



**Detailed Specification of the
FAIR Accelerator Control System Work-Package
"Equipment Control Software"**

Document Name
F-DS-C-28e

Date yyyy-mm-dd
2012-08-22

Abstract

This document describes the Detailed Specification of the accelerator control system work package "Equipment Control Software". This work-package is part of the "Control System Software Packages" work package and covers the PSP code 2.14.10.2.4.



Table of Contents

1. Purpose and Classification of the Document	3
1.1. Responsibilities	3
1.2. Classifications of Requirements	3
2. Scope of the Technical System	4
2.1. System Overview	4
2.2. Limits of the System and Environment	5
2.2.1. Limits	5
2.2.2. Interfaces	5
2.2.3. Environment	5
2.3. Basis of Concept	6
2.3.1. Functional Requirements	6
2.3.2. Non-functional Requirements	7
2.3.3. General Constraints	7
2.3.4. Architectural Principles	7
3. Technical Specifications	7
4. Quality Assurance, Tests and Acceptance	8
4.1. Development Methodology	8
4.2. Quality Assurance System of the Supplier	8
4.3. FAT	8
4.4. SAT	8
5. Documentation	9
6. Warranty	9
7. Scope of Delivery	9
I. Attached Documents	10
II. Related Documentation	10
III. Document Information	10
III.1. Document History	10

List of Tables

Table 1: List of Functional Requirements	6
Table 2: List of Non-functional Requirements	7

List of Figures

Figure 1: Equipment Control Software Overview	4
---	---

1. Purpose and Classification of the Document

The purpose of this document is to specify the Accelerator Control System component "Equipment Control Software" for FAIR (PSP code 2.14.10.2.5).

This document is the most detailed type of document in the hierarchy of Control System specifications.

Whenever regulations and requirements are specified in the General Specifications, Technical Guidelines or Common Specifications of the Control System they are only referenced in this document. The related documents are listed in Appendix II.

No legal or contractual conditions are treated in this document. All related information is given in the General Specifications for FAIR II.

1.1. Responsibilities

The responsibilities with respect to changes and modifications of the present document are entirely in the hands of the Controls Department of the GSI Helmholtz Centre for Heavy Ion Research GmbH (GSI) Darmstadt.

For initial information please contact the administration of the Controls Department.

Further information on the organigram, names of responsible persons and task leaders, as well as the agreed document release and approval procedure is summarized in the organizational note 'Controls Project for FAIR'.

1.2. Classifications of Requirements

The following definitions of requirement classifications are being used throughout the document:

- **"Must"** or **"shall"** or **"is required to"** is used to indicate mandatory requirements, strictly to be followed in order to conform to the standard and from which no deviation is permitted.
- **"Must not"** or **"shall not"** mean that the definition is an absolute prohibition of the specification.
- **"Should"** or **"is recommended"** is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others or that a certain course of action is preferred but not required.
- **"Should not"** or **"is not recommended"** mean that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighted before implementing any behavior described with this label.
- **"May"**, which is equivalent to **"is permitted"**, is used to indicate a course of action permissible within the limits of the standard.

2. Scope of the Technical System

2.1. System Overview

In the front-end control domain of the accelerator control system, FESA (Front-end Software Architecture) software is used to connect any kind of equipment to the control system.

The FESA framework is used to generate so-called FESA classes, which contain the implementation for controlling a special kind of equipment (e.g. a FESA class for power converters). Main task of the FESA device class besides the control of the underlying equipment is to represent a logical device (the set of properties and their functionality which the FESA class implements) that presents physics characteristics to the control system. Therefore, the FESA class implements interfacing to the equipment as well as functional behavior and the logical device interface representation towards the rest of the control system.

This document handles the equipment specific FESA classes which are needed to interface the equipment of the FAIR accelerator complex, unless they are covered in other documents ([3]). The work package contains development of the FESA classes as well as the deployment of the FESA class executable on the corresponding front-end controllers.

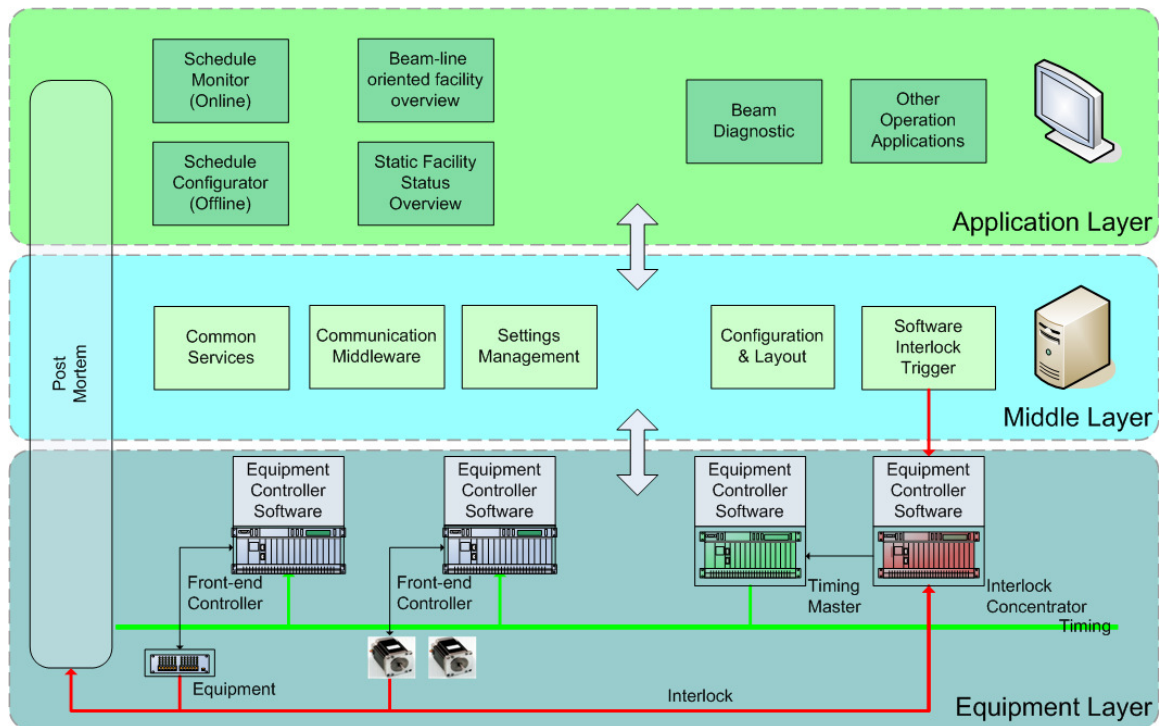


Figure 1: Equipment Control Software Overview

2.2. Limits of the System and Environment

2.2.1. Limits

This document does not cover software which is part of the industrial control system domain in the FAIR control system (see FAIR Technical Guideline "Control System Equipment Control Interfaces", [2]).

The equipment control software cannot fulfill strict hard real-time requirements. This is due to the characteristics of the Linux operating system to be used on the front-end controllers, which even with real-time patches is not capable to guarantee strict real-time limits. While fairly good soft real-time characteristics are achieved, strict hard limits in reaction time require implementation by other means than in the equipment control software.

2.2.2. Interfaces

Equipment control software generated by the FESA framework, the FESA class executable, has interfaces to the FAIR software components which are listed here.

However, the FESA core will handle most of these interfaces. Then the FESA class implementation must only interact with interfaces to the FESA core. This applies for interfaces to:

- Timing System (via the timing receiver)
- Post Mortem System
- Alarm System
- Logging System
- Databases

Besides, the FESA class implementation directly uses interfaces to:

- Hardware drivers for equipment access
- Message library

2.2.3. Environment

Equipment control software must run on equipment controller front-end control hardware as described in the FAIR Technical Guideline "Control System Equipment Control Interfaces", [2].

2.3. Basis of Concept

2.3.1. Functional Requirements

For each type of equipment appropriate equipment control software must be implemented as specific FESA class. The equipment control software must fulfill the following functional requirements:

Number	Description of Requirement
ECS_010	The equipment control software must implement equipment modeling, implementing an abstraction layer to present the equipment specific functionality in a view which is oriented to the physics of the beam handling in the accelerators.
ECS_020	The equipment control software must implement a verification of the communication with the equipment.
ECS_030	The equipment control software must implement FESA properties according to the requirements of operational applications and of equipment maintenance applications which must be defined prior to the development.
ECS_040	The equipment control software must provide the means to always set the equipment to be controlled in a defined state. The equipment control software must handle all set values and commands which are relevant to control the equipment.
ECS_050	All status information and all values, which are required to verify correct operation of the equipment, must be accessible to be read back from the equipment control software.
ECS_060	For each type of equipment it must be checked in the design phase of the equipment control software, whether the equipment, or which part of its overall functionality, is intended to take part in beam multiplexing.
ECS_070	For each type of equipment, or for each part of its functionality, which is proposed to take part in beam multiplexing, the equipment control software must implement multiplexing mechanisms.
ECS_080	The equipment control software may, if requested, implement in addition to the physics oriented presentation a hardware oriented representation of the equipment which is intended for experts and to ease equipment maintenance.
ECS_090	For equipment taking part in synchronized accelerator operations the equipment control software must ensure correct real-time behavior for any actions triggered by timing events, according to the usage of the equipment.
ECS_100	Equipment control software must not be used for tight real time functionality. Jitter in reaction time below 250 μ s cannot be guaranteed.

Table 1: List of Functional Requirements

2.3.2. Non-functional Requirements

The control system must present equipment as a homogeneous set of devices. The equipment control software must fulfill the following non-functional requirements:

Number	Description of Requirement
ECS_210	Equipment control software must be developed using the FESA framework.
ECS_220	Similar pieces of equipment must be handled by common equipment control software: For each type of equipment, a FESA class must be developed.
ECS_230	The equipment control software must provide checks for correct operation and must signal any errors.

Table 2: List of Non-functional Requirements

2.3.3. General Constraints

Equipment control software must be developed using a FESA development environment which is compatible to the FAIR FESA front-end framework. As platforms for front-end controller software only controllers as described in [2] are supported.

2.3.4. Architectural Principles

The Software Architecture Guideline for the Control System [7] fully applies.

3. Technical Specifications

For each type of equipment specific equipment controller software must be developed. Possibly different areas of usage may even require specific equipment control implementations for the same type of equipment.

Front-end controller software must be developed according to the FAIR Technical Guideline "FESA Equipment Software Development Guideline for GSI/FAIR" [5]. Equipment specifics, as described in the FAIR Technical Guideline "Accelerator Control System Equipment Functional Requirements" [4] must be considered.

Since equipment specifics are not yet known in detail, requirements for the various types of equipment specific software cannot be given yet. Such details must be evaluated during the specification and construction of the equipment, as described in the FAIR Development Guideline "Equipment Integration Guideline" [6].

4. Quality Assurance, Tests and Acceptance

4.1. Development Methodology

Main task before starting to develop is to decide together about the interface towards the control system, about the logical device representation. The FESA class design including this interface has to pass a design review, as described in the guideline for connecting new equipment to the control system [6]. The FESA classes must be developed in adherence to the guideline for designing FESA equipment software at the GSI and the FAIR facility [5]. All aspects of these guidelines apply.

Each FESA class must be developed iteratively. At start of development, for each type of equipment the technical design concept and the iteration plan must be established, and must be approved by the FAIR contracting body. The iteration plan must also fix content and duration of the first iteration step.

Each iteration cycle must result in a running system which can be evaluated, and tested, at FAIR site. The first iteration, which has to be available as early as possible, must concentrate on the most critical functionality. In successive iterations, the system is enhanced by adding features until the desired total functionality is reached.

At end of each iteration cycle the achieved status of the system will be evaluated and the iteration plan will be adjusted. Each iteration cycle must be approved by the FAIR contracting body before it can be started.

4.2. Quality Assurance System of the Supplier

The Common Specification "Accelerator Control System" [1] fully applies.

4.3. FAT

The Common Specification "Accelerator Control System" [1] fully applies.

For all FESA classes, it has to be decided and agreed upon in advance, if the FAT can be done at the contractors site, or if the FAT needs to be done at the contracting body's site (due to equipment, that is already installed within the FAIR accelerator complex). If the FAT needs to be done at the contracting body's site, the FAT has to be announced well in advance to be able to access the corresponding equipment if necessary.

4.4. SAT

The Common Specification "Accelerator Control System" [1] fully applies.

Main part of the site integration test is the test of the FESA class together with the real equipment.

Part of the SAT is a test of the FESA class functionality itself. For ongoing integration tests, even when equipment is not working properly, it is necessary to have mock devices of the corresponding FESA class that behave, as if the real equipment were present (e.g. values can be set and read, the values are kept in memory and not sent to the equipment).

Document Title: Detailed Specification Equipment Control Software

The system to be built must adhere to the guidelines and recommendations for software developments in the FAIR accelerator control system context, as referenced in the FAIR Common Specification F-CS-LS-01e_ACS (Common Specification Accelerator Control System). The supplier of the work package must identify the relevant standards and recommendations before start of the development. Details must be fixed as part of the technical design concept in the initialization phase.

5. Documentation

The Common Specification "Accelerator Control System" [1] fully applies.

6. Warranty

The conditions and warranty period specified in the Contract applies.

7. Scope of Delivery

The work package covers all equipment control software, as contained in PSP code 2.14.10.2.4, except of the equipment control software which is described in the FAIR Detailed Specification "FEC device classes" [3].

I. Attached Documents

List of abbreviations for controls (Abbreviations_Controls.pdf).

II. Related Documentation

- [1] F-CS-C-01e, FAIR Common Specification "Accelerator Control System"
- [2] F-TG-C-03e, FAIR Technical Guideline "Control System Equipment Control Interfaces"
- [3] F-DS-C-15e, FAIR Detailed Specification "FEC Device Classes"
- [4] F-TG-C-04e, FAIR Technical Guideline "Control System Equipment Functional Requirements"
- [5] F-DG-C-01e, FAIR Development Guideline "FESA Development Guideline"
- [6] F-DG-C-04e, FAIR Development Guideline "Equipment Integration Guideline"
- [7] F-DG-C-03e, FAIR Development Guideline "Software Architecture Guideline"

III. Document Information

III.1. Document History

Version	Date	Description	Author	Review / Approval
0.1	23. Mar. 2012	Draft	U. Krause	
1.0	30. Mar. 2012	Final version	U. Krause	CCT
3.0	22. Aug. 2012	Incorporated FAIR review comments	CCT	