gncde is GMV’s complete solution for Guidance, Navigation and Control design and development. It provides multiple levels of fully integrated support throughout the complete design process.

gncde consists of an advanced graphical user interface, a set of auxiliary tools, sample mission templates and model libraries with different levels of fidelity representations. The combination of all these elements makes gncde a powerful, comprehensive, easy-to-use solution to streamline the GNC process for any kind of mission.
INNOVATIVE GNC DESIGN PROCEDURE
Unique in the space market, gnnde defines the future of Guidance Navigation and Control design.

gnnde is GMV’s innovative GNC development environment designed specifically to support engineering design activities through the use of integrated resources and a complete tools suite.

Due to the iterative nature of GNC design, the handling of the process data (requirements, synthesis models, parameterisation of the models, mathematical representation of the navigation and control functions, etc) needs to be managed in a consistent way and made available without data integrity loss to every support tool being used in the process.

An integrated GNC development environment is an extremely effective solution to meet this need. It not only provides the tools able to support the analysis, synthesis and evaluation activities required in the GNC process, but also manages in a controlled way the data being used throughout the different analysis tool components.

Developed in Matlab/Simulink, gnnde is based on a user-friendly Graphical User Interface approach consisting of a harmonised set of tools designed for:

- Trajectory/orbit analysis
- Development of guidance, navigation and control functions
- Development of mode and equipment management functions
- Development/integration of environment simulation models
- Performance analysis of GNC functions in closed loop dynamic simulations, in both linear or nonlinear model environments
- Statistical analysis (e.g. covariance, Monte Carlo analyses) of GNC performance
- Automatic generation of code for on board GNC space systems. The generated code can be later used for Monte Carlo analyses or for embedded systems as a preliminary version of flight SW

gnnde SCENARIOS
gnnde is specifically designed to deal with GNC complexities, being easy to use and flexible enough to provide support to a wide set of space mission scenarios, not limited to:

- Rendezvous and docking: circular and elliptical orbits
- Generic 3-axis stabilised spacecraft operations
- Multi-spacecraft Formation Flying
- Launch vehicle ascent trajectory

gnnde IMPLEMENTATION PHILOSOPHY
Designed for GNC professionals, gnnde deploys with a complete range of tools to assist the GNC development. gnnde is fully equipped to help throughout the design process and to yield results meeting the highest level of fidelity expectations.

EASY
Because of the complexity of the GNC design process and the different analyses and tools currently involved, it isn’t always a task easily accomplished. There is so far no operational solution effective at both the novice and expert levels. With gnnde, GMV meets the challenge of developing such a solution, making GNC design and development easier than ever. You will appreciate how much time you save in your GNC design.

INTUITIVE
The human-machine interface is intuitive and makes extensive use of visual cues (dialog boxes, graphical manipulation of models in Simulink, interactive modification of figures) while maintaining in parallel the effective use of ASCII files. As a result, all tasks performed through gnnde can be easily automated and customised.

INTEGRATED
gnnde allows running in the same environment extremely different scenarios, while maintaining all powerful design and analysis capabilities.

MAINTAINABLE
The complete gnnde environment is easily maintainable and scalable, allowing continuous update of models and utilities. This allows gnnde to be easily maintained up-to-date over time, taking advantage of the latest features and capabilities developed for the system.
**gncde COMPONENTS**

*gncde*’s framework is based on Model Libraries, Templates (or Functional Engineering Simulators) and a complete set of support tools. In order to minimize possible duplication of development work in different projects, general code is organized in libraries and every scenario is represented by a Template increasing the efficiency of the design process.

**gncde TEMPLATES**

- A Template is the central resource in *gncde* common to all processes
- The Template contains the organization and structure of all available resources (existing models, data structures...) applicable to the development of a new GNC design
- Once a project is started, *gncde* allows the re-use and customization of a Template in order to integrate new requirements and characteristics of the specific mission scenario
- *gncde* Templates are of two types: Analysis and Design Templates or Mission Templates. Both are scenario representations (including the spacecraft, real world, onboard processor models...) conceived to support the GNC design process at these separate design phases:
  - **Analysis and Design Template:**
    Supports the first tasks involved in the GNC design process in a simplified “Real World” model. It provides the linear state-space representation of the “plant” models and “sensor” models and is prepared to perform simplified simulations (specific for each GNC mode) that allow the basic performance assessment of the controllers and estimators being designed
  - **Mission Template:**
    Supports the full performance assessment of a high-fidelity simulation model. It also includes the verification of high-level requirements, evaluating not only the GNC functions but also other on-board functions (MVM) against complete and, in general, non-linear models of the “Real World”. It includes a spacecraft model, sensors, actuators, dynamics, kinematics and environment as well as all necessary perturbations

*gncde* also includes a wizard to walk the user through the development of a completely new Template from scratch, with the proper infrastructure components. Several Templates developed by GMV are available in *gncde* for default classic mission scenarios.

- Generic 3-axis stabilized satellite (Sentinel-2)
- RendezVous & Docking in LEO (ATV to ISS)
- RendezVous & Docking in elliptic orbits (PROBA-3)
- Multi-spacecraft Formation Flying (DARWIN)
- Launcher Ascent (VEGA)

**gncde LIBRARIES**

The libraries store different models (sensors, actuators, attitude and orbital DKE, guidance and control functions, ...) to allow an easier and faster customisation of the Templates.

Moreover, a user can also develop new models and incorporate them to the libraries and to the Templates. The ESA Matlab/Simulink library solution (SPACELAB), is included in *gncde* as a baseline.
**gncde SUPPORT TOOLS**

Dedicated tools support the design and analysis of GNC systems and allow performing the tasks involved in the most common GNC development activities.

All *gncde* tools can work as stand-alone applications or integrated inside the *gncde* environment. In the same way, the operation philosophy is also unified for the complete set of tools inside *gncde*.

**ACED-Tool**

The *Automatic Control and Estimator Design Tool* supports the process of synthesizing and analysing a compensator and/or state observer for the control problem. It is able to work with the plant model representations obtained from the Analysis and Design Template or with plant models imported from the Matlab workspace, Matlab binary files or ASCII data files. It provides complete control synthesis and analysis capabilities: SISO and MIMO (Classic and Robust control techniques).

**COVA-Tool**

The *Covariance Analysis Tool* is aimed to perform analytical covariance propagation analyses. This tool is able to work with LTI models or LTV (user provided) models that can represent the dynamics of the S/C, of its sensors and the GNC functions (estimator and control) that close the control loop.

**CAD-Tool**

The *CAD-Tool* is a key feature tool developed to support orbital perturbation analyses on a geometric model of the spacecraft. The *gncde* CAD Tool provides both a CAD spacecraft model (specification, import and visualization) and the perturbations computation based on it.

**TESTENV-Tool**

The *gncde* Test Environment Tool automates new Simulink model testing by comparing its performance with validated models or with known input/output data sets.

**STAT-Tool**

Statistical analysis is a key functionality for the detailed assessment of GNC performances and for the evaluation of sensitivity of performance criteria with respect to certain GNC or mission parameters. *STAT-Tool* supports the computation and display of figures of merit through different types of specialised plots for a wide set of statistical analyses.

**MC-Tool**

The *Monte Carlo Analysis Tool* enables to run both parametric and statistical Monte Carlo simulations in *gncde* Templates. MC-Tool is extremely useful to analyse GNC performances and parameter uncertainty sensitivity, as well as to optimise design parameters. It is also very valuable for performance assessment and risk identification.

**GATO-Tool**

The *Guidance Analysis Tool* helps to easily perform preliminary design and analysis of the guidance features (in terms of required impulsive ΔVs, continuous thrust history and reference trajectory profiles) through a simplified dynamic model. This model allows the derivation of analytical solutions for the ΔVs and acceleration profiles, required to fulfill boundary conditions and generate the resulting trajectory.

**AUTOCODING-Tool**

*Gncde* includes an *Autocoding Tool* that is built on top of the Real Time Workshop and Embedded Coder Matlab tools provided with *gncde*. The AUTOCODING-Tool includes additional automation capabilities in a user-friendly format able to exploit the features of the *gncde* Templates.

**3DVIS-Tool**

The *3D Visualisation Tool* is a powerful engine for 3D visualization of the spacecraft and its environment. It provides increased situational awareness for the GNC designer. It accepts orbit data, attitude data or other dynamic information fed internally from other *gncde* tools or externally from other systems.

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