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ALIS Consortium

ALIS Technical Note #1

Galileo Mission Summary

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Summary: This document contains a high-level summary of some aspects of the Galileo mission. It is not intended to be a review all aspects of the mission.

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1. Summary of the Galileo Mission

1.1 Introduction

GALILEO will be a global satellite navigation system under civil control. It will consist of 30 satellites, the associated ground infrastructure and regional/local augmentations.



Figure 1-1: The Galileo Satellite Constellation

(image courtesy of ESA)

The Galileo satellite constellation (shown in Figure 1-1) will be divided into three circular orbits, each inclined at 56° to the equator and at an altitude of around 23,000 KM, to cover the Earth's entire surface. Nine satellites (plus one spare) will be spread evenly around each orbital plane, with each taking ~ 14 hours to orbit the Earth.

The operating principle for Galileo is simple and is the same as GPS:

- The satellites in the constellation are fitted with an atomic clock measuring time very accurately.

- The satellites emit satellite-specific signals indicating the precise time the signal leaves the satellite.
- A user's ground receiver has in its memory the precise details of the orbits of all the satellites in the constellation. By reading the incoming signal, it can recognise a particular satellite, determine the time taken by the signal to arrive and therefore calculate the distance from the satellite.
- Once a user's ground receiver receives the signals from at least four satellites simultaneously, it can calculate an exact position (as illustrated in Figure 1-2).

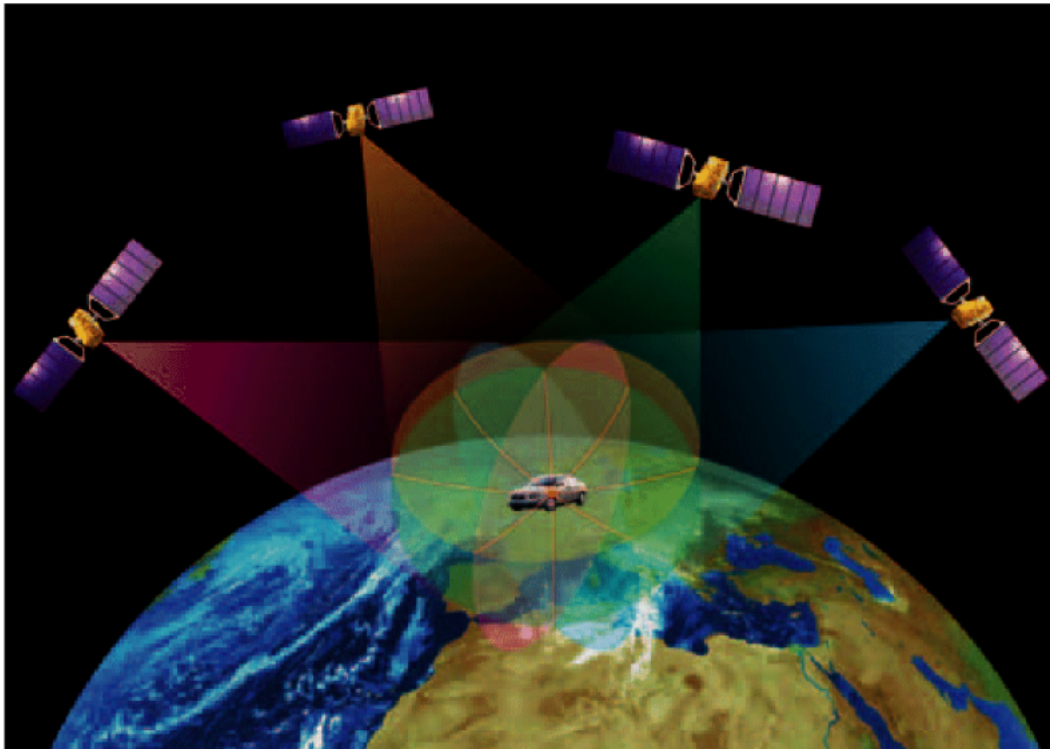


Figure 1-2: The Principle of Positioning by Satellite Navigation

(image courtesy of GJU)

Galileo will transmit 10 signals: six to serve the Open Service and Safety-of-Life Service, two for the Commercial Service and two for the Public Regulated Services. These signals will be broadcast in the following frequency bands:

- E5A-E5B (1164-1215 MHz) and E6 (1260-1300 MHz)
- E2-L1-E1 (1559-1591 MHz).

The latter is already used by GPS, but Galileo will share this band with GPS on a non-interference basis. This is in order to avoid affecting current GPS services while offering users simultaneous access to GPS and Galileo at minimal increases in terminal cost and complexity. The long-term future for the satellite navigation receivers will probably be a combined GPS / Galileo receiver that will be capable of computing signals from both constellations and which will provide the best possible performance, accuracy and reliability. However, since Galileo will not be fully available before 2008, current GPS-receivers will not be able to receive Galileo-signals.

The transmission bands for Galileo and GPS are illustrated in Figure 1-3.

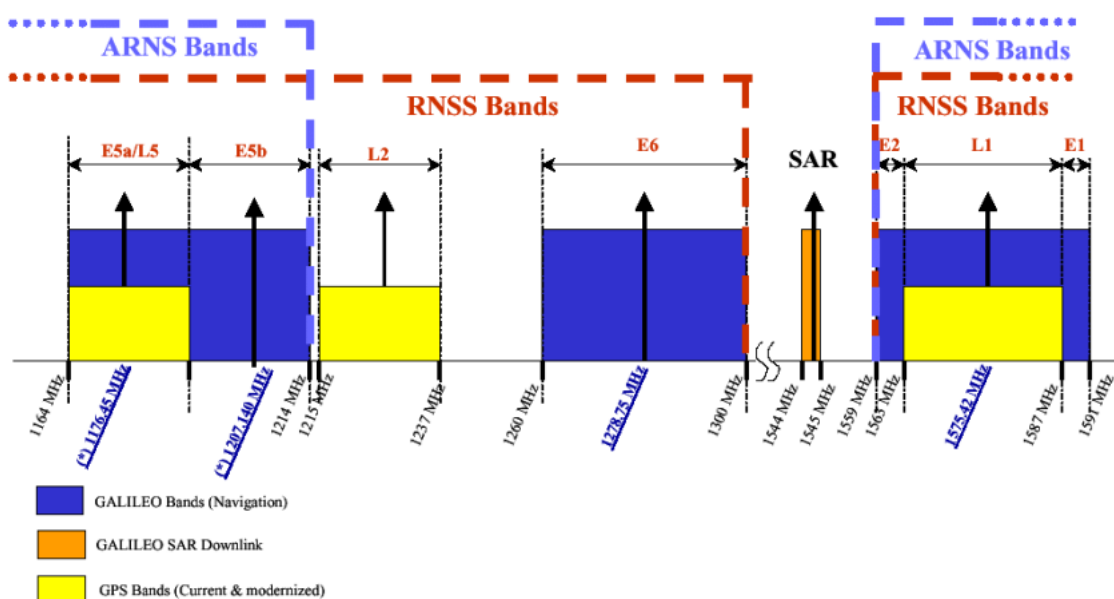


Figure 1-3: Galileo & GPS Transmission Bands

(diagram courtesy of the GJU)

Further details on Galileo Services can be found below.

1.2 Need for GALILEO

GALILEO will ensure independence from other international satellite navigation systems, which could deny access to civil users at any time, and as such will enhance safety and reliability. The US Global Positioning Service (GPS) and the Russian GLONASS system are both military systems and although they are made available to civil users, this is done without any guarantee of continuity.

As well as macro-economic benefits from Galileo, through achieving a European share in the satellite navigation equipment market, efficiency savings for industry as well as social benefits (e.g. through cheaper transport, reduced congestion and less pollution), Galileo will also offer value added services with signal integrity provision and, in some cases, service guarantees, based on a certifiable system.

1.3 Charging for Galileo Services

Like GPS, Galileo will be free of charge to users of the Open Service. However, some Commercial Service applications will have to be paid for, i.e. those requiring a higher quality of service (positional accuracy).

1.4 Galileo Schedule and Management

GALILEO will be fully operable in 2008. However, as part of an 'In-Orbit Validation' (IOV) phase, ESA and the GJU successfully launched the first of two 'Galileo In-Orbit Validation Element' (GIOVE) test satellites, GIOVE-A, on 28 December 2005. GIOVE-A, built by Surrey Satellite Technology Ltd (SSTL), is basically a transmitter beacon and its first navigational signals were received on 12 January 2006. In fact GIOVE-A has two

signal generation units: one able to generate a simple Galileo signal and the second more representative Galileo signals. These two signals will be broadcast by the satellite through an L-band phased-array antenna designed to cover all of the visible Earth under the satellite at any one time.

GIOVE-B, built by Galileo Industries, will have a more advanced payload which includes two atomic clocks and is targeted for launch in the spring of 2006. For both test satellites, the primary objective is achieving the ITU frequency-filing requirements that require using the allocated transmission frequencies by the deadline date. GIOVE-B also has clock and MEO environment characterisation objectives, as well as Signal-In-Space and receiver experiments. GIOVE-B will contain a rubidium atomic clock and the first space-qualified passive hydrogen maser atomic clock.

Following the launch of GIOVE-B, the first of four of the actual Galileo satellites will be launched to complete the IOV phase. Each of these will be fully representative of the 30 Galileo satellites in the Galileo constellation and each will broadcast precise time signals, ephemeris and other navigation and commercial data. In fact on Thursday 19 January 2006, the European Space Agency and Galileo Industries signed a €950 million contract for the development and construction of these first four satellites and their associated ground systems. Following the IOV phase, the full deployment phase will cover the manufacture and launch of the remaining 26 satellites and the completion of the ground segment, an extensive network of stations and local and regional service centres.

The Galileo system will be managed and operated in the form of a concession as part of a public-private partnership (PPP), a structure that allows the project to be financed by both public and private funds. While the private-sector concessionaire will be responsible for managing the deployment and operational phase, a limited public contribution is foreseen for the deployment phase and the first years of the commercial operating phase.

The 'Galileo Joint Undertaking' (GJU) was set up by the EC and ESA to manage the development phase of the Galileo programme and manages the Concession process. The Concession process will be successfully concluded through the establishment of the 'Galileo Concession Contract'. The public counterpart (i.e. the conceding authority), representing the interest of the public partners, will be the 'Galileo Supervisory Authority'.

Major industrial players in Galileo are: Alcatel, EADS, Finmeccanica, Galileo Industries, GSS and Thales.

1.5 Galileo Services

Galileo will offer five types of service:

- **Galileo Open Service.** The Open Service (OS) is aimed at the mass-market of satellite navigation users. As with GPS, it will provide positioning free of charge to a user with a Galileo-compatible receiver. If two separate signal frequencies are used within the OS (dual-frequency mode), then higher positioning accuracies will be achieved, but only one signal need be used (mono-frequency) if the user's application requires reduced accuracy. In addition if OS applications use both Galileo and GPS signals, performance in environments such as urban areas will be improved. The OS will not offer integrity information, and the determination of

the quality of the signals will be left entirely to users. There will be no service guarantee or liability from the Galileo Operating Company on the OS.

- The OS mono-frequency mode will be provided in any of the three OS transmission bands: L1, E5a, and E5b. Receivers using a mono-frequency signal transmitted in the L1 band will achieve <15 m horizontally and <35 m vertically, which is comparable to today's civilian GPS service. The mono-frequency performances that can be achieved when using the OS signals modulated in the E5a and E5b bands are expected to be slightly lower. This may mean horizontal positional accuracy values of <24 m and vertical positional accuracy values of <35 m. Accuracy in velocity determination available with the OS mono-frequency mode should be better than 50 cm/s. The OS dual-frequency mode will use OS signals modulated in the E5a and L1 bands, or the E5b and L1 bands. Galileo receivers supporting the OS dual frequency mode will achieve positional accuracies of <4 m horizontally and <8 m vertically. The accuracy in velocity determination available in OS dual-frequency mode should be better than 20 cm/s.
- The Galileo Mission Requirements Document (MRD) also implies that there may be two low bandwidth data channels available in the OS. In Annex 1 of the MRD, there is mention in the E5a band of a 25 bps low data rate navigation message and in the E5b band of a 125 bps low data rate navigation message. Whether these data channels (and how much of each of them) will be available for third-party use is unclear at this time. In fact the E5b band message description in the MRD refers to it 'also supporting integrity and SAR data', which may mean that its use for other third-party data traffic is not feasible. However, the MRD also contains a statement with reference to these two low rate data messages that the 'Possibility to include commercial data is under assessment'.
- **Galileo Safety-of-Life Service.** The Safety-of-Life Service (SoL) Service will provide the same accuracy in position and timing as the OS dual-frequency mode, but with the addition of signal integrity data. The SOL service will be used for most transport applications (e.g. maritime, aviation and rail) where lives could be endangered if the performance of the navigation system is degraded without real-time notice. The future Galileo Operating Company will guarantee SoL and SoL will be implemented in the frequency bands reserved for the Aeronautical Radio-Navigation Services (i.e. L1 and E5).
- **Galileo Commercial Service.** The Commercial Service (CS) is aimed at applications requiring high positioning accuracies and will require users to pay to use it. The CS will be based on adding two signals to the existing OS signals and these additional CS signals will be protected through commercial encryption. Access will be controlled using access-protection keys in the user's receiver. It is expected that the CS will offer positional accuracies of <1 m. In addition and as with differential GPS, the CS can also be complemented by ground stations to improve the accuracy to <10 cm. The two dedicated CS signals will be transmitted in the E6 band, in addition to the OS signals made available in the L1, E5a and E5b bands. In addition, the CS will provide capacity to broadcast data for added value services at a data rate not less than 500 b/s.

- **Galileo Public Regulated Service.** The Public Regulated Service (PRS) is for government-authorized applications and will be used by groups such as the police, coastguard and customs. Civil institutions will control access to the Public Regulated Service which will be based on encrypted signals. The PRS will be operational at all times and in all circumstances, including during periods of crisis. The PRS will have frequency separation with respect to any other Galileo service to prevent jamming or spoofing during times of crisis. The PRS will provide horizontal positional accuracies < 6.5 m and will provide vertical positional accuracies of < 12 m. PRS velocity accuracies should be < 20 cm/s.
- **Galileo Search & Rescue Service.** The Search and Rescue Service (SAR) is Europe's contribution to the international cooperative effort on humanitarian search and rescue. It will allow important improvements in the existing system, including: near real-time reception of distress messages from anywhere on Earth (the average waiting time is currently an hour); precise location of alerts (a few meters, instead of the currently specified 5 km); multiple satellite detection to overcome terrain blockage in severe conditions; increased availability of the space segment (30 Medium Earth Orbit satellites in addition to the four Low Earth Orbit and the three geostationary satellites in the current COSPAS-SARSAT system). As illustrated in Figure 1-4 the SAR service will detect and position signals transmitted from COSPAS-SARSAT 406 MHz beacons on the 406 to 406.1 MHz frequency band and transmit them to ground stations, within the 1544-1545 MHz band. In addition the SAR service will also support the transmission of SAR 'Return Link' messages via inclusion as data in the OS signals broadcast in the E2-L1-E1 band. The SAR service will provide in the OS signal navigation frame an average of 10 bits/s, for the transmission via the Return Link of 6 acknowledgement messages per minute from the Rescue Centre, each of 100 bits. The inclusion of the SAR return link (i.e. from the Rescue Centre to the distress beacon), should help rescue operations and help reduce the rate of false alerts. The SAR service is being defined in cooperation with COSPAS-SARSAT, and its characteristics and operations are regulated under the auspices of the International Maritime Organisation and the International Civil Aviation Organisation.

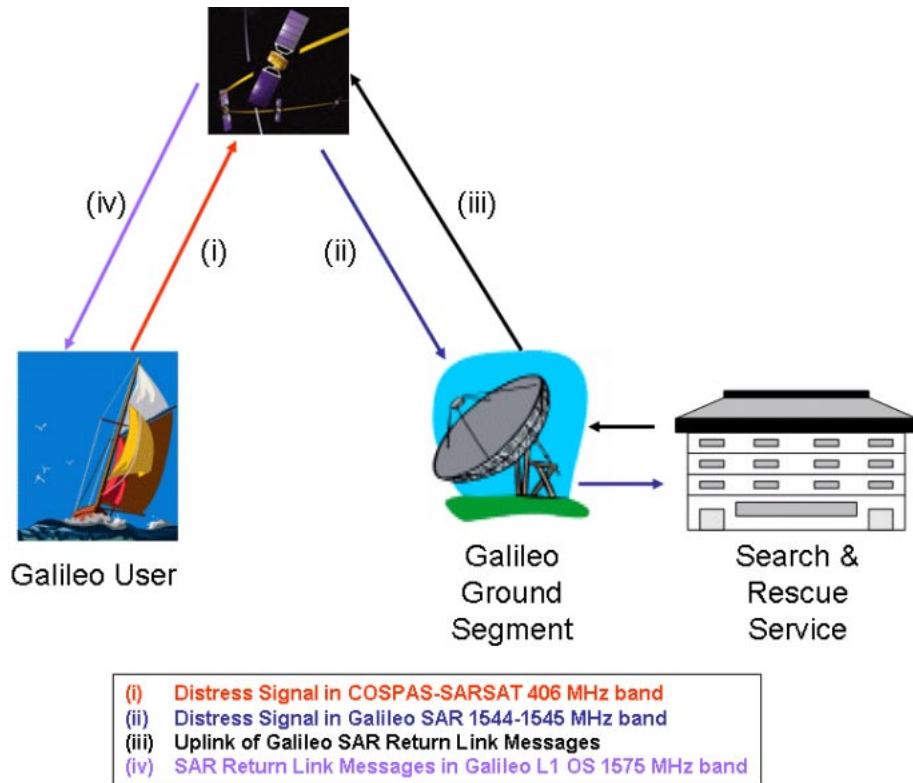


Figure 1-4: Galileo SAR Service Architecture

- Galileo Local Services.** The OS, CS, SOL and PRS can all be enhanced by local Galileo elements to provide local services, which are available within limited areas, ranging from a few meters up to thousands of kilometers. Such Local Services will offer enhanced performance with respect to Galileo services in the domains of accuracy, availability, integrity, continuity and communication. Local Services should be easily incorporated with existing local positioning and communication services (e.g. DGPS and UMTS) to deliver enhanced combined service performances.

The relationship between the transmission bands and the Galileo services is illustrated in Figure 1-5.

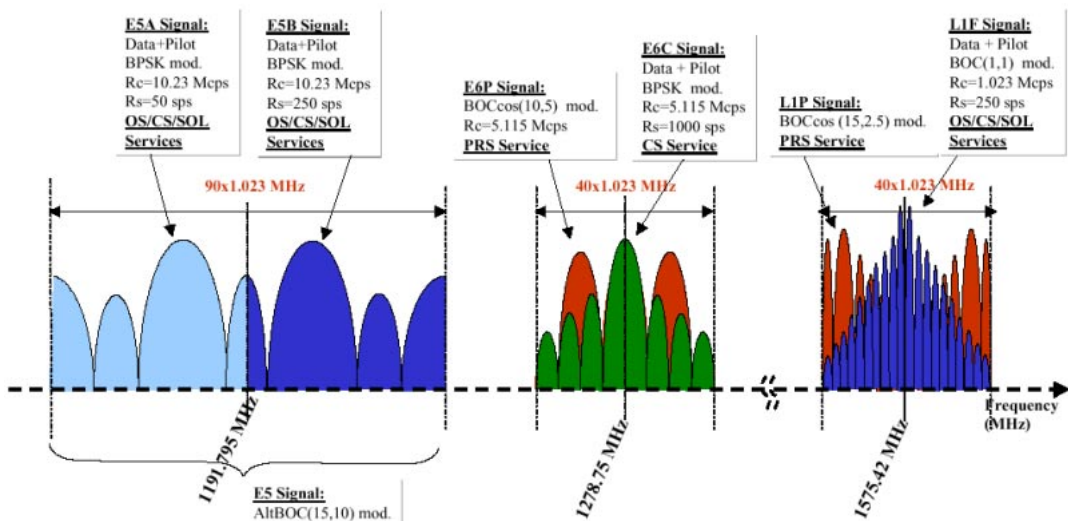


Figure 1-5: Mapping of Galileo Signals & Services
(diagram courtesy of the GJU)

An alternative way of looking at Figure 1-5 is given in Figure 1-6.

Signals	Open Service Users	Safety-Of-life Service Users	Commercial Service Users	Public Regulated Service Users
L1F	x(*)	x(*)	x(*)	
L1P				x
E6C			x	
E6P				x
E5a	x	x	x	
E5b	x(*)	x(*)	x	

(*) with no access to encrypted commercial data

Figure 1-6: Galileo Signals & Services Matrix
(table courtesy of the GJU)

1.6 Galileo Ground Segment

The core of the Galileo ground segment will be the two Galileo Control Centres (GCCs). Each will manage ‘control’ functions supported by a dedicated Ground Control Segment (GCS), and ‘mission’ functions supported by a dedicated Ground Mission Segment (GMS). The GCS will handle satellite housekeeping and constellation maintenance, while the GMS will handle the navigation and timing system.

The GMS will use a global network of nominally 30 L-band Galileo Sensor Stations (GSSs) to monitor the navigation signals of all the satellites. The prime element of a GSS is a ‘Reference Receiver’. Each Galileo satellite will fly a Rubidium and a Hydrogen maser clock as they are very stable over a few hours and because their technology can work in space. However, if they were left to run indefinitely their accuracy would drift, so they need to be synchronised regularly by more stable ground-based reference clocks. These will include clocks based on the Caesium frequency standard, which show a far better long-term stability than Rubidium or Hydrogen maser clocks. GSS data will be disseminated to the GCCs continuously through a comprehensive communications network using satellites and terrestrial connections, with each link duplicated for redundancy. The GMS processing facilities in the GCCs will process the data and produce the navigation and integrity messages up-linked to Galileo satellites via a network of Up-Link Stations (ULSs) operating at C-band. The navigation signals are then generated aboard the Galileo satellites and broadcast to users in the L-band.

The satellite constellation will be controlled from the GCS facilities installed in the GCC, and supported by a worldwide network of Telemetry and Telecommand (TT&C) S-band stations.

2. Potential Advantages of Galileo over GPS

Unlike the current US Global Positioning System (GPS) which is first and foremost a military system, Galileo has been specifically designed for civil purposes and as such will offer a number of state-of-the-art services offering a range of performances in accuracy, continuity and availability. It should therefore be more advanced, efficient and reliable than the current US GPS monopoly.

The EC also believes it to be crucial that Europe has a satellite navigation choice that is independent of GPS and the Russian GLONASS system. In addition, the EC think that the scale of future navigation needs and the requirement for global coverage cannot be satisfied by a single system alone.

These high-level concept statements apart, there are a number of more specific advantages that the adoption of Galileo will bring to the satellite navigation market place:

- Galileo has been designed and developed as a non-military application, while nonetheless incorporating all the necessary protective security features. It will offer a range of services; each targeted at different applications areas. Galileo provides, for some of these services, a very high level of continuity required by modern business, in particular with regard to contractual responsibility.
- In some of its services Galileo will provide a higher degree of positioning precision, thanks to the number of signals being transmitted by the satellites, the structure of the constellation of satellites and the ground-based control and management systems planned. The free-to-use Open Service in dual frequency mode will offer horizontal accuracy to within 4 metres, which is considerably better than the ~10 metres offered by standard GPS. Using the Commercial Service without additional corrections will offer horizontal accuracy to < 1 metre.
- From a user's perspective, Galileo should be more reliable as a tool as it includes a signal 'integrity message' informing the user immediately of any errors (N.B. though not for users of the Open Service). The integrity message means that non-OS users will receive a timely warning whenever the system fails to meet its stated accuracy. The Galileo system guarantees that this warning is sent out quickly enough even for the most demanding of applications, such as aircraft landing.
- Galileo represents a real public service (although it will be operated by a private concessionaire) and, as such, will guarantee continuity of service provision for specific applications.
- The potential use of diversity reception techniques should improve data reception under extreme fading, for example due to interference, or poor visibility conditions, for example in an urban environment. Interoperability with GPS (i.e. user receivers using both Galileo and GPS signals to compute a position) should also improve positioning capabilities in severe (i.e. multi-path) environments.
- Unlike GPS, Galileo has been planned to include data broadcast capability as part of the satellite signal specification. This will be part of the Commercial Service's

offering, where not only will a user's receiver pick up the navigation signals from Galileo, but also be simultaneously able to download application-specific data.

3. Aspects of Galileo of Interest to ALIS

3.1 Galileo Open Service

#	Idea	Pros and Cons	Actions
(i)	<p>Use Data Channels for ALIS Information Broadcasts/User Messages:</p> <p>As discussed in Section 1, there is potential commercial data capacity in the E5a, E5b, and L1 bands (25 bits per second, 125 bits per second and 100 bits per second respectively). Although these data rates are very low and exist in the forward path only, could they be used to either broadcast/multicast small ALIS data messages relevant to groups of ALIS users (such as NAVTEX warnings), or be used to pass specific messages to individual ALIS users (if their return link is via some alternative communications path such as Iridium, GSM, UMTS, etc.)?</p>	<p>It is not sure that these data slots will actually be available for use by individual 3rd party applications.</p> <p>Even if the slots exist, the data rates available are very low.</p> <p>The charging mechanism for 3rd party applications to use these slots even if they exist is unknown.</p>	Put on the 'back-burner'
(ii)	<p>Use Data Channels for ALIS Update Notification Broadcasts:</p> <p>Following on from (i), the Galileo data links could be used to notify ALIS users of the presence of data updates within ALIS, which they could then obtain via the normal ALIS messaging route via their mobile communications links.</p>	As with (i) above	As with (i) above
(iii)	<p>Dual-Frequency Accuracy:</p> <p>The open service includes both mono-frequency and dual-frequency services, where the latter offers more accurate positioning and velocity measurements. Can we offer more</p>	<p>We are unlikely to want to offer more than 'advisory services' only and therefore high precision in positional accuracies is not that key to ALIS. However, dual-frequency horizontal accuracies < 4</p>	Continue to think on ideas / service offerings which would necessitate reasonable positional accuracies.

	sophisticated service components within ALIS to users who are using the more accurate dual-frequency open-service, i.e. can we tailor ALIS to offer capabilities or give results that depend on the level of accuracy the user has at their disposal?	metres and vertical accuracies < 8 metres may support some ALIS components more than those accuracies provided by mono-frequency receivers.	
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3.2 Galileo Commercial Service

#	Idea	Pros and Cons	Actions
(i)	<p>Extreme Positioning and Velocity Accuracies:</p> <p>The commercial service offers extremely accurate position and velocity accuracies in comparison to the open service. Can we offer more sophisticated service components within ALIS or give more accurate results to users who are paying to use the commercial-service? For example, could we offer a ‘Closest Point of (vertical) Approach’ function to the beach/rocks alarm function based on position and depth? This could be along the lines of ‘on current course you will go aground in {n} minutes’.</p>	<p>ALIS as a non-mandatory advisory service is operating in a very cost-sensitive market place. For the bulk of users within the leisure marine market equipment budgets for one-off equipment purchases often exceed their interest in then paying for ongoing services.</p> <p>We would need to be very mindful of litigation risk if we offered services related to navigation based on position.</p> <p>However, that said it may be that there are components within ALIS that could use high-positional accuracies offered by the CS.</p>	<p>We should continue to think on ideas / service offerings which would necessitate high positional accuracies.</p>
(ii)	<p>Use Data Channels for ALIS Information Broadcasts/User Messages:</p> <p>The commercial service has data capacity bandwidth available within the E6 band, with a data rate of at least 500 bits per second, although this is in the forward link only. Can we use this channel to either multicast ALIS</p>	<p>As with (i) above, however a data transmission capability may prove to have uses yet to be determined.</p> <p>If the data channel usage charge is not high then, even if the high accuracy offered by the CS is not required, it could be</p>	<p>We should continue to think on ideas / service offerings which would necessitate high positional accuracies.</p> <p>Accuracy apart, we should continue to investigate the commercial model to</p>

	<p>data messages relevant to groups of ALIS users (such as NAVTEX warnings), or be used to pass specific messages to individual ALIS users (if their return link is via some alternative communications path such as Iridium, GSM, UMTS, etc.)?</p>	<p>worthwhile investigating using this channel for forward link ALIS traffic, particularly information of the broadcast type (e.g. storm warnings).</p>	<p>be used for the CS data channel and be mindful that if competitive this could supply part of the data transmission mechanisms used by ALIS.</p>
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3.3 Galileo Search & Rescue Service

#	Idea	Pros and Cons	Actions
(i)	<p>Extension to Third-Party SAR Services or Inclusion of SAR Services in ALIS:</p> <p>Could ALIS be part of an extended SAR package offered by third party developers of SARs, or could we as developers of ALIS include a SAR component? If we could find an interested SAR service organisation, perhaps the distress beacon and its uplink signal with the corresponding decoding of the SAR return link could be part of ALIS functionality?</p>	<p>Certainly feasible to offer SAR components within ALIS. We would need to interest the right SAR equipment manufacturer to take this further. The link between ALIS and the SAR service need not be highly technical, but more of a branding/marketing activity.</p>	<p>Continue to see who is active in the SAR market place and see if there is interest / synergy.</p>
(ii)	<p>Use of SAR Two-Way Data Channel Capacity:</p> <p>Irrespective of offering or being part of a SAR service, could we (if allowed) make use within ALIS of Galileo's two-way SAR signal capability, i.e. a return path based on the air interface for COSPAS-SARSAT 406 MHz beacons (400 bits per second) and a forward 'SAR Return' link based on Galileo's L1/E1 band data capability (each message of 100 bits being transmitted at 10 bits per second)?</p>	<p>We appreciate that points (ii) through to (iv) in this table would require the SAR uplink (and possibly downlink) to be made available to non-safety applications, such as those focussing on the environment. One way to support this is that since the SAR service probably has sporadic demand, it could be set as 'Priority Traffic' so that the transmission of non-SAR data is over ruled</p>	<p>Put on the 'back-burner' for now.</p>
(iii)	<p>Use of SAR Uplink:</p>	<p>See (ii) above. Note also</p>	<p>Put on the 'back-</p>

	As with (ii), but use the SAR distress beacon uplink to upload ALIS messages that can then be broadcast/multicast to groups of ALIS users using the E6 CS band or L1/E5 OS bands?	that we are not sure that data capacity in the OS will actually be available for applications to use.	burner' for now.
(iv)	<p>Use of SAR Uplink:</p> <p>As with (ii), but use the SAR distress beacon uplink to upload AIS messages from ALIS that can then be broadcast/multicast to Galileo users using the E6 CS band or L1/E5 OS bands?</p>	See (ii) above. Note also that we are not sure that data capacity in the OS will actually be available for applications to use.	Put on the 'back-burner' for now.
(v)	<p>Decode of SAR Forward Link and SAR Return Link Messages:</p> <p>Irrespective of the above, could ALIS disseminate/show to ALIS users the distress calls uploaded to Galileo satellites and then broadcast by the satellites to the Galileo ground segment and onto the rescue services? In addition to this, ALIS could also decode any messages sent via the 'SAR Return Link' by SAR services responding to a distress call and passed back to the distress beacon via the L1 OS band.</p>	<p>The ALIS consortium thought the use of ALIS to act as a decoder of Galileo SAR distress messages so that all ALIS users receive all Galileo distress signals would be of benefit. It could be of interest to sailors and the Authorities to have as much exposure to distress calls as possible and to see that they are being responded to or not.</p> <p>In fact maybe ALIS could act as a broadcast service for a number of distress signals put up by 'Maritime Rescue Co-ordination Centres' (MRCCs), not just Galileo.</p>	Continue to work on this idea and understand how it would have to work technically. We particularly need to establish whether Galileo receivers will be able to receive the SAR downlink transmitted from the Galileo satellites at 1544-1545 MHz to the Galileo ground segment for forwarding onto the relevant search and rescue services (i.e. link ii in Figure 1-4). This would seem to be unlikely as these type 'feeder' links are normally transmitted at very low power to large ground station dishes. However, if this is the case then maybe ALIS can take a feed from the Galileo ground segment once the downlink has occurred. This is

		<p>illustrated in Figure 3-1 below.</p> <p>In addition, we need to know whether the SAR Return Link acknowledgement messages from the rescue services be encoded or encrypted in a particular way (i.e. link iv in Figure 3-1)?</p>
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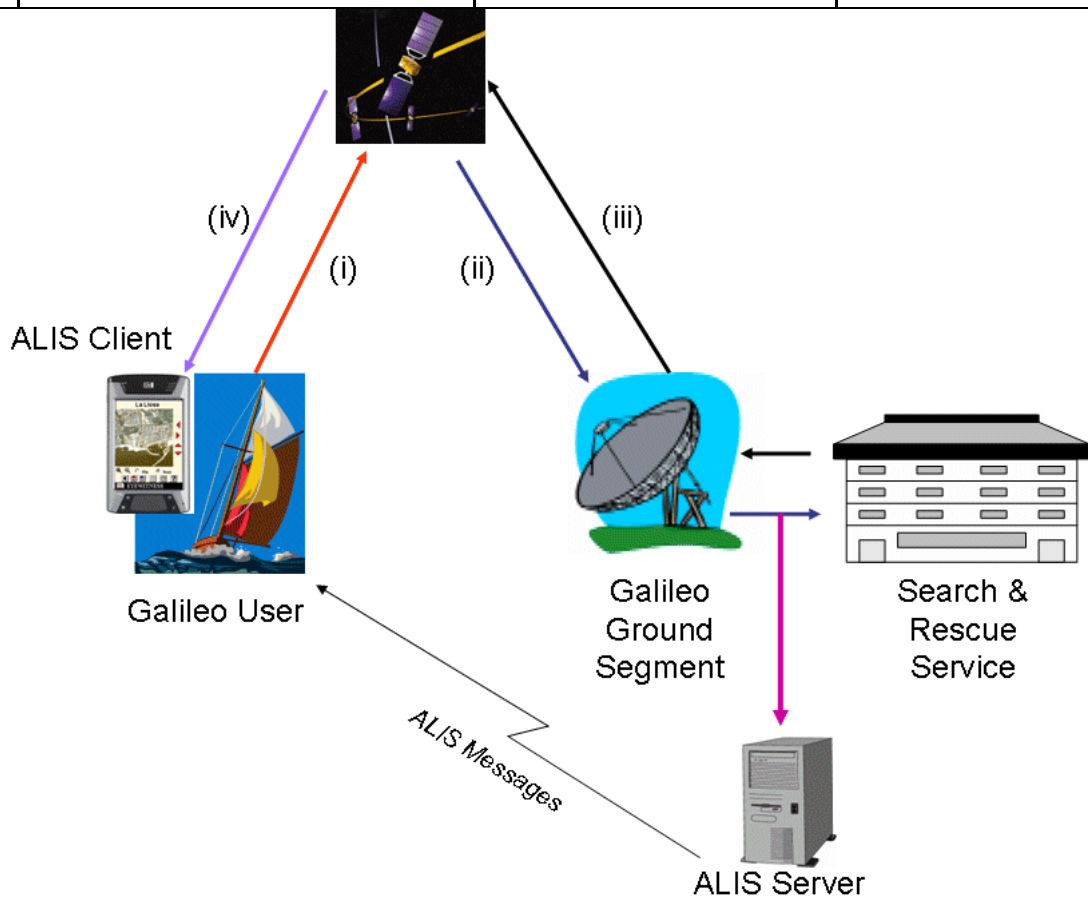


Figure 3-1: Possible Galileo & ALIS Interaction

3.4 Galileo Local Services

#	Idea	Pros and Cons	Actions
(i)	<p>ALIS Sites to Transmit Correction Data:</p> <p>If we aim to have (in the long term) a number of data receivers</p>	<p>Certainly the use of ALIS to pass corrections to a user's Galileo receiver to allow it to compute a more accurate fix was thought to</p>	<p>Continue to work on this idea and understand how it would have to work</p>

	<p>situated in coastal areas of Europe feeding local data into ALIS servers (e.g. NAVTEX data, AIS data, etc.), could we use those sites to transmit correction data out to Galileo terminals (i.e. as with D-GPS)? Alternatively, and especially in the early days of Galileo, could we deploy a local correction service over the mobile/satellite communications links used by ALIS, i.e. use the ALIS messages and intended communications paths to send corrections to user terminals? At the user end, the data could be received, and ‘squirted’ into a serial port of the Galileo receiver. As corrections only vary slowly, for most applications they only needed updating every 20 minutes. We assume that at start-up Galileo won’t have the infrastructure of D-GPS stations up and running that GPS now has, so this could be a useful function provided by ALIS.</p>	<p>be of interest.</p> <p>It is too early in the life of ALIS to consider the accurate surveying of ALIS shore-based equipment to act as base stations for Galileo.</p>	<p>technically.</p>
<p>(ii)</p>	<p>Local Service Centre:</p> <p>Could ALIS act as one or more ‘local service centres’ between Galileo users and the Galileo ground segment, where ALIS messages are used to forward key ancillary information from the ground segment to users? For instance, could ALIS sites receive directly the ‘Global Integrity Message’ from the Galileo Global Component and pass this onto users? As the MTRD states: “this could be of benefit in not only reducing the TTA, but also in increasing the availability of the Integrity Message in difficult environments, in which the potential for the Integrity Broadcasting Satellites to be</p>	<p>Probably too early in the life-cycle of ALIS to consider this in detail at the moment.</p>	<p>Put on the ‘back-burner’</p>

	obscured is a very real risk”.		
(iii)	<p>Pseudolites:</p> <p>If we aim to have in the long term a number of ALIS ‘sites’ situated in coastal areas, could ALIS act as one or more ‘pseudolites’ in specific local areas and transmit Galileo-equivalent ranging signals?</p>	Probably too early in the life-cycle of ALIS to consider this in detail at the moment.	Put on the ‘back-burner’
(iv)	<p>Messenger Capability:</p> <p>Could ALIS provide an interface or ‘messenger’ capability to allow full decoding and simple presentation of all Galileo system information from the ground segment, e.g. warnings on availability, etc.?</p>	Probably too early in the life-cycle of ALIS to consider this in detail at the moment.	Put on the ‘back-burner’
(v)	<p>Determination of Sea-Height:</p> <p>When used with Local Services (i.e. a ‘D-GPS’ approach), could Galileo’s highly accurate vertical measurements be used to determine sea level / height of tide, i.e. with suitable filtering, could ALIS determine this on each vessel, collate the data, and broadcast it/make it available to other users after suitable QC procedures? This could be either by using Galileo’s SAR uplink and open/commercial service downlink, or through other mobile telecoms links employed by ALIS.</p>	The ALIS consortium thought this would be of interest, but the data would need to be reasonably accurate for it to be useful.	Continue to work on this idea and understand how it would have to work technically. Certainly the accuracies available with OS individual readings are not suitable to support the concept. However, maybe averaging readings over time or using measurements made by CS or corrected receivers is the way forward.
(vi)	<p>‘Closest Point of Approach’ Function:</p> <p>If not using the Galileo commercial service, but using a local service instead, could we offer the ‘Closest Point of (vertical) Approach’ function described above in point (i) of the section on the commercial service?</p>	As with (i) in Section 3.2	As with (i) in Section 3.2

4. Conclusions

The purpose of this document is to provide a high-level summary of the Galileo mission, what advantages Galileo will have over GPS and, most importantly, which aspects of Galileo should we take a closer look at as we develop ALIS. In conclusion and with respect to ideas for the latter that can be investigated now and potentially make sense to include at this stage, the following are the main points from Section 3 we will continue to investigate:

- SAR Service. Interception of SAR Forward Link and SAR Return Link Messages.
- SAR Service. Inclusion of ALIS in Third-Party SAR Services and/or Inclusion of SAR Services in ALIS
- Local Service. ALIS to Transmit Correction Data to User Receivers
- Local Service. Determination of Sea-Height.

In addition to these, we will, on a best-effort basis, continue to consider the inclusion within ALIS of the following points from Section 3:

- Open Service Dual-Frequency Accuracy.
- Commercial Service High Positioning and Velocity Accuracies.
- Commercial Service Data Channel Usage.

5. References

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