BLUEFIN™–9 UNMANNED UNDERWATER VEHICLE

THE MOST POWERFUL SENSOR PACKAGE IN A TWO-MAN PORTABLE UUV

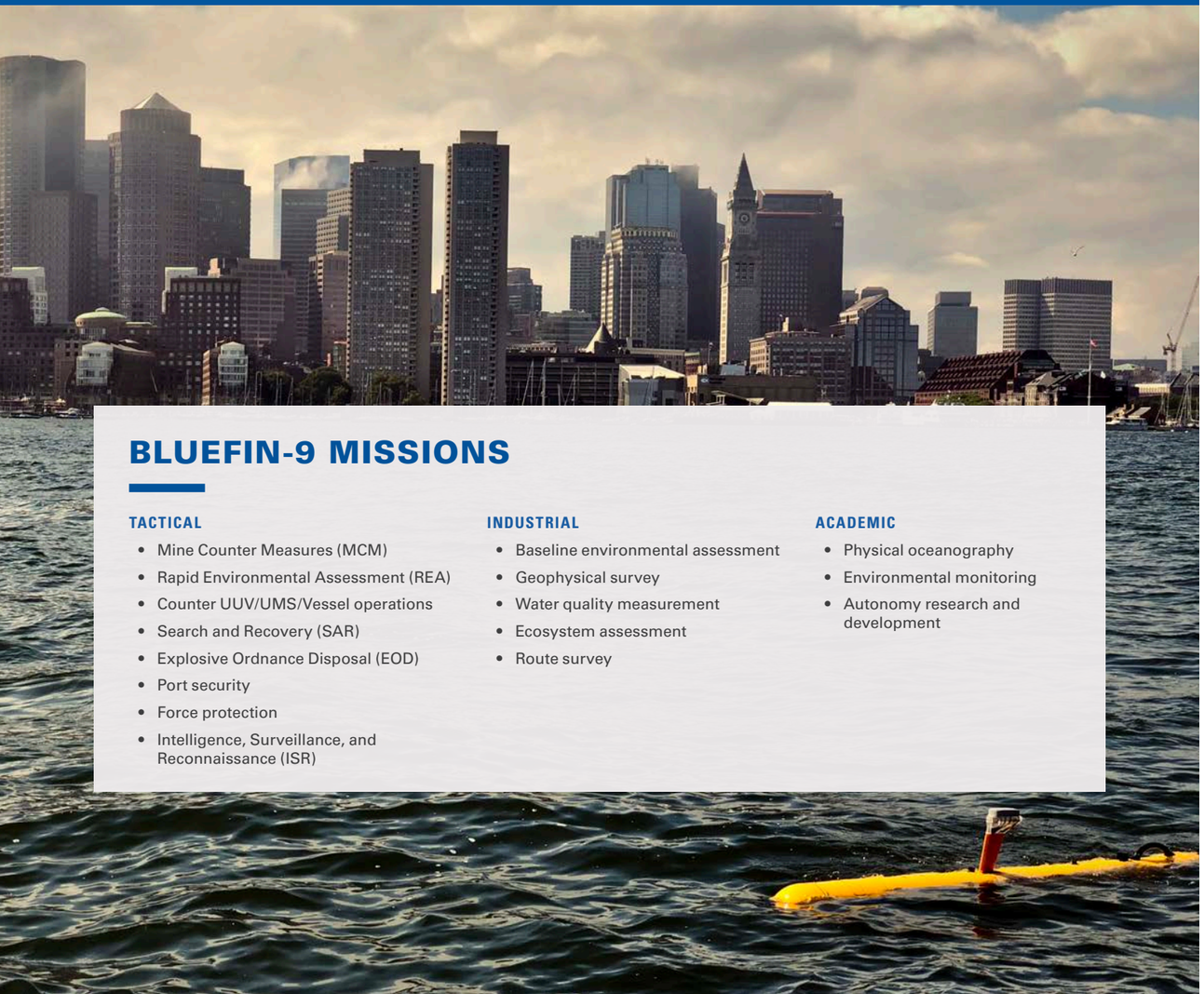
GENERAL DYNAMICS
Mission Systems

BLUEFIN ROBOTICS

BLUEFIN™-9 UNMANNED UNDERWATER VEHICLE (UUV)

THE MOST POWERFUL SENSOR PACKAGE IN A TWO-MAN PORTABLE UUV

The General Dynamics Mission Systems Bluefin™-9 UUV provides unmatched data quality, precise and reliable navigation, and rapid mission turnaround time in a two-man portable system. Featuring a carbon fiber body, a carefully selected and integrated suite of sensors, latest generation communications and navigation components, and new onboard processing capabilities, the Bluefin-9 is the professional's tool to know what's below.



BLUEFIN-9 MISSIONS

TACTICAL

- Mine Counter Measures (MCM)
- Rapid Environmental Assessment (REA)
- Counter UUV/UMS/Vessel operations
- Search and Recovery (SAR)
- Explosive Ordnance Disposal (EOD)
- Port security
- Force protection
- Intelligence, Surveillance, and Reconnaissance (ISR)

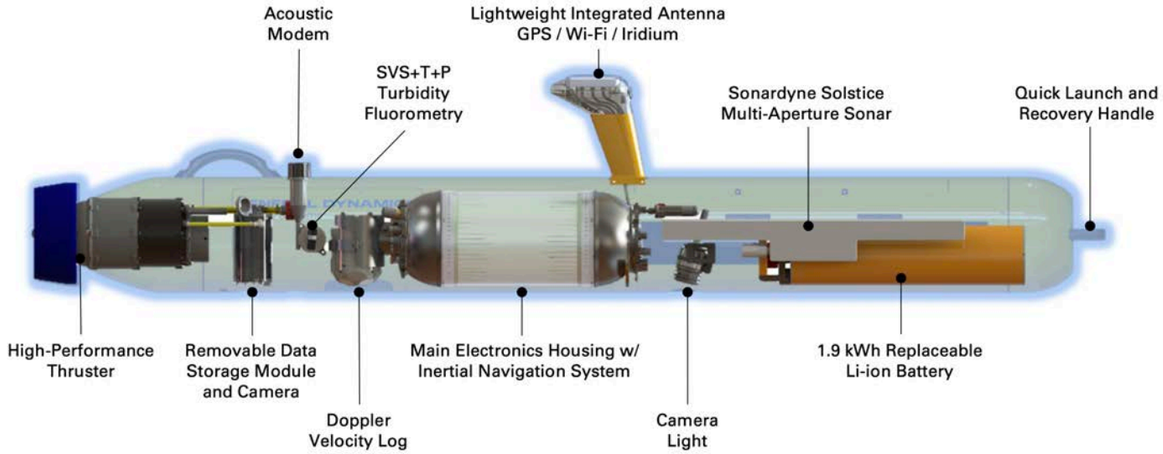
INDUSTRIAL

- Baseline environmental assessment
- Geophysical survey
- Water quality measurement
- Ecosystem assessment
- Route survey

ACADEMIC

- Physical oceanography
- Environmental monitoring
- Autonomy research and development

UNMATCHED DATA QUALITY

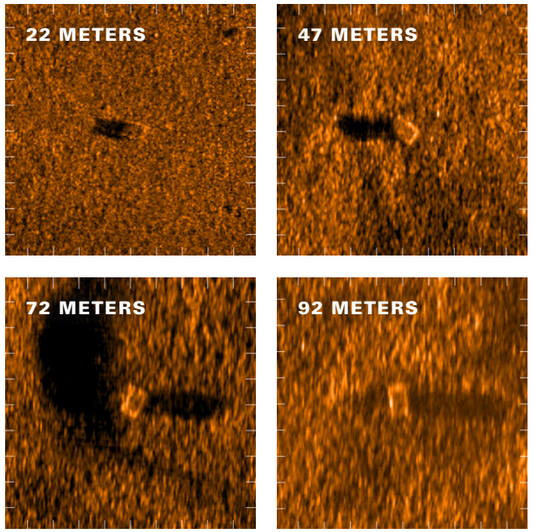


SONARDYNE SOLSTICE: MULTI APERTURE SONAR (MAS)

Designed for detailed hydrographic surveys, the Bluefin-9 is outfitted with Sonardyne Solstice MAS that provides undistorted, high-contrast imagery comparable to Synthetic Aperture Sonar (SAS) in a small, low power (18 W) solution.

KEY SONARDYNE SOLSTICE PARAMETERS

Maximum Range	100 m per side
Across-Track Resolution	3.75 cm
Along-Track Resolution at 20m Slant Range	5 cm
Along-Track Resolution at 75m Slant Range	20 cm
Area Coverage Rate at 3 kt	.99 km^2/hour
Area Coverage Rate at 5 kt	1.656 km^2/hour



High-resolution and positive feature identification across the full swath range. Images here show lobster pots at 22, 47, 72 and 92 meters from the Bluefin-9 UUV.

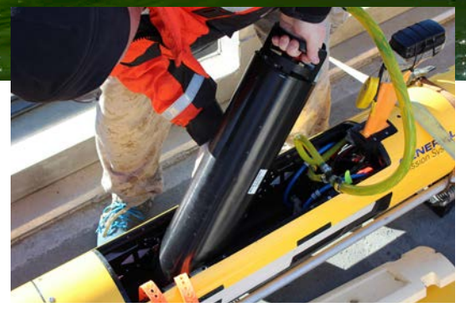
The Bluefin-9's integrated Sonardyne Solstice Multi-Aperture Sonar provides high-resolution data across the entire 200m swath range.

Sonardyne Solstice enables operators to view their data in 3D. Bathymetric data and side scan imagery can be viewed in the same instance to produce detailed digital terrain maps.

Composite image illustrating Bathymetry data overlaying the raw side-scan imagery produced by the Sonardyne Solstice MAS.

EXPEDITIONARY OPERATIONS

The Bluefin-9 has been redesigned to deliver an easy-to-operate, data-focused UUV. The user-friendly Bluefin Mission Planner and Dashboard modules enable intuitive mission planning and execution. The low-logistics, force-multiplying UUV maximizes operator efficiencies. The vehicle sub-assemblies and design allow for in-mission maintenance and extend in-water operation.



1.9 KWH LITHIUM-ION BATTERY

The removable 1.9 kWh Li-ion battery can be easily accessed, removed and replaced in-field in minutes. The battery provides 8 hours of in-water operation, and is fully recharged in 6 hours. The batteries, common across numerous Bluefin UUVs, are also shippable under UN 38.3.

ADVANCED ON-BOARD DATA PROCESSING

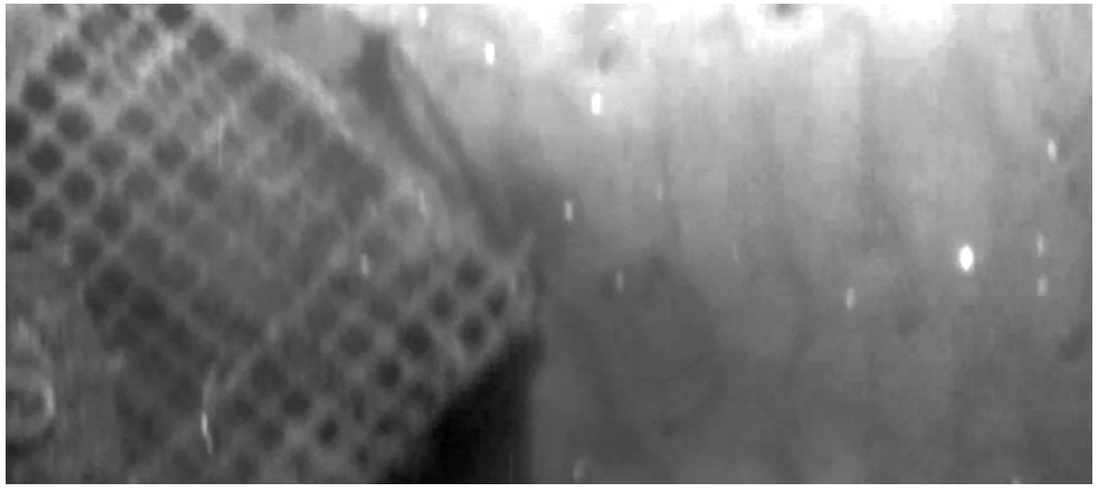
Mission efficiency in vehicle operation extends to the newly designed Removable Data Storage Module (RDSM). Bluefin's RDSM is a field-swappable module that processes and stores data collected by integrated sonar, camera and environmental sensors. An operator is able to recover and redeploy their vehicle in 30 minutes or less and have reviewable or actionable data in-hand immediately.

1TB REMOVABLE DATA STORAGE MODULE (RDSM) WITH CAMERA

Bluefin-9's RDSM acts as an independent data processor, generating and storing post-processed data with a simple interface to an operator's workstation. The RDSM contains a high-definition, machine-vision-grade monochrome camera that captures still images and video. Imagery is geotagged for easy review during post-mission analysis.

Seafloor Optical Camera

The camera is optimized for low-light operation and captures still images at up to 3.2 megapixels or Full HD video. The monochrome camera delivers lower noise and higher overall image quality in a low-light subsea environment. Lighting provided by an LED floodlight can be turned on and off for relevant portions of a mission. All captured images are time-referenced for post-mission processing and analysis.



Still image captured from video collected by Bluefin-9 UUV during operations off of Massachusetts coast.

EMERGENCY SYSTEMS

The Bluefin-9 is designed with an innovative emergency operations system that provides redundancy to the vehicle's core functions in the event of a failure. An independently powered low-power microcontroller ensures key communications systems are able to provide locational data and telemetry to an operator to facilitate prompt and safe recovery of the vehicle.

LOCATION AIDES

The vehicles integrate visible LED strobe lights and a radio direction finder (RDF) beacon that aid in recovery of the vehicle when it is on the surface. While the vehicle is underwater, including while it is in the emergency mode, the vehicle's range can be computed by pinging the acoustic modem.

STATUS MONITORING

Bluefin-9 monitors its own performance while on mission through the use of environmental sensors inside of the pressure vessels that measure the pressure, humidity and temperature, while also monitoring for leaks, to ensure that problems can be remedied before damage occurs from environmental effects. This information is relayed in real-time to the operator to monitor during the mission.

ENVIRONMENTAL SENSING SUITE

The Bluefin-9 UUV is configured with a robust suite of integrated environmental sensors.

SOUND VELOCITY, WATER TEMPERATURE AND SALINITY

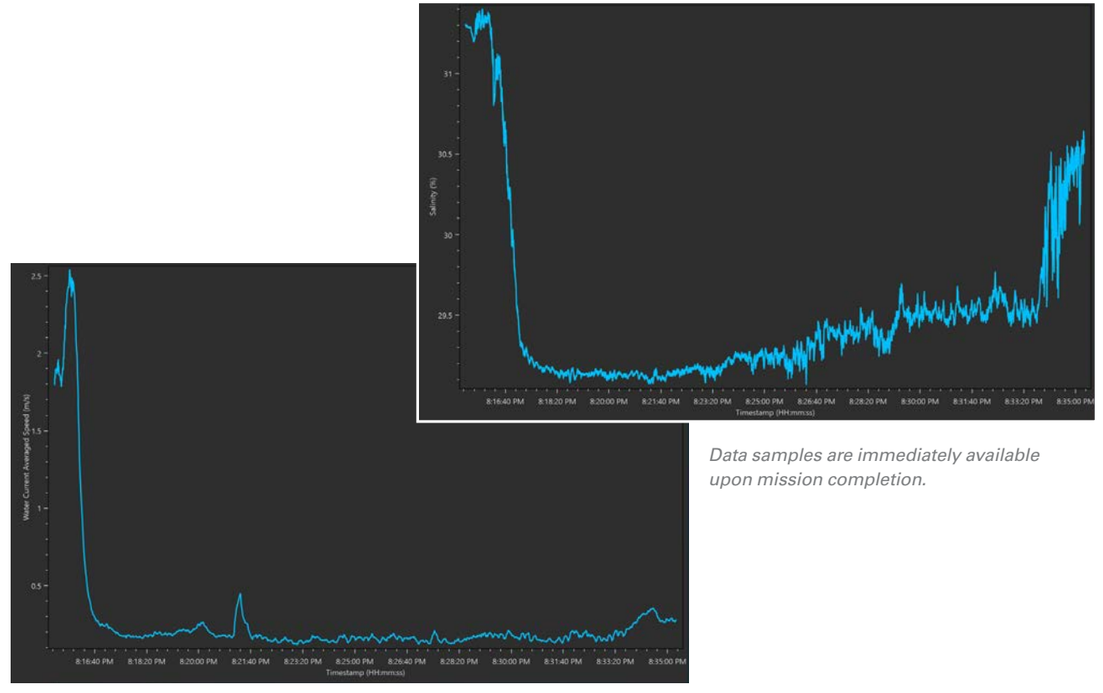
The integrated Valeport UV-SVP Sound Velocity Sensor provides direct measurement of sound velocity, water temperature and ambient water pressure. These measurements are used in the Post-Mission Analysis (PMA) to compute water salinity and conductivity, using known ocean models.

TURBIDITY AND CHLOROPHYLL-A CONCENTRATION

The integrated Sea-Bird Scientific ECO Pucks (Fluorometer and Turbidity (FLNTU) configuration) measures both chlorophyll-a and water turbidity.

WATER CURRENT

The Nortek Doppler Velocity Log (DVL) on the Bluefin-9 is capable of calculating the water current direction and speed near the vehicle, like an Acoustic Doppler Current Profiler (ADCP). The DVL on the Bluefin-9 collects and provides current profiles extending from the vehicle to the seafloor, or to maximum range of the DVL.



Data samples are immediately available upon mission completion.

"The Bluefin-9 is the first product of a new generation of UUVs, designed to meet the dynamic operational challenges of our defense and commercial customers."

— CARLO ZAFFANELLA
Vice President and General Manager of Maritime and Strategic Systems (M&SS) for General Dynamics Mission Systems

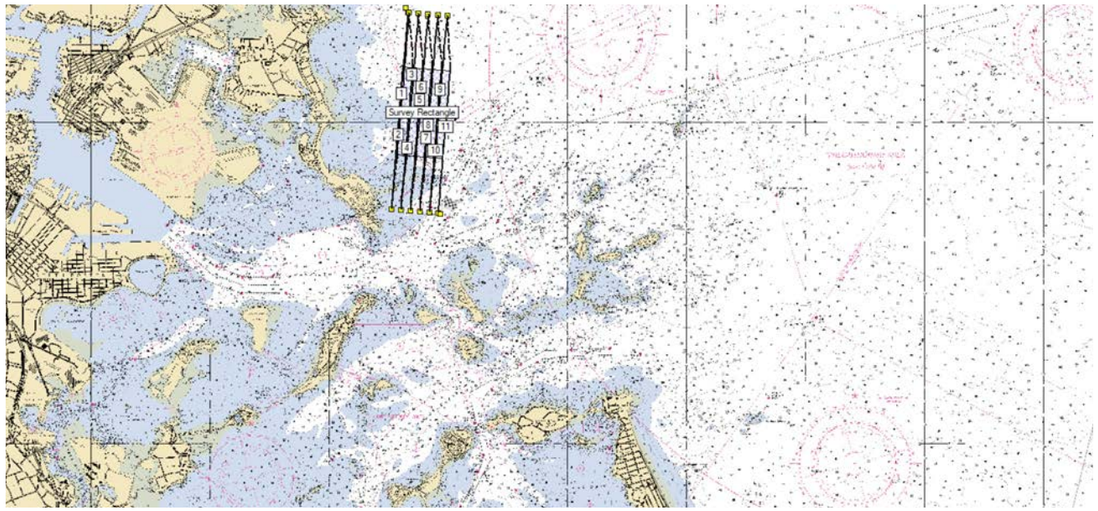
BLUEFIN MISSION PLANNER

MISSION PLANNING AND VERIFICATION

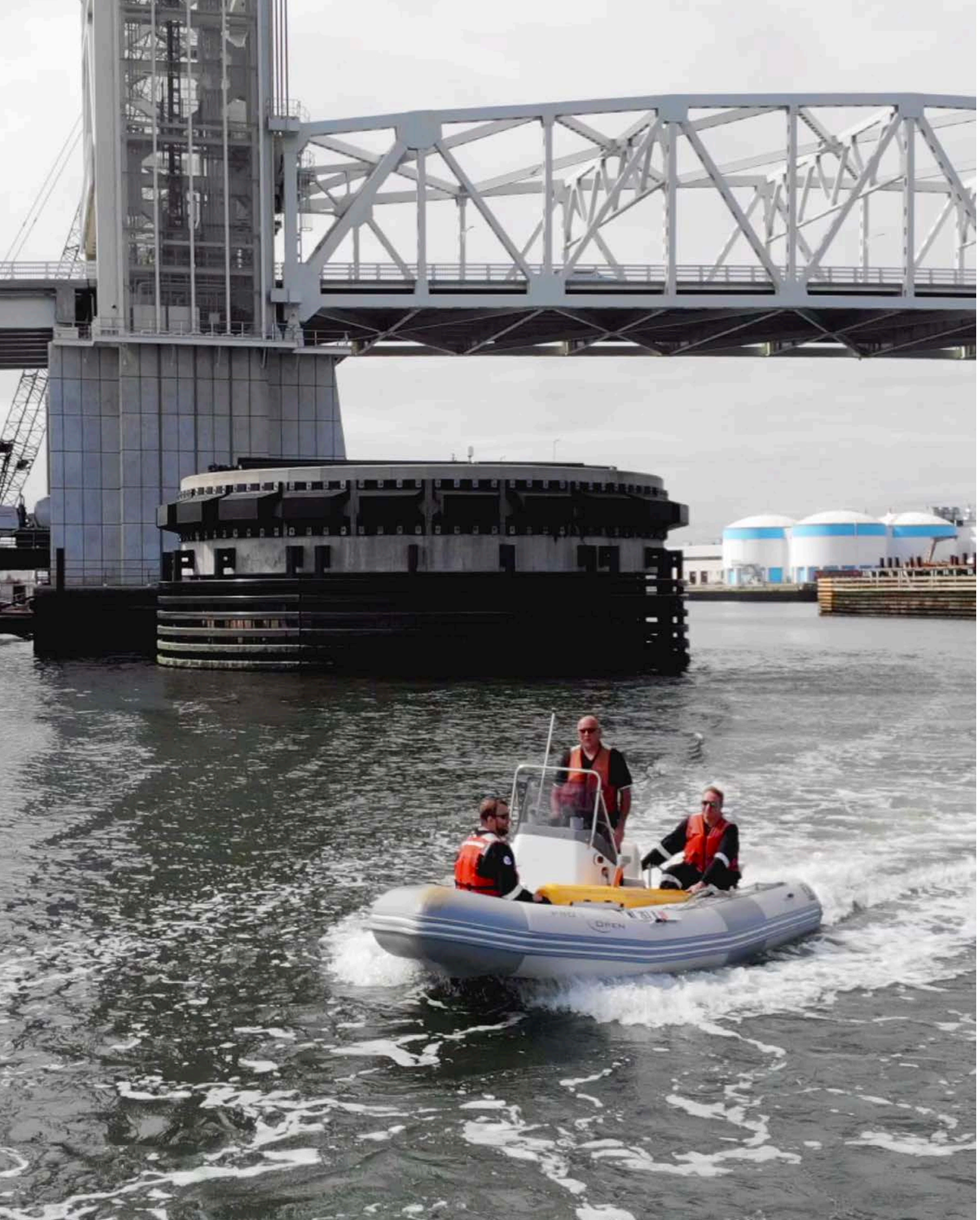
The Bluefin Mission Planner graphical tool provides an intuitive interface to pre-plan your survey mission. Mission plan parameters are easily entered on screen. Mission and safety details are fully accessible, allowing for rapid and accurate mission planning. Planning takes place on top of a chart-based view that accepts raster or digital charts. Operators can specify safety settings, operational constraints, recovery points and return plans. The Mission Planner also allows customer-specific commands to be sent via the Standard Payload Interface.

FULL INTEGRATION OF SEEBYTE SEETRACK 4

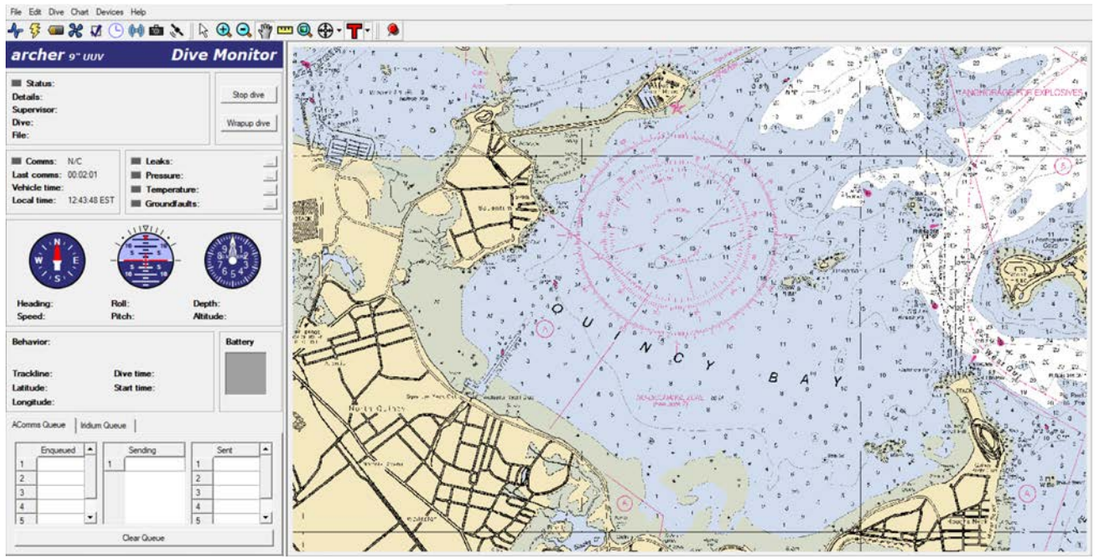
The Bluefin-9 fully supports SeeByte's SeeTrack 4, which allows the user to graphically plan missions on nautical charts and specify operational and safety limits, recovery points and return plans. SeeTrack can display previously collected mission data that allows the user to plan the next mission with full situational awareness. External data sources can easily be imported from a variety of standard formats, including DNC, ENC S-57, ENC S-63, ESRI ShapeFiles and GeoTiff. Additional third-party mission management software can be integrated across the family of Bluefin UUVs.



Bluefin Mission Planner provides user-friendly menu options enabling point/click mission planning including the designation of all parameters: GPS way-point designation, operational depth, altitude, speed and more.



BLUEFIN DASHBOARD



BLUEFIN DASHBOARD

Bluefin Dashboard enables the operator to track vehicles against a chart-based interface that includes ship position indicators, mission plans and a variety of operator-specified annotations. Vehicle status is displayed to the operator via an intuitive interface. Bluefin Dashboard automatically shifts communications to the highest bandwidth channel available, providing you with a dynamic gateway to the vehicle. A variety of specialized diagnostic interfaces aid the preventative and corrective maintenance procedures for each sensor and subsystem.

BLUEFIN DASHBOARD GRAPHICAL USER INTERFACE

The Bluefin Dashboard interface provides monitoring and control capabilities for the UUVs while on a sortie. Bluefin Dashboard provides detailed status and control of individual vehicle subsystems from pre-dive checkout through recovery. The Bluefin-9 uses a variety of communication methods to communicate between the UUV and topside equipment. Operators are able to communicate with multiple vehicles when they are underwater, on surface, over the horizon or on deck.

BLUEFIN TOPICS & BLUEFIN WITNESS

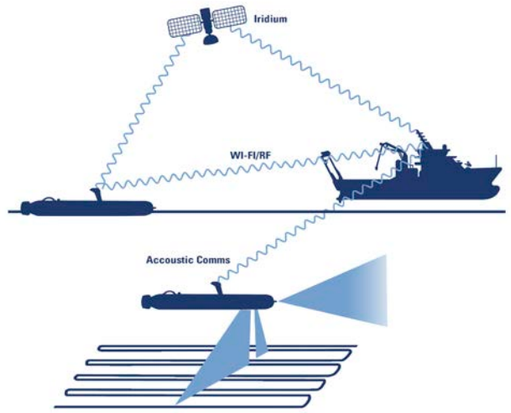
BLUEFIN TOPICS

Bluefin TOPICS is Bluefin Robotics' communications infrastructure for high-latency, low-bandwidth communications, providing wireless in-depth monitoring and command for the user. This system includes:

> *Iridium over-the-horizon communications*

> *Acoustic communications while on the surface*

Bluefin TOPICS reports detailed mission status while on a dive, including the status of the vehicle's subsystems, payload health and data collected. Vehicle position is also plotted on the Bluefin Dashboard chart.



BLUEFIN WITNESS®

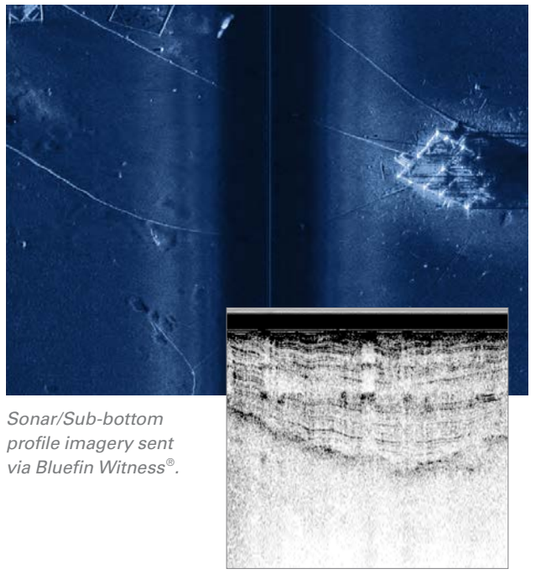
Bluefin Witness® is an end-to-end solution for transferring clips of imagery to operators via Bluefin TOPICS while underwater and underway. Bluefin Witness® allows operators to:

> *Verify payload data quality*

> *Identify objects of interest while underway*

> *Better inform decision making*

Bluefin Witness® processes payload data in real time onboard the UUV, compresses the imagery and sends it to operators via the acoustic communication link throughout a mission.



Sonar/Sub-bottom profile imagery sent via Bluefin Witness®.

TRAINING & SUPPORT

General Dynamics Mission Systems offers comprehensive training that consists of classroom and hands-on instruction for operating and maintaining the system. Training typically ranges between 5–10 days and takes place at our Quincy, MA, UUV facility.

Training material is provided for each student. Extended, on-site and custom training courses are also available. General Dynamics Mission Systems can also run "train-the-trainer" courses, which enable customers to train their own personnel.

Support options include technical support services via email or telephone, and on-site support engineering services at negotiated day-rates. Custom service agreements are available, and can include extended warranty coverage, 24/7 support, defined response periods or global on-site Marine Operations support.

BLUEFIN-9 CAPABILITIES

When the data are mission critical, trust General Dynamics Mission Systems' Bluefin Robotics completely redesigned Bluefin-9 UUV to provide the most reliable and comprehensive data sets in a vehicle of its class.

SONARDYNE SOLSTICE MULTI-APERTURE SONAR

The integrated Sonardyne Solstice multi-aperture sonar delivers high-resolution sonar imagery for hydrographic and bathymetric mapping. Each of the two Solstice arrays has 32 multibeam elements to dynamically focus along the whole length of the swath. High-resolution data across the entire swath results in maximum effective resolution, decreases false-positives and improves operational efficiencies.

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DEDICATED EMERGENCY OPERATIONS SYSTEM

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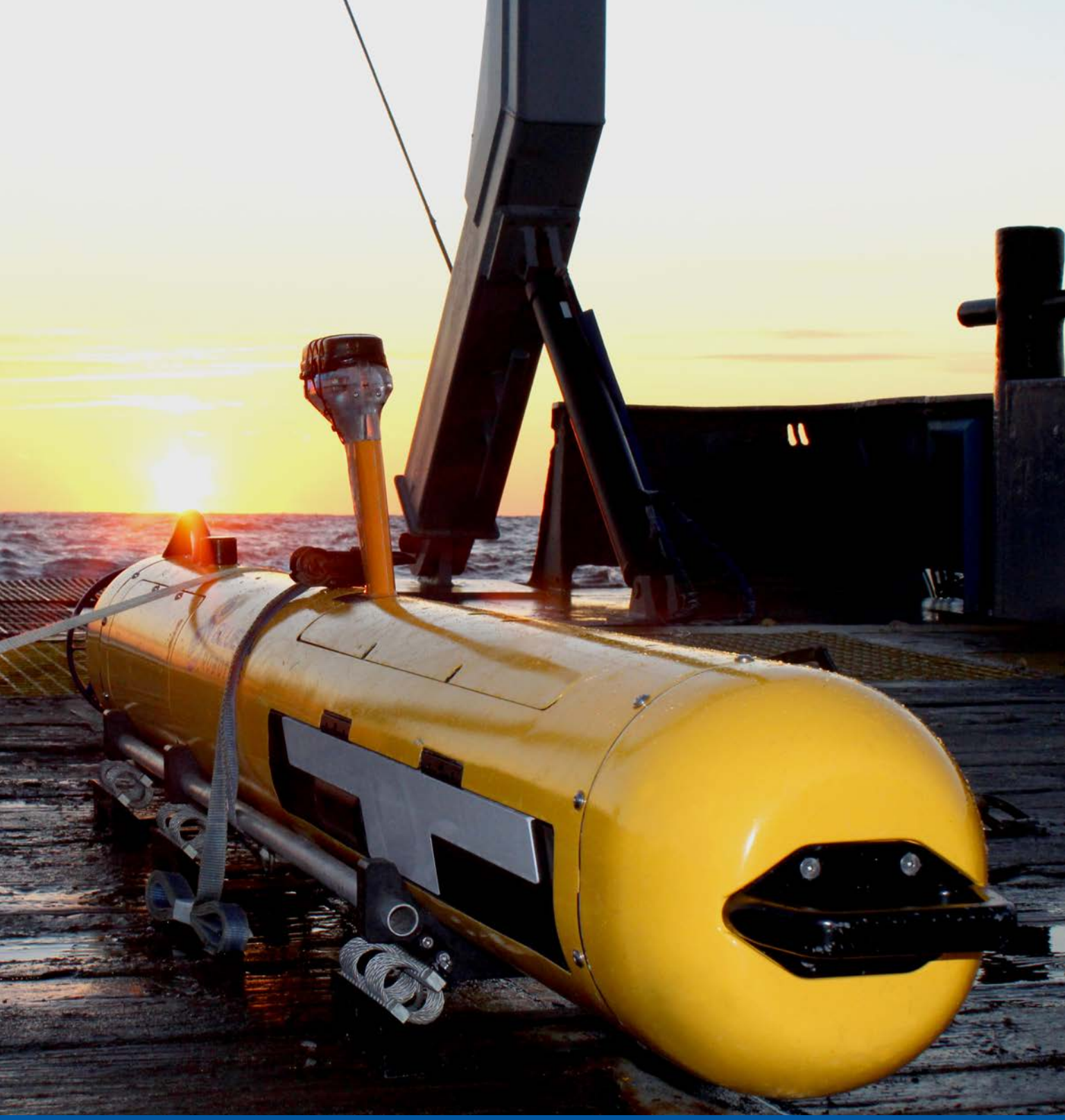
12-MONTH STANDARD LIMITED WARRANTY

Like all Bluefin Robotics solutions, the Bluefin-9 comes with General Dynamics quality, reliability and support. Our 12-month limited warranty provides additional confidence that the Bluefin-9 is the platform of choice for the toughest and most vital missions.

BLUEFIN-9 KEY PARAMETERS

Diameter	9.375 inches (23.8) W x 10.375″ (26.4 cm) H
Max Height (including antenna)	19.7″ (50.7 cm)
Length	95.2″ (241.8 cm)
In-Air Weight	155 lbs. (70 kg)
Depth Rating	656′ (200 m)
Speed	Survey up to 5 kt; Transit up to 6 kt
Navigation Accuracy	0.3% of distance traveled or better
Endurance @ 3 knots	2hr transit + 6hr survey
Max Endurance @ 2 knots	Approximately 12hr transit



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