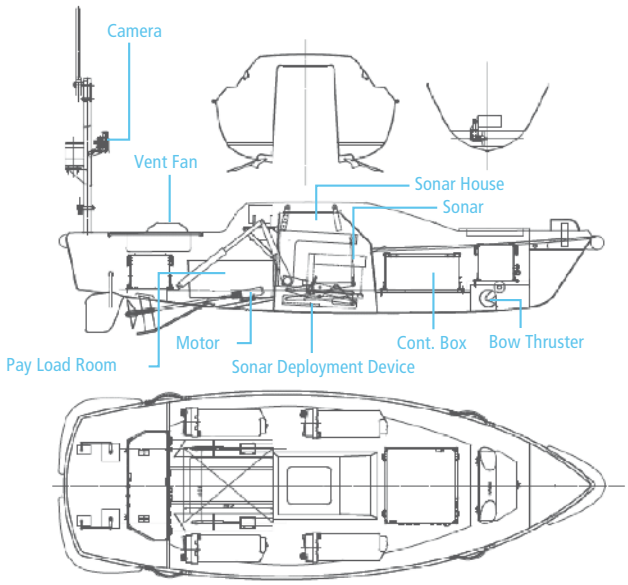
Developing a self-navigating research boat with MicroAutoBox on board.

MicroAutoBox Ahoy!

The Yamaha Motor Corporation, Ltd., is developing an unmanned marine vehicle (UMV) which can be used for numerous measurement and observation tasks. A dSPACE MicroAutoBox performs all the tasks involved in navigating and steering the vehicle.



Principle Dimension

Length over all (without fender)	2.85 m
Breadth	0.98 m
Main motor	RE40 150 W x 2
Reduction gear ratio	3.5
Displacement	170 kg
Battery	lithium ion battery 24Ah x 4
Endurance	3 hrs
Max. speed	4 kt
Cruising	3 kt

The boat provides enough space for various observation devices and also a sufficient current supply.

Why Unmanned Boats?

As a first step, Yamaha Motor Corporation started to develop unmanned land vehicles and the initial version of the unmanned electric observation boat, based on a jet boat. The development of the current UMV version started in 2005. The objective was to produce a vessel that would be able to navigate autonomously using GPS and bearing angle data, and also perform various observation and measurement tasks. This kind of boat makes sense in dangerous locations, and it is also ideal for executing lengthy, monotonous measurement sequences – unlike people, who can get tired and make mistakes, especially in adverse weather conditions.

Sonar and Underwater Camera

The UMV can investigate and monitor its environment acoustically (by sonar) and visually (by underwater camera). The forward-looking DIDSON sonar device from SOUND METRIC can be lowered into the water from a hatch at the bottom of the vessel and used for a wide range of tasks.

> "The MicroAutoBox means that the control algorithms can be implemented smoothly and executed in real time. dSPACE prototyping systems have a good reputation in all model-based development activities at Yamaha."
>
> *Tsuyoshi Kamiya, Yamaha Motor Co., Ltd.*

Typical applications include surveying the beds of lakes, rivers, and the sea; monitoring the silt in reservoirs; testing water quality; and locating submerged objects, for example, to keep harbor shipping lanes clear.

An underwater camera can also be used in addition to sonar. The boat transmits all its data in real time by radio. Its support team on land can use this data, plus the data from the integrated GPS, to follow the UMV's observations live.

Changing to a dSPACE System

The present UMV is an extended, optimized version of its predecessor. In order to avoid obstacles, the UMV needed new tracking algorithms to detect obstacles, generate its evasion route, and follow the complicated generated route. Since the new, more complex control algorithms might overload the old system resources, our engineers decided to upgrade the old system completely. Yamaha Motor chose a dSPACE prototyping system based on a MicroAutoBox to ensure that model-based development would be an efficient control development process. A PC receives the obstacle detection data and generates an

Typical Use for the UMV: Studies on Water Quality on Hokkaido

In cooperation with the Center for Environmental Science and Disaster at the Muroran Institute of Technology, Yamaha Motor is performing experiments with the UMV on Lake Utonai and the Bibi River on Hokkaido. The objective is to improve methods of measuring water quality. Up to now, the measurements were made manually from a canoe. Now the UMV automatically and autonomously runs the entire measurement program for surveying a target location, except for in an adverse environment. This saves research teams a lot of time and money. The UMV's activities on Hokkaido produced a lot of valuable results:

- Data and practical experience for optimizing measurement procedures
- Testing the communication system under real-world conditions. In the open countryside, the range is up to 2 kilometers.
- A precision of 2 meters in following the preprogrammed navigation route on unmanned voyages up- and down-stream.

evasion route; the MicroAutoBox precisely controls the generated tracking route. As a result, the UMV also provides an effective test environment for control logics, as it can find errors easily.

The Decision to Use a dSPACE System

As engineers searched for a suitable new system, they originally considered a PC-based solution as another candidate. However, after real-time capability and model-based development were identified as the decisive requirements, the ultimate choice was for the dSPACE system, since it guarantees a stable, reliable test environment. Moreover, dSPACE

Various observation instruments can be lowered into the water amidships (the photo shows a sonar device).

With a total length of only 2.85 meters, the boat easily fits into a small van to travel to its working location by road and is no problem to launch.

products already proved their value in other Yamaha divisions. Since the dSPACE system was known to be reliable, other systems were not even evaluated. The MicroAutoBox played a major role in simplifying and speeding up development processes.

> "Thanks to ControlDesk's easy-to-use, intuitive graphical interface, we quickly familiarized ourselves with using it."
>
> *Hirotaka Aoki, Yamaha Motor Co., Ltd.*

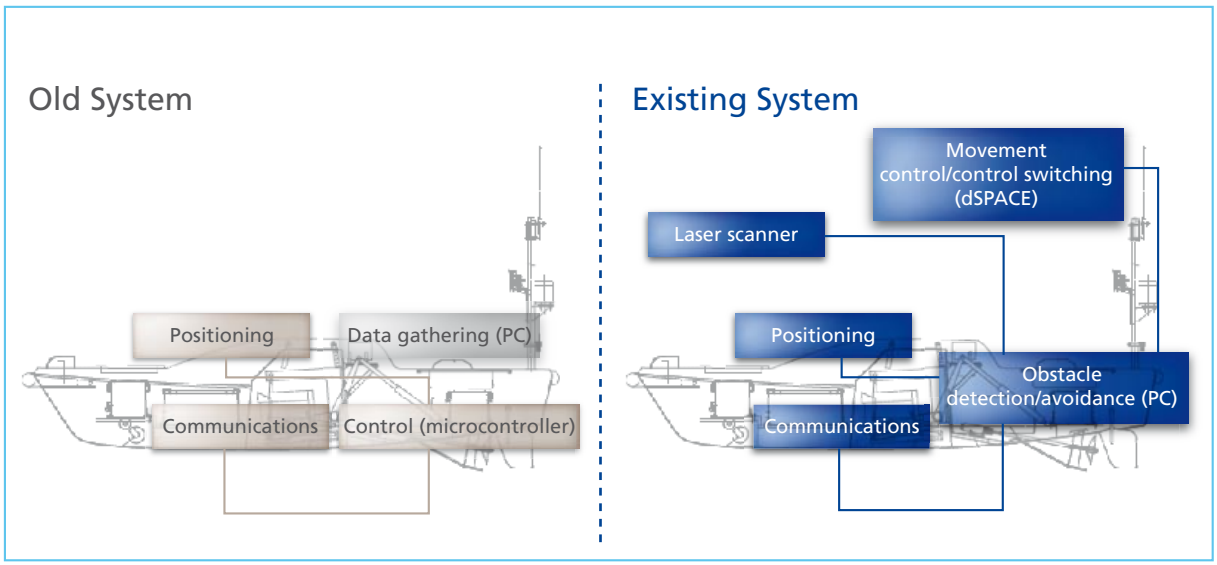
MicroAutoBox at the Helm

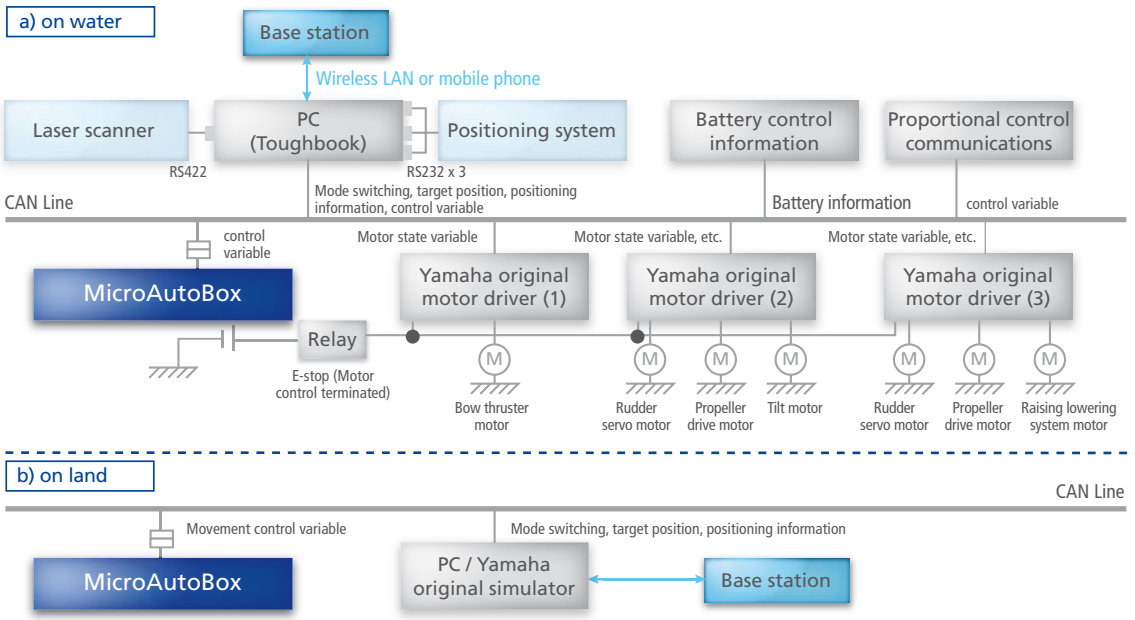
The dSPACE prototyping system receives position data from a GPS system connected to a PC. The MicroAutoBox uses the data to perform navigation calculations and sends the input data for steering the UMV to the motors (propeller drive motor, bow thruster motor, and rudder servo motor) via a motor driver that was specially developed by Yamaha. All the components exchange data via a CAN bus. To develop new control algorithms without using the actual boat, a Yamaha simulator is connected to the MicroAutoBox.

Stepping up Development Activities

The initial stage of developing the unmanned boat focused on the demands of this boat size, as well

Direct comparison between the present UMV (right) and its predecessor (left). The major features of the new boat were obstacle detection integrated into the overall system, and expanded system resources.





a) Schematic of the UMV's control system. To control the boat, the MicroAutoBox uses GPS data and data from an on-deck laser scanner that scans the immediate above-water environment for obstacles. All components communicate via CAN bus.
b) To develop control algorithms on land, a Yamaha simulator plays the part of the boat.

as researching the next challenge. Now that promising results have been obtained, the development team can concentrate on research and further technical development. Yamaha Motor will intensify its development work on the complex UMV control in the future, once more relying on dSPACE's robust prototyping systems. ■

Tsuyoshi Kamiya, Hirotaka Aoki, Yamaha Motor Co., Ltd., Iwata, Japan

The development and implementation process for the control system. The model-based control algorithms are tested and refined by repeated tests on the water and on the Yamaha simulator.