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Computer Aided Design/Drafting

Development Recommendation

for

The Light Source Project

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1.0 Introduction

During all phases of the design of the 6-7 GeV Synchrotron Light Source, the design staff has assumed that most or all design and drafting for the project would be based on modern Computer-Aided Design/Drafting (CAD) equipment. The reasons and justification for this assumption are many and varied and include the following:

1. It represents a cost-effective approach to these tasks.

2. It represents a local and national trend in engineering technology.

3. It opens the possibility for numerical control (NC) interfaces.

4. It opens the possibility for Computer-Aided-Engineering (CAE) applications such as stress, temperature and other finite-element computations.

5. It will enable and insure consistent, high quality drafting work.

6. It will enable long term document control and enable future electronic access to project documentation.

7. It will ease DOE project audits which favor as-built documentation.

8. It can potentially avoid design errors by accurately reproducing and scaling multi-use parts and easily providing extra views and assembly drawings to reduce confusion by different drawing users.

The purpose of this LS note is to document all of the pertinent information gathered so far on this subject as it relates to the Light Source Project and to recommend a development scenario for the exploitation of CAD. This information includes not only generic CAD-related precepts but also that which relates to the special situation and environment of Argonne. Argonne has been lagging behind the technological community at large with respect to CAD (mainly because of a lack of construction projects and their attendant budgets) and is now in an expansion mode, providing training and centralized facilities and promoting CAD applications.

1.1 CAD and the Architect-Engineer and Construction Manager

No matter which architect-engineer (AE) is chosen for the Light Source Project, they will undoubtedly employ some type of CAD system and interfacing with the AE will be much smoother if we can do so with our own CAD system, especially if the two systems are the same or at least are easily translatable. Lester B. Knight, the firm we have been using for preliminary design work, has been told of our desires (in a rather insistent way) and they have already made tangible moves in this direction. This is also an important issue with respect to Plant Facilities and Services (PFS) in that eventually they will become the custodian of the physical plant and its as-built drawing files. For this reason, we should strive to maintain compatibility with their CAD system (AutoCAD).

2.0 Total or Partial Commitment to CAD

The question of whether project management should encourage (or demand) a total commitment to CAD as the only means of producing construction drawing documentation may be a foregone conclusion to some, but it will be important to establish such a commitment early in order to gain most or all of the benefits listed above. For this reason we should insure that the proper equipment be brought on line before it is needed and that all design team members are aware of this total commitment. To this end, the Light Source Project organization has aquired two AutoCAD drafting systems based on their favorable upgrade possibilities (see section 5.1, below).

3.0 Effectiveness of CAD Operators

The effectiveness level that we have been assuming during the design and cost estimation process is a factor of two. That is, once an operator is proficient with the equipment, he can be twice as productive as a conventional designer or draftsman. This assumption, for the most part, is borne out in discussions with CAD operators and supervisors. In reality depending on the complexity of the task, the factor may range from 0.9 to 1.5 in the preparation of the original document. Changes to that original, duplication of parts of it for other drawings, production of additional views, production of partial information drawings (non-dimensioned for slide production or insertion into other drawings, etc.), making special scale drawings for presentations or assembly can all be produced at an improvement factor as high as 10 to 20. This high factor should be tempered by the fact that since additional views or drawings are so easy to make, many more will be made.

4.0 Argonne Computer Aided Engineering (CAE) Committee Recommendations

The Argonne CAE Committee was put in place in an effort to correct the CAD deficiency of the Lab and to guide its implementation. The committee has evaluated several vendors' products and has settled on a two level approach to product recommendation, a basic, low cost drafting system and a full-function, high performance engineering workstation. (It should be kept in mind that as of this date the CAE Committee's recommendations have not been endorsed by the Argonne Computing Policy Committee [CPC]. Nevertheless they are presented here and subscribed to by the author on the basis that they are valid for the Project.)

4.1 Low Cost Drafting System, AutoCAD

AutoCAD is an IBM PC (or AT or XT) based drafting system. It is recommended as a low entry-cost CAD configuration for those groups or divisions having minimal budgets or whose needs do not exceed AutoCAD's capability. Numerous third party vendors provide both hardware and software products to enhance the normal configuration. This trend of increased capability (available from the AutoCAD vendor, Autodesk and from third parties) and the leadership position that AutoCAD has in the CAD industry made this system an obvious choice for the committee.

AutoCAD is a two-dimensional drafting system having a single screen (and single view of a portion of the drawing) display which is usually implemented with a separate, high resolution color display system. The

normal screen is then used for prompts and error messages. It uses a pointing device (mouse or digitizing pad), a dot matrix printer for draft-quality copies, and a plotter for final output. The plotter is more expensive than all other components combined but can be shared by several systems through a simple switch. The pointing device can be the keyboard cursor keys and so an absolute minimal configuration could be a basic IBM PC only.

4.2 Full Function Engineering Workstation, Intergraph

Intergraph is a mainframe (DEC VAX) based system having high performance attributes such as three dimensional manipulation and several add-on software enhancements such as finite-element analysis for stress and temperature, automatic volume calculation for material applications, etc. Third party software enhancements are also available, both as direct additions to Intergraph and by virtue of operating in the standard VAX-VMS environment of the Intergraph host. The same plotters used by AutoCAD are used and can be shared through the same switch. The standard VAX hardware is modified to improve file transfer speeds and so an existing VAX cannot be utilized.

The principal expense in the case of Intergraph are the software licenses, these being based on the host computer not on the workstations or their number. In addition, there are hardware and software maintenance expenses to consider. The host-related expenses are of course shared among the (hopefully) several workstations attached to the host. (The host-related licenses and maintenance do increase for a host computer capable of supporting a larger number of workstations.)

Communication between host and workstations is best provided by Ethernet but other, lower performance links can be used depending on cost and distance considerations. A reduction in screen update speed is the only real penalty paid with a slow speed link (estimated at about a factor of two after a test at Argonne).

A consideration which should not be overlooked is the potential reduction in performance when one or more users invoke a compute-intensive application such as finite-element analysis. Since the host provides most computational services, it will appear to slow down when given a compute-bound task.

Intergraph has recently announced the Interact 32-C model. This workstation has considerable local processing power and Intergraph is migrating application software from the VAX host to operate locally. The VAX host is still used for file service and for applications not yet migrated, therefore all features of the present system are still provided. The use of this workstation instead of the host-dependent version should make the user immune to the host slow-down described above. The cost of this quasi stand-alone system is about $9,000 less than the current model price of $49,000.

As part of its policy of fostering CAD development. the Lab has purchased an Intergraph system for use with workstations provided by user divisions. An initial complement of software was provided by the Lab but

maintenance and day-to-day service required for normal operation (system start-up and reboot, loading archive tapes) is paid for by user divisions (ostensively prorated by number of workstations). This service is provided by personnel of the Computing Services Division (CSD) in building 221 where the host computer is located. The current thinking is that any improvements needed, additional disk memory, additional host computer, will be provided for this central facility with Lab Program Development Funds (PDF). The model on which this feeling is based is that of the Lab telephone system - when the present system capacity is about to be exceeded, the next user is not required to pay for the necessary large increase in capacity.

4.3 AutoCAD / Intergraph Mixed Systems

One important consideration in the two-tier recommendation described above is the interchange of drawing files between the two types of equipment and this question was addressed specifically by the committee. The Engineering Division has both types of systems now in use and have successfully tested a translation program for both directions (AutoCAD to/from Intergraph). This program is now installed and runs in the Intergraph host VAX. It is a one step translation method and DOES NOT use an intermediate graphic representation such as IGES which is a definite point in its favor. The two CAD systems do not have an identical set of features but if care is taken in setting up drafting SOP, the differences can be nearly invisible.

The ability to interchange drawings allows the two systems to be used in applications for which they are best suited. Statements by an operator experienced in both systems reveal that AutoCAD is best for medium to small subjects since it is easier to use and faster whereas Intergraph is a lifesaver when dealing with large or complex layouts. Intergraph can provide up to eight subscreens depicting different portions of a drawing or portions of several different drawings, making possible several maneuvers which are very difficult and time-consuming with AutoCAD. The basis for these statements is the current work for the SDI neutral particle beam lines which represents experience which is directly applicable to the Light Source. The ability of Intergraph to support more complex engineering functions has not been explored by ENG but of course represents a special sphere for which it is suited.

5.0 CAD Development Scenario for the Light Source Project

The following recommendations are intended to guide developement and budget planning during FY 1987 and the following construction years. It is assumed that the project will be committed to CAD as the only method to be used for drawing production (as far as is practical) and that the Lab CAE committee recommendations will be followed as far as system choice is concerned. There are numerous valid reasons for this last assumption including the following:

1. The vendor evaluation used by the CAE committee was valid and resulted in reasonable choices for both systems.

2. Training on both systems will be transferable in the future, an important consideration as the project expands in the future. Also related to this point is the option to temporarily utilize non-project CAD operators.

3. The ability to share drawing files for such things as pumps, valves, and the more common architectural items will benifit the project.

4. The presence of identical CAD systems elsewhere on site opens the possibility of sharing hardware in the event of equipment failure.

5.1 AutoCAD Development

The Light Source Project has already embarked on AutoCAD development with the first system installed and a second system on order. Training of two draftsmen experienced in accelerators has been done at a preliminary level and they are gradually becoming familiar with the system. A plotter is also part of the complex. As activity increases during FY 1987, we should continue to add systems as we add draftsmen in a way that there is always one more system than the number of operators. This policy is justified for 5 reasons: (1) a system will be available for training; (2) a spare system can be used in case of hardware failures in the remaining systems; (3) the extra system can be used to run off plots without interrupting other activities; (4) the extra system can be used for quick looks and searches without interrupting other activities; (5) and the extra system can eventually be used by a drawing and revision checker.

5.1.1 Build-up Rate and Total Systems

It is difficult to assess the eventual design-drafting staff but the CDR indicates that a total of 53 man-years of effort will be needed, peaking at 20 persons during the second construction year. Even if the effort were level, a staff level of 12 draftsmen and coordinators is the result. Since the following sections will recommend the inclusion of an Intergraph capability, the total number of AutoCAD systems will be somewhat lower than implied. For these reasons, we should expect to add AutoCAD systems at a constant rate until the end of the second construction year and totaling 15 systems. At least two plotters will be needed to support these systems with the second brought in early in the first construction year. (These estimates and the cost figures below are, of course, affected by the level of design and engineering work farmed out to vendors.)

5.1.2 Networking AutoCAD to VAX Computers

During FY 1987, the control system task group will be testing the feasibility and utility of connecting both AutoCAD PC's and normal engineers' PC's to DECnet. This is to be accomplished with a "DECnet-DOS" addition to the effected PC's which allows them to use Ethernet for high speed communication with the VAX. The addition enables the PC to utilize the VAX as an additional disk (among other features). This will enable the AutoCAD system to use VAX public or

private storage space for CAD data, making it available to other CAD systems and to engineers as well. The implications of this scenario are important for the Light Source Project short term (design, construction and commissioning phases) and the long term (operational, improvement and experimental support phases).

5.2 Intergraph Development

The inclusion of an Intergraph capability is based on the reasons stated above in sections 1.0, 4.2 and 4.3 are are summarized here:

1. We will benefit from the ability to deal conveniently with large CAD data base representations (entire machines, beam lines, etc.).

2. Although no crying need for numerical control (NC) or finite-element analysis was uncovered during interviews with Light Source design team members, many felt they may eventually make use of such features. Experience indicates that if such feelings exist now and the tool is made available, it will be used and the Project will eventually benefit.

3. Considering the lower cost of the new Interact 32-C system, the cost comparison with AutoCAD begins to indicate a higher cost- effectiveness for Intergraph considering its greater capabilities.

5.2.1 Which Model?

The announcement by Intergraph of a quasi stand-alone model with equal capabilities and lower cost dictates that we monitor this development closely and determine which model to procure when they are needed. Argonne-West will probably install this new workstation and we will benefit from their experience and evaluation.

5.2.2 Build-up Rate and Total Systems

The number of Intergraph systems needed is somewhat harder to estimate since they have specialized applications. The minimum number would seem to be two since this would allow higher priority work to proceed locally when one system is down. An estimate based on the number of draftsmen indicated by the CDR, the number of AutoCAD systems recommended above, and the complexity of the project would indicate at least three systems. The acquisitions should be phased with Project design activity with the first system in place during mid FY 1987, the second in early FY 1988, and the third by mid FY 1988. A 30% contingency should be considered in order to provide an additional system if needed. An additional plotter should also be budgeted making a total of three to serve 15 AutoCAD systems and up to four Intergraph systems.

The single Intergraph system run by ENG will soon be joined by two additional systems to serve Argonne-West in Idaho. If no others are added, ours would become numbers three through six. The

workstation limit of the present host is eight systems (imposed by computer memory space, not disk capacity). Even if our added systems pushed beyond this limit, however, the CSD charging policy alluded to in section 4.2 would seem to affect only the charges for maintenance and services.

5.2.3 Location of Intergraph Host and Service Issues

The location of the host computer has been widely discussed with respect to workstation performance (screen update speed) and with respect to divisional control. The performance issue is really moot since the use of a private fiber-optic Ethernet or the digital PBX (which will be in place when we need it) will provide best-possible performance. The problem of host performance degradation due to other users employing compute-intensive applications such as stress analysis should be eliminated through the use of the newer, stand-alone workstations. A more pertinent issue is that of host service (mounting of archive tapes, system reboots, etc.) since this will affect performance in a more serious way. ENG (user) and CSD (service) are currently feeling their way toward an acceptable service environment. Given the Lab's determination to provide a viable CAD environment, I think that any problems will be worked out.

Nonetheless, given the Lab's historically lenient method of enforcing policy, we should be able to go against the CAE Committee recommendation of using a centrally located host if service problems become serious and lack a solution. The expense involved in providing maintenance and service would not be saved however, it may simply become hidden since we would now have to provide them ourselves. The total expense would, of course, be much greater if we had to procure our own Intergraph host and software. The strong recommendation here is to solve such problems, not pay heavily for a solution. The cost summary which follows includes an option with a dedicated host system to document the up-front costs.

5.3 Cost Summaries

15 AutoCAD Systems

Unit	Unit Cost	Quantity	Cost	Maintenance/yr
IBM PC/AT	$3K	15	$45K	*
Misc. Add-Ons	3K	15	45K	*
AutoCAD SW	2K	15	30K	*
Hi-Res Display and driver	5K		75K	*
Plotter	16K	1	16K	3.6K
		Totals:	$211K	3.6K

(*: Service provided by EL as needed)
Possible additions: Vax DECnet access $1.3K each

3 Intergraph Systems
(assuming 3 other workstations in place)

Unit	Unit Cost	Quantity	Cost	Maintenance/yr	CSD Services/yr
Workstation (model 32-C)	$40K	3	$120K	$30K	$15K*
Plotter	16K	1	16K	3.6K	NA
		Totals:	$136K	$33.6K	$15K

(add 30% contingency)

(*: 3/6 of vendor maintenance and CDS costs)
Possible additions: Dedicated fiber-optic extension of CAD Ethernet to design site $10K.
Additional software as needed $???

3 Intergraph Systems
(assuming host provided locally)

Unit	Unit Cost	Quantity	Cost	Maintenance/yr	Services/yr
Workstation (model 32-C)	$40K	3	$120K	$30K	NA
Plotter	16K	1	16K	3.6K	NA
Host Computer same as present system)	157K	1	157K	15.6K	1/2 FTE
		Totals:	$293K	$49.2K	1/2 FTE

(add one workstation for contingency)

Possible additions: Additional software as needed $???

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