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WG Ground & Marine Radar System

The WG Ground & Marine Radar System provides the ability to detect small and slow moving targets both on land and over the water.

This allows it to operate in littoral or coastal regions where the radar is searching for targets such as walking persons, canoeists, RIB's and jet-skis either over the land, open water or in tidal areas.

In addition to detecting small and slow targets the radar can also detect fast moving boats and/or large ships.

The radar's flexibility allows it to be used for inland water surveillance such as lakes and reservoirs, on the land/sea margin including shoreline and harbour surveillance, and out to open sea for long range surveillance of covert targets.

The WG Ground & Marine radars operate in all weather conditions and continuously 24 hours a day making them particularly useful for security applications at night and in foggy conditions.

The radar is typically used with long-range surveillance cameras and thermal imagers, enabling security staff to detect and then identify the intruders or their boat.

Harbour, Seaport and Naval Base Protection

The WG Ground & Marine Radar uses high-resolution Doppler processing technology to enable it to discriminate very fine movement and reject the radar reflections from static objects, allowing the radar to detect small boats moving alongside moored ships, jetties and other static structures.

This makes the radar well suited for use in harbours, seaports and naval bases where there is a threat from small boats approaching larger high value boats and ships.

The radar is designed to operate over land as well as sea, it can also detect movement on the land surrounding the port area.

This is of particular use at night when intruders on land can also be detected as they move around the boats.

The radar can be integrated with a long-range camera and thermal imager (electro-optic) systems to allow security staff to identify and track the intruders remotely on the electro-optic system, once cued by the radar.

Coastal Surveillance

The WG Ground & Marine radars provide a significant advantage over traditional coastal surveillance radars for security applications due to its state-of-the-art design features.

The electronic-scanning (e-scan) technology has no moving parts and uses a completely solid-state transmitter so reliability is exceptional and no routine maintenance is required for a five year period.

Traditional coastal surveillance radars are limited in range by nature of their mounting height above water and the radar frequency band in use.

This radar's use of the international Ku radar band allows it to be mounted lower for a given detection range, thereby reducing mast infrastructure costs.

The radar uses Doppler processing technology to discriminate and measure the characteristics of the targets it detects. This allows it to discriminate the movement of boats from the motion of waves.

Offshore Platform Security

As well as providing a surveillance platform with exceptional reliability, the radar's e-scan antenna technology and FMCW design allows it to be mounted high on offshore platforms and still see small boats very close to the platform as well as those in the distance.

With options for 10° or 20° elevation beam widths, the radar can see intruders typically as close as a few tens of metres from the radar and out as far as 32km.

The WG B400 series is a modular system, which allows segments of 90°, 180°, 270° or 360° to be configured.

A traditional 360° mechanically rotating radar will inevitably suffer from radar obscuration caused by the platform structure.

The benefit of this radar is that, for instance, two 180° units can be mounted either side of the platform and operated simultaneously, thereby achieving an un-obscured 360° view with double-rate scan time.

An offshore platform will typically be fitted with a myriad of cameras and thermal imagers, to simplify system use and reduce operator fatigue, it is possible to use the target information from the radar to automatically select and “slew and cue” the appropriate camera system to look at the intruder.

Lake and Inland Waterway Monitoring

The radar is effective at detecting small targets that may be using lakes, reservoirs or other inland waterways for leisure, business or other purposes.

The radar’s ability to detect people walking around the land surrounding the water as well as small water targets such as kayaks and jet skis allows it to provide a complete picture of activity.

If there is particular value associated with water, such as; fishing, drinking water, or physical protection of key assets then the radar can provide intensive surveillance of the entire area, this is particularly effective in areas that are normally unused and at night or in foggy conditions.

As lakes and inland waterways are often close to inhabited areas, the radar's low-power FMCW transmission minimises the possibility of interference with commercial communications services, unlike traditional coastal surveillance radars.

It is often inconvenient to route power and communications to some inland surveillance areas, the radar uses very little power and with its embedded signal processing has a very small communications bandwidth requirement.

This provides the opportunity to operate the radar from renewable power, such as solar or wind power and use narrow-band communications infrastructure including SatCom (Satellite communication), GSM, 3G (CDMA) or conventional point-to-point wireless links.

Airport Perimeter Security

The radar can be installed high up on existing infrastructure and provide remote surveillance of the airbase perimeter, the areas within it and depending on the fence construction and surrounding environment, the land around the airbase.

This allows intruders to be detected before they get to the fence and then tracked and followed as they climb the fence and move around the airbase.

A single 360° radar may be used if the site topology allows, however it is typical to use two or three 180° radars to obtain optimal coverage with minimal radar obscuration by buildings etc.

The radar takes advantage of its electronic-scanning technology and Doppler processing system to enable it to detect intruders, walking or crawling even if they are moving next to large static objects such as buildings, vehicles and even under aircraft wings and fuselage.

The radar may be used to cue a long range camera and/or Thermal Imager for intruder identification in daylight or darkness.

Additionally the software allows the radar system to trigger existing surveillance cameras to enable intensive multi-intruder detection and tracking complete with evidential recording.

The radar may be used in fixed installations where the airbase is already established, however for short term installations or where the airbase is being extended, it is possible to deploy the system on a vehicle or trailer mounted platform.

Wireless communications can be used to send the radar data and video back to the control tower or security room.

Checkpoint Security

The radar can look into the distance and provide the checkpoint security staff with early warning of incoming vehicles and especially those approaching with excess speed.

The radar uses Doppler processing technology to instantaneously measure the speed of targets that it detects and this can be used to automatically trigger alert zones to warn the checkpoint staff.

For installations where a single approach road needs to be monitored, the radar's electronic beam scan can be reduced to cover just the area of interest.

This improves the scan time allowing the radar to monitor the road more intensively, alternatively alert zones covering the area between roads can be set up to monitor for intruders intent on entering by non-standard routes.

Forward Observation

It is common practice to use ground surveillance radars to survey land ahead of the current operating position to ensure that there is no undesirable activity or likely security threats.

The radar offers unique capabilities that considerably enhance the quality of Forward Observation.

The radar antenna has a wide 20° elevation beam (10° on the M10S long-range antennas or 5° on the extended-range antennas) enabling it to operate in hilly or mountainous regions where with a single scan it can simultaneously survey the hill-tops and valleys for any people or vehicles.

The electronic-scanning antenna and Doppler processing technology employed by the radar gives it the ability to detect extremely small and slow targets even if they are moving in heavily cluttered land.

This combined with the wide elevation beam allows the radar to be operated in remote hilly and rocky terrain looking for the slightest of movement in the large area it surveys.

The radar is typically used in conjunction with a lightweight electro-optic system, which the radar can control, so that the operator can then observe the activity detected by the radar.

Technical Overview

- Radar type: E-scan Frequency Modulated Continuous Wave (FMCW) Doppler Ground Surveillance Radar
- Frequency band: Ku band
- Spectrum occupancy: Wide-band (WB): 15.7 to 17.2 GHz, Narrow-band (NB): 16.2 to 17.2 GHz
- Scan type: fully electronic-scanning in azimuth ('e-scan') using a Passive Electronically-Scanned Array (PESA)
- Transmitter power (nominal): 1 Watt (standard-power transmitter version) or 4 Watt (high-power transmitter version)
- Multi-radar operation: supported and unlimited
- Embedded software and firmware: field-upgradeable via network connection

Target Detection Performance

Maximum detection ranges:-

- Crawling person (RCS 0.1 m2): 6.0 km (3.7 mi.)*
- Walking person (RCS 1 m2): 15.5 km (9.6 mi.)*
- Moving RIB (RCS 5 m2): 19.1 km (11.9 mi.)*
- Moving vehicle (RCS 30 m2): 22.4 km (13.9 mi.)*
- Large moving vehicle (RCS 100 m2): 27.9 km (17.3 mi.)*
- Large moving vessel (RCS 1000 m2): 32.0 km (19.9 mi.)*
- Maximum targets per scan: 700
- False Alarm Rate (FAR): 1 false-alarm per day
- Minimum detectable target radial speed: 0.37 km/h (0.23 mph)

* HP version fitted with N5S antennas

Coverage

- Instrumented maximum range: 2, 5, 8, 16 or 32 km (1.2, 3.1, 5.0, 9.9 or 19.9 mi.)
- Instrumented minimum range: less than 10 m (33 ft.)
- Azimuth scan angle: 90° , 180° , 270° or 360° horizontal e-scan
- Elevation beam: 5°, 10° or 20° vertical beam width
- Fastest scan time (for 90°): 1 s

Target Output & Identification

- Data format: QZ (custom, open-standard data format)
- Target output port: available for cueing of pan/tilt-mounted cameras and thermal imagers
- Doppler audio modes: optional

Connectivity & Software

- Main I/O interfaces (for radar control and target data): 10/100 Ethernet network interface or optional IEEE 802.11b Wireless LAN (factory build option)
- Auxiliary I/O interfaces: RS-232 and RS-422 control lines, opto-isolated control/status inputs and isolated switched contact outputs
- Software (SDK): API software library (Windows) and generic Interface Control Document (ICD) are both available to System Integrators

Electrical

- Battery/regulated-PSU input range: from 12 V to 28 V (DC)
- Vehicle supply input range: from 12 V to 24 V (DC)
- Power consumption (from 12 V regulated-PSU)*: 38 W (average)
- Endurance*: 10 to 12 hours continuous operation from dual 2590-type batteries

* SP version

Physical, Environmental & Reliability

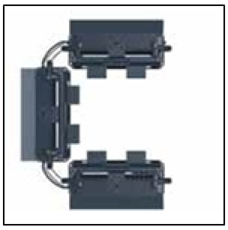
- External dimensions of radar unit(s) *: W666mm x H503mm x D128mm
- Weight of main radar unit*: – Wide-band: 25 kg, Narrow-band: 27 kg
- Weight of auxiliary radar unit(s)*: Wide-band: 21 kg, Narrow-band 24 kg
- Operating temperature: from -30°C to +60°C
- Note: extended operating temperature version available
- IP rating: IP65 dust tight and protected against water jets
- MIL-HDBK-217-F: 10,000
- In-service reliability (estimated): in excess of five years zero maintenance

* Excluding antennas, mountings and solar shield

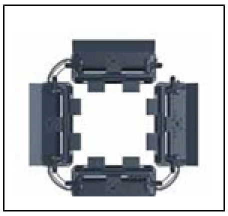
** Depth of narrow-band radar units is 133 mm

90°
1 x Main Radar Unit

180°
1 x Main Radar Unit
1 x Auxiliary Unit



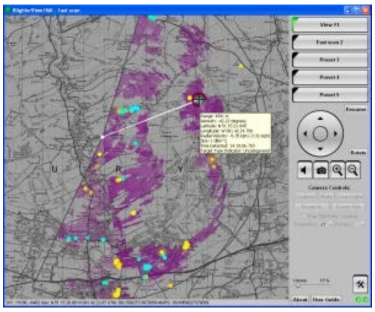
270°
1 x Main Radar Unit
2 x Auxiliary Units



360°
1 x Main Radar Unit
3 x Auxiliary Units

WG View HMI

- Simple, intuitive display and control of one or more WG radars
- Microsoft Windows based
- Automatic selection of background maps
- User definable alert and exclusion zones
- Automatic slew-to-cue of Pan/Tilt camera systems
- Runs on ruggedised laptops or PC workstations



The WG View HMI is a complete PC-based software application for displaying and controlling multiple radar units and associated peripherals, it provides users with an intuitive and simple display allowing all users to obtain the best performance from their integrated surveillance system.

The WG View HMI provides users with a simple interface to control and view one or more radars.

Additional controls are available for advanced users to optimise the radar settings and the HMI display characteristics for specific applications. Radar targets are clearly identified as coloured markers overlaid onto a background map with key target characteristics available on a mouse click; including target location, speed and size.

The colour of each target marker can be configured to represent target speed and direction or target size, allowing the operator to prioritise the targets to be observed. The user can select the duration of 'snail-trail' tracks that are displayed, allowing the path of the target to be plotted and predicted.

The HMI can control a variety of high-performance camera and thermal imaging systems allowing the user to automatically cue the cameras to the target location.

To enable un-manned operation, the WG View HMI includes user-definable alert and exclusion zones, an intruder entering an alert zone will generate a visible and audible alarm thereby alerting the operator to the event.

Exclusion zones allow targets to be ignored within defined areas so that they do not distract the operator, zones may be overlaid and prioritised to select or ignore specific target characteristics such as size and speed.

The WG View HMI operates on a standard PC or laptop running Microsoft Windows, Typically, up to six radars may be displayed simultaneously on a single HMI; each radar can be controlled independently to optimise it for its environment.

For fixed installations each radar may be manually located on the background map, however portable radars may use their internal GPS receivers and compass to locate themselves automatically on the map.

A variety of map formats may be loaded into the WG View HMI, formats such as GeoTIFF provide their own calibration data, whereas standard Bitmap images can be calibrated within the WG View HMI mapping facility.

Doppler ground surveillance radars provide two key advantages that are provided for by the WG View HMI, the ground clutter map produced by the radar shows where it receives radar reflections from static objects within its scan sector.

This ground clutter map may be overlaid onto the background map to identify radar shadow areas and help to predict ground cover.

The other facility is the ability of a Doppler radar to listen to the Doppler movement signature of targets; the WG View HMI allows the user to control the radar so as to listen to the Doppler movement signature of either a fixed area of land or a swathe of land during a radar scan.

Specification

- Sensor Interfaces: Radar QZ format over TCP/IP socket connection; SISS2 interface for high-performance camera and thermal imager systems, Host System for 6 radars
- Processor: Minimum: Pentium 4 (3GHz), or AMD Athlon XP 2600+ (2.1GHz)
  Ideal: Intel Core i5-750 (2.66GHz), or AMD Phenom II X4 965 (3.4GHz)
- Memory: Minimum: 2GB, Ideal: 6GB
- Hard drive: Normal use minimum: 100GB, Data recording minimum: 750GB
- Graphics Minimum: nVidia GeForce FX5200 or ATI Radeon 9200, Ideal: nVidia GTX260/216 896MB or ATI HD4870 1GB
- Audio Minimum: on-board (AC97)
- Networking Minimum: 100Mbit, Ideal: 1000Mbit
- Operating System Minimum (and ideal): Windows XP
- Display Minimum: 19" (1280x1024), Ideal: 22" (1680x1050)
- Loudspeakers (optional) Minimum: powered 3 speaker system (with sub-woofer)

Human-Machine-Interface (HMI)

- Mouse/keyboard and/or touch-screen control interface
- Soft-key licensed including demo mode
- Selection of coordinate formats: Lat/Long, UTM/UPS, MGRS

General controls

- Pre-set view selection
- Pan, zoom, rotate, default-view
- Enable Doppler audio mode
- Enable camera
- Display/hide advanced settings control box
- Main map display area with radar scan sector and camera FOV indicator
- Pop up target information box
- Soft-joystick when camera enabled
- Advanced settings options: Install and name each WG radar (IP address and port No.)Read or set position and rotation of each WG radar
- Camera set-up options (SISS2 format)

HMI display settings including

- Map Target marker and clutter map brightness
- Target marker and clutter map persistence (snail-trail fade time)
- Colour mapping of target markers - speed, size or fixed
- Visibility of other overlays

Radar control interface

- Radar mode selection
- Clutter cut-off control (wind compensation)
- Sensitivity level
- Rain filter selection
- Doppler audio mode selection
- Radar power saving options
- Advanced radar settings

Maps

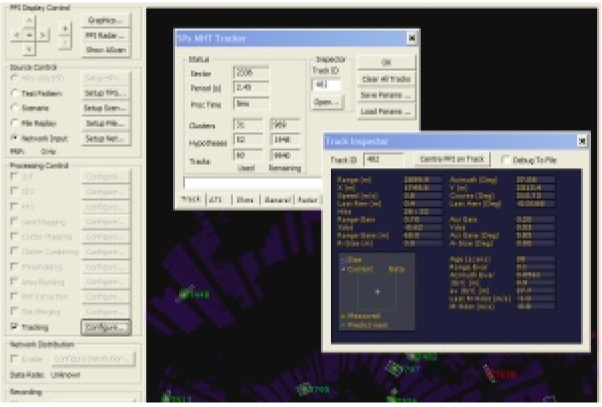
- BMP, TIFF and GeoTIFF file formats;
- Ability to calibrate maps or read existing calibration data
  Manual adjustment of un-calibrated maps

Zones

- Creation of up to 30 zone polygons
- Up to 30 vertices per zone polygon
- Select either alert or exclusion type zone priority ordering
- Associate sound with each zone
- Define min and max velocity for each zone
- Define min and max target size for each zone

WG Radar Tracker

- Software-based radar target tracker
- Adds full Track-While-Scan (TWS) capability to any WG radar system
- Fully parameterised and configurable
- Automatic Track Initiation (ATI) using built-in M from N detector
- Supports multiple hypotheses
- Multiple track filtering modes
- Dynamically calculated gating function



WG Track is Surveillance Systems' fully-configurable, software-based radar target tracker for use with WG ground surveillance radar; it provides automatic track initiation and has full support for multiple hypotheses. It incorporates multiple track filtering modes and gates are calculated dynamically.

WG Track interfaces to the output data stream from the radar's built-in plot extractor and correlates from scan-to-scan to output positional and motion updates, the software is highly configurable and may be used to identify targets according to defined rules.

When plot data is correlated from scan-to-scan, WG Track uses multiple hypotheses to support ambiguous interpretations of the radar plot stream.

The filter uses position, size and historical measurements to correlate existing tracks with new data, providing updated positions and dynamics, as well as a confidence estimate. The behaviour of historical track data is analysed to help interpretation and provide a first-level classification capability.

Track Creation

The tracker maintains an active track database; the contents of the database are updated with new plot data sent by the radar.

New tracks are added to the database automatically, the automatic track creation occurs when plots entered into the database are seen to be un-correlated, or un-gated, with any existing known target.

A new preliminary track is created and is updated with future detections until confidence is established that the track is likely to be a target of interest.

The time a track is held in the preliminary stage is a programmable option and needs to be set to balance the speed of detection with the likelihood of a false alarm.

In a low clutter environment, where extracted plots are likely derived from real targets, the acquisition time may be as short as 2 detections.

For noisy situations, where the plot extractor is reporting false detections, the integration time in the preliminary stage may be extended.

The criterion for promoting a track from the preliminary to full track status is defined through either a binary integrator or an M from N detector, where a minimum of M valid detections are required in N observations

Track Correlation

Established tracks are updated using new measurements provided by the data extraction processing. The first stage of that is the association problem, by which a measurement is associated with the most likely track.

In a simple situation, a true target will give rise to a single plot that can be directly associated with the expected target position. In the general case, there may be ambiguity as to which measurement relates to which track.

A distance measure is computed from the expected position of a track to the position of measurements that are within the track gate. Within WG Track, the gating function uses a dynamically computed area around the expected position of a track.

This area is computed to reflect the likely error in track position derived from the target's possible movement and the measurement noise.

The WG Track gating function uses the best estimates of target dynamics and measurement noise models to compute an accurate gate area at each new measurement.

This helps to ensure that association only considers plots that are likely to derive from the true target and that when the association is made a measure of statistical distance can be used to weight each candidate association.

Multi Hypothesis Tracking

WG Track supports multiple hypotheses, which means that decisions to associate tracks with measurements can be deferred until additional information becomes available. If the tracker isn't sure whether a track should be associated with plot p1 or plot p2, for example, it can create two hypotheses.

This allows both possibilities to be propagated to the next stage of processing. The next measurement might make it clear which of p1 or p2 was the right choice.

The job of a tracker is to interpret radar observations to distinguish real targets from noise, and to construct models to describe the motion of the true targets. The tracker is provided with data, typically in the form of plots, derived from the processing of the radar video.

These plots are connected regions of radar video that satisfy some rules of position, amplitude, size and signal strength.

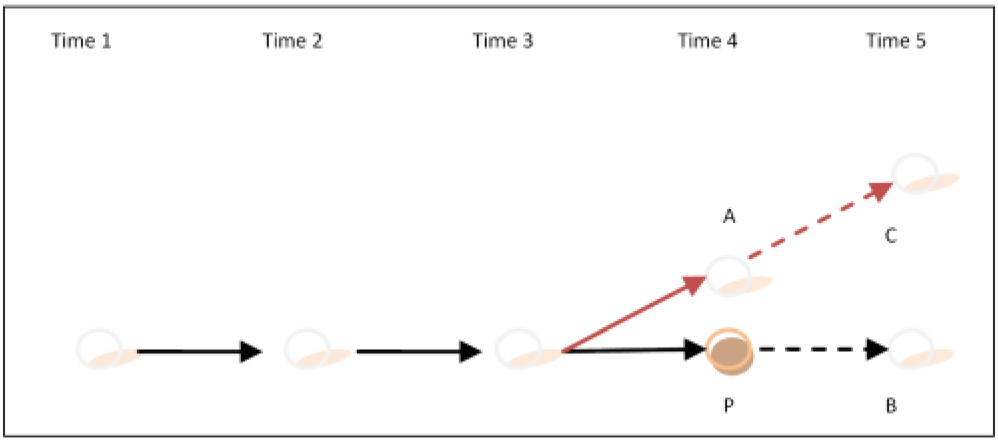
Unfortunately, measurements from the radar are imperfect; there will be noise from the measurement process, clutter from the environment and unpredicted manoeuvres of the targets of interest.

This means that the tracker will be presented with noisy and possibly multiple measurements from the target of interest. The tracker's responsibility is to provide the best interpretation of the data using assumed or calculated statistics for the noise and the likelihood of change.

In the single hypothesis situation, the tracker is forced to make the best interpretation it can of the available data at each update. For some updates, where there is a clear interpretation of the measurement, the best interpretation may be obvious and the single hypothesis offers a satisfactory solution.

Problems arise, however, if the interpretation of the measurements is not obvious. In this case it may be desirable to defer a decision until the next update when additional information will help to decide on the correct interpretation.

The ability to simultaneously consider multiple interpretations of the system is the key to the multi hypothesis tracker.



In the diagram above, a target is moving from left to right. At each update time (Time = 1..4) the position of the target is shown, the target moves in a predictable way at Time = 1, 2 and 3.

The tracker will estimate the target's speed and heading so that the predicated position at Time = 4 is shown as P. However, suppose that at Time = 4 the actual position observed by the measurement is A.

The question now arises as to whether the observation of the target at A is due to a manoeuvre by the target (so that the expected position at Time = 5 will be C), or whether it is due to a measurement error (so that the expected position at Time = 5 will be B).

The single hypothesis tracker has a difficult choice at Time = 4, it has to make a single interpretation of the results, so it has to decide on the single best explanation for the measurement at A.

If it assumes that the measurement is the result of a manoeuvre it will expect the target to be around C at time 5. But if the measurement is really an error, the tracker may not correctly detect the next measurement at B.

The ability of a tracker to detect a measurement around the expected position is defined by a search gate. This is finite-size geometrical shape around the expected position of the target.

The size of the search gate is a compromise between minimising false detections (suggesting a small gate) and accommodating uncertainty in the estimate and allowing a target to manoeuvre (suggesting a larger gate size).

In the face of the uncertainty in making a decision at Time = 4, the single hypothesis tracker may try to "hedge its bets" by selecting one of the choices, but enlarging its search gate to accommodate the next update's measurement if the alternative explanation turns out to be correct.

This might work, but enlarging the search gate in this way is a reflection of the uncertainty in the interpretation at Time = 4.

The enlarged search gate makes the tracker prone to detect additional measurements that may further complicate the hypothesis. Furthermore, for the tracker to be able to respond to either the Time = 5 measurement being B or C, it will probably need to increase its filter gains, further enhancing the likelihood that the track will be corrupted by noisy measurements.

In contrast to the above, the multi-hypothesis tracker solves the problem at Time = 4 by considering both explanations simultaneously. It propagates two hypotheses to Time = 5. One hypothesis says that the next expected measurement is at B, with the measurement at Time = 4 being due to a measurement error.

The other hypothesis believes the measurement and expects the detection at Time = 5 to be at C. At Time = 5, the discovery of the target at either B or C confirms one hypothesis and refutes the other. The refuted one is deleted and the confirmed one continues on to the next update.

Track Filter

For each hypothesis, the tracker updates the current estimated position with the new measurement. If the measurement were known to be completely accurate, the update process would believe the measurement and the new estimate would be exactly the measured value. For various reasons, the measurement is inaccurate so the update process must take a weighted combination of the expected position and the measured position.

This is the track filtering, WG Track offers a number of track filtering modes, the simplest mode uses fixed gains in the components of the measurement, which can be successful for tracking applications where the target is clearly identified and relatively clutter free.

Additionally, WG Track also provides a dynamic gain filter, which automatically adjusts the filter gains to provide good filtering in the steady state, whilst retaining the ability to track through a manoeuvre.

The filter works by computing a dynamic filter gain, K, based on estimated system noise and measurement noise models. The system noise is used to model uncertainty in the known dynamics of the target, including its ability to manoeuvre.

As system noise increases, or equivalently as measurement noise decreases, the filter places more weight on the measurement – the filter gains increase.

As system noise decreases or as measurement noise increases, the filter gains decreases causing less emphasis to be placed on the new measurement.

The filter gains are continually changing and provide, under certain assumptions of the noise characteristics and linearity, an optimal estimation of the true target position.

As part of the update process, the filter also provides a convenient measure of the estimation. This provides a useful confidence assessment of the estimation.

Track and Plot Reporting

WG Track outputs plot and track data onto a standard Ethernet network for delivery to local or remote clients for data fusion or display.

The time-stamped reports are delivered with low latency, and may include both the filtered and measured components of the track's state vector.

Client-side software libraries are provided to receive the network reports and make them available as data structures for client processing or display.