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# Panel Discussion on Management of Control Systems

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## I. INTRODUCTION

In scientific organizations one often encounters the opinion that management is a trivial activity and that project managers enjoy the easy side of the project life, far away from where the real work is. However, examples abound of projects failing to meet their objectives, running behind schedule, overrunning costs, etc., because of poor management. To several aspects which are crucial for the successful completion of a project the attention they deserve has to be paid if the project is to meet its objectives within the constraints that are imposed upon it. Whereas the engineers do things, the manager gets things done; managers are particularly concerned with:

- what is planned to be done: i.e. the product which should be delivered, in our case the control system,
- how long will the project take: i.e. schedule,
- how one will know when the project is finished: completion criteria,
- how much will it cost to implement and to maintain: i.e. the cost.

These issues can e.g. be classified in three categories respectively relating to:

- the project:
  analyse the requirements, define the quality that needs to be achieved, estimate the schedule, evaluate the cost, analyse the trade offs in order to decide e.g. whether it is preferable to phase out or to upgrade an existing system, whether one should build in house or buy commercial products, etc.,

- the logistics (hardware and software):
  what level of support should one expect during the life cycle of the project; how reliable should the system be; how maintainable; what level of safety should one reasonably expect; how much training will be requested so that the user can take up operating the new system himself, etc.,

- the technology:
  what standards should be used; are these standards likely to stay actual during the life cycle of the system; what techniques should be applied for the implementation, (e.g. computer aided software engineering - CASE -, other tools, use of advanced techniques,....); what products are available on the market that meet the requirements, etc.

## II. INTRODUCING THE PANELISTS

The panelists who were invited to animate this session were selected not only on the basis of their experience in conducting control systems but also because they represent a variety of backgrounds and environments. Indeed, they all represent laboratories which are of different sizes and which operate in diverse economical and political conditions.

Each panelist introduces himself and describes briefly his current activities, the project he is concerned with, the size of the group involved in these activities and any possible "cultural" particularities of his environment that influence his activities.

- Don Barton (BNL/RHIC-AGS) heads a group of 11 program analysts, 8 electrical engineers and 9 technical support people. The group is in charge of the controls of both the Alternating Gradient Synchrotron (AGS) and the future Relativistic Heavy Ion Collider (RHIC). In addition to providing maintenance support for the running physics program at the AGS (for both protons and heavy ions) and for the commissioning of the new booster, the group soon will need to initiate the study of the RHIC controls. Besides the evolving technology, the biggest challenge stems from the sheer size of the entire accelerator complex, and consequently also of the control system. At present there are about 60 workstations and 80 to 90 multibus I crates with real time systems in a very distributed environment. The total effort invested so far is around 60 to 70 manyears.

- Winfried Busse (HMI/VICKSI) is responsible for the control system of the VICKSI facility. VICKSI is a comparatively small installation which was put into operation in 1978. Despite an upgrade program, started in 1987, the support the controls receive from the upper management of the laboratory is continuously decreasing. Originally 9 persons strong, the group is now limited to 3 people looking after the everyday running of the system and one person endorsing the entire upgrade program. It is thus no surprise that progress is very slow.

- Lindsay Coffman (SSCL & DOE) works on the DOE (Department of Energy) side of the SSC Laboratory. He is responsible for Systems Engineering across the SSC project. Coffman's office, currently 5 persons but intended to grow to 12, has to ensure that the SSC project follows the proper engineering practices: i.e. follows the modern systems engineering and management practices with discipline, adheres to current standards, follows state of the art software guidelines and development practices, delivers the proper requirement documents, etc.

- Axel Daneels (CERN/AT) involved in controls until 1990, was responsible for the development of the application software of CERN PS accelerator complex. Currently

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responsible for software engineering in the accelerator sector, he conducts a number of small pilot projects using CASE technology for evaluation purposes. The number of persons involved is approximately 25; they belong to different administrative entities and spend only a fraction of their time on these evaluations: this imposes some constraint on the project. In addition, the accelerator sector has little experience with new way of working which breaks quite significantly with the current habits.

- Shin-ichi Kurokawa (KEK) was working in the field of controls from 1981 to 1987. Now chairman of a division within the Accelerator Department, he is responsible for the control system whilst also coordinating the future B factory project. The controls group has 10 to 15 persons and is looking into rejuvenating the system with an eye on the new controls for the B factory. As Japanese companies are very eager to participate in physics project, such as the B factory, the laboratories have developed a skill of collaborating with industry.

- Rudolf Pose (JINR/LCTA) is Director of the Laboratory for Computing and Automation of the Joint Institute for Nuclear Research in Dubna, near Moscow. This laboratory is responsible for all computing activities, including e.g. network communication with the physics community worldwide, and controls. It has a staff of approximately 650 people. Earlier this year (1991) a new heavy ion accelerator project was decided and a small group of 12 people is currently looking into the controls of this new machine. The group will endeavour to use as much as possible existing commercial products, hardware and software.

## III. ISSUES AGREED FOR DISCUSSION

Due to the limited time that is allocated to this panel, it is impossible to discuss all management issues that were mentioned in the introduction. It was therefore suggested to select a reduced number of items which were felt to be rather crucial in todays context. The participants agreed that the discussions should focus the following issues:

- Project:
  a key issue in today's project management is the dilemma of "Make vs. Buy": should we make it all in house or should we buy from industry, and if so, what should we buy ? The decision should be the result of a trade off analysis.

- Logistics:
  laboratories are increasingly concerned with their control systems rapidly becoming out of date because of the pace at which technology evolves. Increased processing power, intelligent hardware, etc., provide opportunities to explore novel, ever more sophisticated operational facilities which are difficult to achieve with the existing system. This leads to the second dilemma: "Should one upgrade the old system or embark on an entirely new project" with its corollary of having to maintenain the old system whilst implementing the new one.

- Technology:
  technology is evolving steadily: methods and techniques are coming up continuously whilst tools, e.g. computer aided software engineering (CASE) tools, are invading the market. They are intended to produce better quality systems and to assist the engineers throughout the lifecycle of their project: i.e. from the early analysis to maintenance. A study has thus to be made to select the most appropriate ones for the type of systems one is concerned with. In addition, standards are emerging and control engineers have to face the difficult choice as to which standards should be adopted.

## IV. SYNTHESIS OF DISCUSSION

In the course of the debate, it appeared that the issue "make vs. buy" was raising a lot of interest: considering the time allocated to this panel, it was thus agreed to extend the discussion on this issue and to skip the one on "logistics".

- Make vs. Buy
  Similar as for other technologies (e.g. magnets, vacuum,....), it is felt that laboratories should develop a policy of market investigation for control systems also. Such a market investigation should be based on specifications resulting from a proper requirement analysis and design study. This approach would allow the laboratories to benefit from a competitive market by bidding for optimum solutions. However, one recognizes that, although it is not so difficult to write specifications and to buy off the shelf individual components, writing a definitive and complete set of requirements and proper specifications for entire systems so that they could be subcontracted, is a difficult task. It is particularly difficult to achieve in the experimental physics community because of their lack of experience, ever moving personnel, continuously changing ideas, etc. Accelerators are never finished products: as soon as the accelerator is commissioned, it becomes an R&D environment for which the controls groups have to provide the proper support. This may of course be a great challenge in itself, but is not particularly propitiuous to defining control systems in sufficient detail so that they can be bought outside. Also the time scale on which the specifications have to be carried out is in general very short and very transitory with regard to the delivery schedule. Finally, the accelerator control systems do not need to meet the same kind of severe conditions as one would expect e.g. from controls of power reactors, even if the regulatory agencies start to look at accelerators in the same way as at reactors. All these aspects are unfortunately not building up much motivation to take up the chore of producing requirements and specifications.

  The requirements should be written for a given application and not against a specific implementation: i.e. one should endeavour to subcontracting the implementation of systems or components to in-house designs, rather than buying off the shelf products which do not quite meet the requirements. A typical example of components that are difficult to find on the market are those which require specific and flexible timing treatment. On the other hand, components that are readily available on the market in general follow different standards which make it difficult for those products to work together. Significant work then has to go into integrating these components into the overall control system. Thus

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control system engineers have to evolve from designers to integrators.

In case complete turn key systems are bought, one if left with the problem of maintenance and upgrade: who will endorse these activities ? One should learn from the Japanese laboratories whose approach is indeed to have complete basic systems supplied by industry: i.e. the computers, the network, and the basic software, complemented by special maintenance contracts. Application programs, however, are provided in house: this is precisely an activity where tools would be of great help, not only for their implementation but also for the management of their implementation.

Industry on the other hand, may only be interested in bidding if the volume of the deal is sufficiently large. This puts the larger laboratories in a more favourable condition than the smaller ones. However, to date this is not a general policy yet even in the large laboratories like e.g. CERN, when compared with another large European Organization such as the European Space Agency (ESA) where such approach is part of their policy. This again highlights the major difference between the European and Japanese accelerator laboratories: the latter have developed a long experience of intimate collaboration with industry. Similarly, though for different reasons, laboratories in Soviet Union are bound to buy on the soviet market. Indeed, most of their budget is financed in rubles (70% of their butget) which make it difficult for those laboratories to buy from foreign countries. They thus must encourage the soviet industry in applying international standards (e.g. multibus II).

- Tools (CASE) and standards

Software engineering methods are emerging to assist the software engineer in analysing, designing and implementing large software packages. Most surprisingly, very little was said at this conference on the use of computer aided software engineering (CASE) tools. Indeed, despite their promises for better quality software and dramatic savings in maintenance, this technology is not yet widely spread in experimental physics laboratories as they tend to be in industry. Without, however, overrating the effectiveness of software houses or other industries concerned with software development in their use of CASE tools, all tend to use methods and tools as a rule. When someone joins that industry, he is instructed on the working practices and disciplines of the house. In the laboratories, however, working habits are almost opposite to everyone doing things his own way. However, one should consider that CASE methods and tools have been primarily introduced for business applications and that, as a consequence, there are not many methods and tools available for real time control applications. Among the many methodologies (structured analysis - structured design, SASD, object orientation, etc.) one needs to evaluate which are best suited for accelerator and large experimental physics control systems. This is a most difficult task as the CASE market is still unstable. New methods keep coming up at a pace that it is difficult to follow: one has not adjusted to a method that yet another one is being advocated as a panacea. These tools which complement these methods are produced by companies that are in general as new as their products; they are in general also small and have it difficult to provide adequate support.

Tools are said to be too expensive for the laboratory's budget. That argument runs into competition with the amount of manpower one has to invest in doing systems the old way. Here again it is a matter of evaluating the trade offs between the cost of buying the tools, the effort to invest in learning to use them, and the savings that can be obtained throughout the lifecycle of the control system, by using these tools. It should also be noted that in general very favourable academic discounts can be obtained for laboratories, so that even smaller laboratories could probably financially afford such tools. It is however recognized that they require a significant learning effort that is often excessively high for small groups heavily involved in every days activities. Regarding these cost considerations it is significant to notice that software houses, that are sensitive to cost and productivity, have a rather unambiguous attittude towards the use of tools: in case the money to be invested in tools competes with the cost of people, software houses tend to prefer laying off people and to buy the tools.

The significant message one should extract from preceding paragraphs is that one should at least have a method. The example of the application software for the controls of the CERN PS accelerator complex, gives an indication of the value of following a method. For that project, in the late 70-ies, structured analysis and structured design was applied extensively. At that time there were no automated tools CASE available, and the SASD was carried out with paper and pencil. However it allowed to breakdown the entire software package in "small" modules which were each completely specified so that they could be handed out to individual programmers.

Shareable software is another issue that has a strong economical impact. The appearance of object oriented (O.O.) design puts the idea of sharing software in a new light. As an example, BNL designed the controls software for the AGS booster with the use of object orientation. The software was broken down in a number of classes (in the O.O. sense) that were implemented separately. Classes could probably be used elsewhere, provided they are designed to be hardware independent.

A major step forward in the direction of sharing of software for accelerator controls could be achieved if one could agree on a standard model. This raises the problem of agreeing on standards. Control systems are costly and can not be changed frequently. They have a rather long life span and the standards which are adopted have to be in effect for several years. In 1972, it was decided to go for a distributed control system for the CERN SPS accelerator; only 20 years later, in 1992, a project is started of replacing that system. In 1972 however a distributed architecture was not so common and the choice that was made at that time might have raised a mortgage on its life cycle.

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The standards that exist today (Unix, X-Windows, Motif, etc.) are primarily of use for the high level control layers where the operator interacts with the system. At the lower end, i.e. near the devices, one sees a several real time Unix operating systems emerging. They all try hard to make their way to becoming a standard. However it is still not clear how both "levels" can be tied together: e.g. what process data highway communication protocol could we standardize upon ?

Still progress in the direction of standardization is steady. At the International Conference on Accelerator and Large Experimental Physics Control Systems in Vancouver (1989) there has been a lively debate around VMS versus UNIX. Since then UNIX has won its spurs and a number of control systems are now based on UNIX. Also when analyzing the systems which were presented here, one realizes that slowly these systems tends to converge to a standard model and to the use of some common standards.

## V. CONCLUSION

It is no surprise that the debates in this panel on "Management of Control System" had a strong economical flavour: the economical climate which currently prevails in most laboratories is a major concern for those involved in technologies that are not directly tied to the laboratories primary objectives, such as e.g. controls.

Laboratories should build up a habit of investigating in how far their control systems could be assembled from comprehensive packages provided by industry. This would allow them to benefit from a competitive market and to use proven products. In case entire systems are subcontracted to industry one should learn from the Japanese who also subcontract the maintenance. However, laboratories first should learn to write comprehensive specifications: a task that is particularly difficult in their ever changing experimental environment. Along these lines, the appearance of computer aided tools is an issue that is worth considering. Despite their "shakiness" and their high cost, that is often outweighed by very favourable academic discounts awarded to non commercial experimental physics laboratories, they are most valuable in producing specifications very early in the project. If it only were for that latter reason, laboratories should endeavour at entering the CASE era early and to grow together with that technology,.... or, at least, to adopt a method.

Sharing software is a dream that might become true in not so long a future. Among the new methodologies, object orientation seem to be a most promising one in view of possible sharing of software. However this issue needs a propitiuous environment of well established standards, and although standards are gradually settling, they mostly apply for the higher level control layers. The device level still has a long way to go and puts the designers in front of the difficult problem to guess which are those that are likely to be stay valid throughout the life cycle of the control system;.... we still are far from a standard model for experimental physics controls.

Finally, as technology is evolving, one recognises a shift in the activities of the control engineers. Using standards and buying "off the shelf" products, in general from different vendors, requires the control engineers to evolve from designers, to integrators who understand the art of making all these pieces work together in an coherent overall frame.