JetTorque from HamiltonJet

A TECHNICAL AND COMMERCIAL VIEW OF THE WATERJET PROPULSION MARKET

HamiltonJet blue ARROW® – The Future of Electronic Waterjet Control

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"The best way to predict the future is to invent it." - Alan Kay

Sir William Hamilton didn't invent the waterjet, but in 1954 he gave the world its first glimpse at the future of marine propulsion. And HamiltonJet didn't invent electronic waterjet controls, but today the company is leading the development of these systems for waterjet-powered vessels.

The preeminent focus of HamiltonJet's electronic controls development to date is the newly released blue ARROW® control system.

What is Electronic Control?

Simply put, it's using electronic signals to communicate between control devices at the helm and hydraulic solenoid valves at the waterjet. These solenoids control actuation of the hydraulic cylinders mounted on the jet to position steering and reverse deflectors for vessel manoeuvring.

The traditional link from bridge to jet is via a manual or hydraulic system – each with its own advantages and disadvantages. Electronic control systems provide additional advantages, in particular the ability to programme the system with a degree of intelligence to make it easier to harness the full capabilities of waterjet propulsion, and characterise it specifically for your boat.

Why Go Electronic?

HamiltonJet has used electronic controls for its larger HM range of waterjets for many years. Early systems basically mirrored mechanical controls so had limited benefits. But with advances in technology used for all manner of shipboard electronics, modern waterjet control systems offer a much greater array of features.

For the development of its blue ARROW® system, HamiltonJet was driven by several key goals…

• **Extend the range of waterjet models available with electronic controls** – HamiltonJet's MECS electronic control system was developed for HM series waterjet models, but has also been used in some larger models in the HJ series when electronic controls have been required. With blue ARROW®, HamiltonJet provides electronic controls for smaller jet models to suit a wider variety of commercial workboats, military/quasi-military craft, and recreational vessels.

• **Superior technology at competitive price** – features available with electronic waterjet control systems for smaller vessels are generally restricted by the cost. As a result most systems are relatively basic, offering few benefits over and above vessel manoeuvring. HamiltonJet's blue ARROW® has been designed to provide a very high level of functionality – with a vast array of integrated features and benefits as well as superior reliability and safety – in a user-friendly and cost-effective package.

• **Compatibility with other vessel components** – electronically controlled engines and gearboxes, autopilots and GPS are no longer the sole domain of larger workboats, passenger ferries and megayachts. These are now commonplace in a wide variety of smaller vessel types, and available from many different manufacturers around the world.

HamiltonJet's blue ARROW® control system is compatible with a wide range of these other on-board electronic components, plus has the ability to integrate with future technology as it becomes available.

Modern helms include a huge variety of electronic vessel status & control devices with many links between them.

The Station Control Panel (SCP), one of which is mounted at each helm station, is the intuitive user interface for blue ARROW® – simple yet packed with advanced features.

• **Simplicity** – while waterjets offer many manoeuvring advantages over other forms of propulsion, getting a boat to perform advanced manoeuvres requires practice and experience.

Operators with propeller experience may feel daunted by the prospect of learning new control techniques, and are thus resistant to operating or buying a waterjet powered boat. What's more, in situations where there is a high operator turnover, or time given to instruction and training is limited, or where operators are required to be multi-functional and perform a variety of tasks on a range of vessels (eg: military), it is important the vessel control system is easily and quickly learned by anyone.

With blue ARROW® HamiltonJet has achieved this aim of an extremely intuitive and user-friendly control system, that is very easy to learn and offers the manoeuvring advantages of waterjets with the most simple of operator commands.

In this Issue…

blue ARROW® Electronic Control System

blue ARROW® is an integrated thrust and steering control system that provides an intuitive, easy to use interface between the operator and the engine, gearbox and waterjet. It is much more than simply substituting hydraulic tubes for electronic cables – blue ARROW® represents a significant step forward in waterjet control simplicity, capability and reliability.

Key System Advantages

High level of Integration

blue ARROW® is designed to provide seamless integration between the waterjet hydraulics and the electronic control system. The control interface modules are mounted on the jet and are calibrated and factory tested prior to delivery and vessel installation.

The system's control algorithms are set up specifically to suit a particular application and the model of waterjet used. System configuration is based on several factors including hull type, engine power and distance between jet units. All parts of the system, including the helm control devices, are provided by HamiltonJet.

These features reduce installation complexity and avoid the need for customisation, ensuring complete compatibility of all parts of the system.

Simplified Installation

With a minimum number of interface modules at helm, waterjet and engine, inclusive of interconnecting cables, installation of the blue ARROW® system can be completed with ease. All cables are supplied pre-terminated and clearly labelled to ensure hook-up is foolproof.

The close integration with the waterjet means all connections between controls and jet hydraulics are pre-established, so installation is largely a matter of connecting the various control system components together.

Multiple levels of Redundancy

To achieve its high reliability and safety, the blue ARROW® system utilises two independent power sources, solid-state switching, multiple lines of communication between system components, and two levels of control for greater redundancy.

As a result the system is immune to single power failures and will not be adversely affected by a single cable fault between the helm and jet/engine room. This ensures the propulsion system is able to return the boat to a safe berth in all but the most major of catastrophes.

System Overview

blue ARROW® is not just a control system for waterjet powered boats – it is a totally integrated waterjet propulsion and electronic control package. It includes single or twin waterjet units (available with HJ292, HJ322, HJ364 and HJ403 waterjets), jet control interfaces, engine and gearbox control interfaces, and helm station operator control devices.

The system is based around a "per jet" architecture (see Fig.1) similar to that of the HamiltonJet MECS control system but on a simplified platform. Often electronic control systems utilise a single interface module controlling multiple jet units. With blue ARROW® each jet unit has its own control interface module mounted on it to control steering and reverse for that unit only. Each engine/gearbox also has its own dedicated control interface module.

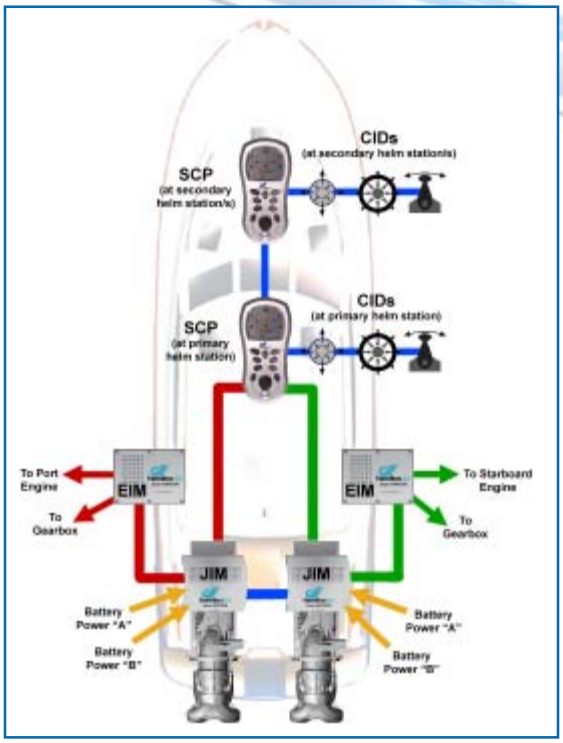

Fig 1: Basic architecture of the blue ARROW® control system

In twin installations there is separate cabling to port and starboard drive-trains, with a cross-link between them to provide a more reliable communication loop should one cable fault occur between helm and waterjet.

However, unlike MECS which has a display/backup helm module for each jet installed, blue ARROW® uses a single operator display at each station to show the status of each drive train individually and across the system as a whole.

This "per jet" architecture provides a very high level of redundancy to ensure communication is maintained and the system remains operational even in a fault situation.

blue ARROW® utilises distributed intelligence Digital Microprocessor technology communicating using a dedicated protocol CANbus network. CAN is an established and reliable control communication interface used in rugged environments such as automotive and marine.

blue ARROW® Modules

Four main components make up the blue ARROW® system. Each module is solidly constructed to be shock and vibration proof, and environmentally sealed (IP66) for mounting on exposed bridges or wing stations…

Station Control Panel (SCP)

This is the main processing point for the system (the decision maker) as well as the operator's point of access at each helm station. Its ergonomic design suits all manner of helm layouts in both work and pleasure boats, where it is a key part of the vessel's operation.

The LCD screen displays steering and reverse deflector positions, provides rapid visual identification of faults and displays system setup and on-going status messages. During blue ARROW® installation the SCP is used for vessel configuration and fine-tuning of the vessel's manoeuvring performance.

The SCP also provides an interface for autopilot (if used). Back-up control is operated from the SCP, via a small joystick, and remains functional even in the unlikely event of a significant system malfunction.

Control Input Devices (CIDs)

blue ARROW® has three CIDs which are daisy-chained to the SCP (see Fig.1). These CIDs provide exceptional functionality with ease of use…

Single Lever Controller (SLC) – provides ahead/astern control of each jet by coordinating engine RPM and astern deflector position on one lever.

Helm unit – fitted with the owner's own choice of wheel design, provides vessel heading by controlling the waterjet's steering nozzle/s.

Manoeuvring Device – this device is the key to allowing anyone to harness the full low-speed manoeuvring potential of waterjet propulsion. blue ARROW® uses differential control of the waterjet astern deflectors to provide sideways vessel movement and other advanced manoeuvres.

Vessel control such as this with a normal hydraulic or manual control system requires complex throttle, steering and ahead/astern lever positioning – blue ARROW® does it all for you in a simple, intuitive manner.

The Waterjet Unit & Jet Interface Module (JIM)

The blue ARROW® system includes a single or pair of waterjets with outboard steering and reverse deflectors whose position is controlled by inboard-mounted hydraulic cylinders. These hydraulics are in turn controlled by an integrated Jet Interface Module (JIM) which is mounted on the waterjet above the hydraulic subsystem (Fig. 2 – HJ292 waterjet shown).

The two sources of electrical power for the blue ARROW® system are connected at the JIM, which provides input power protection and feeds the power to the rest of the system – including the bridge. The JIM monitors hydraulic oil level and temperature, and jet mainshaft speed, for feedback and alarms.

Engine Interface Module (EIM)

This module is mounted on the bulkhead near the engine where it translates absolute throttle demand into relevant electronic signals for the engine. All common throttle types are supported – 4-20mA, Voltage (to +12V), PWM (programmable voltage limits) up to 2KHz 5-95%, Pulse Fq,INC/DEC.

Direct manual actuators are also supported for non-electronic engines.

The EIM also controls gearbox engage/disengage and supports back-flushing if available. Engine start and gearshift interlocks are included to prevent starting of the engines if the blue ARROW® control system is not operational or when throttle or gearbox are not in a "safe" position. A manual override can be connected to provide the skipper full control when necessary.

blue ARROW® Communication Flow

As previously stated one of the key benefits of the blue ARROW® system is its intuitiveness and simplicity of use. This comes about as a result of the advanced communication between all parts of the propulsion system.

Obviously the first communication for the system comes from the helm, with the operator using the CIDs to tell the boat where to go and how to move.

Signals from the CIDs are fed to the SCP, where programmed algorithms determine what combination of throttle, steering and ahead/astern will achieve this. Demand signals are then sent from the SCP to both JIM and EIM which set waterjet hydraulics and engine throttle accordingly. A closed loop Proportional-Integral-Derivative (PID) system on each waterjet's steering and reverse hydraulic cylinders provides feedback of their positions, which is then communicated back to the SCP and displayed to the operator.

Fig 2: The blue ARROW® Jet Interface Module (JIM) mounts on the waterjet unit above the hydraulic block.

To ensure the operator is not overloaded with duplicate data, feedback for engine RPM, temperature etc is not displayed on the SCP.

For normal vessel operation this communication loop is relatively straightforward. However, it's when using the manoeuvring device at low speed or docking that the SCP's programming really stands out.

With twin blue ARROW® jet units installed, simple movement of the manoeuvring device sideways and forward/backward automatically translates to differential bucket control of the jets and appropriate heading position required to move the boat directly sideways or in whatever direction is desired. The vessel's heading can easily be adjusted, as can engine RPM to combat strong side winds or currents (either by moving the manoeuvring device further to the side or by using the port SLC).

Switching between low speed and normal control is a simple matter of synchronising the SLC lever positions with the manoeuvring device. When the "synchronised" icon appears on the SCP the operator activates the "Take Control" button on the required CID. A similar technique is used to swap control between helm stations.

Back-Up & Maintenance

Vessel operation in back-up mode is controlled by the back-up jogstick on the SCP. In the event of primary control failure the SCP will continue to do whatever it can and supply whatever feedback can be given. However the SCP's back-up jogstick is hardwired directly to the JIM so no CANbus signals are required to control the jet's hydraulic subsystem. Advanced controls are lost, with the jogstick only operating steering and ahead/astern in order to get the vessel home safely.

The system is also set up to make replacement of a blue ARROW® module very easy. System and module settings are stored both in the modules themselves and elsewhere in the system. If a module fault occurs a new unconfigured module can be installed which automatically picks up configuration information for the system and carries on just like the original. Setup of the replacement module is minimal to ensure the operator suffers very little vessel downtime.

NZ Survey Vessel Uses blue ARROW® Control System

Above: SeaScan - Twin HJ403 blue ARROW® waterjets.

HamiltonJet's blue ARROW® control system is designed for a wide variety of vessel types and applications, from recreational cruisers to workboats and military vessels. For its first commercial application the system was installed in a 16.5m sea survey catamaran operated by Sea Scan Ltd in New Zealand.

"SeaScan" was built by Q-West Boat Builders to a Teknicraft design. The foil assisted catamaran is powered by a pair of 746kW (1000hp) Caterpillar engines and Hamilton HJ403 blue ARROW® waterjets. This combination gives a top speed of 47 knots and economical cruising speed of 32 knots.

The waterjets allow precise control of the boat at low speed during survey operations, which is often done using one drive only. Sea Scan Ltd says the blue ARROW control system has operated without fault since the first trial and has proved to be intuitive to operate with the system's manoeuvring controller. The controls allow spot turns, sideways movement, emergency stops of a boat length from 40+ knots & full coordination with the autopilot.

"SeaScan" will be used for sea floor sampling , side scan sonar survey , video sledge towing & placing divers in the areas of interest. The vessel is built to MASNZ survey standard, which allows up to three crew and 49 passengers on board for commercial work.

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blue ARROW® for Pleasure Cruiser

For its first recreational application, the blue ARROW® waterjet control system was installed in the LD43 – a 13m (43ft) powerboat from UK yacht designer Oyster Marine and built by McDell Marine in Auckland, New Zealand. A pair of HamiltonJet HJ292 waterjets and 330kW (440hp) Yanmar engines propel the LD43 to over 30 knots.

Waterjets were chosen for their combination of performance, safety, shallow draught, and manoeuvrability, the latter particularly enhanced with the blue ARROW® control system.

The intuitive nature of blue ARROW® makes it ideal for this type of application. The system allows owners with little or no experience of waterjet propulsion to make full use of the manoeuvring benefits of jets in every situation they are likely to encounter in a marina or open water.