend any aerial attacks by the enemy.

(iii) Surface (Coast)-to-Sea Missile: A surface (coast)-to-sea missile is designed to be launched from land to ship in the sea as targets.

(iv) Air-to-Air Missile: An air-to-air missile is launched from an aircraft to destroy the enemy aircraft. The missile flies at a speed of 4 Mach.

(v) Air-to-Surface Missile: An air-to-surface missile is designed for launch from military aircraft and strikes ground targets on land, at sea or both. The missiles are basically guided via laser guidance, infrared guidance and optical guidance or via GPS signals. The type of guidance depends on the type of target.

(vi) Sea-to-Sea Missile: A sea-to-sea missile is designed for launch from one ship to another ship.

(vii) Sea-to-Surface (Coast) Missile: A sea-to-surface missile is designed for launch from ship to land based targets.

(viii) Anti-Tank Missile: An anti-tank missile is a guided missile primarily designed to hit and destroy heavily-armoured tanks and other armoured fighting vehicles. Anti-tank missiles could be launched from aircraft, helicopters, tanks and also from shoulder mounted launcher.

On the basis of Guidance Systems :

(i) Wire Guidance: This system is broadly similar to radio command, but is less susceptible to electronic counter measures. The command signals are passed along a wire (or wires) dispensed from the missile after launch.

(ii) Command Guidance: Command guidance involves tracking the projectile from the launch site or platform and transmitting commands by radio, radar, or laser impulses or along thin wires or optical fibres. Tracking might be accomplished by radar or optical instruments from the launch site or by radar or television imagery relayed from the missile.

(iii) Terrain Comparison Guidance: Terrain Comparison (TERCOM) is used invariably by cruise missiles. The system uses sensitive altimeters to measure the profile of the ground directly below and checks the result against stored information.

(iv) Terrestrial Guidance: This system constantly measures star angles and compares them with the pre-programmed angles expected on the missile's intended trajectory. The guidance system directs the control system whenever an alteration to trajectory is required.

(v) Inertial Guidance: This system is totally contained within the missile and is programmed prior to launch. Three accelerometers, mounted on a platform space-stabilised by gyros, measure accelerations along three mutually perpendicular axes; these accelerations are then integrated twice, the first integration giving velocity and the second giving position. The system then directs the control system to preserve the pre-programmed trajectory. This systems are used in the surface-to-surface missiles and in cruise missiles.

(vi) Beam Rider Guidance: The beam rider concept relies on an external ground or ship-based radar station that transmits a beam of radar energy towards the target. The surface radar tracks the target and also transmits a guidance beam that adjusts its angle as the target moves across the sky.

(vii) Laser Guidance: In laser guidance, a laser beam is focused on the target and the laser beam reflects off the target and gets scattered. The missile has a laser seeker that can detect even miniscule amount of radiation. The seeker provides the direction of the laser scatters to the guidance system. The missile is launched towards the target, the seeker looks out for the laser reflections and the guidance system steers the missile towards the source of laser reflections that is ultimately the target.

(viii) RF and GPS Reference: RF (Radio Frequency) and GPS (Global Positioning System) are examples of technologies that are used in missile guidance systems. A missile uses GPS signal to determine the location of the target. Over the course of its flight, the weapon uses this information to send commands to control surfaces and adjusts its trajectory. In a RF reference, the missile uses RF waves to locate the target.

Intelligence collection augmentation with weapon system, integration into ballistic and cruise missile systems

Ballistic missiles are powered by rockets initially but then follow an unpowered, parabolic, free-falling trajectory toward their targets. They are classified by the maximum distance that they can travel, which is a function of how powerful the missile's engines (rockets) are and the weight of the missile's payload, or warhead. To add more distance to a missile's range, rockets are stacked on top of each other in a configuration referred to as staging.

There are four general classifications of ballistic missiles:

Short-range ballistic missiles

Intermediate range ballistic missiles

Medium -range ballistic missiles

Inter-continental ballistic missiles

1. Short-range ballistic missiles, traveling less than 1,000 kilometers (approximately 620 miles);
2. Medium-range ballistic missiles, traveling between 1,000–3,000 kilometers (approximately 620-1,860 miles);
3. Intermediate-range ballistic missiles, traveling between 3,000–5,500 kilometers (approximately 1,860-3,410 miles); and
4. Intercontinental ballistic missiles (ICBMs), traveling more than 5,500 kilometers.

Short-range ballistic missiles

Medium -range ballistic missiles

Intermediate range ballistic missiles

Inter-continental ballistic missiles

TARGET ACQUISITION

1. Satellite navigation has become very important for military target acquisition operations, reconnaissance, and weapon guidance systems.
2. Tracking of potential targets before they are declared hostile, is a requirement in modern military operations. A number of military systems use GNSS information to track the movement of these potential targets. This data is also collected to feed situation awareness systems and weapon systems.
3. Conventional weapon systems such as smart bombs and guided missiles use the acquired tracking information, enhanced by GNSS receivers information and other guidance

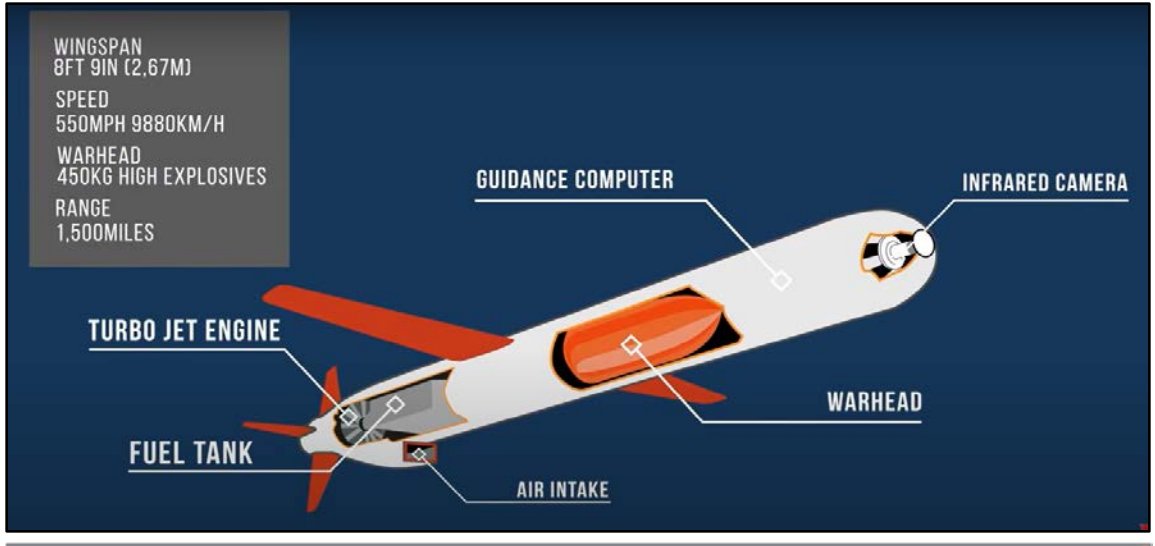
Military GPS Applications

1. Cruise missile is a generic term for self-propelled guided weapons which fly like normal aircraft for much of their flight.

2. Almost all cruise missiles now are outfitted with GPS for navigation.

3. Pentagon's favorite little toy.

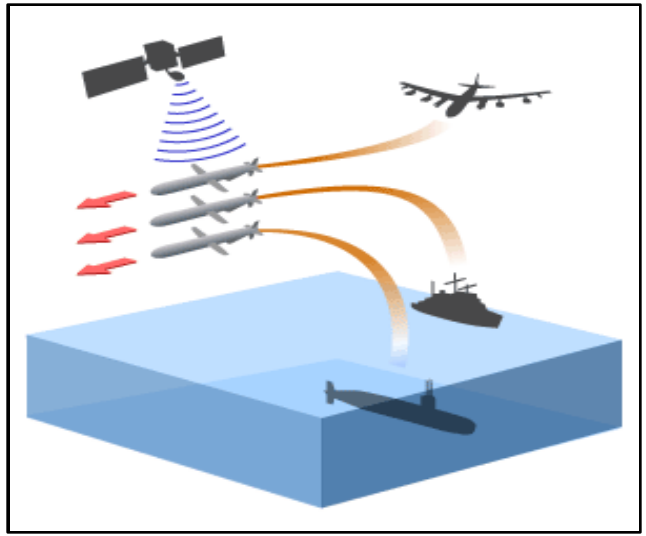
Tomahawks

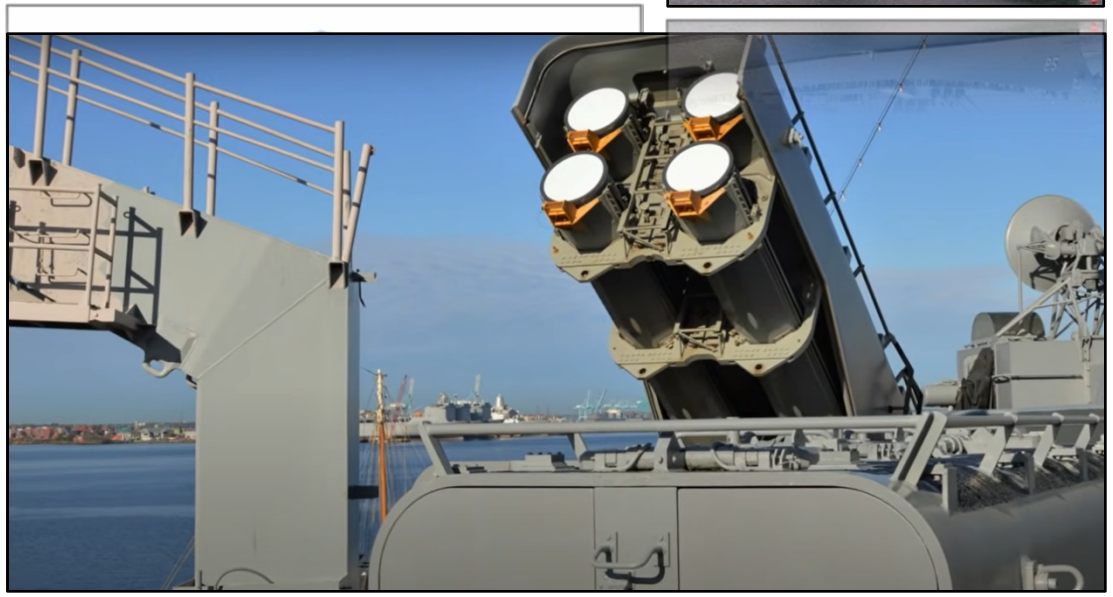


The Tomahawk Land Attack Missile (TLAM) is a long-range, all-weather, jet-powered, subsonic cruise missile that is primarily used by the United States Navy and Royal Navy in ship- and submarine-based land-attack operations.

Tomahawk – GPS' Job

1. Cruise missiles receive an initial thrust from a detachable booster before onboard systems take over.
2. Once airborne, it releases its wings and switches on navigational and communication systems.
3. The missile is guided at this early stage by GPS and onboard calculations based on its movements since launch.

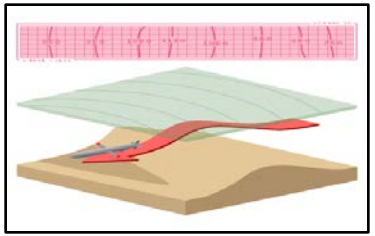




Tomahawk Guidance and control

1. The Tomahawk uses GPS navigation and a satellite data-link to continue through a pre-set course. The missile can be reprogrammed in-flight to a new target.
2. The two-way satellite communications are used to perform post-launch mission changes throughout the flight. The on-board camera provides imagery of the target to the commanders before the strike.
3. The guidance system is assisted by Terrain Contour Matching (TERCOM). The Digital Scene Matching Area Correlation (DSMAC) system or GPS provide terminal guidance.
4. The Tactical Tomahawk Weapons Control System (TTWCS) integrated within the ship's systems computes the path to engage targets. The system enables the planning of new missions on board the launch vessel.
5. TTWCS is also used to communicate with multiple missiles for reassigning the targets and redirecting the missiles in flight.
6. The Tomahawk missile is outfitted with advanced electronic support measure (ESM) seeker. Its joint multi-effects warhead enables the commander to control the blast.

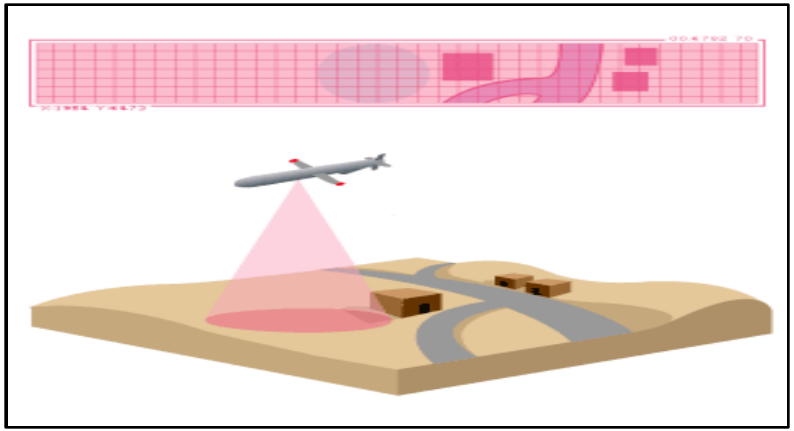
TERCOM



1. Terrain Contour Matching, or TERCOM, is a navigation system used primarily by cruise missiles.
2. It uses a pre-recorded contour map of the terrain that is compared to measurements made during flight by an on-board radar altimeter.
3. A TERCOM system considerably increases the accuracy of a missile compared to inertial navigation systems (INS).
4. The increased accuracy allows a TERCOM-equipped missile to fly closer to obstacles and generally lower altitudes, making it harder to detect by ground radar.

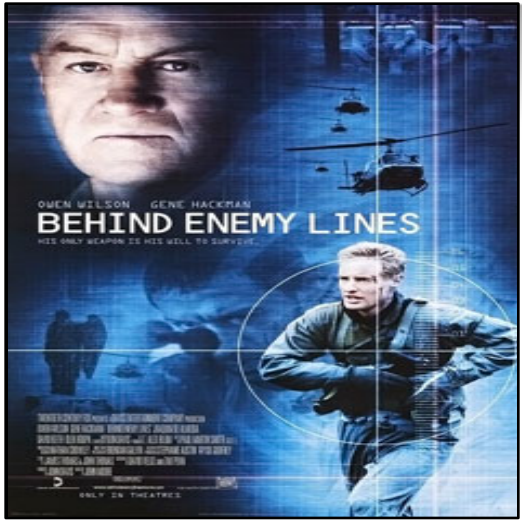
DSMAC

1. DSMAC – Digital Scene Matching Area Correlation
2. Basically a search and destroy system
3. Only as good as the intelligence that the system is based on
4. Most accurate of all guidance systems used in cruise missiles



GPS – The Life Saver

1. June 6, 1995 – Captain Scott O Grady shot down behind enemy lines in Bosnia
2. O’ Grady’s survival pack contained a GPS receiver.



That’s it