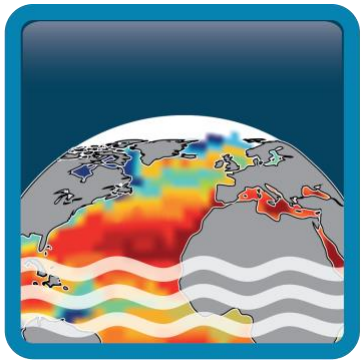
Climate Change Initiative+ (CCI+) Phase 1

Sea Surface Salinity



[D3.3] System Verification Report (SVR)

Customer: ESA

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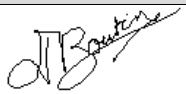
Approved By	Jacqueline Boutin (Science Leader) LOCEAN		22-01-2021
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Amendment Record Sheet

	Document Change Record	
Date / Issue	Description	Section / Page
JUN2019/ v1.0	Delivery to ESA	New document
DEC2019/v1.2	Collected all TBC/TBD validation points as a table	Pages 19 - 24
JUL2020 / 2.1	Update document for year 2	NA
	status system walk through	Annex A
JAN 2021 / 2.2 **(this document)**	Implement ESA feedback (minor changes from previous version)	
JAN 2021 / 2.2	Update production chain year 2 (Figure 2-3)	Section 2.2 / p. 17

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1 Introduction

1.1 Executive Summary

The System Verification Report (SVR) documents the system verification activities for the CCI+ Sea Surface Salinity operational system, as requested in the Statement of Work (SOW Task 3 SOW ref. ESA-CCI-PRGM-EOPS-SW-17-0032), geared to the Salinity Essential Climate Variable (ECV). The SOW states that the SVR consists of a *plan* for the system validation and verification which addresses the SRD, and evidence of compliance to the plan in the form of a *design walkthrough* defined by the SSD.

Note that this is verification plan and it needs to be implemented to become a verification report. Hence all the verification points status in this document are set to "TBC" as *To Be Completed* (Section 3). The final aim being to state that the CCI+SSS processing chain has been correctly implemented, data products are compliant with standards and requirements, tools are implemented for higher level product aggregation and the data is made accessible to end users.

The Annex contains a matrix listing all verification tests, designating which team is responsible, and providing a status column to be marked PASS/FAIL.

1.2 Purpose and Scope

The purpose of the System Verification Report (SVR) is to specify the system verification needed to achieve the operational and production goals for the European Space Agency (ESA) Climate Change Initiative Plus (CCI+) Sea Surface Salinity project.

The CCI+SSS processing chain includes processors as subsystems e.g. L2 SMOS and L1c SNAP processors. Since detailed verification activities have been carried out during the development of these processors it will not be performed within the scope of this project. Instead, in this document, end-to-end verification results will be reported, and verification reports of subsystems implemented within the scope of this project.

The purpose of this document is to report verification, not validation. These activities have different scope:

- Validation – evaluation if the system meets the needs of stakeholders i.e. '*Is the right system built?*'
- Verification – evaluation if the system complies with requirements/specification i.e. *'Is the system built right?*'

Note, however, that several requirements include statements concerning the quality of products and these are in this document considered in the scope of verification, whereas in the Product Validation Plan they would be considered in the scope of validation.

1.3 Intended Audience

The readership of this document is comprised of the CCI+ SSS consortium partners and ESA. There may also be scope, following further investigation, 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 in the Statement of Work (SOW).

1.4 Assumptions

This document is based on issue 1.1 of the System Requirement Document (SRD), and issue 2.2 of the System Specification Document (SSD). Note that the SRD depends on the URD, PSD and DARD, which are living documents likely to change throughout the course of the project, consequently the System Requirement Document (SRD) and System Specification Document (SSD) are also to be considered as a living document and, this System Verification Report (SVR) will require to be updated in the course of the development process to consider any additions to the verification plan and/or changes to existing verification.

1.5 References

1.5.1 Applicable Documents

ID	DOCUMENT	REFERENCE
SOW	CCI+ Phase 1 – New ECV – Statement of Work	ESA-CCI-PRGM-EOPS-SW-17-0032
DSTD	CCI Data Standards	CCI-PRGM-EOPS-TN-13-0009
SRD	CCI+ SSS System Requirements Document	SSS_cci-D3.1-SRD-v1.1
SSD	CCI+ SSS System Specification Document	SSS_cci-D1.2-SSD-v1.1

1.5.2 Reference Documents

ID	DOCUMENT	REFERENCE
PROP	Technical Proposal in response to CCI+ Phase 1 – New ECVS - Salinity	ARG-003-039(3) 27th October 2017
RD01	European Cooperation for Space Standardization: Space Engineering - Software	ECSS-E-ST-40C 6th March 2009
RD02	European Cooperation for Space Standardization: Space Engineering - Verification	ECSS-E-ST-10-02C 1st February 2018
RD03	CF Conventions and Metadata	WEB LINK
RD04	CF Standard Names	WEB LINK
RD05	The Climate Change Initiative Ontology	WEB LINK
RD06	Attribute Convention for Data Discovery (ACCD)	WEB LINK
RD07	UNIDATA Program Center of the University Corporation for Atmospheric Research UDUNITS Software	WEB LINK

1.6 Acronyms

AD	Applicable Document
ACCD	Attribute Convention for Data Discovery
ADF	Auxiliary Data File
AMSR	Advanced Microwave Scanning Radiometer
ATBD	Algorithm Theoretical Basis Document

AUX	Auxiliary
CCI	The ESA Climate Change Initiative (CCI) is formally known as the Global Monitoring for Essential Climate Variables (GMECV) element of the European Earth Watch Programme
CCI+	Climate Change Initiative Extension (CCI+), is an extension of the CCI over the period 2017–2024
CF	Climate Forecasting
CFOSAT	Chinese French Oceanography Satellite
DARD	Data Access Requirements Document
DOI	Digital Object Identifier
E3UB	End-to-End ECV Uncertainty Budget
EC	European Commission
ECMWF	European Centre for Medium Range Weather Forecasts
ECSS	European Cooperation for Space Standardization
ECV	Essential Climate Variable
EO	Earth Observation
ESA	European Space Agency
FOSS	Free Off-the-Shelf Software
FRM	Fiducial Reference Measurements
GCOS	Global Climate Observing System
GNSS	Global Navigation Satellite System
GDPR	General Data Protection Regulations
GUI	Graphical User Interface
INSPIRE	Infrastructure for Spatial Information in Europe
ISDB	in situ database (of Fiducial Reference Measurements and satellite measurements)
L1 / L2 / L3 / L4	Level 1, 2, 3, 4 Products
L2OS	Level 2 Ocean Salinity
LUT	Look Up Table
NASA	National Aeronautics and Space Administration
Obs4MIPs	Observations for Model Intercomparison Projects
OPeNDAP	Open-source Project for a Network Data Access Protocol
OS	Ocean Salinity / Operating System
PSD	Product Specification Document
PUG	Product User Guide
PVP	Product Validation Plan
QC	Quality Control

RAM	Random Access Memory
RD	Reference Document
RMSD	Root Mean Squared Deviation
SEWG	Software Engineering Working Group
SMAP	Soil Moisture Active Passive [mission of NASA)
S.M.A.R.T.	Specific, Measurable, Achievable, Realistic, Timely
SMOS	Soil Moisture and Ocean Salinity [satellite of ESA]
SoW	Statement of Work
SRD	System Requirements Document
SSD	System Specification Document
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SVR	System Verification Report
TDC	To Be Confirmed / Continued
TBD	To Be Defined / Discussed
TDS	Test Data Set
URD	User Requirements Document
UUID	Universal Unique Identifier

1.7 Document Structure

Section 1, this section, provides an executive summary, and introduction outlining the purpose and scope of this document, reference documents, abbreviations etc.

Section 2 contains a brief overview of the CCI SSS system

Section 3 contains a brief overview of the verification process and document syntax.

Section 4 details the verification plan as a series of verifications against the System Requirement Document (SRD); in later versions this plan will be amended to include the results and evidence of verification.

Section 5 provides the design walk-through from the System Specification Document

Annex A contains a verification matrix

Annex B contains an example of the structure of the netCDF file

2 Sea Surface Salinity System Overview

2.1 Objective and scope of the CCI+SSS system

The document that provides the fullest description of the CCI+SSS system is the System Specification Document [SSD].

Note that there is a distinction between the "CCI+SSS System" and the "CCI+SSS Processor". The CCI+SSS system is the more general term covering the end-to-end capabilities developed within the CCI+SSS project. The CCI+SSS processor specifically refers to the chain by which products specified in the Product Specification Document (PSD) are created.

As stated in the SSD the system is designed to answer the following matters:

- Being a help for the CCI+ Salinity Science Team to perform regular and performing computation in view to support them during the different steps of the project. In that respect, in addition to the main production system, computing capacity through virtual machines (VM) on which the processors are installed and configured are made available to the Science researchers for algorithm testing purpose.
- Fully addressing the CCI+ expected production volume by running a complete end-to-end ECV processing system. Except for Year 1 production which will be detailed further in the document, the production will take place at the end of the Years 2 and 3.

The end-to-end system ultimately required for CCI+SSS to deliver its users' needs includes a range of interfaces, as illustrated in Figure 2-1, from the SRD.

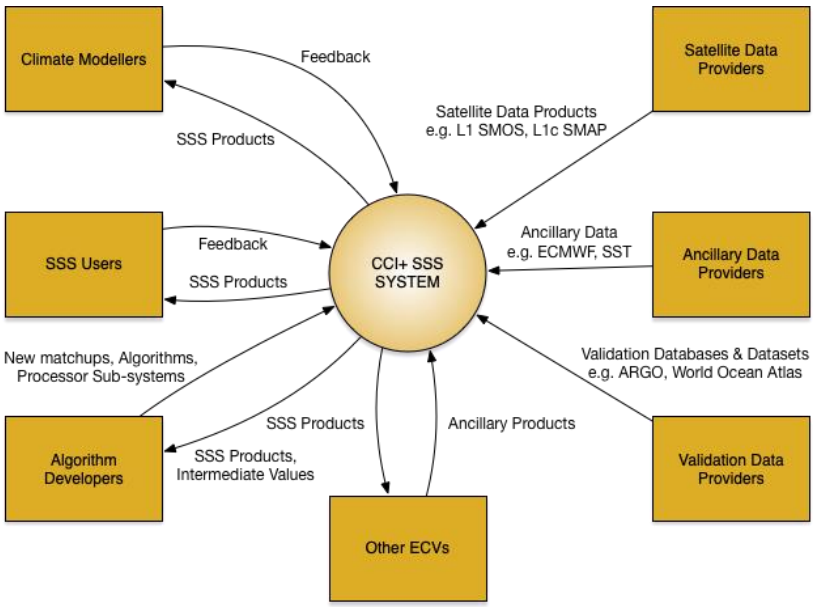

Figure 2-1: CCI+SSS system in context of its interfaces

Each of the interfaces require verification and are included in the Verification Plan. The interfaces and corresponding verification is given in Table 2-1.

Table 2-1: System Interfaces and Verification

Interface	Verification
Satellite Data Interface	VR-0060-FUN-ACQU
Ancillary Data Interface	VR-0070-FUN-ACQU
Validation Data Interface	VR-0080-FUN-ACQU
Other ECV Interface	VR-0170-FUN-DIST Note: Use of other ECV as ancillary data not currently in scope
Algorithm Developers Interface	No specific verification for interface; assume same as below. But interface for improved algorithms, e.g. VR-0610-FUN-PROC
SSS Users Interface	VR-0150-FUN-DIST VR-0160-FUN-DIST Note: The feedback from end-users has not been included in the verification plan
Climate Modellers Interface	VR-0150-FUN-DIST VR-0160-FUN-DIST Note: The feedback from end-users has not been included in the verification plan

2.2 CCI+SSS Processor

The production system is based on a dataflow that gives the utmost priority to the automation of the processing; thus complying with the large processing resources requirements.

The system is composed of the following main components:

- ✓ The data ingestion module
- ✓ The production module
- ✓ The archiving module
- ✓ The data dissemination module
- ✓ The analysis module

The dataflow between these components are illustrated in Figure 2-2.

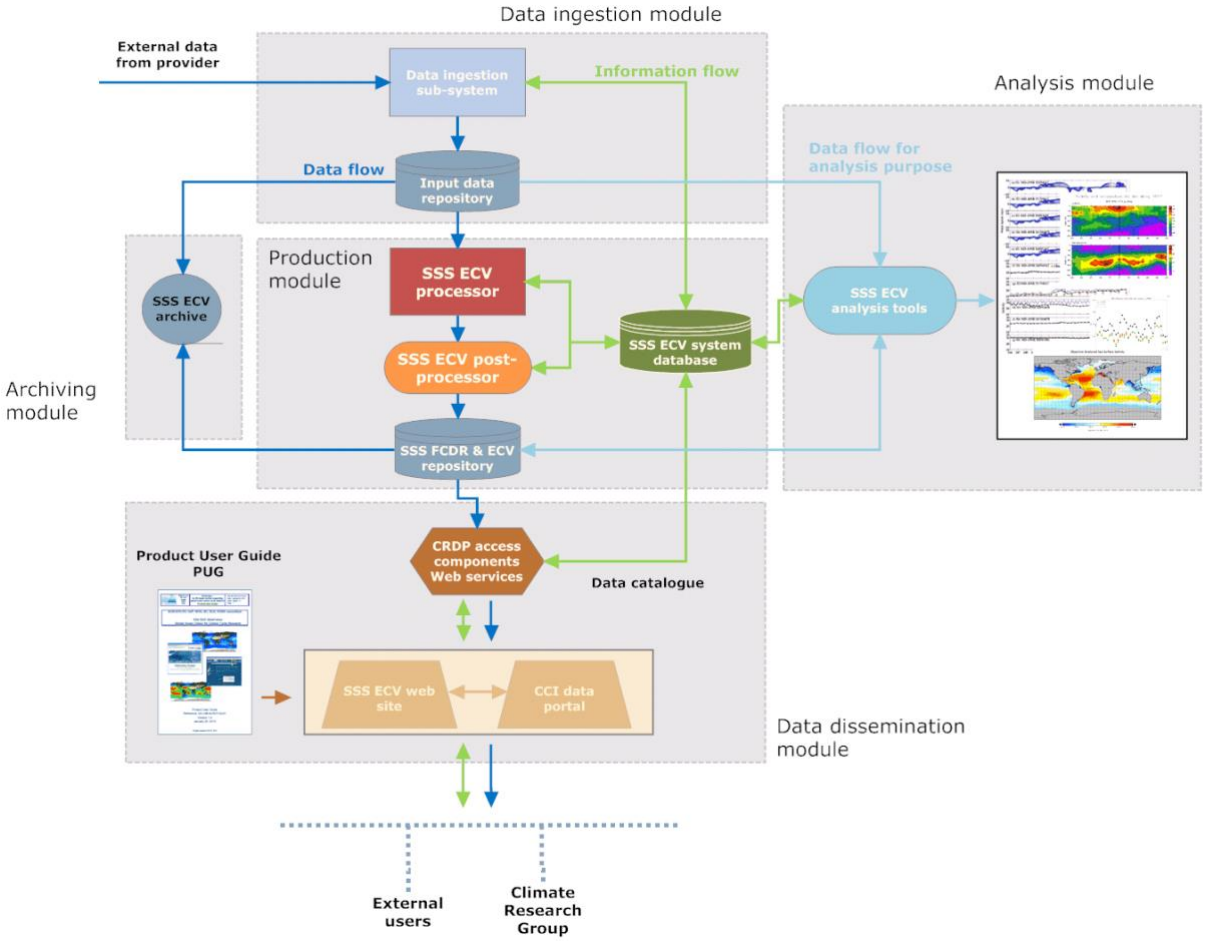

Figure 2-2: CC+SSS Dataflow

In Year 2 (June-2019 to June-2020) the following end-to-end processing chain was in operation. It included L2 SMAP, L3 Aquarius and L2 SMOS products from CATDS that were used to generate the L4 products (Figure 2-3).

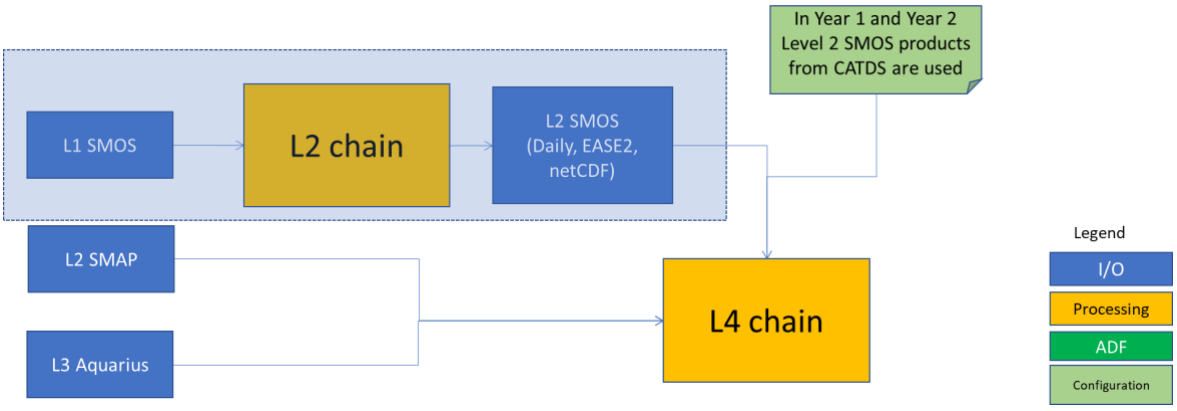

Figure 2-3: CCI+ SSS Production Chain

2.3 CCI+SSS Products

The objective of the CCI+SSS Processor is to create climate data records for Sea Surface Salinity at levels between Levels 2 and 4. In Phase I only Level 4 products were generated.

3 VERIFICATION OVERVIEW

3.1 System Verification

The verification plan is determined by the system requirements, enumerated in the SRD, and given a unique identifier by using the unique identifier of the requirement and replacing the first two characters from 'SR' to 'VP':

Table 3-1 Template for System Verification Description

Verification ID	Requirement Title	Verification
Verification Description		
Evidence:		**Pass / Fail**
Issues:		

A verification description includes the following main fields:

- **Verification ID**: A unique identifier of the format VR-NNN-CAT-SUBJ where NNN is a number unique within the whole set of requirements recorded herein. CAT and SUBJ indicate the assignment to a Requirements Category and a Requirements Subject, respectively (see SRD).
- **Requirement Title**: A short noun form indicating the topic of the requirement that is to be verified, this is the same as used in the SRD
- **Verification Method**: A verification method to be applied in the course of the verification process to confirm that the requirement is fulfilled by the system. One of:
  - INSPECT Verify by observation or examination
  - ANALYZE Verify by showing theoretical compliance
  - DEMONSTRATE Verify by qualitative means
  - TEST Verify by quantitative means
- **Verification Description**: Description of verification required using the keyword from the verification method.
- **Evidence**: To be completed with evidence of the verification
- **Pass / Fail**: Once verified strike out the option that does not apply.

In addition, during verification any issues that are encountered shall be entered into a row called, *Issues*:

The SRD identifies a set of requirements. As stated in the SOW these requirements are used to create a plan for verification i.e. for each requirement there should be at least one verification.

As stated in the Executive Summary several verification points are insufficiently defined by upstream documentation or are impossible to address adequately at this stage and are marked TBC or TBD and will be addressed during the CCI exercises in Year 2 and Year 3. All verification points marked TBC/TBD are listed in the following table:

VR-0100-FUN-PRE

Demonstrate the set of pre-processors that produce AUX data files under the format and specifications required by the L2 algorithms. [TBC] associate each AUX file with L2 processor / algorithm. [TBC] identify the pre-processing of any data set necessary for L4 applications, whenever they are related to L4 SSS ECV datasets or derived variables. This only needs to be demonstrated but currently the information is unavailable
VR-0240-OPL-PROD [TBC] Apart from SSS no other variable has been identified by the URD / PSD so this requirement and verification are incomplete but the SRD **SR-0240-OPL-PROD** provides a possible set: If the USD/PSD provides a list of product variables that match the table the TBC can be removed, or if there is no intention to produce a variable on the list then a comment can be added that the variable has been considered by the USD/PSD team and decided it is not needed.
VR-0260-OPL-PROD [TBC] The SRD only provides a range of temporal frequencies because the USD/PSD does not specify unambiguously WHAT product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible If the USD/PSD provides temporal resolution values the TBC can be removed
VR-0279-OPL-PROD [TBC] The SRD only provides a range of spatial resolutions because the USD/PSD does not specify unambiguously WHAT product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible If the USD/PSD provides spatial resolutions required the TBC can be removed
VR-0280-OPL-PROD The SRD only provides a range of threshold and goal values because the USD/PSD does not specify unambiguously what product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible VR-0310-QTY-PROD

Inspect L4 products for sensors to confirm presence of: What sensors conform to the following inclusions: • random error, • systematic error, • standard deviation of the bias, • good/bad flags computed from different indicators (chi-squared, number of outliers).
VR-0320-QTY-PROD Demonstrate data merging methods, time-dependent and sampling biases in products from different instruments and implemented to correct for these effects During Year 2, the SSS processor merged SSS data from different satellite missions including SMOS, Aquarius and SMAP (see SSD v2)
VR-0330-QTY-PROD Demonstrate that data products include quality indicators and flags, noting that URD indicate 46% users require good/bad flags, 28% for all and 22% for selected quality checks. [TBC] No documented QI/flags currently exist so this verification is not possible and considering that L3/L4 products are created from binned L2 data, which may be merged from differing sensors, the science team must document QI/flags prior to implementation. This is a qualitative test and depends on whether the science team has documented the flags they expect and demonstrate that they exist in the products
VR-0340-QTY-PROD Provide quantitative test that the long-term stability of the CCI+ Salinity time series are within 0.001 / decade Need to enumerate the time-series generated and the methodology of testing long-term stability. To be resolved with the results of third year reprocessing.
VR-0350-RLY-PROD

Provide quantitative test that for each data product the validated estimate of uncertainty at product grid/pixel level is 0.01 or less Need to enumerate the time-series generated and the methodology of testing validated uncertainty. See E3UB document for detailed uncertainty budget. It required by users it is possible to add a note in the PUG.
VR-0360-RLY-PROD Enumerate all ECV products that are to be considered. All the CCI+SSS product are listed in the PUG v2.1.
VR-0700-DOC-GEN As stated in SRD **SR-0700-DOC-GEN** an examination of ECSS-E-ST-40C in comparison with the document deliverables defined in the SOW did not have a 1-to-1 match. The documentation defined by the SOW has been assumed to be a tailoring for the ECSS documentation so that several documents were not included e.g. the Interface Requirements Document (IRD), Interface Control Document (ICD), Software Verification Plan (SVerP), Software refuse file (SRF) and others.
VR-0760-CON-SOFT NOTE the URD suggests >50% of users want tools written in MATLAB. Even though MATLAB is the preferred tool, there is a growing demand to use Python-based tools. As an example, CCI toolbox is written in Python. So it is possible to see that in the coming months there will be change of user software preference from MATLAB to Python.
VR-0770-PRF-HW In order to satisfy this verification, step the timescale for full dataset operation must be known i.e. whether or not computing resources become a constraint depends on how quickly the dataset needs to be generated. This verification is derived from a qualitative statement and is really simply confirming that the processing chain is automatic and the following two verification statements viz processing and storage requirements are true.
VR-0780-PRF-HW

SR-0780-PRF-HW stated that to process the entire dataset within 4 months would require 520 CPU cores and 1.24 TB RAM (the lowest threshold based on L1c à L2 SMOS) Metrics for processing time of all dataset components are available, so CALCULATE the theoretical CPU/RAM need to process the data within the time frame available for processing in the project schedule. PASS if sufficient CPU / RAM else FAIL. The processing time for the entire dataset in 4 months will require 520 CPU cores and 1.24 TB RAM or some suitable scaled threshold depending on experience gained during year 1
VR-0790-PRF-HW **SR-0790-PRF-HW,** based DARD, states the lower threshold for storage requirements is 250TB. The SSD 4.9 includes lists of ancillary data files and intermediary files that are NOT INCLUDED in the DARD. In addition, the DARD output is for 1 complete dataset, and at least 2 are required (since year 1 did not generate a complete dataset). An accurate estimate of storage capacity requires additional analysis. The lower threshold for storage requirements will be analysed to confirm it is 250TB

4 System Verification Plan

4.1 Functional Requirements

Functional requirements specify 'what' the system has to do. They define the purpose of the system.

4.1.1 General (FUN-GEN)

RESPONSIBILITY: Climate Research Group

VR-0010-FUN-GEN	SSS Observing System	INSPECT
Inspect that the system delivers a global ocean salinity observing system.		
Evidence:		**Pass / Fail**

VR-0020-FUN-GEN	Space-based SSS Continuity	INSPECT
Inspect how the system ensures continuity of space-based SSS measurements.		
Evidence:		**Pass / Fail**

VR-0030-FUN-GEN	Develop Retrieval Algorithms	INSPECT
Inspect that the system Test Data Sets (TDS) have been generated from retrieval algorithms described as ATBDs and implemented as processor modules (specifics viz-a-vis temporal and spatial resolution, uncertainties and thresholds detailed in subsequent sections)		
Evidence:		**Pass / Fail**

VR-0040-FUN-GEN	Deliver SSS ECV Products	INSPECT
Inspect that the output SSS ECV products are produced AND there is matchup between these FRM data		

Evidence:	**Pass / Fail**

VR-0050-FUN-GEN	DELIVER VALIDATED PROTOTYPE PRODUCTS	INSPECT
Inspect that validated products are delivered to users for assessment & feedback.		
Evidence:		**Pass / Fail**

4.1.2 Data Acquisition (FUN-ACQU)

RESPONSIBILITY: Engineering Team

VR-0060-FUN-ACQU	INPUT DATA ACQUISITION	INSPECT

Inspect that the Input Data specified in DARD §3.1 are present in source data storage

PRODUCT	COVERAGE	PASS	NOTE
SMOS L1C	2010 to present		Time series completed till Jun 2020
SMOS L2 CATDS	2010 to present		Time series completed till Jun 2019 - To be completed
SMOS L2P CATDS	2010 to present		Time series completed till Jun 2019 – To be completed
SMOS L3QA CATDS	2010 to present		Data for Round Robin Time series from 2010 to Apr 2019 TBC the need to complete time series
SMAP L1C	2015 to present		Unused in Phase I
SMAP L2C RSS v3	2015 to present		Time series completed till May 2019. Downloading remaining

SMAP L2C RSS v4	2015 to present		Time series completed till May 2019. Downloading remaining
Aquarius L1A	2011 to 2015		Unused in Phase I
Aquarius L2 CAP	2011 to 2015		Unused in Phase I
Aquarius L2 OR	2011 to 2015		Unused in Phase I
Aquarius L3 v5 NASA	2011 to 2015		Time series completed
AMSR-E L2A v4	06-2002 to 10-2011		Time series completed
AMSR-E L2B	06-2002 to 10-2011		Time series completed
SSST CCI L4 v2.1	2002-2011		In download
AMSR2 L1R	2012 to present		Unused in Phase I
WindSat L1	2003 to present		Unused in Phase I
WindSat L2	2003 to present		Unused in Phase I
AMSR2 L2	2012 to present		Unused in Phase I

Confirm total storage volume ~ 200 TB

Evidence:	**Pass / Fail**

VR-0070-FUN-ACQU	ANCILLARY DATA ACQUISITION	INSPECT

Inspect that the Ancillary data specified in DARD §3.2 (In-situ) and DARD §3.3 (Inter-comparison) are present in data storage.

PRODUCT	COVERAGE	PASS	NOTE

ARGO profiles	2000 to present		
TSG-GOSUD	2001 to present		
TSG-LEGOS	2003 to present		
TSG-SAMOS	2007 to present		
Marine-Mammals	2004 to present		
Moorings	1979 to present		
Surface drifters	2005 to present		

Confirm total storage ~ 0.15 TB

PRODUCT	COVERAGE	PASS	NOTE
JAMSTEC	2001 to present		
EN4.2.1	1900 to present		
ISAS	2010 to present		
ARGO IPRC	2004 to present		
Roemmich-Gilson Argo Climatology	2004 to present		
MULTIOBS_GLO_PHY_REP_015_002	1993 to 2017		
World Ocean Atlas 2009	1890 to 2008		
World Ocean Atlas 2013	1890 to 2012		
World Ocean Atlas 2018	1890 to 2017		
SMOS L3 CATDS-CPDC	2010 to present		

SMOS L3 CATDS-CECOS-LOCEAN	2010 to present		
SMOS L3 CATDS-CECOS-IFREMER	2010 to present		
SMOS L3 OA BEC	2010 to present		
SMAP L3 JPL	2015 to present		
SMAP L3 RSS (70 km)	2015 to present		
Aquarius L3 CAP	2011 to 2015		
Aquarius L3 OR	2011 to 2015		
SMOS L3 ICDC	2010 to present		
SMOS L4 CATDS-CECOS-IFREMER	2010 to present		
SMOS L4 BEC	2010 to present		
Aquarius L4 OI IPRC	2011 to 2015		
HYCOM	2012 to 2018		
ECCO	2010 to 2015		
MERCATOR	2010 to present		

Confirm data storage ~ 1.5 TB

Evidence:	**Pass / Fail**

VR-0080-FUN-ACQU	AUXILIARY DATA ACQUISITION	INSPECT
Inspect that the Auxiliary data specified in DARD §3.4 are present in data storage.		

PRODUCT	COVERAGE	PASS	NOTE
ECMWF	2010 to present		
NCEP	2010 to present		
L-band Sky map			
Total Electronic content			
ASCAT	From 2010-01-01 to present		
Altimeter waves	From 2010-01-01 to 2017-01		
SST AVHRR	2010 to present		
SST OSTIA	2006 to present		
SST CMC	2010 to present		
SST RSS	2010 to present		
CMORPH	2010 to present		
TRMM	2010 to present		
IMERG	2014 to present		

Confirm data storage > 1.2 TB

Evidence:	**Pass / Fail**

4.1.3 Data Pre-processing (FUN-PRE)

RESPONSIBILITY: Engineering Team

VR-0090-FUN-PRE	L1 DATA PRE-PROCESSING	DEMONSTRATE

Demonstrate that input L1 data, if required, are correctly pre-processed to allow for ingestion into the applicable L2 processor.

PRODUCT	PASS	NOTE
SMOS L1C		
SMAP L1C		
Aquarius L1A		
AMSR2 L1R		
WindSat L1		

Amend table as required [TBD]

Evidence:	**Pass / Fail**

VR-0100-FUN-PRE	AUXILIARY DATA PRE-PROCESSING	DEMONSTRATE

Demonstrate the set of pre-processors that produce AUX data files under the format and specifications required by the L2 algorithms.

PRODUCT	PASS	NOTE
ECMWF		
NCEP		
L-band Sky map		
Total Electronic content		

ASCAT			
Altimeter waves			
SST AVHRR			
SST OSTIA			
SST CMC			
SST RSS			
CMORPH			
TRMM			
IMERG			

[TBC] associate each AUX file with L2 processor / algorithm.

[TBC] identify the pre-processing of any data set necessary for L4 applications, whenever they are related to L4 SSS ECV datasets or derived variables.

Evidence:	**Pass / Fail**

VR-0110-FUN-PRE	INPUT DATA QC - LOGGING	INSPECT
Inspect logging of input data pre-processing and QC reporting		
Evidence:		**Pass / Fail**

VR-0112-FUN-PRE	LOOK-UP TABLE GENERATOR & TOOLS	INSPECT/TEST
[TBC] Need to have LUT specification from ATDBs to list & define properties Test that the LUT(s) used conform to the specification provided in the ATBD		

NB. LUTs provided in re-used components e.g. provided L2 processors, are, like these processors, considered to be verified and are not considered in the SVR. Inspect logging of LUT generation and QC reporting
Evidence: **Pass / Fail**

4.1.4 Data Processing (FUN-PROC)

RESPONSIBILITY: Engineering / Validation Team

VR-0120-FUN-PROC	LEVEL 2 DATA PROCESSING	INSPECT/TEST
For processing modules implemented in scope of the CCI-SSS project: • Test L2 output products, and/or intermediate products, to compare to expected values based on input TDS and ATBD. For processing modules used 'as-is', i.e. pre-build components, verification is assumed to have been performed by the module provider. NOTE: If a module(s) is changed within a pre-build processing chain it is only necessary to verify the new module and the integration within the chain. NOTE: Output from unit tests should be available for all modules, including pre-built modules (if not flag this as an issue to ESA); Integration tests should be performed after the introduction of a new module; Regression tests should be performed after bug/issue solution. Inspect logging of Level 2 data product generation and QC reporting		
Evidence:		**Pass / Fail**

VR-0130-FUN-PROC	LEVEL 3 DATA PROCESSING	INSPECT/TEST
For processing modules implemented in scope of the CCI-SSS project: • Test L3 output products, and/or intermediate products, to compare to expected values based on input TDS. • Inspect that it is possible to delimit processing to:		

○ a defined time series ○ a defined area of interest For processing modules used 'as-is', i.e. pre-build components, verification is assumed to have been performed by the module provider. NOTE: If a module(s) is changed within a pre-build processing chain it is only necessary to verify the new module and the integration within the chain. NOTE: Output from unit tests should be available for all modules, including pre-built modules (if not flag this as an issue to ESA); Integration tests should be performed after the introduction of a new module; Regression tests should be performed after bug/issue solution Inspect logging of Level 3 data product generation and QC reporting
Evidence: **Pass / Fail**

VR-0140-FUN-PROC	LEVEL 4 DATA PROCESSING	INSPECT/TEST
For processing modules implemented in scope of the CCI-SSS project: • Test L4 output products, and/or intermediate products, to compare to expected values based on input TDS. For processing modules used 'as-is', i.e. pre-build components, verification is assumed to have been performed by the module provider. NOTE: If a module(s) is changed within a pre-build processing chain it is only necessary to verify the new module and the integration within the chain. NOTE: Output from unit tests should be available for all modules, including pre-built modules (if not flag this as an issue to ESA); Integration tests should be performed after the introduction of a new module; Regression tests should be performed after bug/issue solution Inspect logging of Level 4 data product generation and QC reporting		
Evidence:		**Pass / Fail**

4.1.5 Data Post Processing (FUN-POST)

RESPONSIBILITY: Climate Research Group / Engineering Team

VR-0145-FUN-PROC	ECV DATA POST-PROCESSING	INSPECT
Inspect that the output data (L2 to L4, possible L1) conform to the Product Format requirements (§4.2.6) and the supporting Data Distribution (§4.1.6). Inspect logging of product post-processing and QC reporting		
Evidence:		**Pass / Fail**

4.1.6 Product Distribution (FUN-DIST)

RESPONSIBILITY: Climate Research Group / Engineering Team

VR-0150-FUN-DIST	FTP DATA ACCESS PROTOCOL	INSPECT
Inspect that output data is available via the FTP protocol.		
Evidence:		**Pass / Fail**

VR-0160-FUN-DIST	OBS4MIPS DELIVERY	INSPECT
Inspect that final ECV products produced in Year 3 are: 1. available to the obs4MIPs initiative, 2. are in obs4MIPs format, 3. include associated obs4MIPs documentation		
Evidence:		**Pass / Fail**

VR-0170-FUN-DIST	CCI OPEN DATA PORTAL DELIVERY	INSPECT

Inspect that sea surface salinity ECV products are available on the CCI Open Data Portal for further dissemination to the user community.	
Evidence:	**Pass / Fail**

VR-0190-FUN-DIST	PUBLIC AVAILABILITY OF ECV PRODUCTS	INSPECT
Inspect that CCI+ Salinity ECV products with the validation results are publically available immediately following the completed validation.		
Evidence:		**Pass / Fail**

4.2 Product Requirements

4.2.1 Functional Considerations (FUN-PROD)

RESPONSIBILITY: Climate Research Group / Engineering Team

VR-0200-FUN-PROD	GLOBAL OCEAN COVERAGE	DEMONSTRATE
Demonstrate that CCI+ Salinity ECV products cover the global ocean, including full coverage of both northern and southern hemispheres as far as possible.		
Evidence:		**Pass / Fail**

VR-0210-FUN-PROD	MISSION LIFETIME COVERAGE	DEMONSTRATE

Demonstrate that CCI+ Salinity ECV products cover the full mission lifetime:

MISSION / DATE RANGE	PASS	NOTES
SMOS 2009 – present		
AQUARIUS 2011-2015		

SMAP 2015 – present		
AMPSRE 2002 – present		
AMSR-11 2012 – present		

Evidence:	**Pass / Fail**

VR-0220-FUN-PROD	AVAILABLE PRODUCT PROCESSING LEVELS	DEMONSTRATE

Demonstrate that CCI+ Salinity products are available at the required processing levels:

MISSION	**L1**	**L2**	**L3**	**L4**
SMOS				
AQUARIUS				
SMAP				
AMPSRE				
AMSR				

NOTE: N/A signifies that there is no requirement for the mission data to be available at that processing level.

Evidence:	**Pass / Fail**

VR-0230-FUN-PROD	AVAILABLE HIGHER-LEVEL PRODUCTS	DEMONSTRATE

Demonstrate that higher-level data products are available:

MISSION	DAILY	MONTHLY	SEASONAL	ANNUAL
SMOS				
AQUARIUS				
SMAP				
AMPSRE				
AMSR				

NOTE: As required add columns for higher levels and/or rows for multi-mission

Evidence:	**Pass / Fail**

4.2.2 Operational Product Requirements (OPL-PROD)

RESPONSIBILITY: Validation Team / Engineering Team

VR-0240-OPL-PROD	PRODUCT VARIABLES	INSPECT

Inspect the datastore to provide evidence of products and higher-level merged product time-series that shall include the following variables:

- Sea surface salinity
- Appropriate [RD-3] derived-variables;
- Appropriate [RD-3] supporting variables;
- Other information relevant to the processing and use of SSS data from space.

[TBC] Apart from SSS no other variable has been identified by the URD / PSD so this requirement and verification are incomplete but the SRD **SR-0240-OPL-PROD** provides a possible set:

CATEGORY	PRODUCT	PASS
ECV Product	Sea Surface Salinity (SSS)	pass

Sub-variables	Bulk surface salinity Skin surface salinity Near surface salinity at stated depth	N/A
Derived variables	Evaporation & precipitation estimates River runoff & glacial/land ice melting rates Sea surface density Sea surface alkalinity Sea surface pO2	
Supporting variables	Sea surface temperature Sea surface winds Precipitation [additionally, other fields used in data processing e.g. RFI maps, galactic contributions, surface ocean roughness etc.	

Evidence:	**Pass / Fail**

VR-0250-POL-PROD	MISSION DATASETS	INSPECT
As it currently stands this is a duplicate of **VR-0210-FUN-PROD** but if additional datasets from other sensors are included based on USD/PSD evolutions these will be added here.		
Evidence:		**Pass / Fail**

VR-0260-OPL-PROD	PRODUCT TEMPORAL FREQUENCY	INSPECT

[TBC] The SRD only provides a range of temporal frequencies because the USD/PSD does not specify unambiguously WHAT product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible
Evidence: **Pass / Fail**

VR-0279-OPL-PROD	PRODUCT SPATIAL RESOLUTION	DEMONSTRATE
[TBC] The SRD only provides a range of spatial resolution because the USD/PSD does not specify unambiguously WHAT product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible		
Evidence: **Pass / Fail**		

VR-0280-OPL-PROD	THRESHOLD & GOAL VALUES	TEST
[TBC] The SRD only provides a range of threshold and goal values because the USD/PSD does not specify unambiguously WHAT product temporal frequencies will be generated and without that detail the SRD cannot be specific or unambiguous so no verification is possible		
Evidence: **Pass / Fail**		

VR-0290-OPL-PROD	USER RESOLUTION, COVERAGE & ACCURACY	INSPECT
Inspect that CCI+ Salinity products have global coverage with a frequency of at least weekly and resolution at least 0.25˚ with an accuracy at least 0.3		
Evidence: **Pass / Fail**		

VR-0300-OPL-PROD	DATASET PRODUCTION SCHEDULE	DEMONSTRATE

Based on SOW, in year 2 CCI+SSS has delivered a "Climate Research Data Package (CRDP) as a fully uncertainty characterised, long time series of global ECV products". These products include: *L4 weekly, 50km smoothing, 25km grid size, global coverage, 01/2010-10/2019* *L4 30 days, 50km smoothing, centred 1st and 15th of the month, 25km, global 01/2010-10/2018* Consequently, achievement of **SR-0300-OPL-PROD** for YEAR 2
Evidence: **Pass / ~~Fail~~**

4.2.3 Product Quality (QTY-PROD)

RESPONSIBILITY: Validation Team

VR-0310-QTY-PROD	LEVEL 4 ERROR SPECIFICATION	INSPECT
Inspect L4 products to confirm presence of: • random error, • systematic error, • standard deviation of the bias, • good/bad flags computed from different indicators (chi-squared, number of outliers).		
Evidence: All documentation relating to Uncertainty budget is gathered in the End-to-End ECV Uncerntainty Budget (E3UB). This includes a throughout description of the error contained in L4 products. Furthermore there is a caveat form available to users, which include a description of the data and the quality control flags to determine the quality of the retrieval.		**Pass / ~~Fail~~**

VR-0320-QTY-PROD	CORRECTION OF INTRA-MISSION BIASES	DEMONSTRATE

Demonstrate data merging methods, time-dependent and sampling biases in products from different instruments and implemented to correct for these effects (ref. to ATBD and E3UB).	
Evidence:	**Pass / ~~Fail~~**

VR-0330-QTY-PROD	QUALITY INDICATORS / FLAGS	DEMONSTRATE
Demonstrate that data products include quality indicators and flags, noting that URD indicate 46% users require good/bad flags, 28% for all and 22% for selected quality checks (ref. PUG).		
Evidence:		**Pass / ~~Fail~~**

VR-0340-QTY-PROD	ASSESSMENT LONG-TERM STABILITY	TEST
Provide quantitative test that the long-term stability of the CCI+ Salinity time series are within 0.001 / decade (GCOS req.). [TBC] Need to enumerate the time-series generated and the methodology of testing long-term stability.		
Evidence:		**Pass / Fail**

4.2.4 Product Uncertainty (RLY-PROD)

RESPONSIBILITY: Validation Team

VR-0350-RLY-PROD	PRODUCT UNCERTAINTY	TEST
Provide quantitative test that for each data product the validated estimate of uncertainty at product grid/pixel level is 0.01 or less (GCOS req.) [TBC] Need to enumerate the time-series generated and the methodology of testing validated uncertainty.		

Evidence:	**Pass / Fail**

VR-0360-RLY-PROD	ECV PRODUCT INCLUDE UNCERTAINTY	DEMONSTRATE
Demonstrate that uncertainties are present within the ECV products for every geophysical measurement. [TBC] Enumerate all ECV products that are to be considered.		
Evidence:		**Pass / Fail**

VR-0370-RLY-PROD	DEFINE UNCERTAINTY METHODOLOGY	ANALYZE
Analyse the **End-to-End ECV Uncertainty Budget (E3UB)** to show evidence of practical method to provide uncertainty estimates for each geophysical data product produced at the pixel/grid level. Analyse to show evidence that the end-to-end uncertainty budget will estimate the uncertainties that arise in each step of the retrieval process and include all potential sources of uncertainty; to combine into the total product uncertainty. This requirement **SR-0370-RLY-PROD** is complex and requires clarification and expansion from the science team		
Evidence:		**Pass / Fail**

VR-0380-RLY-PROD	REPORT UNCERTAINTY TO PUG	INSPECT
Inspect the PUG to ensure that the he method used to derive and validate uncertainties, the characteristics of those uncertainty estimates and advice on how uncertainty estimates are to be used for each product are fully reported.		
Evidence:		**Pass / Fail**

VR-0390-RLY-PROD	USER-DEFINED UNCERTAINTY NEEDS	INSPECT

Inspect the URD to ensure that user requirements for ECV uncertainties have been reported and analysed. [See 3.5 URD **PASS**] Inspect that spatial and temporal error-correlation characteristics of the products are specified and analysed. Inspect that uncertainties difficult or impossible to quantify numerically are considered e.g. related to limitations of sampling, or to retrieval model assumptions.	
Evidence: The URD survey indicates that no single means of communicating uncertainty satisfied all users. Note, however, that the URD proposed a multiple-choice question for users to select which uncertainty methods should be used from the list: • % of explained variance • Confidence intervals • Information about applied adjustments • Probability distribution • RMSD to other data • Random noise plus systematic errors • Separate indicators • Uncertainties of applied adjustments NEITHER specification of spatial and temporal error-correlation NOR difficult / impossible to quantify uncertainty were considered in the URD	**Pass / Fail**

4.2.5 Product Validation (VRF-PROD)

RESPONSIBILITY: Validation Team

VR-0400-VRF-PROD	PRE-DEFINED VALIDATION METRICS	DEMONSTRATE
Demonstrate, by examination of the Product Verification Plan (PVP), that validation metrics and methodology are identified.		
Evidences:		**Pass / Fail**

VR-0410-VRF-PROD	ECV PRODUCT VALIDATION	TEST

The science team to perform a full validation of all sea surface salinity ECV products produced. [TBC] Based on the PVP will enumerate the products, means of validation, and check mark that this has been performed.
Evidence: **Pass / Fail**

VR-0420-VRF-PROD	UNCERTAINTY VALIDATION	TEST
The science team to perform quantification and validation of ECV product uncertainties AND validation of the uncertainty estimates themselves, including assessment of long-term stability of ECV time series. [TBC]. Require the PVP for details of methodology and products considered before can enumerate the verifications required.		
Evidence: **Pass / Fail**		

VR-0430-VRF-PROD	IN SITU FRM DATABASE	INSPECT
Inspect the ISDB to confirm it contains in situ Fiducial Reference Measurements and satellite measurements as defined in the PVP.		
Evidence: **Pass / Fail**		

VR-0440-VRF-PROD	ISDB INCLUDE UNCERTAINTIES	INSPECT
Inspect the ISDB to confirm that it includes all measurements include uncertainty estimates.		
Evidence: **Pass / Fail**		

VR-0450-VRF-PROD	ISDB DOCUMENTATION	INSPECT

Inspect the Technical Report detailing the structure, functionality and operation of the ISDB and its interfaces.	
Evidence:	**Pass / Fail**

VR-0460-VRF-PROD	**ISDB UNCERTAINTIES REPORTED TO PUG**	**INSPECT**
Inspect the PUG for evidence that the methods used to derive and validate ISDB uncertainties and the characteristics of those uncertainty estimates for each product are included.		
Evidence:		**Pass / Fail**

4.2.6 Product Format (INF-FRMT)

RESPONSIBILITY: Validation Team / Engineering Team

VR-0470-INF-FRMT	CCI DATA STANDARDS	INSPECT
Inspect the verification records of the subsequent steps in this section. If all are passed then the DSTD has been fully implemented.		
Evidence:		**Pass / Fail**

VR-0480-INF-FRMT	USE NETCDF-4 (CLASSIC) FORMAT	INSPECT
Inspect that all data products use the netCDF-4 (classic) format.		
Evidence:		**Pass / Fail**

VR-0490-INF-FRMT	USE CF CONVENTION	DEMONSTRATE

Using the CF Checker (GitHub) demonstrate that data products conform to the CF (Climate and Forecasting) convention, in particular the following global variables are required: • title • institution • source • history • Conventions
Evidence: **Pass / Fail**

VR-0500-INF-FRMT	USE ACCD CONVENTION	DEMONSTRATE
Using the CF Checker (GitHub) demonstrate that data products conform to the ACCD convention, in particular the following variables are required: • summary • keywords • id • naming_authority • keywords_vocabulary • cdm_data_type • comment • date_created • creator_name • creator_url • creator_email • project • geospatial_lat_min • geospatial_lat_max • geospatial_lon_min • geospatial_lon_max • time_coverage_start • time coverage_end • time_coverage_duration • time_duration_resolution • standard_name_vocabulary • license		
Evidence: **Pass / Fail**		

VR-0510-INF-FRMT	CCI SPECIFIC METADATA	DEMONSTRATE
Demonstrate that all product files include CCI specific metadata: • platform • sensor • spatial_resolution • key_variables • tracking_id • product_version and for gridded (level 3/4) data on a regular lat/lon grid: • geospatial_lat_units • geospation_lon_units • geospatial_lon_resolution • geospatial_lat_resolution		
Evidence:		**Pass / Fail**

VR-0520-INF-FRMT	MAIN VARIABLES USE CF STANDARD NAMES	DEMONSTRATE
Demonstrate that main product variables are named using CF Standard Names.		
Evidence:		**Pass / Fail**

VR-0530-INF-FRMT	KEY PRIMARY VARIABLES	DEMONSTRATE
Demonstrate that the key primary variables and related ancillary variables (e.g. uncertainty) are identified, and the range of their expected values indicated. NOTE: See SRD **SR-0530-INF-FRMT** for details.		
Evidence:		**Pass / Fail**

VR-0540-INF-FRMT	GRIDDED DATA	DEMONSTRATE

Demonstrate that CCI gridded products have, as a minimum, the following dimensions: time, latitude, longitude (or alternative horizontal grid)	
Evidences:	**Pass / Fail**

VR-0550-INF-FRMT	ADDITIONAL DATA FORMATS	INSPECT
Inspect that all data products provided in other than netCDF format HAVE a netCDF version and comply to latest CCI Data Standards (v2.2)		
Evidence:		**Pass / Fail**

VR-0560-INF-FRMT	INSPIRE METADATA	DEMONSTRATE
Use the INSPIRE validator (webpage) to demonstrate that each dataset contains INSPIRE compliant metadata..		
Evidence:		**Pass / Fail**

VR-0570-INF-FRMT	CCI ONTOLOGY TERMS	DEMONSTRATE
Demonstrate that all netCDF global attributes use terms from the CCI vocabulary tables. See SRD **SR-0570-INF-FRMT**, if terms do not exist, they should be requested.		
Evidence:		**Pass / Fail**

VR-0580-INF-FRMT	DOI Product Identifiers	**INSPECT**
Inspect all publically-available ECV data sets to ensure Digital Object Identifiers (DOI) are assigned.		
Evidence:		**Pass / Fail**

VR-0590-INF-FRMT	DIRECTORY STRUCTURE	INSPECT
Inspect that all output data made available to users is arranged in a directory structure `/<archive root>/<type>/<version>/<time>`		
Evidence:		**Pass / Fail**

VR-0600-INF-FRMT	FILE NAMING CONVENTION	INSPECT
Inspect to confirm that all output data uses the CCI file naming convention: `ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>[-<AdditionalSegregator>]-<IndicativeDate>[<IndicativeTime>]-fv<File version>.nc` Note see SRD **SR-0600-INF-FRMT** for field definitions and note some terms need to be added to the CCI Ontology		
Evidence:		**Pass / Fail**

4.3 Algorithm Development (FUN-PROC)

RESPONSIBILITY: Validation Team

VR-0610-FUN-PROC	DEVELOPMENT OF IMPROVED ALGORITHMS	IGNORE
The requirement that the Contractor **shall** devote significant effort to developing improved algorithms specifically for use in CCI+ Salinity is not S.M.A.R.T and cannot be reasonably verified.		
Evidence:		**N/A**

VR-0620-FUN-PROC	IMPROVE RETRIEVAL ALGORITHMS	DEMONSTRATE

The science team shall demonstrate the new algorithms (ATBDs) developed.	
Evidence:	**Pass / Fail**

VR-0630-FUN-PROC	CALIBRATION & AGING BIASES	ANALYZE
Analyse the treatment of satellite instrument biases with respect to changes in calibration with instrument aging have been included.		
Evidence:		**Pass / Fail**

VR-0640-FUN-PROC	ALGORITHM PERFORMANCE METRICS	ANALYZE
Analyse the set of metrics used when assessing the performance of algorithms.		
Evidence:		**Pass / Fail**

VR-0650-FUN-PROC	PERFORM ROUND-ROBIN INTER-COMPARISON	ANALYZE
Analyse the results from the “round robin” inter-comparison of SSS retrieval algorithms ensuring that a detailed assessment of performance has been performed using metrics defined in **SR-0640-FUN-PROC**. This to include a consistency check of the pre-processing, retrieval algorithm approach, as well as the ancillary data used.		
Evidence:		**Pass / Fail**

VR-0660-FUN-PROC	SELECT DEFINITIVE RETRIEVAL ALGORITHMS	DEMONSTRATE
Demonstrate that the outcome of **SR-0660-FUN-PROC** is the selection of definitive retrieval algorithms to be applied to data from different instruments, based on defined metrics and able to deliver a multi-mission dataset that is as consistent as possible in order to avoid inter-instrument biases within the ECV.		
Evidence:		**Pass / Fail**

VR-0670-FUN-PROC	INVESTIGATE ALTERNATE MEASUREMENTS	DEMONSTRATE
Demonstrate that other measurements (e.g. GNSS, CFOSAT, Sentinels, sun glitter etc.) have been investigated to better meet GCOS requirements for the sea surface salinity ECV.		
Evidence:		**Pass / Fail**

VR-0680-FUN-PROC	USE OF C-BAND RADIOMETERS	DEMONSTRATE
Demonstrate that C-band radiometers have been considered as possible data sources to extend the time series prior to L-band measurements		
Evidence:		**Pass / Fail**

4.4 Software Design & Implementation

RESPONSIBILITY: Engineering Team

NOTE: These requirements in the SRD, and consequently the verification plan, are not very S.M.A.R.T.

VR-0690-DOC-GEN	SYSTEM SPECIFICATION DOCUMENT	INSPECT
Inspect the System Specification Document (SSD) to check it includes: • *Trade-off* criteria and trade-off analysis; • *Engineering methodologies* adopted; • A quantitative justification for *cost-effectiveness* of the system platform, particularly in relation to Cloud facilities; • Security measures preventing malicious access to the system; • A *design walkthrough* describing fully usage of the system; • Conformance to *EU General Data Protection Regulations* (GDPR).		
Evidence:		**Pass / Fail**

VR-0700-DOC-GEN	COMPLIANCE TO ECSS	DEMONSTRATE

Demonstrate the correspondence between the documentation set and applicable software and those required by the applicable Software Standard, *e.g.* appropriate components of ECSS-E-ST-40C. As stated in SRD **SR-0700-DOC-GEN** an examination of ECSS-E-ST-40C in comparison with the document deliverables defined in the SOW did not have a 1-to-1 match.
Evidence: **Pass / Fail**

VR-0710-CON-SOFT	FOSS & COMPONENT RE-USE	INSPECT
Inspect the processing chain identifying FOSS & component re-use, particularly with respect to ECV processing systems.		
Evidence: **Pass / Fail**		

VR-0720-CON-SOFT	OPEN SOURCE SOFTWARE	INSPECT
Inspect that all code is released under the MIT Open Source license, and exceptions are clearly identified.		
Evidence: **Pass / Fail**		

VR-0730-CM-SOFT	SOFTWARE VERSION CONTROL	INSPECT
Inspect the GitHub code repository to ensure all Open Source code is included.		
Evidence: **Pass / Fail**		

VR-0740-CM-SOFT	SYSTEM SUSTAINABILITY	INSPECT
Inspect the system to determine if it contains requirements for sustainability: • configuration control • maintenance (bug tracking, reprocessing, traceability),		

• operability, • transferability.
Evidence: **Pass / Fail**

VR-0750-CON-SOFT	MODULAR & FLEXIBLE DESIGN	INSPECT
Inspect that the system is of a modular and flexible design (significantly that implementation of new algorithms from 'round robin' is easy).		
Evidence: **Pass / Fail**		

VR-0760-CON-SOFT	PROGRAMMING LANGUAGE	INSPECT
SR-0760-CON-SOFT suggests that any the native programming language of standalone processors (e.g. L2 SMOS. L2C SMAP) be used for implementation along with Python. This follows from **SR-0710-CON-SOFT** FOSS and component re-use. Inspect that is the case. NOTE the URD suggests >50% of users want tools written in MATLAB. Userrs may use Python library tools, which are also being implemented at program leve (see CCI Toolbox).		
Evidence: **Pass / Fail**		

4.5 System Infrastructure

RESPONSIBILITY: Engineering Team

NOTE: These requirements, and validations, are not S.M.A.R.T. until the timescale for (re-) processing the entire dataset is known.

VR-0770-PRF-HW	INFRASTRUCTURE SIZING	DEMONSTRATE
The SOW requirement **SR-0770-PRF-HW** is qualitative as stated and practically a duplicate of **SR-0810-PRF-HW.**		

In order to satisfy this verification step the timescale for full dataset operation must be known i.e. whether or not computing resources become a constraint depends on how quickly the dataset needs to be generated. Note: The pass / fail status of this verification step is dependent on: • **SR-0780-PRF-HW** • **SR-0790-PRF-HW** • **SR-0800-PRF-HW**
Evidence: **Pass / Fail**

VR-0780-PRF-HW	PROCESSOR / RAM SIZING	ANALYZE
SR-0780-PRF-HW Preliminary tests showed that the full processing can be performed within 2 months using 600 Cores. when metrics for processing time of all dataset components are available CALCULATE the theoretical CPU/RAM need to process the data within the time frame available for processing in the project schedule. PASS if sufficient CPU / RAM else FAIL.		
Evidence: **Pass / Fail**		

VR-0790-PRF-HW	STORAGE SIZING	ANALYZE
SR-0790-PRF-HW, based DARD, states the lower threshold for storage requirements is 250TB. The SSD includes lists of ancillary data files and intermediary files that are NOT INCLUDED in the DARD. In addition, the DARD output is for 1 complete dataset, and at least 2 are required (since year 1 did not generate a complete dataset). An accurate estimate of storage capacity requires additional analysis.		
Evidence: **Pass / Fail**		

VR-0800-PRF-HW	AUTOMATED HPC PROCESSING CHAIN	INSPECT

Inspect the processing chain used to run automatically, in particular enabling efficient use of the clustered computing environment.	
Evidence:	**Pass / Fail**

SR-0810-PRF-HW	COMPUTING RESOURCE CONSTRAINTS	DEMONSTRATE
The SOW requirement **SR-0810-PRF-HW** is qualitative as stated and practically a duplicate of **SR-0770-PRF-HW.** Similar comments apply: The pass / fail status of this verification step is dependent on: • **SR-0780-PRF-HW** • **SR-0790-PRF-HW** • **SR-0800-PRF-HW** And the processing requirement within the project schedule.		
Evidence:		**Pass / Fail**

5 Verification of Design Walk-through

5.1 Overview

SOW §3.4.4, and the consequent SRD **SR-0690-DOC-GEN** states that the System Specification Document will include a design walk-through. According to ECSS-E-ST-40C [RD02]:

> **3.2.46 walk-through**
>
> static analysis technique in which a designer or programmer leads members of the development team and other interested parties through a software product, and the participants ask questions and make comments about possible errors, violation of development standards, and other problems

No design walk-through has been documented in the SSD and consequently it is not possible to provide a verification.

This section is a placeholder to be completed when a design walk-through has been performed.

Annex A: Verification Matrix

No	ID	CLASS	TITLE	OWNER	STATUS
0010	VR-0010-FUN-GEN	GEN	SSS Observing System	CRG	PASS
0020	VR-0020-FUN-GEN	GEN	Space-based SSS Continuity	CRG	PASS
0030	VR-0030-FUN-GEN	GEN	Develop Retrieval Algorithms	CRG	PASS
0040	VR-0040-FUN-GEN	GEN	Deliver SSS ECV Products	CRG	PASS
0050	VR-0050-FUN-GEN	GEN	Deliver Validated Prototype Products	CRG	PASS
0060	VR-0060-FUN-ACQU	ACQU	Input Data Acquisition	Eng Team	PASS
0070	VR-0070-FUN-ACQU	ACQU	Ancillary Data Acquisition	Eng Team	PASS
0080	VR-0080-FUN-ACQU	ACQU	Auxiliary Data Acquisition	Eng Team	PASS
0090	VR-0090-FUN-PRE	PRE	L1 Data Pre-processing	Eng Team	PASS
0100	VR-0100-FUN-PRE	PRE	Auxiliary Data Pre-processing	Eng Team	PASS
0110	VR-0110-FUN-PRE	PRE	Input Data QC - Logging	Eng Team	PASS
0112	VR-0112-FUN-PRE	PRE	Look-up Table Generator & Tools	Eng Team	PASS
0120	VR-0120-FUN-PROC	PROC	Level 2 Data Processing	Eng Team	PASS
0130	VR-0130-FUN-PROC	PROC	Level 3 Data Processing	Eng Team	PASS
0140	VR-0140-FUN-PROC	PROC	Level 4 Data Processing	Eng Team	PASS
0150	VR-0145-FUN-PROC	PROC	ECV Data Post-processing	CRG / Eng Team	PASS
0160	VR-0150-FUN-DIST	DIST	FTP Data Access Protocol	CRG / Eng Team	PASS
0170	VR-0160-FUN-DIST	DIST	Obs4MIPS Delivery	CRG / Eng Team	PASS
0180	VR-0170-FUN-DIST	DIST	CCI Open Data Portal Delivery	CRG / Eng Team	PASS
0190	VR-0190-FUN-DIST	DIST	Public Availability of ECV Products	CRG / Eng Team	PASS
0200	VR-0200-FUN-PROD	PROD	Global Ocean Coverage	CRG / Eng Team	PASS
0210	VR-0210-FUN-PROD	PROD	Mission Lifetime Coverage	CRG / Eng Team	PASS
0220	VR-0220-FUN-PROD	PROD	Available Product Processing Levels	CRG / Eng Team	PASS
0230	VR-0230-FUN-PROD	PROD	Available Higher-Level Products	CRG / Eng Team	PASS
0240	VR-0240-OPL-PROD	PROD	Product Variables	Valid / Eng Team	PASS
0250	VR-0250-POL-PROD	PROD	Mission Datasets	Valid / Eng Team	PASS
0260	VR-0260-OPL-PROD	PROD	Product Temporal Frequency	Valid / Eng Team	PASS
0270	VR-0279-OPL-PROD	PROD	Product Spatial Resolution	Valid / Eng Team	PASS
0280	VR-0280-OPL-PROD	PROD	Threshold & Goal Values	Valid / Eng Team	PASS

0290	VR-0290-OPL-PROD	PROD	User Resolution, Coverage & Accuracy	Valid / Eng Team	PASS
0300	VR-0300-OPL-PROD	PROD	Dataset Production Schedule	Valid / Eng Team	PASS
0310	VR-0310-QTY-PROD	PROD	Level 4 Error Specification	Valid Team	PASS
0320	VR-0320-QTY-PROD	PROD	Correction of Intra-mission Biases	Valid Team	PASS
0330	VR-0330-QTY-PROD	PROD	Quality Indicators / Flags	Valid Team	PASS
0340	VR-0340-QTY-PROD	PROD	Assessment Long-term Stability	Valid Team	PASS
0350	VR-0350-RLY-PROD	PROD	Product Uncertainty	Valid Team	PASS
0360	VR-0360-RLY-PROD	PROD	ECV Product include Uncertainty	Valid Team	PASS
0370	VR-0370-RLY-PROD	PROD	Define Uncertainty Methodology	Valid Team	PASS
0380	VR-0380-RLY-PROD	PROD	Report Uncertainty to PUG	Valid Team	PASS
0390	VR-0400-VRF-PROD	PROD	Pre-defined Validation Metrics	Valid Team	PASS
0400	VR-0410-VRF-PROD	PROD	ECV Product Validation	Valid Team	PASS
0410	VR-0420-VRF-PROD	PROD	Uncertainty Validation	Valid Team	PASS
0420	VR-0430-VRF-PROD	PROD	In situ FRM Database	Valid Team	PASS
0430	VR-0440-VRF-PROD	PROD	ISDB include Uncertainties	Valid Team	PASS
0440	VR-0450-VRF-PROD	PROD	ISDB Documentation	Valid Team	PASS
0450	VR-0460-VRF-PROD	PROD	ISDB Uncertainties Reported to PUG	Valid Team	PASS
0460	VR-0470-INF-FRMT	FRMT	CCI Data Standards	Valid / Eng Team	PASS
0470	VR-0480-INF-FRMT	FRMT	Use netCDF-4 (Classic) format	Valid / Eng Team	PASS
0480	VR-0490-INF-FRMT	FRMT	Use CF Convention	Valid / Eng Team	PASS
0490	VR-0500-INF-FRMT	FRMT	Use ACCD Convention	Valid / Eng Team	PASS
0500	VR-0510-INF-FRMT	FRMT	CCI Specific Metadata	Valid / Eng Team	PASS
0510	VR-0520-INF-FRMT	FRMT	Main Variables use CF Standard Names	Valid / Eng Team	PASS
0520	VR-0530-INF-FRMT	FRMT	Key Primary Variables	Valid / Eng Team	PASS
0530	VR-0540-INF-FRMT	FRMT	Gridded Data	Valid / Eng Team	PASS
0540	VR-0550-INF-FRMT	FRMT	Additional Data Formats	Valid / Eng Team	PASS
0550	VR-0560-INF-FRMT	FRMT	INSPIRE Metadata	Valid / Eng Team	PASS
0560	VR-0570-INF-FRMT	FRMT	CCI Ontology Terms	Valid / Eng Team	PASS
0570	VR-0580-INF-FRMT	FRMT	DOI Product Identifiers	Valid / Eng Team	PASS
0580	VR-0590-INF-FRMT	FRMT	Directory Structure	Valid / Eng Team	PASS
0590	VR-0600-INF-FRMT	FRMT	File naming Convention	Valid / Eng Team	PASS

0600	VR-0610-FUN-PROC	PROC	Development of Improved Algorithms	Valid Team	PASS
0610	VR-0620-FUN-PROC	PROC	Improve Retrieval Algorithms	Valid Team	PASS
0620	VR-0630-FUN-PROC	PROC	Calibration & Aging Biases	Valid Team	PASS
0630	VR-0640-FUN-PROC	PROC	Algorithm Performance Metrics	Valid Team	PASS
0640	VR-0650-FUN-PROC	PROC	Perform Round-Robin Inter-comparison	Valid Team	PASS
0650	VR-0660-FUN-PROC	PROC	Select Definitive Retrieval Algorithms	Valid Team	PASS
0660	VR-0670-FUN-PROC	PROC	Investigate Alternate Measurements	Valid Team	PASS
0670	VR-0680-FUN-PROC	PROC	Use of C-band Radiometers	Valid Team	N/A
0680	VR-0690-DOC-GEN	GEN	System Specification Document	Eng Team	PASS
0690	VR-0700-DOC-GEN	GEN	Compliance to ECSS	Eng Team	PASS
0700	VR-0710-CON-SOFT	SOFT	FOSS & Component Re-use	Eng Team	PASS
0710	VR-0720-CON-SOFT	SOFT	Open Source Software	Eng Team	PASS
0720	VR-0730-CM-SOFT	SOFT	Software Version Control	Eng Team	PASS
0730	VR-0740-CM-SOFT	SOFT	System Sustainability	Eng Team	PASS
0740	VR-0750-CON-SOFT	SOFT	Modular & Flexible Design	Eng Team	PASS
0750	VR-0760-CON-SOFT	SOFT	Programming Language	Eng Team	PASS
0760	VR-0770-PRF-HW	HW	Infrastructure Sizing	Eng Team	PASS
0770	VR-0780-PRF-HW	HW	Processor / RAM Sizing	Eng Team	PASS
0780	VR-0790-PRF-HW	HW	Storage Sizing	Eng Team	PASS
0790	VR-0800-PRF-HW	HW	Automated HPC Processing Chain	Eng Team	PASS
0800	SR-0810-PRF-HW	HW	Computing Resource Constraints	Eng Team	PASS
					-

Annex B: Example netCDF

netCDF variable example

```
       float variable1(time, lat, lon) ;
                   variable1:long_name = "a_longer_descriptive_name_of variable" ;
                   variable1:standard_name = "CF_standard_name_here" ;
                   variable1:units = "unit from UDUNITS" ;
                   variable1:valid_range = 0f,10f ;
                   variable1:actual_range = 1f,9f ;
                   variable1:anciliary_variables = 'variable1_uncertainty variable1_flag' ;
        float variable1_uncertainty(time, lat, lon) ;
               variable1:long_name = " uncertainty associated with variable1" ;
                   variable1:units = "unit from UDUNITS" ;
           byte variable1_flag(time,lat,lon) ;
                   variable1_flag:long_name = "status flag associated with variable1" ;
                   variable1_flag:standard_name = "status_flag" ;
                   variable1_flag:_FillValue = -128b ;
                   variable1_flag:valid_range = 0b,2b ;
                   variable1_flag:flag_values = 0b,1b,2b ;
                   variable1_flag:flag_meanings = "good_quality problem1 problem2" ;

   //global attributes:
                   :key_variables = "variable1" ;
```

netCDF grid example

```
netcdf CCI_example_grid {
dimensions:
       time = UNLIMITED ;
        lat =  1200 ;
        lon =  1200 ;
        nv = 2 ; //number of vertices (to define the grid boundaries)
variables:
        float lat(lat) ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:bounds = "lat_bnds" ;
        float lon(lon) ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:bounds = "lon_bnds" ;
        double time(time) ;
                time:standard_name = "time" ;
                time:units = "seconds since 1970-01-01 00:00:00 0:00" ;
                time:bounds = "time_bnds" ;
        float lat_bnds(lat,nv)
        float lon_bnds(lon,nv)
        double time_bnds(time,nv)
        float ecv_variable(time, lat, lon) ;
                ecv_variable:long_name = "a_longer_descriptive_name_of_the_variable" ;
```

End of document