GTD
Onboard Software Capabilities
Introduction

Working for the Space & Launchers, Ground and Earth Observation segments, GTD has been supplying best-of-breed high-assurance software solutions to high profile Space industry customers since 1989. From offices in Spain, France and Guyana, GTD brings together the combined expertise in areas that range from system or solution development, to specialized services such as exploitation services outsourcing or independent product assurance.

Our technical capabilities applicable to the space industry are extensive. Our bespoken solutions cover the whole software life-cycle, from planning and analysis, to design, development, integration, testing, maintenance & exploitation, ensuring that our clients’ critical systems and processes embody highly reliable software.

Our major customers are:
- CNES Direction des Lanceurs (DLA/SDS)
- CNES Centre Spatial Guyanais (CSG)
- Arianespace
- Astrium
- Eumetsat
- ESA – ESRIN
- ESA – ESOC
- Thales Alenia Space
Who we are

GTD is a private company for systems engineering applied to space transportation and services for commercial launcher operations.

Over 25 years’ experience working alongside major contractors in the aerospace sector.

We develop global solutions for the space sector – ground control systems, onboard systems and operation tasks at the European Spaceport in French Guiana.

Unique know-how in making software components for civil and military programs.

OBSW applications characterized by having stringent real-time and critical requirements.

On-board software within aircraft & spacecraft computers is one of the most growing activities in GTD.
GTD’s ability is to obtain and complete large system integration contracts and to carry them out successfully.

GTD has for many years produced projects and systems according to spatial standards (primarily the ESA and CNES standards). For many of these projects, GTD has been prime contractor.
Three Space Activities: 1\textsuperscript{st} ‘On-board Segment’

The main features of onboard applications have very demanding high-quality and real-time requirements. Onboard systems, for all kinds of space vehicles, is one of gtd’s fastest growing activities. The most important are the following:

**Launchers On-board Segment**

- Software for launchers space transport vehicle (ARIANE 5, Automated Transfer Vehicle 'ATV', Vega, IXV).
- Launcher avionics systems of experimental vehicles (‘Aldebaran’)

**Satellites On-board Segment**

- Software design and development for control systems of orbit and attitude, guidance, navigation and control of platforms and space instruments.
- Design and development of Artificial Intelligence Systems to support space vehicle operation: ENVISAT, INTEGRAL, XMM, SMART 1.
gtd has been developing and integrating Space Ground Segment systems since 1990, with a strong presence in the European Space Transportation programmes. One of gtd's strategic lines is the development of Ground Segments, which accounts for 30% of the company's total activity. The most important developments in this sector are the following:

Launchers Ground Segment
- Command and control system for rocket preparation and launching (Ariane, Soyuz, Vega).
- Real-time information system for critical processes at the European Spaceport (Ariane, Soyuz and Vega Telemetry, main operation centre to control launching and flight operations, flight tracking systems, flight safety systems and neutralisation).

Satellite Ground Segment
- Systems to prepare and test payloads on the ground.
- Satellite data handling and dissemination centres.
- Knowledge Enabled Services for the automatic creation and exploitation of Earth Observation (EO) Data.
System integration, training and operation, including development and qualification of ground support equipment. Since 1993 and in the framework of long term ESA and CNES contracts, gtd is in charge of maintenance and exploitation of all computerised systems (both operational systems and related facilities) at the Europe Spaceport.

gtd participates in the development and maintenance of the following systems at the space port:
- Telemetry, RADAR Tracking & Flight Safety,
- Mission Control Centres,
- Meteorological Station,
- Launcher & Payload Preparation,
GTD Space On-Board References
GTD “On Board” Summary

Onboard SW for space vehicles:

- Ariane5, Vega & ATV
  - A5 & A5+: Application SW
  - Ariane-5 Consolidation and Evolution Preparation: new tools, unit testing, and automated validation activities
  - VEGA Flight Control, Test Control, Avionics Interface, Scheduler and Bus Interface Software
  - ATV Monitoring and Security Unit and Flight Application System
  - ATV Environment and Crew life Support
  - ATV Docking and refuelling system

Space Avionics:

- ALDEBARAN avionics

Other Space Onboard SW projects:

- ENVISAT Gyro’s health monitoring
- XMM: Reaction wheels control
- SEOSAT
- GOCA (Gaia Optimum Compression Algorithm)
- IXV,...
Software Validation of the platform and payload
Software for EarthCARE. This mission will advance our understanding of the role that clouds and aerosols play in reflecting incident solar radiation back into space and trapping infrared radiation emitted from Earth’s surface. This will improve climate predictions and weather forecasts.

Software Validation of the platform and payload
Software for Sentinel 2. This mission will routinely deliver high-resolution optical images globally. Sentinel-2 will carry an optical payload with visible, near infrared and shortwave infrared sensors comprising 13 spectral bands.

Software Validation of the platform, payload and AOCS Software for Bepicolombo. This is Europe's first mission to Mercury. It will set off in 2015 on a journey to the smallest and least explored terrestrial planet in our Solar System. When it arrives at Mercury in January 2022, it will endure temperatures in excess of 350 °C. GTD is participating in the Bepicolombo platform, payload and AOCS software validation.
Development and validation of Central Flight Software of SEOSAT. SEOSAT/INGENIO program is devoted to provide high resolution multi-spectral land optical images to various Spanish civil, institutional and governmental users and potentially to other European users in the frame of GMES (Global Monitoring for Environment and Security) and GEOSS (Global Earth Observation System of Systems). GTD develops for Astrium-SAS (Prime Contractor), the Seosat Central Software (CSW) is the software running on the Seosat On-Board Computer and it is responsible for commanding and controlling the overall spacecraft, platform and payload.

On Board Software applications for ENVISAT. GTD has developed for ESA/ESOC a tool to monitor the health of the Gyroscopes; the tool, which is being used for the ENVISAT mission, is capable to recognize subtle abnormal behaviour of the Gyros early in advance before the faulty condition. The system is based on Fuzzy Logic and merges, in the same tool, manufacturer models with operator’s experience

On Board Software applications for XMM & INTEGRAL. GTD has developed for ESA/ESOC a system to optimise using Evolutionary Computing (Genetic Algorithms) the momentum downloaded in space-telescope XMM-Newton and applicable – in the future – to the most complex INTEGRAL mission.
Developing the Gaia Optimum Compression Algorithm (GOCA) which will be on boarded on GAIA. Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy. For this process, the star data read out from the detectors are packetized and compressed before they are transmitted to the onboard data storage system and later to the ground. GTD is in charge of developing the Gaia Optimum Compression Algorithm (GOCA) which will be on boarded on GAIA for data processing.

Definition phase of the EChO mission. GTD in collaboration with IEEC is participating in the scientific definition phase of the EChO mission. IEEC takes the responsibility of the data processing (onboard and on ground) as one of the PI for study. GTD brings the experience in many years of development of critical systems, both on board and on ground.
Main References On Board Software for Space Sector: **Vehicles**

**Flight Software for ATV** (Automated Transfer Vehicle) project of ESA. ATV is a part of the international space station (ISS) which will be established during the next years by a cooperation between ESA, NASA, NASDA (Japan) and the Russian space organization. Within an integrated team and under the responsibility of Astrium-ST (ATV industrial architect and main contractor), GTD has performed tasks of Development, Unit Tests and Functional Validation of the On-Board Software for ATV Vehicle.

**Flight Software for VEGA Launcher.** Vega has been designed as a single body launcher with three solid propulsion stages and an additional liquid propulsion upper module for attitude and orbit control, and satellite release. It is a small launcher conceived to put satellites up to 1200 kg, for scientific and Earth observation missions, into polar and low-Earth orbits economically. On behalf of ELV prime responsibility, Astrium-ST (System Architect) subcontracte GTD for the Software for the VEGA’s On-Board Computer (OBC), including:

**Flight Software for Ariane 5+.** Within an integrated team and under the responsibility of Astrium-ST (Ariane 5 industrial architect and main contractor), GTD performed tasks of Design, Development, Unit Tests and Functional Validation of the Software for the On-Board Computer (OBC). Using the real-time information coming from SRI’s, the On-Board Computer (OBC) executes the flight program and controls the nozzles of the solid boosters and the cryogenic engine, via servovalves and hydraulic actuators.
Main References On Board Software for Space Sector: **Vehicles**

**“IXV” Intermediate Experimental Vehicle, Flight SW Validation**

The IXV is designed to be the “intermediate” element of a technology-effective and cost-efficient European roadmap for in-flight verification of technology performance necessary to prepare future ambitious operational system developments with limited risks for Europe.

Within this program, GTD is in charge of the Independent Software Verification and Validation “ISVV” activities. This includes

- Testing for exceptions
- Subjecting the software system to pre-determined stresses, through the imposition of input conditions, failure conditions and loading
- Use verification and validation methods to ensure correctness of the Technical Specifications, the design and the executable software

**ALDEBARAN AVIONICS SYSTEM.** ALDEBARAN is a double purpose launcher, as a Space transportation new technologies demonstrator, and a Micro and Mini satellites commercial launcher.

GTD is responsible of avionics ‘disruptive studies’ including electric and electronic onboard equipments. That includes HW architecture: new buses and processors, Hybrid navigation, autonomous flight security, onboard impact point calculation, ...
GTD Space On-Board
Standard Methodology & Tools
Methodology (1/5)

GTD main expertise is on the Application layer

We are involved during the whole cycle-of-life:
- specification,
- design
- implementation,
- unit tests,
- integration,
- validation,
- qualification

Examples: OBSW for
- A5+
- VEGA
- ATV
GTD team provides LN2 products development from specification to validation

We provide the software layer which manages the sporadic tasks and realizes the interface with the internal Bus

Example: VEGA Avionics Interface Software (AIS) that interfaces with Bus 1553
LN1 is the HW interface (normally under responsibility of the HW provider)

GTD has a deep knowledge of this layer:
- We understand the level of complexity
- We use the interface to apply higher level layers accordingly

Example: VEGA Active Application Program Interface (AAPI)
Methodology (4/5)

ACTIVITIES

- Specification
- Implementation
- Design
- Integration
- Validation
- Unit tests
- Qualification
- Maintenance

GTD participation in Work Package – Firm Fixed Price - Modality
GTD participation in Time & Material Modality
<table>
<thead>
<tr>
<th>Function</th>
<th>Tool name</th>
<th>Used for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration management</td>
<td>ClearCase/ClearQuest, Subversion</td>
<td>Configuration management</td>
</tr>
<tr>
<td>Conception</td>
<td>Enterprise Architect, Topcased, HOOD</td>
<td>Architectural design</td>
</tr>
<tr>
<td>Programming languages</td>
<td>Ada, C, C++, Perl, Scripts, C, Java</td>
<td>On-board code languages, Configuration tools code languages, Validation languages</td>
</tr>
<tr>
<td>Compilation and tests</td>
<td>Logiscope, Polyspace, IBM Test-RT, VectorCast, Reqtify, Doors, Simleon</td>
<td>Metrics and Coding Rules, Code Analysis, Coverage and unit tests, Traceability, Leon Simulator</td>
</tr>
<tr>
<td>Documentation</td>
<td>Frame Maker, MS Word, Excel, Doxygen</td>
<td>Technical documentation, General documentation, Detailed design</td>
</tr>
</tbody>
</table>
GTD Barcelona
Garcia Faria, 17
08005 Barcelona
Ph: +34 93 493 93 00
dc@gtd.es

GTD France
Le Sirius, 9 rue Colonel
Marcel Moraine. F-92360
Meudon La Forêt
Angel.ramirez@criticalsystems.fr

GTD Germany
Ravensburger Str. 30
88677 Markdorf
+49 7544 96440 22
andoni.arregui@gtd-gmbh.de

GTD Guyana (France)
6 Avenue France BP 168
97374 Kourou
Ph: +594 594 32 01 40
gtd-guy@gtd.es

Ibersystems
Garcia Faria, 17
08005 Barcelona
Ph: +34 93 4939300
contacto@ibersystemsdedefensa.es

Cadiz
Centro Europeo de Empresas e Innovación
C/Manantial, 13. Las Salinas
Puerto de Santa María
alicia.sanchez@gtd.es

GDI
Parc Empresarial Granland -Badalona Sud-
c/D de la Mora, 25 E-08918 Badalona +34 93 4864760
gdi@gdiproyc.com

Contact
www.gtd.es