MICROGENESIS

Case Study

Advanced Autonomous Robotics for Defense R&D

Delivering Mission-Ready Navigation in GPS-Denied Environments

40%
Field-Testing Reduction

30%
Deployment Acceleration

Client Profile:

Our client is a premier government research organization operating under the Ministry of Defence, Government of India. Based in Bengaluru, this strategic R&D institution specializes in advanced robotics, autonomous systems, and underwater defense technologies. With a highly skilled workforce of 500+ scientists and engineers, it drives cutting-edge innovations for national security applications, including unmanned platforms, AI-enabled systems, and secure communication solutions.

Problem Statement

The client faced critical gaps in deploying autonomous systems for defense applications:

Localization Failure: Inability to maintain accurate positioning indoors/outdoors without GPS signals, risking mission integrity.

Sensor Fusion Complexity: Unreliable real-time integration of LiDAR, IMU, and stereo camera data, causing navigation drift.

Software Capability Gap: Limited in-house expertise to develop scalable ROS2-based autonomy stacks for path planning and 3D mapping.

Validation Bottlenecks: Absence of Hardware-in-the-Loop Simulation (HILS) delayed algorithm testing, escalating field deployment risks.

Accelerated Timelines: Stringent 12-month deadline to meet Ministry of Defence milestones amid resource constraints.

Our Solution:

MicroGenesis delivered a modular autonomous navigation stack with end-to-end capabilities:

Core Technical Architecture

ROS2 Foxy Navigation Stack:

- Unified framework integrating real-time localization, 3D mapping, path planning, and mission control nodes.
- Seamless sensor fusion for LiDAR, IMU, stereo camera, and GPS.

Validation Infrastructure:

- **Hardware-in-the-Loop Simulation (HILS):** Gazebo/ROS2 framework emulating underwater conditions, enabling 80% pre-deployment validation.

Precision Localization Engine:

- **LiDAR-Inertial SLAM:** Generated real-time 3D maps with <5 cm drift and 12-DOF altitude data.
- **EKF-Based Fusion:** Combined IMU, GPS, and LiDAR inputs for continuous drift compensation in GPS-denied zones.

Accelerated Timelines:

- Stringent 12-month deadline to meet Ministry of Defence milestones amid resource constraints.

Development Approach

Phase	Activities	Tools/Outputs
Development	Custom ROS2 nodes for SLAM, EKF, path planning	C++, Python, Nav2 Stack
Testing	HILS validation of obstacle navigation	Gazebo, RViz, Ubuntu 20.04
Deployment	Docker packaging; on-premises integration	Docker, GitLab CI/CD
Knowledge Transfer	SDD/ICD documentation; on-site training	Technical manuals, simulation reports

Business Impact:

The solution delivered mission-ready autonomy within 12 months, achieving quantifiable outcomes:

Performance Metrics

KPI	Result	Operational Impact
Localization Accuracy	<5 cm drift in GPS-denied environments	Reliable navigation in critical zones
Testing Efficiency	80% validation via HILS pre-deployment	40% reduction in on-site testing time
Deployment Speed	Dockerized configuration	30% faster integration
Project Timeline Compliance	On-time delivery within 12 months	Met MoD defense milestones

Strategic Advantages

Future-Ready Architecture:

Modular design enables AI-based semantic mapping and swarm coordination upgrades.

Client Autonomy:

Comprehensive documentation/training empowered in-house team ownership.

Tactical Demonstration:

Successfully validated autonomous multi-floor transitions with dynamic obstacle avoidance.

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www.mgtechsoft.com
sales@mgtechsoft.com