Consortium Members

ESA Sea level CCI

D3.1 - Phase 2 System Specification Document (SSD) Version 1.1

Chronology Issues:			
Issue:	Date:	Reason for change:	Author
1.0	02/08/12	First Issue of SSD v1	E. Pechorro
1.0	26/09/14	First Issue of Phase 2 SSD v1	E. Pechorro & C. Farquhar
1.1	01/05/15	First update of Phase 2 SSD	C. Farquhar

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Application authorized by (*):	ESA	Date + Initial:(visa ou ref)

In the opposite box: Last and First name of the person

Index Sheet:	
Context:	Baghera tool, project ACT-OCEAN
Keywords:	Oceanography, sea level
Hyperlink:	

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List of tables and figures

List of tables:

List of figures:

List of items to be confirmed or to be defined

Lists of TBC:

No table of contents entries found.

Lists of TBD:

No table of contents entries found.

Applicable documents

AD 1 Sea level CCI project Management Plan
CLS-DOS-NT-10-013

Reference documents

RD 1 System Requirements Document (SRD), Issue 1.3, Reference CLS-DOS-NT-11-080, Nomenclature SLCCI-SRD-012

RD 2 Data Access Requirements Document (DARD), Issue 1.3, Reference CLS-DOS-NT-11-080, Nomenclature SLCCI-SRD-012

RD 3 Preliminary System Analysis Document (PSAD), Issue 1.0, Reference CLS-DOS-NT-10-297, Nomenclature SLCCI-PSAD-006

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RD 26 ISO/IEC 10746 Reference Model of Open Distributed Processing (RM-ODP)

RD 27 The Open Group Architecture Framework (TOGAF) Version 8.1.1 Enterprise Edition Document

RD 28 ESA Climate Change Initiative (CCI) Phase I, Scientific User Consultation and Detailed Specification, Statement of Work, Issue 1.4.

RD 29 ECSS-E-ST-10C, ECSS Standards collection (8th Oct 2010), Space Engineering – System Engineering General Requirements (6th March 2009)

RD 30 Product Specification Document (PSD), Issue 1.1, Reference CLS-DOS-NT-11-015 , Nomenclature SLCCI-PSD-016

RD 31 System Prototype Description (SPD), Issue 1.1, Reference CLS-DOS-NT-11-282, Nomenclature SLCCI-SPD-016

RD 32 System Specification Document (SSD) v0, Issue 1, Reference CLS-DOS-NT-11-159, Nomenclature SLCCI-SSD-013

RD 33 System Specification Document (SSD) v1, Issue 1, Reference CLS-DOS-NT-11-159, Nomenclature SLCCI-SSD-013

RD 34 Output of Engagement with ESA Climate Change Initiative Participants, version 1, CGI Technical Note, Reference CGI-QA4ECV-TN_CGISEWG

RD 35 Phase 2 System Specification Document (SSD) Version 1.0, Reference CLS-DOS-NT-14-176, Nomenclature SLCCI-SSD-013-Phase2-1-0

List of Contents

1. Executive Summary

This document, Phase 2 System Specification Document v1.1, represents a specification of the SLCCI system. We anticipate further activity from our collaborative activities in the CCI System Engineering Working Group (SEWG) may influence another iteration.

This issue is comprised of –

- Identification, reasoning and declaration of appropriate standards for use in SLCCI specification. These standards apply to numerous areas, including System Development, System Modelling, Architectural Description, Product Data Format, Product Visualisation & Access, Cataloguing, and Communications.
- A proposal of System Modelling for SLCCI, and indeed CCI generally, taking the form of a formal extension of UML, definition of a modelling notation, exploration of UML best-practice for adoption, and reasoning towards our identification of a modelling tool.
- A System Overview, including declaration of architectural styles adopted, introduction to functional and deployment architectures, and declaration of a strategy for performing trade-off analysis for the SLCCI system, subsequently realised.
- A specification of SLCCI Viewpoints and Perspectives, traceable to the System Requirements Document, capturing and separating all concerns of SLCCI specification. Our reasoned catalogue of Viewpoints comprises of Functional, Pan-ECV Collaboration, Reuse, Information, Operational, Deployment, and Development viewpoints. Together, our defined Views, associated with these Viewpoints, fully specify the SLCCI system. We offer a complete population of these Views

We place special emphasis on the identification, exploration and exploitation of opportunities for collaboration with other ECV systems, towards realising cost-effectiveness, and sustainability of the SLCCI system beyond the CCI programme. To this end, we –

- Support ESA in their leadership of the System Engineering Working Group, for instance in the setting up and maintenance of a portal, hosting meetings, etc.
- Propose future support to the ESA and the winning consortium in their various activities within the CCI Data Access Portal project including their development of a central data archive, proposed improvements to the CCI websites and contributions to the Obs4MIPs initiative.
- We define a Pan-ECV Collaboration Viewpoint to absorb all concerns related to system collaboration with other ECVs
- We define a CCI Viewpoint catalogue, equally usable by other ECVs, for the capture of all CCI concerns. We plan to distribute this CCI Viewpoint catalogue to the SEWG.
- A formal UML extension is defined, namely CCI UML Profile, for intra-CCI and inter-CCI system modelling, which we plan to distribute to the SEWG. The sharing of such modelling language information with other ECV projects is imperative, considering ECV projects need to be communicating with the same modelling language in their inter-ECV design.
- We define a CCI-common UML notation and iconography, similarly applicable to other CCIs.

2. Terms, Definitions and Abbreviated Terms

Term	Definition
CCI	Climate Change Initiative

Term	Definition
CIS	Central Information System
CMU	Carnegie Mellon University
CRM	Customer Relationship Management
CSW	Catalogue Service
DARD	Data Access Requirements Document
DJF	Design Justification File
DPM	Detailed Processing Model
DSWG	Data Standardisation Working Group
DT	Delayed time
DUACS	Data Unification Altimeter Combination System
ECV product	Essential Climate Variable product. One of the types of product of the Sea Level Climate Change Initiative project.
ESA	European Space Agency
ESGF	Earth System Grid Federation
FCDR	Fundamental Climate Data Record. One of the types of product of the Sea Level Climate Change Initiative project.
FTSS	Fast Track Service Specification
GUI	Graphical User Interface
IODD	Input Output Data Definition
INSPIRE	The Infrastructure for Spatial InfoRmation in Europe
ITIL	IT Infrastructure Library
LRU	Lowest Replaceable Unit (LRU)
LWE	Long Wavelength Error
MFC	Monitoring and Forecast Centre. A type of MyOcean production centre.
MIS	MyOcean Information System
NRT	Near Real Time
Obs4MIPs	Observations for Model Intercomparisons
OE	Orbit Error
OGC	Open Geospatial Consortium
OLA	Operation Level Agreement

Term	Definition
OMG	Object Management Group
OPENDAP	Open-source Project for Network Data Access Protocol
OTS	Off The Shelf
PSD	Product Specification Document
PSS	Procedures, Standards and Specification
PUG	Product User Guide
QA4ECV	Quality Assurance for Essential Climate Variables
QUARG	Quality Assurance Review Group
RAMS	Reliability, Availability, Maintainability and Safety
REP	Reprocessed Time Series
RT	Real Time
SCAMG	System Configuration and Change Management Group
SDD	System Design Document
SEWG	Software Engineering Working Group
SLA	Sea Level Anomaly
SMP	Service Management Plan
SLCCI	Sea Level Climate Change Initiative
SoW	Statement of Work
SPD	System Prototype Description
SPF	Single Point of Failure
SRB	System Requirements Baseline
SRD	System Requirements Document
SSD	System Specification Document
SVR	System Verification Report
TAC	Thematic Assembly Centre (TAC). A type of MyOcean production centre.
TDS	THREDDS Data Server
THREDDS	Thematic Realtime Environmental Data Distributed Service
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptable Power Supply

Term	Definition
URD	User Requirements Document
WMS	Web Map Service

3. Introduction

The System Specification Document (SSD) serves to provide a design of the operational system as requested by the Statement of Work (SoW), and takes as its primary input the System Requirements Document (SRD). It is the aim of the SSD to satisfy the SRD completely, and provide a means of validation of the design to be called on during system development.

According to the SoW, within Phase 1 there were two deliverables associated with the SSD, namely SSD v0 (Deliverable D5.2) [RD32] and SSD v1 (Deliverable D5.3) [RD33], with the SoW indicating the expected content for each. Within Phase 2 there are three iterations of the SSD (Deliverable D3.1) planned to be submitted at regular intervals, at KO+6, KO+15 and KO+24 months. This document is the second of these, namely Deliverable D3.1 v1.1, which provides minor updates to Deliverable D3.1 v1.0 [RD35].

The project successfully completed Phase 1 in February 2014 and is now within Phase 2. Key outcomes of Phase 1 include development of new algorithms for improved altimeter measurements for climate applications, devising of a formal validation protocol, the processing of over 50 years of cumulative altimeter data and the production of an 18 year time series of sea level maps with associated climate indicators.

The primary objectives of Phase 2 will be to further refine the quality of the ECV datasets created in Phase 1 and to provide a more sustainable system of production. This will be achieved by focusing on a number of key developments including refining the user requirements at a climate scale, reducing the errors at some spatial and temporal scales, increasing the length of the time series beyond the 18 years developed in Phase 1 and reducing the gap with present days with extensions and a full reprocessing of the dataset, improving the spatial coverage and reducing errors, particularly within coastal areas and in the Arctic region and by the integrating new altimeter missions.

In addition to the collaboration with other CCI projects, formalised through activities such as the System Engineering Working Group (SEWG), the SLCCI project has engaged with other relevant initiatives. One example is the FP7 Quality Assurance for ECV (QA4ECV) project[1], whose aim is to develop a robust and usable Quality Assurance system for observation data, primarily ECVs. The SLCCI project team, along with five other CCI projects participated in a Software Engineering questionnaire to determine their respective approaches to Quality Assurance and specific methods for error and uncertainty monitoring. These results were collated into a technical note titled '*Output of Engagement with ESA Climate Change Initiative Participants*', which was subsequently distributed to the SEWG and the Data Standards Working Group and is available on the QA4ECV portal[2].

Finally, the SLCCI team acknowledges and welcomes the start of the CCI Data Access Portal project, which is due to begin in May 2015. This ESA project will undertake a series of activities with the aim of facilitating free, open and easy access to ECV data products through the CCI for the international climate user community. Such activities will include:

- Improvements to the design of the CCI programme website and subsequent improvements to the common elements of the individual CCI project websites;
- Development, implementation and operation of a CCI Central Data Archive and Metadata Catalogue

[1] http://www.qa4ecv.eu/

[2] http://www.qa4ecv.eu/publications

- Development, implementation and operations of multiple interfaces to access ECV data and metadata from the CCI Central Data Archive and Metadata Catalogue
- Support to CCI projects to facilitate the contribution of CCI data to the international Obs4MIPs initiative of the CMIP community
- User requirements analysis of a Thematic Exploitation Platform for Climate

The SLCCI team are happy to support the CCI Data Access Portal in these various endeavours.

3.1. Purpose

The System Specification Document (SSD) "incorporates the requirements described in the System Requirements Document and specifies the characteristics of an operational ECV production system from a developer's point of view" [RD28, p52]. The primary objective of the SSD is to specify a design for an operational system satisfying the requirements of the SRD[3].

The SSD is a living document, and it is intended that the document undergo the necessary pressures of review and subsequent revision, during the lifetime of CCI Phase 1, Phase 2 and beyond. Where change takes place in the SRD or other inputs on which the design of the operational system depends, the SSD must be appropriately updated.

3.2. Scope

The scope of the System Specification Document (SSD) is defined by the system boundary as described by the System Requirements Document (SRD). The SRD declares a system requirements baseline based on a scoped SLCCI system. The SRD also draws in "business goals" derived from the Statement of Work (SoW), thus further absorbing information pertaining to the expected scope of an operational system. The SSD also draws in the influence of ongoing activities from other CCI projects, via the System Engineering Working Group (SEWG), wherever possible in order to identify and exploit cost effectiveness. This widens the scope of the SLCCI specification, bringing in other CCI systems wherever viable.

3.3. Document Structure

The SSD v1 comprises of –

- A brief **Executive Summary (§1)** of the SSD.
- A listing of **Abbreviated Terms (§2)** used throughout the document.
- An **Introduction (§3)** to the purpose of the document, plus a description of SLCCI scope, structure, intended audience and assumptions.
- The output of activities to define all appropriate **Standards (§4)** for system specification, covering system development, system modelling, architectural description, product visualisation, algorithm execution, product data format, product cataloguing, communications, and security.

[3] The SRD absorbs the vision of the operational system as expressed in the Statement of Work (SoW), in the form of "business goals". These goals are included in the system requirements baseline described by the SRD. In order to be successful, the System Specification Document (SSD) should satisfy the vision of the operational system as laid out by the SoW.

- A definition of the **System Modelling (§5)** approach used, including the formal definition of a UML profile, definition of adopted UML notation, description of UML good practice adopted, and declaration of the UML tool chosen.
- A **System Overview (§6)** of the specification. Key architectural styles are declared, plus an overview of the functional architecture and deployment architecture. We provide a strategy for trade-off analysis, and observe ECSS content on trade-off analysis. We identify trade-off criteria for consideration, identify themes for trade-off analysis by mining the System Requirements Document (SRD), and arrive at trade-off results.
- The **Architectural Views and Perspectives (§7)** which drive architectural description and separation of concerns are defined. A preliminary description of the SLCCI system is given per view, with our viewpoint portfolio comprising of Functional, Pan-ECV Collaboration, Reuse, Information, Operational, Deployment and Development viewpoints. During viewpoint definition, a view weighting is proposed, allowing apt proportioning of our effort across the Viewpoint spectrum. A set of Perspectives, quality dimension attributes which cross cut the Viewpoints, are similarly defined and explored.
- A **Traceability Mapping (Appendix A)** between SRD v1.3 and this SSD Issue.
- List of **Architectural Scenarios (Appendix B)** used in the construction of the system specification to accompany walkthrough with stakeholders.
- An early **Pan-ECV System Requirements (Appendix C)** baseline for product access & visualisation, proposed by the consortium to the SEWG.

3.4. Intended Audience

As with the System Requirements Document (SRD), the readership of this document is comprised of the SLCCI consortium parties and ESA. There may also be scope as to the use of this document for the Software Engineering Working Group (SEWG), towards finding and forming common ground with other ECV projects as is encouraged by the Statement of Work [SoW].

An advantage to the adoption of Viewpoints (§7) is that our design is described through a formal separation of concerns. As a consequence, each View is relevant and understandable to specific stakeholders. We apply this advantage, introducing a mapping from View to relevant stakeholder(s). Consequently, stakeholder(s) can still absorb all areas of the SSD as they see fit but also, conveniently, may focus on the View most apt to their specific interests.

3.5. Assumptions

This document is based on issue 1.3 of the System Requirements Document (SRD) delivered to ESA in May 2012. In turn, SRD issue 1.3 assumes Task 1 deliverables Data Access Requirements Document (DARD) issue 1.4, Preliminary System Analysis Document (PSAD) issue 1.0, Product Specification Document (PSD) issue 1.1, and User Requirements Document (URD) issue 1.3. This document also assumes Task 3 deliverable System Prototype Description (SPD) issue 1.1.

4. Standards

Before embarking on specification of the SLCCI system, it is pertinent to establish the standards to be adopted, and so attain all the advantages associated with adoption of appropriate standards. The standards we adopt fall into the following identified categories -

- System Development
- Architectural Description
- Visualisation
- Algorithm Execution
- Data Formatting
- Cataloguing
- Communications
- Security

We attend to each of these categories in detail.

4.1. System Development

ECSS standards are the ESA associated standards for the system engineering of space systems, replacing the formerly used PSS standards. The ECSS standards documents are arranged into disciplines pertaining to their broad purpose, either management (M), product assurance (Q), or engineering (E). As advised by the ECSS, usage of ECSS standards may either be via strict observance of the relevant ECSS standard in view of all ECSS documentary context, or rather tailored to the specific needs of the project in hand.

We observe ECSS standards wherever appropriate, given their maturity in the Space domain and ESA, and their likely observance on other ECV projects. As has been the case with the SRD, we adopt and tailor to our specific needs pertinent and appropriate ECSS standards (15_120). We aim to use ECSS standards to inform the SSD in the following manner –

- *System Reuse* - ECSS-Q-ST-80C (Space Product Assurance) §6.2.7 – This ECSS area describes good practice in the reuse of existing systems. The System Requirements Document (SRD) absorbed ECSS advice on reuse into the system requirements baseline, and these are therefore revisited in the System Specification Document (SSD).
- *Trade-off Analysis* - ECSS-E-ST-10C (System Engineering General Requirements), ECSS-E-ST-10-06C (Technical Requirements Specification – These are observed towards our development of a trade-off strategy (§6.4).

4.2. System Modelling

A number of commonly used system modelling languages are available for the practice of systems engineering, each with its own advantages and disadvantages. We must trade-off across the available languages, in order to reason towards our chosen language.

Our criteria for the choosing of a communicative paradigm for our SLCCI system modelling are as follows –

- The language must be sufficiently expressive to communicate the structure and semantics of an SLCCI system, at various levels of granularity, and allow traceability between such levels
- The language must be able to express the behaviour of the SLCCI system, again at various levels of granularity.
- The language must be formal or quasi-formal, therefore sufficiently avoiding ambiguity through informality
- The language should be associated with an intuitive iconography, such that all stakeholders, not just those with a technical background, should be able to easily interpret the diagrams. Yet, the diagrammatic notation should be sufficiently expressive to formally communicate all structural and behavioural characteristics of the system.
- We wish to use a modelling tool with useful associated diagrams, rather than a pure diagramming tool with no understanding of the language's underlying grammar.
- The language needs to be mappable from the SLCCI design view (CCI Phase I), to an implementation view (CCI Phase II), in order to facilitate realisation of the SLCCI specification by the SLCCI implementers.
- The language needs to be formally extendable, in order to allow extension of the language tailored to the SLCCI system, or CCI in general, so accentuating the language's communicative strength
- The language needs to be widely used and mature, so providing us the benefit of recognised industry good practice of the language.

Given the above evaluation criteria for the choosing of a modelling language for SLCCI, we recognise the following candidate languages –

- *UML* – A widely used modelling language standard, defined and managed by the OMG[4]. The current major version is UML 2.
- *SysML* – This OMG modelling language subsets UML and provides an extension to that subset of UML such as a diagrammatic notation specific to requirements.
- *SoaML* – An OMG modelling language standard geared to the modelling of service oriented architectures.
- *Service-Oriented Modelling Framework (SOMF)* – A non-standardised modelling framework specialised to service oriented architectures.
- Other architectural description languages (ADLs) such as *Wright* (CMU[5]), *ACME* (CMU), and *Darwin* (Imperial[6]).

On analysis, we adopt UML for our system modelling. UML satisfies all of the above evaluation criteria. We also offer the following supplementary reasoning -

- UML is a mature modelling language, more so than SysML. We wish to take advantage of this industry familiarity with the language, to help broaden the readership of the SSD as widely as possible across all stakeholders, especially so given the broad spread of different stakeholder types.
- The portfolio of UML 2 diagram types offers us a greater modelling toolbox than SysML.

[4] The Object Management Group (OMG) is the industry consortium responsible for the creation and maintenance of SysML and UML standards.

[5] Developed at Carnegie Mellon University

[6] Developed at Imperial College, University of London

- UML2 will more easily allow the mapping from design to implementation artefacts, than other modelling languages, including SysML. This will be to the advantage of the Phase II implementers.
- We have no need for using SysML for modelling of requirements, as was similarly the case during the writing of the System Requirements Document (SRD), nor any need for SysML parametric diagrams.

Although UML is the de facto industry standard modelling language, it is quasi-formal[7] and open to misinterpretation unless notation is clearly stated. Chapter 5 defines our usage of UML, describing our notation, and formally extending UML to define a CCI Profile for UML.

4.3. Architectural Description

A number of frameworks for architectural description exist, including the following [8] –

- IEEE 1471, ISO/IEC 42010:2007
- European Space Agency Architecture Framework (ESAAF)
- Generic Enterprise Reference Architecture (ISO 15704)
- Reference Architecture for Space Data Systems (RASDS)
- Reference Model for Open Distributed Processing (RM-ODP, ISO/IEC 10746-1)
- Siemens Four Views (S4V)
- The Open Group Architecture Framework (TOGAF)
- Zachman Framework

We adopt standard IEEE 1471[9] for (i) our architectural description of the SLCCI system, and (ii) architectural description of SLCCI collaboration with other CCI systems, given the following evidence –

- The IEEE 1471 standard represents significant and considerable industry consensus on the description of architectures.
- The IEEE 1471 standard is mature enough to have attained a canon of best practice, which we will observe
- The IEEE 1471 standard appropriately separates the concerns of an architecture, through description of Viewpoints and their realisation as Views, with each Viewpoint and View describing different architectural angles to the system. Advantageously, a Viewpoint can be made available only to relevant stakeholder(s). Similarly, Perspectives define the View crossing influences upon a system, such as quality concerns.
- The IEEE 1471 definition of a Viewpoint catalogue may be tailored to the system at hand. There exists a mature canon of industry catalogues of Viewpoints from which an SLCCI specific Viewpoint catalogue may be derived and defined. The IEEE 1471 standard is scoped broadly enough to draw in knowledge of Viewpoint catalogues from other frameworks, such as RM-ODP.

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[7] This is an advantage of UML, as although it has a formal grammar, its expressiveness is flexible.

[8] A more complete listing is available at http://www.iso-architecture.org/ieee-1471/afs/frameworks-table.html

[9] Throughout this document, we use term “IEEE 1471” to refer to both IEEE 1471:2000 [RD8] and ISO/IEC 42010:2007 [RD9]. Standard IEEE 1471:2000 is identical in text to ISO/IEC 42010:2007.

- The IEEE 1471 standard binds well with UML, and so allows us to model the architectural concerns of the SLCCI system with the modelling language of our choice. This is not so evident in other frameworks, such as TOGAF.
- The IEEE 1471 standard is broadly scoped enough to not tie in to particular architectural approaches and domains. This has consequently led to its more widespread adoption, and subsequent body of good practice.
- The IEEE 1471 standard provides a well-defined, and structured, framework for architectural description, encompassing all relevant concerns of an architectural description.

Figure 1 describes the conceptual model of IEEE 1471, and Figure 2 illustrates how SLCCI artefacts map to IEEE 1471. We adopt the following definitions proposed by IEEE 1471 for the benefit of clarity and consistency, during our development of the SLCCI system.

Of particular note on IEEE 1471 conceptual definitions adopted, we point to the following –

- System – "A collection of components organized to accomplish a specific function or set of functions." [RD8,RD9]
- View – "A representation of a whole system from the perspective of a related set of concerns." [RD8,RD9]
- Viewpoint – "A specification of the conventions for constructing and using a view. A pattern or template from which to develop individual views by establishing the purposes and audience for a view and the techniques for its creation and analysis." [RD8,RD9]

A disadvantage of this IEEE 1471 approach is that effort is required to ensure that the separate views are in sync with each other, as each provides a different aspect of the system. However, this is a disadvantage similarly faced with all architectural description frameworks performing a separation of concerns (as is common practice). We have endeavoured to ensure that our Views have been synced, through validation of our architecture using scenario walkthrough (Appendix B).

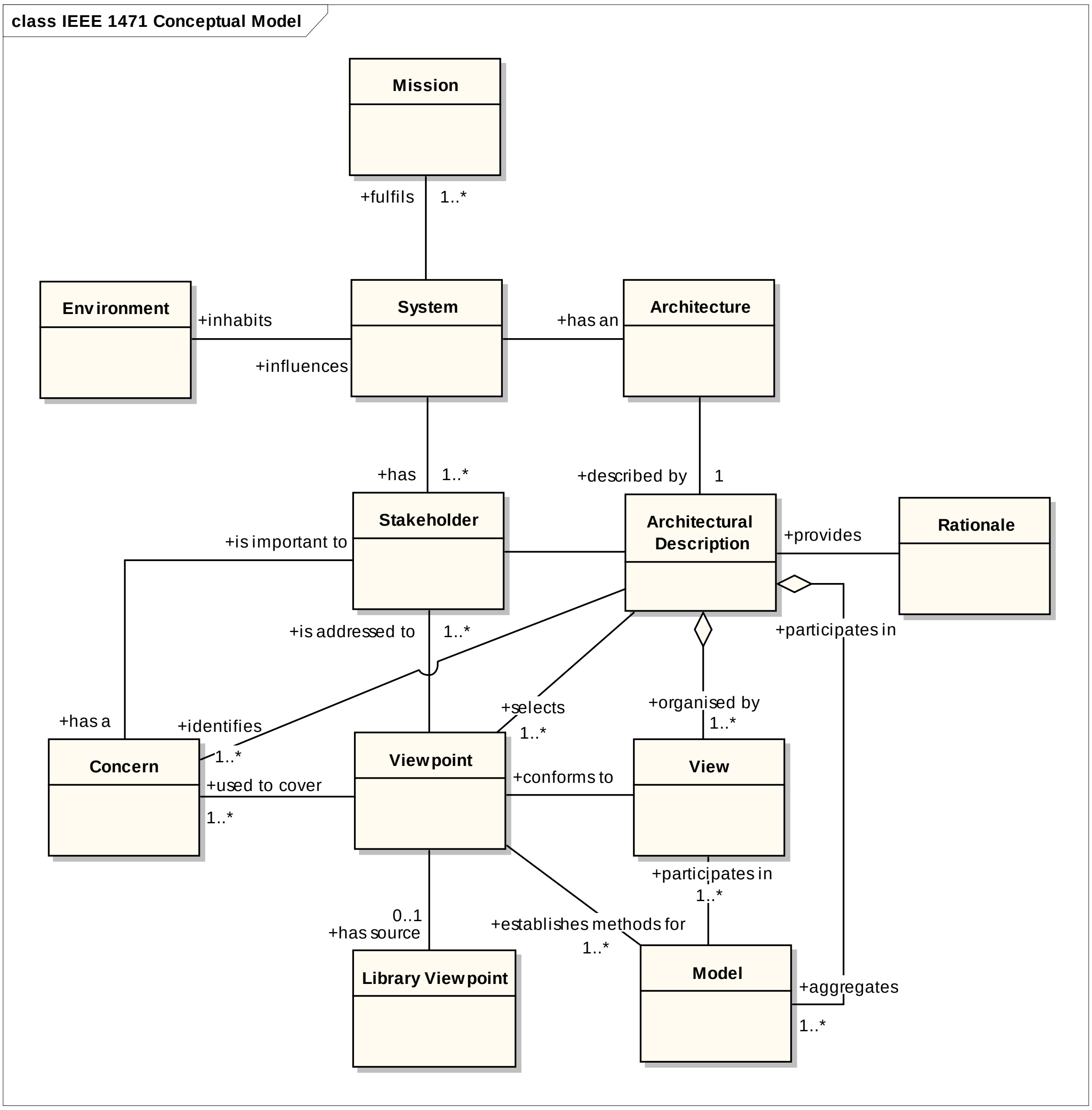

Figure 1 - IEEE 1471 Conceptual Model

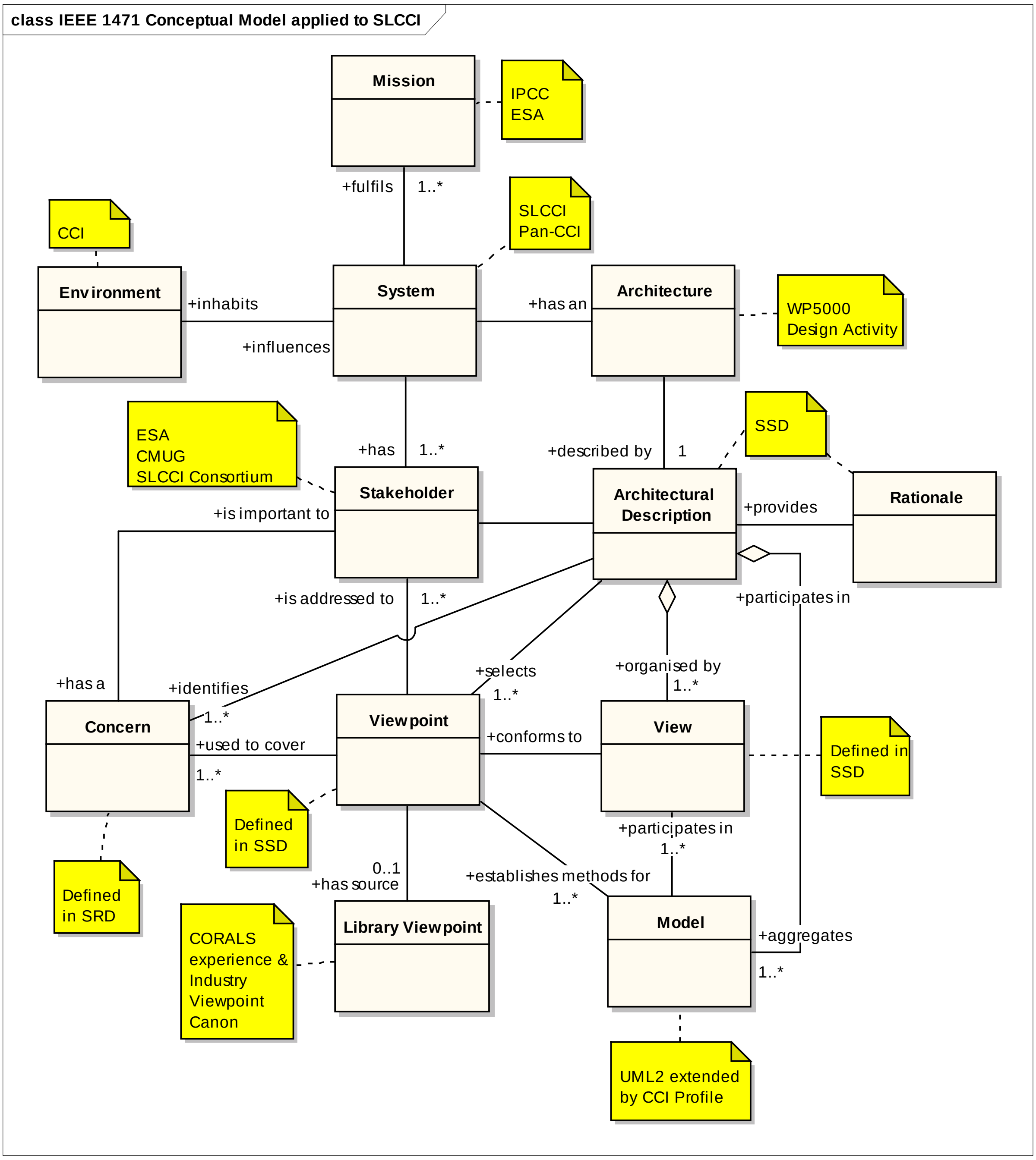

Figure 2 - IEEE 1471 Conceptual Model in Context to SLCCI Architecture

4.4. Algorithm Execution

Effort towards investigating the matter of processing algorithm execution, including possible standardisation, is ongoing. We reserve judgement on the potential for standardised algorithm execution for SLCCI until the collaborative work amongst the ECV projects has reached a higher level of maturity.

4.5. Product Data Formatting

The Product Description Document (PSD) describes the format of the output SLCCI products as being NetCDF. Also, it has been found from the Preliminary System Analysis Documents (PSAD) of other ECV projects that the use of NetCDF is not uncommon. Furthermore, the parties of the CCI Data Standards and Harmonisation Working Group (DSWG) have agreed in principle to use NetCDF across the whole ECV portfolio; those ECV projects which have outputs which are not particularly amenable to the use of NetCDF have agreed in principle to prepare their product such that NetCDF will be adapted to their final product.

4.6. Product Visualisation and Access

The system is required to offer visualisation of output. We propose visualisation of the gridded output of the SLCCI system. We propose access[10], or download, to all products whether gridded or not gridded, which are output by the SLCCI system.

To this end, we adopt THREDDS Data Server (TDS) for both the visualisation and access of the SLCCI ECV product(s); Figure 3 offers an internal illustration of THREDDS. Our reasoning towards adoption of THREDDS for SLCCI product visualisation and access is as follows –

- THREDDS middleware recognises a broad spectrum of data product format, including NetCDF and HDF5, amongst others. The SEWG set of Preliminary System Analysis Documents (PSAD), plus communication between the System Engineering Working Group (SEWG) and Data Standards Working Group (DSWG), indicates the adoption of NetCDF across the ECVs may be common practice. If that is the case, products across all ECVs will be more easily absorbable by THREDDS, given a common NetCDF format across all ECVs would exist. If there were to be ECVs for which their product data set would not be easily or directly absorbable by THREDDS, then a NetCDF library is offered by THREDDS from which an adapter could be explored for development.
- THREDDS middleware offers a broad spectrum of services towards providing data products to clients, including an implementation of the OpenGIS Consortium (OGC) Web Coverage Service (WCS) protocol, and Web Map Service (WMS), so accentuating the possibilities of using THREDDS across the ECVs.

[10] The term “access” here denotes the downloading of the product. For product visualisation to take place, a product must be accessed, but we reserve the term “access” to purely mean the downloading of the product as opposed to the receiving of the product either for visualisation or file download.

- THREDDS offers an aggregation service, so introducing future opportunities for providing higher level pan-ECV products to users; that is, virtual products spanning multiple ECV systems.
- THREDDS is a mature technology.
- THREDDS is founded on Java, with the advantages and tools attained therein, such as offering a library for integration activity.
- THREDDS is a proven technology in the earth sciences domain, as exemplified by its involvement in MyOcean and SeaDataNet. DUACS, the CLS production system being reused for SLCCI, has been proven to work with THREDDS, though DUACS reuse for the MyOcean Sea Level TAC.

The means by which a product could be accessed and visualised via THREDDS will be as follows –

- *OpeNDAP* - A data transfer client-server protocol, allowing basic querying and subsetting of product data from large data sets. Includes provision of OpeNDAP Dataset Access Forms for a user to access data from their web browser. An advantage of OpeNDAP data access over HTTP and FTP is the requesting of subsets, or similarly aggregations, of data from the OpeNDAP server.
- *Web Coverage Service (WCS)* – Data access through the THREDDS implementation of the OpenGIS Consortium (OGC) Web Coverage Service (WCS) specification. Provides gridded data in various formats, including images, based on well formed requests defining geospatial layers of interest. Supports spatial and temporal sub-setting.
- *Web Map Service (WMS)* – Data access through the THREDDS implementation of the OpenGIS Consortium (OGC) Web Map Service (WMS) specification. Provides images (only) of various types based on well formed requests defining geospatial layers of interest. THREDDS 4 introduces a WMS implementation, which was earlier available only externally to THREDDS, for instance via ncWMS.
- *HTTP* – HTTP underlies realisation of the WCS and WMS specifications, but THREDDS also allows direct HTTP bulk file access for user convenience.

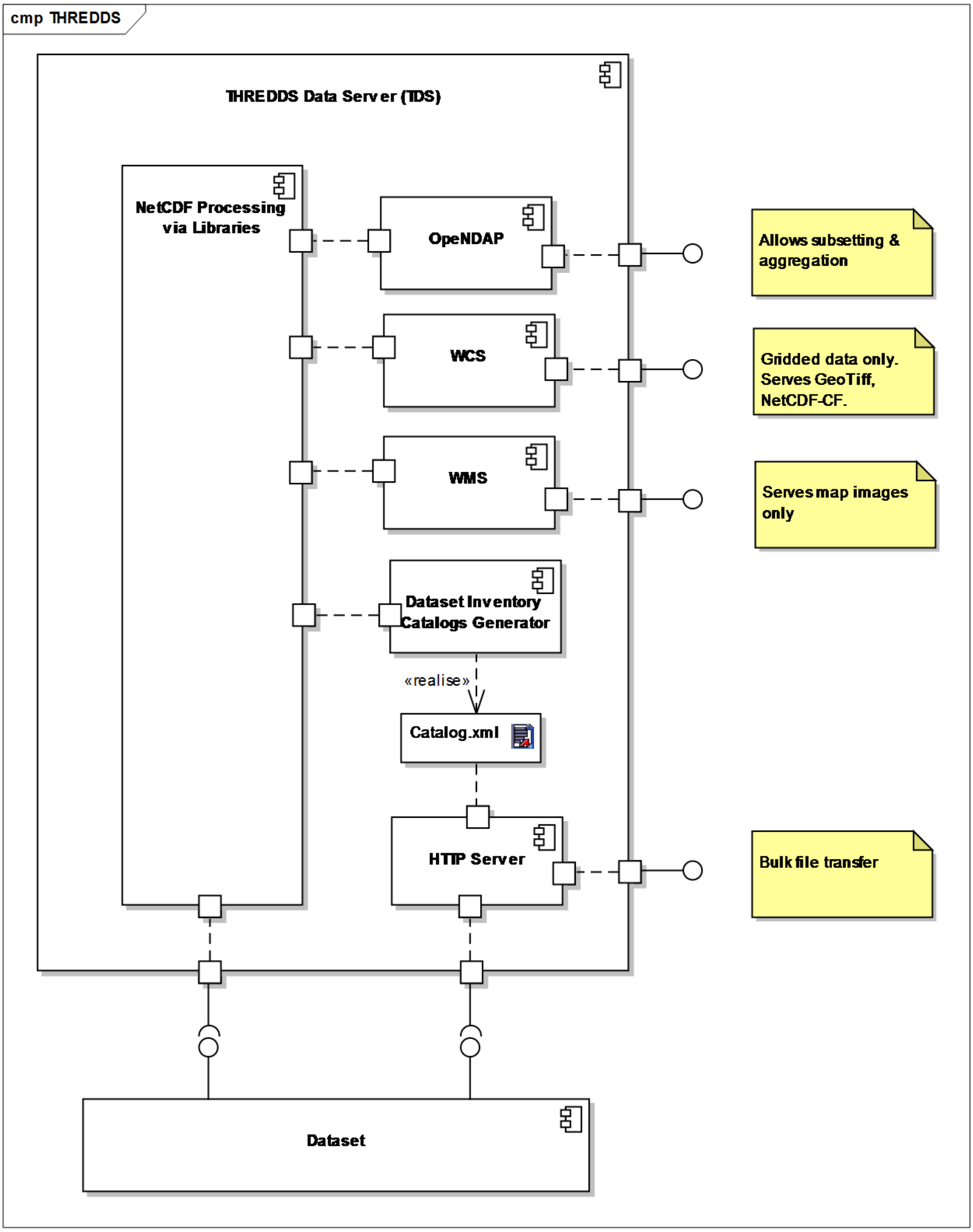

Figure 3 – Internal Illustration of THREDDS

4.7. Cataloguing

As well as offering product access and visualisation, TDS offers product cataloguing; indeed, the THREDDS technology was originally devoted specifically for cataloguing, with product access and visualisation services having been included only in recent versions. A THREDDS catalogue is a formal, XML-ised, catalogue of available products available to users. The catalogue may be statically defined, or dynamically created by THREDDS through assessment of the available dataset.

We adopt THREDDS for the SLCCI product cataloguing, for the following reasons –

- THREDDS is a mature cataloguing technology
- THREDDS has already been used with DUACS, visa the MyOcean Sea Level TAC, and is therefore a proven integratable technology to SLCCI, which is also reusing DUACS.
- THREDDS offers a Java library allowing wider opportunities for integration with other systems, and therefore offers greater opportunities to wide absorption by the CCI community.
- THREDDS allows aggregation of products, and this is reflected by the provision of catalogues for these virtual products.
- Future opportunities exist to creating pan-ECV products, with data spanning more than one ECV product data.
- THREDDS product aggregation includes aggregation of remote as well as local products, therefore providing an opportune advantage to use across the ECV communities. For example, a Central Information System (CIS) would be able to remotely draw in catalogues from all ECV systems, providing a centralised catalogue for all. This is particularly feasible, given the positive endeavours of the Data Standards Working Group (DSWG) towards a common NetCDF format across all ECV systems.
- SLCCI consortium prime CLS is in communication with THREDDS developer, Unidata, towards future introduction of functionality to THREDDS which may be further advantageous to SLCCI.

4.8. Communications

Either HTTP, HTTPS, FTP or a flavour of secure FTP, will be used for bulk file download of SLCCI data products. The matter is in discussion with other members of the SEWG, including the file security expectations of the operational system, and these form one of the trade-off themes concluded herein (§6.3).

4.9. Security

Similarly, common security solutions are being explored across the ECV project spectrum, which will subsequently inform the SSD trade-off analysis (§6.3).

5. System Modelling

In our identification of appropriate Standards (§4), we explored the criteria for our choosing of a language geared to our modelling of the SLCCI system, and subsequently applied evaluation criteria in our reasoning for the use of UML[11].

To further accentuate and clarify our communication to SLCCI stakeholders, it is an appropriate action to tie down our use of UML. It is especially appropriate to do so, before we embark on our SLCCI system modelling (§6, §7).

As UML is a quasi-formal language, and intentionally flexible in the manner in which the language can be expressed and diagrammatically used, it should not suffice merely for our specification to declare use of UML. Rather, we tightly define our flavour of UML in two ways. Firstly, we formally extend UML in order to define our *CCI UML Profile*, by use of the formal UML extension mechanism; this UML Profile definition is accompanied with examples as to its use. Secondly, we clarify our diagrammatic notation for UML, so further defining our UML dialect.

Our CCI UML Profile is defined not only for intra-SLCCI system specification, but also with inter-CCI collaboration in consideration. We will be distributing our UML extension to the System Engineering Working Group community, as this will help all participants speak the same specification language during our collaboration. Indeed, for collaborative system modelling to take place amongst the different ECV projects, a common language, a common communicative understanding, is required

In this chapter we also discuss our perspective on UML best practice, and also reason towards our choosing of a UML tool for modelling.

5.1. Definition of CCI UML Profile and Modeling Notation

UML2 provides a means of extending the semantics and iconography of the language, by defining a “Profile” to the UML meta-language. To clearly communicate the architectural concerns of our SLCCI system, and indeed of CCI systems in general for our collaborative efforts, we propose a UML profile. This definition will more clearly communicate the notation we are using throughout the SSD. We aim that such a notation still be intuitive enough for any stakeholder to understand.

For systems modelling we will adopt UML2, for example using the Component Diagram type for high-level functional modelling of the system. As was recognised widely across industry, system modelling through the first major issue of UML (UML1) was limited, relying largely on the package classifier type to represent high level functional entities; the concept of the Component then was different to UML2, representing only implementation entities. UML2 changed the semantics of the Component concept and Component Diagram. As of UML2, Components are purely logical constructs rather than executable entities[12] (which UML2 now labels as “artefacts”). UML2 introduced a richer expressiveness to the Component Diagram, allowing for their apt use for modelling systems[13].

We formally define our UML Profile, which we call the CCI UML Profile, as follows -

[11] UML2, as specified by the Object Management Group (OMG)

[12] In UML2 a Component is a sibling construct to a Class; both are classifiers. The classifier notation applicable to a Class is similarly applied to a Component.

[13] A comprehensive description of the difference between UML1 and UML2 may be found in [RD17]

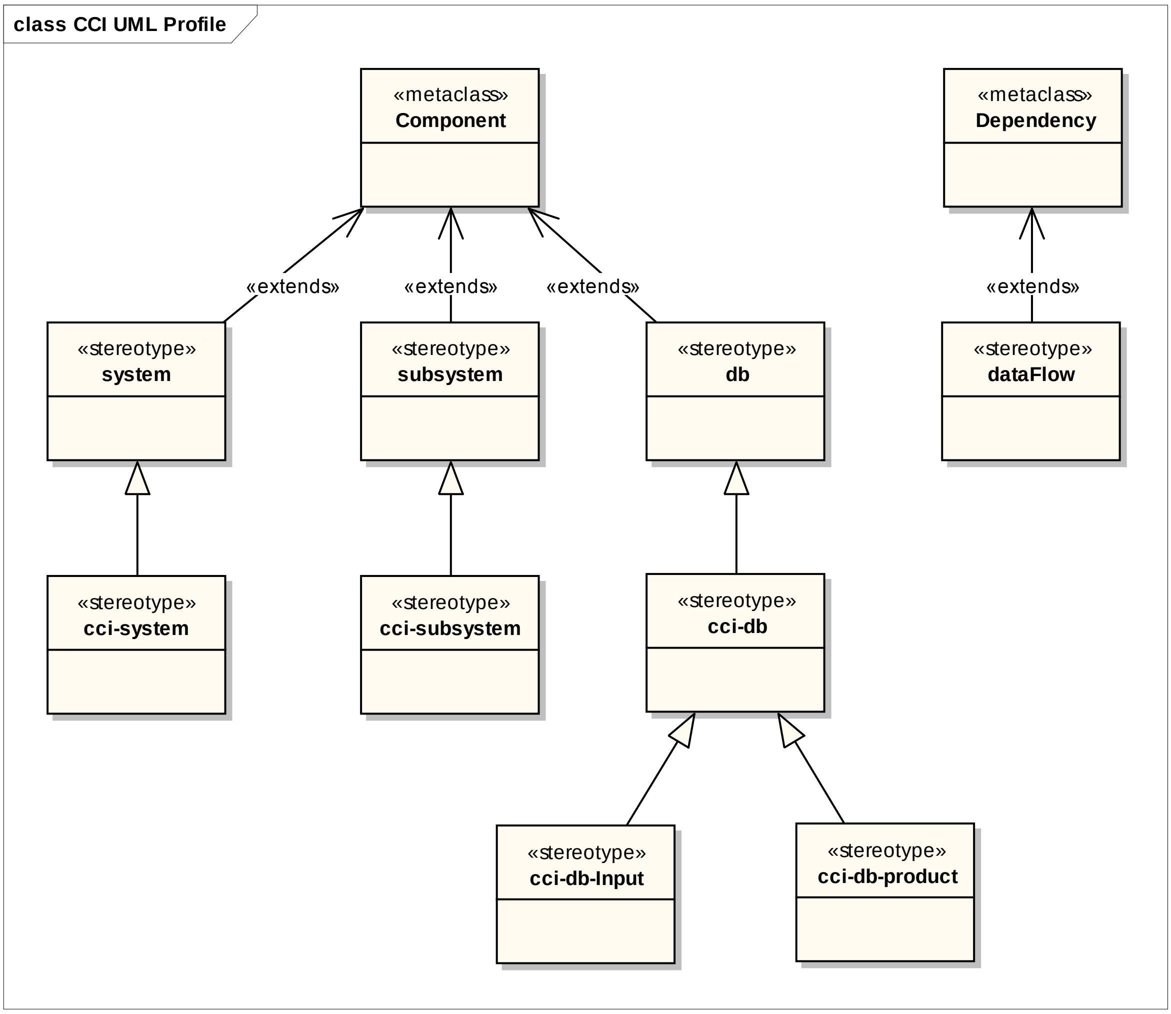

Figure 4 – CCI UML Profile

The CCI UML Profile is further described here in tabular form –

Stereotype	Base class	Metaclass type	Tags	Constr	Definition
<<system>>	-	Component	-	-	A system[14], irrespective of whether a CCI system or a non-CCI system
<<cci-system>>	System	Component	-	-	A CCI system. This CCI system can be any system from the CCI portfolio of systems.

[14] We adopt the IEEE 1471 definition of a *system* as “A collection of components organized to accomplish a specific function or set of functions”.

<<subsystem>>	-	Component	-	-	A sub-system, irrespective of whether a CCI system or a non-CCI system.
<<cci-subsystem>>	Subsystem	Component	-	-	A sub-system pertaining to a CCI system. This CCI sub-system can be associated to any system from the CCI portfolio of systems.
<<db>>	-	Component	-	-	A database component, irrespective of whether associated with a CCI system or a non-CCI system.
<<cci-db>>	Db	Component	-	-	A CCI database sub-component of a database component.
<<cci-db-input>>	cci-db	Component	-	-	A CCI database sub-component of a database component, related to input.
<<cci-db-product>>	cci-db	Component	-	-	A CCI database sub-component of a database component, related to product.
<<dataFlow>>	-	Dependency	-	-	A dependency sub-type, associated with data flow between two classifiers.

Table 1 – CCI UML Profile Description

The following example Component Diagrams illustrating the CCI UML Profile in use –

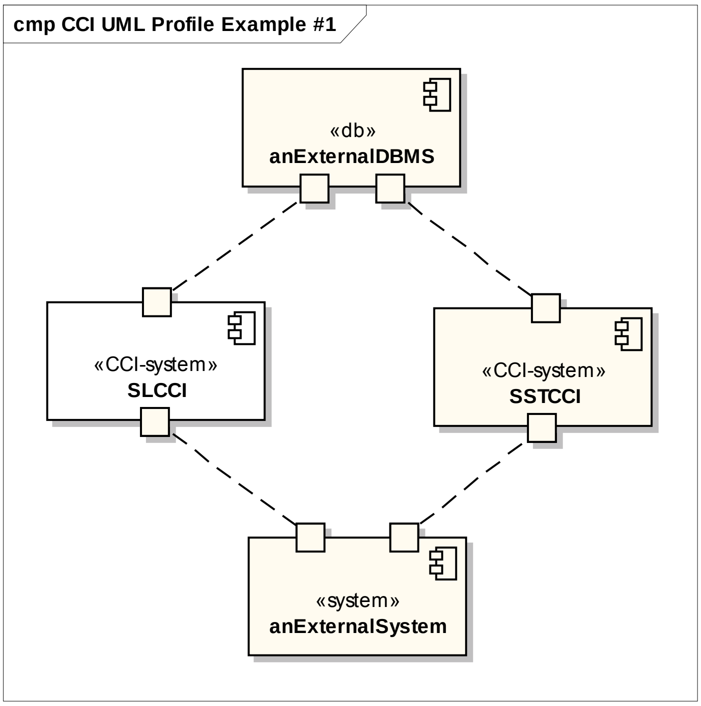

Figure 5 – Example of SLCCI <<system>> and <<database>> stereotypes

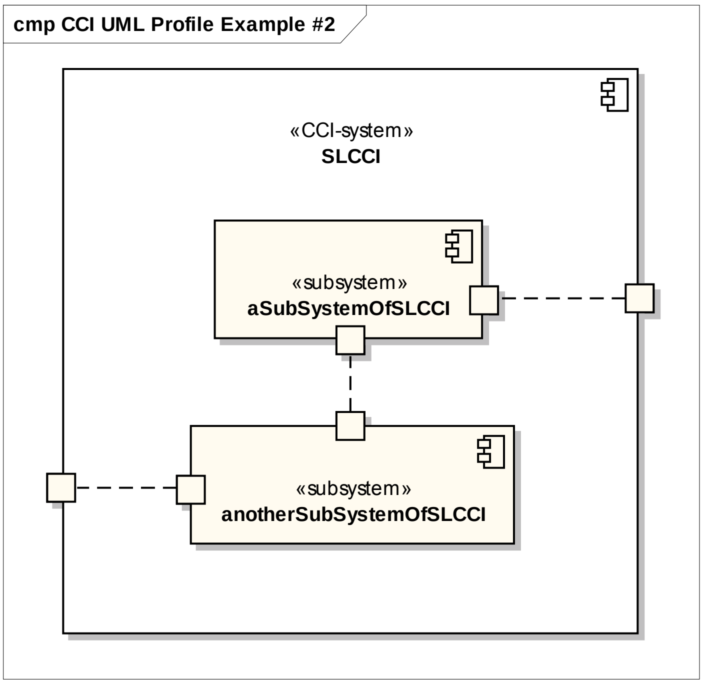

Figure 6 – Example of <<subsystem>> stereotype

Our component modelling notation adheres to the following convention –

- The UML Profile accommodates intra-SLCCI modelling, modelling of other ECV systems as well as SLCCI, and pan-ECV modelling.

- The stereotype <<system>> is used for representing the SLCCI system, any other of the CCI systems, or any external system.
- Any structural diagram, such as component Diagram or Class diagram, signifies the state of the system at build-time rather than run-time. We represent the abstract structure of components rather than state of the system on instantiation of components.
- In order to aid clear diagrammatic communication, our notation is such that we will commonly add a connector between ports which by definition abstractly hold interfaces, rather than explicitly introduce the interfaces held by the port. Again, this is legitimate under the UML grammar; that is, reference to an abstraction container of interfaces rather than explicitly refer to the interfaces contained by the port, if this benefits communication of the diagram. Our judicious use of ports for grouping interfaces is such that -
    - A port is associated with one or more interfaces.
    - A port is structural feature of a Component classifier.
    - Where we wish to portray further details regarding a port, we either explicitly, diagrammatically, introduce the interfaces held by the port, or represent the multiplicity of the port. We illustrate this exercise, through the difference between Figure 6 and Figure 7.
    - An example of the elaboration of interfaces associated by port is in figure below.
- Inter-component relationship is represented by dependency rather than, more restrictively, by association.

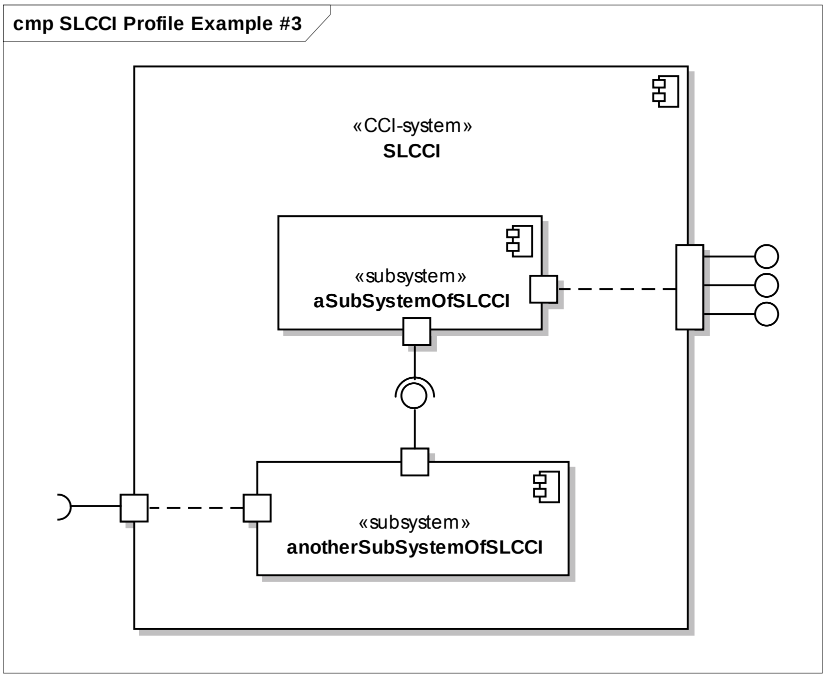

Figure 7 - Example of Port Drilldown to Finer Level of Detail

Our CCI UML Profile also accommodates an extension to the Dependency type, in order to clarify our modelling of Activity diagrams. UML2 Activity Diagrams are such that “control flow” and “object flow” may both be depicted by a straight uninterrupted line. In the CCI UML Profile we introduce a formal extension to UML Dependency type and iconography, via an introduced <<dataFlow>> stereotype. The formally extended Dependency represents object (data) flow arising from an activity; this clarifies SLCCI modelling in the Information View (§7.5), clearly differentiating flow of data from flow of control, in our flow-intensive models. Below we illustrate the use of our CCI UML Profile as used for activity diagrams –

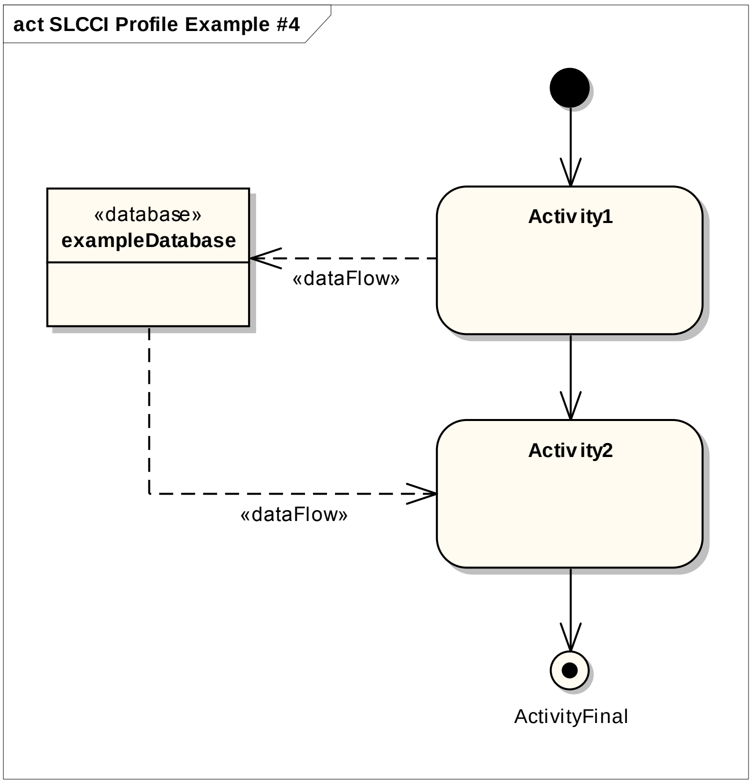

Figure 8 - Example of Usage of <<dataflow>> Dependency Stereotype

5.2. UML Good Practice

UML is a mature enough modelling language to have built a canon of good practice heritage. We take advantage of this to inform our UML modelling activities.

UML, as with any tool, is only of value if used in an appropriate context. Use of UML as our modelling language must be accompanied with an understanding of the language's limitations, benefits, and appreciation of this context. Common anti-patterns of inappropriate UML usage are eloquently described in [RD12, RD13] by Alex E. Bell, and discussed in [RD14] by Grady Booch. An ontology of UML "fevers" is posited by Bell, containing four "meta-fevers" within which finer grained UML fevers are arranged. This arrangement is used by Alex E. Bell to describe common industry scenarios of UML ill-use.

We use this work to validate our appropriate UML usage. We observe other contemporary industry knowledge on UML good practice, including a seminal work on UML usage [RD23].

5.3. UML Tool

For our UML modelling we reject diagramming tools, in favour of tools grounded on formal respect for UML language syntax and semantics. UML is not a diagramming method per se, but rather a quasi-formal modelling language which carries with it a diagramming iconography. A UML modelling tool will disallow ungrammatical or unwell-formed modelling, based on its interpretation of the UML specification.

We choose as our tool Enterprise Architect by Sparx Systems. Although a number of Open modelling tools are available, on balance we choose instead Enterprise Architect as it fully supports the latest interpretations of the UML meta-language and allows for all UML diagramming types. Additionally, the tool offers full export of models through tool-independent XMI format, allowing the sharing of models with other ECV projects. Enterprise Architect also allows the incorporation of formal UML extension through UML Profiles.

6. System Overview

This chapter begins with a discussion of the architectural styles identified for the SLCCI system, before progressing towards an architectural overview of the SLCCI system. A strategy for our trade-off analysis towards the choosing of architectural options is similarly discussed.

6.1. Architectural Styles

There are a number of architectural, high-level, paradigms which are in keeping with the vision of the operational system[15], as follows.

6.1.1. Client - Server

The system adopts the client-server paradigm by virtue of products being served from the SLCCI system to clients controlled by users. Also, within the SLCCI system itself the THREDDS system resides, acting as a server to a number of internal SLCCI components[16]. The SLCCI system itself may also be seen as both a client and server, in its relationship with a Central Information System[17] (CIS).

6.1.2. Data driven

As described by the System Requirements Document (SRD), the SLCCI system shall be data driven wherever feasible, in order to allow changes to the system to be applied without the need to rebuild or restart the system. This approach also affords the SLCCI system both the advantage of greater configurability, and the advantage of configurability by a greater number of internal users than would be possible if system-tuneable variables were only changeable at the implementation level.

6.1.3. Layered

The SLCCI system can be said to be layered, under a number of different guises. The SLCCI system is internally layered into a number of defined components, which will ultimately be further finely layered during Phase II. The THREDDS server, which resides within the SLCCI system, is itself layered from a logical point of view, into the various services it offers. Also, an SLCCI system, as with other CCI systems, represents an ECV-system layer at a different layer to the proposed Central Information System[18] (CIS).

[15] We do not here formally define the concept of an “architectural style”, but are satisfied that for the purposes of this System Specification Document, an architectural style simply denotes a commonly understood high level architectural paradigm.

[16] We assume the definition of “Component” as defined by UML2.

[17] SLCCI-SRB-REQ_15-400

[18] SLCCI-SRB-REQ_15-400

6.2. Architectural Overview

The following diagram portrays the scope of SLCCI. Two pertinent high-level users exist, namely SLCCI Contributor (internally involved in the running of the system), and the SLCCI Product User who ultimately receives the product; the lower level details pertaining to these user types are explained in the SRD. Data is received into the SLCCI, via push and pull, from a variety of sources. The details associated with the input to the SLCCI are in the DARD, and, similarly, the outputs are described by another deliverable document, the Product Specification Document (PSD).

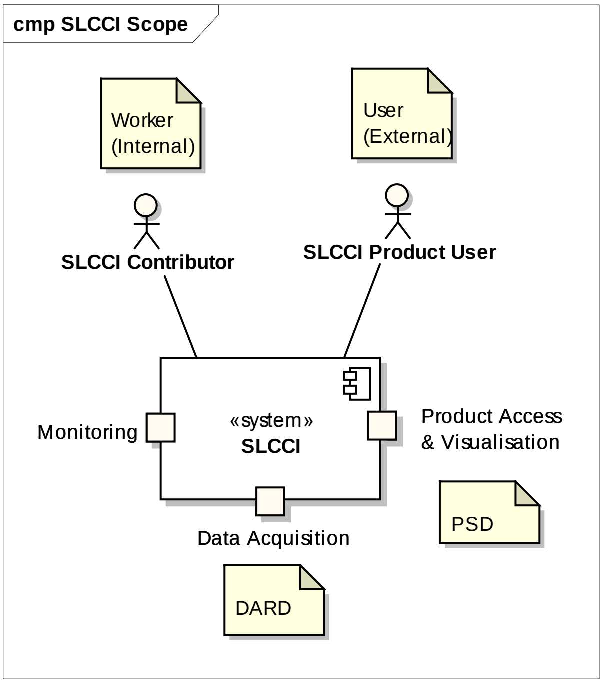

Figure 9 - SLCCI System Scope

We shall be describing two aspects of the internal composition of the SLCCI, a functional architecture and a deployment architecture[19]

6.2.1. Functional Architecture

The SLCCI system is comprised of four components, namely Production, Product Management, Product Access & Visualisation, and Monitoring. These four components map directly to the similarly labelled macro functionalities identified by the System Requirements document (SRD). Figure 10 diagrammatically displays these four categories as <<subsystem>> stereotyped components, internal to the SLCCI <<system>>, through use of our CCI UML Profile. Table 2 offers a brief description of each subsystem component.

[19] This is described as an "Execution Architecture" by the PSAD.

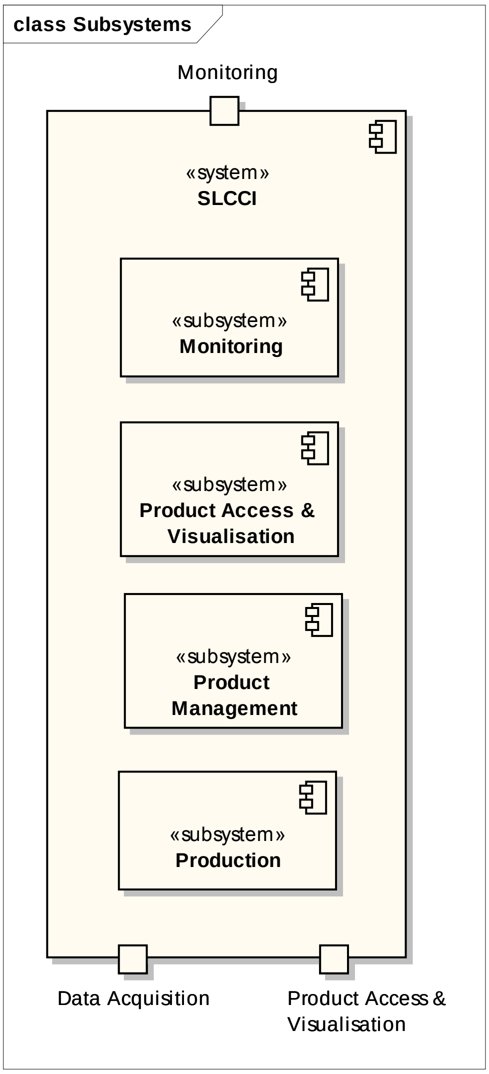

Figure 10 – Internal <<subsystem>> Stereotyped Components of SLCCI

Constituent subsystems	Description
Production	The production chain
Product Access & Visualisation	Access and visualisation of the products by external users and systems
Product Management	Management of the ECV products output by the production pipeline.
Monitoring	Monitoring of the SLCCI system constituents

Table 2 – Brief Description of SLCCI <<subsystem>> Internal Components

Figure 11 displays a reinterpretation of Figure 10, displaying the interfaces connecting the components, and interfaces connecting components to the external interfaces of the SLCCI system. The Functional View (§7.2) describes each component and interface.

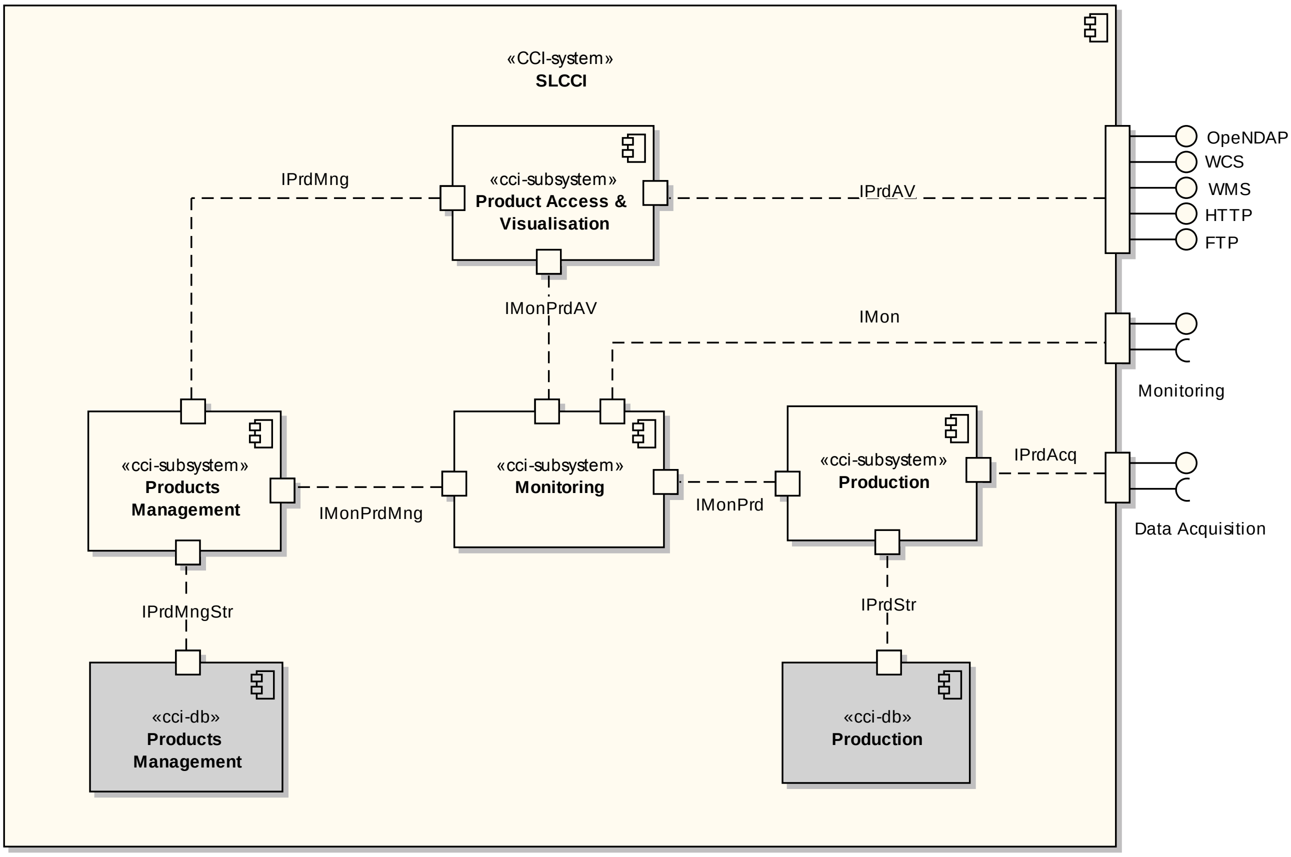

Figure 11 - Component Diagram of SLCCI System

6.2.2. Deployment Architecture

The Functional Architecture overview of §6.2.1 provides a logical overview of the system. The deployment architecture of the SLCCI system is based on re-use of the DUACS system, as expressed in the PSAD [RD3] execution architecture (§3.7).

6.3. Architectural Options

The exercise of an architectural trade off analysis, to realise certain architectural options for the SLCCI system, is important in order to satisfy the "business goals" as expressed by the Statement of Work (SoW), in particular the business goals relating to cost-effectiveness.

Our strategy for the deciding of architectural trade-offs is as follows –

1. *Best Practice in Trade-off Analysis* (§6.3.1) - We recall what the ECSS standards have to say with regards to trade-off analysis, and draw from these standards what is apt and relevant to our SLCCI practice.

2. *Identification of Trade-off Evaluation Criteria* (§6.3.2) - We reason and define a pool of evaluation criteria which we will be using for the trade-off analysis. The criteria are to be applied to each trade-off analysis theme.
3. *Identification of Trade-off Themes* (§6.3.3) – A trade-off theme is a technical area requiring trade-off analysis, as various solutions may exist. We mine the System Requirements Document (SRD), exhaustively going through the whole of the system requirements baseline, in order to elicit the technical themes to which a number of solutions will be applicable, and which therefore demand a trade-off analysis.
4. *Trade-off Reasoning & Conclusion* (§6.3.4) – We apply the criteria to the themes, reasoning and concluding on the decided apt solution for the given theme.

All above items are tackled herein. Furthermore, an important criteria is the matter of pan-ECV collaboration, to which we reason the System Engineering Working Group (SEWG) output has not reached a sufficient level of maturity; more information regarding this consideration will be included in future SSD iterations if progress has been made to which there is reason to accommodate during CCI Phase I.

6.3.1. Best Practice in Trade-off Analyses

As part of ECSS standard ECSS-E-ST-10C (§5.3.3), (i) a list is offered of the areas under which a trade-off analysis may be applied, (ii) a template trade-off report is provided (Annex L), and (iii) a template for documenting alternative system concepts is offered (Annex C).

We turn to the ECSS template trade-off report to give us guidance. Annex L [RD29] refers to the inclusion of key technical requirements into the template, to help identify areas requiring possible alternative solutions. Evaluation criteria are also expressed by the template, with the criteria being selected and judiciously weighted. These criteria may be selected from the themes elicited in a technical specification, as described by ECSS standard ECSS-E-ST-10-06 Annex A. Via the ECSS template, presentation and evaluation of alternative design solutions can thus be realised.

We reason that our strategy for realising architectural options covers these considerations, through the staged strategy earlier described (§6.3), for instance our filtering of technical requirements to find trade-off themes, and weighting of appropriate identified criteria, are activities similarly referred to by the ECSS standards.

In summary, our observance of the ECSS content on trade-off analysis, is mappable to our SLCCI trade-off analysis as follows -

- *Trade-off Themes* - ECSS-E-ST-10C Annex L Section 4 (Key Technical Requirements) suggests that a list of “key technical requirements” be attained, via technical requirements as described in ECSS-E-ST-10-06C Annex A, in order to identify areas where an alternative design solution may be more apt.
    - Our trade-off strategy involves the identification of trade-off themes. These themes represent areas requiring trade-off analysis, and are identified through mining of the System Requirements Document (SRD) containing the system requirements baseline. This mining involves exhaustively going through the system requirements baseline, to identify all viable themes for trade-off analysis. Each theme is potentially associated with numerous solutions.
- *Trade-off Criteria via SLCCI SRD* - ECSS-E-ST-10C Annex L Section 5 (Evaluation Criteria) suggests that selection criteria need be declared. It notes that selection criteria can be

derived from the technical specification "theme by theme"[20], as defined by ECSS-E-ST-10-06 Annex A

  - Our trade-off strategy involves the identification of trade-off criteria. A subset of our criteria set are mappable to the quality categories defined in the SRD[21]; these quality entities, reasoned and defined in the SRD, are traceable to the IEEE 1471 perspectives defined in the System Specification Document (SSD).

- *Trade-off Criteria via ECSS* - ECSS-E-ST-10C Annex L Section 6 (Presentation of the Alternative Design Solutions) refers to specific trade-off criteria, and these have been introduced directly into our evaluation criteria list. This differs to *Trade-off Criteria #1,* which refers to criteria extracted from our system requirements baseline.
- *Weighting* - ECSS-E-ST-10C Annex L (section 5, point b), ECSS-E-ST-10C Annex L (section 8), ECSS-E-ST-10C Annex L (section 9) refer to the practice of weighting of the trade-off criteria. Our strategy similarly involves the exercise of weighting evaluation criteria for each given trade-off theme.
- *Future Maturity* - ECSS-E-ST-10C Annex L (section 4, point b) points out that it should be taken into account that solutions which are not necessarily mature enough at a given time may become mature enough to be viable in future. We absorb this concept into our evaluation criteria set.
- *Provision of Evidence* – We acknowledge, as pointed out by ECSS-E-ST-10C Annex L (section 4, point c), the importance of provision of information to support a design solution, for example research and development results, and recognised best practice. Our strategy will include such provision when conducting trade-off arguments, describing the argument fully.
- *Presentation of Alternative Design Solutions* – As pointed out by ECSS-E-ST-10C Annex L Section 6 and subsequently Section 7, the provision of alternative design solutions is fundamental to trade-off analysis. Our trade-off analysis strategy involves the identification of different solutions as part of its last stage.
- *Evaluation of Alternative Design Solutions* - ECSS-E-ST-10C Annex L Section 7 relates to the reasoning towards a solution given alternative solutions per theme. Similarly, our strategy will be such that the Trade-off Argument stage will discover and argue the pros and cons of all solutions per theme.
- *Risks* – As identified by ECSS-E-ST-10C Annex L (section 8), our trade-off evaluation criteria includes "technical and programmatic risks".

Aside from ECSS standards, we also absorb our consortium experience into the list of criteria.

6.3.2. Identification of Trade-off Evaluation Criteria

We identify the trade-off evaluation criteria which are applicable to the SLCCI. For each identified trade-off theme (§6.3.3) these trade-off criteria have been considered. The list below represents the complete set of trade-off evaluation criteria relevant to the SLCCI across the themes and taken into consideration in broad discussion and reasoning towards results (§6.3.4).

The source of our trade-off evaluation criteria are as follows –

[20] This ECSS usage of the word "theme" differs to our usage of the word "theme" to describe the categories requiring a trade-off analysis. The ECSS usage, in this context, relates to the categories of criteria, which are derivable from a technical specification – this meaning maps to the different categories of evaluation criteria we define as part of the SSD.

[21] The other evaluation criteria which we declare are mappable to sources other than ECSS.

1. Statement of Work trade-off considerations. Evaluation criteria which are explicitly referred to in the SoW.
2. Accommodation of Business Goals (traceable to SoW). Different solutions to the trade-off themes will influence how well the axiomatic requirements of the operational system, as described by the "business goals" elicited in the System Requirement Document (SRD), are satisfied. We therefore absorb these business goals into our trade-off criteria classification, in order to maintain the original vision of the operational system throughout the trade-off decision-making process.
3. Influence on Perspective (traceable to SRD). Broadly speaking, the functional areas of the system will map to the trade-off themes, and the perspectives (the quality-oriented aspects of the system) will map to trade-off criteria. We absorb the Perspectives into the trade-off evaluation criteria.
4. ECSS Standards on trade-offs. Criteria can be garnered from technical requirements, as echoed by ECSS-E-ST-10C [RD29] Annex L (section 5) using ECSS-E-ST-10-06C [RD4] Annex A; we already account for this type of criteria, through the influence of Perspectives (above) which trace to quality categories in the SRD. With regards to ECSS-E-ST-10C [RD29] Annex L (section 6) on presentation of alternative design solutions, specific reference is made to the criteria of maturity, performance capability, and risks.

Our list of evaluation criteria is as follows and includes, for example, SoW considerations relating to technical developments[22] -

1. *Modularity* - Openness to "broad scientific participatory inputs", i.e allowing modularity of scientific processing, such as algorithm, with minimal effect on rest of system, through high tightness of such module and low dependency to other parts of system, through well-defined interface. Source – SoW [R28, pg 27].
2. *Re-processing Capability* - Amenability to "rapid updating and re-processing of data from all contributory sensors". Source – SoW [R28, pg 27].
3. *Ease of User Access to ECV Product* – The ease with which an external user of the SLCCI ECV product is able to access the product(s) being generated. Source – SoW [R28, pg 27].
4. *Ease of Dissemination of ECV Product* - The ease with which an internal user of the SLCCI ECV product is able to distribute the product(s) being generated. Source – SoW [R28, pg 27].
5. *Maintenance of associated Metadata and documentation* – The maintenance of both the product metadata, and all documentation associated with the product, by user(s) internal to the SLCCI system. Source – SoW [R28, pg 27].
6. *User access to associated Metadata and documentation* – The ease with which an external user is able to access the metadata associated with a given product, and all documentation associated with a given product. Source – SoW [R28, pg 27].
7. *System Development Life-cycles and Latency Times* – The time taken to introduce a new feature to the system or change an existing feature, from the time that a system extension is made, to the time at which the introduced feature is introduced to the live system. Source – SoW [R28, pg 27].
8. *Algorithm Development Life-cycles and Latency Times* – The time taken to introduce a new algorithm into the system or change an existing algorithm, whether a scientific algorithm or system oriented algorithm, from the time the new algorithm is requested to the time at which the algorithm is introduced onto the live system. Source – SoW [R28, pg 27].
9. *Cost Models* – The cost model associated with a given solution. Source – SoW [R28, pg 27].

[22] SLCCI_SRD_REQ_15-180, SLCCI_SRD_REQ_15-190, SLCCI_SRD_REQ_15-200,

10. *Achievement of Low Operational Cost* – For a given cost model, the attainment of a low operational cost. Source – SoW [R28, pg 27].
11. *Technical Practicality of Pan-ECV Collaboration* – The technical feasibility associated with accommodation to pan-ECV collaboration. Source – SoW [R28, pg 27].
12. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#1* – "Development of the system shall be undertaken with apt consideration for scientific consensus on performance specification."Source – SRD [R1].
13. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#2* – "Development of the system shall be undertaken with apt consideration for availability of input data from EO archives." Source – SRD [R1].
14. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#3* – "Development of the system shall be undertaken with apt consideration for quality of input data from EO archives." Source – SRD [R1].
15. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#4* – "Development of the system shall be undertaken with apt consideration for availability of associated metadata, cal/val data and documentation." Source – SRD [R1].
16. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#5* – "Development of the system shall be undertaken with apt consideration for quality of associated metadata, cal/val data and documentation." Source – SRD [R1].
17. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#6* – "Development of the system shall be undertaken with apt consideration for compatibility of data from different missions." Source – SRD [R1].
18. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#7* – "Development of the system shall be undertaken with apt consideration for compatibility of data from different sensors." Source – SRD [R1].
19. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#8* – "Development of the system shall be undertaken with apt consideration for trade-off between cost, complexity and impact of new algorithms to be developed and validated during the project." Source – SRD [R1].
20. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#9* – "Development of the system shall be undertaken with apt consideration for advance planning for data from new missions to be integrated during the project." Source – SRD [R1].
21. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#10* – "Development of the system shall be undertaken with apt consideration for end-to-end throughput of ECV production systems." Source – SRD [R1].
22. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#11* – "Development of the system shall be undertaken with apt consideration for re-use of existing capabilities within Europe." Source – SRD [R1].
23. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#12* – "Development of the system shall be undertaken with apt consideration for compliance of ESA standards." Source – SRD [R1].
24. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#13* – "Development of the system shall be undertaken with apt consideration for availability of external validation data." Source – SRD [R1].
25. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#14* – "Development of the system shall be undertaken with apt consideration for avoidance of duplication of activities covered by existing projects." Source – SRD [R1].
26. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#15* – "The system shall be cost effective." Source – SRD [R1].

27. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#16 – "*The pan-ECV operational systems must be cost effective as a whole." Source – SRD [R1].
28. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#17 – "*Operational system timeliness is urgent." Source – SRD [R1].
29. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#18 – "*Full advantage shall be taken of the latest developments in computing architectures." Source – SRD [R1].
30. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#19 – "*Full advantage shall be taken of the latest developments in data management." Source – SRD [R1].
31. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#20 – "*Full advantage shall be taken of the latest developments in communications technology.*"* Source – SRD [R1].
32. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#21 – "*The operational system development should include cooperation with other consortia producing ECV products." Source – SRD [R1].
33. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#22 – "*The system shall have provision for future data set updates.*"* Source – SRD [R1].
34. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#23 – "*The operational system shall allow algorithm change." Source – SRD [R1].
35. *Accommodation of Business Goal SLCCI-SRB-BUSINESS-GOAL_#24 – "*The operational system shall have an archiving facility." Source – SRD [R1].
36. *Influence on Perspective of Design & Implementation Constraints* – Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD.
37. *Influence on Perspective of Security & Privacy* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
38. *Influence on Perspective of Portability* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
39. *Influence on Perspective of Software Quality* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
40. *Influence on Perspective of Reliability (RAMS)* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
41. *Influence on Perspective of Availability (RAMS)* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
42. *Influence on Perspective of Maintainability (RAMS)* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
43. *Influence on Perspective of Safety (RAMS)* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
44. *Influence on Perspective of Configuration & Delivery* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
45. *Influence on Perspective of Human Factors* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
46. *Influence on Perspective of Adaptation & Installation* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
47. *Influence on Perspective of Scalability* - Accommodation of the perspective, traceable to quality attribute of the system as reasoned and defined in the SRD. Source – SRD [R1].
48. *Technology status* – The existing status of the technology observed. Source – [RD29].
49. *Technology readiness & maturity* – The level of maturity of the technology. Source – [RD29].
50. *Performances capability* – The processing, and other, performance. Source – [RD29].

51. *Technical & programmatic risks*. – For example, existing mastership of technologies involved in solution. Source – [RD29].
52. *Future maturity* – will the solution become more amenable and cost-effective in future, such as by the start of Phase II? Source – [RD29].

6.3.3. Identification of Trade-off Themes

We mine the System Requirements Document (SRD) in order to exhaustively identify all appropriate areas where system specification should conduct a trade-off analysis. The following table portrays the output of this mining exercise. For each identified theme, the area within the system requirements baseline is described, the theme labelled, an example system requirement given[23], and a comment offered. One trade-off theme is defined per row.

System Requirements Baseline Area	Trade-off Theme Identified	Example System Requirement Reference	Comment
Data acquisition	File transfer protocols (FTP v SFTP v FTPS, etc)	SLCCI-SRB-REQ_1-000	DUACS already uses FTP, so let's keep it this way.
Data acquisition	Push versus Pull	SLCCI-SRB-REQ_1-010, SLCCI-SRB-REQ_1-070	Already decided at SRD stage that going to have both
Data acquisition	Data detection	SLCCI-SRB-REQ_1-012	Competing solutions for detecting pull & push data? – tools available versus bespoke code? – or just same as push-versus-pull competing solutions above? Want to avoid manual detection, should be easy to automate
Monomission Cal/Val	Statistics calc and reporting	SLCCI-SRB-REQ_3-020 SLCCI-SRB-REQ_6-020	Competing technologies for writing the statistics to a file, for example text/ASCII report, or write actual report e.g via Jasper Report tool. What formats are the stats in – e.g template approach like Jasper reports, or directly to text or .pdf format.
Monomission Cal/Val	CRM	SLCCI-SRB-REQ_3-043	CRM tools for reporting management

[23] Although it has frequently been the case that each identified theme maps to more than one system requirement, our table offers only one example system requirement per theme. The reasoning behind this is that for a theme to be identified as such, only one system requirement needs to be identified.

System Requirements Baseline Area	Trade-off Theme Identified	Example System Requirement Reference	Comment
Multimission cross calibration	Algorithm execution	SLCCI-SRB-REQ_5-010, 5-020, 5-030, 5-031, SLCCI-SRB-REQ_6-020	Standard for algorithm execution (e.g via G-POD like GRID system). For example, using a scripting language which user/support has access to, or just coded by dev team?
FCDR Product Generation	Product formats	SLCCI-SRB-REQ_5-040.	Competing formats for the product - though, NetCDF already decided by SLCCI and in principle by SEWG parties
Product assessment	Product Stats Distribution	SLCCI-SRB-REQ_6-060	How warn and inform Product Expert of stats? CRM versus telephone/email, etc.
Measures & Built Indicators	KPI measurement	SLCCI-SRB-REQ_7-001	Competing ways of measuring KPIs
Measures & Built Indicators	Incident management reporting	SLCCI-SRB-REQ_7-007, SLCCI-SRB-REQ_8-043	Competing incident management reporting systems, e.g informing Service Manager if ftp server fails
Product Dataset Storage	Physical storage	SLCCI-SRB-REQ_8-010	Storage of products on physical space
Product Dataset Storage	Web portal	SLCCI-SRB-REQ_8-010	Competing solutions / technologies for database-friendly Web Portal tools & technologies. Reference made to Central Information system (CIS)
Product Dataset Storage	Data storage fault tolerance	SLCCI-SRB-REQ_8-043	Explore fault tolerance patterns, warm/hot standby, etc
Product Dataset Archiving & Retrieval	Data archiving	SLCCI-SRB-REQ_9-000, SLCCI-SRB-REQ_9-031	Different solutions for data archiving (n.b not the same as database storage of products). Also, automation required?
Product Access & Visualisation	Authentication to Product Access & Visualisation	SLCCI-SRB-REQ_10-210, SLCCI-RB-REQ_10-230	Competing solutions and technologies for authentication towards product access and visualisation. Also, Product download authentication.
Product Access & Visualisation	Interoperability of catalogues	SLCCI-SRB-REQ_10-220	Different ways that this can be realised

System Requirements Baseline Area	Trade-off Theme Identified	Example System Requirement Reference	Comment
Product Access & Visualisation	Product Visualisation	SLCCI-SRB-REQ_10-220	Different ways to perform product visualisation, e.g different THREDDS services.
Product Access & Visualisation	Product download	SLCCI-SRB-REQ_10-220	Different realisations of OGC WCS (not just THREDDS), others services also used for product download.
Product Access & Visualisation	Transaction accounting	SLCCI-RB-REQ_10-230	Competing solutions for transaction accounting
Product Access & Visualisation	Transfer protocol	SLCCI-RB-REQ_10-230	HTTP versus FTP (versus SFTP, etc, other transfer protocols). System can just provide more than one (as perhaps the requirement assumes anyway).
Product Access & Visualisation	Product access ticketing system	SLCCI-SRB-REQ_10-050	Different types of competing ticketing system or/and CRM system for product access and visualisation
Product Access & Visualisation	Product handbook media	SLCCI-SRB-REQ_10-050	Paper versus different forms of online distribution.
Product Access & Visualisation	Word search	SLCCI-SRB-REQ_10-090	Different ways of doing word search – THREDDS/WCS form, natural language, google api, etc. Should keep focus on what users want, and also needs to accommodate future users.
Product management	Metadata Editor	SLCCI-SRB-REQ_11-010	Competing solutions for metadata editor – online/cloud app, bespoke app run on machine and downloaded, applet, etc.
Monitoring	Monitoring tools & technologies.	SLCCI-SRB-REQ_11-010	Different, competing monitoring services and technologies, particular system monitoring.
Monitoring	Monitoring CRM tool (same/diff to product management CRM?)	SLCCI-SRB-REQ_11-016	Potentially already exists for DUACS
Monitoring	Incident management system. (how diff to CRM?)	SLCCI-SRB-REQ_12-060	SLCCI-SRB-REQ_12-092, etc

System Requirements Baseline Area	Trade-off Theme Identified	Example System Requirement Reference	Comment
Monitoring	Fault tolerance patterns (any other patterns used around here, or across system?)	SLCCI-SRB-REQ_12-080	Monitoring of physical resources, use specialised physical resources monitoring system – what are the competing technologies, patterns, solutions here.
Operational	CRM, monitoring	SLCCI-SRB-REQ_1-030	Competing solutions, technologies, for sending out warnings; sms, CRM tool, bespoke software development, etc
Operational	Configuration	SLCCI-SRB-REQ_1-095	Different ways to configure delay
Operational	Patterns to allow backup doesn't interrupt running	SLCCI-SRB-REQ_1-400	Competing solutions for ensuring service not interrupted.
Resources	Simultaneous downloads	SLCCI-SRB-REQ_14-010	Competing solutions and technologies, policies, best-practice, patterns, etc to realise simultaneous downloads, e.g how best to balance resources in order to allow simultaneous downloads, but make sure resources aren't reserved restrictively when there are no downloads taking place.
Resources	Diskspace provision	SLCCI-SRB-REQ_14-020	Competing solutions for disk space provision, cloud, etc – access speed, fault tolerance, etc.
Resources	Inventory system.	SLCCI-SRB-REQ_14-110	Best ways to make provision of inventory, e.g sharing service with another service on a machine. COTS, etc
Security & Privacy	User authentication	SLCCI-SRB-REQ_14-020	"The system shall include the requiring of authentication of SLCCI Product Users"
Security & Privacy	Information security	SLCCI-SRB-REQ_14-220	How much resources on security, given resources
Security & Privacy	Physical security	SLCCI-SRB-REQ_14-410	How much resource can be afforded on physical security – building, guards, etc.
Security & Privacy	Penetration tests	SLCCI-SRB-REQ_14-410	How much resource can be afforded for penetration tests?
Security & Privacy	Encryption facility	SLCCI-SRB-REQ_14-410	Special hardware to speed this up, depending on algorithms used? Externally hosted service, or catered for in-house.
Portability	Machine physical architecture	SLCCI-SRB-REQ_17-010	Cloud, etc, cost up front or on service, what DUACS already has, etc.

System Requirements Baseline Area	Trade-off Theme Identified	Example System Requirement Reference	Comment
Portability	Machine operating system.	SLCCI-SRB-REQ_17-010	Cloud, etc, cost up front or on service
Software Quality	Configuration system	SLCCI-SRB-REQ_15-200	Competing solutions to different artefact / source code configuration tools.
Software Quality	Observation report management system	SLCCI-SRB-REQ_15-210	Competing solutions for observation report systems.
RAMS	Means by which RAMS metrics taken	SLCCI-SRB-REQ_19-010	Means by which all metrics in this section are taken.
System Configuration and Delivery	System tuning	SLCCI-SRB-REQ_20-010	Different ways to tune the system (so rebuild not necessary) from editing of text file and sending signal, to bespoke tool.
Data Definition and Database	Data storage	SLCCI-SRB-REQ_21-010	Data storage solutions.
Data Definition and Database	Data export	SLCCI-SRB-REQ_21-330	Data export solutions
Human Factors	Catalogue provision	SLCCI-SRB-REQ_22-010	Competing solutions for providing catalogue at web portal
Human Factors	Machine activity MMI	SLCCI-SRB-REQ_22-050	Competing solutions for machine activity visualisation.
Human Factors	Meta data query	SLCCI-SRB-REQ_22-080	Competing solutions for meta-data querying

Table 3 – SRD Mining of Architecture Options Themes

6.3.4. Trade-off Results

Applying each trade-off theme (§6.3.3) to identified trade-off criteria (§6.3.2), leads to the following reasoned trade-off solutions to be used in the defined Views (§7).

- *File transfer protocol (Data Acquisition)* – The file transfer protocol chosen is FTP, the de facto standard for file transfer. Additionally -
  - The existing operational system upon which the SLCCI system is based, namely DUACS, acquires the input data for the processing chain through FTP. The FTP usage

for DUACS successfully meets all ECSS criteria associated with software re-use (ECSS-Q-ST-80C §6.2.7.2 to §6.2.7.11).

- The data input sources for the existing SLCCI system, as derived from the DARD, do not necessitate the use of a security flavoured version of FTP such as SFTP or FTPS. The common denominator flavour of FTP, FTP itself without security variant, is communicative with all DARD sources requiring a transfer protocol for electronic transfer of data.
- The FTP security-neutral capability will be apt for easier future modular change to a different, security-flavoured, variant of FTP if or when it becomes necessary for different future data sources, rather than de-engineering FTP security now (when such an FTP security service is not required) to serve a different transfer protocol.
- Chosen: FTP

- *Push versus Pull (Data Acquisition)* – Data Acquisition is accommodated by the interrogation by the SLCCI system of an external directory on which the data is placed when becoming available and which the SLCCI system subsequently draws on (pulled by the SLCCI system), or placed on an SLCCI directory and consequently digested by the SLCCI system (pushed onto the SLCCI system).

  The system on which the SLCCI system is based, DUACS, is serviced by both the pulling of data from external systems and the pushing of data by external systems onto the SLCCI system. This dual approach offers flexibility in arrangements with external parties on how to absorb their input data and has already served well under the existing DUACS operational environment.

  - The data sources on which the SLCCI system are based will be similarly accommodated flexibility by this dual approach.
  - It is anticipated that this dual approach will help accommodate future incorporations of external data acquisition, in view of sustainability of the SLCCI system beyond the CCI programme.
  - Chosen: Dual accommodation of Push and Pull data acquisition

- *Data Detection (Data Acquisition)* – The input data from external sources needs to be detected when it arrives, on the arranged external system directory or SLCCI system directory, for the FTP transfer to then commence.
  - Manual detection of push and pull data as it becomes available is to be avoided, with automated detection preferred; the detection is apt for automation.
  - Usage of an OTS product is unnecessary given the effort required to build a simple bespoke data detection mechanism, tailored to the surrounding infrastructure, rather than incorporate an OTS product which must be positioned within the SLCCI system via adapters to bridge the SLCCI and particular OTS interfaces; the overall resources required for the latter is arguably greater than for the former.
  - Platform APIs commonly provide the facility for detection of content changes within a specified directory, allowing simple bespoke development, for example via FileSystemWatcher Class (.NET), WatchService API (Java), and inotify (Linux Kernal, since 2.6.13).
  - Chosen: Bespoke development of data detection of a given directory.

- *Statistics Calculation & Reporting (Monomission Cal/Val)* – Competing tools and technologies exist for the calculation and reporting of statistical analyses.

- Bespoke logic for the statistical calculation originally performed from the DUACS operational system has been proven as robust within the existing DUACS operational environment, to satisfy ECSS standards on re-use, and flexible to modularly accommodate future statistical aims.
- Statistical calculation is modularly contained within the SLCCI system Production sub-system in distinctive areas within which the calculations are performed; the operational elements to the SLCCI processing chains are described in §7.2.2. This modular departmentalisation of the statistical calculation and reporting supports the future sustainability of the SLCCI system, as statistical reporting changes to meet future CCI demands. The statistical calculation will remain modularly contained.
- Competing technologies exist for the reporting of calculated statistics. Jasper Reports will be used as the development tool used to graphically portray the statistical calculations and associated text, integrated with the DUACS system re-usage. Jasper Reports is open source[24], and allows for flexible deployment and scalability. Moreover, Jasper Reports' robustness in an operational environment is recognised, and provides a significantly greater supporting community than other open source alternatives such as OpenReports[25].
- Given the operational system readership for the reporting of statistics calculation, a similar priority is the clarity of graphical portrayal of statistical information, which Jasper Reports supports, rather than text based statistical reporting.
- Chosen: Jasper Reports integration to bespoke statistical calculation

- *CRM (Monomission Cal/Val)* – As is the case with other tools and technologies requiring selection, it is recognised than numerous apt commercial tools exist. With the emergence of commercial cloud tools for customer relationship management, including capabilities for ticketing, the pricing of such tools becomes more scalable than stand-alone offerings.
    - For instance, tool vTiger[26] has been arguably a compelling commercially licensed tool, particularly given the financially attractive scalability, integration capability and appropriate ticketing functionality.
    - However, open source tools are key where technically feasible and where human resourcing is feasible for both development integration and operational usage. To that end, we decide on Open source CRM tool OpenCRX[27]. Inherent scalability allows cost-effectiveness through use of an operationally minimal ticketing system early on, and having the opportunity to upscale usage of the ticketing system at a later time, for example beyond the end of the CCI programme, to then absorb further user information and enhance the SLCCI service as the ECV user base changes over time.
    - Moreover, OpenCRX is built to integrate with other systems via an API to external applications, and being platform independent similarly increases effectiveness of usage as part of an SLCCI system. Moreover, by default, OpenCRX is built to run with Apache Tomcat and Postgres, which happen to be the web server and relational database management system of choice (to follow) therefore mitigating development risk.

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[24] LGPL license.

[25] http://sourceforge.net/projects/oreports/

[26] www.vtiger.com

[27] www.opencrx.org

- Chosen: OpenCRX

- *Algorithm Execution (Multimission Cross Calibration)* –
    - Rather than hard-wire the SLCCI system to the successful algorithms of Task 2 (subsequently prototyped by Task 3), the operational design of the SLCCI system will indeed accommodate these algorithms, but built with algorithm execution functionally encapsulated therefore more easily allowing future change of the algorithm; moreover this approach mitigates CCI development risk during CCI Phase I given that Task 4, concerned with validation of Task 3 output, is conducted in parallel with Task 5[28]. The Functional View of the processing chain realises this approach (§7.2.2).
    - The algorithm execution interface for the Multimission Cross Calibration functional element of the processing chain, for example, will adhere to a low level algorithm interface accommodating future changes to the underlying logic of the algorithm; such low-level interfaces will be defined and implemented by future Phase II implementers during Phase II.
    - Chosen: Bespoke implementation for algorithm interchangeability

- *Product Formats (FCDR Product Generation)* –
    - The format of the FCDR products, and indeed those of the ECV products, will adhere to the PSD specification. Similarly product format recommendations of the CCI Data Standardisation Working Group (DSWG) will be adhered to, as similarly expressed via the PSD [RD30]. Adherence to consensus of the DSWG to a common format encourages opportunities for future ECV integration and sustainability beyond the CCI programme, and during the CCI programme through ECV integration.
    - Chosen: Product format specified by PSD and CCI DSWG.

- *Product Stats Distribution (Product Assessment)* –
    - The statistical reports generated via Jasper Reports (above) will be distributed by notification to relevant recipients through the chosen CRM tool (above) namely OpenCRX. OpenCRX includes groupware functionality, enabling contacts management and linkage to mail servers through IMAP capability; moreover, OpenCRX contains event subscription and notification. On completion of operations within the Production sub-system, linkage to OpenCRX will allow automated notification of reports availability to relevant parties.
    - Chosen: OpenCRX

- *KPI measurement (Measures & Built Indicators)* –
    - Measurement of key performance indicators to the SLCCI system are necessary for assessment of health of the SLCCI system, and provide the bedrock to measuring the metrics of any future Service Level Agreement for either the user community or other parties prior to the end of the CCI programme.
    - Best of breed assessment for a system the scale of the SLCCI system points to the IBM Tivoli suite of network and event management systems, in particular Netcool/OMNIbus. However, apt consideration of cost-effectiveness deters such a

[28] SLCCI-SRB-REQ_15-130

solution, as does similar consideration for the sustainability of the SLCCI system beyond the CCI programme.
  - High priority consideration to open source alternatives to Netcool/OMNIbus, sufficiently flexible for integration, scalable, and robust has led to OpenNMS[29]. The enterprise-grade tool accommodates service polling, data collection on network status, plus event and notification management. Such capabilities allow the gathering and assessment of metrics for RAMS system requirements, and moreover facilitate integration with the SLCCI system through platform-independence. Moreover, development risk is mitigated given OpenNMS integration with Postgres.
  - Chosen: OpenNMS

- *Incident Management Reporting (Measures & Built Indicators)* –
  - The tool chosen for product statistics distribution, namely OpenCRX, falls under the similar auspices of incident management reporting. OpenCRX includes the capability for informing operational personnel, for example a Service Manager, of failure to monitored operations. A broker operation within the Monitoring sub-system will integrate the network management Web Services offerings of OpenNMS with the OpenCRX Web Services interface, taking the information derived from OpenNMS and distributing it to relevant parties through OpenCRX.
  - Chosen: OpenNMS & OpenCRX

- *Physical Storage (Product Dataset Storage)* –
  - Physical storage of the SLCCI system, realised as databases used for the Production and Product Management sub-systems, are to be catered for by two manners.
  - Firstly, physical fast access disk storage will be used by the Production sub-system to cater for storage of input and intermediary data across the processing chain, and for storage of recent ECV products made available for online access by the Product Management sub-system.
  - Secondly, physical slow access disk storage, which is relatively less expensive, will be used to for offline storage and archiving of earlier generated ECV products. The most appropriate cost-efficient balance between both disk storage types will be decided on by future implementers during Phase II, with then information on the financial resources available for the mix of fast and slow disk space and further dialogue between SEWG participants on sharing of offline storage having taken place.
  - Chosen: Balance of physical fast and slow disk space, and continuing dialogue within SEWG on sharing of disk space.

- *Web Portal (Product Dataset Storage)* –
  - The arguable de facto standard enterprise grade Open source web server facility Apache Tomcat provides the web server scalability and performance suitable for the SLCCI operational aims. Moreover, as the default web server provisioned for OpenNMS and OpenCRX, integration risk is mitigated whilst satisfying the aim for cost effectiveness.
  - Chosen: Apache Tomcat

- *Data Storage Fault Tolerance (Product Dataset Storage)* –

[29] www.opennms.org

- Introduction of physical redundancy to data storage will be accommodated. The standard options of policies for recovery are cold standby, whereby a ready backup server is populated with the state of the failed server only when the primary server fails, warm standby where the backup storage server is updated on configuration and must manually be given responsibility when the primary storage server fails, and hot standby where the redundant secondary storage server is immediately and automatically switched online when the primary device fails.
- Primarily considering the RAMS system requirements, cost effectiveness for the operational system and future sustainability of the system, a cold standby strategy is to be used for both the fast access and slower access disk storage types, with regular tape backups taken of the archived ECV products as deemed by the operational policy of the future Phase II operational facility.
- Moreover, adoption of a cold standby policy provides opportunity to share space resources with other ECV projects, so accentuating cost effectiveness across the ECV spectrum, such as through a common cloud storage facility where subscription storage costs may be diluted by sharing the cost across ECV facilities.
- Chosen: Cold standby redundancy[30], and further dialogue within SEWG towards sharing of spares.

* *Data Archiving (Product Dataset Archiving & Retrieval) –*
  - As referred to above a suitable data storage fault tolerance strategy has been adopted. The same operational policy is adopted regarding how the slow access archival disk storage addresses preservation of the ECV products stored.
  - Chosen: Slow (less expensive) offline database access.

* *Authentication to Product Access & Visualisation (Product Access & Visualisation) –*
  - Bespoke solutions are available for user authentication but are relatively expensive compared to alternative Open source options, considering the effort required in constructing the user authentication functionality. Furthermore, as elsewhere, commercial options are considered but not assessed favourably given the crucial need for cost effectiveness and sustainability of the SLCCI operational system.
  - Open source OpenID and OAuth approaches considered, OpenID is the most appropriate approach assessed. For the SLCCI purposes of user authentication, OpenID offers proof of identity, mechanism for signing on, appropriate security and IT community practice to suggest OpenID as the most suitable candidate. Moreover, as opposed to OAuth, OpenID provides a method to single sign-on to multiple sites, and therefore provides future opportunity to ECV integration with operational facilities being built by other ECV projects. Moreover, OpenID is currently facilitated for the Earth System Grid Federation (ESGF) and may provide opportunity for the SLCCI system to participate as an ESGF node for dissemination of ECV products during Phase II and beyond, so enhancing sustainability opportunities.
  - Chosen: OpenID

* *Interoperability of Catalogues (Product Access & Visualisation) –*
  - The system on which the SLCCI is based, namely DUACS, uses THREDDS for metadata cataloguing and dissemination of data. Given the aim of interoperability between

[30] SLCCI-SRB-REQ_15-510

the products of different ECVs, THREDDS provides a reasoned means by which the SLCCI system will make its catalogue available to the outside world, for users directly and a Central Information System[31]. Furthermore, the NetCDF-CF flavoured format being arranged by the CCI Data standardisation Working Group (DSWG) provides a common means to represent a catalogue, and NetCDF-CF is also the means of representing catalogues by THREDDS. Moreover, interoperability between the SLCCI system with the ESGF is technically viable considering the ESGF is similarly based on THREDDS; OGC web services and virtual cataloguing across the SLCCI system and ESGF beyond the CCI programme offers the opportunity to disseminate ECV products to a wider audience and enhance preservation of the ECV products, so supporting sustainability.
    - Chosen: THREDDS

- *Product Visualisation (Product Access & Visualisation)* –
    - The OGC Web Map Service (WMS) is the de facto standard within Earth Observation for the serving of geo-referenced images across the internet. Furthermore, WMS is the image serving Web Service commonly provisioned by THREDDS. The OGC service is the most apt for product visualisation, of the portfolio of OGC Web Services. On balance, a bespoke design and implementation of a geo-referenced ECV product data would be significantly more expensive than using the implementation already provided by THREDDS. THREDDS is arguably already robust having already been used in Earth Observation operational environments.
    - Chosen: OGC WMS via THREDDS

- *Product Download (Product Access & Visualisation)* –
    - Bulk download of ECV data products are to be made available for the SLCCI operational system by FTP and HTTP, provisioned by the THREDDS Data Server; external users may not wish to use only WMS for viewing and downloading targeted subsets of the ECV data but rather download files representing the whole data set. Given the usage of THREDDS for DUACS, which the SLCCI operational system reuses, and the convenience of already hosting WMS, the use of THREDDS for offering ECV data bulk download by FTP and HTTP is appropriate.
    - Chosen: FTP & HTTP via THREDDS

- *Transaction Accounting (Product Access & Visualisation)* –
    - Transaction accounting will be provisioned by OpenCRX given its usage towards Incident Management for the SLCCI operational system, and for similar reasons as earlier indicated for Incident Management.
    - Chosen: OpenCRX

- *Transfer Protocol (Product Access & Visualisation)* –
    - As reasoned above for the means of Product Download, the transfer protocols to be provided via THREDDS are both HTTP and FTP. Usage of both approaches allows users to bulk download either through FTP client or via a portal centralised fashion with the SLCCI portal (where additionally, context SLCCI information is available nearby, such as the products handbook).

[31] SLCCI-SRB-REQ_15-400

   - Chosen: FTP and HTTP

- *Product Access Ticketing System (Product Access & Visualisation)* –
   - The Customer Relationship Management system described above, namely OpenCRX which makes provision for a ticketing system, is to be adopted based on prior reasoning.
   - Chosen: OpenCRX

- *Product Handbook Media (Product Access & Visualisation)* –
   - The media on which the product handbook is to be distributed must be practical and useful to address different levels of media availability across the user community, whilst also remaining cost effective. The availability of server-side hyperlinked (HTML) and a standalone PDF document, serve this balance.
   - Chosen: HTML & PDF

- *Word Search (Product Access & Visualisation)* –
   - On balance, the local site word search capabilities will ensure completeness of search and by different means, depending on levels of expertise. Tailoring of commercial OTS tools and technologies are beyond the scope of sustainability and cost effectiveness of the SLCCI project, and it is found that the most suitable Open source alternative is Apache Solr, enterprise grade search capability. By default, the tool conveniently resides within a Tomcat server habitat, so mitigating SLCCI development risk given adoption of Tomcat (above).
   - Chosen: Apache Solr

- *Metadata Editor (Product Management)* –
   - The existing bespoke DUACS metadata editor is apt for reuse for the editing of ECV metadata, given its inherent simplicity and usage targeted to Sea Level processing. The exercise of metadata editing will not require any functionality more sophisticated than that already offered by the DUACS editor.
   - Chosen: Reuse of DUACS standalone metadata editor

- *Monitoring Tools & Technologies (Monitoring)* –
   - The criteria for the monitoring tools and technology stack adopted for KPI measurement and incident management similarly apply generally towards the SLCCI monitoring engine for the Monitoring sub-system. OpenNMS remains as the vehicle for this SLCCI capability, as earlier described.
   - Chosen: OpenNMS

- *Monitoring CRM Tool (Monitoring)* –
   - The CRM capabilities associated with the Monitoring sub-system are derived from the same OpenCRX usage as for other SLCCI sub-systems.
   - Chosen: OpenCRX

- *Incident Management System (Monitoring)* –
   - Incident management capabilities required by the Monitoring sub-system similarly serve monitoring for the Incident Management Reporting operation of the processing chain (Measures & Built Indicators) described earlier. OpenNMS and OpenCRX are adopted as the monitoring and reporting tools serving sub-systems incident management capability of the SLCCI system.

- Chosen: OpenNMS & OpenCRX

- *Fault Tolerance Patterns (Monitoring)* –
    - The adoption of the cold standby fault tolerance pattern as defined above for Data Storage Fault Tolerance, similarly applies to fault tolerance across the SLCCI system given the same reasoning.
    - Chosen: Cold standby redundancy, and further dialogue within SEWG towards sharing of spares.

- *CRM, Monitoring (Operational)* –
    - The Customer Relationship Management capability of the SLCCI system is through OpenCRX, the same business-logic functionality applied across the SLCCI system and in this specific case in its usage with monitoring.
    - Chosen: OpenCRX

- *Configuration (Operational)* –
    - As is similarly the case with the metadata editor, the editing of configuration for the SLCCI system will be the responsibility of reused DUACS capability, given cost-effectiveness and robustness of solution, and the operational robustness having been proven by an already existing operational system[32].
    - Chosen: Reuse of DUACS configuration editor

- *Backup Patterns (Operational)* –
    - The SLCCI data archive is driven by the Products Management sub-system, suitably archiving ECV products through offline slow-access physical means, and similarly providing the means of backup of the generated ECV products made available to the outside world through the Products Access & Visualisation sub-system. Moreover, the cold standby pattern adopted earlier for data storage fault tolerance provides a ready vehicle of data duplication of the SLCCI archive.
    - Chosen: SLCCI archive

- *Simultaneous Downloads (Resources)* –
    - Given the tools and technology stack adopted via other trade-off areas above, for instance Apache Tomcat, the provision of enterprise grade scalable download capabilities is comfortably met via the web server. The SLCCI provision of means to simultaneously download products in the form of FTP, HTTP and OGC interfaces are operationally capable and scalable, and supported by THREDDS as the vehicle for data and catalogue dissemination.
    - Chosen: THREDDS & Apache Tomcat capabilities

- *Disk-space Provision (Resources)* –
    - Disk-space will be provisioned for both Production and Product Management databases through reuse of existing DUACS capability, respecting the calculation of total required SLCCI system data.
    - Chosen: Reuse of DUACS disk-space capability

[32] SLCCI-SRB-REQ_15-420

- *Inventory System (Resources) –*
    - The matter of provisioning and maintaining an inventory of SLCCI assets, although not directly related to the production of ECV products, is nonetheless an important operational inclusion. As is similarly the case in reasoning for monitoring and customer relationship management, an open source solution is important for the cost effectiveness, and ultimate sustainability, of the SLCCI system. Given these fundamental criteria, and the need to adopt a scalable tool for an enterprise level operational system, OCS Inventory[33] is adopted. Moreover, usage of this inventory system for SLCCI may potentially also position the CCI spectrum of ECV projects to hold a unified inventory system, sharing effort in administering the facility and exploiting opportunities to share spares on a CCI wide inventory system.
    - Chosen: OCS Inventory

- *User Authentication (Security & Privacy) –*
    - As defined earlier for use of authentication to Product Access and Visualisation, OpenID provides the means by which authentication of user identity will take place.
    - Chosen: OpenID

- *Information Security (Security & Privacy), Physical Security (Security & Privacy), Penetration Tests (Security & Privacy), Encryption Facility (Security & Privacy)*
    - The matter of SLCCI information security, physical security of assets, provision of penetration tests and an encryption facility closely envelop the matter of security and privacy. These concerns will be predicated by the inclusion of the user authentication earlier discussed. Moreover, information and physical security will be provided by the operationally robust environment which has been inhabited by the system on which SLCCI is reused, namely DUACS; the security policies will remain as with DUACS, given the similar security protocols required across both. With regards to penetration testing, it is suggested that this be conducted for the SLCCI system on a periodic bases commencing from completion of CCI Phase II by the future implementers. The commencement of the operational service, where the SLCCI operational system is first made available to the outside world, is an apt moment to perform the penetration testing, and from there onwards it is suggested penetration testing be performed on a yearly basis; this is a reasonable balance given the matter of cost-effectiveness, sustainability and security integrity required for the operational system. In the event of different ECV projects sharing resources during CCI Phase II, penetration testing is one such candidate where joint testing across ECVs would be beneficial. Also, it has been decided that an encryption facility is not a concern requiring satisfaction during Phase I, given the overall security benefit in relation to sustainability of ECV products.
    - Chosen: Operational environment re-use, yearly penetration testing.

- *Machine Operating System (Portability) –*
    - As with the case with the re-used DUACS system, the operating system for the SLCCI system environment will be Linux. An audit of the configuration of DUACS equipment and software will be performed by the future implementers during CCI Phase II, and again confirmed that licensing allows the same operationally proven

[33] www.ocsinventory-ng.org

environment to be reused for the SLCCI system. Moreover, the CCI Phase II audit will affirm, as is confirmed during Phase I, that the operating system will be amenable to virtualisation, allowing the future placement of the SLCCI system potentially on other systems, and therefore accentuating the sustainability of the SLCCI system beyond the CCI programme.
    - Chosen: Linux

- *Configuration System (Software Quality)* –
    - The source code management tool for adoption by future implementers during CCI Phase II is crucial to the source code auditing, traceability, planned organisation and in-parallel work by the then development team. Commercial products which are available to the level of development required for the SLCCI system, particularly IBM Rational ClearCase, are unsustainable in the context of SLCCI maintenance given the responsibility of sustainability. Alternatively, the commonly used tool by the consortium for source code management is Subversion (SVN), allowing versioning and concurrency management. Moreover, traceability of reused code to the DUACS project, on which the SLCCI system is based, will be supported by Subversion which has been similarly used for DUACS.
    - Chosen: Subversion (SVN)

- *Observation Report Management System (Software Quality)* –
    - Issue tracking and management is crucial to the undertaking of Phase II development by future implementers for CCI Phase II. Apache Jira is commonly used by the engineering parties of the consortium, is open source, and scalable to accommodate future usage during CCI Phase II and beyond the end of the CCI Programme when ECV integration may take place. The future implementers of the SLCCI programme during CCI Phase II will need traceability to existing DUACS issues potentially migrated into the SLCCI system, in accordance to the recognised ECSS standards, particularly ECSS-Q-ST-80C.
    - Chosen: Apache Jira

- *RAMS Measurement (RAMS)* –
    - As earlier described during KPI measurement, OpenNMS will provide the means of orchestrating RAMS measurement.
    - Chosen: OpenNMS

- *System Tuning (System Configuration & Delivery)* –
    - As is the case earlier described with operational configuration, system tuning by way of configuration will adopt similar approach by way of reusing existing DUACS configuration editing capability[34].
    - Chosen: Reuse of DUACS system tuning editor

- *Data Storage (Data Definition & Database)* –
    - Data storage volumes and approach to balancing expensive (fast) access with relatively inexpensive (slower) access for archiving, have been earlier explored. The relationship database management of choice is Postgres, given its Open source and

[34] SLCCI-SRB-REQ_15-420

operational grade strengths such as scalability. Moreover, Postgres integrates well with other scalable trade off adopted tools, such as for CRM and KPI accounting.
  - Chosen: Postgres

- *Data Export (Data Definition and Database)* –
  - Export of data is accommodated as features inherent to the data storage tools discussed above, including provision of in-built Postgres functionality to perform data export.
  - Chosen: Postgres

- *Catalogue Provision (Human Factors)* –
  - Similarly, as earlier reasoned for interoperability of catalogues with external systems, the catalogue for the SLCCI system is provided by THREDDS. Through the THREDDS service, the SLCCI system will provide a THREDDS data server catalogue service by which external users can access SLCCI catalogue information through the web portal.
  - Chosen: THREDDS

- *Machine Activity MMI (Human Factors)* –
  - Earlier adoption of OpenNMS was reasoned as the incident management tool for SLCCI system. OpenNMS is built in with a suitable graphical user interface for the portrayal of system integrity status.
  - Chosen: OpenNMS

- *Metadata Query (Human Factors)* –
  - As similarly the case with the above reasoned adoption of THREDDS on a number of other fronts, metadata querying will also be met via the THREDDS provisioning of a catalogue. Textual search of the site is conducted via earlier adoption of Apache Solr and will cover site search only, with metadata search of the SLCCI product catalogue being provided by the THREDDS capability.
  - Chosen: THREDDS

6.4. Collaborative Pan-ECV System

As referred to in the introduction, the matter of attaining cost-effectiveness through collaboration with other ECV systems is of the utmost importance, and with system reuse drives our activities towards cost-effectiveness as desired by the Statement of Work. Indeed, the matter of pan-ECV collaboration must be considered in every area of design of the SLCCI system. To this end, we reason towards, and consequently define, one of our Viewpoints as a Pan-ECV Collaboration View (§7.3).

This matter of involving the SLCCI system with other ECV systems falls under two guises.

- *SLCCI and CIS Interoperability*. The System Requirements Document (SRD) defines a Central Information System[35] (CIS). Through our Functional View (§7.2) and Pan-ECV Collaboration View (§7.3), we define the interface between the SLCCI and the CIS. As will be seen, this interfacing involves (i) product access and visualisation, and (ii) monitoring. Considering TDS

[35] SLCCI-SRB-REQ_15_400, SLCCI-SRB-REQ_15_410

services realise open, common, standards (OpenDAP, WCS, WMS, HTTP/FTP), we have proposed in the SRD, and subsequently to the SEWG, the usage of a common interface to this Central Information System (CIS).

- *Pan-ECV Collaboration*. There is the wider matter of how not only the SLCCI system, but all ECV systems can achieve a sufficiently cost-effective level of collaboration. Again, our concept of a Central Information Service (CIS) comes into play, as a vehicle to centralise all product cataloguing, access and visualisation across the ECVs. The Central Information System is responsible for coordinating information flow between the ECV systems and the users, through interoperable, standard interfaces.

The main functions of the CIS are as follows (n.b to be confirmed by SEWG and ESA) -

- Catalogue and inventory of all ECVs
- To provide an integrated interface to access the catalogue and the data product in an interoperable way.
- To monitor all the technical interfaces provided in the distributed systems, in order to have an updated knowledge of the state of the system of systems for the central user support team.
- To monitor the user transactions, to know who access which ECV and how.

With regards to the potential application of the CIS to other ECVs, we have forwarded a TN to the System Engineering Working Group (SEWG), proposing a preliminary design for a pan-ECV system. Appendix A described the pan-ECV requirements described in the TN. We explore these matters further in the Pan-ECV Collaboration View, and preliminarily illustrate such a pan-ECV system via Figure 12.

We recognise the ambitiousness in reaching a single pan-ECV system across all ECV concerns, rather than proportioning smaller subsets of ECV projects, but we reason that consideration of a full all-ECV system at this stage will more efficiently uncover pan-ECV similarities across the ECV spectrum which can be worked by the SEWG at the earliest opportunity.

We recognize the considerable engineering effort and cooperation required in designing and realising a Central Information System. Equally, however, we reason that the advantages attained (to our common SEWG effort, to the quality of the resulting system, and also ultimately to the end user) outweigh the effort and risk in providing a Central Information System. Also, the provision of a Central Information System across ECVs would accentuate the desired operationalisation of products as described in the SoW towards meeting user needs. Additionally, the engineering of a correctly scoped pan-variable system along similar technologies is a proven practical exercise, as demonstrable through MyOcean and SeaDataNet.

A pertinent advantage to the use of THREDDS for exposing each ECV's product data, is the varied product data formats which THREDDS is able to absorb under its Common Data Model (CDM) structure, so widening the ECV reach of THREDDS – ECV projects adopting THREDDS can find that not only can product data under HDF be absorbed, but also GRIB, NEXRAD and NetCDF. We observe that a number of the ECV Preliminary System Analysis Documents (PSAD) available through the CCI System Engineering Working Group (SEWG) denote the use of NetCDF; absorption of such NetCDF formatted data is accommodated through TDS. Indeed, the Data Standards Working Group (DSWG) is working towards a common NetCDF format across all ECVs.

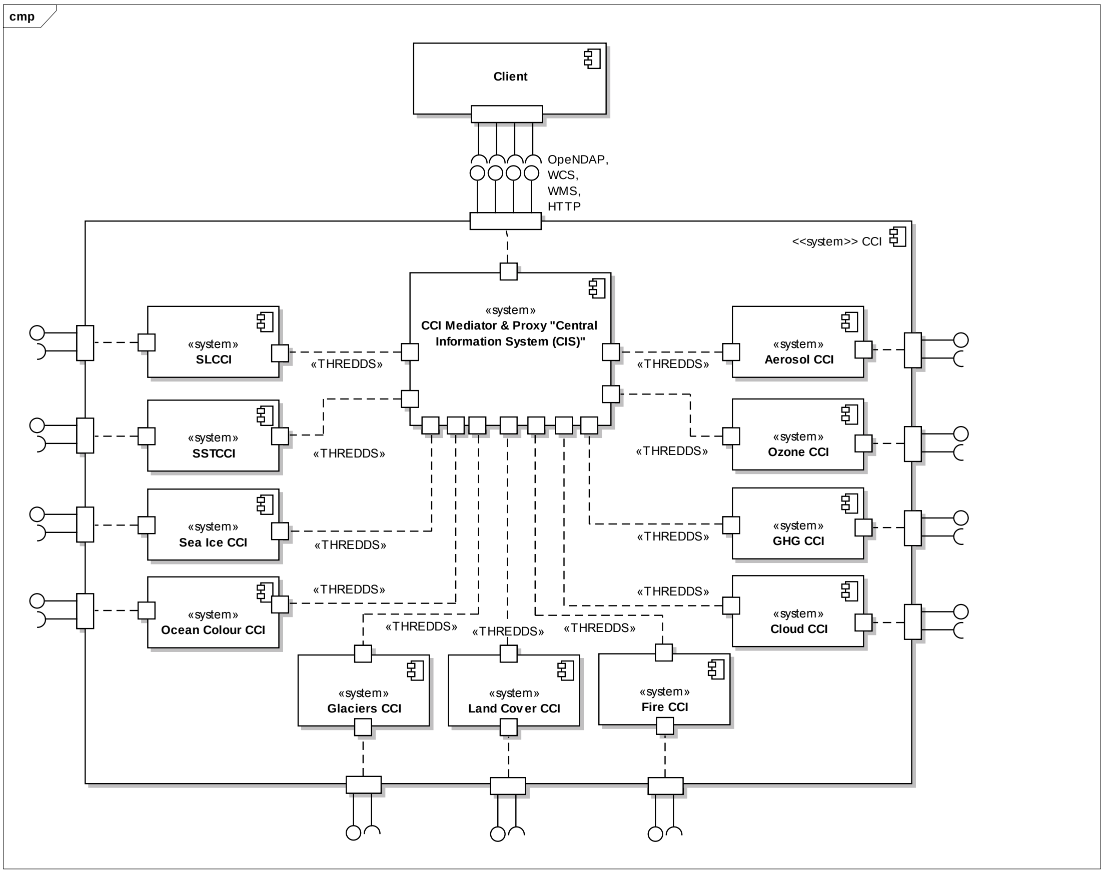

Figure 12 - Distributed Pan-ECV Architecture for a Common Product Access & Visualisation

7. Architectural Views and Perspectives

We have reasoned for the adoption of standard IEEE 1471, a methodology for architectural description of software intensive systems (§4.2). The standard is also an apt vehicle for formally defining a considered separation of concerns during design, tailored to the system at hand through the definition of a Viewpoints catalogue.

In this chapter, we define our Viewpoints for SLCCI. No universally-applicable system engineering catalogue of Viewpoints exists; indeed, no untailored Viewpoint catalogue could conceivably apply universally to all systems engineering activities. Rather, we observe the established Viewpoints catalogues, and draw from these to arrive at a reasoned Viewpoint catalogue definition tailored to SLCCI, which completely encompasses all concerns for an SLCCI specification.

Interestingly, we find that our Viewpoints catalogue is ECV-neutral, and could be equally applied to other ECVs. We exploit this advantageous side effect, to define a CCI Viewpoint catalogue which may be used to help specify, and verify, other ECV systems.

We then weight these newly defined Viewpoints according to their relevance to our design; this weighting will illustrate the relative effort attributable to each Viewpoint during our design activities.

Having defined and weighted our Viewpoints, we embark on their realisation - an exploration and specification of our system, through the Views instantiated by the Viewpoints.

7.1. Definition of SLCCI Viewpoints

We first acknowledge the established industry position on Viewpoints, listing and describing catalogues commonly adopted. We draw from these, to arrive at an argued, tailored, Viewpoint catalogue covering all SLCCI concerns in a complete fashion.

We recognise the following established viewpoint catalogues –

- Kruchten [RD21] - 4 + 1 View Model
  - On the Working Group which devised the IEEE 1471 standard [RD8], and its ISO equivalent ISO/IEC 42010:2007 [RD9], Kruchten's earlier pioneering work towards a similar framework resulted in the 4+1 View Model. Four views are described, relating to Logical, Development, Process and Physical views, with a fifth view describing scenarios intersecting the other four. IEEE 1471 standardised Kruchten's concept of a view, adding at a meta-level the concept of a Viewpoint – the abstract recipe-book upon which an associated view is realised.
- Zachman Framework [RD10]
  - The influential Zachman Framework, which has undergone numerous iterations since its first release, portrays enterprise architectural concerns through a 2 dimensional matrix.
- Rozanski & Woods [RD22] – Viewpoints and Perspectives
  - Rozanski and Woods offer a practitioner-oriented guide to IEEE 1471, providing a viewpoint catalogue from an operational, enterprise, established perspective. The Viewpoints forming the catalogue fall into six categories, namely Functional, Information, Concurrency, Development, Deployment and Operational. Their model defines Viewpoint cross-cutting concerns labelled Perspectives, which cover Security, Performance & Scalability, Availability & Resilience, Evolution, Accessibility, Development Resource, Internationalisation, Location, Regulation and

Usability. Collectively, the Viewpoints and Perspectives offer a complete covering of concerns for a generic architectural specification.

- Hofmeister, Nord & Soni (Siemens Corporate Research) – Views [RD25]
    - Hofmeister et al describe a software architecture as separated into four “views”, namely Conceptual, Module, Execution and Code - these describe the architectural domain elements, the decomposition into layers, a run-time angle, and the mapping to source files, respectively.
- Reference Model for Open Distributed Processing (RM-ODP) [RD26]
    - The RM-ODP methodology ascribes five different “Viewpoints”, namely Enterprise, Information, Computational, Engineering, and Technical, each tackling distinct but inter-related aspects of an architecture, each with its own UML oriented modelling methodology.
- The Open Architecture Framework (TOGAF) [RD27]
    - TOGAF provides a detailed, framework driven, ontology of hierarchical viewpoints. The higher level taxonomy comprises of business architecture views, data architecture views, systems architecture views, technology architecture views, each comprising of lower level, constituent, views; Views and Viewpoints are described in section 35.4 of TOGAF 9. The arrangement is in keeping with the ISO realisation of IEEE 1471 - “In general, TOGAF embraces the concepts and definitions presented in ISO/IEC 42010:2007” [RD27].

In our analysis, we draw from the above established canon of work on viewpoints cataloguing, and make the following observations, before we draw on these frameworks to arrive at our tailored viewpoint catalogue.

Kruchten’s framework is geared exclusively to software architectures with too limited a concern for wider systems engineering and architectural matters, as is demanded for our task at hand. This same observation may be equally levied to the Siemens model.

Consequently, the Rozanski & Woods, RM-ODP, and TOGAF models are likelier candidates for our drawing from, as they fully absorb systems engineering and operational concerns. Of these three, we reason that the RM-ODP is angled towards distributed processing systems, and although this is a significant concern for the SLCCI system, we nonetheless wish for our tailored viewpoints catalogue to be scoped across a fuller gamut of considerations and not be skewed to distributed concerns. As for the TOGAF framework, although judiciously complex and offering a wide spectrum of viewpoint flavours, lacks a direct linkage to UML modelling which we ideally require.

Ultimately, we find that the Rozanski & Woods framework offers a significant match to our SLCCI needs. The constituents in their viewpoint catalogue, which together completely cover all concerns for a generic system, tie in significantly with the separation of concerns demanded for SLCCI. We therefore adopt the main Viewpoint elements of their catalogue, and tailor these to draw in apt input from RM-ODP and TOGAF. Indeed, such tailoring of viewpoints is a common engineering undertaking, as described by TOGAF (§36.6[36])

We add to our tailored SLCCI viewpoint catalogue, viewpoints for two significant concerns to our SLCCI system, namely viewpoints for (i) pan-ECV collaboration, portraying efforts, concerns and modelling towards the significant effort of bringing in pan-ECV collaboration into our design, and (ii) system re-use.

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[36] http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap35.html#tag_35_06

The SLCCI stakeholders are defined via two main groups –

- *Operational system stakeholders* - Stakeholders related to the running of the operational system –

  1. *Scientific Expert* – a direct sub-type of SLCCI Product Contributor; SLCCI Product Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Scientific Expert is responsible for scientific modelling across the production chain of the operational system. This user is also used to express the scientific expertise during Phase I.
  2. *Product Expert* – a direct sub-type of SLCCI Product Contributor; SLCCI Product Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Product Expert is responsible for establishing and assessing the quality of products plus providing scientific judgement across the production chain.
  3. *Product Manager* – a direct sub-type of SLCCI Product Contributor; SLCCI Product Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Product Manager is responsible for maintaining the product database, the product catalogue content and managing metadata, of the operational system.
  4. *Service Desk* - a direct sub-type of SLCCI Support Contributor; SLCCI Support Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Service Desk is responsible for direct interactaction with external users.
  5. *Service Manager* - a direct sub-type of SLCCI Support Contributor; SLCCI Support Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Service Manager is responsible for stewarding the running of the operational system.
  6. *Support Operator* - a direct sub-type of SLCCI Support Contributor; SLCCI Support Contributor is a direct sub-type of SLCCI Contributor, which is a direct sub-type of SLCCI User. The Support Operator undertakes and supports the system operations internally.
  7. *SLCCI Product User* – a direct sub-type of SLCCI User, the ultimate user of the ECV products and typically external to the SLCCI system.

- *Operability development stakeholders* – We also recognise stakeholders involved in the definition and operability of the SLCCI operational system, during the CCI Programme. The type model of these stakeholders is portrayed below; the diagrams portray the stakeholders as tree leafs, above which are portrayed the super-types of those stakeholder types. Scientific expertise expressed during CCI Phase I is represented by the CMUG and Scientific Expert above, the later also accounting for scientific expertise during the operation; this conveniently allows the stakeholder set to have a common scientific expert party, rather than an expert party during development and during operation. The stakeholders are as follows -

  8. *System Development Engineer* – a direct sub-type of SLCCI Support Constructor; a system engineer involved in the development of the operational SLCCI system during CCI Phase II.
  9. *CMUG* – a direct sub-type of SLCCI Constructor; a party representative of the ultimate external user base of the SLCCI operational system.
  10. *Client* – ESA. A direct sub-type of SLCCI Support Contributor; the CCI programme is conducted under the auspices of ESA.

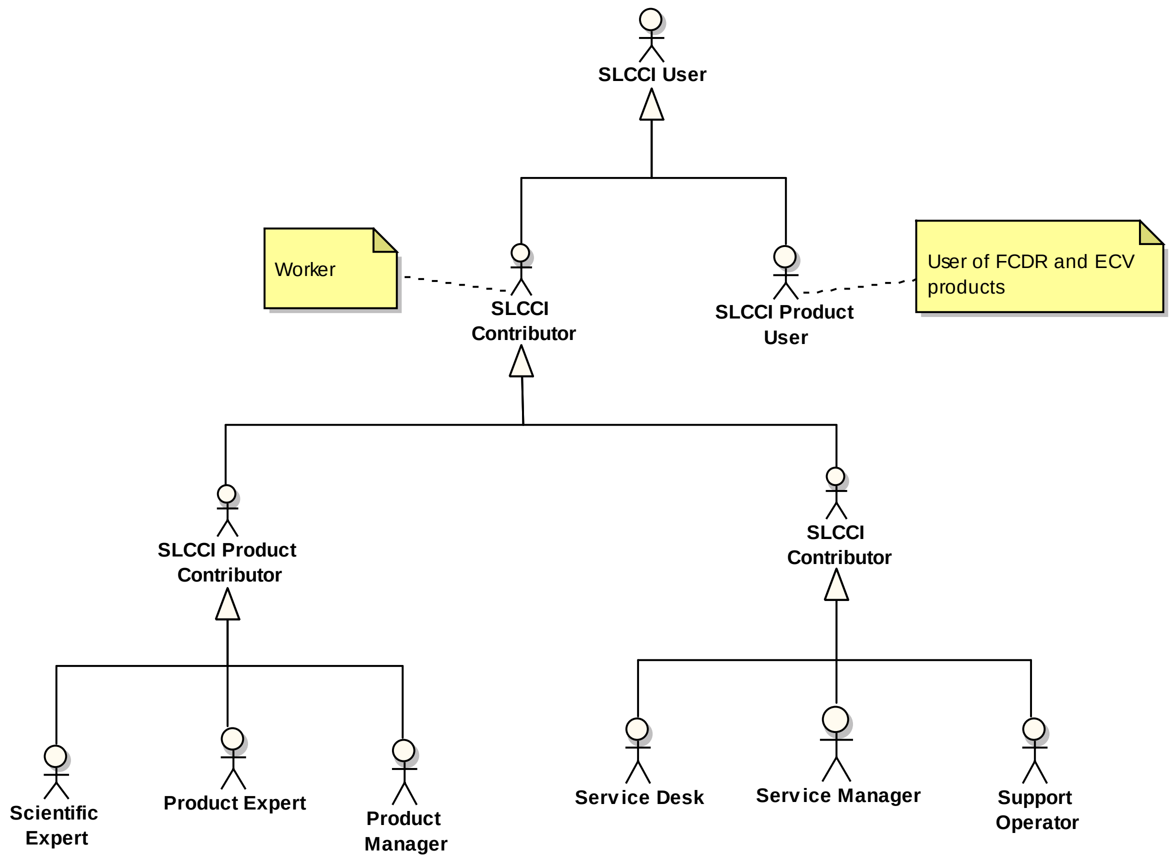

Figure 13 – Operational system stakeholders

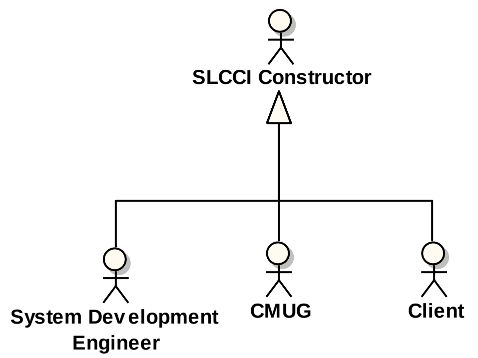

Figure 14 – Operability development stakeholder

We arrive at a categorisation of viewpoints, for the SLCCI system. That is, we propose a tailored viewpoints portfolio which aptly and completely cover all separation of concerns to represent the whole SLCCI system –

1. Functional
2. Pan-ECV Collaboration
3. System Reuse
4. Information
5. Operational
6. Deployment
7. Development

To define these viewpoints, we propose use of the following template, incorporating the style of ISO/IEC 42010 style as interpreted by [RD24] –

- Viewpoint name
- Overview
- Stakeholders
- A summary of the concerns addressed
- Modelling approach – e.g diagram types, profile, etc
- Notes

Our viewpoints may be equally applicable to other CCI projects, and so we hereafter label the views set as *CCI Viewpoints*. We list the CCI Viewpoints are as follows, and elaborate on them further with help from the above template -

CCI Viewpoint Definition **Viewpoint Name –** Functional	
Overview	A Viewpoint representing functionality of the system. This view describes the functional components of the system, and the interfaces between them. This view also defines the interfaces which are exposed by the system to external systems.
Stakeholders	○ *Product Expert* – Interest in knowledge of the functionality of the Production subsystem, to understand context in assessment of the quality of products being developed across production chain. ○ *Product Manager* – Interest in knowledge of the functionality of the Products Management and Production subsystems, to support management of the product arriving from Production subsystem. ○ *Service Manager* – Interest in knowledge of the overall functionality of the system in order to steward the overall running of the operational system. ○ *Support Operator* – Interest in knowledge of the overall functional architecture of the system to support the operational maintenance of the system. ○ *System Development Engineer* – Interest in knowledge of the functional architecture of the system to accurately interpret specification towards implementation. ○ *CMUG* – Interest in knowledge of the external interfaces of the system, to ascertain suitability of product accessibility. ○ *Client* – Interest in knowledge of Functional Viewpoint to be realised in CCI Phase II.
Concerns	The high-level functionality of the system must be exhaustively defined, by functionally describing the components residing in the system, and their associated interfaces.
Modelling approach	UML CCI Profile. UML diagrams used comprise of Component Diagram, to model the internal composition of the system, their interfaces, and interfaces exposed to external system. Inheritance notation may be judiciously used, as is allowed by the UML grammar, to describe sub-types of a component.
Notes	Reference Viewpoints – [RD22,RD29]

Table 4 - Definition of Functional CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name -** Pan-ECV Collaboration	
Overview	A Viewpoint enveloping the concerns related to system engineering towards collaboration between CCI ECV systems.
Stakeholders	○ *Scientific Expert* – Interest in potential Pan-ECV engineering collaboration to satisfy potential Pan-ECV scientific collaboration. ○ *Product Expert* – Interest in potential Pan-ECV engineering collaboration to satisfy potential Pan-ECV product merging collaboration. ○ *Product Manager* – Interest in potential Pan-ECV engineering collaboration towards joint management of pan ECV products. ○ *Service Manager* – Interest in sharing of operational service resources across ECVs, such as sharing of service desk human resources. ○ *Support Operator* – Potential of role being shared across ECVs. ○ *System Development Engineer* – Interest in sharing of system engineering resources across ECVs. ○ *CMUG* – Interest in potential Pan-ECV engineering collaboration to satisfy potential Pan-ECV scientific collaboration. ○ *Client* – cost effectiveness
Concerns	This Viewpoint can be involved in the observation of functionality of any part of the system, with the aim of bringing functional commonality between the SLCCI and other ECV systems wherever cost effective.
Modelling approach	UML CCI Profile. Component Diagrams are used to describe, internally, parts of the SLCCI system, in view of how these parts may be accommodated in the practice of functionally re-locating them to somewhere central. Component Diagrams are also used to describe relationships between different SLCCI systems, and relationships between SLCCI systems and a centralised, facilitating, system such as the Central Information System (CIS).
Notes	-

Table 5 - Definition of Pan-ECV Collaboration CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name –** Reuse	
Overview	This Viewpoint relates to system engineering work towards reuse of existing system.
Stakeholders	○ *System Development Engineer* – Interest in exploitation of existing resources suitable for re-use, for cost-effectiveness across SLCCI system. ○ *Client* – Interest in exploitation of existing resources suitable for re-use, for cost-effectiveness across SLCCI system and encouraging synergies with other already existing European endeavours.
Concerns	The matters pertaining to system reuse. Reuse has bearing on a number of the other viewpoints, in particular, Functional Viewpoint, but for this Reuse viewpoint we lay the details and make sure the process is discussed, nuances and details which are important. This Viewpoint should also describe best practice for system re-use.
Modelling approach	Component Diagram to illustrate limitations of system being reused.
Notes	-

Table 6 - Definition of Reuse CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name –** Information	
Overview	This Viewpoint relates to product processing data within the system (such as processing chain inputs and ECV outputs), non-product processing information within the system (such as data required for the operational running of the system) and information flow via the external interfaces of the system to the outside world.
Stakeholders	○ *Scientific Expert* – Interest in ECV product scientific content ○ *Product Expert* – Interest in ECV product content composition. ○ *Product Manager* – Interest in management of ECV product content. ○ *Service Manager* – Interest in flow of operational information across system to serve operational integrity of the system, e.g flow of information arising from service calls for upkeep of system. ○ *Support Operator* – Interest in flow of operational information across system to serve operational integrity of the system, e.g flow of information arising from service calls for upkeep of system. ○ *System Development Engineer* – Interest in flow of information between sub-systems, and between system and the outside world via external interfaces. ○ *CMUG* – Interest in ECV product content suitability to user community. ○ *Client* – Satisfaction of product content to product suitability.
Concerns	Product processing data within the system, non-product processing information within the system and information flow via the external interfaces of the system to the outside world, in particular the nature of information entering the system (as defined within the DARD) and leaving the system for users (as defined by the PSD).
Modelling approach	Activity Diagrams to model data flow across internal SLCCI components during product generation.
Notes	Reference Viewpoints - [RD22,RD29]

Table 7 - Definition of Information CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name –** Operational	
Overview	Describe all operational aspects of the system, including realisation of reliability, maintainability and accessibility.
Stakeholders	○ *Service Manager* – Interest in satisfying overall operational expectations of users, for example satisfying Availability of product access from system. ○ *Support Operator* – Interest in satisfying operational expectations of users in maintenance of system, e.g mean time taken to maintain system during downtime. ○ *Service Desk* – Interest in satisfying operational expectations of users of system related to correspondence with external users to carry out their requests via ticketing system. ○ *System Development Engineer* – Interest in satisfying operational system requirements. ○ *CMUG* – Interest in operational system capability for satisfying ECV product availability to user community. ○ *Client* – Satisfaction of user expectations.
Concerns	Describe all operational aspects of the system, comprised of monitoring of system operability, storage and maintenance of user information, user hierarchy, system monitoring, and realisation of reliability, maintainability and accessibility.
Modelling approach	Class Diagrams and Component Diagrams.
Notes	Reference Viewpoints - [RD22,RD29]

Table 8 - Definition of Operational CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name –** Deployment	
Overview	A Viewpoint describing the deployment architecture.
Stakeholders	o *Service Manager* – Interest in mitigating system downtime for required deployment during operational running of system. o *Support Operator* – Interest in carrying out required deployment during operational running of system. o *Service Desk* – Interest in user correspondence required during deployment to operational system. o *System Development Engineer* – Interest in system deployment prior to operational start of system, and making provision for future system deployment during operational running. o *Client* – Satisfaction of user expectations.
Concerns	A Viewpoint describing the deployment architecture, realising the functional architecture as described by the Functional Viewpoint.
Modelling approach	Deployment Diagram, with linkage to corresponding Component Diagrams of Information View.
Notes	Reference Viewpoints - [RD22,RD29]

Table 9 - Definition of Deployment CCI Viewpoint

CCI Viewpoint Definition **Viewpoint Name –** Development	
Overview	A Viewpoint describing all system development aspects of the project, towards realising the system specification.
Stakeholders	o *System Development Engineer* – Phase I specification, and Phase II system implementation of specification by future Phase II parties. o *Client* – Satisfaction of system development expectations, on time and to budget accentuating cost-effectiveness.
Concerns	All aspects of implementation of the system, including the realisation of system development of the reused system as described by the Reuse View.
Modelling approach	Class Diagrams to describe the logical model of the already implemented system being reused.
Notes	Reference Viewpoints - [RD22,RD29]

Table 10 - Definition of Development CCI Viewpoint

With regards to our *CCI Perspectives*, our preliminary analysis and input from the System Requirements Document (SRD) suggests that the following Perspectives are pertinent to our architectural description. As with Views these Perspectives are mappable to the SRD, and moreover support the Views.

- Design & Implementation Constraints
- Security & Privacy
- Portability
- Software Quality
- RAMS
- Configuration & Delivery
- Human Factors
- Adaptation & Installation

With the CCI Viewpoints now defined, these need to be weighted according to their importance; this influences the distribution of effort and level of detail afforded to each view[37]. We associate varying strengths to each View and Perspective, as portrayed by the following grid. To this end, we offer the following tables. The first (Table 11) depicts a categorisation of priority, which is used in Table 12 to define the relative weight associated to each of the viewpoint categories in relation to each other.

Colour	Priority
(dark grey)	High priority
(light grey)	Lower priority

Table 11 - Weighting Priorities

Viewpoint category
Functional
Pan-ECV
Reuse
Information
Operational
Deployment
Development

Table 12 - Viewpoints and Their Relative Priorities

The Functional, Information and Operational Viewpoints are all geared to the direct satisfaction of expectations for the user. Pan-ECV and Reuse Viewpoints are paramount considerations for the achievement of cost effectiveness to the CCI programme, and arguably carry equal weight to the preceding Viewpoints. Deployment and Development are described as attributed to relatively lower priority since these are activities indirectly, rather than directly, associated with satisfying user

[37] According to IEEE 1471 terminology, a “View” is the realising of a “Viewpoint”.

expectations, and moreover these are CCI Phase II activities to be performed by future Phase II implementers. At this Phase I stage we describe early information useful for future CCI Phase II parties for their Development and Deployment of the operational system, which happens to have been derived from CCI Phase I activity, towards helping further bridge the system engineering activities between Phase I and Phase II.

Similarly, the following table illustrates the weight of each cross-cutting perspective, in the context of the Viewpoints crossed. The relative priority of each cell, in this case for a cross-cutting perspective, is associated by the colour coding defined in Table 12, towards supporting the Perspectives section (§7.9); similarly as before, these are relative priorities, and so do not portray absolute priorities of each cell. The priority justification follows as earlier argued; the cross-cutting perspectives associated with Deployment and Development Viewpoints are of lower relative priority. Similarly, the perspectives Design & Implementation, Configuration & Delivery, and Adaptation & Installation, are similarly directly associated with the process of realisation of an operational system during CCI Phase II, rather than the directly associated to a description of the operational system itself during Phase I.

Perspective	Design & Implement.	Security & Privacy	Portability	Quality	RAMS	Configuration & Delivery	Human Factors	Adaptation & Installation
Functional								
Pan-ECV								
Reuse								
Information								
Operational								
Deployment								
Development								

Table 13 - The Relative Weight Afforded to Each Perspective Given Their Relevance to Viewpoint

The content for each Perspective in a section devoted exclusively to perspectives (§7.9), since Perspectives are dimensionally cross cut Viewpoints, and we therefore reason that they reside more comfortably in their own section where each Perspective can thus be described more appropriately.

7.2. Functional View

Our first excursion into Views is with the Functional View, arguably the most important of all the Views; nonetheless, no one View can singularly describe the whole system, and the matter of a particular View's importance cannot imply that a View can be interpreted without the context of all other views combined.

We describe the functional system architecture of the SLCCI system, by (i) declaring each component residing within the system, (ii) declaring the interfaces associated with each component, (iii) declaring the externally-facing interfaces associated with the SLCCI system, and illustrating these collectively (Figure 15). Thereafter, we describe each constituent of the SLCCI system, the sub-systems and interfaces, in further detail (§7.2.2 to §7.2.17). For each sub-system/interface we describe a high-level list of the sorts of operations that are expected to be handled and referencing the SRD system requirements baseline.

7.2.1. System Architecture

Figure 15 describes the internal component organisation, and associated interfaces, of the SLCCI system; all internal components, interfaces internal to the SLCCI system, and external-facing interfaces of the SLCCI system are included. We take advantage of our CCI UML Profile to express our model.

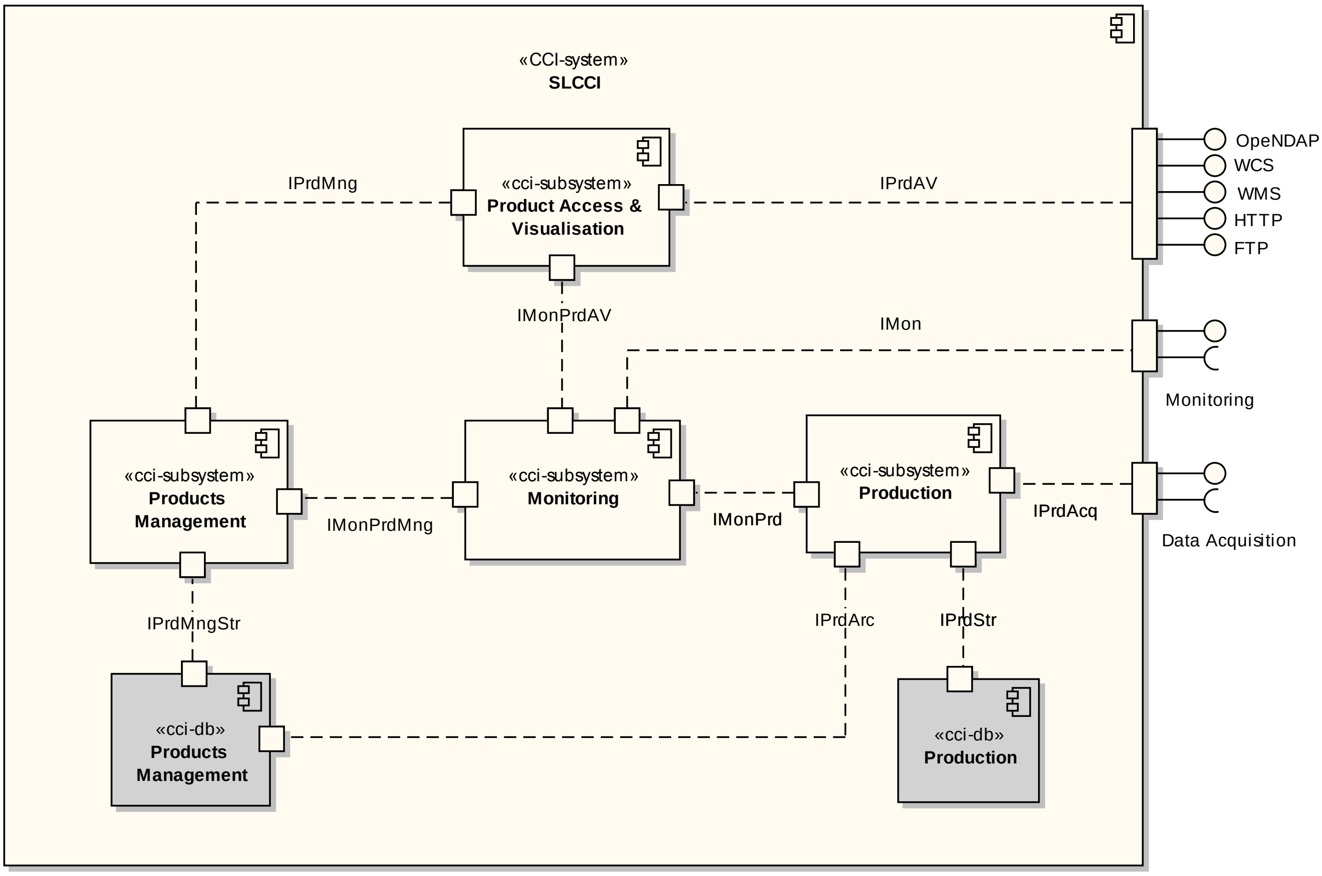

Figure 15 – Model of High Level Functional System Architecture

As well as IPrdAV and IMon serving information to external users directly, we envisage these interfaces as similarly serving a Central Information system (CIS); for example, the THREDDS linkage between the SLCCI system and a CIS, as depicted in Figure 12, provisions the CIS with the potential capability to synchronise a central common CCI catalogue with the SLCCI catalogue, and provisions the CIS with the capability to allow bulk proxy download of SLCCI products via the CCI; moreover, usage of THREDDS creates the opportunity to interface with the Earth System Grid Federation (ESGF), further inviting sustainability of the SLCCI system. The focus of this document remains solely the SLCCI system, nonetheless we recognise the importance of interfacing to a Central Information System as a pertinent vehicle for sustainability of the SLCCI system, and discuss the matter further within the Functional View (§7.2).

The table below describes each constituent of the SLCCI model.

Constituent name	Constituent type, component type (CCI Profile)	Description
Production (§7.2.2)	Subsystem	This subsystem conducts the processing chain for the generation of ECV products. This activity includes the acquisition of the upstream data necessary for this generation, the production of intermediate products across the processing chain, and production of some metadata such as quality indicators.
Product Access & Visualisation (§7.2.3)	Subsystem	This subsystem provides the product access and visualisation services needed for use by external users and external systems (e.g Central Information System). Moreover, responsible for user authentication.
Products Management (§7.2.4)	Subsystem	This subsystem manages the storage of ECV products, provides description of the ECV products through metadata, and the updating of this metadata description.
Monitoring (§7.2.5)	Subsystem	This subsystem provides the monitoring of the Production sub-system (availability of upstream data, production go smoothly), Product Access & Visualisation sub-system (availability of product access to external actors), and Products Management sub-system (availability of ECV products and metadata), forming the basis for RAMS measurement. Moreover, the Monitoring sub-system logically houses the centre of operations for the SLCCI system, supporting inventory management (OCS Inventory), customer relationship management (OpenCRX), as well as monitoring (OpenNMS).
Production (§7.2.6)	cci-db	Storage of data used during the generation of ECV products via Production sub-system, comprised of input data and intermediary data. Generated ECV products are stored in the Products Management database
Products Management (§7.2.7)	cci-db	Storage of ECV products and ECV products metadata, managed by the Products Management subsystem.

IPrdAcq (§7.2.8)	Interface	Interface for the Acquisition of the upstream data needed for the Production and the validation of the ECV products. Both provided interface (data pull) and required interface (data push) iconography are used for this interface on Figure 15, to cater for both push and pull data acquisition approaches (§6.3.4).
IPrdStr (§7.2.9)	Interface	Production subsystem feeds processing chain output into Production database via the IPrdStr interface, and similarly reads data from the Production database as described in §7.5.
IPrdAV (§7.2.10)	Interface (external)	Interface by which external users access the SLCCI products. The interface also serves as the means by which the Central Information System communicates with the SLCCI system.
IPrdMng (§7.2.11)	Interface	Interface for the provision of metadata information from the Products Management subsystem to the Product Access & Visualisation subsystem, and the means by which the Product Access & Visualisation attains ECV products demanded by external users and external systems. Furthermore, responsible for communicating user authentication information from Products Management subsystem to Product Access & Visualisation subsystem where user authentication functionality resides.
IMonPrdMng (§7.2.12)	Interface	Interface for the provision of monitoring information from the Products Management subsystem to the Monitoring sub-system, to allow the Monitoring subsystem to monitor operational integrity of the Products Management sub-system.
IMonPrdAV (§7.2.13)	Interface	Interface for the provision of information about Access and Visualisation sub-system monitoring to the Monitoring sub-system, therefore allowing the Monitoring sub-system to assess the integrity of the Access & Visualisation sub-system.
IMonPrd (§7.2.14)	Interface	Interface for the provision of information about Production sub-system monitoring to the Monitoring sub-system, allowing Monitoring subsystem to assess integrity of Production sub-system.
IMon (§7.2.15)	Interface (external)	Interface providing information on operational status of SLCCI system by the Monitoring sub-system to the outside world (e.g Central Information System).
IPrdMngStr (§7.2.16)	Interface	Interface for Products Management subsystem interaction with Products Management database, storing to and accessing ECV products archive.
IPrdArc (§7.2.17)	Interface	Interface for archiving of generated ECV products from

		Production subsystem.

Table 14 - List of SLCCI Internal Constituents

7.2.2. Production

7.2.2.1. Interfaces

The interfaces related to the production pipeline component are defined as follows.

Interface	Communicating subsystem
IPrdAcq (§7.2.8)	SLCCI interface to outside of SLCCI system for acquisition of input data to Production subsystem.
IMonPrd (§7.2.14)	Monitoring and communication of the Production subsystem.
IPrdStr (§7.2.9)	Storage and retrieval of data used across the Production subsystem process chain.
IPrdArc (§7.2.17)	Storage and archiving of resulting ECV products to Products Management database.

Table 15 – Production Component Interfaces

7.2.2.2. Functional Definition

This component represents the processing chain for the SLCCI, reused from DUACS, incorporating the prototype created by Task 3, and aligns with the System Prototype Description [RD31] processing chain. The timing of ECV production is governed by SLCCI scientific consensus under the auspices of the science lead[38], with a frequency envisaged to be once per year, the timing of which being dependent on the availability of required inputs[39]. Moreover, two modes for the ECV production exist, Delayed Time (DT) as new input data becomes available via IPrdAcq, and Reprocessing (REP) of the entire time series given evolved scientific consensus[40] as the processing chain improves within the Production sub-system. The modular approach instilled across the SLCCI system, including the constituents of the Production sub-system itself, encourages easier introduction or exchange of processing logic across the processing chain[41].

[38] SLCCI-SRB-REQ_15-010

[39] SLCCI-SRB-REQ_5-042, SLCCI-SRB-REQ_5-052

[40] SLCCI-SRB-REQ_0-053, SLCCI-SRB-REQ_15-010

[41] SLCCI-SRB-REQ_0-500, SLCCI-SRB-REQ_15-100

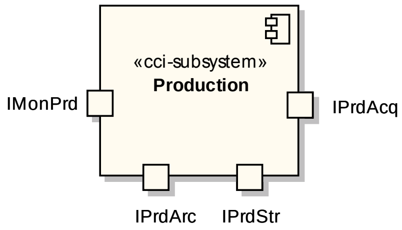

Figure 16 – Production subsystem

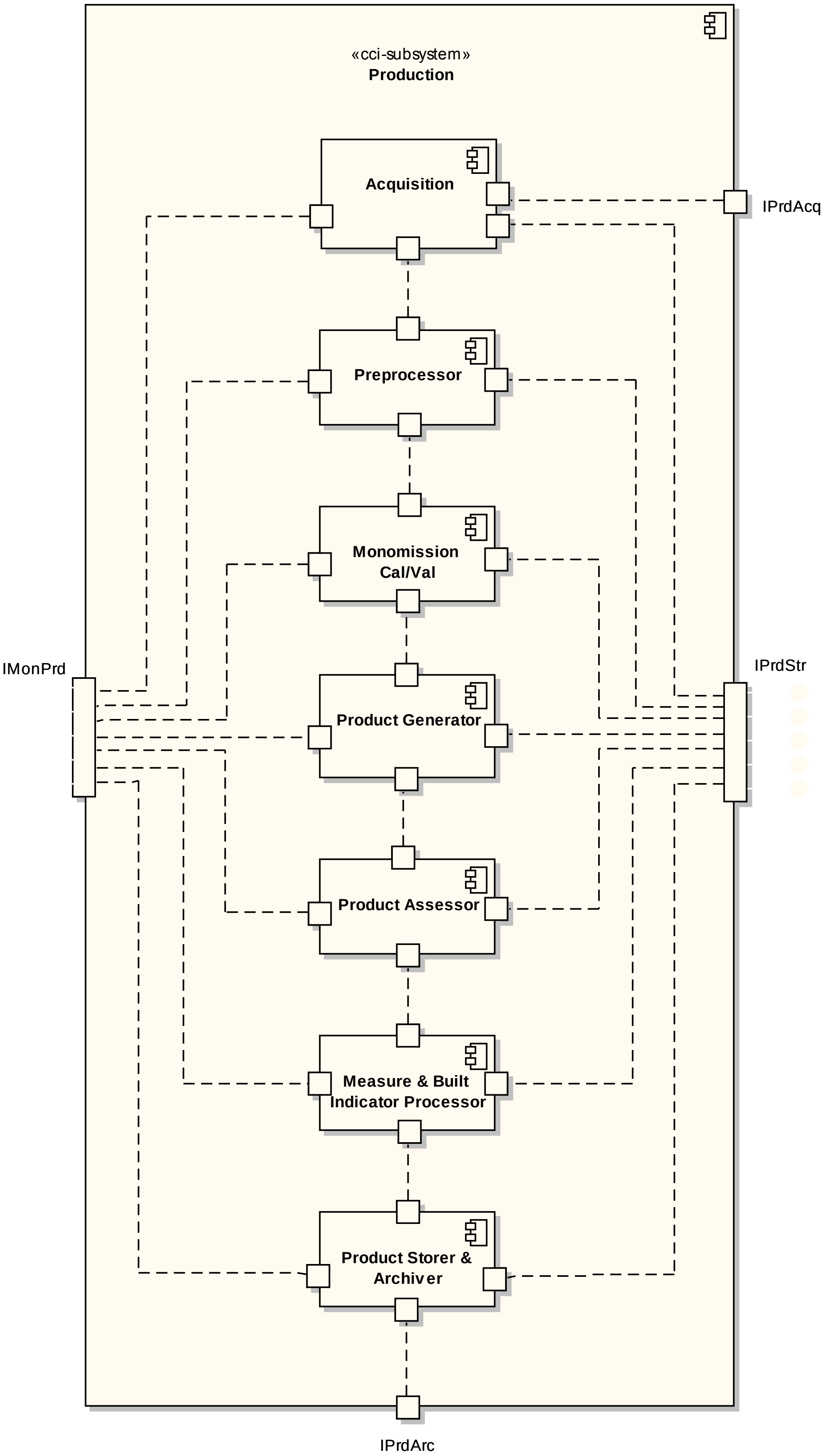

Figure 17 – Low level perspective of Production subsystem

7.2.2.2.1. Acquisition function - high level operations:

There follows a high-level list of the kinds of operations that the subsystem[42] is expected to handle.

1. *StartProcessingJob, EndProcessingJob*. Processing chain operations by which staff may commence or end a product processing chain, given the mode of processing (DT, REPO) and defined build configuration; operation EndProcessing may be called at any point during the processing chain. Moreover, the status of each processing step is communicated to the Monitoring system, via IMon, for absorption to OpenNMS[43].
2. *DetectPrimaryData*. Automatic detection of new primary satellite data[44] via IPrdAcq by bespoke[45] observing other systems' remote directories at a configurable frequency[46] to absorb data within 5 minutes[47] or alternatively detect data placed within SLCCI directory by another system to be absorbed within 5 minutes[48]; usage of both pull and pull data identified by trade-off analysis[49] (§6.3.4). Moreover, the operation will expect the availability of each recognised input product to be available within recognised frequencies[50], otherwise the anomaly will be notified through IPrdMon. The trade-off analysis identified FTP as the protocol for file transfer (§6.3.4).
3. *DetectAuxiliaryData*. Similar functionality as for DetectPrimaryData[51] in this case targeted to auxiliary data required for ECV production[52], again via IPrdAcq and checked through a remote directory at a configurable frequency [53]to be absorbed within 5 minutes of appearing[54], or alternatively data placed within an SLCCI directory by another system for absorption within 5 minutes[55]; as with DetectPrimaryData, usage of both pull and pull data identified by trade-off analysis (§6.3.4). Again, the trade-off analysis also identified FTP as the protocol for file transfer (§6.3.4).

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[42] Use of the term SLCCI *subsystem* is equivalent to *module* reference in the Statement if Work (SoW)

[43] SLCCI-SRB-REQ_15-010

[44] SLCCI-SRB-REQ_1-010

[45] Identified by trade-off analysis (§6.3.4).

[46] SLCCI-SRB-REQ_1-070

[47] SLCCI-SRB-REQ_1-101

[48] SLCCI-SRB-REQ_1-100

[49] SLCCI-SRB-REQ_15-040

[50] SLCCI-SRB-REQ_1-202

[51] SLCCI-SRB-REQ_15-020

[52] SLCCI-SRB-REQ_1-012

[53] SLCCI-SRB-REQ_1-070

[54] SLCCI-SRB-REQ_1-101

[55] SLCCI-SRB-REQ_1-100

4. *CheckGrammar.* Checking of the format of acquired data in order to validate the logical grammar of the primary satellite data[56] and ancillary data[57]. The operation is self-contained allowing for intra-*module* change of logic to recognise other data types in future[58].
5. *CheckLogicalType, CheckLogicalRange.* Similarly, a check on the values of data is undertaken to ensure that they pertain to an accepted logical type and range for primary satellite data[59] and ancillary data[60]. In checking type and range of acquired data, the altimetry products[61]and their auxiliary products[62] will be checked to ensure they are the recognised types[63] rather than unrecognised product types, including the metadata which describes the data therein[64]. Again, the Acquisition function is self-contained allowing for intra-*module* change to other data types in future[65].
6. *CheckProcessingReadiness.* The operation ascertains whether all required data is available to commence product processing[66] by passing control there.
7. *SetQueue.* Manipulates the queue to allow synchronisation of acquired primary and ancillary arriving through IPrdAcq, such that if ancillary data is present without the associated primary data then that existing data is moved to a waiting queue[67], and similarly primary data held is held in a queue in the case where required ancillary data needs to be acquired[68], with the queuing needing to take place within 5 minutes of being acquired[69].
8. *Monitoring* of these operations is conducted through IMonPrd to the Monitoring sub-system[70].
9. *AltimetryDatabasePopulation*. The output of the Acquisition function is fed to the Altimetry database (Postgres) through IPrdStr within a temporal threshold of 10 minutes following processing[71]; §7.5.1, Altimetry <<cci-db>>, Figure 30. On completion of this database population, control is passed to the Processing subsystem's Preprocessing function.

[56] SLCCI-SRB-REQ_1-011-a

[57] SLCCI-SRB-REQ_1-013-a, SLCCI-SRB-REQ_15_030

[58] SLCCI-SRB-REQ_15-220

[59] SLCCI-SRB-REQ_1-011-b

[60] SLCCI-SRB-REQ_1-013-b

[61] SLCCI-SRB-REQ_0-013

[62] SLCCI-SRB-REQ_SRB-0-024, SLCCI-SRB-REQ_0-029

[63] SLCCI-SRB-REQ_SRB-1-102

[64] SLCCI-SRB-REQ_SRB-0-05, SLCCI-SRB-REQ_15_030

[65] SLCCI-SRB-REQ_15-220

[66] SLCCI-SRB-REQ_1-020

[67] SLCCI-SRB-REQ_1-060

[68] SLCCI-SRB-REQ_1-020

[69] SLCCI-SRB-REQ_1-235

[70] SLCCI-SRB-REQ_15-010

[71] SLCCI-SRB-REQ_1-236

7.2.2.2.2. Preprocessing function - high level operations:

1. *Homogenisation*. This function is responsible for the homogenisation of the data output by the Acquisition function to the Altimetry database (§7.5.1, Altimetry <<cci-db>>, Figure 31). This is performed by automated[72] application of geophysical corrections to calculate sea level anomaly[73] with spurious measurements[74], by means of comparison of measurement to a threshold. The low-level mission/instrument-neutral format onto which each mission/instrument-specific data source is represented is a homogenisation across the associated mission/instruments[75]; the specific format of the homogenisation format will be realised by future Phase II implementers, and should be sufficiently flexible to accommodate future satellites and missions[76] following trade-off based on this homogenisation operation[77]. Furthermore, the Preprocessing function is self-contained allowing for intra-*module* change to homogenise new data types in future[78].
2. *HomogenisationMonitoring*. The function needs to complete its actions within a temporal threshold proportional to datasize[79], and this comparison will be observed by the Monitoring sub-system via IMonPrd.
3. *HomogenisationRecording*. The output of this preprocessing is fed to the Altimetry database (§7.5.1, Altimetry <<cci-db>>, Figure 30) through IPrdStr.

7.2.2.2.3. Monomission cal/val function - high level operations:

1. *Cal/val*. This operation is responsible for cal/val[80] taking as its input the pre-processed altimetry data from the Altimetry database via IPrdStr, which was output by the preceding Preprocessing function (§7.5.1, Altimetry <<cci-db>>, Figure 30), and processing a comparison based on manually specified thresholds by an SLCCI Product Contributor[81].
2. *ComparisonProcessing*. The function compares the (mono-mission) input data arrived from IPrdStr to the manually specified quality thresholds, generating quality statistics on the input data containing the configurable field defined, the associated threshold and a unique identifier representing the comparison[82].
3. *QualityCheckReportGeneration*. A human-readable Quality Check report is generated, containing resulting details and arranged into areas of cal/val, global multi-mission, plus global altimetry to

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[72] SLCCI-SRB-REQ_2-011

[73] SLCCI-SRB-REQ_2-010

[74] SLCCI-SRB-REQ_2-012

[75] SLCCI-SRB-REQ_15-070

[76] SLCCI-SRB-REQ_0-012

[77] SLCCI-SRB-REQ_15-080, SLCCI-SRB-REQ_15-090

[78] SLCCI-SRB-REQ_15-220

[79] SLCCI-SRB-REQ_2-100

[80] SLCCI-SRB-REQ_15_040

[81] SLCCI-SRB-REQ_3-019

[82] SLCCI-SRB-REQ_3-020, SLCCI-SRB-REQ_15_050

in-situ data comparisons[83]. The report is generated within a configurable reasonable time proportional to the amount of data to be contained within the report[84], in order to be checked by the Product Expert[85] in good time. As identified by trade-off (§6.3.4), OTS[86] tool Jasper is used to generate the statistics report based on bespoke statistical calculations geared to the ECV product. The availability of the report is communicated by a call to OpenCRX residing on the Monitoring sub-system (IMonPrd), communicating the availability of the report to staff.

4. *QualityCheckComparison.* If the automated quality check through the data, comparing the input data to the manually specified quality thresholds, falls outside of any quality threshold then a Product Expert will investigate the source of the discovered error, alerting the upstream system from which the data was derived, allowing the system to re-input the upstream data if necessary with correct data from that source, and alerting the Service Desk Manager of the anomaly [3-030]. In such a case, the anomalous data is flagged as so within the Altimetry database via IPrdStr for record (§7.5.1, Altimetry <<cci-db>>, Figure 30) and alerted via IMonPrd.
5. *ProductionContinuation*. If the problem is critical however, such that the upstream system on which the data was derived cannot correct the anomaly, then the system will continue with production, with the Service Desk being informed of the anomaly and the anomaly being noted in the resulting ECV product[87].
6. *QualityCheckMonitoring*. The automated quality checking needs to be monitored that it has been performed within a configurable temporal threshold[88], and information pertaining to this will be monitored through IMonPrd.
7. *RecordForCrossovers*. All processed data, still dealt as mono-mission at this stage now, and with any added information such as derived via point 4. above, is fed into the Crossovers database through IPrdStr; the accumulated data from this function is to be cross-compared by the next function (Multi-mission Cross Calibration) towards then forming crossovers; (§7.5.1, Crossovers <<cci-db>>, Figure 32).

7.2.2.2.4. Product Generator - high level operations:

1. *MultiMissionCrossoverPreProcessing.* This operation is responsible for taking the resulting multiple series of mono-mission data derived for the preceding monomission cal/val function from the Crossovers database via IPrdStr, towards generating cross-calibrated data to feed back into the Crossovers database[89]; §7.5.1, Crossovers <<cci-db>>, Figure 32.
2. *MultiMissionCrossoverProcessing.* This operation calculates the sea level anomaly (SLA) for each mono-mission's along-track data[90], orbit error and long wavelength error (LWE) for each data

[83] SLCCI-SRB-REQ_4-010

[84] SLCCI-SRB-REQ_3-201

[85] SLCCI-SRB-REQ_4-011

[86] SLCCI-SRB-REQ_15_430

[87] SLCCI-SRB-REQ_3-040

[88] SLCCI-SRB-REQ_3-200

[89] SLCCI-SRB-REQ_5-000

[90] SLCCI-SRB-REQ_5-020

flow[91], and correcting the SLA for the LWE of each data flow[92]. As similarly undertaken in point 1., the result is fed back into the Crossovers database[93] over IPrdStr; §7.5.1, Crossovers <<cci-db>>, Figure 32.

3. *FCDRProductGeneration, ECVProductGeneration.* These operations generate their respective (ECV, FCDR) products[94] given the MultiMissionCrossoverProcessing output, computed over the successful round-robin algorithms prescribed by Task 2. The format of product generated by these operations will conform to CCI DSWG description of FCDR and ECV product through NetCDF-CF[95], following trade-off analysis (§6.3.4). Moreover, the algorithms are bespoke coded, as identified during trade-off analysis (§6.3.4), and contained entirely within the *FCDRProductGeneration* and *ECVProductGeneration* operations for modular integrity, so mitigating development risk algorithm change in future[96].
4. Each of these operations needs to be accomplished within a configurable time period, the multi-mission operation being completed within a configurable time proportional to the data size processed[97], as is similarly the case for the FCDR Product Generation[98] and ECV Product Generation[99] operations. The results of these checks will be monitored over IMonPrd.
5. The resulting FCDR and ECV products are in an in-memory form rather than database form, and directly accessed by the *Product Assessment* and *Measures & Built Indicators* functions rather than accessed via the Production database (Figure 29)

7.2.2.2.5. Product Assessment - high level operations:

1. *ThresholdComparison*. On the generated ECV product by the earlier *Product Generator* function, accessed directly in-memory (§7.2.2.2.4 point 4), the enactment of output checks, quality control and scientific validation are performed[100] by way of comparison of manually defined fields to similarly manually defined thresholds[101].
2. *StatisticsGeneration*. The Product Assessment function generates quality statistics for the product, based on comparison between the manually configurable threshold for each data field defined[102]. The availability of statistics is communicated to the Monitoring sub-system via IMonPrd to the OpenNMS installation, which in turn informs relevant internal users through

[91] SLCCI-SRB-REQ_5-010, SLCCI-SRB-REQ_5-030

[92] SLCCI-SRB-REQ_5-031

[93] SLCCI-SRB-REQ_5-000

[94] SLCCI-SRB-REQ_5-040, SLCCI-SRB-REQ_5-050

[95] SLCCI-SRB-REQ_0-047, SLCCI-SRB-REQ_0-048

[96] SLCCI-SRB-REQ_15_230

[97] SLCCI-SRB-REQ_5-032

[98] SLCCI-SRB-REQ_5-044

[99] SLCCI-SRB-REQ_5-054

[100] SLCCI-SRB-REQ_6-000

[101] SLCCI-SRB-REQ_6-019

[102] SLCCI-SRB-REQ_6-020

OpenCRX (the customer relationship management system supporting ticketing, as identified during trade-off analysis, §6.3.4).

3. *ProductAssessmentMonitoring*. On reading the quality statistics and determining statistical readings outside of the configurable range, the Product Expert warns the Support Operator and Service Manager via IMonPrd for further analysis, and re-executes the processing pipeline for the anomaly to be corrected[103]; to facilitate integrity of the product, analyses are conducted to determine the anomaly, including multi-mission comparison of global datasets and global comparison between mission and in-situ data[104]. Communication with Monitoring takes the form of informing OpenNMS on the Monitoring sub-system via IMonPrd.

7.2.2.2.6. Measure & Built Indicators – high level operations:

1. *ProcessMeasures*. This operation will comprise of processing of scientific (product quality and accuracy) and system measurements[105], (available bandwidth, reprocessing date & time), drawing from both statistics data and temporary products through IPrdStr which were generated during the product generation function.
2. *ProcessBuildIndicators*. Similarly, this operation will comprise of processing for calculation of different ocean indicators, such as mean sea level trends, to complement product assessment[106], again drawing from statistics data and temporary products via IPrdStr.
3. *Measures&BuildIndicatorMonitoring*. In the event that the processing of measure or built indicator is not attainable, the support operator or product expert (on being informed by the event being communicated via IMonPrd to OpenNMS) will investigate, correct and report the problem to the Service Manager[107].

7.2.2.2.7. Product Storer & Archiver - high level operations:

1. *ProductStorer*. The most recently generated ECV products are stored to a fast-access database via IPrdArc[108], to be made immediately available to the SLCCI portal and Central Information System (CIS) through the Products Management subsystem. To ensure optimal operational performance, the transfer via IPrdArc will be done so within a temporal threshold proportional to the data volume to be stored[109], otherwise the Monitoring sub-system will be informed (IMonPrd).
2. *ProductArchiver*. The most recently generated ECV products are similarly stored to an offline large-volume slow-access database[110] via IPrdArc, together with ancillary data used to generate

[103] SLCCI-SRB-REQ_15_030

[104] SLCCI-SRB-REQ_6-060

[105] SLCCI-SRB-REQ_7-000-a

[106] SLCCI-SRB-REQ_7-000-b

[107] SLCCI-SRB-REQ_7-004

[108] SLCCI-SRB-REQ_8-010

[109] SLCCI-SRB-REQ_8-042

[110] SLCCI-SRB-REQ_9-010-a

the product[111], with use of both types of storage identified in trade-off analysis (§6.3.4). As is similarly the case with the *ProductStorer* operation, archiving must be accomplished within a temporal threshold directly proportional to the data volume to be archived[112]. Furthermore, the function operation receives and processes the most recently generated ECV product via IPrdAcc, as is the case with operation ProductStorer, and this serves as a backup to the same product stored to fast-access by ProductStorer; this backing up of product does not interrupt the processing chain in the Production sub-system, as the ECV product is forwarded to the Product Management sub-system which is asynchronously handed responsibility for the automated[113] (the Product Management sub-system is motivated for such activity, so given sub-system status) storing and archiving of the ECV product[114]. Efficiencies are garnered by the Processing having to asynchronously send the ECV product once, to the Product Management sub-system[115].

7.2.3. Product Access & Visualisation

7.2.3.1. Interfaces

The interfaces related to the Product Access & Visualisation SLCCI component are defined by.

Interface	Communicating component
IPrdAV (§7.2.10)	SLCCI boundary to outside of system
IPrdMng (§7.2.11)	Products Management
IMonPrdAV (§7.2.13)	Monitoring and communication of events

Table 16 – Product Access & Visualisation Component Interfaces

7.2.3.2. Functional Definition

This subsystem is responsible for the product access and visualisation of the SLCCI system, and in so doing accommodates the following kinds of high level operations –

1. *CollateProduct*. The Product Access & Visualisation subsystem gets an ECV Product for provision to the outside world through IPrdAV, by first internally accessing the product via IPrdMng. IPrdAV is realised as a Web Portal with THREDDS provision and may similarly be used as a vehicle for communication with a Central Information System[116].
2. *ProvideProduct*. FTP and HTTP protocols are realised through IPrdAV to provide the means for external facilities to access the ECV products as are open implementations of the OGC specifications for WMS and WCS, where images are produced at different resolutions for the

[111] SLCCI-SRB-REQ_9-010-b, SLCCI-SRB-REQ_15-240

[112] SLCCI-SRB-REQ_8-042

[113] SLCCI-SRB-REQ_1-420

[114] SLCCI-SRB-REQ_1-400

[115] SLCCI-SRB-REQ_1-401

[116] SLCCI-SRB-REQ_8-010, SLCCI-SRB-REQ_15-400, SLCCI-SRB-REQ_15-410

convenience of external users[117]. The provision of a Tomcat web server and THREDDS to offering bulk downloads through IPrdAV allows for simultaneous downloading of ECV products[118]; THREDDS and Tomcat identified at trade-off analysis (§6.3.4).

3. *SearchProduct*. An INSPIRE adherent search facility is provided through the web portal[119] via IPrdAV HTTP access; see §7.9.1 and §7.9.5.
4. *AuthenticateUser*. Service for user authentication[120] taking calls via IPrdAV for user authentication, and engaging stored user registration details via IPrdMng.
5. *RegisterUser*, similarly as AuthenticateUser, for user registration.

7.2.4. Products Management

7.2.4.1. Interfaces

The Products Management component interacts with other components via the following interfaces.

Interface	Communicating component
IPrdMng (§7.2.11)	Product Access & Visualisation
IMonPrdMng (§7.2.12)	Monitoring and communication of events
IPrdMngStr (§7.2.16)	Products Management database

Table 17 – Products Management Component Interfaces

7.2.4.2. Functional Definition

This component envelops the products management functionality of the SLCCI system, comprising of the sorts of product metadata registration and maintenance operations as follows -

1. *PerformArchive*. The Products Management contains the operation via IPrdMngStr to choose which recent (online) ECV Products in the fast-access data storage facility from IPrdArc are to be taken offline efficiently[121] and remain archived in the offline slow-access archive facility[122]; the usage of slow (less expensive) storage for archiving and fast (for online access) data storage was identified at the trade-off analysis (§6.3.4). The archiving procedure will conform to the Open Archival Information System reference model[123] through this operation.
2. *ConstructMetadata.* The Product Management sub-system manages a metadata catalogue containing metadata description of all ECV products contained within storage and archive[124]

[117] SLCCI-SRB-REQ_10-000, SLCCI-SRB-REQ_10-020 & 10-021, SLCCI-SRB-REQ_10-040

[118] SLCCI-SRB-REQ_14-010

[119] SLCCI-SRB-REQ_10-220

[120] SLCCI-SRB-REQ_10-201

[121] SLCCI-SRB-REQ_9-051

[122] SLCCI-SRB-REQ_9-030, SLCCI-SRB-REQ_9-031

[123] SLCCI-SRB-REQ_9-200

[124] SLCCI-SRB-REQ_11-500

drawn from IPrdArc. We endeavour to ensure the metadata catalogue is akin to those collectively agreed via ongoing SEWG activity[125].

3. *MetadataCompliance*. The Product Management sub-system will ensure that standards ISO19115, ISO19119 and ISO19139 are adhered to[126], though a metadata compliance operation.
4. *MetadataEditing*. Human input, through the Product Manager, is needed for the editing of metadata, using available Open tools to accommodate actions[127]; a metadata editor will be made available for the Product Manager to edit metadata prior to product release[128], and assuming SEWG progress allows it to be the case the same editor could be provisioned for a CIS[129]; as is declared elsewhere, the matter of SEWG progress and consensus is a continuing activity. We anticipate that the SEWG can similarly drive consensus for editing of metadata centrally for the registration, updating and deletion of product information across respective ECVs[130] based on a central resource, containing information for each ECV and accommodating synchronisation of the metadata[131] with each ECV system.
5. *ProductRegistration.* This operation, for use by the Product Manager, allows addition of new products onto the database[132], with the metadata updating being conducted automatically[133] on already existing products (i.e where the metadata does not vary across the already existing version and added version); this updating of metadata is enacted via (i) static updating where the product in any form has not been registered, in which case the information which is static across any version of the product is added manually, and (ii) dynamic updating where an existing product is updated and the dynamic information, that is the information which varies across different versions of the same product, is updated[134].
6. *ProductMaintenanceTypes.* Metadata maintenance takes different forms, including update and deletion of Product Line metadata, update and deletion of Product Specification metadata, and updating of the dynamic metadata representing quality characteristics of the product[135].
7. *AuthenticateUser*. Supporting the Product Access & Visualisation sub-system, a high level operation for user authentication[136] taking calls via IPrdMng for user authentication. Includes the recording of events for users needing authentication through logging in[137].
8. *RegisterUser*, similarly as AuthenticateUser, for user registration, in support of AuthenticateUser. Includes recording of user registration events[138].

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[125] SLCCI-SRB-REQ_11-110

[126] SLCCI-SRB-REQ_11-120

[127] SLCCI-SRB-REQ_11-010

[128] SLCCI-SRB-REQ_8-020

[129] SLCCI-SRB-REQ_11-011

[130] SLCCI-SRB-REQ_11-050, SLCCI-SRB-REQ_11-060, SLCCI-SRB-REQ_11-070, SLCCI-SRB-REQ_11-080

[131] SLCCI-SRB-REQ_11-090

[132] SLCCI-SRB-REQ_11-020

[133] SLCCI-SRB-REQ_11-021

[134] SLCCI-SRB-REQ_11-030

[135] SLCCI-SRB-REQ_11-033

[136] SLCCI-SRB-REQ_10-201

[137] SLCCI-SRB-REQ_10-240

7.2.5. Monitoring

7.2.5.1. Interfaces

The Monitoring component interacts with other functional entities via the following interfaces.

Interface	Communicating component
IMonPrdMng (§7.2.12)	Products Management
IMonPrdAV (§7.2.13)	Product Access & Visualisation
IMonPrd (§7.2.14)	Production
IMon (§7.2.15)	SLCCI boundary to outside of system

Table 18 – Monitoring Component Interfaces

7.2.5.2. Functional Definition

Three system operational services[139] reside in the Monitoring sub-system, providing an overview of the SLCCI system status, visually realised as a monitoring dashboard, comprising of the following functional tools –

- *OpenNMS* installation for retrieval of generated messages from the Products Management (IMonPrdMng), Product Access & Visualisation (IMonPrdAV) and Production (IMonPrd) sub-systems. Moreover, as earlier indicated (§7.2.2), the Production sub-system is regularly updating the Monitoring System, via IMonPrd, on processing pipeline status, including processing job manipulation by operating staff on the Production sub-system.
- *OpenCRX* installation of a ticket messaging and customer relationship management system, for tracking of queries and issues collated by the Service Desk from external users through Product Access & Visualisation (IMonPrdAV), and for tracking of issues received by the OpenNMS installation for addressing by the operations team.
- *OCS Inventory* standalone inventory management tool for use by the operations team for management and accounting of SLCCI assets.

The Monitoring sub-system is responsible for the following types of high level operations -

1. *ProductionMonitor*. The monitoring of processing chain product integrity[140] via IMonPrd.
2. *SystemMonitor*. Monitoring health of the computing infrastructure[141], including physical resources[142], and comprises of monitoring of the interfaces to upstream systems (IMon) with access including a future CIS (IMonPrdAV), physical resources associated with the production pipeline (IMonPrd) and resources holding products[143] (IMonPrdMng). Monitoring of physical

[138] SLCCI-SRB-REQ_10-240

[139] SLCCI-SRB-REQ_15-430

[140] SLCCI-SRB-REQ_12-010-a

[141] SLCCI-SRB-REQ_12-010-b

[142] SLCCI-SRB-REQ_12-080

[143] SLCCI-SRB-REQ_12-091

resources will rely on thresholds for measurable resources being set[144], the configurability of which is supported by a Support Operator who has overall responsibility for system monitoring[145] including configuration of thresholds[146]. Similarly, information pertaining to the system resources processor, memory and network load, are communicated to the Monitor sub-system for the operating staff; these contribute to the forming of measurements for RAMS calculations (point 5.).

3. *RequestMonitor*. Engaging with users with points and concerns, managed via a CRM ticketing system and Service Desk[147] via IMonPrdAV.
4. *SelfMonitor*. The Monitoring subsystem will also monitor its own activity, ensuring that the sub-system does not contribute significantly to the overall performance of the SLCCI system[148].
5. *AdherenceToRAMS*. The Monitoring sub-system receives monitoring information via IMonPrd, IMonPrdAV and IMonPrdMng for Production, Product Access & Visualisation Products Management, respectively; moreover, the Monitoring sub-system similarly monitors its own system events. System monitoring events across the SLCCI sub-systems allow the Monitoring subsystem to observe MTBM, MMD, MTBF and MTTR metrics, towards calculating overall system availability, ensuring availability targets are reliably met through prudent operational planning[149].
6. *Inventory Management*. In its capacity as administration centre of the SLCCI system, the inventory management facility (OCS Inventory) functionally resides in the Monitoring sub-system as a standalone tool for the Support Operator.
7. *ReportAlerting*. Communication of report availability from Production, to be used by OpenCRX residing on the Monitoring subsystem to inform internal users of new reports.

7.2.6. Production database

7.2.6.1. Interfaces

The interfaces directly related to the Production database are as follows.

Interface	Communicating component
IPrdStr (§7.2.9)	Production

[144] SLCCI-SRB-REQ_12-100

[145] SLCCI-SRB-REQ_12-090

[146] SLCCI-SRB-REQ_12-101, SLCCI-SRB-REQ_15-420

[147] SLCCI-SRB-REQ_12-010-c

[148] SLCCI-SRB-REQ_12-200, SLCCI-SRB-REQ_12-210 & SLCCI-SRB-REQ_12-220

[149] SLCCI-SRB-REQ_19-010, SLCCI-SRB-REQ_19-020, SLCCI-SRB-REQ_19-030, SLCCI-SRB-REQ_19-040, SLCCI-SRB-REQ_19-050, SLCCI-SRB-REQ_19-060, SLCCI-SRB-REQ_19-070, SLCCI-SRB-REQ_19-080, SLCCI-SRB-REQ_19-090, SLCCI-SRB-REQ_19-100, SLCCI-SRB-REQ_19-110, SLCCI-SRB-REQ_19-120, SLCCI-SRB-REQ_19-200, SLCCI-SRB-REQ_19-210, SLCCI-SRB-REQ_19-220, SLCCI-SRB-REQ_19-230, SLCCI-SRB-REQ_19-240, SLCCI-SRB-REQ_19-250, SLCCI-SRB-REQ_19-260, SLCCI-SRB-REQ_19-270 SLCCI-SRB-REQ_19-280, SLCCI-SRB-REQ_19-290

Table 19 – Production Database Component Interfaces

7.2.6.2. Functional Definition

The Production database is Postgres based, as identified by trade-off analysis (§6.3.4). The Production database component represents all data stores involved in the generation of SLCCI products, including storage of input and ancillary information used to generate the product[150] and intermediary products generated across the processing chain[151]. The ECV products ultimately produced are stored in the Products Management database.

The Production database component comprises of four sub-components, namely Statistics, Temporary Product Files, Crossovers and Altimetry, as illustrated below. These databases are described via the Information View (§7.5.1), including their contents and activity across the Production subsystem processing chain.

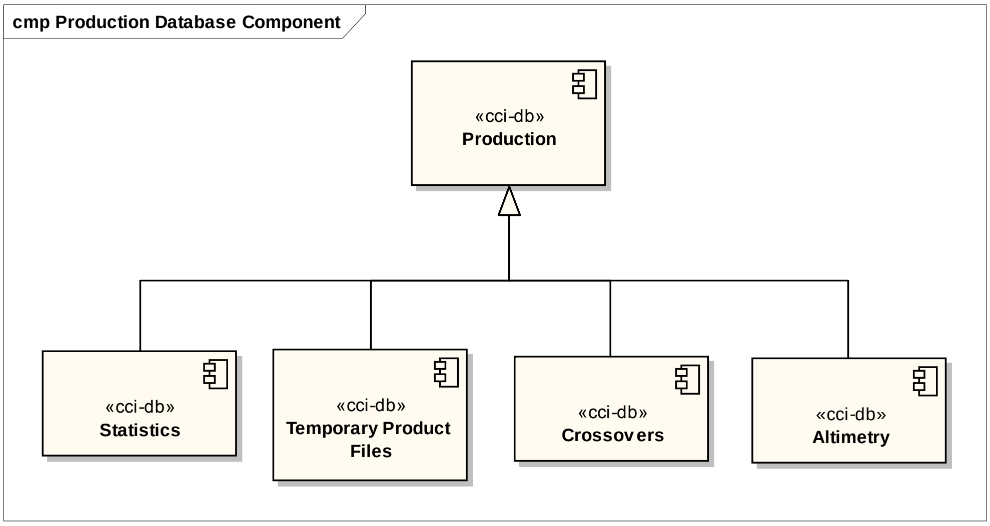

Figure 18 - Constituents of Production Database Component

7.2.7. Products Management database

7.2.7.1. Interfaces

The interfaces directly related to the Products Management database are as follows.

Interface	Communicating component
IPrdMngStr (§7.2.9)	Products Management

[150] SLCCI-SRB-REQ_21-010

[151] SLCCI-SRB-REQ_21-330

IPrdArc	Production

Table 20 – Production Database Component Interfaces

7.2.7.2. Functional Definition

The Production database is Postgres based, as identified by trade-off analysis (§6.3.4). As discussed earlier, the Products Management database is formed of fast data access (relatively expensive) containing the most recent ECV product for ready delivery to the outside world, and a (relatively less expensive) slow data access offline database for archiving of ECV products. The importance of the Products Management database is critical to satisfying sufficient availability, thus two physical databases are used to represent the logical Products Management database, moreover allowing a cost effective split between fast and slow access.

Furthermore, interface supports queries for user authentication to database, recording of registration, and recording of authentication and registration events.

7.2.8. IPrdAcq

The IPrdAcq interface is defined by Table 21. As described by Table 14, the IPrdAcq interface is for the Acquisition of the upstream data needed for the Production and the validation of the ECV products. Moreover, both provided interface and required interface iconography are used for this interface on Figure 15, to cater for both push and pull data acquisition approaches (§6.3.4) as identified through trade-off (§6.3.4). Interface IPrdAcq features in the Production sub-system functional description (§7.2.2.2) as the vehicle for the source of data on which the Acquisition function operates (§7.2.2.2.1).

Interface Name	IPrdAcq
Technology	FTP Server
Protocol	FTP
Format	GDR, OPR & ancillary data
Provider	ESA/CNES/NASA/NOAA [RD2]
Comment	See PSAD [RD3, §3.4.1, §3.4.2]

Table 21 – Interface Details for IPrdAcq

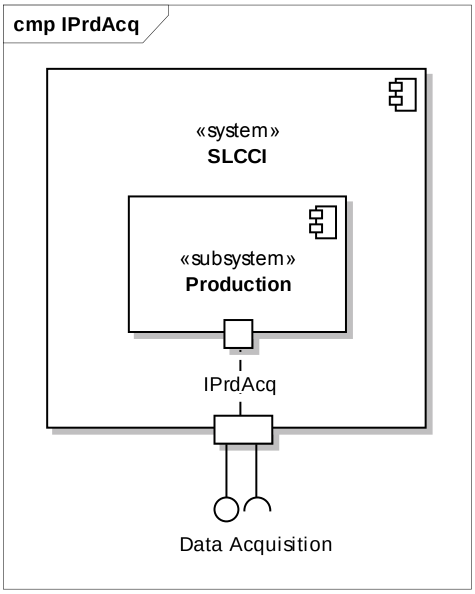

Figure 19 - Illustration of IPrdAcq Context

7.2.9. IPrdStr

The IPrdStr interface is defined by Table 22. As described by Table 14, the Production subsystem feeds processing chain output into Production database via the IPrdStr database, and similarly accesses ancillary data from the Production database as described for information flow for Product Generation (§7.5.1).

Interface Name	IPrdStr
Technology	Postgres Database; relational database management system.
Protocol	Postgres database access protocol
Format	Postgres database access format
Provider	Postgres database provider
Comment	-

Table 22 - Interface Details for IPrdStr

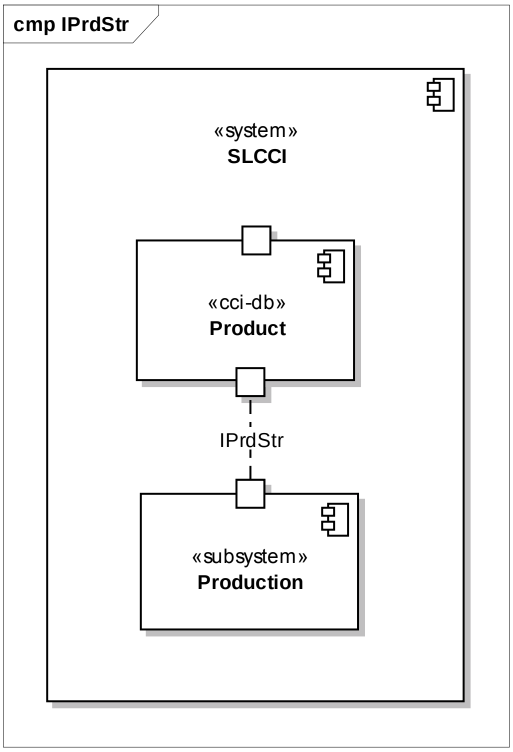

Figure 20 – Illustration of IPrdStr Context

7.2.10. IPrdAV (External)

As expressed earlier, ultimately this (external) interface may be defined in collaboration with the System Engineering Working Group (SEWG) and ESA, as it serves the dual purpose of providing SLCCI products directly to external users and an external Central Information System (CIS), the latter requiring consensus across the ECV projects. The IPrdAV interface is defined by Table 23, and described by Table 14 as the interface by which external users and external systems access the SLCCI products, so including the means by which the Central Information System communicates with the SLCCI system for product information.

Interface Name	IPrdAV
Technology	FTP Server & THREDDS
Protocol	OPENDAP & WMS & WCS & FTP & HTTP
Format	NetCDF-CF
Provider	SLCCI & SEWG
Comment	See Product Specification Document [RD30]

Table 23 - Interface Details for IPrdAV

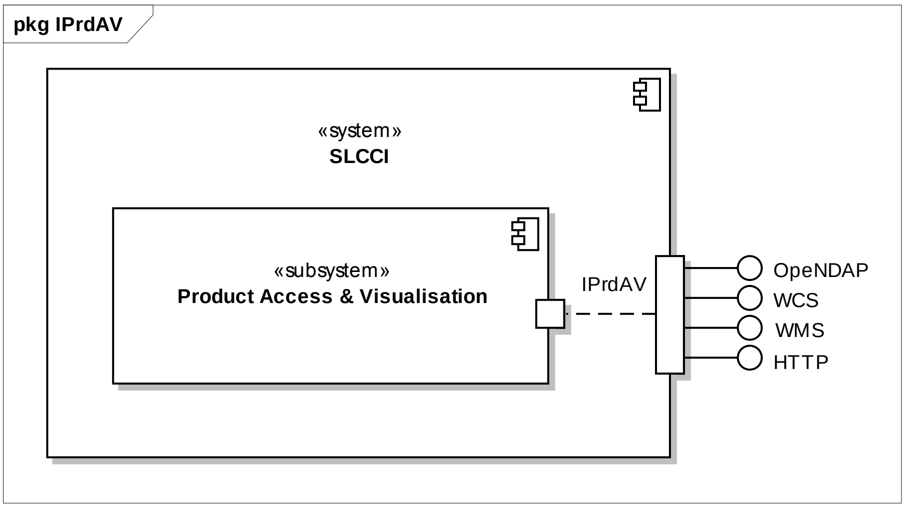

Figure 21 – Illustration of IPrdAV Context

7.2.11. IPrdMng

The IPrdMng interface is defined by Table 24. As described in Table 14, IPrdMng is the interface for the provision of ECV product and metadata information, between the Products Management and Product Access & Visualisation subsystems. ECV products management is governed by the Products Management sub-system, which communicates with the Product Access and Visualisation sub-system to make provision to external users of the ECV products and their metadata information; the IPrdMng supports this Product Access & Visualisation provision to external users by interfacing with the Products Management sub-system; this interface is apt considering the modular separation of concerns between products access with visualisation, and products management.

Interface Name	IPrdMng
Technology	FTP Server & THREDDS
Protocol	OPENDAP & WMS & WCS & FTP & HTTP
Format	NetCDF-CF
Provider	CLS
Comment	-

Table 24 - Interface Details for IPrdMng

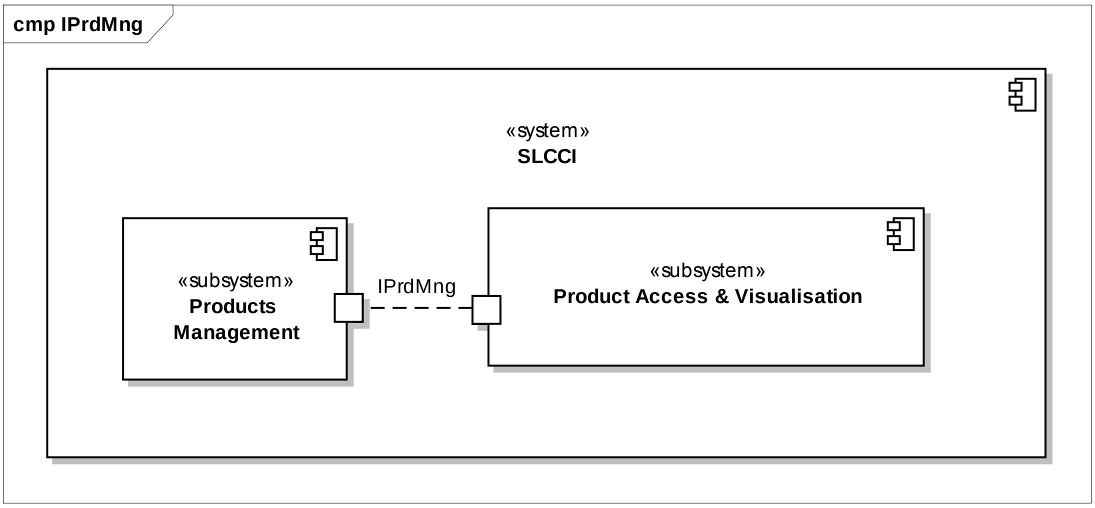

Figure 22 – Illustration of IPrdMng Context

7.2.12. IMonPrdMng

The IMonPrdMng interface is defined by Table 25. As described in Table 14, the IMonPrdMng is the interface for the provision of monitoring information, between Products Management and Monitoring subsystems. The Monitoring sub-system monitors the operational integrity of the Products Management sub-system via the IMonPrdMng interface.

Interface Name	IMonPrdMng
Technology	Bespoke low level interface supported by OpenNMS
Protocol	HTTP
Format	XML
Provider	CLS
Comment	-

Table 25 – Interface Details for IMonPrdMng

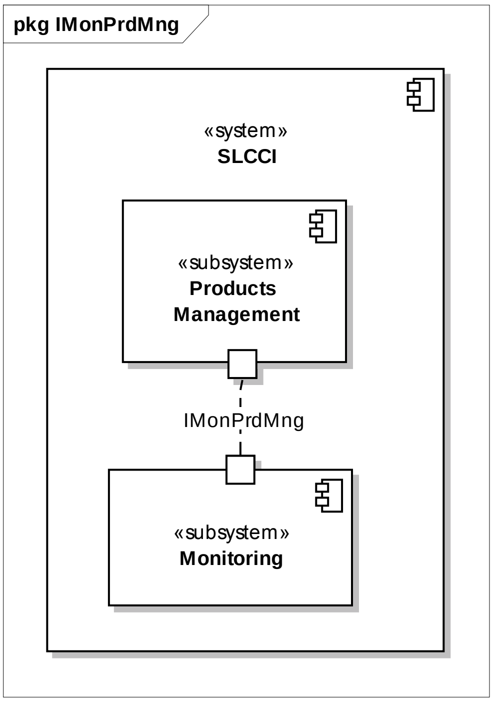

Figure 23 –Illustration of IMonPrdMng Context

7.2.13. IMonPrdAV

The IMonPrdAV interface is defined by Table 26. As described in Table 14, IMonPrdAV is the interface for the provision of information for Access and Visualisation monitoring, between the Product Access & Visualisation and Monitoring subsystems. The Monitor sub-system attains the status of operational integrity of the Product Access & Visualisation sub-system through the IMonPrdAV interfaced.

Interface Name	IMonAV
Technology	Bespoke low level interface supported by OpenNMS
Protocol	HTTP
Format	XML
Provider	CLS
Comment	-

Table 26 - Interface Details for IMonPrdAV

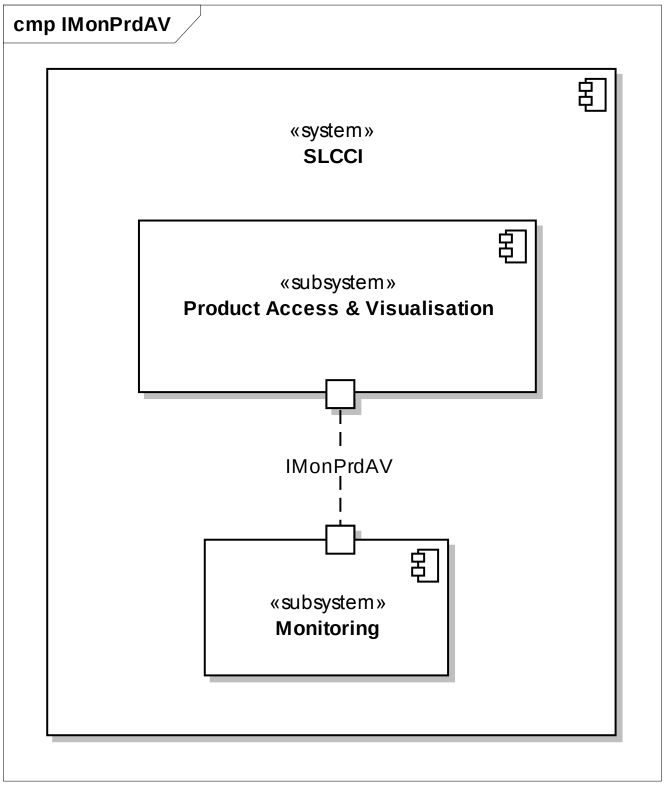

Figure 24 – Illustration of IMonPrdAV Context

7.2.14. IMonPrd

The IMonPrd interface is defined by Table 27. As described in Table 14, IMonPrd is the interface for the provision of information for Monitoring, between the Production and Monitoring subsystems. The Monitoring sub-system oversees the integrity of operation of the Production sub-system via the IMonPrd interface.

Interface Name	IMonPrd
Technology	Bespoke low level interface supported by OpenNMS
Protocol	HTTP
Format	XML
Provider	CLS
Comment	-

Table 27 - Interface Details for IMonPrd

7.2.15. IMon (External)

Ultimately, this (external) interface must be defined in collaboration with the System Engineering Working Group (SEWG) and ESA. The IMon interface is defined by Table 28. As described by Table 14, IMon is the interface between the Monitoring subsystem, and the Central Information System; the Central Information System is external to the SLCCI system.

Interface Name	IMon
Technology	SEWG to reach consensus
Protocol	HTTP
Format	XML
Provider	SEWG
Comment	-

Table 28 - Interface Details for IMon

7.2.16. IPrdMngStr

The IPrdMngStr interface is defined by Table 22. As described by Table 14, the Products Management subsystem engages processing chain ECV product output with the Products Management database via the IPrdMngStr interface, and similarly engages product metadata which is similarly stored on the Products Management database. Furthermore, this database is used to user authentication information from user registrations, and accessed to attain such information to use at user logins.

Interface Name	IPrdMngStr
Technology	Postgres database; relational database management system.
Protocol	Postgres database access protocol
Format	Postgres database access format
Provider	Postgres database provider
Comment	-

Table 29 - Interface Details for IPrdMngStr

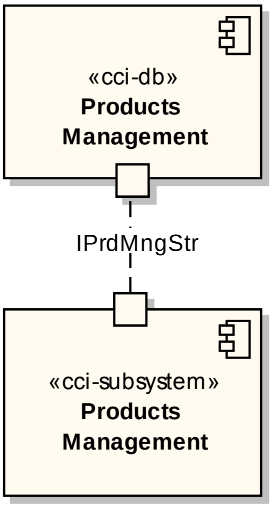

Figure 25 – Illustration of IPrdStr Context

7.2.17. IPrdArc

The IPrdArc interface is defined by Table 30. As described by Table 14, the Production subsystem engages the Production Management database via the IPrcArc interface, for archiving of generated ECV products from the Production subsystem.

Interface Name	IPrdMngStr
Technology	Database; relational database management system.
Protocol	Database access protocol
Format	Database access format
Provider	Database provider
Comment	-

Table 30 - Interface Details for IPrdArc

7.2.18. Central Information System (CIS)

We also allow for the feasibility of Pan-ECV collaboration, by allowing remote catalogue storage and data access through a Central Information system (CIS), plus information pertaining to SLCCI system integrity to the CIS via the SLCCI Monitoring interface, as described in §6.4.

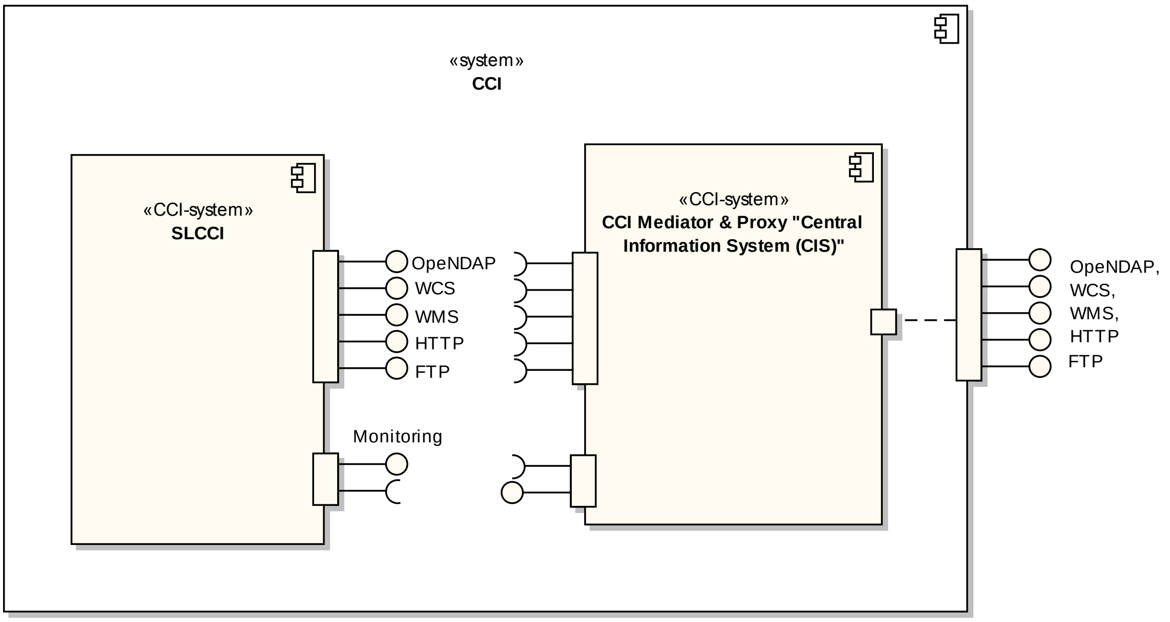

Figure 26 - Illustration of SLCCI CCI Communication context

The System Requirements Document (SRD) makes provision for a Central Information System (CIS). As part of the System Engineering Working Group we propose that the CIS will form a centralised proxy for the provision of product access and cataloguing of CCI products. The work being conducted within the System Engineering Working Group is ongoing, and we anticipate further information regarding collaboration. Further information regarding pan-ECV collaboration is available from the Pan-ECV Collaboration View (§7.3).

7.2.19. Identification of Patterns

Design Patterns are categorised, reusable, useful architectural snippets, recognised from industry-wide best practice. The industry categorisation of design patterns improves communication through the use of a common vocabulary of architectural design. Each design pattern is defined in such a way that prescribes a context to which they best fit. There has been significant and considerable effort within industry to attain a commonly recognised design pattern vocabulary; arguably, the most influential work in this area towards software aspect of systems has been by Gamma et al [15]. Established patterns for operational, enterprise, systems similarly exist, e.g [RD16].

The identification of Design Patterns is important to the SLCCI on a number of fronts.

- The identification of design patterns introduces industry recognised best-practice to the SLCCI design
- The usage of design patterns establishes an advantageous link between specification and implementation for the CCI during Phase 2
- Communication with other CCI projects is accentuated, by the use of an industry-wide recognised vocabulary of design snippets

7.3. Pan-ECV Collaboration View

It is rarely, if ever, the case that during a large scale systems engineering project, there exists the opportunity to share risk, cost, resources, infrastructure, expertise, etc, with ten other similar parallel, concurrent, projects. We have the benefit of this scenario across the CCI ECV projects during Phase I and beyond.

As explored in the System Requirements Document (SRD), the ESA CCI Statement of Work (SoW) expressed the desirability for the sharing of operational resources across the eleven parallel ECV projects. This makes sense from a Systems Engineering perspective, given that there are a number of areas where resources could be practically shared amongst the ECV projects, both during systems development and ultimately for the running of the delivered systems. Such sharing of resources could lead to a number of advantages including, but not exclusively comprised of, the following –

- *Cost effectiveness*. Amongst the evidence supporting cost effectiveness is the SoW statement that the Phase II operational systems "must also be cost-effective as a whole"; Appendix A contains a list of the business goals elicited from the CCI SoW as part of the SLCCI SRD. Cost effectiveness through ECV collaboration, can take a number of forms, such as
    - During system development -
        - Cost effectiveness through the sharing of system engineering human resources across ECV projects, such as the efficient sharing of expertise on a CCI universally used tool or technology
        - Cost effectiveness through sharing of trade off analyses and information pertaining to novel solutions such as Cloud and GRID, some of which will arguably yield similar results across subsets of ECVs if not the whole ECV spectrum.
    - Following delivery of the system –
        - Cost effectiveness through the sharing of physical resources ultimately required for housing the operational systems, such as a shared hosted service
        - Cost effectiveness through burden sharing on the operational need for fault tolerance, including redundancy. Depending on the Service Level Agreements adopted across ECV systems, efficiencies may be gained through the sharing of redundancy capability, such as the sharing of redundant data storage responsibilities
- *Mitigation of Phase II development risk* - avoiding Faults. Risk may be mitigated from the perspective that ECV parties will be collaboratively involved in the engineering of the same (shared) architectural resource and can therefore more significantly anticipate upcoming concerns towards Fault avoidance.
- *Mitigation of Phase II development risk* - dealing with Failures. Risk may be mitigated from the perspective that if a (missed) fault to a (shared) resource eventually becomes a failure, then there are ECV parties at hand to collaboratively correct the matter (compared to the case where a single ECV project deals alone with a failure).
- *Operational Personnel* - In the running of an operational system, there may exist efficiencies gained by the sharing of operational personnel across a number of ECVs, for instance with regards to client-facing support.
- *Risk mitigation via shared adoption of development tools* – risk of choosing inappropriate development tools is lessened, and risk of managing change of tools lessened (in the event

of, for instance, having chosen an unapt tool), if shared across ECV parties, where the criteria for system development tools overlaps across ECV parties.

We propose the areas most practically amenable to ECV collaboration as follows -

1. Product Visualisation and Access
2. Data Storage & Archiving
    - including input data as well as product data
3. Product-generation Processing
    - The CCI ECV systems require Delayed Time, rather than Real Time or Near Real Time product generation, nonetheless the computational expense required at each ECV is considerable, and warrants a trade-off analysis of the competing solutions.
4. User & Product Support
    - People internal to a CCI operational system mark key constituents to the running of a system. They also represent a considerable cost and effort upon a system. If any commonality across the ECVs can be found with regards to the roles adopted by such people, then there may be opportunity for the associating of people to more than one ECV, so sharing cost burden across those ECVs.
5. Security
    - The sharing of security effort, tools, and human resources, although to some extent dependent on geographical location, is likely to offer some insight into sharing, as the security concerns across ECVs are to some degree common.
6. Infrastructure
7. System development tools
    - Including commonality across ECVs on certain Open tools.

We are actively participating in the CCI Systems Engineering Working Group (SEWG) towards us collectively reaching consensus within the SEWG where feasible.

7.3.1. Cost effectiveness

Given the "business goals" of the operational system, as elicited for the System requirements Document (SRD), we must observe cost-effectiveness of Pan-ECV collaboration as being significant matter across all areas. This criteria proves to be a significant contributive factor in deciding whether Pan-ECV collaboration is practical for SLCCI.

To this end, the Perspectives offers a note on portability of DUACS, influencing how it may be involved in pan-ECV collaboration, therefore denoting here whether practical or impractical to be involved.

7.3.2. Product Visualisation & Access

The sharing of Product Visualisation & Access resources across ECVs could be facilitated by the adoption of each ECV to -

1. the same underlying Product Visualisation & Access tools and technologies. This would potentially

- accentuate cost effectiveness across the sharing ECV parties, such as through the opportunity to share a common platform for such tools, pooling common tool purchase, common training across system users, etc
- mitigate engineering risk, as earlier discussed
- amplify common shared expertise across the ECVs, so further mitigating development risk.

2. the same logical interface between each ECV system and client accessing the respective ECV product.
    - A pertinent advantage to this conformance is that it would allow any external user to use the same client tool to access any ECV product, rather than an external user having to use potentially different client tools to access different ECV products across the ECV spectrum. We envisage this to be a pertinent advantage, considering that, in cases, each external user may be requiring a portfolio of ECV products (spanning the ECV project spectrum) rather than focussing on one ECV type exclusively; there is a semantic affinity between certain ECVs, such as Sea Level and Sea Surface Temperature, and an operational system should provide uniform practical access across such ECVs.
    - As a side-effect, this architecture more easily leaves future opportunity to construct higher level pan-ECV products for users, if they so require, for example a future product containing both Land Cover and Fire data.

We have earlier reasoned for our adoption of THREDDS, towards the cataloguing of SLCCI products (§4.7), and their access and visualisation (§4.6). Our perspective on use of THREDDS appears under two guises, communication between the SLCCI system and a Central Information System (Figure 28), and communication between all ECV systems and the CIS (Figure 29). The SLCCI perspective on ECV collaboration (Figure 28) illustrates the use of the SLCCI system interface (Figure 15, Figure 27) in interaction with the foreign Central Information System, the communication of product information of the SLCCI system (OpeNDAP, WCS, WMS, HTTP, FTP) conducted via THREDDS, and monitoring via HTTP protocol. The interaction between SLCCI and external systems for both scenarios should be further explored given the output of activities in the System Engineering Working Group (SEWG).

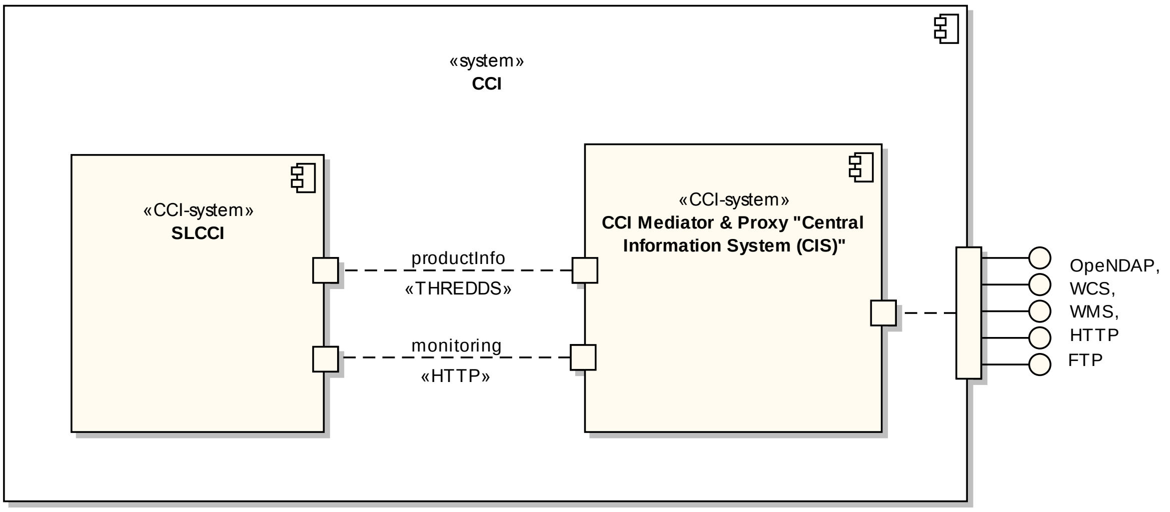

Figure 27 – SLCCI Perspective On ECV Collaborative System

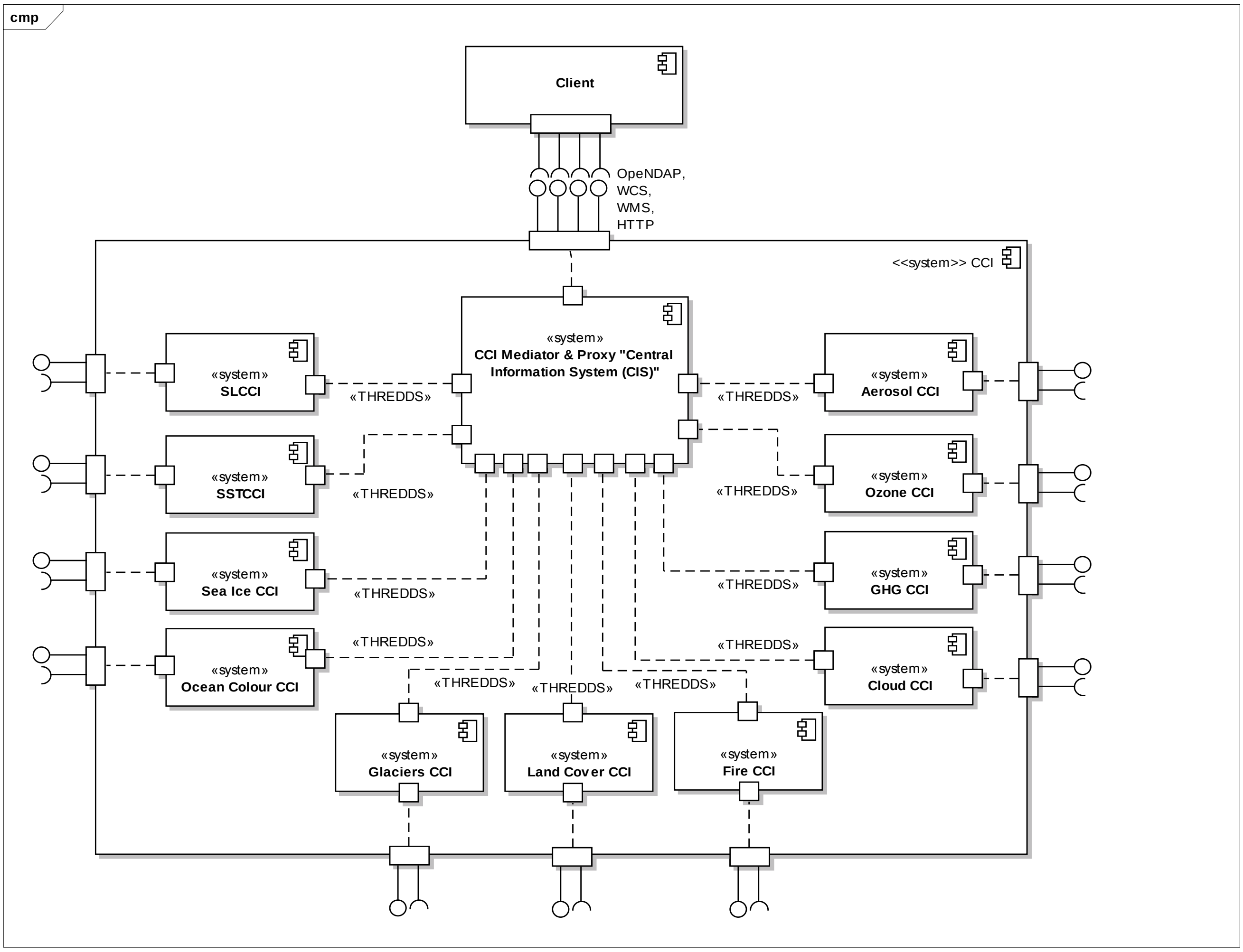

Figure 28 - CCI Perspective on Pan-ECV Collaborative System

7.3.3. Data Storage

Given evidence from the required balancing for cost effectiveness, and the portability of the DUACS production system, our preliminary analysis suggests that full remote storage of all SLCCI data is not sufficiently practical to attain cost effectiveness compared to keeping the existing CLS data architecture. The most likely area for amalgamation of SLCCI data storage with other CCI systems, is the making available of SLCCI products and their cataloguing information to a Central Information System, or the transfer of SLCCI products to a central CCI resource.

7.3.4. Processing

Similarly, the sharing of resources for consolidated processing of ECV products in an ongoing SEWG concern. The most practical way forward is the distributed processing of ECV products and a common catalogue at a central location representing those products, which this consortium proposed early on. This is ongoing work within the System Engineering Working Group (SEWG), and progress has been accommodated in the SLCCI by definition of a Central Information System (CIS) acting as a functional vehicle for this progress.

7.3.5. User & Product support

Preliminary findings of the System Engineering Working Group suggest that there may be opportunities for pan-ECV collaboration in the sharing of non-scientific human resources for product support. It is likely that such collaboration would depend on the sharing of CCI resources towards a common ticketing system, or at least the adaptation of existing CCI ticketing systems to collaborate via a common interface to a central organising resource. The efforts in pan-ECV collaboration for support design are ongoing, and represented herein by a Central Information System (CIS).

7.3.6. Security & Transaction Accounting

The matter of security is pertinent to the SLCCI, given the system must provide an operational service, and should guarantee the integrity of the SLCCI products on offer against malicious activity. The observation of user transactions is, similar to the matter of security, related to the accounting of users, and an area where collaboration across ECV systems may be viable. These activities are ongoing in the SEWG, and should provide a sharing of information given that the security concerns are common across ECV projects.

7.3.7. Infrastructure

The matter of infrastructure sharing, such as the housing of computer equipment, sharing of spare equipment, and sharing of network equipment, is a matter in discussion within the SEWG which we have similarly proposed.

7.3.8. Development Tools

As described earlier (§7.3), there are certain advantages associated with the sharing of development tools if there is a cost effectiveness associated with that sharing. These are ongoing in discussion.

7.4. Reuse View

The Reuse view, which realises the Reuse Viewpoint, concerns all aspects of reuse of existing systems for the purpose of absorption into the SLCCI system. As argued earlier, the Reuse Viewpoint has been defined and adopted for the SSD, due to the pertinent nature of system reuse.

The System Requirements Document provides a comprehensive argument both for system reuse for SLCCI, and for use of DUACS as the specific system for reuse; this follows a Preliminary System Analysis Document (PSAD) which identified DUACS as a useful object of system reuse. The full reasoning behind adoption of DUACS is not re-covered in this System Specification Document, but rather wholly made in the System Requirements Document (SRD) (15-110), as is similarly the avoidance of duplication with existing operational activities (15-140).

The Reuse View, therefore, is concerned with the architectural matters brought on by SLCCI adoption of the DUACS system, adopted in order to provide the basis for product generation for the SLCCI system. The Reuse View houses all pertinent information regarding this concern, as part of our architectural description of the SLCCI system, and so comprises of the following which inform our architectural description –

- In order to mitigate development risk, an exploration of inheritance of issues in the adoption of DUACS,
- An exploration of best practice in system reuse, elicited from the ECSS standards, and how these are realised for SLCCI design.

The DUACS system forms the SLCCI Production component (§7.2.2). This issue specifies Task 3 realisation by DUACS via the Reuse View and throughout the Views portfolio.

7.4.1. Inheritence of Issues

In adopting an existing system, we must also absorb all known issues associated with that existing system. These inherited issues must be acknowledged, and subsequently accommodated, in the SLCCI as part of our architectural system.

Our strategy for coping with these inherited issues, is to advise the future CCI Phase II implementers to absorb such matters into an SLCCI RIDS tool, namely Apache Jira (§6.3.4), and declare their type as being inherited issues. With purely inherited issues, it will be assessed how to approach the correction of the RID, whether in the target, SLCCI, system or the original system first.

7.4.2. SLCCI Best Practice

In the System Requirements Document, we acknowledged the ECSS say on system reuse. Below we include the requirements we created in view of this ECSS content, and for each assess how we realise the statement for the benefit of appropriately fulfilling our Reuse View.

SLCCI-SRB-REQ_18-100	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.2) such that an analysis shall be carried out of the advantages and disadvantages to be attained with the selection of existing software over new development.

Table 31 - SLCCI-SRB-REQ_18-100

We have satisfied SLCCI-SRB-REQ_18-100 via the System Requirements Document[152]. We argue that the advantages towards adoption of an existing system for product generation, over creation of a new production system from scratch, have been fully explored in the System Requirements Document (SRD).

SLCCI-SRB-REQ_18-110	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.3) such that existing software shall be assessed with respect to functional, performance and quality requirements, with a view on identification of an appropriate software system for re-use.

Table 32 - SLCCI-SRB-REQ_18-110

Moreover, we argue in the SRD for the specific adoption of DUACS, and reason as to advantages offered by DUACS, such as its maturity and proven competence in a pan-variable operational system. This line of argument satisfies requirement SLCCI-SRB-REQ_18-110[153]. The arguments fulfilling both SLCCI-SRB-REQ_18-100 and SLCCI-SRB-REQ_18-110 are predicated on the CCI desirability's as expressed by the Statement of Work, and similarly explored in the SRD via extraction of "business goals" representing the axiomatic needs for the system, so forming the operational vision for CCI.

SLCCI-SRB-REQ_18-120	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.4) such that the quality level of the existing software shall be assessed with regards to project requirements.

Table 33 - SLCCI-SRB-REQ_18-120

We will endeavour to explore the quality level of DUACS and confirm it is of a sufficient quality for the SLCCI, in the Perspectives section (§7.9). Here we assess quality dimensions of the SLCCI system, and reason that the adopted DUACS system accommodates these, otherwise illustrating any gaps which emerge.

SLCCI-SRB-REQ_18-130	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.5) such that results of the software reuse analysis shall be documented, including assumptions and methods applied towards estimating level of reuse.

Table 34 - SLCCI-SRB-REQ_18-130

[152] SLCCI-SRB-REQ_18-100

[153] SLCCI-SRB-REQ_18-110

As expressed by SLCCI-SRB-REQ_18-130[154], we fully explore the reuse analysis in this System Specification Document (SSD), focussing reuse interest in a defined Reuse View.

SLCCI-SRB-REQ_18-140	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.6) such that the suitability of the reusable system shall include assessment of
(a)	Acceptance and warranty conditions
(b)	Support documentation
(c)	Conditions under which installation, preparation, training and use take place
(d)	Identification & registration via configuration management
(e)	Maintenance
(f)	Durability and validity of earlier tools which may be re-used
(g)	Constraints relating to copyright and intellectual property rights
(h)	Conditions of licensing
(i)	Constraints associated with exportability

Table 35 - SLCCI-SRB-REQ_18-140 to SLCCI-SRB-REQ_18-149

Acceptance and warranty conditions[155], support documentation[156], copyright and intellectual property[157] and other such matters[158] are supported for the SLCCI system.

We argue that the matter of durability and validity of earlier re-usable tools is deemed irrelevant, due to the arguments proposed in the SSD towards adoption of an existing system, and that the system being reused should be DUACS.

The matter of installation, preparation, and training[159] is judiciously explored in the Operational View, as are matters pertaining to configuration management[160] and exportability[161]. Maintenance is covered[162] by the RAMS element in Perspectives.

[154] SLCCI-SRB-REQ_18-130

[155] SLCCI-SRB-REQ_18-141

[156] SLCCI-SRB-REQ_18-142

[157] SLCCI-SRB-REQ_18-147

[158] SLCCI-SRB-REQ_18-148

[159] SLCCI-SRB-REQ_18-143

[160] SLCCI-SRB-REQ_18-144

[161] SLCCI-SRB-REQ_18-149

[162] SLCCI-SRB-REQ_18-145

SLCCI-SRB-REQ_18-150	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.7) such that corrective actions shall be identified and appropriately documented where the reused software does not meet the appropriate requirements of the SLCCI system.

Table 36 - SLCCI-SRB-REQ_18-150

With regards to SLCCI-SRB-REQ_18-150[163], it is pertinent that the System Requirements Document be fully satisfied by the System Specification Document. Any requirement which is unsatisfiable must indeed be documented and managed in order to find the pertinent point along the documentation or engineering chain at which a change is required. This should involve communication with stakeholders and consensus building wherever necessary to introduce the required change if applicable. The Reuse View takes full responsibility for housing such information.

SLCCI-SRB-REQ_18-160	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.8) such that missing documentation shall be attained to aptly reach verification and validation coverage.

Table 37 - SLCCI-SRB-REQ_18-160

The System Requirements Document fully incorporates the DUACS system, in terms of what is expected by the SLCCI re-use. The System Specification Document fully realises these system reuses needs. Therefore, verification and validation of an implemented (Phase II) system may be accomplished by use of the System Requirements Document. Similarly, the System Specification Document may be used to validate the system architecturally, with the aid of architectural scenarios.

SLCCI-SRB-REQ_18-170	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.9) such that identified corrective actions shall be appropriately updated and documented at project milestones.

Table 38 - SLCCI-SRB-REQ_18-170

Corrective actions shall be made and documented in the natural course of activities in Phase I in constructing the SRD and SSD. This practise should be put into practice during Phase II by whichever party conducts the exercise.

SLCCI-SRB-REQ_18-180	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.10) such that the system being reused shall be kept under configuration control.

[163] SLCCI-SRB-REQ_18-150

Table 39 - SLCCI-SRB-REQ_18-180

Requirement SLCCI-SRB-REQ_18-180 shall be put under practice during Phase II; it is at this stage that the actual reuse of the software (comprising of integration of all its artefacts) will take place. Similarly, with regards to requirement SLCCI-SRB-REQ_18-190, we propose this be put into practice during Phase II.

SLCCI-SRB-REQ_18-190	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.11) such that the configuration status of the baseline associated with the reused software shall be appropriately documented.

Table 40 - SLCCI-SRB-REQ_18-190

The ECSS-derived requirements on system reuse are derived as follows -

System Requirement	Where Satisfied
SLCCI-SRB-REQ_18-100	SRD §6.3.4
SLCCI-SRB-REQ_18-110	SRD §6.3, SRD §8.2, PSAD
SLCCI-SRB-REQ_18-120	§7.9 (Perspectives)
SLCCI-SRB-REQ_18-130	§7.4 (Reuse View)
SLCCI-SRB-REQ_18-140 - a	§7.4 (Reuse View), §7.6 (Operational View), §7.9 (Perspectives), §7.4.2
SLCCI-SRB-REQ_18-141 – b	§7.4 (Reuse View), §7.4.2
SLCCI-SRB-REQ_18-142 – c	§7.4 (Reuse View), §7.4.2
SLCCI-SRB-REQ_18-143 – d	§7.6 (Operational View), §7.4.2
SLCCI-SRB-REQ_18-144 – e	§7.6 (Operational View), §7.4.2
SLCCI-SRB-REQ_18-145 – f	§7.9 (Perspectives), §7.4.2
SLCCI-SRB-REQ_18-146 – g	SRD §6.3, PSAD, §7.4.2
SLCCI-SRB-REQ_18-147 – h	§7.4 (Reuse View), §7.4.2
SLCCI-SRB-REQ_18-148 – i	§7.4 (Reuse View), §7.4.2
SLCCI-SRB-REQ_18-149 – j	§7.6 (Operational View), §7.4.2
SLCCI-SRB-REQ_18-150	§7.4 (Reuse View), §7.4.2
SLCCI-SRB-REQ_18-160	Phase II (see Development View, §7.8), §7.4.2
SLCCI-SRB-REQ_18-170	Phase II (see Development View, §7.8), §7.4.2
SLCCI-SRB-REQ_18-180	Phase II (see Development View, §7.8), §7.4.2
SLCCI-SRB-REQ_18-190	Phase II (see Development View, §7.8), §7.4.2

Table 41 – ECSS Reuse Requirements Traceability

7.5. Information View

The Information View concerns all matters pertaining to the flow, distribution, storage, manipulation and management of data, whether data stored persistently in a database or equally data treated transiently in memory.

We first describe the role of information in the product pipeline, as the content which leads to inclusion as parameters in the final product, ancillary earth observation data used for the creation of the product, and all non-product information involved in the product pipeline such as long term statistics.

The DARD describes the complete set of data acquired by the SLCCI system, required to feed into the product pipeline to generate the SLCCI products. We concisely summarise the content of the DARD, with a slant on leading to the volumetrics required for the SLCCI system. Having explored volumetrics and the data needs for SLCCI, we introduce how such needs can be partially fulfilled by the SLCCI system.

We define the information interface between the SLCCI system and the rest of the world. This definition falls under two categories. Firstly, the nature of information flow between SLCCI and the rest of the world in the event of the SLCCI acting independently to all other ECV activity[164]. Secondly, an understanding of how SLCCI information plays an important role in the analysis for integration of the SLCCI with other ECVs, or indeed a pan-ECV system. We briefly discuss this exercise, before referral to full discourse in the Pan-ECV View.

Aside from the above product-centred information, we must also account for the operational data ascribed to SLCCI. To this end, we briefly describe the operational databases of SLCCI, before passing the responsibility of a fuller account to the Operational View.

7.5.1. Product Generation

For the purposes of product generation, the following databases are used –

Database Name	Description
Altimetry	Contains all parameters of acquired data needed to directly include in and build the SLCCI products, including all ancillary data relating to correction and environment parameters required for product generation.

[164] We do not here propose that the SLCCI system should act independently of all other ECVs. Indeed, the advantages of a pan-ECV system, and our activities towards its aim, are argued within both the System Requirements Document (SRD) and the System Specification Document (SSD). Rather, a treatment of how the SLCCI would act, irrespective of other ECVs, informs our analysis as to what the information needs of the SLCCI system are, and this information can then be subsequently used to assess how we can go about satisfying the same information needs via a pan-ECV system.

Crossovers Database	Contains all crossover related information, such as the position of the crossover, date and time the crossover occurred, and the content of the measurements at that time and place for both arcs. This database is used for orbit error reduction and monitoring of data quality.
Statistics Database	Contains all long term statistics and metrics relating to the relevant missions.
Temporary Product Files Database	Contains intermediary information generated during the product generation. This database is used for practical reasons, to avoid effort duplication if datasets must be reprocessed.

Table 42 - Databases Used By Product Pipeline

These database components are constituents of the Production database.

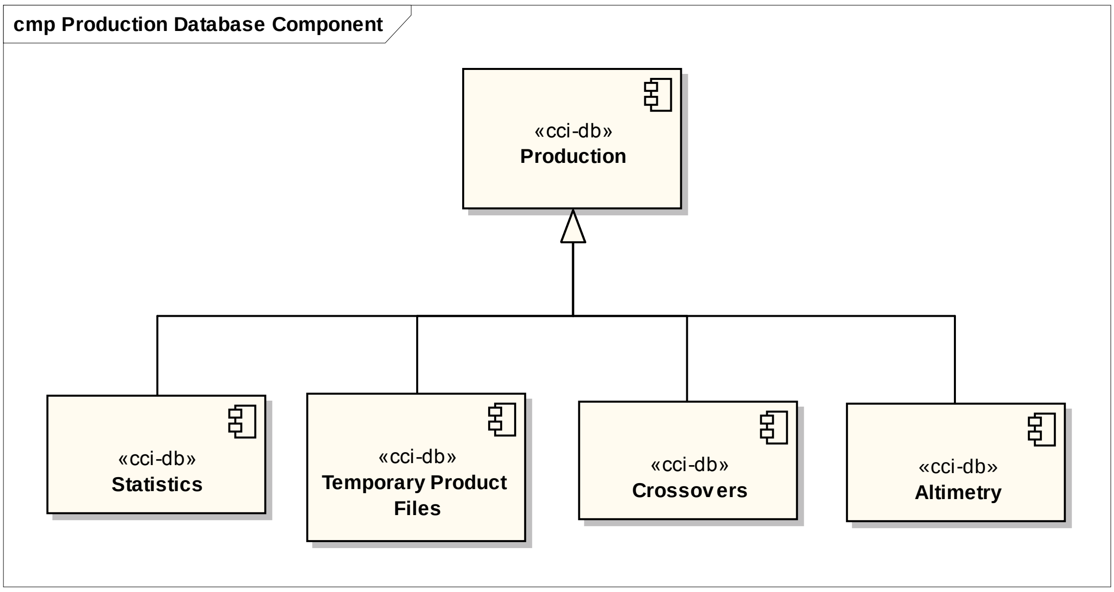

Figure 29 - Constituent Components of Production database

The diagrams below map these databases to stages of the product pipeline; these stages are formally defined in the System Requirements Document (SRD). Two diagrams exist per database, illustrating the data flow input and output to the stages of the product pipeline. Chapter 5 fully describes the notation adopted, including the UML Profile formally defined for our UML usage.

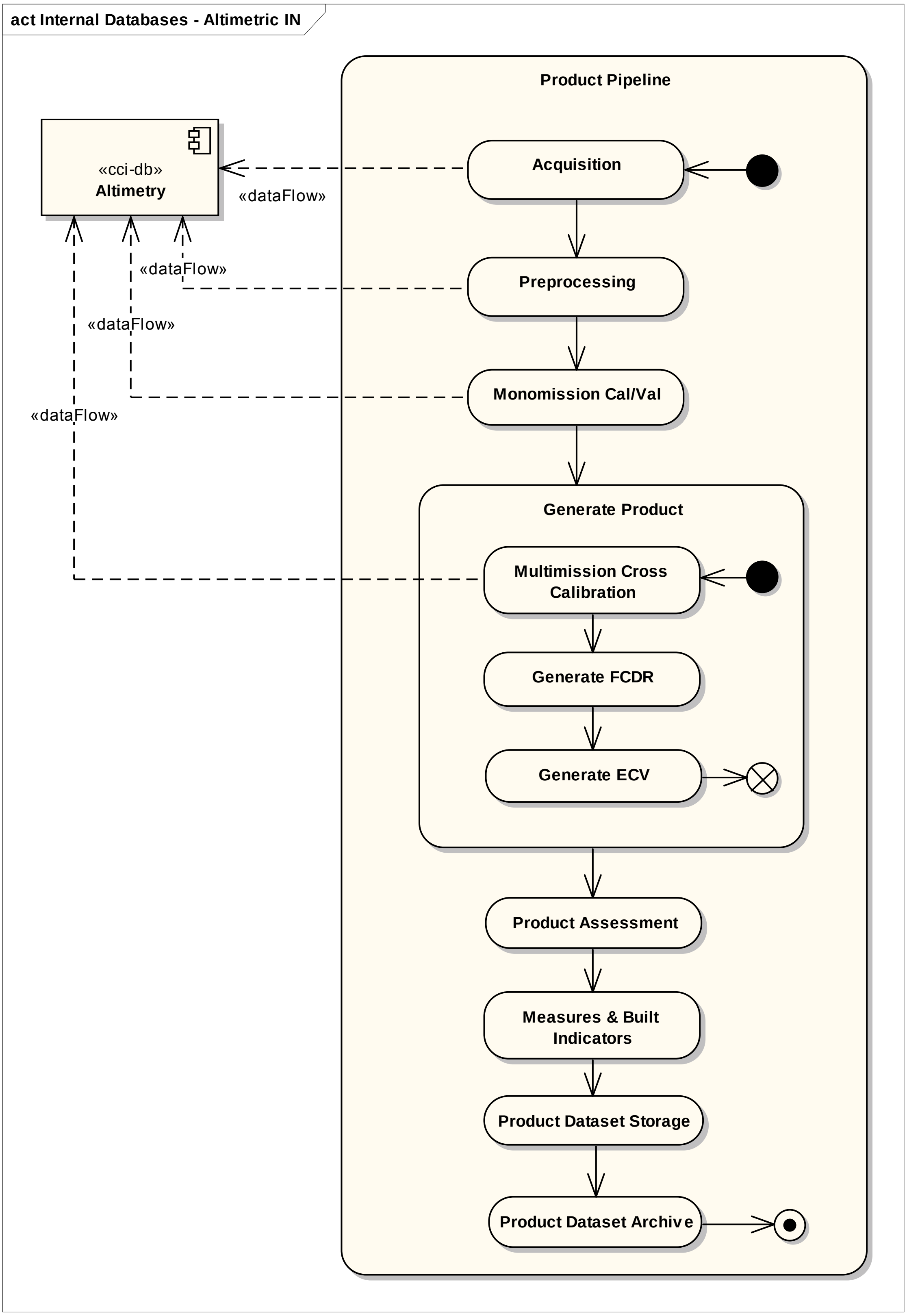

Figure 30 - Input to Altimetric Database in Context to Product Pipeline

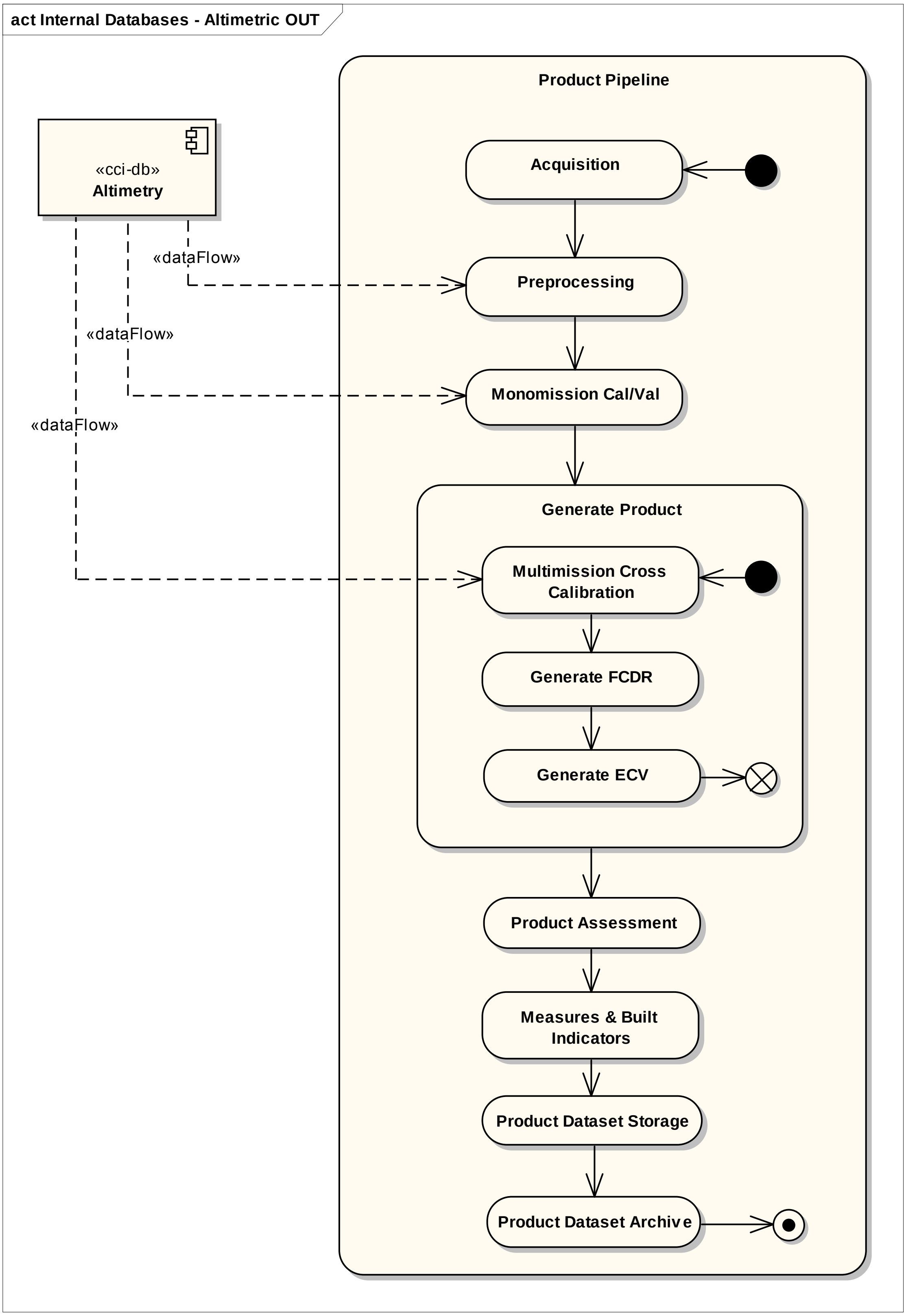

Figure 31 - Output from Altimetric Database in Context to Product Pipeline

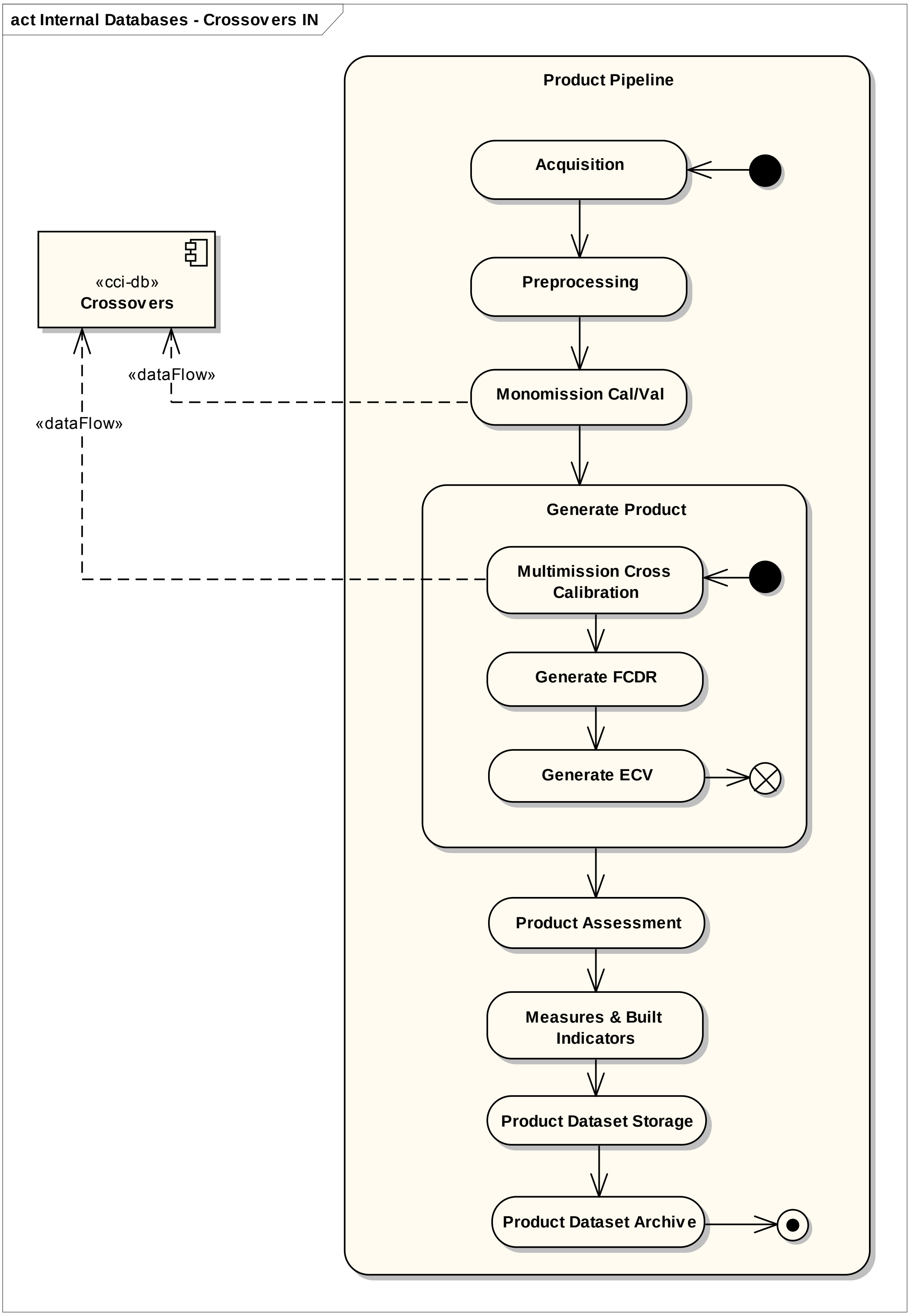

Figure 32 - Input to Crossovers Database in Context to Product Pipeline

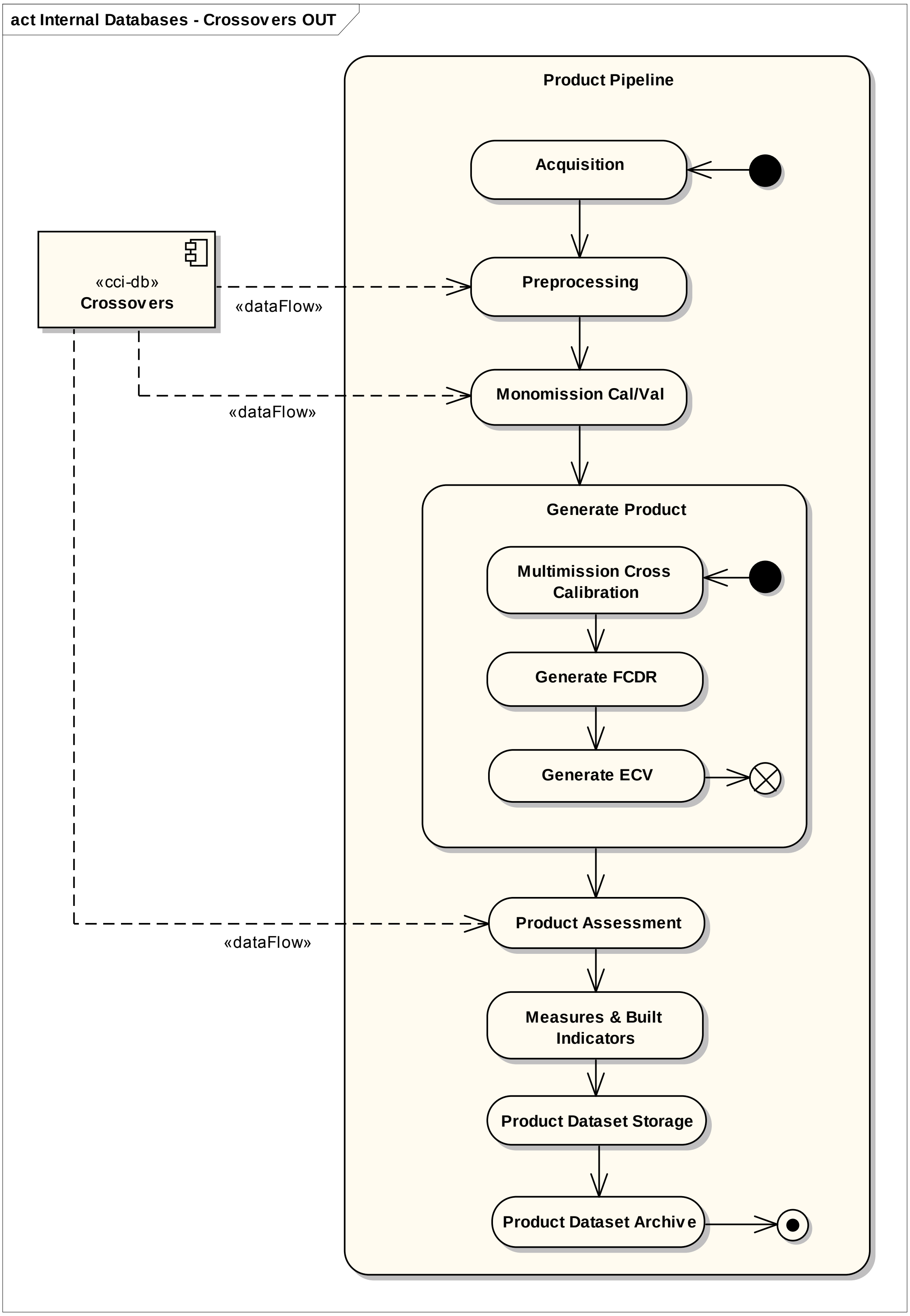

Figure 33 - Output from Crossovers Database in Context to Product Pipeline

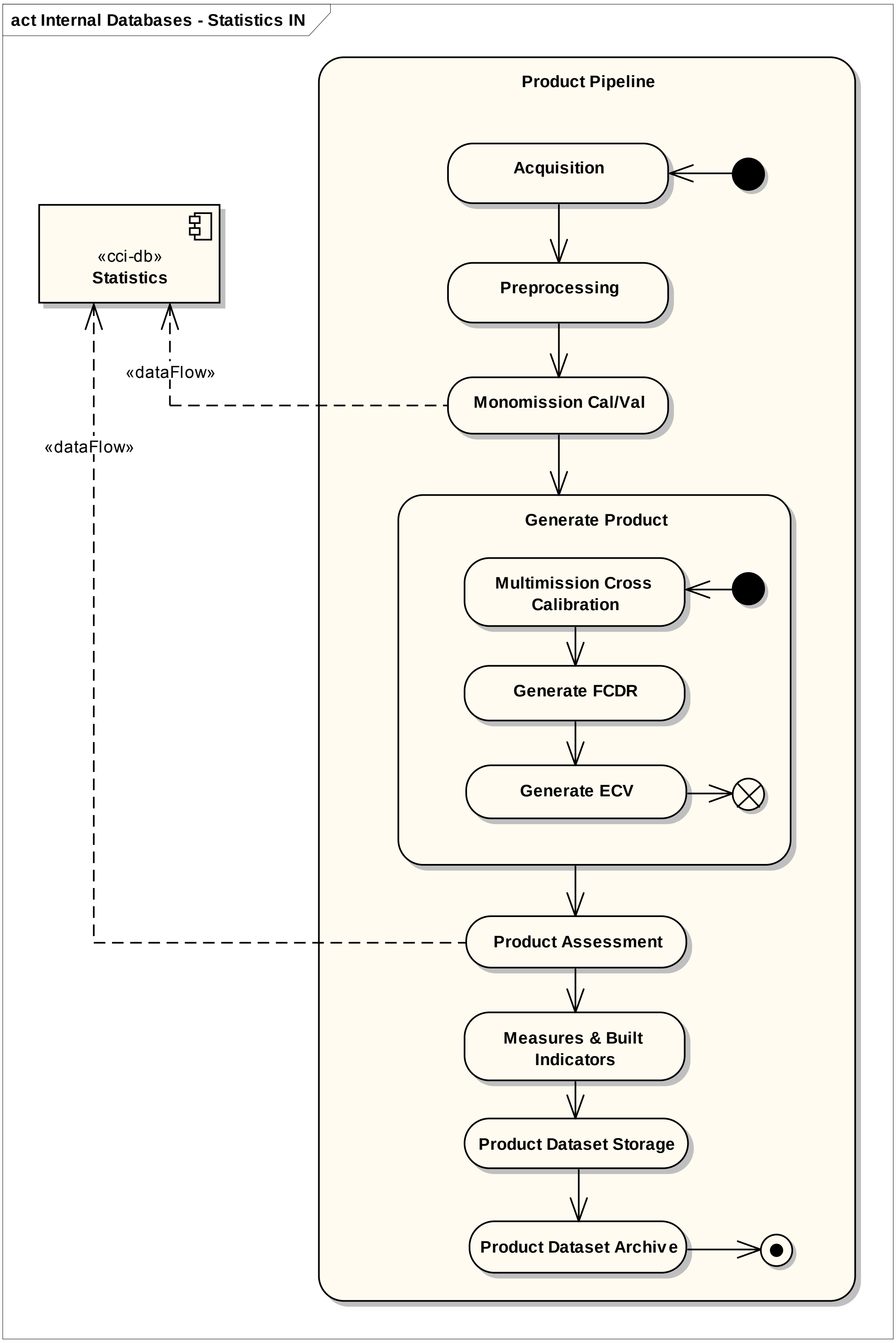

Figure 34 - Input to Statistics Database in Context to Product Pipeline

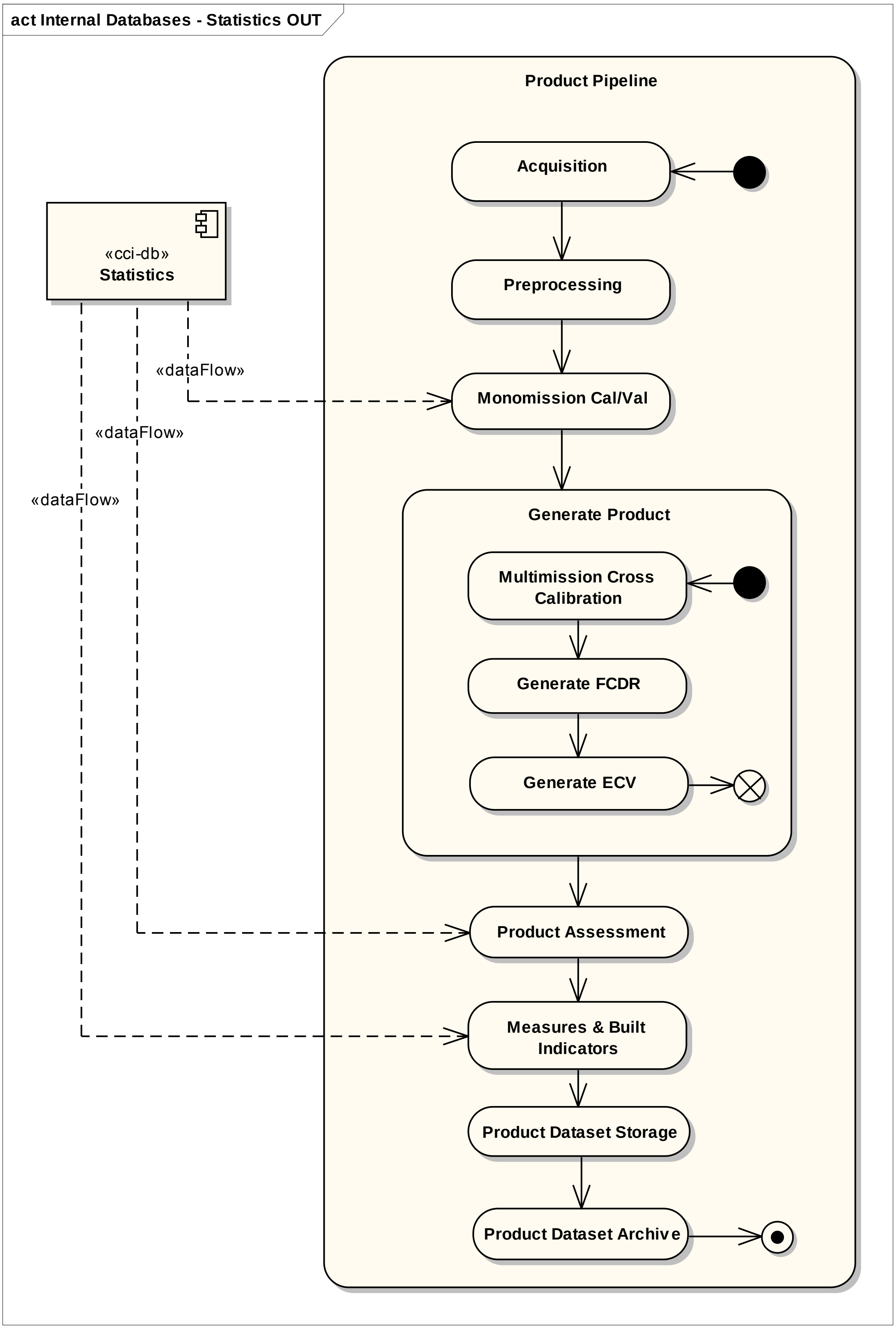

Figure 35 - Output from Statistics Database in Context to Product Pipeline

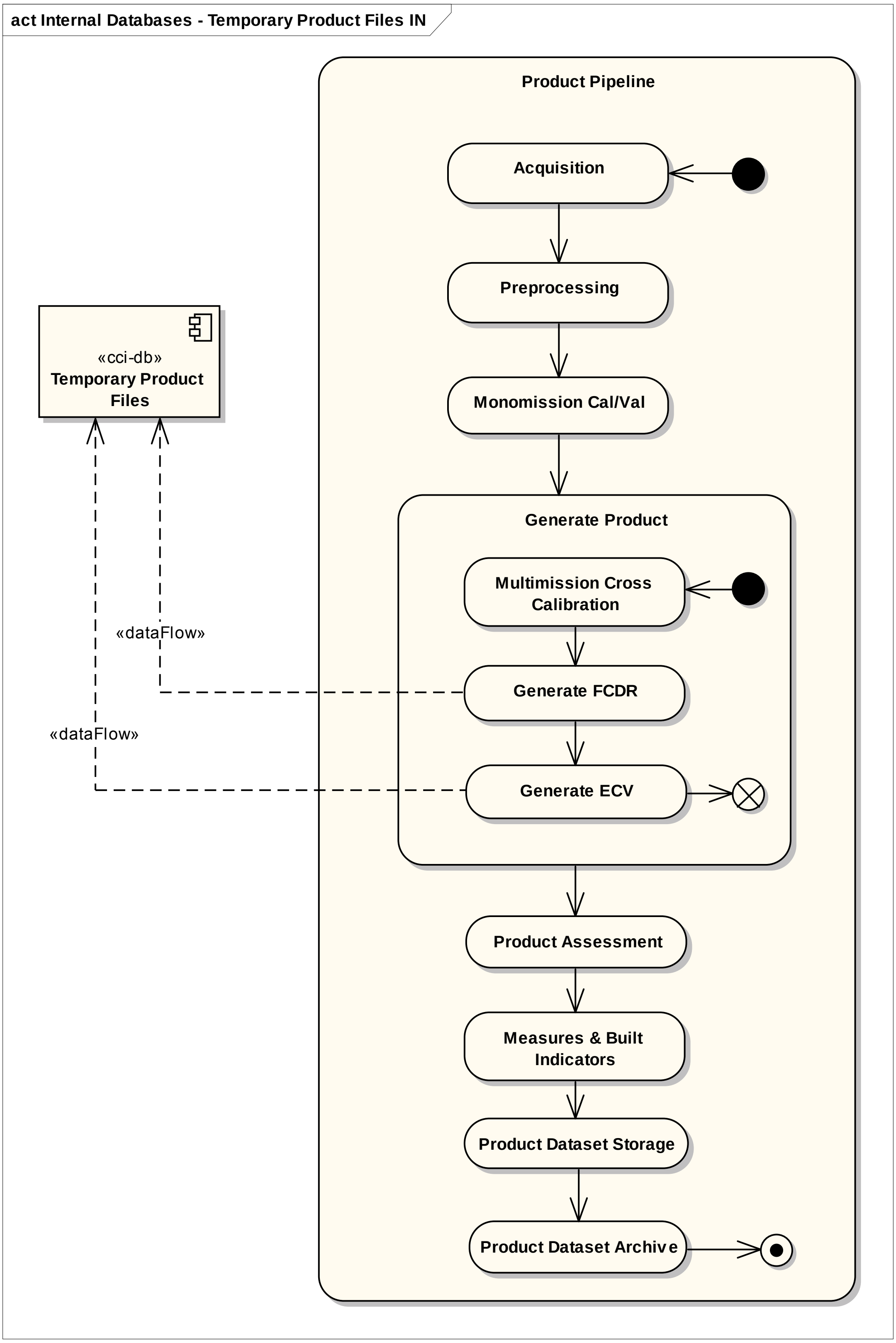

Figure 36 - Input to Temporary Product Files Database in Context to Product Pipeline

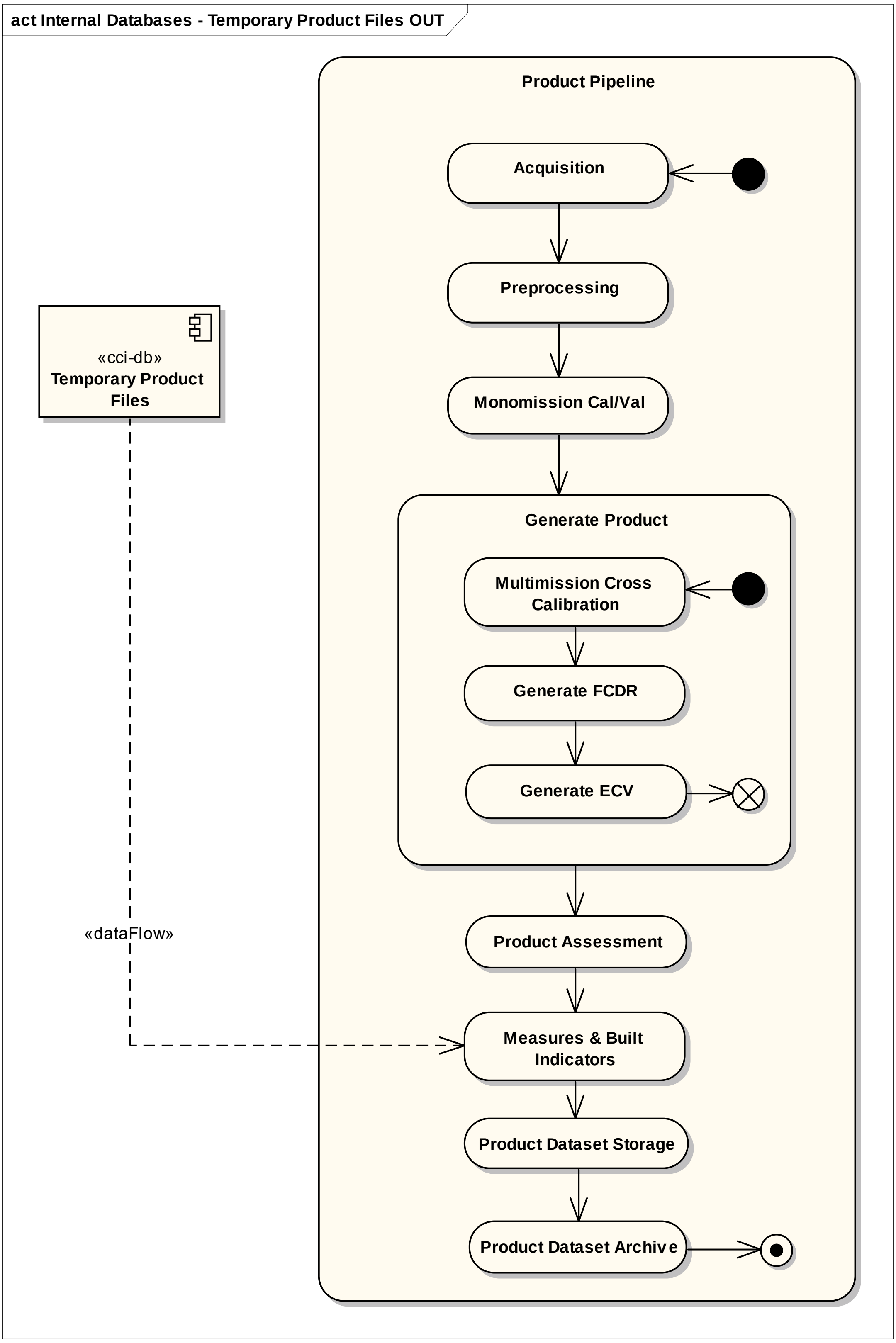

Figure 37 - Output to Temporary Product Files Database in Context to Product Pipeline

7.5.2. Data Acquisition Content

We can logically partition all input data required by the SLCCI into four groups. Together, the data content associated with each defined category of data, fully defines the Data Acquisition information required for the SLCCI. This classification is pertinent, as the strategy for absorbing the required input data into SLCCI will vary significantly across the categories.

There exist subtle but significant differences across the distinct categories, which we below distil into four categories representing the strategy for Phase I. During Phase II, a low level strategy will be realised for each of these categories by the future Phase II implementers, as to how to accommodate this data into the SLCCI system equivalent of DUACS, which will include appropriate preservation of Postgres database integrity and checking through use of the Postgres locking facility.

- Category 1 SLCCI Input Data -
  - All data required for SLCCI Data Acquisition which is already fully residing within the DUACS system. There is data already in existence in DUACS, contained within the Altimetric, Crossovers, Statistics, and Temporary Product Files databases belonging to DUACS. A low level strategy is needed as to how we fully reuse this valued data and safely ignore the irrelevant data already residing on DUACS.
- Category 2 SLCCI Input Data –
  - All data required for SLCCI Data Acquisition which is already on CLS premises but not absorbed within the DUACS system. A low level strategy will be put in place by future Phase II implementers as to how to accommodate this data into the SLCCI system equivalent of DUACS.
- Category 3 SLCCI Input Data –
  - All data required for SLCCI Data Acquisition which is exists externally but is yet to be acquired. The Data Access Requirements Document (DARD) describes the data yet to be acquired for the SLCCI project, for the purposes of the algorithm development and inter-comparison. It is yet to be determined which subset of this data will be required, ultimately, for the SLCCI system. Once this subset is decided[165], a strategy will be needed to absorb the data into the SLCCI equivalent of the DUACS production system, echoing the Category 3 strategy.
- Category 4 SLCCI Input Data –
  - Future data, not yet existing, which will be arriving from external systems either by push or pull bulk access. As demanded by the Statement of Work, the system needs to accommodate future data needs. It is assumed that the absorption of this kind of data mirrors categories 2 and 3; that is, once the external data is acquired and brought in to the consortium premises, the absorption of data into the SLCCI system will be the same for categories 2, 3 and 4.

[165] Once the subset is decided, the DARD will be updated to a newer edition describing the subset of such data which is still needed for the operational system. On updating the DARD, the System Specification Document (SSD) will be updated to formally account for this change.

7.5.3. Product Storage

For the purposes of product management, the means by which the stored products are accessed by the Products Management sub-system, the following databases are used –

Database Name	Description
ECV Products	Contains ECV products
ECV Metadata	Contains metadata associated with the ECV products.

Table 43 - Databases Used by Products Management sub-system

These databases are constituents of the Products Management database.

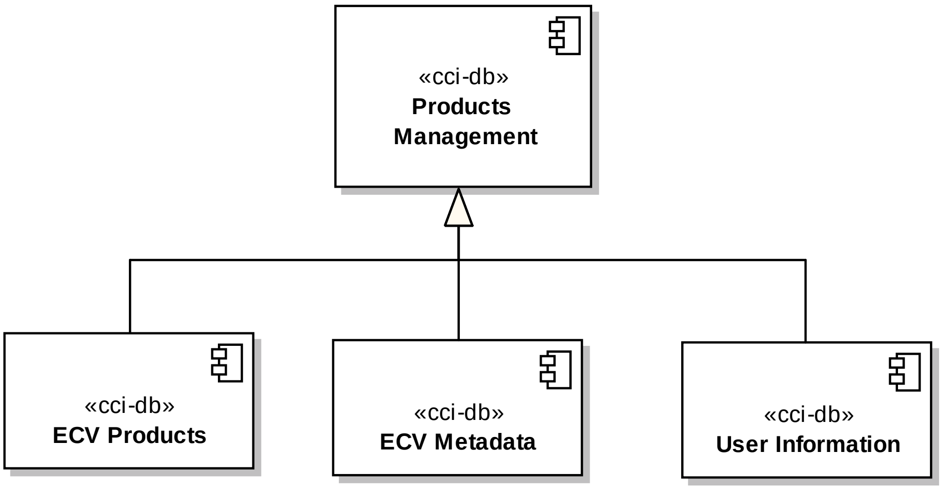

Figure 38 - Constituent Components of Production database

As with earlier diagrams, Chapter 5 describes the notation adopted, including the UML Profile formally defined for our UML usage.

7.5.4. System Metrics

Given our analysis of the data volumes the system will be experiencing across all 4 categories, the following are estimated; the volumetrics have a bearing on the processing metrics, so we describe these here in the same location. These define the provision of disk storage dedicated to the product pipeline through the Production database[166] for hosting of stored and readily available ECV products [167] and archived ECV products[168]; resources permitting, maximum database sizes will be

[166] SLCCI-SRB-REQ_14-020, SLCCI-SRB-REQ_1-300

[167] SLCCI-SRB-REQ_14-030

[168] SLCCI-SRB-REQ_14-040, SLCCI-SRB-REQ_9-205

accommodated allowing for contingency in data volume variability across the processing chain databases[169] including forthcoming mission data[170].

- Disk storage needed for input and intermediate data (Production database, Figure 15) : 200 GBytes
- Disk storage needed for output data (Production database, Figure 15): 250 GBytes; 50GBytes online fast storage[171], 200GBytes offline slow archive[172].
- Disk storage needed for user information; 100Mb, maximum data volume size provisioned: 110 GBytes[173].
- Power Processing:
    - 3 hours to process 7 days of altimetric data (L3 and L4 products) on a standard computer (Xeon 2 cores, 8GB RAM)
    - So, for 20 years = 3 200 hours on one computer = 4 month
    - So for 20 years on the RAN production cluster (50 computers shared with others projects) = 2 months

7.5.5. Reuse of DUACS Information

The Information View has described the reuse of DUACS information, formally categorising such data as Category 1 SLCCI Input Data; this category of data represents the information already residing in DUACS, which happens to be relevant and required for the SLCCI operational system, before the DUACS system has been reused for DUACS.

In this view we have categorised reused DUACS information, and described a strategy as to how that DUACS information is made visible for the SLCCI system. This view does not, and should not, describe the strategy or process by which the DUACS system itself[174] is reused, to function in the guise of an SLCCI production system. Our architectural description for reuse of the DUACS production system is contained in the Functional View (§7.2) and Reuse View (§7.4).

7.5.6. Information Flow Across SLCCI System Interface

There exist two permutations with which an interface between the SLCCI system and the outside world are defined, and it is imperative, for clarity, that the distinction between both scenarios be properly accounted for. These two scenarios are –

1. SLCCI system communication with the outside world, irrespective and independent to the other ECV systems. This comprises of interfaces for Monitoring, and Product Access & Visualisation. This does not include communication with a Central Information system (CIS).

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[169] SLCCI-SRB-REQ_21-500, SLCCI-SRB-REQ_21-510, SLCCI-SRB-REQ_21-520

[170] SLCCI-SRB-REQ_21-440

[171] SLCCI-SRB-REQ_8-045

[172] SLCCI-SRB-REQ_9-205

[173] SLCCI-SRB-REQ_21-530

[174] The SLCCI system without the information which resides in the SLCCI system

2. SLCCI system communication with the outside world, in cooperation with other ECV systems. This includes communication with a Central Information system (CIS).

For point 1, the Functional View defines all interfaces with the outside world, and is described by the Functional View (§7.2). For point 2, we similarly preliminarily describe this in the Functional View (§7.2), and we anticipate that, through activities within the System Engineering Working Group that such considerations may evolve further before CCI Phase II.

7.5.7. User Data

As described earlier[175], operationally, the SLCCI system does not only store and manage information directly pertaining to the SLCCI products and their generation. The system must also accommodate data used by the SLCCI in an operational context, comprising of data pertaining to users consulting the SLCCI site, accessing and visualising its products.

7.6. Operational View

The Operational View conveniently focuses our concern for operational matters related to the SLCCI system. In so doing, we describe the forces within the system responsible for administration, support and other influences allowing the product generation to take place on the live system.

Having been functionally described by the Functional View, we begin the Operational View by defining the monitoring system, including the data management burden which the system must carry. A description of the database responsible for holding of user data then follows. The data is collected and provides an invaluable window on how the end users are collecting the product. We take our definition of user hierarchy defined in the System Requirements Document (SRD) and explore further here, enough to functionally specify the operational responsibilities of the system.

7.6.1. Operational users

Similarly, the System Requirements Document (SRD) defined a user hierarchy; for convenience, we display this structure below. We are further investigating this structure for our operational needs, pertinently in relation to pan-ECV collaboration towards sharing of human resources, and sharing of tools used by the operational users, such as support ticketing systems.

[175] §7.5.6, §7.2.11

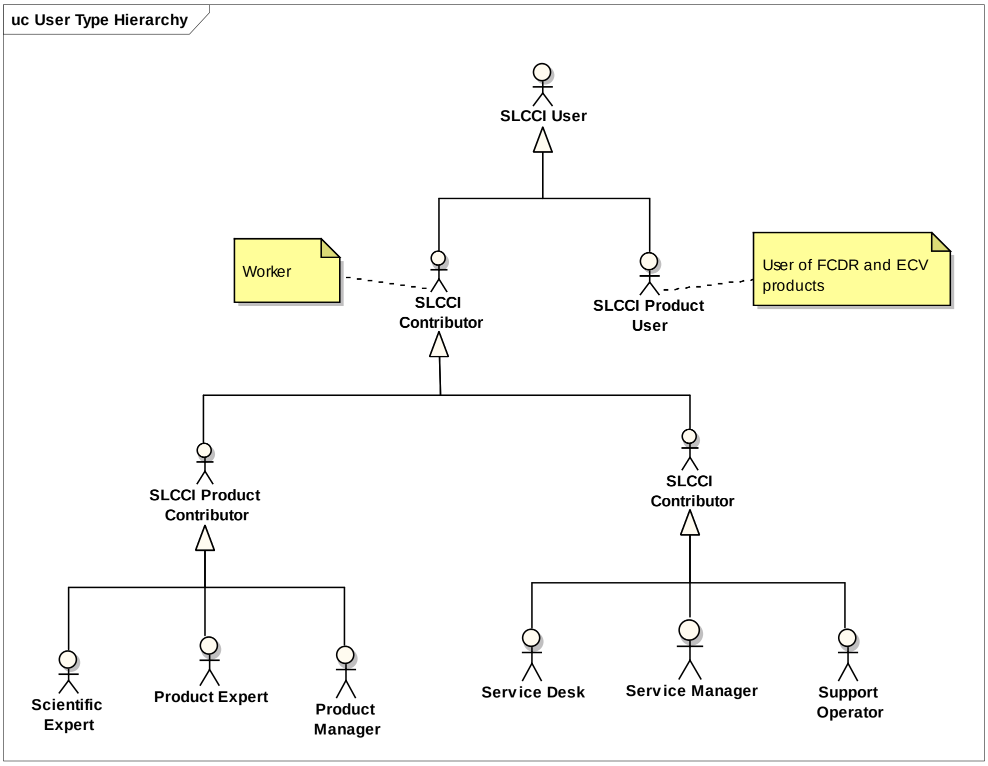

Figure 39 – User Type Hierarchy

The SLCCI Contributors responsible for the *operational* running of the system comprise of the following -

- *Service Manager* is informed of and responsible for Product Access & Visualisation portal failures, such as to ftp server, http server and OGC web services[176]. The Service Manager deals with requests by SLCCI Product Users to make offline content from the product archive online for access[177], and similarly deals with seeing through the request until completion[178].
- *Service Desk* is responsible for engagement with SLCCI Product Users, enacted through correspondence by e-mail, transfer protocol (HTTP) and phone[179], with all such engagement addressed to a ticketing system. Tickets are newly registered and closed by an OpenNMS console. The user facing stance of the Service Desk role demands that each ticket must be responded to within a period of 72 hours[180].
- *Support Operator* has a significant role supporting the Service Manager and liaising with the Service Desk to satisfy registered support tickets. A dashboard on a terminal portraying the status of the residing OpenNMS and status of OpenCRX support tickets are the tools by which the Support Operator monitors the health of the SLCCI system and takes on support tickets to manage the health of the system[181]. The system monitoring OpenNMS tool

[176] SLCCI-SRB-REQ_8-043, SLCCI-SRB-REQ_8-044

[177] SLCCI-SRB-REQ_9-040

[178] SLCCI-SRB-REQ_9-050

[179] SLCCI-SRB-REQ_10-080

[180] SLCCI-SRB-REQ_10-081

[181] SLCCI-SRB-REQ_12-050

receives alerts from the Production System for the Support Operator, when the format of acquired primary input data lacks in syntactic[182] or semantic[183] integrity, or size unrecognised[184]. Similarly, the Production subsystem informs the Support Operator via IMonPrd to the Monitoring subsystem console panel of anomalous ancillary data[185]. On receiving such information on a console terminal via IMonPrd the Support Operator can act, engaging with the upstream system responsible for anomalous data for redelivery[186] and ensuring the SLCCI system is in a ready state to re-receive the data[187]. On progress in enacting such anomalies, tickets are updated via the same console on OpenCRX. Moreover, in the event that a system issue is discovered by the Support Operator, the Service Desk, responsible for registering and closing support tickets, will be informed[188]. Additionally, the Support Officer will be responsible for inventory management of SLCCI system assets, including operation of the PCS Inventory System and ensuring assets label usage is correct, under the auspices of the Service Manager.

7.6.2. Ticketing system

The provision of a ticketing system has been discussed[189] with OpenCRX introduced[190]. As with the inventory system, OCS Inventory[191] and system monitoring centre[192], OpenNMS, the ticketing system will reside within the Monitoring sub-system, the administrative centre of the SLCCI system. Requests arrive electronically or by phone from users, the Service Desk user then creating the electronic OpenCRX ticket[193], with the ultimate result being communicated back to the user[194].

The processing of an OpenCRX ticket will go through a lifecycle prior to the closing of the request. All incoming requests are acknowledged to the external user by the Service Desk on ticket creation. Tickets are assessed to ascertain the parties most qualified to solve the ticketed issue, with the ticket then being dispatched to those parties. The fixing parties have responsibility to solve the ticketed issue prior to communicating the result of the attempt to the Service Desk. In the case where the ticketed issue hasn't been resolved, the Service Desk will either re-assign the ticket to another SLCCI worker, or as a last resort communicate to the user that the ticket could not be resolved and the

[182] SLCCI-SRB-REQ_1-030

[183] SLCCI-SRB-REQ_1-031

[184] SLCCI-SRB-REQ_1-036

[185] SLCCI-SRB-REQ_1-032, SLCCI-SRB-REQ_1-033

[186] SLCCI-SRB-REQ_1-034

[187] SLCCI-SRB-REQ_1-035

[188] SLCCI-SRB-REQ_1-096

[189] §6.3.4, §7.6.1

[190] SLCCI-SRB-REQ_10-050

[191] §6.3.4, §7.6.4

[192] §6.3.4, §7.6.3

[193] SLCCI-SRB-REQ_10-051, SLCCI-SRB-REQ_10-054

[194] SLCCI-SRB-REQ_10-080

issue will be registered for future resolution[195]. In this last case, the ticket is realised as a recorded issue within Apache Jira, which also resides internally at the Monitoring sub-system.

7.6.3. Monitoring system

The component responsible for the monitoring of the SLCCI system has been functionally described in the Functional View, in context of the other functional components residing in the SLCCI system and the monitoring component's interfacing with them. As identified by trade off analysis, OpenNMS will be used by the Monitoring sub-system to absorb monitoring events communicated by bespoke-developed senders in other sub-systems, to which operations team personnel may ticket on OpenCRX.

7.6.4. Inventory Management

Inventory management is required for the efficient management and accountability of all assets[196], and for the realising of the SLCCI cold standby[197] fault tolerance strategy (§6.3.4) to account for spares. Inventory management system OCS Inventory will support asset management by the Support Operator (§7.6.1). OCS Inventory will be functionally reside in the Monitoring sub-system as a standalone operations tool for the Support Operator, allowing console display of OCS Inventory to sit alongside OpenNMS and OpenCRX for operating convenience. The OCS Inventory system must refer uniquely to the SLCCI lowest replaceable units, and this is accomplished by means of an asset identification label attached to all maintainable physical assets[198]. To account for assets accurately the physical assets need identification labels which are clearly accessible[199] and the Support Operator is responsible for this under the governance of the Service Manager.

7.6.5. Storage and Management of User Information

Another operational feature required for the SLCCI system is the storage and management of user information, both for the purposes of security and auditing user activity. User registration will be mandatory for the accessing of ECV products[200], requiring registration of a username and password only[201]. Authentication will be conducted through OpenID, as identified earlier during trade-off analysis (§6.3.4) and reside on the Product Access & Visualisation sub-system[202].

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[195] SLCCI-SRB-REQ_10-055

[196] SLCCI-SRB-REQ_14-100, SLCCI-SRB-REQ_14-110

[197] SLCCI-SRB-REQ_15-500, SLCCI-SRB-REQ_15-510

[198] SLCCI-SRB-REQ_14-120, SLCCI-SRB-REQ_14-450

[199] [199] SLCCI-SRB-REQ_14-120, [199] SLCCI-SRB-REQ_14-130

[200] SLCCI-SRB-REQ_10-230

[201] SLCCI-SRB-REQ_10-200, SLCCI-SRB-REQ_21-340

[202] SLCCI-SRB-REQ_10-201, SLCCI-SRB-REQ_10-210

For the convenience of the operational staff of the SLCCI system, the user information stored within the SLCCI Postgres database will be exportable[203], which involves the operational staff exporting user information through bespoke Postgres scripts developed by future implementers during Phase II[204]. Likewise, export facilities will be setup to allow operational staff to export all primary, auxiliary and crossover data[205].

Given activity in the CCI System Engineering Working Group (SEWG), we anticipate further development on this matter pertaining to shared user resources across the spectrum of CCI systems.

7.6.6. Support Plan

To ensure a methodical approach to system maintenance and dissemination of best practice across the operational users, a support plan will be constructed by the Support Operator and Service Manager. Similarly, the support plan will serve as an operational day to day handbook for use by the Service Manager, Service Desk and Support Operator.

The support plan will include a maintenance section describing not only the management of physical assets, but also proprietary software, OTS software and Open source software[206]. Pertinent to this will be a stepwise description of how asset updates and service packs are addressed[207]. Equally pertinent, instructions for the operating staff will include strategies for asset obsolescence[208]. Moreover, a support plan will also network infrastructure details, allowing operations staff to act efficiently when a support ticket arrives via OpenCRX or event information via OpenNMS[209].

The Support Plan also includes security and privacy protocols to be adhered to by the internal users of the SLCCI system, as further described in (§7.9.1)

7.7. Deployment View

Operational deployment of the SLCCI system to the target infrastructure will be a necessary activity of the future SLCCI Phase II implementers. We propose an SLCCI Installation and Adaptation Guide to be constructed during Phase II, defining the order and means by which the SLCCI operational system is initially deployed, and so also advising on future adaptation instruction, containing the following instruction –

- installation of network infrastructure[210]
- installation of existing DUACS altimetry to the SLCCI system[211]

[203] SLCCI-SRB-REQ_21-400

[204] SLCCI-SRB-REQ_21-420

[205] SLCCI-SRB-REQ_21-430

[206] SLCCI-SRB-REQ_14-460, SLCCI-SRB-REQ_14-470

[207] SLCCI-SRB-REQ_14-510, SLCCI-SRB-REQ_14-520

[208] SLCCI-SRB-REQ_14-530

[209] SLCCI-SRB-REQ_14-610

[210] SLCCI-SRB-REQ_23-020

- installation of existing DUACS crossovers to the SLCCI system[212]
- defined time expectations for software deployment to the hardware infrastructure[213], network setup[214], installation of DUACS altimetry[215], and installation of DUACS crossovers[216].

7.8. Development View

This view[217] is pertinent to the future CCI Phase II stakeholder(s) involved in implementing the SLCCI system. We do not intend to propose a process or architecture for development of our target SLCCI system in this section, as that is the direct responsibility of the implementer organisations. Rather, we here communicate Development View influences arisen and noteworthy, particularly given the importance of timeliness across the CCI programme and therefore the need to efficient communication between the CCI Phases[218]. We propose that Phase II implementers directly satisfy the following from the SRD system requirements baseline which are relevant to be satisfied by Phase II, as described in the Reuse View[219].

System Requirements Baseline Requirement Reference	System Requirements Baseline Requirement Description
SLCCI-SRB-REQ_18-170	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.9) such that identified corrective actions shall be appropriately updated and documented at project milestones.
SLCCI-SRB-REQ_18-180	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.10) such that the system being reused shall be kept under configuration control.
SLCCI-SRB-REQ_18-190	During system development apt attention shall

211 SLCCI-SRB-REQ_23-030

212 SLCCI-SRB-REQ_23-040

213 SLCCI-SRB-REQ_23-050

214 SLCCI-SRB-REQ_23-060

215 SLCCI-SRB-REQ_23-070

216 SLCCI-SRB-REQ_23-080

217 This View assumes capture of the Design & Implementation Constraints perspective and Software Quality perspective.

218 SLCCI-SRB-REQ_15_170

219 §7.4.2

	be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.11) such that the configuration status of the baseline associated with the reused software shall be appropriately documented.

Table 44 – System Requirements To Be Satisfied During Phase II

The Development View relevant tools identified in the trade-off analysis (§6.3.4) towards helping manage these needs includes observation report management tool Apache Jira. Moreover, trade-off analysis noted Subversion (SVN) as the most apt configuration system.

7.9. Perspectives

We have identified and defined the pertinent Perspectives for the SLCCI specification[220], and have declared traceability between the Perspectives and the System Requirements Document[221].

7.9.1. Security & Privacy

Security and privacy are a Viewpoint cross-cutting matter relevant to the whole SLCCI system, and represents one of the areas being explored in the SEWG as an area for collaboration. The SLCCI System will have provision for a user registration facility, absorbing user details, aside from username and password authentication[222], to record portal usage and consequently better manage and provision resources to the maintenance and improvement of the portal depending on priority of portal demand[223]. Access to the ECV products will be predicated on provision of a registered username and password[224], and access to the products granted only after correct user authentication[225]. Any non-registered user however will be allowed to search the web portal and product catalogue[226].

Given the important nature of the assets to be generated by the CCI programme, the utmost of care needs to be taken in securing the SLCCI system and the integrity of all data contained therein against malicious breach. Protection of malicious breach through security holes[227], worms[228] and viruses[229]

[220] §7.1

[221] System Requirements Document v1.3 [RD1]

[222] SLCCI-SRB-REQ_10-200, SLCCI-SRB-REQ_10-210

[223] SLCCI-SRB-REQ_10-240

[224] SLCCI-SRB-REQ_10-201

[225] SLCCI-SRB-REQ_10-230

[226] SLCCI-SRB-REQ_16-070, SLCCI-SRB-REQ_16-071

[227] SLCCI-SRB-REQ_16-080

[228] SLCCI-SRB-REQ_16-090

[229] SLCCI-SRB-REQ_16-090

will be catered for[230]; the specificities of such security matters require reanalysis during Phase II as considerations for lower level perspectives of the system are required prior to solution.

The operational facility on which Phase II will be realised by future implementers will update their security protocol to account for CCI specific security policy. Such policy will take form in the Support Plan [231]and include instruction that –

- Information should will be disclosed by internal users[232] to unauthorised parties[233]
- Internal users need to login and logout of the system, when the start and end their shift, respectively[234].
- Internal users should not share passwords[235] or communicate password to external users[236]; furthermore, as is standard in contemporary systems, passwords will be encrypted [237]and only dealt with internally in such a form[238] unless the dissemination of password for new users precludes it.
- Internal users need to be security cleared to handle sensitive intellectual data[239], similarly allowing physical access to the assets[240].
- Internal users should be clearly assigned security profiles[241], and the system will have the means to disassociate users from their roles[242]. Moreover internal users will only have physical access to SLCCI physical resources holding commercially sensitive information if cleared to do so [16-410].

The observation of security events is accomplished by the sending of event information to OpenNMS residing on the Monitoring sub-system, via IMonPrd, IMon, IMonPrdAV and IMonPrdMng, in accordance with where the event took place. During Phase II, simple bespoke code residing on each of the subsystems shall register the occurrence of events requiring informing to the Monitoring sub-system, including the logging of internal user logins[243] and logouts[244], for instance via bespoke code

[230] SLCCI-SRB-REQ_16-100

[231] §7.6.6

[232] SLCCI Contributors

[233] SLCCI-SRB-REQ_16-220

[234] SLCCI-SRB-REQ_16-241, SLCCI-SRB-REQ_16-250

[235] SLCCI-SRB-REQ_16-500

[236] SLCCI-SRB-REQ_16-530

[237] SLCCI-SRB-REQ_16-510

[238] SLCCI-SRB-REQ_16-520

[239] SLCCI-SRB-REQ_16-400

[240] SLCCI-SRB-REQ_16-400

[241] SLCCI-SRB-REQ_16-240

[242] SLCCI-SRB-REQ_16-420

[243] SLCCI-SRB-REQ_16-260

[244] SLCCI-SRB-REQ_16-270

interpreting Linux system audits. Similarly, bespoke code access to observe system security audits and events in order to communicate them to the Monitoring subsystem will operate[245]. Logging of such activity to the Monitoring subsystem includes a timestamp, description of the type of activity (), result of activity, location of activity, and identification of user where viable[246]. The future Phase II implementers of the SLCCI system will be tasked with defining the low level security event types for transmission from the location of events to the Monitoring sub-system for OpenNMS and OpenNMX recognition.

To test the security integrity of the operational system, a system security health check will be conducted by the future Phase II implementers at the end of their Phase II development activity[247], which should also be conducted in tandem with security penetration testing. Thereafter the security penetration testing needs to be taking place periodically, yearly[248].

7.9.2. Portability

The DUACS system, particularly its components for Production, Product Management, elements of the Monitoring component, and partially the Product Access & Visualisation component, were not designed to be portable on different systems architecture. This portability limitation was taken into consideration during trade-off analysis, and assessing the cost-effectiveness of involvement of the SLCCI production system, based on DUACS, for sharing processing and data storage with other ECVs.

All hardware machines are geared to be based on server-oriented Intel compatible x86 machines[249] and running on Linux[250] (32-bit). Our preliminary analysis suggests this may be an additional area with possible pan-CCI influences, and we will continue to engage with the SEWG. The monitoring dashboard residing in the Monitoring sub-system should be coded in a platform-neutral manner by future CCI Phase II implementers, given the ECV-neutral viability of the monitoring facility to be re-used by other ECVs[251] during CCI Phase II.

7.9.3. RAMS

The system requirements for reliability, availability, maintainability and safety are defined by the System Requirements Baseline. To SLCCI system has been fundamentally specified herein to cater for an operational availability of 95% and other key performance indicators defined by the System Requirements Baseline, for example –

- Monitoring (§7.2.5) sub-system dedicated to the monitoring of messages received from other sub-systems pertaining to system and product integrity, through OpenNMS.

[245] SLCCI-SRB-REQ_16-280

[246] SLCCI-SRB-REQ_16-330

[247] SLCCI-SRB-REQ_16-430

[248] SLCCI-SRB-REQ_16-440

[249] SLCCI-SRB-REQ_17-010

[250] SLCCI-SRB-REQ_17-020

[251] SLCCI-SRB-REQ_15-300

- A means of measuring system availability via statistics building based on OpenNMS monitoring (§7.2.5), so ensuring availability aims reliably met via operational planning.
- Efficient ticketing and tracking of issues raised by external users and operating staff via OpenCRX (§7.2.5).
- Communication of the SLCCI product handbook and system status information to SLCCI web portal users, thus minimising load of ticketed matters from external users (§7.9.5).
- Realisation of cold standby pattern in readiness of system failure (§6.3.4)
- Management of spares through an SLCCI inventory system, based on OCS Inventory (§7.6.4)
- Security and penetration testing (§7.9.1)
- Operating staff readiness for system problem solving through provision of an operations Support Plan (§7.6.6).

7.9.4. Configuration & Delivery

Configuration exists under two SLCCI guises, the operational configuration of metadata information to represent the products existing on the system, and configuration of the system assets during development, the former to be conducted by a bespoke DUACS reused editor[252] and the later through an instance of Subversion operating upon the Monitoring administrative system (§6.3.4).

On delivery of the realised SLCCI system, we advise this to be undertaken by the future implementers of Phase II and advise to input to the SEWG working group and similarly attain feedback from the group.

7.9.5. Human Factors

The SLCCI web portal operates through Tomcat (§6.3.4) HTTP provisioned by IPrdAV from the Product Access & Visualisation subsystem. The web portal to be developed by future Phase II implementers during Phase II will fully convey information comprised of the following types –

- A human-readable description of all products and services[253]. An SLCCI handbook will contain all such information[254] also, and will itself be available from the SLCCI web portal[255] in both HTML and PDF forms as identified during trade-off analysis (§6.3.4).
- Availability status of the SLCCI system[256] from IPrdAV, including on-going activity[257]. Pertinent to this prompt conveying of system information is information on algorithms in use by the processing chain[258], and the status of the processing chain within a reasonable time of a significant event occurring[259]; should the event communication not occur within a

[252] SLCCI-SRB-REQ_20-010

[253] SLCCI-SRB-REQ_10-100-a

[254] SLCCI-SRB-REQ_10-060

[255] SLCCI-SRB-REQ_10-060, SLCCI-SRB-REQ_10-061

[256] SLCCI-SRB-REQ_10-100-b

[257] SLCCI-SRB-REQ_22-050

[258] SLCCI-SRB-REQ_22-040

[259] SLCCI-SRB-REQ_22-060

predefined period, the Monitoring sub-system is informed as is the case with other system anomalies.

- Data policy[260]
- technical details of the product dissemination interface[261] (IPrdAV)
- "How to" styled information for novice users of ECV products[262],
- products catalogue in human-readable form and NetCDF-CF metadata form[263] (adhering to the CCI Data Standardisation Working Group),
- historical status of the ECV products immediately available and archived offline[264],
- technical capabilities details of the SLCCI system[265],
- an FAQ built up from engagement with users via the Service Desk[266]
- Tips on usage of the SLCCI system[267]
- Training information on usage of the SLCCI system[268]
- A discussion forum for SLCCI users to share best-practice and advice[269]
- Service-desk related information whereby a user may initiate, or address the status of, a CRM ticket[270]
- Contact information for non Service Desk users[271]
- Status of all recent status events, such as recent faults and improvements, complementing the above availability status of the SLCCI system[272]

Moreover, an intelligent web search facility for the SLCCI portal will be available, allowing users to perform textual search across all portal contained information[273], via the Apache Solr tool as identified by trade-off (§6.3.4). Similarly, a search for products will be possible from the web portal via search of the metadata catalogue[274], on metadata fields comprising of product type, product name, mission name, date of acquisition, time of acquisition, and geospatial area of interest[275] by use of THRESS and a NetCDF product catalogue, similarly identified during trade-off (§6.3.4). The

[260] SLCCI-SRB-REQ_10-100-c

[261] SLCCI-SRB-REQ_10-100-d

[262] SLCCI-SRB-REQ_10-100-e

[263] SLCCI-SRB-REQ_10-100-f

[264] SLCCI-SRB-REQ_10-100-e

[265] SLCCI-SRB-REQ_10-100-g

[266] SLCCI-SRB-REQ_10-100-h

[267] SLCCI-SRB-REQ_10-100-i

[268] SLCCI-SRB-REQ_10-100-j

[269] SLCCI-SRB-REQ_10-100-k

[270] SLCCI-SRB-REQ_10-100-l

[271] SLCCI-SRB-REQ_10-100-m

[272] SLCCI-SRB-REQ_10-100-n

[273] SLCCI-SRB-REQ_10-090

[274] SLCCI-SRB-REQ_22-080, SLCCI-SRB-REQ_22-160

[275] SLCCI-SRB-REQ_22-090

web portal will freely provide all metadata information for users irrespective of their registration status[276].

Consistency is important in the look and feel of the web portal. To that end the future implementers of the SLCCI Phase II system must define a policy on style in the form of an SLCCI Portal Style Guide, towards enforcing consistency across SLCCI graphical user interfaces[277].

7.9.6. Adaptation & Installation

This perspective will be of specific interest to future Phase II stakeholders, and we therefore reserve such considerations for the future Phase II implementers. Furthermore, it is here advised that the Reuse View and Deployment View considerations be fully observed by the future Phase II implementers.

[276] SLCCI-SRB-REQ_22-010

[277] SLCCI-SRB-REQ_22-200, SLCCI-SRB-REQ_22-210

Appendix A - SSD Traceability to SRD

The following table traces SSD content to [RD1] –

the system, the (ii) outputs from the system, and the (iii) user expectations.

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_0-047	FCDR products shall be represented using -	
(a)	NetCDF (Network Common Data Format)	§7.2.2.2.4-3
(b)	CF (Climate and Forecast) convention version 1.4.	§7.2.2.2.4-3
SLCCI-SRB-REQ_0-048	ECV products shall be represented using -	
(a)	NetCDF (Network Common Data Format)	§7.2.2.2.4-3
(b)	CF (Climate and Forecast) convention	§7.2.2.2.4-3
SLCCI-SRB-REQ_0-012	The system shall be extendable to recognition of data associated with future missions	§7.2.2.2.2-1
SLCCI-SRB-REQ_0-013	The system shall take as input, data from the following altimetry products -	-
(a)	ERS-1 Phase C OPR V6	§7.2.2.2.1-4
(b)	ERS-1 Phase E OPR V3	§7.2.2.2.1-4
(c)	ERS-1 Phase F OPR V3	§7.2.2.2.1-4
(d)	ERS-1 Phase G OPR V6	§7.2.2.2.1-4
(e)	ERS-2 OPR V6	§7.2.2.2.1-4
(f)	Envisat GDR 1	§7.2.2.2.1-4
(g)	T/P MGDR	§7.2.2.2.1-4
(h)	Jason-1 GDR-C	§7.2.2.2.1-4
(i)	Jason-2 GDR-C	§7.2.2.2.1-4
(j)	GFO GDR NOAA	§7.2.2.2.1-4
SLCCI-SRB-REQ_0-024	The system shall take as input the following auxiliary products for the product generation	-
(a)	Instrumental auxiliary products	§7.2.2.2.1-4
(b)	Orbit auxiliary products	§7.2.2.2.1-4
(c)	Meteo auxiliary products	§7.2.2.2.1-4
(d)	Ionosphere auxiliary products	§7.2.2.2.1-4
SLCCI-SRB-REQ_0-029	The system shall take as input the following auxiliary products for the product validation	-

ID	Requirement	SSD Trc
(a)	Tide gauges measurements	§7.2.2.2.1-4
(b)	Temperature/Salinity Argo profiles	§7.2.2.2.1-4
SLCCI-SRB-REQ_0-051	The system shall be able to accommodate the following with regards to metadata associated with each product type -	-
(a)	Syntactically parse the metadata	§7.2.2.2.1-4
(b)	Semantically interpret the metadata	§7.2.2.2.1-4
SLCCI-SRB-REQ_0-053	The system shall be able to work in two modes	-
(a)	Delayed Time (DT): periodical update (~semi annual) by addition of new data	§7.2.2.2
(b)	Reprocessing mode (REP): reprocessing of the whole time series records, when calibration improves or ECV generation methods evolve (~bi-annual)	§7.2.2.2
SLCCI-SRB-REQ_0-500	The system shall accommodate the following as part of the production chain -	-
(a)	long term data sets covering at least 30 years.	§7.2.2.2
(b)	continuous coverage from at least one high-precision satellite altimeter at all times, whilst accommodating with planned extensive overlaps between successive missions and two complementary altimeters in different orbits with lower precision but higher resolution.	§7.2.2.2
(c)	account for the necessity to ensure an overlap of 6 months between a satellite follow up and its predecessor	§7.2.2.2
(d)	need of precision altimetry for establishment of an ongoing series of follow-on missions in the same orbit	§7.2.2.2
(e)	increased spatial and temporal sampling for mesoscale and coastal areas	§7.2.2.2
(f)	monitoring of tides which imply selection of orbit that avoids aliasing of the majors constituents at periods longer than 180 days	§7.2.2.2
(g)	Development and maintenance of space and in situ techniques	§7.2.2.2
(h)	Consideration of other in situ and space observing systems for cal/val, such as Argo, and GRACE space gravimetry.	§7.2.2.2

ID	Requirement	SSD Trc
(i)	Characterization of uncertainties, towards providing full error budget.	§7.2.2.2
(j)	Access to data at least once a year	§7.2.2.2
(k)	Access to data through ftp and/or OpenDap	§7.2.2.2
(l)	increased spatial and temporal sampling for high latitude regions	§7.2.2.2
SLCCI-SRB-REQ_1-010	The system shall automatically detect the presence of new primary satellite data where such data is as defined by the DARD.	§7.2.2.2.1-1
SLCCI-SRB-REQ_1-011	The system shall automatically check the following with regards to primary satellite data, where such integrity is as derived from the DARD -	-
(a)	the format of the data should adhere to the accepted logical grammar.	§7.2.2.2.1-3
(b)	the values content of the data should adhere to the accepted logical type and range.	§7.2.2.2.1-4
SLCCI-SRB-REQ_1-012	The system shall automatically detect new ancillary data associated with recognised primary satellite data where such ancillary data is as defined by the DARD.	§7.2.2.2.1-2
SLCCI-SRB-REQ_1-013	The system shall automatically check the following with regards to the ancillary data associated with recognised primary satellite data, where such integrity is as derived via the DARD -	-
(a)	the format of the data should adhere to the accepted logical grammar,	§7.2.2.2.1-3
(b)	the values content of the data should adhere to the accepted logical type and range.	§7.2.2.2.1-4
SLCCI-SRB-REQ_1-020	If the application detects that it lacks at least one item of auxiliary data to generate the product then the data flow shall be moved to a waiting queue; this logic acknowledges the ‘synchronisation’ dependency relationship between altimetry data and auxiliary data required before product generation can commence.	§7.2.2.2.1-5
SLCCI-SRB-REQ_1-060	If required ancillary data is not already acquired when the associated primary data arrives, then the primary satellite data shall be held in a queue until the related ancillary data arrives.	§7.2.2.2.1-6

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_1-100	Once data is made available for Passive Acquisition as defined in the PSAD, the data shall start to be processed within <x> seconds.	§7.2.2.2.1-1
SLCCI-SRB-REQ_1-101	Once data is made available for Active Acquisition as defined in the PSAD, the data shall start to be processed within <x> seconds.	§7.2.2.2.1-1
SLCCI-SRB-REQ_1-070	In order to accomplish Active Acquisition for a given data product, the system shall check the defined remote directory at a configurable frequency, starting from a configurable date and time.	§7.2.2.2.1-2
SLCCI-SRB-REQ_1-235	If a data file is to be queued because necessary synchronisation cannot yet take place, then the file will start to be acquired for queuing within <x> seconds.	§7.2.2.2.1-6
SLCCI-SRB-REQ_1-236	The database storage of an acquired data file shall be completed within a temporal threshold, which is a multiple of <x> kilobytes acquired and <y> seconds.	§7.2.2.2.1-8
SLCCI-SRB-REQ_2-010	The system shall make provision for an automated homogenisation of input data by using suitable geophysical corrections to calculate the Sea Level Anomaly for each altimetry mission.	§7.2.2.2.2-1
SLCCI-SRB-REQ_2-011	The system application of homogenous geophysical corrections shall be automated.	§7.2.2.2.2-1
SLCCI-SRB-REQ_2-012	The system shall make provision for the automated editing of data in order to remove spurious measurements.	§7.2.2.2.2-1
SLCCI-SRB-REQ_2-100	The system shall complete the pre-processing stage, prior to the editing of spurious measurements, within a multiple of <x> kilobytes acquired and <y> seconds.	§7.2.2.2.2-2
SLCCI-SRB-REQ_3-019	A tool shall be provided for an SLCCI Product Contributor to manually accomplish the following -	-
(a)	the specification of a list of fields as free text, where each field must textually match the data field of statistical interest in input data	§7.2.2.2.3-1
(b)	the specification of a numerical quality threshold associated with each entry in the listed fields of (a).	§7.2.2.2.3-1

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_3-020	The system shall automatically generate data quality statistics on input data, comprised of the following -	-
(a)	a display of the configurable data field defined,	§7.2.2.2.3-2
(b)	the associated quality threshold defined,	§7.2.2.2.3-2
(c)	unique identification of all items of data matching the configured data field label which have values falling outside the defined threshold.	§7.2.2.2.3-2
SLCCI-SRB-REQ_3-030	If it is found from the quality checks on the input data that some statistical results fall outside an associated quality threshold, then -	-
(a)	the Product Expert shall investigate the source of the errors.	§7.2.2.2.3-4
(b)	the Product Expert shall warn the relevant upstream system of the anomaly detected on the input data flows	§7.2.2.2.3-4
(c)	the system shall be set in a state whereby it can accommodate a new version of the same data flow being redelivered	§7.2.2.2.3-4
(d)	the Product Expert will report the anomaly to the Service Desk Manager	§7.2.2.2.3-4
SLCCI-SRB-REQ_3-040	If on investigating a Cal/Val related anomaly in input data the Product Expert finds that the problem is more serious, such as non-critical loss of an instrument on the platform, then -	-
(a)	the system shall have provision to allow the new configuration of input data, where the decision for the modification must be validated by the Service Manager	§7.2.2.2.3-5
(b)	the outputs shall still be generated	§7.2.2.2.3-5
(c)	information pertaining to the quality of the products shall be reported to the Service Desk from the Service Desk Manager	§7.2.2.2.3-5
(d)	information pertaining to the quality of the products shall be integrated into the resulting SLCCI product	§7.2.2.2.3-5
SLCCI-SRB-REQ_4-010	The system shall have provision to generate a Quality Check report, comprising of -	-
(a)	scientific Cal/Val	§7.2.2.2.3-3
(b)	global multi-mission comparisons	§7.2.2.2.3-3

ID	Requirement	SSD Trc
(c)	global altimetry and In-situ data comparison	§7.2.2.2.3-3
SLCCI-SRB-REQ_4-011	The Quality Check report shall be checked by the Product Expert.	§7.2.2.2.3-3
SLCCI-SRB-REQ_3-200	The system shall complete the automatic quality check of a given data flow within a time value threshold, which is calculated as being a multiple of the kilobytes of data flow and a calculation weighting value <y>.	§7.2.2.2.3-6
SLCCI-SRB-REQ_3-201	The system shall complete the generation of a Quality Check report for a given data flow within a time value threshold, which is calculated as being a multiple of the kilobytes of data flow associated with the report and a calculation weighting value <y>.	§7.2.2.2.3-3
SLCCI-SRB-REQ_5-000	The system shall generate cross calibrated products	§7.2.2.2.4-1
SLCCI-SRB-REQ_5-010	The system shall perform a calculation of orbit error for the given data flow.	§7.2.2.2.4-2
SLCCI-SRB-REQ_5-020	The system shall perform a sea level anomaly (SLA) calculation for each mission along-track of the given data flow.	§7.2.2.2.4-2
SLCCI-SRB-REQ_5-030	The system shall perform a calculation of the long wavelength error (LWE) of the given data flow.	§7.2.2.2.4-2
SLCCI-SRB-REQ_5-031	The system shall correct the SLA for the LWE of the given data flow.	§7.2.2.2.4-2
SLCCI-SRB-REQ_5-032	The Multimission Cross Calibration stage shall be completed within a multiple of <x> kilobytes and <y> seconds for the given data flow.	§7.2.2.2.4-4
SLCCI-SRB-REQ_5-040	The system shall generate a Fundamental Climate Data Record (FCDR) product as defined by the PSD.	§7.2.2.2.4-3
SLCCI-SRB-REQ_5-042	The FCDR product shall be generated with a frequency of once per year, the timing of which during each year to be determined by the availability of L0 and L1 reprocessing accomplished by ground segments.	§7.2.2.2
SLCCI-SRB-REQ_5-044	The FCDR Product Generation stage shall be completed within a multiple of <x> kilobytes and <y> seconds for the given data flow.	§7.2.2.2.4-3
SLCCI-SRB-REQ_5-050	The system shall generate an Essential Climate Variable (ECV) as defined by the PSD.	§7.2.2.2.4-3

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_5-052	The ECV product shall be generated with a frequency of once per year, the timing of which during each year to be determined by the availability of L0 and L1 reprocessing accomplished by ground segments.	§7.2.2.2
SLCCI-SRB-REQ_5-054	The stage shall be completed within a multiple of <x> kilobytes and <y> seconds for the given data flow.	§7.2.2.2.4-3
SLCCI-SRB-REQ_6-000	The system shall perform the following on the generated product -	-
(a)	output checks	§7.2.2.2.5-1
(b)	quality control	§7.2.2.2.5-1
(c)	scientific validation	§7.2.2.2.5-1
SLCCI-SRB-REQ_6-019	The system shall make provision for the definition of a threshold to each item in a user-defined list of configurable data fields associated with the generated product, for output checks, quality control and scientific validation. Each configurable data field shall be specified as free text, which must textually match the data field of interest in order for statistics to be generated for that data product field of the generated product.	§7.2.2.2.5-1
SLCCI-SRB-REQ_6-020	The system shall automatically generate data quality statistics on produced data, comprised of • a display of the configurable data field defined • the associated quality threshold defined unique identification of all items of produced data matching the configured data field label which have values falling outside the defined threshold.	§7.2.2.2.5-2
SLCCI-SRB-REQ_6-060	If the Product Expert detects that some statistical readings are out of the user configured expected range for a user configured field then -	-
(a)	the Product Expert shall warn the Support Operator	§7.2.2.2.5-3
(b)	the Product Expert will inform the Service Manager if required	§7.2.2.2.5-3
(c)	the Product Expert shall run the production pipeline again if the anomaly can be corrected within the system	§7.2.2.2.5-3

ID	Requirement	SSD Trc
(d)	the system shall produce scientific analyses and detect subtle errors	§7.2.2.2.5-3
(e)	the system shall generate Global internal analyses	§7.2.2.2.5-3
(f)	the system shall generate Global multi-mission comparisons	§7.2.2.2.5-3
(g)	the system shall generate Global altimetry and In-situ data comparison	§7.2.2.2.5-3
SLCCI-SRB-REQ_7-000	The system shall process -	-
(a)	Measures; these comprise of two kinds of measurements - (i) scientific measurements (e.g product quality, accuracy), and (ii) system measurements related to the build (e.g available bandwidth, reprocessing date & time) which complement the product assessment.	§7.2.2.2.6-1
(b)	Build indicators; these are used for calculating different ocean indicators (e.g mean sea level trends, El Nino) which complement the product assessment.	§7.2.2.2.6-2
SLCCI-SRB-REQ_7-004	If a performed measure or indicator is not calculated, either the Support Operator or Product Expert shall -	-
(a)	investigate the problem	§7.2.2.2.6-3
(b)	correct the problem	§7.2.2.2.6-3
(c)	report the incident to the Service Manager	§7.2.2.2.6-3
SLCCI-SRB-REQ_8-010	The system shall store the most recent <x> versions of products on a physical space accessible by the -	-
(a)	Web Portal; a web portal within the SLCCI system, comprised of both an http server and an ftp server.	§7.2.2.2.7-1
(b)	Central Information System (CIS); a conceptual pan-ECV system with linkage to the SLCCI system, and is outside of the SLCCI system.	§7.2.2.2.7-1
SLCCI-SRB-REQ_8-020	The Product Expert shall add content to a product's metadata before the product is made available via the	-
(a)	Web Portal; the web portal within the SLCCI system.	§7.2.4.2-4
(b)	Central Information System (CIS); a conceptual pan-ECV system with linkage to the SLCCI system.	§7.2.4.2-4
SLCCI-SRB-REQ_8-043	If the Web Portal ftp server fails the system shall inform the Service Manager.	§7.6.1
SLCCI-SRB-REQ_8-044	If the Web Portal http server fails the system shall inform the Service Manager.	§7.6.1

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_8-045	The system shall make provision for <x> Gb of physical space for the product data storage.	§7.5.4
SLCCI-SRB-REQ_8-042	Product storage onto physical space shall take no longer than <x> seconds per <y> kilobytes of product size.	§7.2.2.2.7-1
SLCCI-SRB-REQ_9-010	In order to accommodate the long term preservation of data the system shall archive	-
(a)	all generated products	§7.2.2.2.7-2
(b)	all associated context needed for traceability	§7.2.2.2.7-2
SLCCI-SRB-REQ_9-030	The system decision to start the archive procedure shall be automated	§7.2.4.2-1
SLCCI-SRB-REQ_9-031	The system shall have provision for an automated archive procedure describing all targets for archiving.	§7.2.4.2-1
SLCCI-SRB-REQ_9-040	Archived products shall only be retrievable for a Product User through a request to a Service Manager, rather than made permanently available.	§7.6.1
SLCCI-SRB-REQ_9-050	If the archive procedure fails then the incident shall be reported to the Service Manager for repair.	§7.6.1
SLCCI-SRB-REQ_9-200	The archive procedure shall conform to international open standards and follow the Open Archival Information System reference model	§7.2.4.2-1
SLCCI-SRB-REQ_9-205	The system shall make provision for <x> Gb of physical space for the product data archive.	§7.5.4
SLCCI-SRB-REQ_9-051	Product archive onto physical space shall take no longer than <x> seconds per <y> kilobytes of product size.	§7.2.4.2-1
SLCCI-SRB-REQ_10-000	The system shall make provision for functionality to view a product.	§7.2.3.2-2
SLCCI-SRB-REQ_10-020	The system shall generate low resolution static images of its products for preview functionality, at a resolution of 5 percent of maximum resolution.	§7.2.3.2-2
SLCCI-SRB-REQ_10-021	The system shall generate maximum resolution static images of its products for full view functionality	§7.2.3.2-2
SLCCI-SRB-REQ_10-200	The system shall make provision for user registration functionality, requiring a	-
(a)	Username	§7.6.5; §7.9.1
(b)	Password	§7.6.5; §7.9.1

ID	Requirement	SSD Trc
(c)	<TBD>	§7.6.5; §7.9.1
SLCCI-SRB-REQ_10-201	The system shall make provision for user access functionality requiring a username and password.	§7.2.3.2-4; §7.2.4.2-7; §7.6.5
SLCCI-SRB-REQ_10-210	The system shall provide an interface for user authentication.	§7.6.5; §7.9.1
SLCCI-SRB-REQ_10-220	The system shall provide an interface for catalogue search, in order to allow interoperability of catalogues (CSW – OGC) and compliance with INSPIRE European Directive (Cf INSPIRE “Invoke” function).	§7.2.3.2-3
SLCCI-SRB-REQ_10-040	The system shall provide an interface to allow download of products from a Central Information System (CIS), compliant with OGC Web Coverage Service.	§7.2.3.2-2
SLCCI-SRB-REQ_10-230	The system shall allow download of products only following user authentication.	§7.6.5
SLCCI-SRB-REQ_10-240	The system shall make provision for the logging of product downloading, in order to attain information which may be useful for the enhancement of data dissemination to users in future.	§7.9.1
SLCCI-SRB-REQ_10-050	The system shall make provision for a ticketing system for dealing with requests from SLCCI Users	§7.6.2
SLCCI-SRB-REQ_10-051	Requests may be addressed to the ticketing system via emailable electronic form.	§7.6.2
SLCCI-SRB-REQ_10-054	When a request arrives at the ticketing system it shall be addressed by the Service Desk user	§7.6.2
SLCCI-SRB-REQ_10-055	The processing of a request will take the form of the following phases -	-
(a)	Acknowledgement to the requester that the request has been received	§7.6.2
(b)	The request is analysed to determine action and relevant stakeholders	§7.6.2
(c)	The request is dispatched to the relevant user for treatment	§7.6.2
(d)	Once the request is satisfied, the Service Desk is informed whereby the request ticket is closed and the requester is informed.	§7.6.2

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_10-060	The system shall provide a product information handbook to SLCCI Product Users.	§7.9.5
SLCCI-SRB-REQ_10-061	The product information handbook shall be made available via the Web Portal.	§7.9.5
SLCCI-SRB-REQ_10-080	The Service Desk may return an answer related to an information request by different means of communication, comprised of -	-
(a)	Email	§7.6.1
(b)	Transfer protocol	§7.6.1
(c)	Paper	§7.6.1
(d)	Phone	§7.6.1
SLCCI-SRB-REQ_10-100	The system shall make available the following types of information on the Web Portal -	-
(a)	Information on products and services	§7.9.5
(b)	Availability	§7.9.5
(c)	Data policy	§7.9.5
(d)	Product dissemination interfaces	§7.9.5
(e)	“How to” information	§7.9.5
(f)	Products catalogue	§7.9.5
(g)	Status on products	§7.9.5
(h)	Technical information pertaining to the SLCCI system	§7.9.5
(i)	FAQ	§7.9.5
(j)	Tips	§7.9.5
(k)	Training information	§7.9.5
(l)	Discussion forum	§7.9.5
(m)	Service desk related information, e.g related to support ticketing system	§7.9.5
(n)	Contact information to relevant SLCCI Contributors (the workers)	§7.9.5
(o)	Information pertaining to system events, such as system incidents and failures.	§7.9.5
SLCCI-SRB-REQ_10-090	The system shall provide requested information to users if available via a Web Portal intelligent word search of the available types of information.	§7.9.5

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_10-081	The Service Desk shall return an answer related to an information request within <x> minutes of the request being made.	§7.6.1
SLCCI-SRB-REQ_11-500	The system shall provide a catalogue of metadata, containing the products and access services descriptions, in order to allow the user to discover the resources	§7.2.4.2-2
SLCCI-SRB-REQ_11-110	The system shall make provision for a catalogue of metadata compliant with the Central Information System (CSW – OGC).	§7.2.4.2-2
SLCCI-SRB-REQ_11-120	The metadata format shall comply with principal international standards on this subject -	-
(a)	ISO19115 for spatial product metadata	§7.2.4.2-3
(b)	ISO19119 for spatial access	§7.2.4.2-3
(c)	ISO19139 official implementation of the two precedent standards	§7.2.4.2-3
SLCCI-SRB-REQ_11-010	A Product Manager shall have provision of a metadata editor to maintain the product database	§7.2.4.2-4
SLCCI-SRB-REQ_11-011	The Metadata Editor shall reside on the Central Information System (CIS)	§7.2.4.2-4
SLCCI-SRB-REQ_11-020	The Product Manager shall register a new product by manually adding it to the product database.	§7.2.4.2-5
SLCCI-SRB-REQ_11-021	The system shall make provision for the automatic updating of products which are not new; for instance in the case where the time coverage is extended through a reanalysis.	§7.2.4.2-5
SLCCI-SRB-REQ_11-030	A Product Manager shall have provision to maintain product information in the form of	-
(a)	Static metadata	§7.2.4.2-5
(b)	Dynamic metadata	§7.2.4.2-5
SLCCI-SRB-REQ_11-033	A product can be maintained in the product database by	-
(a)	Updating of “Product Line” static metadata	§7.2.4.2-6
(b)	Updating of “Product Specification” static metadata	§7.2.4.2-6
(c)	Deleting of “Product Specification” static metadata	§7.2.4.2-6
(d)	Deletion of “Product Line” static metadata	§7.2.4.2-6
(e)	Update of dynamic metadata of a product, representing quality characteristics of the product	§7.2.4.2-6

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_11-050	The Product Manager shall have the provision to, via the Central Information System (CIS), create	-
(a)	a new Product Line	§7.2.4.2-4
(b)	a new Product Specification	§7.2.4.2-4
SLCCI-SRB-REQ_11-060	The Product Manager shall register as Product Lines all upstream data delivered	§7.2.4.2-4
SLCCI-SRB-REQ_11-070	The Product Manager shall have provision, via the Central Information System (CIS), to update	-
(a)	Product Line static metadata	§7.2.4.2-4
(b)	Product Specification static metadata	§7.2.4.2-4
SLCCI-SRB-REQ_11-080	The Product Manager shall have provision, via the Central Information System (CIS), to delete	-
(a)	Product Line static metadata	§7.2.4.2-4
(b)	Product Specification static metadata	§7.2.4.2-4
SLCCI-SRB-REQ_11-090	Delivery characteristics shall be generated for each Product, comprised of -	-
(a)	Delivery target locations	§7.2.4.2-4
(b)	Total number of deliveries to the locations	§7.2.4.2-4
(c)	Product identifier	§7.2.4.2-4
SLCCI-SRB-REQ_12-010	The system shall have provision for three types of monitoring	-
(a)	Production monitoring, the monitoring of the product pipeline	§7.2.5.2-1
(b)	System monitoring, the monitoring of system events, including the monitoring of external activity to the SLCCI system supplying required data fields to the SLCCI system.	§7.2.5.2-2
(c)	Request monitoring of transaction accounted downloads accomplished through a Customer Relationship Management (CRM) tool under the auspices of the Service Desk.	§7.2.5.2-3
SLCCI-SRB-REQ_12-050	The system shall provide a dashboard illustrating the state of all monitoring.	§7.6.1
SLCCI-SRB-REQ_12-080	The system shall have provision to monitor the SLCCI physical resources	§7.2.5.2-2
SLCCI-SRB-REQ_12-090	A Support Operator shall be responsible for system monitoring	§7.2.5.2-2
SLCCI-SRB-REQ_12-091	System Monitoring shall comprise of -	-

ID	Requirement	SSD Trc
(a)	Monitoring of interfaces with upstream systems	§7.2.5.2-2
(b)	Monitoring of physical resources associated with production pipeline	§7.2.5.2-2
(c)	Monitoring of physical resources associated with the file server which houses the products	§7.2.5.2-2
(d)	Monitoring of the Central Information System (CIS) gateway	§7.2.5.2-2
SLCCI-SRB-REQ_12-100	The system shall make provision for automated system monitoring only where the SLCCI physical resource being monitored can have a threshold set	§7.2.5.2-2
SLCCI-SRB-REQ_12-101	The thresholds for automated system monitoring shall be configurable by a Support Operator.	§7.2.5.2-2
SLCCI-SRB-REQ_12-200	Production Monitoring shall not contribute to overall performance of the system by more than 1 %.	§7.2.5.2-4
SLCCI-SRB-REQ_12-210	System Monitoring shall not contribute to overall performance of the system by more than 1 %.	§7.2.5.2-4
SLCCI-SRB-REQ_12-220	Request Monitoring shall not contribute to overall performance of the system by more than 1 %.	§7.2.5.2-4
SLCCI-SRB-REQ_1-030	If the format of the received satellite data products does not adhere to the accepted logical grammar as expected, then the system shall send out a warning to the Support Operator via the dashboard.	§7.6.1
SLCCI-SRB-REQ_1-031	If the values content of the received satellite data products does not adhere to the accepted logical type or range as expected, then the system shall send out a warning to the Support Operator via the dashboard.	§7.6.1
SLCCI-SRB-REQ_1-032	If the format of the ancillary data does not adhere to the accepted logical grammar as expected, then the system shall send out a warning to the Support Operator via the dashboard.	§7.6.1
SLCCI-SRB-REQ_1-033	If the values content of the ancillary data does not adhere to the accepted logical type or range as expected, then the system shall send out a warning to the Support Operator via the dashboard.	§7.6.1
SLCCI-SRB-REQ_1-034	On receiving a warning regarding the integrity of input data, the Support Operator shall ask the upstream system to re-deliver the input.	§7.6.1
SLCCI-SRB-REQ_1-035	On receiving a warning regarding the integrity of input data, the Support Operator shall set the system in a state accommodating towards the resending of the input by the upstream operator.	§7.6.1

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_1-036	The system shall send a warning via the dashboard to Support Operator where data input size is larger than the maximum recognised for the data as derived via the DARD.	§7.6.1
SLCCI-SRB-REQ_1-096	If an input data flow does not arrive by a defined date plus a configurable delay and the unavailability is definitive then -	-
(a)	products for the mission shall not be produced any more	§7.6.1
(b)	the incident shall be reported to the Service Desk	§7.6.1
SLCCI-SRB-REQ_1-400	Any data backup operation shall not interrupt the normal operation of the system.	§7.2.2.2.7-2
SLCCI-SRB-REQ_1-401	Any data backup operation shall not comprise a performance cost of more than 1% of the performance cost of the whole system.	§7.2.2.2.7-2
SLCCI-SRB-REQ_1-420	Data backup operation shall be automated where possible.	§7.2.2.2.7-2
SLCCI-SRB-REQ_1-102	The following data type shall be acquired by either Active or Passive acquisition as specified -	-
(a)	ERS-1 Phase C OPR V6 - <active/passive>	§7.2.2.2.1-4
(b)	ERS-1 Phase E OPR V3 - <active/passive>	§7.2.2.2.1-4
(c)	ERS-1 Phase F OPR V3 - <active/passive>	§7.2.2.2.1-4
(d)	ERS-1 Phase G OPR V6 - <active/passive>	§7.2.2.2.1-4
(e)	ERS-2 OPR V6 - <active/passive>	§7.2.2.2.1-4
(f)	Envisat GDR 1 - <active/passive>	§7.2.2.2.1-4
(g)	T/P MGDR - <active/passive>	§7.2.2.2.1-4
(h)	Jason-1 GDR-C - <active/passive>	§7.2.2.2.1-4
(i)	Jason-2 GDR-C - <active/passive>	§7.2.2.2.1-4
(j)	GFO GDR NOAA - <active/passive>	§7.2.2.2.1-4
(k)	auxiliary products for the product generation - <active/passive>	§7.2.2.2.1-4
(l)	auxiliary products for the product validation - <active/passive>	§7.2.2.2.1-4
SLCCI-SRB-REQ_1-202	The following data types shall be expected at the following frequencies -	-
(a)	ERS-1 Phase C OPR V6 – at least one update every <x> days	§7.2.2.2.1-1

ID	Requirement	SSD Trc
(b)	ERS-1 Phase E OPR V3 – at least one update every <x> days	§7.2.2.2.1-1
(c)	ERS-1 Phase F OPR V3 – at least one update every <x> days	§7.2.2.2.1-1
(d)	ERS-1 Phase G OPR V6 – at least one update every <x> days	§7.2.2.2.1-1
(e)	ERS-2 OPR V6 – at least one update every <x> days	§7.2.2.2.1-1
(f)	Envisat GDR 1 – at least one update every <x> days	§7.2.2.2.1-1
(g)	T/P MGDR – at least one update every <x> days	§7.2.2.2.1-1
(h)	Jason-1 GDR-C – at least one update every <x> days	§7.2.2.2.1-1
(i)	Jason-2 GDR-C – at least one update every <x> days	§7.2.2.2.1-1
(j)	GFO GDR NOAA – at least one update every <x> days	§7.2.2.2.1-1
(k)	auxiliary products for the product generation – at least one update every <x> days	§7.2.2.2.1-1
(l)	auxiliary products for the product validation – at least one update every <x> days	§7.2.2.2.1-1
SLCCI-SRB-REQ_14-010	The system shall allow for simultaneous downloads from <x> SLCCI Product Users.	§7.2.3.2-2
SLCCI-SRB-REQ_14-020	The system shall make provision for at least <x> TBs of disk storage dedicated to the product pipeline.	§7.5.4
SLCCI-SRB-REQ_14-030	The system shall make provision for at least <x> TBs of disk storage dedicated to hosting SLCCI products ready for download by SLCCI Product Users.	§7.5.4
SLCCI-SRB-REQ_14-040	The system shall make provision for at least <x> TBs of disk storage dedicated for SLCCI product archiving.	§7.5.4
SLCCI-SRB-REQ_1-300	The system shall be able to accommodate an update absorption of the following expected sizes per data type as expected frequencies -	-
(a)	ERS-1 Phase C OPR V6 - <x> Mb	§7.5.4
(b)	ERS-1 Phase E OPR V3 - <x> Mb	§7.5.4
(c)	ERS-1 Phase F OPR V3 - <x> Mb	§7.5.4
(d)	ERS-1 Phase G OPR V6 - <x> Mb	§7.5.4
(e)	ERS-2 OPR V6 - <x> Mb	§7.5.4
(f)	Envisat GDR 1 - <x> Mb	§7.5.4
(g)	T/P MGDR - <x> Mb	§7.5.4
(h)	Jason-1 GDR-C - <x> Mb	§7.5.4

ID	Requirement	SSD Trc
(i)	Jason-2 GDR-C - <x> Mb	§7.5.4
(j)	GFO GDR NOAA - <x> Mb	§7.5.4
(k)	auxiliary products for the product generation - <x> Mb	§7.5.4
(l)	auxiliary products for the product validation - <x> Mb	§7.5.4
SLCCI-SRB-REQ_14-100	[Definition] An item of hardware is deemed to be an SLCCI physical resource if it resides as part of the SLCCI system and is at the level of a Lowest Replaceable Unit (LRU).	§7.6.4
SLCCI-SRB-REQ_14-110	The system shall allow for the provision of an inventory to account for all SLCCI physical resources associated with the system.	§7.6.4
SLCCI-SRB-REQ_14-120	All SLCCI physical resources shall have an asset identification label.	§7.6.4
SLCCI-SRB-REQ_14-130	All asset identification labels shall be easily accessible for viewing	§7.6.4
SLCCI-SRB-REQ_14-450	The SLCCI physical resources shall be maintainable	§7.6.4
SLCCI-SRB-REQ_14-460	A Support Contributor shall provide a support plan indicating how all system assets are to be maintained.	§7.6.6
SLCCI-SRB-REQ_14-470	The maintenance support plan shall cover all SLCCI assets, comprising	-
(a)	Proprietary software	§7.6.6
(b)	OTS software	§7.6.6
(c)	SLCCI physical resources	§7.6.6
(d)	Open source software	§7.6.6
SLCCI-SRB-REQ_14-510	The support plan shall define how updates shall be addressed for all SLCCI assets	§7.6.6
SLCCI-SRB-REQ_14-520	The support plan shall define how service packs shall be addressed for all SLCCI assets	§7.6.6
SLCCI-SRB-REQ_14-530	The support plan shall define how SLCCI assets must be treated when no longer needed for the SLCCI system ; for example, if an SLCCI physical resource experiences a physical failure which is beyond repair and a new item needs to be purchased, then the support plan needs to describe how the obsolescence of the expired SLCCI physical resource should be treated, such as describing considerations for environmental and sustainability matters which need to be taken into account when disposing of the equipment.	§7.6.6

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_14-610	The network infrastructure on which the SLCCI physical resources reside shall accommodate IP based communication	§7.6.6
SLCCI-SRB-REQ_15-010	Development of the system shall be undertaken with apt consideration for scientific consensus on performance specification of the operational system.	§7.2.2.2
SLCCI-SRB-REQ_15-020	Development of the system shall be undertaken with apt consideration for availability of input data from EO archives.	§7.2.2.2
SLCCI-SRB-REQ_15-030	Development of the system shall be undertaken with apt consideration for quality of input data from EO archives.	§7.2.2.2
SLCCI-SRB-REQ_15-040	Development of the system shall be undertaken with apt consideration for availability of associated metadata, cal/val data and documentation.	§7.2.2.2
SLCCI-SRB-REQ_15-050	Development of the system shall be undertaken with apt consideration for quality of associated metadata, cal/val data and documentation.	§7.2.2.2
SLCCI-SRB-REQ_15-060	Development of the system shall be undertaken with apt consideration for compatibility of data from different missions.	§7.2.2.2
SLCCI-SRB-REQ_15-070	Development of the system shall be undertaken with apt consideration for compatibility of data from different sensors.	§7.2.2.2
SLCCI-SRB-REQ_15-080	Development of the system shall be undertaken with apt consideration for trade-off between cost, complexity and impact of new algorithms to be developed and validated during the project.	§7.2.2.2
SLCCI-SRB-REQ_15-090	Development of the system shall be undertaken with apt consideration for advance planning for data from new missions to be integrated during the project.	§7.2.2.2
SLCCI-SRB-REQ_15-100	Development of the system shall be undertaken with apt consideration for end-to-end throughput of ECV production systems.	§7.2.2.2
SLCCI-SRB-REQ_15-110	Development of the system shall be undertaken with apt consideration for re-use of existing capabilities within Europe.	§7.4
SLCCI-SRB-REQ_15-120	Development of the system shall be undertaken with apt consideration for compliance of ESA standards.	§4.1
SLCCI-SRB-REQ_15-130	Development of the system shall be undertaken with apt consideration for availability of external validation data.	§6.3.4

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_15-140	Development of the system shall be undertaken with apt consideration for avoidance of duplication of activities covered by existing operational projects.	§7.4
SLCCI-SRB-REQ_15-150	The system shall be cost effective.	§7.4, §1, §3.2, §6.3, §6.4, §7.2, §7.3, §7.9.2
SLCCI-SRB-REQ_15-160	The pan-ECV systems must be cost effective as a whole	§1, §3.2, §6.3, §6.4
SLCCI-SRB-REQ_15-170	System timeliness is urgent	§7.8
SLCCI-SRB-REQ_15-180	Full advantage shall be taken of the latest developments in computing architectures in the development of the system.	§6.3.2
SLCCI-SRB-REQ_15-190	Full advantage shall be taken of the latest developments in data management in development of the system.	§6.3.2
SLCCI-SRB-REQ_15-200	Full advantage shall be taken of the latest developments in communications technology in development of the system.	§6.3.2
SLCCI-SRB-REQ_15-210	The system development should include cooperation with other consortia producing ECV products.	§6.4
SLCCI-SRB-REQ_15-220	The system shall have provision for future data set updates.	§7.2.2.2
SLCCI-SRB-REQ_15-230	The system shall allow algorithm change.	§7.2.2.2
SLCCI-SRB-REQ_15-240	The system shall have an archiving facility.	§7.2.2.2
SLCCI-SRB-REQ_15-300	The monitoring dashboard software shall be usable on	-
(a)	Windows OS	§7.9.2, §7.5.2
(b)	Linux OS	§7.9.2, §7.5.2
SLCCI-SRB-REQ_15-400	The system shall be designed to allow amenable interfacing to a higher level system responsible for pan-ECV collaboration, namely the Central Information System.	§6.1.1, §6.1.3, §6.3.4, §6.4, §7.2.3
SLCCI-SRB-REQ_15-410	The design of the system shall be as similar as possible to external systems associated with parallel ECV projects	§6.4, §7.2.3
SLCCI-SRB-REQ_15-420	The system shall be designed to be data driven wherever possible	§6.1.2, §6.3.4, §7.2.5

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_15-430	The design of the system shall incorporate proven and scalable Off The Shelf (OTS) systems where possible	§7.2.2, §7.2.5.2
SLCCI-SRB-REQ_15-500	The design of the system shall identify particularly critical components of the system.	§7.6.4
SLCCI-SRB-REQ_15-510	The system shall be provisioned with increased redundancy for identified critical components.	§6.3.4, §7.6.4
SLCCI-SRB-REQ_16-070	Any non-registered user shall be able to access all areas of the SLCCI web portal other than for the downloading of SLCCI products.	§7.9.1
SLCCI-SRB-REQ_16-071	Any non-registered user shall be able to search the SLCCI web portal, including the product catalogue.	§7.9.1
SLCCI-SRB-REQ_16-080	The web portal shall be protected against exploitation of security holes.	§7.9.1
SLCCI-SRB-REQ_16-090	The web portal shall be protected against exploitation of worms.	§7.9.1
SLCCI-SRB-REQ_16-100	The web portal shall be protected against exploitation of viruses.	§7.9.1
SLCCI-SRB-REQ_16-220	The system shall prevent any disclosure of information to unauthorised parties.	§7.9.1
SLCCI-SRB-REQ_16-240	The system shall allow access profiles for each SLCCI Contributor to be configurable, so associating each SLCCI Contributor with the privileges required for their role(s).	§7.9.1
SLCCI-SRB-REQ_16-241	At the start of their shift, the SLCCI Contributor shall be required to login to the system.	§7.9.1
SLCCI-SRB-REQ_16-250	At the end of their shift, the SLCCI Contributor shall be required to logout of the system.	§7.9.1
SLCCI-SRB-REQ_16-260	The system shall have provision for the logging of SLCCI Contributor logins.	§7.9.1
SLCCI-SRB-REQ_16-270	The system shall have provision for the logging of SLCCI Contributor logout.	§7.9.1
SLCCI-SRB-REQ_16-280	The logging of such security related activity by the system shall be comprised of the following -	-
(a)	Administrative activity	§7.9.1
(b)	Firewall activity	§7.9.1
(c)	Login attempts	§7.9.1
(d)	Logout attempts	§7.9.1
SLCCI-SRB-REQ_16-330	Each security related activity logging shall be comprised of the following -	-

ID	Requirement	SSD Trc
(a)	Date & time of the event	§7.9.1
(b)	The type of security related activity	§7.9.1
(c)	Whether the activity resulted in success or failure	§7.9.1
(d)	Information pertaining to the terminal at which the event occurred	§7.9.1
(e)	Identification of the user involved	§7.9.1
SLCCI-SRB-REQ_16-400	All SLCCI Contributors shall be cleared to handle commercially sensitive intellectual property where required.	§7.9.1
SLCCI-SRB-REQ_16-410	Only SLCCI Contributors cleared to handle relevant commercially sensitive intellectual property shall have physical access to SLCCI physical resources on which the information is stored.	§7.9.1
SLCCI-SRB-REQ_16-420	It shall be possible to disassociate a user from any role.	§7.9.1
SLCCI-SRB-REQ_16-430	The system shall undergo a security health check as part of a test activities programme.	§7.9.1
SLCCI-SRB-REQ_16-440	The test activities programme shall include system penetration tests.	§7.9.1
SLCCI-SRB-REQ_16-500	SLCCI Contributors shall not share passwords.	§7.9.1
SLCCI-SRB-REQ_16-510	Passwords stored on the system shall be stored in an encrypted form.	§7.9.1
SLCCI-SRB-REQ_16-520	Passwords shall be communicated in an encrypted form if the communication of passwords is required between two SLCCI physical resource units.	§7.9.1
SLCCI-SRB-REQ_16-530	Passwords shall not be communicated, electronically or verbally, to any party external to the system	§7.9.1
SLCCI-SRB-REQ_17-010	All computers within the SLCCI system shall be server-oriented Intel-compatible x86 machines.	§7.9.2
SLCCI-SRB-REQ_17-020	All computers within the SLCCI system shall run with the Linux operating system (32 bit).	§7.9.2
SLCCI-SRB-REQ_15-200	A software configuration system shall be used to manage all source code artefacts during software implementation, so maintaining integrity and traceability during development.	§7.8
SLCCI-SRB-REQ_15-210	An observation report management system shall be employed to track all observation reports during software implementation	§7.8

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_18-100	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.2) such that an analysis shall be carried out of the advantages and disadvantages to be attained with the selection of existing software over new development.	§7.4.2, §7.4.2, SRD §6.3.4
SLCCI-SRB-REQ_18-110	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.3) such that existing software shall be assessed with respect to functional, performance and quality requirements, with a view on identification of an appropriate software system for re-use.	§7.4.2, §7.4.2, SRD §8.2, PSAD
SLCCI-SRB-REQ_18-120	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.4) such that the quality level of the existing software shall be assessed with regards to project requirements.	§7.4.2, §7.9
SLCCI-SRB-REQ_18-130	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.5) such that results of the software reuse analysis shall be documented, including assumptions and methods applied towards estimating level of reuse.	§7.4.2, §7.4
SLCCI-SRB-REQ_18-140	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.6) such that the suitability of the reusable system shall include assessment of	-
(a)	Acceptance and warranty conditions	§7.4.2, §7.4, §7.6, §7.9
(b)	Support documentation	§7.4, §7.4.2
(c)	Conditions under which installation, preparation, training and use take place	§7.4, §7.4.2
(d)	Identification & registration via configuration management	§7.6, §7.4.2
(e)	Maintenance	§7.6, §7.4.2
(f)	Durability and validity of earlier tools which may be re-used	§7.9, §7.4.2
(g)	Constraints relating to copyright and intellectual property rights	§7.4.2, SRD §6.3, PSAD

ID	Requirement	SSD Trc
(h)	Conditions of licensing	§7.4, §7.4.2
(i)	Constraints associated with exportability	§7.6, §7.4.2
SLCCI-SRB-REQ_18-150	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.7) such that corrective actions shall be identified and appropriately documented where the reused software does not meet the appropriate requirements of the SLCCI system.	§7.4, §7.4.2
SLCCI-SRB-REQ_18-160	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.8) such that missing documentation shall be attained to aptly reach verification and validation coverage.	§7.4.2, §7.8 (Phase II)
SLCCI-SRB-REQ_18-170	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.9) such that identified corrective actions shall be appropriately updated and documented at project milestones.	§7.4.2 §7.8 (Phase II)
SLCCI-SRB-REQ_18-180	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.10) such that the system being reused shall be kept under configuration control.	§7.4.2 §7.8 (Phase II)
SLCCI-SRB-REQ_18-190	During system development apt attention shall be given to ECSS standard ECSS-Q-ST-80C (Space Product Assurance) as per reuse of existing software (section 6.2.7.11) such that the configuration status of the baseline associated with the reused software shall be appropriately documented.	§7.4.2 §7.8 (Phase II)
SLCCI-SRB-REQ_19-010	[Definition] The Mean Time Between Maintenance (MTBM) is the mean length of time taken between the end of a planned maintenance session and the start of the following planned maintenance session.	§7.2.5.2-5
SLCCI-SRB-REQ_19-020	The Mean Time Between Maintenance (MTBM) for the system shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-030	The Mean Time Between Maintenance (MTBM) specific to functionality within the production pipeline shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-040	The Mean Time Between Maintenance (MTBM) specific to monitoring functionality shall be at least <x> hours.	§7.2.5.2-5

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_19-050	The Mean Time Between Maintenance (MTBM) specific to product access and visualisation functionality shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-060	The Mean Time Between Maintenance (MTBM) specific to product management functionality shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-070	[Definition] The Mean Maintenance Downtime (MMD) is the mean amount of time that the system is non-operational for the purpose of scheduled maintenance.	§7.2.5.2-5
SLCCI-SRB-REQ_19-080	The Mean Maintenance Downtime (MMD) of the system shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-090	The Mean Maintenance Downtime (MMD) for functionality specific to the production pipeline shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-100	The Mean Maintenance Downtime (MMD) specific to monitoring functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-110	The Mean Maintenance Downtime (MMD) specific to product access & visualisation functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-120	The Mean Maintenance Downtime (MMD) specific to product management functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-200	[Definition] The Mean Time Between Failures (MTBF) is the mean of the amount of time taken between the end of a period where the system was non-operational due to a failure, to the start of the next period where the system was non operational due to a failure. MTBF is a measure of reliability, expressing the amount of non-failure operational up time of the system.	§7.2.5.2-5
SLCCI-SRB-REQ_19-210	[Definition] The Mean Time To Repair (MTTR) is the mean amount of down time experienced by a system whilst repair to a system failure takes place.	§7.2.5.2-5
SLCCI-SRB-REQ_19-220	The Mean Time Between Failures (MTBF) for all functionality within the production pipeline shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-230	The Mean Time Between Failures (MTBF) specific to monitoring functionality shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-240	The Mean Time Between Failures (MTBF) specific to product access and visualisation functionality shall be at least <x> hours.	§7.2.5.2-5

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_19-250	The Mean Time Between Failures (MTBF) specific to product management functionality shall be at least <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-260	The Mean Time To Repair (MTTR) specific to the production pipeline shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-270	The Mean Time To Repair (MTTR) specific to monitoring functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-280	The Mean Time To Repair (MTTR) specific to product access and visualisation functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-290	The Mean Time To Repair (MTTR) specific to product management functionality shall be no more than <x> hours.	§7.2.5.2-5
SLCCI-SRB-REQ_19-500	The system architecture shall be free of any single point of failure (SPF).	§7.9.4
SLCCI-SRB-REQ_20-010	The software within the system shall be configurable during run-time rather than configurable during down-time wherever feasible, so helping avoid the need to harm availability of the system.	§7.9.4
SLCCI-SRB-REQ_21-010	The system shall be able to permanently store data related to the following altimetry products -	-
(a)	ERS-1 Phase C OPR V6	§7.2.6.2
(b)	ERS-1 Phase E OPR V3	§7.2.6.2
(c)	ERS-1 Phase F OPR V3	§7.2.6.2
(d)	ERS-1 Phase G OPR V6	§7.2.6.2
(e)	ERS-2 OPR V6	§7.2.6.2
(f)	Envisat GDR 1	§7.2.6.2
(g)	T/P MGDR	§7.2.6.2
(h)	Jason-1 GDR-C	§7.2.6.2
(i)	Jason-2 GDR-C	§7.2.6.2
(j)	GFO GDR NOAA	§7.2.6.2
(k)	Tide Gauges Time Series	§7.2.6.2
(l)	Argo	§7.2.6.2
SLCCI-SRB-REQ_21-330	The system shall be able to permanently store data related to crossovers in the context of the input altimetry satellite data.	§7.2.6.2

ID	Requirement	SSD Trc
SLCCI-SRB-REQ_21-340	The system shall be able to store all user registration information comprising of	-
(a)	Username	§7.6.5
(b)	Password	§7.6.5
SLCCI-SRB-REQ_21-400	The system shall have a provision to export all primary satellite data that it holds.	§7.6.5
SLCCI-SRB-REQ_21-410	The system shall have a provision to export all ancillary data that it holds.	T
SLCCI-SRB-REQ_21-420	The system shall have a provision to export all user registration information that it holds.	§7.6.5
SLCCI-SRB-REQ_21-430	The system shall have a provision to export all crossover data that it holds.	§7.6.5
SLCCI-SRB-REQ_21-440	The database component used shall be computationally capable of processing the data load of future mission data	§7.5.4
LCCI-SRB-REQ_21-500	The maximum database size provision for primary satellite data shall be <x> Mb.	§7.5.4
SLCCI-SRB-REQ_21-510	The maximum database size provision for ancillary data shall be <x> Mb.	§7.5.4
SLCCI-SRB-REQ_21-520	The maximum database size provision for crossover information shall be <x> Mb.	§7.5.4
SLCCI-SRB-REQ_21-530	The maximum database size provision for user information shall be <x> Mb.	§7.5.4
SLCCI-SRB-REQ_22-010	The Web portal shall freely provide all metadata product information irrespective of whether the user has registered or not, for product types -	-
(a)	FCDR	§7.2.6.2
(b)	ECV	§7.2.6.2
SLCCI-SRB-REQ_22-040	The system shall provide information denoting the algorithms used across production pipeline.	§7.9.5
SLCCI-SRB-REQ_22-050	The system shall provide the means for portal users to view on-going system activity.	§7.9.5
SLCCI-SRB-REQ_22-060	The system shall provide event status information on production pipeline within <x> seconds of a significant event occurring.	§7.9.5
SLCCI-SRB-REQ_22-080	Any user shall be allowed to perform a search query on the product meta information	§7.9.5
SLCCI-SRB-REQ_22-090	The queries on product metadata shall allow a user to specify	-

ID	Requirement	SSD Trc
(a)	Product type	§7.9.5
(b)	Product name	§7.9.5
(c)	Mission name	§7.9.5
(d)	Date of acquisition	§7.9.5
(e)	Time of acquisition	§7.9.5
(f)	Area of interest	§7.9.5
SLCCI-SRB-REQ_22-160	A registered user shall be able to perform a query on the content across all products	§7.9.5
SLCCI-SRB-REQ_22-200	A style guide shall be constructed for SLCCI graphical user interfaces (GUI).	§7.9.5
SLCCI-SRB-REQ_22-210	All GUIs shall conform to the SLCCI style guide	§7.9.5
SLCCI-SRB-REQ_23-020	The system shall have associated with it a formal, well defined series of instructions for the setting up of all network infrastructure associated with all SLCCI hardware.	§7.7
SLCCI-SRB-REQ_23-030	The system shall have associated with it a formal, well defined series of instructions associated with conducting the absorption of the DUACS altimetric database into the SLCCI altimetric database.	§7.7
SLCCI-SRB-REQ_23-040	The system shall have associated with it a formal, well defined series of instructions associated with conducting the absorption of the DUACS crossovers database into the SLCCI crossovers database.	§7.7
SLCCI-SRB-REQ_23-050	It shall on average take an SLCCI Contributor no longer than <x> minutes to deploy all software to the SLCCI physical hardware	§7.7
SLCCI-SRB-REQ_23-060	It shall on average take no longer than <x> minutes to set up all network infrastructure associated with SLCCI hardware.	§7.7
SLCCI-SRB-REQ_23-070	It shall on average take no longer than <x> minutes to conduct the absorption of the DUACS altimetric database into the SLCCI altimetric database.	§7.7
SLCCI-SRB-REQ_23-080	It shall on average take no longer than <x> minutes to conduct the absorption of the DUACS crossovers database into the SLCCI crossovers database.	§7.7

Appendix B - Architectural Scenarios

The architectural scenarios form a significant vehicle for validation of the architecture. These scenarios will primarily be used for walkthroughs by stakeholders with consortium system engineers, to assess whether the system satisfies the situations which it will be finding itself in operationally. We declare our scenarios with an architectural slant, in order to act as a source of scenarios for walkthrough for architectural validation

We identify two high level scenario groups, Scenario_Group_#1 and Scenario_Group_#2, which cover Normal Operation and Abnormal Operation, respectively. Together, these two scenario groups logically cover all scenarios therein. Similarly, each Scenario Group should exhaustively comprise of all high level scenarios associated with that group.

Scenario_Group_#1 - Normal Operation

- HL_Scenario_#1-1 - Data ingested to create product
- HL_Scenario_#1-2 - User visualises product
- HL_Scenario_#1-3 - User downloads product
- HL_Scenario_#1-4 - User makes support enquiry

Scenario_Group_#2 - Abnormal Operation

- HL_Scenario_#2-1 - Failure encountered during data ingestion to create product
- HL_Scenario_#2-2 - Failure encountered during user visualisation of product
- HL_Scenario_#2-3 - Failure encountered during user download of product
- HL_Scenario_#2-4 - Failure encountered during user support enquiry

These Scenario Groups and constituent scenarios are complete, and defined at the appropriate level of detail, having been used as a tool during SSD construction.

Appendix C - Pan-ECV System Requirements for Product Access & Visualisation

The following represents system requirements declared in document “CCI SEWG Technical Note – Towards a Collaborative ECV System on Tools and Technology” Issue 1.1, written for the System Engineering Working Group (SEWG) by Logica. The system requirements are geared to a pan-ECV collaborative Product Access & Visualisation system.

The system requirements are housed in the following format -

Pan-CCI_SysReq_#<index>
<description>

The proposed system requirements are as follows -

Pan-CCI_SysReq_#1
Each ECV shall engineer access to their product data via THREDDS Data Server (TDS) middleware.

Pan-CCI_SysReq_#2
Each ECV shall allow access to their product data via OpeNDAP.

Pan-CCI_SysReq_#3
Each ECV shall allow access and visualisation to their product data via the Web Coverage Service (WCS) specification.

Pan-CCI_SysReq_#4
Each ECV shall allow access and visualisation to their product data via the Web Map Service (WMS) specification.

Pan-CCI_SysReq_#5
Each ECV shall allow access to their product data files via HTTP.

Pan-CCI_SysReq_#6
Each ECV shall either • generate products in at least one TDS friendly format (HDF, NetCDF, GRIB or NEXRAD), or • allow access to their products in at least one TDS friendly format (HDF, NetCDF, GRIB or NEXRAD) via construction of an adapter.

Pan-CCI_SysReq_#7
The CCI Software Engineering Group (SEWG) shall make provision of a Central Information System (CIS) which will • provide a single point of contact for the access of all ECV products • provide a single point of contact for the visualisation of all ECV products

- provide a catalogue describing all ECV products

Pan-CCI_SysReq_#8
The Central Information System (CIS) shall provide access and visualisation to any ECV product by the following means – • OpeNDAP (access only) • WCS • WMS • HTTP (access only)

Pan-CCI_SysReq_#9
The Central Information System (CIS) shall have access to the TDS catalogues generated by all ECVs.

Pan-CCI_SysReq_#10
On being queried by an external user for the TDS catalogue of an ECV product, the Central Information System (CIS) shall make available the TDS catalogue of the relevant ECV.

Pan-CCI_SysReq_#11
On being requested by an external user for access to an ECV product, the Central Information System (CIS) shall provide the relevant ECV product, either directly (via the relevant ECV system itself) or indirectly (via the CIS).

Pan-CCI_SysReq_#12
On being requested by an external user for visualisation to an ECV product, the Central Information System (CIS) shall provide the relevant ECV visualisation, either directly (via the relevant ECV system itself) or indirectly (via the CIS).

Pan-CCI_SysReq_#13
The Central Information System (CIS) shall be designed such that possible future multi-ECV product generation shall be practicable.

Pan-CCI_SysReq_#14
The Central Information System (CIS) shall be designed such that possible future multi-ECV visualisation shall be practicable.

Pan-CCI_SysReq_#15
The Central Information System (CIS) shall be compliant with the INSPIRE (Infrastructure for Spatial InfoRmation in Europe) European directive.