2 WAY MESSAGING DATA USING AVL & IMS/SN

1. TECHNICAL PROPOSAL

1.1 Technical Proposal Executive Summary

This Proposal details the scope of hardware and software supply for an **AVL / GIS System** based **Automatic Vehicle Location System** (AVLS) and **Interactive Messaging System/Satellite Navigation** (IMS/SN) System operating over a GSM (GPRS enabled) network in the Kingdom of Saudi Arabia. The same system can also be operated over a TETRA network or a satellite network such as Thuraya, with little or no hardware redundancy should the need arise at a later date.

Though the proposal is focussed on the supply of a AVL and IM/SN system for one Saudi Region, the same solution can be applied to the other regions with no alteration to the system architecture as each region has its own system and each city its own control room (command room). Almost as importantly, the in-vehicle units can be programmed to report to a number of communications gateways offering some protection against disaster by allowing other control rooms to accept tasking directly.

1.2 Project Objectives

The main objectives of the project are;

1. Integration of a number of vehicles fleet with different duties and activities.
2. To improve safety and mobility, and enhance clients drivers efficiency.

The AVL units and associated equipment will be installed into the client vehicles around the country. These vehicles could include cars, motors, tracks and heavy machines.

The location information from the vehicles will be transferred back to the command rooms to show the position on a map with the various reporting options available to the client. There

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is also provision for a position to be shown on a map within the vehicle on a MDT (Mobile Data Terminal).

In the Control Room, the output from the AVLS Server is fed into the host GIS Application which provides map based displays of vehicle positions and status. The GIS System software and AVL system will be integrated with any Command and Control system that is also being implemented into the command rooms in the regions.

The following security and safety features are addressed by the AVL solution.

- Vehicle security
- Tracking
- Positioning
- Driver safety
- System Administration
- Communications

During typical operation of the system, the AVL unit installed in the vehicle continually monitors and records data about a vehicle's current situation to include position, speed, heading and vehicle status.

This data – or selected elements of the data – is transmitted across the communications network to the fixed site Command Rooms, where the AVL Host System receives, processes and stores vehicle data. All AVL vehicle data is stored on a database on the AVLS server, and forwarded to the GIS application that is used for monitoring and tracking multiple vehicles on a map. The information is also transferred as required to the CAD system.

1.2.1 Real-Time Vehicle Location:

Vehicle location information and operational status are updated automatically as the vehicle goes about its normal duties. This information is shown in near real-time, allowing the control room to see at a glance the position of all vehicles and enabling the nearest resource to be despatched to an incident.

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1.2.2 Historical Journey Replays

Management reports provide details such as vehicle journeys and locations visited. In addition, movements for any range of date/time can be replayed on screen, utilising the freeze-frame and fast advance facilities to support post-incident de-briefing and reduce running costs.

1.2.3 Black-Box

In the event of a vehicle being involved in an incident, driving history can be recovered, showing exactly how the vehicle was being driven prior to the incident.

In summary, not only can the AVL unit provide you with the necessary tracking and management functionality that you require today, but it can also meet your Mobile Data needs for the future.

1.3 Solution Summary

The central element of the system is the Communication Gateway server which provides the communication, storage, retrieval and tracking of vehicles/resources and hosts the interactive messaging gateway that presents incoming messages to third party applications such as CAD and accepts outbound messages from CAD etc addressed to vehicles.

The messaging system will use the same GPRS facility as the AVL unit. As with AVL the messages could also be sent over other bearers such as TETRA with the addition of suitable TETRA radio equipment and a central TETRA data presentation.

The AVL unit is a software based vehicle mounted unit consisting of a modern multi- channel GPS receiver and a processor based data modem capable of working over a variety of communication networks. It also contains as standard, an external interface of 4 digital inputs and 2 outputs allowing connection to - or monitoring of, other vehicle items such as the siren and emergency lights.

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The AVL unit is the latest version of this unit incorporating a number of enhanced features based on feedback from existing users which has resulted in an increased I/O capability – allowing the unit to act as a vehicle centric hub for other on board systems together with an inbuilt GSM/GPRS data unit.

To meet the "Vehicle On-board Unit & Display" requirements, a Personal Navigation Device (PND) will be used, which has an Arabic user interface and provides local maps and interactive messaging. Incoming messages types can include general text, incident descriptions and incident locations that will prime the Satellite Navigation function with a destination. The vehicle operator can send general text and acknowledgements that they are travelling to or at an incident destination.

The PND is attached to the AVL unit and all messages pass via the AVL unit over the GPRS network to the central GIS system.

1.4 Solution Architecture

The ARLS system when used with the intelligent in vehicle unit provides all of the functionality required for Automatic Vehicle Location (AVL).

The GIS system is a suite of software, which provides the communication, storage, retrieval and tracking of vehicles/resources. It is built from a number of components and includes a map client that can show the vehicle locations to end user operators. However, in this case the end user mapping display will be provided by the CAD supplier and real time AVL positional data can will be presented on the “3rd Party Interface” to the CAD system to allow that system to display vehicle locations.

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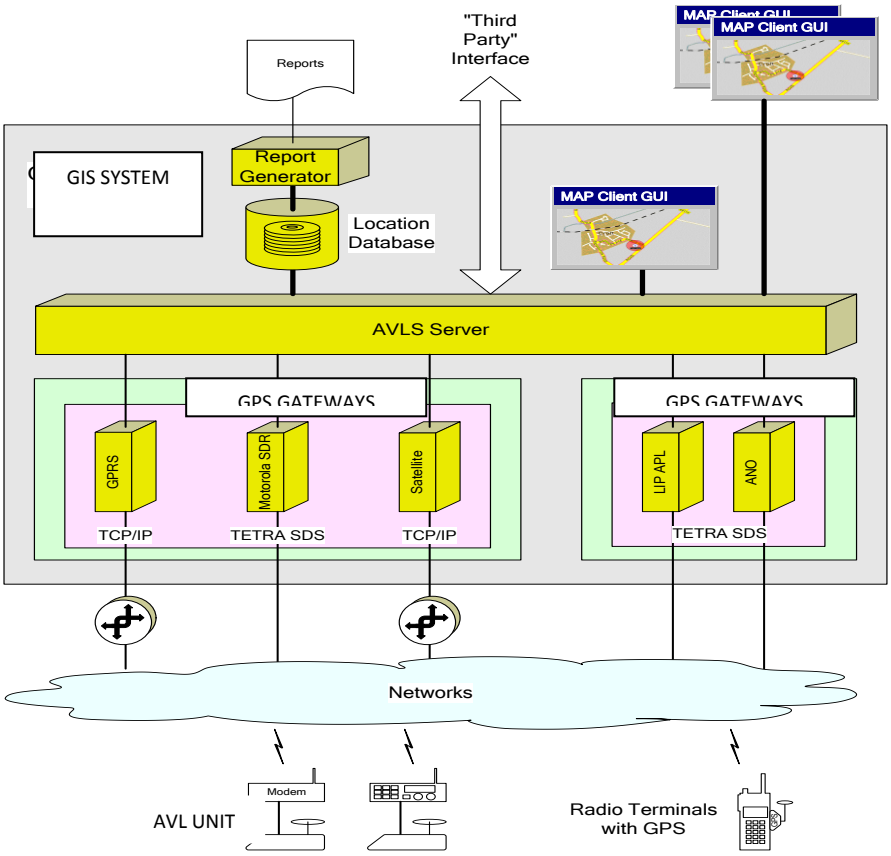
The components that make up a typical system are shown below.



Although the standard AVL / GIS system features meet and exceed most core vehicle tracking requirements, additional "Vehicle On-board Unit & Display" requirements cane be met by supplementing the AVL / GIS system with an in-vehicle PND. The PND unit has an Arabic user interface and provides local maps and interactive messaging. Incoming messages types can include general text, incident descriptions and incident locations that will prime the PND function with a destination. The vehicle operator can send general text and acknowledgements that they are travelling to or at an incident destination.

The PND is attached to the AVL unit and all messages pass via the AVL unit over the GPRS network to the central GIS system.

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A typical system configuration can be seen in Figure 2 below.

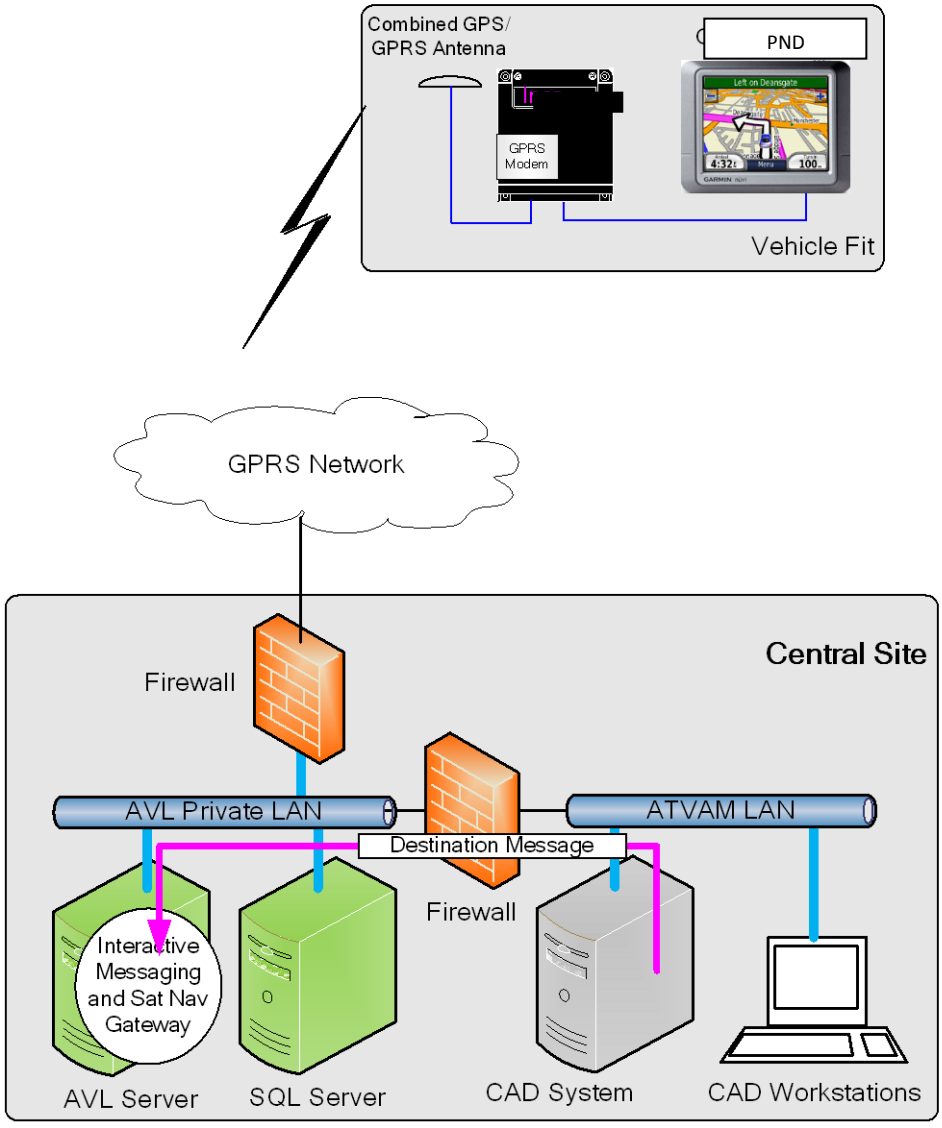

FIGURE 2

1.4.1 GPRS Options

The Project Requirement calls for the vehicle tracking system to be able to operate over a GPRS enabled GSM public mobile phone network.

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It should be noted that the AVL unit and supporting systems, are also configured to operate over a number of different networks which can be implemented should the need arise without further development:

The other networks that are operable over are **TETRA**, and **Satellite** but at extra cost.

It has been assumed that operation will be based on using GPRS using a KSA Network Provider to install and commission the Access Point (APN) and the Radius Server if such is required.

If and when the situation requires switching the units to operate on the TETRA network, this is easily achievable.

1.4.1.1 GPRS Connections to Customer Site

The data traffic over a GPRS network is IP based and can be delivered over a private or public network infrastructure to the customer's premises. Currently, this can be achieved in 3 ways;

- **Fixed Line** - the Network provider will run a fixed line from their network to the customer's site which normally terminates in a Router. The LAN connection (RJ45) from the Router is connected into the Customer's Ethernet network on which the AVL server is also connected. This Fixed line connection is called an "APN" (Access Point Node) and the GSM/GPRS data module in each vehicle has to be configured to connect to that APN.

  The use of an APN effectively creates a private closed user group; however there are some concerns about the administration policy employed by some Network providers which potentially allow for an interloper to ask for a particular SIM to be added to the APN list without any security validation. It is therefore recommended that specific

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questions are asked of the chosen provider regarding new SIM introductions into existing APN lists.

Using fixed line, you can have static, network assigned or customer RADIUS assigned IP addresses.

- **Internet Portal** - the APN and each SIM is configured for the Network Provider's public internet portal. The AVL server then has to have a public internet address. As a result, in this configuration the customer has to have a good firewall and access security policy to reduce the threat of unauthorised access to customer systems via the Internet.

The IP addresses on each phone can only be dynamically assigned by the Network and are generally restricted in operation (NAT) – allowing for only inbound vehicle reports whilst inhibiting outbound messages. This restricts the Application's ability to request updates but does minimise security breaches.

This approach is not recommended for large fleet sizes, significant message volumes and mission critical AVL applications.

- **VPN Tunnelling** - the Network Provider configures a virtual private network (VPN) and "tunnels" it in over the Internet, normally using the IPSEC protocol. This has many of the advantages of Fixed Line, but without the cost of renting a leased line. However it is subject to the availability of Internet access and variable latency and is not recommended for mission critical/high volume applications.

1.4.1.2 Recommended Approach

Given the large fleet sizes envisaged in this application, the **leased line** method is strongly recommended.

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1.5 GIS System Gateway

The Gateway acts as a central information processing hub by:

- Connecting to the chosen communications network (in this case GPRS).
- Gathering all GPS updates from the dedicated in vehicle GPS unit
- Logging them to a database & resolving any aliasing issues
- Either, displaying the location and status of the Resources on it's on own Map clients, or forwarding location updates in real-time to third party systems such as a CAD.

The system consists of the following active elements:

Communication Gateway(s) – An Application that connects to the selected communications network to receive location data from vehicles fitted with AVL units.

The Communications Gateway receives messages transmitted by these units across a communications network, decodes the incoming messages, and passes them onto the AVLS Server for processing. There may be multiple Communications Gateways installed to handle alternative networks.

IMPORTANT INFORMATION

Where a TETRA communication network is available the system can utilise TETRA as the bearer and it can also contain gateways that can receive updates from GPS enabled TETRA radios as well as AVL units. This is given as information for the future and that capability is not included in the core offer.

AVLS Server – located at a central/host site, this Server accepts incoming location data from the Communications Gateway(s), stores the data in the AVLS Server database, and forwards resource location information either to its own Map Clients or a CAD System via the 3rd Party Interface. The location data will be forwarded to the CAD system.

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The key components of the system showing a range of potential bearer networks including the GPRS network to be used are illustrated in Figure 1 above.

1.6 System Administrator

The System Administrator is a set of software utilities that allows the AVLS system administrator to configure and maintain the AVLS Server database. The software utilities contained with System Administrator are:

1. Maintain vehicles used within the AVLS System.

    a. Maintain vehicle types within the AVLS System.
    b. Maintain vehicle groups within the AVLS System.
    c. Maintain user access and privilege rights.

2. Symbol Configuration Editor which enables the user to maintain the symbols that represent vehicles and their status when viewed in the Map Client.

1.7 AVL Management Reports

AVL Reports is one of a suite of PC-based applications that make up the GIS location system, which allows you to create, display, and review reports on data collected from vehicles fitted with an AVL unit. The data that the Reports use is stored in the AVLS database.

All report production and parameter maintenance is performed using the Report Viewer, a software tool that shows a hierarchy of reports and their available parameter sets. Reports and parameter sets can be configured and adapted to the needs of your organisation. The following Reports are provided as standard:

- *Journey Detail.*

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- *Journey Start/Stop.*
- *Journey Summary.*
- *Last Reported Date/Time.*
- *Sites Visited by Site.*
- *Sites Visited by Vehicle.*
- *Timesheet by Date.*
- *Reported Today.*
- *Not Reported Today.*
- *Speed Exception.*
- *Vehicles by Type.*
- *Vehicles by Group.*
- *Missing Vehicle Data.*
- *Duplicated Serial Numbers.*

Various facilities are available to help generate and configure reports. These include;

- *Run reports on all historical and current data in the GIS System database.*
- *Create and configure report parameter sets for specific reporting requirements.*
- *Schedule reporting jobs to run automatically via the MS Windows Task Scheduler.*

In addition to the built-in reports, Users can also use standard reporting packages such as **Seagate Crystal Reports** or **Business Objects**, to interrogate the underlying SQL database.

This enables an almost unlimited range of reports to be easily produced.

1.8 Intelligent Vehicle Tracking and Location

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The AVL unit is an intelligent microprocessor based unit containing a multi-channel GPS receiver and a software based data modem that is installed in the vehicles, and which transmits vehicle situation information back to the AVLS Server over a suitable radio link.

During the typical operation of the system, the AVL unit continually monitors and records data about a vehicle's current situation (its position, speed, direction of travel, operational status etc). This data – or selected elements of the data – is transmitted across a radio network to a fixed site, where the GIS system receives, processes and stores vehicle data.

The AVL unit is designed to be a Vehicle **Centric Hub** for onboard equipment and provides a range of connectivity using CANbus, Ethernet, USB, RS232, analogue inputs and Digital I/O.

The AVL unit has a built-in GPRS quad-band modem. External communications devices, such as a **TETRA radio** or a **Satellite data unit,** can be connected to one of the RS232 ports either as the only bearer or in a dual-bearer configuration.

1.8.1 Vehicle Hardware

The vehicle mounted hardware consists of;

- The AVL Unit – a GPS modem that runs intelligent GPS Automatic Vehicle Location software with an integral GSM/GPRS data transmission unit.
- A GPS antenna – an external Antenna connected to the AVL unit to capture the GPS signal – which can be combined with a GSM antenna to provide a single-hole fix.
- A versatile and comprehensive I/O interface allowing a wide range of connections to be made to vehicle mounted systems.

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1.8.2 AVL Unit Vehicle Software

The AVL unit's embedded software performs the following tasks;

Monitoring of a vehicles situation; logging of vehicle situation data to the AVL unit's on-board data log and transmission of selected vehicle data to the central ARL System.

Programming of the AVL unit to monitor certain vehicle situations, and to invoke a sequence of actions if a particular event occurs.

The heart of the AVL unit is the event processing functionality. Virtually every piece of the AVL unit functionality will generate triggers and set and clear conditions. This provides significant benefits over simple GPS processing units.

For example units that cannot be configured to report only when a "significant" event has occurred inherently introduce compromises between tracking accuracy and airtime cost. To illustrate this, consider a unit that can only report at a fixed rate: it may report a vehicles position after every 500m travelled (say) at 40mph, but is only reporting the vehicles position every 1000m if the vehicle speeds up to 80mph. Conversely, if the reporting rate is increased to send a location update over the wireless communications system every 500m when travelling at 80mph, then unnecessary messages will be sent when travelling at 40mph.

The AVL unit is not subject to these sorts of compromises as it is able to modify its reporting behaviour in response to a wide range of conditions e.g. distance travelled in the previous illustration.

The specific nature of each trigger and condition is not relevant; only how they are processed:

- A trigger occurs when something happens (e.g. an input being activated, or a timer expiring). As a result of a trigger an action can occur.

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- A condition is used within an event to filter triggers. A condition is the Boolean state of some aspect of the AVL unit (e.g. whether an input is active or inactive).

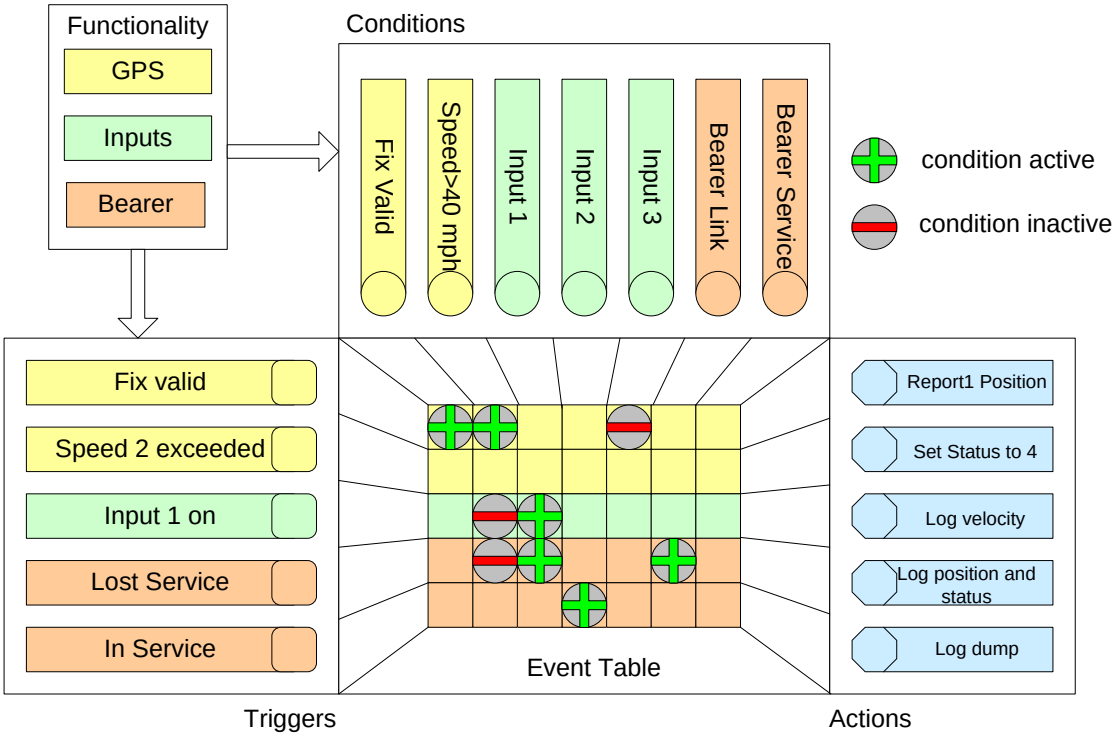

FIGURE 3

Consider Figure 3. This figure describes the behaviour of a particular configuration. The functionality sets and clears conditions and feeds triggers into the event table. From this it can be seen the behaviour of this AVL unit can be described as follows:

- When GPS fix becomes valid, if GPS fix is valid and speed is greater than 40 mph and input 3 is off, report position to the report1 address
- When GPS speed exceeds the configured speed 2, set status to 4.
- When input 1 becomes on, if speed is less than 40 mph and input 1 is on, log the velocity.
- When the bearer loses service, if speed is less than 40 mph and input 1 is on and the bearer link is valid, log position and status.

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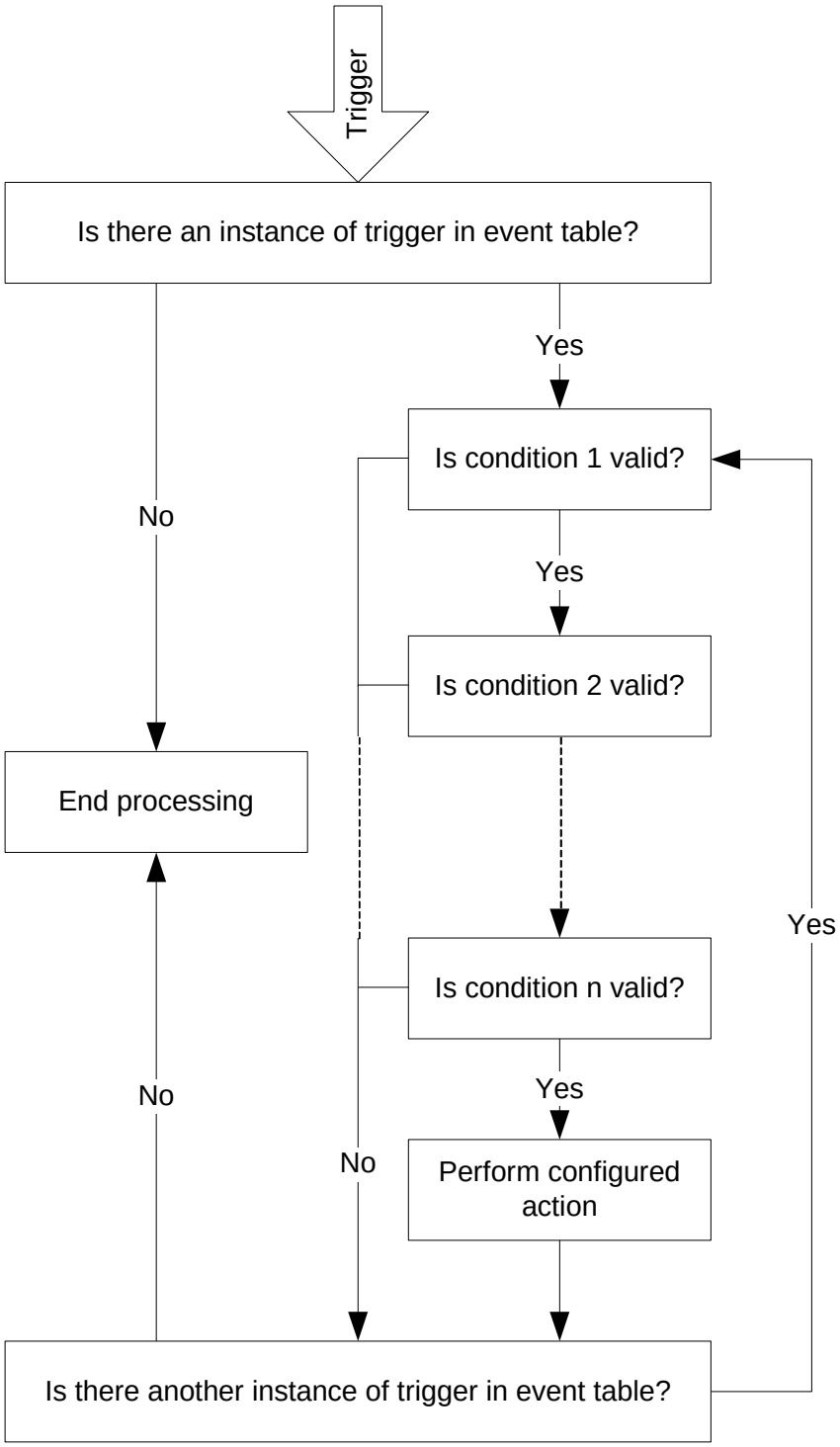
- When the bearer obtains/regains service, if input 2 is on, send all unsent logged data to the log dump address.

The diagram below illustrates the sequence involved in processing the event table.



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When a trigger occurs (such as GPS fix becoming valid), the first entry in the event table with that trigger is found. If there is an entry, the first condition (GPS fix valid) is checked. If this is valid, the second condition (speed greater than 40 mph) is checked. This continues until all conditions in the event have been checked. If they are all valid, the configured action is performed. If there are no conditions, the action is performed. If any of the conditions are invalid the action is not performed. When that event has been processed, whether successfully or not, the event table is searched to find the next event with that trigger. This is repeated until the end of the event table is reached. Processing then ceases until another trigger is generated.

Triggers and conditions allow the AVL unit to be incredibly flexible. The following example could be used for emergency vehicles. A timer (timer 1) could be set to expire every ten minutes, a different timer (timer 2) set to expire every thirty seconds and an input connected to the blue lights and siren of the vehicle.

By using triggers generated by the two timers expiring, and a condition of the state of the input, the AVL unit can be configured to report its position every ten minutes unless the lights and sirens are on, in which case it will report its position every thirty seconds.

1.8.3 Toolbox and Geo Fences

1.8.3.1 Toolbox

The Toolbox is a set of integrated software applications that are used for programming an AVL unit, consisting of:

- Application Configuration editor – enables you to configure an AVL unit to determine the way in which the AVL unit operates.
- Bearer Configuration editor – enables you to configure an alternative communications bearer used by an AVL unit for transmitting over air data to the AVLS System.

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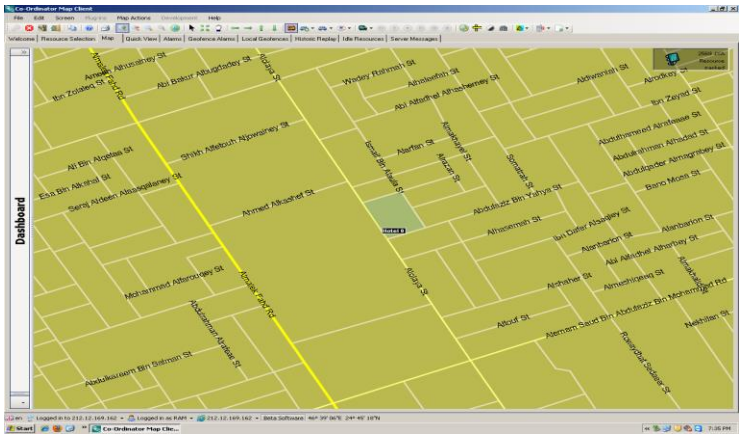
- Flash Disk Reader – enables you to read, save, and erase the data that is recorded in an AVL unit's on-board data log.
- Geofence Transfer Utility – enables you to read and write details of geofences to and from an AVL unit, and which you can use for uploading new Geofence data to an AVL unit.
- Geofence Editor – a software application that is used for defining bounded geographical zones to assist in tracking vehicle movements.

1.8.3.2 Geofences

A Geofence is a name for a bounded geographical area that is stored within the AVL unit. The boundary of the Geofence is defined using the GIS System Geofence Editor tool. It is used to provide additional information about the location of a vehicle without the need for continually requesting a vehicle's position, for example, to check whether a vehicle is at or near a particular location. Typically, geofences correspond to a feature or an area of interest such as a motorway, city, or a depot. An AVL can store up to 2000 Geofences.



1.8.4 Personal Safety – Vehicle Panic Buttons

A 'panic button' is a connection to an AVL unit that if it should be triggered will instruct AVL to send an immediate priority call to the control room, signalling a driver in distress.

This panic button option takes the form of a push-button. A further option of a driver worn panic button is available (at additional cost) that can do the same job up to about 400 metres from the vehicle dependent upon environmental conditions.
The system will be installed with a wired panic button in each vehicle.

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1.8.5 Inputs and Outputs

Each of the AVL units has 4 digital inputs and 2 analogue inputs as standard and these inputs can, for example, be utilised to connect to:

1. Other vehicle mounted devices – such as a personal security alarm system
2. Monitor and record vehicle statuses i.e.:

- *Ignition on/off*
- *Panic Button(s),*
- *Emergency light bar activation*
- *LPR "hit" trigger*

Together with the digital inputs, there are also 2 digital outputs as standard on each AVL unit. These outputs are normally interfaced with vehicle system through isolation devices such as a power relay.

A high reliability "LPR trigger" can be installed to the AVL system so that the controller receives a pop up message with date, time, and position message informing the back office management of the incident. Once the trigger is monitored, the AVL unit is then configured to increase its reporting frequency so that a more accurate "snail trail" is seen by the mapping system. The output from the AVL unit can be used to reset the trigger allowing only the management to cancel the alert.

1.8.6 Vehicle Security

The AVL unit can be set to generate an **alarm condition** under a wide range of situations such that rules covering what would be considered "unauthorised movement" can be created and actioned upon.

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These rules include movement with/without ignition on, movement outside “working hours”, etc. In addition, a facility exists within the AVL unit that allows a geographical area to have a boundary placed around it. This is termed as a ‘Geofence’.

Each of the vehicle mounted AVL units can have up to 2000 individual geofences, and this facility could then be utilised to raise an alarm should the vehicle cross the geo-fence. Geofences can be placed around sites etc, and an alarm can be triggered should a vehicle enter or leave the Geofence depending upon the configuration.

1.9 Interactive Messaging and Navigation System

1.9.1 Personal Navigation Device (PND)

The AVL unit data port connects to the PND control interface and in association with a GIS system Interactive Messaging and Sat Nav Gateway, destinations can be automatically sent to a PND in a vehicle.

The solution uses the Data Transport capability of the AVL / GIS system.

The PND is connected in vehicle to the AVL unit using a specialised cable and the AVL contains firmware to support the protocol required by the PND.

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At the host end, an Interactive Messaging and Sat Nav Gateway provides a TCP/IP server connection for 3rd Party application to exchange XML formatted messages.
These XML messages can instruct the PND to navigate to a specific destination and in response, the Interactive Messaging and Sat Nav Gateway will forward status messages indicating the user has selected the destination, marked the destination as “done” or deleted the destination.

The XML messages also allow text messages to be sent to the PND where they are displayed. The vehicle user can compose and send text messages to the interface using the on screen keyboard.

Whilst there are a number of other features available on the PND’s, it is not proposed to provide any support for these features in this release of the Interactive Messaging and Sat Nav Gateway.

1.9.2 Incident Messages – Method of Operation

The CAD system will make and maintain a TCP/IP connection to the Interactive Messaging and Sat Nav Gateway on the AVLS server.

The CAD system can send a structured XML incident message to the Interactive Messaging and Sat Nav Gateway which will contain the following elements. This message, subject to being correctly formatted, will be delivered to the PND Support module within the AVL unit.

- The Alias of the AVL unit as defined in the GIS System database.
- The Latitude and Longitude expressed as decimal degrees using the WGS84 coordinate system.
- Up to 80 bytes of text, which is displayed to the user as an explanation of the destination.

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- A 32bit Unique Identifier (UID) for the destination.

For low grade incidents/visits it is envisaged that the UID of the message will be any value but 1, and the destination message will be appended to the list of destinations currently held in the in the PND and the user will be alerted to the arrival of the message. The limit to the number of destination messages is a minimum of 10 messages.

When the message is delivered to the PND, the user will be notified, and will be given the opportunity to select the destination for the Sat Nav to navigate to. It will be possible to send more than one destination to a unit.

For “Grade A” incidents, the UID of the message will be set to the value 1, and the PND Module in the AVL unit will take specific action as follows:

- It will command the PND to stop navigating to its current destination.
- It will delete destinations with UID of 1 from the PND.
- It will download the new destination to the unit.
- It will command the unit to start navigating to the new destination.

The user has the ability to interact with the destination messages as follows:

- To select a destination message and navigate to the destination.
- To mark a destination message as “done”.
- To delete a destination message.

Each of the above events will cause a “status” message to be delivered to the C&C system as a structured XML message. The C&C system will be able to determine the related message from the AVL unit Alias and the UID provided in the message.

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1.9.3 Text Messages – Method of Operation

The CAD system will make and maintain a TCP/IP connection to the Interactive Messaging and Sat Nav Gateway on the AVLS server.

The CAD system can send a structured XML text message to the Interactive Messaging and Sat Nav Gateway which will contain the following elements. This message, subject to being correctly formatted, will be delivered to the PND Support module within the AVL unit.

- The Alias of the AVL unit as defined in the GIS System database.
- Up to 80 bytes of text, which is displayed to the user as a free text message.

The vehicle user can reply to a text message or generate a new message as required using the onscreen keyboard. This will be sent over air and be presented on the Interactive Messaging and Sat Nav Gateway on the AVLS server for collection by the CAD system. The CAD system will need to resolve which operator(s) in the control room are monitoring that vehicle and hence should see the message.

1.9.4 Additional System Messages

Additional system messages will be provided for the following communication events:

- Destination message delivered to the PND.
- Delivered to the AVL unit, but the PND not responding.
- Failed to deliver to the AVL unit.
- Error detected by the Interactive Messaging and Sat Nav Gateway, i.e. link to AVLS down or XML message formatting error.

1.9.5 Typical Server Central Specifications

To allow for future expansion of the vehicle fleet and to support the deployment of APL a two server configuration is proposed in which the SQL database and the AVLS application software run on separate servers.

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1.9.5.1 Typical AVLS Application Server Specification

For the AVLS Application Server the following typical specification will be used:

Dell PowerEdge™ 2950 (2U).
Two Hot-plug Power Supplies for Redundancy.
Dual Gigabit Ethernet Ports.
Single Serial Port.
2 X USB 2.0 Ports.
2 X Dual Core Intel® Xeon® 5148LV, 4MB Cache, 2.33GHz, 1333FSB.
4GB FB 667MHz FBD (4x1GB dual rank DIMMs).
2 X 73GB 15,000rpm 80-pin Ultra320 SCSI hard drive in a Raid 1 configuration.
Operating System Windows 2003.

1.9.5.2 Typical SQL Server Database Specification

For the SQL Server Database the following typical specification will be used:

Dell PowerEdge™ 2950 (2U).
Two Hot-plug Power Supplies for Redundancy.
Dual Gigabit Ethernet Ports.
Single Serial Port.
2 X USB 2.0 Ports.
2 X Dual Core Intel® Xeon® 5148LV, 4MB Cache, 2.33GHz, 1333FSB.
4GB FB 667MHz FBD (4x1GB dual rank DIMMs).
2 X 73GB 15,000rpm 80-pin Ultra320 SCSI hard drive in a Raid 1 configuration.
2 X (3 X 73GB 15,000rpm 80-pin Ultra320 SCSI hard drives) in a Raid 5 configuration.
Operating System Windows 2003 and Database MS SQL 2005.

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