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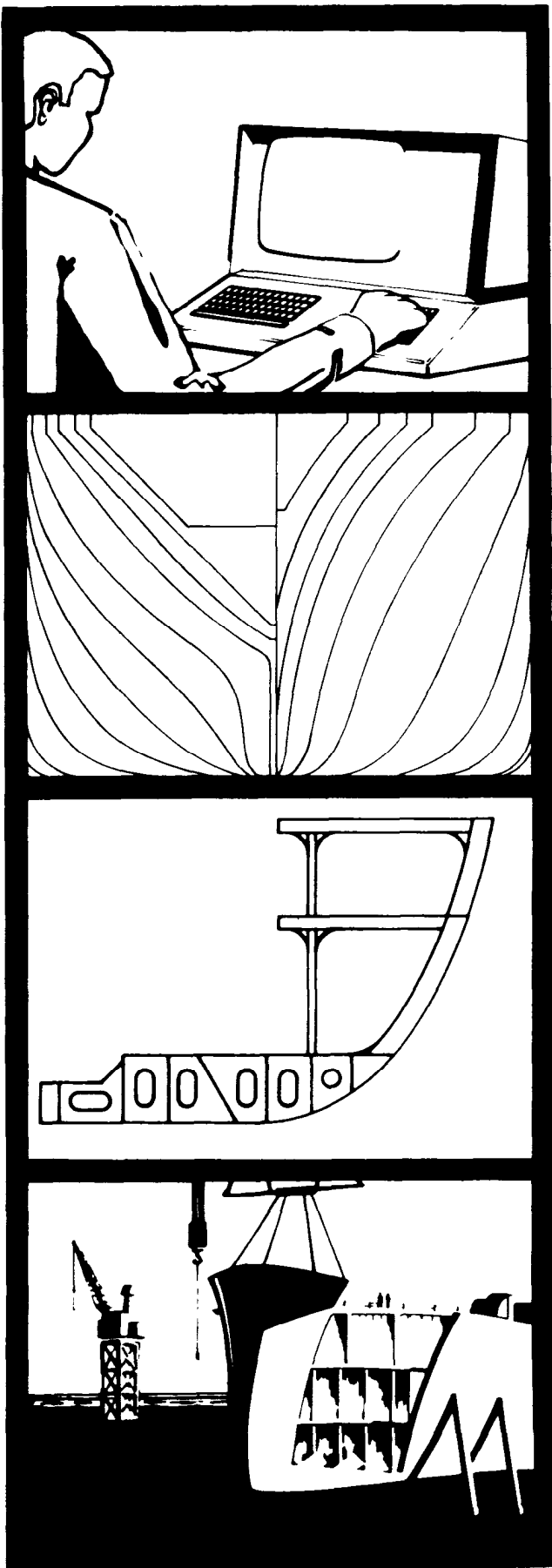
Paper No. 9: Drawing Office to Part Cutting with a Mini-Based On-Line System

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DRAWING OFFICE TO PART CUTTING WITH A MINI-BASED ON-LINE SYSTEM

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ABSTRACT

Port Weller Dry Docks, a small, progressive Canadian shipyard has recently installed AUTOKON-79, AUTOPART, AUTONEST and developed several pipe fabrication and installation programs on an in-house PRIME 550 minicomputer. In addition, the company has purchased several graphic peripherals and a Union Carbide Plasma burning machine with DNC capabilities that are used in conjunction with the software.

This paper summarizes the reasons for making these moves, the justifications, and the problems encountered.

1 Overview of the Computer-related Changes Made at P.W.D.D.

In the last year, many computer-related changes have occurred at Port Weller Dry Docks. These changes include the purchase of the following hardware components:

- a PRIME P 550 computer and related hardware
- two additional TEKTRONIX 4014 graphic terminals
- a TEKTRONIX 4863 plotter
- a CALCOMP 960 plotter with a 907 controller
- a UNION CARBIDE CM-150 plasma burning machine

In addition, PORT WELLER purchased the AUTOKON-79 application software package from SHIPPING RESEARCH SERVICES.

2 Hardware Description

2.1 The PRIME Computer.

The computer purchased consists of the central processing unit, three-quarters of a megabyte of error detecting and correcting main memory, one AMLC (asynchronous multi-line controller) board that allows 1b peripheral devices to communicate with the computer, a 75 IPS, 1600 BPI magnetic tape driver, and two disk drives for the storage of databases and programs. Each disk drive has the capacity of storing approximately 80 million bytes of information.

In addition, several other minor peripherals were either purchased or 'borrowed' from the previously used SPERRY-UNIVAC mini-computer. These include several VOLKER-CRAIG CRT'S two PRINTRONIX 300 line per minute printers;, and a FACIT serially interfaced paper tape punch.

2.2 The TEKTRONIX equipment

Prior to the purchase of the equipment described in this paper PWDD had purchased a TEKTRONIX 4014 graphic crt with the enhanced graphics option, and a TEKTRONIX 4662 plotter. Both of these devices were used on our 'other' computer for the validation of ESSI elements. The 4662 is a very small, slow flatbed plotter with a plotting area of 11. by 15 inches.

The additional TEKTRONIX equipment purchased consisted of two 4014's identical to the existing one and a TEKTRONIX 4663 flat bed plotter. The 4663 is larger (15 by 22 inches), faster than the 4662 and has many additional features (some that are extra cost options) that are heavily used. For example, all circular elements are generated by the 4663 with a single 'draw an arc' command from a computer program in the PRIME. The 4662 requires the driving program to fabricate a circular element as a large number of very short chords. This feature greatly reduces CPU and data transmission overhead, and as a result, increases plotting throughput.

Secondly, the 4663 can accommodate two pens of a different colour. This feature allows us to use one colour to show 'burning' while the other colour represents 'rapid traverse' while drawing ESSI elements. Again this represents an increase in throughput because the many pen up pen down pen accelerate and pen decelerate operations found in the conventional dashed line representation of rapid traverse lines are not required.

A third heavily used 'additional' feature of the 4663, is its capability to feed paper over the plotting surface from a roll of paper stored on the plotter. This allows continuous plotting of ESSI elements without any operator intervention. The program in the PRIME produces one plot, moves the paper, produces the next plot.....

2.3 The CALCOMP plotter

The CALCOMP 960 plotter is a mylar 'loop' plotter that is a cross between a flatbed and drum plotter. As such, it has both the good and bad features of each concept of plotter. The plotting surface is large enough to handle nearly all of PWDD's plotting requirements (33 by 60 inches). Two pens are available, giving it the speed advantage found in the TEKTRONIX 4663 plotter. Plotting speed is very fast --- 30 inches per second axial, 42 inches per second diagonal. Pen acceleration is 4g axially. Plotting resolution is 0.0005 in.

The 907 controller interfaces the 960 plotter to the PRIME computer. It is a micro-processor based device that has many additional features not found in the 960 plotter. In addition to containing a 2K byte buffer, circular elements and dashed lines can be generated with very short commands from a program in the PRIME, thus reducing CPU and data transmission overhead.

2.4 The UNION CARBIDE CM-150 plasma burning machine

The UNION CARBIDE CM-150 gantry style burning machine is equipped with two plasma arc torches, two zinc powder spray marking units and is controlled by a COMPUTER AUTOMATION mini-computer. The torches are powered by two 600 amp power supplies.

By using a newly developed height sensor, underwater cutting was achieved, thus eliminating noise, smoke and ultra-violet rays. This is done in one of the three pairs of 13 by 38 foot water tables. Water from a reservoir beneath the tables is forced over the plates to be cut using compressed air. The flooding process takes only a few seconds.

Cutting is performed at a rate of 90 inches per minute through 12 MM plate. Zinc marking is performed at 90 inches per minute, with intermediate rapid traverse at 250 inches per minute.

The COMPUTER AUTOMATION mini-computer is equipped with a keyboard, paper tape reader, five inch CRT and floppy disk. Burning instructions can be manually entered into the computers memory via the keyboard, or to the floppy disk via the paper tape reader or over telephone lines directly from the PRIME computer.

3 Reasons for upgrading PWDD's computer facilities

Prior to adding the additional computer power, PORT WELER DRY DOCKS used the services of a service bureau's UNIVAC 1108 computer. The 1108 was a fairly old machine, and its reliability posed a problem to PWDD's production schedule. The machine was 'down' on a near regular basis. Turnaround time was not as good as should be expected because, in addition to its already heavy workload all users were behind following an extended period of down time.

However, the service bureau replaced the 1108 with a faster, much more expensive UNIVAC 1180/1 computer. As the turnaround speed increased, so did the cost of the services !

In addition, SHIPPING RESEARCH SERVICES were beginning to market some interactive ship building packages. Because of their interactive nature and the distances involved, the cost of data communications would have prohibited their use.

By this point in time, technology in the mini-computer field had advanced to the stage where several mini-computer vendors were offering reasonably priced machines capable of handling the AUTOKON package.

The combination of the above warranted a serious investigation of the feasibility of 'in-house' AUTOKON. After careful study the decision was made to purchase the PRIME computer, TEKTRONIX graphic peripherals and the AUTOKON-79 software. The decision to purchase the CALCOMP plotter came as a result of continuous unreliability of PWDD's existing large flatbed plotter.

4 Reasons for upgrading PWDD's flame cutting facilities

The plasma machine was purchased to realize increased speed and accuracy over the oxy-fuel machine that it replaced. Cutting costs and fit-up costs have been greatly reduced. Cutting speed⁵ were increased by about 400 % and accuracy is now +/- 1 MM as compared to +/- 3 MM for the oxy-fuel cutting.

5 Additional Software

5.1 The Pipe System

Several year⁵ ago, PWDD purchased CONRAC pipe bending and WELCA cutting machines. The machines are not numerically controlled, but rather are manually controlled from a panel containing several function switches and dials. The bending machines are capable of bending up to 8 inch pipe cold and the cutting machine can cut mitre, saddle, contour and bevelled end⁵ and holes.

When the machine⁵ were first used, the pipe squad had to perform a large series of tricky trigonometric calculations to determine the machine setup. Not only were these calculations time consuming and a Source of much frustration, they were prone to many errors.

Several computer programs were written to reduce some of the drawback⁵ associated with the use of these pipe preparation machines. The pipe squad fed the ship coordinates of each critical point in a pipe to the computer. The computer then performed all of the calculation⁵ and printed a report that is used by the machine operator to setup hi⁵ machine.

This approach was a vast improvement, but still allowed errors to slip through. Graphical feedback was needed. The appropriate program⁵ were written to draw a single line representation of the pipes that were fed into the computer by the pipe squad. This reduced errors before they got to the pipe shop and therefore reduced

wasted materials and manhours.

Recently, the decision to expand the computer's role in the piping operation has been made. The expanded concept includes :

- extending the graphic capabilities to allow the computer to draw 'pipe details' (rather than doing it manually) to draw 'installation drawings' that can be given to a pipe-fitter when he goes aboard ship and to draw composite drawings' of entire piping systems.

- establishing a pipe database that contains details and statistical data. This will allow the pipe shop to minimize machine setup time because they will be able to extract pipe by 'categories'. For example they will be able to ask for a list of 'all seamless 4 inch pipe that are ready to be bent'. In addition the planning department will be able to track the progress of pipe systems as they move through the various Work stations.

- prepare installation packages consisting of 'installation diagrams' and a material requisition list of all materials needed by the pipe fitter to perform the installation.

At this point in time, only a limited portion of the expanded concept is in active use. The additional required software is currently under development.

5.2 The Hull Steel Software

The AUTOKON software was updated to include all new developments and enhancements to the SHIPPING RESEARCH SERVICES software. The most significant additions were TRALOS TRADET, and DRAW programs for the design office, and AUTOPART, AUTONEST, and AUTODRAW for the mould loft.

The design programs are used to load all internal Structure, and has the facility for providing drawings for use by designers. The information can later be retrieved by programmer for the production of coded parts for N/C flame cutting.

The production programs are accessed with a graphic terminal and allow an N/C part coder to interactively code a part, or nest' previously coded part at the terminal. This concept greatly reduces lead time required by the mould loft.

6 Problems Encountered During the Expansion

6.1 Hardware Installation and Reliability.

All hardware was installed in early November, 1979. The PRIME computer, disk and tape drives, and one of the 300 LPM printers were installed in PWDD's existing computer room which is located in our main administrative building. The balance of the hardware was installed in PWDD's 'old' computer room that is located in the mould loft, adjacent to the men who deal with the AUTOKON system on a daily basis.

The decision to install the PRIME computer and major peripherals in PWDD's existing computer room, as opposed to in the loft was based upon two years experience of having a computer located in the loft. The loft location had several deficiencies that were hazardous to the successful operation of a computer. These include electronic pollution in the form of radar, from ships passing through the WELLAND CANAL; electronic pollution from heavy welding and gouging operations located in the shop below the mould loft; noise and the electrical power lines caused by heavy power usage in the shop below; vibration problems resulting from the two 10 ton cranes in the shop; and a general dust problem resulting from dirt particles migrating from the shop into the computer area.

The distance between the two locations, about 400 metres, posed the first installation problem. It was necessary to run a shielded multi-conductor (52 pairs) cable from the computer to its peripherals. In addition, the distance required signal amplification in the form of short range modems at either end of each RS-232 communications line. The other communication lines, set up to run 20 ma current loop, did not require these modems.

Installing the PRIME computer along side the original

computer posed the second problem. Because of the electrical demand found in a shipyard, the power sources are subject to certain noise and instability that are detrimental to the successful operation of a computer. PWDD had resolved the problem by installing several voltage stabilizing transformers to protect the original computer. However, there was not enough capacity in these units to accommodate the additional power requirement of the second computer, nor was there enough physical room to add additional units. As a result, it was necessary to install a new 75 KVA voltage stabilizing unit in place of the older, smaller ones. The units that were removed were relocated to protect the graphic peripherals in the loft area.

The hardware has been installed and running for nearly a year. It has performed remarkably well with only minor problems. One disk drive went down thanks to a washer that was floating freely in the area of the coil that controls the head movement. This caused major damage to the drive. Prime REPLACED the entire drive. Other minor problems have occurred, but nothing significant enough to interrupt the use of the machine for longer than a couple of hours.

Only one major disappointment in the area of expected hardware performance has occurred. The TEKTRONIX 4663 plotter was purchased with the understanding that ball point pens could be used to get the very fine plot line required to check accuracy in tenth scale drawings. Unfortunately, TEKTRONIX has not been able to deliver such a pen even after being pressured to fulfill their end of the contract concerning this matter. Currently, felt tip pens must be used, yielding a plot line that is fairly wide.

6.2 Systems Software

Although the software supplied by SRS could directly be run on the PRIME with little or no change, it was necessary to write additional programs to organize data structures, control resources, drive graphics devices, and generally make the best use of the hardware and software in as foolproof and simple a fashion as possible.

All data files are separated into 'project areas-' on the disk. A typical project area is the aft end of a ship. These project areas are further divided into three 'sub-areas': one for ALKON part manuscripts, one for NEST

manuscripts, and one for miscellaneous files. Each of these 'sub-areas' is further divided into three sections: one for input text files (manuscripts), one for output print files, and one for paper tape image files. Corresponding file5 in each of these final three areas have the same name.

With this 'tree structure' approach, file5 seldom get lost and can be collectively manipulated, thus reducing housekeeping to a minimum.

The non-interactive software supplied by SRS runs in a fashion similar to the way it runs on a large mainframe Computer. A JCL file and data file are presented to the computer, which in turn executes the specified program producing a listing and perhaps a paper tape file. As in the mainframe, one and only one program may manipulate a database at any given time. To ensure this is the case, and to eliminate the concept of JCL file5 entirely, PWDD developed a queuing system.

An operator will 'login' to a specific area of a project, type a manuscript into a file, and then instruct the computer to execute a program with a simple command such as 'Q ALKON PART 12' to run ALKON using manuscript PART 12. The queuing system takes over. It maintains a queue for each database, each plotter and the paper tape punch. If one of these resources has a 'Job' waiting to run, if no other 'Job' is using the resource, and if the computer is not already working too hard (page fault count is respectable), the queue dispatcher will initiate the Job. This is done by taking a 'JCL template' file filling in the appropriate blanks (project number, database name, data file name....) to generate an appropriate JCL file, and finally starting the JCL stream into execution. When the Job finishes, it automatically notifies the dispatcher program that this is the case. The dispatcher will start the next Job for that device or database.

A queue monitor was also written. This allows any operator or data entry clerk to manually control the queuing system. For example, the operator can stop the dispatcher from starting any new Jobs for a given queue, manipulate the order of queue entries, delete entries from a given queue, or re-route platter requests from one plotter to another.

In addition' this monitor displays certain performance characteristics for each 'Job' and or user in the system. Such detail5 a5 accumulated CPU and I/O time, amount of memory occupied....are available at a glance. Also, general machine performance characteristics are displayed. These include page fault information, CPU usage and I/O activity.

An additional data manipulation system has recently been installed. This concern5 the control of data transfers from the PRIME computer to the UNION CARBIDE plasma flame cutting machine. Once an ESS1 tape ha5 been validated and approved by the mould loft' an entry is made into the control file indicating that this is the case. The shop can interactively inspect this control file to determine which of the 'released' burn tape5 they wish to select far their burning schedules. Once the selection is made, an operator in the shop will instruct the PRIME to transfer the burn tape electronically over telephone lines to a file on the plasma cutting machines floppy disk. A5 the transfer of files takes place, the PRIME computer records when' and where the file has been transfered.

This DNC approach virtually eliminates paper tape at PWDD and automatically prepare5 records of burn tape transfer5 from the mould loft to the shop.

6.3 SRS Software

The installation of the SRS software on the PRIME computer was a massive undertaking. Not only was there several hundred thousand lines of field proven programs to be converted to run on the PRIME, but there were the new programs, which were not fully field proven, to install. Taking this into consideration' it must be stated that the SRS software is, in the mast part, holding its own on our mini.

The initial release of the proven software did contain several 'bugs' that have now been fixed. Periodically' PWDD uncovers new 'bugs' in the newer programs. As they are uncovered' the are fixed--either by PWDD staff' or, if the bugs are of a major nature, by SRS staff. Soon, this software will be fully field proven.

The most significant disappointment in the software enhancements' from a 'systems man' point of view' is the database incompatibility between the various systems.

ALKON, TRALOS, TRADET and DRAW employ the AUTOBASE type database. AUTOPART and AUTONEST each employ their own style of database. Although this approach was taken to facilitate the necessary quick response time needed in an interactive system, it requires careful management to control the transfer of appropriate information from one database storage method to another.

7 Summary

PORT WELLS DRY DOCKS is a pioneer in many areas of shipbuilding. One of these areas is in the use of an 'in-house' mini-computer for N/C tape preparation. Being a pioneer can be very expensive---a lot of hard work, a fairly extensive capital layout, and non-productive time smoothing out the rough areas, learning from our own mistakes as opposed to the mistakes of others.....

However' the efforts of our pioneering are now beginning to bear fruit and will continue to do so in an ever increasing fashion as time progresses.

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