REALIZING BENEFITS FOLLOWING THE ACQUISITION OF A CAD SYSTEM

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ABSTRACT

NOVA, AN ALBERTA CORPORATION, as a heavily engineering oriented company, makes use of several different CAD systems and AEC applications for piping layouts for compressor and meter stations. The CAD equipment was originally purchased for drafting the final engineering construction drawings and more recently has been expanded for use as a design tool. Although the systems are graphically 'turn key', there has been a substantial amount of tailoring done in order to effectively realize increased productivity benefits. Productive use of a CAD system for drafting as well as design has presented some procedural and processing bottlenecks which we are attempting to overcome. The following paper presents an overview of our development work and the problems we are trying to resolve.

KEYWORDS: CAD, AEC, benefits

INTRODUCTION

The use of electronics for Computer Aided Design began at NOVA in December 1977 with the delivery of an Intergraph (then M&S Computing) PDP 11/34 based interactive graphic system. It was installed in the Drafting department to be used as a drafting tool for the purpose of generating engineering drawings which would be used to construct compressor and meter stations. Cost justification was based on productivity increases required to offset the need for overtime and contract work which was then increasing drafting costs at a rate of 22% per year. CAD vendors at the time, were quoting productivity increases of 4:1 for brand new drawings done on their systems and 10:1 for redrawing from existing designs. Such figures certainly justified the purchase, however, there was really no way to verify their accuracy. Regardless, productivity increases were expected to be the major benefit realized from the acquisition, thus eliminating the need for contract personnel and improving the drawing turnaround time. As well, it was thought, the capability would exist to enforce drawing standardization.

Following installation, the first major software development project on the system was incorporating interactive graphics, and computer facilities generally, into the departments' work flow. This took the form of a drawing library index system to:

1. Provide a cataloguing of all computerized drawings.

2. Manage resources by providing tape archiving and a tape library system.

3. Provide the potential to track other administrative functions such as time reporting, accounting, and general project management.

The development and maintenance of this system has been ongoing over the past four years and will be discussed in some detail later. It is mentioned here because in the fall of 1980 the Drafting department load indicated a need for expanded capabilities and a second market study was undertaken to determine what equipment should be obtained. At this time it was possible to generate statistics from the Drawing Library system with respect to the type of work being done and the length of time taken to do it. The productivity increase resulting from the use of the Intergraph system had averaged 3.7:1 over conventional drafting and the number of draftpersons had decreased although the work load had not.

The result of the study was the addition of a four station Calma system delivered in September 1981 and a second Calma system acquired in November 1982. Again the primary justification was increased productivity, however, the decision to purchase the Calma system was also a decision to enter a 3D modelling environment or, as the marketing representatives call it, the Architectural, Engineering and Construction (AEC) area. Over the past four years the Intergraph system has been upgraded several times also and our present hardware configuration is shown in Figure 1.

Although the systems are graphically turn-key, it has been our experience that a substantial amount of work must be done in house before they are truly productivity-increasing tools for either design or drafting. The rest of the discussion will cover this development.

DEVELOPMENT APPLICATIONS

Before our CAD system could be productively used for drafting or design, two basic items had to be put in place:

1. STANDARDS

   One of the powers of CAD systems is the reusability of a design or drawing. At NOVA, this has evolved into the generation of standard base drawings from which new designs are created. Electrical drawings, in particular, have proven conducive to standardization so that the estimated productivity increase ratio here is 8:1.

2. ACCURATE ENGINEERING DATA BASE

   The validity and usefulness of the piping model or drawing is totally dependent on the information used to build the model - pressure ratings, temperature ratings, inlet/outlet diameters, material, etc. Creation of the data base(s) is intially a labour intensive data entry task involving cross referencing from different equipment catalogues. Maintenance of the data base must be the responsibility of a designated individual who understands both the data base administrative concepts such as transaction processing, format, adequate backup, and so on, as well as knowing the piping discipline well enough to verify data accuracy. This is added overhead to the CAD department, however, without it the system is not useful as an engineering tool.

With the basics then in place to generate drawings or to design, development began on applications to tailor the systems to NOVA's specific needs and to attempt to fully realize benefits in the form of productivity increases. To date, these applications have covered four main areas.

1. DOUBLE LINE PIPING SYSTEM

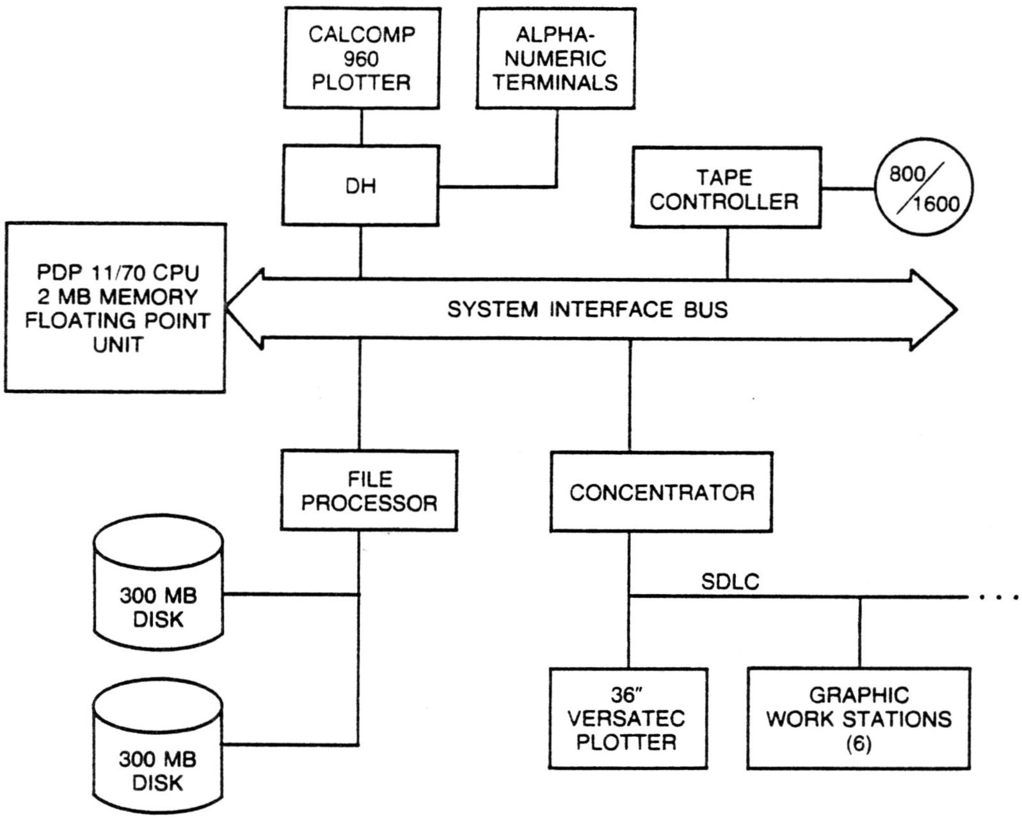
   The drafting disciplines used on the systems are mainly mechanical, civil and electrical. Mechanical, at NOVA, implies piping which is a design intensive specialty. Complex spatial relationships and highly variable specifications for components demand a sophisticated integration of information for relatively simple piping networks.

   From the initial installation of the Intergraph system, a constant requirement has been to produce double line piping drawings for valve assemblies, blowdowns, meter runs, yard piping, etc. Records show that over 30% of the work load has been in generating these drawings, thus development has been undertaken to automate this process as much as possible. Among the first areas of development on the Intergraph system was a set of Double Line Piping Routines.

   The Double Line Piping package allows the interactive placement of pipe runs and a minimal set of fittings (tees, reducers, end caps, elbows (90 and 45), flanges and valves) in plan or elevation views with dimensions as stored in the piping data base (currently all standard fittings up to 34" nominal pipe diameter - stored in metric). Both single and double line representations are available for socket, threaded and butt welded fittings. The actual placement of pipe and fittings occurs in a direction indicated by the draftsperson and can run in centreline, face or repeat mode.

   - Centreline mode requires the identification of an existing centreline which will remain the working centreline until an elbow is placed. At this point the new centreline automatically becomes the working centreline with the direction running in the direction of the turn.

INTERGRAPH



CALMA (Two Systems)

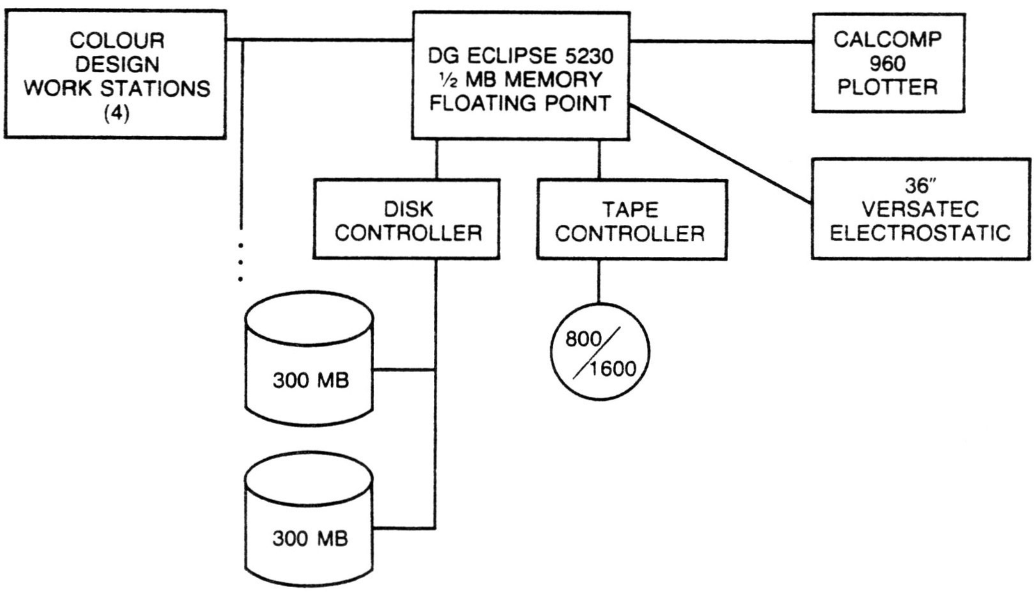


FIGURE 1

Graphics Interface '83

- Face mode also requires the establishment of a working centreline and direction, and each fitting placed requires the identification of an existing weld face or the raised face of a flanged end.

- Repeat mode allows the draftsperson to move about the drawing placing fittings as required. It requests the identification of two centrelines for each placement.

Work on this project has resulted in a more formalized standard for the symbolic representation of piping elements and has greatly improved efficiency in producing piping drawings. It is, however, strictly a graphic representation and no non-graphic information is associated with the drawings.

2. 3D DESIGN TO 2D DRAWING CONVERSION

With the addition of the two Calma systems, a method of quickly providing the symbolic representation of pipe runs and fittings evolved for slightly different reasons. There are distinct capabilities which separate an efficient drafting graphic system from an effective design graphic system.

For example, high priorities for a draft ing system would be:

a. System response - speed
Ideally, we would all like instantaneous response all of the time. However, in a production environment system speed is much more critical to drafting because the design phase has been completed, it has possible taken longer than expected, there are deadlines to meet, revisions to be made and a complete set of drawings was needed yesterday.

b. Ease of editing

Again, mainly due to deadlines, the graphic editing process must facilitate expeditious use in a drafting environment as the first set of drawings produced will not be the last.

c. Drafting capabilities

Most drafting work is done two-dimensionally. Piping elements need to be represented symbolically as the drawings will be used during actual construction and ambiguity must be avoided.

Whereas, for a design system, additional significant concerns are:

a. 3D facilities

True edge view display of elements with accurate dimensions is necessary for interference checking. Rotation and sectioning capabilities and some form of hidden line removal are required for producting final drawings from designs.

b. Non-graphic information

The real design power lies in maintaining intelligent information within or associated to one's model so that analysis of the design can occur.

Both of these criteria will significantly impact the drafting priorities of system response and editing ease.

The initial CAD installation at NOVA was specifically for drafting purposes and to-date the predominate function is the creation of engineering drawings for construction. However, with the acquisition of the second and third systems, modelling and design characteristics weighed heavily in the selection process. We are, therefore, endeavouring to efficiently use a graphic system for both design and drafting and have had to undertake some development work to expedite the 3D model to 2D drawing conversion process.

Specifically, a model is composed of a collection of elements drawn to scale with, non-graphic information associated with each element. A simple example is shown in Figure 2. The required graphics for the final drawing are shown in Figure 3. Our specific bottleneck in the design to drawing transfer is that Figure 2 is composed of elements such as pipes, valves,

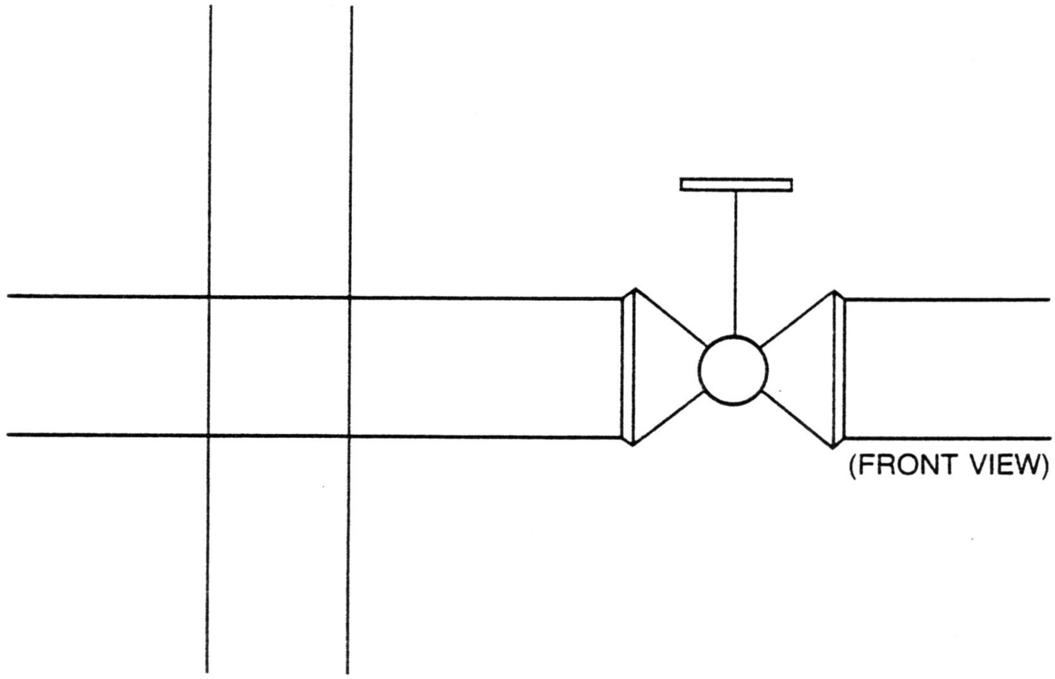


FIGURE 2

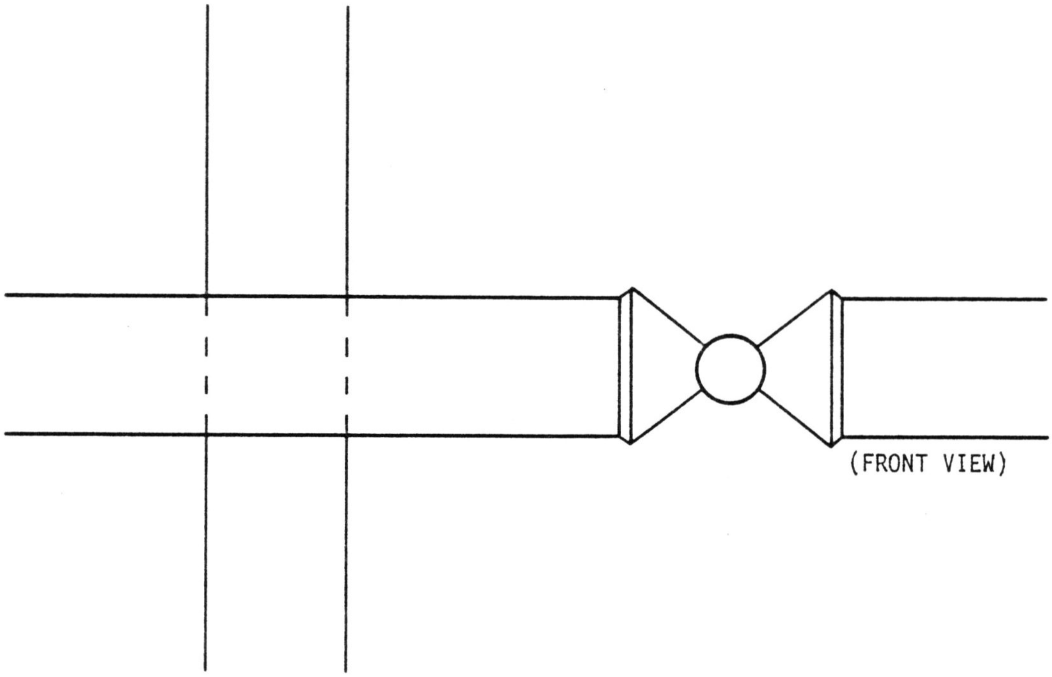


FIGURE 3

fittings, etc. and not graphic primitives such as lines and circles. In order to edit and 'clean up' the design for drawing representation, the individual primitives of the elements must be editable and the 3D representation substututed by a conventional symbolic representation. (The problem is somewhat exaggerated by the fact that we do not have a full hidden line removal package which would allow elimination or fonting of lines to indicate, for example, which pipe is below the other.)

Very briefly our process for the 2D supercedence is as follows:

a. Those elements to be replaced are selected. The replacement must take place in a view or orientation of the model which is orthogonal to its model co-ordinate system.

b. A point in space is identified which will be the depth value for the final orientation window. This is necessary to handle Z-clipped or sectioned views, as the plane onto which 2D representation is projected must lie within the depth of the section in order to be seen.

c. Non-graphic data carried with each element and with each type of element provides dimension information and co-ordinate points associated with the element. The model working co-ordinate system is aligned to the plane at these points at a depth of 0, the symbolic representation is drawn on the plane and translated to the depth specified.

The process is not all-encompassing as we have only included elbows, valves, tees, flanges, unions and pipe. These cover approximately 80% of the fittings used by the department. The pilot project which is being used to test the system has not yet been completed, so there are currently no figures available regarding time savings, aside from our intuition and initial estimate that 'clean up' (not actual design time) could be cut by at least 40 to 50%.

3. BILL OF MATERIALS

A time-consuming, error prone task has always been doing materials takeoff from the final drawings. On the system being used for modelling, a Bill of Materials utility is provided which has simply been modified to conform to NOVA's BOM format. A dilemma arises, however, when working in a production environment with approaching deadlines and numerous revisions to drawings. The fastest 'back drafting' process is to go straight to the drawing, not the model, and edit it. In doing so, however, the integrity of the model is lost as the changes are not reflected in it, therefore, the integrity of the bill of materials is lost for the drawing itself carries no non-graphic information. If the changes are made to the model, the drawings are automatically updated, however, additional 'clean up' is then required to produce the proper drawing symbology. The problem is further compounded if a design project is split over two different systems. Again, as we are just completing our pilot project, a workable solution to the problem has not been decided upon. In the meantime, a set of programs has been developed to accelerate the traditional manual approach by allowing one to follow a run of pipe, entering pipe lengths, valves, elbows, etc. as they occur. Tallying and cross-referencing to material specifications is then automatic.

4. DRAWING MANAGEMENT

The ability to track drawings through the department and identify operator work loads and productivity comes largely from the genesis of a Drawing Management System, referred to earlier, which stores all drawing and project histories. Features of the sytem include:

a. The ability to interactively search the Drawing Index on file descriptive information. Figure 4 lists possible search criteria and provides an indication of the type of data recorded for each drawing.

THE SEARCH PROGRAM ENABLES THE INDEX TO BE SELECTIVELY SEARCHED ON ANY OF THE FIELDS OR SUBFIELDS OF AN INDEX RECORD. UP TO 10 FIELDS MAY BE SCANNED AT ANY ONE TIME. CHOOSE A FIELD FROM THE LIST WHICH FOLLOWS AND ENTER THE PATTERN OF CHARACTERS YOU WANT TO MATCH. EQ.:
Specify a field number: 2<cr>
Specify field contents (9 characters): SAMPLE<CR>
Specify a field number: 45<CR>
CAUSES A SEARCH FOR ALL FILES WITH 'SAMPLE ' IN FIELD 2
(NOTE: YOU CAN DIRECT OUTPUT TO TI: OR LP:).

WILDCARDING IS ALLOWED.
'*' MATCHES ANY CHARACTER.
'?' AT THE END OF AN ENTRY IS THE SAME AS '*'s TO THE END OF THE FIELDS MAXIMUM LENGTH.
'?' AT THE BEGINNING OF AN ENTRY LOOKS FOR THE PATTERN STARTING ANYWHERE IN THE FIELD.

EG.: '?*412? WILL LOOK AT THE PATTERN OF ANY CHARACTER FOLLOWED BY '412' ANYWHERE IN THE ENTIRE FIELD.

SEARCHING MAY BE DONE OVER ANY OF THE FOLLOWING FIELDS:

1 : EXACT FILE NAME	17: FULL DATE OBSOLETE	33: COMPANY DIVISION
2 : FILE NAME	18: YEAR OBSOLETE	34: DEPARTMENT
3 : FILE TYPE	19: MONTH OBSOLETE	35: JOB REQUEST NO.
4 : FILE VERSION	20: DAY OBSOLETE	36: CHARGE CODE
5 : EXACT UIC	21: FULL DATE TAPED	37: CHARGE NO.
6 : GROUP	22: YEAR TAPED	38: DATE REQUESTED BY
7 : MEMBER	23: MONTH TAPED	39: FULL DATE DONE
8 : NOVA DRAWING NO.	24: DAY TAPED	40: YEAR DONE
9 : PLANT NO.	25: FULL DATE TO DISK	41: MONTH DONE
10: REVISION NO.	26: YEAR TO DISK	42: DAY DONE
11: BLOCKS ON DISK	27: MONTH TO DISK	43: FUTURE USE
12: DEVICE	28: DAY TO DISK	44: TITLE/DESCRIPTION
13: MAJ. DRAWING CODE	29: FULL DATE IN INDEX	
14: MIN. DRAWING CODE	30: YEAR IN INDEX	
15: FILE STATUS CODE	31: MONTH IN INDEX	
16: TAPE VOLSER	32: DAY in INDEX	

IN ADDITION YOU MAY SELECT 0 - FOR LIST OF CHOICES
45- COMMENCE SEARCH

FIGURE 4.

b. A tape archive/restore function to maximize online storage utilization. Drawings are normally 'marked for archive' and off-loaded to tape in a bulk process. A tape library system is part of this element.

c. Incorporation of time accounting information giving an indication of design station activity. Station samples are taken at regular intervals (currently every 6 minutes) and record drawings being worked on or idle time.

d. General maintenance tasks such as:

   - Online modification of the index.
   - Generation of a tape compress list.
   - The addition of new tapes to the archive library.
   - Tape status reports.
   - Consistency checks against the index and actual disk files.
   - Count of files to be archived.
   - Archival of a complete project.
   - Review of trace reports.

e. The production of standard periodic reports:

   - Projects by status - ongoing/complete
   - System usage by operator which includes active and idle times.
   - Index lists of all drawings associated with a given project, department or plant.
   - Operator time log reports suitable for use in filling out daily time sheets.

   As well, the ability to create ad hoc reports on a request basis exists.

Rigorous use of this system now means that drawings tend not to get 'lost'. With the wide range of search criteria available a drawing can be located with a minimal amount of information known about it. By being able to track entire projects, a history of activity is being built up to provide improved estimating and resource scheduling for future projects.

SUMMARY

Tailoring a CAD system to the specific needs of a company will take time and resources. We have found that it takes from six months to a year to tune a new system to an acceptable productive mode and this is not always a cost which is budgeted for as part of the initial acquisition. Following the development period, ongoing support and expansion of system capabilities occur both within the company and, of course, by the vendor.

Having realized increased benefits over conventional drafting, the CAD process should now be introduced earlier in the project so that it can be effectively used as a design too. If design and analysis can be finalized using the three-dimensional model, then the number of revisions necessary to the final drawings should drop substantially. If this happened, the items noted earlier as being priorities for a drawing system over a design system would soon merge and productivity benefits covering the total project rather than only the drafting portion of it could be realized. The potential of our Computer Aided Design systems at NOVA now lie in their integration into the total design and construction process.