Offshore Drilling Application
Controlling ROVs via SoftPLC

Application Problems

The environment is appalling -- dealing with massive pressures found 5 kilometers underwater is only the start. Weather is often horrible and even subsea the visibility is only a few inches. Surface operations can see a five ton machine thrown around like a toy. Currents can exceed 3 knots and operators may need to weave their way around downlines from vessels, scaffold poles and debris on the seabed. Operators work with 5kv voltages, mV signals, digital and analog electronics, computers and software, hydraulics, mechanics, fiber optics, acoustics, electromagnetics, X-ray equipment and of course the ever present sea.

What are we talking about? Control systems for free-flying Remotely Operated Vehicle's (ROV's), such as those used in offshore oil rigs.

> *"In some respects, the environment is as alien and as tough as outer space - yet the industry can't support the kind of funding even the simplest of rockets will get."*

Massive structures are lowered onto the seabed by crane barges and positioned by the ROV's. With special tools, these machines will then pick up the ends of pipelines and align them to valves on the structures, inserting gaskets, nuts and bolts before tightening them to preset torques. They operate valves and other machinery using manipulators controlled from the surface with a delicacy that has to be seen to be believed. Ten minutes later they may have to ram a 20 ton pile into position so the structure can be pinned into the ground. Piling hammers create shockwaves that will quickly destroy poorly designed electronics and hardware.

In the past, much of this work was done by divers but commercial diving rarely goes below 400 meters. Most ROV's are capable of 3000 – 5000 meters or more. Why? Because in the hunt for new oil reserves, that's where we have to go.

The solution of course, is to keep it simple. Complex equipment will not be reliable in this environment. However, keeping it simple is often not that easy. For example, putting a nut on a bolt can only be achieved when you know exactly where the nut is, where the bolt is, where the holes are and you can align all the pieces perfectly while coping with bad visibility and strong ocean currents.

> *"Oil reserves seem to be located in the most godforsaken corners of the world -- places with poor communications, minimal transport facilities, language difficulties, zero sources for spares..."*

The industry is highly competitive. Successes are largely forgotten but screw-ups will be remembered for years, so even the smallest of jobs must work perfectly. The oil industry is particularly conscious of price and delivery. Companies like C&M Group Ltd have built up a niche market where complete control systems can be designed, built and delivered in just a few weeks. Most of these systems are unique to each job so development costs cannot be amortized over a large production run. Even a product that may have a production run of 30 units over a 3 year period and a unit cost of $3,000,000, will have a control system adapted to the client's specific needs.

There are other issues. There is a history of customized projects that quickly became unsupportable within a few years. Employee turnover is high. Long term support is difficult when the historical knowledge base from a company has dissipated. Yet ROV's and tooling systems can have a life in excess of ten years. Clients need assurance that critical hardware and support will still be around long after the manufacturer, engineers or software programmers have disappeared.

Rate of technical change is high. Systems must be able to accommodate new tools and technologies that will come into use. Clients need to be able to expand systems to cater to demands that they can't even begin to imagine. No operator wants to be ruled out of contracts due to compatibility issues on a system barely a few years old.

Of course, there are commercial, political and safety concerns too. Equipment has to not only get the job done and be compliant with regulations and guidelines -- but it also has to look good and be easy to use and maintain.

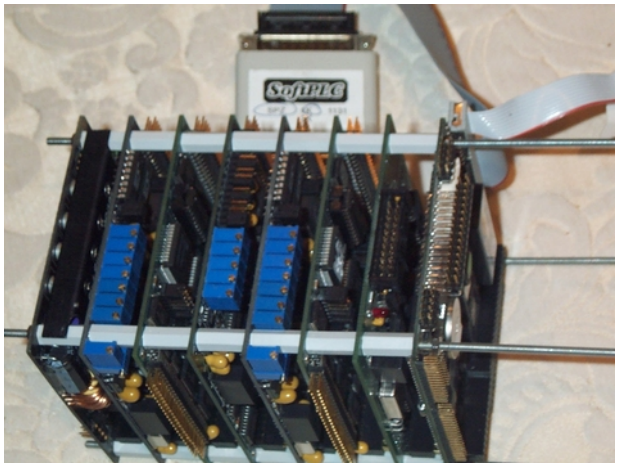
Technical support offshore is critical. Systems must be easy to diagnose, HMI's need to be able to display different languages. Spares must be provided to cover most eventualities without breaking the bank through overstocking.

"It's easy to design a product in a nice air-conditioned office. The real test is how it works on the back of a heaving vessel in a force 5 with high humidity, vibration, shock loads, tired operators who don't speak English and a client standing behind you screaming his head off."

Application Solution

So designers of equipment for underwater use have to be very careful in their selection of technology. There is no right and wrong system design, all the systems working are good, bad ones quickly disappear. At C&M Group, the solutions we aim for are not meant to be clever, they are meant to be simple and reliable. We use industry standard products with emphasis on compatibility and longevity. The obvious example here is PC's. No engineer will claim that PC technology is the best technology, but due to the massive user base, you know that compatible components will be around long after specialty industrial or proprietary solutions have disappeared.

Hardware: We often use PC/104 PC's, which are industrial, virtually immune to vibration and small in size. On the plus side, PC/104 stacks are extremely rugged. The cost of the boards is low, so supplying complete built and tested stacks as spares is commercially viable. The physical size allows smaller diameter housings to be used which are more suited to the high pressures of deep water.



There are hundreds of PC/104 manufacturers -- the quality and range of products is superb. Although products may change over time, if necessary we can create new drivers in a couple of hours. Our system software is normally supplied on Flash disk so an update can be emailed out and dropped straight onto the networked system by the operators. Or on satellite linked systems, we can do it ourselves from here in the UK.

The PC/104 implementation of PC's does have a few drawbacks. Dismantling a PC/104 stack needs a lot of care and I've never liked ribbon cables in noisy environments.

"With software, we need to be compatible with the widest range of systems. For control, we use a product from a US company called SoftPLC Corporation."

Software: SoftPLC control software allows us to quickly create our applications using ladder programming. The product has a range of communications options including RS-232/RS-485 and Ethernet and a peer-to-peer communications link can be set up to reliably transfer a large amount of data with a single instruction.

SoftPLC also has a toolkit that allows us to easily tie in our own instructions written in C for time critical situations or unusual algorithms. We have built a library of modules both for hardware interfaces and applications such as notch filters, saving and reading set-up files and interfaces to intelligent sensors. Most of these routines were written purely to optimize existing SoftPLC instructions. It is an extremely versatile language.

This alone is not enough to justify using this product but it has two other superb qualities. Because it's simple, ladder can be read and understood by other programmers. Trying to get to grips with someone else's "C" Code is usually a nightmare, but a well written ladder program can be very quickly figured out.

The biggest advantage of all over custom code is that SoftPLC programs can be monitored and changed in real time. Final development and bug finding can be carried out live while the equipment is being operated. The reduction in development time and thus cost from this simple technique is incredible. The client can watch during commissioning and say "Yes that's good, but can we do this and make that do this", and our programmer can implement live changes to a system while in-water function testing is going on.

"Me, I sit next to the coffee machine with a laptop, a TV monitor and a comms set, listening and watching the pilots fly the vehicle. I have a window into the software. I can change parameters or code in real-time and I can even take over control of the system - flying a 5 ton ROV around the seabed using my laptop."

The SoftPLC software is not hardware dependent so it can be ported to a wide variety of PC hardware, with only I/O drivers needing to change. We have used SoftPLC on VME and STD legacy equipment without any problems. SoftPLC brings years of development and utter reliability. For low volume and unique products in a highly competitive market, where future changes and upgrades will be a way of life, this solution is hard to beat.

So that's the base control system. The design is simple, spares easily obtained and a projected life of well over the ten years we are looking for. Should an interface card become obsolete, operators have dozens of choices for alternatives and the driver module can be rewritten by any competent programmer.

"On the surface ship, a control panel of switches and joysticks connected directly to a SoftPLC communicate with a network of 1 or more subsea SoftPLC controllers up to 5km away through fiber optic links bringing video, telemetry, Ethernet and analog or digital sonar data back to the operators. Fast, efficient and highly robust.

In over 8 years of using the product we have not had a single critical failure that wasn't caused by water ingress. Our clients appreciate the simplicity and ease of use. "

What of the graphical HMI? Operator displays are critical. Not just for monitoring conditions and navigation but for diagnostics and fault handling/backup systems. The typical OEM solution is a team of programmers locked away developing screens in Visual Basic or C++. However, one-off projects can't justify this expense nor the potential for costly mistakes. Modern PC based HMI/SCADA products are incredibly. With SoftPLC, any HMI/SCADA product is an option so we can adhere to a customer standard, or select the best product for each project.

Our systems are built using a common procedure. First we get the client's specification. Then we try to work out what the client actually needs. We create the structure and do a first pass with mock up screens which are submitted for approval. A programmer then sits down with the client, and modifies the screens and operations to their preference. None of this affects the underlying design but the client buys into the product through helping to develop an interface that suits his purposes. Once he's gone, we then tie the dynamic functions into the SoftPLC by linking a readout or switch to an input or output on the SoftPLC through a drop down list of I/O created originally in Excel. The software is then loaded to the newly built hardware, debugged and tested. Then it gets interesting.

We send a programmer and an electronics engineer out with the system for commissioning. While the operator works with the system, the engineers are monitoring and adjusting the system to make it work in the real world -- with feedback and language translations supplied by the people who actually use the system and diagnostics that cope with the reality of the situation.

Our systems are open source. We train the operators not only to use the system but how to modify it. If operators don't like your system, it's a kiss of death. By letting them change the interface to suit their needs without letting them into the core, it very quickly becomes "their" system.

> *"The products we select are highly respected products and from companies with development and support teams that are knowledgeable and most importantly accessible. In the past their engineers have given us home phone numbers and even interrupted Christmas dinner for a quick technical chat. Over the years, these guys have bent over backwards to provide solutions for our unusual requests."*

The use of the SoftPLC open architecture control software and PC hardware provides C&M Group with the lowest cost, fastest development time solutions available. We're at the leading edge of development but have the reliability of established designs. Our clients are comfortable. They can modify systems themselves or bring us or anyone else in to do it for them. They get longevity and easy sourcing, simplicity with extreme ruggedness and a future upgrade path. The use of Windows for the HMI is not to everyone's liking but the graphics are not integral to the control. Should the top side graphics fail, the controller is unaffected. Should the top side controller fail, the HMI can talk directly to the subsea pods to allow an emergency recovery.

Are these systems as reliable as a purpose built system? **Yes!** In fact, in our opinion, they are more reliable. The systems we design are by nature intricate. The products we use have 100's of man years of engineering by their manufacturers and are used in all kinds of control applications worldwide. A hand crafted system cannot match this experience.

This is critical. My clients want solutions yesterday and knowing I can draw on the resources of companies like SoftPLC lets us sleep at night. SoftPLC is not unique, there are many good companies out there who go that extra distance, with engineers who give a damn, who want your business and want to help you succeed. *(But they aren't the "big" suppliers.)* There are many rubbish products out there too. Famous names who couldn't give a toss whether your product works or not unless you're going to buy huge quantities and even then only let you talk to an engineer via email or through a witless salesman.

Does our solution have drawbacks? Well yes, of course it does, it cuts into our profits for one. These products are not cheap solutions. They are also not proprietary solutions. Our clients can take the product and run with it themselves or go to any other company for support. Although our clients are keen on the idea, being open with your technology can be a risky business.

It may be possible to design systems that are smaller or cheaper or more reliable but you can only get one of those options at the expense of at least two of the others. The use of open architecture technology gives the best blend of reliability, performance and price.

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About the Author

Chris Ward joined Subsea offshore back in 1979. He had never seen an oil rig, and was probably the first person to land on Forties Alpha wearing a three piece interview suit and carrying a suitcase. Some hairy arsed bears then bundled him into a basket and suggested he hold on. Tight. That was his first basket transfer onto a ship and was a little unexpected, as they told him they just wanted to weigh him . . .

Despite this slightly surreal start, he quickly realised he had found his future path in life. These silly buggers not only paid him but gave him millions of pounds worth of toys to play with. Since then he has worked in every continent in the world. He has operated and built eyeballs and construction vehicles, ploughs and trenchers, giant cutters and some of the wierdest tools imaginable. These days he runs his own business (ROV.NET) and designs and builds systems to order. His particular specialty is control systems and electronics which are used in all areas of technology, not just the underwater arena.

About ROV.NET

ROV.NET is a UK based control systems consultancy specialising in underwater robotics and tooling. This is a global market covering everything from simple tools for academic research such as seabed or water samplers through to advanced oil industry and military robots designed to carry out construction work or hunt for mines. Other applications include cable and pipeline ploughs and trenchers that bury fibre optic cables or oil pipes to protect them from fishing nets and anchors. Autonomous battery powered robots thatsearch hundreds of miles of seabed . . . the list of applications is endless. Our clients come from the UK, USA, Europe, China, Russia and the Far East.