Cluster Science Data System
Architectural Design for the Scandinavian Data Centre

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1	2	94 June 13	Chapter 6: Included reference to the SDC-ICD for a detailed description of network connections to the SDC. This change was initiated by the CSDS ADR RFA 92
1	3	94 Sep 26	Modifications related to the removal of EFW commanding services and a modified summary plot production and distribution procedure.
1	4	94 Oct 5	After CEDAS meeting 94-5.

Contents

1 Introduction

1.1 Purpose of the document

This document describes the architectural design of the CSDS Scandinavian Data Centre. It is primarily intended to constitute the basis for the detailed design of the components.

1.2 Scope of the software

The scope of the software is to provide means to accommodate the services and products of the SDC as defined in the SDC Interface Control Document [Ref. 6].

1.3 Definitions, acronyms, and abbreviations

A complete list of acronyms is given in Appendix D.

1.4 Applicable documents

The SDC architectural design is based on the user requirements [Ref. 5] and the software requirements [Ref. 7] documents. Other reference documents are cited throughout the report. A complete reference list is found on page 24.

1.5 Overview of the document

The document follows the tree structure inherent in the data flow diagrams as produced by the Yourdon method (see 4.1). The document describes the design to one level below the system level. In appendices, the Quality assurance and Management plans are provided. Critical components of the whole CSDS are the computer networks. A special appendix (C) is therefore devoted to a short discussion to alternatives to using computer networks for communication of data between the data centres and to customers. The general structure of the document adheres to the ESA recommendations for the architectural design phase [Ref. 3].

2 System overview

The Scandinavian Data Centre constitutes one national data centre (NDC) out of 7 national data centres in the Cluster Science Data System. The SDC has responsibility for feeding EFW data products into the CSDS, and its prime customers are the Scandinavian science community and the other data centres.

The SDC will be physically located at the Alfvén Laboratory, Royal Institute of Technology, Stockholm, Sweden. The implementation workload is, however shared between Cluster EFW CoI research groups in Sweden, Norway and Finland. The implementation work and operations will be done basically within the frame of normal research department resources.

The limited resources for the software development implies that the design has to be made in a work-load efficient way, and no major new development can be undertaken. Examples of such consequences are:

- Implementation will be made on an existing Open-VMS/Alpha system where we have deep system knowledge due to long experience of using VMS systems.
- The Data Base Server will contain modules from the ISDAT data base handler which has been developed as a prototype for Cluster detailed data handling over several years.
- The SDC depends on the CSDS User Interface as external user interface and for certain data base services.

A major advantage of the SDC development situation is that all development is done in close contact with (or even directly by) the EFW scientists, thus assuring high product quality from the scientific point of view.

3 System context

The SDC system context diagram is shown in Figure 1. The respective interfaces are described in the following sub-sections. The data flow diagram on the system level is shown in Figure 2

3.1 Interface to SDC operator

The interface to the SDC operator will be via a simple menu type of interface or via the normal operating system. The operator will work on site via a console or other terminal.

3.2 Interface to ESOC

Except for the RDM delivery, the traffic to ESOC will be over networks as specified in the table.

Interface to ESOC

Data	Medium	Documents
in: RDM	CD-ROM	[Ref. 9]
in: DDS-file	TBD network	[Ref. 9] [Ref. 8]
in: Command confirmation	part of DDS-file	
out: DDS request	TBD network	[Ref. 9]

3.3 Interface to JSOC

There are no direct interfaces to JSOC

3.4 Interface to EFW PI

In the ADD context the EFW PI should be understood as the EFW PI personally or a representative for the EFW PI with special privileges with respect to instrument commanding etc. He will log in using his personal password and can enter the SDC processes by entering the SDC user interface. He can work locally or remotely via NORDUnet. The EFW PI will be the most privileged user of the SDC. The EFW PI, of course, also has the privileges of the EFW CoI's.

3.5 Interface to EFW CoI's

The active EFW CoI's will be registered as users on the SDC. They will log in using personal passwords and can access SDC processes by entering the SDC user interface. They can work locally or remotely via NORDUnet. The EFW CoI's will have a limited access to EFW instrument related processes at the SDC.

3.6 Interface to the Scandinavian science community

The SDC databases are accessed via the CSDS User Interface. Scandinavian scientists will access the SDC via NORDUnet.

3.7 Interface to FGM PI

The *FGM PI* interface is used only for special purposes, e.g. FGM DDS file transfer or FGM calibration update.

Figure 1: SDC system context diagram

Interface to FGM PI

Data	Medium	Documents
in: FGM DDS data	TBD network	[Ref. 6]
in: FGM calibration files	TBD network	
out: FGM DDS request	TBD network	

3.8 Interface to ASPOC PI

The *ASPOC PI* interface is used only for special purposes, e.g. ASPOC DDS file transfer.

Interface to ASPOC PI

Data	Medium	Documents
in: ASPOC DDS file	TBD network	[Ref. 6]
out: ASPOC DDS request	TBD network	

3.9 Interface to the GCDC

Summary plots will be produced at the GCDC and will be copied to the SDC.

3.10 Interface to NDC's

This represents the interfaces to all national data centres for distribution of CSDS products.

Interface to CFC

Data	Medium	Documents
in: CSDS products	TBD network	[Ref. 6]
in: CSDS prod. status		
out: CSDS products	TBD network	

4 System design

4.1 Design method

The architectural design is carried out using the Yourdon method as implemented in the tool DECdesign Version 2.0 by Digital Equipment Corporation ([Ref. 2] and [Ref. 11]). The data flow diagrams shown in this document are directly originating from the DECdesign software package.

4.2 Decomposition description

The SDC system is decomposed into:

1. Reception
2. Interactive processing
3. Data base server
4. EFW DB production
5. (SDC) User interface
6. CSDS User Interface

as shown in Figure 2.

Figure 2: SDC system data flow

5 Component description

Under the *purpose* headline in the component descriptions we list the relevant software requirements as listed in the SDC Software Requirements Document [Ref. 7].

5.1 Reception

The *reception* covers some manual procedures to receive E-mail addressed to the SDC, reception of the CD-ROM's from ESOC and some other non-routine data input to the SDC. The data flow diagram for the Reception component is shown in Figure 3.

5.1.1 RDM reception

Type Process

Purpose Fulfils **SR-SDC-8** (receive, verify, catalogue, archive RDM).

Function The function of this component is to receive, validate and register the RDM's at the SDC.

Subordinates See Figure 3.

Dependencies See Figure 3.

References [Ref. 9]

Processing Partly manual. This component is fully controlled by the SDC operator.

Data In: RDM CD-ROM via mail, Data via networks.

5.1.2 RDM handling

Type Process

Purpose Fulfils in part **SR-SDC-9** (access to RDM catalogue)

Function The function of this component is to provide on line access of RDM data.

Subordinates See Figure 3.

Dependencies See Figure 3.

Processing Partly manual

Data In: CD-ROM stored off line.

Figure 3: SDC reception data flow

5.1.3 Retrieve from other sources

Type Process

Purpose To partially fulfil SR-SDC-28. The FGM calibration is needed for the EFW processing.

Function The function of this component is to update the FGM calibration tables and the non-EFW data bases. It also handles the summary plot reception from the GCDC.

Subordinates See Figure 3.

Dependencies See Figure 3.

5.1.4 RDM storage

This is the off-line SDC storage of the RDM.

5.1.5 RDM

This is the on-line storage of portions of the RDM files. It may consist of a CD-ROM mounted in a CD-ROM drive, or a copy on magnetic disk.

5.2 Interactive processing

The *interactive processing* covers mainly EFW instrument related functions, and the use of these functions are restricted to EFW CoI's or the EFW PI. The data flow diagram for SDC interactive processing is shown in Figure 4.

5.2.1 Access control

Type Process

Purpose Fulfils in part **SR-SDC-43** (access control for non-CSDS UI access points).

Function The function of this component is to provide access control to the EFW instrument related functions.

Subordinates See Figure 4

Dependencies See Figure 4

References [Ref. 7]

5.2.2 EFW health control

Type Process

Figure 4: SDC interactive processing data flow

Purpose To fulfil the following software requirements:

SR-SDC-5 Quick-look, health and safety

SR-SDC-1 Query DDS catalogues.

SR-SDC-4 Maintain local DDS catalogue.

SR-SDC-2 Get a local copy of EFW parts of DDS file

SR-SDC-6 Get ASPOC near real time data

SR-SDC-7 Get FGM near real time data.

SR-SDC-40 Maintain EFW command log.

Function The function of this component is to provide means for an interactive analysis of EFW data earlier than the delivery of the RDM. The interactive analysis is needed for quick look science analysis, instrument health verification, and instrument safety verification.

Subordinates See Figure 4

Dependencies See Figure 4

References [Ref. 9], [Ref. 8], [Ref. 10], [Ref. 6]

Processing The process is activated by EFW CoI's. The use is restricted to EFW CoI's.

5.2.3 Calibration update

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-32 Calibration software tools

SR-SDC-34 File version tracking

SR-SDC-33 Make EFW cal. available to other DC's

Function To maintain EFW calibration files.

Subordinates See Figure 4

Dependencies See Figure 4

References [Ref. 6], [Ref. 7]

Processing The process is activated by EFW PI. The use is restricted to EFW PI.

5.3 DB server

The *DB server* covers all long or short term data base storage, deposition, and retrieval both for internal and external use. It also accommodates the conversion to physical units. Parts of the functions will be executed by the *ISDAT data base handler*. The data flow diagram for the data base server is shown in Figure 5.

5.3.1 PDB

This is the component containing the validated parameter data base.

Type Data base

Purpose To fulfil the following software requirements:

SR-SDC-17 Keep Cluster PPDB on line

SR-SDC-18 Keep PPDB accessible to Scand community

SR-SDC-25 Keep Cluster SPDB on line

SR-SDC-26 Keep SPDB accessible to Scand community

SR-SDC-28 Keep SPL available to Scand. community

5.3.2 Local Data Base

This is the component containing the un-validated data bases.

Type Data base

Purpose To fulfil the following software requirements:

SR-SDC-3 Provide temporary storage of the EFW DDS file

SR-SDC-4 Keep a catalogue of locally stored DDS files.

SR-SDC-12 Keep a record of SDC PP software version history.

SR-SDC-20 Keep a record of SDC SP software version history.

SR-SDC-29 Keep a catalogue of all SDC on line data bases.

Function The function of this component is to provide on-line storage for a number of data bases.

Subordinates See Figure 5

Dependencies See Figure 5

References [Ref. 6]

5.3.3 ISDAT Raw DBH

Type Process (ISDAT server)

Figure 5: SDC data base server data flow

Purpose Not related to any specific SR.

Function The function of this component is to provide the other processing components with experimental data in physical units for the requested time interval and instrument.

Subordinates See Figure 5

Dependencies See Figure 5

Interfaces This component has an interface of client-server type towards the "interactive processing" and "EFW DB production" components.

5.3.4 ISDAT Local DBH

Type Process (ISDAT server)

Purpose Not related to any specific SR.

Function The function of this component is to provide the other processing components with experimental data in physical units for the requested time interval and instrument.

Subordinates See Figure 5

Dependencies See Figure 5

Interfaces This component has an interface of client-server type towards the "SDC User shell".

5.3.5 Raw Data Base

This is the component containing the raw data used for data base producton.

Type Data base

Purpose To fulfil the following software requirements:

SR-SDC-3 Provide temporary storage of the EFW DDS file

Function The function of this component is to provide on-line storage for a number of data bases.

Subordinates See Figure 5

Dependencies See Figure 5

References [Ref. 6]

5.4 EFW DB production

The *EFW DB production* covers the production of the EFW CSDS data products. Note, however, that conversion to physical units is made in *DB server*. The EFW DB production comprises essentially the production of the EFW part of the CSDS databases. The data flow diagram for the processing of the CSDS parameters is shown in Figure 6.

5.4.1 Convert EFW-PPD to CDF

Type Process

Purpose To partially fulfil **SR-SDC-46** (CDF format)

Function To convert to the agreed format for data exchange.

Subordinates See Figure 6.

Dependencies See Figure 6.

References [Ref. 6], [Ref. 1]

5.4.2 Convert EFW-SPD to CDF

Type Process

Purpose To partially fulfil **SR-SDC-46** (CDF format)

Function To convert to the agreed format for data exchange.

Subordinates See Figure 6.

Dependencies See Figure 6.

5.4.3 Data reduction

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-11 Produce EFW PP.

SR-SDC-19 Produce EFW SP

Function To perform the actual production of CSDS EFW DB parameters.

Subordinates See Figure 6.

Figure 6: SDC data base production data flow

Dependencies See Figure 6.

5.4.4 Retrieve data

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-101 Reprocessing of EFW DB's shall be possible.

Function To supply calibrated EFW values to the processes responsible for production of CSDS EFW DB's.

Subordinates See Figure 6.

Dependencies See Figure 6.

5.4.5 Validate EFW-PPD

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-13 Provide means to validate EFW PP

SR-SDC-55 Validate EFW PP

SR-SDC-30 Trace software version used.

SR-SDC-31 Trace calibration files used.

Function To make a scientific validation of the produced EFW parameters prior to making them available outside the SDC.

Subordinates See Figure 6.

Dependencies See Figure 6.

Processing Restricted to EFW PI

5.4.6 Validate EFW-SPD

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-13 Provide means to validate EFW SP

SR-SDC-55 Validate EFW SP

SR-SDC-30 Trace software version used.

SR-SDC-31 Trace calibration files used.

Function To make a scientific validation of the produced EFW parameters prior to making them available outside the SDC.

Subordinates See Figure 6.

Dependencies See Figure 6.

Processing Restricted to EFW PI

5.5 (SDC) User Interface

The *User interface* constitutes the primary user entry point to the SDC. It also covers certain access control functions. The data flow diagram for the user interface is shown in Figure 7. It should be distinguised from the *CSDS User Interface* provided the CSDS project.

5.5.1 SDC user shell

Type Process

Purpose To fulfil the following software requirements:

SR-SDC-53 an experimentalist interface

SR-SDC-42 Network access for Scand. users.

Function To constitute a user interface as well as providing access control and identify the users.

Subordinates See Figure 7.

Dependencies See Figure 7.

5.6 CSDS User Interface

The CSDS UI consist of external software. The interfaces to the CSDS UI are described in [Ref. 4].

Figure 7: SDC user interface data flow

6 Feasibility and Resource estimate

Currently available computer resources on the VMS cluster at the Alfvén Laboratory, Department of Plasma Physics are listed below. Only appropriate parts will be allocated to the SDC.

Major components are:

- 1 VAX 6000-610 with 64 MBytes of memory.
- 3 VAXstations 3100 with 16 MBytes of memory each.
- 1 VAXstation 4000/VLC with 16 MBytes of memory.
- 1 DEC 3000 model 400 (AXP) with 160 MBytes of memory.
- 5 VXT 2000+ (X terminal) with 4 MBytes of memory each, booting from an Infoserver 150.
- 1 Infoserver 150.
- Disks with a total capacity of 14 GBytes.
- 5 DAT drives
- 2 CD drives.
- 1 1600/6250 bpi tape station

Also available are an inkjet colour printer and several line printers and laser printers (including a PrintServer 17 connected directly to Ethernet).

We expect to add more disks and some number of CD drives to the system in a near future.

The computers and the Infoserver are connected to a Thin Wire Ethernet. The local network is in its turn connected with optical fibre to NORDUnet and to KTHLAN. A detailed description of the network connections to the SDC is found in [Ref. 6].

The VAXes are currently running OpenVMS V5.5-2. The AXP is running OpenVMS V1.5.

We have a campus site licence, which means we have access to all Digital's software without any extra cost.

7 Traceability matrix

Software requirement	Component
SR-SDC-1 Query DDS cat.	2.2 Health ctrl
SR-SDC-2 Get DDS-file	2.2 Health ctrl
SR-SDC-3 Store DDS-file	3.2 Data base
SR-SDC-4 Local DDS cat.	2.2 Health control
SR-SDC-5 EFW quick look	2.2 Health ctrl
SR-SDC-6 Get ASPOC data	2.2 Health ctrl
SR-SDC-7 Get FGM data	2.2 Health ctrl
SR-SDC-8 Receive RDM	1.1 Reception
SR-SDC-9 Make RDM cat.	1.4 RDM handling
SR-SDC-10 Level 1	
SR-SDC-11 Make EFW PP	4.3 Data reduction
SR-SDC-12 Maintain PP s/w	3.2 Data base
SR-SDC-13 Validate PP	4.5 Validate EFW PP
SR-SDC-14 EFW PPD	6 CSDS UI
SR-SDC-15 Import PPD	6 CSDS UI
SR-SDC-16 Merge PPD	6 CSDS UI
SR-SDC-17 Cluster PPD	3.2 Data base
SR-SDC-18 Make PPD available	3.2 Data base
SR-SDC-19 Make EFW SP	4.3 Data reduction
SR-SDC-20 Maintain SP s/w	3.2 Data base
SR-SDC-21 Validate EFW SP	4.6 Validate EFW SPD
SR-SDC-22 EFW SPD	6 CSDS UI
SR-SDC-23 Import SPD	6 CSDS UI
SR-SDC-24 Merge SPD	6 CSDS UI
SR-SDC-25 Cluster SPD	3.2 Data base
SR-SDC-26 Make SPD available	3.2 Data base
SR-SDC-27 Not used	
SR-SDC-28 Make Cluster SPL available	3.2 Data base

Table 1: Software requirements vs. components (first part)

Software requirement	Component
SR-SDC-29 Keep local DB cat.	3.2 Data base
SR-SDC-30 Trace s/w version	4.5,4.6 Validate EFW param
SR-SDC-31 Trace cal. version	4.5,4.6 Validate EFW param
SR-SDC-32 Maintain EFW cal. files	2.3 Calibration update
SR-SDC-33 Make EFW cal. available	Case by case agreements
SR-SDC-34 Log cal. versions	2.3 Update cal.
SR-SDC-35 Provide NDC with EFW data during initial data phase	
SR-SDC-36 Import data from NDC during initial data phase	
SR-SDC-37 Communicate EFW command sequences	Requirement removed
SR-SDC-38 Make EFW command sequences	Requirement removed
SR-SDC-39 Update and stor EFW command lib	Requirement removed
SR-SDC-40 Maintain EFW comand log file	2.2 EFW health control
SR-SDC-41 Provide JSOC services	
SR-SDC-42 Provide network access to SDC	5.1 SDC user shell
SR-SDC-43 Access control	2.1 Access control
SR-SDC-44 Development schedule	Not applicable
SR-SDC-45 Comply with CSDS	Not applicable
SR-SDC-46 CDF format	4.1 Convert to CDF
SR-SDC-47 Coding languages	See section A.1 Standards
SR-SDC-48 Documents in English	A.2 Documentation
SR-SDC-49 DBMS	6 CSDS UI
SR-SDC-50 CSDS hardware standards	3.1 DB mgr (See also q/a plan)
SR-SDC-51 Location at KTH	
SR-SDC-52 Operators interface	
SR-SDC-53 Experimentalists interface	5.1 SDC user shell
SR-SDC-54 Manpower	Not applicable
SR-SDC-55 Validation of DB	4.5 4.6
SR-SDC-56 SDC-ICD	Not applicable
SR-SDC-57 SDC-URD	Not applicable
SR-SDC-58 SDC-SRD	Not applicable
SR-SDC-101 Re-processing of DB's	4.4 Retrieve data

Table 2: Software requirements vs. components (second part)

References

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[8] H. Lötterle. Cluster DDCS network interface document. Technical Report CL-ESC-ID-0002, European Space Agency, February 1992.

[9] Steve Smith. Data delivery interface document (DDID). Technical Report CL-ESC-ID-0001, Logica Space and Communications Ltd, January 1994. Issue 2.0.

[10] P. A. Vaughan. Interface control document for the JSOC. Technical Report DS-JSO-ID-0001, RAL, July 1993.

[11] Yourdon reference manual. Technical Report AA-PGYOA-TE, Digital Equipment Corporation, August 1992.

A Quality assurance plan

A.1 Standards

The SDC will adhere to standards agreed upon within the CSDS. In particular, all code will be written in FORTRAN or ANSI C languages.

A.2 Documentation

All documents will be written in the English Language.

A.3 Review and audits

There will be no formal reviews or audits in addition to the reviews on CSDS level.

A.4 Software configuration control

The DEC CMS will be used for code configuration control during the development phases. In addition a special version tracking system will be in operation during the operational phase.

B Management plan

The mananagement of the SDC development is described in the project plan for EFW data analysis software development. The text of this section is basically an excerpt from that document.

B.1 Project principals and governing group

Resources for the project (manpower, funding for hardware and software procurement, travel funds) have to be allocated within the participating scientific groups by a number of institute heads or group heads and/or holders of research contracts with various funding agencies. By definition, the project then has several Principals (the function, unit or person which pays for the project).

The Project Manager thus must have as his superior a Governing Group (as a body) comprising the EFW PI and the Principals (group heads and/or contract holders). The project may presumably be carried out without formal meetings of this group. The governing group should:

- Assign the Project Manager
- Decide on start of the project
- Approve the project plan
- Evaluate the progress of the project
- Decide on termination of the project

In conflicting matters, or in other matters concerning the governing group, the project manager will approach the EFW PI.

The Governing group thus consist of:

- the EFW PI
- a representative for IRF-U[1]
- a representative for KTH, plasmafysik
- a representative for UiO
- a representative for Oulu

B.2 Advisory group

The EFW team (PI and CoI:s) will constitute an Advisory group that may be consulted by the project manager for advice on project objectives, review of the project plan and alterations thereof, etc. Normally, progress will be reported and advice will be sought at regular EFW science and technical team meetings.

B.3 Project Manager

The main responsibility of the project manager is to plan and control the execution of the project within the limits of the project such that the Project Objectives are achieved. If the limits of the project have been or are expected to be exceeded, the Project Manager must notify the Governing Group through the EFW PI.

[1] At present, the EFW PI also represents IRF-U

Function	Inst.	Name
SDC Manager	IRF-U	Gunnar Holmgren
Technical Manager	KTH	Bengt Harald Nilsson
SDC scientist	KTH	Per-Arne Lindqvist

Table 3: SDC Project Group

B.4 Project Organisation Structure

The overall responsibility for the project lies with the project manager. He is guided by a project scientist and a technical manager. He is reporting to the EFW PI (as representative of the governing group). Some technical design and integration responsibilities are delegated to a technical manager. The present manning of the project functions is shown in Table 3.

C Alternatives to using networks

It is foreseen to use networks for all data transport within the CSDS, except for the RDM. In particular, the SDC will have network interfaces to ESOC, JSOC, EFW PI, EFW CoI's, the Scandinavian user community, and all the other NDC's. In most of these cases, there is no realistic alternative to using the networks. For example, access to the DDS file at ESOC must necessarily be over the network to minimize time delays. The only case where an alternative to the network might be possible is for the shipment of the CSDS products between the NDC's, and this case is discussed further below.

It is foreseen to use the networks to ship the Summary Parameters and Prime Parameters between the data centres. The volume of these data would be the following.

From SDC to each of the other 6 data centers:

- 10 parameters, both in SPDB and PPDB
- 4 bytes/value
- SPDB: 1 value/minute
- PPDB: 4 values/4 seconds = 60 values/minute

Assuming 50 % duty cycle of Cluster data taking, this is

$$0.5 \times 6 \times 10 \times 4 \times (1 + 60) \times 60 \times 24 = 10.5 \text{ Mbytes/day} = 7.7 \text{ Gbytes/2 years}$$

With a network capacity of 64 kbits/s, and 50 % efficiency, these data may be transferred in

$$10.5 \times 10^6 \times 8/64 \times 10^3/0.5 = 2635 \text{ seconds/day} = 44 \text{ minutes/day}$$

.

To SDC from each of the other data centres:

	SPDB	PPDB	
UKDC	22	24	parameters
CFC	35	43	parameters
GDC	19	19	parameters
ADC	4	4	parameters
USDC	4	4	parameters
HDC	32	3	parameters
Total	116	97	parameters

This is a total of

$$0.5 \times 4 \times (116 + 97 \times 60) \times 60 \times 24 = 17.1 \text{ Mbytes/day} = 12.5 \text{ Gbytes/2 years}$$

With the same network capacity, the transfer time is

$$17.1 \times 10^6 \times 8/64 \times 10^3/0.5 = 4274 \text{ seconds/day} = 71 \text{ minutes/day}$$

The total data volume to be transferred is 27.6 Mbytes/day = 20.2 Gbytes/2 years, with a network transfer time of 115 minutes/day.

It is necessary that the network really have this capacity to enable the efficient transfer of the data. If the network is not available, an alternative solution would be to ship data with DAT tapes. Over the network, the data transfer would probably take place once per day. To ship one tape per day would be desirable to keep the delay in the data base production to a minimum, but this would be prohibitively expensive. In the example below, it is assumed that the tapes are shipped once per week.

The cost for the DAT tape shipping is mainly the cost of postage and of handling the tapes. In addition, hardware and a certain number of DAT tapes should be purchased initially. The tapes should, of course, be re-used, but there is a limit to the number of times a DAT tape may be written. Here we assume that this limit is 20 times.

In the calculations below, only the cost for the *sending* of tapes is calculated. Similar calculations should hold for the other data centres to send tapes also. The cost of operator time includes also receiving and handling the incoming tapes, and is probably an underestimate.

Total number of shipments: 104 weeks $\times$ 6 data centres = 624 shipments.
Number of tapes needed:

$$624 \text{ shipments}/20 \text{ tape re-uses} = 32 \text{ tapes}$$

Hardware costs:	
1 DAT tape drive	20000 SEK
32 DAT tapes	3200 SEK
Running costs:	
Postage 624 * 50 SEK	31200 SEK
Packing material 624 * 10 SEK	6240 SEK
Operator time 624 * 1 hour * 200 SEK	124800 SEK
Total cost	185440 SEK

It is seen that the cost of an alternative solution to using network transfer of data is very high. In addition, the quality of service is reduced significantly, since the collection of one week's worth of data for each tape and the time before other data centres receive the tape introduce significant delays in the system.

D Acronyms

Acronym	Meaning
ADC	Austrian Data Centre
ADR	Architectural Design Review
ASPOC	Active Spacecraft Potential Control
C	A programming language
CDDS	Cluster Data Disposition System
CDDS file	New notation for SHF
CDF	Common Data Format
CD-ROM	Compact Disc Read Only Memory
CEDAS	Cluster EFW Data Analysis System
CFC	Centre Français Cluster
CoI	Co-investigator
CSDS	Cluster Science Data System
DAT	Digital Audio Tape
DB	Data Base
DC	Data Centre
DDS	Data Disposition System
DEC	Digital Equipment Corporation
EFW	Electric Field and Wave Experiment
ESA	European Space Agency
ESANET	European Space Agency Network
ESIS	European Space Information System
ESOC	European Space Operations Centre
ESTEC	European Space Technology Centre
FGM	Flux Gate Magnetometer
FORTRAN	FORmula TRANslator
GCDC	German Cluster Data Centre
GDC	German Data Centre
HDC	Hungarian Data Centre
IRF-U	Institutet för Rymdfysik, Uppsalaavdelningen Swedish Inst. of Space Phys., Uppsala Division
ISDAT	Interactive Science Data Analysis Tool
JSOC	Joint Science Operations Centre
KTH	Kungliga Tekniska Högskolan Royal Institute of Technology
NDC	National Data Centre
Oulu	University of Oulu
PI	Principal Investigator
PP	Prime Parameter
PPDB	Prime Parameter Data Base
RDM	Raw Data Medium
RFA	Request for Action
SDC	Scandinavian Data Centre
SP	Summary Parameter
SPDB	Summary Parameter Data Base
SPL	Summary Plot
SR	Software Requirement
SWT	Science Working Team
TBD	To be defined
UiO	Universitetet i Oslo University of Oslo
UKDC	United Kingdom Data Centre
Unix	Operating system
UR	User Requirement
USDC	United States Data Centre
VAX	A Computer architecture
VMS	Operating system
WBD	Wide Band Data
WEC	Wave Experiment Consortium
WHISPER	Waves of High Frequency and Sounder for Probing of the Electron Density by Relaxation

Table 4: Acronyms