CERN
CH-1211 Geneva 23
Switzerland

the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-PM-QA-304.00 rev 1.1

CERN Div./Group or Supplier/Contractor Document No.

EDMS Document No.
103557

Date:1999-11-16

Quality Assurance Procedure

CONFIGURATION MANAGEMENT - CHANGE PROCESS AND CONTROL

Abstract

This document describes the procedures and responsibilities for the systematic and uniform review of all engineering changes to the LHC configuration baseline, to ensure that the impact of changes on performance, cost and schedule are identified and thoroughly evaluated before the decision to incorporate them is taken.

Prepared by :	***Checked by :***	***Approved by :***
M Mottier EST/ISS Marcel.Mottier@cern.ch	**LHC Quality Assurance Working Group**	**Paul Faugeras** Deputy to LHC Project Leader for Quality Assurance

History of Changes

Rev. No.	Date	Pages	Description of Changes
0.1	1998-06-17		1st draft
0.2	1998-07-30		Update following QAPWG meeting.
1.0	1998-09-17		Released
1.1	1999-11-16		Correction of reference in section 9

Table of Contents

1. PURPOSE 4
2. SCOPE 4
3. POLICY 4
4. RESPONSIBILITIES 4
5. DEFINITIONS 5
6. INTRODUCTION TO CONFIGURATION BASELINE AND CHANGE CONTROL 5
6.1 BASELINE 5
6.2 CHANGE CONTROL 6
7. SELECTION OF CONFIGURATION ITEMS 6
7.1 HARDWARE ITEMS 7
7.2 PARAMETERS 7
7.3 DOCUMENTS 8
8. CHANGE PROCESS AND CONTROL 8
8.1 CORRECTION OF TRANSCRIPTION ERRORS 8
8.2 CHANGE REQUEST 9
8.3 ECR PREPARATION 9
8.4 ECR EVALUATION 9
8.4.1 IMPACT ON COST, SCHEDULE AND TECHNICAL PERFORMANCE 11
8.4.2 IMPACT ON RELATED ITEMS 11
8.5 CLASSIFICATION OF CHANGES 13
8.6 PROCESSING CLASS I CHANGES 13
8.7 PROCESSING CLASS II CHANGES 13
8.7.1 NORMAL PROCEDURE 13
8.7.2 SIMPLIFIED PROCEDURE 14
8.8 NOTIFICATION OF CLASS I CHANGE COMPLETION 14
9. RELATED DOCUMENTATION 14
10. ANNEXES 14

1. PURPOSE

To provide a procedure for the systematic and uniform review of all engineering changes to the LHC configuration baseline, to ensure that the impact of changes on performance, cost and schedule are identified and thoroughly evaluated before the decision to incorporate them is taken.

2. SCOPE

This procedure is applicable to:

- All the hardware assemblies, sub-assemblies and parts of the LHC systems that are included in the Project Breakdown Structure (PBS) of the Project.
- All the critical measuring and test equipment required to manufacture, install and verify the performance of the LHC.
- All the main parameters defining the LHC and the injector chain layouts and beam performance.
- All the LHC systems parameters that have an effect on the LHC performance.
- All the LHC systems parameters which may affect the LHC performance through indirectly induced changes on other systems. (See " Documents and Parameters Process and Control" [1]).

3. POLICY

Configuration management (CM) is the management process that ensures that consistency is maintained among the parameters, the requirements, the physical and functional configuration of the LHC and its documentation, particularly as changes are made throughout the LHC life-cycle.

The CM process ensures the integrity of the LHC systems and components during their design, procurement, installation, operation and maintenance life-cycle stages.

CM is applied to the parameters, systems, components, instructions and procedures whose failure to satisfy requirements could lead to violations of safety requirements; non-compliance with regulations; significant loss of research capability; significant changes in cost or schedule.

CM is applied using a graded approach. A graded approach means that the depth and rigor of details necessary and the magnitude of resources required to carry-out the CM process are commensurate with the relative importance of systems, components, instructions and procedures in terms of safety, performance, cost, and complexity.

4. RESPONSIBILITIES

The Technical Co-ordination Committee Chairman has the responsibility for all aspects of configuration management.

The Parameters and Layouts Committee Chairman has responsibility for the configuration management of the Project level parameters and layouts (see " Documents and Parameters Process and Control "[1], section 7.2.1).

Project Engineers (PE) in charge of systems, sub-systems, assemblies and parts are responsible for:

- Verifying that the structure of the systems, sub-systems, assemblies and parts for which they are responsible are correctly represented in the LHC PBS and maintained up to date.

- Verifying that the configuration baseline documents of the systems, sub-systems, assemblies and parts for which they are responsible are stored in the Engineering Data Management System and maintained up to date.
- Managing engineering change proposals in accordance with the procedures described in this document.
- Defining appropriate configuration management procedures to be applied during the fabrication, assembly, test and installation phases of systems, sub-systems, assemblies and parts.

5. DEFINITIONS

Configuration:	The functional and physical characteristics of hardware as described in technical documentation and achieved in a product.
Configuration Management (CM):	The systematic evaluation, co-ordination, review, approval or disapproval, documentation and implementation of all proposed changes in the configuration of a product, after formal establishment of its configuration baseline.
Configuration Items (CI):	Configuration items are the basic units of configuration management. They may vary in complexity, size and type, from a cryo-magnet assembly to a coil spacer. Regardless of complexity, type or size, the configuration of a CI is documented and controlled.
Configuration Baseline:	The set of approved and released documents that represent the definition of a product at a specific point in time. Configuration baselines are established whenever it is necessary to define a reference configuration during the product's life-cycle. This baseline is then used as a starting point for further activities.
Engineering Change:	Any design change that will require a revision of the Configuration Baseline and associated documents. This includes changes that will impact the cost, schedule and performance of the LHC.
Engineering Change Request (ECR):	A document used to propose an engineering change.
Engineering Change Order (ECO):	A document used to implement an approved engineering change.
Engineering Change Notification (ECN)	A document used to notify individuals that an approved engineering change is implemented.

6. INTRODUCTION TO CONFIGURATION BASELINE AND CHANGE CONTROL

6.1 BASELINE

The LHC configuration baseline is the set of approved and released parameters and documents that represent the definition of the LHC as it is designed.

This "as-designed" configuration baseline is established as a reference configuration. It can then be used to follow the evolution of the Project through its life-cycle phases, design, procurement, installation, commissioning, and finally operation and maintenance.

At the end of the design phase the configuration baseline will contain all the drawings, specifications and manufacturing procedures necessary to manufacture, assemble, install and commission the LHC.

When the installation is completed the "as-designed" configuration baseline, incorporating all the changes required during the construction, will represent the LHC as it will have been built. It will also include the measured main characteristics of systems and components useful for operation and maintenance.

This "as-built" configuration will then be used as a reference to follow the evolution of the machine during its operating phase.

6.2 CHANGE CONTROL

As the Project advances the technical requirements become better defined as a result of the design and development activity, and technical changes have to be considered. It is the role of the engineering change control procedure to ensure that the changes are consistently reviewed, approved or rejected, implemented and reported.

The procedure defines the items to control and a method to:

- Ensure that changes to the configuration baseline are well defined, documented and approved before implementation.
- Ensure that decisions are made at the appropriate management level.

7. SELECTION OF CONFIGURATION ITEMS

Selected items of the LHC systems hardware or software (or combination of both), which need to have their configuration managed, are designated as configuration items.

Configuration items are the basic units of configuration management. They may vary in complexity, size and type, from a cryo-magnet assembly to a coil spacer. Regardless of complexity, type or size, the configuration of a CI is documented and controlled.

Not all assemblies and parts require the same level of configuration control. The more critical an item is, in terms of machine performance, reliability and safety, the more important it is to be able to trace its characteristics and history. This is valid whether the item is a complex assembly or a single component.

During the design phase of the Project, configuration management is applied to all the items listed in the PBS and their associated design and contracting data and documents.

During the production and installation phases, configuration management is applied selectively, the level of detail being commensurate with the criticality of the items.

For critical items produced in series, it may be necessary to keep track of the fully detailed bill of materials and of all the manufacturing, measurements and test data, of each individual unit. For non-critical items a sampling procedure may be adequate.

The Project Engineers in charge of systems, sub-systems, assemblies and parts shall establish, with the assistance of the Technical Coordination Committee, the appropriate level of configuration management to be applied to their equipment.

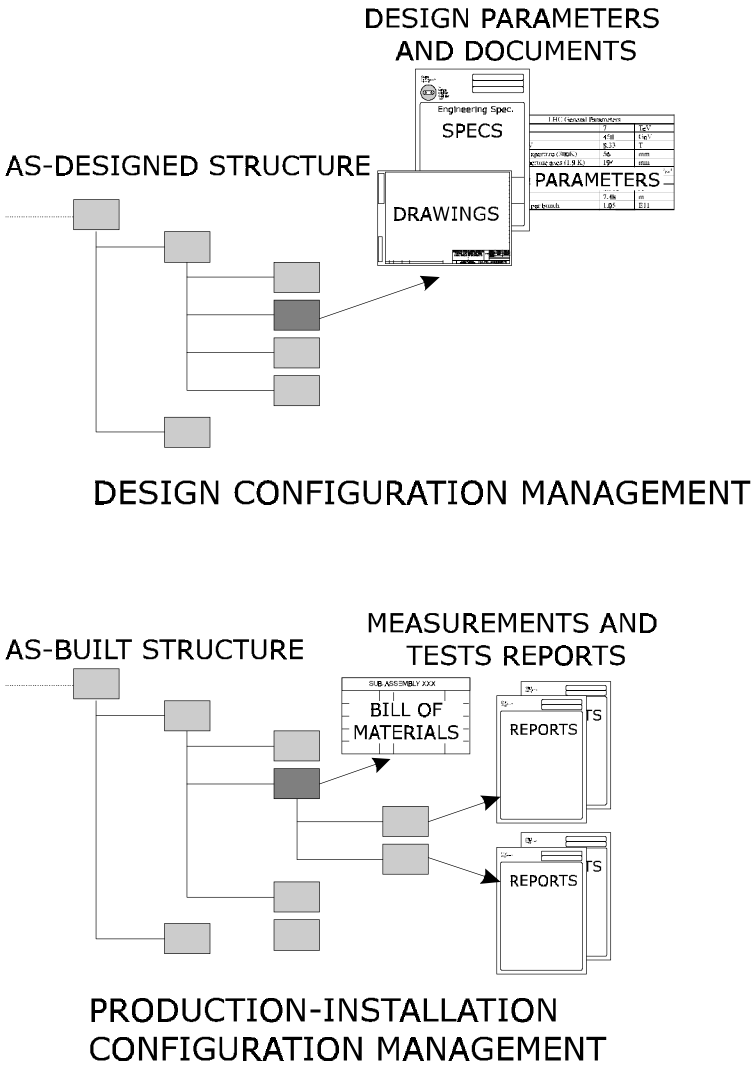

Figure 1: Configuration Management and Life-Cycle Phases

7.1 HARDWARE ITEMS

The LHC Project configuration items comprises:

- All the hardware assemblies, sub-assemblies and parts of the LHC systems that are included in the Project Breakdown Structure (PBS) of the Project.
- All the critical measuring and test equipment that are included in the PBS.

7.2 PARAMETERS

1. All the main parameters defining the LHC and the injector chain layouts and beam performance.
2. All the LHC systems parameters that have an effect on the LHC performance.
3. All the LHC systems parameters that have an effect on the design of other LHC systems.

The definitions in points 2 and 3 above apply to the following LHC systems:

- Magnet.
- Cryogenic.

- Powering.
- Vacuum.
- Survey.
- Beam losses and cleaning.
- RF and feedback.
- Injection and transfer lines.
- Ejection and dump.
- Instrumentation and controls.

7.3 DOCUMENTS

The following document types that describe the parameters, assemblies, sub-assemblies and parts listed in points 1, 2 and 3 above:

- Functional specifications.
- Interface specifications.
- Technical Description for Market Surveys.
- Technical Specifications (Technical Description for Invitations to Tender and for Price Enquiries).
- Engineering Drawings.
- Schedules.

This list shall be completed as appropriate with the reports established during the fabrication, assembly, test and installation phases of configuration items.

8. CHANGE PROCESS AND CONTROL

8.1 CORRECTION OF TRANSCRIPTION ERRORS

Despite the use of review and approval procedures to ensure that parameters and documents are checked prior to their release, errors and omissions may occur. The reason maybe a typing mistake; the omission of a word or sentence; a technical problem when translating a document from the native text processing software to the on-line format used for distribution on the Web; or any other cause. All errors of this type are identified as **transcription errors**.

Once a parameter table or a document has been released it may be read, printed and copied. Any correction requires that the revised parameter table or document be released once more with a new revision index.

To clearly set apart correction of transcription errors from real engineering changes the following rules shall apply:

- Corrections of transcription errors are carried under the sole responsibility of the parameter table or document author.
- Transcription errors are documented in the parameter table or document change history as "Minor correction".
- The correction of a transcription error is the only case where a new revision of a baseline parameter table or document may be released without the change being documented by an ECR.

8.2 CHANGE REQUEST

The change control procedure is shown on fig. 2.

The change process starts when a proposal for a change is formulated. Any competent person involved in the Project, at CERN, Institutes or Contractors, may propose a change. Before the formal change process is started with the preparation of an Engineering Change Request (ECR) it is recommended that the originator discuss the proposal with the responsible Project Engineer or the PLC Chairman. This exchange of ideas shall establish how the proposed change should be processed. The possibilities are:

A. The originator of the proposal, together with the responsible PE or the PLC Chairman, agree that the justification for the change is inadequate and should not be pursued.

B. The responsible PE, or the PLC Chairman, is able to assess, without a formal ECR evaluation, that the change is of low-impact (as defined in section 8.4.1) and is local (as defined in section 8.4.2). In that case, the PE or the PLC Chairman has the choice to :

- Go ahead with a formal ECR or
- Apply the simplified procedure described in section 8.7.2.

C. The change proposal requires a full evaluation, an ECR shall be prepared.

Cases which cannot be decided by the responsible PE, or the PLC Chairman, shall be referred to the TCC Chairman.

8.3 ECR PREPARATION

The LHC Project formal change process is initiated by the preparation of an ECR document completed by the originator of the proposal, with the assistance of either the PE in charge of the affected hardware item or the PLC Chairman as appropriate. PE's and designers of items and parameters affected by the change may be called upon to assist with the ECR preparation.

Once ready the ECR shall be forwarded to:

- The PE in charge of the affected item in the case of hardware changes.
- The PLC Chairman in the case of parameter changes.

In cases where a Contractor proposes an engineering change, the CERN's technical contact person shall prepare the ECR.

Changes affecting both parameters and hardware items shall be forwarded to the "Technical Coordination Committee" Chairman.

ECR are managed as described in "Documents and Parameters Process and Control" [1], and they shall be prepared in accordance with the "Instructions for the completion of ECR's"[2].

8.4 ECR EVALUATION

The PE or the PLC Chairman, in collaboration with PE's and Project Committees responsible for items affected by the proposal, shall first examine the merits of the proposed change, and decide whether to go ahead with a detailed evaluation or to reject the proposal.

In case the proposal is rejected at that stage, the PE or the PLC secretary shall inform the originator of the decision.

If the ECR is considered valid, it shall be evaluated to determine:

- The impact on cost, schedule or technical performance.
- The impact on related items in the PBS.

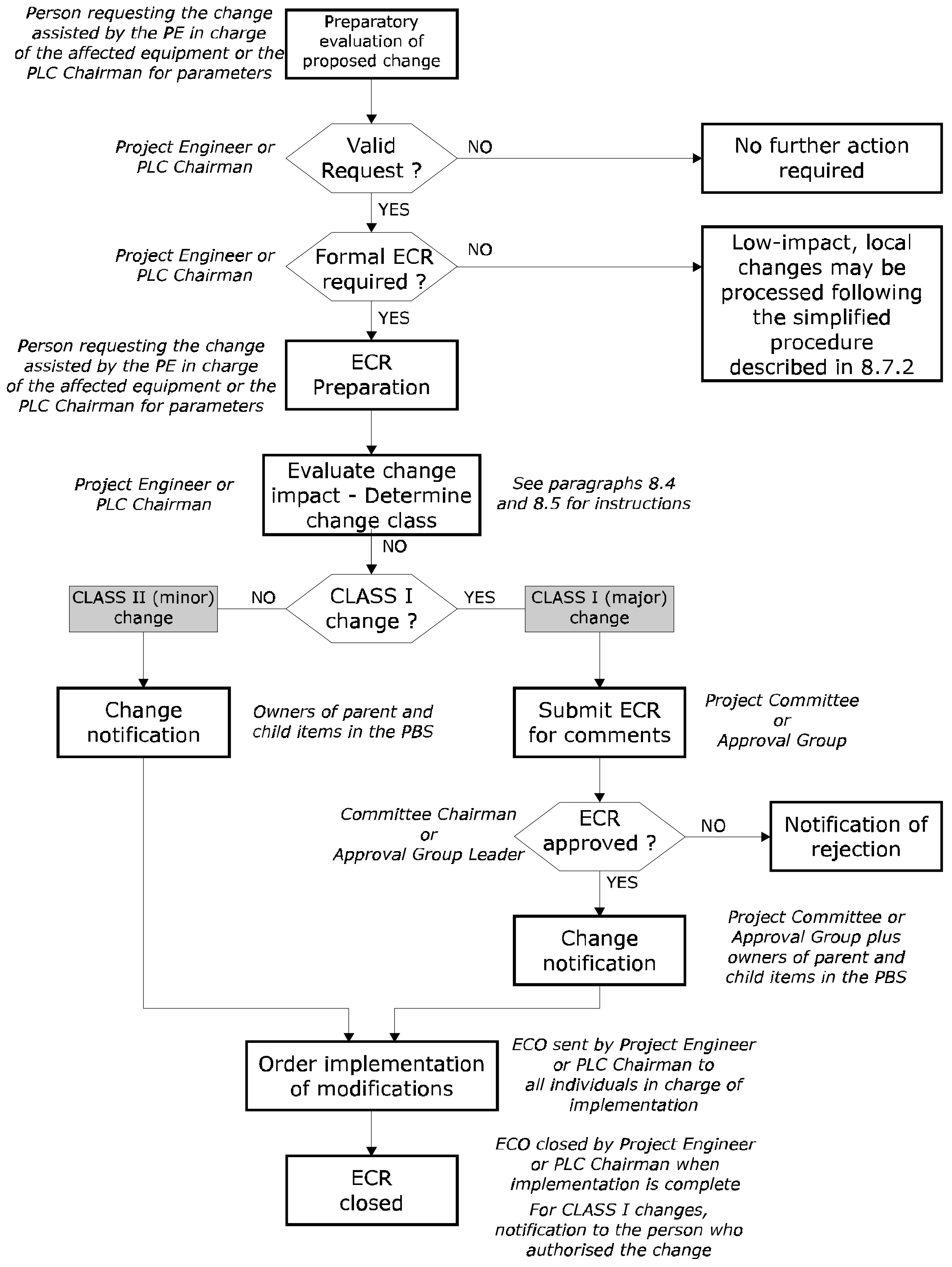

Figure 2: Change Process and Control Diagram

8.4.1 IMPACT ON COST, SCHEDULE AND TECHNICAL PERFORMANCE

For the purpose of change control, impact on cost, schedule and technical performance shall be classified as **low impact** or **high impact** based on the criteria given in table 1.

	Cost	***Schedule***	***Performance***
Low impact	Change of less than CHF 200'000.-	Less than 1 month deviation on LHC completion target date	Less than 5% deviation from functional requirements
High impact	Change of CHF 200'000.- or more	1 month or more deviation on LHC completion target date	5% or more deviation from functional requirements

Table 1: Definition of Impact on Cost, Schedule and Performance

When using table 1 the impact on cost, schedule and performance shall be compared individually to each of the criteria. It is sufficient that one of the high impact criteria be met to determine that the change is high impact.

Ii may be difficult for a PE to evaluate all the implications of a change. If this is the case the PE may seek the assistance of his supervisor and of Project Committees in carrying out the impact assessment.

8.4.2 IMPACT ON RELATED ITEMS

The second step of the evaluation shall establish whether the change's impact is **extended** or **local**.

Extended changes are changes affecting:

- LHC systems parameters.
- Principal items and their parent items in the LHC PBS.
- Identical child items of principal item attached to two or more principal items.

Local changes are changes affecting:

- one or more child items of a single principal item.

An extract of the PBS is shown in fig. 3 with examples of principal and child items.

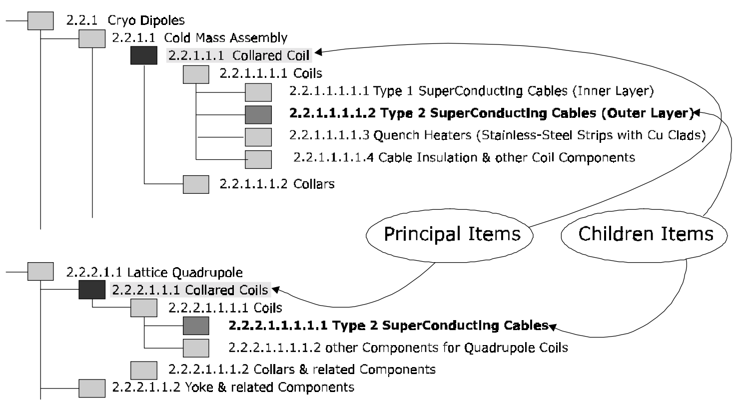

Figure 3: Principal and Child Items in the PBS

When evaluating the extent of a change the interchangeability of the affected items shall be evaluated as well.

Interchangeability is defined as follows:

- Two or more parts or assemblies are considered interchangeable if, in all applications, they are:
- Of an acceptable form and appearance to fulfil all requirements defined in the specification.
- Of a proper fit (physical dimensions) to assemble with other mating items.
- Of a proper function to meet the item specification.

Parts and assemblies meeting these criteria are completely interchangeable, one for the other (both ways) with no special adjustments, modifications, or alterations to themselves or to related parts and assemblies.

The reference to all applications means that when a part or a assembly is used in more then one parent assembly the evaluation of interchangeability must be done for each different assembly.

When evaluating the interchangeability of the children of a principal item the analysis must be done recurrently for all the children up to the principal item until it is found that the item is interchangeable.

If the analysis shows that the principal item becomes non-interchangeable as a result of the change, the change becomes an **extended change**.

The process of interchangeability analysis is shown on fig. 4.

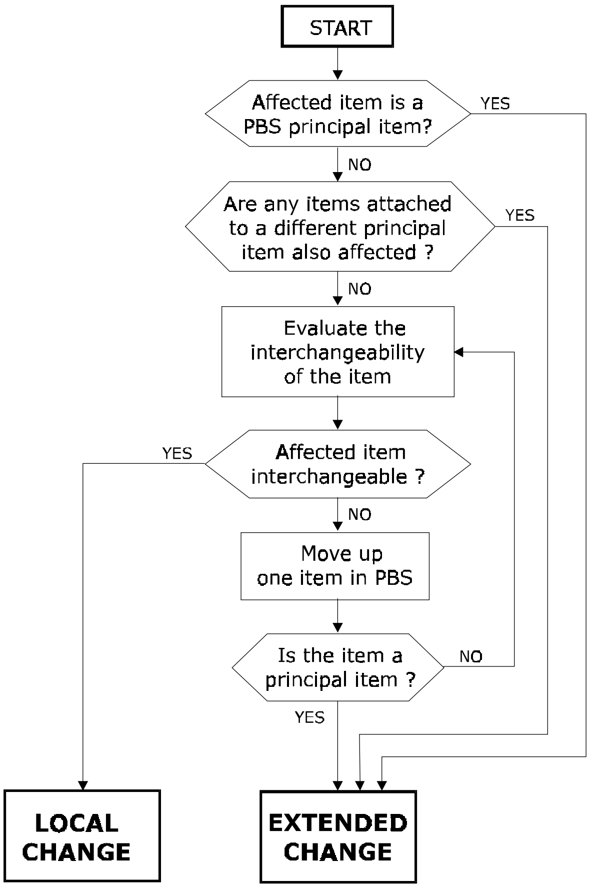

Figure 4: Interchangeability Evaluation Diagram

8.5 CLASSIFICATION OF CHANGES

The use of classes makes it possible to adapt the change process to the evaluated impact of changes and to minimize the effort required to process the change.

Two classes of changes are defined as follows:

CLASS I **Major change**-Non-interchangeable hardware modifications and changes with a significant impact on cost, schedule or technical performance.

CLASS II **Minor change**-Interchangeable hardware modifications and changes with a low impact on cost, schedule or technical performance.

Based on the evaluation of the impact of a change and its extent, the change class can be determined the definitions in table2.

	Local change	***Extended change***
Low impact change	CLASS II	CLASS I
High impact change	CLASS I	CLASS I

Table 2: Change class definition

8.6 PROCESSING CLASS I CHANGES

Once the evaluation is complete the PE shall update the ECR with:

- The impact, extent and resulting CLASS of the change.
- His recommendation on the acceptance or refusal of the change.
- The list of actions necessary to implement the change.
- His name and the date of the recommendation.

The ECR shall then be forwarded to the appropriate Committee Chairman and/or Approval Group Leader. The Committee Chairman and/or Approval Group Leader shall then forward the ECR to Committee members and/or Approval Group members with a request for comments.

At the end of the time allocated for the submission of comments the Committee Chairman and/or Approval Group Leader shall review the comments ant take the final decision of approval or rejection of the ECR. He shall then update the ECR with:

- The final decision of acceptance or refusal of the change.
- His name and the date of the decision.

The completed ECR is used as an ECN to inform all the involved individuals of the approved change. The involved persons are:

- The members of the Committee and/or the members of the Approval Group.
- The PE in charge of the parent and child items of the affected item in the PBS.
- The PE's design team members.

The completed ECR is also forwarded as an ECO to all individuals in charge of the implementation of the change.

8.7 PROCESSING CLASS II CHANGES

8.7.1 NORMAL PROCEDURE

Once the evaluation is complete the PE shall update the ECR with:

- The impact, extent and resulting CLASS of the change.
- His decision on the acceptance or refusal of the change.
- The list of actions necessary to implement the change.
- His name and the date of the decision.

The completed ECR is used as an ECN to inform all the involved individuals of the approved change. The involved persons are:

- The PE in charge of the parent and child items of the changed item in the PBS.
- The PE's design team members.

The completed ECR is also forwarded as an ECO to all individuals in charge of the implementation of the change.

8.7.2 SIMPLIFIED PROCEDURE

The simplified procedure may be applied only for low-impact changes that are localised to a single item of the PBS, with no effect whatever to other PBS items. To ensure the traceability of change following this procedure, particular care shall be taken to accurately describe the change in modified drawings and documents.

The PE responsible for the item shall:

- Instruct the design office to make the necessary modifications to CAD models and drawings. The precise nature of the modification shall be entered in each drawing's modification list.
- Instruct authors of documents, in particular engineering specifications, to make the necessary changes. The precise nature of the modification shall be entered in each document's change history.
- Submit the drawings and documents to the appropriate review and approval process.
- Notify the PE responsible for the parent item in the PBS.

8.8 NOTIFICATION OF CLASS I CHANGE COMPLETION

When all the necessary actions to implement a CLASS I ECO are completed the PE in charge of the implementation shall:

- Update the ECO with his name and the date of the completion.
- Notify the person who authorised the change of the completion.

9. RELATED DOCUMENTATION

[1] LHC-PM-QA-303.00 Documents and Parameters Process and Control

[2] LHC-PM-QA-608.00 Instructions for the completion of ECR's

10. ANNEXES

A.1 ECR document cover page.

A.2 Extract of the LHC Project Breakdown Structure.
(For the current up-to-date version of the PBS see http://edms.cern.ch/TWDM/cgi/twdmproto.pm?project=LHC&action=start) .

CERN
CH-1211 Geneva 23
Switzerland

the **Large Hadron Collider** project

LHC Project Document No. **[doc no.]**
EDMS Document No.
Engineering Change requested by (Name & Div./Grp.) : **[Name]** [Div./Grp.]

Date:

Engineering Change Request – Class I

Brief description of the proposed change(s) :

Equipment concerned :	***Drawings concerned :***	***Documents concerned :***

PE in charge of the item :	***PE in charge of parent item in PBS :***
Decision of the Project Engineer : ☐☑ Rejected. ☐☑ Accepted by Project Engineer, no impact on other items. *Actions identified by Project Engineer* ☐☑ Accepted by Project Engineer, but impact on other items. *Comments from other Project Engineers required* *Final decision & actions by Project Management*	***Decision of the PLO for Class I changes :*** ☐☑ Not requested. ☐☑ Rejected. ☐☑ Accepted by the Project Leader Office. *Actions identified by Project Leader Office*
Date of Approval :	***Date of Approval :***

Actions to be undertaken :	
Date of Completion :	***Visa of QA Officer :***

*Note : when approved, an **Engineering Change Request** becomes an **Engineering Change Order/Notification**.*

Annex A1: ECR Document Cover Page.

Large Hadron Collider	Lyn EVANS	
1 Infrastructure & General Machine Services	Paul FAUGERAS	
1.1 Civil Engineering Infrastructure	J.-Luc BALDY	LK
1.2 Electrical Distribution Network	Gunnar FERNQVIST	
1.2.1 AC Mains Network	John PEDERSEN	E,EH,EM
1.2.2 DC Network Schematics	Paul PROUDLOCK	D
1.3 Control & Data Network	Robin LAUCKNER	
1.4 Fluid Networks	Mats WILHELMSSON	
1.4.1 Air Ventilation	Jean ROCHE	FA
1.4.2 Water Cooling	Bernard PIROLLET	FW,FP,PR
1.5 Ring Cryogenic System	Philippe LEBRUN	Q
1.6 Tunnel Transportation Equipt & Infrastructure	Keith KERSHAW	LJ
1.7 Survey Equipt	Jean-Pierre QUESNEL	G
2 Arc & Dispersion Suppressor Equipt & Facilities	Paul FAUGERAS	
2.1 Cryo Distribution Line	Wolfgang ERDT	QRL
2.1.1 Supporting System	Wolfgang ERDT	HQRL
2.1.2 Standard Pipe Sections	Wolfgang ERDT	QRLP
2.1.3 Compensation Modules	Wolfgang ERDT	
2.1.4 Service Modules	Wolfgang ERDT	QRLS
2.1.5 QRL Jumpers	Wolfgang ERDT	
2.1.6 Return Box	Wolfgang ERDT	
2.2 Cryo Magnets	Jean-Pierre GOURBER	
2.2.1 Cryo Dipoles	Carlo WYSS	LBA
2.2.1.1 Cold Mass Assembly	Jos VLOGAERT	LBM
2.2.1.1.1 Collared Coil	Diego PERINI	MB_A
2.2.1.1.2 Spool Pieces	Albert IJSPEERT	
2.2.1.1.3 Bus Bars	Jean-Louis PERINET-MARQUET	DC
2.2.1.1.4 Yoke & related Components	Diego PERINI	MB_A
2.2.1.1.5 Shrinking Cylinder & related Equipt	Frederic SAVARY	MB_S
2.2.1.1.6 Quench Diode Assembly	Dietrich HAGEDORN	DQD
2.2.1.1.7 Cold Bore Pipes & Insulation	Frederic SAVARY	VCCB
2.2.1.1.8 Beam Screens	Oswald GROBNER	VCSB
2.2.1.1.9 Heat Exchanger Tube	Laurent Jean TAVIAN	
2.2.1.1.10 Cold Mass Instrumentation Equipt	Jos VLOGAERT	
2.2.1.2 Dipole Cryostat & related Equipt	Alain PONCET	QBA
2.2.1.2.1 Vacuum Vessel	Lloyd Ralph WILLIAMS	QBA
2.2.1.2.2 Thermal Shield	Lloyd Ralph WILLIAMS	
2.2.1.2.3 Radiation Screen	Lloyd Ralph WILLIAMS	
2.2.1.2.4 Multi Layer Insulation	Tore WIKBERG	
2.2.1.2.5 Support Systems	Vittorio PARMA	QBH
2.2.1.2.6 Cryostat Instrumentation & Capillaries	Lloyd Ralph WILLIAMS	
2.2.1.2.7 Vacuum Tank Support System	Lloyd Ralph WILLIAMS	
2.2.1.2.8 Survey Reference Sockets	Jean-Pierre QUESNEL	
2.2.1.2.9 Fastening Devices for Transportation	Lloyd Ralph WILLIAMS	
2.2.2 Standard Arc Short Straight Sections	Jean-Pierre GOURBER	LQA
2.2.2.1 SSS Cold Mass Assembly	Theodor Tortschanoff	LQM
2.2.2.1.1 Lattice Quadrupole	Jean-Michel RIFFLET	MQ
2.2.2.1.1.1 Collared Coils	Jean-Michel RIFFLET	MQ
2.2.2.1.1.2 Yoke & related Components	Jean-Michel RIFFLET	
2.2.2.1.2 Inertia Tube & Flange Assembly	Jean-Michel RIFFLET	
2.2.2.1.3 Combined Sextupole-Dipole Magnet	Albert IJSPEERT	MSCB
2.2.2.1.4 Octupole Corrector	Albert IJSPEERT	MO
2.2.2.1.5 Tuning Quadrupole	Albert IJSPEERT	MQT
2.2.2.1.6 Skew Quadrupole	Albert IJSPEERT	MQS
2.2.2.1.7 Mounting Devices for Correctors	Michel GENET	
2.2.2.1.8 Electrical Connections	Jean-Michel RIFFLET	
2.2.2.1.9 Bus Bars	Jean-Louis PERINET-MARQUET	DC
2.2.2.1.10 Quench Diode Assembly	Jean-Michel RIFFLET	DQD
2.2.2.1.11 Cold Bore Pipes & Insulation	Frederic SAVARY	VCCQ
2.2.2.1.12 Beam Screens	Oswald GROBNER	VCSQ
2.2.2.1.13 Heat Exchanger Tube	Laurent Jean TAVIAN	
2.2.2.1.14 Cold Mass Instrumentation Equipt	Theodor Tortschanoff	
2.2.2.2 SSS Cryostat & related Equipt	Peter ROHMIG	QQA
2.2.2.2.1 SSS Vacuum Vessel Assembly	Daniel VINCENT	QQA
2.2.2.2.2 Thermal Shield	Daniel VINCENT	

Annex A2 Extract of the LHC ProjectBreakdown Structure (page 1)

2.2.2.2.3 Radiation Screen	Daniel VINCENT	
2.2.2.2.4 Multi Layer Insulation	Tore WIKBERG	
2.2.2.2.5 Support Systems	Vittorio PARMA	QQH
2.2.2.2.6 Cryostat Instrumentation & Capillaries	Lloyd Ralph WILLIAMS	
2.2.2.2.7 Vacuum Vessel Support System	Peter ROHMIG	
2.2.2.2.8 Survey Reference Sockets	Jean-Pierre QUESNEL	
2.2.2.2.9 Fastening Devices for Transportation	Keith KERSHAW	
2.2.2.2.10 Beam Loss Monitors	Claude FISCHER	
2.2.2.3 Technical Service Module	Peter ROHMIG	QQS
2.2.2.3.1 BPM & Beam Screen Assembly	Peter ROHMIG	
2.2.2.3.2 Cryogenic Components	Wolfgang ERDT	QQS
2.2.2.3.3 Insulation Vacuum Barrier System	Vittorio PARMA	QQV
2.2.2.3.4 Dipole Corrector Current Feedthrough Assembly	Peter ROHMIG	DFL
2.2.2.3.5 Cold Mass Instrumentation Feedthrough	Peter ROHMIG	
2.2.2.3.6 TSM Vacuum Vessel Assembly	Peter ROHMIG	QQS
2.2.2.3.7 Thermal Shield	Peter ROHMIG	
2.2.2.3.8 QQS Instrumentation	Peter ROHMIG	
2.2.3 Dispersion Suppressor Short Straight Sections	Jean-Pierre GOURBER	
2.3 other Arc Cryostats Components	Alain PONCET	
2.3.1 Interconnects	Jean-Claude BRUNET	LI
2.3.2 Auxilliary Bus Bars	Knud DAHLERUP-PETERSEN	DCC
2.3.3 other Vacuum Equipt	Pierre STRUBIN	
2.4 Powering Equipt	Gunnar FERNQVIST	RB ,RQF,RQD
2.4.1 Feed & Return Boxes	Roberto SABAN	DFB,DRB
2.4.2 Power Converters	Frederick BORDRY	RB ,RQF,RQD
2.4.3 Quench Protection System	Felix RODRIGUEZ-MATEO	DQ
2.5 Electronics & Control Equipment in Tunnel	Robin LAUCKNER	
2.5.1 Beam Instrumentation Electronics	Claude FISCHER	
2.5.2 Beam Loss Monitors	Claude FISCHER	
2.5.3 Vacuum Controls	Pierre STRUBIN	
2.5.4 Radiation Monitors	Graham Roger STEVENSON	
3 Insertion Region Equipt & Facilities at Points 1 & 5	Paul FAUGERAS	
3.1 Infrastructure & General Services	Paul FAUGERAS	
3.1.1 Civil Engineering Infrastructure	J.-Luc BALDY	
3.1.1.1 CE Infrastructure at Point 1	Hubert RAMMER	
3.1.1.2 CE Infrastructure at Point 5	Timothy WATSON	
3.1.2 AC Electrical Distribution Network	John PEDERSEN	E,EH,EM
3.1.3 Control & Data Network	Robin LAUCKNER	
3.1.4 Fluid Networks	Mats WILHELMSSON	
3.1.4.1 Air Ventilation	Jean ROCHE	FA
3.1.4.2 Water Cooling	Bernard PIROLLET	FW
3.2 Cryo Distribution Line	Wolfgang ERDT	QRL
3.3 Insertion Magnets	Thomas TAYLOR	
3.3.1 Inner Triplet	Ranko OSTOJIC	
3.3.1.1 SuperConducting Quadrupole Modules	Ranko OSTOJIC	MQX
3.3.1.2 Common Cryostats	Ranko OSTOJIC	QQX
3.3.1.3 Specific Feed Boxes	Ranko OSTOJIC	
3.3.2 other SuperConducting Quadrupoles	Ranko OSTOJIC	
3.3.2.1 SuperConducting Quadrupole Modules	Ranko OSTOJIC	MQY
3.3.2.2 Cryostats and Feed Boxes	Ranko OSTOJIC	QQY
3.3.3 Separation Magnets	Thomas TAYLOR	
3.3.3.1 Warm D1 Magnet Modules	Thomas TAYLOR	MBXW
3.3.3.2 SuperConducting D2 Magnet	Thomas TAYLOR	MBR
3.3.4 Corrector Magnets	Albert IJSPEERT	MCBX
3.4 Collimators	Thomas TAYLOR	TAN
3.5 Powering Equipt	Gunnar FERNQVIST	
3.5.1 Power Converters	Frederick BORDRY	
3.5.2 Copper Leads	John PEDERSEN	DW
3.5.3 HTS Current Leads	Thomas TAYLOR	DFL
3.6 other Vacuum Equipt	Pierre STRUBIN	
3.7 Beam Instrumentation	Claude FISCHER	
3.8 ATLAS Experiment PBS (Point1)	Gerard BACHY	
3.9 CMS Experiment PBS (Point 5)	Thomas MEYER	
4 Insertion Region Equipt & Facilities at Points 2 & 8	Paul FAUGERAS	
4.1 Infrastructure & General Services	Paul FAUGERAS	
4.1.1 Civil Engineering Infrastructure	J.-Luc BALDY	
4.1.2 AC Electrical Distribution Network	John PEDERSEN	E,EH,EM

Annex A2 Extract of the LHC ProjectBreakdown Structure (page 2)

4.1.3	Control & Data Network	Robin LAUCKNER	
4.1.4	Fluid Networks	Mats WILHELMSSON	
4.1.4.1	Air Ventilation	Jean ROCHE	FA
4.1.4.2	Water Cooling	Bernard PIROLLET	FW
4.2	Cryo Distribution System	Philippe LEBRUN	
4.2.1	Surface Cryogenic Plant	Udo WAGNER	QSC,QSR
4.2.2	Cold Compressor Boxes	Laurent Jean TAVIAN	QUR,QURC
4.2.3	Interconnecting Box	Laurent Jean TAVIAN	QUI
4.2.4	Cryogenic Distribution Line	Wolfgang ERDT	QRL
4.3	Insertion Magnets	Thomas TAYLOR	
4.3.1	Inner Triplet	Ranko OSTOJIC	
4.3.1.1	SuperConducting Quadrupole Modules	Ranko OSTOJIC	MQX
4.3.1.2	Common Cryostats	Ranko OSTOJIC	QQX
4.3.1.3	Specific Feed Boxes	Ranko OSTOJIC	
4.3.2	other SuperConducting Quadrupoles	Ranko OSTOJIC	
4.3.2.1	SuperConducting Quadrupole Modules	Ranko OSTOJIC	MQY
4.3.2.2	Cryostats and Feed Boxes	Ranko OSTOJIC	QQY
4.3.3	SuperConducting Separation Magnets	Thomas TAYLOR	MBR
4.3.4	Corrector Magnets	Albert IJSPEERT	MCBX
4.4	Collimators	Thomas TAYLOR	TAS
4.5	Injection System	Volker MERTENS	
4.5.1	Injection Kickers	Gerhard SCHRODER	MKI
4.5.2	Injection Septa	Roger GUINAND	MSI
4.6	Beam Stoppers	Serge PERAIRE	TDI
4.7	Powering Equipt	Gunnar FERNQVIST	
4.7.1	Power Converters	Frederick BORDRY	
4.7.2	Copper Leads	John PEDERSEN	DW
4.7.3	HTS Current Leads	Thomas TAYLOR	DFL
4.8	other Vacuum Equipt	Pierre STRUBIN	
4.9	Beam Instrumentation	Claude FISCHER	
4.10.	ALICE Experiment PBS (Point 2)	Wolfgang KLEMPT	
4.11	LHC-B Experiment PBS (Point 8)	Hans Jurgen HILKE	
5	Insertion Region Equipt & Facilities at Point 4	Paul FAUGERAS	
5.1	Infrastructure & General Services	Paul FAUGERAS	
5.1.1	Civil Engineering Infrastructure	J.-Luc BALDY	
5.1.2	AC Electrical Distribution Network	John PEDERSEN	E,EH,EM
5.1.3	Control & Data Network	Robin LAUCKNER	
5.1.4	Fluid Networks	Mats WILHELMSSON	
5.1.4.1	Air Ventilation	Jean ROCHE	FA
5.1.4.2	Water Cooling	Bernard PIROLLET	FW
5.2	Cryo Plant & Cryo Distribution System	Philippe LEBRUN	
5.2.1	Surface Cryogenic Plant	Udo WAGNER	QSC,QSR
5.2.2	Cold Compressor Boxes	Laurent Jean TAVIAN	QUR,QURC
5.2.3	Interconnecting Box	Laurent Jean TAVIAN	QUI
5.2.4	Cryogenic Distribution Line	Wolfgang ERDT	QRL
5.3	Insertion Quadrupoles	Thomas TAYLOR	LQR
5.3.1	Quadrupole Cold Mass	Thomas TAYLOR	MQR
5.3.2	Isolated Cryostat	Thomas TAYLOR	QQR
5.3.3	Electrical Feed Box	Thomas TAYLOR	DFB
5.4	SuperConducting Separation Magnets	Thomas TAYLOR	MBR
5.5	Collimators	Thomas TAYLOR	
5.6	Powering Equipt	Gunnar FERNQVIST	
5.6.1	Power Converters	Frederick BORDRY	
5.6.2	Copper Leads	John PEDERSEN	DW
5.6.3	HTS Current Leads	Thomas TAYLOR	DFL
5.7	Radio Frequency Equipt	Daniel BOUSSARD	A
5.7.1	SuperConducting Cavities	Volker RODEL	ACS
5.7.2	Feedback Systems	Trevor LINNECAR	AD
5.7.2.1	Transverse Feedback Systems	Trevor LINNECAR	ADT
5.7.2.2	Longitudinal Feedback Systems	Trevor LINNECAR	ADL
5.7.3	Radio Frequency Power Plant	Volker RODEL	
5.7.4	Radio Frequency Instrum. & Control Equipt	Volker RODEL	ABD
5.8	other Vacuum Equipt	Pierre STRUBIN	
5.9	Beam Instrumentation	Claude FISCHER	
6	Insertion Region Equipt & Facilities at Points 3 & 7	Paul FAUGERAS	
6.1	Infrastructure & General Services	Paul FAUGERAS	
6.1.1	Civil Engineering Infrastructure	J.-Luc BALDY	

Annex A2 Extract of the LHC Project Breakdown Structure (page 3)

6.1.2	AC Electrical Distribution Network	John PEDERSEN	E,EH,EM
6.1.3	Control & Data Network	Robin LAUCKNER	
6.1.4	Fluid Networks	Mats WILHELMSSON	
6.1.4.1	Air Ventilation	Jean ROCHE	FA
6.1.4.2	Water Cooling	Bernard PIROLLET	FW
6.2	Cryo Distribution Line	Wolfgang ERDT	QRL
6.3	Warm Quadrupoles	Thomas TAYLOR	MQW
6.4	Warm Separation Magnets	Thomas TAYLOR	MBW
6.5	Collimators, Absorbers & Scapers	Thomas TAYLOR	TC
6.6	Radiation Shielding	Graham Roger STEVENSON	
6.7	Powering Equipt	Gunnar FERNQVIST	R
6.8	other Vacuum Equipt	Pierre STRUBIN	
6.9	Beam Instrumentation	Claude FISCHER	
7	Insertion Region Equipt & Facilities at Point 6	Paul FAUGERAS	
7.1	Infrastructure & General Services	Paul FAUGERAS	
7.1.1	Civil Engineering Infrastructure	J.-Luc BALDY	
7.1.2	AC Electrical Distribution Network	John PEDERSEN	E,EH,EM
7.1.3	Control & Data Network	Robin LAUCKNER	
7.1.4	Fluid Networks	Mats WILHELMSSON	
7.1.4.1	Air Ventilation	Jean ROCHE	FA
7.1.4.2	Water Cooling	Bernard PIROLLET	FW
7.2	Cryo Plant & Cryo Distribution System	Philippe LEBRUN	
7.2.1	Surface Cryogenic Plant	Udo WAGNER	QSC,QSR
7.2.2	Cold Compressor Boxes	Laurent Jean TAVIAN	QUR,QURC
7.2.3	Interconnecting Box	Laurent Jean TAVIAN	QUI
7.2.4	Cryogenic Distribution Line	Wolfgang ERDT	QRL
7.3	Insertion Quadrupoles	Thomas TAYLOR	
7.3.1	Quadrupole Cold Mass	Thomas TAYLOR	MQY
7.3.2	Isolated Cryostat	Thomas TAYLOR	QQY
7.3.3	Electrical Feed Box	Thomas TAYLOR	DFB
7.4	Collimators	Thomas TAYLOR	TC
7.5	Powering Equipt	Gunnar FERNQVIST	
7.5.1	Power Converters	Frederick BORDRY	
7.5.2	Copper Leads	John PEDERSEN	DW
7.5.3	HTS Current Leads	Thomas TAYLOR	DFL
7.6	Beam Dump Equipt	Eberhard WEISSE	
7.6.1	Ejection Kickers	Gerhard SCHRODER	MKD
7.6.2	Ejection Septa	Urban JANSSON	MSD
7.6.3	Dilution Kickers	Gerhard SCHRODER	MKB
7.6.4	Ejection Collimators	Serge PERAIRE	
7.6.5	Absorber Blocks	Claude FISCHER	TDE
7.6.6	Vacuum Equipment in Extraction Lines	Ian COLLINS	
7.7	other Vacuum Equipt	Ian COLLINS	
7.8	Instrumentation & Control Equipt	Claude FISCHER	
8	Point 1.8 Special Equipment & Facilities	Paul FAUGERAS	
8.1	Infrastructure & General Services	Paul FAUGERAS	
8.1.1	Civil Engineering Infrastructure	J.-Luc BALDY	
8.1.2	AC Electrical Distribution Network	John PEDERSEN	
8.1.3	Control & Data Network	Robin LAUCKNER	
8.1.4	Fluid Networks	Mats WILHELMSSON	
8.1.4.1	Air Ventilation	Jean ROCHE	FA
8.1.4.2	Water Cooling	Bernard PIROLLET	FW
8.2	Cryo Plant & Cryo Distribution System	Philippe LEBRUN	
8.2.1	Surface Cryogenic Plant	Udo WAGNER	QSC,QSR
8.2.2	Cold Compressor Boxes	Laurent Jean TAVIAN	QUR,QURC
8.2.3	Interconnecting Box	Laurent Jean TAVIAN	QUI
8.2.4	Cryogenic Distribution Line	Wolfgang ERDT	QRL
8.3	Magnet Measuring Benches	Peter SIEVERS	MM
8.4	Reference Magnets	Paul PROUDLOCK	
8.4.1	Reference Magnets Proper	Louis WALCKIERS	
8.4.2	Cryogenics and Feed Boxes	Bruno VULLIERME	
8.4.3	Magnet Powering	Frederick BORDRY	
8.5	Test String	Roberto SABAN	
9	Transfer Line Equipment & Facilities	Paul FAUGERAS	
9.1	Infrastructure & General Services	Paul FAUGERAS	
9.1.1	Civil Engineering Infrastructure	J.-Luc BALDY	
9.1.1.1	Tunnel TI2 and Pit PMI2	Pedro D'ACA CASTEL-BR	

Annex A2 Extract of the LHC Product Breakdown Structure (page 4)

9.1.1.2	Tunnel TI8	Luz Anastasia LOPEZ-HERNANDEZ	
9.1.2	AC Electrical Distribution Network	John PEDERSEN	
9.1.3	Control & Data Network	Robin LAUCKNER	
9.1.4	Fluid Networks	Mats WILHELMSSON	
9.1.4.1	Air Ventilation	Jean ROCHE	FA
9.1.4.2	Water Cooling	Bernard PIROLLET	FW
9.1.5	Tunnel Transportation Equipt & Infrastructure	Keith KERSHAW	
9.1.6	Survey Equipt	Jean-Pierre QUESNEL	
9.2	Transfer Lines by themselves	Eberhard WEISSE	
9.2.1	Warm Dipoles	Volker MERTENS	MBI
9.2.2	Warm Quadrupoles	Volker MERTENS	MQI
9.2.3	Switch Magnets	Volker MERTENS	
9.2.4	Vacuum Chambers	Pierre STRUBIN	
9.3	Powering Equipt	Gunnar FERNQVIST	
9.4	Beam Instrumentation	Claude FISCHER	
10	LHC Injector Chain	Kurt HUBNER	
10.1	SPS	Karl-Heinz KISSLER	
10.2	CPS Complex	Karlheinz SCHINDL	

Annex A2 Extract of the LHC ProjectBreakdown Structure (page 5)