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GRAPHIC SERVER
A REAL TIME SYSTEM FOR DISPLAYING AND MONITORING TELEMETRY DATA OF SEVERAL SATELLITES

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ABSTRACT - Known as a Graphic Server, the system presented in this paper was designed for the control ground segment of the ***Telecom 2*** satellites. It is a tool used to dynamically display telemetry data within graphic pages, also known as views. The views are created off-line through various utilities then, on the operator's request, displayed and animated in real time as data is received. The system was designed as an independent component, and is installed in different Telecom 2 operational control centers. It enables operators to monitor changes in the platform and satellite payloads in real time. It has been in operation since December 1991.

GENERAL PRESENTATION

The Graphic Server system is a system for displaying and monitoring telemetry data of several satellites. It is based on the dynamic visualization of information on what are known as ***graphic pages*** (or ***views***).

Logged in to a data server with which it can interact, it receives telemetry parameters in real time, interprets them and refreshes the graphic pages that the operator is currently displaying by inserting the new values. The operator therefore has access to images or views that reflect in real time the state of the satellites.

Graphic pages are made up of a background part and animated objects whose value, representation and colour vary in relation to the telemetry parameters with which they are associated. A relay, for example (an animated object) in an electrical circuit diagram (graphic page) will appear open or closed depending on the value of the corresponding telemetry parameter, and its outline colour will indicate any anomaly.

Graphic pages are firstly drawn up off-line using a graphic editor, then checked before operational use. This check serves to confirm their coherence with the satellite databases. An animation environment is then generated and acts as a medium on which the real time animation can occur.

Several different graphic pages can be displayed at the same time in real time, for one or more satellites. The rate at which the views are animated then depends on the telemetry acquisition cycle, and the operator can quickly change page due to the graphic objects built into the views.

From a functional viewpoint then, the Graphic Server system integrates both a off-line mode offering the tools used to create and check the graphic pages, and a real time mode for actually using the graphic pages, acquiring data and animating the views.

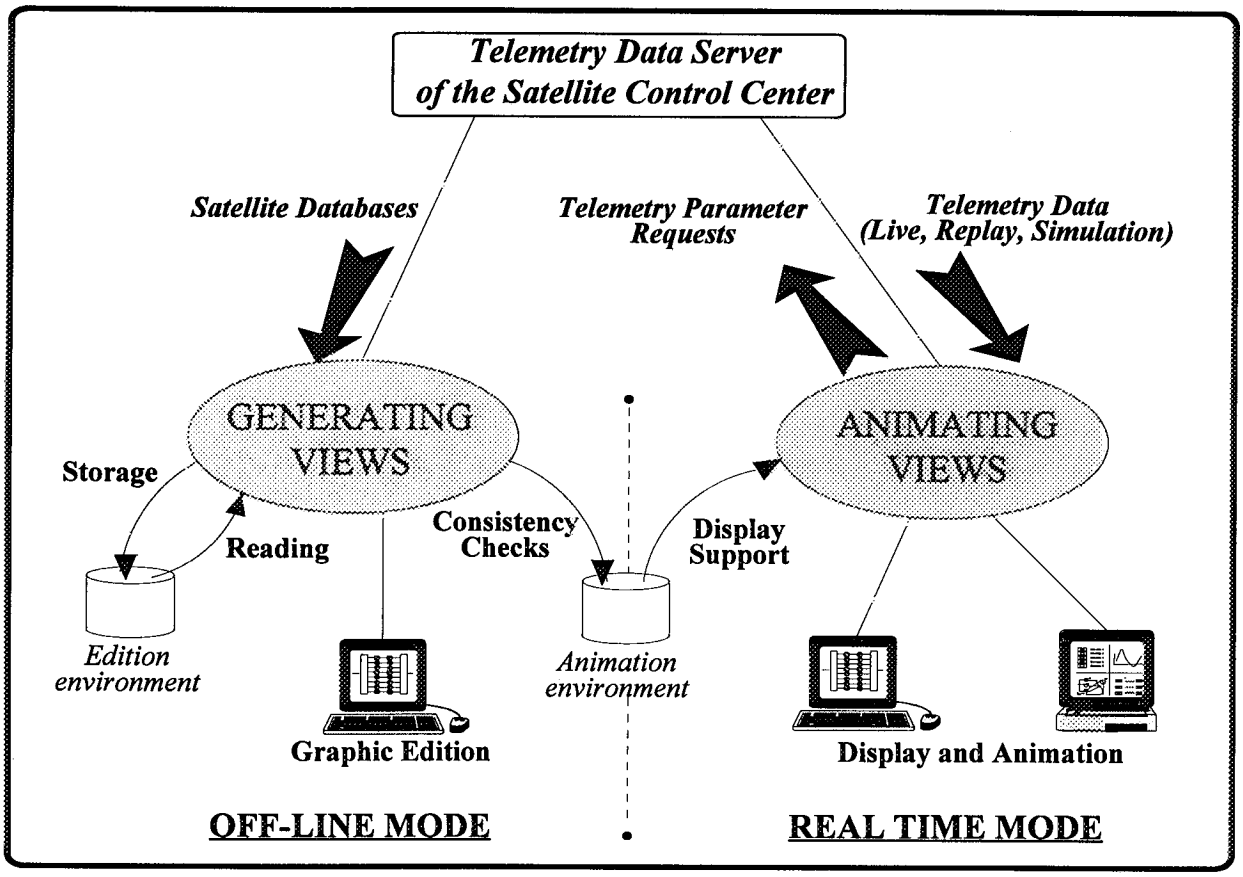

Fig.1 - Operating principles behind the graphic server system

OFF-LINE MODE: GENERATING VIEWS

The tools used in off-line mode are a graphic editor, used to create or modify graphic pages, and various utilities used to check the pages or analyze results obtained.

Creating views

Graphic pages are wholly created by the users, who thus have a wide range of freedom in the organization and representation of telemetry data, in the choice of viewpoint taken by each page (thermal, electrical, orbitography etc.) and in the synthetic degree of the detail represented. Within a page, each parameter can be shown several times in forms which may or may not be complementary, which means that the user can have greater or more detailed information on certain parameters.

The first stage consists of formatting the content of the graphic pages, each page being able to include the following three types of objects:

- ***static objects*** constituting the background,
- ***animated objects***, materializing in various forms the values of telemetry parameters,
- ***pointable objects***, used to support operator dialog in real time mode (point and click objects).

Static objects are composed of graphic objects such as polylines, polygons, texts etc.

Animated objects include:

- alphanumeric and digital readouts used to display the raw or physical value of parameters in different display formats (binary, octal, hexadecimal, decimal and label),
- active symbols used to associate a particular graphic representation with each labelled value (e.g. relay open or closed); a maximum of sixteen such representations are allowed per parameter, each being defined by users and able to be put in a library for use with other parameters and different pages,
- scrolling curves of parameters in relation to time : these curves may optionnaly stop, restart from the origin or shift left (two-thirds of scale) and continue plotting when the right-hand axis is reached,
- moving symbols (e.g. dial with a needle such as a voltmeter).

Pointable objects include:

- static or dynamic tags (these objects, whose graphic representations are defined by the users, enable the user to change from one page to another simply by pointing to the object with the mouse and clicking it),
- data entry fields (these objects may be used to change page by typing in the name of the new page, satellite and display peripheral).

The second stage of edition is designed to associate telemetry parameter identifiers with the corresponding animated objects. This association is based on ***simple naming rules***.

Finally, the last stage consists of "compiling" the pages that have been created so as to optimize real time performance for each page displayed.

Coherence check on views

The coherence check is carried out at one time on all the graphic pages created. The contents of each graphic page are validated with respect to the database for each satellite. If any errors are detected within a page, it cannot be used (for those satellites where an error has been found). To correct the page, the previous stages must be repeated.

During the coherence check, a check is carried out to see that the naming rules mentioned earlier have been correctly applied. The checks are ***syntaxical*** to confirm the existence of names and labels of telemetry parameters, and ***semantic*** to check that the animated objects chosen to represent each telemetry parameter are coherent with its type (an analog parameter, for example, could not be associated with an active symbol as, by its very nature, it cannot have more than sixteen values).

At the end of this phase, the user has a real time animation environment in which the telemetry data received in real time mode may be displayed.

REAL TIME MODE : ANIMATING VIEWS

Available on all the computers in the system, the Real Time application uses the animation environment created off-line and performs the graphic animation on the various display peripherals.

Acquisition of telemetry data

The Graphic Server system can manage and receive telemetry data from several different satellites at the same time. This data may correspond to ***"live" telemetry***, to telemetry that has been recorded and is being played back in deferred time (***"replay" telemetry***), or even ***simulated telemetry***.

The data is received in a ***processed form***, and the raw value, the physical value (which may correspond to either a value or a label) and alarm status are associated with each telemetry parameter. Telemetry data is received via virtual X25 channels, each of which transmits the data for one particular satellite.

Displaying a new page automatically leads to dissemination requests being sent to the data server. The latter then interrupts the dissemination of parameters associated with the display of the previous graphic page and then transmits the new parameters needed by the graphic server to animate this new view. This principle allows operators to access almost all the telemetry parameters in terms of animation (virtual access). It does not affect the other pages displayed.

However, telemetry parameters may be systematically received and memorized by a graphic server. This capability means that when changing a page, the operator can immediately display the latest information on these parameters without having to wait for the acquisition cycle of them within the telemetry. For the Telecom 2 ground segment, for example, each graphic server in the control center receives all the parameters of a satellite, whatever the pages currently on display. On the other hand, the graphic servers in the payload control centers only receive those parameters needed to animate the pages actually displayed by the operators. This is because of the low transmission rates of the X25 links between these graphic servers and the data server of the Telecom 2 satellite control center. Like this, the operators can display all the wiews they want.

When a graphic server is used in a "off-line processing context" (such as telemetry replay or simulation), the systematic dissemination of all the telemetry parameters and their storage in memory by the graphic server grants the operator potential access to all these parameters in terms of display. The acquisition of at least one telemetry format and the interruption of replay telemetry or simulation, enables the user to consult whatever pages he wishes to in order to check particular points, diagnose a failure, divide up information and so on at his ease.

Display and graphic animation

Graphic animation, triggered whenever a new telemetry frame is acquired, can have different forms depending on the type of animated objects chosen to represent the telemetry parameters (cf. creating views).

Graphic animation also covers general parameters associated with each view and includes the name of the satellite and station, the number and date of the telemetry frame.

A default system of graphic representation is used to materialize parameters whose value is unknown. By this means, users quickly distinguish those parameters which, for special reasons are not received in Real Time, from parameters actually received and whose value is therefore significant.

The colour of each animated object varies in relation to the alarm status of the telemetry parameter with which it is associated (grey in the case of a telemetry drop, green when the parameter is nominal, orange or red when its status is simple or dangerous alarm). This means that any anomalies may be identified very quickly.

The number of graphic pages able to be displayed at any one time may be configured before the start of a Real Time session and may vary from one to five. The graphic peripherals may be used either in full screen mode (one page then filling the entire screen) or in quarter screen mode (four pages displayed on the screen).

Operator dialog

The user interface is the means by which a graphic page may be directed to a particular peripheral for a given satellite. The user dialog is based on the pointable objects (graphic objets able to be selected by the user) available in each view.

Data entry fields are used to type in information: name of the new page and/or name of the

satellite and/or number of the peripheral. The operator thus needs to entry data.

Static tags offer more limited functions in that their use limits the page change to the current peripheral for the same satellite. However, simply by using the mouse, this type of object may be used to change page automatically.

Dynamic tags have both the advantages of data entry fields and static tags. The operator can use them to define or modify a preselection of pages in real time. This makes calling them easier. The operator first associates the new page to be displayed, the satellite and the display peripheral with each dynamic tag. When the user next points to the tag, the corresponding page will automatically be displayed, with no need for any data entry.

FEATURES OF THE ARCHITECTURE

The Graphic Server's software includes the ***ANIMATOR®*** graphic software package developed and distributed by ***Syseca***. This package comprises a graphic edition module, a Real Time animation module and an access library module.

The Graphic Server application uses the concepts and mechanisms of ***data streams*** (the arrival of data triggers off processing by tasks which themselves generate data for other tasks. Communication mechanisms are based on system V IPC). Processing systems for one data stream are independent from processing systems for another stream, which ensures continuity in downgraded mode should certain failures occur. As the application operates with multiple display stations, the failure of one of them does not interfere with graphic animation on another. Likewise, as the application also operates with multiple satellites, a problem linked to the telemetry data stream for one satellite does not perturb the processing of data streams for other telemetry. Furthermore, these mechanisms ensure a certain extendability of the system (management of further satellites, addition of graphic workstations etc.).

The Graphic Server hardware architecture is based on Hewlett Packard HP 9000 from the 800 series.

There are three types of configuration :

- "off-line configuration" for generating views that includes a bitmap, a printer and an Ethernet link,
- "real-time configuration" for animatig views that includes a bitmap, a X terminal, an optional printer and a X25 link,
- "full configuration" for both, generating and animating views (cf. Fig.2)

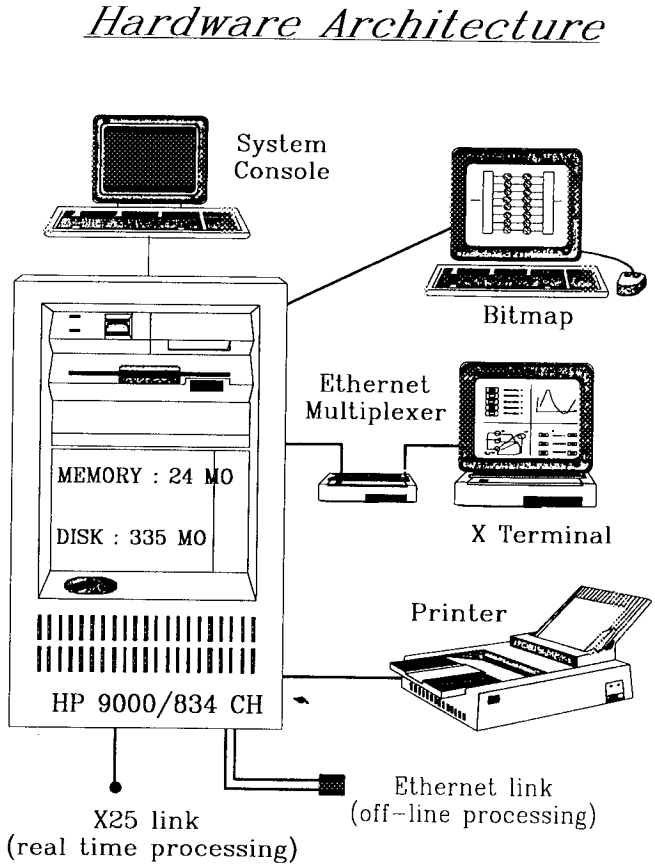

Fig. 2 - "Full configuration" of Graphic Server

The views can be generated on an "off-line configuration" and then, the associated animation environment can be exported by streaming tape on others "real time configurations". This possibility allows the users to centralize the creation and the management of the views.

In off-line mode, the bitmap is used for editing views and running the utilities (consistency check, storage on streaming tape, ...). Consistency check results can be displayed on bitmap or printed. Telemetry parameters description files of the satellites are transmitted by Ethernet link via File Transfert Protocole.

In real-time mode, the bitmap is the support of the operator dialog. The views are displayed and animated on the bitmap (one "full screen" view) and on the X terminal (one "full screen" view or four "quarter screen" views). System and sofware messages are listed on the system console. The printer can be used to have a small logbook (some high level messages are printer as a telemetry drop warning, alarme status transition of a parameter). Telemetry data is received via X25 link and the telemetry parameter requests are sent by the same way.

OPERATIONAL VIEWS ON TELECOM 2

Constructed for the control ground segment of Telecom 2 satellites, the Graphic Server system has been operating in various operational Telecom 2 control centers since December 1991. There is a configuration reserved for the drawing up of pages. Drawn up then checked by satellite engineers, the pages are exported and finally animated on the "real time" graphic servers.

After over two years of operation, nearly ***two hundred and fifty views*** able to animate approximately ***two thousand telemetry parameters*** have been constructed according to team needs. Different categories of page have been created and correspond to special uses.

The following may be distinguished:

- ***page catalogs***,
- ***parameter dictionaries*** and ***specialized pages***,
- ***parameter curves***,
- ***functional synoptic displays of satellite subsystems (mimics)***,
- ***summaries of satellites in standby mode***.

Page catalogs grant rapid access to a given view. They are made up of static tags, each being associated with a particular page. Pointing to the name of a catalog page with the mouse automatically displays it.

Parameter dictionaries and specialized pages contain lists of telemetry parameter names with their raw and physical values. These dictionaries grant rapid access to a parameter (in alphabetic order), whereas specialized pages bring together related parameters needed for particular operations.

Parameter curves, used either in standby mode or during operations, are used to monitor in real time the changes in one or more parameters over time.

The functional synoptic displays of satellite subsystems (mimics) represent, in various forms, the state of the various satellite components. These pages are gradually broken down, moving progressively from a general level granting an understanding of the state of a subsystem down to a highly detailed level for specialists. The pages are linked together and the user can reach the level of representation he wants very quickly.

The summaries of satellites in standby mode are pages for general satellite monitoring. They inform the operators of any anomalies and of the main characteristics relating to the state of platforms and payloads (cf. example Fig. 3). The operator is thus kept continually informed of any alarm, its nature and its severity, and can display the most detailed views whenever he wants, so as to diagnose the origin of a failure.

All these views are detailed on [Loub1].

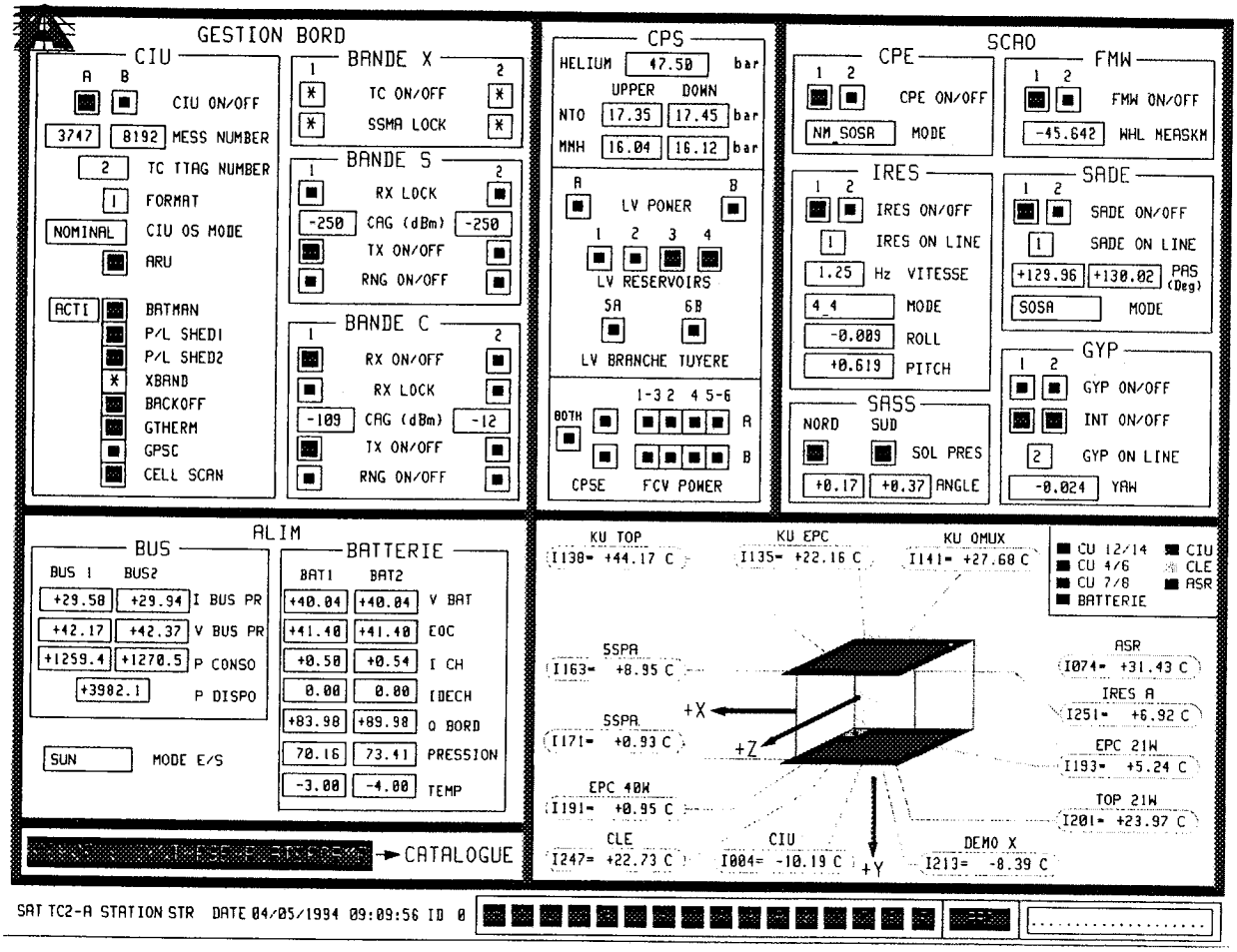

Fig. 3 - Example of a Telecom 2 operational view
(150 parameters are animated)

FUTURE PROSPECTS

The graphic server system has become a vital tool for Telecom 2 operations because of its functional characteristics, its ease of use in real time mode, its graphic modelling capabilities, high-speed access to information, and the visual verification it allows on the state of satellites and their alarms. This system can also be used for control center applications and, more generally, adapted for use in ***monitoring and "process" control*** situations (the term "process" being taken in its widest sense, and may mean a satellite, test or simulation bench, an industrial manufacturing process etc.).

The Graphic Server system currently includes specificities peculiar to the Telecom 2 environment, mostly with respect to the mode of acquiring telemetry data and the format in which this data is disseminated. If this interface were to be made more general, the system could be put to a wide variety of uses involving the graphic display of data streams.

REFERENCES

[Loub 94] Jean-Philippe Loubeyre : "A graphic server for telemetry monitoring and procedure performing", SpaceOps 94.