General Dynamics Moves Knifefish Production to New UUV Center of Excellence

General Dynamics Mission Systems and U.S. Navy representatives dedicate the opening of the General Dynamics Unmanned Underwater Vehicle Center of Excellence at Taunton, Massachusetts. The facility will manufacture the Knifefish mine countermeasures UUV. *GENERAL DYNAMICS*

General Dynamics Mission Systems cut the ribbon to open a new and expanded production line for its Knifefish medium-class surface mine countermeasure unmanned underwater vehicle (SMCM UUV) systems at the company's UUV Center of Excellence (COE) in Taunton, Massachusetts.

Up until now, Knifefish has been assembled at the General Dynamics Bluefin Robotics facility in Quincy, Massachusetts. The system achieved a successful Milestone C decision and approval to enter low-rate initial production (LRIP) in 2019, followed by a contract for five Knifefish systems (10 total UUVs) and support equipment in August of 2019. The first of those Knifefish under that contract were delivered to the Navy in March.

The 20,000 square-foot COE occupies repurposed manufacturing space within the company's Taunton facility to provide manufacturing, assembly and testing capabilities for Knifefish and Bluefin UUVs. The 500,000 square-foot Taunton manufacturing plant develops communications systems for the U.S. Army and provides engineering, manufacturing and production support for a number of the company's products and programs.

"Our manufacturing facility has decades of experience in manufacturing high-consequence, highly critical components and

electronic assemblies for many agencies across the Department of Defense," said Paul Dalton, vice president of undersea systems. "And we are thrilled today to be adding unmanned underwater vehicles to that strong legacy of manufacturing performance."

Carlo Zaffanella, vice president and general manager of maritime and strategic systems for General Dynamics Mission Systems, was pleased that the company has invested about $30 million in UUV design and manufacturing, and is bringing manufacturing work for its traditional Navy businesses to the Taunton plant that has long supported Army customers.

"Opening this manufacturing and assembly facility allows us to leverage the highly skilled and extremely experienced Taunton workforce. This skill set found in our Taunton employees is exactly the type of expertise we need to manufacture highly reliable UUVs," said Zaffanella. "We have expanded our maritime operations to include the Taunton UUV Manufacturing and Assembly Center of Excellence to produce our existing best in class small and medium UUVs and allow for additional expansion space for growth on future UUV programs of all sizes. This location was specifically selected to provide additional capacity that will allow for larger scaling and optimization of UUV production with purpose-built manufacturing cells, fixtures, and special test equipment, while maintaining proximity to our Bluefin Robotics engineering team in Quincy."

General Dynamics moved the production line to Taunton to allow for growth. Once Knifefish gets into full rate production with the Navy, the company said there's still room here to grow to support the Navy, commercial customers or foreign military sales.

"Capacity was a big reason for setting this up," said Craig Regnier, who manages the Taunton operation. We want it to be able to scale to meet the demands, likely in the volume of

systems. With our Bluefin-9 and Bluefin-12, and our other commercial vehicle production lines running at the same time, we needed the ability to scale all those up in volume to meet demand. We dedicated our 8,000 square feet today, and we can expand easily up to 12,000 square feet and beyond."

Regnier said the factory has the space, capacity, and most of all, the skilled workers to take on the new product line. "The kind of manufacturing that was already done here is exactly the kind of manufacturing that we need for Knifefish. The workers will learn certain processes that are new and unique and different. But generally speaking, we already have the right people who are highly skilled at electronic system integration. We can do immersive salt water testing in a very controlled environment here at our manufacturing facility, and then bring it to Quincy, where we have our waterfront and our own dedicated ship that we can go out into the harbor and launch and recover, and do the different levels of testing that the navy needs from us. It's really just ideal setup for us."

Knifefish is based on the Bluefin-21 UUV. It is intended for deployment from the Navy's littoral combat ship (LCS) MCM mission package, as well as operating from other Navy vessels of opportunity. Knifefish will reduce risk to personnel by operating within minefields as an off-board sensor while the host ship stays outside the minefield boundaries.

General Dynamics Mission Systems is the system integrator for the Independence-variant of the Navy's LCS. "We brought some of our expertise to making the mission modules and mission packages that go on that ship," Zaffanella said.

The Navy program of record is for 30 Knifefish systems, with each system including two vehicles and associated equipment.

"It goes back to taking the man out of the minefield, the more we can do and expand that portfolio of capabilities that can

be done unmanned, the more we can remove those threats from the sea. Unmanned is a gamechanger in that regard," said Capt. Godfrey "Gus" Weekes, Program Manager, LCS Mission Modules (PMS 420).

A Knifefish unmanned undersea vehicle training model undergoes crane operations aboard the Military Sealift Command expeditionary fast transport vessel USNS Spearhead (T-EPF 1) as part of a training exercise enabling mine countermeasure missions from an EPF as a vessel of opportunity. *U.S. NAVY / Master-at-Arms 1st Class Alexander Knapp*

While Knifefish is one of the mission modules in the LCS mine countermeasures mission package, the full mission package has not reached initial operating capability.

As the prime contractor for the SMCM UUV, which later became Knifefish, General Dynamics partnered with Bluefin Robotics to provide the vehicle, and in 2016, General Dynamics Mission Systems bought Bluefin Robotics.

The battery-powered Knifefish can propel itself, use its sensors and process large amounts of data on board for missions of 24 hours and more. The Taunton facility will manufacture the batteries used in Knifefish and other Bluefin Robotics vehicles.

Knifefish has a low-frequency broadband sonar system (LFBB) capable of detecting bottom and buried "proud" mines, as well as identifying mines in high clutter environments.

According to the Naval Research Laboratory's Acoustics Division Superintendent, Dr. Brian Houston, LFBB is an an active sonar that employs synthetic aperture processing, and artificial intelligence for detection and classification.

"LFBB exploits the structural acoustics involved with underwater sonar. When you transmit sound, the acoustic return is very different depending on the physical object reflecting

that acoustic energy. It might be a naturally occurring thing like a rock on the bottom, or something that's man-made, like a mine. In the water column, it might be a submarine versus a whale. What's in the acoustic return is very different for each of those targets. Sonar has traditionally helped us know where something is, how far a way it is, and sometime provides an image. But in addition to bearing and range, we can now determine what it is," Houston said. "That return has specific physics in it that we can exploit, and we can know something about the physical object and based on how it responds."

Because if its capabilities, Knifefish is subject to International Traffic in Arms Regulations (ITAR) restrictions. But the basic Bluefin Robotics vehicles are commercially available. "We've constructed and architected our commercial vehicles so that they're largely ITAR free. In fact, the Bluefin-9 and Bluefin-12 are being delivered today into a program for a military customer overseas," said Zaffanella. "When we designed those vehicles, the intent was to keep them free from ITAR restrictions."

Knifefish is the only UUV that can identify proud mines. But, with its open architecture and modular design, General Dynamics officials say that Knifefish could be equipped with other sensors, as well. Knifefish is designed and architected – both software and hardware – to accommodate upgrades as it goes forward. "We designed Knifefish using an open architecture concept that can be quickly and efficiently modified to accommodate a wide range of missions," Zaffanella said.

"What makes Knifefish different from other vehicles is the sonar that can detect buried mines," said Zaffanella. "But the sensor is not something that's bolted on to the vehicle. The electrical and mechanical integration of the sonar into the vehicle is a fundamental part of its design and is necessary in order to make it work. Buttoned up it looks like a relatively simple and straightforward UUV. But the amount of

technology that is inside of that is breathtaking.”

The free-flooding design allows the vehicle to be assembled in sections, which makes it easier to ship and store. “This is genuine modularity – both physical and software modularity. It comes apart in sections and you can upgrade each of the things that are in there, whether it’s the system electronic portion, the communications, or the batteries. In a modular system like this, it’s pretty easy to change out one section for another to add or change capability,” Zaffanella said.

Knifefish operates autonomously, so that an operator doesn’t have to tell it what to do. “We strongly believe that the era of maritime autonomy is very much upon us,” said Zaffanella. “The ability to make systems that are unmanned, that can do things that manned vessels cannot, and take sailors out of harm’s way, that era, and engineering the technologies needed, all of that now exists.”

“We foresee unmanned vessels will eventually be part of the fundamental fabric of how the Navy conducts its operations,” he said. “Our Taunton facility and the great manufacturing expertise here will be at the forefront of it all.”