SISNeT

User Interface Document

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DOCUMENT CHANGE RECORD

Issue	Revision	Date	Change Status	Origin
0	0	15/11/01	Draft	FT
1	0	21/11/01	First release of the document	FT
2	0	01/02/02	Detailed information about the new SISNeT authorisation process included (major change of the DS2DC protocol)	FT
2	1	28/05/02	New EPHEM and GPS_IONO messages added to the DS2DC protocol	FT
3	1	05/05/06	Major change in the DS2DC protocol: CRLF separators. New DS2DC messages added, including new START/STOP mechanism, quick receiver initialisation and retrieval of already broadcast EGNOS messages.	FT/AM

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Purpose of the Document

This document provides a description of the SISNeT user interface at different levels, from the more general concepts down to the message format and compression algorithm description. The main purpose is to provide all the information that must be known to develop SISNeT – based applications. The concepts and techniques exposed in this document shall be carefully applied in any SISNeT development, in order to obtain SISNeT - compliant applications.

1.2 Organisation of the Document

The document is organised as follows:

- Section 1 explains the objectives of this User Interface Document (UID) and presents an overview of its contents.
- Section 2 provides a top-level view of the SISNeT platform, justifying its added-value and describing all the components of the platform. In addition, some SISNeT-based applications developed by ESA are shown.
- Section 3 introduces the higher-level concepts related to SISNeT user application development.
- Section 4 is centred on the development of the most important component of any SISNeT application: the DS2DC client. The DS2DC protocol and the SINCA compression algorithm are explained in detail.
- Appendix A explains in detail the available DS2DC messages
- Appendix B shows the available error codes and error messages, returned by the SISNeT Data Server.

1.3 Reading Guidelines

This document is characterised by a top-down design. It starts from a top-level view of the SISNeT platform, and goes down, progressively, towards lower–level aspects. As a consequence, the intended readership is wide. Depending on the reader's technical background, more or less sections should be read.

A reader with non–technical interest should read Sections 2 and 3, obtaining a clear top–level view of the SISNeT technology and the general ideas about the UAS development process.

Section 4 is related to the software development. This section has interest mainly for the engineers who plan to develop SISNeT applications, giving a clear idea of what to do, before they start coding. Therefore, knowledge about programming is required.

1.4 Changes Introduced in Issue 3.1

With respect to version 2.1 (the previous version) of this document, and responding to user's feedback, a nomenclature change has been introduced. Now, R-Commands, S-Commands and A-Commands are renamed as R-Messages, S-Messages and A-Messages, respectively. In addition, the M-Commands are now renamed as E-Messages, being the initial "E" referred to Event-Triggered messages.

A major change to the DS2DC protocol has been introduced: the termination of R–Messages and S–Messages (A–Messages and E–Messages) with a carriage return followed by a line feed character. This change is not compatible with the previous versions of the protocol. In other words, any application developed according to versions 1.0 to 2.1 of the SISNeT User Interface Document (UID) will not work with the present SISNeT platform, which implements version 3.1 of the UID (the present Document).

Although backwards compatibility constitutes the most respected principle in the evolution of the SISNeT service, ESA has made an exception in this particular case, taking into account the following facts:

- SISNeT users have requested the implementation of this change repeatedly. In other words, this change responds to the user requests.

- This change allows "manually" interacting with the Data Server through a telnet session, avoiding having to implement software for that purpose.

- In addition, in the case that any message or answer is broken (by the TCP protocol) into several independent text messages, CRLF separators allow recovering the information in an adequate form.

- ESA has a close communication with the SISNeT user community. The upgrade has been communicated to all the users with enough anticipation. Indeed, a testing version 3.0 of the SISNeT platform, implementing the change, has been running since more than 1.5 years, giving users enough time to adapt their applications. This testing version has been announced by e-mail to all the SISNeT users, and to all the new users, as well as via different papers and presentations at International Conferences.

- In this phase of the project, all the SISNeT developers have full control on the source code of their applications, being able to adapt the software to the new version 3.1 of the DS2DC protocol.

- The necessary adaptation to make applications compatible with the current specification (version 3.1) is, in general, easy to implement.

In addition to this major change, several messages have been added to the DS2DC protocol. These changes are concentrated in Appendices A and B, and include the following features:

- Fast authentication and initialisation of receivers, through a new variant of the AUTH message. This capability will allow dramatically reducing the Time–to–First–Fix (TTFF). If a GPRS wireless link to the Internet is used, TTFF is typically reduced to about 30 seconds.

- Ability to get messages already broadcast by EGNOS on demand, via the new GETMSG message. One of the powerful applications of this new feature (based on the non Safety of Life nature of SISNeT) is the optimisation of communications bandwidth, by requesting the different messages types with a different periodicity, which corresponds to fast / slow nature of the requested information.

- The new START message enables the user to get EGNOS messages continuously until the new STOP message is sent. This is equivalent to sending a MSG message every second. Therefore a considerable bandwith is gained thanks to this START/STOP mechanism.

2. THE SISNeT PLATFORM

2.1 Introduction

This Section provides a clear big-picture of the SISNeT technology. In particular, the following questions are answered:

- What is the utility of SISNeT?
- What is the general architecture of the SISNeT platform?
- What is the architecture of the main SISNeT components?
- Which are the currently existing SISNeT developments?

2.2 SISNeT Objectives

The main purpose of the SISNeT platform is to provide worldwide access to the EGNOS [2–10] signal through the internet. In other words, SISNeT offers a novel technology for the development of applications integrating EGNOS–powered Satellite Navigation and Internet development. The main advantages of SISNeT are the following:

- The EGNOS [2-10] signal is available, even if Geostationary (GEO) satellites are not visible;
- Any user equipment may have free access to a virtual EGNOS receiver, with the only condition of being connected to the internet;
- SISNeT requires a transfer rate of less than 1 kbps. This is appropriate for accessing SISNeT from a mobile terminal (e.g. GSM).

For more information about the SISNeT platform, the reading of [11 – 37] is recommended.

2.3 Is SISNeT useful?

SISNeT can provide the EGNOS signal to land–mobile users in urban areas. In that situation the visibility of the GPS and GEO satellites is frequently poor. Hence, the question to answer is the following:

Is it really useful to have access to the EGNOS services under low visibility conditions?

ESA has performed a preliminary study, in order to answer this question. The study is based on the use of the ESA ESPADA [38 – 40] simulator. The output of the study is a Technical Note [24], which is available at [12]. Assumptions used for this analysis may be considered conservative: they are based on specified URE of 6 meters for the GPS satellites [42], and also on specified residual corrections statistical errors for EGNOS. A major outcome of this study is illustrated in the bar plot of Figure 1.

The bar plot corresponds to a mask angle of 25 degrees (low visibility conditions). Each bar indicates the availability, corresponding to an accuracy requirement (horizontal axis). The blue bars refer to a GPS-only scenario, while the red bars correspond to a GPS+EGNOS configuration.

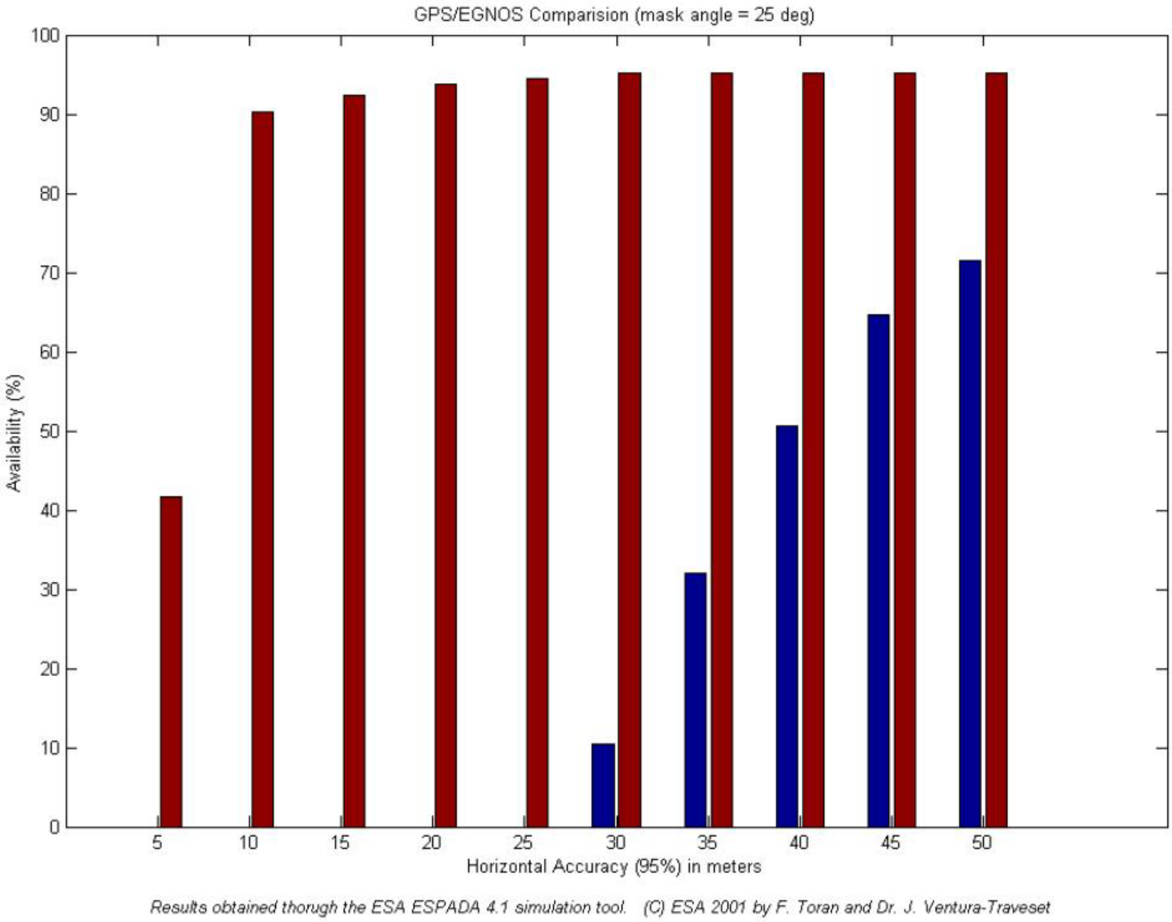


Figure 1. GPS/EGNOS comparative bar plot for a mask angle of 25 degrees

The reading of this plot is the following:

Under low visibility conditions (mask angle of 25 degrees):

- *GPS offers low availability. Even in the case of an accuracy requirement of 50 meters, GPS is available less than 75% of time, while EGNOS is available 95% of the time;*

- *EGNOS is much more resistant to masking angle limitations, providing a high availability (90% to 100%) even for an accuracy requirement of 10 meters.*

Taking those readings into account, a main conclusion can be formulated:

EGNOS provides better availability of accuracy than GPS, for any masking angle. Interestingly, in situations in which user visibility of GPS satellites is limited (say to 4–5 satellites), the availability of the SBAS corrections plays a major role. Indeed, SBAS-available accuracy is quite insensitive to the number of GPS satellites in visibility, while GPS-only accuracy degrades significantly. SISNeT benefits from this, making SBAS messages available regardless of the user visibility conditions.

This conclusion demonstrates the SISNeT potential. Even if the GEO signals are not accessible and the GPS satellites are seen with difficulty, the access through other means (e.g. GSM or GPRS via SISNeT) allows taking benefit of the EGNOS power, i.e. improving the accuracy of positioning.

2.4 Overview of the SISNeT platform

Figure 2 depicts the SISNeT architecture. The three main components of the platform are the following:

Base Station (BS). A PC computer connected to an EGNOS receiver through a serial port. Several software components are installed on the computer, allowing acquiring the EGNOS messages and sending it to a remote computer (the Data Server) in real-time.

Data Server (DS). A high-performance computer, optimised for running server applications with a large amount of connected users. The DS functionality is implemented through a software application called SISNeT Data Server (SDS). This software receives the EGNOS messages from the BS and transfers them to the remote SISNeT users in real time through the Internet. In addition, the SDS implements all the extra services (present and future) provided by the SISNeT system to the users.

User Application Software (UAS). A Software application that accomplishes the SISNeT interface specifications (exposed in this document), being able to obtain the EGNOS messages in real time (1 message per second or 250 bps) from the DS. Moreover, the UAS can access and apply the present and future additional SISNeT services. Each specific application of the SISNeT platform is defined by a particular implementation of the UAS. The software can be embedded in different kind of computers and electronic devices (e.g. Personal Digital Assistants).

At the moment, the BS and the DS are installed on the ESA Radionavigation Laboratory at the ESA ESTEC centre (Noordwijk, The Netherlands). The first implementation of the UAS was developed in the EGNOS Project Office (PO) in Toulouse (France), where the SISNeT concept was validated for the first time during year 2001. The SISNeT UAS has been kept internal since then. However, the ESA UAS has been updated and is planned to be made available for download via the ESA website. Figure 3 illustrates the current location of the SISNeT components. In Figure 3, the UAS is located in Toulouse to illustrate the location of the first UAS implementation, but obviously, at the time of this writing (May 2006), there are hundreds of different UAS running over Europe and beyond, with different purposes (EGNOS message real-time processing, SISNeT receivers, etc.).

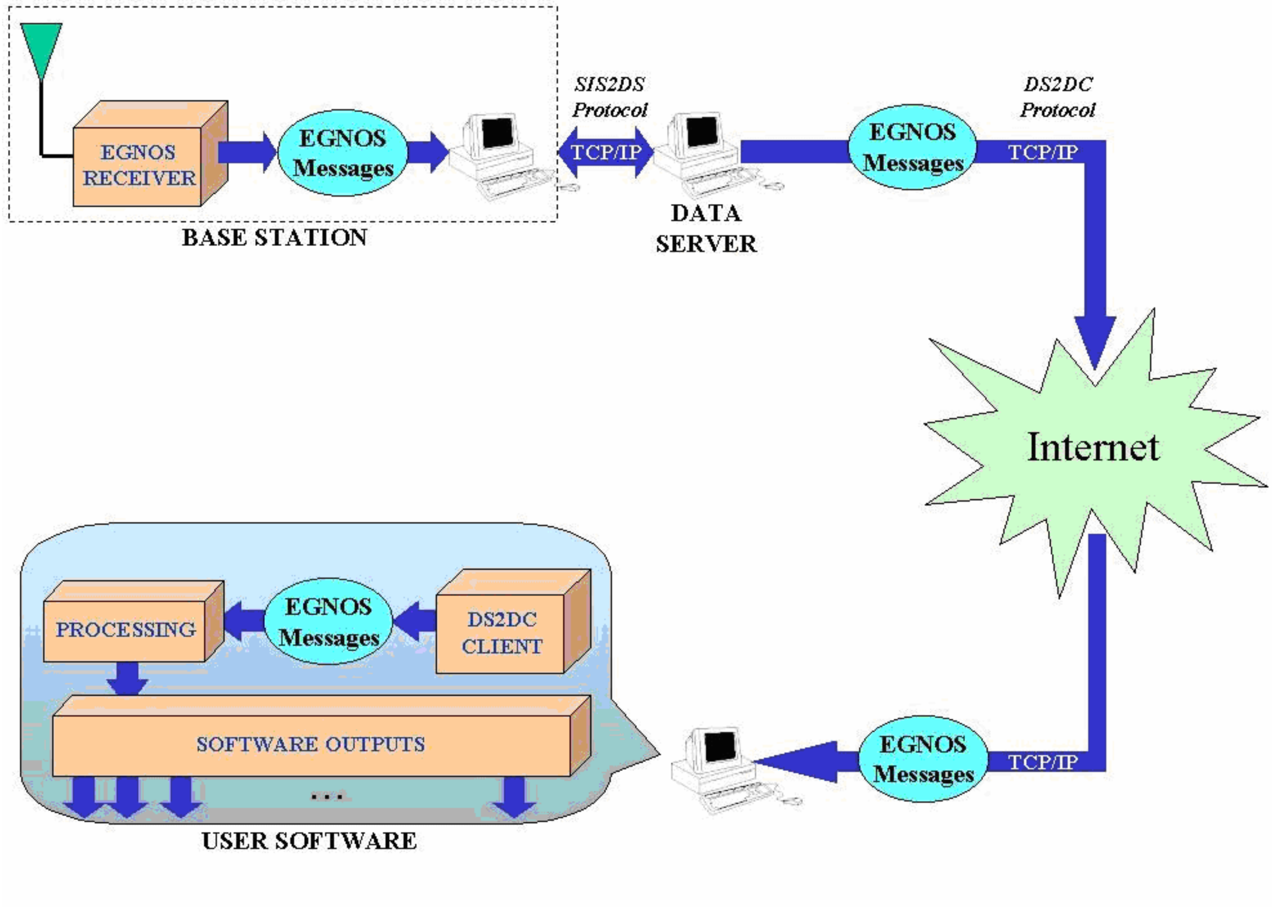


Figure 2. Architecture of the SISNeT Platform

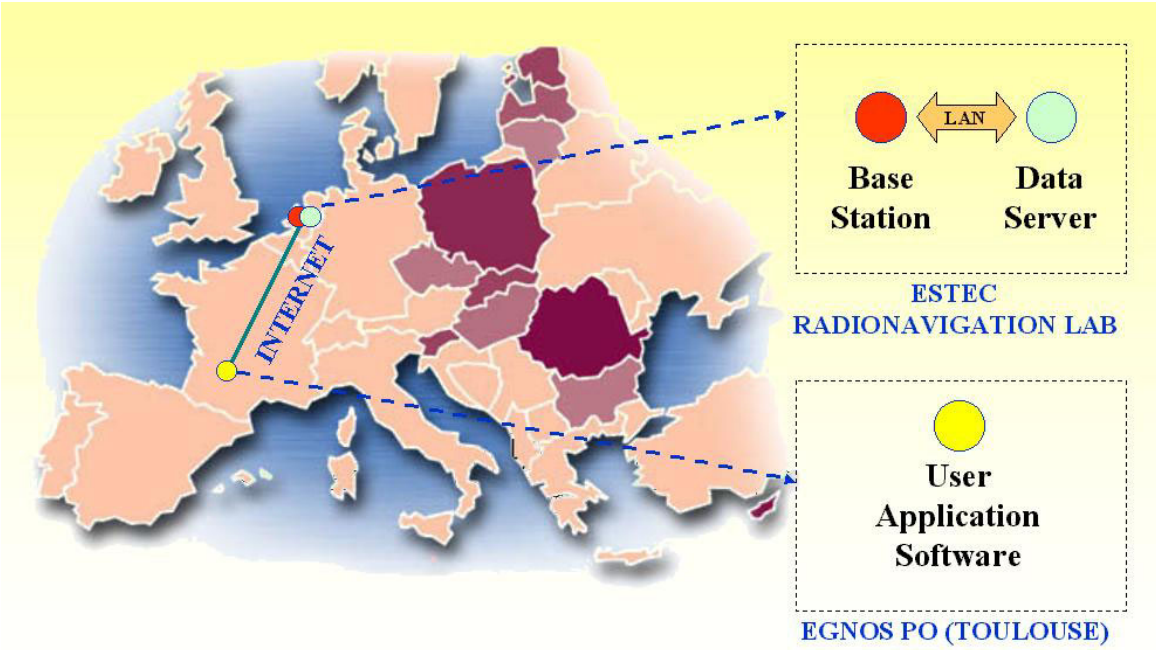


Figure 3. Current location of the SISNeT components

2.5 The SISNeT Components

2.5.1 The Base Station

The BS consists of the following components (see Figure 4):

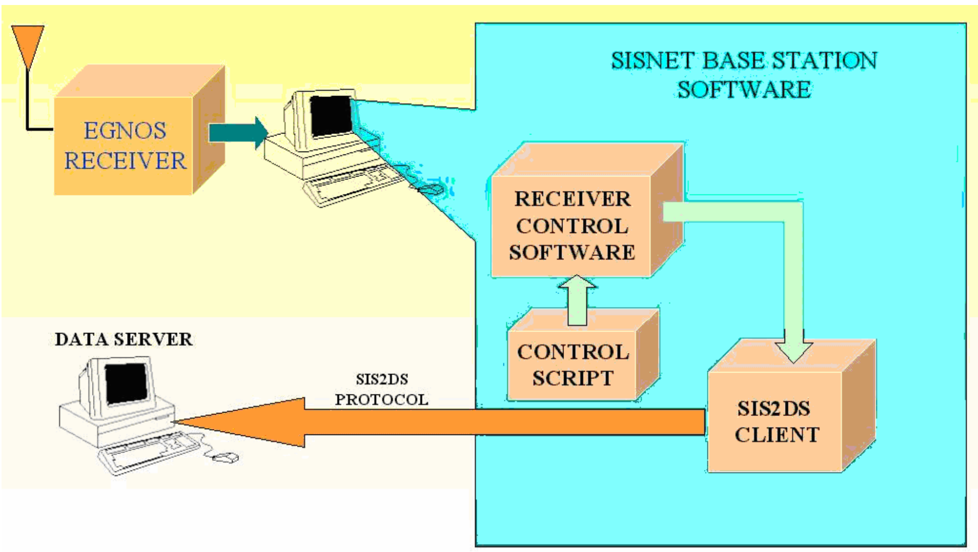


Figure 4. Architecture of the SISNeT Base Station

- **An EGNOS Receiver**. The receiver is connected to a PC computer through a serial port.

- **Receiver Control Module (RCM)**. A software component in contact with the EGNOS receiver. The RCM controls the receiver via serial or USB port, by sending commands. The receiver answers by sending logs to the computer each second, containing the EGNOS messages for different EGNOS GEOs. The way the RCM manages the receiver is defined through an interpreted scripting language. This allows a total control of the process, and also gives flexibility to support different types of receivers.

- **SIS2DS Client**. A client software component, implementing a SISNeT-specific protocol called SIS2DS. The SIS2DS client takes the EGNOS messages and sends them to the DS. SIS2DS is based on the TCP/IP protocol and is optimised for transferring the EGNOS messages to the DS in real time.

2.5.2 The Data Server

The DS just contains one component: a server application called Data Server Software (DSS). The DSS implements two server processes:

- **The SIS2DS Server**, linking the DS with the BS.
- **The DS2DC Server,** linking the DS with the users. This server listens to one port by default.

Before sending the EGNOS messages to the users, a data compression algorithm (called SINCA) is applied. The length of the EGNOS message being transferred is always less than 67 bytes. The compression algorithm frequently reduces the data size to 25% of the original size.

2.5.3 The User Equipment

The SISNeT User Equipment (SUE) is the most flexible part of SISNeT. Figure 5 shows the architecture of the SUE, which is made up of two main components:

- **A hardware platform**, which can be freely selected. Examples of possible hardware are PC computers and Personal Data Assistants (PDA).

- **The UAS,** running on the hardware platform. Any software developer can freely create new UAS implementations, i.e. define new SISNeT-based applications.

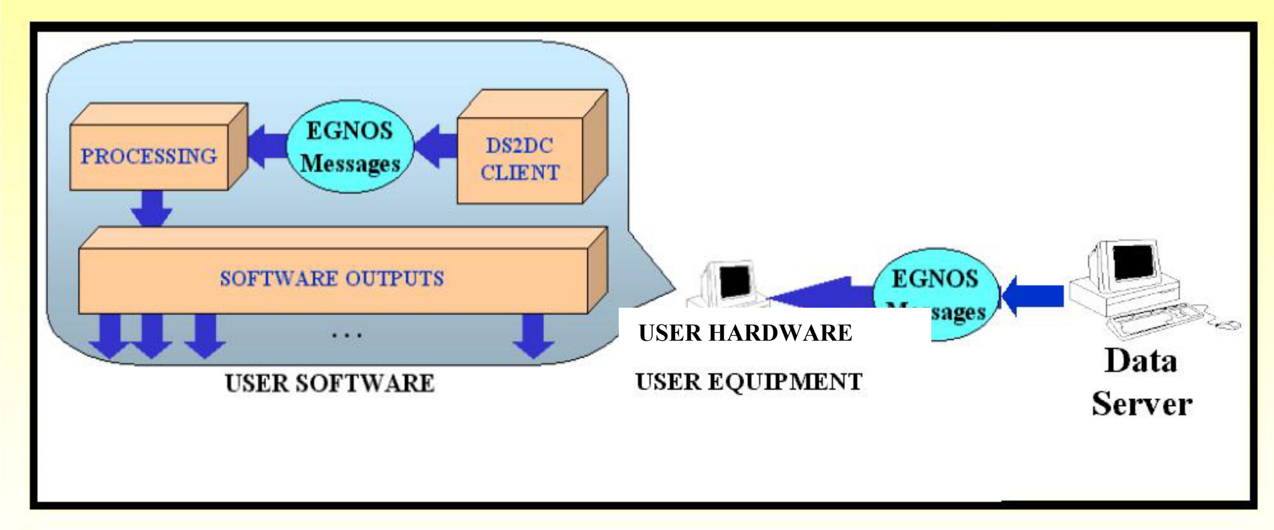


Figure 5. User Equipment architecture

The User Application Software

The UAS (Figure 5) includes the following software components:

- **DS2DC Client**. A client software component, implementing the DS2DC protocol. This component connects to the DS and obtains the EGNOS messages in real time. In addition, the DS2DC client can take benefit of all the additional services offered by SISNeT (the number of services is continuously growing). This component **shall** respect all the specifications and recommendations about the DS2DC protocol (see Sections 3 and 4 of this document), in order to obtain a SISNeT-compliant UAS.

- **Processing stage**. This block can be freely created by the developer, defining the functionality of each specific UAS implementation.

- **Output Interface**, constituting the user interface of the SISNeT User Equipment.

The ESA SISNeT User Application Software

In 2001, ESA developed a first implementation of the SISNeT UAS, providing the following benefits:

- It allowed validating the SISNeT concept;
- It was used as a platform for the integration of new SISNeT applications. In fact, three SISNeT-based applications were internally developed and integrated into the UAS by ESA, in order to demonstrate the potential of the SISNeT technology;

The ESA UAS has been enhanced significantly; allowing to process most of the SBAS messages defined in RTCA MOPS DO229C, and present their contents in a user-friendly form. This software is intended to be made available for free download before the end of 2006, through the SISNeT Website [11].

Figure 6 shows the appearance of the first implementation of the ESA SISNeT UAS (developed in 2001).

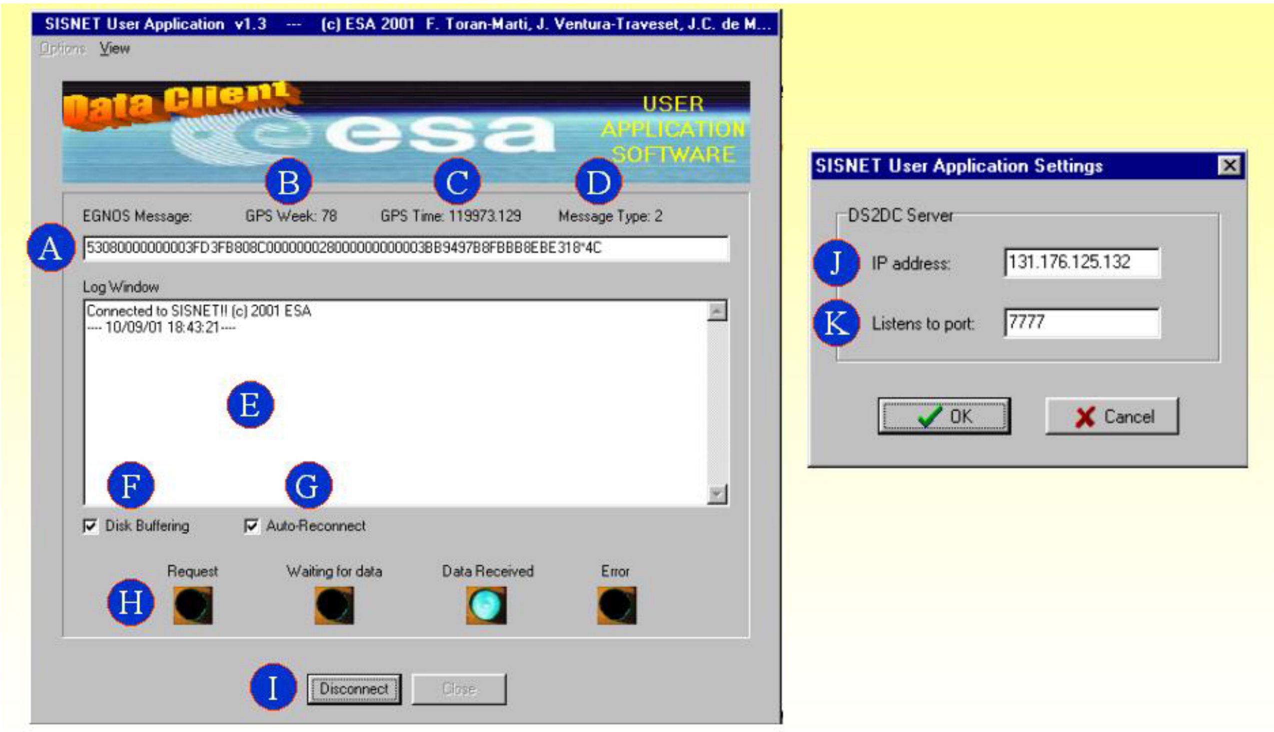


Figure 6. The first ESA implementation of the UAS

The main GUI contains the following controls:

A. The contents of the EGNOS message received from the DS. This information is updated in real time (one message per second).

B. The GPS week corresponding to the current EGNOS message.

C. The GPS time corresponding to the current EGNOS message.

D. The message type (MT) corresponding to the current EGNOS message. The purpose and contents of each MT can be found in [1].

E. Log Window, containing messages about the status of the UAS operation.

F. Disk buffering option. If checked, a live buffer of EGNOS messages is maintained on the hard disk. This allows linking the ESA UAS with external applications, such as the ESA ESPADA [38-40] simulator or other analysis software.

G. Auto-reconnect option. If checked, the UAS will automatically attempt to reconnect to SISNeT when the client is disconnected from the Data Server.

H. Traffic lights, indicating the status of communications.

I. Command buttons for the control of the UAS.

2.6 ESA SISNeT-based developments

In 2001, ESA developed four UAS applications, with the aim of demonstrating the potential of the SISNeT platform. Those applications have been integrated with the ESA SISNeT UAS. The integration consists on substituting the original processing block of the ESA UAS by four independent processing stages, which run in parallel and define four different applications (see Figure 7). That degree of parallelism has involved the use of multi-threading techniques.

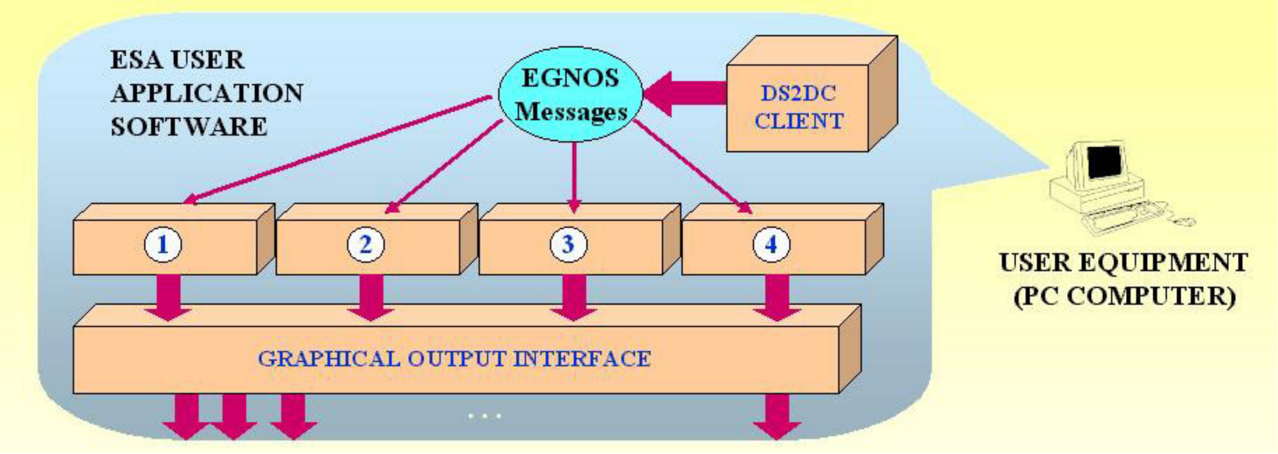


Figure 7. Integration of parallel processing blocks into the UAS

Those applications are the following:

1. Real-time monitoring of the ESTB performance;
2. Positioning through the Internet (various projects developed by the industry);
3. Real-time analysis of the ESTB messages;

4. Real-time monitoring of the ESTB Signal-In-Space (SIS) broadcast status through the Internet.

Note Figure 7 presents four processing blocks. In fact, the second application mentioned above (positioning through the Internet) has been developed in the next years through different ESA contracts with Industry.

For information, the next Sections describe in more detail those four applications.

2.6.1 Real-time monitoring of the ESTB performance

The objective of this application is to periodically provide maps of the ESTB performance. Each map must contain the Vertical Protection Limit (VPL) availability over a specific service volume, for the last 24 hours and for a given alarm limit (AL). In other words, the objective is to calculate - for each location on the map - the percentage of time during which VPL is under the AL.

Figure 8 depicts the architecture employed to achieve that goal. The only change with respect to the general SISNeT architecture (Figure 2) is centred in the processing block of the UAS. In this case, the processing block contains an interface with ESPADA [38–40], an advanced EGNOS simulation tool developed by ESA. The ESPADA software is able to generate offline ESTB performance maps using files, previously logged through a receiver and the appropriate software. Thanks to the new interface, ESPADA is now able to provide those maps in real time (one map each 6 minutes).

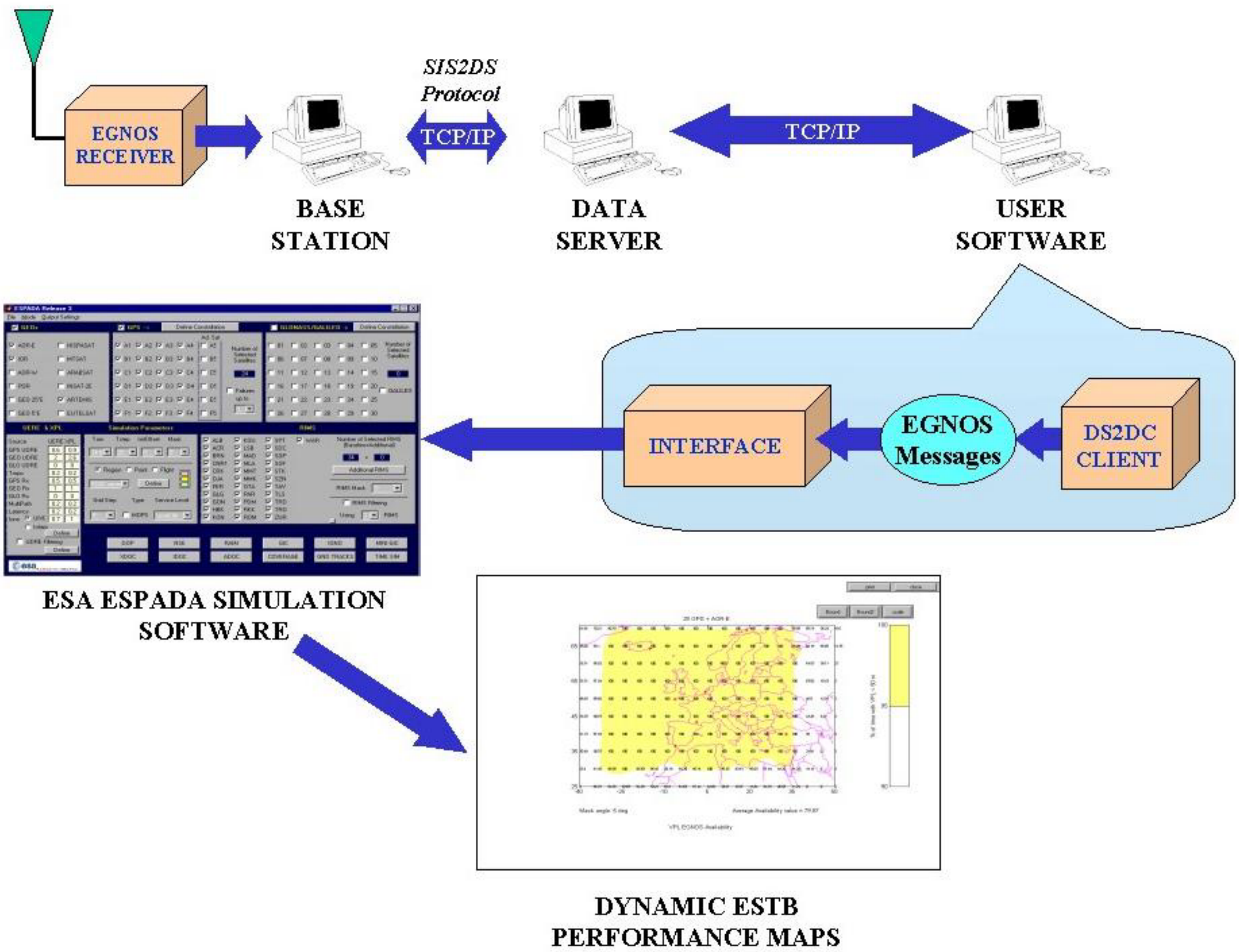


Figure 8. Real-time monitoring of the ESTB performance

ESPADA can store the maps in two well-known formats:

- Power Point slides.
- AVI video files (generated on a daily basis).

This application has been a precursor of the present EGNOS Real-Time monitoring network.

2.6.2 Positioning through the Internet

The goal of these applications is to provide wireless EGNOS services to land-mobile users through the Internet. Figure 9 shows the architecture of one such SISNeT-based system.

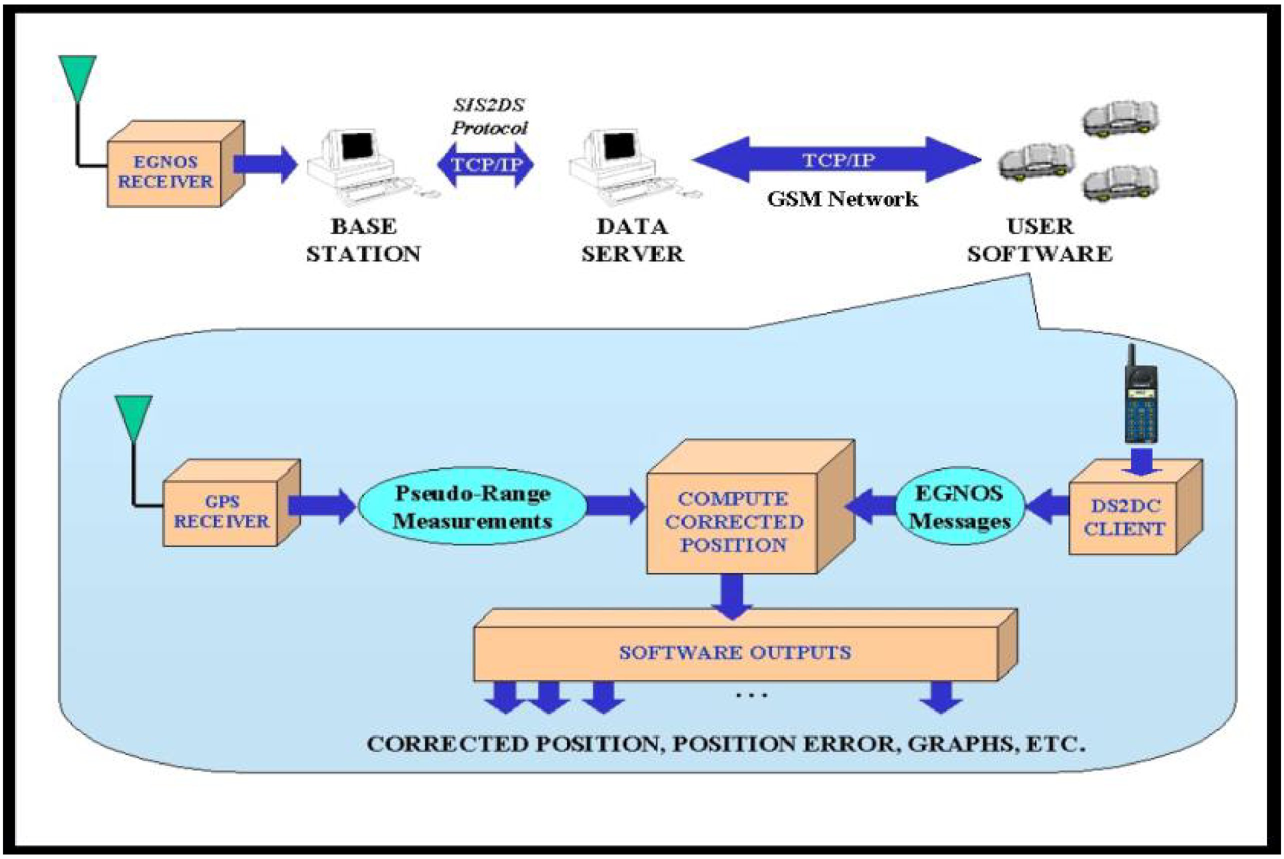


Figure 9. Positioning through the Internet

In this case, the user equipment is embedded into vehicles or handheld equipment (e.g. mobile phones or PDAs), and the connection to the Internet is achieved through a GSM or GPRS modem. The DS2DC client obtains the EGNOS messages in real-time, and a GPS receiver provides pseudorange measurements, also in real time. The processing block takes the pseudorange measurements and applies the EGNOS corrections, obtaining a significant improvement of position accuracy.

This activity and other similar activities have been developed by the industry through a number of ESA contracts. It is worth to note that, at the time of this writing (May 2006), several SISNeT-based contracts are ongoing. Some of those applications are the following:

- SISNeT receiver based on a PDA device.
- SISNeT based receiver used in urban buses of Toulouse, France demonstrated the utility of SISNeT in urban areas of low satellite visibility conditions.[29]

- SISNeT-ONCE project. A personal navigator for Blind pedestrians in cities was developed.[31]
- ShPIDER, a SISNeT based professional receiver was developed.
- MOMO: Personal navigation tool for blind pedestrians on a mobile phone. This contract is currently (May 2006) ongoing.[41]

2.6.3 Real-time analysis of the ESTB messages

This application consists on the real-time analysis of the messages broadcast by EGNOS (presently, the ESTB). The objective has been achieved through the integration of several monitoring panels into the ESA UAS (Figure 10). Each panel shows the contents of the EGNOS messages in a graphical and organised way, allowing the user to quickly find the desired information.

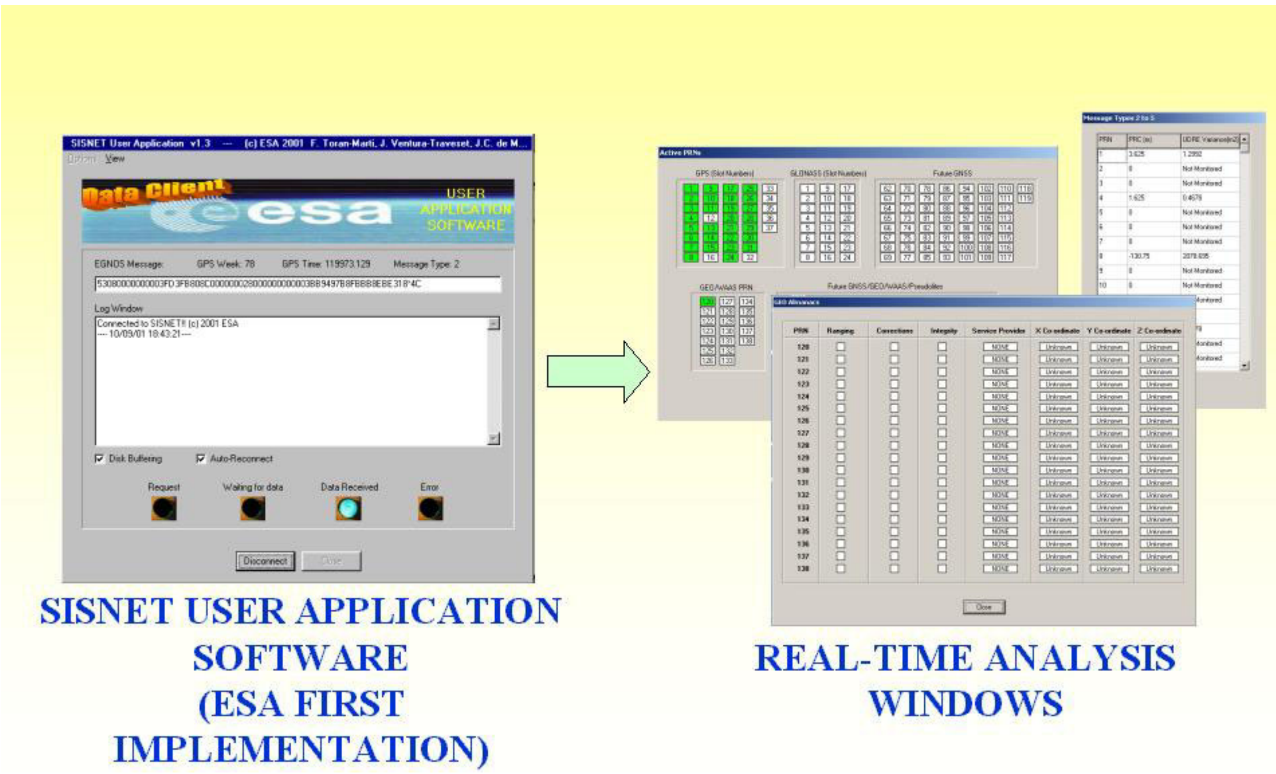


Figure 10. Real-time monitoring of the ESTB SIS status: integration of monitoring windows into the ESA SISNeT UAS

The original ESA SISNeT UAS integrated the panels for the analysis of the following message types (MTs):

- **Analysis of MT1 (Figure 11)**. This panel presents all the possible satellites that can be active, classified by constellations. The satellites are referred by the pseudorandom code number (PRN). All the active PRNs are coloured in green. Due to the specifications of MT1 [1] the maximum allowed number of active satellites is 51.

- **Analysis of MT2 to MT5 (Figure 12)**. This panel shows the information regarding the fast corrections, laid out on a table. For each PRN (first column), the user can quickly find the pseudorange corrections (PRC) and the User Differential Ranging Error (UDRE) variance.

- **Analysis of MT17 (Figure 13)**. This panel informs about the GEO almanacs. For each PRN corresponding to a GEO satellite, the user can know if ranging, corrections and integrity information is being broadcast. The service providers and the co-ordinates of the GEO satellites are also included.

- **Analysis of MT25 (Figure 14)**. This panel shows the long-term satellite error corrections, laid out on a table. For each PRN, the table indicates the corrections to the satellites' orbits, its rates of change, the clock offset and drift, and the time of day applicability (if pertinent).

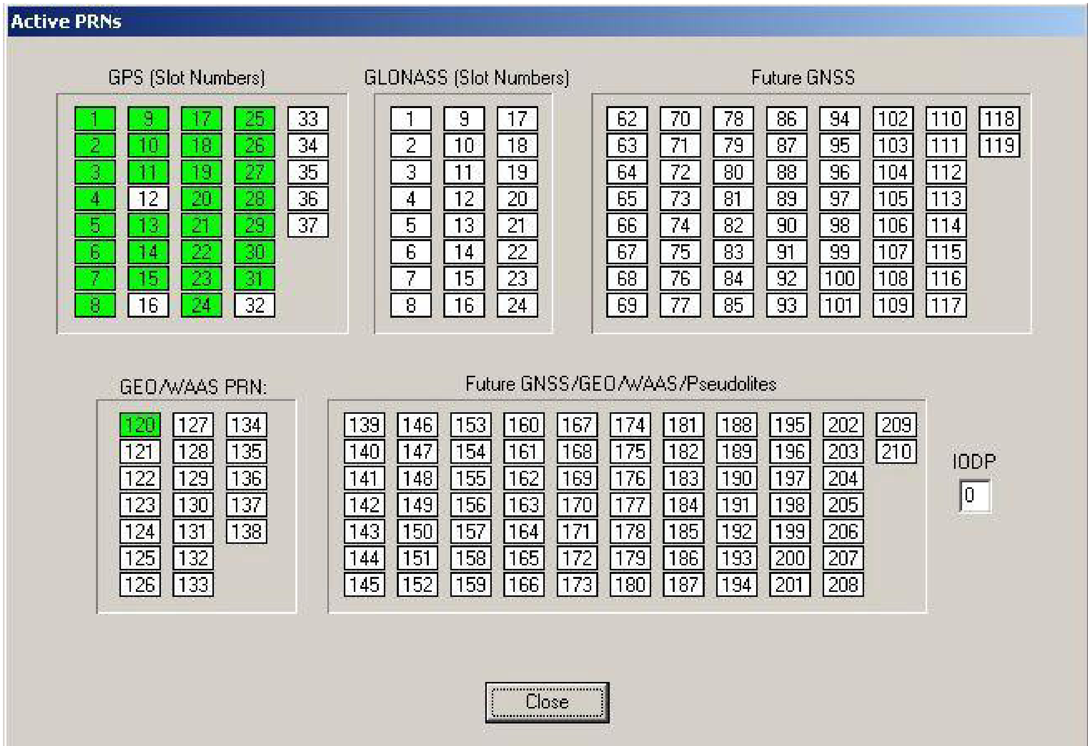


Figure 11. Real-time analysis window for MT1 (PRN mask)

A monitoring panel for each EGNOS message type is available.

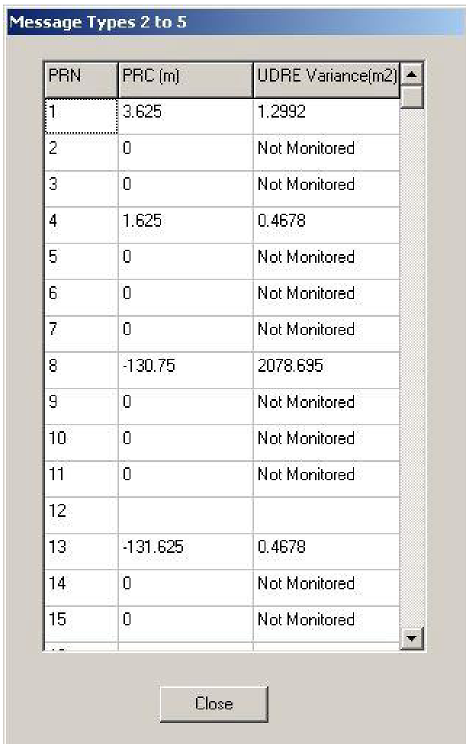
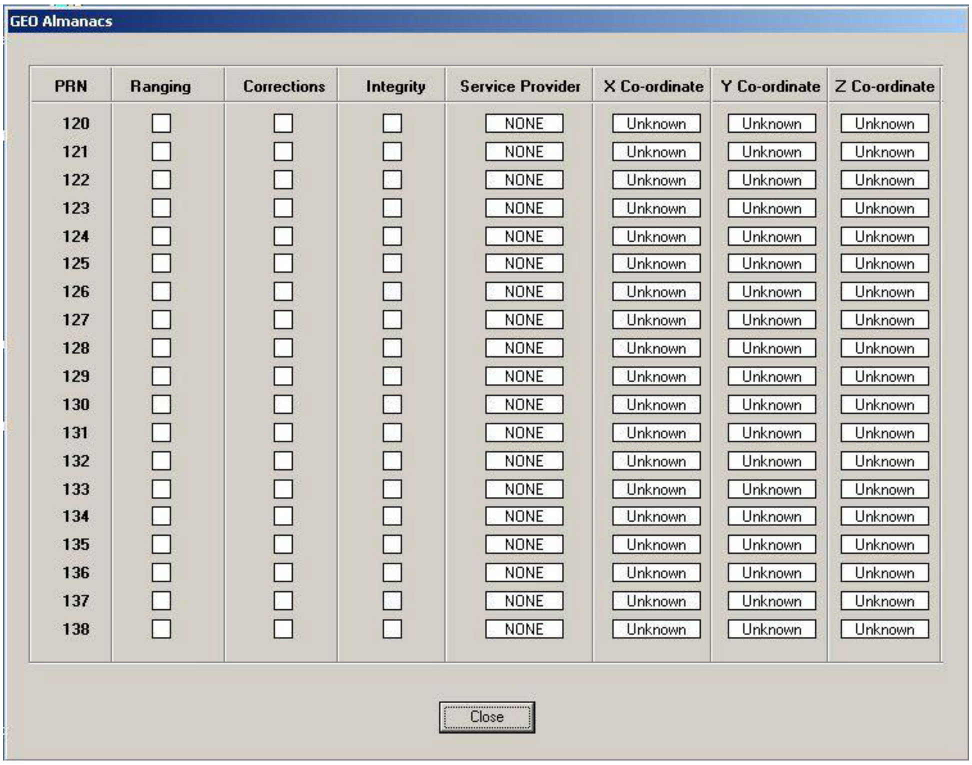


Figure 12. Real-time analysis window for message types 2 to 5 (fast corrections)

The ESA UAS has been recently enhanced, and it is ESA intention to make this tool available for free download before the end of 2006.

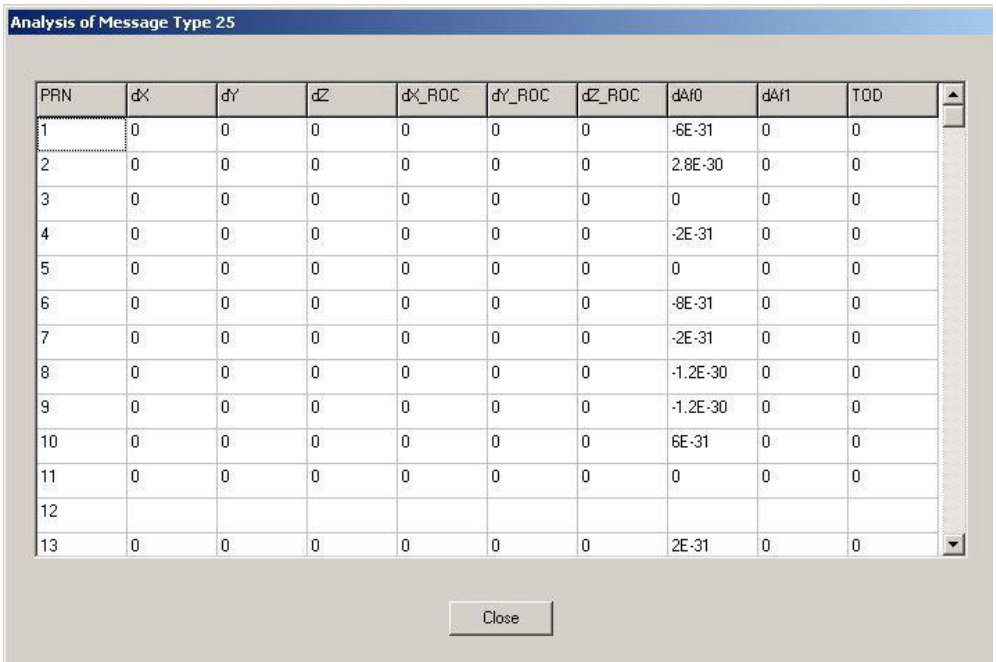


GEO Almanacs

PRN	Ranging	Corrections	Integrity	Service Provider	X Co-ordinate	Y Co-ordinate	Z Co-ordinate
120	☐	☐	☐	NONE	Unknown	Unknown	Unknown
121	☐	☐	☐	NONE	Unknown	Unknown	Unknown
122	☐	☐	☐	NONE	Unknown	Unknown	Unknown
123	☐	☐	☐	NONE	Unknown	Unknown	Unknown
124	☐	☐	☐	NONE	Unknown	Unknown	Unknown
125	☐	☐	☐	NONE	Unknown	Unknown	Unknown
126	☐	☐	☐	NONE	Unknown	Unknown	Unknown
127	☐	☐	☐	NONE	Unknown	Unknown	Unknown
128	☐	☐	☐	NONE	Unknown	Unknown	Unknown
129	☐	☐	☐	NONE	Unknown	Unknown	Unknown
130	☐	☐	☐	NONE	Unknown	Unknown	Unknown
131	☐	☐	☐	NONE	Unknown	Unknown	Unknown
132	☐	☐	☐	NONE	Unknown	Unknown	Unknown
133	☐	☐	☐	NONE	Unknown	Unknown	Unknown
134	☐	☐	☐	NONE	Unknown	Unknown	Unknown
135	☐	☐	☐	NONE	Unknown	Unknown	Unknown
136	☐	☐	☐	NONE	Unknown	Unknown	Unknown
137	☐	☐	☐	NONE	Unknown	Unknown	Unknown
138	☐	☐	☐	NONE	Unknown	Unknown	Unknown

Close

Figure 13. Real-time analysis window for MT17 (GEO almanacs)



Analysis of Message Type 25

PRN	dX	dY	dZ	dX_ROC	dY_ROC	dZ_ROC	dAf0	dAf1	TOD
1	0	0	0	0	0	0	-6E-31	0	0
2	0	0	0	0	0	0	2.8E-30	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	-2E-31	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	-8E-31	0	0
7	0	0	0	0	0	0	-2E-31	0	0
8	0	0	0	0	0	0	-1.2E-30	0	0
9	0	0	0	0	0	0	-1.2E-30	0	0
10	0	0	0	0	0	0	6E-31	0	0
11	0	0	0	0	0	0	0	0	0
12									
13	0	0	0	0	0	0	2E-31	0	0

Close

Figure 14. Real-time analysis window for MT25 (long term satellite error corrections)

2.6.4 Real-time monitoring of the ESTB SIS status through the Internet

This application allows monitoring the ESTB broadcast status and its performance in real time and through the Internet, concretely across the World Wide Web (WWW). This application was based on interfacing the UAS with the ESA ESPADA simulation tool.

2.7 Summary

This section has presented the top-level aspects of the SISNeT technology. Firstly, the utility of the SISNeT concept has been demonstrated. After that, an overview of the SISNeT platform has been presented, focusing the main components. Finally, several ongoing SISNeT developments, aimed at demonstrating the potential behind the SISNeT concept, have been described, including (for information) the very first internal activities performed by ESA in the early days of SISNeT.

Next Section goes to a more technical level of detail, showing high-level concepts regarding the development of SISNeT applications.

3. USER APPLICATION SOFTWARE DEVELOPMENT

3.1 Introduction

The applications shown in Section 2 (the previous Section) are just an example of the potential of the SISNeT technology, centred in the EGNOS system monitoring and also in EGNOS-augmented positioning. Furthermore, SISNeT brings the opportunity to combine:

- Any Science or Engineering field;
- The potential of the Internet;
- The potential of EGNOS-augmented Satellite Navigation.

This section presents how to create a new SISNeT application, i.e. creating a new UAS. Recommended and mandatory practices are also included. The low-level technical knowledge involved in that process is covered in Section 4.

The user hardware can be freely implemented and has no impact on the UAS development process. Therefore, no guidelines about hardware development are presented here.

3.2 How to develop the UAS?

Once the user hardware/software platform is implemented (e.g. a PC computer with Microsoft Windows OS), the application Software part of the user equipment (i.e. the UAS) must be implemented, in order to provide the desired functionality. As stated in Section 2.8, the UAS development involves the implementation of three Software components:

- The DS2DC client;
- One or more processing blocks;
- A user interface.

The main function of the DS2DC client is to communicate with the Data Server, in order to obtain the EGNOS messages in real time. The communications protocol is called DS2DC (Data Server to Data Client), and is totally based on the TCP/IP protocol. In addition, the DS2DC protocol allows implementing other functionalities different than the broadcast of EGNOS messages (e.g. broadcast of text messages to the users).

The processing block works over the EGNOS messages provided by the DS2DC client, and optionally over any other external system (e.g. a GPS receiver, as explained in Section 2.12). This block defines the UAS functionality. Finally, the output interface allows the user to communicate with the UAS, normally through a GUI.

Since the processing block and the output interface are particular to each UAS implementation, they can be freely developed without any restriction. However, the DS2DC client accomplishes an essential task: obtaining the EGNOS messages in real time from the SISNeT Data Server. In fact, the UAS will correctly work only if the DS2DC protocol is properly implemented.

Section 3.3 (the next Section) explains how to develop such a component.

3.3 How to develop the DS2DC Client?

Figure 15 shows the architecture of the DS2DC client. The boxes represent functional components, while the ellipses represent information. The blue ellipses represent the output data of the DS2DC client.

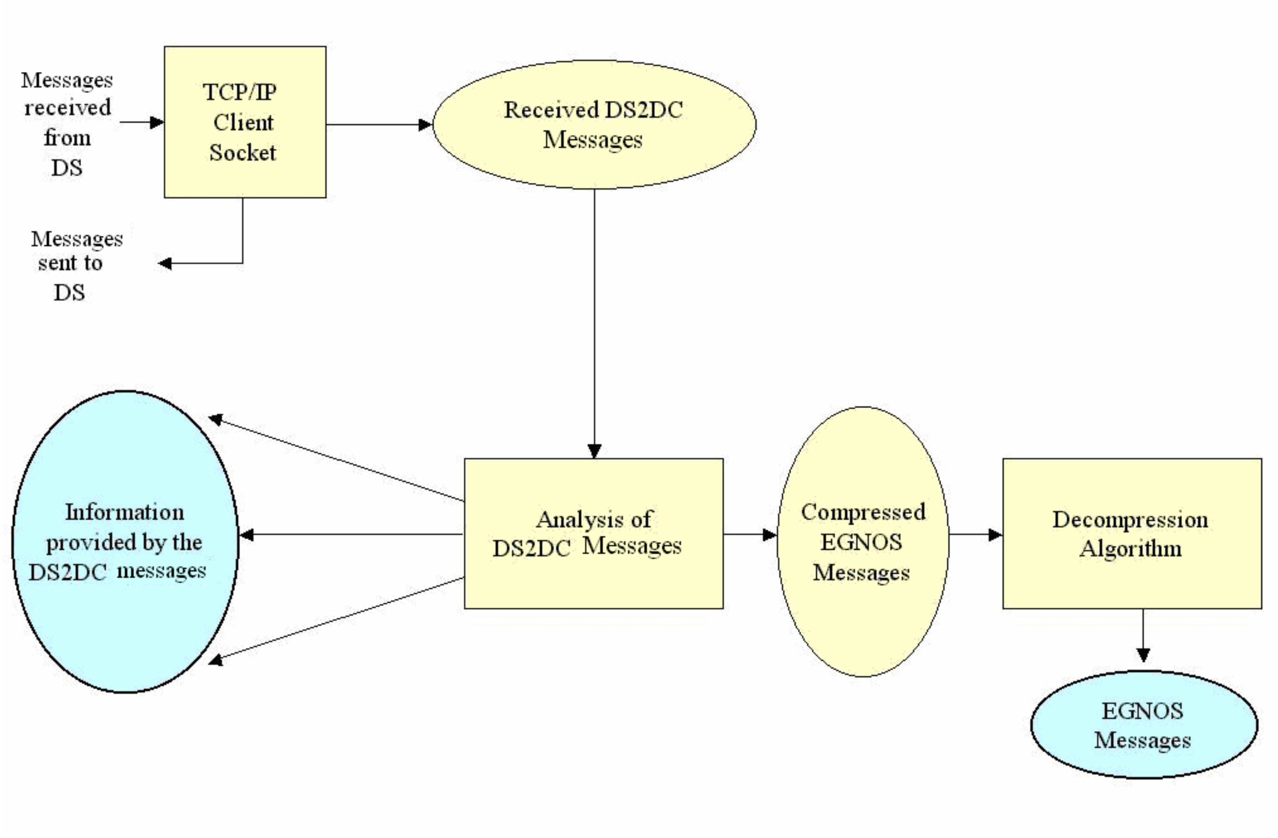


Figure 15. Architecture of the DS2DC Client

The functional blocks of the DS2DC client's architecture are the following:

- **TCP/IP Client Socket (TCS)**. This block opens a TCP/IP connection to the DS, using a previously agreed IP address and port. It allows sending text messages to the DS, and receiving the text messages sent by the DS as an answer.

- **Analysis of DS2DC Messages (ADM)**. This block analyses the contents of the messages sent by the DS. As a result, the information contained in those messages is extracted and converted to an easy-to-process format.

- **Decompression Algorithm (DA)**. In the particular case of the EGNOS messages, the information extracted by the ADM is compressed through a specific protocol. The DS applies a compression algorithm (called SINCA) to the EGNOS messages before sending them to users. That means a decompression algorithm must be implemented into the DS2DC client, only applicable to the messages containing EGNOS messages. The SINCA algorithm is explained in Section 4.

The components work together as follows:

1. A TCP/IP connection to the DS is opened, using the TCS for that purpose;

2. The TCS sends the desired messages to the DS (e.g. a message requesting an EGNOS message)

3. The TCS is always listening for incoming messages from the DS. Those messages can be:
   - Answers to previously sent messages;
   - Messages spontaneously sent by the DS.

4. When a message arrives from the DS, it is captured by the TCS as a text string;

5. The received message is analysed using the ADM block. This block must extract the relevant information contained in each message and provide it as an output of the DS2DC client. The format of that output should be as simple as possible. The goal is to ease the work to the rest of the UAS.

6. If the received messages contain an EGNOS message, the DA must be applied. That block's output must be the decompressed EGNOS message (i.e. the message broadcast by the EGNOS system). The EGNOS messages are part of the DS2DC Client output.

The architecture shown in Figure 15 shall be implemented as shown. The only exception could be implementing the ADM block as a part of the DS2DC Client's processing block. However, this practice is not recommended, since the function of the processing block is just defining the specific functionality of the UAS, and not performing a general task like DS2DC message analysis.

The most recommended practice is to implement the DS2DC Client as a re-usable Software component (e.g. an ActiveX or VCL component, or DLL library). The user of the component must see the interface shown in Figure 16, in which the green ellipses indicate the input data, and the output data is represented by blue ellipses.

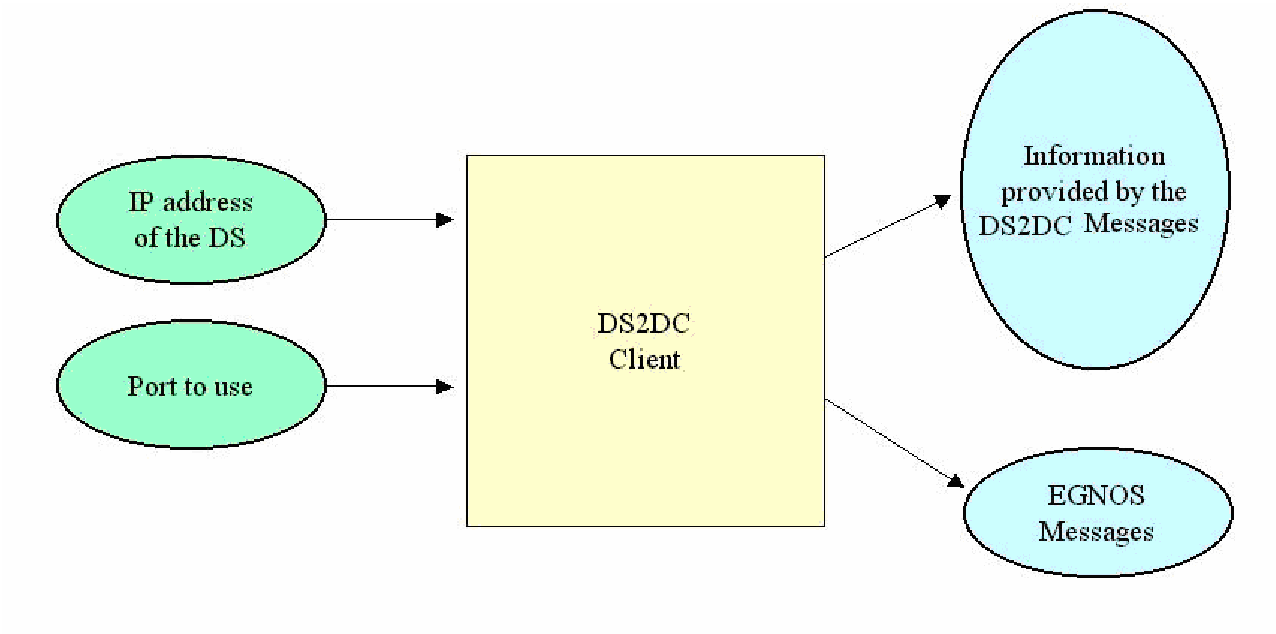


Figure 16. DS2DC Client interface.

Using this approach, the processing block of the UAS will not receive DS2DC messages. Instead, it will directly receive the relevant information to process.

All the blocks (TCS, ADM and DA) **shall** accomplish the functionality exposed in this Section. In addition, the specific requirements to respect in the development of each block are the following:

- **TCS:** shall implement the DS2DC protocol (explained in Section 4). Any non-DS2DC incoming message shall be ignored and the user shall be informed about that. Only DS2DC messages shall be sent to the DS.
- **ADM:** analysis shall be performed strictly following the DS2DC protocol specifications.
- **DA:** the SINCA decompression algorithm shall be correctly implemented, as explained in this document..

The valid DS2DC messages are just those specified in this Document. The DS2DC Client shall ignore any other message, and the user **shall** be informed about that. The developer **shall** motivate the user to inform ESA in case of receiving invalid messages (through warning windows or similar means). In addition, the DS will detect users sending invalid messages, and will apply several categories of **penalties** (including rejecting future connections). This will improve security.

3.4 Conclusions

This section has presented the process to follow when developing a new SISNeT application, including recommendations and restrictions to take into account.

The main conclusions are the following:

- The development of a SISNeT application is reduced to the development of the UAS, running on a pre-selected hardware platform (PDAs, mobile phones, PC computers, etc.)

- The development of the UAS involves the creation of three blocks: the DS2DC client, a processing block and a user interface. Development is only restricted with respect to the DS2DC client, which shall respect the specfications provided in this User Interface Document.

- The development of the DS2DC client involves the creation of three blocks: the TCS, the ADM and the DA. All those blocks shall respect the specifications of the present UID document.

Section 4 presents in detail he DS2DC protocol and the SINCA algorithm specifications, which shall be respected in order to obtain SISNeT-compliant UAS.

4. TECHNICAL SPECIFICATIONS OF THE DS2DC CLIENT

4.1 Introduction

Section 3 has explained the process to follow when creating a new SISNeT UAS, highlighting the restrictions to take into account. Those restrictions are related to the components of the DS2DC client, and require a low-level technical explanation of:

- The DS2DC protocol specifications;
- The SINCA compression algorithm.

This Section provides those technical inputs, which shall be strictly respected, in order to assure the UAS is SISNeT-compliant.

4.2 The DS2DC protocol

4.2.1 Fundamentals of the ESA DS2DC protocol

The DS2DC protocol works with text strings, directly sent and received through the TCP/IP protocol (via the activation of a TCP socket linking the DS2DC Client and the DS). Those text strings will be called "messages" hereinafter. Each message is composed of text fields, which are separated by commas. Each field contains a specific portion of the information included in the message. The first field is an uppercase text label, identifying the purpose of the message. That label will be referred as the "Message Name" hereinafter. Figure 17 illustrates the general structure of a DS2DC message.

Message Name	,	Field 1	,	Field 2	,	...	,	Field N-1	,	Field N	<LF> or <CR><LF>

Figure 17. General structure of a DS2DC message

It is important to note that any message shall end with:

- **A line feed (LF) character, or**
- **A carriage-return character followed by a line feed character (CRLF).**

Depending on their directionality, the messages can be classified in two groups:

- **Messages going from the UAS to the DS**. Following the SISNeT terminology, these messages receive the name of R-Messages or RMs, since they usually **R**equest services to the DS. The R-Messages are usually called "DS2DC messages".

- **Messages going from the DS to the UAS**. Following the SISNeT terminology, these messages receive the name of S-Messages or SMs, since the DS uses them to provide a **S**ervice. The SMs can be classified in two groups:

    - **SMs sent as a response to previously sent RMs**. These messages receive the name of A-Messages or AMs, since they provide an **A**nswer.

    - **SMs spontaneously sent by the DS**. These messages receive the name of E-Messages or EMs, since they usually act as **E**vent-trigger signals.

Note that a message could belong to several different categories, depending on the context in which it is being used each time. One example is the '*ERR' message. This message can act as an EM for spontaneously reporting some conflicting situation. On the other hand, if a RM is not correctly formatted / employed, or contains incorrect information, the *ERR message acts as an AM, reporting about the error situation. Classification of the DS2DC messages is illustrated in Figure 18.

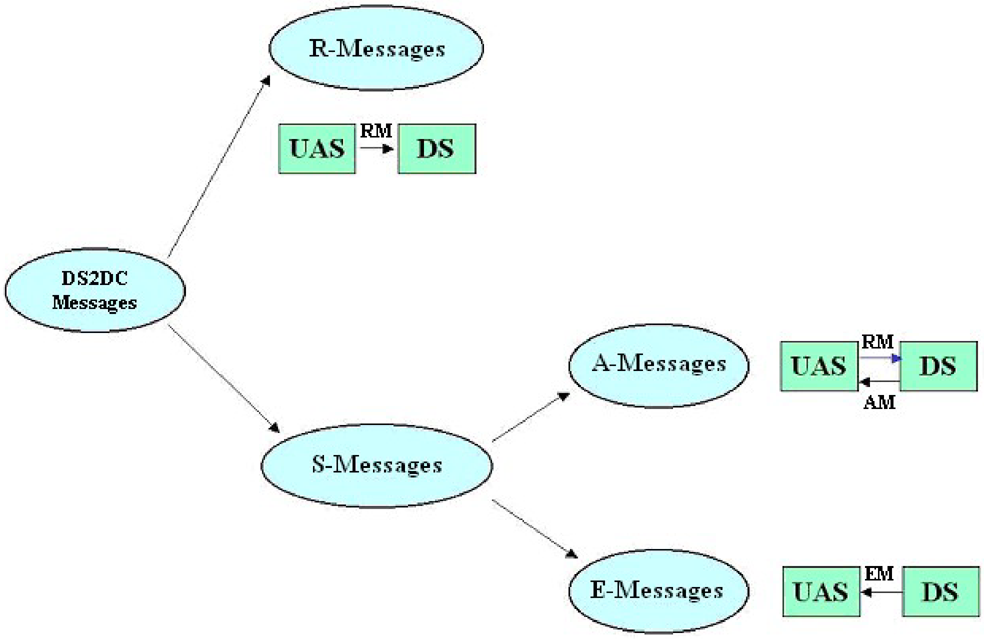


Figure 18. Types of DS2DC messages

A relationship exists between message names and message types. The naming rules are the following:

- **RMs**: Message names always start with an alphabetic character.
- **AMs**: Message names always start by a '*' character, followed by the message name being answered. For instance, the AM associated with a RM called 'MSG' is '*MSG' (or '*ERR' in case of error).
- **EMs**: Message names always start by a '*' character.

From those rules it is concluded that the '*' character indicates DS to UAS direction, and its absence indicates UAS to DS way. After presenting the theoretical aspects behind the DS2DC protocol, Section 4.2.2 focuses on more practical issues, presenting some available DS2DC messages.

4.2.2 Available DS2DC Messages

The following list explains the purpose of some of the currently available DS2DC messages, using the classification criteria introduced in the previous section. More information on the syntax of these messages is available in the Appendix A.

- R – Messages:
  - **AUTH.** This RM makes possible the implementation of an authentication process, which is mandatory before any interaction with the DS. For further information on this process, see Section 4.3.
  - **MSG**. Asks the DS for an EGNOS message. This RM is intended to be used in a synchronous way, i.e. sending the MSG message, and waiting for the response, and then sending another MSG message, and so on. Loss of messages could appear, especially when connecting to the Internet via GSM or GPRS links. The DS2DC protocol offers a solution to the problem of message losses: the possibility to retrieve an already broadcast EGNOS message (provided its message type is known) after detecting its absence. See the ‘GETMSG’ RM.
  - **GETMSG**. This RM allows retrieving an already broadcast EGNOS message. The message to retrieve is identified by MT number and order of occurrence. This RM

has a special interest to quickly obtain the MTs which are broadcast with a low frequency by the SBAS system. For example, this is the case of the ionospheric corrections. The UAS can collect all the necessary information to start applying the ionospheric corrections, without having to wait several minutes for all the necessary information to be broadcast. The result is a dramatical reduction of the Time To First Fix (TTFF).

- **START**. This RM allows the user to receive the EGNOS messages continuously from the data server, until the STOP message is sent.

- **STOP**. This RM is useful if the user wishes to stop receiving the EGNOS messages after the START message is sent.

- **EPHEM**. This RM can be used to request ephemeris information for a given GPS satellite. The ephemeris information is expressed in a RINEX-like format, i.e containing 8 lines of ASCII characters. The PRN number of the GPS satellite and the line number (1 to 8) of the ephemeris information must be sent along with the request.

- **GPS_IONO**. This RM can be used to request the parameters of the Klobuchar ionospheric model (broadcast by the GPS system).

• A – Messages:

- ***AUTH**. A positive answer to an authentication message (AUTH). Indicates that the DS2DC Client has permission to interact with the DS.

- ***MSG**. This AM answers the request of an EGNOS message. Its fields include the most updated EGNOS message, together with the GPS time and GPS week number. The EGNOS message is provided in hexadecimal format. Each EGNOS message is formed by 63 hexadecimal digits (252 bits). Note that the received message could present 64 hexadecimal digits. In that case, the last digit is always set to zero and should be ignored. Since the EGNOS messages contain 250 bits, the last 2 bits of the 63rd digit should be ignored. The message is terminated by an asterisk '*' symbol, followed by two hexadecimal digits constituting a checksum (XOR operation of the bytes forming the EGNOS message). This checksum can be used by the UAS to detect transmission errors from the DS to the user. Also note that the EGNOS messages contain a 24-bit CRC code, generated by EGNOS before transmission.

  - ***GETMSG.** The answer to the 'GETMSG' message. Contains the requested past message (see Appendix A for details).

  - ***START.** The answer to the START message. This answer is continuously followed by the EGNOS messages, received through the *MSG A-Message..

  - ***STOP.** The answer to the STOP message indicates that the reception of continuous EGNOS messages has been stopped.

  - ***EPHEM.** It is an answer to the EPHEM message, along with the requested ephemeris line.

  - *** GPS_IONO.** It is an answer to the GPS_IONO message, providing the Klobuchar model parameters as broadcast by the GPS system.

  - ***ERR**. This message informs about an error. Its contents include an error code and a text string explaining the problem (see Appendix B). The error code can be used for identifying the error source.

- E – Messages:

  - ***TXT**. This EM allows the SISNeT operators broadcasting informative text strings to the users (e.g. information about new SISNeT applications, DS2DC protocol upgrades, etc.). The normal reaction to this message is to present those strings on the available output device (PC monitor, LCD display, etc.). When a maintenance activity is scheduled, this message is usually sent to notify users in advance.

The complete reference of available messages can be found in Appendix A of this Document. As a complement, Appendix B introduces the available error messages that the Data Server can return.

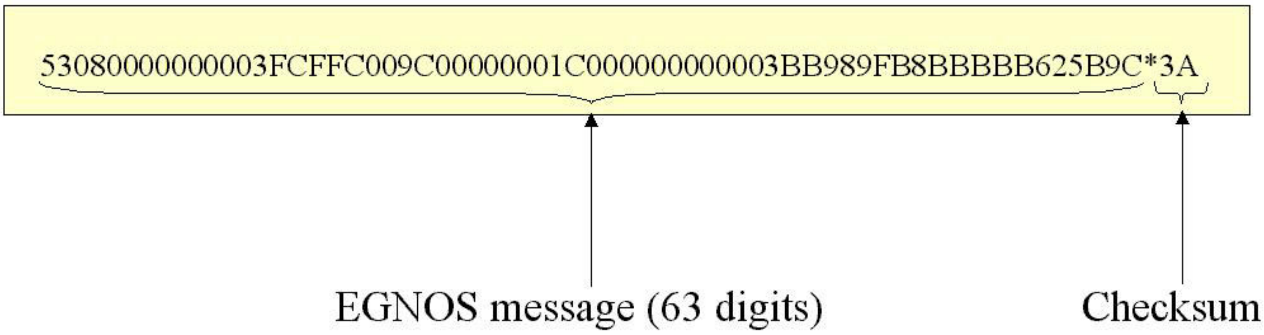


Figure 19. General structure of the EGNOS messages provided by SISNeT

The number of DS2DC messages will be continuously growing and, hence, being reflected into new revisions of this document. Those messages are exclusively managed by ESA. Any suggestion of new messages is welcome, and will be studied by ESA. Sending messages not included in this Document to the DS is strictly prohibited.

A detailed explanation of the format of each available DS2DC message is presented in Appendix A. The messages reserved for future use are not included, since they are under study and development.

4.3 The Authentication Process

After opening a connection to the Data Server, the Client Socket must maintain an authentication dialog with the DS, in order to obtain permission for accessing the SISNeT services. As introduced in Section 4.2 (the previous Section), the authentication protocol relays on the use of the "AUTH" R–Message, and its associated "*AUTH" A–Message. The complete sequence of actions is the following:

1. The DS2DC Client establishes a connection with the DS.

2. The DS2DC Client sends an AUTH message, containing the private information corresponding to a valid account, i.e. user name and password.

3. If the authentication data correspond to a valid account, the Data Server returns an *AUTH message, indicating that the access to the DS is allowed. The DS2DC client can then start its normal interaction with the DS.

4. If the authentication data is not correct, the DS returns an *ERR message containing error code number 2. This message indicates the access to the DS is denied. The DS disconnects the DS2DC client immediately after.

Note the authentication process is mandatory before any interaction with the DS, and must be respected exactly as shown above. The following remarks shall be taken into account:

- Obviously, no user can access the Data Server without having a valid SISNeT account. SISNeT accounts are managed by ESA, and must be requested through contacting the ESA SISNeT project team (sisnet@esa.int). A specific username and password for the use of SISNeT by the future client will then be set up.
- If the authentication phase is repeated certain number of times without success in a short time-frame, the DS will apply a penalty to the client, rejecting its connection requests during a certain number of hours.
- If the DS2DC Client tries to send other DS2DC messages before successfully passing the authentication phase, the DS will return an *ERR message, containing error code set to 1. This message indicates the authorisation process is required. The DS disconnects the client immediately after.
- The user name is limited to 15 characters.
- The password is limited to 8 characters.
- The authentication protocol does not avoid the possible future release of public SISNeT Data Servers. In this particular case, any user will be able to access the DS through common authentication data, which will be made public. A hybrid version of the Data Server is also possible, allowing the public access through common authentication data, as well as private accounts (which will usually have some privileges in terms of performance).

From version 3.1 of the SISNeT User Interface Document, a new variant of the AUTH message has been included, enabling authentication combined with quick initialisation of SBAS receivers.

4.4 The SINCA compression algorithm

The SISNeT Compression Algorithm (SINCA) is a simple technique, used by the DS to improve the communications speed when performing the most critical task: sending the EGNOS messages through the '*MSG' message. If the EGNOS message were not compressed, its length into that message would always be 66 (or even 67) bytes, as shown in Figure 19. Using the SINCA algorithm, that length is frequently reduced down to 16 bytes, or even less. The compression rate depends on the contents of each concrete message.

In order to know how to decompress the messages, it is necessary to start by knowing how the messages are compressed. The SINCA compression algorithm is illustrated in Figure 20.

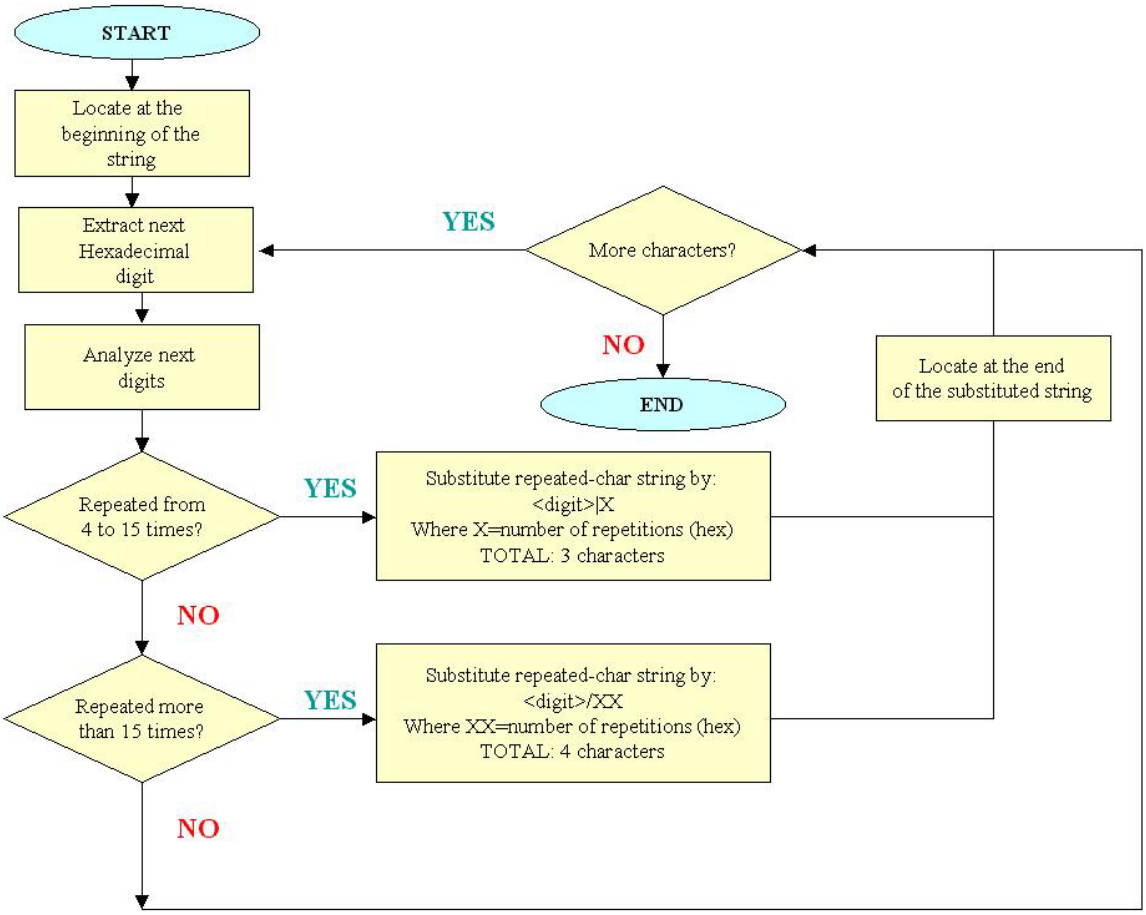


Figure 20. SINCA compression algorithm.

The process consists on evaluating each digit of the hexadecimal string. If the digit is repeated from 4 to 15 times, all the repetitions are substituted by:

<repeated_digit>|X

Where X is a hexadecimal digit indicating the number of repetitions. For instance, if the following sub-string is found:

AAAAAAAAAAAA

That string will be substituted by:

A|C

Since 'A' is repeated 12 times. Note just one digit is used to indicate the number of repetitions. That is the reason to allow a maximum of 15 repetitions. A minimum of 4 repetitions has been established, since the compressed string always has three characters. Otherwise, no compression would be achieved.

And, what happens if the digit is repeated more than 15 times? The way to compress is the same, but indicating the number of repetitions with two digits, and using the '/' separator:

<repeated_digit>/XX

The reason to use a different separator is to ease the decompression. The '|' character indicates to read only the next character. On the other hand, the '/' character indicates to read the next two characters.

Figure 21 shows an example of SINCA compression, performed over a real EGNOS MT0. The EGNOS message length goes from 66 characters down to only 16 characters. That means the message has been reduced to 24.2% of the original size.

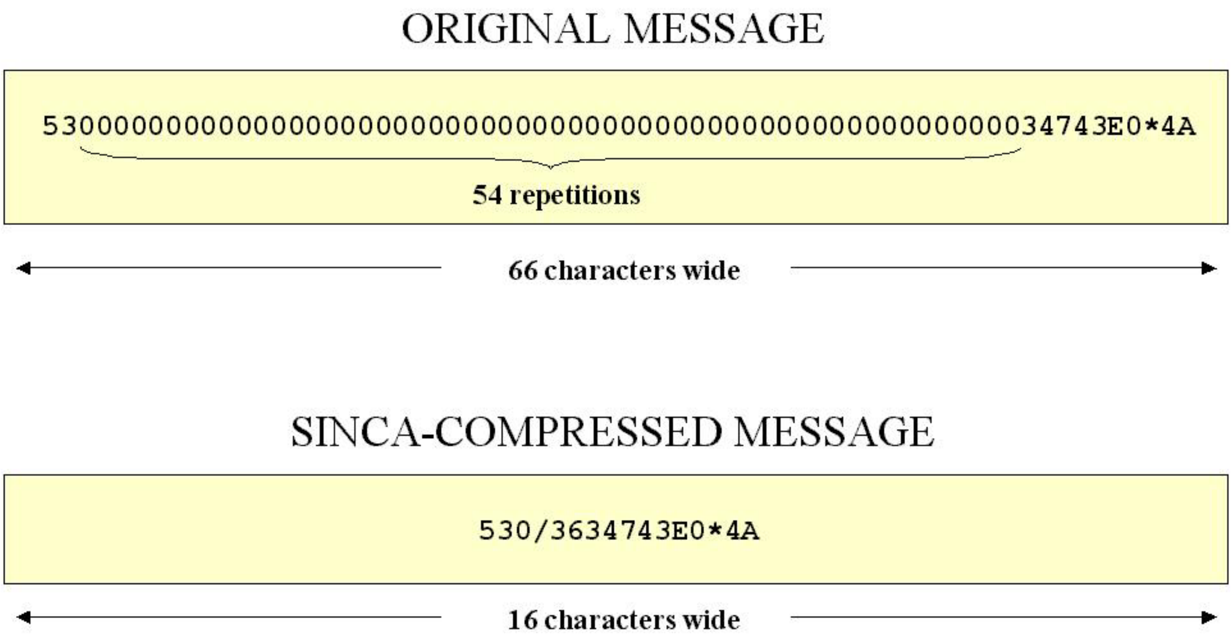


Figure 21. Example of SINCA compression.

4.5 SINCA decompression algorithm

Once the process of compression is clear, the SINCA decompression algorithm is quite easy to implement. This algorithm must be implemented by any UAS developer, in order to apply it to the compressed EGNOS messages included inside the '*MSG' message. Figure 22 illustrates how to implement such an algorithm.

The process consists on evaluating each character of the compressed string. When an 'X|Y' string is found, that string is replaced by: 'XX…X', where 'X' has been repeated Y times (note Y is an hexadecimal digit). When a 'X/YY' string is found, that string is replaced by 'XX…X', where 'X' has been repeated YY times (note YY is a two-digit hexadecimal number). The algorithm ends when reaching the end of the compressed string.

Figure 23 shows an example of SINCA-decompression, based on a real message broadcast by the ESTB. The original string was 26 characters wide. After decompression, the resulting string is 66 characters wide, i.e. 2.54 times longer.

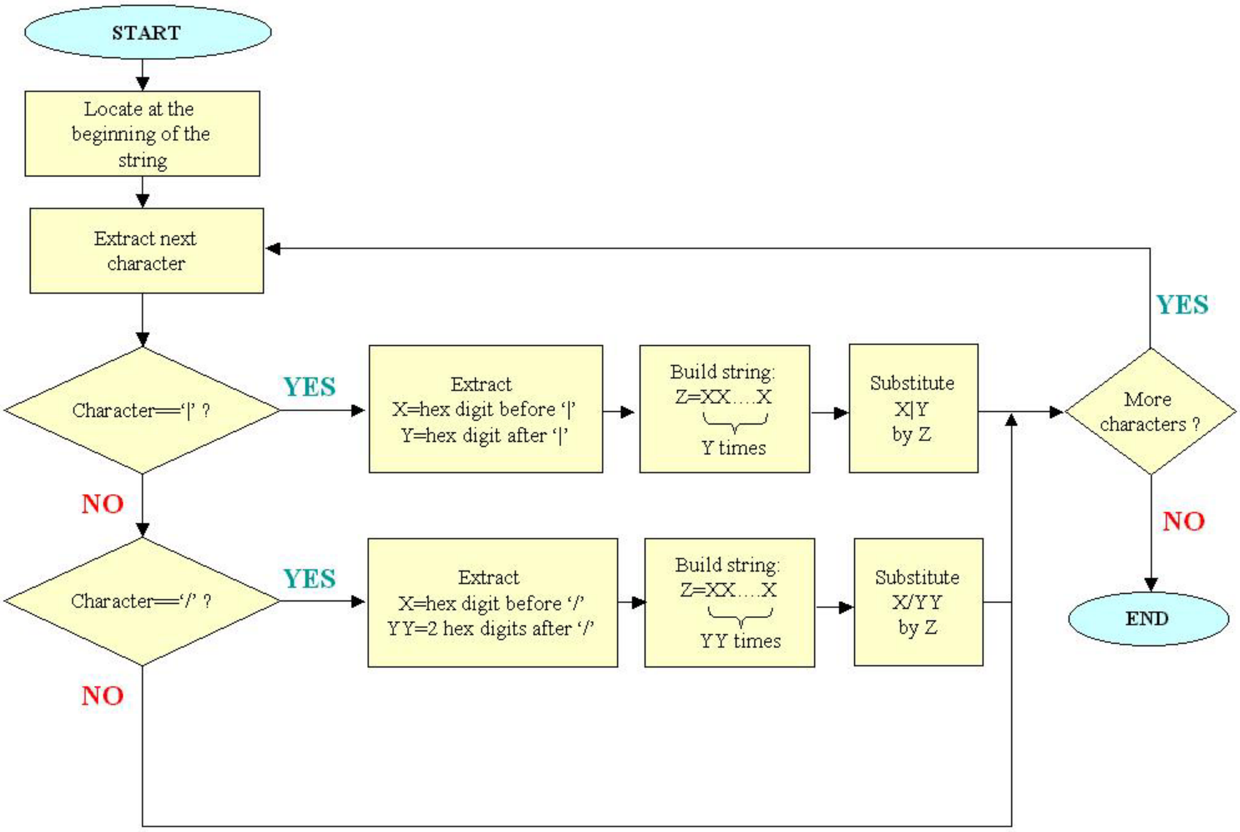


Figure 22. SINCA decompression algorithm

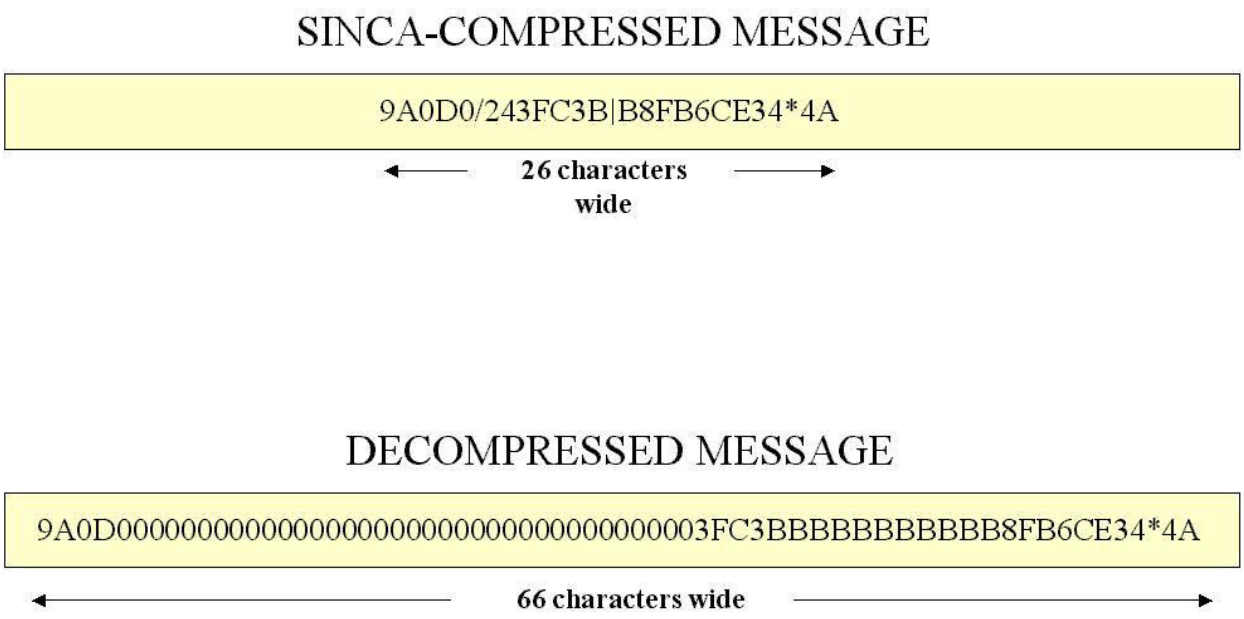


Figure 23. Example of SINCA decompression

4.6 Summary

This section has added more technical details to the concepts introduced in Section 3. The knowledge needed for the development of the DS2DC client (i.e. the most critical and restricted part of the UAS) has been introduced.

Concretely, the following information has been provided:

- **A technical description of the DS2DC protocol**, including the fundamental theory and the available DS2DC messages (see Appendix A).

- **A technical description of the SINCA compression algorithm**. Firstly, the compression algorithm has been described, since this knowledge is necessary to understand how to decompress the information contained in the '*MSG' messages. Then, the decompression algorithm has been explained. The text has been illustrated through flow diagrams and examples.

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6. LIST OF ACRONYMS

AM	A–Message (Answer–Message)
ADM	Analysis of DS2DC Messages
AL	Alarm Limit
BS	Base Station
BSS	Base Station Software
DA	Decompression Algorithm
DS	Data Server
DSS	Data Server Software
DS2DC	Data Server to Data Client protocol
EGNOS	European Geostationary Navigation Overlay Service
EM	E–Message (Event triggered–Message)
ESTB	EGNOS System Test Bed
FTP	File Transfer Protocol
GEO	Geostationary Satellite
GUI	Graphical User Interface
JPEG	Joint Photographic Experts Group
MT	Message Type
PRC	Pseudo-Range Correction
PRN	Pseudo-Random code number
RC	R–Message (Request–Message)
RCS	Receiver Control Software
SC	S–Message (Service–Message)
SDS	SISNeT Data Server
SE	Software Engineering
SINCA	SISNeT Compression Algorithm
SIS	Signal In Space
SISNeT	Signal In Space through the interNET
SUI	SISNeT User Interface
TCS	TCP/IP Client Socket
UAS	User Application Software
UDRE	User Differential Ranging Error
UID	User Interface Document
VPL	Vertical Protection Limit
WWW	World Wide Web

APPENDIX A. DS2DC Message Reference.

The different messages available in the DS2DC protocol are explained in this section. **Please note that each message should terminate in a CRLF or LF.** This is one of the major changes implemented in this version 3.1 of SISNeT. Please refer to Section 1.4 for more information on this change. **It is important to note that any message shall end with:**

- **A line feed (LF) character, or**
- **A carriage-return character followed by a line feed character (CRLF).**

Depending on their directionality, the messages can be classified in two groups:

- **Messages going from the UAS to the DS**. Following the SISNeT terminology, these messages receive the name of R-Messages or RMs, since they usually **R**equest services to the DS. The R-Messages are usually called "DS2DC messages".

- **Messages going from the DS to the UAS**. Following the SISNeT terminology, these messages receive the name of S-Messages or SMs, since the DS uses them to provide a **S**ervice. The SMs can be classified in two groups:

  - **SMs sent as a response to previously sent RMs**. These messages receive the name of A-Messages or AMs, since they provide an **A**nswer.

  - **SMs spontaneously sent by the DS**. These messages receive the name of E-Messages or EMs, since they usually act as **E**vent-trigger signals.

AUTH Message

Type

R–Message

Purpose

This R–Message is the first to be sent after connecting to the Data Server. It is the base of the SISNeT authentication protocol, providing information on a particular SISNeT account (i.e. username and password). This message has an optional field that allows the user to quickly initialise his receiver. The format is shown below. If the AUTH message ends with a 'q' then the server will return *AUTH followed by all the necessary messages to initialize the receiver (separated by LF or CRLF). If the optional 'q' field is omitted, the user is simply authorised to access the SISNeT data server, provided the user name and password are correct.

Format

AUTH	,	User	,	Password	,	q

Fields:

Field	Comments
AUTH	The message name
User	Username corresponding to a valid SISNeT account.
Password	The corresponding password.
q	This field is optional and can be used to quickly initialise the receiver.

***AUTH Message**

Type

A–Message

Purpose

This message gives a positive answer to the AUTH message, indicating that a remote user is authorised to use the Data Server. If the user is not authorised, an *ERR message (error code 2) will be sent instead. Section 4.3 of this Document explains the details of the authentication protocol. If the AUTH message ends with a ‘q’ then the server will return *AUTH followed by all the necessary messages to initialize the receiver (separated by LF or CRLF). If the optional ‘q’ field is omitted, the user is simply authorised to access the SISNeT data server, provided the user name and password are correct.

Format

*AUTH

Fields:

Field	Comments
*AUTH	The message name

MSG Message

Type

R–Message

Purpose

This RM asks the DS for the most recent EGNOS message. This RM is intended to be used in a synchronous way, i.e. sending the MSG message, and waiting for the response, and then sending another MSG message, and so on. Loss of messages could appear, especially when connecting to the Internet via GSM or GPRS links. The DS2DC protocol offers a solution to the problem of message losses: the possibility to retrieve an already broadcast EGNOS message after detecting its absence. See the 'GETMSG' RM.

Format

Fields:

Field	Comments
MSG	The message name.

Remarks:

- The DS shall ignore any field included in this message.
- If (for any reason) the DS cannot provide the service to the UAS, a '*ERR' message will be returned.
- The UAS is expected to send this message once per second. However, higher rates can be employed, depending on the concrete characteristics of the communications link.

***MSG Message**

Type

A–Message

Purpose

This AM constitutes an immediate answer to the MSG message, returning the most recent EGNOS message, along with the GPS week and GPS time. The EGNOS message is provided in the hexadecimal format.

Format

***MSG**	,	GPS Week	,	GPS time	,	EGNOS Message (hex)

Fields:

Field	**Comments**
*MSG	The message name.
GPS Week	The GPS week corresponding to the EGNOS message
GPS time	The GPS time corresponding to the EGNOS message
EGNOS message (hex)	The EGNOS message, compressed through the SINCA algorithm (see Sections 4.4 and 4.5)

Remarks:

- The GPS week number is represented using 10 bits, so that the number ranges form 0 to 1023. At the time of this writing (May 2006), the first rollover was crossed. Since SISNeT can use different kinds of EGNOS receivers, and each receiver works with a different GPS week format, it is possible to receive a GPS week that does not take rollover into account. For instance, if the UAS receives a week number of 78, this means the real week is 78+1024=1102. On the other hand, if the UAS receives week 1102, no processing is needed. The developer of the UAS must take this effect into account.

GETMSG Message

Type

R–Message

Purpose

This RM allows the user retrieving an SBAS message already broadcast by EGNOS. The SISNeT Data Server configuration determines the length of the historical archive. As a rule, the Data Server will always try to make available the latest 30 messages of each message type.

Format

GETMSG	,	Message Type	,	Order of Occurrence

Fields:

Field	Comments
GETMSG	The message name.
Message Type	The message type number corresponding to the SBAS message to retrieve.
Order of Occurrence	The order of occurrence. A value of 1 means the last occurrence of the selected message type, and so on. For instance, say the ESTB broadcasts MT1 at time t1, and the next time it broadcasts MT1 is at time t2. Then, “GETMSG,1,1” will return MT1 broadcasted at t2, while “GETMSG,1,2” will return the MT1 broadcasted at t1.

*GETMSG Message

Type

A–Message

Purpose

This AM constitutes an immediate answer to the GETMSG message, returning the selected (already broadcast) SBAS message.

Format

***GETMSG**	,	GPS Week	,	GPS time	,	EGNOS Message (hex)

Fields:

Field	Comments
*GETMSG	The message name.
GPS Week	The GPS week corresponding to the EGNOS message
GPS time	The GPS time corresponding to the EGNOS message
EGNOS message (hex)	The EGNOS message, compressed through the SINCA algorithm (see Sections 4.4 and 4.5)

START Message

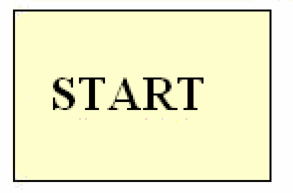
Type

R–Message

Purpose

This RM is useful when the user wishes to receive EGNOS messages continuously. Sending this message to the DS is equivalent to sending the MSG message every second. The data server answers with the EGNOS messages continuously until the STOP message is received.

Format



Fields:

Field	Comments
START	The message name.

***START Message**

Type

A–Message

Purpose

This AM constitutes an immediate answer to the START message. This AM is immediately followed by continuous *MSG messages each returning the most recent EGNOS message, along with the GPS week and GPS time, until the STOP message is sent. The EGNOS message is provided in the hexadecimal format.

Format

* START

Fields:

Field	Comments
*START	The message name.

STOP Message

Type

R–Message

Purpose

This RM is useful when the user wishes to stop receiving the EGNOS messages, that had been started by the START message.

Format

Fields:

Field	Comments
STOP	The message name.

***STOP Message**

Type

A–Message

Purpose

This AM constitutes an immediate answer to the STOP message and the continuous EGNOS messages, which were being received due to the START message, stop.

Format

```
* STOP
```

Fields:

Field	Comments
*STOP	The message name.

EPHEM Message

Type

R–Message

Purpose

This RM requests information on the GPS ephemeris. The second field specifies the PRN number for which the information is requested. The resulting information is returned through the *EPHEM message, being expressed in a RINEX-like format, i.e. containing 8 lines of ASCII characters. The following example shows the GPS ephemeris information corresponding to PRN 1, on the 24th of April 2002 at 6:00:00 UTC:

```
1 02  4 24  6  0  0.0  .226148404181D-03  .159161572810D-11  .000000000000D+00
    .710000000000D+02  .237500000000D+02  .499163649312D-08  .299753671406D+01
    .101514160633D-05  .530451152008D-02  .300258398056D-05  .515364340401D+04
    .280800000000D+06  .968575477600D-07 -.217827995687D+01 -.651925802231D-07
    .968381023219D+00  .326937500000D+03 -.168433737953D+01 -.847713882114D-08
    .284654714154D-09  .000000000000D+00  .116300000000D+04  .000000000000D+00
    .400000000000D+01  .000000000000D+00 -.325962901115D-08  .583000000000D+03
    .280799000000D+06
```

The *EPHEM message does not return the whole block of lines. Instead, each line must be requested separately. The line number to receive is indicated through the third parameter. Following the example above, if the client application sends:

EPHEM,1,3

The answer from the DS will be:

**EPHEM,.101514160633D-05 .530451152008D-02 .300258398056D-05 .515364340401D+04*

Format

EPHEM	,	PRN	,	Line

Fields:

Field	**Comments**
EPHEM	The message name
PRN	PRN of the GPS satellite for which ephemeris information is requested
Line	A number between 1&8 (both inclusive), identifying a line of the resulting RINEX-like block

*EPHEM Message

Type

A–Message

Purpose

This AM constitutes an immediate answer to an EPHEM message. It contains the ephemeris information for the requested GPS satellite in a RINEX-like format, i.e. 8 lines of ASCII characters. The information is retrieved on a line-by-line basis. As a consequence, the *EPHEM message returns – for the requested PRN – just the requested line of the corresponding RINEX-like block. Therefore, 8 *EPHEM messages are needed to retrieve all the ephemeris information for a given satellite.

Format

*EPHEM	,	Text string

Fields:

Field	Comments
*EPHEM	The message name
Text string	The requested line of the RINEX-like block, corresponding to the requested GPS satellite.

Remarks:

- If no information is available for the requested PRN, error code 6 is returned.
- The associated EPHEM message must requested a line number greater than 1 and lower than 8 (both inclusive). Otherwise, error code 5 is returned.

GPS_IONO Message

Type

R–Message

Purpose

This RM requests the 8 parameters (α_0, α_1, α_2, α_3, β_0, β_1, β_2 and β_3), of the Klobuchar ionospheric model (broadcast by the GPS system).

Format

GPS_IONO

Fields:

Field	Comments
GPS_IONO	The message name.

***GPS_IONO Message**

Type

A–Message

Purpose

This AM answers a "GPS_IONO" message, providing the 8 parameters of the Klobuchar ionospheric model (α_0, α_1, α_2, α_3, β_0, β_1, β_2 and β_3). Those parameters are broadcast by the GPS system.

Format

*GPS_IONO	,	α_0	,	α_1	,	α_2	,	α_3	,	β_0	,	β_1	,	β_2	,	β_3

Fields:

Field	Comments
*GPS_IONO	The message name.
$\alpha_0 \ldots \alpha_3$, $\beta_0 \ldots \beta_3$	Parameters of the Klobuchar ionospheric model

Remarks:

If no information is available, each parameter is substituted by the " – " character.

***ERR Message**

Type

A–Message. Note this message is an exception to the naming rule for A–Message. It uses the same message name for answering any R–Message.

Purpose

This AM informs about any error thrown during the communications between the UAS and the DS.

Format

***ERR**	,	Error code	,	Error message

Fields:

Field	Comments
*ERR	The message name.
Error code	A number identifying the error. It is used by the UAS to easily identify what has happened and how to proceed.
Error message	A text string explaining the error.

Remarks:

See Appendix B for a comprehensive reference of error codes and messages.

***TXT Message**

Type

E–Message

Purpose

The DS uses this message to broadcast text messages to all the users connected to SISNeT. The UAS should be able to present the received text messages, normally using a GUI. Some possible usages of those messages are the following:

- Informing the users about SISNeT-related events (e.g. new enhancements);
- Warning the users about a scheduled outage of the SISNeT service;

Format

*TXT	,	Text string

Fields:

Field	Comments
*TXT	The message name
Text string	The text broadcast from the DS

APPENDIX B. SISNeT Error Codes and Error Messages.

Error Code	Error Message	Comments
1	Authorisation required	This error code is returned when the client application sends a DS2DC message without successfully passing the initial authentication process. After receiving this message, the client is disconnected from the DS. If the client maintains the same attitude (i.e. avoiding the authentication process), a penalty will be applied (e.g. access denied for a certain number of hours).
2	Access Denied	Indicates the user has not successfully passed the authentication process. Hence, the access to SISNeT is denied. If the user fails to pass the authorisation process more than N times, a penalty will be applied (N to be determined and susceptible to change during the operational life of SISNeT)
3	Unknown DS2DC Message	Returned when the Data Server receives an unknown message. A penalty is applied if a given user continually sends unknown messages.
4	Message was not successfully completed	Indicates the Data Server was not able to complete the requested action. This can be due to several reasons, e.g. eventual failures. The user is encouraged to report this situation to the SISNeT team.
5	Invalid line number (**x**)	An EPHEM message has requested a line number (**x**) less than 1 or greater than 8.
6	Information not available for PRN **x**	There is no ephemeris information available for the requested PRN (**x**).
7	Requested EGNOS message is not available	The message requested through a GETMSG message is not available.

8	GPS week not available	Reserved Error Message.
9	GPS time not available	Reserved Error Message
10	Already authorized.	This message is returned when the UAS sends an AUTH message, having successfully passed the authentication process. Note that some implementations of the Data Server could directly disconnect the user when attempting to AUTH for the second time, without sending error message code 10.