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DYNAMIC POSITIONING CONFERENCE
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Risk

Growth Stimulates Innovation in DP Technology

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Abstract

The recent upswing in new-build, dynamically positioned drilling rigs has highlighted the need for proficient crews and subsequently, a means of evaluating that proficiency. The rising choice in training and assessment venues are virtual vessels and simulated environments and fault scenarios. Transocean's efforts to develop power management simulations for Operator training have highlighted some interesting parallels and potential segways with OPC-based servers and HIL-Test scenarios.

This paper will explore developments, which could closely couple and compliment these three data-based activities.

1. DP & Power Plant Simulator under development by Kongsberg Maritime and Transocean
    A. developed to train DPOs to handle complex failure modes, but with an eye towards improving rig performance
    B. interface between automations systems is the same as an operational rig
    C. potentially, any DP automation system could be interfaced to any vessel automation system
    D. development tool, if simulator model of vessel is accurate enough a new automation system (any brand name, either DP or VMS) can be "run against" a proven model, allowing preliminary tuning and identify problems or conflicts before shipyard.

2. HIL under development
    A. HIL could "sit between" the simulators
    B. advanced device models allow HIL to create more complex failure modes than the simple models used in a typical simulator, and much faster because HIL models will have more parameters to adjust.
    C. HIL could allow testing of new types of sensors (riser angle, inertial, NASNET) with a variety of DP and Automation systems more cheaply than modifying every simulator. Allows us do some validation of "blue sky" development, cheaply

3. OPC data logger
    A. creates a "High Definition" record of operational data
    B. connect in parallel with simulator and feed environmental data to DP, then record performance data, and "match up" simulator response to actual performance data. This would allow improvement of simulations.
    C. Once the simulations closely match actual performance data, insert the HIL and record data to verify the HIL closely models the machinery.
    D. with simulations and HIL aligned to real data, now you can use the simulators and HIL to substitute alternate equipment and produce realistic evaluation data, e.g. we can evaluate performance improvement of an existing design with more smaller generators, or fewer larger units, turbines, a new drilling package, or anything for which we can obtain an accurate HIL model.

Technical Paper

Challenges in the Current Growth Period

Following the 1996 build cycle of Mobile Offshore Drilling Units, we all vowed to "do it better next time". Well here we are in 2006-7, and we find ourselves chasing the dream again! With the sheer magnitude of this growth cycle, several novel innovations will be implemented within these new DP vessels and will enter the Drilling Industry over the next three years. Transocean's focus on DP Excellence has three areas of interest which although loosely coupled, have highlighted surprising opportunities to enhance equipment selection and rig performance while reducing cost and time-to-decide. This paper hopes to stimulate even more innovative development for those vessels, their owners, operators and clients.

Beyond the Engineer's "adrenalin rush" when challenged with building vessels which are more efficient, reliable and robust, Rig Owners are faced with some clear demands on manpower, technical proficiency and training of new personnel. Using some simple math we could attempt to calculate the number of DP crewmen required to staff the new-builds under construction. With ~50 new DP rigs (alone), times ~10-14 DP personnel per vessel, we reach rough sums of 500-700 DP proficient crewmen? Let's do a sanity check; how many rigs are we retiring? How many crews are surplus? That's right (maybe none), so we have a manpower problem and we have a training challenge!

DP Operator Training

In 2002 Transocean decided to implement some changes to reduce the frequency and severity of DP Incidents. The initial action was to perform DP Audits of all of our DP rigs, which at the time consisted of 20 rigs, roughly distributed 1/3 in the US GoM, 1/3 in Brazil, and 1/3 in Africa and India.

The DP audits were quite extensive, measuring both equipment and people. A DP skills test was given to all DPOs, and misconceptions and serious knowledge gaps addressed with on the spot training. Procedures, practices, and policies were measured and compared across the fleet. Every rig was found to have at least one "best practice" that was captured and immediately sent to the remainder of the fleet.

The DP audits discovered that despite the wide variety of rigs, operating regions, and environments encountered within our large world wide fleet, the causes of DP Incidents were remarkably similar on all the rigs.

The DP Audit findings were:

1. 20 rigs operating in all regions were remarkably similar. The GoM, Brazil, Africa, and India, despite widely different environments, clients, and cultures, had almost identical strengths and weaknesses.
2. DP Incidents resulted from a wide range of root causes, with power plant anomalies the single largest contributor.
3. Human error was a major factor, right behind power plants. Specifically, lack of understanding how DP Control Systems and power management function.
4. Most DP Incidents could be prevented by swift corrective action.
5. Human error was a factor in most DP Incidents
    a. DPO mistakes causing the incident were rare, maybe 10%

b. DPO failure to act allowing the incident to progress, about 30%. In fact all but one incident could have been prevented had the DPO understood the DP and Power systems better.
c. DPO wrong action making situations worse, about 60%. Some of these DP Incidents would have self corrected if left alone.

It appears that if we could eliminate the incidents where DPOs either failed to act or made things worse, 90% of DP Incidents could be eliminated. More than likely the other 10% would also disappear with better training.

One of the key findings of the DP Audits was that the majority of our DPOs had little or no understanding of how the power plant operates, or how closed loop DP control systems operate. They were well versed in how to operate the DP System, but knew very little about how the DP system operates, or fails. Additionally, they knew almost nothing about power plants, power management, and the failure modes of each.

Next we looked at existing training programs. One key requirement of our training requirement was Nautical Institute certification of DPO status. On closer examination we discovered that Nautical Institute DP Certification is designed to produce a trainee DPO, not a highly experienced DPO, and is of little value for handling faults and failures. The focus of the Nautical Institute scheme is assuring a certain minimum exposure to DP, but has no means to measure or control the quality of that exposure, or the level of overall learning.

We looked at vendor training programs. Vendor training focused on subsystems, not the whole rig. The goal of the vendor was teaching the DPO to use their particular screens and panels. The focus was not aimed at improving DPO understanding of DP theory, nor was it aimed at how to handle faults and failures outside the DP room.

Interestingly, the main focal areas of existing training were the areas where we had few operational problems, while the causes of most of our incidents were ignored. Inadequate DPO understanding of how DP systems and power plants operate was clearly the “low hanging fruit”.

To correct the identified problem, Transocean developed an in house training program called DP Lessons Learned. This 2.5 day course covered DP Theory, Thrusters, Power Plant, advanced operations, SIMOPS, position references, and included more than 30 workshops based on DP Incidents from our fleet history.

This DPLL course was made mandatory for all DP Personnel, including OIMs and Captains, not just DPOs! Clients, rig manager, and Engineers are invited, and many have attended, particularly Petrobras. Over the last two years more than 30 courses have been held at Transocean training centers and hotels in the USA, Brazil, Aberdeen, Singapore, and Mumbai. More than half of our DPOs have attended. So, what is the result?

Since 2005 there has been a marked reduction in DP Incidents. Human error in particular is down by about 80%. While we still have DP Incidents, the DPOs almost always take proper corrective action to reduce and often prevent a failure from escalating into an Incident.

In 2005 we decided to see if we could reduce or eliminate the remaining 20%. From quizzes and discussions held during DPLL courses, we were satisfied that the DPLL course was teaching effectively, but we had reached the saturation point of how much a DPO could learn in a short course of classroom lectures. We decided to progress to a simulator.

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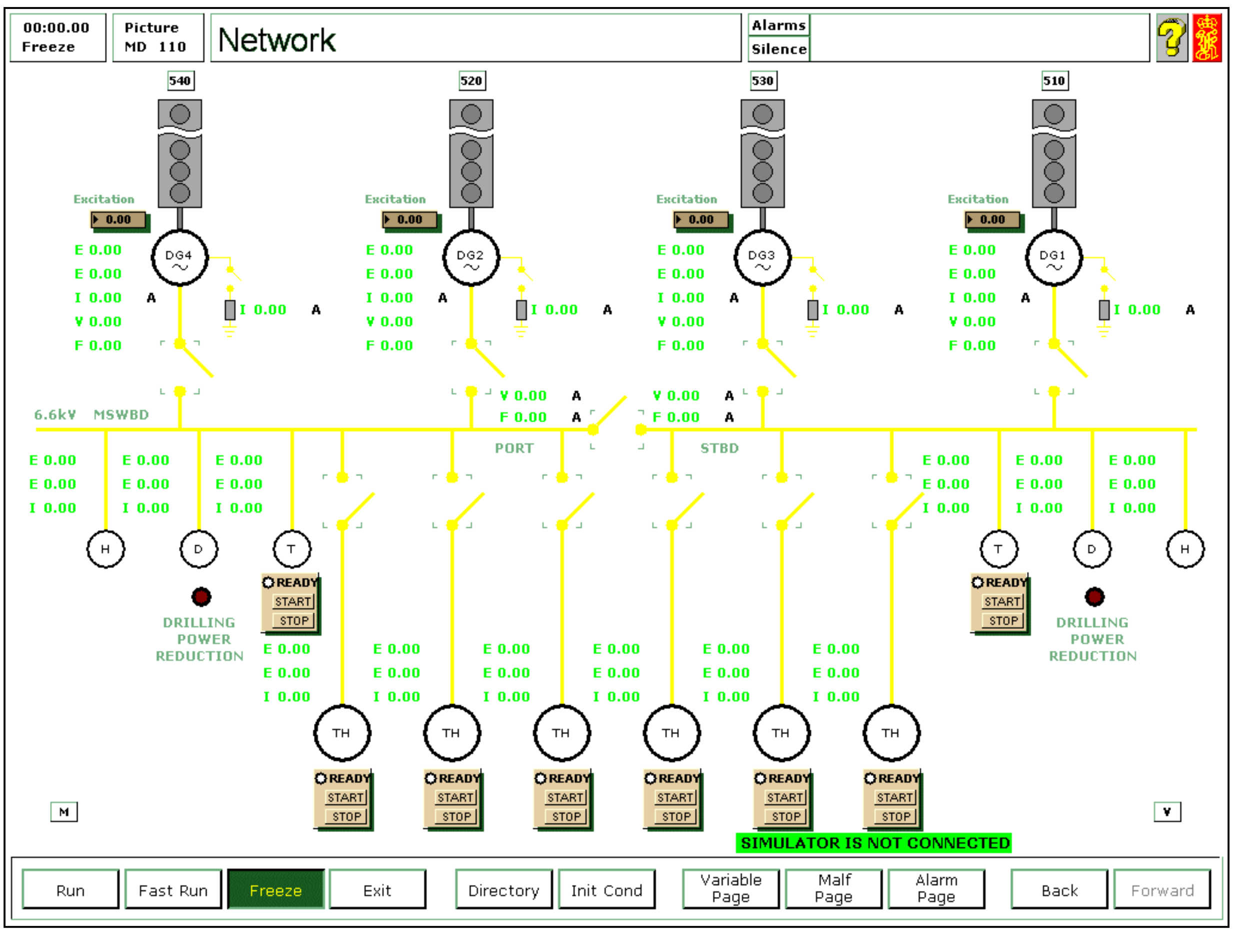
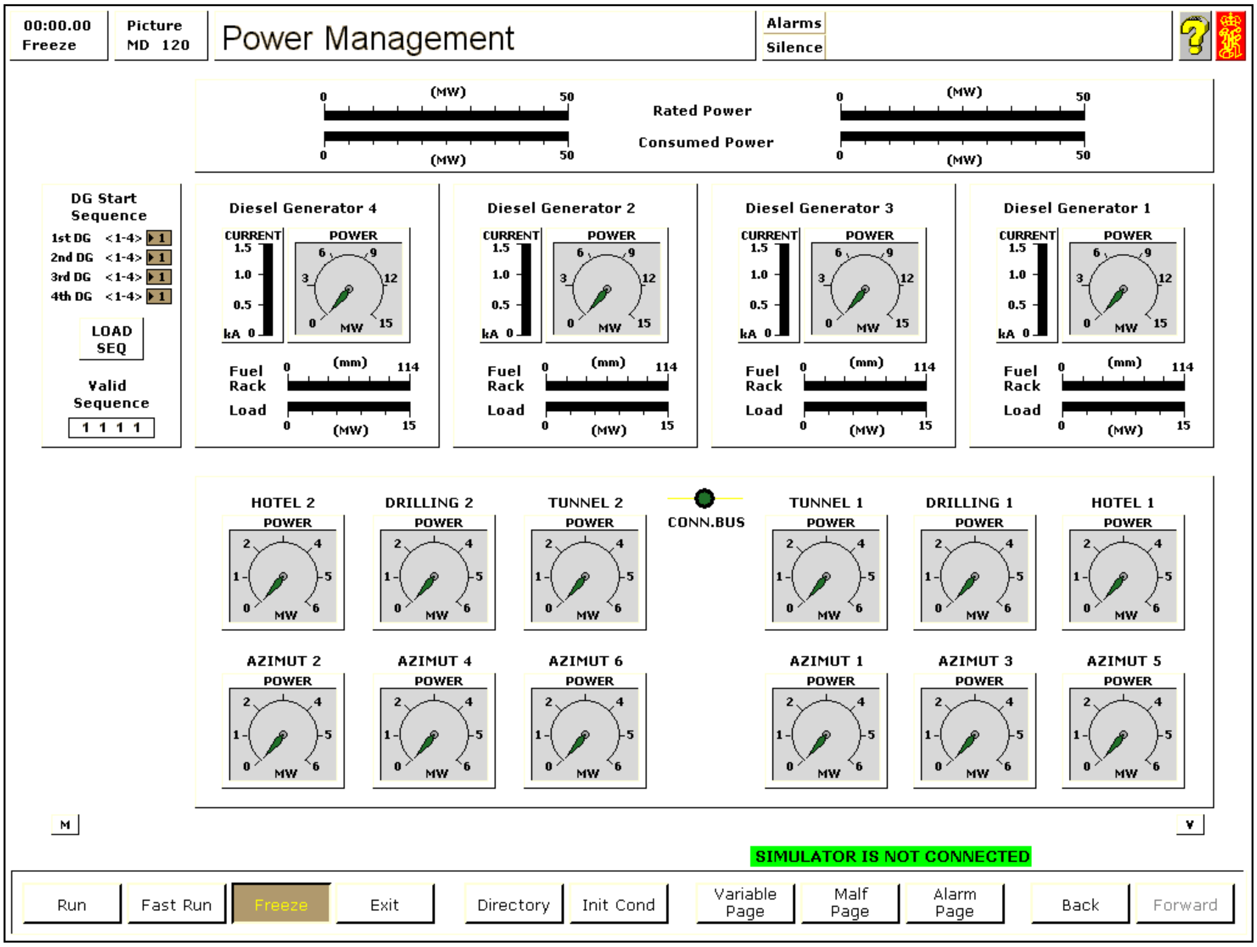
In order to present the students with a rig-like learning experience, the simulator would have to go far beyond existing simulators. It would have to be able to simulate the actual faults and failures we have experienced. Three DP vendors were contacted. Kongsberg Maritime was the first company to embrace the concept and move forward with development work under their own funding. Kongsberg proposed to marry an existing operator training simulator (utilized for their cruise-line clientele), with their existing DP Simulator. This combined simulator appeared readily adaptable to our Power Management scenario.

Over the next two years Kongsberg and Transocean worked closely to develop a simulator that could recreate all of the DP Incidents experienced in the Transocean fleet. This required a lot of effort and coordination, but eventually we had something we could use to train DPOs to handle a wide range of failures, including power plants, sensors, and thrusters.

The simulation includes a DP System Simulator and a Power Plant Simulator. The power plant simulator has diesels, generators, pumps, and all normal auxiliary equipment found in an engine room. The equipment also has the same characteristics as real equipment, for example a diesel cannot come to full load instantly. The simulation is quite powerful in that we can stop, start, backup, replay faster or slower, and restart just before a fault to let DPOs try different responses to the same incident.



In 2007 we held two prototype simulation courses. Senior DPOs were invited to give it an acid test. To our surprise, the course proceeded far better than anticipated. The students got value out of the first day, and even more as the three day course proceeded. In 2008 it will be rolled out to the entire company, and available to the entire industry.



During the creation of the simulator we discussed many ideas. One idea we discussed was providing the ability to “plug in” different types of diesels and run them before buying them. The main programmer told us that his software was not currently designed to change diesels, but that the entire characteristics of the diesel were programmed into the software, so that at least in theory we could end up some day with software that allows us to “plug in” different diesels. Other equipment is also internally modeled, such as thrusters, pumps, transformers, and DP sensors.

This has tremendous potential value for rig design. For example, our Enterprise class vessels presently have Wartsila diesels. Our new enhanced Enterprise-class vessel, the Discoverer Clear Leader, uses MANN diesels. When the DCL was being designed there was a lot of discussion about which diesel to purchase. That decision would have been much easier if we could go to Kongsberg and “drop” Mann diesels into the simulator. We would know in minutes exactly what to expect from the MANN diesels, rather than the weeks of data gathering it took before the decision was made. Eventually, we might also be able to estimate how fast we can ramp thrusters with a particular diesel, or which transformer and generator combination can provide the fastest blackout recovery.

Hardware in the Loop Testing

"Hardware in the Loop" (HIL) testing has been around for a number of years, but has primarily focused on the manufacturing industries (i.e. automotive, aerospace, avionics, telecommunications, etc). An entrée into Dynamic Positioning came in the fall of 2004 with Marine Cybernetics of Trondheim, Norway. DNV now offer certification of HIL Testing; the first being issued in 2006. Transocean has been following the growing application of HIL testing to dynamically positioned vessels. Our primary interests in HIL Testing are the potential for man-hour savings in the shipyard during commissioning and sea trials, and as mitigation against potential off-contract time resulting from flawed software upgrades or integration. In other words, the ability to validate application software offline, before taking revenue earning equipment out of service.

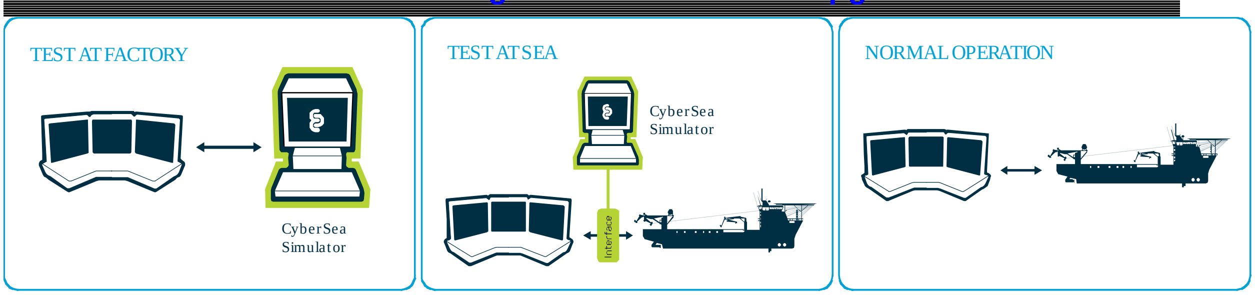
HIL focuses on the validation testing of software configuration and algorithms and more significantly, validation of the software 'running' on the actual control hardware installed or destined for installation. In a fully integrated HIL simulation it is used in lieu of environment and thruster forces and simulates/models the responses of vessel systems extraneous of the system under test. Currently, HIL testing is considered for three vessel control system applications; the Dynamic Positioning System, Power Management System (PMS) and Failure Mode Effects Analysis (FMEA) Proving Test.

1. For DP HIL, some manufacturers have developed direct HIL interfaces to their respective DP system controller(s).
2. For PMS HIL, vendor's I/O hardware must be emulated or manipulated by extraneous hardware/software to simulate system response. Some manufacturers are working on a direct HIL interface for their respective PMS controller(s).
3. For FMEA HIL, the simulation computer is positioned between the manufacturers HMI hardware and control hardware to simulate software/hardware failure or the inadvertent, unintended action, as exposed or speculated under an FMEA.

Note:

- DP-HIL testing first conducted by Marine Cybernetics in 2004 onboard *Viking Poseidon;* equipped with a Kongsberg Maritime DP system.
- First PMS-HIL testing conducted in 2006 onboard the *Bourbon Mistral*; equipped with an Ulstein/Megacon PMS.
- First HIL Test Certification issued by DNV in 2007 for the *Acergy Osprey*; equipped with a Kongsberg Maritime DP system.

To be used at FAT (Factory Acceptance Tests), Sea Trials, Annual Trials, Periodic Testing and after Software Upgrades.



HIL Testing of Control Systems:

- **Dynamic Positioning: DP-HIL (since 2004)**
- **Power Management Systems: PMS-HIL (since 2006)**
- **FMEA HIL (Verification of findings/assumptions)**

Data Logging and Analysis

Throughout the drilling industry the expectation for more detailed drilling data has grown steadily over the past ten years. While most of the interest currently circulates around the drilling operation and performance, fluid management and well control, we have every reason to expect vessel operation and efficiency will ultimately be scrutinized through data analysis. DP systems have historically integrated a logger/historian, but the integration of loggers is being promoted within Transocean Engineering for other critical control systems such as BOP multiplexed controls, integrated drill floor robotics and safety systems. We are currently focused on "OPC Compliance" for this data exchange.

What is OPC? For a detailed, technical explanation, please refer to the OPC Foundation (www.opcfoundation.org/), but in brief the organization strives to adapt or create standards and specifications in support of open data "connectivity in industrial automation and the enterprise systems that support industry". Depending on your age and exposure to Control-Geek acronyms, you may well recall "OLE for Process Control", although it's been rumored that there are attempts to reinvent the name. "OPC" that is, not "Geek". Sliding deeper into acronyms, OLE or Object Linking and Embedding, was developed by Microsoft and allows objects from one application to be embedded within another (i.e. taking an MS-Excel spreadsheet and putting it into an MS-Word document). OLE is commonly coupled (OLE/COM) with COM, or Component Object Model technology in the Microsoft Windows set of Operating Systems. COM enables software components to communicate whereby developers create re-usable software components, link components together to build applications, and take advantage of MS-Windows services.

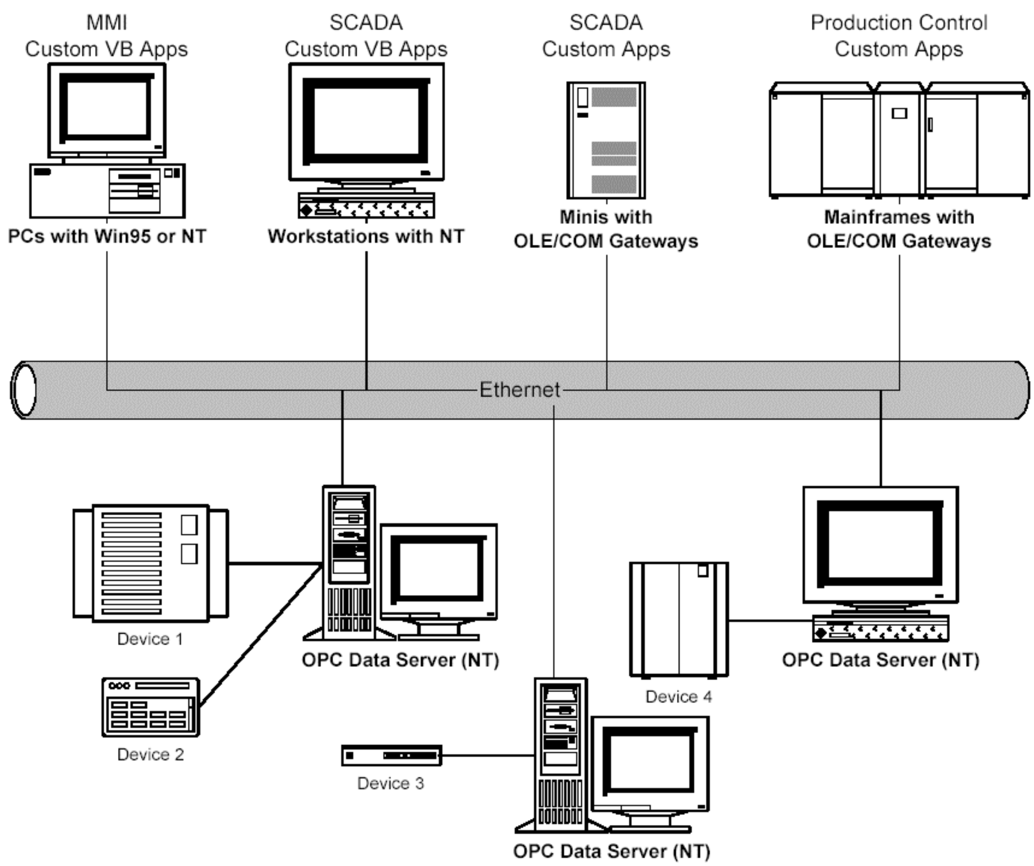


Figure 1-3. Heterogeneous Computing Environment

In 2004 Transocean began developing DP and Vessel Management System specifications which called for OPC-DA compliance. Progressively through 2005 to 2007, we have pushed this requirement to Integrated Drilling Control and BOP-Multiplex Control Systems. Not surprisingly, the 'DA' is derived from Data Acquisition. We are also considering the merit of other OPC tiers such as OPC-HDA (Historical DA) and OPC-XML.

The data sharing 'vision' is to facilitate a common (networked) database whereby Transocean can access all variables, real-time and historical data, regardless of whether it lies within DP, Vessel Management, Integrated Drilling Control, or the BOP Multiplex Control System. This vision is not always in concert with the vendor's product development. Each vendor attempts to develop and market a 'Trend and Reporting' package which focuses on the visual presentation; their vision of presentation. Our major concern is the retrieval of time synchronized data. With seamless access to the data, we as the end-user can then select the presentation package which best suites our specific needs (i.e. trend analysis, event analysis, periodic reporting, etc.).

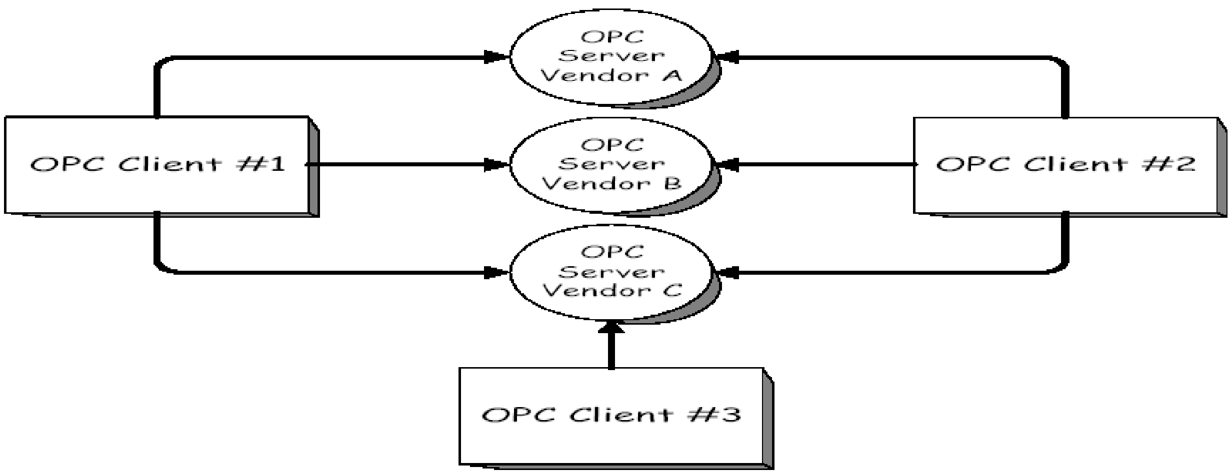


Figure 2-2 OPC Client/Server Relationship

<u>Thinking about the Possibilities</u>

As we continue to address the implementation of each of these three issues, we realize the potential for interaction of data if we are able to seamlessly interface the systems.

1. Capture of historical data via the OPC exchange has the potential to playback 'live' incidents directly on a Training Simulator.
2. Capture of historical data via the OPC exchange has the potential to playback 'live' incidents directly on an HIL Simulator.
3. Utilization of logged events/data via OPC exchange could shorten program development of Training and HIL Simulators.
4. High speed data exchange may facilitate utilization of the HIL 'test-bed' (e.g. the actual, operating hardware and software) as the DP Training Console, or vice-versa.
5. The OPC data logger could serve as the historical archive for Trainee assessment and performance could be trended over any period or level of severity.
6. The OPC data logger could serve as the historical archive for HIL Verification Test(s).

7. A combination of advanced simulation and HIL could utilize sophisticated equipment models to accurately emulate real world plant response and HIL technology to accurately emulate failure modes – as detailed by the data logger records. The failure mode simulation can be verified against a known rig model by comparing the simulated failure results to actual data logging records. If the predicted and historical results agree, the same failure mode can be retested with different diesels, generators, or thrusters. This has the potential to dramatically speed up the design process, and allow us to utilize entirely new technologies with less risk of extended delivery due to unforeseen problems. By eliminating surprises, it also has the potential to improve the delivery schedule.