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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Device equipment operating below 1 GHz; Systems Reference Document for introduction of systems for Asset Tracking using Frequency Hopping Spread Spectrum (FHSS) in the band 865-868 MHz

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

1 Scope

The present document applies to Radio equipment to be operated in the 25 MHz to 1 000 MHz frequency range and using a Frequency Hopping Spread Spectrum modulation technique for Asset Tracking items.

The system is expected to operate in the 865 MHz to 868 MHz frequency range, according to the spectrum mask limits in the clause C.4 and subject to SE 24 compatibility studies needed.

The duty cycle of a transmission is very low - typically twice a day, 3,6 s transmission (< 0,001 %). Only in exceptional situations, i.e. in cases of emergency or in a specific situation in which a customer requires an additional location, he is polling the end-unit transmitter via existing paging networks, according to a pre-programmed plan.

The program name is ASAP (Assets Surveillance And Protection)

It is a cost sharing contract of IST (Information Society Technologies). The Project Reference is:ITS-2000-30071 and the Project Fact Sheet can be viewed at: project facts sheets. Search by Entering search term(s): "ASAP" and on the outcome page click on the blue "ASAP".

Nexus Telocation Systems Ltd. submitted an obligation to the European Commission that the air-protocol of the system will be made public.

The following information is given in the annexes:

- Annex A: Market information & Contribution to community social objectives;
- Annex B: Technical information;
- Annex C: Expected compatibility issues.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[2] CEPT/ERC/Recommendation 74-01E (Siófok 1998, Nice 1999): "Spurious emissions".

[3] ITU Radio Regulations (2001).

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

power density: level of power in Watts per Hertz generated within the power envelope

spread spectrum modulation: modulation technique in which the energy of a transmitted signal is spread throughout a relatively large portion of the frequency spectrum

Frequency Hopping Spread Spectrum (FHSS): modulation technique whereby the radio transmitter frequency-hops from channel to channel in a predetermined but pseudorandom manner

end-unit: unit attached to the assets, consisting of a paging receiver & FHSS transmitter

polling: interrogation by the control centre to invite an asset to transmit a predetermined message

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AoA	Azimuth of Arrival
ASAP	Assets Surveillance And Protection
BS	Base Station
CCC	Command & Control Centre
CEPT	European Conference of Postal and Telecommunications Administrations
DSSS	Direct Sequence Spread Spectrum
e.i.r.p.	effective isotropic radiated power
ECC	Electronic Communications Committee
FEC	Front-End Controller
FHSS	Frequency Hopping Spread Spectrum
HSE	Health and Safety Executive
ITU	International Telecommunications Union
RF	Radio Frequency
RFID	Radio Frequency Identification
SMR	Special Mobile Radio
TRRL	Tactical Radio Relay Link

4 Executive summary

The following document describes the characteristics of the system and its benefits to the European community. The ASAP system is designed to provide economical benefits by shortening the delivery time of large and expensive freights such as containers, efficient distribution of produced cars etc. On top, the system protects the goods against loss and theft. One of the main benefits of the system is its safety related ability to alert a potential leakage of hazardous materials. The system can interface with the regulating authorities controlling transportation of dangerous goods and also with national Health and Safety Executive offices (HSE).

The system uplink (from the end unit to the control centre) is designed to operate in the 865 to 868 bands. The transmission is Frequency Hopping Spread Spectrum (FHSS).

The typical duty cycle of an end-unit is extremely low (< 0,001 %). The end units are programmed to transmit either periodically twice a day, upon a request or after a trigger by an internal sensor such as in a hazardous materials leakage situation.

A typical transmission lasts less than 3,6 s with peak power of 500 mW e.i.r.p. During this period of time the unit is located by the receivers infrastructure and a short message is delivered from the end unit indicating the status of its sensors.

The uniqueness of the system is in its sparse infrastructure. The receivers on one hand are very sensitive (better than -140 dBm) and on the other hand are unsusceptible to interferences. The AoA is measured in 7 different frequencies.

In urban areas, the receivers are placed about 15 km apart. In rural areas the receiver are placed 25 km to 40 km apart, depending on the terrain and the antennas height.

Note that ASAP infrastructure is a **"receive only system"**. Exploiting existing commercial paging networks carries out the downlink command (from the control centre to the end unit receiver).

These characteristics provide an efficient use of the spectrum without causing interference to other systems and does allow operation of several spread spectrum systems in the same frequency band. Note that in Israel a FHSS commercial system is operated concurrently with a DSSS system, such as ITURAN (www.ituran.com) system, designed for tracking stolen vehicles with practically no mutual interference.

The transmission of the end unit produces minimal out of band interference and complies with ITU Recommendation and CEPT/ERC/Recommendation 74-01E [2].

The usage of ASAP provides:

- Highly reliable communication link coupled with location.
- Very low spectral pollution.
- A low cost & realistic solution for a prolonged problem.

Nexus Telocation Systems Ltd. has conducted in the past compatibility tests with CT-2 Telepoint system; the cross interference was minimal.

5 Detailed information on various aspects

5.1 Estimated number of FHSS transmissions (worst condition)

The number of containers and other large assets that are on the road is estimated at 20 000 000. These assets are dispersed all over Europe. The geographical area of Europe is 10 360 000 square km. Therefore; there are on average 2 end units per square km, provided that all potential assets are equipped with ASAP end units.

5.2 Estimated interference

The transmission of ASAP end units produces extremely low out-of-band energy. On the other hand the system is highly non susceptible to other transmissions interference.

The very sparse transmissions guarantee the ability of other systems to coexist with the ASAP system.

5.3 Limitation of the duty cycle of the end units

The end-units connected to the assets are programmed to transmit twice a day unless a rare occurrence happens which requires tracking of a specific end-unit.

5.4 Polling transmitter

No additional high power paging transmitters are required. asap technology does exploit the existing paging networks.

5.5 The economic benefits

ASAP is addressing the problem of freight transportation across Europe. Freight often travels on multi modal transportation, mainly to reduce transportation prices, especially these days where the demand of higher usage of trains and other low pollution means of transportation is on the rise. Therefore an efficient freight management tool is required. Many times, while in transit, assets are lost or damaged. Existing systems do not fully address this need.

Using the existing technology of location, which is mostly attached to the vehicle rather than to the goods (see clause A.2), it is very difficult to know the exact location of a specific shipment in real time. The available information is sparse and usually includes only the departure date and the approximate arrival date. In some cases, the gateways through which the assets have passed are also available.

There are several results to the present situation:

1) Low level of service the logistics companies can offer to the market.

2) Enormous waste of time and money is caused just by not knowing the exact arrival time of the sent goods, hence not being able to plan one's work efficiently.

3) More damage, when goods arrive too late, or are stolen or broken into during shipment.

4) When the goods shipped are of a hazardous nature, and the goods are damaged, the owner of the goods, who is the responsible person, and therefore has the best knowledge on the goods and on the countermeasures to be taken, is informed about the event only post factum, i.e. after all emergency crews have been summoned, and thus he cannot help them.

The total financial costs resulting from shipments being delayed, damaged, lost or stolen is estimated by the transporters to be of the order of between 0,5 % and 5 % of the total value of the goods shipped. The actual value depends on the type of goods being delivered and the type of damage. Only instance for stolen cigarettes and drinks account for about 1 % of the total value of such shipments. Late arrival of hazardous goods costs the shipper about 5 % of the value of the goods (and sometimes this loss can even reach 20 %).

In the field of automotive distribution, 15 % of new vehicles are delayed, while 1,5 % are damaged and 0,02 % stolen. These figures represent roughly, when considering also stolen cars, a yearly total of 17 billion Euros.

Real time location information, security and surveillance on the assets while in transition will give the owner of the goods, and the transportation company, timely warnings on:

- Timely arrival and departure of goods from stations along the way.
- Whether the shipment is safe or damaged.
- If damaged, where exactly did it happen.
- If the damage is in hazardous shipments, the person most knowledgeable is immediately alerted and contacts the rescuing authorities, giving them direct instruction on the nature of the cargo and countermeasures to be taken.
- Locating misplaced freight.
- Provide data for Intelligent Transportation Systems and Environmental Organizations.
- Provide information for mobile users and Internet users.
- Provide efficient tool for "pay per kilometre" projects.

In addition, in the case of unlawful action on the cargo, since the information on this action will be immediately sent to the owner, very rapid law enforcement action could be initiated, with much higher chances of solving the crime.

5.6 Social benefit

In addition to the economic benefit, introduction of this technology will contribute to the quality of life by:

- Improvements in the employment situation by shortening the time to deliver of assets.
- Improvements in the quality of life, health and safety of European citizens by monitoring spill or leakage of dangerous materials.
- Prevention of theft of shipped natural resources, expensive materials or dangerous materials.
- Cargo real-time database will provide information of transportation all over Europe and will provide better services to the European population.

5.7 Spectrum requirement and justification

The Strategic Plan for the 862 MHz to 868 MHz proposed by the SRD MG and approved by WG FM offers the opportunity for introduction of the FHSS technology:

"The frequency band 863 MHz to 870 MHz should be considered for non-specific spread spectrum SRD applications by using Direct Sequence Spread Spectrum (DSSS) and/or Frequency Hopping Spread Spectrum (FHSS) with a power level of 25 mW. The technical parameters for the power density for DSSS and the channel scheme/power level/hopping system should be defined based on detailed compatibility studies in order to provide sufficient protection to other services in the band and in particular safety services such as Social Alarms."

Nexus Telocation Systems Ltd proposes to assign the sub band 865 MHz to 868 MHz for FHSS ASAP systems, which operate with very low duty cycle (below 0,001 %) and a maximum permitted power level of 500 mW e.i.r.p. in the 865 MHz to 868 MHz band. Due to very low spurious emission, the system will meet the restrictions set in the adjacent bands 863 MHz to 865 MHz and 868 MHz to 870 MHz.

5.8 Technical Issues

Market information & Contribution to community social objectives: see annex A

Technical information: see annex B

Expected Compatibility studies: see annex C

5.9 Current Regulation - Region 1 and CEPT allocation

RR Region 1 Allocation and RR footnotes relevant to CEPT and frequency band	**European Common Allocation**	**Utilization**	**EU footnote**	**ECC/ERC document**	**Standard**	**Note**
862 - 870 MHz BROADCASTING 5.322 FIXED MOBILE except aeronautical mobile 5.317A 5.319 5.323	MOBILE	Cordless Telephones		ERC DEC (01) 02		To be phased out in accordance with ERC Decisions (01) 02
	5.323 EU2 EU13	Defence systems				
		Radio microphones		ERC REC 70- 03	EN 300 422 EN 301 357	Within the band 863- 865 MHz
		Social Alarms		ERC DEC (97) 06 ERC REC 70- 03	EN 300 220	Within the band 869,2- 869,25 MHz
		SRD in 868- 870 MHz		ERC REC 70- 03 ERC DEC (01) 04	EN 300 220	Strategic Plan for the use of SRD within the band 862- 870 MHz adopted
		Wireless Audio		ERC DEC (01) 18 ERC REC 70- 03	EN 301 357	Within the band 863- 865 MHz

6 Main conclusions

The UHF band 865 MHz to 868 MHz could meet market requirements by allowing low duty cycle FHSS systems to operate providing co-existence with other SRD applications, enabling both economical & social benefits of ASAP system.

Compatibility evaluations and studies for services are as listed in annex C.

Annex A: Market information & Contribution to community social objectives

A.1 Introduction

ASAP introduces a new concept for asset surveillance and protection. Based on Nexus Telocation Systems Ltd. wireless network, it includes end unit devices, sensors, infrastructure and inter-connected databases. ASAP uses real time location, sensor and security information to improve logistic management of assets as they are transported across Europe. ASAP is affordable, accurate and user friendly.

Assets worth billions of Euros are transferred daily with delivery periods ranging from one week to several months. Many different types of transportation are used and available information is sparse. A significant percentage of the freight is forced open, stolen or lost. Assets are also frequently misplaced, damaged or do arrive late.

The environmental benefits of ASAP are of particular importance. According to European ADR data, road transport of dangerous goods represents 15 % of all road transport. The ASAP end unit includes a multi-sensor device to monitor spills and leaks, thus reducing environmental hazards. ASAP interfaces with the regulating authorities on the transport of dangerous goods and with HSE (Health Safety and Environment).

ASAP provides a total system solution with integrated registration, management, monitoring and billing of each shipment. Location, environmental and security information is made available as needed, anywhere, any time, in any way the user requires, including access to both the mobile user and via the Internet. The system integrates with the European wide Intelligent Transport System (ITS) database.

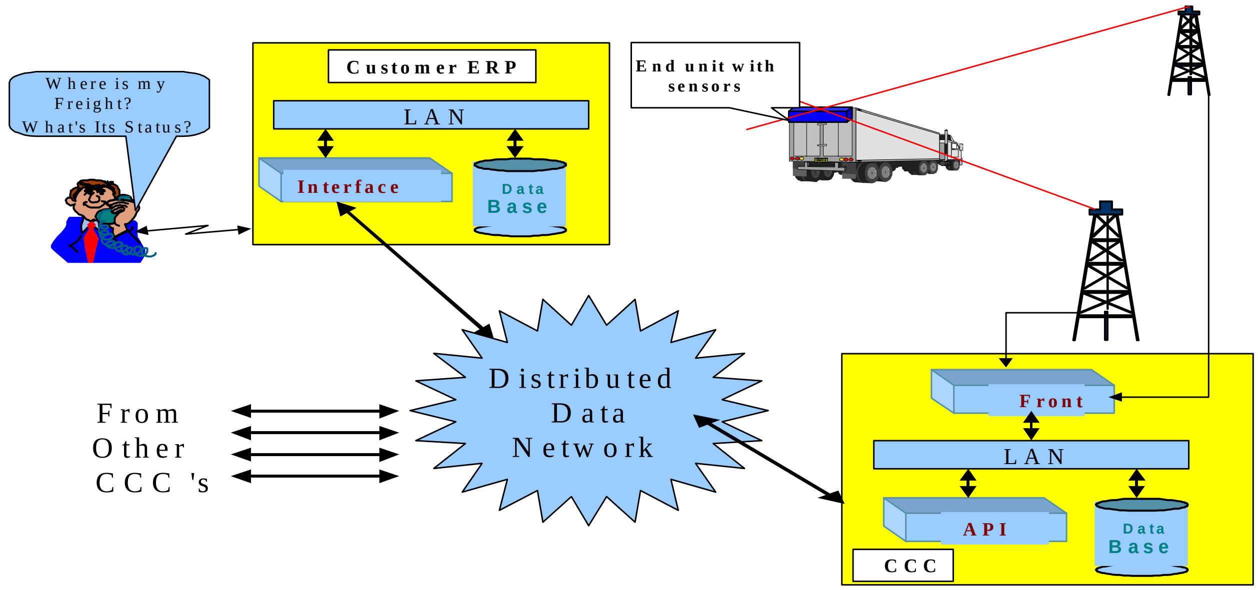


Figure A.1: ASAP System concept

A.2 ASAP key features

- ASAP monitors hazardous materials online in real time.
- The end unit is attached to the asset and provides both location of the freight and two-way communication capabilities with it.
- ASAP provides a sparse, high sensitivity, terrestrial infrastructure. There is a need for one base station for about every 20 base stations used in a GSM infrastructure.
- Location triangulation does not require line of sight between the base station and the end unit as in conventional satellite based systems.
- The ASAP software is based on a distributed database European network giving both real time location and all relevant freight information to users anywhere at all times, online, via mobile or via the Internet.
- The system is designed to operate at about 20 % of the cost of present systems that use SMS technology.
- The end unit is capable of withstanding harsh environmental conditions.
- The end unit costs less than 100 Euros as opposed to existing systems, which cost from 250 Euros to 400 Euros.
- The end unit is a low power unit, allowing the battery to be used for more than 100 days without recharging or replacing.

A.3 Improvements in the employment situation

Accurate, real time information on the location, arrival time and safety of a freight shipped in Europe will contribute immensely to the competitiveness of the European industry. This was shown by the preliminary market survey conducted by Nexus Telocation Systems Ltd. prior to the initiation of this project, and by the large number of requests received for joining the project from all over Europe.

Knowing where the cargo is, or, for that matter, where the empty containers are, enables efficient planning of production and distribution. Gone will be the days where shipping took between a week and six months, and the shipper could not know whether the goods were just delayed, stolen, or misplaced.

Increasing the efficiency of distribution will influence the whole production - service chain. When the whole chain becomes more efficient, Industry at large becomes more competitive, hence the increase in the number of jobs.

This situation is particularly true for SMEs. The small companies suffer from a double problem which would be rectified by the results of the project ASAP: they usually get less than the best service, and they cannot financially afford having large quantities of goods in transit on the roads, or a large number of containers not returning, or returning late to their base.

A.4 Improvements in the quality of life, health and safety of European citizens

The results of the project ASAP will contribute to the quality of life, health and safety of European citizens in several ways mostly connected with the danger of leaks or spills of hazardous materials and with the ability to remotely control, and if necessary re-routing of cargoes, to minimize the disturbance to the European citizens.

Large quantities of hazardous materials are transported in Europe. According to Eurostat (assuming that dangerous goods belong to the groups of petroleum and petroleum products and chemicals and fertilizers), in 1996, 13 % of all tonne-km of goods transported by road and 20 % transported by rail were classified as dangerous. This totals 150 billion tonne-km transported by road and 44 billion tonne-km transported by rail. Leaks or accidents happen at all times, always with considerable disturbance to the quality of life (such as long traffic jams), health of the citizens who may be exposed to hazardous, noxious or inflammable material, impacting on the quality of the immediate environment suffering from both the spill or leak and the exhaust gases of the vehicles waiting in the blocked traffic.

Quite often, but almost always in the case of the more dangerous accidents, the owner of the goods is called to give information on the nature of the leaking substance. Locating the owner of the freight may take a long time and in that time the rescue crew does what they can, but are sometimes working with no relevant information. If the owner of the cargo can be located immediately, and this can happen because of the information about the accident that will be forwarded to him through a paging service or via a cellular phone, he could call the rescue team to establish contact and give them the needed information immediately.

A.5 Preservation of the environment or natural resources

The ASAP project will contribute to the enhancement of the environment and natural resources in three different ways:

- The contribution of ASAP project results to the enhancement, or rather, to the lesser deterioration, of the environment. Being able to correctly deal fast with leaks and spillage will reduce damage considerably.
- Reducing the thefts of goods from containers through the use of the ASAP system, will also contribute to the saving of natural resources now used for replacement of the stolen goods.
- Last but not least, if the owner of the cargo is notified in real time about an attempted theft of the container or its contents, he can call the police force to the location, resulting in stopping the thieves and punishing them. This will no doubt reduce the theft of such cargoes.

Saving time in long-distance shipments will also save energy, with all its well-known environmental benefits (reduce SO_2, NO_X and CO_2 emissions).

A.6 Contribution to meeting regulatory requirements

The transportation of, especially dangerous goods, are subject to many regulations. Many of them require supplying information about the content of the load by a special label or by special document (e.g. MSDS). The assumption behind some of the regulations is that the owner of the cargo, the one who knows best, is not available if an accident happens.

However, one of the results of the ASAP project will be the immediate availability of the owner of the cargo by telephone or in person. This will, no doubt, influence regulatory requirements in a way that is not clear at the moment.

Another possible contribution of the ASAP project to the evolution of regulation is the following: the database including information on the transportation of goods along the major highways and railroads of Europe will become available once the ASAP system is exploited. The availability of this information may influence the thinking of the regulatory bodies in ways that are as yet unpredictable.

A.7 Summary

ASAP provides a new method of dealing with a critical problem; the management and location of freight assets in transit. It provides a full system solution with integrated registration, management, monitoring and billing of each shipment. The information is available, as needed anywhere, any time in any way the user wants. It does this while providing a low cost infrastructure with low cost end units and operating costs.

Annex B: Technical information

B.1 The need for a different technology

Present technologies that could potentially provide a solution to the ASAP issues consist of a combination of Navigation, LEO and Terrestrial location.

1) Existing navigation systems such as GPS (or Galileo in the future) are combined with a communication system like GSM/SMS, GPRS, TETRA and UMTS have several constrains when applied to an ASAP application:

    - They consume relatively large amounts of power.
    - An antenna cannot always be installed with line of sight with a satellite navigation system. This is particularly noticeable in urban areas and in warehouses.
    - Present wireless systems are not designed for very long operation on a single battery. A larger battery is not a solution as size and cost are both limiting factors.
    - New location technologies have recently been developed (SnapTrack for GPS embedded in mobile phones, CPS technology for location over GSM). Both technologies are focused on mobile phones and are not yet commercial.
    - The cost of the unit, which consists of location, communication and power devices, is much higher than the integrated ASAP unit.

2) Low orbit satellite (LEO) system. LEO satellites systems, positioned in orbit at a height of 400 km to 800 km with a revolution period of a few hours, theoretically provide a non-terrestrial location system. They are unattractive because the end units and operation costs are too expensive, and the power consumption too high.

3) Terrestrial location technologies such as Datatrak in the Netherlands, Great Britain and South America are operational. The location is based on a derivation of LORAN-C combined with a private communication protocol, but the end units are too large, too expensive and consume too much power.

In summary, existing wireless communication networks are of limited value in asset tracking.

B.2 ASAP Technology

Figure B.1 illustrates information data flow in the ASAP system.

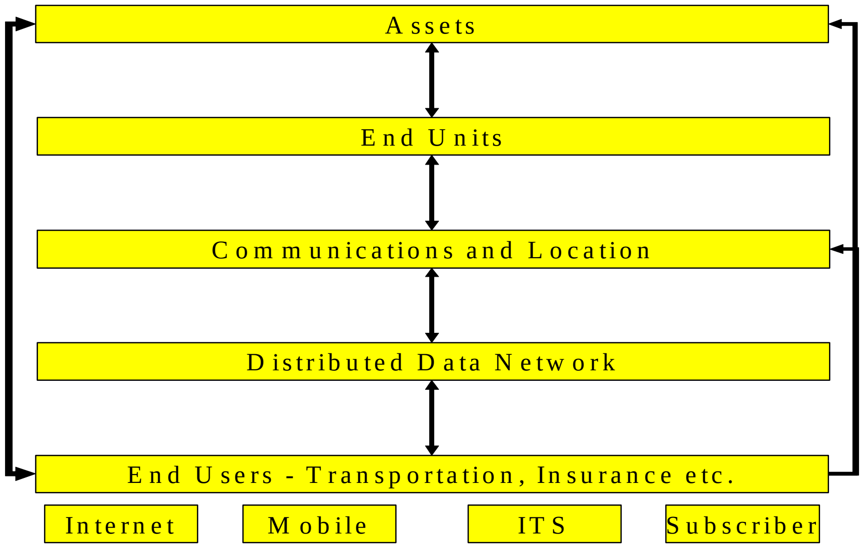


Figure B.1: Block Diagram of the information data flow in ASAP

B.3 System Principles of Operation

The principles of operation of the system are as follows (see figure B.2):

1) Each assets moving in Europe is attached with end-unit, which consists of:

   a) Transceiver, which consists of a commercial paging receiver, frequency-hopping transmitter and controller.

   b) Power source (battery).

   c) Sensors.

2) The end units are programmed to transmit either:

   a) Periodically, typically twice a day.

   b) Upon an event triggered by the sensors (rare occasions).

   c) Upon request by the customer (rare occasion).

3) The transmissions are not coordinated.

4) Several receivers BS receive the signal.

5) Each receiver is equipped with up to 4 interferometer arrays, which estimate the Azimuth of Arrival (AoA) of the incoming signals. Each AoA is measured in 7 different independent frequencies, with typical accuracies of 0,3°.

6) Each message lasts for 3,6 second. The symbol rate is 200 bit/s. The modulation is BIT/SK.

7) The message carries about 180 bits on top of end-unit identification number. The bits will be used to provide the sensors status. The information is coded with error correction code based on Turbo Product Coding.

8) The information is collected by a local Command & Control Centre (CCC) through a Front-End Controller (FEC). The communication lines are preferred to be IP WAN networks.

9) The CCC performs triangulation & the information is further collected in a central database.

10) The information is distributed to customers.

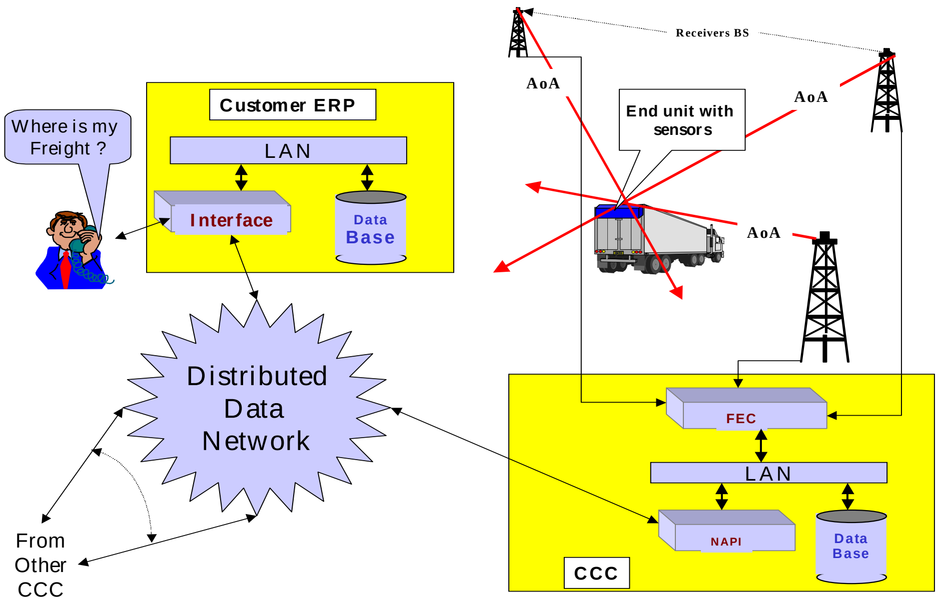


Figure B.2: The principles of operation of the system in ASAP

B.4 Assets

Each asset is equipped with an end unit. The user initiates an assignment procedure that ties the asset to the end unit with all necessary assignment information being distributed to the relevant databases, both local and remote.

B.5 End Units

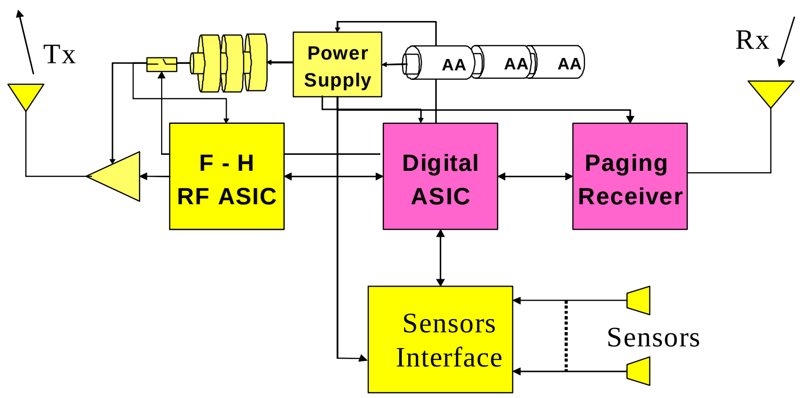


Figure B.3: End Unit Block Diagram

The end unit is a communication device resistant to harsh environmental conditions and with low power consumption. It is registered in the distributed database and programmed over the air to transmit periodically. It also reacts to a change in the sensors condition and triggers an alert transmission.

B.6 Communications and Location

The communication protocol is based on two technologies:

1) The Downlink (to the end unit), is a multicast commercial paging system, outside the 865 MHz to 868 MHz band.

2) The Uplink (from the end unit), is a unique protocol, designed to operate between 865 MHz to 868 MHz, employing a 2 MHz spreading band.

The communication subsystem consists of receiving Base Stations (BS) and a Command and Control Centre (CCC), and an open system built around a local area network. The BS do receive the transmissions (uplink) from the end units and transfer the messages and bearings to the CCC, via dedicated telephone lines, dial up lines, frame relay, wireless, etc. The CCC computes the locations of the end units using the bearings received from the BS's and the processed messages are written to the database.

The downlink messages and end unit commands are transmitted from the CCC using existing one-way paging equipment. The downlink protocol could also be based on cellular, Special Mobile Radio (SMR) but paging is preferred because it exploits existing lightly used networks and enables the use of a low power receiver.

Frequency hopping for the uplink enables the use of a combination of a very sensitive receiver with the ability to overcome multi-path problems in direction measurements. It also enables random access. The uplink spread spectrum frequency hopping protocol enables coexistence with other wireless networks in the same frequency band. Transmitter-Receiver tracking is based on a synchronization scheme, which provides a real time clock to each and every end unit in the system.

The location technology used in Azimuth of Arrival (AoA), is based on RF interferometry. The direction calculations do use the phase difference from the wave front hitting the antennas and so there is no need for GPS. This is shown in figure B.4.

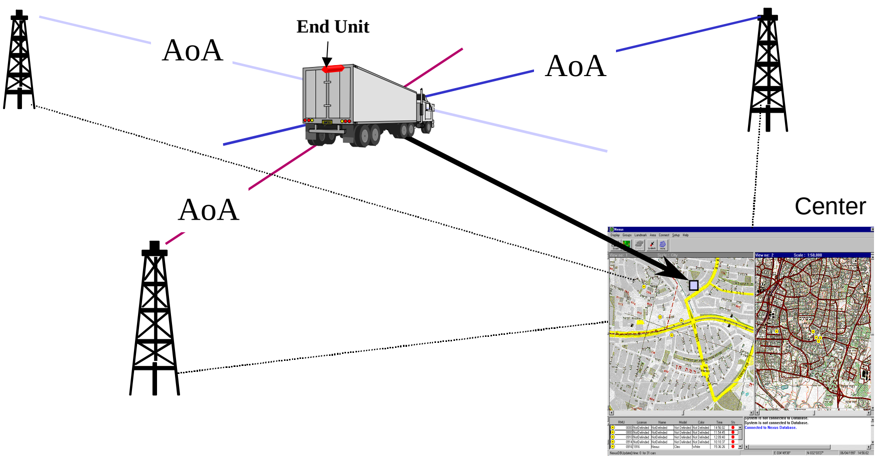


Figure B.4: AoA Technology

B.7 Distributed Data network

The system consists of several separate local communications and location systems each with a different local CCC and database. These local databases are connected together as a distributed database with a central managing point in a star network.

The assignment information tying the end unit, the sensor information and the container together is stored in either the local database or in a remote database located on another CCC. When the end unit transmits data, the receiving Base Stations transfer it to those CCC's, which are physically connected to the stations, not necessarily to the CCC containing the original assignment data.

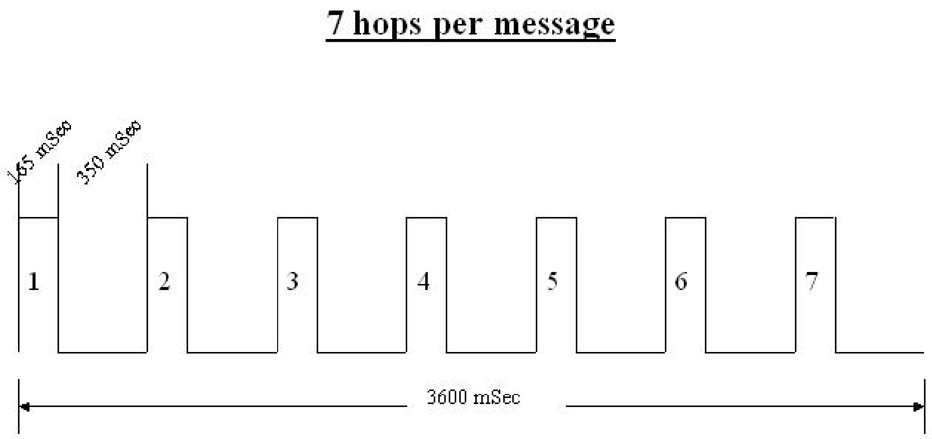
The network control and management system connects all the sub-parts of all the separate communications systems and CCC's and all the different parts of the distributed database.

B.8 End users

The location and status information is accessible to the end user in a variety of different ways, directly, by mobile telephone or via the Internet. In addition the system integrates to a European wide ITS. All users will have access to freight and database information in accordance with local and system wide security handling procedures.

B.9 Frequency hopping characteristics

A message has a total duration of 3,6 s. It is comprised of 7 hops, each hop is 30 KHz wide. The centre frequency of the hop is randomly selected within a bandwidth of 1,92 MHz in the 865 MHz to 868 MHZ band. Each hop duration is 165 ms and the time between adjacent hops is 350 ms.



B.10 Sensitivity

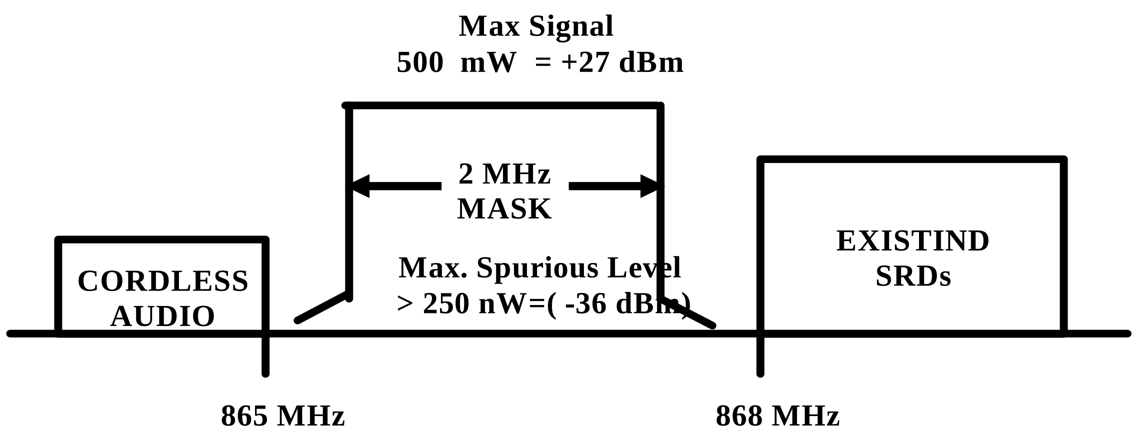
The information is transmitted in 7 different frequencies allowing a diversity of 6. The result is a gain of 10 dB to 15 dB in fading margin which double the reception range of a base station.

B.11 Frequency mask for FHSS

For ASAP FHSS system a maximum e.i.r.p. level of 500 mW will be sufficient. The system will need maximum bandwidth of 2 MHz for spreading the hops.

The spurious level of the system was measured between -40 dBm to -45 dBm, according to specified test method of CEPT/ERC/Recommendation 74-01E [2].

Given these parameters, the system may well meet future 865 MHz to 868 MHz band requirements.



In order to have independent frequencies, the hops are to be at least the inverse of the average delay spread, which is in the order of 3 µs in urban areas (≈300 kHz). Reception in seven independent frequencies leads to the need for ≈2 MHz.

Two attributes of FHSS needs to be mentioned:

1) The out-of-band energy leakage is exceptionally small compared to DSSS systems.

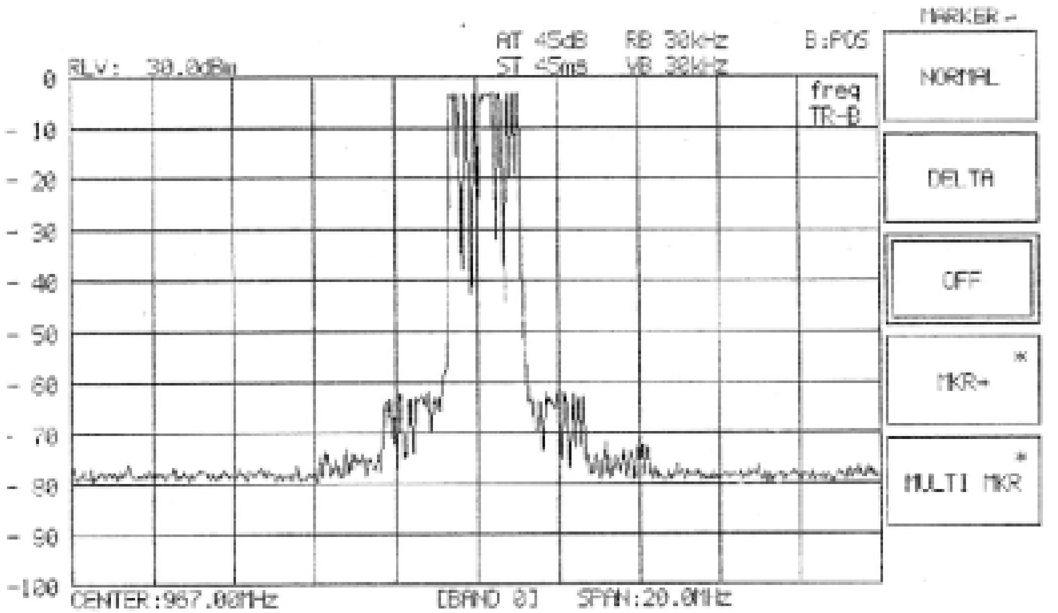
2) The system could operate in non-contiguous bands or narrower bands with reduced performances.

B.12 Peak Power Density

The Peak Power Density, using FHSS modulation, per 30 kHz channel is: ≈ 500 mW/30 kHz.

B.13 Frequency Spurious Emission (measured)

NOTE: The equipment which was used for frequency mask measurement is commercially available at 967 MHz. It is planned to shift it to the 865 MHz to 868 MHz band once this band is allocated.



In a frequency hopping spread spectrum system the carrier is modulated with the coded information in a conventional manner causing a conventional spreading of the RF energy about the frequency carrier. The frequency of the carrier is not fixed but changes at fixed intervals under the direction of a coded sequence. The wide RF bandwidth needed by such a system is not required by spreading the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop. The test of a frequency hopping system is that the near term distribution of hops appears random, the long term distribution appears evenly distributed over the hop set, and sequential hops are randomly distributed in both direction and magnitude of change in the hop set.

B.14 Hot Spot

The "hot spots" in ASAP system are in containers or swap bodies hubs that might contain up to 5 000 assets to be tracked. The containers reside in the hub.

The transmission policy is as follows:

1) Assets that do not move transmit twice a day.
2) Assets on the move transmit once an hour.
3) Assets reside one week on average in a hub.
4) Transmission length is 3,6 s.
5) An asset moves out of the hot spot area within less than an hour.

The number of transmissions per day is:

All units transmit twice a day, 2/7 of the units are moving in or out and therefore transmits an additional transmission (and then move out of the hot spot area).

Altogether: 5 000(2+2/7) = ≈11 428 daily transmissions.

Per hour: ≈476 transmissions per hour.

Assuming that we check the duty cycle per a channel of 30 kHz, the duty cycle will be 476 × 3,6 / (3 600 × 64) ≈ 0,007

B.15 Technical justifications for spectrum

Spread Spectrum systems inherently need wide band spectrum. Use of FHSS for communication associated with AoA based location technology provide the following features:

- Enable accurate location of very weak signals.
- Sparse and low-cost infrastructure.
- FHSS presents very low probability of interference to other devices operating in the same band.
- Because of very low spurious emissions produced by FHSS, adjacent band services are not to be affected.
- Provides means for successfully overcoming the multipath phenomena in urban environment.

Due to the intended use of the system in urban environment, sufficient propagation can only be achieved working in the UHF band below 1 GHz. The band 865 MHz to 868 MHz would be suitable for FHSS on a frequency-sharing basis.

Annex C: Expected compatibility issues

C.1 Coexistence tests and studies

In addition to the sharing tests mentioned below, compatibility studies between different services and systems will probably be requested by CEPT/ECC SE 24.

Studies will be necessary between FHSS and other systems using the same band or adjacent bands:

- Tactical Radio Relay Link (TRRL).
- CT-2 systems and - other SRD's such as tele-alarm, telemetry, RFID, DSSS and cordless audio devices in adjacent bands and within the defined sub-bands.
- Television (channel 69) and aeronautical radionavigation in some countries (ITU Radio Regulations [3]).

Annex D: Bibliography

- Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).
- Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations.
- ETSI ETR 028: "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".
- ERC Report 25: "Frequency range 29.7 MHz to 105 GHz and associated European table of frequency allocations and utilizations"

History

Document history		
V1.1.1	November 2002	Publication