ABSTRACT – GMV has developed an internal project, called focus, which is aimed at producing a new generation of Flight Dynamics systems by exploiting all GMV’s past and present experience in the domain and all the current baseline of GMV’s Flight Dynamics systems. Project focus came through successful requirements definition during the first half of 1999 and the development phase started in August 1999. focus has very ambitious goals in mind, in particular the development of a truly generic operational FDS for all type of satellite missions (including GEO, LEOP, LEO, satellite formations, constellations, etc.) to be commercialised as a COTS product..


INTRODUCTION

focus is now progressing in a phased approach and the first member of this family has been oriented to GEO satellites. In this context, a sub-project named focusGEO has been conceived to produce a first version of focus including all fundamental features of the final system (MMI, graphics, data access, on-line help, process manager, events logging, automation), in order to provide a new generation Flight Dynamics product for geostationary satellites. This focusGEO version is now available and operational at HISPASAT and EUTELSAT.

Further upgrades and extensions to the system are also being worked in parallel and planned to end up with a truly generic high performance all-types-of-mission multi-mission flight dynamics application.

The following paragraphs describe at a high level the functionalities of focus which are common for all the members of the focus families:

• A computation and data layer based on the extensive reuse of existing and improved software. A large variety of satellite platforms (including Aérospatiale's Spacebus, MMS’s Eurostar 2000/2000+, Alcatel’s Spacebus 3000/3000B, NPO/PM's SESAT and soon Alenia's Satelcom, Boeing and S/S Loral).

• A client/server architecture: All data and functionalities reside on a server which is accessed via a client MMI. Communications between client and server are done via TCP/IP. The possibility to work over the Internet with the appropriate degree of security has been foreseen.

• Database driven: All important mission data is stored in a database residing on the server side. The possibility to plug a commercial RDBMS like ORACLE into focus has been foreseen, although this is not mandatory being a proprietary database by default.

• An advanced MMI: The MMI integrates advanced widgets and a design philosophy
based on commercial desktop applications for the office: “everything-in-one-working-area” and “all-one-click-away” (tabs). The MMI implementation is based on a proprietary toolkit called TkForms that allows a development through configuration files rather than through code.

- Procedures automation capability through the AutoFocus extension, which is able to produce an automatic sequence and execution of modules required to fulfill a particular procedure. This automation is based on a dedicated language: SoL (Spacecraft Operations Language) also developed and integrated by GMV.

- Advanced graphical capabilities: Dedicated widgets for generic X-Y plots and Events visualization have been developed for focus.

- On-line help: Complete User Manual available on-line in PDF format, with hypertext and navigation capabilities.

- Portability (UNIX/Windows NT): Both the client and the server part run under UNIX and Windows-NT. Any combination of the two operating systems is possible (UNIX/UNIX, UNIX/Windows-NT, Windows-NT/Windows-NT, Windows-NT/UNIX). Virtually all flavours of UNIX are supported, including Linux. At the client side any of Windows 95/98/2000/NT/XP are also supported.

- Extensibility: Any extra functionality following certain I/O rules can be easily integrated within focus via configuration files. A server Interface Description and a graphical Server Manager are available.

- Capability to perform unlimited Undo/Redo operations: Any data editing and function execution operation can be undone and redone an unlimited number of times. This allows a quick and user-friendly operating of the product while maintaining at the same time the user confidence and the data integrity.

ARCHITECTURE

focus is a database-driven framework, built as a three-layer architecture (MMI Layer/Computation Layer/Data Layer). Focus is also conceived as a client-server system, where multiple clients may be accessing concurrently the same server and database.

![Figure 1 focusSuite Components](image)

focus integrates many common components shared across the suite (focusSuite®):

- MMI
- Events Logging
- Automation
- Process Management
- Data Management

A client/server architecture is considered as baseline for data transmission. All data and functionalities reside on a server which is accessed via a client MMI. Communications between client and server are done via TCP/IP. The possibility to work over the Internet with the appropriate degree of security has been foreseen.

![Client/Server Architecture Diagram]

**Figure 2 Client/Server architecture**

The Computation Layer is the bridge between user and data services. It responds to requests from the user (or other computation processes) in order to execute a process. This protocol insulates the user from direct interaction with the database. Two different types of processes are included in this layer.

- The Process Manager is a single process, receiving requests from the clients and starting and controlling the computation processes.

- The Computation Processes are multiple processes that can run concurrently and perform the computations needed by the system. The computation and data layer are based on the extensive reuse of existing and improved software (e.g. PEPSOC, NAPEOS). The Data Layer maintains, accesses, and updates data. It also manages and satisfies requests to manipulate data that are initiated by computation processes. Separation of data services allows the data structure and access mechanisms to be maintained, modified, or, if necessary, even redesigned without affecting the computation or user layer. Two different single processes running permanently can be identified in this layer. The Database API Back-end handles all the requests received from the computation processes.

The Relational database (RDBMS). All important mission data is stored in a database residing on the server side. In the standard version of Focus the relational database has been implemented as a set of standard ASCII files. However the interface between the database and the Computation Layer is done through a dedicated API, in such a way that the database data can be easily ported to a commercial relational database system (RDBMS) such as ORACLE. Both the client and the server part run under UNIX and Windows. Any combination of the two operating systems is possible (UNIX/UNIX, UNIX/Windows, Windows/Windows, Windows/UNIX). Virtually all flavours of UNIX are supported, including Linux. At the client side any of Windows 95/98/2000/NT/XP are also supported. That allows a complete portability of the system. The system MMI integrates advanced widgets and a design philosophy based on commercial desktop applications for the office: “everything-in-one-working-area” and “all-one-click-away” (tabs). The MMI implementation is based on a proprietary toolkit called TkForms (based on tcl/tk) that allows a development through
configuration files rather than through code. Advanced **graphical capabilities** are also included. Dedicated widgets for generic X-Y plots and Events visualization have been developed for focus (grafos tool). New generation called **visualFocus** is also available.

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Figure 3 System MMI

Procedures automation capability through the **AutoFocus** extension, is able to produce an automatic sequence and execution of modules required to fulfil a particular procedure. This automation is based on a dedicated language: **SoL** (Spacecraft Operations Language) also developed and integrated by GMV

We can also highlight the following aspects

- **Extensibility**: Any extra functionality following certain I/O rules can be easily integrated within focus via configuration files. A server Interface Description and a graphical Server Manager are available. Capability to perform **unlimited Undo/Redo** operations: Any data editing and function execution operation can be undone and redone an unlimited number of times. This allows a quick and user-friendly operating of the product while maintaining at the same time the user confidence and the data integrity. **On-line help**: Complete User Manual available on-line in PDF format, with hypertext and navigation capabilities.

- **No licenses** of external products are required

**focusGEO** : OPERATIONAL EXAMPLE OF FOCUSSUITE

**focus** is now progressing in a phased approach and the first member of this family has been oriented to GEO satellites. In this context, a sub-project named **focusGEO** has been conceived to produce a first version of **focus** including all fundamental features of the final system (MMI, graphics, data access, on-line help, process manager, events logging, automation), in order to provide a new
generation Flight Dynamics product for geostationary satellites. This FocusGEO version is now available and operational at HISPASAT and EUTELSAT.

FocusGEO integrates the following elements as part of the common focusSuite infrastructure:

- Mission independent SW inherited mostly from PEPSOC and GMV internal developments and improvements.
- Multi-satellite platform system:
  - Astrium’s Eurostar 2000/2000+/3000
  - Alcatel’s Spacebus 3000/3000B
  - NPO/PM’s SESAT
  - Alenia’s SATELCOM
  - HP376 Boeing (spinning satellite)
  - FS1300 SS/Loral
- Collocation Station Keeping and Inclined orbit (in collocation also)
- Multiple reference frames
- Ion thrusting
- Reporting capabilities
- Contingencies and AOCS support
- LEOP support (launch window, transfer optimisation)
- Status: Operational

From a computational point of view, we can highlight the following strategies:

- Orbit determination is based on a weighted least squares method able to estimate orbit, station biases, CpeSM, delays, maneuvers... using ranging, angular, doppler, turn-around, interferometry data.
- Numerical orbit propagator is based on a Runge Kutta, taking into account impulsive and continuous manoeuvres.
- Maneuver computation is based on minimum fuel (several options depending on the cycle length,...) inclination control.
- Maneuver computation is based on sun pointing perigee strategy for eccentricity and longitude control. Additional eccentricity/longitude control strategies implemented for severe satellite constraints (reduce window, high cross-coupling.