SOluciones **T**ecnológicas **I**nnovadoras para **C**ontrol **Ó**ptimo y p**L**anificación (SOTICOL)

Objective

The main goal of **SOTICOL Robotics Systems** is to mainly attend the current demand on technologies applied to RPAS & robots. We provide exclusive technologically products giving priority to 3 fundamental concepts:

Efficiency

One of the most exclusive technological characteristics is the optimal functionality of our products. In this sense, we always search the design *efficiency* in our products. All our research has been always focused on algorithms and techniques based on a robust scientific baseline, which combines intelligent learning schemes and computational techniques of systems' dynamics. The research has been tested on experimental platforms to demonstrate its applicability in aeronautical, automation and robotic sectors.

Innovation

The quality of the provided products has been supported by prestigious international journals. In this way, the *innovation* in our solutions has been reached by means of a scientific work and a practical vision.

Security

Due to the fact that *Security* is one of the most critical aspect in our scope, all provided products have been undergone to standardization methods and official approval procedures for achieving a quality control enough from the design until development and testing phases.

Autopilots for RPAS

Our autopilots incorporate the last technologies related to sensing and instrumentation. They consist of an innovative modular architecture with a reduced weight and a high level of integration. In this way, the autopilots can grow from a functional and operational point of view. They can be also armed and activated during flight.

The autopilots use simultaneously 3 communication bands with redundancy. Also, they can use specific servos for physical opening or switching devices, such as a safety parachute (optional).

Thanks to the On Screen Display (OSD) technology, the telemetry acquired by the pilot can be integrated in the imagery transmitted from the camera in order to complement the vision capability of the operator.

The optical autolocation module (optional) is based on imagery & laser-telemetry digital processing. Sensorial fusion techniques are used for integration.

Functional capacities

Our autopilots have a full control with fault tolerant over the platform. They include the following elements (optional items are referenced with **[O]**):

- Multi-process modular control system with distributed functionality (attitude control, planning, communications and monitoring) and a fail-safe mode system integrated.
- Automatic Take-Off and Landing (ATOL) on dynamic surfaces using 3-DOF. **[O]**
- Inertial autolocation instrumentation (GPS, gyroscope, accelerometer, etc.)
- Advanced autolocation instrumentation in order to reach milimetric accuracy. **[O]**
- Sensorial fusion advanced system using different devices: laser, sonar, IR, etc. **[O]**
- Real-time planning system considering possible dynamic changes in the environment or possible physical changes in the platform.
- 3-axis stabilizer for embedding a camera in order to focus a specific target. **[O]**
- Recovery device integrated by means of a parachute in case of failure. **[O]**
- ROI (Region-Of-Interest). The platform is automatically focus to the surveillance instrumentation to a specific ROI, independently of the trajectory or attitude. **[O]**

Flight planning

The operation modes implemented in the autopilots are the following:

- *Manual mode*, where the reliability of mission depends on the ability of pilot driver.
- *Safe manual mode*, which sets constraints and returns automatically in case of failure.
- *Autonomous mode*, which lets the platform run the mission autonomously.
- *Optimal autonomous mode*, which lets the platform generate optimal 4-D or 5-D trajectories for reaching the goal.

SOTICOL Ground Control Station (SGCS)

The SGCS incorporates an autolocation technology based on sensorial fusion between GPS positioning and inertial sensing in order to provide support to aerial platforms (approximation and landing) and ground platforms (planning and control). Supporting aerial platforms is especially useful when landing on a dynamic surface (e.g. deck of a ship).

The SGCS can be also used when changes in the mission must be done in real-time or needed to take a manual control and in this way, providing a First Person View (FPV) work mode.

SOTICOL Robotics Systems has the technology development for telemetry links. In this way, we have two different and exclusive SGCS models, even with the capacity to be adapted to the client's required needs:

Remote Control (RC)

- Touchscreen display: 5” or 7” display
- Manual and intertial control, with a 10-DOF-IMU
- Geo-positioning using GPS
- Support to navigation with an integrated speech synthesizer (English & Spanish)
- Battery life: 1,5h and recharge ability in operation
- Redundancy technique for communications and encrypted links (anti-hacking)
- Graphical Interface for the Sense And Avoid (SAA) capacity and planning
- Removable visor for outdoor operation
- Safe shutdown
- Battery monitoring
- Logs storage
- Real Time Clock (RTC) for a synchonization and timing interactive

Remote Portable Station (RPS)

With a 17” screen and endowed with a great computing power, it allows us to perform processing imagery in real-time. Also, it has the ability to schedule interactive missions in real-time through a Geographic Information System (GIS).

Controllers for ground vehicles and robots

Controllers for ground vehicles and robots designed by SOTICOL Robotics Systems perform optimal motion planning taking into account kinematics & dynamics constraints and static & dynamic obstacles. They are composed of an innovative modular architecture and a high level of integration.

Functional capacities

Our autopilots have a full control with fault tolerant over the platform. They include the following elements (optional items are referenced with an 'O' letter):

- Multi-process modular control system with distributed functionality (motion planning, communications and monitoring).
- Advanced autolocation instrumentation in order to reach milimetric accuracy. **[O]**
- Sensorial fusion advanced system using different laser, sonar, infrared, etc. **[O]**
- Real-time planning system considering possible dynamic changes in the environment or possible physical changes in the platform.

Trajectory planning

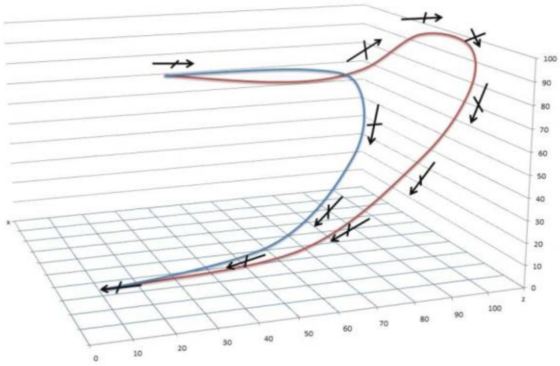
The ground platforms equipped with the controllers designed by SOTICOL Robotics Systems can be directed by means of the following operation modes:

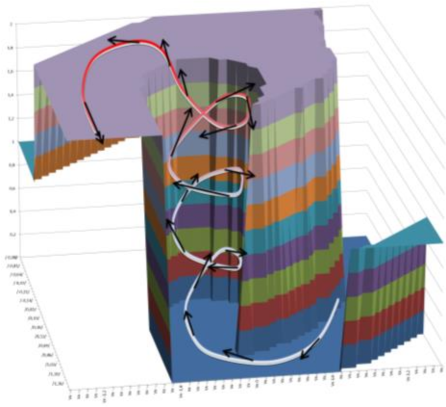
- *Manual mode*, where the reliability of mission depends on the ability of pilot driver.
- *Optimal autonomous mode*, by means of which the platform generates optimal trajectories for reaching the goal.

Air Traffic Optimal Management and Optimal Planning with Detect & Avoid technology

The technology developed by SOTICOL Robotics Systems is able to implement an Air Traffic Optimal Management (ATOM) in real-time. The most relevant characteristics of this technology are: optimality, linear computing complexity and the ability to perform an optimal navigation avoiding collisions using optimization specific criteria (e.g. minimum time, minimum risk or minimum consumption of fuel). The offered technology can be simultaneously applied to N RPAS inside the same airspace. All of this is possible thanks to combining mathematical methods, Cell Mapping concepts and reinforcement learning techniques.

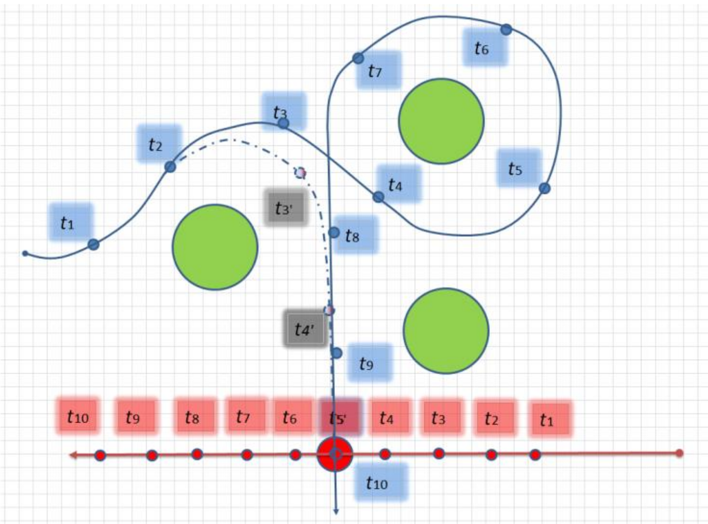
The right Figure shows an optimal trajectory in time (blue line) and next to it, another optimal trajectory in energy (red line). In both cases, the upstream features of the environment are exploited.





In this case, the Figure is a 4-D trajectory for a fixed wing platform. We can observe an escape upward path. The platform minimises the required cycles inside the tube in order to reach the exit in minimum time.

Finally, the following Figure shows a 5-D trajectory, where the dashed blue line represents an initial path with a potential collision in t_5'. In this way, a trajectory change is performed in real-time in t_2 (continuous blue line) for preventing the possible collision in t_5'. The new planning takes into account possible risk aspects (too close or abnormally slow speed) and the final result will be only a delay at the conflict zone (t_{10}).

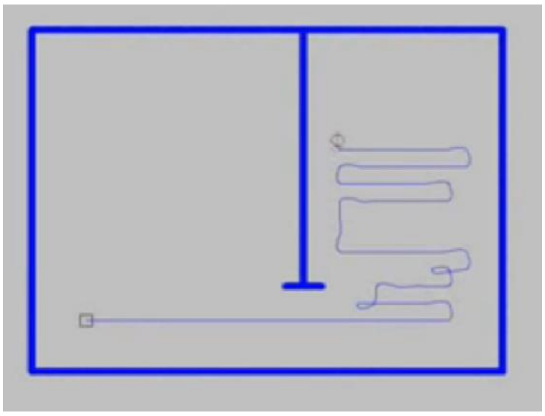


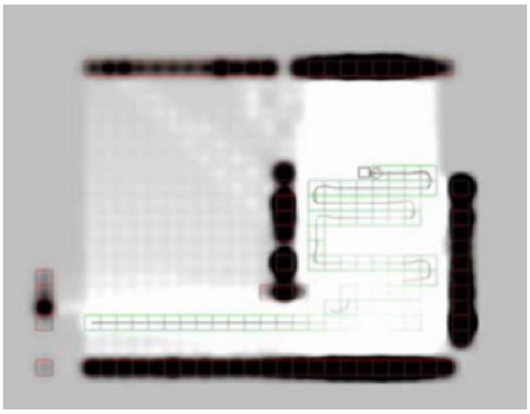
***Indoor* & *Outdoor* Autolocation**

The indoor & outdoor autolocation system developed by SOTICOL Robotics Systems estimates the position and orientation of the platform and it simultaneously generates the discovery of the environment by means of a 2-D or 3-D map. Even, the autopilot that embeds this capacity is able to generate optimal trajectories avoiding possible obstacles (see the left Figure).

The accuracy and characteristics of the used sensors (mainly sonars) are directly related to the quality of the achieved results. Thanks to the use of algorithms based on mathematical techniques and methods, SOTICOL RS reaches milimetric precisions with low-cost sensors.

The following figures show an exploration and discovery example performed by a ground platform using only sonar sensors in a 2-D environment. In this way, the robotic system scans two rooms and returns to origin position when the exploration completely finishes.



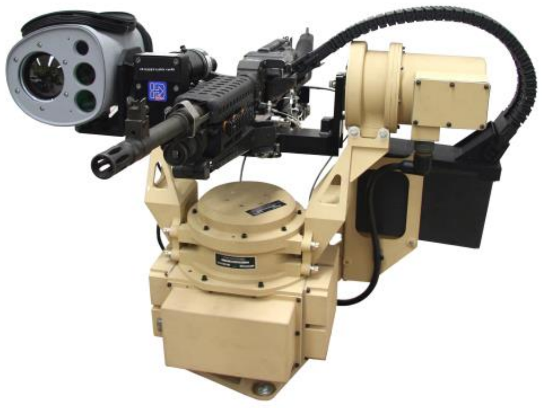


Functional capacities

The implementation of SLAM (Simultaneous Location And Mapping) algorithm makes sensorial fusion using different types of sensors (infrared, sonars, imagery, etc.). In this way, the system can scan the environment and set its position even in the absence of illumination.

By means of this system, we have the ability to build a map inside an unknown perfectly environment, always keeping a traceability of the current position. Also with this innovative system, the technique of abduction can be solved.

Gyro-stabilization of gun turrets

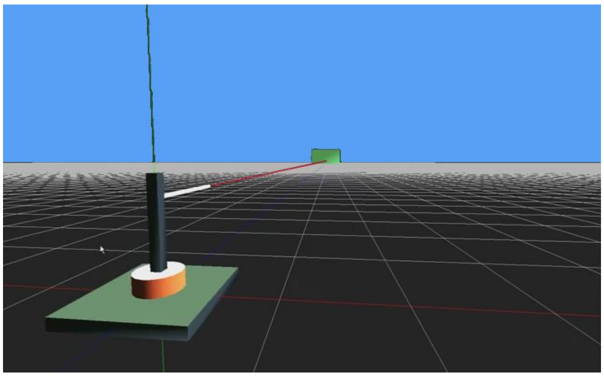


The solutions of SOTICOL Robotics Systems to gyro-stabilization of gun turrets include the following characteristics:

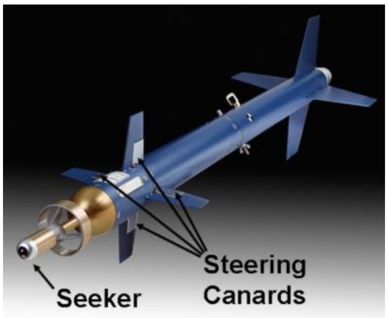
- 4-DOF (X-Y, azimuth, elevation)
- “Feed-Forward P/PI” control
- Non-linear optimization
- Optimal control capacity (CACM-RL)
- Continuous autocalibration
- Real-time failures detection
- Secure operation
- Removing of the drift error

The different operation modes that are included in these kinds of controllers are:

- Autonomous and optimal
- Autonomous through a tracking process
- Manual through a joystick



Guided munition



SOTICOL Robotics Systems provides specific autopilots to guide rockets and missiles based on Semi-Active Laser (SAL) technology. These autopilots run an optimal control and the planning guided to the goal.