Concurrent Design Facility
System Requirements Document

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</tbody>
</table>
# Table of Contents

1 INTRODUCTION ................................................................................................................................................... 4  
   APPLICABILITY ............................................................................................................................................... 4  
   1.2 PURPOSE.................................................................................................................................................. 4  
   1.3 SCOPE.................................................................................................................................................... 4  
   1.4 DEFINITION OF TERMS........................................................................................................................... 4  
2 GENERAL SYSTEM REQUIREMENTS ............................................................................................................ 5  
3 HARDWARE REQUIREMENTS ........................................................................................................................ 5  
   3.1 FACILITY LAYOUT ................................................................................................................................. 5  
   3.2 COMPUTER HARDWARE ....................................................................................................................... 6  
4 SOFTWARE REQUIREMENTS ......................................................................................................................... 8  
   4.1 OVERALL OPERATING SYSTEM ............................................................................................................ 8  
      4.1.1 The Core System Model ................................................................................................................. 8  
      4.1.2 Training And Support .................................................................................................................... 9  
      4.1.3 Workbooks Layout ....................................................................................................................... 9  
      4.1.4 External Input Data ...................................................................................................................... 10  
      4.1.5 External Tools ............................................................................................................................. 10  
      4.1.6 Workbook Integration ................................................................................................................. 12  
      4.1.7 Administration ............................................................................................................................ 12  
      4.1.8 Recording Of Session Discussions ............................................................................................ 12  
      4.1.9 Documentation software ............................................................................................................ 13  
5 OPERATIONAL REQUIREMENTS .......................................................................................................... 14  
6 DOCUMENTATION REQUIREMENTS ........................................................................................................ 16  
7 ACRONYMS .................................................................................................................................................. 17
1 INTRODUCTION

1.1 Applicability

The document contains an evolving list of requirements commencing with the original experimental facility requirements. It is intended to record a set of complete requirements for future development of the CDF.

Currently it contains the requirements gathered from the lessons learned from the first studies completed in the facility. This includes suggestions from the team members that took part in these studies. These ideas are spread across various aspects of the CDF.

Further evolution will incorporate those new requirements agreed by the CDF Configuration Control [1].

1.2 Purpose

This document contains the System requirements for the development of the ESTEC Concurrent Design Facility (CDF). The CDF is a continuing development and the system requirements document structure reflects this aspect.

1.3 Scope

The document records the top-level requirements for the evolving development of the ESTEC Concurrent Design Facility (CDF). The system concept is described briefly and then the hardware, software, operational, documentation and administrative requirements are defined. The rationale for these requirements has been described in reference [2].

1.4 Definition of Terms

The use of the word facility or CDF in this document refers to the entire internal working environment, including the team, hardware and software within the facility.

1.5 References

[1]. CDF Configuration Management, CDF-ADM-02
[2]. YGT Report, CDF-YGT-001, 3/00
2 GENERAL SYSTEM REQUIREMENTS

The top-level requirements on the facility come from two major sources:
- The philosophy behind the design approach.
- The interaction with external entities that place demands on the facility.

The philosophy should be a result of the demands placed on the facility, but in practice it is necessary to separate them. The concurrent design and management approach can lead to requirements being placed on external entities and visa-versa.

1 The ESTEC Concurrent Design Facility shall be a design centre capable of producing system designs at varying levels of detail at a high rate of turn over and to a high standard of work.
2 It shall achieve this using a concurrent engineering approach and the expertise of its personnel.
3 A study room(s) will be used to complete the work and to aid communication between team members, the customer and other experts.
4 The study room(s) will contain all the relevant tools needed to complete the work including hardware and software.
5 A team of engineers and scientists shall be assembled to complete the design work, and will meet in a study room at various intervals through a given study to work concurrently.
6 A system model will be developed for each project based on the software available within the facility and limited use of external specialist software.
7 The facility will be able to produce various system models for different space systems, including Earth orbiting satellites, exploration spacecraft, planetary probes and rovers.
8 The studies worked on in the CDF will be at varying levels of detail depending on customer requirements.
9 The CDF shall adhere to the General Concurrent Engineering Philosophy defined as follows:

   Development of an engineering design team covering all relevant disciplines from the kick-off; working and communicating in a single environment; to establish a system(s) design; within a short period of time; and in a more consistent way; with respect to other approaches.

10 The internal organisation will be developed around the concurrent engineering approach.

3 HARDWARE REQUIREMENTS

3.1 Facility Layout

The facility architecture covers the environment in which the CDF operates.
A focal point shall be created within the CDF Session room to direct discussions and allow presentations to take place. During Sessions this will be the ‘focal point’ for discussions, presentations, and group design work.

Two projector screens shall be placed at the focal point of the Session room to allow the presentation of data. The screens shall be viewable by all Team and customer positions during a Session.

The positions of the computers for each domain will be set out taking into account the frequency of communication between disciplines. Related disciplines shall be placed close together to ease communications.

The CAD system operational controls shall be placed close to the projected display to allow fast and easy control of the display while presenting to the group.

The rooms in which the Sessions take place shall be large enough to adequately cope with Entire Team (at least 20), the Customer (at least 3) and other guests (at least 5). They shall be given adequate room to sit (including a chair) and work.

The CDF shall be set-up to allow several discussions to take place at the same time, without the disturbance to one another. However, all groups shall be quickly gathered together when necessary.

The Team shall be provided with adequate conditions to work individually at any point in time (including Sessions) and for over both short (minutes) and long (weeks) periods of time. These working areas will be quiet (enough to think clearly) and not cramped.

The facility rooms shall have false floors to allow cabling to be hidden under it and re-routed quickly.

### 3.2 Computer Hardware

The facility will contain enough PCs/workstations to allow the Team to work together in the facility at the same time.

PC/Workstations shall installed for the following areas:

- **Systems**
- **Power**
- **Telecommunications**
- **Ground Systems and Operations**
- **Data Handling (DHS)**
- **Attitude and Orbit Control (AOCS)**
- **CDF Manager**
- **Customer**
- **Documentation**
- **Mission Analysis**
- **Instruments**
- **Structure and Configuration**
- **Thermal**
- **Propulsion**
- **Mechanisms**
- **Administration**
- **Cost**
- **Risk**
Note: other disciplines may be added or replace the above disciplines according to the study needs and a related workbook and data sources installed.

21 A minimum of 4 general-purpose machines shall also be required for the use of other personnel involved in a project.

22 (Silicon Graphics) Computers/workstations shall be available to run specialised tools.

23 The following machines shall be installed:
   - CAD Station
   - Simulation Station

24 The following machines will also be present:
   - Thermal Analysis Station
   - Structural Analysis Station

25 The CDF shall have an independent network to stop external network problems affecting the facility.

26 The CDF network shall be supported by appropriate personnel.

27 A fast A4 black and white laser printer shall be installed. It shall include a large enough buffer memory to cope with large word documents.

28 A4 colour LaserJet printers shall be installed. It shall include a large enough buffer memory to cope with large word documents.

29 An A0 Plotter will be installed, capable of reproducing high resolution, 3D CAD images.

30 Video switching shall be installed to allow fast switching of (at least) key computers for the projection system. These key computers include CATIA and EUROSIM Unix workstations, as well as at least two PCs (including Systems PC). The goal is to have every computer linked to the projection units.

31 Hardware shall be installed to allow display creation, and control of the ‘flip-chart’ software.

32 The facility will have the capability to create small physical models of the space systems under development. These models will be easily modified during Sessions to aid discussions.

33 Computer hardware shall be available to create back-ups of all files that can be stored externally form the facility.

34 A CD writing machine will be installed in the facility.

35 A Colour A3 Scanner shall be installed to allow the electronic storage of all graphics and documents.
4 SOFTWARE REQUIREMENTS

4.1 Overall Operating System

36 The file management and interface will be constructed so that the user can be guided to files with the minimum effort.
37 The software will prevent any incorrect saving, deleting, overwriting and moving of files.
38 A CDF user interface shall be provided.

4.1.1 The Core System Model

39 The Core System Model shall be based on Microsoft Excel97.
   This software is used throughout industry, as well as being installed as standard on most PCs. It provides the most flexible tool for simple calculations, and is supported by Visual Basic for more complex tasks. MS Excel also has good presentation capabilities, and is integrated with Microsoft’s other Office tools (such as Word, PowerPoint and Access).
40 The Core System Model shall be separated into domain workbooks to allow specialists to work of their specific part of the Model concurrently. These workbooks shall be linked together to form an integrated model.
41 A central workbook (the Data Exchange) shall be used, which all data flow between workbooks shall pass through.
42 Domain workbooks shall not pass design data electronically without passing it through the Data Exchange workbook.
43 The configuration management of the Model shall be analysed and implemented in a clear and uniform manner.
44 The System Design shall be included in the configuration management.
45 The Equipment List will be stored in the Data Exchange as a reference for the Team and use within domain workbooks.
46 The Equipment List shall be controlled within the Systems workbook.
47 The model must be able to cope with several (at least 5) integrated space systems being developed at the same time.
48 The Model shall allow both separated and integrated output from the systems.
49 The model shall produce several different types of output.
   Some outputs are required to generate other results within the model and to assess the current state of the system(s) design. Others are required as results of the study itself for the customer.
4.1.2 Training And Support

50 User guides shall be produced for all Excel workbooks of the model, allowing new users to understand how to use it and why it has been set-up in such a way.

51 The user guide shall provide sufficient information to enable new users to develop the workbooks for required study and discipline specific tasks.

52 The User Guide(s) explain all the MS Excel facilities useful to model workbooks. It should explain how they are used, and what they can be used for. This could be known as a reference of model implementation methods.

53 Support in the use of MS Excel® and Visual Basic® shall be available to help discipline specialists to develop their models, through training and/or direct modification of workbooks.

54 Support shall be provided to the System Model Administrator for the maintenance and development of the entire Model.

55 Support shall be provided to the System Model Administrator for the organisation of all workbooks and links.

4.1.3 Workbooks Layout

56 Each domain workbook shall include a Summary sheet, containing information on the given domain (sub-system), including all relevant (summarised) design information, such as assumptions, design features, mass & power budgets. This sheet shall be given a uniform format across the entire model.

57 The style format of every workbook must be standardised throughout the model.

58 Worksheet layouts (especially common sheets) must be the same including fonts, layouts and margins.

59 Every sub-system workbook shall include a sheet containing a block diagram of the design of the sub-system.

60 The sheet containing the block diagram will include any other diagrams useful for communicating design information.

61 The sheet containing the block diagram shall be uniformly formatted for all workbooks.

62 The Results worksheets of the Model domains shall be formatted so that they can be used in reports, and clearly displayed (projected) within Sessions. This shall also apply to results from other software tools.

4.1.4 External Input Data

63 A comprehensive database of launch vehicle information shall be available within the facility and for use with the Model.

64 Research will be conducted to identify existing databases of information that could be used to enhance study tasks using the CDF.
Assessment of input information sources will be made to identify how their use is best implemented in the CDF.

4.1.5 External Tools

A suitable CAD tool, such as CATIA® shall be implemented within the facility.

The electronic linking of the CAD tool (CATIA®) and Excel® shall be analysed and developed.

The use and integration of more complex tools with the core model, including those already being used within ESA, shall be investigated.

The use of the Satellite Tool Kit (STK) as part of the Model will be assessed, especially in relation to its use for mission planning.

4.1.6 Workbook Integration

The format of Cell Names within the Output sheets of Domain workbooks shall be formalised and made uniform throughout the model.

The format of cell names shall allow fast creation of references within Input sheets.

The format of Cell Names shall be documented in the respective User Guides as a reference for the Team in case new outputs are required.

The updating of Data Exchange workbook shall be kept simple, and run smoothly and quickly. It shall be kept controllable, allowing selection of different workbooks to be updated.

When opening workbooks to update the Data Exchange, the process shall not allow calculations within domain workbooks to be updated that can automatically change output values.

The source (domain workbook) of each set of output parameters shall be defined, and any overlaps removed, i.e. output parameters shall only be produced in one place.

The structure of the output parameters of domain workbooks shall be formalised throughout the Model.

Parameter links between workbooks shall be set out in a centrally controlled way.

All workbook parameters will be uniformly defined.

The flow of information, which cannot be passed through the Data Exchange, shall be analysed to see if it needs to be transferred, and how it can be transferred.

The flow of information process that is not passed through the Data Exchange shall be formalised and recorded in the model.

Each workbook of the Model shall be cleared of any obsolete links (references), either between sheets, or to other files (workbooks) at the beginning of a new study.
82 The method for the “set-up” of the workbooks for a new study shall be recorded in the CDF User Guide.

<table>
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<tr>
<th>The use of “units” (items, equipment) for data exchange shall be defined, taking into account the needs of the various specialists.</th>
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<tr>
<td>The use of Design Margins throughout the Model shall be standardised and documented.</td>
</tr>
<tr>
<td>The design margins shall consider design maturity, and calculation uncertainties.</td>
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<tr>
<td>Design margins shall be clearly visible within the Model.</td>
</tr>
<tr>
<td>Standard maturity level margins can be applied to each sub-system, and then (when defined) each piece of equipment. This standard has three levels:</td>
</tr>
<tr>
<td>5% - System is developed (off-the-shelf)</td>
</tr>
<tr>
<td>10% - System requires modification</td>
</tr>
<tr>
<td>20% - System requires development</td>
</tr>
<tr>
<td>Other margins can be added where the uncertainties lie with calculations, and can be added to either the input or output of a calculation. These should be clearly highlighted in the domain models. To make the margins clearly visible they could be added to the Data Exchange and summarised for analysis.</td>
</tr>
<tr>
<td>Mission information shall be available within the model which can be modified within a session, or at least within a working day. This information shall include all parameters required by other domains to complete their work.</td>
</tr>
<tr>
<td>The Model shall be capable of recording changes in the iterative design, and will allow the team to step back to earlier iterations.</td>
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There are a number of ways to find references for removal:

- The *Links...* window - This is found in the *Edit* menu, and shows all the external files referenced by the workbook. This can be used to identify what links have to be removed. It can also be used to change the source of references, and to check that the directory path points to the correct files.

- The *Auditing* menu - This can be called up and used to identify references with a workbook.

The *Define Cell Names* window - This is found in the *Insert* menu under *Names...Define*. All Cell Names present in the workbook are shown, selecting them brings up the source of the name, which can include external files. Obsolete Names can be removed here.
4.1.7 Administration

91 The use of MS Excel® (the Model workbooks) during presentations, as well as MS PowerPoint®, shall be used.

92 Where practical, the MSExcel® Model shall be used directly to produce reports and other documentation.

93 All ‘key words’, abbreviations and acronyms shall be documented and standardised.

94 Methods for flagging errors and misalignment in data shall be investigated as part of the evolving CDF design during studies, and practically implemented into the Model.

95 A database that contains information on past design solutions will be developed, including search engine to find required information.

96 Limits will be set on the expansion of the core model according to the demands of the study being conducted in the CDF, and definitions on the level of detail required from each domain will be created.

97 It will be possible to visualise (simulate) the mission within the sessions as early as possible in the study. Specifically needed for developing the mission characteristics.

98 The use of the Risk specialist and model shall be developed so that risk data can be produced quickly.

99 During CDF studies identify and record where the Risk specialist could be used more effectively for design assessment for continuing evolution of the CDF capability.

100 Implement a “lessons learned” record for continual use during CDF studies by all Team members.

101 The use of Radiation and EMC data when developing the design shall be implemented. This data will be used at an early stage to reduce the chance of under-designing (or over-designing) certain systems.

102 File protection shall be used throughout the model to stop unauthorised changes taking place. This protection shall be uniformly used throughout the Model.

4.1.8 Recording Of Session Discussions

103 The flow of the discussion with Design Sessions will be recorded along with the minutes. This will be at a high level, indicating the topics of discussion rather than specific information. This will be used to gather understanding about the design process, and to allow all discussion topics to be concluded successfully.

104 Any actions given during a session shall be prioritised so that those that could halt the design process are given top priority.

105 A software tool(s) shall be selected and installed to allow information to be created, presented and stored electronically within a single Session.

106 The software tool for session information records shall allow the use of both graphics and text.
107 The software tool for session information will allow the production of 3D graphics in real-time during a Session.

4.1.9 Documentation software

108 A software tool shall be available to produce CD covers, which can include graphics.
109 The storage of data within a CD shall be clear and easy to use, with a simple to understand file structure.
110 Software to help users navigate the information within a CD will also be added.
5 OPERATIONAL REQUIREMENTS

Operations using the CDF are derived for planning, session conduct and team structure and responsibilities.

111 Time shall be allowed for training the Team and Customer to work in the CDF environment, including dealing with Sessions and use of the Model prior to each study period.

112 A schedule shall be produced for each project, indicating times and dates of Sessions and milestones of the study. **A Gantt chart will be produced for this purpose.**

113 A high level plan for the design process shall be produced, outlining the ideal progression of the design process. This will include a timeline of, domain definition and areas of discussion.

114 The facility shall be made available for training to increase participant’s knowledge of space systems engineering, ESA practices, and concurrent design.

115 The CDF shall be capable of conducting meetings with people in external both visual and audible.

116 Meetings involving the whole Team during Sessions, and with several (at least 2) external sites at the same time shall be possible visually and audibly.

117 A method of verifying that everyone has understood everything in the same way in a session shall be developed and implemented.

118 All results of meetings held outside of the main Sessions shall be recorded and presented/communicated to the entire Team and Customer.

119 The Model shall be used extensively within Sessions to present information and produce real-time results.

120 Time and facilities shall be made available for individuals to have off-line contact with one another, either one-on-one or in small groups.

121 The Model shall have at least one Model Manager (System Analyst), who is in overall charge of the maintenance and development of the Model.

122 An expert (CDF Administrator) in the use of MS Excel® and Visual Basic® will be made available to the Team to help them improve their models during each study.

123 An expert (CDF Administrator) will be available to the Model Manager (System Analyst) to help solve overall system level problems.

124 A member of the CDF Team will be responsible for planning the future of the CDF including the following tasks, schedule future projects and sessions and plan the overall development of the facility.

125 A flexible manning system shall be developed in co-operation with the ESTEC departments that supply staff to make up the CDF Team.

126 During the development of the CDF assessment shall be made of the impact of short-term availability on the departments and the CDF.
127 Each position within the Team shall be given a replacement person (specialist) or “position second” who will stand in when the normal team member is not available.

128 The “position second” shall be trained to work in the facility, and will be kept up-to-date with developments in the mission design under study.

129 A specialist shall represent every domain during every Design Session. If a Team member is not available, a temporary replacement shall be found.

130 The Team will be given guidelines as to their role within the CDF and the study under design. Specific guidelines will be given to each specialist, as well as general instructions for the whole Team.

131 The Systems positions within the Team shall be analysed to see what is exactly needed from each individual.

132 When the Systems position function is established for a particular study a job description shall be produced, and the rest of the Team informed.

133 The scheduling of Sessions shall be assessed, taking into account the availability of staff, and time needed in-between Sessions to completed adequate work.

134 The session Team Lead shall not allow the discussion to wonder too far from the objectives of that session. Discussions that move away from the objective will be concluded and recorded for discussion at a later time at the discretion of the Team Lead.

135 Method(s) shall be found to reduce the effect of dominant personalities on the direction of the design.

136 All Team members shall have an influence on the design relative to the technical issues and not personality.

137 All relevant information noted by the Team during a session shall be transferred to an electronic format, either in the Model or accompanying electronic documents.

138 At the end of each a study an archive shall be stored (and a CD shall be cut) containing all the important electronically stored data for that study. This shall include as a minimum reports and the model and the session minutes.
6 DOCUMENTATION REQUIREMENTS

The CDF documentation includes system requirements and descriptions and User Guides for the facility and outputs from the study sessions conducted in the CDF, the session minutes and support documents and study reports.

139 The rationale/philosophy behind the facility and facility description shall be documented in a System Description document.

140 An identifier/logo will be developed for the CDF, and used throughout the facility, Model, and documents.

141 Guidelines will be developed indicating how the sessions are conducted and Team and Customer interactions and responsibilities.

142 The facility documentation shall be made flexible enough for revision as the CDF develops.

143 A User Guide document will be produced for each individual element of the model, including domain workbooks and other software tools.

144 The User Guides will be used to train members of the Team.

145 A uniform format shall be adopted for the User Guides with flexibility consistent with domain specific content.

146 The method of producing minutes of Sessions/meetings shall be made as efficient as possible.
ACRONYMS

ACS  Attitude (and Orbit) Control System
ADM  Administration
AIV  Assembly, Integration and Verification
CDF  Concurrent Design Facility
CST  Cost
DHS  Data Handling System
EPS  Electrical Power System
ESA  European Space Agency
ESTEC  European Space Technical and Engineering Centre
GOS  Ground Operations System
IDM  Integrated Design Model
INS  Instruments/Payload
ISM  Integrated System Model
MEC  Mechanisms
MIS  Mission (Analysis)
MMS  Matra Marconi Space
PR  Procedure
PRC  Procedure
PRO  Propulsion
PYR  Pyrotechnics
REV  Revision
RIS  Risk (Assessment)
SIM  Simulations
STR  Structure (System)
SYS  System
TCS  Thermal Control System
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