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Report of the Working Group set up to Study The Requirements for Operating the SPS Within the INB Framework

(INBOPS)

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Abstract

The convention signed with the French authorities for the LHC defines a new Installation Nucléaire de Base (INB). The LHC machine tunnel, the experiments, some buildings which cover access shafts to the machine and the SPS with its extraction lines up to the targets are all inside the new perimeter. The new convention came into effect in September 2000 and therefore the SPS fell within the new context from that time. As a consequence, SL has to operate the SPS within this new regulatory framework and a small working group was set up to look at the requirements and to estimate the resources required. The conclusions of the working group are reported in this paper.

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1 Executive Summary

Having the SPS and LHC classified as "Installations Nucléaires de Base" (INB) under French law imposes a certain number of constraints on CERN. Firstly there are some procedures which have to be implemented in the fields of safety, traceability, zonage of the installations and waste management practices, and secondly documents describing safety and operational procedures have to be submitted and approved by the French authorities before operation can commence. The INBOPS working group was set up to outline a strategy for operating the SPS within the INB framework and to quantify the resources.

This report presents the conclusions of the working group and is intended as a guide to management for the resource planning in the immediate future. The report covers the four main areas of activity which are associated with operating within the INB framework: documentation, zoning, traceability and waste management. This is not a design study; the aim was to suggest a reasonable minimum operational scenario and to estimate the resources for its implementation. In a next step the detailed design will have to be made and at that time the resources can be more accurately determined. The resources stated here should be regarded as a good first approximation to what will be required.

The total manpower for implementation of the project has been estimated and some indication of what might be available from existing resources is indicated. There is clearly insufficient manpower available in CERN at present and it is not clear that the missing resources can be outsourced. However a global estimate for replacing missing in house resources by outsourcing is included in the values below.

1.1 Documentation

The SPS has become an INB under the convention signed for the LHC. Most of the documentation that is required will cover all installations mentioned in the convention, namely the SPS and its extraction lines up to the targets, the CNGS beam line (internally this will be included up to the hadron stop which is in Switzerland and therefore not technically part of the INB), the LHC and its transfer lines. A schedule for the delivery of documents to the French authorities has been established and the majority of the documents have to be submitted for mid 2003 in order to obtain approval for the sector test in April 2004 with injection the of beam in October 2004. A complete waste management document covering all of CERN’s activities has to be prepared for submission in mid-2004.

It is estimated that 1 FTE (Full Time Equivalent) will be required continuously over the next three years to cover the editorial effort for this. During the period of preparation of these documents substantial secretarial support will be required in the INB liaison office (>0.5 FTE on these activities). From 2004 on, about 0.1 FTE will be required continuously for editing the quarterly and annual reports which have to be sent to the French authorities together with a secretarial support >0.2 FTE.

Much of the technical content for the documents has to be prepared by the experts in the equipment and support groups. On average each equipment group will have to devote about two man-months to this effort, meaning a total of about 2 man-years. Some groups however, like SL-MR, TIS-GS and TIS-RP will have to devote far greater resources (totalling around 1.5 man-years spread over 3 years) because they will have to define strategies and procedures.

The financial costs (printing, travel etc.) which total around 15 kCHF per annum, are assumed to be a negligible part of the various group's travel and exploitation budgets.

1.2 Zonage

A simplistic operational zonage was implemented for the SPS for the 2000-2001 shutdown – everywhere in the horizontal underground areas was classified as a nuclear zone. The major disadvantage of this was that **all** waste coming from the SPS automatically became classified as nuclear waste, even if it was not radioactive. Since it is not possible to de-classify waste under French regulations, it will cost a significant sum to dispose of it. If a definitive zonage can be established, it should afford significant financial savings in the long term. To produce such a scheme will require effort from highly skilled scientific and technical staff.

The manpower required during the initial period totals approximately 10 man-years and these resources are currently not available. For the continuing effort, a further 1.8 FTE are required in addition to the existing staff.

The new hardware for the RP group will cost around 130 kCHF and there will be annual maintenance costs. The additional beam instrumentation for the SPS cannot be specified at this time and will have to be added at a later date once the design study has been completed.

1.3 Traceability

Traceability of materials coming out of an INB is one of the primary requirements from the French authorities. The reason for having traceability is to be able to understand and identify anomalies and in this instance the typical anomaly is the discovery of a radioactive substance in something which was thought to be conventional. The conventional equipment is therefore as important as the radioactive material to trace.

The traceability system introduced in the SPS for the 2000 - 2001 shutdown was a temporary solution which minimised resources and met the minimum requirements. This system will become unmanageable very soon – the volume of data is already significant and it is in the form of paper records. If it was necessary to trace an anomaly now it would involve a huge amount of work sorting through this stack of papers. The plan is to manually introduce this information in the computer and once this has been done, a simple database query will return the complete information. The long term solution is therefore to have a fully computerised system which will provide something which is much easier to maintain and much more flexible to operate.

In order to design and implement a traceability system for the SPS some 6 man-years of manpower should be backed up with about 1.4 MCHF. This work will cover the mechanical design and implementation of buffer zones equipped with self-service traceability stations at each of the 12 access points. At the same time there will be database design and implementation, data collection, software design and implementation for the user interfaces and finally design and implementation of the software required to interface the barcode readers and to produce other functionality like printing of barcodes. Maintenance and operation of the system will require 1.5 FTE at engineer level and 5 FTE technicians. Hardware and operating costs are estimated to be around 100 kCHF per annum. It is not possible to estimate the cost of infrastructure changes in laboratories and workshops, this will have to be done at the design stage but it is clear that the manpower in the equipment groups required for operating and maintaining traceability will be at about the level of one man-month per annum and per equipment group. There are about 20 equipment groups concerned by these activities of which about 10 will be heavily involved in traceability activities.

1.4 Waste Management

Waste management at CERN is being studied as a global project and the SPS INB is just one aspect of it. The cost of implementing this system is not evaluated in this report but some specific activities are required to operate the SPS in the INB framework before this study is completed in 2004. The motivation for a maximum effort in this direction is the cost of disposal: for well documented (inventory of radionuclides), compacted, low activity waste the minimum current cost for disposal is around 30 kCHF / m^3.

Nuclear waste should be minimised at all stages in the life cycle – design, operation and processing for disposal. Use of certain materials should be avoided if possible because they are likely to generate higher levels of radioactive waste. The list of such materials should be established and design of new equipment should be verified in this respect. Operation of the accelerator should be optimised so as to minimise activation and finally waste should be processed to separate the radioactive and non-radioactive parts and to minimise the volume.

The chemical composition of the existing nuclear waste from SPS has to be identified and procedures for the provision of this information concerning future waste also have to be put in place. The provision of this information should be included in the shutdown planning.

Conventional waste from the surface buildings of the SPS which are inside the INB perimeter should be disposed of through agreed channels and a trace maintained. This will require the implementation of a new infrastructure and a new contract for disposal to be established.

In order to put these systems in place for the SPS it will cost around 200 kCHF and consume 1.5 man years. The on-going costs for operation and maintenance will be around 2.5 FTE and 30 kCHF per annum.

1.5 General Infrastructure

The weigh bridge and gate monitor purchased for LEP Dismantling will continue to be used and will therefore consume resources and require maintenance. One person will have to be available all of the time to operate the weigh bridge and a radiation protection technician should also be available from time to time. Thus one FTE is required and this could be outsourced.

The database has to be modified to integrate specifications for all of the equipment to be found within the nuclear zones. This information is required for disposal but details of the location(s) of equipment in the tunnel is also important for traceability. This work will require around 4 man-months of effort at the database end and an average of about one man-month in each of the 20 equipment groups.

More detailed planning, accounting for waste management (specification of materials, storage etc.) will have to be established. This will add about 2 man-months of effort to the current planning activities for the SPS shutdowns.

Quality assurance affects activities across the operation of the INB and people in the equipment groups and others concerned with operation will have to define procedures and work with the quality unit to establish the plan. This will require about 1 man-month per group (totalling around 2 man-years) initially and a continuing equivalent amount to follow the execution of the procedures and maintain them.

Improved security for the SPS sites is envisaged with a minimum level being one dedicated 24 hour mobile surveillance team. In addition, the perimeter fences on the SPS sites will require improvements. The cost for security activities will be around 850 kCHF per annum and a one-off cost of around 200 kCHF for site improvements and then annual maintenance.

During LEP dismantling it was necessary to employ additional personnel for the management of the storage facilities. This will probably be needed again during the shutdown periods, corresponding to an additional outsourcing of around 1 man-year/year plus maintenance costs.

1.6 Summary of Resources:

The following table summarises the resources required:

	Initial				Continuing			
	Materials (kCHF)	**HR (my)**	**Existing**	**Possible to Outsource**	**Materials (kCHF)**	**HR (FTE)**	**Existing**	**Possible to Outsource**
Documentation		8.0	8.0			0.3	0.3	
Zonage	130	10.0	1.5		25	1.8		1.8
Traceability	1400	6.0	6.0		100	6.5	2.0	4.0
Waste	200	1.5	0		30	2.0	2.0	
Weigh bridge		0			25	1.0		1.0
Database		2.0	0			0		
QA		2.0	2.0			2.0	2.0	
Security	200	0			25	10.0	0	10.0
Storage areas		0			50	1.0	0	1.0
Total	**1900**	**29.5**	**17.5**		**255**	**24.1**	**6.3**	**17.8**

It can be seen that in the initial period and investment of around 2 MCHF would be required and that there is a shortfall in the human resources available. It is not clear that this shortfall can be outsourced because of the particular expertise required but if it was, then it would cost around 1.5 MCHF (12 man-years at engineer level). During the operational phase the material costs are modest but there is a large commitment of human resources with an outsourced 18 FTE which would cost around 2 MCHF per year.

It is therefore the conclusion of the working group that an initial investment of between 2 and 3.5 MCHF, with some 12 man-years of effort currently not identified from CERN's resources, and running costs of around 2 MCHF per annum will be required for operation of the SPS in the INB context.

1.7 Recommendation

A project should be initiated to define and implement the necessary measures for operation of the SPS within the INB framework and sufficient resources should be allocated.

2 Background Information

The signature of the convention with the French authorities for the LHC created a new Installation Nucléaire de Base (INB). The LHC machine tunnel, the experiments, some buildings which cover access shafts to the machine and the SPS with its extraction lines up to the targets (including the CNGS beam line) are all within the perimeter which is defined by this document. The new convention came into effect in the year 2000 and therefore the SPS fell within the new context from that time. CERN therefore has to operate the SPS within this framework and a small working group was set up to look at the resources required.

The working group called INBOPS (for INB OPerations of SPS) was formed from representatives of the various groups directly involved and the LHC experiments were invited to send delegates so that they might prepare for the LHC INB in a few years time (see membership list in the Appendix). The aim of the working group was to propose a working scenario for the SPS as a possible prototype for the LHC, to estimate the resources which will be required and to indicate the timescale for implementation.

The report covers the four main areas of activity which are associated with operating within the INB framework: documentation, zoning, traceability and waste management. The proposals presented here are not the result of a design study; the aim was to suggest a reasonable minimum operational scenario and to estimate the resources for its implementation.

3 Documentation

3.1 Introduction

The work which is considered here only concerns the preparation of documents for the SPS/CNGS (LHC is not included). Furthermore, it only evaluates the resources for a few of the studies which will have to be done in order to produce the necessary data. The “Étude Rejets et Effluents” for SPS/CNGS, quoted in the “zonage” section is accounted for. The “Compléments sur le Fonctionnement de l’ensemble SPS/CNGS” which will also have to be included in the “Rapport Préliminaire de Sûreté du LHC” is not accounted for. The latter report has to be finished by mid 2002 in order to be presented to the “Groupe Permanent Labos et Usines” before it can be incorporated in the “Rapport Provisoire de Sûreté du LHC” the latter will be needed by mid 2003 to get the authorisation for sector test in spring 2004.

The production of the documentation required for the operation of an INB represents a heavy work load and in this chapter the process is reviewed and the resources discussed.

3.2 Reports

The French authorities have laid down a minimum set of regulations concerning nuclear installations and in general it is up to the operator, CERN in our case, to clearly document various aspects of his activities. In this documentation the operator defines his goals, strategies and procedures. The documents are then examined by the authorities and once they have been approved the operator is given permission to start operations accordingly.

Throughout the life cycle of the installation further documentation and regular reports are required for the authorities to assess the results of the chosen strategies and for the operator to refine or propose new goals, strategies or procedures.

For the INB the main documents which have to be produced are listed in the Appendix (section 8.5), together with the schedule for publication as agreed with the DSIN in November 2000. These documents have to be assembled from various contributions, edited and submitted to the authorities in a timely manner.

In the near future **three main reports** have to be prepared for the SPS:

- ‘**Étude des Rejets et Effluents**’(mid 2002): this study of emissions and effluents concerns the whole of the new INB but since the SPS, CNGS and LHC all operate with proton beams of high intensities and high energies, most of the work that needs to be done in the short term for the SPS can be reused for the other two facilities.

- ‘**Gestion des Déchets**’ (early 2004): this study concerns the waste management for the whole of the new INB. Note that since the CNGS and LHC installations are completely new, the SPS will be the major producer of waste, in volume and tonnage, in the near future.

- ‘**Rapport Provisoire de Sûreté**’(mid 2003): this Provisional Safety Report contains two main sections (Safety and Risk Analysis and General Operating Procedures). Once discussed and approved this will turn into a Final Safety Report.

The scope of these reports is clearly the whole of the new INB, but we estimate that about two-thirds of the effort of writing these documents is directly or indirectly linked to the fact that the SPS is included in the perimeter of the new INB.

The production of these documents obviously requires many experts and engineers to write the chapters concerned with their particular domain under a central editorial guidance. A constant secretarial support is also required in the preparation of the documents and in the organisation of the various activities associated with liaison with the French authorities. While it is possible to estimate the resources necessary for the central editorial team and the secretarial support, it is difficult to estimate those associated with the work of the experts and engineers in the fields of safety, radiation protection, quality assurance, operations, equipment groups and so on. Based on the LEP Dismantling experience this will correspond to about 4 man-years and will have to come from resources within CERN.

3.3 Visits and Inspections

Another time consuming activity is centred around the visits of the French authorities for all machines in the INB perimeter (LEP, LHC, SPS, CNGS). These visits may be official visits like inspections, informal visits like technical exchanges and discussions (typically IPSN representatives visiting CERN or vice versa), or meetings to defend a document.

While the visits themselves represent only a few days each time, the preparation and follow-up take a significant amount of time for the people directly involved, typically 6 to 8, not including the many experts and engineers from several divisions who are consulted in this process. It is difficult to estimate this workload and to a large extent these activities are not considered in the present analysis.

3.4 Resources

From the above considerations, and based on the experience gained with the LEP Dismantling project, the necessary resources for the documentation activities have been estimated and are summarised in the following table:

Activities	**Initial Effort** (per annum, over the next 3 years)	**Continuing Effort** (per annum)
Editing of the main **reports**	1 my	0.1 my
Secretariat for **main reports, visits and relations** with authorities	0.6 my	0.2 my

The above estimate only concerns the central role of the editors and a much more effort has to come from the various experts who are regularly consulted and asked to write up their contributions to the main reports. This additional effort is estimated to be of the order of 4 man-years, spread across about 8 groups in LHC, SL, SPL, ST and TIS and concerning about 20 people.

4 Zonage

4.1 Introduction

This chapter estimates the workload which will be required to define the *zonage* (zoning) of the SPS, including CNGS. The study will require theoretical estimates (mostly Monte Carlo simulations) confirmed by experimental measurements and complemented by an assessment of past operational history of the machine. The *zonage* study will have close links with:

1) the traceability system: the LEP experience has shown that the *zonage* is a 3-D problem; the material removed from the tunnel will have to be traced according to its position in the tunnel and its classification;
2) the waste management: the studies for the *zonage* can possibly provide (part of) the information on radionuclide inventories present in the waste generated from the SPS, which is needed for its final disposal. It will also help with the planning of waste production and provide feedback for minimisation of waste;
3) machine operation and data logging.

The aim of the *zonage* study will be to classify the various regions of the machine tunnel, access tunnels and auxiliary buildings in "*zones à déchets conventionels*" (conventional waste), "*zones à déchets TFA*" (very low activity waste), "*zones à déchets FA*" (low activity waste), "*zones à déchets MA*" (medium activity waste) and "*zones à déchets HA*" (high activity waste). The French legislation does not provide clear indication for the classification of material in either category according to the induced radioactivity.

The long term goals of the *zonage* study are:
1) easy maintenance and interaction with other activities (such as traceability report writing for INB) in order to minimise resources needed in the long-term;
2) minimise the amount of nuclear waste and materials, especially TFA waste.

4.2 The LEP Experience

As a starting point it is useful to review the experience gained with LEP. The LEP *zonage* was performed with limited additional manpower and resources, exploiting previous studies carried out during LEP operation. These studies provided information on radiation sources, essentially from synchrotron radiation measurements as well as measurements performed on the superconducting cavities. The definition of the LEP *zonage* involved the following:

1. calculations - both analytical and Monte Carlo;
2. dedicated measurements of irradiated samples or samples taken from material and equipment installed in LEP;
3. setting-up of dedicated monitoring electronics and software at the LEP dump, to monitor the number of leptons dumped so that the measurements mentioned above could be normalised;
4. detailed radiation surveys in addition to the routine ring surveys carried out at the beginning of long shutdowns;
5. a detailed analysis of the history of the 11-year operation of LEP;
6. write-up of 14 reports summarising the results of calculations and measurement;

7. a consistent contribution to the write-up of the various official reports transmitted to DSIN and IPSN for the dismantling authorisation.

The LEP *zonage* study lasted about 2 years and required a total of about 5 man-years of scientific staff and 2 man-years of technical staff. These figures do not include the work done for the *zonage* of the four experiments.

4.3 *Zonage* Study for SPS

The SPS presents particular differences with respect to LEP: apart from the CNGS areas which are “virgin”, the SPS has been in operation for almost thirty years both as an accelerator and a collider. Equipment may have been installed for a number of years in a certain zone of the machine, then removed, stored for months or years, and possibly re-installed in a different zone. Areas to be considered in the *zonage* study of SPS are:

- the SPS ring,
- the transfer tunnels up to the targets,
- the access tunnels linking the machine and transfer tunnels with the access shafts,
- the access shafts linking the surface buildings with the underground areas,
- the BA buildings (some of which contain the ion-exchangers where radioactive water circulates),
- the ventilation buildings (the ventilation filters may be active because of radon and its daughters),
- the pits draining water from the transfer tunnels,
- the berm on top of TCC 2,
- the CNGS areas.

Overviews of the various areas (SPS, targets stations and CNGS) are shown in Figures 1-2.

The *zonage* study will require calculations and measurements of the hadron fluence around the SPS and subsequent extrapolation to the adjacent areas such as service and access tunnels, shafts, etc. A relationship will have to be established between proton losses and hadron fluence at the various locations around the accelerator for a number of representative situations and operating conditions. The *zonage* will necessarily have to be, at least partially, based on the past radiological history of the SPS, i.e. the results of past measurements and radiation surveys, as well as beam loss scenarios.

For any given area, the computational effort will be proportional to the dimension and “complication” (in terms of geometry) of the area. The *zonage* will most likely be a function of distance from the beam axis. Thus the machine and transfer tunnels may or may not require a *sub-zonage* to separate the accelerator and beam line components from cable and cable-trays running on the tunnel walls, as well as the walls themselves. Most of the calculation effort will probably be required for the classification of access tunnels and shafts. The calculations will have to be confirmed by gamma-spectrometry measurements on samples taken from the various areas.

It is considered that the best approach is to establish a well-defined initial *zonage*, which will require a substantial amount of work (“**prior**” effort) and subsequently to update it annually with a relatively minor effort, i.e. as far as we can a “low maintenance” work (“**continuing**” effort).

To obtain a first idea on where the limit between conventional areas and TFA areas may be located around the SPS, radiation surveys were carried out in the access shafts and access tunnels (TAs) at all BAs. Being in a shutdown period, these measurements were influenced by the background created by radioactive material temporarily stored in some of the TA tunnels, in addition to the background coming from the machine tunnel generated by activated SPS components. These surveys have been complemented by gamma spectrometry measurements performed on concrete samples collected in all TAs. The measurements have shown negligible values of induced radioactivity in most samples, with the exception of samples taken in TA2, TA6 and TA7. These samples showed traces of one or more of the following radionuclides: ^{22}Na, ^{54}Mn, ^{60}Co, ^{152}Eu and ^{154}Eu, with a maximum of 0.5 Bq/g of ^{152}Eu in one sample from TA7. These surveys and measurements indicate that the limit between conventional and TFA material will most likely be located either at the interface between the shaft and the TA tunnel or somewhere in the TA tunnel.

For a few areas it is worth making specific comments:

TT10

The upstream part of TT10 will be excluded from the *zonage*, as in this area activation can only be produced by beam losses in TT2, i.e. losses due to operation of the PS which is not under SPS control. A precise limit which corresponds to a physical barrier in the tunnel will have to be defined.

TCC2

The downstream end of the target hall is geographically delimited by physical barriers (gates) separating it from the transfer tunnels TT81, TT82 and TT83. From a traceability point-of-view, all TCC2 is included in the INB perimeter, as it will be impossible to distinguish between material coming from the areas upstream and downstream of the targets. The same approach is recommended for the *zonage*.

TCC6

The same approach applies to TCC6, which is physically separated from the downstream tunnel TT61 by a gate.

4.4 Type of Activities

The *zonage* study will require the following activities:

HISTORY: mostly a **prior** effort to find out the history of the different zones. This will represent a large workload but it can be spread over a certain period consistent with the document delivery schedule.

CALCULATIONS: mostly a **prior** effort, to establish the activation in different materials/elements for a given loss pattern and for the different zones. There will then be some **continuing** effort (but not much), mostly when operating conditions change drastically. Some of these calculations involve environmental aspects (air and water releases). Whether the known MA/HA zones should be also subject to calculations is debatable.

MEASUREMENTS: a **prior** effort to do detailed spectrometry, dose rate and contamination measurements on samples taken from the different zones. This will be required to justify any conventional or TFA (vs. FA, MA or HA) zoning. **Continuing** measurements should be done should the operating conditions change drastically for confirmation of the revised *zonage*.

INSTRUMENTATION: definition of additional instrumentation needed in the tunnel or service areas. A **prior** effort mostly, to be revised regularly (**continuing** effort) if operating conditions change drastically.

LOGGING/MONITORING of the beam parameters (intensity, losses, energy, etc.), mostly a **continuing** effort. Someone will have to be responsible for the monitoring of the logging processes and ensuring that everything is properly documented. Particular effort will be needed to document the changes made to the different zones during technical stops and shutdowns, including linking with the traceability database to ensure that the proper route is chosen. The implementation of the logging, given the instrumentation is a **prior** effort.

SURVEY of the induced radioactivity, either with active instrumentation or passive dosimetry. Regular ring surveys at beginning of shutdown fall in this category. It is clearly a **continuing** activity.

DOCUMENTATION or making sure that all the above information are tracked in a consistent and centralised way. It is clearly a **continuing** effort which will ease the reporting to DSIN/IPSN. Another part of this is a study of improvements in operating conditions and protections to minimise the amount of waste produced; this is also a **continuing** effort which is part of the waste study. This might include suggesting additional shielding/doors to better define the zones where active waste is produced, changes or additions to instrumentation to better control a specific loss pattern, etc.

The above activities are summarised in the following table:

	SUMMARY FOR ACTIVITIES	
HISTORY	PRIOR	
CALCULATIONS	PRIOR	continuing
MEASUREMENTS	PRIOR	continuing
INSTRUMENTATION	PRIOR	continuing
LOGGING		CONTINUING
SURVEY		CONTINUING
DOCUMENTATION		CONTINUING

4.5 Breakdown of Work and Resources Required

Tables 1-3 in Section 8.3 of the Appendix provide estimates of what will be required to define the classification for each area in terms of *zonage*.

The requirements in terms of documentation are not specifically mentioned because this item clearly applies to all activities.

Based on the estimate of the work needed, the manpower requirements for the various activity and areas of the SPS and CNGS are listed in Tables 4-7 (Section 8.3).

It should be noted that there is no continuing effort required in terms of calculations, both for SPS and CNGS, once the initial picture has been established. However, any change of operation conditions or abnormal operation will require some additional calculations. This potential effort cannot be foreseen at present.

In addition to the specific requirements listed in Tables 7-10, some very generic calculations and measurements are deemed necessary:

Generic calculations
For the SPS tunnel, generic calculations will be required for a standard complete machine period, valid for all tunnel sectors, at the injection energy and at the maximum energy. These calculations will evaluate the activation pattern as a function of beam loss pattern. The estimated time is **6 man-months**.

Etude de rejets for SPS.
Separate studies will be needed for air and cooling water releases (*étude de rejets*) from points 1, 2, 4 and 6. The estimated time is 2-3 man-months for each area, i.e. a total of **8-12 man-months**.

TCC2 and TCC6 will both require 4 man-months for a total of **8 man-months**. The dumps in TT20, TT40 and TT60 will require 1 man-month each for a total of **3 man-months**. The re-calculation of ground-water activation around TCC2 (this study is coupled with the study of air and cooling water releases) will require **4 man-months**.

Generic gamma-spectrometry measurements
Gamma-spectrometry measurements on reference samples irradiated at specific locations around the SPS will serve two purposes:
1. to link beam losses to specific activity induced in the various materials present in the tunnel, similar to what was done for LEP
2. to help in establishing a radionuclide inventory needed for final disposal of radioactive waste.

In principle these measurements will be done only once and will require **4 man-months**. They may need to be repeated if the operation conditions change drastically or if new materials are introduced in the machine tunnel.

4.6 Summary of Manpower Requirements

The global manpower requirements for the *zonage* of SPS and CNGS (covering the generic studies and measurements and the area specific work) can be summarised as follows:

SPS	Prior:	103 man-months of scientific staff (91 man-months TIS/RP, 12 man-months SL)
	Continuing:	7 man-months of high-level technical staff (4 man-months TIS/RP, 3 man-months SL) This manpower has to be added to the present 18 man-months of TIS/RP technical staff dedicated to the SPS areas.
CNGS	Prior:	10 man-months (6 man-months technical staff, 4 man-month scientific staff, all with TIS/RP)
	Continuing:	12 man-months (high-level technical staff in TIS/RP)

For the sake of completeness, it should be underlined that the effort currently under way (until December 2001) already amounts to 36 man-months.

The above figure of manpower needs for the “prior” effort for SPS (103 man-months) compares well with the time spent for the LEP *zonage* (approximately 7 man-years, i.e. 84 man-months).

In terms of planning, the “prior” effort of the *zonage* study for SPS and CNGS will approximately require 3 TIS/RP scientific staff for 2.5 years, 1 SL scientific staff for 1 year and 1 high-level TIS/RP technical staff for 1.5 years. This manpower is on top of the present staff available. The “continuing” effort will require, in addition to the present staff, 1.5 high-level TIS/RP technical staff and 0.3 high-level SL technical staff.

4.7 Infrastructure and Instrumentation Required

For the computational activities a few desktop computers will be needed and the cost will be of the order of 10 kCHF.

For the gamma-spectrometry measurements a dedicated Ge-spectrometer will probably be needed; the overall cost of the detectors, lead shielding, electronics and software is of the order of 120 kCHF. Maintenance of RP equipment will cost around 25 kCHF per annum.

The cost of additional instrumentation for the SPS cannot be estimated at present, but it will have to be addressed by the working group which will carry out the *zonage* study.

Finally, it should be pointed out that additional effort will be needed to review or define issues such as position of interlocked gates and operational dosimetry. This effort, which is difficult to estimate at present, will have to be shared amongst the SL, TIS and ST Division. It might also be worth investigating an alternative high-level dosimetry approach, for example resorting to colour tape dosimetry as used in the past. This or a similar system may complement the beam loss monitoring system. In turn, the beam loss monitors may complement the RP induced activity monitoring system. Some of the installed induced activity monitors and beam loss monitors could be designated as “INB monitors” and be used to prove whether or not there have been losses in a certain area of the machine over a given period of time. It is not excluded that additional monitors will have to be installed for this purpose.

5 Traceability

5.1 Introduction

For a future long-term SPS traceability system, the following problems were addressed:

- identification of equipment,
- data management,
- recording the traces - underground equipment and surface waste,
- tracing equipment during repairs and modifications,
- integration with RP systems,
- storage specifications for managed buildings (ISR, 879 etc.) and labs/workshops

5.2 Current Implementation of SPS Traceability

Given the fact that the SPS became classified as an INB on 11 July 2000, with the signature of the Convention between CERN and the French authorities, an *intermediate SPS traceability system* was put in place just in time for the SPS shutdown 2000-2001. This intermediate traceability is fully paper-based without computerised support. As such, the traceability system depends heavily on the participation and good will of the intervening parties (equipment groups, TIS/RP and SL/MR). It is recognised that the current implementation slows down the evacuation of equipment and the overall shutdown work.
Given the experience that is being gained with the *LEP dismantling traceability system*, it is clear that a more flexible and maintainable traceability system for SPS will have to be computerised and built around a central database for proper data management.

5.3 Comparison between LEP and SPS

The obvious question is *"Why not apply the LEP solution for SPS?"*. In order to answer this question, we must outline the differences between the INB traceability needed for LEP and for SPS. The major point is that LEP is being fully dismantled and 30000 tons of material are coming out of the LEP INB perimeter. This is clearly not the case for SPS despite the fact that the shutdown 2000-2001 is a major undertaking. For LEP, the establishment of a *complete inventory* of all LEP underground equipment started the database work. The identification and the quest for all necessary information on more than 40000 objects, proved to be a nightmare. The data were scattered, imprecise, insufficient and out of date. Moreover, the data collected only covered well-known equipment and it was understood that bulk material such as cables and pipe-work could not be identified in advance.

The numbers in the following table are estimates of resources deployed for putting the LEP traceability system in place. These numbers are only rough estimates due to the fact that several details are dispersed in the dismantling project budget; also, the use of normal CERN services is not taken into account. Note that a *result-oriented contract* is the major resource for the execution phase of the LEP dismantling traceability.

LEP Traceability	*Prior Resources*	*Execution Resources*
Software Development	24 man-months (engineer)	
Hardware Installation	250 kCHF (readers, printers, computers,…)	
Traceability Execution		1 MCHF (result-oriented contract)
Traceability Follow-up		24 man-months (engineer)

5.4 Future SPS Traceability

In order to estimate the necessary resources for the future SPS traceability, a *new concept* needs to be outlined for the implementation of this system. The intention is not here to specify a detailed final solution, but rather to outline certain basic choices.

As mentioned above, the system will depend on a centralised database. The term ***object*** will be used to refer to a piece of equipment of the SPS in the most general sense and could be anything from a magnet assembly to radioactive waste bin. Four major areas of interest are defined:

1. identification of the object
2. necessary attributes of the objects
3. establishing the trace of the object
4. temporary storage of the object

Within each group concerned, some resources will have to be devoted to traceability activities. Groups having equipment in the SPS INB are:

- EST – SU
- LHC – ACR,VAC
- SL – BI, BT, CO, EA, HRF, MR, MS, PO
- ST – AA, CV, EL
- TIS – FB, GS, RP

5.5 Object Identification

The objects concerned are all equipment within the SPS underground perimeter i.e. SPS ring, TT10, extraction lines up to target zones and the CNGS. A physical barrier, such as a gate or a door, always defines the limit of the perimeter. In the case of the TT20 target area for example, the perimeter extends beyond the targets to the next physical barrier (PPX81 and PPX82). For all zones, the limits must be unambiguously defined (e.g. for the transfer lines TT10 and TT70). The normal access points to these areas are:

Access Point	*Zones in the perimeter*
BA1	LSS1, $TS1^+$, $TS1^-$, TT10
BA2	LSS2, $TS2^+$, $TS2^-$, TT20
BA3	LSS3, $TS3^+$, $TS3^-$
BA4	LSS4, $TS4^+$, $TS4^-$
BA5	LSS5, $TS5^+$, $TS5^-$
BA6	LSS6, $TS6^+$, $TS6^-$, TT60
BA7	TNC
BA80	TCC2, TDC2
ECA4	ECX4, TT40, TA40, TI8
ECA5	ECX5
BDW	TCC6, TT60, TI2, TT70
PMI2	TI2

Note however, that all *Access Points* allow access to the complete underground perimeter.

In order to keep track of equipment it is not necessary to identify *all* objects concerned in the traceability database - identification could be limited to the *objects leaving the perimeter*. However, we should also consider the case of ***objects that change place within the perimeter*** because of the *zoning* issue.

The working group considers that ***tools*** should not be considered as objects that need to be identified. The definition of tools in this context is material which does not reside within the nuclear zones during operation with beam of the SPS. The working group assumes that there is no risk of radioactivation outside the period of beam operation. This assumption needs to be confirmed by the zoning and related radiological work. If the risk of contamination exists, additional measurement equipment must also be considered.

The *identifier* of the object should be unique. The *name* of the installed object cannot be used as identifier since the object's name might change over time. A unique traceability identifier that is *created at the time of the evacuation or movement of the object* is recommended. In the temporary system, such an identifier is already present in the alphanumeric format 'S123456' as well as the corresponding barcode which is also reproduced on the sticker. The location of the barcode sticker on the object is important for later processing and storage.

5.6 Object Attributes

Without going into too much detail, it is useful to have an idea of the information needed to trace an object.

Object Identification	Barcode Type name Owner (i.e. responsible person within CERN)
Type Attributes	Dimensions, weight, conditioning, number Chemical composition, radionuclide inventory
Object Attributes & Trace (dated events)	Installed location, zoning Movement, destination Radiological measurements Changes: name, owner, (dis-)assembly

5.7 Establishing the Trace

Traceability requirements will inevitably mean additional work for the groups responsible for equipment within the INB perimeter. It is difficult to estimate this additional workload which varies from group to group as a function of the amount of equipment installed and the frequency of its movement. For this reason and in the light of diminishing human resources, the *modus operandi* of the traceability system interface must be standard, easy to use, flexible within a rigid scope, manageable, maintainable and beneficial for the overall organisation of SPS equipment follow-up.

Taking into account that over 90% of the evacuation of objects takes place during the annual shutdown, the effort should clearly be targeted to optimise the shutdown traceability. Nevertheless, the system proposed should also cater for unplanned one-off interventions.

The working group proposes the development of a standardised (web-based) interface, that captures in a user-friendly way ***all*** information needed about an object and stores this information in the central database. This interface must have query capabilities to retrieve stored information. Two levels of information have already been outlined: the ***type*** of the object and the specific ***object*** itself.

For the shutdown work, which is carefully planned, each equipment group could introduce the information necessary in advance through this interface and consequently prepare the group's shutdown work very precisely. Even for unplanned piquet interventions, the information about the object *type* could be prepared.

The information introduced during this ***preparation phase*** must be completed with the actual evacuation of the object during the ***execution phase***. Therefore, the same interface must be available at each of the "Access Points" or "Exit Points" to give a more appropriate name. This would require a kind of kiosk installation with access to the central database, barcode reading capability and a distribution mechanism for barcode stickers.

The software developments for the system would have to cover the database and the associated interfaces and the software for barcode reader functionality. For LEP Dismantling the traceability system also produces transfer slips for the distribution of materials and similar extensions of the system functionality will be required for the SPS. The software development is therefore not simply a matter of building a database and having a couple of interfaces, it requires a sophisticated integration of several technologies implemented in a distributed system.

5.8 Buffer Zone and Storage Area

Before leaving the SPS INB perimeter, the requirements for traceability, radiological verification and storage need to be fulfilled. In some cases this could be nicely organised and co-ordinated, in other cases this would be impossible. Therefore, the object to be evacuated must reside in a "*buffer zone*" before the exit point, where it is on hold in order to receive the authorisation of all intervening parties. We will refer to this zone as "***buffer zone***" or "***zone tampon***" in French. The design of the buffer zone should take into account the type of equipment that will be evacuated through this zone; e.g. large, heavy and radioactive elements usually come out through BA3.

Only when all authorisations are received can an object be removed from the buffer zone and transported to its destination storage area. The *storage manager* can refuse the evacuation of the object if no adequate space has been assigned within the proposed storage area. Except for conventional waste, which follows an authorised disposal channel through SPL, four types of temporary storage areas can be distinguished, depending on the nature of the stored objects:

- Conventional material for future reuse
- Radioactive material for future reuse
- Radioactive waste
- Equipment returned temporarily to a lab or workshop

The application of the *general* rules and constraints for *INB storage areas,* especially the radioactive storage areas, on top of the current implementation at CERN, are not fully specified yet. This aspect should be treated as part of the independently funded waste management system. A clear policy needs to be elaborated concerning the temporary storage of equipment in a laboratory or workshop – mixing of INB and non-INB equipment must be avoided and the trace must be maintained by the person responsible for the equipment. Groups requiring the facility of storing and working on equipment from the INB's will therefore have to implement some infrastructure modifications and devote human resources to traceability activity.

5.9 Resource Estimates

The working group has quantified the resources required:

- ***Initial Resources*** needed in order to put the new system in place
- ***Continuous Resources*** needed once the new system is in place (during 5 years at least)
- ***Financial Resources*** mainly for hardware equipment
- ***Human Resources***: *engineering* (Eng.) and *technical* (Tech.) manpower

There are three areas where the resources are needed for the traceability: *Infrastructure*, *Development* and *Execution*. The table in Appendix 8.4 gives the details of this analysis.

The table below summarises the estimations for the additional resources needed to implement a future SPS traceability system as outlined above:

Initial Resources			***Continuous resources (per year)***		
Engineer	**Technician**	**Financial**	**Engineer**	**Technician**	**Financial**
4.5 man-year	**1.5 man-year**	**1.4 MCHF**	**1.5**	**5**	**0.1 MCHF**

These figures do not take into account the following topics, which need to be evaluated at a later stage by the competent bodies:

- The detailed study and proposed implementation of the *buffer zones*
- The possible risk of radioactive *contamination* and prevention
- The application of the general, *non-traceability-specific* INB requirements for storage areas
- Additional storage infrastructures, including the creation of a *radioactive workshop*

6 WASTE MANAGEMENT

6.1 Introduction

The LEP dismantling will produce a huge amount of waste, both conventional and nuclear. The study which was required by the French authorities to obtain permission for dismantling, lead to the development of an appropriate framework for CERN to manage waste in the context of INB.

Working on the assumption that all conventional waste is disposed of through external channels (recycling agencies), all conventional material is managed by its owners (Accelerator Sector) and that all nuclear material is also managed in the divisions under the supervision of TIS, the waste problem is mainly a problem of management of nuclear waste.

Nuclear waste is produced by all CERN accelerators, located on French and Swiss territory; its management involves specific areas for interim storage and treatment and specific disposal channels. A distinction has to be made between waste produced in Switzerland and France and between the INB or non INB origin of the waste.

The SPS waste management has therefore to be considered within the framework of the global CERN approach.

6.2 Global CERN Approach to Nuclear Waste Management

The preliminary recommendations of a (draft) study by TIS concerning radioactive waste management at CERN are:

1) A professional CERN interim storage facility including a waste processing and clearance measurement facility should be established.
2) All actions necessary to permit the determination of radionuclide inventories should be started immediately.
3) Practical and stable channels for disposal of radioactive waste to external depositories and for clearance of material which is no longer radioactive will be established in agreement with the authorities of the Host States.
4) A set of clear procedures should be defined for waste transfer within CERN. These will cater for the management and provision of storage space, ensure traceability, facilitate the determination of radionuclide inventories and minimise the exposure of staff during handling.
5) The design of future facilities and installations must include the minimisation of the radioactive waste that will be produced when the equipment is finally destroyed.
6) Costs for handling, storing and disposal of waste should be borne by the owner of the equipment and should be included in the overall costs estimate at the design stage ("polluter pays principle").

Such an approach implies the allocation of substantial additional financial resources which will be implemented as a CERN-wide project and which are therefore outside of the scope of INBOPS.

6.3 SPS Waste Management

Definition

Once the zoning of the installation has been established, the SPS INB will, by definition, produce either:

- conventional waste: coming out of a conventional zone
- nuclear waste: coming out of a nuclear zone.

Nuclear Waste

According to the data recorded by TIS, the average radioactive waste flux coming out of the SPS INB is estimated to be more than 100 m^3 per year (50% of CERN's total nuclear waste production); this amount doubled during 2000 and 2001 when the machine underwent substantial reconstruction in preparation for LHC.

Conventional Waste

The quantity of conventional waste produced each year is not known. All conventional waste produced by CERN is evacuated, either through the SPL Division or through subcontractors working for contracts placed by the ST division. The total tonnage which goes through the SPL division is 3500 tons/year (averaged over the last two years) and this for the whole CERN. The way the waste is presently collected does not allow precise estimates for the SPS-INB but is estimated to be of the order of 500 tons per year.

In order to minimise the costs, some constituents of the waste like metallic parts (copper, iron, aluminium) have to be regrouped in dedicated containers. The major part of the SPS waste is generated during the annual 4 month shutdown. At present waste coming from areas other than the tunnel is not checked for radioactivity and it is mixed with other conventional waste.

It will require one person working full time during the shutdown to ensure the correct separation of the waste and some extra funding will be required to buy the containers and provide a suitable space at each of the SPS sites and possibly at a central location as well. The French authorities require traceability for all conventional waste and the new contract should make provision for this. The traceability of conventional waste from surface buildings could be established at the level of recording quantities removed from the CERN site, rather than from specific locations within the INB perimeter. This would therefore be a simpler and much cheaper system to implement than that required for the underground areas.

Putting the containers, traceability and new contract in place will take around six man-months to set up (planning, placing contracts and implementation) and will have to be followed with a continuing effort of about 1man-month per annum.

The extra resources needed are therefore ~0.5 man-year during each shutdown (should be outsourced) and an estimated 200 kCHF for containers and space.

6.4 Estimated Resources and Costs

An estimate of the resources and costs for the treatment of the nuclear and conventional waste coming from the SPS INB has been made; it corresponds to a permanent effort of 2.5 FTE (i.e. 2.5 man-years per year) of which 1 is at engineer level and 1.5 at technician level, plus a one-off input of 1.5 man-years at engineer level, and a cost of 30 kCHF according to the following breakdown:

Waste Management

Choice of materials to be installed in the ring, checks of contracts, careful management of the beam losses during operation,…[continuous]	1 my
Define and implement new conventional waste management procedures [prior]	0.5 my
Estimation of annual conventional and nuclear flux [prior]	0.5 my
Waste management at source (checking in the tunnel or in BA's) [continuous]	0.5 my
Nuclear waste processing [continuous]	0.5 my
Infrastructure for conventional waste from surface buildings [prior]	200 kCHF
Waste database maintenance cost [continuous]	30 kCHF

Documentation and report writing:

Annual balance of waste fluxes [continuous]	0.1 my
Waste management procedures [prior]	0.5 my

The infrastructure of interim storage and treatment centre and the management of these facilities are not taken into account

7 General Infrastructure

7.1 Waste Handling

Modifications are required to the infrastructure to accommodate traceability and waste disposal procedures. The bulk of the infrastructure for traceability has been discussed in chapter 5 but there was no provision at that stage for the weigh bridge and gate monitor. This equipment was put in place for LEP Dismantling but there is an on going cost for its operation – manpower and maintenance. The weigh bridge will require an operator for working hours and assistance from a radiation technician from time to time.

7.2 Database

It is clear from the work of the zoning sub-group that at least all individual pieces which are within the nuclear zones of the machine should be identified and their specification should be available from the database. This information is required for the ultimate disposal and whilst it is not necessary for the traceability, it is closely related and the database should be built so that there is a seamless interface with the traceability data. It would be a formidable task to try and establish this database from the start but it should be possible to build it up over a few years, ensuring that anything which is moved during a shutdown is identified in this database. This will consume at least 4 man months of effort at the database end and probably another man-month per equipment group concerned (searching out specifications and historical information from the 20 or so groups concerned).

7.3 Planning

There will have to be major changes in the planning activities for each shutdown because each piece of equipment which will be removed from the tunnel should be specified before the shutdown. This specification will include the identification and usual description of the elements but should also include the chemical composition of the element if it is to be disposed of as waste (for conventional waste to determine its value and for radioactive waste for its ultimate disposal).

There is a critical lack of storage space at present and this will certainly continue in the medium term. It is essential that the planning establishes the destination for each element to be removed from the tunnel and it should be verified that there is space available at the destination.

7.4 Quality Assurance

The INB Quality Assurance Unit will base its plans on procedures established by the groups involved in managing the various activities. For example a result oriented contract concerning traceability should have a number of procedures and checks included and it will be these procedures which are referred to by the INB quality plan. Groups will therefore have to devote resources to the creation of their procedures and the follow up during the execution of the contract. The procedures will have to be documented by the groups and the quality plan established in conjunction with the unit in ST Division.

7.5 Security

SPS sites are relatively open at present and there is no permanent presence. LEP experience has shown that there is an increasingly significant volume of theft from the sites (particularly scrap metal like copper and aluminium) and therefore some improved level of site security is required for the SPS sites. The minimum that one might expect would be to have 24 hour surveillance by mobile security teams and to improve the perimeter fences. The cost for a security patrol team will be around 850 kCHF per annum and the modification of the fences an initial one-off cost of 200 kCHF. Maintenance of the sites and and security facilities and provision of equipment for the personnel will require an annual materials expenditure of around 25 kCHF.

7.6 Storage Facilities

During LEP dismantling it was necessary to employ additional personnel for the management of the storage facilities. This will probably be needed again during the shutdown periods to handle the increased activities and will correspond to an additional outsourcing of around 1 man-year per year. These facilities also require maintenance and additional hardware like racking from time to time and therefore a materials budget of around 50 kCHF per annum should be envisaged.

8 APPENDICES

8.1 Members of INBOPS

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8.2.3 Zonage

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8.3 ZONAGE NOTES AND TABLES

Key to abbreviations used in the following tables

C = calculations (Monte Carlo, analytical)
S = radiation surveys (with active instrumentation or passive dosimetry)
M = gamma-spectrometry measurements on samples taken from the area and/or smear tests
H = reconstruction of operation "history" of the area and estimate of beam losses
I = additional instrumentation needed in the tunnel or service areas. Design work required.
L = data logging

Table 1 : Underground Areas of SPS

Area	Function	Specific hazard	Possible classification	Needs
TS 1^+ / TS 1^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS1	Straight section 1	Internal dumps	MA/HA around dumps, FA elsewhere	H,S,I,L,C
PP1	Shaft, Personnel	None	Conventional	C,S,I,M
TA1	Access tunnel	None	Conventional/TFA	C,S,I,M
TS 2^+ / TS 2^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS2	Straight section 2	Extraction elements, separators	MA/HA around septa, FA elsewhere	H,S,I,L,C
PP2	Shaft, Personnel	None	Conventional	C,S,I,M
TA2	Access tunnel	None	Conventional/TFA	C,S,I,M
TS 3^+ / TS 3^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS3	Straight section 3	RF cavities	Mainly TFA, perhaps some FA	H,S,I,L
PP3	Shaft, Personnel	None	Conventional	C,S,I,M
TA3	Access tunnel	None	Conventional/TFA	C,S,I,M
TS 4^+ / TS 4^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS4	Straight section 4	Future extraction elements for CNGS and LHC	TFA/FA (now), MA/HA around septa (future)	H,S,I,L,C
PP4	Shaft, Personnel	None	Conventional	C,S,I,M
TA4	Access tunnel	None	Conventional/TFA	C,S,I,M
PAM4	Shaft, Material	None	Conventional/TFA	Part of ECA4 study
PAP4	Shaft, Personnel	None	Conventional/TFA	
ECX4	Experimental cavern, experiment	Future extraction elements for CNGS and LHC	TFA/FA (now), MA/HA around septa (future)	H,S,I,L,C, M
ECA4	Experimental cavern, service	Piping lines with radioactive air and cooling water from CNGS + temporary storage of rad. material	Conventional/TFA	H,C,M
TS 5^+ / TS 5^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS5	Straight section 5	None	TFA/FA	H,S,I,L

Table 1 (continued)

Area	Function	Specific hazard	Possible classification	Needs
PP5	Shaft, Personnel	None	Conventional	C,S,I,M
TA5	Access tunnel	None	Conventional/TFA	C,S,I,M
ECX5	Experimental cavern, experiment	None	TFA/FA	H,S,I,L,C
ECA5	Experimental cavern, service	None	Conventional/TFA	H,C,M
TS 6^+ / TS 6^-	Tunnel ring sextant	None	TFA/FA	H,S,I,L
LSS6	Straight section 6	Extraction elements, separators	MA/HA around septa, FA elsewhere	H,S,I,L,C
PP6	Shaft, Personnel	None	Conventional	C,S,I,M
TA6	Access tunnel	None	Conventional/TFA	C,S,I,M
TNC	Neutrino cave	Neutrino target and beam line	MA/HA	S,M
PP7	Shaft, Personnel	None	Conventional/TFA	S,I,M
TA7	Access tunnel	None	Conventional/TFA	S,M
Bldg. 846	Escape shaft	None	Conventional to FA	S,M
TT 60	Transfer tunnel	External dump	MA/HA	H,S,I,L,C
TCC 6	Target area	Target station T1	MA/HA	H,S,I,L
TI2	Transfer tunnel	Proton injection line SPS-LHC	TFA/FA	I,L,S,C
PMI2	Shaft	None	Conventional	I,L,S
TI8	Transfer tunnel	Proton injection line SPS-LHC	TFA/FA	I,L,S,C
TJ8/PGC8	Switchyard	Back-up dumps	TFA/FA	I,L,S
TT 10	Transfer tunnel	Proton injection line PS-SPS	TFA/FA	H,S,I,L,C
PGC1	Civil engineering shaft, ventilation shaft coupled	None	Conventional	I,L,S
TT 20	Transfer tunnel	External dump	MA/HA around dumps, FA elsewhere	H,S,I,L,C
DP 522 (TT 20)	Well (*puisard*) and ventilation shaft	None	Conventional	S,C,M
DP 523 (TCC 2)	Well (*puisard*) and ventilation shaft	None	Conventional	S,C,M
TT 40	Access tunnel to CNGS and TJ8 + beam tunnel	Dump	Conventional/TFA HA/MA around dumps	I,L,S,C
TDC 2	Tunnel divider cave	Splitters	MA/HA	H,S,I,L
TCC 2	Tunnel target cave	Target Stations T2, T4, T6, TAXs	MA/HA	H,S,I,L
TA801	Access tunnel	None	Conventional/TFA	S,M
GL802	Liaison gallery	None	Conventional/TFA	S,M,
PGT802	Shaft 889/GL802	None	Conventional	S,M

Table 2: Surface Areas of SPS

Area	Function	Specific hazard	Possible classification	Needs
BA1 (888)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BA2 (869)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BA3 (870)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BA4 (871)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BB4 (921)	Auxiliary building annex	None	Conventional	S
BA5 (872)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BB5 (899)	Auxiliary building annex	None	Conventional	S
BA6 (873)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BA7 (876)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
BA80 (889)	Auxiliary building	Water treatment areas	Conventional, TFA in the ion exchangers	S
898	Ventilation TT20	Air filters	Conventional, TFA in the filters	S
874	PCR	None	Conventional	S
TCC 2 berm	Shielding	Beam in TCC2 (beam on)	TFA	S,M

Table 3: CNGS Areas

Area	Function	Specific hazard	Possible classification	Need
TA41	Access tunnel from ECA4	None	Conventional, except near the target station where it could be TFA	S,M
TCV4	Ventilation chamber	Air and water treatment	TFA, but will contain air filters and rad. water	S,M,C
TSG40	Radioactive storage	It will contain storage of radioactive items	Conventional/TFA	S,M
TSG41	Link to target cave	Storage of crane cable	TFA/FA	S,M,C
TSG4	Service gallery	Storage of radioactive water and slightly radioactive transformers, vacuum pumps, etc.	TFA/FA/MA, but will contain water sumps etc.	S,M,C
TSG42-48	Cross-tunnels	Stripline, cables, water pipes, etc.	FA/MA	S,M,C
TT41	Proton beam tunnel	Transfer beam line elements	TFA/FA to MA close to the target cave	S,M,C
TCC4	Target cave	Target station, horn, reflector	MA to HA	S,M,C
TND4	Decay tunnel	Windows and tunnel pipes	MA to HA	S,M,C
TNB4	Hadron stopper	Graphite and steel stopper	MA to HA	S,M,C
TNM1	First muon detectors	None	Conventional but TFA where the beam hits.	S,M,C
TNM2	Second muon detectors	None	Conventional but TFA where the beam hits.	S,M
TZ80-82	Access connections to hadron stop and muon detector areas	None	Conventional	S,M

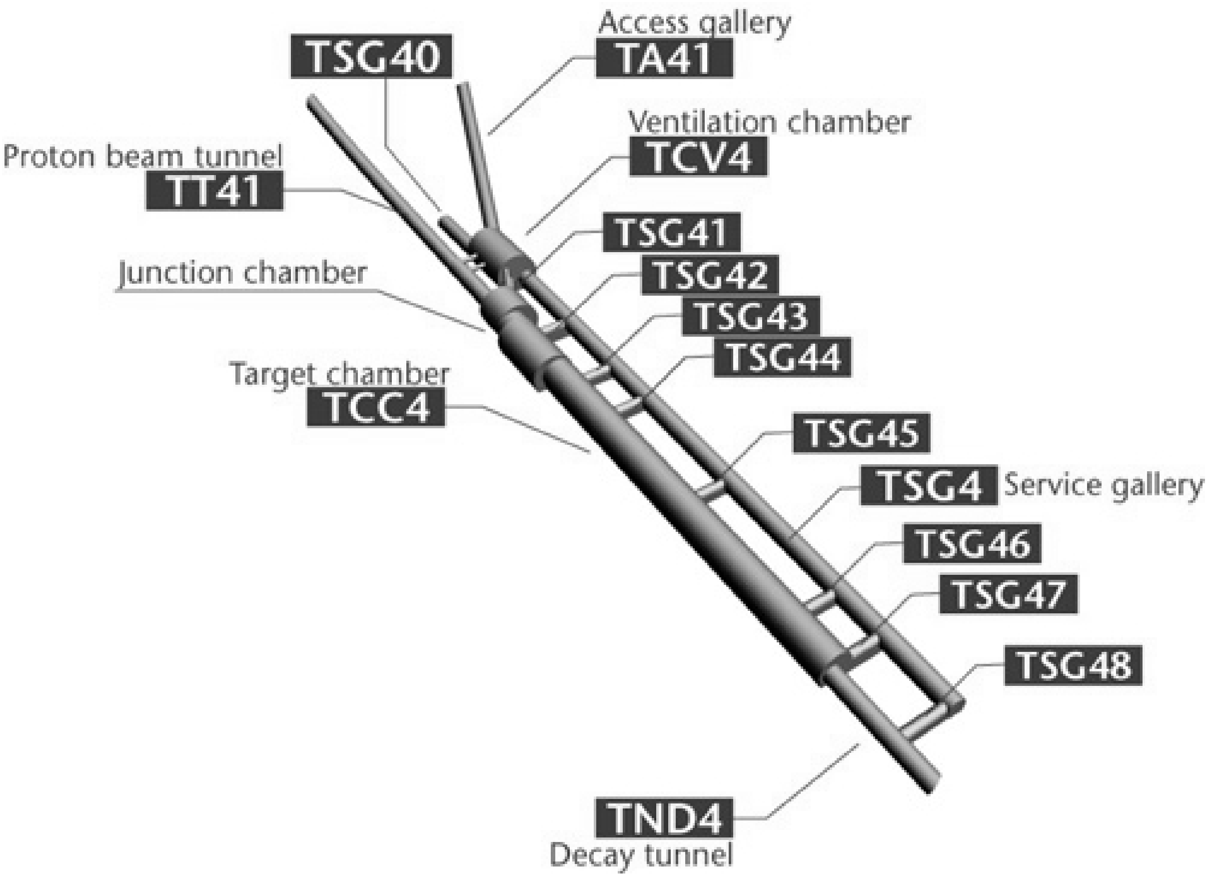

Figure 1: Layout of the LHC extraction and CNGS transfer lines.

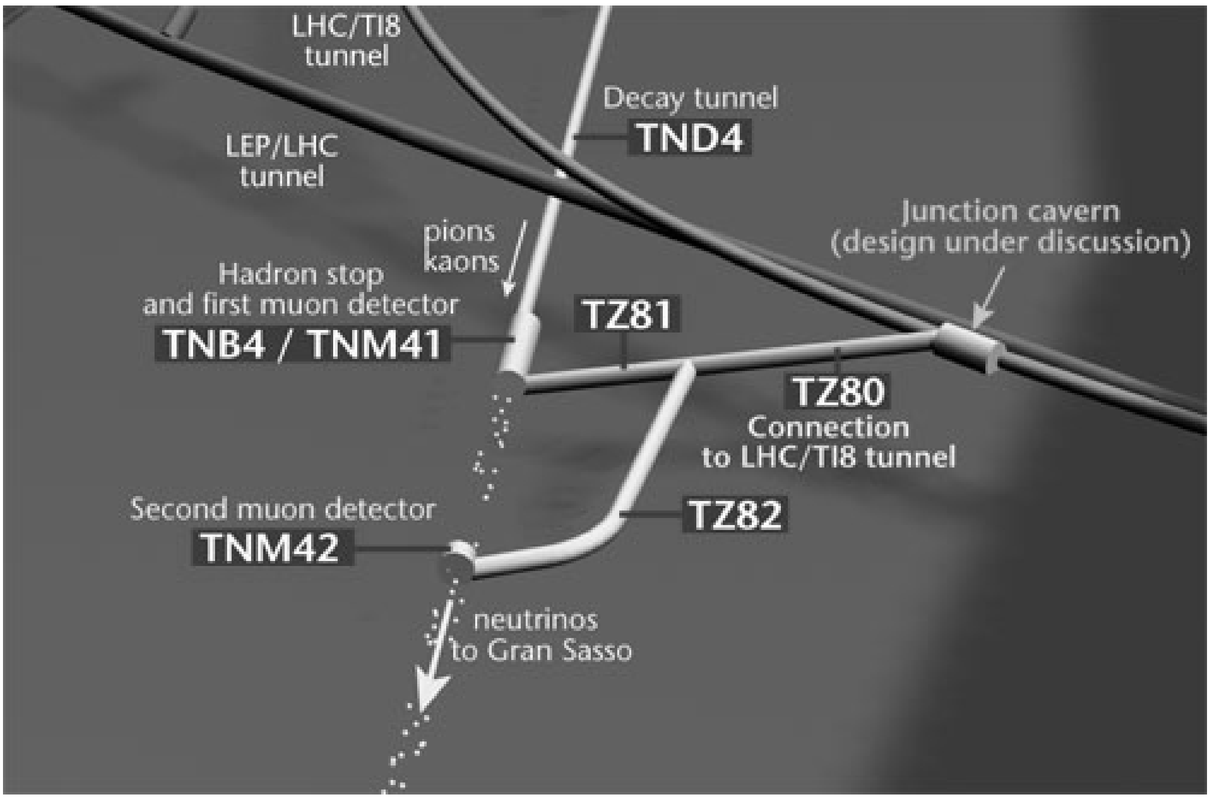

Figure 2: Layout of CNGS tunnels in the downstream area.

Table 4: Manpower requirement for the zonage of the underground areas of SPS.

AREA	MANPOWER REQUIREMENT (MAN-MONTHS)												
	PRIOR						CONTINUING						NOTES
	H	S	I	L	M	C	H	S	I	L	M	C	
TS 1^+ / TS 1^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS1	(a)	(b)	(c)	(d)	None	6	(f)	(b)	(g)	(h)	None	None	Calculations for LSS1 includes PP1 and TA1
PP1	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA1	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TS 2^+ / TS 2^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS2	(a)	(b)	(c)	(d)	None	3	(f)	(b)	(g)	(h)	None	None	Calculations for LSS2 includes PP2 and TA2
PP2	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA2	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TS 3^+ / TS 3^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS3	(a)	(b)	(c)	(d)	None	1	(f)	(b)	(g)	(h)	None	None	Calculations for LSS3 includes PP3 and TA3
PP3	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA3	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TS 4^+ / TS 4^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS4	(a)	(b)	(c)	(d)	None	4	(f)	(b)	(g)	(h)	None	None	Calculations for LSS4 includes PP4 and TA4
PP4	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA4	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
ECX4/ECA4	(a)	(b)	(c)	(d)	(e)	4	(f)	(b)	(g)	(h)	(i)	None	Includes PAM4 / PAP4
TS 5^+ / TS 5^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS5	(a)	(b)	(c)	(d)	None	1	(f)	(b)	(g)	(h)	None	None	Calculations for LSS5 includes PP5 and TA5
PP5	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA5	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	

Table 4 (continued).

AREA	MANPOWER REQUIREMENT (MAN-MONTHS)												
	PRIOR						CONTINUING						NOTES
	H	S	I	L	M	C	H	S	I	L	M	C	
ECX5/ECA5	(a)	(b)	(c)	(d)	None	6	(f)	(b)	(g)	(h)	None	None	
TS 6^+ / TS 6^-	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
LSS6	(a)	(b)	(c)	(d)	None	3	(f)	(b)	(g)	(h)	None	None	Calculations for LSS6 includes PP6 and TA6
PP6	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TA6	None	(b)	(c)	None	(e)		None	(b)	(g)	None	(i)	None	
TNC	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	
PP7	None	(b)	(c)	None	(e)	None	None	(b)	(g)	None	(i)	None	
TA7	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	
Bldg. 846	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	
TT 60	(a)	(b)	(c)	(d)	None	2	(f)	(b)	(g)	(h)	None	None	
TCC 6	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
TI2	None	(b)	(c)	(d)	None	1	None	(b)	(g)	(h)	None	None	TI2/TI8/TT41 done together, total 3 man-months
PMI2	None	(b)	(c)	(d)	None	None	None	(b)	(g)	(h)	None	None	
TI8	None	(b)	(c)	(d)	None	1	None	(b)	(g)	(h)	None	None	TI2/TI8/TT41 done together, total 3 man-months
TJ8/PGC8	None	(b)	(c)	(d)	None	2	None	(b)	(g)	(h)	None	None	Calculations of induced activity missing
TT 10	(a)	(b)	(c)	(d)	None	3	(f)	(b)	(g)	(h)	None	None	
PGC1	None	(b)	(c)	(d)	None	3	None	(b)	(g)	(h)	None	None	
TT 20	(a)	(b)	(c)	(d)	None	2	(f)	(b)	(g)	(h)	None	None	

Table 4 (continued).

AREA	MANPOWER REQUIREMENT (MAN-MONTHS)												
	PRIOR						CONTINUING						NOTES
	H	S	I	L	M	C	H	S	I	L	M	C	
DP522	None	(b)	None	None	(e)	3	None	(b)	None	None	(i)	None	
DP523	None	(b)	None	None	(e)		None	(b)	None	None	(i)	None	
TT 40	None	(b)	(c)	(d)	None	5	None	(b)	(g)	(h)	None	None	
TDC 2	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
TCC 2	(a)	(b)	(c)	(d)	None	None	(f)	(b)	(g)	(h)	None	None	
TA801	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	
GL802	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	
PGT802	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	

Table 5: Manpower requirement for the zonage of the surface areas of SPS.

AREA	MANPOWER REQUIREMENT (MAN-MONTHS)												
	PRIOR						CONTINUING						NOTES
	H	S	I	L	M	C	H	S	I	L	M	C	
BA1 (888)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA2 (869)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA3 (870)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA4 (871)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BB4 (921)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA5 (872)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BB5 (899)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA6 (873)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA7 (876)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
BA80 (889)	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
898	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
874	None	(b)	None	None	None	None	None	(b)	None	None	None	None	
TCC 2 berm	None	(b)	None	None	(e)	None	None	(b)	None	None	(i)	None	

Table 6: Total manpower requirement for the zonage of SPS.

	MANPOWER REQUIREMENT (MAN-MONTHS)											
	PRIOR						CONTINUING					
	H	S	I	L	M	C	H	S	I	L	M	C
TOTAL	6	0	4	6	6	50	1	0	1	1	4	0

NOTES

(a) Global effort for all areas concerned: 6 man-months.
(b) No additional manpower is estimated necessary with respect to what is presently done by the available staff. Some additional TLD monitoring will be necessary, but this should not require a large effort. The present manpower involved in the radiation surveys and monitoring is estimated at 1.5 man-years of technical staff in TIS/RP.
(c) Global effort for all areas concerned: 4 man-months. This is essentially represented by effort to be done by TIS/RP to review existing installation of beam loss monitors (BLM) and induced activity monitors (PMI), to specify additional instrumentation which may be needed and to implement it.
(d) Global effort for all areas concerned: 6 man-months.
(e) Global effort for all areas concerned: 6 man-months. Collection of samples, reduction to form suitable for gamma spectrometry, gamma-spectrometry measurements and data analysis.
(f) Global effort for all areas concerned (including CNGS): 1 man-months. Collecting information and updating documentation.
(g) Global effort for all areas concerned: 1 man-months. Follow-up of upgraded instrumentation.
(h) Global effort for all areas concerned: 1 man-months. Essentially data analysis.
(i) Global effort for all areas concerned: 4 man-months.

Table 7: Manpower requirement for the zonage of CNGS.

AREA	MANPOWER REQUIREMENT (MAN-MONTHS)												
	PRIOR						CONTINUING						NOTES
	H	S	I	L	M	C	H	S	I	L	M	C	
TA41	None	(a)	None	None	(b)	None	None	(a)	None	None	(d)	None	
TCV4	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TSG40	None	(a)	None	None	(b)	None	None	(a)	None	None	(d)	None	
TSG41	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TSG4	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TSG42-48	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TT41	None	(a)	None	None	(b)	1	None	(a)	None	None	(d)	None	TI2/TI8/TT41 done together, total 3 man-months
TCC4	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TND4	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TNB4	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TNM1	None	(a)	None	None	(b)	(c)	None	(a)	None	None	(d)	None	
TNM2	None	(a)	None	None	(b)	None	None	(a)	None	None	(d)	None	
TZ80-82	None	(a)	None	None	(b)	None	None	(a)	None	None	(d)	None	

Total for CNGS areas

TOTAL	0	6	0	0	3	1	0	6	0	0	6	0

NOTES

(a) Global effort for all areas concerned (prior + continuing): 6 man-months.
(b) Global effort for all areas concerned: 3 man-months.
(c) Calculations for all areas are under way and will be finished by the end of the year. Global effort = 3 man-years.
(d) Global effort (including measurements of water releases and on rock samples) for all areas concerned: 6 man-months.

8.4 TRACEABILITY NOTES AND TABLES

	Initial Human		**Initial Financial**	**Continuous Human**		**Continuous Financial**	**Comment**
Infrastructure	*Man-month*		*kCHF*	Man-month/year		*kCHF/year*	
	Eng.	Tech		Eng.	Tech.		
Kiosks	3	3	100	-	2	25	At all 12 Exit Points Conception and installation
Buffer zones	3	3	1000(*)	-	-	-	sas type BA3 at BA4 Larger BA3 sas
Conventional Storage	2		100	-	24	25	Storage Managers INB Zone delimiting
Radioactive Storage	2		200(**)	-	24	25	Storage Managers
Containers	-	-	25	-	-	25	For small objects
Developments	*Man-month*		*kCHF*	Man-month/year		*kCHF/year*	
	Eng	Tech		Eng	Tech		
Interface	24	-	-	5	-	-	Standardised for Office and Kiosk
Execution	*Man-month*		*kCHF*	Man-Month/year		*kCHF/year*	
	Eng	Tech		Eng	Tech		
Liaison INB / group	2 ×10	-	-	1 ×10	-	-	Training Information dispatching for each of ~10 groups
Preparation & follow up / group	-	1 ×10	-	-	1 ×10	-	Mainly for shutdown in each of ~10 groups
Follow-up central		-	-	2	-	-	"Service après-vente"

Note that the installation work for the *buffer zones* (*) takes up most of the financial resources. Since this covers mainly civil engineering work, the actual estimation of 1 million Swiss francs might be optimistic. The estimation for the modifications to the radioactive storage areas (**) depends on the general requirements for INB and does not take into account the construction of additional buildings. Equally outside this scope is the creation of a *radioactive workshop* for the treatment of radioactive waste, which must be a serious consideration.

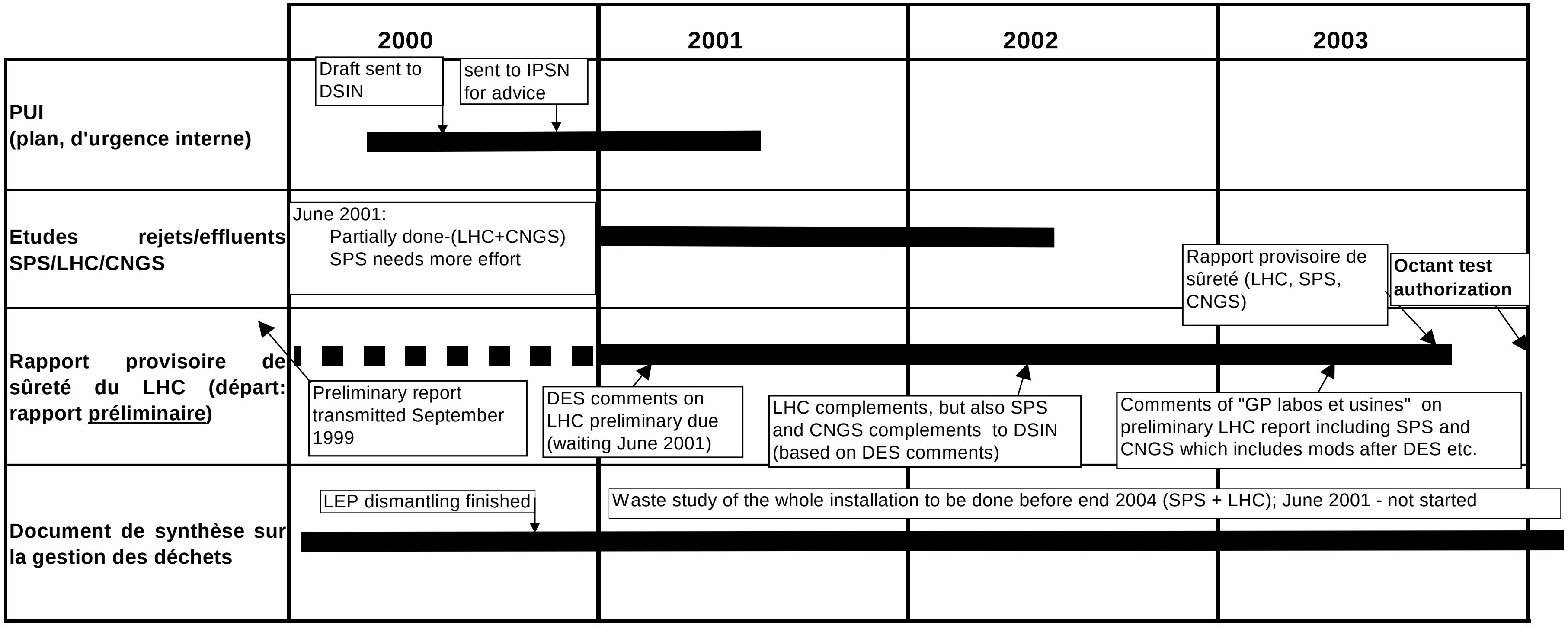

Figure 4. Documents to present to DSIN in the coming 3 years - agreed with DSIN November 2000