Chapter 9

Project Schedule, Organisation, Personnel And Costs

Authors and Contributors

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9 PROJECT SCHEDULE, ORGANISATION, PERSONNEL AND COSTS

9.1 OVERVIEW

In January 2003 it became clear, that a decision to build ESS would not likely be forthcoming by the end of 2003 or early 2004, but rather would be delayed by several years. This chapter deals with the main consequences for project planning, schedule and costing after the subsequent decision of the ESS Council to wind down all technical and project planning activities, which were aimed at starting construction of ESS early 2004.

The present status of pre-planning is analysed, and since a delay of the ESS project now seems unavoidable, the work to be carried out, when re-launching ESS or any similar spallation source project, is summarised. Also, following the ESFRI discussions, an alternative staged approach for the realisation of ESS has been worked out.

Construction of the ESS facility will take 8 years after project approval, including 2 years of sequential commissioning of the complete chain of accelerators, the 2 targets and the first set of 10 instruments. First neutrons will be produced 7 years after project go-ahead, and after one year of machine commissioning.

The overall cost during the 8 years of construction of the ESS facility (capital investments, consumables, in-house and subcontracted staff) amounts to:

1552 M€$_{2000}$[1]

A 15% contingency, corresponding to 202 M€$_{2000}$ is included [Bohn, 2002/1].

Some areas, which offer the potential for construction cost or operating cost reductions, have been identified. These include the new superconducting (SC) reference linac and the ring building where construction costs of ~20 M€ and operating costs of ~3 M€/year may be achieved. These need further investigation during project baselining and prototyping. The envisaged savings have therefore been allocated to the contingency.

The annual budget for operating ESS in a full user service mode (USM) is estimated at:

142 M€ $_{2000}$

A highly user-oriented facility operation is assumed with up to 5500 hours per year in User Service Mode with 44 instruments, including recurrent expenditure for the development and systematic refurbishment and replacement of 3 instruments per year on average. A permanent staff of 600 plus 50 students are assumed for the long term.

A staged approach to the present ESS (ESFRI, 2003), where the long pulse target station (LP) is built first (Stage 1) and the compressor rings and short pulse target station (SP) at a later stage (Stage 2), is estimated to cost:

[1] Price basis: year 2000

Staged ESS -Stage 1 (5 MW LP)	Capital costs: Operations costs:	989 M€ $_{2000}$ 79 M€ $_{2000}$ /year
Staged ESS -Stage 2 (5 MW SP)	Additional Capital costs: Total Operations costs:	673 M€ $_{2000}$ 142 M€ $_{2000}$ /year

The staged approach adds about 110 M€ to the total capital costs for the non-staged ESS, but will spread the costs over a much longer period; long term operating costs will remain unchanged.

Figure 9.1.1 shows the proposed organisation for a future ESS facility. The organisation is based on the ESRF model [Palanque, 2002/1] and the points of view expressed in the Bonn 2002 report [ESS, 2002] remain valid.

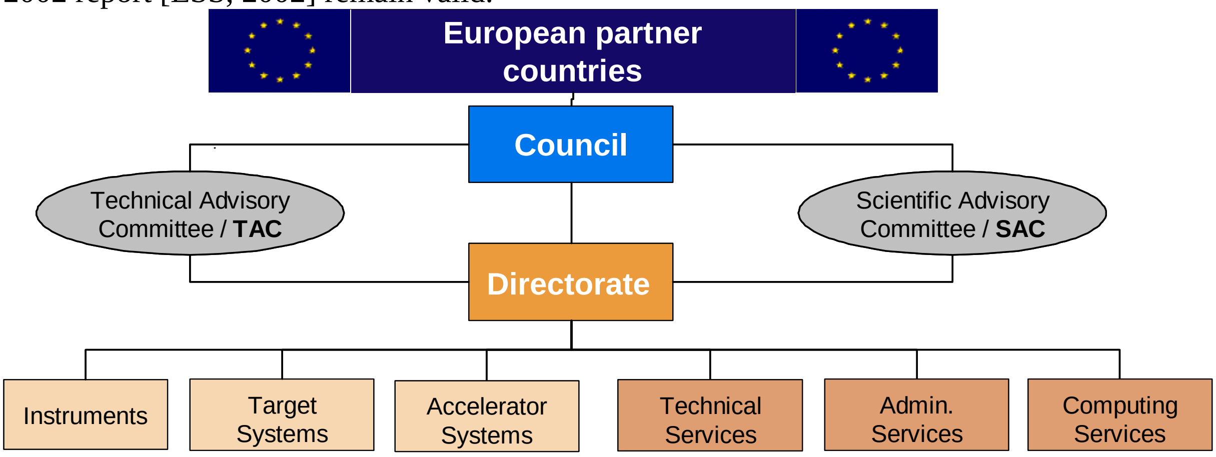


Figure 9.1.1: ESS organisation chart

9.2 PROJECT SCHEDULE

9.2.1 The ESS time scale

The decision by the ESS Council to wind down all technical and project planning activities in January 2003 effectively meant that approximately 1.5 years of project baselining and prototyping, prior to the project construction, are still outstanding.

Recruiting a new project team to organise and coordinate the efforts when re-launching the ESS project will require of the order of another half a year. This adds up to approximately two years of planning and baselining, prior to the ESS construction.

Figure 9.2.1.1 shows the time scale for the re-launch and realisation of the ESS facility, taking account of this situation. The 8 year construction period, including assembly and commissioning, has not been changed. The same is true for the operations phase and availability of the 44 instruments.

Prior to the 2 year project baselining phase, a preceding phase has been added to the time scale since discussions in Europe must lead to a final strategy and concept for the facility. This may take weeks, if the Bonn ESS concept with 5 + 5 MW long and short pulse target stations is selected, but is more likely to take a few years. Meanwhile continued updating of the science case in combination with ideas on the most competitive, cost effective, top tier, European facility will be required.

Three years of prototype activities have been added to the ESS time scale. Approximately two years of prototyping will be dedicated to cost and schedule critical issues. This means, that the more of these activities carried out before final approval, the smaller the uncertainties on cost and schedule will be. They must be concluded prior to construction. The remaining year of prototyping will be needed to prepare for series fabrication. In the figure, it is assumed that prototyping starts soon after the start of baselining.

An advanced technology programme will be very important to maintain technical competence and capabilities. It will also contribute to further raise performance levels of a European facility. It is not, however, part of the project schedule as such, and it can be effectively carried out in relevant technical collaborations which need not be focused on a spallation source.

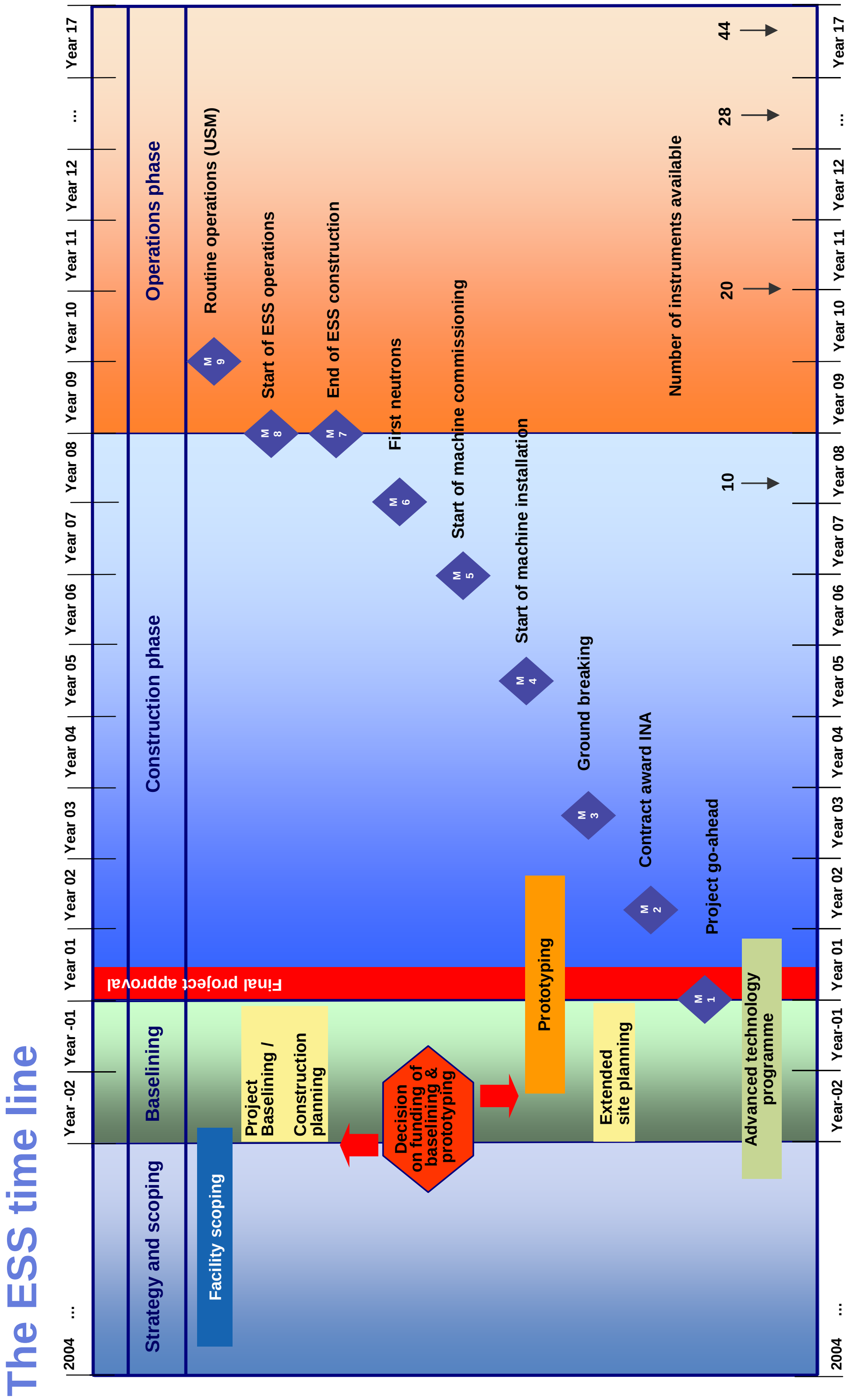


Figure 9.2.1.1: The ESS time scale; milestones 1-9 are described in the text

9.2.2 Project summary schedule

Figure 9.2.2.1 shows the summary of the ESS project schedule indicating major activities and milestones for the unchanged 8 years construction phase in terms of “undated” project years.

A two year project baselining and pre-planning period, prior to construction, and a three year prototyping phase, overlapping with construction, as explained before, are scheduled to take place during year “-2”, and year “-1”.

The duration of the construction phase is based on industrial studies and experience gained from the construction of similar complex facilities like ISIS, PSI & SNS. The conventional facility programme is the most critical one from the standpoint of schedule and costs, representing ~ 35% of the total project costs. High priority must be given to placing the Industrial Architect (INA) contract following the decision for the project go-ahead. This requires assured funds to complete the building programme, at least for all critical buildings.

9.2.2.1 Construction phase Activity and Milestone description

Milestone 1: “Project Go-ahead”

The project go-ahead will be the start of a 15 months period to start recruiting the project team, revising the program in accordance with the funding profile, launching the call for tenders and awarding the INA contract. Approximately 1 year after M 1 first procurements will be made.

Milestone 2: “Contract Award INA”

(Milestone M 1 + 15 months) is marked by awarding the INA contract. Also, it will be the beginning of a period of 6 months dedicated to subsystem design refinement, after which another 12 months are needed to produce detailed execution drawings. Design activities for less critical items will follow this period. As soon as the building permits - initiated for selected sites well before project approval - are obtained (1 year after M2) the call for tenders for ground breaking and conventional facilities will be issued. The first contracts can be awarded.

Milestone 3: “Ground Breaking”

(M 1 + 32 months) is marked for ground breaking. Site preparation, required to start the building programme, is planned to last 10 months after which construction of the conventional facilities can begin. The total period, for tendering for conventional facilities and awarding of contracts, is assumed to require 15 months. Out of the total period of 36 months for conventional facilities construction, 24 months will be devoted to construction, commissioning and acceptance of the technical service buildings providing electricity, fluid media and HVAC.

During this period, in a pre-defined order, the first buildings housing machine subsystems will be made available for Beneficial Occupancy (BO) and installation. That latter event defines the next milestone.

Milestone 4: “Start of Machine Installations”

(M 1 + 54 months) corresponds to the start of the installation of components inside the first buildings, which have been completed for BO. It is expected that BO of the front end and linac buildings will occur 12, and 15 months after the start of the conventional facilities construction.

Milestone 5: “Start of Machine Commissioning”
(M 1 + 72 months) corresponds to the start of the commissioning of machine subsystems. The subsequent period will be dedicated to sequential testing and commissioning of the accelerator and targets subsystems and first instruments. Regarding the first 10 instruments, those requiring the longest development and construction time will have to be started first.

Milestone 6: “First Neutrons”
(M 1 + 84 months) After one year of machine subsystems commissioning, the facility will produce first neutrons.

Milestone 7: “End of ESS Construction”
(M 1 + 96 months) The construction period will terminate at the end of year 08 and first operations will start at the beginning of year 09.
The power delivered by the accelerator to the targets will increase step by step up to full performance at 5+5 MW.

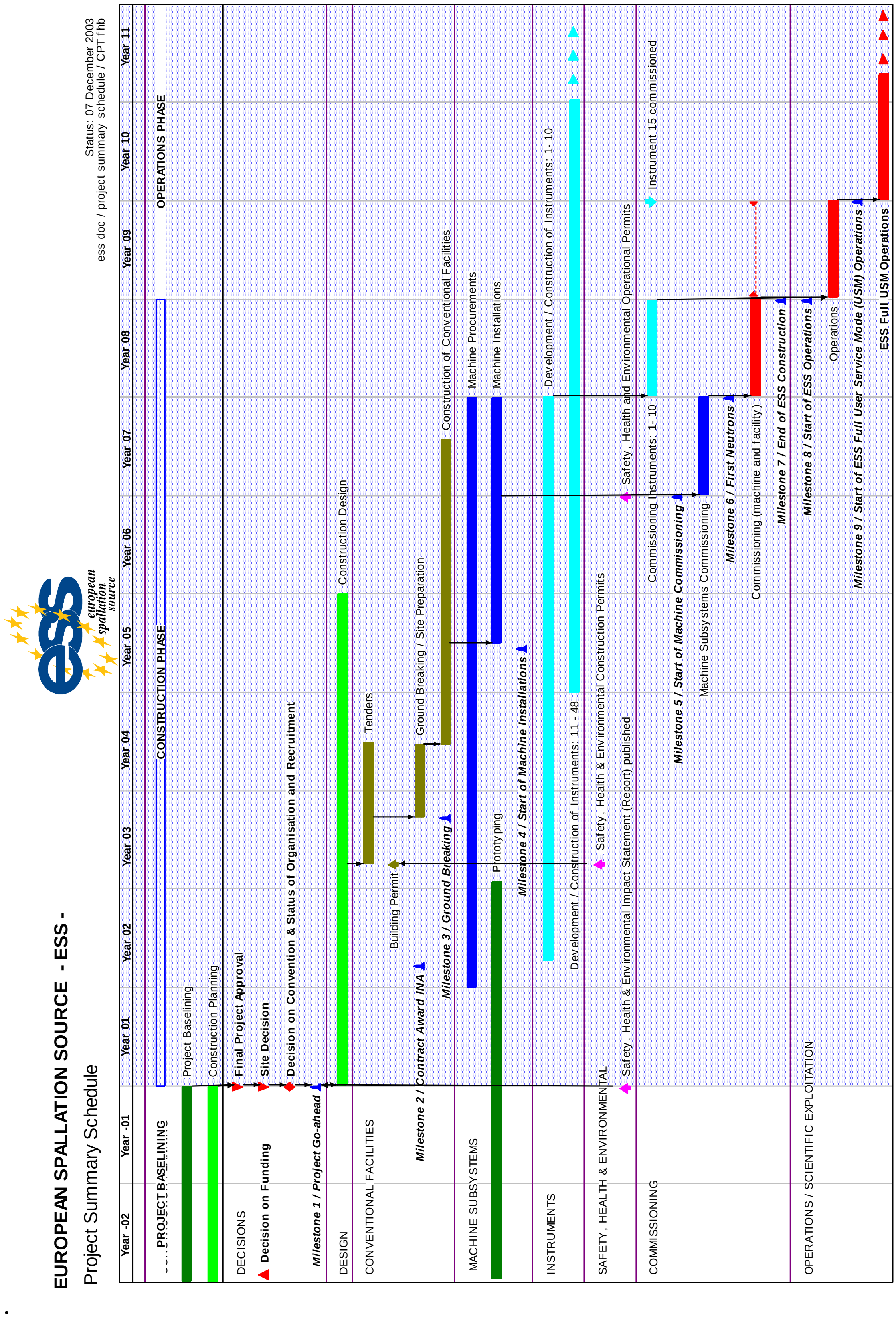


Figure 9.2.2.1: Project summary schedule

9.2.3 Operations schedule

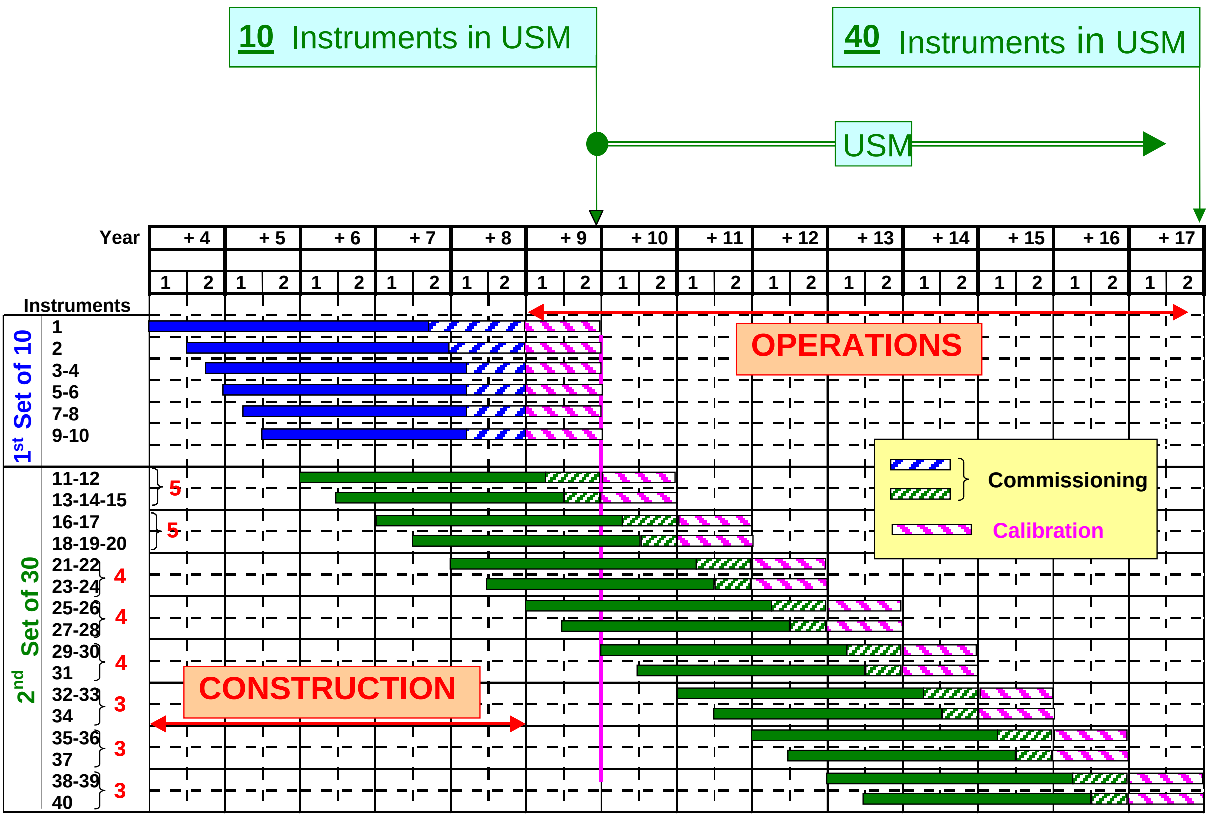
Milestone 8: "Start of ESS Operations"

(M 1 + 96 months) The 9th year after project go-ahead will be the first year of operations of the facility, producing the first scientific results. To demonstrate that the experimental performance will be achieved, pre-defined calibration experiments specific to each of the first 10 instruments will be performed.

Milestone 9: "Start of ESS Full User Service Mode (USM) Operations"

(M 1 + 108 months) After one year, during which routine operations with 10 instruments at full power will be achieved, full USM will start at the beginning of year 10. During year 9, the commissioning of 5 new instruments will be started leading to a total of 15 instruments available for users at the beginning of year 11 (see Table 9.2.1). At the end of year 17, the 40 (+4) instruments in USM will be available. In the subsequent years, a refurbishment or enhancement or replacement, equivalent to 3 new instruments per year is foreseen.

Table 9.2.1: Schedule for instruments



9.3 PROJECT COSTS

9.3.1 Basis for costing

The following briefly describes the ESS life-cycle costs considered and their basis. The following categories should be accounted for in the overall project costs.

1. **Pre-project costs.** Costs for project definition, preplanning, baselining, construction preparation, prototyping, and project approval.
2. **Site development costs.** Costs for making a specific site including its infrastructure available for construction, according to reference conditions. Costs for administrative and technical project support during the first years of construction. These costs are assumed to be borne by the hosting country or regional administration.
3. **Construction costs. A**ll costs from project go-ahead to fabrication, assembly, test, and commissioning.
4. **Operation costs,** 40 years long term operations, full user service mode, developments, refurbishments / enhancements.
5. **Decommissioning costs** / "return to green field", radioactive waste disposal.

ESS costing has concentrated on:

3. **Construction costs**
4. **Operation costs**

Recently estimates have been prepared for:

1. **Pre-project costs,** to complete the yet unfinished project baselinig, advanced technology development and prototyping, when re-launching ESS.

All costs for ESS construction and operation are quoted at year 2000 prices, and are exclusive of Value Added Taxes (VAT) and customs duties. They are based on the assumption that ESS is free to choose "best value for money" for offers meeting the technical specifications [Bohn, 2002/2]. A 15% contingency is generally included in the overall costs. Specific terms for costing are quoted in the relevant chapters.

9.3.2 Construction costs

Overall construction costs for the ESS facility (1.3GeV; 5 MW delivered to each of the two targets; 10 instruments at the start of operation and those under construction, including costs for pre-operations) amount to 1552 M€ $_{2000}$, including 15% contingency, corresponding to 202 M€ $_{2000.}$

Regarding the site costs, it is supposed that the site is donated free of charge without any tax payments and that access roads, infrastructures, electrical power supplies, telephone and computer links, water mains, fire brigades etc. are supplied free of charge at the site boundaries by the hosting country. Furthermore, it is assumed that technical and administrative support will be given by the hosting country during the first period of the construction phase, while the autonomous ESS legal organisation is being implemented. Finally, the host country will cover any cost arising from site conditions deviating from the reference site specifications.

Construction cost estimates are based on a bottom up technique and on extrapolation from available costing for similar facilities to ESS as specified in [ESS, 2002] and [ESS, 2003]. Additionally, expertise from industry and large-scale European projects has been involved and the on-going construction of SNS has been followed closely.

Critical cost issues have been cross-checked independently, for example:

- Linac (accelerator components, klystrons, power supplies, wave guides, magic T-loads, electronics, etc) from industrial quotations.
- Cryomodules, cryogenics and controls, networks and computer systems by experts running similar complex facilities.
- Conventional facility buildings through architect engineers.

Rough cost estimates for the recently completed new reference SC linac design show that the reductions in volume of the front end and accelerator buildings, together with reduced cryogenic power requirements, may lead to overall cost savings in the order of 10 M€$_{2000}$. Potential cost savings of the same order have been identified in other areas, however, they require more detailed design work for confirmation. The total of these potential savings has therefore been included in the overall contingency.

Costs during the 8-year construction phase include a first set of 10 instruments as well as the cumulative costs for another 18 of the second set of 30 instruments, which must be initiated during the construction phase.

Instruments will be of different design and therefore costs will vary significantly. An average unit price per instrument of 8.5 M€ (7.0 M€ capital costs plus 1.5 M€ staff costs) has been estimated, taking into account experiences gained at ILL, ISIS and SNS.

A total of 3300 PY (Person Years) will be required during construction to cover project design, procurement, contract monitoring, quality assurance, testing, prototyping, installation and commissioning. Of these, it is estimated that 1800 PY will be in-house staff and 1500 PY will be subcontracted externally.

9.3.3 Work breakdown structure as a basis for construction costing

The ESS work breakdown structure for the construction phase is shown in Figure 9.3.3.1. The blue area represents level 1-3 items of the project structure. They are, together with the technical and the interface specifications, the basis for costing. For bottom-up estimating, up to 6 WBS levels have been developed. The yellow area indicates the facility structure of the envisaged ESS organisation.

During the first years of construction, while the ESS organisation is been implemented, the hosting country is assumed to provide temporary administrative and technical project support.

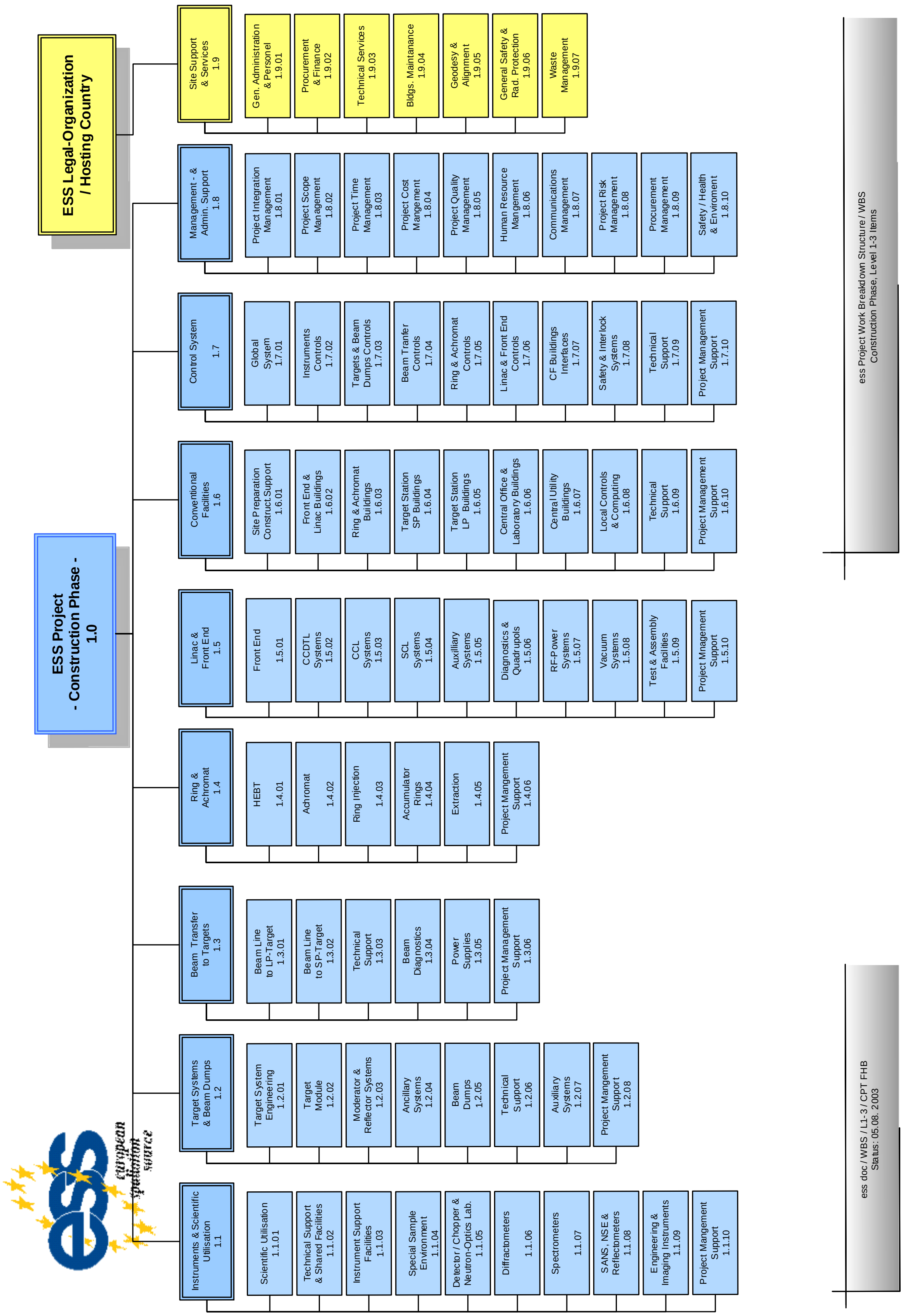


Figure 9.3.3.1: ESS work breakdown structure (WBS) Level 1-3 Items. When the ESS project is re-launched safety and licensing activities should appear in the WBS structure as a level 1 item, see section 8.1.

Table 9.3.1: Breakdown of construction costs into major subsystems

Major sub-systems	Construction costs M € $_{2000}$
1.1 Instruments & Scientific Utilisation	115
1.2 Target Systems	180
1.3 Beam Transfer to Targets	20
1.4 Ring & Achromat	85
1.5 Linac & Front End	370
1.6 Conventional Facilities	465
1.7 Control System	55
1.8 Management & Admin. Support	60
Total Estimated Costs	**1350**
Contingency (15 %)	202
Total Project Costs	1552

9.3.4 Operation costs

The long term operation costs have been estimated at 142 M€ per year at 2000 prices. Figure 9.3.4.1 shows the operation costs break down into cost categories.

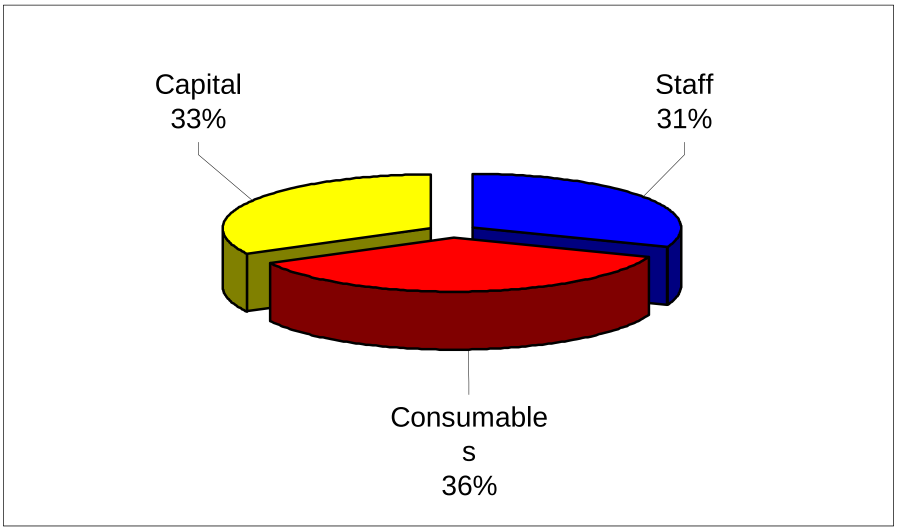


Figure 9.3.4.1: Breakdown of operation budget

- Staff costs amount to 31% of the operations budget and are based on experiences from ISIS, PSI, SNS. Allowance is made for a total of 650 posts, including post-docs and students, operating the facility with 40 instruments.

  Costs for consumables are estimated at 36% of the operation budget. They are assigned to the individual programmes, providing resources for the facility for 5500 hours per year in USM. 1000 hours will be necessary for maintenance and "accelerator and targets development".
  Consumables are largely determined by the costs for electricity. Assuming the unit cost for electricity as paid by ESRF, of 0.040 €/kWh, the ESS expenditures for electricity will amount to 28 M€ per year.
- Capital costs are calculated at 33% of the operations budget; they are devoted to instrument development or refurbishment or replacement of three instruments per year on the long term. The other part relates to the replacement of components for machine subsystems, including provisions for the maintenance of conventional facilities and computing services [Palanque, 2002/2].

9.3.5 Staged approach to the ESS

In the table 9.3.2, the capital cost for the construction of the full ESS has been compared with a staged approach where the long pulse target station is built first (Stage 1) and the short pulse target station (Stage 2, full ESS) at a later stage.
The staged approach adds about 110 M€ to the total cost, but will spread the additional cost for adding missing components for the full ESS over a longer period.

Table 9.3.2: Construction costs for staged ESS, broken down into major ESS subsystems

ESS subsystems		ESS	Staged ESS -stage 1	Staged ESS -stage 2
		5 MW SP/5 MW LP	5 MW LP	5 MW LP/SP
		11.3% DC	3.8% DC	11.3% DC
		M€ 2000	M€ 2000	M€ 2000
Instruments & scientific utilization		115	60	55
Target systems		180	90	90
Accelerator systems	Linac (L=570 m)	370	330	80
	Achromat & rings	85	0	85
	Beam transfer to targets	20	10	10
Conventional facilities		465	305	215
Controls & networks		55	30	25
Management & admin. support		60	35	25
Total estimated costs		1350	860	585
Contingency (15%)		202	129	88
Construction costs for stages (including manpower)			**989**	**673** (additional)
Total construction costs (including manpower)		**1552**	**1662**	

Table 9.3.3 shows the estimated operating costs for the full versus the staged approach, broken down into major cost categories.

Table 9.3.3: Operation costs for staged ESS, broken down into major cost categories

Breakdown of operations costs	5 MW SP/5 MW LP 11.3% DC M€ 2000		5 MW LP 3.8% DC M€ 2000		5 MW LP/SP 11.3% DC M€ 2000	
Energy	28	(107 MW, AC)	9.5	(36 MW, AC)	28	(107 MW, AC)
Other consumables	23		15		23	
Personnel	44	(650 fte)	28	(412fte)	44	(650 fte)
Maintenance, spares	22		14		22	
Instruments	25		12.5		25	
Total	**142**		**79**		**142**	(total)

9.4 RE-LAUNCHING ESS OR ANY SIMILAR SPALLATION SOURCE PROJECT

The following reflects on the resumption and completion of the pre-planning phase, when re-launching ESS or any similar spallation source project. The pre-planning work to be finished before the construction phase can start is described, and the related costs are indicated.

9.4.1 Completion of the project baselining / pre-planning phase

The project baselining and preplanning phase for ESS consists of following steps [Bohn, 2003/1].

1. Basic findings
2. Conceptual planning
3. Outline design
4. Baselining
5. License planning
6. Construction (execution) planning
7. Contract preparation

Regarding the accomplished status, up to the decision of the ESS council to terminate all technical and costing activities, planning steps 1, 2, and 3 have been completed and step 4, baselining, has been initiated [Bohn, 2003/4].

As stated in 9.2.2, the construction schedule calls for high priority in starting the conventional facility programme; this requires the completion of construction planning for conventional facilities before starting the construction phase.

Thus the following planning steps and tasks have to be taken up, when re-launching ESS:

4. **Baselining** (scoping/interface specifications/design to cost)
5. **License planning** (buildings/safety, health, environmental)
6. **Construction planning** (building programme/extended site planning/construction design/procedures and rules) [Bohn, 2003/2]
7. **Contract preparation** (INA/tendering/extended site evaluations)

Furthermore, to ensure accurate planning, scheduling and costing, some prototyping activities are to be given high priority during baselining. In addition, an advanced technology programme will be important for maintaining staff capabilities and making use of the latest technological developments in the design.

Thus, the following accompanying R&D activities must be considered:

1. Prototyping of components and subsystems
2. Advanced technology programme

None of these activities has been started so far. Prototyping, especially for cost critical items should preferably start during baselining. If delayed until the start of construction, the consequences will be less accuracy on costing and construction scheduling.

The advanced technology programme is important to maintain technical competence. These activities could span the time gap until prototyping/construction is started.

The following tasks have been identified for R&D:

1. Target systems and beam dumps
    - Manufacturing process and sealing of proton beam window
    - Shutter wheel with mock up test stand for insert exchange
    - Target exchange system
    - Gas bubble injection system
    - Solid cryogenic moderator R&D for future source improvement, presently not part of the proposal.
2. Linac & front end
    - Prototyping of front end components, including beam testing
    - Development of SC cryomodules and high power operation
3. Safety / health and environment
    - Development of concept for waste disposal of mercury target and demonstration of hot cell techniques handling
    - Determination of long lived nuclides in irradiated mercury and tungsten

9.4.2 Costs of the project pre-planning phase

The overall costs for completing the project pre-planning phase, together with prototyping, have been estimated at a total of:

40 M€$_{2000}$

Consisting of:

Completion of the project baselining and pre-planning: 20 M€$_{2000}$

Accomplishment of the first two years of prototyping that runs in parallel with the two years of pre-planning, requires another: 20 M€$_{2000}$

Financing of the one remaining year of prototyping that overlaps with the construction phase, will be part of the construction budget.

9.5 DOCUMENTATION

Documentation of the "Project Schedule, Organisation, Personnel and Costs", [Bohn, 2003/4], is available on electronic media and as hard copies of more detailed reports. Costing has been documented on an ESS data bank system and is not available for general distribution.
For further information and procedures, see ESS-web sites: http://www.neutron-eu.net

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