EXPERIENCE WITH INDUSTRY DURING THE CONSTRUCTION OF A LARGE ACCELERATOR

D. Krämer, BESSY, Berlin, Germany

Abstract

There is a long and successful cooperation between highly specialised companies and the many accelerator laboratories in the field of development and procurement of accelerators, subsystems or of individual components. Especially the smaller labs take advantage of the expertise of industry during the construction of their machines. However, purchasing components rather than ordering tune key solutions is the rule.

Based on the experience with a substantial number of industrial partners during the construction of medium sized project, a 3rd generation light source, the boundaries in the relations between labs and industrial partners are discussed.

1 INTRODUCTION

After World War II a substantial number of accelerators were delivered to laboratories from well-known companies. Electrostatic machines as Single Ended Van de Graaffs and tandems as well as cyclotrons, betatrons and linacs were designed and supplies by industry according to the needs of the nuclear physics community, hospitals for therapy and industrial users. Ordering turn key solutions was common practise rather than the exception.

In the early 1980ies this successful interconnection of science and commerce slowed down. One reason, amongst others, was the decline of medium energy nuclear physics. In addition new machine concepts were brought up such as heavy ion storage rings, synchrotron light sources, furthermore superconductive cavities and magnet-systems played an increasing role in new accelerator projects.

As a consequence of the new requirements especially the "big" companies left the market segment of accelerators; nevertheless a number of highly specialised suppliers continued delivery of components and/or subsystems.

The reaction to this development was design and prototype development for most accelerator projects by the labs' in-house resources while the production series were ordered from industry. The implications, acting in project management and solving logistic problems rather than working in accelerator R&D, had to be learned by the smaller labs especially.

2 ACCELERATRORS FROM INDUSTRY

An impressive list of accelerator projects in Germany realised turn key from industry in the years 1949 to 2000 is listed in ref. [1]. More than a 100 projects are described in detail. Until the 1980ies most of the projects realized in Germany were electrostatic machines as Van de Graaffs and tandems, cyclotrons and linear accelerators delivered turn key from industry for basic research. The market of accelerators in applications as medical cancer therapy or in industrial production opened the opportunity to produce series of identical or at least similar machines, during those days. So it is not surprising that a substantial number of companies were busy in this market.

The small production series allowed for a sound calculation basis when judging for the project risks and production costs. On the other hand the sophisticated projects increased the company's expertise in production processes not that widely used as well as the internal know how on exotic materials and the way to handle them. Not to forget the aspect of publicity; there is no way more convincing the capabilities of a high-tech company than showing successful references.

In the early 1980ies in basic research new concepts came up and the requirements changed. The heavy ion storage rings and later the various synchrotron light source projects as well as the superconducting accelerator projects still were realised in close cooperation with industry, nevertheless the tendency to supply components rather than turn key systems became obvious.

2.1 Rearrangement of the market

The reason for the rearrangements on the market of accelerators and components partly was due to the lack of experience with the new concepts rather than the lack of production know-how required. The economic recession in many European countries in parallel forced the companies to evaluate their "special project" departments especially with respect to economical aspects.

As a consequence numerous former suppliers ended or severely reduced their engagement in the field. The technical and financial risk in accelerator subsystems indeed is an economical burden for any private operating company. Nevertheless a number of suppliers remained active, many of them restricted on special hardware components, e.g. vacuum-vessels, rf-cavities, magnets or power supplies etc.

2.2 R&D at the Laboratories

On the other hand the situation at the labs changed also. Reduced budgets and the increasing pressure to reduce staff and costs required to search for new ways in managing the projects.

Efficient in-house R&D programs had to be done to diminish the technological and financial risk for the suppliers. Thanks to the availability of powerful computers and software codes it was possible to simulate the hardware and its functions prior to production. A good deal of risk associated with mechanical and the electro-magnetic behaviour of components as well as tolerance studies could be done to a very detailed level.

Thus the way of specifying components could be restricted to fabrication tolerances rather than requesting functionality. The subsequent savings on costs are obvious.

Despite the fact that know-how in design and experience in prototyping was to a large fraction on the lab's side now, industry took benefit from the production orders as their competence increased in parallel due to the excellent contacts and know-how transfer necessary for the on-going production of components.

3 EXPERIENCES FROM A PROJECT

The project of the low emittance high brilliance 1.7 GeV 3rd generation synchrotron light source BESSY II also had to find solution to the market situation described above. Approved in mid 1992 the electron storage ring delivered first photon beams in early 1998, ref [2, 3].

A fixed and tight budget of 100 M€ for a completely new institute on the Berlin-Adlershof site required a clear definition of the scope of the project, as well as strategies on the procurement policy right from the beginning.

The BESSY project comprised a circular 120 m in diameter experimental hall with the injector, booster synchrotron and storage ring at the inside of the building. Offices and small laboratories were located in an addition to the building. The project included 6 undulators and the instrumentation for 12 beam lines ready to use at the start of the scientific program in January 1999. Thus the budget for all accelerator related investments was 28 M€ in total.

3.1 Contracts and Orders

Based on the strict purchasing regulations the project had to handle ca. 15.000 individual orders and formal contracts altogether. The standardisation of juridical clarified commercial conditions with the technical specification helped considerably to avoid problems in the process of the project.

Based on a detailed project schedule to identify the critical path with respect to availability and time schedule, weak points thus became transparent and facilitated matching to the existing resources and anticipated money-flow. Continuously updated detailed information on the progress of the project and status of the procurements helped to keep control.

All these standard controlling tools, used in industry and at the 'bigger' laboratories for a long time, had to be accepted and adopted by those not used to it.

3.2 Contacts to Industry

The best way to minimise the risk of delays and/or financial claims are detailed but clear specification without ambiguity. Especially un-ambiguous acceptance conditions with a clear description of the measurements to perform and the tolerances to meet avoided unclear situations and discussions.

In the preliminary stages of the tender process it turned out to be extremely useful to visit possible suppliers. As with the visits at other accelerator labs the discussion together with technical staff at the companies always was of great benefit. Minimising technological problems in the manufacturing process, optimisation of material aspects and last but not least aspects cost savings resulted from these early contacts when properly considered during the final design and specification phase.

3.3 Competitors from the East

The political changes in East Europe and the GUS during the early 90ies opened the possibility for contacts to Russian science institutes able and willing to supply components and/or to procure complete systems. The motivation: earning money and thus improve the poor financial situation of their institute.

The profound technical knowledge and the expertise in accelerator physics and construction in combination with excellent equipped workshops - as The Budker Institute for Nuclear Physics (BINP) in Novosibirsk or the EFREMOV Institute in St. Petersburg - increased the number of potential suppliers for the accelerator projects at that time.

Including these institutes into the call for tender procedures resulted in a number of components contracted to the GUS. The unusual low wages especially at that time gave them considerable price advantage in the tenders.

During the BESSY project BINP delivered magnets for the booster and vacuum components for the storage ring – at a later stage the institute was awarded with the contracts for producing three superconducting insertion devices. The well established contacts between BINP and BESSY, going back to the early 80ies, facilitated these project despite the far distances and thus the limited number of visits at the manufacturers site. At no point language problems caused problems.

The quality of the accelerator items always met specification and the long distances for transportations had no negative drawback to the products.

3.4 Professional Management and Controlling

Realising a complex accelerator together with the demand for fast commissioning, high reliability and smooth operation needs an excellent team. The logistic challenges and for an efficient coordination within the project, when time and money are of concern, the use of modern management and controlling tools is required.

Thinking in terms of time schedule, resource plans, etc. is of use and helpful during the construction of a complex machine. Technical difficulties and associated delays nevertheless are always good for surprises and request adaptation of the plans to the actual situation.

However the way of management and controlling necessary approaches the effective object oriented strategies used in industry. Thus a step in improved efficiency and professionalism goes along with the new and ambitious projects.

3.5 The Human Capital

Companies by themselves are sometimes believed to keep the know-how and competence. Nevertheless experience tells that the retirement of an experienced project manager or specialist in the workshops can have negative drawback to products that was successfully manufactured for many years to the full satisfaction of the customer. But is it a real surprise that new staff members will have a large influence to a product which requires the same people's "golden hand" and specific knowledge?

Know-how is in human's brains – regardless if written down in formal quality assurance procedures. However single components produced in low number always will be strongly associated to the individual who is 'doing' it.

Thus it is the 'human capital' finally that is decisive for the success of an order or taking a bad turn.

4 LIMITS OF COOPERATION

The production quantities of items ordered, small series at the best, single items as the rule, are showing up in the high price level. The question for standardization of accelerator components, for example magnets, has been rejected in the past. Indeed there are many reasons to justify one's individual design from machine performance reasons. But standardization is not only a question of pricing. Product identity, low tolerance production processes can improve the overall quality; on the other hand delivery time may become shorter – both aspects being important in any project. However the author is sceptic that the later arguments will make one's way and lead to a number of standard elements in future.

People's argument modern accelerators are too complex for a single company are not free from prejudice. The argument is true for most of the recently built accelerators for the time being. None of the active companies in the field of accelerators covers all aspects in their present production. Nevertheless it is interesting to realise that companies started to hire accelerator physicists to improve their capabilities. Thus present limitations of cooperation are not static but change with time.

5 CONCLUSION

There is a long-term excellent cooperation of accelerator physicists and commercial manufacturers of accelerator components and subsystem. Though there is a strong economical pressure in this market segment, there is an excellent relationship between both parties. The knowledge that R&D work at the labs and the experience and competence in production techniques is of mutual benefit. The know-how transfer associated with any common projects gives advantages on both sides and will guarantee competent partners for the accelerator labs in future.

The complexity of today's accelerator projects will prevent to come back to the situation when accelerators could be ordered off shelf. The man-power required for a complex modern accelerator project will in general not amortise from an economical point of view, the market simply is too small. Transfer of know-how, exchange with universities and the accelerator labs, common R&D activities are efficient tools for further improving the positive and successful cooperation of people working in the field of accelerators and industry.

6 ACKNOWLEDGEMENT

The author wants to thank the many persons from industry as well as numerous colleagues from accelerator labs; their patience and advice. Their highly professional work contributed significantly to the success of the BESSY project. Last but not least the excellent work of the BESSY team is acknowledged.

7 REFERENCES

[1] Die Deutschen Teilchenbeschleuniger, U. Schmidt-Rohr, ISBN 3-00-008183-6, Heidelberg 2001.

[2] E. Jaeschke et al., Lattice Design for the 1.7 GeV Light Source BESSY II, 1993 IEEE Part. Acc. Conf., p. 1474

[3] D. Krämer et al., Start of Commissioning of the High Brilliance Synchrotron Radiation Source BESSY II, EPAC 1998, p. 262