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**CERN - PS DIVISION**

PS/DR/Note 2002-187

**CONSOLIDATION PROJECT  
FOR THE PS COMPLEX**

**- 2003 to 2010 -**

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In order for the PS complex to completely cope with its different functions over the next few years, and above all its role as pre-injector for the LHC, the necessary consolidations must be planned and achieved. The aim of this note is to give, in the framework of the Long Term Plan budget (2003-2010), an inventory of the consolidation activities that are required in the long term, so that the PS complex continues to run at its current performance levels.

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## 1. Introduction : consolidation of the PS complex, past, present and future situation

### 1.1 Consolidation during 1993 - 2002

Taking into account the growing needs of the overall maintenance of the different accelerators in the PS Complex and above all the ageing equipment, consolidation since the 1990's has become a necessary activity: the maintenance of the equipment's functionality with a minimum of breakdowns and interruptions is an important objective of the PS Division.

Two separate budgets have financed the consolidation over the last few years:

- the consolidation project (PS/D-082) which is allocated yearly to the PS Division and since 1993 amounts to ~ 860 kCHF per year.
- a specific amount (called "PS Subvention") which since 1993 is taken each year from the exploitation budget of the Division: an average amount of 1 MCHF was allocated up until the 1999 budget year, mainly for the renovation and the consolidation.

The budget restrictions that have been applied successively over the last few years have severely reduced the exploitation budgets. The direct consequence of this budget reduction has been on consolidation: since 2000, the total allocated amount has also been reduced and was in 2002 only 620 kCHF, which is no longer sufficient. Table 1 indicates the evolution of these two budgets during the last 10 years.

### 1.2 Consolidation for the future

The decision to use the PS complex as an injector for the LHC for over 10 years, due to start in 2007, implies the necessity for a longer-term consolidation. The renovation project of the PSB and PS for the LHC (PS-9514 Project, 1995-2000) should be considered as a first stage of consolidation, that concerns the energy increase of the PSB and the improvement of the beams for the LHC. A second stage leads us to define **a core consolidation of the equipment for the long term.**

Consolidation is important for the future, not only for the performance levels and to be in phase with technology, but also due to a reduction in staff. We must have an accelerator complex that is more effective and reliable, as we will have less staff to ensure its operation.

### 1.3 Detailed analysis done in 2001

A long-term consolidation programme was established in 2001, giving a complete inventory of the consolidation activities that are required in the medium and long term. The work and the necessary resources are detailed in the Note PS/DR 2001-047. Conclusions drawn from this analysis for the next 5 years:

	Jobs in Priorities 1 + 2	Jobs in Priority 1
Budget (incl. Ind Sup.) (per year)	3.1 MCHF	2.2 MCHF
CERN Staff (per year)	12.5 FTE	9 FTE
Industrial Support (per year)	10 man-years	6-7 man-years

(**priority 1**: jobs for PS as LHC Injector, **priority 2**: other machines & areas)

Due to budget limitation, the recommendations led to shifting jobs in priority 2 to the next slice. In this case **the required amount was 2.2 MCHF per year**, for 2002-2006. From then on, **an increased budget of 3.1 MCHF** was foreseen for the second slice (2007-2011) to assume the delayed consolidations (jobs in priority 2).

## **2. Consolidation in the framework of the new LTP budget 2003-2010**

### 2.1 LTP budget

A budget is allocated for the consolidation of the PS Complex in the framework of the LTP (Long Term Plan), on the period 2003 to 2010. Amounts were proposed for the different activities in the groups, taking into consideration the prorata of the former consolidation analysis. Table 2 gives the distribution of budget per group and per year. From these budget amounts, the Group Leaders and persons responsible were invited to define the activities of the consolidation, in parallel with the definition of the Staff Plan, while taking into account the required personnel, staff and Industrial Support.

### 2.2 Definition of the work packages and Staff Plan

In collaboration with the different groups, in the framework of the new A&B Division, the work packages dedicated to the consolidation were defined in detail, and together form the « PS Complex Consolidation Project ».

The Staff Plan Summary gives the estimated resources for the consolidation, according to the corresponding PPA (Annex 1).

This note analyzes the different aspects of this new consolidation programme.

## **3. Definition of the consolidation and priorities**

### 3.1 Definition

The consolidation is based on the replacement of equipment (on a one to one basis) and a certain number of criteria have been defined to encompass the specific priorities:

- old equipment: > 35 years for static hardware elements  
18 - 20 years for electronic equipment  
(in general, but maybe less for the control modules)
- equipment that no longer meets security standards,
- equipment subjected to radiation, with a limited lifetime,
- equipment showing a noticeable increase in faults or a lack of reliability with the risk of long term breakdowns,
- equipment that has problems with the supply of reserve parts,
- equipment that has a maintenance workload that is too expensive,
- equipment that could be replaced with “new family”: the consolidation should strongly encourage the standardization of equipment.

The above list is not exhaustive and some criteria could be combined to reinforce the priorities and justifications.

### 3.2 Priorities

The consolidation concerns all of the equipment of the accelerators and the experimental areas of the PS Complex: LI 2&3, PSB, PS, TT2, ISOLDE, AD, East Area.

For the magnets consolidation of the PS Complex, the ABP Group has given the estimations in the different tables.

To help set up the consolidation project, the priorities have been defined as follows:

- on the one hand the priorities that deal with the accelerators and beams:
  - priority 1: PS Complex as LHC Injector Chain
  - priority 2: SPS Fixed Target and PS Exp. Areas (East Area, ISOLDE & AD)
- on the other hand the priorities 1 or 2 that relate to specific equipment:  
high priority or medium/low priority

3.3 The listing of the activities was finalized within the Groups, taking into account the budget, the staff plan, and the different conditions mentioned above.

The consolidations concerning civil engineering, electricity distribution, water, ventilation and security have not been included in this analysis.

#### **4. Consolidation project for the years 2003 - 2010**

A detailed inventory of equipment to be renewed for each group is given in the tables, indicating for each job: financial estimation, required staff (all categories) and Industrial Support (Result + Field Support and Man Power), and specifying the time periods foreseen for the different jobs; Annex 2 shows the tables established by the different groups/activities in the frame of the new A&B Division, relative to the PS Complex.

The financial resources for the consolidation are summarized in Table 2; the staff requests and the need for industrial support are shown in Table 3 & Table 4.

#### **Main remarks for the different consolidation activities :**

##### **4.1 ABP**

After investigations and review of the needs, most of the proposed consolidation work concerns magnets :

- i) For the PS main magnets, Unit MU01 has been exchanged during the 2001/02 shut-down with the help of the upgraded handling device (locomotive). A first step of a consolidation programme is now to carry out a complete check-up of this unit, which could not be launched this year due to the reduction in Industrial Support resource allocations. The aim of this check-up is to determine a complete renovation programme that could be set up and spread over 12 to 15 years (6 to 8 magnets upgraded per year). The evaluation study requires few resources, but the complete programme, once evaluated, may require large amounts, more in terms of industrial support than material.

The same is valid for the PSB magnets, with lower priority.

- ii) Construction of spare magnets, already started for MNP23, but awaiting financing for Q120, is vital to ensure that test beams and physics in the East Area do not suffer major stops in the future.

This work will be carried out within the group responsible for warm magnets in the new Accelerator Sector structure (presently the SL/MS group). It requires that the team involved is able, not only to cope with the induced workload, but also to prepare the required documentation (which may need significant resources).

This consolidation does not include a consolidation programme for the AD, as this should be a dedicated project beyond 2006, similar to the project launched for ISOLDE.

## 4.2 BDI

For the consolidation and rejuvenation required by the different beam diagnostics domains in order to be ready for the LHC era, two different cases have to be considered:

- Systems technically obsolete for which spare parts are not available anymore and for which a redesign will reduce the preventive maintenance workloads.
- Systems for which the existing technology developed in the PS or SL divisions is still valid and a straightforward reconstruction, possibly with moderate adaptations is convenient.

Furthermore, with the merging of beam instrumentation activities in SL and PS, the promotion of common standards is reinforced leading to common developments as well as a common exploitation with potential cost savings.

i) Into the first category two systems are considered:

- The MTV system (camera, screen mechanism, image transmission etc.) that has been recently insourced and for which an urgent renovation is needed using a solution common to all Cern accelerators.
- The renovation of the beam charge and position measurement in the Linac to PSB transfer lines.

ii) In the second category four systems are considered:

- The electronics and computer interfaces of the PS transverse position observation and measurement systems, which will be completely rebuild using new technologies to simplify and increase its robustness as well as its performances for the observation of protons and ions beams for LHC.
- The electronic interfaces of the instruments of the PS experimental areas, East Hall and AD for which already developed SL-BI interfaces can be used in order to allow the exploitation of the instrumentation by the same team as for the instrumentation of North and West areas of the SPS.
- The renovation of the PS tune meter.
- The renovation of the control electronics for all in/out and stepping motors mechanism.
- The rejuvenation and the standardization of the acquisition system of the TT2 Semgrids.

The main changes compared to 2001 requests concern the MTV systems which has to be renewed urgently accounting for 660 kFs in place of about 400kFs which will have to be found and the renovation of the experimental area electronics for which the SL standard has to be used, the final bill depending on the possibility of reusing spares from North or West SPS areas. Furthermore due to the budget and manpower shortage, the renovation of the less critical PS instrumentation have been regrouped and delayed to the period 2005 2009.

#### 4.3 CO

- i) The "SOS Video" system is essential for the operation team, allowing among other things to visualize the beams on scintillator screens. This system is 20 years old; the hardware is completely obsolete and only one single person in CO has still some hints on how the related software works. It is also the last part of the control system which is hardwired between the TV cameras and the observation displays in MCR. Collaboration with BD is part of the project since BD handles the mechanical parts of the system (screen movements, and camera controls). This consolidation will be performed in the frame of the new AB Division.
- ii) The CAMAC control of PSB (+ last remains in PS) and AD (lower priority) power supplies is also a legacy system for which competence is fading away and for which the hardware is no more part of the standard equipment of the PS control system. The replacement of this control system by MIL 1553 is linked to the replacement of the power supplies themselves. It is handled in collaboration with PO and BT.
- iii) nAos is an observation system for the analogue signals coming from accelerator equipment. It is indispensable (i.e. more than 99.5 % availability needed) to adjust the machines, mainly to synchronize precisely all the pulsed elements. The system is still fully operational but the 2 main VXI modules (crate controllers and oscilloscope modules) are no longer available, and no equivalent modules are being produced. Within a timeframe of a few years the spare modules will all be in operation and a progressive seamless replacement with an other technology will have to be started. This consolidation will also be performed in the frame of the new A&B Division.

#### 4.5 PO

- i) A large contingent of dissimilar power supplies required to power Pole Face Windings (PFW), dipole, quadrupole and multipole magnets for Linacs 2 and 3, PSB, PS and the transfer lines, need urgent consolidation or replacement in order to cope with short term requirements and to be ready for the LHC start-up and exploitation. Some important power converters are also very special: there is an urgent need to study and replace these old models.
- ii) The Motor-Generator set of the PS main power supply (MPS) was put into service in 1968 with a planned lifetime of 35 to 40 years. This time limit will be reached at LHC start-up. Although, according to the yearly revisions, the pulsed rotating machines seem actually in reasonable shape, its future replacement must be planned. A major breakdown could easily lead to many months of interruption of physics at CERN. A preliminary study proposes to substitute the motor generator set by a direct link of the PS MPS to the power grid. This requires a new transformer of 400/18 kV, with a 150 Mvar reactive power compensator, an upgrading of the MP6 overhead line from the Prévessin to the Meyrin site and a further transformer of 18/6 kV. A new power group (12 phase system, 10 kV) must be also foreseen. A 6 kV substation with switchyard to permit rapid commutation of the PS MPS from the Motor-Generator set to the new installation and the corresponding building and infrastructure are also needed.  
A solid collaboration between PS and ST divisions and the Services Industriels de Genève is indispensable for the achievement of a serious study (year 2003-2004) and the final execution of this necessary and essential project to CERN.

The main generator project will be treated as a separated project, as its cost - of the order of 10 MCHF - is much larger than any other item at the PS.

#### 4.6 BT

The BT group is responsible for a large variety of different equipment that needs to be consolidated to remain exploitable in the near future:

- i) There is still much outdated electronic equipment to control, protect and monitor power supplies for kickers and septa, for which no spare parts are obtainable and systems with archaic controls interfaces that are no longer maintainable. Renovation of this equipment is of prime importance and concerns mainly kicker systems for fast ejection and Continuous Transfer of protons from the PS.
- ii) The beam slicing septa used for the continuous transfer is a very delicate device, because it has to resist large radiation doses. A new bakeable electrostatic septum, that can be quickly replaced, must be constructed to replace the existing fragile septum.
- iii) The entire Continuous Transfer fast ejection kicker system is completely outdated. Both the different pulse generators and the electronics control system need total renewal. However, the PS division has not yet clarified whether a new, entirely different transfer scheme will be used. Either way, new equipment or heavy renovation is required.

#### 4.7 RF

- i) The RF equipment of the proton Linac (Linac 2) was designed and built during the 1970's, and the major part of the low level electronics requires an important effort to be upgraded into a satisfactory state for its vital role as the source of protons for LHC. The heavy ion Linac (Linac 3) needs a similar effort, because many parts have been simply copied from Linac 2 or even recuperated from Linac 1. The renovation of the interlock systems started in 2001 and must be actively pursued in 2002 and 2003. The study of renovation of the low level RF using modern technology should begin in 2003 and be implemented in 2004 and 2005.
- ii) The performance of the PS ferrite cavities system still needs to be improved over the next 5 years, especially concerning the impedance seen by the beam (RF feedback). The gap short circuit relays are also an important source of concern, because they age fast and require frequent maintenance with a single supplier left in the market: effort is required quickly to develop spare solutions and implement them.
- iii) Beam synchronization is a delicate operation that takes place at every transfer of particles between synchrotrons, and the capabilities of existing analogue electronics limits the reproducibility of performance. Development of new equipment based on DSP technology is needed to help guarantee the beam characteristics at the standard of the LHC era.

## 5. Resources for the next few years 2003 - 2010

### 5.1 Budget request for material

The total budget of the consolidation project for the PS complex foreseen in the LTP amounts to 700 kCHF in 2003, 1 MCHF during the years 2004 & 2005, and 2 MCHF after the year 2005.

The budget of the exercise done in 2001 has been established while elaborating the list of the declared activities in priority 1, for which a total budget of 2.2 MCHF/year was recognized (see paragraph 1.2). The budget difference indicates that less urgent jobs - defined in priority 1 - will have to be delayed to after this period of 2003-2010. These delayed jobs will increase the necessary budget and manpower after that time.

Isolde consolidation activities are not included: a separated consolidation budget has been defined.

### 5.2 Industrial Support

Requests for Industrial Support represent approximately 4 to 6 man-years, per year, over the first three years 2003-2005. Actually some 4 to 5 man-years of the Industrial Support is already working on the consolidation in progress, financed by the normal exploitation budget. This part of the actual Industrial Support budget (~ **380 kCHF**) **should remain to be allocated next year to the consolidation budget.**

After the year 2005, the consolidation needs an extra 5 man-years, per year, for 2006-2007, decreasing in 2008. This represents **a budget of 400 kCHF**, which must be then taken from the consolidation budget (see Table 5). The ratio of Industrial Support to material budget is very different for the various groups. Therefore this repartition of the extra Industrial Support budget should be discussed and allocated at a later stage.

### 5.3 CERN manpower requirement

The CERN staff needed to ensure the consolidation is on average 10 to 13 man-years, per year, till 2008, decreasing in 2009-2010. The estimates of the staff that are currently working on the consolidation projects show us that we need to increase the staff level by 35 man-years per year. The staff plans of the division take in account the manpower needed for this activity.

## 6. Conclusion

The budget for the next years 2002-2010 has been defined by the new LTP: it represents a total amount of 12700 kCHF for the PS Complex consolidation, and covers only part of the high priority consolidation activities for LHC.

Part of the budget for the Industrial Support must be shifted from the exploitation budget to the consolidation budget during the next three years. After that time, the supplementary cost of the Industrial Support will require an extra of 400 kCHF, which must be taken from the consolidation budget.

**The consolidation project is a long-term and ongoing project: these estimations are valid for the next 34 years, and will be reviewed later, in particular for certain activities for which the priorities could change.**

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Table 1 : Consolidation and subvention budgets 1993-2002

Table 2 : Budget allocations 2003-2010

Table 3 : Required staff 2003-2010

Table 4 : Industrial support 2003-2010

Table 5 : Result of the analysis of the Staff Plan

Annex 1: Staff plan summary

Annex 2: Detail of activities of each groups

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