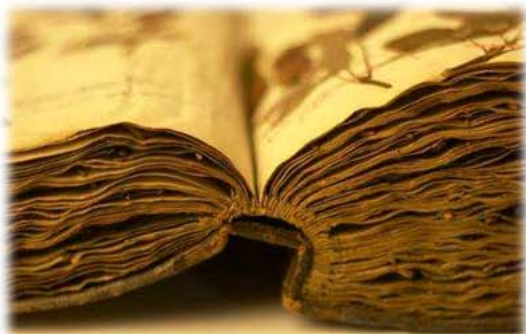


ARGANS, BROCKMANN CONSULT, ARRAY SYSTEM, ACRI-ST and isardSAT Proposal
in answer to ESA ITT ESRIN/11/1-6990/11/I-AM

Sentinel User Handbook and Exploitation Tools



Books



Processing



Wiki



GMES



ARGANS



**BROCKMANN
CONSULT GMBH**



isardSAT®

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Applicable Documents

Ref	Title	Document Code	Version	Date
AD 1	Statement of Work of Sentinel User Handbook and Exploitation Tools	GMES-GSEG-EOPG-SW-11-0058	1.2	07-Oct-11
AD 2	Draft Contract Conditions	Appendix II to ESRIN/AO/1-6990/11/I-AM		04-Nov-11
AD 3	Special Conditions of Tender	Appendix III to ESRIN/AO/1-6990/11/I-AM		04-Nov-11
AD 4	ECSS Software Engineering Standards	ECSS-E-40		
AD 5	ESA Software Product Assurance	ECSS-Q-80C		

Reference Documents

Ref	Title	Document Code	Version	Date
RD 1	RSS Join and Share; RESEARCH & SERVICE SUPPORT	http://wiki.services.eoportal.org/tiki-custom_home.php		Accessed on 01/12/2011
RD 2	GSC Sentinel-2 PDGS Operations Concept Document [OCD]	GMES-GSEG-EOPG-TN-09-0008	2.1	

RD 3	GMES Space Component – Draft Operations Concept	GMES GSC Ops Concept - PB-EO Nov. 2010	1.0	
RD 4	GMES Space Component Data Access Portfolio: Data Warehouse 2011-2014	GSC DAP DWH	2.2	
RD 5	ESA 2011 GMES Space Component Data Access webpage	http://gmesdata.esa.int/web/gsc/home		Accessed on 01/12/2011
RD 6	www.w3schools.com	http://www.w3schools.com/browsers/browsers_display.asp		Accessed on 02/12/2011
RD 7	External Interface Control Document Download Manager	ngEO-14-ICD-EOX-080	1.0	
RD 8	Operation Scenarios	ngEO-13-TN-MFR-055	1.0	
RD 9	ASAR Product Handbook		2.2	2007
RD 10	Sentinel-1 Product Specification	S-1-RS-MDA-52-7441	2.2	2011
RD 11	Sentinel-1 Product Definition	S-1-RS-MDA-52-7440	2.3	2011
RD 12	Sentinel-1 SAR Instrument Calibration and Characterization Plan	S-1-PL-ASDPL-0001	6.0	2010
RD 13	Sentinel-1 SAR Calibration Algorithms	S-1-DD-DLRSY-0002	2.0	2010
RD 14	Sentinel-1 Core PDGS Level-0 Product Format Specification	S-1PD.SP.00110.AST	1.0	2010
RD 15	Sentinel-1 Instrument Technical Description	S-1-DD-ASDPL-0001	5.2	2010
RD 16	SAR Data Decompression for S-1	S-1-TN-ASUPL-0023	5.0	2010
RD 17	ESA SAR products for Interferometry	Nuno Miranda, TerraFirma Presentation		2010

1. EXECUTIVE SUMMARY

1.1. Team Composition and Organisation

The selection of the partners forming the consortium has been motivated by their strong involvement in the Sentinel-1, -2 and -3 programmes and in the Sentinel exploitation tools BEAM and NEST.

As Prime contractor, ARGANS has drawn together a team of recognised companies to ensure the success of the “Sentinel User Handbook and Exploitation Tools” project. The consortium partners will be provided with subcontracts tiered down from the ESA contract provided to ARGANS.

Table 1-1: Company addresses and Project role

Company	Address	Project role
	<p>ARGANS Ltd Atlas Building, Harwell Oxford, Didcot, Oxfordshire, OX11 0QX United Kingdom</p>	<p>Project Manager, Handbook Engineering activities Leader / overall coordinator and Sentinel-2 User Handbook</p>
	<p>Brockmann Consult GmbH (BC) Max-Planck-Strasse 2 21502 Geesthacht Germany</p>	<p>Exploitation tools coordinator and BEAM Leader</p>
	<p>Array Systems Computing Inc. (ARRAY) 1120 Finch Avenue West, Suite 700 M3J 3H7 Toronto, Ontario, Canada</p>	<p>Sentinel-1 User Handbook Leader and NEST Leader</p>
	<p>ACRI-ST 260 route du Pin Montard BP 234 06904 Sophia Antipolis Cedex, France</p>	<p>Sentinel-3 User Handbook Leader for OLCI, SLSTR and SYN</p>
	<p>isardSAT Address Number: 230434 (office) c/ Marie Curie, 8-14 08042 Barcelona, Catalunya</p>	<p>Sentinel-3 User Product Handbook for SRAL L2 products</p>

1.2. Overview of Work Programme and the Approach Taken

The technical proposal is split into the development of the Sentinel User Handbook (hereafter referred to as Handbook) and Exploitation Tools Activity (hereafter referred to as Tools). The Handbook activity (lead by ARGANS) starts first with the Definition Phase (Phase 1) that further refines the approach outlined in technical proposal: Case Studies; User Requirements; Handbook Architecture; GSCDA website analysis. The Development Phase (Phase 2) then starts with Tools development starting 1/3 of the way through the project at T0 + 6 months. The Development Phase

conclusion (Phase 3) is initiated by the Sentinel Stakeholders Consultation Meeting, where the first version of the Tools (BEAM and NEST) is presented and then concludes with the Sentinel User Handbook Acceptance Meeting. The Consolidation and Maintenance Phase (Phase 4) includes the development of the BEAM Sentinel-2 Atmospheric Correction Processor.

1.3. Contents, Layout and Traceability

The contents and layout of the tender is as detailed below:

- ◆ Chapter 1: Executive Summary (this document)
- ◆ Chapter 2: Technical Proposal
 - ◆ Section 1: Understanding of Requirements
 - ◆ Section 2: Study Logic
 - ◆ Section 3: Sentinel User Handbook
 - ◆ Section 4: Sentinel Exploitation Tools
 - ◆ Section 5: Software Product Assurance Programme
 - ◆ Section 6: Technical Risk Register
 - ◆ Section 7: Technical Compliance
- ◆ Chapter 3: Management Proposal
 - ◆ Section 1: Presentation of the Consortium
 - ◆ Section 2: Presentation of the Team
 - ◆ Section 3: Facilities and Resources
 - ◆ Section 4: Project Management Plan
 - ◆ Section 5: Management Compliance
 - ◆ Appendix: CVs
- ◆ Chapter 5: Financial and Contractual Proposal
 - ◆ Section 1: Price
 - ◆ Section 2: Financial Plans
 - ◆ Section 3: Validity
 - ◆ Section 4: Contractual Proposal
 - ◆ Section 5: Financial and Contractual Compliance
 - ◆ Appendix 1: Work Package Descriptions
 - ◆ Appendix 2: PSS forms

As further detailed in the proposal, this proposal is fully compliant with the technical, management and contractual requirements that have been identified; including the Draft Contract provision expressed in the request for proposal. However, some critical paths have been identified and are presented in the next section.

1.4. Major Critical Areas

1.4.1. Management

1. The consortium rapidly starts technical activities after the Kick Off Meeting as the Handbook development has a stringent schedule: the ARGANS staff are permanent employees and so can be mobilised rapidly.
2. There is clear communication with the consortium so that the Handbook reads as a harmonised document and the Tools are linked to the Handbook.

1.4.2. Technical

1. It's critical to organise the elements of the Handbook information in such a way that anyone, depending on their interest, could:
 - a. Find any information related to a given Sentinel mission, at any level (from downstream services to instrument data sheet);
 - b. Discover and understand the potential of GMES and the Sentinel missions;
 - c. Be routed accordingly to his interest and his skills.
2. Critical analysis of GSCDA website to ensure that the Handbook is optimally included for maximum user friendliness and accessibility.
3. The development of the Tools depends strongly on the availability of the "operational" product specifications from the 3 Sentinel missions and access to simulated data products.

1.5. List of the Assumptions

1. The last applicable issue of the technical documents listed in Annex A of the SoW shall be agreed between ESA and the contractor at the Kick Off and will be reviewed before entering the Consolidation and Maintenance Phase.
2. ESA will make available a wiki authoring environment for the development of the Handbook, which includes training and support as well as maintenance of the infrastructure.
3. ESA will provide the Sentinel-2 Atmospheric Correction Processor in source code, which is assumed to be the Python programming language, and executable format.

1.6. List of Acronyms and Abbreviations

The list of abbreviations below is common to technical and management/financial parts of the proposal.

AATSR	Advanced Along-Track Scanning Radiometer
ACP	Atmospheric Correction Processor
AD	Applicable Document
AIL	Action Item List
API	Application Programming Interfaces
ARGANS	Applied Research in Geomatics, Atmosphere, Nature and Space
ATBD	Algorithm Theoretical Baseline Document
ATP	Acceptance Test Plan
BC	Brockmann Consult GmbH
BEAM	Basic Envisat AATSR and MERIS Toolbox
BEAM VISAT	BEAM Visualisation and Analysis Tool
BEST	Basic Envisat SAR Toolbox
CDS	Coordinated Data access System
CDS-CI	CDS Core Infrastructure
CDS-PPE	CDS Post Processing Element
CDS-SCI	CDS Services Coordinated Interface
CDS-SPR	CDS System Performance and Reporting
CF	Climate Format
CFI	Customer Furnished Item
CFS	Canadian Forest Service
CLI	Command-Line Interface
CQC	Coordinated Quality Control
CRAAS	Centralized Routing Authentication and Authorisation Service
CSA	Canadian Space Agency
CCS	Cascading Style Sheet
DAM	Data Access Management
DAP	Data Access Protocol
DAT	Display and Analysis Tool
DDF	Design Definition File
DEM	Digital Elevation Model
DIL	Deliverable Item Status List
DLR	Germany's national research center for aeronautics and space
DND	Canadian Department of National Defence

DPM	Detailed Processing Model document
DWH	Data Warehouse
EC	European Commission
EO	Earth Observation
EOQC	Earth Observation Quality Control
ESA	European Space Agency
ESLs	Expert Support Laboratories
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EW	Extra-Wide Swath
FAQ	Frequently Asked Questions
FBDAQ	Flexible Dynamic Block Adaptive Quantization
FR	Full Resolution
FRP	Fire Radiative Power
GCMs	GMES Contributing Missions
GMES	Global Monitoring for Environment and Security
GML	Geography Markup Language
GPF	Graph Processing Framework
GPM	Generic Product Model
GRD	Ground Range Detected
GSC	Geological Survey of Canada
GSCDA	GMES Space Component Data Access
GSPs	GMES Service Projects
GUI	Graphical User Interface
HH	Horizontal transmit, Horizontal receive SAR polarization
HR	High Resolution
HTML	HyperText Markup Language
HV	Horizontal transmit, Vertical receive SAR polarization
I/O	Input/Output
IDE	Integrated Development Environment
IGC	Instrument Group Coordinator
IODD	Input Output Data Definition Document
ISPRS	International Society for Photogrammetry and Remote Sensing
IW	Interferometric Wideswath
JAI	Java Advanced Imaging
JAR	Java archive file
JPEG	Joint Photographic Experts Group, but commonly used to describe and

	image format
KML	Keyhole Markup Language
KO	Kick Off
KOM	KO Meeting
L1	Level 1
L2	Level 2
L3	Level 3
LST	Land Surface Temperature
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectrometer
MPC	Mission Performance Centres
MPR	Monthly Progress Report
MR	Medium Resolution
MSI	Multi-Spectral imaging Instrument
NEST	Next ESA SAR Toolbox
NetCDF	Network Common Data Form
OLCI	Ocean and Land Colour Instrument
OSW	Ocean SWell spectra
OWI	Ocean WInd field
PDF	Portable Document Format
PDGS	Payload Data Ground Segment
PDU	Product Data Units
PM	Progress Meeting
QC	Quality Control
QWG	Quality Working Group
RSTB	RADARSAT-2 Toolbox
RB	Requirement Baseline
RCP	Rich Client Platform
RD	Reference Document
ROI	Region Of Interest
RSPSoc	Remote Sensing and Photogrammetry Society
RVL	surface Radial VeLocity
S/W	Software
S-1	Sentinel-1
S-2	Sentinel-2
S-3	Sentinel-3

SAFE	Standard Archive Format for Europe
SAR	Synthetic Aperture Radar
SDP	Software Development Plan
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SLC	Single Look Complex
SLSTR	Sea and Land Surface Temperature Radiometer
SM	Stripmap
SME	Small to Medium sized Enterprise
SoW	Statement of Work
SPA	Software Product Assurance
SRAL	Synthetic Aperture Radar Altimeter
SRevP	Software Review Plan
SRR	Software Review Report
SST	Sea Surface Temperature
SUHET	Sentinel User Handbook and Exploitation Tools
SUM	Software User Manual
SVR	Software Validation Report
SWRR	Software Requirements Review
SYN	Level 2 vegetal products derived from SLSTR/OLCI Level 1C synergy
TBC	To Be Confirmed
TBD	To Be Determined
TNs	Technical Notes
TOA	Top Of Atmosphere
TOPSAR	Terrain Observation with Progressive Scans SAR
TS	Technical Specification
UCAR	University Corporation for Atmospheric Research
UML	Unified Modelling Language
URD	User Requirement Document
UTM	Universal Transverse Mercator
VGT	Level 2 continuation of SPOT VEGETATION products
VH	Vertical transmit, Horizontal receive SAR polarization
VV	Vertical transmit, Vertical receive SAR polarization
WAQSS	Water Quality Service System
WBS	Work Breakdown Structure
WGS	World Geodetic System
WP	Work Packages

WPD	Work Package Description
WV	Wave Mode
XML	Extensible Markup Language

1.7. Structure of the Proposal

The structure of our proposal is split into several chapters:

- ◆ The Cover Letter (enclosed separately from this document)
- ◆ Chapter 1 – Executive Summary (this chapter)
- ◆ Chapter 2 – Technical Proposal
- ◆ Appendix – CVs
- ◆ Chapter 3 – Management Proposal
- ◆ Chapter 4 – Financial and Contractual Proposal
- ◆ Appendix – Work Package Description
- ◆ Appendix – PSS forms

2. TECHNICAL PROPOSAL

This chapter corresponds to the technical proposal for the Sentinel User Handbook and Exploitation Tools (SUHET) project.

2.1. Understanding of Requirements

The project is split into 2 separate activities, one concerning the development of the Sentinel user Handbook and the other being devoted to the Sentinel data exploitation tools. These two activities will be conducted in parallel although strong linkages exist.

Sentinel missions will respond to needs expressed by the Global Monitoring for Environment and Security (GMES) European Programme for the establishment of a European capacity for Earth Observation (EO). Each mission comprises several satellites whose development is undertaken by the European Space Agency (ESA). From 2013 onwards, the first 3 satellites will be launched increasing the operational capability of the European Commission (EC) and ESA:

- ◆ **Sentinel-1 (S-1)**: polar-orbiting satellite system for the continuation of Synthetic Aperture Radar (SAR) operational applications;
- ◆ **Sentinel-2 (S-2)**: will routinely deliver high-resolution optical images globally, providing enhanced continuity of SPOT- and Landsat-type data via the Multi-Spectral imaging Instrument (MSI);
- ◆ **Sentinel-3 (S-3)**: to measure sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour with high-end accuracy and reliability in support of ocean forecasting systems, and for environmental and climate monitoring. It hosts 3 sensors that are in-part the continuation of Envisat mission instruments: Ocean and Land Colour Instrument (OLCI); Sea and Land Surface Temperature Radiometer (SLSTR); Synthetic Aperture Radar Altimeter (SRAL). In addition, OLCI & SLSTR data are combined to provide the Level 2 (L2) Synergy (SYN) vegetal products derived from SLSTR/OLCI Level 1c (L1C) synergy and continuation of SPOT VEGETATION (VGT).

The SUHET project is focused on these 3 Sentinel missions with the products listed in Table 2-1 considered to be the core products as given in the Statement of Work (SoW) [AD 1].

Table 2-1: List of Sentinel products

Sentinel-1	Sentinel-2	Sentinel-3
SAR L0		
SAR L1 SLC	MSI L1B	OLCI L1
SAR L1 GRD	MSI L1C	SLSTR L1
SAR L2 OCN		OLCI Water Color L2
		OLCI Land L2
		SLSTR Water L2
		SLSTR Land L2
		SRAL L2
		SYN/VGT L2

Sentinel User Handbook

There are several objectives associated to the Sentinel User Handbook that are summarised hereafter; derived from the SOW [AD 1] and in particular from the requirements that are expressed in [AD 2]. In summary, the objectives are:

- ◆ To give access to the diverse and significant amount of information related to the Sentinel missions and to GMES in an easy and efficient way;
- ◆ To allow users to discover and understand the benefits from their own activities of GMES and Sentinel products or services;
- ◆ To guide users in their navigation of the Handbook, and to help them go from high-level information down to very specific information;
- ◆ To provide users with comprehensive information about the Sentinels, including links to external sites.

From these objectives, a number of important requirements have been derived:

- ◆ The user Handbook will benefit from the flexibility of an IT solution (like a wiki) to facilitate the navigation and the update of the contents, but a more classical “book” will remain a deliverable;
- ◆ Establish case studies for different user categories from which the architecture of the user Handbook will be defined;
- ◆ Links between the GMES services or application fields and delivered Sentinel products.

In the following sections an insight into the approach that will be followed to achieve the Handbook, as well as the identified case studies, is proposed.

Exploitation Tools

The main objective of the Sentinel Exploitation Tools development is to provide users with a means to work with the Sentinel data: to visualise, analyse and process the data. The requested methodology is to extend the existing ESA toolboxes, NEST (for the Sentinel 1 products) and BEAM (for the Sentinel 2 + 3 products), with dedicated reader plug-ins for the Sentinel user products. This way, the majority of the pre-existing features are applicable to the Sentinel products.

In addition to a number of dedicated readers, an atmospheric correction processor for Sentinel 2 L1 data shall be integrated in the BEAM toolbox. This processor is currently being developed by VEGA under contract to ESA and is an implementation of an algorithm developed at DLR. The atmospheric correction processor is presumed to be realised using the Python programming language as mentioned in the SoW [AD 1].

Developing efficient tools for the Sentinel data products is a challenging task in part due to the greatly increased data volumes. Single Sentinel data products are magnitudes larger than their Envisat counterparts, providing much more information including increased spatial and spectral resolution coupled with the provision of per-pixel annotations such as geolocation, sensing time, measurement uncertainties and other quality information.

2.2. Study Logic

The logic of the activities to be completed, derived from the SOW [AD 1], during this project is displayed in Figure 2-1. The main steps of the project are:

- ◆ **Definition of the Handbook** (Phase 1): this Phase includes consolidating and completing the preliminary elements within this proposal and in defining precisely the development in the following Phases of the project; in particular, the case studies will be strengthened as they are seen as the cornerstone of the user Handbook;
- ◆ A **Handbook Working Meeting** will conclude this first short Phase during which a definition of what shall be the Handbook will be decided and agreed by ESA;
- ◆ **Development of the Handbook** (Phase 2): based on documents prepared during the first Phase, the development of the Handbook will start; a progress meeting will provide iteration with ESA in order to take into account any orientation or new element that should be included;
- ◆ **The Stakeholder Consultation Meeting** will present the draft version of the Handbook to ESA and the stakeholders;
- ◆ The **development of the Handbook will be completed during Phase 3** by considering all comments and feedback collected during the Stakeholder Consultation Meeting;
- ◆ Last Phase will be devoted to the **deployment of the Handbook in the GMES Space Component Data Access (GSCDA)** and to the **maintenance of the Handbook**.

Though being presented as separate activities, we consider that there should be links between the development of the Handbook and the activities related to the exploitation tools. Indeed, for the exploitation tool activities, the study logic is as follow:

- ◆ A Progress Meeting which will be the Kick Off (KO) of the **development of the Sentinel data readers** for BEAM and NEST;
- ◆ During the **Stakeholders Consultation Meeting** the readers will be presented;
- ◆ According to the planning of the SoW [AD 1], the **integration of the S-2 Atmospheric Correction Processor (ACP)** will be done later;
- ◆ **Software (S/W) Maintenance activities** are proposed to cover any issue encountered from the delivery of the S/W till the end of the project.

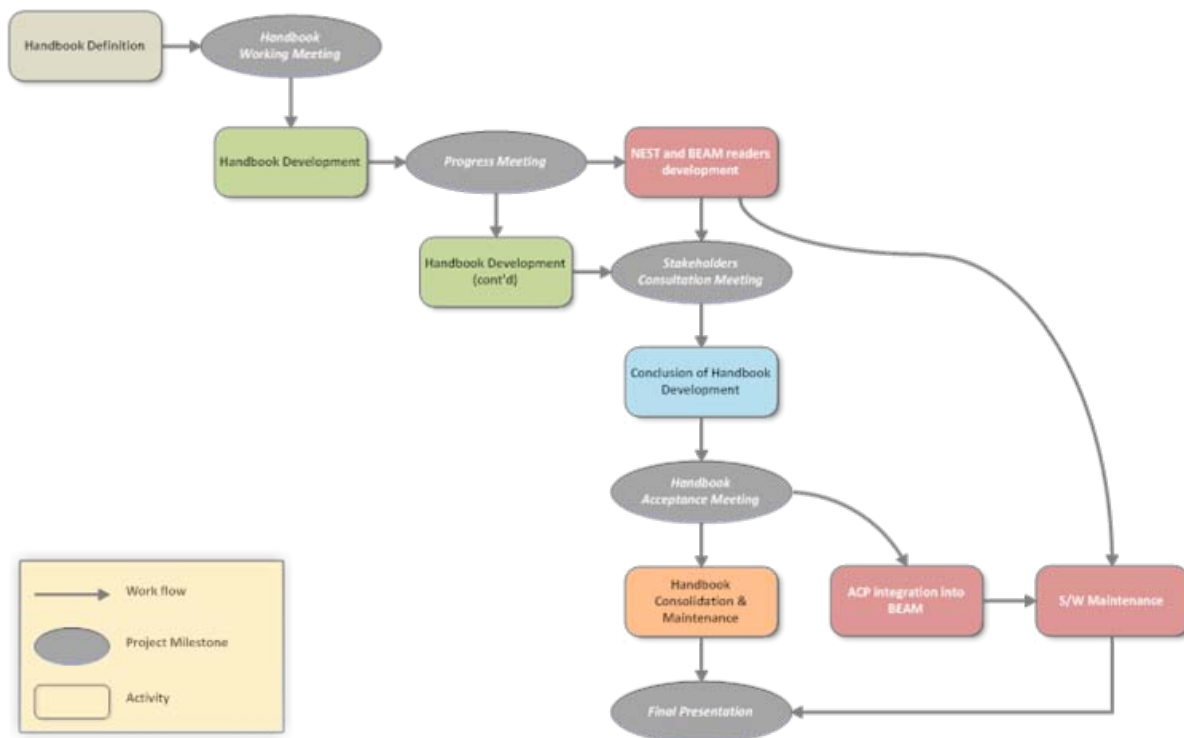


Figure 2-1: SUHET study logic

2.3. Sentinel User Handbook

The consortium offer expertise in the following areas:

- ◆ EO domain expertise required to analyse the case studies;
- ◆ Domain expertise required to refine and prepare the available Sentinel knowledge;
- ◆ Didactics and design expertise to represent that knowledge to our audience;
- ◆ IT expertise to realise the technical solution.

As the lead for the Handbook, ARGANS needs to be able to not only understand the EO / Sentinel knowledge but also be able to convey it to end users through both clear explanation and design. Therefore, the team involved includes an experienced EO scientist (Samantha Lavender), a software engineer/scientist with an experience of working in the GMES domain and designing user interfaces (Stephen Emsley) and a Software Engineer with experience of ESA EO user support (Jan Jackson). Support for the derivation of the user requirements is provided by ARRAY who have extensive SAR expertise.

2.3.1. Case studies

Once the Sentinel missions become operational there will be a large amount of information available, and it's of important for the agency to make these individual pieces of information easily accessible. Tools exist to search for information in a vast ensemble of documents, like search engines which are now largely used by the public, but it's also acknowledged that these search engines are not really adapted to those who do not know exactly what they are looking for. And even for people who know precisely what they are searching for, answers may not be accurate enough or may prevent the refinement of the search until the useful information is eventually obtained.

In the frame of the Sentinel missions, which will provide many different information products and from which many EO-based services will be based from local services to pan-European core services, it's critical to organise the information in such a way that anyone, depending on their interest, could:

- ◆ Find any information related to a given Sentinel mission, at any level (from downstream services to instrument data sheet);
- ◆ Discover and understand the potential of GMES and the Sentinel missions;
- ◆ Be routed accordingly to their interest and skills.

One of the main objectives of the Sentinel User Handbook is to make available and accessible all the available information related to the Sentinel missions and related information, and also to structure it accordingly to the principles stated above. There are actually 3 levels around which the Handbook will be derived:

- ◆ The topics of the Handbook, like chapters of a book;
- ◆ The case studies for each class of user;
- ◆ The different thematic areas, linked to the various services supported by GMES.

These 3 levels can be seen as 3 dimensions on a graph, as shown in Figure 2-2:

- ◆ A user, depending on their profile, will be preferably routed to specific topics;
- ◆ He/she will have the possibility to further explore the Handbook - each topic proposing links to other related topics;
- ◆ The information content will depends on the thematic areas in which the user is more interested.

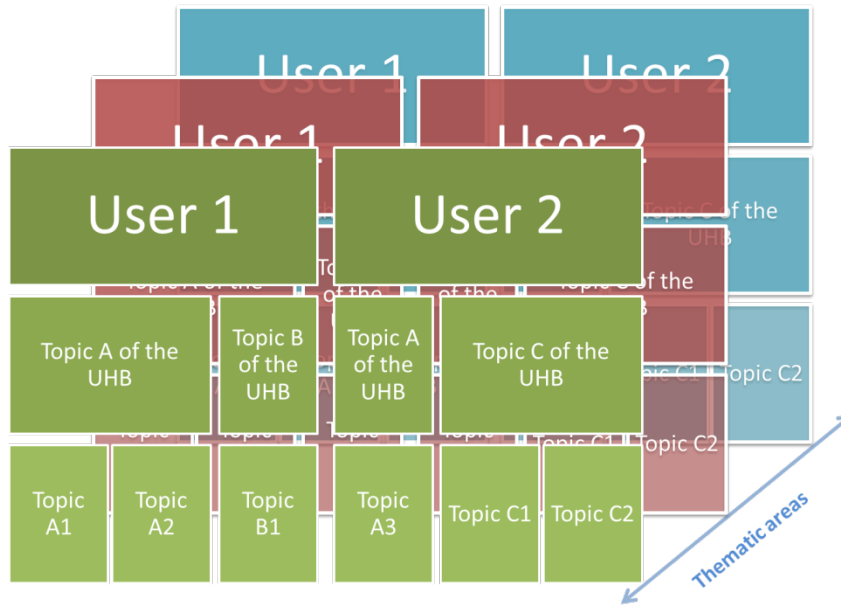


Figure 2-2: Conceptual view of the user Handbook

2.3.1.1. User handbook topics

Several topics have been identified, which are further detailed in Table 2-2. The list will be discussed during the KO Meeting (KOM) and further refined during the definition Phase. The different topics are ranked from the highest- (typically the applications/services layers) to lowest-level of information (typically the detailed information about an instrument).

Table 2-2: List of topics within the User Handbook

Topic	Description	Comments
Overview of the Sentinel Missions	<ul style="list-style-type: none"> General description of GMES and the Sentinel missions Overview of the potential of GMES and the Sentinels in terms of services Overview of the benefits for the users (depending on their "profile") 	<ul style="list-style-type: none"> A special section "What can the Sentinels do for you and how?"
Services based on Sentinel data	Description of available and foreseen services based on Sentinel data	<ul style="list-style-type: none"> Examples of these services will be given e.g. sample products When possible, links onwards toward dedicated portals will be proposed
Description of the mission, spacecraft and instruments	<ul style="list-style-type: none"> For each Sentinel mission (1, 2 and 3) detailed description of the mission, spacecraft and instruments The description will go down to the unit level or even component level where appropriate 	<ul style="list-style-type: none"> Time revisit as well as timeliness of product delivery Photos and diagrams, as well as videos when appropriate

Topic	Description	Comments
Description of instrument performances	<ul style="list-style-type: none"> For the main instruments of each Sentinel mission, a detailed description of the instrument performance 	<ul style="list-style-type: none"> Performance will be specified in terms of both geometric and radiometric attributes
Instrument calibration	<ul style="list-style-type: none"> Detailed description of instrument calibration and on-ground characterization 	
Key technical documents	<ul style="list-style-type: none"> Overview of all key technical documents related to the mission, the instruments and the products Links to all the operational “configuration item” documents 	<ul style="list-style-type: none"> Technical documents where there is no restriction on their distribution e.g. Algorithm Theoretical Baseline Documents (ATBDs) as the scientific description plus Detailed Processing Model documents (DPMs) and Input Output Data Definition Documents (IODDs) to describe the processors
Data access	<ul style="list-style-type: none"> Overview of the data policy (price, licence, ownership etc) Overview of how data will be accessible Appropriate links to service / data providers 	<ul style="list-style-type: none"> Links to GSCDA, EUMETSAT as well as with any service / data providers as agreed by ESA
Exploitation tools	<ul style="list-style-type: none"> Overview of the exploitation tools able to handle and process Sentinel data 	<ul style="list-style-type: none"> BEAM and NEST tools, a focus of this project, will be key but a wider selection will be agreed with ESA
Glossary	<ul style="list-style-type: none"> A glossary of all terms and acronyms 	

2.3.1.2. Typical users

A list of typical users has been established and will be discussed during the KOM; Table 2-3 lists these users and their characterisation. This aim is to cover the spectrum of potential Handbook users and the description shall be carefully assessed during the definition Phase as the architecture will be based on the requirements raised by the different user categories.

Table 2-3: List of typical users

Type of users	Description
Kids and Educators	Typically between 8 and 16 years old, without any specific skills in maths or physics
Students	From 16 years, years including undergraduate and postgraduate students studying at University, with skills in maths and physics
Public	Anyone interested by space activities and eager to discover GMES offer
Policymakers & Institutional users	People or bodies who would use space information to support their mandate or a given policy (e.g. Water Framework Directive, Marine Strategy Directive etc)

Type of users	Description
End-users	Users who receive dedicated information products delivered through a service
Non-European users	This category is closed to the end-users one. It aims at providing these users (e.g. from Africa or Asia) with information about products or services available in their regions.
EO value-added companies	Companies who provide added-value to products routinely delivered, without necessary delivering a service
Core services (Ocean, Land, Risk etc)	European services set up by the EC that will make an extensive use of Sentinel data
Science users	Users who use satellite data for research purpose, usually without any timeliness constraint. Research fields can be on algorithm development or improvement. EO data are also being used as inputs in models developed by the scientific community.
Service Providers	Institute or company that deliver various information products on an operational basis; in particular, they ensure the distribution of these products.
Media	TV, newspaper, magazines, internet etc
Defence	National Departments of Defence or affiliate institutes that will use Sentinel data as a complement of other sources of information (military satellites, ground collection etc)

2.3.1.3. Thematic areas

All thematic areas where GMES provides a support will be addressed in the Handbook. These application fields are:

- ◆ Marine Monitoring;
- ◆ Land Monitoring;
- ◆ Emergency Response;
- ◆ Security;
- ◆ Atmosphere Monitoring;
- ◆ Monitoring of Climate Change.

For each of these thematic areas, the Handbook will include:

- ◆ A short description of the main stakeholders;
- ◆ A description of the response brought by GMES;
- ◆ A description of the usefulness of the Sentinel data to support some or all the stakeholders identified above;
- ◆ A description of the limitations of the Sentinel data and the needs for complementary information, such as airborne data, in-situ measurements and modeling outputs;

- ◆ A list of the existing or planned services deployed in the frame of GMES and links to main actors (e.g. core and downstream service providers).

2.3.1.4. Case study analysis

The Handbook will be structured around users' requirements, these requirements being derived from the typical user's case studies. We have tried to analyse which Handbook topics would interest each category of user. Depending on their interest, the user will be routed so their first contact with the Handbook is customised to meet their expectations. However, it shall be noted that at any moment the user will have the possibility to access any Handbook topic, even if this topic is a priori of low interest for them.

Table 2-4 maps, for each category of users, their foreseen interest:

- ◆ **High interest:** the user is supposed to have a strong interest for this topic which shall thus be proposed to them as they are connected to the Handbook;
- ◆ **Medium interest:** thought weaker, the user has a relatively strong interest in the topic and after exploring the high interest topics, they will be routed to these medium interest topics;
- ◆ **Low interest:** it's expected that this topic will be of low interest for the user, and thus routes to these topics shall not be focused on;
- ◆ **No interest:** we assume that either by very low interest or by lack of skills (e.g. instrument calibration details for non-specialists), the user will not be interested in these topics; if the user wants to explore these topics a route will be provided e.g. Handbook index.

In Table 2-4, when a user is expected to have a high interest for two or more topics one topic is marked in red: this is the assumed most favoured topic which shall be proposed first. Figure 2-3 shows the links between users' interests and the different topics of the Handbook. In order to avoid graphic overload, only links represented with 3 red crosses in Table 2-4 have been displayed.

Table 2-4: “Typical users” case studies

	Overview of the Sentinels	Services based on Sentinel	Core Sentinel products	Missions, spacecraft’s & instruments	Instrument performances	Instrument calibration	Key technical documents	Data access	Exploitation tools
Kids and educators	XXX		X						
Students	XXX	X	X	XX					XX
Public	XXX	XX	X	X					
Policymakers and institutional users	XX	XXX	XX	XX	X			XX	
End-users	XXX	XXX	XX	X				XXX	XX
Non European users	XXX	XXX	XX	X				XXX	XX
EO value-added companies	X	XXX	XXX	XX	XXX	XXX	XXX	XXX	X
EC Core services	X	X	XXX	XX	XXX	XXX	XXX	X	
Science users	X	X	XXX	XX	XXX	XXX	XXX	XXX	XXX
Service Providers	X	XXX	XXX	XXX	XXX	XXX		XXX	
Media	XXX	XX	XXX	X					
Defence	XX		XXX						

XXX: High interest (in red, first topic to display) – XX: Medium interest – X: Low interest

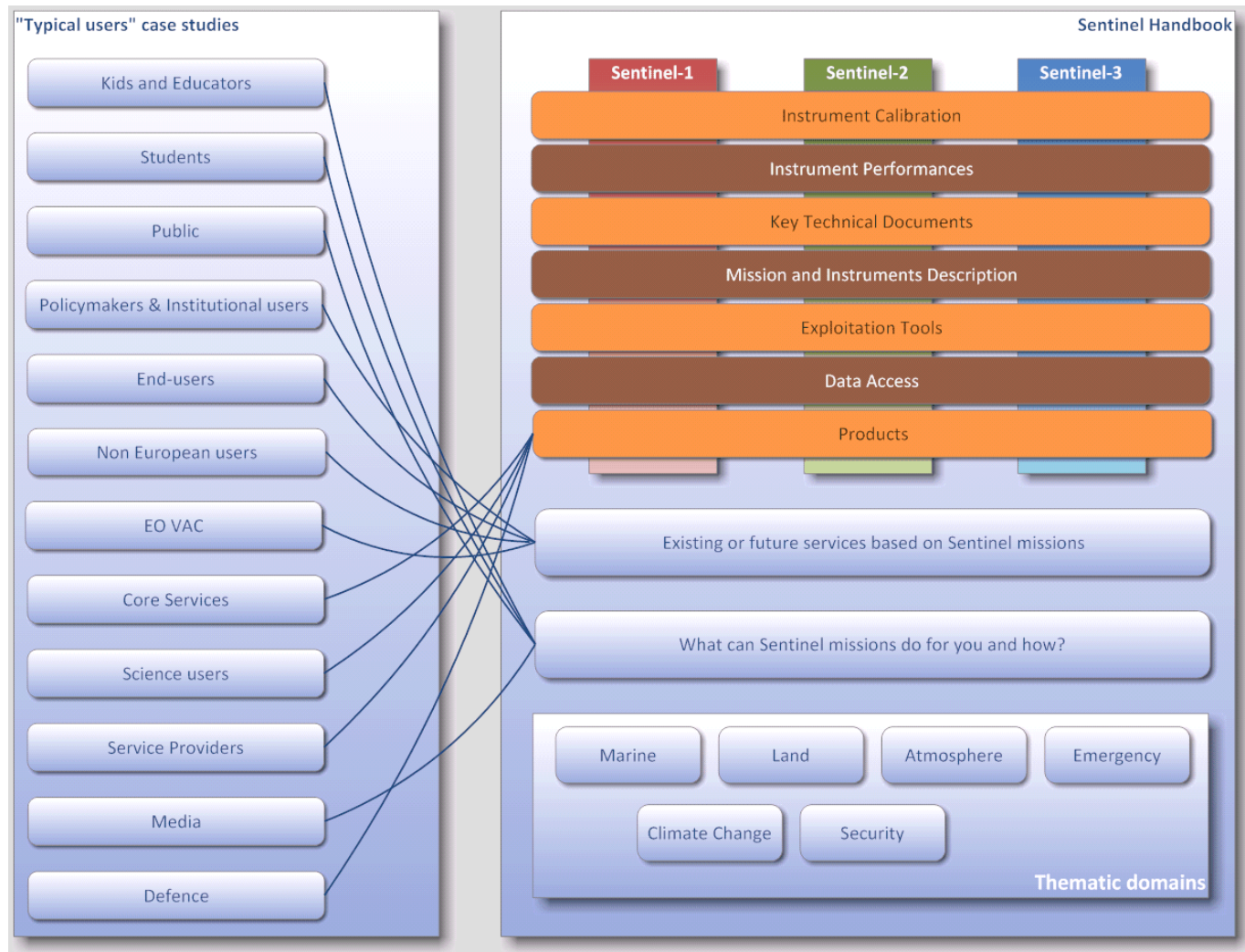


Figure 2-3: User Handbook structure and links with users' interests

2.3.2. Handbook approach

There are many documents detailing the Sentinel missions at all levels: system, spacecraft, instruments, components, products, applications etc. These documents will be used as inputs to populate the contents of the Handbook. One challenge will be to establish links between the different categories of the Handbook, and more particularly between the thematic areas and the Sentinel missions, instruments and products. These links will be used to guide a users' initially interaction and then navigations inside the Handbook.

In the following tables a first iteration of the links between the applications and products delivered by one or more Sentinel instruments has been made, which will allow the user to easily access the relevant and useful information to support the applications of interest. The tables will be revised and consolidated during the Definition Phase.

Marine Monitoring

Applications	Sentinel Mission(s)	Instrument(s)
Impacts of land use and river runoff (agriculture, forestry, mining...)	S-3	OLCI
Impacts of coastal development (tourism, harbour etc)	S-3	OLCI
Global change and regional biogeochemical cycles, Air-sea carbon flux	S-3	OLCI & SLSTR
Conservation of marine ecosystems and biodiversity, Ecosystem model validation	S-3	OLCI & SLSTR
Tourism: Monitoring and maintaining a healthy coastal environment	S-3	OLCI & SLSTR
Wild fisheries (degradation of coastal water quality and loss of habitats through increased nutrient and sediment loads, and coastal development	S-3	OLCI & SLSTR
Maritime operations (visibility, bathymetry, ice, waves, and bottom type can be used to support navigation)	S-1 & S-3	SAR, OLCI & SLSTR
Optimization of seaborne monitoring	S-3	OLCI & SLSTR
Integrated coastal zone management	S-3	OLCI & SLSTR
Aquaculture & shellfish including Harmful Algae Bloom detection	S-3	OLCI & SLSTR
Marine mammal distributions	S-3	OLCI & SLSTR
Fish stock management	S-3	OLCI & SLSTR
Eutrophication monitoring	S-3	OLCI & SLSTR
Bottom topography for shallow waters	S-1	SAR
Monitoring of Arctic sea-ice extent	S-1 & S-3	SAR & OLCI
Marine Climatology and Wave forecasting (inputs about waves, wind, currents, eddies, fronts...)	S-1 & S-3	SAR, OLCI, SLSTR & SRAL
Sea Ice cover edge and thickness	S-1 & S-3	SLSTR, SAR & SRAL

Applications	Sentinel Mission(s)	Instrument(s)
Sea level elevation (global warming)	S-3	SRAL

Land Monitoring

Applications	Sentinel mission(s)	Instrument(s)
Global/regional land cover classification mapping and monitoring (agriculture, environmental applications)	S-1, S-2 & S-3	SAR, MSI, OLCI, SLSTR & SYN
Agriculture and Forestry	S-1, S-2 & S-3	SAR, MSI, OLCI, SLSTR & SYN
Vegetation indices	S-1, S-2 & S-3	SAR, MSI, OLCI, SLSTR & SYN
Hydrology (River/lake mapping, level)	S-1, S-2 & S-3	SAR, MSI, OLCI & SRAL
Elevation models and detection of small surface movements	S-1	SAR
Global Soil moisture monitoring	S-1	SAR
Global scale fire monitoring	S-3	SLSTR

Emergency Response

Applications	Sentinel mission(s)	Instrument(s)
Fire	S-1 & S-2	SAR & MSI
Flood	S-1 & S-2	SAR & MSI
Humanitarian crisis	S-1 & S-2	SAR & MSI
Landslides	S-1 & S-2	SAR & MSI
Storms	S-1 & S-2	SAR & MSI
Earthquakes and Volcanoes	S-1 & S-2	SAR & MSI
Tsunami	S-1 & S-2	SAR & MSI

Security

Applications	Sentinel mission(s)	Instrument(s)
Near real time traffic monitoring of vessel movements	S-1	SAR
Strategic monitoring for anomaly detection and threat characterisation (presence or absence or abnormal speed, heading, size or number of ships)	S-1	SAR
Food security	S-1, S-2 & S-3	SAR, MSI & SYN
Ship Detection	S-1	SAR

Applications	Sentinel mission(s)	Instrument(s)
Illegal or accidental Oil spill detection	S-1	SAR

Atmospheric monitoring

Applications	Sentinel mission(s)	Instrument(s)
Aerosol product is used to study aerosol climatology, sources and sinks of specific aerosol types (e.g. sulphates and biomass-burning aerosol), interaction of aerosols with clouds, and atmospheric corrections of remotely sensed surface reflectance over the land.	S-3	OLCI & SLSTR
Characterization of atmospheric properties (gaseous absorption and aerosol scattering)	S-3	OLCI & SLSTR
Meteorology (Cloud, Water Vapour, Rain, Wind, Cyclones, Hurricanes)	S-3	OLCI, SLSTR & SRAL
Climatology and Meteorology forecasting	S-3	SLSTR & SRAL

Climate Change Monitoring

Applications	Sentinel mission(s)	Instrument(s)
Atmospheric aerosols	S-3	OLCI & SLSTR
Cloud	S-3	OLCI & SLSTR
Fire	S-3	SLSTR
Greenhouse gases	S-3	OLCI & SLSTR
Glaciers	S-2	MSI
Land cover	S-1, S-2 & S-3	SAR, MSI, OLCI, SLSTR & SYN
Ocean colour	S-3	OLCI
Ozone	S-3	OLCI
Sea ice	S-1 & S-3	SAR, SLSTR & SRAL
Sea level	S-3	SRAL
Sea Surface Temperature	S-3	SLSTR

2.3.3. Handbook contents

As previously discussed at the start of Section 2.3.1, the Handbook will have 3 levels as represented within Figure 2-2: topics, like chapters of a book; case studies for each class of user; different thematic areas, linked to the GMES services. These have all been previously outlined in Section 2.3.1 (Case studies) from which the Case Study Report (within WP1100 that occurs during the first 2 months of the study) will be derived. In this section we discuss the role of the consultants in

producing the first Chapter and the role of the consortium in providing the Sentinel specific information for the topics and thematic areas.

2.3.3.1. What can Sentinel do for you and how?

This will be a high-level chapter addressing the benefits that any user could get from GMES and the Sentinel missions. To write this chapter, the consortium will request support from external consultants who will be asked to contribute. The consultant details are not yet defined and will depend on the project start date / consultants' availability. Should they personally have sufficient time, they could write the whole first draft of the chapter in their domain of excellence. As a minimum, the aim is to get their inputs by means such as interviews, teleconferences etc. It shall be noted a budget has been reserved to cover expenses linked to consultants' work; see Section 4.1.6.

We have not proposed a final list of consultants as we expect some support from ESA during the negotiation meeting and KOM; it's foreseen that ESA already have strong links with a number of experts through existing projects / activities who can provide strong links between the Handbook and user exploitation activities. However, we have proposed some experts in Table 2-5; some have been contacted, but due to the Christmas break their definitive answer has not been received.

Table 2-5: Potential list of consultants

Consultant	Institute	Thematic area
David Antoine	International Ocean Colour Coordinating Group (IOCCG)	Marine Monitoring
Peter Minnett	Group for High-Resolution Sea Surface Temperature	Marine Monitoring
Johnny Johannessen	Nansen Environmental and Remote Sensing Center (NERSC)	Marine Monitoring
Etienne Bartholomé	Joint Research Centre (JRC)	Land Monitoring
Marc Leroy	CNES, France	Land Monitoring
José Moreno	Univ. of Valencia, Spain	Land Monitoring
Colm Jacob / Stuart Marsh	British Geological Survey, UK	Emergency Response
TBC	Global Disaster Alert and Coordination System, United Nations	Emergency Response
TBC	European Union Satellite Centre, Spain	Security
Stewart Turner	Met Office, UK	Atmosphere Monitoring
John Remedios / Paul Monks	University of Leicester, UK	Atmosphere Monitoring
TBC	Global Climate Observing System (GCOS)	Monitoring of Climate Change

2.3.3.2. Sentinel -1, -2 and -3 mission components

The consortium has significant experience with partners being involved in both relevant historical missions and projects in preparation for the Sentinel missions. ARGANS takes the lead for the

Handbook and hence the first Chapter where the external consultants will bring their expertise (Section 2.3.3.1). The Sentinel mission specific text is covered by the following partners:

- ◆ S-1 SAR: ARRAY
- ◆ S-2 MSI: ARGANS
- ◆ S-3 Optical (OLCI, SLSTR & SYN): ACRI-ST
- ◆ S-3 SRAL: isardSAT

2.3.4. Technical solution for the wiki

The following assumptions are imposed by ESA:

Wiki Authoring Environment

ESA will provide, as a Customer Furnished Item (CFI), the wiki-authoring environment with constraints imposed upon the 'look and feel'; this is a significant style and design constraint as the 'look and feel' of subsidiary elements of the web site (e.g. header, navigation and footer elements) form the backdrop to the dynamic content i.e. the Handbook. This could be a significant constraint as ESA (with web sites such as Earthnet) impose a rigid and, in 2012, somewhat dated model of web design best practice. The horizontal extent is limited, to be viewable in low-resolution monitors that are no longer the norm but the exception. Essentially the useable tableau for the information, i.e. the Handbook content, is limited to approximately 500 pixels in a central panel of a classic header, 3 columns, and footer design. This is implemented using Hypertext Markup Language (HTML) tables, not Cascading Style Sheet (CSS) <div> elements, which has accessibility issues – particularly for screen readers. With the adoption of Liferay these limitations would be overcome.

The set of documents is listed in Annex A of the SoW [AD 1] which are 'live' meaning that they are not the last applicable issue and will evolve during the development stage. Considering the Sentinel 3 Products & Algorithms documentation as an example, there are potential issues since the documentation is in Word/PDF format, which would require transformation to a markup language for web publishing. As this is technical documentation it includes text, images, tables and equations. Also, it has been produced by many authors, of differing nationalities and, hence, English literacy skills, with varying degrees of harmonisation of template and styles.

Wiki

ESA proposes using a wiki to develop and publish the Sentinel User Handbook. A 'wiki' is defined as a web site developed collaboratively by a community of users, allowing any user to add and edit content. Also, it's a website that allows the creation and editing of interlinked web pages via a web browser using a simplified markup language or WYSIWYG text editor that typically is used collaboratively by multiple users. The defining characteristics of a wiki are not necessarily appropriate when the aim is to create an extensive and coherent document with meaningful navigation and interlinking. These characteristics are:

- ◆ Any registered users can edit any page or create new pages;

- ◆ Linking within pages easily forms topic associations;
- ◆ Rather than a carefully crafted site, a wiki is a dynamically changing landscape.

Therefore, the essence of a wiki is openness and absence of review that fosters an environment in which content changes rapidly and undergoes a selection process in which inappropriate, inaccurate or irrelevant material is culled, edited and replaced. This has led to the concept of 'Darwinism' – the socially Darwinian process to which wiki pages are subject as if they are an ecology of ideas undergoing constant evolution. In essence the Handbook will have a pre-determined architecture, as one output of the Definition Phase is the site map: the page layout (i.e. "look and feel"), navigation and what should appear on each page. This is contrary to the expectation of users of a wiki. An example of an ESA site with wiki editing is the Research and Support Service (rss) Join&Share area, see http://wiki.services.eoportal.org/tiki-view_blog.php?blogId=2 [RD 1]. Once logged in a user can edit community pages, but there is limited evidence of users (other than ESA) doing this.

The only apparent reason to use a wiki for authoring appears to be in facilitating collaborative document generation within this projects' consortium although predominantly it's expected that any particular page is likely to have a single author, it is simply that the entire collection of pages that make up the Handbook will have input from several authors. It's envisaged that the Handbook will only be published, i.e. go 'live', when completed so it could instead be considered that the deliverable is not actually the wiki but a static web site that will, like any other web site, be subject to maintenance updates over varying degrees.

Liferay

The candidate system is the Liferay (<http://www.liferay.com>). Liferay is not, in fact, a wiki although it does include wiki functionality; it does not appear in the comparison of wiki software on Wikipedia (http://en.wikipedia.org/wiki/Comparison_of_wiki_software). Liferay is an open source web platform encompassing a variety of web technologies.

The features offered by Liferay are extensive and include a wiki that, like any other, offers typical functionality:

- ◆ Authors can use a WYSIWYG editor or Creole markup;
- ◆ Version control and revisions are supported alongside track changes;
- ◆ File Attachments can be appended;
- ◆ Comments can be made, and are threaded;
- ◆ Pages can be tagged, and navigated via tags;
- ◆ RSS feeds can be created.

Wiki Creole (Wiki markup language): Creole is a wiki markup language; a system of annotating text to convey information be that typesetting instructions, structural metadata (Extensible Markup Language, XML), or structural markers with presentation semantics (HTML). Unlike XML/HTML it is a

lightweight markup language designed with a simple syntax facilitating web-based publishing that, through wiki implementation, is converted to document markup language (HTML/XHTML) on the server. However, Liferay doesn't allow switching between Creole and HTML and so using HTML would be better as it will allow easier creation of the "book", see Section 2.3.5.

Web Publishing: Rather than as a wiki, using Liferay as a content management system for web publishing appears the predominant Use Case with respect to the Handbook. As stated above, all documentation could be converted into a common markup. A review of existing tools will be undertaken although past experience indicates that none will be satisfactory particularly considering the various word processing software used for document generation (comprising Microsoft Word versions 2003 to 2010 and Open Document Format). In addition, embedded styles are not standardised and localisation issues are common e.g. embedded language specific features and there is no satisfactory way of converting equations (frequently used in technical documents) into web content. Therefore, the two most acceptable methods are converting equations to images or using a MathML capable utility; rely on user interaction rather than being automatic.

Web Portal: Liferay is, first and foremost, a web portal application. A web portal is a site that functions as a point of access of information and presents such information from diverse sources in a unified way. Typical web portals include AOL, Excite and Yahoo! Portals provide a means to provide a standard 'look and feel' with access control for multiple applications, which otherwise would be different entities altogether.

Web portals are the established means of content aggregation technology, although Liferay also includes the newer and more flexible Web 2.0 mashup technology, which enables information from disparate sources to be combined to produce value-added content.

There is nothing in [AD 1] to suggest that content aggregation is a feature that will be used in the published Sentinel Handbook. However, the portal features could be leveraged in order to create a collaborative workspace to facilitate developing the Handbook and Tools. A portal is essentially a presentation layer that allows users and administrators to quickly personalise pages by drag & drop of User Interface elements in order to integrate a variety of systems into a single end user interface.

Other Services: The remainder of the available services, see Table 2-6, are classified into those that would be used by the project versus those that could be made available because of a wider ESA usage. Experience has shown that these features can have resistance to take-up so their use by the envisaged Users would have to be actively encouraged in a sustained way.

Table 2-6: Liferay Services

Service	Usage	General Description
Blogs	Project/ESA: User Announcements	Online commentary, generally maintained by an individual
Message Boards	Project/ESA: User Support	Online threaded discussion, AKA a forum
Knowledge Base	Project/ESA: User Interaction e.g.	Organised, searchable and shared

	Tools and Demonstration Data Sets	information source
Calendar	Wider ESA usage?	Shared events and task lists, exportable to Outlook/iCal
Webmail Client	Wider ESA usage?	Email client enabling sending & receiving
Instant Messaging	Wider ESA usage?	Chat client enabling real time communication
Social Networking	Wider ESA usage?	Activity tracking and status updates
Mashups	Project/ESA: Linkage to content from 3 rd party portals e.g. BEAM and NEST Help pages are already in Liferay and there is also a Google Maps Portlet	Integrating web apps from multiple sources, Web 2.0
Announcements	Project/ESA: User Announcements	Group delivery of alerts etc. via email / SMS

2.3.4.1. Proposed wiki solution

The SoW [AD 1] states that not only is the wiki meant to facilitate authoring, but also the Handbook will be published as a wiki. It's assumed that it will not be openly editable by the users although interactive elements are possible (see Table 2-6). As Liferay is predominately a web portal application then the Sentinel Handbook would actually be within a portal environment, see Figure 2-4.



Figure 2-4: GEO Portal based on Liferay

Source http://www.geoportal.org/web/guest/geo_home?cache_control=0

We would seek early discussions with the ESA Liferay team to ensure that we fully understand the Liferay adoption and hence would functionality is possible within this project e.g. Liferay allows multiple user types to access a unique page view (depending on their group or personal preferences) from a single URL. In addition, both ARRAY and BC have significant experience in developing Liferay sites for ESA e.g. both the BEAM and NEST software sites and the CalVal portal.

At KO there will need to be a defined procedure, or workflow, to ensure document updates are propagated to the web-based documentation, and/or vice versa. Hence, a Content Management System (CMS) needs to be implemented which allows the input projects 'live' documentation to be linked to the Handbook documentation; Liferay Document Library Portlet. Critical content will be converted/generated so that it can be displayed as part of the Handbook while complex external documents will be provided as weblinks to the original documents; see Section 2.3.5.

2.3.5. Technical solution for the "printable" book

The link to the Wikipedia site ([RQT 5] in the SoW [AD 1]) is of limited help as this book creation service is only available to create books from a collection of Wikipedia pages. It also does not impose any linearity upon the Wikipedia articles that are included in the book. There are methodologies that have been used to create books from wikis, but these have received varied reviews. A more reliable method to convert a series of web pages to a book would be to use an HTML converter, such as HTMLDOC that converts HTML to PDF. Of course, the webpages would have to be structured in a linear, chapter-like, order with a consistent naming convention imposing that order to ensure the conversion is consistent with the logical order of the information content.

Another approach would be to approach the problem from another perspective and use a semantic markup language specifically designed for technical documentation. There are two languages that have a long and well-respected history among technical authors: LaTeX and DocBook. Both can be rendered in various formats, including HTML and PDF, and both importantly enable authoring equations and pseudo code etc. They have been the choice of technical authors for many years and are likely the best option for authoring the Sentinel Handbook. Based on a preliminary analysis, the templates could be DocBook XSL Stylesheets with the pages stored in the Liferay Web Content Management portlet.

2.3.6. Deployment in GMES Space Component Data Access (GSCDA)

The Coordinated Data access System (CDS): The GSCDA point of contact for Users who require access to EO products from the GSC is the Services Coordinated Data access System Services Coordinated Interface (CDS-SCI). The SCI is one of a number of functions within the CDS that are available to the GMES Service Projects (GSPs) and GMES Contributing Missions (GCMs). Others include:

- ◆ The Core Infrastructure (CDS-CI): Responsible for the coordination of data distribution with the GSPs, and communicates with the CDS-SCI. It supplies GCM products to the Coordinated Data access System Post Processing Element (CDS-PPE).

- ◆ The System Performance and Reporting (CDS-SPR): Responsible for reporting upon general system performance and product quality. The GCMs provide the CDS-SPR Coordinated Quality Control (CQC) with specialised support about their own data quality anomalies and other issues as they arise. For the Sentinel missions, the Quality Control (QC) and data management functions are the remit of dedicated Mission Performance Centres (MPCs). For S-2, this is in line with the operational context set out in [RD 2].

Between the S-2 Payload Data Ground Segment (PDGS) and the GSCDA/CDS, the general subsidiarity principle defined by the GSCDA versus any GCM will apply, in that any function provided by the S-2 PDGS will not be duplicated in the CDS whenever the function is S-2 specific. Liaison between the Sentinel Missions (as GCMs) and GMES will be the task of the GSC Core Ground Segment [RD 3].

The over-arching remit of the CQC ensures that data from those GCMs that do not host QC structures, practices or offices are – despite the variety of different EO applications – are able to submit Quality Information on common parameters (such as Instantaneous Field-Of-View, Orbital Characteristics etc.). This commonality allows the GSPs to assess the potential of a pool of products to fulfil their requirements in a “one-stop shop”, and to provide a focus for harmonisation in quality control procedures across all GCMs.

Along with the CI and SPR functions, the CDS also includes:

- ◆ The CDS-PPE: Performs “in house” post-processing of products supplied by the GCMs. The CDS-PPE is not accessible to entities outside the CDS.
- ◆ Centralized Routing Authentication and Authorisation Service (CRAAS) that is responsible for the handling of authorisation, access and validation requests from the GSPs.

In addition to the CDS, the other significant component of the GSCDA is the Data Access Management (DAM) that is responsible for enabling data procurement with the GCMs via contracts, managing the functional response of the CDS, and evolution of the Data Access Protocol (DAP).

Data Access Protocol (DAP)

ESA data provision to the GSC is via the DAP, current status of the DAP is outlined in [RD 4], that provides the GMES Services with a “data offer” from GCMs within a fixed period; these products are held in a Data Warehouse (DWH) environment. The “data offer” is not fixed: it’s an evolving document that takes into account issues such as including the changing needs of the GSPs, levels of appropriate funding, and the capability of existing and future EO systems to deliver. The DWH hosts two specific datasets:

- ◆ CORE: these are fixed (generally large) datasets with fixed specifications that fulfil the common requirements of a general user community.
- ◆ ADDITIONAL: these are products that can be requested from a GCM on-demand, and cater for ordering for individual needs (including emergency requirements). ADDITIONAL datasets are handled via bulk agreements with data providers. The size of the financial support of ADDITIONAL data is pre-determined by the EC, with reviews every 6 months.

General overview of the webpage presentation

The point of contact for users wishing to find information on existing GMES services is the GSCDA web portal (<http://gmesdata.esa.int>) [RD 5]. From this page, the user can access a number of webpages, and 'Browse GMES Space Component Data' using a number of criteria. The GSCDA homepage (<http://gmesdata.esa.int/web/gsc/home>) represents the 'front of house' for the user wishing to find about GMES and what it can do for them. However, what the user sees at first glance varies depending on the size of their monitor:

- ◆ 15.6" / 40 cm monitor set to the maximum 1366 x 768 size restricts the view to the top half of the whole page: the 'Browse GMES Space Component Data' section is only just visible, while the Adobe Flash-powered carousel highlighting 'Browse GMES Contributing Missions' is not in sight.
- ◆ 21.5"/55 cm monitor set to the maximum 1920 x 1080 size allows 82% of the page to be visible at a glance; the 'Browse GMES Space Component Data' section is visible, while the Adobe Flash-powered carousel highlighting 'Browse GMES Contributing Missions' is in sight.

In both formats outlined above, the webpage is surrounded by a considerable amount of white space. As the webpages are in the 'default' ESA style a lot of information is presented in the small central strip and it's presumed that this format is a consequence of matching the page boundaries to earlier monitor sizes. Current trends in monitor technology show a move towards increased resolution, see Table 2-7.

Table 2-7: Changes in Screen Resolution of W3Schools Users since the year 2000

Date	Higher	1024x768	800x600	640x480	Other
January 2011	85%	14%	0%	0%	1%
January 2010	76%	20%	1%	0%	3%
January 2009	57%	36%	4%	0%	3%
January 2008	38%	48%	8%	0%	6%
January 2007	26%	54%	14%	0%	6%
January 2006	17%	57%	20%	0%	6%
January 2005	12%	53%	30%	0%	5%
January 2004	10%	47%	37%	1%	5%
January 2003	6%	40%	47%	2%	5%
January 2002	6%	34%	52%	3%	5%
January 2001	5%	29%	55%	6%	5%
January 2000	4%	25%	56%	11%	4%

Note: the 'Higher' rating has a minimum of 1152 x 864 and a maximum of 1920x1200. (Source: <http://www.w3schools.com/default.asp>) [RD 6]

Specific comments about the GSCDA online environment:

- I. On the left-hand side of the webpage a significant amount of information needs to be presented to the User, resulting in the 7 Headings (GSC Data Access, News, GSCDA Terms and Conditions, GMES Services, GSC Mission Groups, GSCDA Data Provision Status and GSC Data Portal) only available via a drop-down menu. When the users are navigating within the Handbook it is foreseen it will be useful to have Handbook specific headings in their own tab in a strip between the page header and the content.
- II. Under the 'GSC Data Access' box the user is directed to a page (http://gmesdata.esa.int/web/gsc/dap_document) that outlines the DAP document. However, the document listed is limited to latest version (2.2), whereas the 'Browse GMES Space Component Data' has a box specifically tailored to 'Browse datasets by DAP Version'. Here the user can search by using either DAP v1 AND DAP v2. Therefore, there needs to be versioning control that allows users to access historical versions of the DAP.
- III. The right-hand side of the GSCDA homepage is given over to the (currently 17 including ESA) 'GMES Space Component Contributors'; these are direct links to the contributors webpages. These links can also be accessed from the summary page via the 'Browse GMES Contributing Missions' carousel on the homepage. As the GSCDA system is the interface for accessing the GMES Space Component EO products it would be helpful if the homepage also informed users about the missions that gather the EO data. Therefore, the space currently occupied by the 'GMES Space Component Contributors' could be instead utilised by the 'GMES Contributing Missions' in list form, which would provide one route to access the Handbook.
- IV. The Adobe Flash-powered carousel highlighting 'Browse GMES Contributing Missions' makes no mention of Sentinels 2 and 3 (only Sentinel 1). There is detailed information (http://www.esa.int/esaEO/SEMTO MASS2G_index_0_m.html) accessible from the 'Observing the Earth' webpage (<http://www.esa.int/esaEO/index.html>) that should be linked to / from the GSCDA homepage; these elements could be linked via the Handbook.

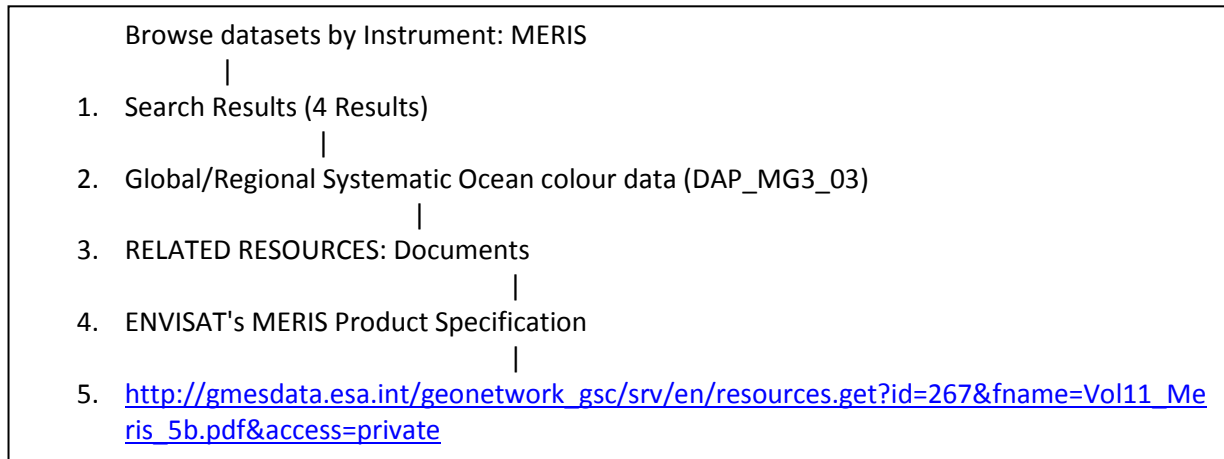
Summary

Items I to IV above could be mitigated by a re-working of the ESA website to supply a more up-to-date interface, which is in line with current technological trends.

The Handbook as described in the SoW [AD 1] specifically asks for a user Handbook that will be available as a wiki webpage, and a printable "book" structure – in a similar manner to that currently possible via Wikipedia <http://en.wikipedia.org/wiki/Special:Book>. ESA already hosts Wiki's for several programmes – including Sentinels4Science (SEN4SCI) [RD 1] – these share the same 'default' ESA style described above, in that they are concentrated in a narrow vertical median strip.

As highlighted previously, the GSCDA webpage [RD 4] is the first page the user sees and so the Handbook wiki should be made available at this point. It's anticipated that as a result of their capability, data products from the Sentinel missions will be required to support a number of Core and Additional DAPs, and so the user will need to access information about the instruments – and

their suitability - **before** drilling down through the 'Browse GMES Space Component Data' layers. In the current scenario, and using the Medium Resolution Imaging Spectrometer (MERIS) Product Specification as an example, the User has to go through five levels before they are able to access the document (and are required to save it to a local destination in PDF form):



If the Sentinel Missions are individually added to the 'GMES Contributing Missions' in list form then relevant Handbook links should be placed alongside them. Furthermore, in addition to being available from the GSCDA webpage, the Handbook should be available to users from the 'More information' area on the Sentinels Overview page (http://www.esa.int/esaLP/SEM097EH1TF_LPgmes_0.html). This page also links through to the GSCDA GSC homepage [RD 4] (this link should open a new tab; not – as currently - a new window).

2.3.7. Activities of each phase

2.3.7.1. Phase 1: Definition Phase

At KO the Case Studies (see Section 2.3.1) will be complemented by ESA inputs to form the backdrop against which the User Requirements will be derived and justified. A preliminary analysis of the Sentinel User Handbook wiki / "book" structure (see Section 2.3.5) is already outlined in this proposal, with project the consortium (ARGANS leading) refining this to form to a detailed specification within the first 2 months. The outputs will first be presented at the 1st Progress Meeting (KO+1 month) and then consolidated at the Sentinel User Handbook Working Meeting (KO+2 months).

2.3.7.2. Phase 2: Development Phase

This Phase produces a mature draft version of the Sentinel User Handbook wiki / "book". Progress is monitored at the 2nd Progress Meeting (KO+5 months) and concluded by the Sentinel Stakeholders Consultation Meeting (KO+8 months) where the "users" will review the Handbook's content and proposed improvements.

2.3.7.3. Phase 3: Conclusion of Development Phase

This Phase takes into account the feedback received from the users during the previous Phase and updates the Sentinel User Handbook wiki / “book” as appropriate with progress reviewed via the 3rd Progress Meeting (KO+10 months). It then concludes with the first issue of the Sentinel User Handbook wiki / “book” being delivered at the Sentinel User Handbook Acceptance Meeting (KO+12 months).

2.3.7.4. Phase 4: Consolidation/Maintenance Phase


During this Phase the Handbook wiki / “book”, exploitation tools and associated demonstration datasets will be updated to account for evolutions within the Sentinel 1,2 and 3 missions; the readers (BEAM and NEST, see Section 2.4) having already started their developments during the Development Phase. This Phase will be reviewed at the 5th Progress Meeting (KO+15 months) and concluded by the Sentinel User Handbook Final Presentation (KO+18 months). In addition, the GSCDA contractor will integrate the Sentinel User Handbook into the ESA GSCDA website (<http://gmesdata.esa.int/>).

2.4. Sentinel Exploitation Tools

2.4.1. BEAM and NEST

In the following sections brief introductions to BEAM and NEST toolboxes are provided. This is then followed by a high-level description of the characteristics of each of the Sentinel product types to be supported. Finally, those features of BEAM and NEST, which are most important and useful for exploiting Sentinel data, are reviewed in the light of the various Sentinel product types. This shall give an indication of the overall complexity and effort of the work to be done.

2.4.1.1. BEAM toolbox

 BEAM is being developed by Brockmann Consult (BC) under contract to ESA. The project started in 2002 with the main objective to enable users exploit the optical data products of the Envisat satellite (BEAM = Basic Envisat AATSR and MERIS Toolbox). Besides Envisat-specific tools, such as the MERIS Smile Correction or the AATSR SST retrieval, a number of sensor neutral tools have been implemented. These more generic BEAM features, for example the band arithmetic or map-projection, as well as the sensor-specific tools all operate on the same internal data structures – the BEAM generic product model. Over the years, this product data model and its associated software Application Programming Interfaces (API) evolved and are now applicable to a wide range of EO data products. New

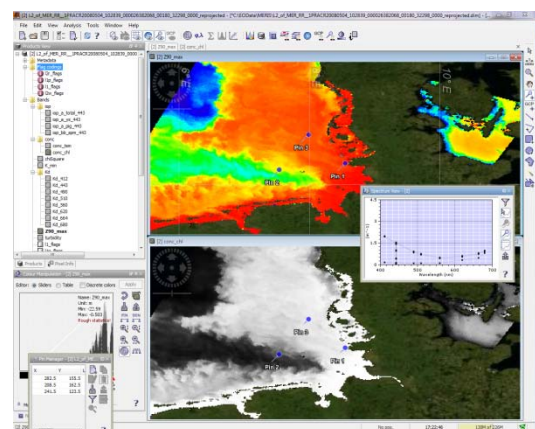


Figure 2-5: BEAM VISAT user interface

sensors and data formats are supported by providing specific reader plug-ins that convert an external data format into a common product data model. New tools are developed as new processor plug-ins. The entirety of this software extension points is referred to as the BEAM development platform. It is today the basis of a number of very efficient EO data applications. Among those, the most prominent application is NEST, a specialisation of BEAM comprising many new readers, processors and Graphical User Interface (GUI) extensions dedicated to the exploitation of SAR data.

BEAM VISAT, the Visualisation and Analysis Tool, provides an intuitive graphical user interface for the visualisation, analysis, manipulation and processing and of earth observation data. Due to VISAT's clear interface design, new users immediately know how to open and browse EO imagery and quickly learn how to operate the more advanced features such as scene collocation or Level 3 (L3) binning. The majority of the tools exposed by VISAT can also be called from the Unix and Windows command-lines in order to perform batch-mode processing invoked via shell scripts.

A major feature of BEAM is the BEAM Development Platform: A number of dedicated Java APIs that have been designed and developed from the beginning to allow third parties to extend BEAM or re-use it in their own applications. The most important extension points provided by the BEAM Development Platform are:

- ◆ Product I/O API – allows to extend BEAM for new data product readers and writers
- ◆ Graph Processing Framework (GPF) API – allows to rapidly develop new data processors (processing “Operators”) and construct processing graphs
- ◆ VISAT RCP – A “rich client platform” used to build efficient EO imaging applications for the desktop, such as BEAM VISAT, NEST DAT, LeoWorks and recently also SeaDAS 7.

2.4.1.2. NEST - next ESA SAR toolbox



In October 2007, ESA awarded Array a contract to develop the Next ESA SAR Toolbox (NEST). ESA required a fully open source toolbox that had the potential to grow in the future through modules implemented by the user community. NEST is a user friendly open source toolbox for reading, post-processing, analysing and visualising the large archive of L1 data from ESA SAR missions including ERS-1 & 2, ENVISAT as well as party missions including JERS-1, ALOS PALSAR, TerraSAR-X, RADARSAT-1 & 2 and Cosmo-Skymed.

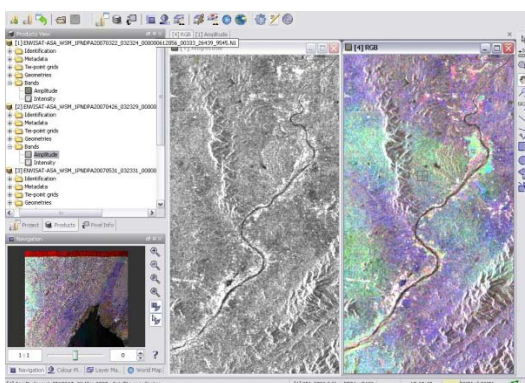


Figure 2-6: NEST DAT user interface

NEST has been built using the BEAM Development Platform and it covers the functionality of the older Basic Envisat SAR Toolbox (BEST).

NEST's Display and Analysis Tool (DAT) is a clear and intuitive user interface for visualizing and analyzing the data and accessing the data manipulation tools available in the toolbox. The DAT is created using the BEAM VISAT RCP and lets the user organize product datasets using projects; allow the management and viewing of multiple products simultaneously.

NEST also provides a flexible GPF reused and enhanced from the BEAM Platform allowing the user to create processing graphs for batch processing and customized processing chains. The Graph Builder allows the user to graphically assemble graphs from a list of available operators and connect operator nodes to their sources. Graphs can then be saved and batched processed from the GUI or from the command line.

NEST offers SAR tools for Calibration, Speckle Filtering, Co-registration, Orthorectification, Mosaicing, Change Detection, Interferometric and Polarimetric processing.

2.4.1.3. Generic product model (GPM)

Both BEAM and NEST use the Generic Product Model (GPM) within BEAM. Data product reader modules know how to ingest all the data of a particular product and transform it into the GPM data structure. The GPM is abstract in order to handle all types of EO data products, without losing any required information. The tools have only one interface to the GPM in order to work with the data. Data product writers are able to take the data from the GPM and produce an external file format. With a GPM, file conversions from one file format to another are easily achieved with the appropriate reader and writer modules. Furthermore, NEST and BEAM modules such as DAT or VISAT, processing tools and future plug-ins are independent of whatever data products are supported or any specific complexities of the file formats¹.

NEST enhances the GPM by adding the Abstracted Metadata. The Abstracted Metadata is an extract of information and parameters from the actual metadata of the product. The readers convert product specific metadata into this common format for all Operators to understand. The Abstracted Metadata is the only metadata that an Operator should use and update.

The memory management of the Toolbox has been designed such that very large data products, exceeding the available memory, can be handled efficiently by the processing and visualization tools. To do so, a tiled approach is used. The dataset is divided into workable areas called tiles. Only the data for tiles being visualized is read in and in some cases the data can be down-sampled to view the desired area at the expense of resolution. Depending on the tool, data is ingested for a tile or a set of tiles, processing is applied only to the current set of tiles, and then the data is written to a file and released from memory. The process is then repeated on a new set of tiled data from the large data product.

This tiling approach is important, if not essential, for working with the large amount of Sentinel data; however, it needs revision due to the new complexity introduced by the Sentinel series of products as described in the following.

¹ The applicability is restricted where a certain processing function requires specific sensor characteristics; e.g. an AATSR SST retrieval will be disabled for products other than AATSR.

2.4.2. Overview of the sentinel user product types

This chapter describes briefly the characteristics of the Sentinel data products to be supported. It shall not be considered complete as some properties of user products may still change. The purpose of the overview is to characterise the product types to be supported in the light of the Sentinel Exploitation Tools and their representation in the BEAM/NEST data models.

2.4.2.1. Sentinel-1 data products

Sentinel-1 will operate in four exclusive acquisition modes: Stripmap (SM), Interferometric Wideswath (IW), Extra-Wide Swath (EW), and Wave Mode (WV)

SM, IW and EW will be acquired at high bit rate and will be available in single (HH or VV) or dual polarization (HH+HV or VV+VH). WV will be acquired at low bit rate and will be single polarization only (HH or VV).

Stripmap Mode: Stripmap mode acquires data with an 80 km swath at 5x5 m spatial resolution. With Stripmap, the ground swath is illuminated with a continuous sequence of pulses while the antenna beam is pointing to a fixed azimuth angle and an approximately fixed off-nadir angle. SM can operate with one of 6 predefined elevation beams, each at a different incidence angle.

Interferometric Wideswath Mode: Interferometric Wide-Swath mode acquires data with a 250 km swath at 5x20 m spatial resolution. The IW mode images 3 sub-swaths using Terrain Observation with Progressive Scans SAR (TOPSAR). With the TOPSAR technique, the beam is electronically steered from backward to forward in the azimuth direction for each burst, avoiding scalloping and resulting in a higher quality image. Bursts are synchronised from pass to pass to ensure the alignment of interferometric pairs.

Extra-Wide Swath Mode: Extra-Wide-Swath mode acquires data with 400 km swath at 20x40 m spatial resolution. The EW mode images 5 sub-swaths using TOPSAR.

Wave Mode: The S-1 Wave mode is similar to ERS and ENVISAT wave mode imaging. Wave mode acquires data in 20x20 km imaggettes at 5x5 m spatial resolution every 100 km along the orbit with alternating incidence angles between near range and far range.

Each mode will produce products at SAR Level 0, Level 1 SLC, Level 1 GRD, and Level 2 OCN.

SAR Level 0: The SAR L0 products consist of the sequence of FDBAQ compressed unfocused SAR data. It includes noise, internal calibration and echo source packets as well as orbit and attitude information.

Level 1 SLC: L1 Single Look Complex (SLC) products consists of focused SAR data geo-referenced using orbit and attitude data from the satellite and provided in zero-Doppler slant-range geometry. The products include the full TX signal bandwidth and uses complex samples preserving the Phase information. Stripmap SLCs contain one image per swath and polarization band. SM contains 1 image

per polarization band. IW, having 3 swaths, has 3 images in single pol and 6 images for dual pol. EW, having 5 swaths, has 5 images for single pol and 10 images for dual pol. Each sub-swath consists of a series of bursts. Each burst has been processed as a separate SLC image.

Level 1 GRD: L1 Ground Range Detected (GRD) products consist of focused SAR data that has been projected to ground range using an Earth ellipsoid model, detected and multilooked. Phase information is lost. GRD products can be in one of three resolutions Full Resolution (FR), High Resolution (HR), or Medium Resolution (MR). L1 GRD products come in MR and HR for IW and EW modes, MR for WV mode and MR, HR and FR or SM mode.

Level 2 OCN: The L2 Ocean products may include Ocean Wind field (OWI), Ocean Swell spectra (OSW) and surface Radial Velocity (RVL) information derived from the SAR data. The OWI is a ground range gridded estimate of the surface wind speed and direction at 10m above the surface derived from the L1 GRD images of SM, IW or EW modes. The OSW is a two-dimensional ocean surface swell spectrum and also includes an estimate of the wind speed and direction per swell spectrum. The OSW is generated from SM and WV modes only. For SM, there are multiple spectras derived from the L1 SLC image. For WV, there is one spectra per vignette. The RVL is a ground range gridded difference between the measured L2 Doppler grid and the L1 calculated geometrical Doppler.

Table 2-8 lists the S-1 data product types that will be supported by the Sentinel Exploitation Tools.

Table 2-8: S-1 products supported by the Sentinel Exploitation Tools

Product Type	Characteristics	Discussion wrt. NEST Integration
SM_RAW_OS	SM, unfocused raw data	S-1 L0 Reader Will need to be decompressed
IW_RAW_OS	IW, unfocused raw data	S-1 L0 Reader Will need to be decompressed
EW_RAW_OS	EW, unfocused raw data	S-1 L0 Reader Will need to be decompressed
WV_RAW_OS	WV, unfocused raw data	S-1 L0 Reader Will need to be decompressed
SM_SLC_1S	SM, Slant-Range, Single Look Complex	S-1 L1 Reader
SM_GRD_1S	SM, Ground Range, Detected	S-1 L1 Reader
IW_SLC_1S	IW, Slant-Range, Single Look Complex	S-1 L1 Reader Will need to be deburst
IW_GRD_1S	IW, Ground Range, Detected	S-1 L1 Reader
EW_SLC_1S	EW, Slant-Range, Single Look Complex	S-1 L1 Reader Will need to be deburst
EW_GRD_1S	EW, Ground Range, Detected	S-1 L1 Reader
WV_SLC_1S	Wave, Slant-Range, Single Look Complex	S-1 L1 Reader
WV_GRD_1S	WV, Ground Range, Detected	S-1 L1 Reader

SM_OCN_2S	SM, Ground Range (OSW, OWI and RVL)	S-1 L2 Reader
IW_OCN_2S	IW, Ground Range (OWI and RVL)	S-1 L2 Reader
EW_OCN_2S	EW, Ground Range (OWI and RVL)	S-1 L2 Reader
WV_OCN_2S	WV, Ground Range (OSW, OWI and RVL)	S-1 L2 Reader

2.4.2.2. Sentinel-2 data products

The S-2 mission will deliver high-resolution optical images, providing an enhanced continuity of SPOT- and Landsat-type data with a focus on the remote sensing of land surfaces. The mission comprises the two satellites Sentinel-2A and -2B. The pair has a 14.3 orbits / day cycle leading to a 5-day revisit time at the equator under same viewing conditions at the equator.

MSI: The S-2 user products originate from the MSI, an optical 13-band push-broom imager. The spectral bands are measured by detectors spanning from the near infra red to the short wave infrared. The MSI detectors provide images at three different spatial resolutions, 10 m, 20 m and 60 m with an overall field of view of 290 km.

User product format: S-2 data products comprise metadata, measurement raster data, vector data and a preview. The physical format will be a directory comprising a number of files and sub-directories. Presumably it will be delivered in a packed form (tar/ZIP).

- ◆ **Metadata:** Metadata comprises the main metadata that describes the overall product structure. Other metadata comprise auxiliary data and pixel level quality indicator data. The main metadata is stored in an XML manifest file conforming to the Standard Archive Format for Europe (SAFE) standard.
- ◆ **Raster data:** The MSI systematically provides imaging “datastrips” with a length of up to 15,000 km by continuous observation. Sentinel 2 Level 1B (also Level 0 and 1A) are provided in the form of elementary **granules**, which are sub-images of a datastrip. A granule covers 23 x 25 km². Due to the MSI complex focal plane, the 13 spectral bands are *not natively co-registered*. This means that, at a given instant, the imaged landscape is not the same for the different spectral band. At Level 1C (and presumably at Level 2A), raster data is binned / regrided into 100 x 100 km² **tiles** using an Universal Transverse Mercator (UTM) projection and the WGS 84 datum. S-2 Level 1B and 1C raster data will be provided in form of compressed JPEG 2000 images.
- ◆ **Vector data** may also be provided with the product (quality masks). These vector data are compliant with ESRI Shapefile or Geography Markup Language (GML) format.
- ◆ A **Preview** of the final product is always available within the product. The Preview of the final product consists of an image limited to 3 visible-bands in ground geometry at 320 m resolution.

Table 2-9 lists the Sentinel 2 data product types that will be supported by the Sentinel Exploitation Tools:

Table 2-9: S-2 products that will be supported by the Sentinel Exploitation Tools

Product Type	Characteristics	Discussion wrt. BEAM Integration
S-2 MSI L1B	<p>Radiometrically-corrected (calibrated) MSI image data with 13 spectral bands coarsely co-registered and refined geometric model appended but not applied.</p> <p>Per detector and along -track on -board scene size: 25 km across-track and 23 km along-track. Number of resulting across track pixels: 2548 (10 m), 1274 (20 m), 426 (60 m).</p> <p>A user product corresponds to a collection of elementary units, also called “granules” and can covers up to 12 detectors x 13 bands of the orbit in full resolution. A sub-set of the 13 bands can be provided. Multiple granules may be aggregated in a single file. The geographical coverage of granules of a detector overlaps in along track direction.</p>	<p>A dedicated S-2 L1B Reader will be developed.</p> <p>The L1B reader will need to deal with the varying spatial resolution resulting in also varying image dimensions contained within a single MSI L1B product.</p> <p>the multiple overlapping granules contained in a MSI L1B product compressed JPEG2000 data format (which is not yet one of the supported binary BEAM data formats)</p>
S-2 MSI L1C	<p>Ortho-rectified and UTM geo-coded Top-of Atmosphere Reflectance with sub-pixel multi spectral and multi-date registration. Raster data is binned / re-gridded into 100 x 100 km² tiles using an UTM projection and the WGS 84 datum.</p> <p>A user product corresponds to a collection of tiles intersecting a requested geographical boundary and can covers up to 13 bands. Tiles overlap at UTM zone boundaries. A sub-set of the 13 bands can be provided.</p>	<p>A dedicated S-2 L1C Reader will be developed.</p> <p>The L1C reader will need to deal with the varying spatial resolution resulting in also varying image dimensions contained within a single MSI L1B product.</p> <p>with the multiple tiles contained in a MSI L1B product compressed JPEG2000 data format (which is not yet one of the supported binary BEAM data formats)</p> <p>The L1B reader will need to deal with the multiple tiles contained in a MSI L1B product.</p>
S-2 MSI L2A	<p>Atmospherically corrected, Bottom-of- Atmosphere reflectance product comprising the 13 spectral MSI bands.</p> <p>The Level-2A is provisionally included in the list as a prototype product and will not be systematically generated. Its generation is planned to be performed on the user side based on the Atmospheric Correction Processor (ACP) either stand-alone or as part of the Sentinel Exploitation Tools (= ACP integrated into BEAM).</p> <p><i>Note: Although support for this format is not requested in the SoW, a reader for it is required as part of the ACP integration into BEAM.</i></p>	<p>A dedicated S-2 L2A Reader will be developed.</p> <p>The L2A Reader will have to deal with the same issues as the L1C Reader.</p>

2.4.2.3. Sentinel-3 data products

The S-3 product suite to be supported within the Sentinel Exploitation Tools are acquired by the OLCI and SLSTR instruments and produced by three processing branches: SLSTR, OLCI and SYN. Both SLSTR and OLCI L2 processing branches produce land and marine products, where coastal zones are contained in both. The swath of OLCI is almost completely contained within the SLSTR nadir swath. The SYN L2 branch produces synergistically retrieved aerosol properties and atmosphere-corrected surface reflectance over land. The Synergy VGT processing produces the VGT Continuity series of products.

SLSTR: In total the SLSTR instrument has eleven channels: 3 thermal infra-red channels at 3.7, 10.8 and 12 micron wavelength (1 km resolution); 2 fire channels at 3.7, and 10.8 micron (1 km resolution); and 6 reflective channels at 0.55, 0.67, 0.87, 1.375, 1.6, and 2.25 micron (500 m resolution). Topography-corrected geo-location information is provided.

OLCI: T an imaging spectrometer providing imagery at 21 spectral bands with a full width swath of about 1265 km. Images are available in full resolution (290 m along-track, about 270 m across-track) and reduced resolution, which provides sampling rates decreased by a factor of 4 in both spatial dimensions. All raster datasets share the same geo-location information, which is provided pixel-wise (topography-corrected) as well as for tie-points (wrt. the WGS 84 ellipsoid).

SYN: include most of the SLSTR and OLCI measurement datasets for the common daylight part of the SLSTR nadir view and OLCI swaths. In addition, so termed misregistration and collocation datasets are included, which provide information on the ground displacement of OLCI and SLSTR acquisitions for all channels relative to a specific OLCI reference channel. A particular derivate is the VGT Continuity series of products.

User product format: Similar to S-1 and S-2, the S-3 products include measurement and annotation datasets. Measurement datasets are provided pixel-wise, annotation datasets are typically provided on regular tie-points grids. The physical format is a directory constituting a number of files and sub-directories. Presumably the data will be disseminated in packed form.

The datasets as well as common metadata are described in an XML manifest file conforming to the SAFE (for L2 and VGT data) specifications and ESA Earth Explorer (for L1 data, will finally be wrapped by SAFE) specifications. Measurement and annotation datasets are stored in NetCDF 4 format using the classic model and metadata conforming to Climate Format (CF) 1.4 convention.

Table 2-10 lists the S-3 data product types that will be supported by the Sentinel Exploitation Tools.

Table 2-10: S-3 products that will be supported by the Sentinel Exploitation Tools

Product Type	Characteristics	Discussion wrt. BEAM Integration
S-3 SLSTR L1B	Top of atmosphere radiances and brightness temperatures (34 measurement datasets in total, 17 measurement datasets per view) from the nadir and oblique views, mapped onto a	A dedicated S-3 SLSTR L1B Reader will be developed. The L1B reader will need to deal with the

Product Type	Characteristics	Discussion wrt. BEAM Integration
	<p>rectangular grid of spatial resolution appropriate to the channel: 1 km for the thermal IR channels, 0.5 km for the reflective channels. Supplemented by a further eight flag and 34 calibration measurement or ancillary datasets, and 20 annotation datasets, providing geo-location and other geometric information.</p> <p>The nadir/oblique view pixel grids have a width of 1490/790 and 2980/1580 pixels for the thermal and the reflective channels, respectively, and a height of up to about 40,000 lines for the thermal, and up to about 80,000 lines for the reflective channels.</p>	<p>varying spatial resolution (0.5 and 1 km) resulting in also varying image dimensions occurring within a single MSI L1C product.</p>
S-3 SLSTR L2	<p>SST, Land Surface Temperature (LST) and Fire Radiative Power (FRP) onto a rectangular grid of a spatial resolution of 1 km (the same as at SLSTR L1B). Geodetic and flag annotation datasets.</p>	<p>A dedicated S-3 SLSTR L1B Reader will be developed based on the basic one BC has already developed within the S-3L2PP project (refer to discussion of SLSTR products in Section 2.4.4).</p>
S-3 OLCI L1B	<p>Top of atmosphere radiances and error estimates for 21 spectral channels, calibrated to geophysical units, geo-referenced onto the Earth surface, spatially re-gridded onto an evenly spaced grid and annotated with Illumination and observation geometry, environment data (meteorological data), and quality and classification flags. The product is provided at full and reduced resolution; FR and RR, respectively. The RR product results from aggregation of FR.</p> <p>The FR grid has a width of 4865 columns and a height of up to about 60,000 lines.</p>	<p>A dedicated S-3 OCLI L1B Reader will be developed based on the basic one BC has already developed within the S-3L2PP project (refer to discussion of OLCI products in Section 2.4.4).</p>
S-3 OLCI L2	<p>Land-colour and ocean-colour products in FR and RR. The product grids are the same as those for OLCI L1C.</p>	<p>A dedicated S-3 OCLI L2 Reader will be developed based on the basic one BC has already developed within the S-3L2PP project (refer to discussion of OLCI products in Section 2.4.4).</p>
S-3 SYN L1C	<p>All OLCI and SLSTR L1B top of atmosphere radiance and brightness temperature measurement datasets in acquisition geometry for the daily part of the orbit and the common swath of OLCI and SLSTR. Besides OLCI and SLSTR L1B annotations, annotated with co-registration information for all OLCI and SLSTR channels with respect to a specific OLCI reference channel.</p> <p>The different product grids reflect the acquisition geometry of the individual instruments. The OLCI measurement datasets have a three-dimensional grid, consisting of 5 camera images, each of which has a width of 740 columns and a height of</p>	<p>A dedicated S-3 OCLI SYN L1C Reader will be developed.</p> <p>The SYN L1C reader will need to merge the separated OLCI camera grids to single, geo-coded images.</p> <p>This reader is not explicitly demanded by the SoW [AD 1], but BC will offer it here, because there is no extra effort in its development due to its structural compatibility with the SYN L2 product</p>

Product Type	Characteristics	Discussion wrt. BEAM Integration
	up to 60,000 lines. The SLSTR the nadir/oblique view measurement datasets consist of images exhibiting 1050/500 columns and a height of up to 17,600 lines for the thermal channels, and 2100/1000 columns and 35,200 lines for the reflective channels. The co-registration information uses the OLCI grid.	type.
S-3 SYN L2	Aerosol properties and surface reflectance and error estimates for all non-absorbing OLCI channels (18 channels in total) and the SLSTR reflective channels for both nadir and oblique views. Selected annotations from OLCI and SLSTR L1B as well as SYN L2 specific flags. The product grid is the same as the SYN L1C OLCI grid	A dedicated S-3 OCLI SYN L1C Reader will be developed. The SYN L1C reader will need to merge the separated OLCI camera grids to single, geo-coded images.
S-3 VGT P	Top of atmosphere reflectance for synthesized SPOT VGT channels (in total 4 channels), status flags, annotated with viewing and illumination geometries, aerosol optical depth, water vapour and ozone columns. The product grid corresponds to an equirectangular map projection (Plate-Carrée) with a pixel size of 1 km and dimensions depending on the size of the selected region.	A dedicated S-3 VGT P Reader will be developed. Although, VGT P products are CF-compliant NetCDF files, which can be already read by BEAM, the dedicated reader will also support read and represent SAFE manifest metadata.
S-3 VGT S	Daily and ten-day maximum NDVI composites of surface reflectance and NDVI annotated with viewing and illumination geometries and the synthesis time. The product grid corresponds to an equirectangular map projection (Plate-Carrée) with a pixel size of 1 km and dimensions depending on the size of the selected region.	A dedicated S-3 VGT S Reader will be developed. Although, VGT S products are CF-compliant NetCDF files, which can be already read by BEAM, the dedicated reader will also support read and represent SAFE manifest metadata.

2.4.3. Software requirements

In this chapter, we list the most important existing NEST and BEAM tools in order to assess their applicability to the Sentinel user product types. This will be followed by some design considerations that provide the software requirements to be addressed in the implementation of the Sentinel Exploitation Tools software.

2.4.3.1. Compatibility with existing NEST tools

After reading in the S-1 products into NEST, some but not all of the processing operators will be available for S-1 products. All operators rely on specific flags in the product metadata to verify that the operator can work on that data. If a product does not pass the input verification step of the operator then the user will be informed.

For L0 products, it will be possible to display the data in an image view and also to view the associated product metadata. Most SAR operations will not be available to Level 0 data products.

For L2 OCN products, the polar graph views used by NEST for visualization of ASAR L2 Wave products will need to be modified to properly handle S-1 OCN products.

Table 2-11: NEST Feature Compatibility

NEST Feature	L0	L1	L2	Comments
Command line processing	✓	✓	✓	Available via the GPT. Note that there are no operators that process L2 products however, if an operator is developed, the GPT would work with the L2 product reader.
Graph Builder	✓	✓	✓	The Graph Builder will allow the use of the S-1 readers without any need for modification.
Batch Processing	✓	✓	✓	Batch Processing will allow the use of the S-1 readers without any need for modification.
Product Library	✓	✓	✓	The Product Library will allow the quick scanning of local Sentinel products and importing of metadata to a database for quick retrieval. Some modification is anticipated to handle all S-1 products and will be implemented as part of this contract.
WorldWind World Map		✓	✓	The WorldWind World Map will show the footprint of all Sentinel products. Some modification will be needed to handle products such as S-1 SLC and will be implemented as part of this contract.
Region of Interest (ROI) Statistics	✓	✓		ROI statistics will work with all raster products including L0, L1 and Wave mode imagettes. However, ROIs are not implemented to work with polar views.
Layer Management		✓		The Layer Manager will work with L1 products without any modification.
RGB View		✓		The RGB View will work with L1 products without any modification.
HSV View		✓		The HSV View will work with L1 products without any modification.
Find CCD Pair		✓		The Find CCD Pairs will work with L1 products without any modification.
ASAR L2 Polar View				Some modifications would be needed to the L2 Polar View to allow it to handle S-1 L2 products.
Module Manager	✓	✓	✓	Modules developed in this contract will work with the module manager without any need for modification.

Table 2-12: NEST Operator Compatibility

NEST Operator	L0	L1	L2	Comments
Calibration				Similar to RADARSAT-2 calibration, S-1 L1 products have four LUTs for converting to σ^0 , β^0 , γ or DN. A Sentinel-1 Calibrator will need to be implemented as part of future development.
Multilook		✓		Multilooking should be possible on L1 products without any modification to the Multilook operator.

NEST Operator	L0	L1	L2	Comments
Terrain Correction		✓		Assuming accurate timings and orbit state vectors from the products, the Range Doppler should work on L1 products without any modification. Radiometric Normalization will not be available as it would depend on the Calibration operator.
SAR Simulation Terrain Correction		✓		SAR Simulation Terrain Correction should work on L1 products without any modification. Radiometric Normalization will not be available as it would depend on the Calibration operator.
Ellipsoid Correction		✓		Ellipsoid Correction should work on L1 products without any modification.
Slant Range to Ground Range		✓		SRGR should work on L1 SLC products without any modification.
ASAR WSS Debursting				The ASAR WSS Deburst is implemented for ASAR WSS products only. A similar S-1 Debursting will be implemented for S-1 within this contract.
Resampling		✓		It will be possible to oversample and undersample L1 products without any modification.
Band Arithmetic	✓	✓		It will be possible to use band arithmetic on L0 and L1 products without any modification.
Image Filtering		✓		It will be possible to image filter L1 products without any modification.
Speckle Filtering		✓		It will be possible to speckle filter L1 products without any modification.
Multi-temporal Speckle Filtering		✓		It will be possible to speckle filter L1 stacks without any modification.
Reprojection		✓		It will be possible to reproject L1 products without any modification.
Image Analysis		✓		It will be possible to analyse L1 products without any modification.
Coregistration		✓		It will be possible to coregister L1 SLC and GRD products without any modification.
Principle Component Analysis		✓		It will be possible to do PCA with a coregistered L1 stack without any modification.
Convert Datatype	✓	✓		It will be possible to convert datatype of products without any modification.
Apply Orbit File				The Apply Orbit File operator is only implemented to update metadata from external orbit files for ERS-1, ERS-2 and ENVISAT.
Subset		✓		It will be possible to create subsets of products without any modification.
Mosaic		✓		It will be possible to mosaic L1 products without any modification.
Coherence Estimation		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.

NEST Operator	L0	L1	L2	Comments
Interferogram Generation		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
Topographic Phase Removal		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
Azimuth/Range Filtering		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
Phase Filtering		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
Phase Unwrapping		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
DEM (Digital Elevation Model) Generation		✓		It will be possible to run interferometric processing on L1 SM however; optimizations will be needed for IW and EW.
Create Elevation		✓		It will be possible to create an elevation band on L1 products without any modification.
Create LandMask		✓		It will be possible to create a land mask on L1 products without any modification.
Oil Spill Detection		✓		It will be possible to run oil spill detection on L1 products without any modification. However, calibrated data will be required.
Ship Detection		✓		It will be possible to run ship detection on L1 products without any modification. However, calibrated data will be required.
Windfield Estimation		✓		It will be possible to run windfield estimation on L1 products without any modification. However, calibrated data will be required.
Polarimetric Tools				Yet to be released polarimetric tools developed for CSA have been developed for Quad Pol data. This includes polarimetric speckle filters, decompositions, supervised and unsupervised classification. Future development would need some modification for the tools to handle Dual Pol data.

2.4.3.2. Compatibility with existing BEAM tools

After reading in the Sentinel-2 and Sentinel-3 products into BEAM, the majority of the tools will be available for these products.

Table 2-13: BEAM VISAT Features

VISAT Feature	MSI	SLSTR	OLCI	SYN	Comments
Spectrum view	✓	✓	✓	✓	Will be subject of performance improvement. The spectrum view requires fast loading of pixels of all bands distributed over multiple (JPEG2000/ NetCDF) files.

VISAT Feature	MSI	SLSTR	OLCI	SYN	Comments
Flag overlay	✓	✓	✓	✓	No change required. Flag overlays are special image layers whose pixel data is generated by evaluation of (Boolean) band arithmetic expressions.
Layer Management	✓	✓	✓	✓	For MSI, we will provide extra layers for the vector data contained in the S-2 user products. OLCI/SLSTR, no modification required.
Mask management	✓	✓	✓	✓	For MSI, we will provide extra layers for the vector data contained in the S-2 user products. OLCI/SLSTR, no modification required.
Pin Management	✓	✓	✓	✓	No change required.
Band Arithmetic	✓	✓	✓	✓	No change required.
Orthorectification		✓	✓	✓	No change required. For MSI, the current DEM used in BEAM is too coarse.
Reprojection	✓	✓	✓	✓	No change required.
Transects	✓	✓	✓	✓	No change required.
ROI Statistics	✓	✓	✓	✓	No change required.
Time series	✓	✓	✓	✓	BEAM 4.10 will be released with in-build time series capabilities (from GlobToolbox project)
Mosaicing	✓	✓	✓	✓	No change required.
RGB View	✓	✓	✓	✓	No change required.
Metadata View	✓	✓	✓	✓	All metadata of all product types will be represented in BEAM GPM and displayed in VISAT.
Attach Pixel-Geocoding		✓	✓		No change required. MSI L1B and SYN will always use Pixel-Geocoding. MSI L1C uses a Map-Geocoding (UTM). SLSTR and OLCI use Tie-point-Geocoding by default.
Product Grabber	✓	✓	✓	✓	No change required. May be optimised by directly using S-1 and S-2 quicklooks instead of generating them.
Module Manager	✓	✓	✓	✓	Applies not to data products but to reader modules, especially reader module updates. All reader modules can be installed via the module manager.

Table 2-14 lists only generic, sensor- and format-neutral BEAM operators.

Table 2-14: BEAM Operators

BEAM Operators	MSI	SLSTR	OLCI	SYN	Comments
Band Maths	✓	✓	✓	✓	No change required.
Collocation	✓	✓	✓	✓	No change required.
Mosaicing	✓	✓	✓	✓	No change required.

BEAM Operators	MSI	SLSTR	OLCI	SYN	Comments
Cluster Analysis (EM, K-Means)	(✓)	✓	✓	✓	Performance / memory problems expected for MSI. For other sensors, no change required.
Pixel Extraction	✓	✓	✓	✓	No change required.
Reprojection	✓	✓	✓	✓	No change required.
Subset	✓	✓	✓	✓	No change required.
Spectral Unmixing	(✓)	✓	✓	✓	Performance / memory problems expected for MSI. For other sensors, no change required.

2.4.3.3. Design considerations for Sentinel products

By providing readers for the various Sentinel data formats, the majority of the existing NEST and BEAM features immediately become usable. However, specific characteristics of the Sentinel products require a number of technical issues to be solved in order to allow users efficient and responsive workflows. These issues mainly originate from some of the characteristics of Sentinel data and make the development of fast readers with a low memory footprint a non-trivial task. In the following, a summary of these issues is given.

Volume: The new Sentinel series of satellites will provide Product Data Units (PDU) that are magnitudes higher than that of former missions. These high data rates are caused by an increased spatial and/or spectral resolution. Additionally many products are accompanied by corresponding error/uncertainty measures. For example an SLSTR L1B full orbit product S-3 is up to 45 GB whereas its counterpart, AATSR L1B of Envisat is “only” 800 MB.

Image dimensions: The high spatial resolution, especially of Sentinel 1 and 2 data, combined with a large coverage results in very large image sizes. For example, a typical S-2 L1C product comprises multiple 100x100 km² tiles in 13 spectral bands each represented by a JPEG2000 image having a size of 10,000 x 10,000 pixels. Even though it is expected that computer memory becomes cheaper in the future, such image buffers cannot be kept in memory, especially when working with multiple images are when looking at different zoom levels. Although BEAM already supports image tiling and provides a tile caching mechanism, the frequent reloading of tiles removed from the cache may cause display performance problems.

Packaging: Sentinel data products are file containers - directories comprising XML headers and binary data files. It is expected, that data is delivered to users in the form of (possibly compressed) file archives (tar, tgz, zip). Visualising and processing more than one band at the same time requires simultaneous reading of image data. When visualising multiple layers of images, especially when considering the image size, I/O bottlenecks with considerable performance drawbacks are expected due to high-frequent tile access. These need to be addressed as well.

Varying product grids: S-2 MSI and S-3 SLSTR L1 products are composed of image files of varying spatial resolution resulting in also varying image dimensions. The current version of the GPM only supports collection of raster images having the same dimension and geo-location. We will either

have to extend the data model so that it supports multiple grids within one product instance (favoured solution, natural to users) or split such inputs into more products (unfavoured, confusing for users).

S-1 TOPSAR Debursting: Sentinel-1 L1 IW and EW SLC products require debursting and mosaicing of subswaths.

Product Granules and Tiles: S-2 L1B products are provided as elementary 23 x 25 km² granules (see description above), overlapping in the along track direction. S-2 L1C and presumably L2A products are provided in a number of 100x100 km² tiles, overlapping at UTM zone borders. As for S-1 data, the rationale for this physical product layout is to have manageable product sizes and to foster parallel processing of a granules / tiles.

Camera separation: The S-3 SYN L2 product follows the convention of the SYN L1C format by keeping the images of the five OLCI cameras in separate datasets. This is not what users expect. We will have to resample the pixels of five camera images on-the-fly to the OLCI L1B grid.

Time coding: Many Sentinel products come with a time value provided for each pixel. The BEAM product model does currently not handle time coding of pixels. We will have to extend the data model by various time coding implementation (per-pixel time, tie-point-based time coding, start time - stop time coding, time range time coding)

Image tiling: We definitely will need to optimize the existing BEAM tile caching strategy (if cache is full, sort tiles by last access time, remove oldest) or develop new ones based on the use case: batch-mode processing or Desktop Application VISAT. (Due to the very large number of pixels to be processed, it may also make sense to offer support of OpenCL / CUDA-enabled devices.)

File containers: Sentinel products are aggregations of files and directories (directory, tgz, tar.bz2, zip). We will generalise the reading of files and image data from such containers so that users don't have to unpack them first.

JPEG2000: S-2 imagery is stored in JPEG2000 format. The support of this format through the Java Image I/O and JAI (these are the libraries that are used in BEAM) lack performance and are buggy. Developing an own, efficient JPEG2000 decoder is an extremely complex task and is clearly out of scope. We will have to directly use the latest version of a dedicated library, e.g. jj2000 (<http://code.google.com/p/jj2000/>). This becomes especially an issue when considering a pure Java implementation of the ACP tool.

BigTIFF: The 32-bit limitations of the GeoTIFF format restrict it to images of a maximum of 4 GB in size. The BigTIFF specification will need to be supported to handle image data larger than 4 GB.

FBDAQ decompression for S-1 L0: The S-1 L0 products are compressed using Flexible Dynamic Block Adaptive Quantization (FBDAQ) and will need to be decompressed. For performance and avoiding the use of intermediary files, it will be best if the S-1 L0 reader handled decompression as the product is read.

Common metadata: We will need a programmatic support (API) for the common set of Sentinel metadata fields. NEST already has uses a common metadata structure. This needs to be adapted to the requirements of the various Sentinel formats and made part of the BEAM product model. There are various concepts and sources for storing metadata for each of the Sentinel products (e.g. SAFE manifest header, GeoTIFF header, CF attributes in a NetCDF file, EarthExplorer fixed and variable header). Furthermore, the harmonization of metadata is a technical issue that would allow many features developed for NEST to be reused within BEAM.

2.4.4. Software design

This chapter provides preliminary design decisions regarding the implementation of the Sentinel readers and the S-2 Atmospheric Correction Processor. Before specific implementation details are discussed, we provide an introduction to the BEAM architecture which also fully applies to NEST.

2.4.4.1. The BEAM architecture

BEAM is developed on top of the Java SE 1.6 platform. It uses several popular and established 3rd party Java libraries such as JIDE, JFreeChart, XStream, Java Advanced Imaging (JAI) and also GeoTools, bringing GIS functionality into BEAM. The BEAM high level architecture comprises a hierarchy of *modules*, the building blocks of BEAM. Figure 2-7 shows some of the BEAM system modules (yellow and red) and a selection of application modules such as the desktop application VISAT or specific image analysis tools and data processors (grey).

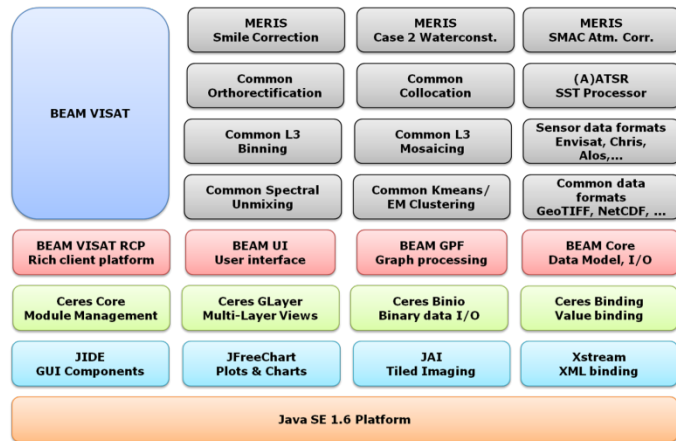


Figure 2-7: BEAM high level architecture

Extendibility was one of the most important requirements to be taken into account while designing the foundation architecture for BEAM. The first version of BEAM already offered the possibility to extend it by new reader and writer plug-ins for specific remote sensing file types and formats. The number of possible BEAM extension points quickly grew and hereby the level of abstraction and generality of the BEAM core libraries greatly increased. One of its most important is the abstraction of remote sensing products from their external file format. Product readers create instances of the aforementioned GPM. Once the data model is instantiated in memory, various higher-level BEAM APIs and frameworks can use it for data processing, analysis and visualisation.

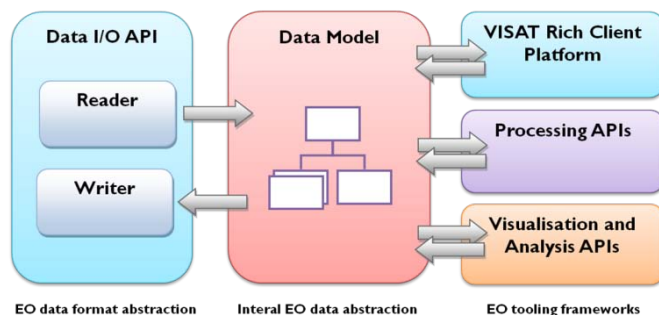


Figure 2-8: Generic Product Model

BEAM's modular architecture is not only logical but also physical. A BEAM module is a Java archive file (JAR) that is plugged into an existing BEAM installation directory. It comprises compiled Java code and a module descriptor, which is providing module metadata including dependencies to other modules and extension points and extensions:

- ◆ Any module can provide extension points, e.g. the host module "beam-core" provides (amongst others) the extension point "productReaders" symbolized as a socket in Figure 2-9. Extension points can be executable code or configuration.
- ◆ A client module can extend the functionality by providing an extension (service interface) to an existing extension point, e.g. "S3Olcil1bReader" symbolised as a lolly in Figure 2-9.
- ◆ Any module can provide both, extensions and extension points.

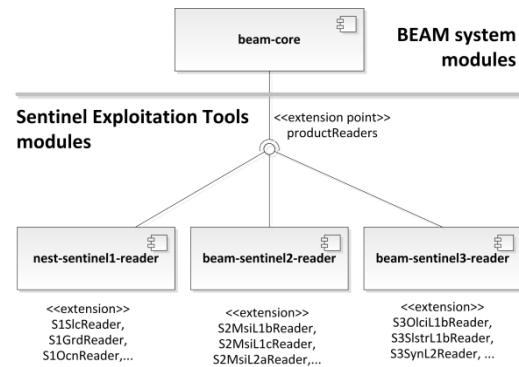


Figure 2-9: Extension points and extensions

BEAM modules are managed by the BEAM runtime system Ceres, an open source project managed by BC. When a BEAM application (such as VISAT) is launched, Ceres runtime searches for modules at dedicated locations, loads all module descriptors, resolves module dependencies and finally activates each resolved module by taking into account a certain order determined by the dependency hierarchy. If the application shuts down, the modules are deactivated in the reverse order they've been activated. In order to allow for customized one-time module start-up (and shutdown), modules may also contain a user provided Activator object providing the two methods *start()* and *stop()*. The major usage for activators is parsing configurations of other dependent module's extensions to an extension point the module offers.

Figure 2-10 shows the *BEAM development platform* comprising - a set of Ceres and BEAM system modules that offer a number of core libraries, APIs and extension points. Basic extension points provided by the Ceres system modules are:

- ◆ Applications that run on the Ceres module runtime, for example the BEAM VISAT or NEST DAT desktop applications (module ceres-core);
- ◆ Visible layer types that render any kind of vector or raster data to a graphics context (module ceres-glayer).

Basic extension points of the BEAM system modules are:

- ◆ Readers and writers for EO data formats (module beam-core);
- ◆ Operators for implementation of EO data processors and image analysis (module beam-gpf);
- ◆ Map projections and digital elevation models (module beam-core);
- ◆ GIS layer sources for GIS interoperability and suitable layer editors(module beam-ui);

- ◆ Tools, action commands, tool windows, tool bars (module beam-ui);
- ◆ "Rich client" imaging applications (module beam-visat-rcp).

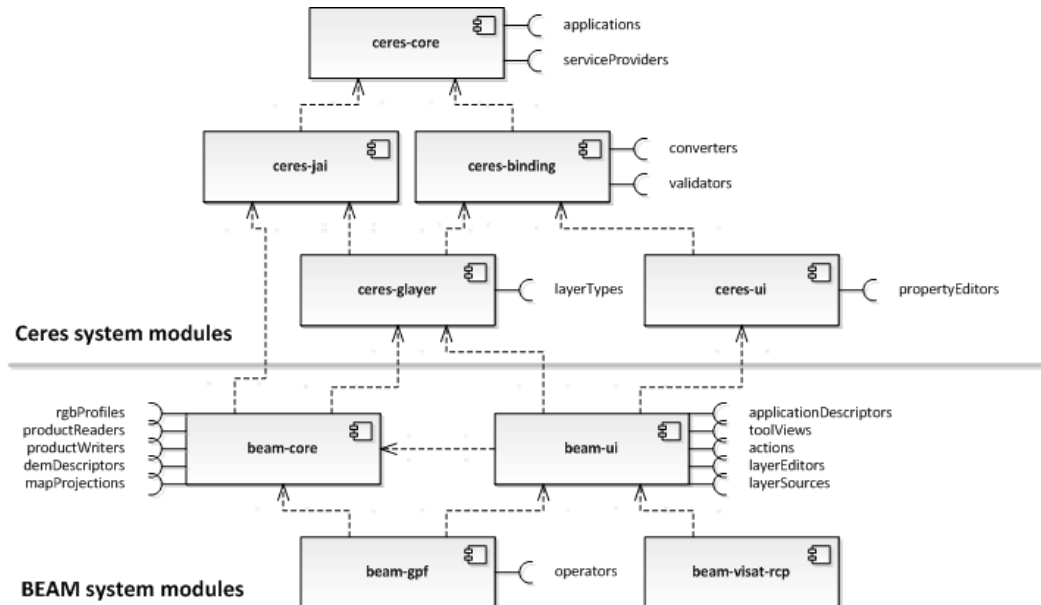


Figure 2-10: BEAM development platform

At the same time, BEAM also provides a rich set of modules that provide ready-to-use extensions to the extension points listed above. The BEAM desktop application VISAT is in fact an extension to many of the core modules offering a variety of views, tools, tool windows and actions. Figure 2-11 is a screenshot of the module manager in VISAT. It lets a user inspect installed modules and also download and install new modules.

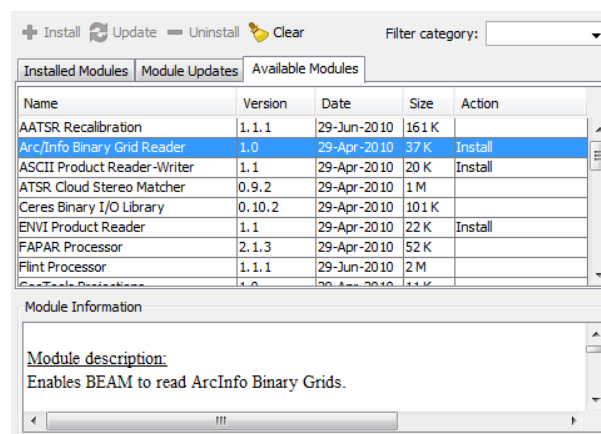


Figure 2-11: BEAM module manager user interface

2.4.4.2. BEAM/NEST product readers

Product readers within BEAM and NEST are developed as Java plug-in modules. A Read operator calls all available reader modules to examine an input product and automatically determine which reader

will best support that input product. If there isn't a product reader available for reading the data, the user will be informed.

When opening a data product, the BEAM/NEST is able to inspect and display information about the data without actually reading in the full dataset. Information such as metadata and geographical extent will be displayed. The user is also able to select which measurement datasets are read in entirely or specify a user-defined region of interest to be read in. Multiple data products may be opened into the at once.

Measurement datasets (raster data) are read as needed based on the tile dimensions requested by the graph operators. This ensures a manageable memory footprint when processing very large products that cannot fit entirely in memory.

Products read in can be exported to several file formats including the internal BEAM-DIMAP format. All readers can be used equally from the GUI or from the command-line processor.

The UML class diagram below shows the relationship between the various components of the BEAM generic product model, comprising a representation of the product itself as well as the abstractions it uses, namely the reader, writer, the bands and tie-point grids and a geo-coding.

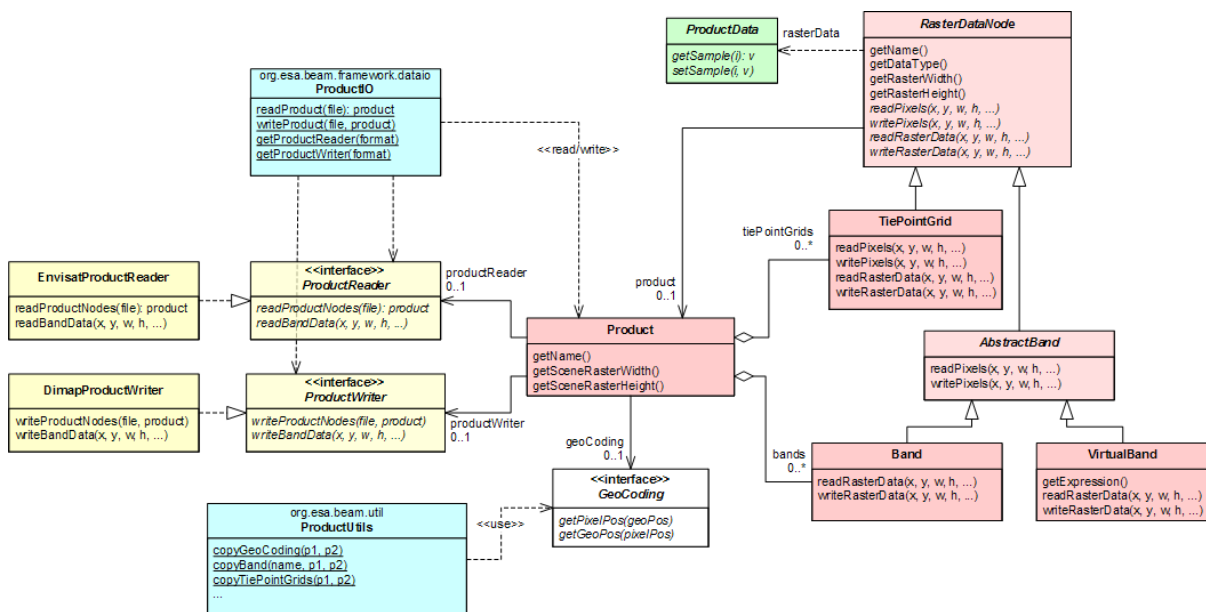


Figure 2-12: Simplified UML class diagram of the BEAM generic product model

The readers for each Sentinel mission will be developed in its own modules. As such, the Sentinel readers can be optionally installed and uninstalled using the Module Manager. The readers will also be included by default within a new install of the complete toolboxes.

2.4.4.3. Sentinel product configuration database

Today the BEAM API allows a developer of a product reader to programmatically (=hard-coded into the reader source code) add product type specific configurations and customisations to a data

product instance in memory. For example, the Envisat reader adds to MERIS and AATSR products a comprehensive list of sensor-specific flag mask definitions and also adds type specific RGB profiles. Other readers programmatically define default colour bars and value ranges for specific geo-physical variables. Although users can later on change these configurations by specific tools, they have to change it again and again for each product instance opened in DAT or VISAT, e.g. by using the Colour Manipulation tool or the Mask definition tool.

We propose to develop a common Sentinel Product Configurations Database to be used for all Sentinel product types. Instead of coding into each reader which sensor-specific configurations to add, a reader simply asks the database to configure the product instance, i.e. which customisations to add to each product instance. Based on the sensor and the processing level, the database provides for each product type:

- ◆ definitions of the (flag) overlay and ROI masks;
- ◆ definition of colour bars and value ranges for S-1 InSAR interferograms and S-2/S-3 geo-physical products;
- ◆ definitions of extra layers for the layer manager in DAT / VISAT;
- ◆ definitions of RGB/HSV profiles;
- ◆ definitions of product reader parameters.

The configuration database will provide default, read-only values for all of its entries. But users will also be able to modify the configuration database's contents via the BEAM / NEST user preferences dialog or by directly modifying the user preferences store (a plain text, key-value file). For example, the reader parameter settings given in the mock-up screen shots above will be stored as default values for the next time the dialog is displayed.

The automatic configuration of products using the configuration database increases the testability of readers and will save development time compared to a programmatic product configuration.

2.4.4.4. SAFE format

Most of the Sentinel data products are based on the SAFE format specification, which has been designed to act as a common format for archiving and conveying data within ESA EO archiving facilities. SAFE has been recommended for the harmonization of the GMES missions by the GMES Product Harmonization Study. Although there exists the XFDU Java API for creating wrappers to be able to read any binary format within the SAFE specification, preliminary study into its feasibility of use indicate performance will be poor. We believe reading the binary formats directly in GeoTIFF and NetCDF will be a better solution in terms of performance.

A Sentinel product refers to a directory folder that contains a collection of information. It includes a "manifest.safe" file which holds the general product information in XML, and can include several subfolders for measurement datasets containing image data in various binary formats, a preview folder containing quicklooks in PNG, Google Earth overlays in Keyhole Markup Language (KML) and

HTML previews, an annotation folder containing the metadata in XML as well as calibration data and a support folder containing the XML schemes describing the product XML.

It is expected that Sentinel products will be distributed in form of manageable file archives each representing a packaged and possibly compressed SAFE directory. Typical archive formats are tar, tar.gz and zip.

Figure 2-13 shows an example of the SAFE file structure for a dual pol S-1 product. For other missions and products the content and folders may be different but the overall structure is the same.

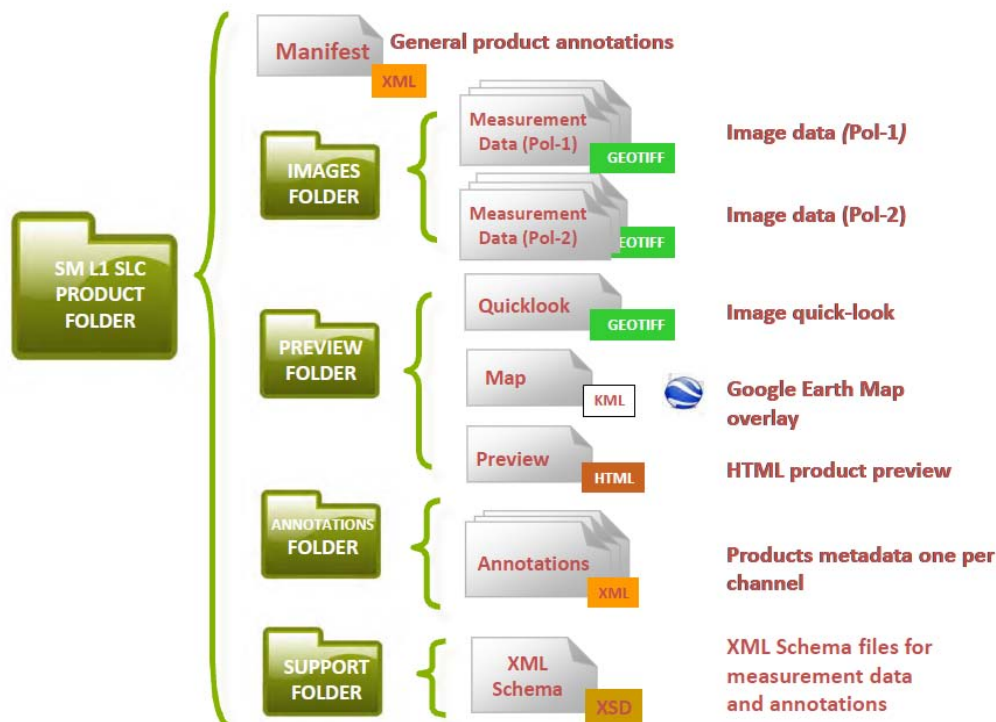


Figure 2-13: SAFE Product Structure [RD 17]

2.4.4.5. S-1 base SAFE reader

The RADARSAT-2 and TerraSAR-X product readers in NEST use a common XML reader for parsing metadata manifest files and a GEOTIFF, NITF and/or COS reader for interpreting the image data. The S-1 product specification follows this same pattern. As such, the S-1 reader could easily be implemented by extending the existing XML based reader. Therefore, the S-1 reader will abstract the required metadata from the product into the Abstracted Metadata of the GPM to be used in a common way by all processing operators.

Measurement datasets will be read according to their format - GeoTIFF, NetCDF, etc. Quicklooks will be read as PNG using JAVA's ImageIO library. The Google Earth KML Map overlays and HTML previews will not be read or presented by the readers or toolboxes.

2.4.4.6. Sentinel-1 Level 0 reader

L0 data products are compressed using FBDAQ, which provides a variable bit rate coding that increases the number of bits to be allocated to bright scatterers. For the data to be usable, it will need to be decompressed as it is read in by the reader. The decompression algorithm will be implemented according to [RD 16] SAR Data Decompression for S-1.

The following auxiliary data will be required and are provided in the appendices of S-1-TN-ASU-PL-0023:

- ◆ SAR Data Sample Magnitude Reconstruction LUTs to support BAQ modes with no Entropy Coding;
- ◆ SAR Data Sample Magnitude Reconstruction LUTs to support modes with Entropy Coding used, i.e. FDBAQ modes;
- ◆ Huffman Coding tables for the construction of the decoding functions.

2.4.4.7. Sentinel-1 Level 1 reader

The S-1 L1 reader will be used for reading both SLC and GRD products. For SLC products it must be able to handle complex data samples. For GRD products it will need to handle detected samples. The reader will abstract the slant range to ground range coefficients contained in the coordinate conversion data set record of L1 GRD products.

For TOPSAR SLC products, the reader will produce one complex band per swath per polarization. For GRD products, the reader will produce one detected band per polarization.

The S-1 L1 reader will use the existing GeoTIFF ImageIO reader to read the measurement datasets. GeoTIFF is an extension to TIFF 6.0 specification. The 32-bit limitations of the GeoTIFF format restrict it to images of a maximum of 4GB in size. The BigTIFF format codec available in the ImageIO-Ext of the GeoTools library will be able to extend the capabilities of the reader to support files of an arbitrarily large size.

2.4.4.8. Sentinel-1 Level 1 IW and EW SLC debursting and swath merging

For the TOPSAR IW and EW SLC products, each product consists of one image per swath per polarization. IW products have 3 swaths and EW have 5 swaths. Each sub-swath image consists of a series of bursts, where each burst was processed as a separate SLC image. The individually focused complex burst images are included, in azimuth-time order, into a single subswath image, with black-fill demarcation in between, similar to the ENVISAT ASAR Wide ScanSAR SLC products.

For IW, a focused burst has a duration of 2.75 sec and a burst overlap of ~50-100 samples. For EW, a focused burst has a duration of 3.19 sec. Overlap increases in range within a sub-swath. Images for all bursts in all sub-swaths of an IW SLC product are re-sampled to a common pixel spacing grid in range and azimuth. Burst synchronisation is ensured for both IW and EW products.

Unlike ASAR WSS which contains large overlap between beams, for S-1 TOPSAR, the imaged ground area of adjacent bursts will only marginally overlap in azimuth just enough to provide contiguous coverage of the ground as seen in Figure 2-14. This is due to the one natural azimuth look inherent in the data.

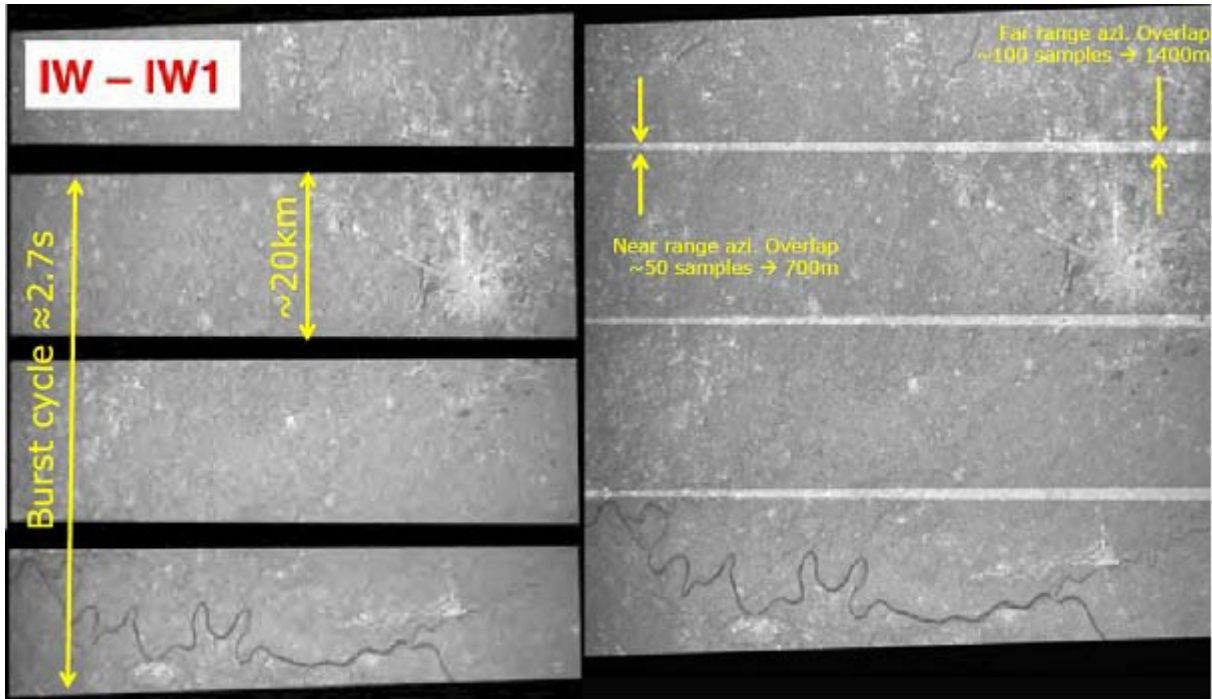


Figure 2-14: Burst Overlap in S-1 TOPSAR SLCs [RD 17]

The Swath Timing data set record contains information about the bursts including dimensions, timing and location. The Swath Merging data set record contains information on how to merge the swaths together by identifying swath boundaries. S-1 SLC products will be deburst and merged ensuring that the Phase information is preserved allowing for interferometric processing.

2.4.4.9. Sentinel-1 Level 2 reader

S-1 L2 OCN products are stored in NetCDF file format. The format includes both the annotation and measurement datasets in one self-describing, self-contained file. The BEAM/NEST NetCDF reader uses the NetCDF Java libraries from the University Corporation for Atmospheric Research (UCAR).

It will be possible to read the OCN data products using the S-1 L2 reader however; displaying of the measurement datasets may not be possible within this contract due to budgetary constraints. Some effort will be need in the future to enhance the NEST ASAR Wave product polar view to properly support the display and analysis of S-1 L2 OWI, OSW and RVL datasets.

2.4.4.10. Sentinel-2 MSI Level 1 and 2 readers

Three issues make the implementation of an efficient S-2 reader challenging:

1. Single data products contain bands of varying spatial resolutions. Challenge: The BEAM product model requires all bands in a product to have the same raster dimensions.
2. Products comprise a number of partly, overlapping raster data granules (L1B) and UTM tiles (L1C and L2A) each having a different geo-coding. Challenge: the BEAM product model requires a non-overlapping tiling and a consistent geo-coding for all tiles. See Figure 2-15.
3. All raster data is stored in compressed JPEG2K images. Challenge: BEAM uses Java Image I/O (IIIO) and JAI, but these libraries use an outdated JPEG2K codec, which is slow and buggy.

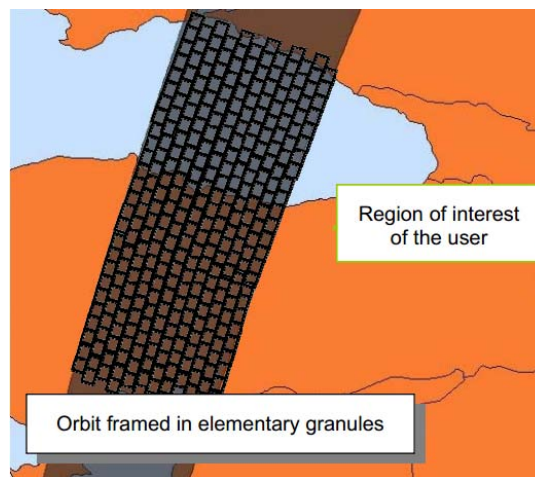


Figure 2-15: MSI L1B detector-separated granules (taken from the GMES S-2 PDD)

The first issue will be resolved by extending the BEAM product I/O API to be able to handle reader-specific parameters. As of BEAM 4.9, reader (and writers) cannot have any other parameters than the data product's file location. Readers that offer parameterisation, can display a configuration dialog just after the user has selected a S-2 MSI product file (or directory). Using dedicated control parameters, the S-2 MSI reader can be configured to meet the user's needs regarding the best representation of the various spatial MSI resolutions. Figure 2-16 is a screenshot of a configuration dialog mock-up for the S-2 MSI L1B product reader (the one for L1C will be similar).

The second issue is not easily solved and its solution also heavily depends on the user's requirements and expectations. From a VISAT-user's point of view, a "natural" way to display all the granules or tiles of a L1B or L1C product would be to display them all in a single giant image. However, for L1B this would involve a massive data reprojection and mosaicing to the coordinate reference

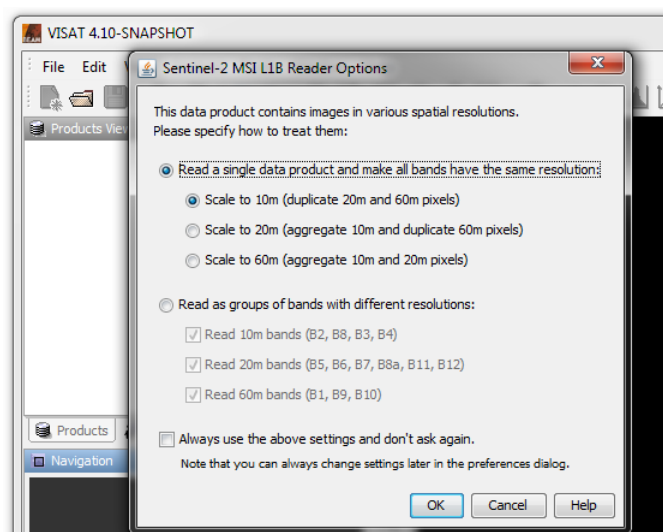


Figure 2-16: Mock-up of a S-2 MSI reader configuration dialog

system of the target image. This is actually part of the L1B to L1C processing. From a data processing point of view the MSI reader shall be able to ingest one granule or tile by another, ideally in a parallel fashion. We therefore propose to only open single granules or tiles in VISAT, however the final approach may be also to create on-the-fly mosaics, this depends on the requirements baseline and an in-detail analysis of the effort to implement an efficient S-2 mosaic display.

The third issue will be resolved by directly using the latest version of the pure Java JPEG2K codec that is used both by IIO and JAI. Luckily, the project “jj2000” that maintains the codec is still active and is hosted at <http://code.google.com/p/jj2000/>. It fixes most of the problems of the outdated version used in IIO and JAI. The codec fully supports tiling and also image pyramids so that it can be easily wrapped and used by a BEAM product reader or GPF operator.

2.4.4.11. Sentinel-3 OCLI L1B and L2 readers

The implementation of the OLCI L1B and L2 (land and ocean) readers is straight forward, however the pure amount of data in each data product (tens of gigabytes) make an efficient implementation a challenging task.

BC already has developed basic, non-optimised S-3 OLCI L1B and L2 readers within the frame of the ESA project “Sentinel-3 Optical Products and Algorithm Definition” (S3L2PP). The open-source code is hosted at <https://github.com/bcdev/S-3-synergy>. These readers will serve as the basis for the fully featured implementations to be developed with the frame of this project. The work to be done includes the definitions for the Sentinel Product Configuration Database, the complete ingestion of SAFE metadata and the exploitation of the pixel-wise time coding provided in S-3 products.

2.4.4.12. Sentinel-3 SLSTR L1 and L2 readers

The SLSTR L1B reader also provides bands in two spatial resolutions (0.5 and 1 km). The same approach as for S-2 MSI will be used: We will parameterize the SLSTR L1B reader, so that users have the choice of how to deal with the product’s contents as shown in the mock-up screenshot to the right.

However, the implementation of the SLSTR L2 (land and ocean) reader is straight forward. There are no special issues to be addressed, besides an efficient handling of the pure amount of data that each product comprises (tens of gigabytes). As for OLCI L2, BC has already developed a very basic reader for SLSTR L2 within the frame of the ESA S3L2PP project. This will be used as a basis for the fully featured version that will comprise complete metadata and mask definitions.

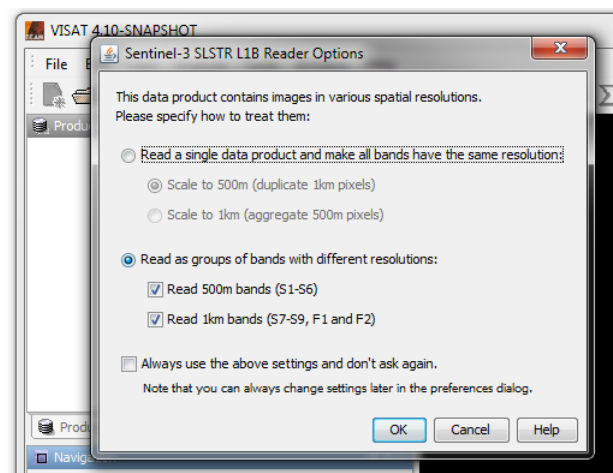


Figure 2-17: Mock-up of a S-3 SLSTR reader configuration dialog

Both L1 and L2 products provide geo-location information either at tie-points (defined on the WGS 84 ellipsoid) or for each pixel (DEM corrected). The reader is aware of this and thus users will have the choice to either use the tie-point or the pixel geo-locations.

2.4.4.13. Sentinel-3 SYN readers

The SYN L1C and L2 data products use the OLCI reference grid for storing raster data. This means, the NetCDF datasets are 3D, where the 3rd dimension is given by the 5 OLCI cameras. This is in contrast to the OLCI L1B products where the camera grids are already resampled to single images. It is obvious, that users will expect to see a single image when opening this type of products in BEAM VISAT. Therefore the SYN reader has to implement an on-the-fly resampling, ideally using the OLCI L1B methodology.

Although, BC has already developed a simple reader for SYN L2 within the frame of the ESA S3L2PP project, it will barely serve as a basis for the Sentinel Exploitation Tool because of its very basic capabilities. For example, the OLCI camera images are still not merged, thus the number of OLCI bands is multiplied by 5 in BEAM.

2.4.4.14. BEAM core module updates

A number of changes and extensions to the BEAM core module have already been identified in order to support Sentinel user products with best possible performance and best representation within the BEAM generic product model. These will be implemented in collaboration between BC and Array during the iterative development of the readers according to the priority of each update given in the table below.

Table 2-15: BEAM core module updates

Change / Extension	Description	Priority	Alternative Realisation
Extend the BEAM I/O API by reader parameters	Product reader shall accept reader parameters telling them how to operate and interpret data. As described above, some data readers (S-2 MSI, S-3 SLSTR) urgently need parameterisation.	High – a strategy of how to handle this issue must be provided.	Change the product model to also support multiple pixel resolutions. This change is out of scope because it implies too many changes in other modules. Scale up all bands to the highest pixel resolution.
Alternative tile caching strategy	BEAM's default tile caching strategy is not ideal for all use cases. Details are described below in 2.4.5 Chapter Reader optimization.	High – it is obvious, that the current tile caching strategy will not work sufficiently for low-bandwidth storage devices.	Raise minimum system requirements for computers running the Sentinel Exploitation Tools (e.g. use faster devices, more RAM, etc).
Allow all Sentinel product readers to directly read from file archives.	SAFE is a container format. A product usually refers to a directory of files. It is expected that Sentinel products will be distributed	High – Users should not be forced to unpack Sentinel file archives (SAFE containers).	Users must unpack Sentinel product packages before they can be used in BEAM or NEST.

Change / Extension	Description	Priority	Alternative Realisation
	in packaged and compressed form (tar, tar.gz, zip archives).		
Detection of low-bandwidth of storage device of source data product	For users it is hard to tell whether the software performs poorly or the storage device is slow, especially for large data products. Details are described below in Section 2.4.5.	Medium – an alternative tile caching strategy might solve the issue.	None.
Update BEAM core library with NEST patches.	NEST partly uses patched BEAM source codes. After integrating these patches in the BEAM core module (e.g. take over NEST abstract metadata), a number of NEST features that become available in BEAM: Graph Builder, Batch Processing, Product Library, NASA WorldWind World Map, HSV View (Hue-saturation-value), Labelling enhancements.	Low – Having NEST functionality in BEAM is not demanded by the SoW.	None.
Extend BEAM generic product model by time-coding	The BEAM generic product model supports sensing start time and stop time, but does not provide means to exploit time information on a per pixel level. However, Sentinel data comes with a per-pixel time coding.	Low – per-pixel time information display is not demanded by the SoW.	The only alternative is to provide the inaccurate time information based on sensing start and stop time and interpolate in between (as done now in BEAM).
Extend BEAM generic product model by common metadata model	Based on NEST's Abstracted Metadata, a comprehensive metadata model will be established taking into account the metadata profiles of SAFE and the NetCDF CF conventions.	Low – since BEAM can already display metadata.	None.

2.4.4.15. Integration of the ACP in BEAM

The Sentinel 2 Atmospheric Correction Prototype (ACP) is a tool that is used to compute S-2 atmospherically corrected, bottom of atmosphere reflectances (L2A products) from S-2 Top Of Atmosphere (TOA) radiances (L1C products). The ACP tool is currently developed by VEGA under ESA

contract and is an implementation of an algorithm developed at DLR. The atmospheric correction processor is presumed to be realised using the Python programming language.

The ACP tool shall be integrated into BEAM as tight as possible. Ideally, users shall be able to operate the tool in the same way like existing BEAM tools, especially the data processors. There are two basic strategies to integrate the ACP into BEAM:

1. Keep the ACP tool as an **executable on its own** and invoke it via its command-line interface (CLI) from within BEAM.
2. Migrate the ACP source code to Java and develop a **BEAM S-2 AC Operator** using the BEAM Graph Processing Framework.

With both integration strategies, the AC tool will appear in VISAT's tools menu and will have a GUI similar to other BEAM processors. In both cases, the resulting Sentinel L2A product will be opened in VISAT after AC processing. Figure 2-18 and Figure 2-19 below depict the implementation strategies in terms of a UML component models.

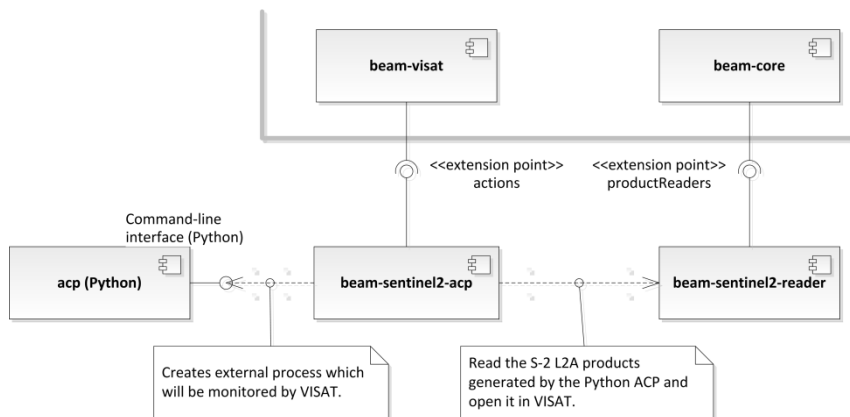


Figure 2-18: ACP integration using the original Python executable

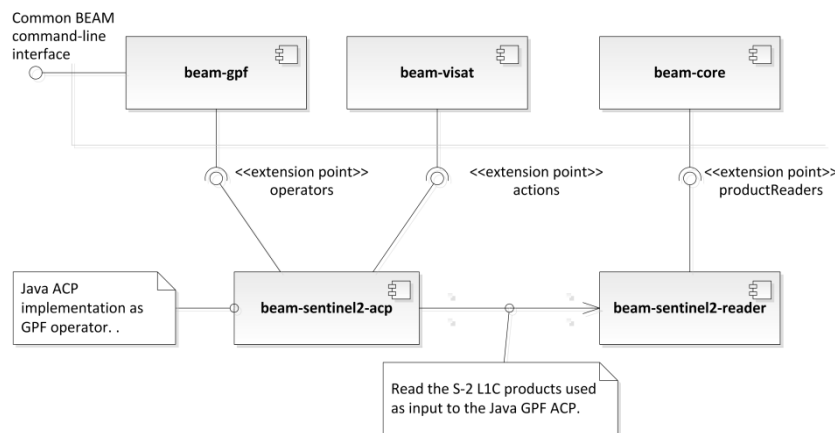


Figure 2-19: ACP integration as a BEAM GPF operator

The following table provides a more detailed comparison of the two implementation strategies.

Table 2-16: Comparison of ACP integration strategies

	Strategy 1	Strategy 2
Assumptions	<p>The ACP tool has a CLI and the CLI</p> <ul style="list-style-type: none"> ▪ is directly callable or via a shell script ▪ supports parameterization by CLI arguments or parameter files (plain text) ▪ provides minimum means to report processing progress and to signal errors ▪ is available on Unix, Mac OS and Windows platforms 	<p>Python source code</p> <ul style="list-style-type: none"> ▪ is available, complete and documented. ▪ can be redistributed under GPL after migration to Java
Graphical User Interface (GUI)	<ol style="list-style-type: none"> (1) New entry in VISAT's tools menu: "Sentinel 2 Atmospheric Correction". Opens a dedicated processor UI panel. (2) Default input product will be the currently selected S-2 MSI L1C product in VISAT. (3) Users can edit various processing parameters and finally press run. (4) A product will be written to disk, which VISAT will automatically open and display. 	<ol style="list-style-type: none"> (1) Identical (2) Identical (3) Identical (4) Users can already work with the generated L2A product without the need to write it to disk.
Command-line interface (CLI)	Use of the ACP's own CLI. A CLI must be available, see assumptions above.	Provided by the BEAM GPF since all BEAM Operators automatically have a CLI (this is a framework service). The AC Operator's CLI will be very similar to the one of other BEAM and NEST operators.
Help / User Manual	<p>Two options exist:</p> <ul style="list-style-type: none"> ▪ Reuse the existing ACP manual (provided there will be one available) ▪ Write new help pages for VISAT online help 	VISAT online help pages
Deployment	Deployment is done as part of the "Sentinel Exploitation Tools for BEAM"-installer which will also install (1) the native ACP, (2) optionally a Python runtime, and (3) the BEAM VISAT "glue" module.	Deployment will be done as part of the "Sentinel Exploitation Tools for BEAM"-installer. Since the AC tool will be a usual BEAM plug-in module, users can also install via the BEAM module manager.
Runtime Performance	If not supported by dedicated native C-libraries, pure numerical Python code is by magnitudes slower than Java.	Usually very good. BEAM GPF Operators fully exploit multiple CPU cores. GPU acceleration possible.
Maintenance	Done by the original developers of the	Maintenance is fully covered by the Sentinel

	Strategy 1	Strategy 2
	Python code (TBC).	Exploitation Tools contract. Bug reports are tracked by Sentinel Exploitation Tools team (BEAM issue tracker, BEAM forum) Bugs and issues are fixed can be directly fixed by the
Other Pros and Cons	(+) No need to develop and test new science code. (-) Unknown runtime performance of the ACP, may result in poor user experience. (-) Unknown capabilities of the CLI. (-) Extra Python interpreter required. (-) Different setups for Windows and Unix environments. (-) Users may mistakenly trace back problems caused by the external ACP to BEAM (-) Updates of the ACP executable may require updates of the Sentinel Exploitation Tools	(+) The AC Operator code becomes part of BEAM and its user community (Issue tracker, Forum). Maintenance including fixes and updates are directly provided by the Sentinel Exploitation Tools team. (-) High risk due to the unknown complexity of the algorithms used, which in turn cause a high migration and testing effort. (-) Unclear maintenance in case of algorithm or auxdata updates

The finally selected implementation strategy heavily depends on the provision of the ACP Python code and its consecutive analysis by the BEAM development team.

2.4.5. Reader optimization

The acceptance and usability of the Sentinel Exploitation Tools will strongly depend on their responsiveness and functional performance. Special care will be taken during the development of the readers in order to identify performance bottlenecks already at early stages of the implementation.

Product readers are used by the BEAM system in different ways dependent on the use case. For example, displaying images in VISAT or DAT causes the reader to provide data tiles in an unpredictable, undetermined manner. This is because data is reloaded on request, depending on the subset of the image the user is currently looking at. Very likely, parts of images will be revisited more than once, so BEAM uses a tile cache to quickly reuse or reload data tiles. A different use case is the transformation of an entire source data product into another data product, e.g. map projections or atmospheric correction. In this case, all data is read in sequence. Previous tiles will usually not be used again (with the exception of processes that require for each output pixel a specified neighbourhood of input pixels, e.g. image convolutions).

The following flow chart depicts the proposed strategy used to mitigate performance problems during the development of the readers.

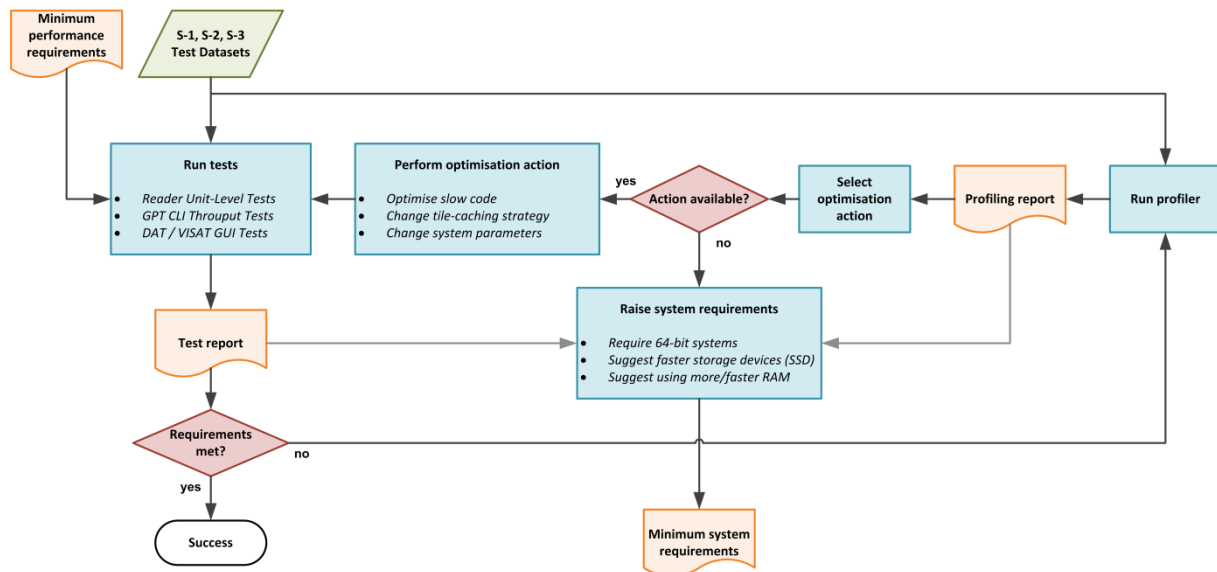


Figure 2-20: Flow chart for the mitigation of performance bottlenecks

Starting from a set of minimum performance requirements and the set of simulated test data for all supported product types, a series of tests will be executed. The tests address the different reader use cases; there will be

- ◆ Unit-level tests asserting that performance requirements are met at the API level (e.g. “Reading a single S-2 MSI tile of 512x512 pixels must not take longer than 50 ms when read from a local device.”).
- ◆ System tests asserting that the minimum requirements regarding imaging performance in DAT and VISAT is met (“Displaying a full S-3 L1B image must not take longer than 2 seconds.”, “It should be possible to display at least four S-2 images at the same time.”),
- ◆ System tests asserting that minimum data processing throughput requirements are met (“Reading a S-2 MSI L1B product and writing it as BEAM-DIMAP must not take longer than 30 seconds.”).

If one of these tests fail, the cause of the failure will be investigated by using a Java profiler (we use ej-Technologies’ JProfiler). Based on the profiling report, a suitable optimisation strategy will be selected. If a suitable optimisation action is found, it will be performed. Most obvious actions are code optimisation, or adapting one of the many internal control parameters for BEAM’s tile caching or even exchanging the tile caching strategy. (Array and BC gained a lot of experience regarding performance optimisation during the implementation of various readers and data processors for NEST and BEAM.) Then, tests are repeated again. If all possible optimisation actions fail, or rather no other optimisation action seem realisable within the given time and budget, the minimum system requirements for the Sentinel Exploitation Tools must be raised. Options include requiring 64-bit systems so that available memory can be increased without limits or suggesting to the user an improvement of data throughput by using faster storage devices.

One common performance problem occurs, if DAT or VISAT are used to display and analyse data products stored on low-bandwidth devices. Often, users then complain about bad VISAT performance not knowing that actually the hardware is causing the problem. Since DAT and VISAT constantly reload data tiles during image display, the overall imaging performance heavily depends on the data throughput from hardware device to cached memory. However, the BEAM API currently cannot determine whether a file is stored on a low-bandwidth device, such as a slow network file system, an overloaded local file system, a CD-drive or USB stick.

Therefore we also offer to implement a detection mechanism in NEST and BEAM that will inform users that data is currently loaded from a low-bandwidth device. It will also tell users how to solve the problem, e.g. by copying the data onto a faster device or by switching to another tile caching strategy (currently a NEST / BEAM system parameter). At least one additional tile caching strategy will be implemented as an alternative to the default strategy (which is: if tile cache is full, sort tiles by last access time, remove oldest tiles).

The minimum performance requirements will be part of the requirements baseline document deliverable.

2.4.6. Sentinel exploitation tools – outlook

During the implementation of the Sentinel reader the development team will provide to ESA a technical note, which will assess the various Sentinel data formats from the perspective of the Sentinel Exploitation Tools. It will address the suitability of the Sentinel data formats as end-user formats (since the SAFE package has been developed as an archive format) and include suggestions and recommendations for improvements (if any). It will also comprise a compilation of new tools that will need to be developed in order to fully support Sentinel data products and allow the end user to take full advantage of their capabilities. Although we list some of these features here, they fall outside of the scope of this proposal and will need to be developed as part of a future work to be done.

2.4.6.1. Future tools for Sentinel-1

L1 Slice Concatenation Tool: for a given data take, the corresponding L1 products may be provided in slices, each being in itself a nominal product, but which need to be assembled to have a unique continuous L1 product. This operation is basically an image concatenation and annotation consolidation task. The resulting assembled L1 product should conform to the standard L1 product format. Metadata will need to be included, merged or concatenated as described in the S-1 Product Specification [RD 10].

Re-noising and De-noising Tool: S-1 L1 products will be systematically de-noised as part of standard processing. All information to remove this correction will be annotated. NEST should be able to remove this correction based on the product annotations (i.e. to re-introduce the noise signal that was removed). NEST should also be able to apply this correction in case it has not been already applied.

Visualization and Analysis of L2 OCN products: In order to visualize all the information available in the OWI, OSW and RVL components of the L2 OCN products, the NEST visualization of ASAR Wave mode products will need to be extended.

Support for Dual Polarized data: By mid-2012, NEST will have absorbed a collection of polarimetric tools developed by Array for the Canadian Space Agency (CSA) in cooperation with the Canadian Forest Service (CFS) and the Geological Survey of Canada (GSC). These include polarimetric speckle filters, decompositions, supervised and unsupervised classification as well as wizards and enhanced labelling. The operators have been designed to work with Quad Pol RADARSAT-2 SLC products. With some modification, NEST should be able to apply these polarimetric operators to Dual Pol data in order to support Sentinel-1 and ENVISAT ASAR.

2.4.6.2. Future tools for Sentinel-3

Uncertainty exploitation: The uncertainty measure that comes with all the OLCI/SLSTR geophysical variables will be usable in BEAM, e.g. but not in a natural way. A number of tools can be built on an extension of the BEAM generic product model that associates the uncertainty measure directly with the geophysical L2 variable. In fact, this concept already exists in the BEAM API in form a binary mask (the internal “no-data mask”), which tells whether pixel data exists or not. In opposite to the binary nature of the no-data mask, the uncertainty provides a numerical, continuous, floating point validity measure. The following tools could be established on top of this product model extension:

- ◆ A special image display type could either use the alpha channel (transparency) or a special overlay in order to indicate uncertainty.
- ◆ New band arithmetic with automatic, in-built error propagation. If a band maths expression combines one or more bands with associated uncertainty, the result will be again a band with uncertainty information.
- ◆ The BEAM GPF (GPF API, used in NEST and BEAM to develop data processors) would be extended in order to facilitate the exploitation and processing of uncertainty information.

2.5. Software Product Assurance Programme

The objectives of the Software Product Assurance (SPA) Programme for the “Sentinel User Handbook and Exploitation Tools” project are to provide adequate confidence to ESA as well as to the development team that the developed/reused software satisfies its requirements during the project duration and generally throughout the lifetime of the software. In particular, that the Handbook wiki Tools developed is performed properly and safely in its targeted environment, meeting the quality objectives agreed for the project. Requirement [RQT-48] of the SoW requests an SPA for the Sentinel Exploitation Tools; a comparable programme is also applied to the software elements developed for the Handbook.

The exploitation tools are composed of upgrades to the BEAM and NEST toolboxes; each of which being independent and self-contained, but with an identical set of core modules. Those are maintained on the BEAM side and used by NEST. Both companies, BC and Array, working on the

development of these software components, have a Product Assurance Programme in place² which will be applied to the individual development process. Both individual programmes are derived from the ECSS standard [AD 4] and [AD 5]. In this Section we define the top level programme that ensures the overall objectives, the compliancy with Annex D of the SoW [AD 1], and which refers to the individual programmes where applicable.

2.5.1. SPA organisation and responsibilities

The overall Handbook development effort, through Liferay, will be lead by ARGANS. ARGANS has successfully supported Handbook development in the past, through the IDEAS SPPA project where ARGANS is the Optical Instrument Group Coordinator (IGC); these handbooks are HTML pages and so we are aware of the limitations imposed. The team is proposing Stephen Emsley from ARGANS as Handbook SPA Manager. Stephen Emsley is the Head of IT at ARGANS and has several years of experience in software development and quality assurance e.g. being a Lecturer for the Open University. He is also involved in the ongoing ARGANS GMES S-3 Products and Algorithms Definition project for ESA.

The overall tool development effort for the Sentinel tools will be lead by BC. The S-1 readers will be developed by Array into NEST. The S-2, S-3 readers and the integration of the ACP will be developed by BC into BEAM. This team has successfully worked together in the past and we have a comfortable and efficient working process for collaboration. The team is proposing Norman Fomferra from BC as Tools SPA Manager, i.e. Norman will be the person being responsible for the SPA of the tools development. Norman Fomferra is head of the Environmental Engineering Branch of BC, has more than 20 years of experience in software development and quality assurance, including a large number of successful software development projects for ESA. Norman has introduced the ECSS compliant software development and quality assurance process in BC.

2.5.2. SPA reporting

All Handbook and Tools related deliverables will be checked and approved by the relevant SPA Manager before submitted to the prime/ Project Manager. Reporting on the SPA will be done on a monthly basis and as part of the Monthly Progress Report (MPR). A chapter summarizing the achievements, problems and proposed solutions occurring during the reporting period will be provided by the SPA Managers to the Project Manager for integration into the overall MPR.

All problems related to the Handbook will be registered, followed up and documented in a JIRA issue tracker system; JIRA is a project tracking tool for teams building software. It tracks bugs and defects, link issues to related source code, plans agile development, monitors activities, and supports reporting on project status. JIRA has been used by ARGANS as part of the GMES S-3 Products and Algorithms Definition project and we have a local installation that can be activated. JIRA has also

² Array conducts systems and software engineering activities according to its ISO 9001:2008 Quality Management System (QMS) procedures.

been used by BC for several years for all software development projects, and Array has agreed to use the BC JIRA as common issue tracker for the Tools development.

2.5.3. Software lifecycle

The software development approach taken by BC and Array is fully compliant to the ECSS-E-ST-40 software engineering standards [AD 4]. It has evolved from practices, which have established well in numerous projects. As a type of agile software development, our approach advocates frequent releases in multiple development cycles, involving Extreme Programming techniques and activities like stand up meetings, pair negotiation, unit testing and pair programming (see Figure 2-21). These techniques and activities have shown to improve software quality and responsiveness to changing customer requirements.



Figure 2-21: Typical time scales associated with elements of the software development life cycle

ARGANS will also employ an agile approach for the Handbook development, but because of the time constraints (Handbook architecture, WP1300, developed in 2 months) the full software lifecycle will need to be compressed. Therefore, Section 2.5.4 is focused on the Tools rather than Handbook lifecycle. ARGANS is certified to ISO 9001:2008, which provides documented procedures for all development and delivery processes such that performance is repeatable, predictable and quality is assured. Also, an independent QA organization provides autonomous assurance of product and process quality.

2.5.4. Tools development lifecycle

2.5.4.1. Requirements Engineering 1: early requirements and architecture engineering: developing an overall model

The development team in consultation with ESA develops a high-level abstraction of the system and its context. General use case diagrams, raw sketches of component collaborations and an initial interface design are used to provide an overall view of the project. Unified Modelling Language (UML) diagrams form the basis for discussion and documentation. Input to this step is the SoW [AD 1] and the proposal with the output being the Requirement Baseline (RB).

2.5.4.2. Requirements Engineering 2: intermediate requirements and architecture engineering: building a feature list

The development team identifies and groups different features of the system. Each feature is weighted in terms of complexity and prioritised according to its logical order of development and its class-relation constraints. This activity results in a detailed feature list grouped into major system parts and feature sets. ESA, the SPA manager and the project manager are involved for review. The output of this step is an initial Technical Specification (TS) of the system and an initial Acceptance Test Plan (ATP).

2.5.4.3. Requirements Engineering 3: late requirements and architecture engineering: planning by feature

Based on the weighted and prioritised list of features, the Tools SPA Manager in consultation with the development team proposes and agrees with ESA milestones for the further development cycles. Each milestone terms a set of classes involved, their detailed class collaborations, and, for each class, assigns a developer being responsible for implementing and testing the class (in the following termed class owner). Input to this step are the RB and the draft TS. The output of this step is included in updates of the TS and ATP.

2.5.4.4. Early design and implementation: designing by feature

Identifying the core classes associated with a feature and instructing class owners to start the detailed design initiate the design and implementation Phase. Class owners prepare detailed sequence diagrams involving all class collaborations. This activity results in core classes with detailed method signatures, complementing code fragments included in the Design Definition File (DDF) to form a prototype of the feature under development.

2.5.4.5. Late design and implementation: implementing by feature

This step involves the concrete implementation of class functionalities and class or unit-level tests. Late and early design and implementation steps constitute an iterative procedure. ESA, who decides whether the project objectives are achieved, must approve the result of each iteration cycle. The design implementation Phase is completed when all features are implemented and all unit-level and internal acceptance tests are passed.

2.5.4.6. Delivery and acceptance

The completed software along with its design documentation is delivered when all internal software acceptance tests are passed internally. The final ATP is carried out under supervision of the customer ESA. The software will be delivered in form of executable installers, which take care about proper installation and configuration of the software. Maintenance updates are usually delivered in form executable installers as well.

2.5.4.7. Verification Engineering 1: Validation

Software validation is the process ensuring that the requirements baseline functions and performances are correctly and completely implemented in the final software. The SPA ensures software validity by testing on three major levels: unit-level testing, integration testing and acceptance testing.

- ◆ Unit level testing ensures the correct functionality and validity of individual, usually relatively small, software units: a procedure or function in a procedural language, or a class in an object-oriented language. Explicit dependencies on external interface implementations are avoided by means of mock-up implementations, resulting in full control of the test environment. Unit-level tests are defined and carried out by software developers. The primary input for the definition of unit-level tests is common sense and domain-specific knowledge, as well as the RB and TS.
- ◆ Integration testing ensures that the developed software behaves as expected within the Target environment. Quality testers define integration tests for which the primary input is the RB. Implicit and informal integration testing as also carried out by developers while running or debugging the software within the integrated development environment.
- ◆ Acceptance testing allows the customer to validate the software. The final acceptance tests are performed under supervision of the customer. Nevertheless continuous acceptance testing carried out by quality testers, is integrated into the software development life cycle, revealing problems and mis-development at an early stage. The major input for the definition of acceptance tests is the RB and the acceptance test plan (ATP).

2.5.4.8. Verification Engineering 2: Software verification

Software verification is the process ensuring that adequate specifications and inputs exist for any software development activity, and that the outputs of the activities are correct and consistent with the specifications and input. For each software module the procedure is the following:

- ◆ Algorithm understanding:
 - ◆ Software developers understand the physical and/or mathematics background of the functionality to be implemented (often in form of an ATBD or – in the case of the product readers the product format description) and prototype software where available;
 - ◆ Auxiliary data are analysed for completeness and conformance with the RB.
- ◆ Architecture design:
 - ◆ Software developers decompose a module into components, e.g., processor modules are decomposed into BEAM GPF nodes;
 - ◆ Each module is defined in terms of its interface and dependencies;
 - ◆ Processors are defined in terms of input data, processing parameters, and output data: bands, flags, metadata; mandatory and optional elements.
- ◆ Software implementation:

- ◆ Input data readers;
- ◆ Auxiliary data readers;
- ◆ Algorithms;
- ◆ User interface.
- ◆ Software verification by iterative interaction with the user:
 - ◆ Scientists (at BC, Array, ARGANS, ACRI-ST, isardSAT as well as at ESA) use the software and report inconsistencies and issues;
 - ◆ Software developers resolve inconsistencies and issues, and implement algorithmic improvements provided by scientists.
- ◆ User help and documentation:
 - ◆ Software developers prepare integrated Java help and user documentation;
 - ◆ SPA manager (supported by team scientists) review the documentation.

2.5.4.9. Maintenance Activities

The tools will be published as plug-ins to the BEAM and NEST toolboxes. As described in Section 2.5.1 all problems related to the tools will be registered, followed up and documented in the JIRA issue tracker system run at BC, which is publicly visible under the BEAM Website. Once the tools have been made public the users will have open access to view or submit bugs to JIRA via the web-based interface. NEST users may also submit their bug reports to the NEST issue trackers; they will be transferred into the JIRA by Array. The problem reports created by the users and developers could be on particular faults of the software, mistakes found in the documentation, or wish-list items they would like to see added. The JIRA (and TRAC of NEST) system allows the tracking of such tasks to be visible by all if desired. Bugs will be corrected by the next software release. All fixes and improvements will be noted in the accompanying documentation for each release.

2.5.4.10. Configuration management

Configuration management ensures adequate control over all items (in the following termed configuration items) necessary for creating or supporting the software deliverables and associated text documents. All software deliverables use unique version identifier consisting of up to three integer numbers and an optional qualifier:

Table 2-17: Version identification syntax

<code><version-id> ::= <major>[.<minor>[.<micro>[-<qualifier>]]]</code>	
<code><major></code>	Integer number starting from zero and increasing with major enhancements (mandatory)
<code><minor></code>	Integer number starting from zero and increasing with minor enhancements
<code><micro></code>	Integer number starting from zero and increasing with issues fixed
<code><qualifier></code>	Used to distinguish different build or working versions (only used internally, not for deployed versions)

Some configuration items require that their version be expressed in the file name. This applies to installer artefacts and libraries as well as to text documents. Such items have their version identifier appended to their base name. All other configuration items like source code and resources are managed by a version control system (Git), which manages the version identification.

2.5.4.11. Continuous software integration

The software development cycle is integrated into the system development cycle (Section 2.5.4.14). We will use the TeamCity build server at BC for providing ready-to-install software packages continuously. Continuous Integration helps to perform integration and performance tests at any time during the design and implementation Phase. Any build problems or failed tests will immediately trigger an email to notify the developer responsible for that code. Upon a successful build, unit tests, integration tests, coding standards audits and metrics will be executed automatically. In this way, problems are identified quickly and developers can have confidence in the code as they continue to refactor and add new features.

2.5.4.12. Software testing

Unit level tests: As part of the test-driven, incremental software development, unit-level tests will be defined and coded before a new feature of a reader is implemented. A developer realises a new feature by making its associated unit-level tests succeed. For example, typical product reader unit level tests assert that the product read:

- ◆ has the expected metadata;
- ◆ has the expected number of bands;
- ◆ is geo-coded, and geo-coding is correct etc;
- ◆ provides the expected values for selected pixels within the measurement data sets.

The unit level tests will work on samples of the provided test dataset and are executed manually during feature implementation. For the verification of the S-2 L2A output of the BEAM-integrated S-2 ACP, the output of the native Python ACP will be used.

Integration tests: All the unit-level tests will run automatically during the continuous integration of the Sentinel Exploitation Tools on our build servers (TeamCity). Rebuilds take place whenever source code in the source code repository changes (GitHub). If there is a problem with the build, an email notification is sent to the software lead. If the built is successful, the unit-level tests are executed. The integration tests also include low level unit tests which test individual classes in isolation (as described above) as well as tests which test higher level concepts such as reading a product and processing it with an operator chain (tests within an integrated environment). The automated tests for the Sentinel readers will test nightly if the readers are able to read all of the supported products from the provided test data set. The automated tests will also include compatibility tests with existing, and applicable NEST and BEAM GPF operators. The sentinel data will be processed by each operator and the output product will be verified to be as expected.

Stress tests: Special tests will be performed on the readers to test extreme cases such as extremely large data takes. Stress tests will be benchmarked and will provide input to any optimizations required; for details see Section 2.4.5.

System tests: Dedicated tests will be defined and performed using the system the user faces after installing the Sentinel Exploitation Tools (= BEAM or NEST and all the readers and the ACP) on their computer. Though, these tests are also automated, they are still supervised by a denominated tester who is part of the development team. Automation covers typical workflows as performed by users in VISAT and DAT. The workflows to be tested using the dedicated software QF-Test. These tests will include cover all the NEST DAT and BEAM VISAT tools applicable to Sentinel data. The outcome of the testing activity is a Test Report that will be delivered to ESA.

2.5.4.13. Software protection against corruption

The central repository of the source code is GitHub, a cloud-based service manage that hosts public and private Git repositories (<https://github.com>). GitHub is the most popular code host with more than 3.5 million hosted repositories. It has an uptime availability of 99.69% in 2010. Due to the characteristics of the Git version control system, every developer of the SUHET team will host a complete copy of the Git repository on his local machine. It is a feature of Git that each developer can become the central master repository without any change for the development process.

The continuous builds, i.e. the executable software, are assembled on the TeamCity Server of BC. This server is mirrored in the BC IT infrastructure, where the mirror is located in a separate building. Mirroring is established via the ZFS file system with balancing taking place every 5 minutes. The same strategy is applied to all auxiliary data.

The public releases of BEAM and NEST are uploaded into the Amazon S-3 cloud. Amazon S-3 provides a highly durable storage infrastructure designed for mission-critical and primary data storage, designed to provide 99.99999999% durability and 99.99% availability of objects over a given year. More information can be found on aws.amazon.com/S-3//182-0540930-1085545/#protecting.

2.5.4.14. System development process

The overall process from user requirements to public release is depicted in Figure 2-22. It shows how requirements originating from users (initially through ESA) are registered in the JIRA issue tracker, which is central to the whole development process. The developers work along these requirements with the code stored in the GitHub code repository. Continuous builds are used by the testers at BC and Array to verify the software against the user requirements and issues as registered in JIRA. Public releases are uploaded to the Amazon S-3 file system. Here they can be downloaded by users (via the BEAM and NEST web sites) with a guaranteed high band width. Users may find bugs or come up with new requirements which are reported in the JIRA repository / which list and which lead to the next iteration cycle. Initially the requirements are defined by ESA through the SoW [AD 1]. During the Maintenance Phase external users will contribute to the process.

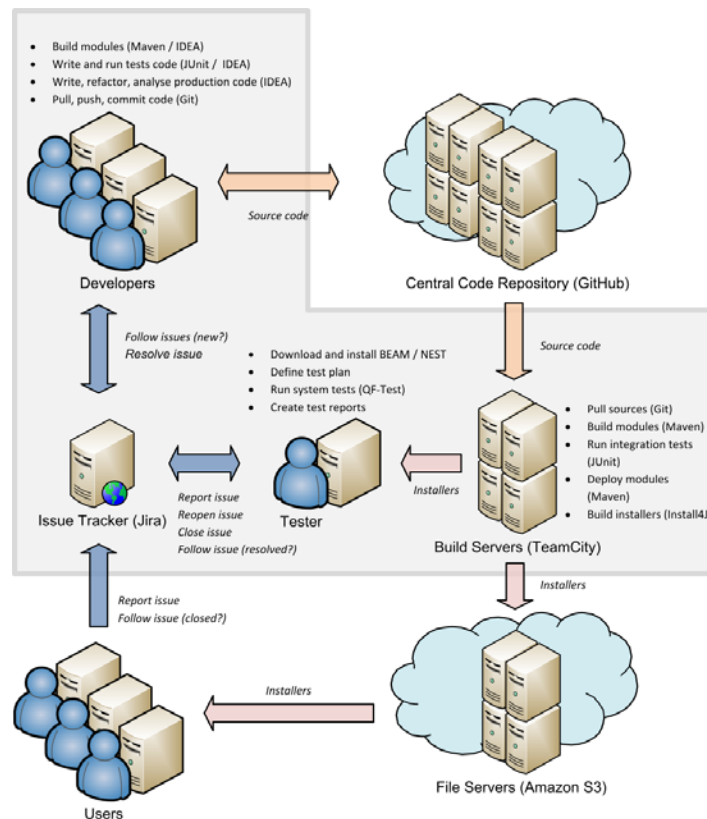


Figure 2-22: System development process in an agile, iterative cycle

2.5.4.15. Software development

Development will take place on Mac OS X, Linux Ubuntu and Microsoft Windows operating systems running on COTS hardware. All development tools used will be freely available such that a similar development environment could be reproduced by the end user.

The software will be written exclusively in Java. Java is an object-oriented programming language capable of allowing the same program to be executed on multiple operating systems. Oracle's Java JDK Platform has many APIs and tools ready for use which will minimize development cost and help to produce robust, cross-platform code.

The software will be compiled and debugged with the Oracle JDK using IntelliJ IDEA. IDEA is a Java integrated development environment (IDE) designed to maximize developer productivity by providing the necessary tools and graphical environment for all areas of development including coding, refactoring, code analysis, debugging and testing.

Hardware independence is achieved by the use of Java. Java code is implicitly portable. Java source code is compiled into a universal format called byte-code. This compiled Java byte-code can be executed by a Java runtime interpreter on any platform. The runtime system is a Virtual Machine that performs all the normal activities of a real processor, including executing the instruction set and managing memory. The portability of Java software will allow the software to be written once,

compiled once, and then be able to run on any hardware and operating system supporting the Java virtual machine.

2.5.4.16. Coding standards

The project will follow the coding conventions of the Java Programming Language originally developed at Sun Microsystems³. The guidelines are recommendations to the programmers, and should be followed except when rigorous adherence to them undermines the achievement of readability, maintainability, or portability, and can be justified. Java coding standards and conventions will be routinely monitored using IntelliJ IDEA which can help programmers write Java code that adheres to a coding standard immediately as they type. Metrics will be gathered routinely using IntelliJ IDEA and performance testing will be profiled using JProfiler.

The project will hold monthly release reviews including code inspection (video conf). ESA is invited to participate. The SPA manager will verify compliancy with the coding standards during these review meetings.

2.5.4.17. Developer documentation

The documentation of source code and all the application programming interfaces is solely done using Javadoc. Javadoc is a tool that parses the declarations and documentation comments in a set of source files and produces a set of HTML pages describing the classes, interfaces, constructors, methods, and fields. The default Javadoc output format is HTML, but it can be configured to also produce RTF or PDF documents.

2.5.4.18. Compliancy with ECSS-E-ST-40C

The software engineering approach as described above is fully compliant with the ECSS-E-ST-40C tailoring given in the SoW, Annex C [AD 1]. We provide here a short discussion of these requirements, including the resulting documents and their life cycle.

- ◆ 5.2.2.1a – 5.2.4.7a: The System Requirement Analysis will address the functions and system performance, validation, operations, real time, and quality requirements. The results will be documented in the RB. The software to be reused consists of the BEAM and NEST toolboxes. This will be very briefly addressed in the RB.
- ◆ 5.2.5a & 5.3.4.1: A system requirements review meeting will be hold during Progress Meeting (PM) 2 (T0+6).
- ◆ 5.3.2.1a-d: The software life cycle is defined in this proposal and will be maintained in the SDP.
- ◆ 5.3.2.5a: Configuration changes will be registered and documented in a traceable form in the JIRA issue tracker and the GitHub repository.

³ <http://www.oracle.com/technetwork/java/codeconv-138413.html>

- ◆ 5.3.3.1a – 5.3.3.3c: Review will be held as defined in the milestones plan (Section 2.5.4.19). A software review plan (SRevP) and report (SRR) will be issued.
- ◆ 5.3.4.2a: A PDR will be held as part of the Stakeholder Consultation Meeting at T0+8 (or a dedicated teleconf at that time, if timing of the stakeholder meeting does not permit merging with the PDR).
- ◆ 5.3.4.5a: An acceptance review will be held at T0+12 (see Section 2.5.4.19).
- ◆ 5.3.7.1a & 5.3.8.1a: The interface documentation and the technical budgets and margins computations will be part of the TS.
- ◆ 5.3.9.1a: The ECSS compliancy matrix will become part of the SDP.
- ◆ 5.4.2.1a-c, g-l, 5.4.2.2-4 & 5.4.3: The results of the software requirements analysis including the logical model will lead to the architectural design and will be documented in the TS. The Software Requirements Review (SWRR) will be held as part of the PDR (as specified in Section 5.4.2.4).
- ◆ 5.5.2.8 & 5.6.6.3a & 5.6.4.3a: The Software User Manual (SUM) will be provided as online help of the NEST and BEAM toolboxes.
- ◆ 5.5.3.1a-b: The software development and build process is described here in Sections 2.5.4.11 and 2.5.4.14.
- ◆ 5.6.2.1.a-c, 5.6.3.1a-c, 5.7.3.1-6, 5.8.2.1a-c & 5.8.3.8a-b: The software validation and verification process is described here in Sections 2.5.4.7, 2.5.4.8 and 2.5.4.12 and will be further documented in the Software Development Plan (SDP) and the Software Validation Report (SVR), which comprises the ATP and the test results.
- ◆ 5.7.2, 5.9.3.3 & 5.10.2.1-4: The software delivery and installation process is described here in Sections 2.5.4.6 and 2.5.4.14. Problem reports will be handled through the JIRA, available to ESA and to public during software maintenance.

The requirements of the ECSS-E-ST-40C tailored to this project lead to the following documents to be produced:

- ◆ Software Development Plan (SDP): This will include the content provided in this proposal in Sections 2.5.4.14 and updated during the project lifetime. Specifically it will include the description of the evolutionary software life cycle, the software configuration and documentation management, the design methodology, coding standards and test strategy. A first version of the SDP will be provided at KO and will be updated at every project review meeting.
- ◆ Requirements Baseline Document (RB): This will contain the outcome of the requirements engineering process (see Section 2.5.4). The first version of the RB will be provided at start of the tools development Phase (T0+6) and the final version will be provided after the SRR.
- ◆ Technical Specification Document (TS): The TS will comprise the interface definition, system design and architectural design. The initial version of the TS will be provided at the PDR (T0+8)

and will be updated for every iteration release. A stable version will be presented AR (T0+12) and the final version at project end (T0+18).

- ◆ **Software Verification Report (SVR):** This SVP will include the ATP, and the results of the software acceptance tests. The initial version of the SVR will be provided at PDR (T0+8) with updates after PDR and AR.
- ◆ **Software User Manual (SUM):** This user documentation will be available as online documentation which is part of the BEAM and NEST toolboxes.

2.5.4.19. Software milestones

Figure 2-18 lists the proposed milestones for the development of the Sentinel Exploitation Tools.

Table 2-18: Software milestones

Month relative to T0	Event	SW iteration release (internal to ESA and all project partners)	SW public release
6	Start tools development; Progress Meeting #2 - Development Phase (TC) including System Requirements Review		
7		monthly iteration release 1	
8	Stakeholder Consultation Meeting (ESRIN); PDR: presentation of iteration release 2 and review with ESA	monthly iteration release 2	
9	Public release of readers and start SW maintenance		BEAM and NEST readers version 1.0
10	Progress Meeting #3 - Detailed development Phase (TC) – review of BEAM and NEST readers v1, planning of updates/ improvements and of ACP processor		
11		monthly iteration release 4 (optional maintenance release)	
12	Acceptance Meeting	monthly iteration release 5 (optional maintenance release)	
13	Start development of ACP processor	monthly iteration release 6	
14		monthly iteration release 7	
15	Progress Meeting #4 - Maintenance - consolidation Phase – review of iteration release 7		S-2-ACP processor for BEAM version 1.0 BEAM and NEST readers version 1.1

Month relative to T0	Event	SW iteration release (internal to ESA and all project partners)	SW public release
16		monthly iteration release 8 (optional maintenance release)	
17		monthly iteration release 9 (optional maintenance release)	
18	Final Presentation (ESRIN)		Readers and ACP readers version 1.2 (final release)

2.6. Technical Risk Register

Table 2-19, the Technical Risk Register, presents the identified potential technical risks which may affect the project during its lifetime. Risk mitigations for each identified risk are proposed in the last column of this table.

Table 2-19: Technical Risk Register

Risk ID	Risk Description	Probability: Low, Medium, High	Impact: Low, Medium, High	Potential effect	Risk mitigation
R1	Access to documentation	Low	Medium	Detailed information in the Handbook may be missing or over simplified	Request all required documentation early. Use unreleased drafts if need be
R2	Access to the Liferay Portal	Low	High	Unable to use the agile approach towards the Handbook development	ARGANS will install the Liferay Portal locally
R3	Lack of timely responses/inputs from the external consultants	Medium	Medium	ARGANS will have to devote more time to writing the case studies and have less independent input	ARGANS will seek to get inputs from the consultants via a variety of methodologies e.g. interviews, teleconferences etc
R4	Access to simulated data products	Low	High	Testing of the readers cannot start	Create our own simulated data products
R5	Format changes of Sentinel products	High	Low	Delay of the work; lack of funding when changes come after completion of work.	Start with consolidated formats; planning has foreseen iterations, during which format changes can be coped with.
R6	Performance on large volume of Sentinel product	Low	Medium	Inability to process very large data products	Better tile size determination and caching strategies proposed. Refer to dedicated chapter above.

Risk ID	Risk Description	Probability: Low, Medium, High	Impact: Low, Medium, High	Potential effect	Risk mitigation
R7	I/O bottlenecks for packed file format	Low	Medium	Slow performance, waiting time for users during product opening and reading	First solution is the development of a dedicated container reading class (see proposal section); if this turns out to be not working, files will be unpacked before reading
R8	Resampling of SYN product too slow	Low	Low	In the SYN product the 5 cameras of OLCI are separated. Resampling will be performed on the fly. This may be too slow.	Parallelisation in multi-core machines (default solution proposed) Preprocessing step, which would be separately performed
R9	JP2000 support	Medium	High	Sentinel 2 imagery is stored in JPEG2000 format. The support of this format through the Java Image I/O and JAI lack performance and are buggy. We will use the latest version of a dedicated library, e.g. jj2000 (http://code.google.com/p/jj2000/). The risk is that this (or other) libraries are also not satisfying.	Use native JP2000 implementation via JNI (Java native Interface) or use GDAL Java bindings.
R10	ACP (algorithm) changes	Medium	Medium	Delay of the work; lack of funding when changes come after completion of work.	Continue with the version of the ACP as originally made available by ESA.

2.7. Technical Compliance

This section presents the technical compliance matrix for the SoW [AD 1] requirements.

Table 2-20: SOW Table of compliance

SOW Req.	SOW Req. description	Compliance	Traceability	Comment
Sentinel User Handbook – Phase 1				
[RQT 1]	<p>The contractor shall compile a case study report, based on the bidders proposal and include the points raised by ESA and agreed to at the negotiation/K.O. meeting.</p> <p>Output: Case study report following the negotiation/K.O. meeting</p>	☑	§2.3.1 §3.4.4	The case study report will be discussed during the KOM and issued 2 weeks later.
[RQT 2]	<p>Based on the “case studies” described above, the contractor shall derive “user requirements” to be used for the justification of the Sentinel User Handbook content.</p> <p>Output: A User Requirements Document to be used as metrics during the development of the Sentinel User Handbook structure.</p>	☑	§2.2 §3.4.4	Users’ requirements for each category of users identified in the case study will be derived.
[RQT 3]	<p>The contractor shall propose a detailed Sentinel User Handbook wiki structure:</p> <p>The Sentinel User Handbook shall include as a minimum the following:</p> <ul style="list-style-type: none"> - Overview of the SENTINELS – including elements of outreach such as “What Sentinel can do for you” <p>N.B. Great care should be given to this chapter to capture the Sentinels Users attention and navigate him/her to the appropriate level of details he/she requires.</p> <ul style="list-style-type: none"> - Description of available and foreseen services based on Sentinel data - Detailed description of the mission, spacecraft and instruments down to unit level and component level where appropriate i.e. CCD. - Detailed description of instrument performances - Detailed description of instrument calibration and on-ground characterization - Executive overview of all key technical documents (i.e.: ATBDs TGRDs, DPMs, IODD/Prod Specs) including links to these operational “configuration Item” documents. - Executive overview of the data access including appropriate links (i.e. GSCDA, 	☑	§2.3.1.1	Topics of the User Handbook have been based on this requirement. One additional has been included (“Glossary”)

SOW Req.	SOW Req. description	Compliance	Traceability	Comment
	EUMETSAT ...) - Executive overview of the exploitation tools including links to Beam and Nest. Output: A TN describing the proposed Sentinel User-Handbook wiki structure			
[RQT 4]	The contractor shall justify the proposed Sentinel User Handbook wiki structure using the “case studies” derived user requirements. Output: A TN(s) justifying the “content” needs and method to access it (i.e. how many clicks) required by the typical “case studies” user requirements.	<input checked="" type="checkbox"/>	§3.4.4	The structure will be derived from the case study report and justified accordingly.
[RQT 5]	The contractor shall propose a printable “book” structure for the Sentinel User Handbook (see: http://en.wikipedia.org/w/index.php?title=Special:Book&bookcmd=book_creator&referer=Main+Page) N.B. The contractor shall take care in defining the content of the wiki pages as such as to allow for the generation of a “linear” version of the Sentinel User Handbook. Output: A TN describing the proposed Sentinel User Handbook printable “book” structure.	<input checked="" type="checkbox"/>	§2.3.5 §3.4.4	The link to the Wikipedia site is of limited help as this book creation service is only available to create books from a collection of Wikipedia pages.
[RQT 6]	The contractor shall justify the proposed Sentinel User Handbook “book” structure using the “case studies” derived user requirements. Output: A TN(s) justifying the selected content of the printable “book” version of the Sentinel User-Handbook, as required by the typical “case studies” user requirements.	<input checked="" type="checkbox"/>	§3.4.4	
[RQT 7]	Discuss the suitability of the ESA provided wiki development environment infrastructure, for the development of the Sentinel User Handbook (wiki & “book”). Output: TN proposing and justifying evolutions needed by the contractor on the ESA provided wiki development environment infrastructure.	<input checked="" type="checkbox"/>	§3.4.4	
[RQT 8]	Define the required extent of the multimedia needed for the Sentinel User Handbook content. Output: TN describing and justifying the extent of the multimedia requirements needed in the wiki incarnation of the Sentinel User Handbook.	<input checked="" type="checkbox"/>	§3.4.4	Multimedia items will be suggested quite early, as they need to be adapted to the case study.

SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 9]	<p>Perform a critical analysis of the ESA’s GSCDA web site (gmesdata.esa.int), and provide properly justified recommendations - including a web site map - as to how the Sentinel User-Handbook could interface it “elegantly”.</p> <p>Output: TN including recommendations for the evolution of ESA’s GSCDA web site (gmesdata.esa.int) to interface the Sentinel User Handbook “elegantly”. The TN shall include as a minimum: a) Recommendations, b) A web site map, c) Proper justifications for the recommendations based on the above mentioned case studies.</p>	☑	§3.4.4	
[RQT 10]	<p>Active participation to the Sentinel User-Handbook working meeting at ESRIN</p> <p>Output: Presentations and minutes of the Phase 1 Sentinel User-Handbook working meeting.</p>	☑	§3.4.2.1	ARGANS and the consortium will actively participate to the meeting
Sentinel User Handbook – Phase 2				
[RQT 11]	<p>Update the Technical Notes of [RQT 7], [RQT 8] & [RQT 9] reflecting the agreement reached during the Phase 1 working meeting, and the feedback provided wrt. multimedia content and interface with the ESA-GSCDA web site described above.</p> <p>Output: TNs describing and justifying the contractor requirements wrt. wiki development environment infrastructure, extent of the multimedia needs and evolution of ESA’s GSCDA web site.</p>	☑	§3.4.4	
[RQT 12]	<p>Update the Technical Notes of [RQT 2], [RQT 3], [RQT 4], [RQT 5] & [RQT 6] reflecting the agreement reached during the Phase 1 working meeting, and the feedback provided wrt. multimedia extent and interface with the ESA-GSCDA web site described above.</p> <p>Output: TNs describing and justifying the proposed Sentinel User Handbook wiki and “book” structure.</p>	☑	§3.4.4	
[RQT 13]	<p>The contractor’s consultants shall contribute significantly to the introductory chapters mentioned above, as well as to the service description they are the most familiar with, and provide the contractor with recommendations wrt. the overall wiki structure as well as to the specific content of the more science / user oriented wiki pages.</p>	☑		Consultants will be involved in the writing of high-level sections of the Handbook, in particular the “What can the Sentinels do for you and how?” Section.

SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 14]	The User Handbook shall be in English.	☑		The Handbook will be written in English.
[RQT 15]	The contractor shall include in his proposal a native English speaking professional technical writer, to ensure that the text provided is well written.	☑	§3.2	The project manager is native from England.
[RQT 16]	<p>The contractor shall develop the detailed CONTENT of the Sentinel User-Handbook wiki and “book” as agreed at the end of Phase 1, and confirmed during PM2.</p> <p>N.B. The wiki authoring environment will be based on “Liferay” (http://www.liferay.com) open source software, using the Creole mark-up language (http://www.wikicreole.org/wiki/Home). As mentioned earlier, ESA will provide a ready for use development environment etc... as described under § 1.3 “Assumptions on ESA”.</p> <p>Output: Content (iss=draft) of ALL pages of the Sentinel User-Handbook wiki and “book” as agreed to at the beginning of Phase 2.</p>	☑	§3.4.4	
[RQT 17]	<p>The contractor shall prepare and actively participate to an Sentinel Stake holders consultation meeting, including: Presentation of the Sentinel User Handbook wiki – including justifications based on case studies and associated user requirements, and prepare the Sentinel Stake holder recommendations report.</p> <p>Output: 1) Presentations of the Sentinel User Handbook wiki to the stakeholders 2) Minutes of the Stakeholder’s meeting 3) Stake Holders Recommendations report.</p>	☑	§3.4.2.1	ARGANS and the consortium will actively participate to the meeting
Sentinel User Handbook – Phase 3				
[RQT 18]	<p>For PM3, the contractor shall provide a detailed analysis of the recommendations included in the SENTINELS-Stakeholders recommendation report to be included - in-scope - in the Sentinel User Handbook (wiki and “book”).</p> <p>Output: Sentinel Stakeholders recommendations analysis report.</p>	☑	§3.4.1.1 §3.4.2.1 §3.4.2.2	WP3100 is dedicated to this activity.



SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 19]	For PM3, the contractor shall update of the TN defining the contractor's needs wrt. a) The wiki development environment, its multimedia needs and its interface with ESA's GSCDA web site, in line with the SENTINELS-Stake-holders recommendations analysis report of [RQT 18]. Output: Updates of the TN of [RQT 11] to reflect the analysis of [RQT 18]	<input checked="" type="checkbox"/>	§3.4.4	
[RQT 20]	For PM3, the contractor shall update of the "definition" TN of [RQT 12] in line with the SENTINELS-Stake-holders recommendations analysis report of [RQT 18]. Output: Updates of the TN of [RQT 12] to reflect the analysis of [RQT 18]	<input checked="" type="checkbox"/>	§3.4.4	
[RQT 21]	Actively participate to PM3 to get an approval from ESA regarding the "improvements" suggested by the SENTINELS-Stake holders and selected by the contractor under [RQT 18], N.B. PM3 is foreseen less than one month after the start of Phase 3, and can be considered as a negotiation working meeting with ESA as to the extent of the content improvement between Draft and version-1 to be included in the Sentinel User Handbook to be delivered at the Phase 3 (4 months) Output: Presentation and minutes of the agreement reached during PM3.	<input checked="" type="checkbox"/>	§3.4.4	ARGANS and the consortium will actively participate to the meeting
[RQT 22]	The contractor shall update all relevant TNs (see of [RQT 19] & [RQT 20]) to reflect the agreement reached in PM3. Output: "Interface" and "Definition" TN(s) updated as appropriate in accordance with agreement reached in PM3.	<input checked="" type="checkbox"/>	§3.4.4	
[RQT 23]	The contractor shall complete the development of the CONTENT of the Sentinel User Handbook as agreed to at the end of Phase 2, and confirmed during PM3. Output: Content (iss=1) of ALL pages of the Sentinel User-Handbook wiki and "book" as agreed to at the beginning of Phase 3.	<input checked="" type="checkbox"/>	§3.4.1.1 §3.4.2.1 §3.4.2.2	

SOW Req.	SOW Req. description	Compliance	Traceability	Comment						
[RQT 24]	<p>The contractor shall prepare and actively participate to the “presentation” of the completed Sentinel User Handbook to ESA, including:</p> <ul style="list-style-type: none"> • Demonstration based on users case studies of the iss 1 of the Sentinel User Handbook wiki, including justifications • Presentation of the “book” version of the Sentinel User Handbook, including justifications, • Compilation of the ESA recommendations gathered during the “acceptance meeting”. <p>Output: 1) Presentations of the Sentinel User Handbook wiki and “book” 2) Report listing and detailing the ESA recommendations brought forward during the meeting (This report can be considered as the minutes of this meeting)</p>	<input checked="" type="checkbox"/>	§3.4.2.2	ARGANS and the consortium will actively participate to the meeting						
Sentinel User Handbook – Phase 4										
[RQT 25]	<p>The contractor shall maintain the Sentinel User Handbook wiki, “book” and associated links up to date with regards to: i) Evolution of the mission (i.e. launch dates, models etc.) ii) Availability of characterisation data and evolution of instrument performances, iii) Evolution of the data products iv) Evolutions of the Sentinel’s Data Product Ground Segment (DPGS) v) Evolution of services and user expectations etc.</p> <p>Output: Updates of the Sentinel User Handbook wiki and “book” available on-line via ESA’s GSCDA (gmesdata.esa.int) web site.</p>	<input checked="" type="checkbox"/>	§3.4.1.1 §3.4.1.2 §3.4.2.2	This is the purpose of WP4200						
Sentinel Exploitation Tools										
[RQT 26]	<p>The contractor shall develop data readers for the Sentinel ESA core products of table 1, excluding the SRAL L2 altimetry products. The references to the prod spec – when already available – can be found in annex A.</p> <p>Output: Data readers for:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">NEST</td> <td style="width: 15%;">Sentinel-1</td> <td>SAR L0, L1 SLC, L1 GRD, L2 OCN</td> </tr> <tr> <td>BEAM</td> <td>Sentinel-2</td> <td>MSI L1B, MSI L1C</td> </tr> </table>	NEST	Sentinel-1	SAR L0, L1 SLC, L1 GRD, L2 OCN	BEAM	Sentinel-2	MSI L1B, MSI L1C	<input checked="" type="checkbox"/>	§2.4.3 §2.4.4	<p>All data readers will be developed as requested.</p> <p>Additionally, we will provide product readers for S-2 L1C and the S-2 VGT P and VGT S products.</p>
NEST	Sentinel-1	SAR L0, L1 SLC, L1 GRD, L2 OCN								
BEAM	Sentinel-2	MSI L1B, MSI L1C								



SOW Req.	SOW Req. description		Compliance	Traceability	Comment
	Sentinel-3	OLCI L1, OLCI Water Color L2, OLCI Land L2			
		SLSTR L1, SLSTR Water L2, SLSTR Land L2			
		Synergy/Vegetation L2			
[RQT 27]	<p>The contractor shall develop a data reader for the ingestion of the L2A output products as generated with the native Python S-2 Atmospheric Correction Processor. Output: BEAM data reader for the native S-2 L2A atmospheric correction products.</p>		<input checked="" type="checkbox"/>	§2.4.2.2 §2.4.4.10	The S-2 L2A product reader is part of this offer.
[RQT 28]	<p>The contractor shall integrate the S-2 Atmospheric Correction Processor (coded in Python) as close as possible with the general BEAM toolbox architecture. Possible technical solutions for this integration (such as e.g. development of wrapper plug-in, software interfacing to the Python executable or rewriting the Python code in BEAM compliant JAVA code) shall be discussed and pros and cons shall be critically assessed in the proposal. Output: Software for integrating the S-2 Atmospheric Correction Processor.</p>		<input checked="" type="checkbox"/>	§2.4.4.15	The best integration strategy will be selected.
[RQT 29]	<p>The contractor shall verify that the BEAM-integrated S-2 Atmospheric Correction generates the same output as the native Python code. Output: A test report verifying the correct integration of the S-2 Atmospheric Correction Processor.</p>		<input checked="" type="checkbox"/>	§2.5.4.12	Verified by unit-level and system tests.
[RQT 30]	<p>The data readers shall enable the ingestion of all the Level 0 (for SAR), Level 1 and Level 2 products listed in [RQT 26] above and saving them in the internal BEAM-DIMAP format for further visualisation and processing. Note: In order to display and visualize the S-1 L1 Single Look Complex products the contractor shall adapt the existing NEST SLC debursting and detection tool to the S-1 SLC products.</p>		<input checked="" type="checkbox"/>	§2.4.1.3 §2.4.4.8	Once data is represented in the GPM, it can be saved as BEAM-DIMAP.

SOW Req.	SOW Req. description	Compliance	Traceability	Comment				
[RQT 31]	The data readers shall automatically recognise the type and characteristics of a supported product in order to ingest it correctly.	☑	§2.4.4.2 §2.4.4.3	Detection of the correct product reader for a given data source is part of the BEAM I/O API. Once the Sentinel product type is identified, resulting products will be configured by a dedicated database.				
[RQT 32]	The performance of the loading of very large datasets such as e.g. OLCI products shall be optimised by making use of the tiled imaging approach available in the current BEAM and NEST version.	☑	§2.4.1.3 §2.4.5	We fully agree that the reader optimisation is a very important task and we will carefully address this issue.				
[RQT 33]	<p>After loading the S-1, S-2 and S-3 data products it shall be possible to apply all basic visualisation and analysis functions currently available in the BEAM and NEST Toolboxes:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">For S-2 and S-3 products</th> <th style="width: 50%;">For S-1 products (excluding SAR L0)</th> </tr> </thead> <tbody> <tr> <td> <ul style="list-style-type: none"> • Spectrum view • Flag overlay • Layer Management • Mask management • Band Arithmetic • Geo corrections / projections • Transects • Region of Interest Statistics • Time series • Mosaicking </td> <td> <ul style="list-style-type: none"> • Resampling • Band Arithmetic • Image Filtering • Speckle Filtering • Region of Interest Statistics • Reprojection • Layer Management • Image Analysis • Principle Component Analysis </td> </tr> </tbody> </table>	For S-2 and S-3 products	For S-1 products (excluding SAR L0)	<ul style="list-style-type: none"> • Spectrum view • Flag overlay • Layer Management • Mask management • Band Arithmetic • Geo corrections / projections • Transects • Region of Interest Statistics • Time series • Mosaicking 	<ul style="list-style-type: none"> • Resampling • Band Arithmetic • Image Filtering • Speckle Filtering • Region of Interest Statistics • Reprojection • Layer Management • Image Analysis • Principle Component Analysis 	☑	§2.4.3.1 §2.4.3.2	All of the mentioned tools will also work with Sentinel data.
For S-2 and S-3 products	For S-1 products (excluding SAR L0)							
<ul style="list-style-type: none"> • Spectrum view • Flag overlay • Layer Management • Mask management • Band Arithmetic • Geo corrections / projections • Transects • Region of Interest Statistics • Time series • Mosaicking 	<ul style="list-style-type: none"> • Resampling • Band Arithmetic • Image Filtering • Speckle Filtering • Region of Interest Statistics • Reprojection • Layer Management • Image Analysis • Principle Component Analysis 							



SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 34]	Installation and de-installation of the data readers shall be enabled through the BEAM/NEST module manager.	<input checked="" type="checkbox"/>	§2.7.3.1 §2.7.3.2	The S-1, S-2 and S-3 data readers and the S-2 ACP will be developed as separate modules, which users can install, update and uninstall via the module manager. We will also bundle these modules with the upcoming NEST and BEAM releases.
[RQT 35]	The data readers and the BEAM-integrated S-2 Atmospheric Correction Processor shall run on every platform where the Java VM is available. This includes Windows, Mac OS, Linux and other Unix system.	<input checked="" type="checkbox"/>	§2.4.4.1	Pure Java implementations will be used for all modules.
[RQT 36]	The user shall be able to operate all data readers from within the visualisation tool interface of BEAM/NEST and from the command-line.	<input checked="" type="checkbox"/>	§2.7.3.1 §2.7.3.2	Operation of readers from the command-line will be automatically enabled for applicable GPF operators via the GPT tool using in NEST and BEAM.
[RQT 37]	It shall be possible to read the whole data product or only parts of the product, e.g. selected Measurement Datasets; user-defined region of interest.	<input checked="" type="checkbox"/>	§2.7.3.1 §2.7.3.2	This is a common function of the BEAM API and will be applicable to Sentinel data as well.
[RQT 38]	The functional performance of the BEAM and NEST toolboxes shall be critically assessed using simulated Sentinel products and the main performance bottlenecks shall be identified. The main bottlenecks shall be mitigated by optimising toolbox settings (Java VM settings, tiled memory settings etc.) and code optimisation. In case these optimisations do not yield a satisfactory user experience from a performance point-of-view, solutions for mitigating the performance bottlenecks shall be proposed.	<input checked="" type="checkbox"/>	§2.4.5	A preliminary strategy for the mitigation performance bottlenecks is given in this proposal and will be elaborated in-detail during the detailed design of the readers.
[RQT 39]	The data readers shall be coded as JAVA plug-ins to the existing BEAM and NEST toolboxes ensuring easy portability to different platforms including Windows, Mac OS, and Linux.	<input checked="" type="checkbox"/>	§2.4.4.1	



SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 40]	The data readers shall reuse BEAM and NEST core libraries as appropriate.	<input checked="" type="checkbox"/>	§2.4.4.2	
[RQT 41]	The data readers and the software for integrating the S-2 Atmospheric Correction Processor shall be developed adhering to an iterative & evolutionary software development process model that allows for flexibility in response to evolving user requirements. The Contractor shall create a specific WP for the maintenance of the developed software items to cope with all potential evolutions (such as e.g. changes in product format specifications) during this contract.	<input checked="" type="checkbox"/>	§2.5.3 §0	BC and Array will continue the iterative & evolutionary software development process that was also performed during the development of BEAM and NEST.
[RQT 42]	All software items as soon as they become available shall be integrated as a 1 st delivery into the actual version of the BEAM / NEST toolbox. A final version of each software item shall be delivered at the end of contract at KO + 18 months.	<input checked="" type="checkbox"/>	§2.5.4.19	
[RQT 43]	All software items shall be freely distributed in full source-code and in executable format under the GNU General Public License (GPLv3).	<input checked="" type="checkbox"/>	§1	All project source code will be hosted on a public version control system.
[RQT 44]	High coding standards and code quality shall be enforced by using software tools for automatic code audits, automated unit testing, bug tracking, and version control etc.	<input checked="" type="checkbox"/>	§2.5	BC and Array will continue enforcing the high coding standards and code quality using the development environment that has been used during the development of BEAM and NEST.
[RQT 45]	Documentation shall be kept to the necessary minimum during the iterations as the commented code itself should be the ultimate documentation for future developers.	<input checked="" type="checkbox"/>	§2.5.4.17	ESCC related documents will be provided as requested. We will write and deploy API and detailed design documentation generated by the Javadoc tool.
[RQT 46]	The data readers and the BEAM-integrated S-2 Atmospheric Correction Processor shall be fully tested and verified on representative instrument test data sets containing operational core data products from the Sentinel instruments.	<input checked="" type="checkbox"/>	§2.5.4.12	Integration tests will use the entire test data set for verification of reader functionality.



SOW Req.	SOW Req. description	Compliance	Traceability	Comment																																																																	
[RQT 47]	All software engineering activities shall be based on the ECSS Software Engineering Standards [AD 1] with the tailoring of the requirements in this Standard as specified in the Annex C.	<input checked="" type="checkbox"/>	§2.5.4.18																																																																		
[RQT 48]	The contractor shall define, document and implement a software product assurance programme based on ECSS-ST-Q-80C [AD 5] with emphasis on the requirements specified in Annex D.	<input checked="" type="checkbox"/>	§2.5																																																																		
[RQT 49]	All software development work described in this contract shall be carried out at the Contractor's premises.	<input checked="" type="checkbox"/>	§1																																																																		
[RQT 50]	<p>The Contractor shall deliver the following items:</p> <table border="1"> <thead> <tr> <th>Handbook Deliverable Items</th> <th>Requirements</th> <th>Delivery dates (foreseen)</th> </tr> </thead> <tbody> <tr><td>Case Study Report</td><td>1</td><td>k.o. +2w, 8m & 9m</td></tr> <tr><td>Sentinel User Handbook User Requirements Document</td><td>2, 12, 20 & 22</td><td>k.o. +2m,8m & 9m</td></tr> <tr><td>Sentinel User-Handbook wiki structure description Document</td><td>3, 12, 20 & 22</td><td>k.o. +2m,8m & 9m</td></tr> <tr><td>Sentinel User-Handbook wiki structure justification Document</td><td>4, 12, 20 & 22</td><td>k.o. +2m,8m & 9m</td></tr> <tr><td>Sentinel User-Handbook "book" structure description Document</td><td>5, 12, 20 & 22</td><td>k.o. +2m,8m & 9m</td></tr> <tr><td>Sentinel User-Handbook "book" structure justification Document</td><td>6, 12, 20 & 22</td><td>k.o. +2m,8m & 9m</td></tr> <tr><td>Suitability of User-Handbook wiki development environment</td><td>7, 11, 19 & 22</td><td>k.o. +2m & 9m</td></tr> <tr><td>Multimedia requirements for the Sentinel User-Handbook wiki</td><td>8, 11, 19 & 22</td><td>k.o. +2m & 9m</td></tr> <tr><td>Critical Analysis of ESA's GSCDA web site document</td><td>9, 11, 19 & 22</td><td>k.o. +2m & 9m</td></tr> <tr><td>Sentinel User Handbook Draft</td><td>16</td><td>k.o. +8m</td></tr> <tr><td>Sentinel Stakeholder's recommendations report & analysis</td><td>17 & 18</td><td>k.o. +9m</td></tr> <tr><td>Sentinel User Handbook iss1</td><td>23</td><td>k.o. +12m</td></tr> <tr><td>Recommendation for evolution of the Sentinel User Handbook</td><td>24</td><td>k.o. +12m</td></tr> <tr><td>Sentinel User Handbook iss1.1</td><td>25</td><td>k.o. +18m</td></tr> <tr><td>Monthly Progress Reports</td><td>51</td><td></td></tr> <tr><td>Presentations hands out</td><td>51</td><td></td></tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Software Deliverable Items</th> <th>Delivery dates (foreseen)</th> </tr> </thead> <tbody> <tr><td>S1 Data readers for NEST (1st delivery)</td><td>k.o. + 9m</td></tr> <tr><td>S2 Data readers for BEAM (1st delivery)</td><td>k.o. + 9m</td></tr> <tr><td>S3 Data readers For BEAM (1st delivery)</td><td>k.o. + 9m</td></tr> <tr><td>Integrated S2 Atmospheric Correction Processor (1st delivery)</td><td>k.o. + 15m</td></tr> <tr><td>Final delivery of all software items</td><td>k.o.+ 18 m</td></tr> <tr><td>ECSS related documents as specified in Annex C and D</td><td>As per ECSS Annex C</td></tr> </tbody> </table>	Handbook Deliverable Items	Requirements	Delivery dates (foreseen)	Case Study Report	1	k.o. +2w, 8m & 9m	Sentinel User Handbook User Requirements Document	2, 12, 20 & 22	k.o. +2m,8m & 9m	Sentinel User-Handbook wiki structure description Document	3, 12, 20 & 22	k.o. +2m,8m & 9m	Sentinel User-Handbook wiki structure justification Document	4, 12, 20 & 22	k.o. +2m,8m & 9m	Sentinel User-Handbook "book" structure description Document	5, 12, 20 & 22	k.o. +2m,8m & 9m	Sentinel User-Handbook "book" structure justification Document	6, 12, 20 & 22	k.o. +2m,8m & 9m	Suitability of User-Handbook wiki development environment	7, 11, 19 & 22	k.o. +2m & 9m	Multimedia requirements for the Sentinel User-Handbook wiki	8, 11, 19 & 22	k.o. +2m & 9m	Critical Analysis of ESA's GSCDA web site document	9, 11, 19 & 22	k.o. +2m & 9m	Sentinel User Handbook Draft	16	k.o. +8m	Sentinel Stakeholder's recommendations report & analysis	17 & 18	k.o. +9m	Sentinel User Handbook iss1	23	k.o. +12m	Recommendation for evolution of the Sentinel User Handbook	24	k.o. +12m	Sentinel User Handbook iss1.1	25	k.o. +18m	Monthly Progress Reports	51		Presentations hands out	51		Software Deliverable Items	Delivery dates (foreseen)	S1 Data readers for NEST (1 st delivery)	k.o. + 9m	S2 Data readers for BEAM (1 st delivery)	k.o. + 9m	S3 Data readers For BEAM (1 st delivery)	k.o. + 9m	Integrated S2 Atmospheric Correction Processor (1 st delivery)	k.o. + 15m	Final delivery of all software items	k.o.+ 18 m	ECSS related documents as specified in Annex C and D	As per ECSS Annex C	<input checked="" type="checkbox"/>	§3.4.4	
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SOW Req.	SOW Req. description	Compliance	Traceability	Comment
[RQT 51]	<p>The Contractor shall</p> <ul style="list-style-type: none"> • Provide monthly progress reports including subcontractors activities, • Issue in electronic form the report and associated presentations (if any) 10 days in advance of the meeting • Issue the minutes of meeting in 2 working days after the meeting • Prepare and actively participate to the following meetings: <ul style="list-style-type: none"> o Kick off meeting o PM1 – Definition Phase o Definition working meeting at ESRIN o PM2 – Development Phase o Stakeholder consultation meeting at ESRIN o PM3 – Detailed development Phase o “Acceptance” meeting at ESRIN o PM4 – Maintenance – consolidation Phase o ECSS reviews as specified in Annex C and D o Final presentation at ESRIN 	<input checked="" type="checkbox"/>	§3.4	<p>The consortium requests to relax the constraint to send 10 days prior a meeting all presentations. This will be discussed at the KOM.</p> <p>If not accepted by ESA, the consortium will conform to this requirement.</p>

3. MANAGEMENT PROPOSAL

This chapter corresponds to our management proposal for the “Sentinel User Handbook and Exploitation Tools” project.

3.1. Presentation of the Consortium

The Consortium presented by ARGANS in the framework of this project groups together companies highly qualified and involved in the Sentinel programme.

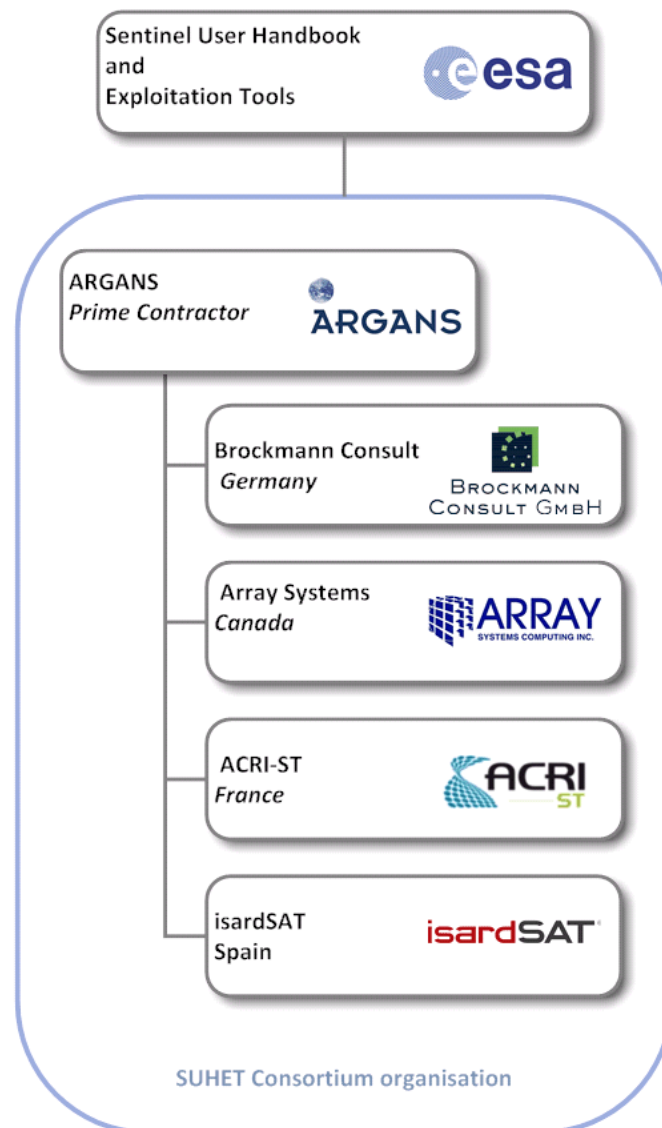


Figure 3-1: Consortium of the “Sentinel User Handbook and Exploitation Tools” project

Prime Contractor:

- ◆ ARGANS (UK) is the prime contractor and the main interface with ESA at the contractual, project management and technical levels;

Sub-contractors:

- ◆ Brockmann Consult (Germany);
- ◆ Array Systems (Canada);
- ◆ ACRI-ST (France);
- ◆ isardSAT (Spain).

3.1.1. Consortium roles and responsibilities

ARGANS acts as Prime Contractor and consequently is in charge of the all project management activities. The technical roles and responsibilities of each company are clearly defined and allocated on the basis of the experience and competences of the companies.

- ◆ Activities related to Sentinel User Handbook (Handbook):
 - ◆ **ARGANS** coordinates all the Handbook activities from the structure definition to its deployment and Handbook SPA Manager. ARGANS also leads the S-2 User Handbook development.
 - ◆ **ARRAY SYSTEMS** leads the S-1 User Handbook development;
 - ◆ **ACRI-ST** leads the S-3 OLCI, SLSTR and SYN User Handbook development.
 - ◆ **isardSAT** leads the S-3 SRAL/MWR L2 User Handbook development.
- ◆ Activities related to Sentinel Exploitation Tools
 - ◆ **Brockmann Consult** coordinates the Exploitation Tools activities, is responsible for the development of S-2 and S-3 readers for BEAM and the integration of ACP into BEAM. Brockmann Consult is also the Tools SPA Manager;
 - ◆ **ARRAY SYSTEMS** is responsible for the development of S-1 readers for NEST.

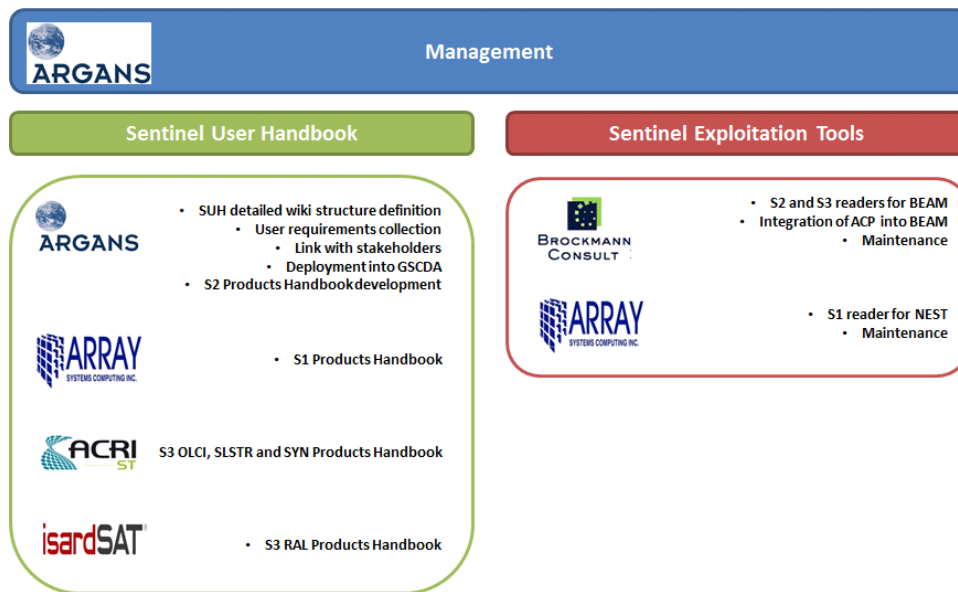


Figure 3-2: Consortium organisation and role

3.1.2. Relevant experiences of the partners

This Section introduces the partners and presents their relevant experience for this project.

3.1.2.1. ARGANS

ARGANS (Applied Research in Geomatics, Atmosphere, Nature and Space) Limited is an independent customer-oriented industrial company of highly skilled and innovative scientists and engineers bringing state of the art research to solve industrial, operational and scientific requirements. It was established as a Private Limited SME (Small to Medium sized Enterprise) Company in the United Kingdom in 2007. The shareholders, including ACRI-ST and the University of Plymouth, have representatives who sit within a Board of Directors.

Its Managing Director is Dr Samantha Lavender; an EO expert who has worked in the field for over 15 years and is involved in both the UK and International research community. Mr Lance Fleischer is the Administrative Director who comes from an international business background and so is responsible for business development/exploitation and overseeing administration.

The operational base is Plymouth (Tamar Science Park, Phase 3 building of our own), which allows ARGANS to make the most of the support for and links with marine activities within the South West through the University of Plymouth and wider Plymouth community. The Tamar Science Park⁴ is a partnership between Plymouth City Council and the University of Plymouth. It maintains a rigid client entry criteria aligned to the internationally accepted ethos of a science park; physical and operational environment that serves as a vehicle for the promotion of innovation, incubation, wealth-creation

⁴ <http://www.tamarsciencepark.com/>

and job-creation through the nurturing of knowledge-based businesses from those first early stages along the continuum to maturity.

From 2010 ARGANS has also initiated a 2nd office at Harwell Oxford (within the Atlas Building, the same location as the European Space Agency, ESA, and Harwell). This offers opportunities for strong collaboration with organisations based on the Campus (e.g. ESA, STFC/Rutherford Appleton Laboratory and UK Space Agency) and a location for meetings/staff close to London and its associated transport infrastructure.

Human Resources is based in Plymouth and ensures that the management of staff, including those at remote locations, is monitored on a day-to-day basis with regular appraisals and appropriate training being offered either in-house or through links with wider organisations including the University of Plymouth. The Head of Admin (Rabiah Nasir-Habeeb) reports directly to the Managing Director and Administrative Director.

Project Managers report to the Managing Director with resources allocated at the project level so that the managers have the required authority and autonomy to lead on project related matters. In addition, a centralised structure provides support to all the projects; examples include the computer servers and underlying infrastructure, project accounting and support to organising meetings/travel.

Activities in the space domain are focused on the development and exploitation of EO missions (see Figure 3-3).



Figure 3-3: ARGANS EO activities

Example projects:

- ◆ **Consultancy:** ARGANS provides expert knowledge support/training to those who wish to use EO data to aid in decision making whether directly or through the assimilation into numerical models. Dr Lavender is Chairman of the Remote Sensing and Photogrammetry Society (RSPSoc) and co-Chair for Oceans Working Group (VIII/9) of the International Society for Photogrammetry

and Remote Sensing (ISPRS). Activities also include peer reviewing proposals, membership of conference/symposia scientific committees, supervision of PhD students.

- ◆ **Earth Observation Quality Control (EOQC)**: in this contract (VEGA, ESA/ESRIN 2008 - 2012) ARGANS is the coordinator for the Optical Instrument Group with become the coordinator for the Optical Instrument Group with operational responsibility for Landsat, MERIS, Moderate Resolution Imaging Spectrometer (MODIS) and Sea-viewing Wide Field-of-view Sensor (SeaWiFS). The regular activities include: contributions to daily, cyclic and monthly reports; technical notes, Frequently Asked Questions (FAQ) and quality control plans; input to the evolution of the service.
- ◆ **EC GMES Downstream service, Aquamar**: in this contract (Thales Alenia Space, EC 2010 – 2013), under FP7 GMES programme, in the context of Marine downstream Services linked to water quality, ARGANS leads the User Training within Aquamar.
- ◆ **EC GMES Downstream service, OSS-2015**: in this contract (ACRI-ST, EC 2011 – 2014), under FP7 GMES programme, ARGANS works alongside 9 partners (6 scientific research institutions and 3 SMEs) to generate and validate satellite derived global time series of advanced biogeochemical products for carbon cycle science; derive 3D and 4D representations of biogeochemical variables from the integration of in situ (gliders and floats) and satellite data into cutting-edge numerical biogeochemical and bio-optical models; implement a prototype platform of "on-demand" services for product generation and distribution; analyse the social and economical benefits / value of the products and services generated.
- ◆ **International Charter Space & Major Disasters**: In this contract (ESA/ESRIN 2009 - 2012), ARGANS provides support to ESA in implementing actions defined by the Charter Executive Secretariat with a primary focus on the development of the Charter in Africa in collaboration with GEO and its Secretariat in Geneva. This is through a programme of organised meetings and workshops and promotion materials to explain the Charter, its activities and how it can be activated.
- ◆ **MEREMSII**: In this contract (ESA/ESTEC 2010 - 2012), ARGANS provides support to the DIMITRI (Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison) development and defining the key elements to put in place to go towards an operational radiometric calibration of the medium resolution multi-spectral imager component of GEOSS. These activities are linked to the CEOS Working Group on Calibration and Validation subgroup on Infrared and Visible Optical Sensors chaired by Dr Nigel Fox from the National Physics Laboratory, UK.
- ◆ **MERIS and GOMOS Software maintenance and evolution and support to CAL/VAL operations**: In the frame of this contract (ACRI-ST, ESA/ESRIN 2008 - 2012), ARGANS is responsible for the maintenance of the MERIS match-up database (MERMAID); update of the MERIS reference model for the ocean; studies aimed at improving algorithms, analysis of the MERIS products and new ideas put forward by the Quality Working Group (QWG).
- ◆ **MERIS Coastal**: ARGANS leads the contract (ESA/ESTEC 2008 – 2012) that is developing the MERIS Bright Pixel Atmosphere Correction and undertaking laboratory plus fieldwork to quantify the near-infra red optical signal.

- ◆ **Radiative Transfer Modelling**: ARGANS is developing a software suite to scientifically model light transfer / the radiance distribution in both terrestrial and underwater environments. Internal work is being undertaken via the Software as a Service model where the code is run on specifically tailored in-house hardware; use of Graphical Processor Units. Externally funded projects being supported include: predicting the impacts of dredging on seagrass with Edith Cowan University (Australia).
- ◆ **Sentinel-3 OLCI and SLSTR**: ARGANS leads the contract (ESA/ESRIN 2008 - 2012) that is developing the L2 and L3 algorithms and Level 2/3 prototype processing software for the OLCI & SLSTR instruments plus the synergy products of the two. This is a large contract that includes many companies and scientific institutions/universities across Europe.
- ◆ **SMOS Salinity Level 2 processor**: In this contract (ESA/ESRIN 2008 - 2012) ARGANS has developed the SMOS L2 Ocean Salinity processor; used to process L1 to L2 data products. The processor will be released to the community and used to produce the ESA products.
- ◆ **WaterRadiance**: In this contract (HMZ, ESA/ESTEC 2009 - 2012) ARGANS is working with European and International experts to develop a new optical model for water and corresponding advanced ocean colour remote sensing algorithms that make use of the new spectral bands provided by the S-3 mission, and in particular to make use of the extended spectral range into the UV and NIR/SWIR spectral range.

3.1.2.2. Brockmann Consult

Brockmann Consult GmbH (BC) is a private company, founded in 2002, and offering scientific consultancy and environmental informatics services. The company is actively involved in the service provision and software development for Earth Observation data management and processing. Brockmann Consult GmbH is led by Dr. Carsten Brockmann, a physical oceanographer, who has been working now for over 20 years in the fields of optical remote sensing and software development. The current 30 employees are a mix of software engineers, physicists and environmental scientists. Brockmann Consult has two branches: Environmental Informatics and Geoinformation Services, which complement each other. The objective of Environmental Informatics is the development of custom made software solutions for environmental data. A major part of the activities of Brockmann Consult is system development for Earth Observation Processing Systems. Brockmann Consult has been and is deeply involved in the preparation, quality control and evolution of software for the processing of MERIS data. BC has long term experience in professional software development for EO data (BEAM, ESOV-NG, Calvalus) and operational service provision for coastal and marine environmental monitoring (customers are national and European monitoring agencies). BC is priming the ESA CoastColour project which has the objective to develop and distribute best quality coastal water quality products to global coastal users, including NRT service. The company is continuously improving its technical and scientific capabilities through RD activities, including EC-funded projects. The company is providing services to the European Space Agency ESA for software development, validation activities and EO data service provision. Within the GSE projects CoastWatch and MarCoast, BC has implemented and established its Water Quality Service System (WAQSS). This service compasses several products derived from Earth Observation data, tailored to users' needs.

One of the most successful activities of Brockmann Consult is the development of the BEAM Earth Observation data processing and analysis software on behalf of ESA. BEAM is a collection of tools for the visualisation, interpretation, conversion and processing of optical and radar EO data. The success of the open source BEAM project is based on the deep involvement of the company in the development, verification and validation of the operational MERIS processor.

The objective of the Geoinformation Services group is the provision of custom made information products and consultancy services, connected with environmental data. This includes value-added products and thematic information derived from remote sensing data and scientific consultancy for environmental concerns. WAQSS has been developed during the past years, partly funded by GMES activities such as MarCoast. WAQSS is providing satellite derived information for coastal waters and intertidal flats to customers around the North Sea and Baltic Sea and is currently extended to new products including lakes and combined products **including ecosystem modelling**.

The customers of Brockmann Consult are mainly from public agencies and administrations, both on national and European levels. A selection of projects which BC has undertaken in recent is shown hereafter.

BEAM BEAM	
<p>BEAM is a toolbox for viewing, analysing and processing of optical remote sensing data. It was originally developed to facilitate the utilisation of image data from Envisat's optical instruments MERIS and AATSR. Today, BEAM supports a growing number of other sensors such as MODIS, AVHRR, AVNIR, PRISM and CHRIS/Proba.</p> <p>BEAM is an open source project, comprising a collection of executable tools and an application programming interface (API).</p>	<p>from 2003 to 2010</p>
<p>Contact Person: Norman Fomferra</p>	

Calvalus	
<p>Calvalus is a high performance processing system, that fulfils the needs of rapid improvement, development, processing and validation of Earth Observation data products. The processing system based on Apache Hadoop, an open-source implementation of the MapReduce programming model combined with a Distributed File System. Both concepts have first been published by Google Labs and are addressing the analysis of ultra-large datasets. Calvalus gains its performance from massive parallelisation of tasks and the "data-local" execution of code (software programs are brought to the data, not the other way round) and operates on a cluster</p>	<p>from 2009 to 2011</p>

of 20 commodity computers.

The Calvalus study is an [ESA LET-SME](#) project.

Contact Person: [Norman Fomferra](#)

BEAM Scientific Processors

Brockmann Consult is supporting scientific laboratories and ESA in developing processors for BEAM. A processor is generating new products from Earth Observation input data: from 2003 to 2009

- ICOL ... Adjacency correction for MERIS data (project lead by Prof. Richard Santer, LISE, France)
- Case2Regional ... Atmospheric correction and retrieval of water constituents over Case 2 waters (project lead by Dr. Roland Doerffer, GKSS, Germany)
- Lakes ... Atmospheric correction over lakes and retrieval of water constituent concentrations (project lead Sampsa Koponen, Technical University Helsinki, Finland)
- Glint ... Correction of glint reflectance for MERIS (project lead by Dr. Roland Doerffer, GKSS, Germany)
- O2 ... Retrieval of atmospheric parameters from measurements in the oxygen absorption band (project lead Prof. J. Fischer, Freie Universität Berlin, Germany)
- Synergy ... Synergistic use of AATSR and MERIS for cloud detection, aerosol retrieval and atmospheric correction over land (project lead P. North, University Swansea, UK)
- MERIS Land ... Atmospheric correction over land and retrieval of fAPAR, LAI (leaf area index) and fraction of cover (project lead by B. Berthelot, Noveltis, France)

Contact Person: [Norman Fomferra](#)

BEAM Instrument Toolboxes

Brockmann Consult is developing toolboxes supporting specific earth observation instruments. The toolboxes are based on BEAM technology and implement specific processing functions based on user requirements. from 2006 to 2008

- Chris-Box ... Supporting the multi spectral / multi-view instrument Chris on the Proba satellite
- Smos-Box ... Supporting the Soil Moisture and Ocean Salinity Sensors SMOS (launch Nov. 2008)
- NEST ... NEST is the next generation SAR toolbox supporting a wide range of currently flying and future SAR instruments. The Prime contractor for the NEST development is Array Systems, Canada, with support by Brockmann Consult. NEST is fully based on BEAM technology. NEST and BEAM will be compatible on product as well as on plug-in level.
- AVISA and IAVISA ... Tools supporting AVHRR and IASI on Eumetsat Metop satellites for the special purpose of cloud labelling

Contact Person: [Norman Fomferra](#)



[CHRIS Toolbox for BEAM](#)

BEAM is an ESA funded open-source toolbox and development platform for viewing, analysing and processing of remote sensing raster data. Originally developed to facilitate the utilisation of image data from Envisat's optical instruments, now supports a growing number of other raster data formats. A dedicated set of tools for CHRIS/Proba has been developed under the BEAM toolbox framework. CHRIS products are provided in top of the atmosphere (TOA) radiance (Radiometrically calibrated data). The noise reduction and geometric correction tools are preprocessing steps for cloud screening and atmospheric correction tools, which together the CHRIS Toolbox. from 2007 to 2010

Contact Person: [Dr. Ralf Quast](#)

3.1.2.3. ARRAY

Array Systems Computing Inc. is a privately owned Canadian company that was established in 1981. Array has more than 80% of its technical staff holding graduate degrees from some of the finest Canadian and international universities. Array has become a recognised leader in scientific interdisciplinary computer solutions, specialising in quality software development and systems integration. The company's continued success has been the result of its superior capabilities in advanced computing, high-speed signal processing and image and analysis applications.

Array's annual business volume is <\$10Million. Array's main markets include the domestic and international defence and telecommunications industries, specialising in the area of signal processing and display systems. Array's key customers include the Canadian Department of National Defence (DND), Defence Research and Development Canada, Canada Centre for Remote Sensing, CSA, ESA, Försvarets materialverk Sweden, Bundesamt für Wehrtechnik und Beschaffung Germany, United Kingdom's Ministry of Defence (through Thales Sensors Ltd.), the United States Navy (through Northrop Grumman), Lockheed Martin, and AT&T.

Array's technical team is highly experienced in developing SAR technologies and applications of comparable scope and complexity. The proposed team possesses all the capabilities required to perform the work on time, within budget and meeting the requirements of the ESA.

Array has significant experience in remote sensing and a long history of successfully delivered operational systems. Our areas of expertise include developing leading-edge algorithms, producing complex systems, and performing system integration. We first became involved with airborne SAR surveillance systems in the early 1980's, and have worked on a number of advanced development projects since then. Array has also provided SAR technology expertise to Japan, Korea, Brazil and Turkey and is currently under contract to CSA to develop the RADARSAT-2 Toolbox and to ESA to develop NEST.

In addition to radar, Array has also been actively involved in the area of remote sensing. Array offers remote sensing technology to its customers by tailoring each installation to satisfy the user's specific needs. We can provide satellite ground station components, or complete turnkey systems. We also participate in technology transfer and development programs. Array has been an active partner in Canadian and international Remote Sensing programs since its inception. Array's most recent contribution in the area of remote sensing is the implementation of the L2 Soil Moisture prototype processor and core operational processor for the SMOS satellite for the ESA.

Array has developed processors for many Earth Observation satellites including RADARSAT, ERS, SPOT, Landsat, and others. The company has a deep understanding of the scientific and operational issues related to the development of Ground Segments and is very familiar with the needs of the user community in this area. Array is experienced with a variety of data formats supported by the operational processors. The company's contributions to the remote sensing industry include the first real-time SAR processor for the Canadian RADARSAT satellite (FastScan); a toolkit for conversion between various data products including CEOS, TIFF, HDF, etc. (Image Exchange); an image analysis

and calibration analysis system for RADARSAT (Image Data Calibration Workstation); and several ground processing segments for the governments of Canada, South Korea and Malaysia (High Resolution Picture Transmission, Canadian Earth Observation Architecture).

Table 3-1: Array Relevant Experience

Wiki developments
<p>Array is quite familiar with developing web content using Liferay. Array's project websites for the NEST Toolbox, SMOS L2 processor and the GEOINT Toolbox are all based on Liferay. Array configures and manages the websites used by thousands of users to download software, participate in forums and get access to the latest information.</p>
<ul style="list-style-type: none"> ▪ NEST Liferay website ▪ SMOS L2 Processor website ▪ GEOINT Liferay website
Sentinel-1 experience
<p>Array has extensive experience developing SAR processors and SAR simulations.</p> <p>Array is quite familiar with the S-1 documentation. Array has previously examined the feasibility of developing a S-1 reader for simulated Sentinel-1 products at the request of Dr. Daniel Sabel and Dr. Wolfgang Wagner of the Microwave Remote Sensing Group of the Vienna University of Technology.</p> <p>Array's team has substantial experience in remote sensing and SAR in particular. Array has taught SAR theory courses, SAR tools user courses and developed several user documents and manuals for the projects listed below.</p>
<ul style="list-style-type: none"> ▪ NEST ▪ RADARSAT-2 Toolbox ▪ GEOINT SAR Toolbox ▪ Replacement Maritime Patrol Aircraft ▪ SAR Simulation Toolbox ▪ FastScan SAR Processor ▪ RADARSAT Precision Processor ▪ Image Display and Calibration Workstation
NEST experience
<p>No other company has greater insight into the development of NEST than Array. Array has been developing NEST for ESA since 2007. Array has added readers and processing support for RADARSAT-2, TerraSAR-X and Cosmo-Skymed which share a similar effort to Sentinel-1.</p> <p>Array has developed polarimetric and interferometric tools for the CSA, Canadian Forest Service and GSC with the RADARSAT-2 Toolbox based on NEST.</p> <p>Array is currently developing enhancements to the RADARSAT-2 Toolbox based on NEST in support of SMOS time series analysis and soil moisture retrieval from RADARSAT-2 polarimetric data for CSA and Agriculture Canada.</p> <p>Array has developed change detection and area of interest monitoring tools for operational Arctic surveillance for the Canadian Department of Defence with the GEOINT SAR Toolbox based on NEST.</p>
<ul style="list-style-type: none"> ▪ NEST ▪ RADARSAT-2 Toolbox ▪ GEOINT SAR Toolbox

Summary of few of these projects is provided below. All projects are described in ARRAY's proposal.

<p>Project Title: RADARSAT-2 Toolbox</p>		
<p>Client Organization: Canadian Space Agency (ESA)</p>	<p>Start Date: December 2010</p>	<p>End Date: (Planned) March 2012</p>
<p>Project Personnel & Roles: Rajesh Jha – Project Manager; Luis Veci – Project Engineer; Jun Lu – Project Scientist</p>		
<p>Project Description: Array was awarded a contract by the CSA under the Earth Observation Application Development Program to develop an Open Source RADARSAT-2 Toolbox (RSTB). The primary objective of the project is to develop an Open Source RADARSAT-2 specific toolbox for processing, visualising and analyzing of RADARSAT-2 SAR products. Having the RSTB available to process, visualize and analyze RADARSAT-2 data would encourage government organization, industry and academia to maximize their utilization of RADARSAT-2 to produce more scientific research and applications.</p> <p>The project is in collaboration with the Canadian Forest Service and the GSC to enhance their Radarsat-2 analysis capabilities. Together, the project hopes to cooperate with and support some of the largest users of RADARSAT-2 data.</p> <p>RSTB provides a suite of tools for processing polarimetric data. RSTB also adds to the interferometric tools of NEST. RSTB will be tested against all types of RADARSAT-2 products and in particular making use of several multi-temporal stacks of polarimetric RADARSAT-2 products over different parts of Canada. Usability will also be improved through the development of a searchable product database, enhanced labelling and reporting tools and wizards.</p> <p>The RADARSAT-2 Toolbox will include:</p> <ul style="list-style-type: none"> ▪ The ability to read, visualize and process all modes and products for RADARSAT-2 ▪ Calibration of RADARSAT-2 products ▪ Terrain Correction and Radiometric Normalization of RADARSAT-2 products ▪ Co-registration of Quad-Pol RADARSAT-2 products ▪ Polarimetric Decomposition and Exploitation Tools ▪ Polarimetric Speckle Filtering ▪ Differential Interferometric Tools ▪ Data Fusion with data products from other missions ▪ Searchable Product Database ▪ Enhanced Labelling and Reporting Tools 		

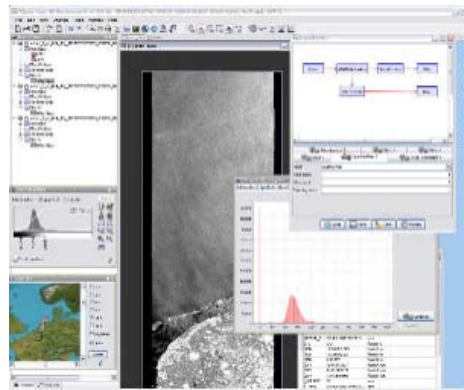
▪ Simplified Wizards for Novice Users

The RADARSAT-2 Toolbox is fully compatible with NEST thereby allowing both projects to share modules and enhancements while maintaining their own identity.

The development of an open source RADARSAT-2 specific toolbox for processing and analysis of polarimetric and interferometric RADARSAT-2 data will help develop the Canadian EO community by freely providing the tools to process, analyze, train and develop with the new capabilities of RADARSAT-2. The project has been managed on budget and on schedule to date.

The project is relevant because it adds polarimetric functionality to the NEST Toolbox and includes several tutorials, wizards and training.

Project Title: NEST



Client Organization:
ESA

Start Date: October 2007

End Date: Ongoing

Project Personnel & Roles: Rajesh Jha – Project Manager; Luis Veci – Project Engineer; Jun Lu – Project Scientist

Project Description:

NEST is used for reading, post-processing, analyzing and visualizing the large archive of data from ESA SAR missions including ERS-1 & 2, ENVISAT and eventually Sentinel-1, as well as third-party SAR-data from JERS SAR, ALOS PALSAR, TerraSAR-X, RADARSAT-1 and RADARSAT-2. NEST will help the remote sensing community by handling ESA SAR products and complimenting existing commercial packages.

Array's role is as Prime Contractor on the NEST programme. Array is responsible for the development of all the NEST software, using the Java programming language. NEST is licensed as an open-source project under the GNU Public Licence (GPL). Array has developed NEST following an iterative development methodology, which has included regular interim releases of the software to the user community. The development methodology of NEST is driven by the demands of the user community. Software releases are made regularly, with a three-month cadence, and the features to be included in the next release are determined by considering the feedback from the user community. The NEST website (<http://www.array.ca/nest>), which includes forums as well as software downloads, provides a focal point for this community to coalesce around.

The main components of the NEST are as follows:

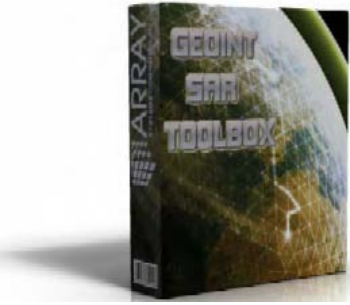
- DAT - A desktop application used for EO data visualisation, analysing and processing.
- A rich collection of readers and writers to allow easy and efficient access to SAR data, abstracted internal representation and output to common formats for compatibility with other software.
- A set of scientific data processors running either from the command line or invoked by DAT.
- A powerful and flexible graph processing framework to create user-specified processing chains.

- An API which provides ready-to-use components for remote sensing related application development and plug-in points for new NEST extension modules.

In addition to standard image analysis and manipulation tools, NEST supports calibration, speckle filtering, coregistration, orthorectification, mosaicking and interferometric processing of SAR images from the different missions.

NEST provides a solid foundation for the development of additional remote sensing tools, and provides an integrated environment within which all image analysis and product generation may be performed.

The NEST project has been considered to be successful to date. Regular software releases have been made on a three-monthly basis, with each release offering incremental improvements and new features. The NEST user community has been gradually building in size. More than 3000 NEST users have registered on the project website. The NEST toolbox is seeing increasing use in the remote sensing community. The project has been managed on budget and on schedule.

<p>Project Title: GEOINT SAR Toolbox</p>			
<p>Client: DND</p>	<p>Organization:</p>	<p>Start Date: Jun 2010</p>	<p>End Date: Maintenance</p>
<p>Project Personnel & Roles: Luis Veci – Software Lead; Jun Lu – Software Developer</p>			
<p>Project Description:</p> <p>The GEOINT SAR Toolbox was licensed to DND for use in project Polar Epsilon for coherent change detection of RADARSAT-2 products. The coherence maps generated by the software will be used by the Arctic Surveillance (Land) (AS(L)) operator (AS Op) as one of many inputs to the generation of intelligence and information image products in response to requests from operational units within the Canadian Forces.</p> <p>The software was delivered on time and within budget and is currently in use operationally by the Arctic Surveillance Land Image Analyst.</p> <p>This project is relevant as it is an operational system at DND based on the NEST framework.</p>			

3.1.2.4. ACRI-ST

ACRI was established in Sophia Antipolis, France, in 1989 and is a SME of more than 100 staff, in France and abroad. Its earth sciences branch, ACRI-ST, is a supplier of space agencies in all Phases of Earth Observation missions including system requirements, analysis and ground segment design, mission operation and environmental services provision towards final users.

ACRI-ST has more than twenty years of experience in the **definition, specification, development, maintenance, operation** and exploitation of Earth Observations missions.

Table 3-2: ACRI-ST relevant experience

Deep knowledge of the Sentinel-3 Optical mission (OLCI, SLSTR and SYN)

ACRI-ST has a deep **knowledge of the Sentinel-3 Optical mission**. Indeed, ACRI-ST is a member of the **core team** led by Thales Alenia Space – France, awarded by ESA for Sentinel-3 B2/C/D/E1 program. ACRI-ST is responsible for the development and procurement of the **Optical Ground Processing Prototype (O-GPP)** for the two Sentinel-3 satellites (S-3-A and S-3-B) and the associated expertise:

- ◆ Consolidation of the performance requirements
- ◆ Support to the development and the validation of the operational level 0, level 1b processor
- ◆ Support to the development of the instruments
- ◆ Assessment of the end-to-end mission performances
- ◆ Support during the In Orbit Commissioning Phase

The activity includes:

- ◆ the detailed definition of OLCI and SLSTR L0 and L1b products
- ◆ the detailed definition of OLCI and SLSTR L0 and L1b algorithms
- ◆ the detailed definition of SYN L1c products and algorithms
- ◆ Under TAS-F/DEIMOS contract, ACRI-ST is responsible for the development of the OLCI instrument simulator software inside the S-3-OSPS simulation system;
- ◆ Under TAS-F/DEIMOS contract, ACRI-ST is responsible for the development of the SLSTR and OLCI Target scene simulator software inside the S-3-OSPS simulation system;
- ◆ Under ESRIN/ARGANS S-3 Ground Segment GMES contract, ACRI-ST is responsible for the Sentinel 3 optical payload (OLCI, SLSTR, SYN) ground processing prototype, L2;
- ◆ Within ESRIN/ARGANS consortium, ACRI-ST is in charge of the OLCI L2 prototype detailed algorithms specification.

Experience in designing optical instrument processing facilities

- ◆ Under ESA contracts, ACRI-ST has successfully performed the **three re-processing and dissemination towards ESA of MERIS L1b, L2 and L3 products** relying on an operational system designed and developed by ACRI-ST to acquire level 0 and auxiliary data, process, archive, catalogue and disseminate higher level products. The full operational system has been developed and is permanently operated by ACRI-ST.
- ◆ Since 2002, ACRI-ST manages a full MERIS RR archive, including L0 to L3 data.
- ◆ ACRI-ST has successfully led the **ESA DUE GlobColour project** (2005-2009) which has evolved into an operational system serving merged Ocean Colour products to a continuously increasing user community (September 2011: 977 users and 13 Tb of products distributed through 1.200.000 files).

- ◆ In the frame of the **ODESA project**, ACRI-ST has designed, implemented and is currently maintaining and operating an on-line processing service allowing any registered user to process MERIS L0 products on a specified area and time range with different versions of the MERIS prototype software (MEGS). This system has been intensively used during the validation stage prior to the MERIS 3rd reprocessing activities performed in ACRI-ST. The processing system is available at http://www.odesa-info.eu/process_basic. ODESA hosts the Ground Processor Prototype of the whole S-3 optical L2 processing chain.
- ◆ **EC GMES MyOcean**: under FP7/2007-2013 GMES programme (grant agreement n° 218812), in the context of Marine Core Services, ACRI-ST is the operator of the **global Production Unit of the Ocean Colour Thematic Assembly Centre**, thanks to its acknowledged experience in processing, validating, archiving and disseminating satellite ocean colour data.

Experience in algorithm specification and development for EO missions

MERIS

- ◆ Specification, development and maintenance of the MERIS ground-segment prototype (MEGS).
- ◆ Specification and development of the MERIS L3 generation software (MKL3).
- ◆ Specification of the detailed definition of MERIS L1, L2 and L3 products.
- ◆ Specification of the detailed definition of MERIS L1, L2 and L3 processing algorithms.
- ◆ Specification and development of the MERIS in-flight calibration software (MESCAL).
- ◆ Specification, development and validation of the MERIS end-to-end processing chain

Knowledge of existing Optical instruments and Optical data products

ACRI-ST has more than twenty years of experience in the development and exploitation of Earth Observations missions and in optical sensors missions. In particular ACRI-ST has been involved in the MERIS mission on-board ENVISAT since its mission specification in the early 90's until the successful leadership of the consortiums for L1 and L2 processors since 1996, followed by the commissioning and still on-going CAL/VAL and maintenance activities.

In this context, ACRI-ST is also playing a role of coordination of Expert Support Laboratories (reference for the algorithms and products Level 1 & 2) for MERIS. Such ESLs are teaming all European Laboratories involved in the MERIS data processing and quality assessment. ACRI-ST is also responsible for the management of the MERMAID database (processing and extraction facilities, database, web portal, maintenance and operation).

ACRI-ST is coordinating Expert Support Laboratories (reference for the algorithms and Level 1 & 2 products) for the following Earth Observation missions:

- ◆ **MERIS**: head and coordinator of the MERIS Expert Support Laboratories (ESLs) – the consortium of European laboratories and private companies - to define and validate the scientific algorithms used for the MERIS data processing.
- ◆ **GOMOS**: head and coordinator of the GOMOS ESLs – FMI (Finland), SA (France) and IASB (Belgium) - to define and validate the scientific algorithms used for the GOMOS data processing.

These ESL facilities include validated end to end processors (Level 1 & 2), end to end simulators, atmosphere and target models, calibration and data analysis support tools and associated databases (including the generation of the look-up tables which are being used in the data product processors).

ACRI-ST has coordinated the CAL/VAL activities for the MERIS and GOMOS Commissioning Phase.

ACRI-ST is a member of the MERIS and GOMOS Quality Working Groups.

Under CNES contract, ACRI-ST is performing several trade-off analysis studies for future geostationary ocean colour mission. In 2010, ACRI-ST has been awarded by CNES the national frame contract on Ocean Colour algorithms development and validation for the period 2010-2015.

ACRI-ST co-operates with several international organisations:

- ◆ ACRI-ST and LOV are joining their research activities on ocean colour through a “Groupement d’Intérêt Scientifique” (GIS) called COOC (for “COuleur de l’OCéan”) starting in 2010 and which is intended to be the basement of a scientific cluster addressing ocean colour sensing, algorithms, calibration/validation and applications;
- ◆ ACRI-ST team members are PI of CROCS: Collaborative Research for Ocean Colour Sciences in response to the ISRO OCEANSAT-2: Announcement of Opportunity;
- ◆ ACRI-ST team members are co-PI of the Ocean Color Research & Applications proposed in response to the GOCI Announcement of Opportunity (PI David Antoine LOV);
- ◆ ACRI-ST team members participate to the MERIS Quality Working Group (QWG) and to the MERIS and AATSR Validation Team (MAVT).

Experience in Ground Segment projects

- ◆ Development and integration of the L1 processor of the SMOS instrument in the frame of the CATDS (SMOS Data Processing Downstream Center).
- ◆ Development and integration of the SMOS L1c and L2 data processing chains in the CATDS environment (CNES contract);
- ◆ SMOS commissioning Phase and CAL/VAL activities: SMOS data validation;
- ◆ ACRI-ST has performed a successful integration of the L2 Ocean Salinity prototype in the operational IPF.
- ◆ **METRIC:** MERIS Extraction Tool for Radiometric Indirect Calibration: operated by the IECF at ESRIN, systematically fed by MERIS L1 child products over calibration sites (Desert and Oligotrophic), proceeds to data extraction, filtering and formatting to provide external vicarious calibration experts (CNES, RAL, EUMETSAT).
- ◆ **AMORGOS:** ACRI-ST has developed and maintains the Accurate MERIS Ortho-Rectified Geolocation Operational Software (AMORGOS) tool whose objective is to generate accurate geolocation information - longitude, latitude, altitude for each MERIS pixel, starting from a MERIS Full Resolution product: either a Full Swath or a standard half-swath Scene product. (<http://earth.esa.int/object/index.cfm?fobjectid=4410>)
- ◆ **MESCAL:** MERIS Calibration software includes the operational in-flight calibration data processing (radiometric and spectral, as well as ground characterization data post-processing tools. Operated by the IRCF at ESRIN each time a calibration LO is available.
- ◆ Specification, development and implementation of the GOMOS - on-board Envisat - in-flight calibration software (CALEX). CALEX is used inside the Envisat IECF on a weekly basis to automatically update the GOMOS calibration ADFs: dark charge maps, wavelength assignment.

- ◆ Under the **DPQC programme**, ACRI-ST was responsible for providing support to Quality Control of products generated by ESA's MERIS instrument aboard Envisat (SERCO 2007 - 2008).
- ◆ Under the **IDEAS programme**, ACRI-ST is responsible for providing support to Quality Control of products generated by ESA's MERIS instrument aboard Envisat (VEGA Ltd 2008 - on going).
- ◆ In the frame of the **Collaborative Ground Segments** envisaged by ESA in the frame of the Sentinels ground segment, ACRI-ST, in partnership with CLS, IFREMER, SHOM and other French players, has been awarded a grant by the French Ministry of Industry and to three French regions for the development of a **Marine Collaborative Ground Segment (MCGS)**. This MCGS will be set-up to generate further regional, global, and NRT (Near Real Time) products, in order to feed the development of downstream commercial services on Ocean products, including coastal applications, and Hydrology. The MCGS will process Ocean data (colour, temperature, topography) from S-3, and products from S-1. The MCGS project has started in August 2011 and will be achieved in April 2014; the collaborative ground segment being ready at the time of launch of S-3.

ACRI-ST specific knowledge of the Sentinel-3 Optical mission

ACRI-ST has a deep **knowledge of the Sentinel-3 Optical mission**, and especially OLCI. Indeed, ACRI-ST is a member of the **core team** led by Thales Alenia Space – France, awarded by ESA for S-3 B2/C/D/E1 program. ACRI-ST is responsible for the development and procurement of the **Optical Ground Processing Prototype (O-GPP)** for the two S-3 satellites (S-3A and S-3B) and the associated expertise:

- ◆ Consolidation of the performance requirements
- ◆ Support to the development and the validation of the operational L0, L1b processor
- ◆ Support to the development of the instruments
- ◆ Assessment of the end-to-end mission performances
- ◆ Support during the In Orbit Commissioning Phase

The activity includes:

- ◆ the detailed definition of **OLCI and SLSTR L0 and L1b products**
- ◆ the detailed definition of **OLCI and SLSTR L0 and L1b algorithms**
- ◆ the detailed definition of **SYN L1c products and algorithms**
- ◆ Under TAS-F/DEIMOS contract, ACRI-ST is responsible for the development of the OLCI instrument simulator software inside the S-3-OSPS simulation system;
- ◆ Under TAS-F/DEIMOS contract, ACRI-ST is responsible for the development of the SLSTR and OLCI target scene simulator software inside the S-3-OSPS simulation system;
- ◆ Under ESRIN/ARGANS Sentinel 3 Ground Segment GMES contract, ACRI-ST is responsible for the Sentinel 3 optical payload (OLCI, SLSTR, SYN) ground processing prototype, L2;
- ◆ Within ESRIN/ARGANS consortium, ACRI-ST is in charge of the OLCI L2 prototype detailed algorithms specification.

3.1.2.5. isardSAT

isardSAT is a Catalan research enterprise that provides engineering and scientific services in the field of Earth Observation.



The company founder had ten years of experience in the ESA as the System Performance Engineer of the Envisat Radar Altimeter (RA-2) instrument. This provides isardSAT with not only high knowledge of the technical aspects of a complete system, but also with a deep knowledge of the ESA product development cycle and its high quality standards required.

isardSAT is an enterprise leader in the first level of processing of radar altimetry data from ESA satellites. isardSAT is involved in the design, calibration and maintenance of civil remote sensing radar instruments. Finally, isardSAT performs studies for scientific applications with the data acquired by these instruments.

isardSAT is organised in two lines of knowledge and experience that work together in order to achieve the best performance in domains such as developing new algorithms, technologies and products for scientific applications: one line of remote sensing instrumentation and one line of applications. On the one hand, isardSAT develops projects that require knowledge on the measuring instrument and that are therefore led by engineers (instrumental department). On the other hand, isardSAT undertakes projects that require a deeper knowledge of the final application (scientific applications department) which are typically led by scientist. Synergies between the two departments allow achieving higher quality and utility results.

isardSAT aims at improving our knowledge of the Earth by understanding the nature of its changes. In order for us to achieve this knowledge and do science we first need to understand the data acquired over the Earth. We believe that only when we understand the way these data have been acquired by the instruments, and therefore the instruments themselves, we will be able to achieve the scientific objectives and properly assess the errors in such process.

Table 3-3: isardSAT's projects particularly relevant for the proposed project:

	<p>Jason-CS L1b prototype development isardSAT is responsible for the development (specification and implementation) of the Jason-CS Poseidon 4 L1b science processing prototype.</p>
	<p>S-3 L0 and L1 prototype development isardSAT has implemented the L0 and L1b processors of the S-3 SRAL in the S-3 B2/C/D/E1 program. (2010-2013) S-3 is an ESA project. isardSAT is subcontracted by CLS.</p>



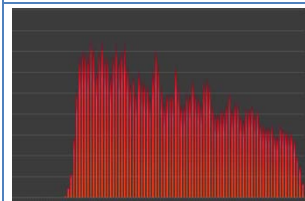
REAPER: Re-processing of ERS-1&2 data *a la Envisat*.
isardSAT is the responsible for the Level 1 algorithm development and implementation. (2009-2011)
Partnership of MSSL/UCL (UK), isardSAT (Cat), CLS (France), ESOC (ESA), GFZ (Germany), DEOS (Netherlands), Altimetrics (US)



CryoSat-2 SIRAL Calibration:
isardSAT is responsible of the calibration of SIRAL SAR-In mode using the Svalbard transponder. (2009-2010, 2011-2013)
Principal Investigator on SIRAL Doppler beam formation calibration through an ESA transponder. (2006, 2009-2010)



RA-2 L1B ESL:
isardSAT is the Expert Support Laboratory of the Envisat RA-2 Level 1b since 2006.



RAIES: Radar Altimeter Individual Echoes and S-band
isardSAT has developed the complete algorithm to process the RA-2 Individual Echoes, and has implemented the processing (Pildo Labs project). (2004 - 2007).
isardSAT has developed a retracker in order to calibrate S-band range against Ku-band over the Uyuni salar.
Partnership of CLS (France), isardSAT (Cat), UCL (UK), IFREMER (France) and LEGOS (France).



RA-2 LTS (IOP): RA-2 Sensor Long term support
isardSAT provides specific expertise necessary to analyse and maintain the performance evolution and operability of the RA-2 subsystems and more specifically for the investigation and recovery of the RA-2 anomalies.



CAL/VAL SMOS:
isardSAT is responsible for the Calibration and Validation of SMOS brightness temperature over the Salar de Uyuni (ESA SMOS Cal/Val Announcement of Opportunities (ID 6317).



MalarSat: Malaria risk assessment using Earth Observation data
isardSAT is the scientific leader of the project and develops the most challenging part of the project: the use of radar altimeter data to detect water puddles of very reduced dimensions. RDITSCON07-1-0004. (2007-2008)
Partnership of GTD, isardSAT and Pildo Labs (all Catalan enterprises).



SMOScat: Disaggregation of SMOS Soil Moisture products over Catalonia
The aim of the SMOScat project is to use SMOS data (40 km spatial resolution) to provide soil moisture maps at high spatial resolution. (2010-2012)



AGORA: Snow remote sensing for the assessment of reservoir water content.
isardSAT is responsible for the retrieval of snow volume, in the Catalan Pyrenees area, using altimetry data. RD09-1-0070 (2009-2011)
Partnership of Starlabs, isardSAT, GTD, Hyds, Applus (all Catalan enterprises).

3.2. Presentation of the Team

3.2.1. Team structure and organization

Figure 3-4 presents the first level of the team organization under the responsibility of the project manager.

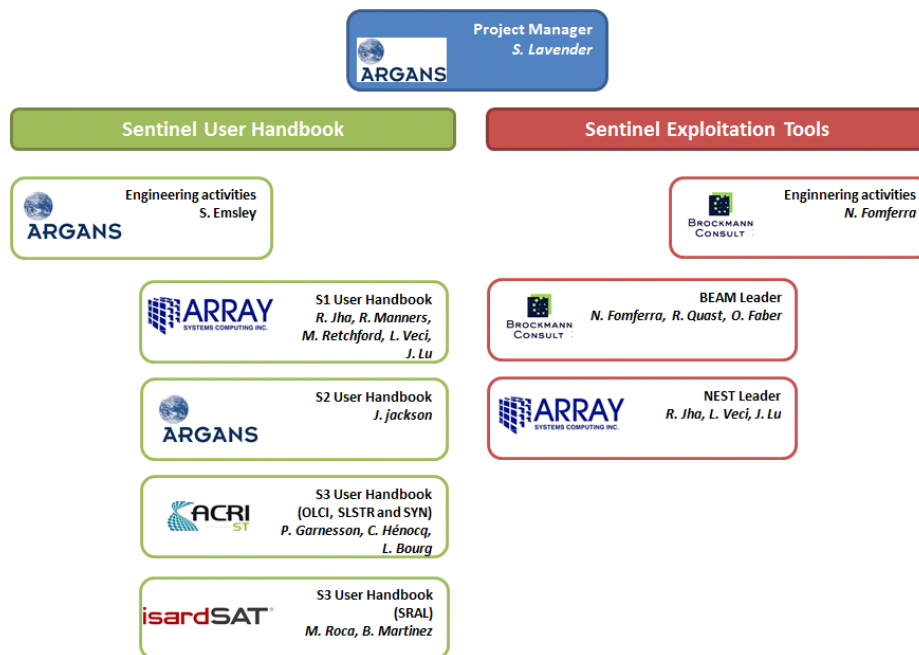


Figure 3-4: Team organisation and responsibilities

3.2.2. List of the key people

The key people are presented in Table 3-4.

Table 3-4: List of the key people

Key personnel	Organisation	Role / Responsibilities
S. Lavender	ARGANS	Project Manager
S. Emsley	ARGANS	User Handbook infrastructure
J. Jackson	ARGANS	S-2 User Handbook Leader
N. Fomferra	Brockmann Consult	Exploitation tools coordinator and BEAM Leader
R. Quast	Brockmann Consult	BEAM development support
O. Faber	Brockmann Consult	BEAM development support
R. Jha	ARRAY	ARRAY Project Manager
R. Manners	ARRAY	S-1 User Handbook Leader
M. Retchford	ARRAY	S-1 User Handbook Technical Writer
L. Veci	ARRAY	NEST leader; S-1 User Handbook Contributor
J. Lu	ARRAY	NEST Developer, S-1 User Handbook Contributor

Key personnel	Organisation	Role / Responsibilities
P. Garnesson	ACRI-ST	S-3 OLCI, SLSTR and SYN User Handbook Leader
C. Hénocq	ACRI-ST	S-3 OLCI, SLSTR and SYN User Handbook contributor
L. Bourg	ACRI-ST	S-3 OLCI, SLSTR and SYN instruments and products expert
M. Roca	isardSAT	S-3 SRAL User Handbook Leader
B. Martinez	isardSAT	S-3 SRAL User Handbook contributor

3.2.3. Qualification of the key people

Table 3-5 presents the individual qualifications, relevant experience and current positions of the proposed key people; the detailed CVs are presented in Section 3.6.

Table 3-5: Relevant experience of the key people

Key personnel	Organisation	Relevant experience
S. Lavender	ARGANS	<ul style="list-style-type: none"> ▪ Scientific Principle Investigator / Project Manager since 1999 ▪ Expert in marine and land optical remote sensing with peer reviewed papers (examples are shown within her CV, see Section 3.6.1) ▪ Project manager for the GMES-3 Products and Algorithms Definition project
S. Emsley	ARGANS	<ul style="list-style-type: none"> ▪ Engineering activities Leader who leads IT activities within ARGANS (including website developments) ▪ Technical support within the GMES S-3 Products and Algorithms Definition project
J. Jackson	ARGANS	<ul style="list-style-type: none"> ▪ Deputy Optical Instrument Coordinator and operational lead for Landsat within the ESA SPPA IDEAS contract
N. Fomferra	Brockmann Consult	<ul style="list-style-type: none"> ▪ BEAM project manager; BEAM software developer; quality control
R. Quast	Brockmann Consult	<ul style="list-style-type: none"> ▪ BEAM software developer
O. Faber	Brockmann Consult	<ul style="list-style-type: none"> ▪ Software quality control
R. Jha	ARRAY	<ul style="list-style-type: none"> ▪ RSAT-2 Toolbox project manager ▪ NEST project manager ▪ PMP certified
R. Manners	ARRAY	<ul style="list-style-type: none"> ▪ Project Scientific on RSAT-2 toolbox ▪ SAR instrument expert
L. Veci	ARRAY	<ul style="list-style-type: none"> ▪ Software Lead on the RSTB ▪ Software Lead on Next ESA SAR Toolbox (NEST)
M. Retchford	ARRAY	<ul style="list-style-type: none"> ▪ Technical writer at ARRAY since 1999 ▪ Professional Certificate in Information Design from the University of Toronto

Key personnel	Organisation	Relevant experience
J. Lu	ARRAY	<ul style="list-style-type: none"> Software developer of RSAT-2 toolbox Software developer of NEST
P. Garnesson	ACRI-ST	<ul style="list-style-type: none"> Senior Engineer managing production and quality assurance Technical Manager of the Global Ocean Colour Thematic Assembling Centre for the MyOcean project
C. Hénoq	ACRI-ST	<ul style="list-style-type: none"> Technical Management of S-3 L1 project: Optical Ground Processor Prototype (O-GPP)
L. Bourg	ACRI-ST	<ul style="list-style-type: none"> Optical instrument and processing expert e.g. OLCI Level 2 scientific coordinator in the GMES S-3 Products and Algorithms Definition project and involved in the S-3 Definition Study
M. Roca	isardSAT	<ul style="list-style-type: none"> Previously ESTEC Radar Altimeter System Performance Engineer within the Envisat Project Team Leading the S-3 SRAL L0 and L1b Ground Prototype Processor development
B. Martinez	isardSAT	<ul style="list-style-type: none"> L1b Reprocessing of the ERS data (ESA REAPER project) Involved in the development of S-3 L0 and L1b Ground Processor Prototype

3.2.4. Time allocation of the key people

Table 3-6 presents the proportion of key personnel's working time allocated to the project.

Table 3-6: Percentage of working time dedicated to the project per key personnel

Key personnel	Organisation	WPs and individual time allocations (hours)	Average % of working time over whole project
S. Lavender	ARGANS	WP1100, WP1200, WP2100, WP2500, WP3100 & WP4200 (covered by WP6000 hours) WP6000 (287)	11%
S. Emsley	ARGANS	WP1300 (160), WP1400 (16), WP2500 (32), WP3100 (8), WP4100 (80) & WP4200 (40)	14%
J. Jackson	ARGANS	WP1100 (80), WP1200 (40), WP1400 (8), WP2100 (16), WP2300 (200), WP2500 (8), WP3100 (8), WP3220 (88), WP4100 (16) & WP4200 (24)	18%
N. Fomferra	Brockmann Consult	WP5120 (227), WP5220 (157) & WP5300 (43)	36%
R. Quast	Brockmann Consult	WP5120 (227), WP5220 (157) & WP5300 (43)	36%
O. Faber	Brockmann Consult	WP5120 (126), WP5220 (87) & WP5300 (24)	20%
R. Jha	ARRAY	WP1200 (16), WP2200 (32), WP3210 (16), WP5110 (16) & WP5300 (4)	4%
J. Lu	ARRAY	WP2200 (82), WP3210 (36), WP5110 (294) & WP5300 (22)	18%
R. Manners	ARRAY	WP2200 (316) & WP3210 (100)	15%

Key personnel	Organisation	WPs and individual time allocations (hours)	Average % of working time over whole project
L. Veci	ARRAY	WP1200 (16), WP2200 (200), WP3210 (32), WP5110 (168) & WP5300 (24)	20%
P. Garnesson	ACRI-ST	WP2410 (413) , WP3231 (62) & WP4200 (0)	35%
C. Hénocq	ACRI-ST	WP2410 (234), WP3231 (156) & WP4200 (156)	40%
L. Bourg	ACRI-ST	WP2410 (23) , WP3231 (23) & WP4200 (0)	5%
M. Roca	isardSAT	WP2420 (80), WP3232 (20) & WP4200 (20)	5%
B. Martinez	isardSAT	WP2420 (140), WP3232 (80) & WP4200 (32)	10%

3.2.5. External Services

To write the Handbook Chapter titled “What can Sentinel do for you and how?” the consortium will receive support from external consultants. The cost has been included in the ARGANS PSS forms (under “3.7 External Services Cost” within WP 2100) and proposed list of names is provided in Table 2-5.

3.3. Facilities and Resources

This Section lists and describes both general and specific facilities i.e. project partner resources.

3.3.1. ARGANS

3.3.1.1. Hardware

The facilities available already include:

- ◆ ARGANS-Plymouth Computer Park structured around virtualised Windows and Linux servers, connected to a terabyte disk storage array.
- ◆ ARGANS engineers work on PC’s (Windows XP/7/Linux) linked to the Linux servers. Each PC owns its local disk space and there’s secured disk space of over 40 TB for applications and a separate Windows server for Microsoft applications / email and administrative purposes.
- ◆ The exchange of information between the various projects within ARGANS is made easier thanks to a project management service and virtual drives.
- ◆ Hardware located within a Data Centre is protected by air-conditioning, physical security, dual UPS and backup generator.
- ◆ LTO manual system available.
- ◆ Plymouth has dedicated internet access with 20 Mb/s uncontended capacities for FTP transfer and separate 10Mb/s link for email/VPN access and as a backup system.

3.3.1.2. Software

Concerning the software, there is a variety of packages at ARGANS (both COTS and developed in-house):

- ◆ In-house software is being actively developed using C, IDL, MATLAB and PHP scripts – applications include the S-3 Level2/3 Optical Prototype Processor, SMOS salinity processor, CASIDAS this was used within the SEN3EXP campaign to atmospherically correct hyperspectral airborne data (includes the MERIS Bright Pixel Atmospheric Correction), applications to perform quality control within the SPPA IDEAS contract and commercial applications (in confidence so cannot be detailed).
- ◆ Several image processing / Earth Observation packages are used across the company e.g. BEAM VISAT & SeaDAS that can handle MERIS and MODIS, and AMALFI, QUISS & Telimago (can be used for high resolutions sensors such as Landsat and S-2).
- ◆ ARGANS has access to ESA funded software developments: GlobColour, ODESA, SMOS salinity processor.

3.3.2. Brockmann Consult

Brockmann Consult GmbH has its offices in the Geesthacht Innovation and Technology Center which itself is situated on the grounds of the national research institute “Helmholtz Center Geesthacht, Centre for Materials and Coastal Research”. It can therefore avail of the most modern infrastructure including, for example, conference and meeting rooms, video conferencing, fast internet access and security.

Brockmann Consult has been actively involved in software development for Earth Observation data processing for many years, and it has at its disposal all commonly used state-of-the-art hardware and software, including large clusters (with several hundreds of TB’s and multiple of processing nodes), computer servers and fast internet access for data distribution and customer support.

The BEAM software, which is central to the present project, was developed at Brockmann Consult under contract to the ESA.

The integrated development environments Brockmann Consult uses for its Java developments include IntelliJ IDEA, Eclipse and Oracle JDeveloper. For C/C++ Microsoft Visual Studio and Eclipse is in use. For software testing Brockmann Consult uses QFS QF-Test. For continuous software build and integration Brockmann Consult uses Apache Maven and Apache Ant backed by Apache Continuum. The version control systems in use are both Subversion and CVS. The web services hosted at Brockmann Consult are backed by Apache HTTP Server web-servers, Apache Tomcat application servers. BC is currently running two CalValus cluster systems, each composed of 20 nodes (commodity computers; 80 CPU cores) and 130TB storage space. These systems are presently being used for the rapid processing of MERIS data in the framework of the ESA Climate Change Initiatives Ocean Colour and Land Cover. The processing system software is based on Apache Hadoop – an open-source implementation of MR and DSF in Java. The database management systems in use are

Oracle 9i+10g, MySQL and Postgres. Website development is performed using Macromedia DreamWeaver and Liferay's Liferay (a content management system). BC has been using Liferay for several years now and has realised several projects using this CMS, including for example the CEOS CalVal Portal or the national GMES DeMarine Portal. The BEAM Website as well as the BEAM Forum is implemented under Liferay. We have extensive experience in setting-up, configuring and developing complex applications as Portlets with Liferay, and, of course, in using it as an editor.

For team collaboration Brockmann Consult uses the commercial software packages Atlassian Confluence (an enterprise wiki) for all information collection and organisation and Atlassian JIRA (an enterprise issue tracker). The latter is used to register all activities and follow up their life cycle until completion.

3.3.3. ARRAY

3.3.3.1. Office and Lab Facilities

Array's facilities, over 15,000 square feet in size, are located in North York Ontario (near Dufferin and Finch), relatively close to the Toronto International Airport and Highways 401, 427, and 407. This location provides ready access to all Southern Ontario urban areas.



Array's administrative office equipment includes state of the art photocopying, faxing, binding, multi-line phone systems, voice mail, postage system, and electronic mail.

Array has dedicated office and lab space available for running computer simulation or experiments, and access to larger spaces for making full scale simulations of moderate size.

Array also has the physical facilities for the production and storage of secure documents. Array is equipped with windowless, lockable rooms which can be used for reviewing materials with security clearance issues. These rooms have been Tempest certified in the past, and are described in additional detail below.

These rooms contain computers (not connected to any LANs or the internet) with removable drives. Local printing is available. Procedures are in place for the usage of the room for projects with security requirements, and the receipt, storage, retrieval, and transmission of secure materials.

3.3.3.2. Array's In-House Library

Array maintains an extensive in-house technical library of over 700 books, conference proceedings, and guidelines, 25 binders of Military Standards and specifications, more than 1000 reprints and bibliographic references. Array subscribes to more than 20 technical and business journals and

magazines. Several volumes extend back for nearly twenty years. Array's configuration management system currently tracks over 2000 documents.

3.3.3.3. *Computing Resources*

Array's corporate network is a mixed 1000BaseT/100BaseT network with more than 50% of the computers connected to the gigabit backbone. The network is connected to the Internet via a high speed network interface. The primary file server of the company uses Linux as the OS has a 1 TB storage capacity serving files to both UNIX based network clients and Windows based network clients.

The mail server network is composed of three computers with multiple redundant paths to process email. Virus checking is performed on each stage of processing and spam checking is performed on the primary server prior to the delivery of emails to clients. Array also maintains both internal and external web servers to provide information for internal users and customers as well as external interested parties. Our customer support web pages are encrypted with 128-bit SSL. In addition, Array maintains many internal services in support of various needs and contracts: Database, DNS, LDAP, NIS, VPN, Webmail, etc.

Array makes use of both Linux and Windows domain structures. However, the computer clients see themselves as clients to the Windows domain while the Linux domain emulates Windows server behaviour. Each Array staff member has a state-of-the-art personal computer at their disposal and a personalized Array e-mail address.

Array's technical and administrative systems are backed up nightly. Tapes are stored off-site.


3.3.3.4. *Test facilities*

Special test facilities or equipment are not foreseen for the project. Array will provide at its location the computer equipment to generate, process and store data, intermediate and final outputs as well as back-up facilities for the software and data.

3.3.4. *ACRI-ST*

Table 3-7: Management and communication software and facilities

Software	Description
Genesys	Integrated tool used by ACRI-ST for projects and staff management: schedules, time tracking per project, expense reports, vacation, planning, training, clearances. Reports can be generated on request at any time, for a global overview of the project resources and expenses.

Office 2010 (SharePoint, Word)	<p>All project documentation will be managed by a custom Documentation Management Platform under Microsoft Office SharePoint Server 2010 environment hosted in ACRI-ST.</p> <p>The meeting minutes will be written in a SharePoint wiki environment or in Microsoft Word 2010 with possible translation in PDF format, and shared through the Documentation Management platform of the project.</p>
CISCO WebEx	<p>ACRI-ST owns several licenses of the Cisco WebEx Meeting Center for video-meetings and video-conferences. No registration is required for other participants.</p> <p>ACRI-ST owns three meeting rooms with capacities of 12, 20 and 20-200 participants. All rooms are equipped to host a videoconference.</p> <div style="border: 1px solid black; padding: 5px;">  <p style="text-align: center;">ACRI-ST meeting rooms 12, 20 and 20-200 participants Audio and video-conference</p> </div>

Access to scientific information

ACRI-ST uses several means of access to scientific information with specially the subscription to international scientific publications, the possibility to access to the main libraries of Universities and other European and American institutions and the participation to numerous symposiums and conferences.

3.3.5. isardSAT

isardSAT is located at the Technological Park BCNord, in Barcelona, Catalunya. Using the resources shared by the companies at the park, isardSAT has immediate access to:

- ◆ video conference rooms and a fully-equipped auditorium with capacity for 240 people,
- ◆ 5 meeting rooms with capacity for 8-20 people, with interconnection to the company's private network,
- ◆ 9 classrooms fully equipped with individual computers for conducting business and technical courses, all with Internet access and its own projection systems.

isardSAT owns 14 high processing capacity computers under Macintosh, Linux and Windows operating systems, several printers and photocopiers, 2 fax machines, and backup external hard drives. isardSAT also owns 2 data processing dedicated 8-core Linux System Workstations and a web server with 28 TB NAS storage. It has also installed a parabolic satellite receiver tuned to the ESA TV channel.

3.4. Project Management Plan

This Section corresponds to the Project Management Plan of the “Sentinel User Handbook and Exploitation Tools” project.

3.4.1. Structure of the activities

3.4.1.1. Work Breakdown Structure

The proposed Work Breakdown Structure (WBS) is described in Figure 3-5. It is developed on the basis of the tasks identified in the SoW [AD 1] and contains:

- ◆ 5 technical high-level Work Packages (WP) split into
 - ◆ 4 high-level WPs corresponding to the 4 development Phases of the Sentinel User Handbook (WP 1000 to WP 4000);
 - ◆ 1 high-level WP for the Sentinel Exploitation Tools (WP 5000);
- ◆ 1 WP dedicated to the management (WP 6000).

Each WP is split into sub-WPs if necessary.

All companies involved in a WP are mentioned, the leading one being underlined. If a WP has no company mentioned, it means that it is a header WP in which no effective activity is carried out.

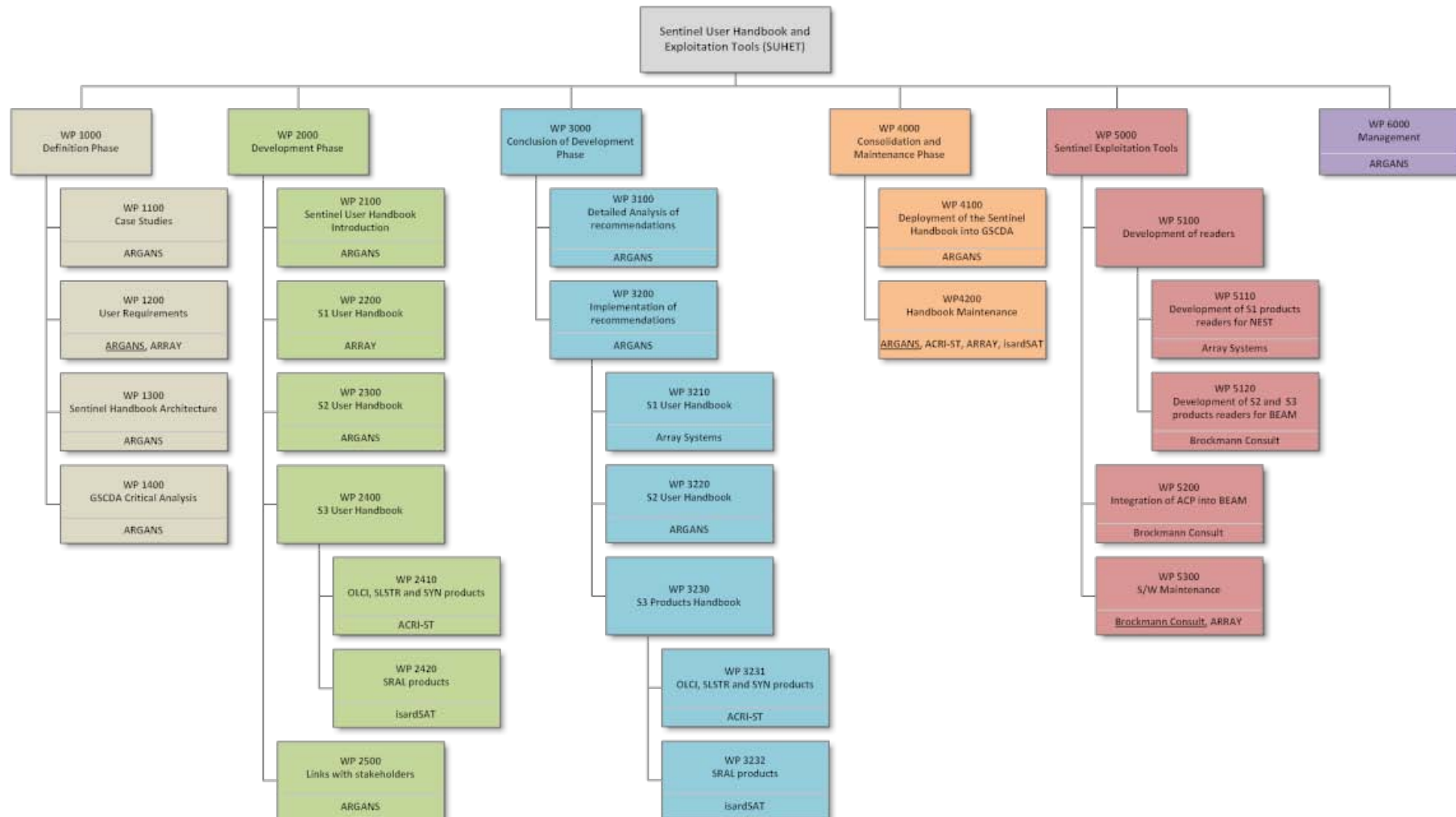


Figure 3-5: Work Breakdown Structure

	ARGANS	ACRI-ST	BC	ARRAY	ISARDSAT
1000 Definition Phase					
1100 Case Studies	[L]				
1200 User Requirements	[L]				
1300 Sentinel Handbook Architecture	[L]				
1400 GSCDA Critical Analysis	[L]				
2000 Development Phase					
2100 S1 products handbook				[L]	
2200 S2 products handbook	[L]				
2310 S3-OLCI, SLSTR, SYN products handbook		[L]			
2320 S3-SRAL products handbook					[L]
2400 Links with stakeholders	[L]				
3000 Conclusion of development phase					
3100 Detailed analysis of recommendations	[L]				
3200 Implementation of recommendations	[L]				
3210 S1 products handbook				[L]	
3220 S2 products handbook	[L]				
3231 S3-OLCI, SLSTR, SYN products handbook		[L]			
3232 S3-SRAL products handbook					[L]
4000 Consolidation and Maintenance Phase					
4100 Deployment into GSCDA	[L]				
4200 Handbook Maintenance	[L]	[C]		[C]	[C]
5000 Sentinel Exploitation Tools					
5110 Development of readers for BEAM			[L]		
5120 Development of readers for NEST				[L]	
5200 Integration of S2 ACP into BEAM			[L]		
5300 S/W maintenance			[L]	[C]	
6000 Management	[L]				

Figure 3-6: WP responsibilities: [L] = Leader and [C] = Contributor.

3.4.1.2. Work Package Descriptions

Each task of the WBS is defined in a description sheet called Work Package Description (WPD), which includes:

- ◆ WP reference;
- ◆ WP title;
- ◆ WP Manager and contributors;
- ◆ Start and end event;
- ◆ Date of the task beginning and its duration;
- ◆ WP objective;
- ◆ Necessary inputs;
- ◆ Activities to be performed, detailed per company;
- ◆ List of outputs (documents, data, etc.);
- ◆ Efforts in hours allocated to the WP activities, per company.

Detailed WPD forms are available in Section 0 (Appendix 1) of this document.

3.4.2. Schedule

3.4.2.1. Milestones

Table 3-8 presents the list of the project milestones and meetings plus the purpose of the meeting, its location, theoretical date related to the project start date and the companies who will participate.

Table 3-8: List of meetings and reviews

Milestone	Location	Date	Participants
Kick-Off Meeting	ESRIN	T0	ARGANS & BC
Progress Meeting #1 - Definition Phase	Teleconf	T0 + 1 month	All
Definition Working Meeting	ESRIN	T0 + 2 months	All
Progress Meeting #2 - Development Phase	Teleconf	T0 + 5 months	All
Stakeholder Consultation Meeting	ESRIN	T0 + 8 months	All
Progress Meeting #3 - Detailed development Phase	Teleconf	T0 + 10 months	All
Acceptance Meeting	ESRIN	T0 + 12 months	ARGANS, ACRI-ST, BC & isardSAT
Progress Meeting #4 - Maintenance - consolidation Phase	Teleconf	T0 + 15 months	All
Final Presentation	ESRIN	T0 + 18 months	ARGANS, ACRI-ST, BC & isardSAT

In addition to these meetings and as required in the draft contract (Section 2.2.1 of Article 2 – Delivery, Meetings and Reviews [AD 2]). ARGANS will organize and participate in the monthly Progress Meetings by teleconference (for months without any other meetings).

3.4.2.2. Schedule

The planning of all activities is displayed in Figure 3-7. The following legend has been applied:

- ◆ The tasks/activities are presented with coloured bars in line with the colours of the WBS presented above (Light yellow for Definition Phase, Light green for Development Phase, Cyan for conclusion of the Development Phase, Orange for Consolidation and Maintenance Phase, Light red for Exploitation Tools and purple for Management Activities);
- ◆ The main milestones are presented by a red star.

Once agreed by ESA, this schedule is used for the communication with the Agency and for the internal project reporting. It constitutes the baseline for planning, monitoring, controlling and progress reporting. The assumptions considered to develop this schedule are:

- ◆ The KOM date is expected to be on **01 March 2012**;
- ◆ The duration of the project does not exceed 18 months;
- ◆ For the Handbook activities:
 - ◆ Phase 1 will last 2 months;
 - ◆ Phase 2 will last 6 months;
 - ◆ Phase 3 will last 4 months;
 - ◆ Phase 4 will last 6 months.
- ◆ For the exploitation tools activities:
 - ◆ The development of readers will last 4 months;
 - ◆ The integration of the ACP into BEAM will last 3 months.

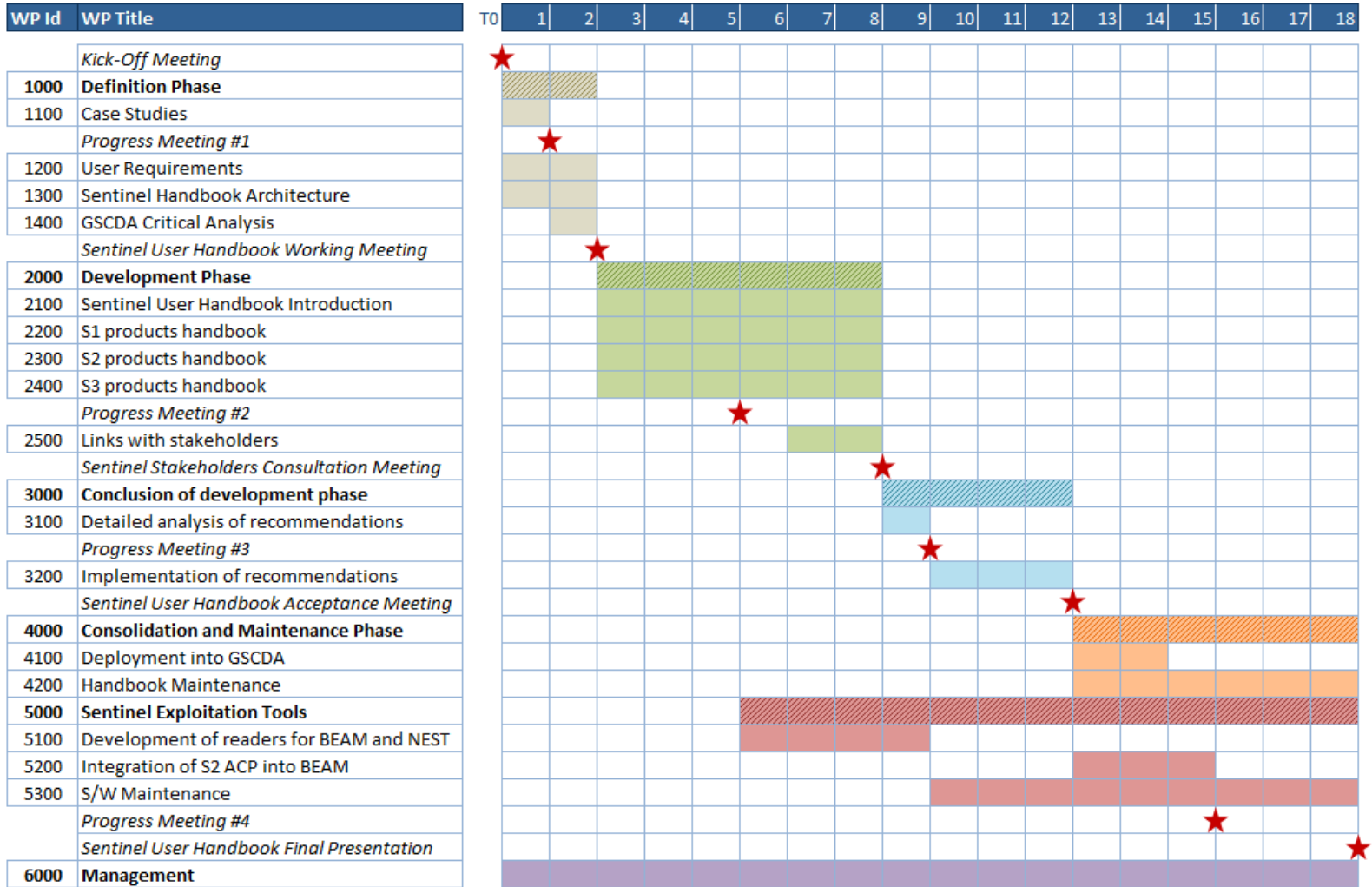


Figure 3-7: Project schedule

3.4.3. Management rules

3.4.3.1. Communication lines

Figure 3-8 presents the formal contractual and management interfaces between, on the one hand ARGANS and the Agency and on the other hand, ARGANS and the sub-contractors. These interfaces have to be understood as two-way lines for communication and reporting.

- ◆ The technical and management interface between the Agency and ARGANS is ensured by the ARGANS Project Manager, Samantha Lavender, who reports to the ESA Technical Officer. She also interfaces with each of the sub-contractors' leaders;
- ◆ The contractual interface between the Agency and ARGANS is ensured by the ARGANS Contract Officer who supports the Project Manager for legal and contractual matters and reports to the ESA Contract Officer. Similarly to the management line, she also interfaces with each of the sub-contractors' contract officers. For ARGANS, the Contract Officer is Rabiah-Nasir Habeeb although contracts will be signed by Samantha Lavender who is the Managing Director of ARGANS.

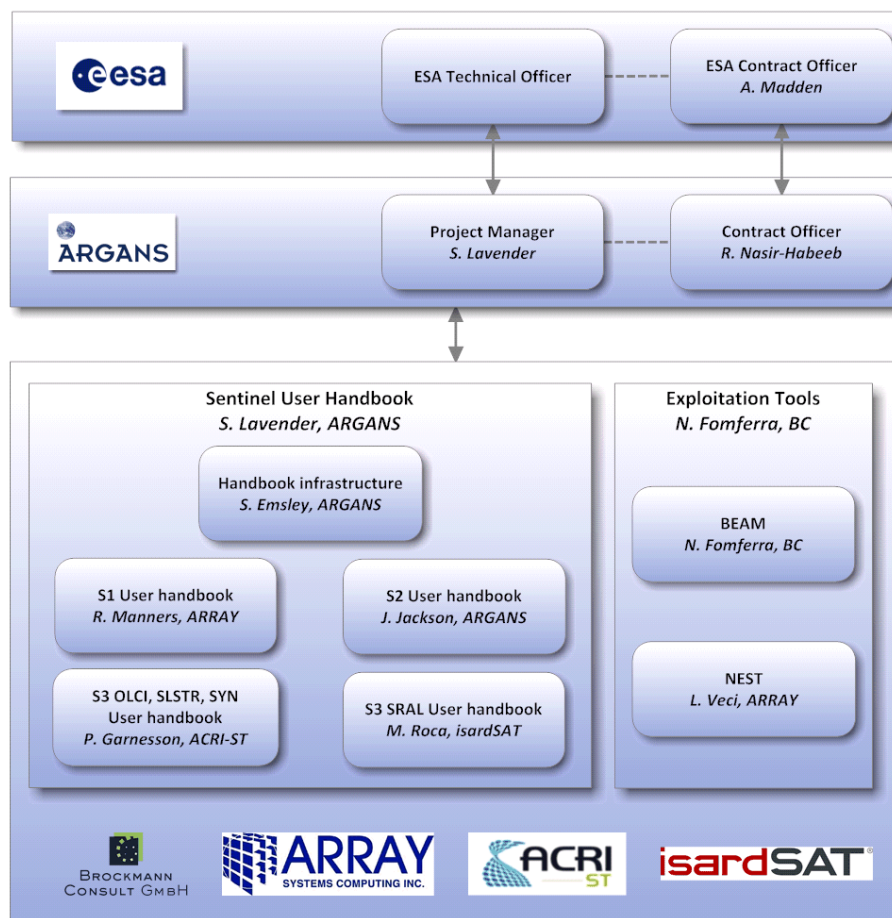


Figure 3-8: Contractual, Management / Technical communication lines

Table 3-9: Technical and Contractual managers

Company	Project or Technical Manager	Contract Officer
ESA	TBD	A. Madden
ARGANS	S. Lavender	R. Nasir-Habeeb
Brockmann Consult	N. Fomferra	D. Murphy
ARRAY	R. Jha	N. Keslassy
ACRI-ST	P. Garnesson	O. Fanton d'Andon
isardSAT	M. Roca	L. Vinyals

3.4.3.2. Role of the Project Manager and the Technical Officer

Project Manager

The Project Manager is fully responsible for ensuring suitable performance and quality of all activities defined in the contract with the main objective of the client satisfaction.

- ◆ She is given full authority to perform the requisite planning, direction and supervision functions with regard to the team consortium;
- ◆ She is in charge of the management of all subcontractors;
- ◆ She is in charge of preparing the reporting documents;
- ◆ She is in charge of the organization of all meetings and the writing and dissemination of the minutes;
- ◆ She supervises the documentation, configuration and data management;
- ◆ She undertakes the overall quality actions and he is responsible for the quality of all deliverables.

For all contractual and administrative matters, the project manager will receive the support from the Contract Manager who ensures the following activities:

- ◆ Finalisation of the main contract with the Agency and with all sub-contractors;
- ◆ Contract follow-up with ESA;
- ◆ Contract follow-up with sub-contractors;
- ◆ Invoicing processes (with ESA and sub-contractors);
- ◆ CCN issuing (if any).

Technical Manager

The Technical Manager defines the technical/scientific solution and approach adopted in the frame of the project, respecting the constraints and objectives defined by the Agency and presented in the SoW [AD 1]. For the Handbook this is Stephen Emsley (ARGANS) and for the Tools this is Norman Fomferra (BC):

- ◆ He selects the technical/scientific solution the most appropriate to reach the scientific objectives;
- ◆ He ensures the scientific conformity of the project outputs regarding the SOW requirements;
- ◆ He participates to solve scientific project issues;
- ◆ He coordinates the pool of scientific experts who support him in his work.

3.4.3.3. Progress reporting

At any moment, the Project Manager has to be able to provide ESA with a comprehensive overview of the progress of all tasks and activities led in the framework of the project. The status of each task is compared to the project schedule baseline. Any deviations are identified and analysed in terms of impact and possible corrective actions are proposed to ESA.

In order to offer full visibility of the progress of the project activities, ARGANS sends to the Agency's Technical and Contractual Officers, a MPR setting forth the status of the work under the contract. The report is sent by the Project Manager via electronic mail. It provides a progress summary highlighting adverse trends in technical, schedule and cost performance, identifying potential problems, proposing corrective actions. The content includes the following topics:

- ◆ Analysed period of activity;
- ◆ For each work package:
 - ◆ Brief description of the technical activities carried out under the period;
 - ◆ Brief description of difficulties affecting this activity;
 - ◆ Major events;
 - ◆ Activities to be carried out during the next period;
- ◆ Extract of the Action Item List with only the actions not closed (e.g., open, on-going, on hold, etc) except those closed during the period;
- ◆ Updated Deliverable Item List;
- ◆ Updated project schedule including reasons for slippage and corrective actions taken if any;
- ◆ Updated status of the milestones;
- ◆ Updated Risk Register;
- ◆ Status of the payment plan;
- ◆ AOB.

The MPR will cover the activities completed during the past period (e.g. calendar month) and is written under the responsibility of the Project Manager. It will be sent not later than 5 working days after the end of the reporting period.

3.4.3.4. Purpose of and procedure for Progress Meetings with the Agency

The project progress is assessed through a series of meetings and reviews. Meetings may be of two types:

- ◆ Internal meetings with only project team members;
- ◆ External meetings with both the Agency and representatives of the project team.

Internal meetings are organised by the Project Manager in order to:

- ◆ Assess the progress of the work on a regular basis (e.g. each month);
- ◆ Preparations for external meetings or reviews with the Client;
- ◆ Focus on specific technical issues.

These meetings allow the:

- ◆ Project Team to summarise the progress of their work and report on any problems they encounter; it's also an opportunity for them to query other team members on specific points;
- ◆ Project Manager to provide general information to the project team and focus on specific issues considered important.

The frequency of these meetings depends on the status the project and number of actions to deal with. Remote communication tools are preferred in order to reduce cost and loss of time. Tools like Skype or WebEx⁵ for audio-conferencing or video-conferencing are efficient solutions and actively used by ARGANS for other projects.

External meetings are two types:

- ◆ The reviews mark out the project; they achieve major steps of the project and determine a go/no go to the next step;
- ◆ The progress meetings are regularly organised; they review the progress of the work performed by the project team; during SUHET, progress meetings have been fixed with respect to other working meetings or reviews imposed by the SoW [AD 1].

Reviews usually require intense documentary preparation, mobilize more people (both on the client and consortium sides) and last longer than a progress meeting. The reviews usually have a precise goal while progress meetings are primarily intended to showcase the work done and allow a regular exchange with the client and partners. The aim is to follow this timetable for preparing and holding these meetings (adjusted according to events).

⁵ WebEx is already used by ESA (<http://www.webex.com/>)

In advance:

- ◆ Date, place and participants fixed in advance - if possible 3 months;
- ◆ Agenda is sent out with a definitive list of participants to ESA for approval no later than 10 working days prior to the meeting;
- ◆ Solicitation of all stakeholders based on clear meeting guidelines sent by the Project Manager;
- ◆ Preparation of all meeting materials (e.g. slides, reports, deliverables, etc.);
- ◆ Publication of all meeting materials on the intranet section of the project website (e.g. ARGANS normally sets up a project area on its Confluence⁶ server) no later than one week before the meeting (accessible to ESA and project members).

Note: in the SOW [RQT 51], it is asked to send presentations 10 days before the meeting. We would appreciate more flexibility and so reduce this deadline to 5 days. If this is not accepted by ESA, the consortium will conform to [RQT 51].

During the meeting:

- ◆ Introduction to recall the objectives of the meeting and presentation of the agenda;
- ◆ Actions review;
- ◆ Presentation of the agenda items;
- ◆ Round table;
- ◆ Writing minutes - by the Project Manager or a secretary;
- ◆ Recording and update of action items and major decisions;
- ◆ Choice of a date for next meeting;
- ◆ If possible, agreement and joint signature of the minutes at the end of meeting - between the Project Manager and the Agency's representative;

After the meeting:

- ◆ Post all meeting presentations and typed version of the minutes on the project website within 2 working days following the meeting;
- ◆ Distribution of the minutes to the participants and to people who must be informed or actioned;

3.4.3.5. Supervision and reporting mechanisms

Management principles

ARGANS has been involved in numerous important projects related to the development of technical documentation and tools and is skilled to coordinate scientific experts. Moreover, the proposed

⁶ <http://www.atlassian.com/en/software/confluence/overview>

Project Manager knows well both the Agency and the partners of the consortium. All these are positive assets for a smooth development of the project. The main management principles proposed by ARGANS are:

- ◆ Presenting and sharing the management principles and applicable rules with all participants of the consortium in order to have a common understanding and to ensure efficiency;
- ◆ Defining the tasks to be performed, the planning of activities and corresponding acceptance criteria of achievement for all activities;
- ◆ Defining the role and responsibilities of each participant, especially the WP leaders, and identifying clearly the interfaces between all participants;
- ◆ Ensuring tight management of all sub-contractors through regular remote conference meetings;
- ◆ Exchanging regular information with the Agency, in order to give the best overview of the achievements during the contract;
- ◆ Alerting, when a difficulty arises, the Agency at the earliest and committing to do their best to find the solutions needed;
- ◆ Anticipating possible problems in order to make fast decisions in coordination with ESA.

Sub-contractor management

In response to the SoW requirements [AD 1], ARGANS has formed a consortium of (1) scientific engineers with a high level of knowledge of the GMES programme, and (2) designers of the Sentinel exploitation tools (BEAM and NEST). Close management of the involved companies is required to ensure effective and successful outputs. The ARGANS Project Manager is fully responsible for coordinating and controlling all sub-contractors' activities. In this respect, she is in charge of:

- ◆ Before the beginning of the work:
 - ◆ Contract signature between ARGANS and the subcontractor before the KOM;
 - ◆ Presentation of the management and organisation principles and standards;
 - ◆ Presentation of the activities to be performed, the deliverables or the contribution to the deliverables to be provided and associated schedule;
- ◆ During the contract:
 - ◆ Great emphasis on communication;
 - ◆ Frequent interaction with the sub-contractors using regular remote conferences, electronic exchanges or face-to-face meetings;
 - ◆ Monitoring / control of activities performed and assessment of progress;
 - ◆ Formal monthly progress reporting - sent by the Project Manager to the Agency;
 - ◆ Review of the deliverables before final delivery to the Agency;

- ◆ Anticipation of possible issues and proposition mitigation actions to reduce the associated risk;
- ◆ Authorisation to send sub-contractor's invoices following ESA acceptance of the deliverables.
- ◆ At the end of the contract:
 - ◆ Proposition of a meeting with the sub-contractors to capture learnt lessons about the project and partnership.

Deliverable management

The Project Manager is responsible for the management of all the deliverables due in the framework of the project. The **Deliverable Item Status List** (DIL) recording all deliverables is maintained through the project life. This list summarises the information related to each due deliverable: deliverable type (documentation, software etc), leader, due date, etc. and information about the deliverable status which can be: not started, on-going, in progress for review by ESA, approved, change request, rejected.

The Deliverable Item Status List is annexed to the MPR and reviewed during the project review.

Documentation management – Documentation Item List

The Project Manager is responsible for the management of all the documentation provided in the frame of this project. Two types of documentation are identified:

- ◆ Communication documentation such as letters, faxes, memos etc;
- ◆ Technical (technical note, specification document etc) and management (MPRs, minutes etc) documents.

The **Documentation Item List** recording all documents produced during the project (both communication and project). This list indicates for each recorded document the: reference, document type, version, issue date, document status (draft, approved, etc.), confidentiality level and distribution list. It is a subset of the Deliverable Item Status List, all documentation items corresponding to formal deliverables are extracted from the DIL, annexed to the monthly progress report and reviewed during the project review.

Action management – Action Item List

The purpose action management is to maintain a record of all the action items raised during the project and in particular those decided during meetings – such as questions to be answered, documents to be provided, investigations to be made – to monitor their implementation, and to keep the history throughout the project. The Action Item List (AIL) refers each action with:

- ◆ A unique identification number allowing anyone to easily find the context where the action was decided (e.g., meeting, external solicitation etc.);
- ◆ The initiator;

- ◆ The description of the action item (clear and concise);
- ◆ The company and/or the person responsible for the action;
- ◆ The due date;
- ◆ The current status (open, proposed for closure, closed);
- ◆ The closing date (when the action item is closed);
- ◆ A closing reference (document, mail, fax, etc.).

The AIL is continuously and attached to meeting minutes and annexed to the MPR.

Schedule control

ARGANS generates and maintains the project schedule compliant with the WBS and the associated WPs throughout the project life. Any modification of the schedule needs to have prior approval by the Agency. The update of the project schedule is a continuous process; the schedule is analysed by the Project Manager in terms of progress made regarding the status of all activities carried out by the project team, the identification of any deviation with the initial planning impacting the duration of the logic of the project activities, the proposition of corrective actions. The project schedule is part of the MPR.

3.4.3.6. Disagreement settlement

The management reporting and communication lines with both the Agency and sub-contractors are simple and clear. This ensures the swift resolution of day-to-day technical and management issues with a low overhead. There are two potential sources of conflict during the lifetime of the project:

- ◆ Between ESA and the prime contractor, ARGANS;
- ◆ Between the prime contractor and the sub-contractors.

If there is any disagreement between ESA and ARGANS regarding the way the project is conducted, we propose to implement the following mechanisms in order to sort out very shortly the issue:

- ◆ First, clarify the disagreement(s) in order to first check that everybody has the same understanding of the situation; for sake of clarity, this should be done by written;
- ◆ Organise a teleconference in order to share the different points of view and to propose solutions. This teleconference is organised by the Project Manager;
- ◆ However, if the Project Manager cannot solve the issue she reports the situation to the Board of ARGANS (an escalation process); for example proposing to have a face-to-face meeting with the ESA technical and/or contractual officers in ESA premises. As the Project Manager is the Managing Director of ARGANS (the default contact point for escalation) then another Director or the Chairman would provide support.

It is important to record all decisions made during these stages and to monitor the effective implementation of all decisions made. This will be done through minutes of the meeting(s) held and through the list of actions.

In case of disagreement between ARGANS and one of the sub-contractors, we propose to implement the same type of procedures as that between ARGANS and ESA:

- ◆ Clarification of disagreement in writing;
- ◆ Teleconference(s) to find a solution;
- ◆ Escalation process – if required.

After the analysis of the situation, and depending on the criticality of the situation, ARGANS will decide to inform or even to include ESA in the discussion. Any important decision that ARGANS may impose to its sub-contractors will be checked previously with ESA whose approval will be needed.

3.4.4. List of deliverables

Table 3-10 presents the list of the project deliverables depending on the type of activities and the delivery date. This table is called Deliverable Item List (DIL).

Table 3-10: Deliverable Item List

Deliverable	Id	Type	Date of delivery	Revision
Case Study Report	DEL-1	Document	T0+2w	T0+8m, T0+9m
Sentinel User Handbook User Requirements Document	DEL-2	Document	T0+2m	T0+8m, T0+9m
Sentinel User Handbook wiki structure description Document	DEL-3	Document	T0+2m	T0+8m, T0+9m
Sentinel User Handbook wiki structure justification Document	DEL-4	Document	T0+2m	T0+8m, T0+9m
Sentinel User Handbook “book” structure description Document	DEL-5	Document	T0+2m	T0+8m, T0+9m
Sentinel User Handbook “book” structure justification Document	DEL-6	Document	T0+2m	T0+8m, T0+9m
Suitability of User Handbook wiki development environment	DEL-7	Document	T0+2m	T0+9m
Multimedia requirements for the Sentinel User Handbook wiki	DEL-8	Document	T0+2m	T0+9m
Critical Analysis of ESA’s GSCDA web site doc.	DEL-9	Document	T0+2m	T0+9m
Sentinel User Handbook draft	DEL-10	Wiki document	T0+8m	
Sentinel Stakeholder’s recommendations report & analysis	DEL-11	Document	T0+9m	
Sentinel User Handbook issue 1	DEL-12	Wiki document	T0+12m	

Recommendation for evolution of the Sentinel User Handbook	DEL-13	Document	T0+12m	
Sentinel User Handbook issue 1.1	DEL-14	Wiki document	T0+18m	
Monthly Progress Reports	DEL-15	Document	Each month	
Presentations hands out	DEL-16	Document	As per review	
S-1 Data readers for NEST (1st delivery)	DEL-17	S/W	T0+9m	
S-2 Data readers for BEAM (1st delivery)	DEL-18	S/W	T0+9m	
S-3 Data readers for BEAM (1st delivery)	DEL-19	S/W	T0+9m	
Integrated S-2 ACP (1st delivery)	DEL-20	S/W	T0+15m	
Final delivery of all S/W items	DEL-21	S/W	T0+18m	
ECSS related documents as specified	DEL-22	S/W		

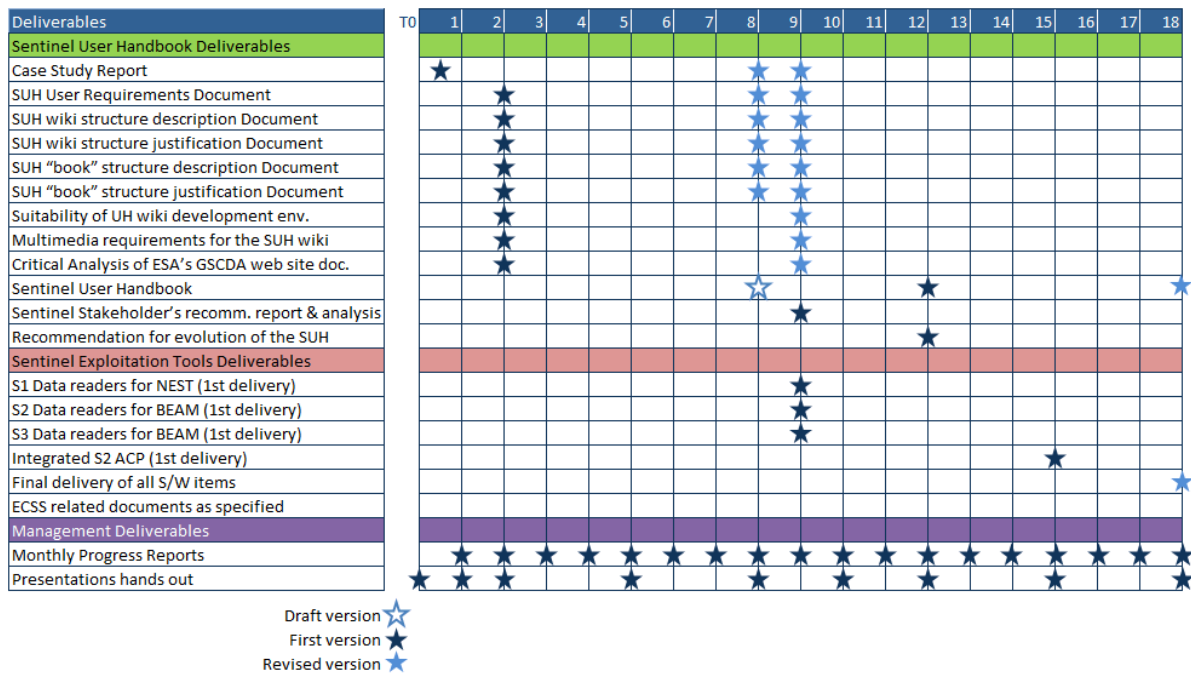


Figure 3-9: Deliverable Item List

3.4.5. Document Requirement Definition

This Section presents the documents that will be delivered within the frame of this project, in terms of objective, table of contents and plan for updating the deliverable during the life of the project.

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-1
Title: Case Study Report	
Objectives: <i>To present at least 10 case studies representing the maximum extent of potential users of the Sentinel User Handbook</i>	
Table Of Contents: <ul style="list-style-type: none"> ▪ Overview of main thematics (Marine Monitoring, Land monitoring, Emergency response, Atmosphere Monitoring, Security and Monitoring of Climate Change) ▪ Presentation of typical users organised per profile ▪ Derivation of users' interest wrt each topic of the Sentinel User Handbook 	
Plan for updating the deliverable during the life of the project: <ul style="list-style-type: none"> ▪ First version at T0 + 2 weeks ▪ Updated version at T0 + 8 months ▪ Updated version at T0 + 9 months 	

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-2
Title: Sentinel User Handbook – User Requirement Document (URD)	Sheet 1 of 1
Objectives: <i>To derive the user requirements from the case studies</i>	
Table Of Contents: <ul style="list-style-type: none"> ▪ For each type of user, derivation of their requirements from the Sentinel User Handbook 	
Plan for updating the deliverable during the life of the project: <ul style="list-style-type: none"> ▪ First version at T0 + 2 months ▪ Updated version at T0 + 8 months ▪ Updated version at T0 + 9 months 	

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-3
Title: Sentinel User Handbook – wiki structure description Document	
Objectives: <i>To describe the Sentinel User Handbook wiki structure</i>	
Table Of Contents: <ul style="list-style-type: none"> ▪ Presentation of the architecture of the wiki ▪ Presentation of the main pages of the wiki <ul style="list-style-type: none"> ✓ Overview of the Sentinels, including a section titled “What can the Sentinels do for you and how?” ✓ Description of the available and foreseen services based on the Sentinel products ▪ For each Sentinel mission <ul style="list-style-type: none"> ✓ Detailed description of the mission, spacecraft and instruments etc ✓ Detailed description of the instrument performances ✓ Detailed description of instrument calibration and on-ground characterization 	

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-3

- ✓ Executive overview of all key technical documents (ATBDs, TGRDs, DPMs, IODDs/Product Specs)
- ✓ Executive overview of the data access including appropriate links (GSCDA, EUMETSAT etc)
- ✓ Executive overview of the exploitation tools including links to BEAM and NEST

Plan for updating the deliverable during the life of the project:

- First version at T0 + 2 months
- Updated version at T0 + 8 months
- Updated version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-4

Title: Sentinel User Handbook – wiki structure justification Document

Objectives: *To justify the contents and the ergonomics of the wiki*

Table Of Contents:

- Table of compliance between the Sentinel User Handbook wiki structure and the user requirements
- Justification of each topic to be part of the Handbook
- Justification of the contents to be included in the Handbook
- Analysis of the ergonomics

Plan for updating the deliverable during the life of the project:

- First version at T0 + 2 months
- Updated version at T0 + 8 months
- Updated version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-5

Title: Sentinel User Handbook – book structure description Document

Objectives: *To describe the Sentinel User Handbook printable book structure*

Table Of Contents:

- For each typical user identified in the case studies
 - ✓ Define the structure of the “printable” book structure

Plan for updating the deliverable during the life of the project:

- First version at T0 + 2 months
- Updated version at T0 + 8 months
- Updated version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-6

Title: Sentinel User Handbook – book structure justification Document

Objectives: *To justify the Sentinel User Handbook printable book structure*

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-6

Table Of Contents:

- For each typical user identified in the case studies report
 - ✓ Justify the structure of the “printable” book structure

Plan for updating the deliverable during the life of the project:

- First version at T0 + 2 months
- Updated version at T0 + 8 months
- Updated version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-7

Title: Suitability of User Handbook wiki development environment

Objectives: *To analyse the development environment infrastructure proposed by ESA*

Table Of Contents:

- Analysis of Liferay open source software
- Detailed analysis of the infrastructure provided by ESA at KOM
- Proposed and justified evolutions of the environment

Plan for updating the deliverable during the life of the project:

- First version at T0 + 2 months
- Updated version at T0 + 8 months
- Updated version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-8

Title: Multimedia requirements for the Sentinel User Handbook wiki

Objectives: *To propose multimedia items needed for the Handbook*

Table Of Contents:

- Based on DEL-1 and DEL-2, propose and justify the needs for multimedia items
- Applications and GMES services
 - ✓ Sketches, photos, videos illustrating the main stakes of the applications and GEMS services to be served by the Sentinel mission
- Products
 - ✓ Images of main products to be delivered by the Sentinel
 - ✓ Dynamic animations
- Missions
 - ✓ Sketches, photos, videos showing the 3 Sentinel missions
- Instruments
 - ✓ Sketches, photos, videos illustrating the functioning of main instruments of Sentinel
- Exploitation Tools

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-8
<ul style="list-style-type: none"> ✓ Diagrams showing the functioning of BEAM and NEST ✓ Screen snapshots of the GUIs for BEAM and NEST 	
<p>Plan for updating the deliverable during the life of the project:</p> <ul style="list-style-type: none"> ▪ First version at T0 + 2 months ▪ Updated version at T0 + 8 months ▪ Updated version at T0 + 9 months 	

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-9
<p>Title: Critical Analysis of ESA's GSCDA website document</p>	
<p>Objectives: <i>To perform a critical analysis of GSCDA and make recommendations</i></p>	
<p>Table Of Contents:</p> <ul style="list-style-type: none"> ▪ Short analysis of GSCDA ▪ Recommendations about the integration of the Handbook within GSCDA ▪ Propose a web site map showing clearly where and how the two "tools" will interface and communicate ▪ Justification of the recommendations with respect to the case studies 	
<p>Plan for updating the deliverable during the life of the project:</p> <ul style="list-style-type: none"> ▪ First version at T0 + 2 months ▪ Updated version at T0 + 9 months 	

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-10
<p>Title: Sentinel User Handbook draft</p>	
<p>Objectives: <i>First draft of the Sentinel User Handbook</i></p>	
<p>Table Of Contents:</p> <ul style="list-style-type: none"> ▪ Content accordingly to the structure defined in DEL-3 	
<p>Plan for updating the deliverable during the life of the project:</p> <ul style="list-style-type: none"> ▪ Draft version at T0 + 8 months ▪ Updated version at T0 + 12 months ▪ Updated version at T0 + 18 months 	

Sentinel User Handbook and Exploitation Tools	DRD Ref: DEL-11
<p>Title: Sentinel Stakeholder's recommendations and analysis</p>	
<p>Objectives: <i>To analyse the recommendations raised by the stakeholders</i></p>	

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-11

Table Of Contents:

- Per stakeholder, synthesise all recommendations
- Analyse all recommendations in terms of
 - ✓ Relevance with respect to the case studies
 - ✓ Technical impact for further implementation
 - ✓ Effort impact for further implementation
- Propose, define and justify an implementation of these recommendations

Plan for updating the deliverable during the life of the project:

- First version at T0 + 9 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-12

Title: Sentinel User Handbook issue 1

Objectives: *First issue of the Sentinel User Handbook*

Table Of Contents:

- Content accordingly to the structure defined in DEL-3

Plan for updating the deliverable during the life of the project:

- Draft version at T0 + 8 months
- Updated version at T0 + 12 months
- Updated version at T0 + 18 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-13

Title: Recommendation for evolution of the Sentinel User Handbook

Objectives: *To make recommendations based on feedbacks gained during the project*

Table Of Contents:

- Presentation and analysis of results of demonstration of the effective use of the user Handbook for each typical users identified in the case studies
- Presentation and analysis of the “book” version of the Sentinel User Handbook
- Compilation of the ESA recommendations gathered during the “acceptance meeting”
- Recommendations for future evolutions

Plan for updating the deliverable during the life of the project:

- First version at T0 + 12 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-14

Title: Sentinel User Handbook issue 1.1

Objectives: *Revised issue of the Sentinel User Handbook*

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-14

Table Of Contents:

- Content accordingly to the structure defined in DEL-3

Plan for updating the deliverable during the life of the project:

- Draft version at T0 + 8 months
- Updated version at T0 + 12 months
- Updated version at T0 + 18 months

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-15

Title: Monthly Progress Reports

Objectives: *To present activities carried during the period of activity*

Table Of Contents:

- Analysed period of activity
- For each work package
 - ✓ Brief description of the technical activities carried out under the period
 - ✓ Brief description of difficulties affecting this activity
 - ✓ Major events
 - ✓ Activities to be carried out during the next period
- Extract of the Action Item List with only the actions not closed (e.g. open, on-going, on hold, etc.) except those closed during the period
- Updated Deliverable Item List
- Updated project schedule including reasons for slippage and corrective actions taken if any
- Updated status of the milestones
- Updated Risk Register
- Status of the payment plan
- AOB

Plan for updating the deliverable during the life of the project:

- A report is issued every month

Sentinel User Handbook and Exploitation Tools

DRD Ref: DEL-16

Title: Presentations hands out

Objectives: *Slides presented during meetings and reviews*

Table Of Contents:

- Depends on the agenda of the meeting

Plan for updating the deliverable during the life of the project:

- Delivered after each meeting or review

3.5. Management Compliance

The management requirements listed in Table 3-11 are extracted from the Special Conditions of Tender [AD 3]. Each “shall” found in Section 5.4 “Chapter 3 – Management Proposal” is turned into a requirement in the Management requirements compliance table.

Table 3-11: Management Requirements compliance table

Mgt. Req.	Management Req. description	Compliance	Traceability	Comment
5.4	The bidder shall submit a Management Proposal, in which the bidder shall demonstrate how it would manage the activities with the resources it has available to it, and meet the constraints of schedule and finance.	C	§ 3	
5.4.1.1	The bidder shall describe in detail its experience relevant to the project and the experience of all proposed partners.	C	§ 3.1	The consortium is first listed in terms of their roles and responsibilities, and then the relevance is given for each partner
5.4.1.2	The bidder shall identify each member of Key Personnel who, because of their individual qualifications, experience and current positions, are proposed for the work. Key personnel should be proposed at least to one level below the Project Manager, both for the prime contractor and any subcontractors, and every Work Package Manager shall be included as Key Personnel.	C	§ 3.2	The key people are initially listed in terms of their project roles, then key experience and lastly their WP and time allocation
5.4.1.3a	For each member of key personnel the bidder shall: Describe in detail the role and respective responsibilities which that member of key personnel shall perform.	C	§ 3.2.2	
5.4.1.3b	For each member of key personnel the bidder shall: Explain why, in terms of the individual’s qualifications, relevant experience and current positions, he/she has been proposed for the work.	C	§ 3.2.3	

Mgt. Req.	Management Req. description	Compliance	Traceability	Comment
5.4.1.3c	For each member of key personnel the bidder shall: Provide a full curriculum vitae (CV), which should demonstrate clearly the relevant experience of the person concerned and the person's ability to carry out the tasks allocated to him. The CV should also contain a brief description of the person's present job and responsibilities. All of the CVs shall be provided in an Annex to Chapter 3.	C	§ 3.6	A CV is provided for each of the key personnel
5.4.1.3d	For each member of key personnel the bidder shall: State the proportion of the individual's working time he/she will commit to the project.	C	§ 3.2.4	
5.4.1.3e	For each member of key personnel the bidder shall: Provide a table showing, for each member of Key Personnel, the role each member of Key Personnel will play in each Work Package and the proportion of the person's working time which the person will devote to each Work Package.	C	§ 3.2.4	
5.4.1.4	The procurement of external services, or tools which may be required during the project shall be listed and quoted, and the name of the service provider must be given.	C	§ 3.2.5	External consultants will provide support writing the handbook: technical requirement [RQT 13]
5.4.2.1	The bidder shall submit a brief description of all facilities and resources which it proposes using for the project.	C	§ 3.2.5	The facilities are listed for each member of the consortium
5.4.2.2	The bidder shall describe what means of access it has to information resources, such as software libraries, data sources etc, if these are required for the project proposed.	C	§ 3.2.5	Included within the facilities Sections
5.4.3.1	The bidder shall provide a Project Management Plan (PMP), in which it shall describe in detail the management plans, policies and procedures for this activity, and analyse any foreseeable risk factors.	C	§ 3.4	A Section of the proposal is provided as a preliminary version of the PMP, which will be updated during the projects' lifecycle
5.4.3.1a	The PMP shall contain, as a minimum, a Work Breakdown Structure (WBS)	C	§ 3.4.1.1	
5.4.3.1b	The PMP shall contain, as a minimum, a project schedule	C	§ 3.4.2	

Mgt. Req.	Management Req. description	Compliance	Traceability	Comment
5.4.3.1c	The PMP shall contain, as a minimum, a presentation of the structure of the project team	C	§ 3.2.1	Provided as a Figure showing the responsibilities
5.4.3.1d	<p>The PMP shall contain, as a minimum, a detailed description of:</p> <ul style="list-style-type: none"> o the lines of communication which will operate throughout the team structure; o the respective roles of the team's project manager and technical officer; o the arrangements for internal team meetings; o the contents of the monthly Progress Reports; o the purpose of and procedure for Progress Meetings with the Agency; o the supervision and reporting mechanisms; and the procedure for settling disagreements during the project (if relevant, ie if subcontractors are proposed). The procedure should provide for a final and binding decision to be taken at the ultimate stage. <ul style="list-style-type: none"> • a clear and exhaustive List of Deliverables, showing all items and products which will be delivered to the Agency at the end of each WP, in accordance with the requirements of the SoW. • Document Requirement Definition (DRD) sheets for any document-type deliverable. The DRDs shall present the objectives of the deliverables, describe the major elements of the deliverables, include a preliminary table of contents, and outline the plan for updating the deliverables during the lifetime of the project. 	C	§ 3.4.3	Given within the Management rules Section
5.4.4	The bidder shall provide a table tracing its compliance with all of the management requirements listed in these SCTs.	C	§ 3.5	This table

3.6. Appendix: CVs

3.6.1. ARGANS CVs


	<p>Dr Samantha Lavender</p> <p>Company Position: Managing Director</p> <p>Project Role: Project Manager / Senior Engineer</p>
<p>Degree</p>	<p>2000 – 2001, PgCert, University of Plymouth: Learning and Teaching in Higher Education.</p> <p>1992 – 1996, PhD, University of Plymouth: Remote Sensing of Suspended Sediment.</p> <p>1989 – 1992, First Class BSc Honours Degree in Oceanography and Marine Computer Applications, University of Plymouth.</p>
<p>Experience</p>	<p>2009 - Honorary Reader, School of Marine Science and Engineering, Plymouth University.</p> <p>2007 - Managing Director, ARGANS Limited (www.argans.co.uk).</p> <p>2005 – 2009, Reader in Geomatics, School of Earth, Ocean and Environmental Sciences (SEOES), University of Plymouth (UoP).</p> <p>2002 – 2005, Senior Lecturer in Geomatics, SEOES, UoP.</p> <p>2000 – 2002, Lecturer in Geomatics, Institute of Marine Studies, UoP.</p> <p>1997 – 2000, HSO Remote Sensing Scientist, Plymouth Marine Laboratory.</p> <p>1995 – 1997, Manager of the NERC Remote Sensing & GIS Unit, Natural Environment Research Council.</p> <p>1992 – 2000, Part-Time Lecturer and Demonstrator, Institute of Marine Studies, UoP.</p>
<p>Professional Activities (2005 onwards)</p>	<p>2010 – UK representative and Council member for the European Association of Remote Sensing Laboratories (EARSeL).</p> <p>2010 - Remote Sensing and Photogrammetry Society (RSPSoc) Chairman</p> <p>2008 – RSPSoc Chair of External Affairs & co-chair ISPRS Working Group VIII.6 on Oceans.</p> <p>2007 - NERC Centre for Earth Observation Instrumentation (CEOI) steering committee.</p> <p>2006 - Member of International Ocean Colour Co-ordinating Group (IOCCG), ESA peer reviewer for Cat-1 applications, NASA grants application reviewer and member of the NERC peer-review college.</p> <p>2005 – 2007 Council member of the Remote Sensing and Photogrammetric Society (RSPSoc) and chair of the Special Interest Group Committee.</p> <p>2004 – 2008 Chair of the International Society for Photogrammetry and Remote Sensing (ISPRS) Working Group VIII.6 on Coastal Zones Management, Ocean Colour and Ocean State Forecasting.</p> <p>2002 – 2008 Centre for observation of Air-Sea Interactions and fluxes (CASIX) scientific team leader and scientific steering committee member.</p> <p>Member of: Challenger Society for Marine Science (CSMS), The Hydrographic Society UK, Royal Meteorological Society (Fellow) and RSPSoc.</p>

Nationality	British
Recent (2005 onwards)	<p><u>Lavender, S.</u> Accepted. Ocean Measurements and Applications, Ocean Color. <i>Encyclopaedia of Remote Sensing</i>. Springer.</p> <p><u>Lavender, S.</u>, Fanton d'Andon, O., Kay, S., Bourg, L., Emsley, S., Gilles, N., Nightingale, T., Quast, R., Bates, M., Storm, T., Hedley, J., Knul, M., Sotis, G., Nasir-Habeeb, R., Goryl, P. and Sentinel-3 L2 Products and Algorithm Team. In Press. Applying Uncertainties to Ocean Colour Data. <i>Metrologia</i>.</p> <p>Abdel Hamid, I., Abbott, V., <u>Lavender, S.</u> and Kingston, K. 2011. Chromo-stereoscopy for Enhanced Viewing in Opaque Environment. <i>FIG Working Week 2011: Bridging the Gap between Cultures</i>, Marrakech, Morocco, May 2011, 14 pp.</p> <p>Kay, S., Hedley, J., <u>Lavender, S.</u>, and Nimmo-Smith, A. 2011. Light transfer at the ocean surface modeled using high resolution sea surface realizations. <i>Optics Express</i>, 19(7), pp. 6493-6504</p> <p><u>Lavender, S.</u>, Barker, K., Fanton d'Andon, O., Kay, S., Bourg, L., Kent, C., Emsley, S., McCulloch, M., Goryl, P. and Sentinel-3 L2 Products and Algorithm Team. 2011. Ocean Colour Uncertainties. <i>34th International Symposium on Remote Sensing of Environment</i>, Sydney, Australia, April 2011, 4 pp.</p> <p>Raitsos, D.E., <u>Lavender, S.J.</u>, Maravelias, C.D., Haralabous, J., McQuatters-Gollop, A., Edwards, M. and Reid, P.C. 2011. Macroscale factors affecting diatom abundance: a synergistic use of Continuous Plankton Recorder and satellite remote sensing data. <i>International Journal of Remote Sensing</i>, 32 (8), pp. 2081-2094</p> <p>Brewin, R.J.W., Hardman-Mountford, N.J., <u>Lavender, S.J.</u>, Raitsos, D.E., Hirata, T., Uitz, J., Devred, E., Bricaud, A., Ciotti, A. and Gentili, B. 2010. An intercomparison of bio-optical techniques for detecting dominant phytoplankton size class from satellite remote sensing. <i>Remote Sensing of Environment</i>, 115, pp. 325-339</p> <p>Brewin, R.J., <u>Lavender, S.J.</u>, Hardman-Mountford. 2010. Mapping size-specific phytoplankton primary production on a global scale. <i>Journal of Maps Student Edition</i>, pp. 12-25</p> <p>Brewin, R.J., <u>Lavender, S.J.</u>, Hardman-Mountford, N.J and Hirata, T. 2010. A spectral response approach for detecting dominant phytoplankton size class from satellite remote sensing. <i>Acta Oceanologica Sinica</i>, 28(6), pp. 1-19</p> <p>Brewin, R.J.W., Sathyendranath, S., Hirata, T., <u>Lavender, S.J.</u>, Barciela, R.M. and Hardman-Mountford, N.J. 2010. A three-component model of phytoplankton size class for the Atlantic Ocean. <i>Ecological Modelling</i>, 221(11), pp. 1472-1483</p> <p><u>Lavender, S.J.</u> et al. 2010. Products Definition and Determining Uncertainties; Sentinel-3 Optical Level 2 Prototype Processor. <i>ESA Living Planet Symposium</i>, Bergen, Norway, June-July 2010, 5 pp.</p> <p>Aiken, J., Pradhan, Y., Barlow, R., <u>Lavender, S.</u>, Poulton, A., Holligan, P. and Hardman-Mountford, N. 2009. Phytoplankton pigments and functional types in the Atlantic Ocean: A decadal assessment, 1995-2005. <i>Deep Sea Research Part II: Topical Studies in Oceanography</i>, 56(15), pp. 899-</p>

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Additional Activities	Languages , English: native; French: intermediate; German: beginner.

	<p>Dr Stephen Emsley</p> <p>Company Position: Head of IT / Advanced Engineer</p> <p>Project Role: Lead for the Sentinel User Handbook development</p>
Degree	<p>2000, PhD, University of Warwick, School of Biological Sciences: Towards an object orientated virtual ecology of plankton population dynamics.</p> <p>1995, MSc, University of Plymouth, Centre for Intelligent Systems: Cognitive Science, Artificial Intelligence, Human Computer Interaction, Knowledge Engineering, Machine Vision, Machine Learning. Developed an Artificial Neural Network trained with pigment biomarker signatures to identify phytoplankton</p>

	<p>groups present in water samples subjected to HPLC pigment separation.</p> <p>1993, BA (Hon. 1st class), Open University, Fundamentals of Computing, Mathematics in Computing, The Digital Computer, Programming & Programming Languages, Topics in Software Engineering, Oceanography, Evolution.</p> <p>1979, BA, Clare College, Cambridge. Natural Sciences Tripos: Biology of Cells, Biology of Organisms, Physiology, Mathematics for Biologists, Experimental Psychology, Biochemistry, Pathology – specialising in 3rd year Immunology & Virology.</p>
Experience	<p>ARGANS:</p> <ul style="list-style-type: none"> • Head of IT: <ul style="list-style-type: none"> ○ To provide an interface between the technical and management interests; be informed of developments in technology; negotiate with resellers and third-party suppliers to ensure products and services purchased are both fit for purpose and competitively priced. ○ Linux, Microsoft Windows Server and Network administrator. ○ Web authoring including development of ARGANS website. • Advanced Engineer: Part of the Sentinel-3 Level 2 prototype team. Has developed the overarching scripting / code to link the individual sensor executables: unpacking of Level 1 input packages / handling of metadata, pre-processing of configuration files, and updating metadata / packaging of SAFE Level 2 output packages. <p>External:</p> <ul style="list-style-type: none"> • 2000 –, Associate Lecturer, Open University: Since joining ARGANS has maintained role as exam marker and representative on Examinations & Awards Board. • 2004 – 2007, Programmer / Developer, British Oceanographic Data Centre: Re-engineered mission critical legacy FORTRAN software into MATLAB enabling migration to new hardware platform on deadline. • 2002 – 2004, Research Fellow, University of Plymouth: EU funded project - Human Interaction with Large Scale Coastal Morphological Evolution. Developed a parametric model of cross-shore sand bar development to investigate the processes involved, and to aid prediction of short to medium scale changes, in beach morphology. Implemented in MATLAB and designed an interface to enable the user to explore and visualize the parameter space with ease and intuitive accessibility. • 2000 – 2002, Research Assistant, Scottish Association of Marine Science: NERC funded project - Marine Productivity. Analysis of a large data set (ADCP backscatter & LICOR irradiance) to provide behavioural heuristics used to model zooplankton diel migration strategies and to investigate the interaction between these, the flow fields in the Irish Sea (using POLCOMS data), and the potential ecological implications of retention and dispersion.

Nationality	British
Publications	<p>Lavender, S., Fanton d'Andon, O., Kay, S., Bourg, L., Emsley, S., Gilles, N., Nightingale, T., Quast, R., Bates, M., Storm, T., Hedley, J., Knul, M., Sotis, G., Nasir-Habeb, R., Goryl, P. and Sentinel-3 L2 Products and Algorithm Team. In Press. Applying Uncertainties to Ocean Colour Data. <i>Metrologia</i>.</p> <p>Lavender, S., Barker, K., Fanton d'Andon, O., Kay, S., Bourg, L., Kent, C., Emsley, S., McCulloch, M., Goryl, P. and Sentinel-3 L2 Products and Algorithm Team. 2011. Ocean Colour Uncertainties. <i>34th International Symposium on Remote Sensing of Environment</i>, Sydney, Australia, April 2011, 4 pp.</p> <p>O'Hare, T.J., Ostrowski, R., Emsley, S.M., and Huntley, D.A. 2006. Application of two contrasting coastal profile evolution models to Lubiatowo, Poland and La Barrosa, Spain, <i>Archives of Hydro-Engineering and Environmental Mechanics</i>, 53, 3-35.</p> <p>Emsley, S.M., Tarling, G.A. and Burrows, M.T. 2005. The effect of vertical migration strategy on retention and dispersion in the Irish Sea during spring-summer <i>Fisheries and Oceanography</i>, 14:3, 161-174.</p> <p>Tarling, G.A., Jarvis, T., Emsley, S.M. and Matthews, J. 2002. Midnight Sinking behaviour in <i>Calanus finmarchicus</i>: a response to satiation or Krill predation <i>MEPS</i>, 240: 183-194.</p> <p>Baird, M.E., Emsley, S.M. and McGlade, J. 2001. Using a phytoplankton model to predict the fractionation of stable carbon isotopes. <i>Journal of Plankton Research</i>, 23: 829-840.</p> <p>Baird, M.E., Emsley, S.M. and McGlade, J. 2001. Modelling the interacting effects of nutrient uptake, light capture and temperature on phytoplankton growth. <i>Journal of Plankton Research</i>, 23: 809-829.</p> <p>Baird, M.E. and Emsley, S.M. 1999. Towards a mechanistic model of plankton population dynamics. <i>Journal of Plankton Research</i>, 21: 85-126.</p>

	<p>Mr Jan Jackson</p> <p>Company Position: Advanced engineer and ARGANS Earth Observation Quality Control lead</p> <p>Project Role: S-2 Handbook lead</p>
Degree	<p>MSc in Applied Marine Sciences at the University of Plymouth (UoP).</p> <p>Dissertation: Low Earth Orbit (LEO) Satellite Systems for cost-effective near-real time data transfer from anywhere on the Earth's Surface.</p>
Experience	<p>Currently responsible for Technical Lead of Quality Control activities under the ESA IDEAS Sensor Performance & Product Assessment (SPPA) for the following Optical Instruments:</p> <ul style="list-style-type: none"> • ENVISAT MERIS • Landsat 5 & 7 • SeaWiFS • MODIS (AQUA & TERRA)

	<p>Tasks include:</p> <ul style="list-style-type: none"> • Management of Instrument-specific project resources to ensure that the delivery to the User is performed seamlessly and in a timely and efficient manner. • Oversight and liaison with contract partners to provide support to appropriate instrument/mission QC tools, and thereby to provide necessary inputs to scheduled activities such as daily, weekly and cyclic reports • Provide routine monitoring of selected near real time data products quality and operations and raise issues with supporting agencies when necessary. • Perform anomaly detection and clarification for Users instrument/mission products • Provide recommendations for improvements for all activities undertaken by the SPPA Teams • Provide routine monitoring of off-line data products quality and operations • Provide validation and assessment of changes implemented in the Instrument Processor configuration • Oversee the preparation of Weekly, Cyclic and Yearly (calendar basis) reporting <p>Outputs include:</p> <ul style="list-style-type: none"> • Daily reports on product quality, instrument availability and sensor performance • Early product quality anomaly detection reports • Weekly and other periodic quality reports • Recommendations for evolutions (software, documentation, etc.) for routine operations and sensor performance assessment • Author of Technical Notes where applicable • Presentation to review meetings, Progress Meetings, Instrument Quality Working Groups etc. • Supporting contractual documentation (SoWs, PSS forms etc).
Publications	Kent, C., Jackson, J. , Borg, A., Sautreau, D., Lavender, S., Bourg, L., Saunier, S., and Goryl, P. 2010. Data quality control for operational satellite borne instruments. Proceedings of the ESA Living Planet Symposium, 28 June – 02 July 2010. Bergen, Norway, 6 pp.
Professional Activities	British Association of Remote Sensing Companies (BARSC) representation
Nationality	British

3.6.2. BROCKMANN CONSULT CVs

Family name	Given name	Title
Fomferra	Norman	Mr.

Title of post in proposed work		
Software Lead		
Outline of responsibilities in proposed work		
Software Development and Development Coordination		
Software Product Assurance		
Academic and professional qualifications relevant to this task		
Diploma in Bio-Engineering and Environmental Techniques (1993)		
Microsoft System Engineer (Certificate awarded 1996)		
Other significant training and skills relevant to this task		
Diploma thesis on mathematical modelling and real time simulation of bio-technical processes. Development of a pre-compiler for dynamical simulations and the simulator itself.		
Four years software development of an object-oriented architectural CAD-system using LISP, C and C++ under AutoCAD.		
Microsoft Windows programming using MFC with Visual C++.		
OO Architectures and API design for EO data visualisation, processing and analysis systems with Java, C++/UML.		
Service-oriented Architectures for EO data archiving and processing systems using Java EE technologies.		
Other significant elements (e.g. professional experience) relating to this Invitation To Tender		
16 years software engineering experience including 14 years object-oriented software design including 11 years development using Java and UML.		
Technical supervisor for all software development projects at BC.		
Project manager and lead architect for ESA BEAM (Basic Envisat Toolbox for AATSR and MERIS) and multiple BEAM related projects.		
Mentor and consultant for 3 rd party BEAM platform developments (ESA NEST, ESA LeoWorks, NASA SeaDAS)		
Project manager and developer for the Calvalus EO Data Processing System (ESTEC contract)		
Long-time experience in processing of large remote sensing datasets		
Year of birth	Country of birth	Nationality/Nationalities
1965	Germany	German
European Community Languages spoken (best first)		
German	English	Spanish

Currently working for (organisation)	Since (yr.)
Brockmann Consult	1999

Family name	Given name	Title	
Quast	Ralf	Dr.	
Title of post in proposed work			
Software Engineer			
Outline of responsibilities in proposed work			
Software development			
Software quality assurance			
Software maintenance			
Academic and professional qualifications relevant to this task			
Diploma in Physics (1998)			
PhD in Physics (2006)			
Other significant training and skills relevant to this task			
5 years experience in the development of software (C++) for the analysis and modelling of high-resolution QSO spectra.			
5 years experience in the object-oriented software development (C++, Java) in projects related to remote-sensing data.			
Other significant elements (e.g. professional experience) relating to this Invitation To Tender			
Development of the aerosol processor for the MERIS Application and Regional Products Project			
Implementation of climate data operators (CDO) for the analysis of climate and forecast model data produced by the Max-Planck Institute for Meteorology			
Development of BEAM plug-ins for importing and processing CHRIS/Proba data: noise reduction, cloud screening, atmospheric correction, geometric correction			
Development of BEAM plug-ins for importing and visualising SMOS Level 1c and Level 2 science user data			
Development of improved cloud detection algorithms for EUMETSAT IASI			
Management, development and documentation of the Sentinel-3 SYN/VGT prototype processors and products sub-project			
Year of birth	Country of birth	Nationality/Nationalities	
1967	Germany	German	
European Community Languages spoken (best first)			
German	English	French	Spanish
Currently working for (organisation)			Since (yr.)
Brockmann Consult			2005

Family name		Given name		Title
Faber		Olga		Mrs.
Title of post in proposed work				
Software Tester				
Outline of responsibilities in proposed work				
Software Verification				
Software Quality Control				
Academic and professional qualifications relevant to this task				
Diploma in Physics (1975)				
Other significant training and skills relevant to this task				
8 years experience in software verification and validation within the EO domain.				
In-depth knowledge of software testing practice (test plan development, automation) using QF-Test				
Long-time experience in managing of large remote sensing (test) datasets.				
Other significant elements (e.g. professional experience) relating to this Invitation To Tender				
Tester of BEAM				
Tester of BEAM plug-ins for importing Sentinel 3 data (ESA Sentinel-3 SYN/VGT prototype processors)				
Tester of BEAM plug-ins for importing and processing CHRIS/Proba data				
Tester of BEAM plug-ins for importing and processing SMOS data				
Tester of the ESA CalValPortal and ESA web applications (ESRIN contracts)				
Tester of the Calvalus EO Data Processing System and web portal (ESTEC contract)				
Year of birth	Country of birth	Nationality/Nationalities		
1953	Russia	Russian		
European Community Languages spoken (best first)				
Russian	German	English		
Currently working for (organisation)				Since (yr.)
Brockmann Consult				2000

3.6.3. ARRAY CVs

Rajesh Jha, M.A.Sc., P.M.P.
Array Systems Computing Inc.
1120 Finch Avenue West, 7th Floor
Toronto, Ontario, Canada M3J 3H7
Tel.: (416) 736-0900 ext. 269
Fax: (416) 736-4715
rajesh@array.ca

Security Clearance Level

Rajesh holds a valid personnel security screening at the level of NATO Secret, granted and approved by CIISD/PWGSC.

Experience/Qualifications

1994 – Present: Array Systems Computing Inc., Toronto, Ontario

February 2009 – Director of Programs
Present:

As Director of Programs, Rajesh manages the engineering department and oversees all projects within Array. He has over ten years of experience managing projects in application areas such as sonar, radar, remote sensing, modelling and simulation, and intelligent transportation systems.

May 2011 – Project Manager
Present: Light Version of COMPASS Software (NGCSLITE)

The Next Generation COMPASS Software (NGCS) was recently deployed in Central Region's Downview and Burlington Traffic Operation Centres (TOC). The next Phase of NGCS is to develop a lighter version, NGCS-Lite, for deployment at other regional traffic operation centres, specifically Ministry of Transportation (MTO) East and West Regions. The scope of this Total Project Management (TPM) assignment includes reviewing/analyzing the NGCS and to modify, customize or develop additional software components so that an NGCS-Lite version can be deployed in the East and West Regional TOCs.

Rajesh is currently the Project Manager on this project.

*February 2011 – Present: Project Manager
Canadian Towed Array Sonar System (CANTASS) Mission Simulator (CMS) Upgrade (CMSU)*

Array was awarded a contract by the Department of National Defence (DND) to upgrade the Canadian Towed Array Sonar System (CANTASS) Mission Simulators.

The first CMS was commissioned in March 2000, the CANTASS Mission Simulator (Atlantic) (CMS(A)) and is installed in the training facility at Canadian Forces Naval Operations School, Halifax (CFNOS). A second CMS for the Pacific coast (CMSP) was developed by Array and commissioned in October 2002. It is installed in the training facility at Canadian Forces Fleet School, Esquimalt (CFFS(E)).

The CMS must undergo a technology upgrade in order to remain operational and Array will perform the required technology upgrades.

Rajesh is the Project Manager on this project.

*November 2010 – Present: Project Manager
Radarsat-2 SAR Toolbox (RSTB)*

Array was awarded a contract by the Canadian Space Agency (CSA) under the Earth Observation Application Development Program (EOADP) to develop an Open Source RADARSAT-2 Toolbox (RSTB). The primary objective of the project is to develop an Open Source RADARSAT-2 specific toolbox for processing, visualising and analyzing of RADARSAT-2 Polarimetric Synthetic Aperture Radar (SAR) products.

Rajesh is the Project Manager on this project.

*October 2007 – Present: Project Manager
Next ESA SAR Toolbox (NEST)*

Array is developing the NEST toolbox for the European Space Agency (ESA). NEST is an open-source software toolbox intended for reading, post-processing, analysing and visualising SAR images processed to Level 1 or higher. NEST will ingest the data formats of past, present and planned ESA SAR missions, including Sentinel-1, as well as third-party SAR-data from JERS SAR, ALOS PALSAR, TerraSAR-X and RADARSAT-2, for example. NEST is being developed in Java and has an easily portable, modular design allowing modules to be added by third-party users.

Rajesh is currently the technical project manager and has been heavily involved with algorithm definition and design, and testing including development of test stubs in Matlab.

January 2009 – Project Manager
November 2009: SAR Simulation Toolbox for UAV Applications, Turkey

In early 2009, Array was awarded a contract by a major defence contractor in Turkey to deliver a SAR Simulation Toolbox covering all the functionality required for UAV-type applications. The imaging modes included are Stripmap, Spotlight and ISAR, together with GMTI functionality. Two Stripmap imaging algorithms are included – the classic Range-Doppler (rectangular) algorithm and the Chirp-Scaling Algorithm, which may be used to form strip images in squinted imaging configurations. Spotlight and ISAR processing are performed using the Polar Format Algorithm, which is combined with target tracking and rotational parameter estimation in ISAR mode. Two GMTI modes of operation are included – a simple single-channel “exocutter” GMTI and a Displaced Phase Centre Algorithm (DPCA) type method which extracts multiple Doppler bands from a single physical antenna.

New functional modules have been developed using Matlab in order to perform modelling of radar clutter and a number of noise distributions. The Chirp Scaling Algorithm stripmap-mode implementation was also developed for this contract. Additionally, enhancements were made to the toolbox to allow the modelling of three-dimensional clusters of point targets for ISAR mode applications.

The STB Turkey program included two training courses in SAR imaging theory in general, and the use of the SAR Toolbox in particular. Both these training courses were conducted at the customer’s site in Turkey.

Rajesh was responsible for the technical management and was primarily involved in requirements definition, algorithm definition, software design, and testing,

March 2008 – Project Manager
March 2009: SAR Data Generation and Processing for Stripmap, Brazil

Array was contracted to deliver a Stripmap SAR toolkit, based on the SAR Toolbox product line. The customer had a number of unique imaging requirements, which Array was able to accommodate by making modifications to the SAR Toolbox. The delivered components included the Data Generation Tool (DGT), Motion Compensation (MoComp), Stripmap imaging, and the Image Quality Tool (IQT). A unique requirement for this project was the ability to be able to import optical image data stored in GeoTIFF files along with associated DEM into the SAR Toolbox and to convert the pixel intensities in order to model the RCS of the scatterers in the scene.

Rajesh was responsible for the technical management and was involved in definition of requirements for the optical-to-raw SAR data convertor and identification of improvements to the toolbox. He was also involved with testing and documentation.

*June 2006 – July 2008: Project Manager
Dynamic Message Sign Device Manager (DMSDM)*

Rajesh was the Technical Project Manager for the DMSDM distributed function of the NGCS system being developed by the Ministry of Transportation Ontario (MTO). DMSDM is the software that will serve as the “master controller” for dispatching the messages to the Dynamic Message Signs (DMS) in the field. It will support all types of sign communication protocols (both vendor-specific and National Transportation Communications for ITS Protocol (NTCIP)).

The DMSDM software is implemented in Java running under Linux. It has three main components – a web-based browser interface that provides the user the GUI to manage and control DMS signs; a central device manager component that handles all communication between the DMSDM and the DMS sign controllers, as well as other NGCS components; and a database component that uses stored procedures to interact with the central NGCS database for data on sign configuration, parameters, status and reports.

*March 2007 – December 2007: Project Manager
SAR Simulation Toolbox for Agency for Defence Development, Korea*

Array provided a SAR simulation toolbox with data generation, Stripmap, Spotlight, ISAR, GMTI processing and image quality tool for this project. A number of enhancements were made to the SAR Toolbox. These included the implementation of an ISAR imaging mode based on the Polar Format Algorithm (PFA). This ISAR implementation incorporates target tracking and motion estimation, including rotational parameter estimation. The Graphical User Interface of the SAR Toolbox was enhanced with the addition of an interactive Point target Editor, allowing arrays of synthetic targets to be defined and visualized conveniently.

Rajesh was responsible for the technical management and was primarily involved in requirements definition, software design, and testing,

*April 2005 – March 2008: Project Manager
Advanced Deployable Day/Night Simulation*

Rajesh was the Project Manager for the ADDNS project at Array. A key requirement of the project was the development and supply of an Image Generator to DRDC-Toronto for an ultra high resolution projector. The work included the design, assembly and integration of the hardware as well as rendering software and continuing warranty and maintenance support for a period of five years.

*January 8, 2004 – March 2006: Project Manager
Underwater Acoustic Analysis System (UAAS)*

Rajesh was the Project Manager on the Underwater Acoustic Analysis System (UAAS) project. The UAAS is a flexible modular sonar post-analysis system that Array developed for the German Navy. Rajesh had the overall responsibility for the project and was involved in the systems engineering and design activities.

The UAAS was successfully delivered in March 2006, and the project is now under the support and maintenance Phase.

*May 2002 – June 2006: Deputy Project Manager
Sonar Acoustic Post Processing System (SAPPS)*

Rajesh was the Deputy Project Manager on the Sonar Acoustic Post Processing System (SAPPS) project. The SAPPS is a flexible modular sonar post-analysis system that Array developed for the Royal Swedish Navy (RSwN).

Rajesh's responsibilities on this project included assisting in the technical and schedule management. This included supervising a team which consisted of over 24 staff at its peak. His experience from managing large sonar and radar programs was valuable in assisting in the management of the project and ensuring that the project deliveries were within specification and schedule.

The system was delivered in June 2006 and is currently under the support and maintenance Phase.

*January 2003- May 2003: Project Manager
Parallel Processing Issues in Acoustic Modelling and Simulation (PPIAMS)*

Rajesh was the Project Manager on the PPIAMS project. The project involved a study, evaluation and recommendations for development and selection of suitable parallel processing architectures for computationally intensive acoustic modelling and simulation environments.

*June 2003- September 2003: Project Manager
Packaging the Chain Link Model from CANTASS (PCLMC)*

Rajesh was the Project Manager on the PCLMC project. For this project, Array packaged the Chain Link Model from the Canadian Towed Array Sonar System (CANTASS) for the Defence Research & Development Canada-Atlantic (DRDC-Atlantic). Basically, the PCLMC team developed a C++ wrapper that encapsulates the Chain Link Model simulator, which was developed in the 1980s using FORTRAN, into an independent module called a Generic Signal Processing Block (GSPB). By doing so, the simulator can now be dynamically linked with or removed from the Generic Post Analysis System (GPAS), also developed by Array. A Graphical User Interface (GUI) for using the GSPB was also developed.

*April 2003- March 2005: Project Manager
Data Acquisition and Modelling Services (DAMS)*

Rajesh was the Project Manager for the 3D Data Acquisition and Modelling Services (DAMS) project. He provided project management for the standing offer for visualization, rendering, and modelling services under standing offer to DRDC-Toronto (SA: Pierre Meunier) for laser-scan modelling, data-processing, reach-study visualization, sensor integration, and human factors studies. All call-ups were completed on time and on budget, to the client's satisfaction.

Rajesh reviewed and supervised the production of a high fidelity 3D graphics model from raw laser-scan point clouds using advanced rendering, data filtering, smoothing, polygonization, surfacing, and Constructive Solid Geometry (CSG).

*July 2003 – July 2004: Project Manager
Software for the Simulation of Flight Missions (SSFM)*

Rajesh was Project Manager for the software and systems development of a networked, dual-computer real-time 3D flight simulator for training and simulation experiments.

Rajesh supervised the entire project, including the programming of framework and experimental conditions, user interfaces (GUIs), real-time 3D graphics rendering and texturing, and network communications. The system was delivered on a dual Windows XP platform using Matlab (with VR toolkit), C/C++, Java, and VRML 97.

Rajesh supervised on-site installation and testing at DRDC-Toronto, and assisted in the preparation of a user manual and on-line help files. The project was completed on time and below budget, to the client's satisfaction.

*December 2002-
June 2003: Project Manager/Project Engineer
Initial Design Study for the HYDROS SAR Processor (IDSHSP)*

Rajesh was the Project Manager/Project Engineer on the IDSHSP project. This project involved the initial design of the ground processor for the HYDROS satellite, and involved analysis of processor requirements, identification and evaluation of algorithms, and preparation of a development plan.

*January 2000 –
December 2002: Project Manager/Project Engineer
CANTASS Mission Simulator (CMS)*

Rajesh was the Project Manager/Project Engineer on the Canadian Towed Array Sonar System (CANTASS) Mission Simulator (CMS) Pacific (Sonar Simulator) project. He was responsible for technical management, schedule and budget. He supervised a team of 12 software engineers, systems engineers and hardware engineers. A significant portion of the work was the Graphical User Interface (GUI), setting up missions for training, and displaying the results of the acoustic signal processing in a variety of formats. The technology used on this project included C, Ada, PPC, Solaris O/S, MCOS, and VME Architecture.

*January 2000 –
November 2000: Project Manager/Project Engineer
SAR Processing Toolbox, Japan*

Rajesh was the Project Manager/Project Engineer on the SAR Simulation project. He was responsible for implementing algorithms for stripmap processing. He was also responsible for technical management, schedule and budget.

August 1998 – Project Manager/Project Engineer
July 1999: Spotlight Synthetic Aperture Radar (SSAR)

Rajesh was the Project Manager/Project Engineer for the SSAR project. He was responsible for the technical management and schedule. He led a team of 16 software engineers, systems engineers, and hardware engineers.

In addition to the real-time issues for radar signal processing, the work included GUI for the radar control, SAR displays, manipulation of the SAR displays, and implementation, in an off-line mode, of image-processing operations to enhance and aid the visualization of the displayed imagery including 2D and 3D displays.

The technologies used on this project included C, Ada, Mercury I-860, PPC, VxWorks, MCOS, and VME Architecture.

December 1997 – Project Manager/Project Engineer
May 1999: Digital Scan Converter and Image Processing System for AHP (Airborne SAR)

Rajesh was the Project Manager/Project Engineer on the Digital Scan Converter and Image Processing System for AHP (Airborne SAR) project. He was responsible for the technical management and schedule. He also led systems engineering and design. Work on the project included the GUI for the control as well as conventional radar and SAR displays.

On this project, he managed a team of 12 software engineers, systems engineers, and hardware engineers. The technologies used on this project included C, C++, Mercury I-860, PPC, VxWorks O/S, MCOS, and VME Architecture.

November 1996 – Project Manager/Project Engineer
March 2000: Image Data Calibration Workstation (IDCW)

Rajesh was the Project Manager/Project Engineer on the Upgrade and Support of the Image Data Calibration Workstation (IDCW), and the implementation of upgrades to the IDCW software and support. The technologies used on this project included C, C++, IDL, GUI, Sun-Sparc, and Solaris O/S.

June 1997 - Project Leader
November 1997: Replacement Maritime Patrol Aircraft (RMPA)

Rajesh was the Project Leader on the Image Processing for Replacement Maritime Patrol Aircraft (RMPA) (Airborne SAR), and real time processing of airborne SAR raw data on multi-processor hardware. He was responsible for systems engineering and design. The technologies used on this project included C, C++, Customized multi-processor hardware, and VME Architecture.

November 1995 Senior Systems Analyst
May – 1997: RADARSAT Precision Processor (RPP)

Rajesh was a Senior Systems Analyst on the RADARSAT Precision Processor project. He developed algorithms and software for the processing of RADARSAT data. The software included work on signal processing and image processing.

The work also included implementing a variety of 2D and 3D displays to visualize the

intermediate and final results of the signal processing and also to compute signal quality measurements. The GUI programming was done in IDL.

The technologies used on this project included C, C++, IDL, GUI, SUN-Sparc, and Solaris O/S.

*January 1994 – October 1995: Senior Systems Analyst
Image Data Calibration Workstation (IDCW)*

Rajesh was a Senior Systems Analyst on the Image Data Calibration Workstation project. He developed algorithms and software for calibration of the RADARSAT satellite. The software included work in signal processing, image processing, and database management.

The work also included implementing a variety of 2D and 3D displays to visualize the signals and compute signal quality measurements. The GUI programming was done in IDL.

The technologies used on this project included C, C++, IDL, GUI, Sybase, SUN-SPARC, and Solaris O/S.

*January 1994 – October 1995: Senior Systems Analyst
Next Generation Signal Processor (NGSP)*

Rajesh was the Senior Systems Analyst on the Next Generation Signal Processor (NGSP) project. He implemented neural network algorithms for the NGSP machine. He also evaluated the NGSP on the LINPACK (a linear algebra) benchmark. The technology used on this project was parallel processing.

**1991 – 1992: McMaster University, Hamilton, Ontario
Research Engineer**

Rajesh developed neural network software on a parallel machine (WARP machine). His responsibilities included developing software for the visualization of neural network algorithms, working on the classification and segmentation of weather radar imagery, and developing software for IPIX radar operation and control.

**1987 – 1990: University of Waterloo, Waterloo, Ontario
Research Assistant**

Rajesh researched SAR Image Analysis: Image Modelling, filtering, classification, and segmentation of sea ice SAR imagery. The technology used in this research was C, Matlab, X-11, DEC-Vax, and Ultrix O/S.

Education/Training

2006: Rajesh is a certified Project Management Professional (PMP). For this certification, he completed the following formal training in project management: “PMP Preparation Course” by Open Vistas Inc., November 10-11 and 17-18, 2006.

1998: Completed “Senior Project Management Course” by the Canadian Management Centre of the American Management Association International, June 16-June 18, 1998.

Course work for Ph.D., Systems Design Engineering, University of Waterloo.

MASc, Operations Research, Industrial Engineering Dept., University of Toronto.

B. Tech., Mechanical Engineering, Indian Institute of Technology, New Delhi, India.

Luis Veci, B.Sc.

Array Systems Computing Inc.
1120 Finch Avenue West, 7th Floor
Toronto, Ontario, Canada M3J 3H7
Tel.: (416) 736-0900 ext. 298
Fax: (416) 736-4715
lveci@array.ca

Security Clearance Level

Luis holds a valid personnel security screening at the level of NATO Secret, granted and approved by CIISD/PWGSC.

Experience/Qualifications

1999 – Present: Array Systems Computing Inc., Toronto, Ontario

May 2011 – Software Developer
Present: Light Version of COMPASS Software (NGCSLITE)

The Next Generation COMPASS Software (NGCS) was recently deployed in Central Region’s Downsview and Burlington Traffic Operation Centres (TOC). The next Phase of NGCS is to develop a lighter version, NGCS-Lite, for deployment at other regional traffic operation centres, specifically Ministry of Transportation (MTO) East and West Regions. The scope of this Total Project Management (TPM) assignment includes reviewing/analyzing the NGCS and to modify, customize or develop additional software components so that an NGCS-Lite version can be deployed in the East and West Regional TOCs.

Luis is currently a Software Developer on this project.

November 2010 – Lead Software Engineer
Present: RADARSAT-2 Toolbox (RSTB)

Array was awarded a contract by the Canadian Space Agency (CSA) under the Earth Observation Application Development Program (EOADP) to develop an Open Source RADARSAT-2 Toolbox (RSTB). The primary objective of the project is to develop an Open Source RADARSAT-2 specific toolbox for processing, visualising and analyzing of RADARSAT-2 Polarimetric Synthetic Aperture Radar (SAR) products.

Luis is the Software Lead on this project.

*October 2010 -
March 2011:* *Lead Software Engineer
WebGIS/MobilGIS*

Array developed the WebGIS/MobileGIS software for DRDC Toronto. The projects dealt with the creation of a GIS platform for experimentation with GIS layers and symbology in a web application and on mobile devices.

*October 2010 –
Present:* *Lead Software Engineer
GEOINT SAR Toolbox*

Luis is the Lead Software Engineer on the GEOINT SAR Toolbox project.

The GEOINT SAR Toolbox is intended specifically for the Geospatial Intelligence community in assisting IMINT and GEOINT analysis. The Toolbox is able to automatically process user defined processing chains on products over multiple Areas of Interests.

The GEOINT SAR Toolbox provides numerous tools to aid in the detection and classification of targets of interest on land and sea including Coherent Change Detection, Amplitude Change Detection, RGB views, alpha blending, layer management, bitmask editing, ROI analysis, band arithmetic, image filters, principle component analysis, k-means cluster analysis, and EM cluster analysis. In addition, the Toolbox provides a set of ocean tools which include land masking, ship detection, wind field estimation and oil spill detection and measurement.

*October 2007 –
Present:* *Lead Software Engineer
Next ESA SAR Toolbox (NEST)*

Luis is the Lead Software Engineer on the NEST project.

Array is developing NEST for the European Space Agency (ESA). NEST is used for reading, post-processing, analyzing and visualizing the large archive of data from present and planned ESA SAR missions including Sentinel-1, as well as third-party SAR-data from JERS SAR, ALOS PALSAR, TerraSAR-X and RADARSAT-2. NEST is extensible with a Java API that allows users to easily create their own plug-in Readers, Processors and Writers.

June 2007: *Software Engineer
Dynamic Message Sign Device Manager (DMSDM)*

The DMSDM is being developed for the Ministry of Transportation Ontario (MTO) for the Development of the Next Generation COMPASS Software (NGCS).

Luis was responsible for reviewing the design of the DMSDM and auditing the source code.

2002-2007: *Lead Software Engineer
Sonar Acoustic Post Processing System (SAPPS)*

Luis was the Lead Software Engineer on the SAPPS project. He was responsible for the design and development of the Operator Workstation (OW) Graphical User Interface (GUI). The OW consists of a number of sonar displays, GIS visualizations, user defined plug-ins and analytical tools created for windows XP using Visual C++ .Net, MFC, OpenGL and GDI+.

*Jan. 2004 –
March 2006:* *Lead Software Engineer
Underwater Acoustic Analysis System (UAAS)*

Luis was the Lead Software Engineer on the UAAS project.

The UAAS is Array's third-generation shore-based sonar post-analysis system, and it builds on the proven design of the Canadian Towed Array Sonar System (CANTASS) Post Analysis System (PAS) delivered to the Canadian Navy and the Sonar Acoustic Post Processing System (SAPPS) for the Royal Swedish Navy (RSwN).

Array developed the UAAS for the Bundesamt für Wehrtechnik und Beschaffung (BWB) for use at the German Navy Hydroacoustic Analysis Centre (HAM).

Luis was responsible for the design and development of the Operator Workstation (OW) Graphical User Interface (GUI) to the UAAS. He led a team of 12 developers to incorporate the requirements from BWB into the UAAS architecture derived from SAPPS.

The UAAS project is currently under warranty Phase.

1999 – 2002: *Lead Software Engineer
Generic Acoustic Stimulation System (GASS)*

Luis was a Lead Software Engineer on the GASS project. The purpose of the GASS project was to upgrade the acoustic modeling capabilities of four different air Anti-Submarine Warfare (ASW) trainers for the US Navy. Array provided the instructor displays and controls for both the on-line (during training) and off-line (during scenario definition) modes.

Luis began work on the instructor station portion of the GASS at the design stage. He was closely involved in the detailed design of the software and was responsible for the design of the Graphical User Interface (GUI) and of all graphic displays.

After the design, Luis's responsibilities included coordinating the development team and optimizing the graphic code to draw within millisecond times. The work involved plotting various 2D data in X Windows under a Solaris environment. Ocean-bottom topography data is displayed both in 2D plot and 3D plot using OpenGL and C++.

1998 – 1999: **Regal Capital Planners, St. Catharines, Ontario**
Software Developer

Luis designed and developed a contact tracker with automated forms for use by representatives across Canada. The work involved creating a system that would import data from various sources and the system would automate form filling and order processing. The work required an understanding of the Mutual Fund industry as well as C and Windows NT programming. The system helped increase productivity by 80% and decrease human error.

1996 – 1997: **Caledonia Paratransit, Hamilton, Ontario**
Software Developer



Luis was a key team member throughout the complete life cycle of an Optimized School Bus Route Manager developed for Windows 95 using Object Ada95. This involved the plotting of Statistics Canada's MapInfo street data of the city of Hamilton and searching for optimal routes using a genetic algorithm.

Technical Skills

Experience working with C++, Java, C, Ada95, prolog, OpenGL, Xwindows, Motif, Win32, MFC, XML, Maven, GDAL/OGR, SQL, HTML

Experience designing and developing GIS visualizations, working with various GIS formats including Shape, S-57, DBDBV, Tiger, MapInfo, GeoTiff, ECW, JPEG2000, ArcGrid, DTED

Experience with various Artificial Intelligence methodologies and algorithms

Experience programming on various UNIX/Linux and Windows platforms.

Education/Training

1994-1999: B.Sc. Honours. Computing Science, Brock University, St. Catharines, Canada

Publications

Barchanski, J. A. & Veci, L. A., Simulation of Multiagent Behavior-Based Robotic Systems, Workshop on Agent-Based Simulation, Passau, Germany, May 2-3, 2000.

Dr. Jun Lu

Array Systems Computing Inc.
1120 Finch Avenue West, 7th Floor
Toronto, Ontario, Canada M3J 3H7
Tel.: (416) 736-0900 ext. 238
Fax: (416) 736-4715
junlu@array.ca

Security Clearance Level

Dr. Lu holds a valid personnel security screening at the level of Secret, granted and approved by CIISD/PWGSC.

Experience/Qualifications

2003 – Present: **Array Systems Computing Inc., Toronto, Ontario**

November 2010 *Software Developer*

– *Present:* RADARSAT-2 Toolbox (RSTB)

Array was awarded a contract by the Canadian Space Agency (CSA) under the Earth Observation Application Development Program (EOADP) to develop an Open Source RADARSAT-2 Toolbox (RSTB). The primary objective of the project is to develop an Open Source RADARSAT-2 specific toolbox for processing, visualising and analyzing of RADARSAT-2 Polarimetric Synthetic Aperture Radar (SAR) products.

Jun is the Software Developer on this project.

October 2007 – Present: *Software Developer*
Next ESA SAR Toolbox (NEST)

NEST is a European Space Agency (ESA) project. For this project, Array is developing an open source SAR image processing toolbox that has the potential to grow in the future through modules implemented by the user community.

Jun is a Software Engineer on this project and his responsibilities include designing, coding and testing modules for speckle filtering, radiometric and geometric calibration, image co-registration and orthorectification.

June 2005 – March 2008: *Software Developer*
SMOS Level 2 Soil Moisture Processor Development (SMPPD)

SMPPD is a European Space Agency (ESA) project that is part of ESA's Living Planet Programme. For this project, Array is developing the Soil Moisture and Ocean Salinity (SMOS) mission Level 2 processor prototype that will be used to build, verify and maintain the SMOS Level 2 operational processor.

Jun was a Software Engineer on this project and his responsibilities included simulating processing algorithms in Matlab, coding retrieval algorithms in C++, testing and integrating the software, and writing technical documents and reports.

December 2004 – August 2005: *Signal Processing Software (SPS) Engineer*
Underwater Acoustic Analysis System (UAAS)

The UAAS is Array's third generation shore-based sonar post analysis system developed for the German Navy Hydroacoustic Analysis Centre (HAM). The UAAS was successfully delivered in March 2006, and the project is now under the support and maintenance Phase.

Jun was responsible for writing code using MFC for target tracker display, tactical display, and the display of some other modules.

June 2003 – May 2005: *Signal Processing Software (SPS) Engineer*
Sonar Acoustic Post Processing System (SAPPS)

The SAPPS is a flexible modular sonar post-analysis system that Array developed for the Royal Swedish Navy (RSwN). The system was delivered in June 2006 and is currently under the support and maintenance Phase.

As an SPS Engineer on the SAPPS project, Jun was responsible for writing code using MFC for displaying the processed sonar signals of different modes. He was also responsible for designing test cases and simulating synthetic sonar signals using Matlab

for testing all display modules.

December 2003 – Software Engineer
August 2004: SAR Processing Toolbox, Japan

Jun's responsibilities on this project included testing, writing the Polar Format Algorithm (PFA) Guide Book, and training customers.

June 2003 – Signal Processing Software (SPS) Engineer
August 2003: Packaging the Chain Link Model from CANTASS (PCLMC)

Jun was an SPS Engineer in the Packaging the Chain Link Model from CANTASS (PCLMC) project. For this project, Array packaged the Chain Link Model from the Canadian Towed Array Sonar System (CANTASS) for the Defense Research & Development Canada-Atlantic (DRDC Atlantic).

The PCLMC team developed a C++ wrapper that encapsulates the Chain Link Model simulator, which was developed in the 1980s using FORTRAN, into an independent module called a Generic Signal Processing Block (GSPB). By doing so, the simulator can now be dynamically linked with the Generic Post Analysis System (GPAS), also developed by Array. In addition, Array developed a Graphical User Interface (GUI) for using the GSPB.

May 2000 – May 2003: McMaster University, Hamilton, Ontario, Canada.
Electrical and Computer Engineering Department
Research Engineer

Jun conducted research on Blind Signal Separation and Blind System Identification.

May 1996 – April 2000: Array Systems Computing Inc., Toronto, Ontario
Senior Software Analyst
Spotlight Synthetic Aperture Radar (SSAR)

Jun was a Senior Software Analyst on the SSAR project. For this project, Array developed a SAR processor for the Canadian Forces CP-140 maritime patrol aircraft. The system augments the existing AN/APS-506 radar on the aircraft by providing real-time SAR imagery in three distinct modes: RDP, Spotlight and Strip-Map. The SSAR technology is licensed to Array for commercialization as Array's TriSAR product.

In this project, Jun was responsible for developing code for real-time non-adaptive mode Spotlight SAR imaging using C, and integrating, testing and tuning the SAR imaging system on VxWorks and the Mercury board. He was also responsible for simulating Spotlight and Strip-map mode SAR data using Matlab for testing the SAR imagery software.

January 1993 – May 1996: McMaster University, Hamilton, Ontario, Canada.
Electrical and Computer Engineering Department
Research & Teaching Assistant

As a Research & Teaching Assistant at McMaster, Jun researched Image Compression using Wavelet Transform, and Echo Cancellation using Sub-band Coding. He also tutored courses in "Numerical Methods" and "Data Structures and Computer Algorithms".

May 1987 – January 1993: **China Software and Computer Technique Service Co. Ltd., Beijing, China.**
Software Engineer

As a Software Engineer, Jun participated in system and applied software development. He localized a XENIX operating system using C, developed a vectorized Chinese font sub-system using C, and developed a bank account-inquiry system using C.

Education/Training

- 2004: Ph.D.Eng., Electrical and Computer Engineering
McMaster University, Hamilton, Ontario, Canada.
Area of specialization: Blind signal separation, Image/Speech compression, and Echo cancellation.
- 1987: M.Sc., Applied Mathematics
Dalian University of Technology, Dalian, China.
Area of specialization: Numerical optimization.
- 1984: B.Sc., Mathematics
Peking University, Beijing, China.
Area of specialization: Statistics.

Dr. Robert (Bob) Manners

Array Systems Computing Inc.
1120 Finch Avenue West, 7th Floor
Toronto, Ontario, Canada M3J 3H7
Tel.: (416) 736-0900 ext. 237
Fax: (416) 736-4715
rmanners@array.ca


Security Clearance Level

Dr. Manners holds a valid personnel security screening at the level of NATO Secret, granted and approved by CIISD/PWGSC.

Experience/Qualifications

1998 – Present: **Array Systems Computing Inc., Toronto, Ontario**

May 2011 – Lead Software Developer

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Present: *Light Version of COMPASS Software (NGCSLITE)*

The Next Generation COMPASS Software (NGCS) was recently deployed in Central Region's Downsvew and Burlington Traffic Operation Centres (TOC). The next Phase of NGCS is to develop a lighter version, NGCS-Lite, for deployment at other regional traffic operation centres, specifically Ministry of Transportation (MTO) East and West Regions. The scope of this Total Project Management (TPM) assignment includes reviewing/analyzing the NGCS and to modify, customize or develop additional software components so that an NGCS-Lite version can be deployed in the East and West Regional TOCs.

Bob is currently the Lead Software Developer on this project.

February 2011 – Present: *Project Engineer*
Canadian Towed Array Sonar System (CANTASS) Mission Simulator (CMS) Upgrade (CMSU)

Array was awarded a contract by the Department of National Defence (DND) to upgrade the Canadian Towed Array Sonar System (CANTASS) Mission Simulators.

The first CMS was commissioned in March 2000, the CANTASS Mission Simulator (Atlantic) (CMS(A)) and is installed in the training facility at Canadian Forces Naval Operations School, Halifax (CFNOS). A second CMS for the Pacific coast (CMSP) was developed by Array and commissioned in October 2002. It is installed in the training facility at Canadian Forces Fleet School, Esquimalt (CFFS(E)).

The CMS must undergo a technology upgrade in order to remain operational and Array will perform the required technology upgrades.

Bob is a Project Engineer on this project.

November 2010 – Present: *Project Scientist*
RADARSAT-2 Toolbox (RSTB)

Array was awarded a contract by the Canadian Space Agency (CSA) under the Earth Observation Application Development Program (EOADP) to develop an Open Source RADARSAT-2 Toolbox (RSTB). The primary objective of the project is to develop an Open Source RADARSAT-2 specific toolbox for processing, visualising and analyzing of RADARSAT-2 Polarimetric Synthetic Aperture Radar (SAR) products.

Bob is the Project Scientist on this project.

January 2009 – November 2009: *Project Engineer*
SAR Simulation Toolbox for UAV Applications, Turkey

Bob is currently Project Engineer for the STB Turkey project.

In early 2009, Array was awarded a contract by a major defence contractor in Turkey to deliver a SAR Simulation Toolbox covering all the functionality required for UAV-type applications. The imaging modes included are Stripmap, Spotlight and ISAR, together with GMTI functionality. Two Stripmap imaging algorithms are included – the classic Range-Doppler (rectangular) algorithm and the Chirp-Scaling Algorithm, which may be used to form strip images in squinted imaging configurations. Spotlight and ISAR processing are performed using the Polar Format Algorithm, which is

combined with target tracking and rotational parameter estimation in ISAR mode. Two GMTI modes of operation are included – a simple single-channel “exoclutter” GMTI and a Displaced Phase Centre Algorithm (DPCA) type method which extracts multiple Doppler bands from a single physical antenna.

Bob has been involved in all aspects of the project, including the development of new modules and additional functionality to be integrated with the baseline SAR Toolbox product. New functional modules have been developed using Matlab in order to perform modelling of radar clutter and a number of noise distributions. Design and coding is currently underway for the Chirp Scaling Algorithm stripmap-mode implementation. Additionally, enhancements are being made to allow the modelling of three-dimensional clusters of point targets for ISAR mode applications.

The STB Turkey program includes two training courses in SAR imaging theory in general, and the use of the SAR Toolbox in particular. The first of these training courses was completed in June / July 2009 at the customer’s site in Turkey. Bob was the Lead Instructor, with support from another scientist from Array. The second training course is scheduled for later in the year.

*March 2008 –
Present:*

Project Engineer

Total Project Management for Systems Integration and Database Management (SIDM) for the Next Generation COMPASS Software

Bob is currently Project Engineer for the SIDM project.

The SIDM project is part of the larger Next Generation COMPASS Software (NGCS) program, which aims to develop a replacement of the existing COMPASS system, currently used to manage major freeways in the province of Ontario. The functionality of COMPASS includes monitoring traffic conditions in real-time by means of loop sensors under the highway surface, determining how best to handle incidents and other events as they occur, and providing information to motorists by means of Dynamic Message Signs (DMS) installed along the freeway. The customer is the Ministry of Transportation Ontario (MTO).

There are two aspects to the work to be performed under the SIDM contract. The first part involves the design, implementation and testing of the Database Manager (DBM) software. The DBM software is responsible for managing incidents and other events, processing operator alarms, handling scheduled events, generating reports, managing email distribution lists, and a number of other miscellaneous functions. The DBM is implemented in Java and uses the Java Messaging Service (JMS) for communication with other NGCS components and the Java Database Connectivity (JDBC) API for accessing the NGCS Oracle database. The second part of the SIDM work involves the integration of the various components of the NGCS, including the DBM and a number of modules developed by other contractors. The integrated NGCS must then be subjected to formal acceptance testing, which includes parallel operation with the existing legacy COMPASS system, before going live.

As Project Engineer, Bob is responsible for the technical aspects of the SIDM project, including the detailed design, implementation and testing of the DBM components.

March 2008 – Project Engineer
March 2009: SAR Data Generation and Processing for Stripmap, Brazil

Bob was Project Engineer for the Brazil program.

Array was contracted to deliver a Stripmap SAR toolkit, based on the SAR Toolbox product line. The customer had a number of unique imaging requirements, which Array was able to accommodate by making modifications to the SAR Toolbox. The delivered components included the Data Generation Tool (DGT), Motion Compensation (MoComp), Stripmap imaging and the Image Quality Tool (IQT).

A unique requirement for this project was the ability to be able to import optical image data stored in GeoTIFF files into the SAR Toolbox and to convert the pixel intensities in order to roughly model the RCS of the scatterers in the scene. A non-linear lookup table was used to map from optical intensity to RCS. The geometry of the SAR imaging was taken into account when considering the position of the return from each scatterer in the slant plane. A provision was included to allow the user to specify a Digital Elevation Model (DEM) describing the elevation of each pixel in the GeoTIFF image. This information is then exploited in the SAR Toolbox data simulation to model shadow and layover effects.

All the code to generate synthetic SAR raw data from optical images was implemented in Matlab during the course of the STB Brazil project. The Matlab Mapping Toolbox was exploited for this purpose.

March 2007 – Project Engineer
December 2007: SAR Simulation Toolbox for Agency for Defence Development, Korea

During 2007, Bob undertook the role of Project Engineer and Lead Instructor for the STB Korea project.

The Agency for Defense Development (ADD) of the Republic of Korea awarded Array a contract to develop a SAR Simulation Toolbox. The SAR Toolbox includes a synthetic raw radar data generator, a simulation of aircraft platform motion in the presence of turbulence, and a simulation of an Inertial Navigation Sensor (INS). Signal processing code is included for Motion Compensation, Stripmap SAR, Spotlight SAR and Inverse-SAR (ISAR) imaging modes, together with a Ground Moving target Indicator (GMTI) mode of operation. An Image Quality Tool is included, allowing the fidelity of the SAR signal processing to be assessed. The SAR Toolbox is implemented in the Matlab language, allowing easy modification of the code to permit experimentation.

Under the STB Korea project, a number of enhancements were made to the SAR Toolbox. These included the implementation of an ISAR imaging mode based on the Polar Format Algorithm (PFA). This ISAR implementation incorporates target tracking and motion estimation, including rotational parameter estimation. These techniques are based on code previously proved in operational SAR processors, such as Array's RMPA implementation.

The Graphical User Interface of the SAR Toolbox was enhanced with the addition of an interactive Point target Editor, allowing arrays of synthetic targets to be defined and visualized conveniently.

Bob was engaged in the design and implementation of these enhancements to the baseline SAR Toolbox product, and performed the coding work in Matlab. Bob was also responsible for planning the test cases and conducting formal testing of the toolbox prior to release to the customer.

Bob was the Lead Instructor for the two one-week-duration training courses that were

delivered as part of the project. Training took place at ADD's facilities in Daejeon, Republic of Korea, in July and August of 2007. The training covered all aspects of the theory of SAR image formation. The first training course focussed on Stripmap and Spotlight image formation algorithms; ISAR and GMTI methods were presented during the second course.

October 2005 – Project Engineer
March 2007: Real Time Signal Processor (RTSP)

Bob was the Project Engineer for the RTSP project.

The RTSP is a real-time sonar and electromagnetic signal processor, based on Array's proven Scalable Generic Signal Processor (GSP) architecture. Array developed the RTSP for the Försvarets Materielverk (FMV) for use by the Royal Swedish Navy (RSwN).

As Project Engineer, Bob was responsible for all engineering aspects of the project, including the design of additional software modules, implementation and testing of those modules, integration of the software and hardware components of the system, and installation and set-to-work at the customer site.

The complete RTSP system consists of a Signal Processor, a Mass Storage subsystem, a number of I/O units and an Operator Workstation. The Signal Processor is a Yellow Dog Linux based Beowulf cluster, consisting of three Apple XServe G5 systems. The Mass Storage subsystem consists of an AMD Opteron server running RedHat Linux, together with a pair of fibre channel connected RAID units. There are three I/O units, each with an AMD Opteron server running Redhat Linux. Each I/O unit has analog-to-digital (ADC) converters for acquiring data from analog sensors. Two of the I/O units are installed on an uninhabited island, and send acoustic and electromagnetic sensor data to the Signal Processor using TCP/IP over an under-sea optical fibre connection. The third I/O unit is installed in the same location as the RTSP Signal Processor.

January 2004 – Signal Processing Software (SPS) Software Lead
December 2005: Underwater Acoustic Analysis System (UAAS)

Bob was the Signal Processing Software (SPS) Software Lead on the UAAS project.

The UAAS is Array's third-generation shore-based sonar post-analysis system, building on the proven design of the Canadian Towed Array Sonar System (CANTASS) Post-Analysis System (PAS) delivered to the Canadian Navy and the Sonar Acoustic Post Processing System (SAPPS) for the Royal Swedish Navy (RSwN).

Array developed the UAAS for the Bundesamt für Wehrtechnik und Beschaffung (BWB) for use at the German Navy Hydroacoustic Analysis Centre (HAM). The system was installed at HAM in December 2005 and is now in the support and maintenance Phase.

Bob was responsible for the further development of the UAAS Signal Processing Software, which is derived from the Scalable Generic Signal Processor (GSP) architecture developed by Array for the SAPPS project. During the course of the UAAS development cycle, the Scalable GSP core was enhanced and refined in order to improve flexibility, to simplify the task of developers of individual 'plug in' signal processing modules, and to further generalize the framework so that it may be incorporated into a wider range of high-performance signal processing applications.

October 2003 – Systems/Software Engineer
September 2005: SAR System Performance Analysis, Japan

Bob was the Systems/Software Engineer on this project. Array specified data requirements and subcontracted the collection of raw SAR data for Stripmap and Spotlight modes. The performance of existing SAR processing tools in the SAR processing toolbox were analyzed using the real data. Array provided the real raw data, an evaluation scheme for a SAR processor and SAR system, and methods and techniques for performing error analysis of airborne SAR systems to its customer.

Bob was responsible for analyzing and specifying the data requirements, managing the data collection, and defining the error analysis techniques.

May 2002 – Lead Software Engineer, and Signal Processor and System Architect
June 2006: Sonar Acoustic Post Processing System (SAPPS)

Bob was the Lead Software Engineer, and Signal Processor and System Architect on the SAPPS project.

The SAPPS is a flexible modular sonar post-analysis system that Array developed for Försvarets Materielverk (FMV) for delivery to the Royal Swedish Navy (RSwN). The system was delivered in June 2006 and is now in the support and maintenance Phase.

Bob was responsible for the design and implementation of the Signal Processor software components of the system.

The SAPPS signal processor is coded in C++ and runs under the Yellow Dog Linux operating system. Extensive use is made of standard libraries such as MPI, for communication over InfiniBand, and the VSIPL vector math library.

The SAPPS Signal Processor consists of a Beowulf cluster of Apple XServe G5 hosts. The system employs 20 XServes, for a total of 40 PowerPC G5 processors. The design of the software is such that it is able to scale from a single CPU to a large parallel cluster.

In addition to the Signal Processor itself, the system includes two AMD Opteron-based I/O servers, which run the Microsoft Windows operating system, and an AMD Opteron-based Mass Storage server, which runs RedHat Linux. Each I/O server contains an analog-to-digital (ADC) converter, and a number of interfaces for digital tape and disk devices. The Mass Storage server provides the interface to four fibre-channel connected RAID5s.

Bob was involved with the SAPPS program from before the contract award, and helped in the development of the basic high-level-design concepts of time-division-multiplexed data routing with generic 'plug in' signal processing blocks.

2000 – 2002: Lead Software Engineer, Instructor Station
CANTASS Mission Simulator (Pacific) (CMS(P))

Bob was the Lead Software Engineer responsible for the development of the instructor station portion of the CMS(P) system.

The work involved porting a large body of existing signal processing and control code, which performs the function of a sonar stimulator, to a new Digital Signal Processor (DSP) architecture. Whereas the previous target system had employed CSPI cards based on Intel i860-based DSPs, the new target used ten Mercury Computers DSP

boards for a total of 40 PowerPC G3 processors. In addition to the work required to port the software between platforms, significant enhancements were made to the algorithmic capabilities of the sonar stimulator. New functionality was also added to the Instructor Station Graphical User Interface (GUI), a large and complex application coded in Ada. Due to the complexity of the CMS system, a great deal of work was required to integrate a number of different software components.

The work required an understanding of sonar technology, signal processing algorithms, and real-time systems development in C under Mercury Computers MC/OS and Sun Solaris operating systems. In addition, experience of debugging hardware problems also proved to be valuable throughout the project lifecycle. The work on the GUI required an understanding of Ada, and Oracle / SQL database concepts.

1998 –

Systems/Software Engineer

April 2000:

Replacement Maritime Patrol Aircraft (RMPA) Synthetic Aperture Radar Program

Bob was fortunate to join the RMPA team early in the product life cycle. He was closely involved in the detailed design of the software and was responsible for the design of four of the six Computer Software Components (CSCs). After the design had been completed, Bob's responsibilities included coordinating the development team. He was directly involved in the development and testing of the Communications and Spotlight Synthetic Aperture Radar (SAR) CSCs.

During the course of the RMPA project, Bob learned a great deal about radar systems in general and synthetic aperture processing in particular. He was able to apply this knowledge to his existing expertise in DSP to develop the RMPA Image Processing Software (IPS), which performs complex DSP operations in real time. Although the IPS was coded in C rather than assembly language, Bob's low-level system integration and troubleshooting skills also proved to be invaluable, given that the target platform was a VME system consisting of custom DSP boards which lacked any operating system support. In all, 40 SHARC processors were used to provide the parallel processing bandwidth required for the RMPA IPS application.

1998:

Systems/Software Engineer

Australian Helicopter Program (AHP) Inverse Synthetic Aperture Radar Processor

Bob worked briefly as Systems/Software Engineer on the Australian Helicopter Program. He developed the control and interface code for the inverse SAR processor.

1994 – 1997:

University of Oxford, United Kingdom

Application Development in Support of D.Phil.

During the course of undertaking research into fluid flow field velocity measurement and imaging techniques, Bob developed a number of graphically-intensive applications. These software programs combined X-window GUI interfaces with non real-time signal processing, and used 3-D projection of the processed results to allow rapid interactive visualization of large datasets. The C and C++ programming languages were used, targeting Linux, SGI IRIX and Sun Solaris platforms.

Education/Training

2001:

Internal Array Sonar Training Course

- 1999: Georgia Institute of Technology. Modern Synthetic Aperture Imaging.
- 1998: Internal Array SAR Training Course
- 1994 - 1997: D.Phil. Engineering Science, University of Oxford, UK. Thesis: "Image Processing Techniques for Doppler Global Velocimetry"
- 1990 - 1994: M.Eng. Engineering and Computing Science, University of Oxford, UK

Publications

Manners R.J., 2006, "Array's Scalable Generic Signal Processor Architecture as a Platform for Sonar Post-Analysis", Undersea Defence Technology Pacific, 2006.

Manners R.J., 1998, "Image Processing Techniques for Doppler Global Velocimetry", D.Phil. Thesis.

Ainsworth R.W., Thorpe S.J., & Manners R.J., 1997, "A New Approach to Flow-Field Measurement --- A View of Doppler Global Velocimetry Techniques", International Journal of Heat and Fluid Flow, Vol. 18, pp. 116-130.

Quinlan N.J., Ainsworth R.W., Bellhouse B.J., Manners R.J., Thorpe S.J., 1997, "Application of Doppler Global Velocimetry to Supersonic Gas-Particle Flows in Drug Delivery", Proceedings of Laser Anemometry Advances and Applications.

Manners R.J., Thorpe S.J., & Ainsworth R.W., 1996, "Image Processing Techniques for Doppler Global Velocimetry", Proceedings of Optical Methods and Data Processing in Heat and Fluid Flow, City University, London, U.K.

Thorpe S.J., Ainsworth R.W., & Manners R.J., 1996, "Time Averaged Free Jet Measurements using Doppler Global Velocimetry", Proceedings of the Symposium on Experimental and Numerical Flow Visualisation and Laser Anemometry, San Diego, California, U.S.A.

Ainsworth R.W., Thorpe S.J., & Manners R.J., 1996, "A New Approach to Flow-Field Measurement --- A Review of Doppler Global Velocimetry Techniques", Invited Paper presented at the International Conference on Turbulent Heat Transfer, San Diego, U.S.A., organised by the Engineering Foundation, New York, U.S.A.

Thorpe S.J., Ainsworth R.W., & Manners R.J., 1995, "The Development of a Doppler Global Velocimeter and its Application to a Free Jet Flow", Proceedings of the ASME/EALA 6th International Conference on Laser Anemometry, Advances and Applications, Hilton Head Island, South Carolina, U.S.A.

Manners R.J., 1994, "Doppler Global Velocimetry", Transfer of Status Thesis.

Misty Retchford, B.A.

Array Systems Computing Inc.

1120 Finch Avenue West, 7th Floor

Toronto, Ontario, Canada M3J 3H7

Tel.: (416) 736-0900 ext. 303

Fax: (416) 736-4715

misty@array.ca

Security Clearance Level

Misty holds a valid personnel security screening at the level of NATO Secret, granted and approved by CIISD/PWGSC.

Experience/Qualifications

1999 – Present: **Array Systems Computing Inc., Toronto, Ontario**
Technical Writer

Misty has been working as a Technical Writer at Array since 1999. She has a B.A. in Translation and a Certificate in Technical and Professional Writing from York University. She also holds a Certificate in Information Design from the University of Toronto.

Misty has worked on a number of projects in each of the company's key areas of expertise including Sonar, Radar and Remote Sensing, 3D Modelling and Simulation, Software Defined Radio, and Intelligent Transportation Systems.

As technical writer she is responsible for creating, reviewing and formatting documentation. She ensures that Array's documents are clear, concise and well designed. Her activities include preparing document templates according to strict customer specifications, reviewing project documents, preparing complex graphics, and maintaining project directories. She also ensures change management procedures are followed for each new version of a document and makes certain proper documentation is completed to track changes.

Misty is also the Configuration Management Administrator (CMA) for Array. She records and reports on software and hardware configuration items and documentation throughout the evolution of a project. This role includes managing a configuration management system and revision control system.

Misty has experience using the following software tools:

- Microsoft Office Suite
- Adobe FrameMaker
- Microsoft Visio
- Microsoft Project
- Adobe PageMaker
- Adobe Acrobat
- TechSmith Camtasia

Education/Training

2004 - 2007: Professional Certificate in Information Design from the University of Toronto. Courses included website design and implementation, introduction to XML, enterprise content management, information design, and usability testing.

1999: Adobe FrameMaker Course

1994 - 1998: B.A., Specialized Honours Degree in Translation, York University
Certificate in Technical and Professional Writing, York University

3.6.4. ACRI-ST CVs

Name	▪ Philippe GARNESSON
Current Position	▪ Senior Engineer
Role in the project	▪ ACRI-ST project manager, responsible for Sentinel-3 optical mission related information user Handbook
Degree	▪ PhD in Computer Vision Sciences, University of Nice-Sophia Antipolis, 1991
Experience	<p><u>Joined ACRI-ST in 1993</u></p> <ul style="list-style-type: none"> ▪ Managing production and quality assurance (2004-present) ▪ MyOcean project: Technical manager of the Global OCTAC (Ocean Colour Thematic Assembling Centre). Set in place quality assurance procedures required by MyOcean for production and dissemination (upstream monitoring, output format/protocol, catalogue description, validation of products) (2009-present). ▪ Participation to the ODESA project (Optical Data processor of the European Space Agency) (2010-present). ▪ 2005-2011: AMORGOS project development and maintenance (MERIS FR products with an improved geo-location): participation to the validation of the new products. ▪ in the frame of the European MyOcean, MarCoast 2, PROMOTE, COASTWATCH, and part of the GLOBCOLOUR/HERMES services (GMES/GSE): <ul style="list-style-type: none"> - Interface with end users to specify requirements - Development of an operational system to disseminate EO data in Near Real Time. It concerns mainly MERIS, MODIS and AVHRR products. The system is operational 365 days per a year - Dissemination of products and support to various end users and application domains: French navy (EPSHOM), scientific missions (KEOPS, BIOSOPE, PROBIO), fishing, aquaculture... - Services consist in daily delivery of products (Chlorophyll, Sea surface temperature, Transparency, Sea Level anomalies, temporal animation...) corresponding to swath or composite products. Auxiliary products (quality index, temporal map...) and services (sea structure analysis) are also provided. ▪ Specification and Development of the operational GEORIS tools for the WEU (1997-2005). The GEORIS system is dedicated to the geo-coding of various Digital Imagery Landsat, ERS, Spot, IRS-1, IKONOS...)including importing, viewing, exporting with geometric correction. ▪ Specifications and Development of user interface (1995-1996) (MERIS, GOMOS) for the European Spatial Agency. ▪ Development of WWW servers for European Institutions (1994-1996): <ul style="list-style-type: none"> - WEU(Western European Union) - CEO (Center for Earth Observation) - HCM (Human and capital mobility)
Nationality	▪ French
Date of birth	▪ January 30th, 1963

Languages	<ul style="list-style-type: none"> ▪ French, English
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Name	Claire Henocq
Current Position	<ul style="list-style-type: none"> ▪ Research Engineer
Role in the project	<ul style="list-style-type: none"> ▪ Support for writing the S-3 optical part of the User Sentinel Handbook
Degree	<ul style="list-style-type: none"> ▪ December 2009 : PhD in Environment Science (ACRI-St / LOCEAN, Paris) ▪ September 2006 : Engineering degree from Ecole Nationale et Supérieure des Mines de Nancy (Nancy France) ▪ June 2006 : Master « Ocean, Atmosphere, climate et remote sensing » (UPMC, PARIS)
Experience	<p><u>ACRI-ST (since october 2006)</u></p> <ul style="list-style-type: none"> ▪ Sentinel-3 – Optical Ground Processor Prototype (O-GPP), ESA contract <ul style="list-style-type: none"> - Responsible for the technical management of Sentinel-3 Level 1 project: milestones, schedule and contractual aspects management - Responsible for the procurement of the Ground Processor Prototype dedicated to the Level 1 processing (calibration, geolocation, etc.) of Sea & Land Surface Temperatures Radiometer (SLSTR) and of the Synergy product, i.e. a combination of SLSTR and Ocean and Land Colour Instrument (OLCI) products ▪ Member of SMOS team : <ul style="list-style-type: none"> - Analysis of vertical salinity differences in the first meter below the oceanic surface (CNES/TOSCA project) - Test and validation of Level 2 salinity prototype (ESA contract)
Nationality	<ul style="list-style-type: none"> ▪ French
Date of birth	<ul style="list-style-type: none"> ▪ 5 october 1982
Languages	<ul style="list-style-type: none"> ▪ French, English

Name	Ludovic Bourg
Current Position	<ul style="list-style-type: none"> ▪ Research Engineer
Role in the project	<ul style="list-style-type: none"> ▪ Expert of optical S-3 instruments and products
Degree	Ph.D.: Doctorat de l'Université Paris 7 – Spécialité Méthodes Physiques en Télédétection
Experience	<p><u>ACRI-ST (since July 1995)</u></p> <p>ACRI (since July 1995)</p> <p>10-present: involved in the MEREMSII (inter-calibration of medium resolution multispectral imagers) as MERIS calibration expert.</p> <p>08-present: involved in GMES Sentinel-3 Products and Algorithms Definition project, in a consortium lead by ARGANS, as OLCI Level 2 scientific coordinator</p> <p>06-present: involved in the Sentinel-3 Definition Study, in a consortium lead by Thales Alenia Space as Ocean and Land Colour Expert</p>

	<p>05-present : MERIS expert for the Data Quality Control service led by Serco ltd.</p> <p>03- present: in charge of the MERIS maintenance: algorithm enhancement, calibration, validation activities</p> <p>00-02: project manager: "MERIS Commissioning Phase", preparation and execution of the commissioning Phase for the MERIS instrument (Medium Resolution Imaging Spectrometer) onboard ENVISAT-1, involving co-operation with 5 research laboratories and 3 industrial companies.</p> <p>99 : project manager: "MERIS Processing Chain Validation", completion of the Ground Segment prototype and validation of the algorithms involved in the level 1 and 2 processing of MERIS data, involving co-operation with 5 research laboratories and 3 industrial companies.</p> <p>98 : engineer: MERIS Project, responsible for the definition of the calibration algorithms and the development of associated software.</p> <p>96-97 : engineer: MERIS Project, responsible for the definition of the Level 1b Ground Segment processing and the corresponding prototype processor (3 engineers)</p> <p>95-96 : engineer: design et development of instrument simulators for MERIS and SeaWIFS (Sea-viewing Wide Field of view Sensor)</p> <p>Service d'aéronomie du CNRS</p> <p>92-95 : validation committee of the French-Canadian WINDII measurements (WIND Imaging Interferometer, onboard UARS) measuring wind and temperature in high atmosphere, design and tuning of data processing algorithms, management of the technical interface between the laboratory and CNES (French Space Agency, software project owner), .</p> <p>87-91 : French-Russian mission MARS94-MARS96, . algorithms design for the computation, onboard and in real time, of the velocity of a balloon, using ground imaging data analysis, for the measurement of the horizontal wind component in the atmosphere of Mars. Two month stay at Jet Propulsion Laboratory (California) as invited scientist.</p>
Nationality	<ul style="list-style-type: none"> ▪ French
Date of birth	<ul style="list-style-type: none"> ▪ 23 December, 1961
Languages	<ul style="list-style-type: none"> ▪ French, English

Name	<ul style="list-style-type: none"> ▪ Odile Fanton D'Andon
Current Position	<ul style="list-style-type: none"> ▪ Head of ACRI-ST
Role in the project	<ul style="list-style-type: none"> ▪ Contract Manager
Degree	<ul style="list-style-type: none"> ▪ Ph. D.: Doctorat de l'Université Paris 6- Spécialité Mécanique ▪ Master "Ecole Nationale Supérieure des Mines de Paris" ▪ Bachelor Degree in Applied Mathematics
Experience	<p>ACRI (since July 1990)</p> <ul style="list-style-type: none"> ▪ 2009 – present : Coordinator of the ODESA project, ESA contract (including a forum and MEGS software distribution) ▪ 2009-Present project manager of the Global Production Unit - TAC-Ocean colour project – MyOcean ▪ 2008 – present : coordinator of OLCI on Sentinel 3 O-L2PP level 2 project

	<ul style="list-style-type: none"> ▪ 2005-2009: project manager of GlobColour project ▪ 2005-2008: Contributor to the Data Processing and Quality Control project, part of the EO Frame contract under Serco ltd leadership. ▪ 2002-present: project manager of MERIS and GOMOS software maintenance and evolution support to CAL/VAL operations: member of GOMOS QWG ▪ 2000-2002: project manager: "GOMOS Commissioning Phase", preparation and execution of the commissioning Phase for the GOMOS instrument (Global Ozone Monitoring by Occultation of Stars) onboard ENVISAT-1: responsible, involving co-operation with 3 research laboratories, 1 industrial company and ESA staff. ▪ 1998-1999 : Coordinator of the EU funded MSDOL project; assimilation of ozone measurements in a chemistry-transport model ▪ 1994-1998 : Consultant for EUMETSAT EPS mission : Definition of the users requirements, level 1b and 2 data products specification, level 1b algorithm definition ▪ 1993-1997 : Project Manager for the development of numerical models related to radiative transfer and remote sensing: ▪ Radiative transfer and scintillation for GOMOS simulator in co-operation with Service d'Aéronomie (Dr J-L. Bertaux) and FMI (E. Kyrölä) ▪ Atmospheric corrections for MERIS instrument in co-operation with the Free University of Berlin (Pr. J. Fischer) ▪ 1994 : Project Manager for "Integration of Remote Sensing, In-Situ Observations and Numerical Modelling Applied to the North-East Atlantic" (CEC Human Capital and Mobility programme) ▪ Principal investigator of many projects involving celestial mechanics and earth remote sensing instruments, for instance:) ▪ Technical assistance to ESA on the mission aspects and sampling of MERIS, GOMOS, MIMR, MIPAS ▪ Medium Resolution Imaging Spectrometer on board the future European Polar Platform : coverage performances, interference by sun illumination conditions, tilt angle facility etc ▪ Meteorological Package (AMSU, AVHRR, IASI..) on board the future European Polar Platform : coverage capability when satellite is in contact with on-ground station network. ▪ Orbit properties determination to cover specific user requirements in sounding and imagery meteorological missions.
<p>Nationality</p>	<ul style="list-style-type: none"> ▪ French
<p>Date of birth</p>	<ul style="list-style-type: none"> ▪ 10 march 1959
<p>Languages</p>	<ul style="list-style-type: none"> ▪ French, English

3.6.5. isardSAT CVs

Name	<ul style="list-style-type: none"> ▪ Mònica Roca
Current Position	<ul style="list-style-type: none"> ▪ isardSAT director
Role in the project	<ul style="list-style-type: none"> ▪ S-3 SRAL user Handbook
Degree	<ul style="list-style-type: none"> ▪ Ph. D. from the Delft University of Technology, Delft, The Netherlands, for: “The end-to-end development of the EnviSat Radar Altimeter measuring system”. Doctorat de l’Université Paris 6- Spécialité Mécanique ▪ Master Degree Telecommunications and Electronics Engineering, from the Universitat Politècnica de Catalunya (UPC), Barcelona, in 1995
Experience	<ul style="list-style-type: none"> ▪ She joined the European Space Research and Technology Centre (ESTEC), in 1994 and became the Radar Altimeter System Performance Engineer, within the EnviSat Project Team in 1996. Her responsibilities covered all system and mission aspects of this instrument. In March 2003, after the EnviSat Commissioning Phase, she moved to PiLDo Labs, Barcelona, as Head of the “Earth Observation & Remote Sensing Department”. Her responsibilities were all technical and managerial activities within the department, in which engineering and scientific consultancy and research projects were carried out with international organisations, scientific institutes and industry. In July 2006 she co-founded isardSAT as a spin-off of PiLDo Labs Earth Observation department. She then became the Manager and R&D Director of isardSAT. isardSAT is a Catalan SME highly specialised in Altimetry, that runs altimetry projects providing high level of expertise to the space agencies and public clients, both in the technical (instrumental and data products), and application aspects. ▪ Mònica has led teams in a number of successful ESA projects (e.g. EnviSat RA-2 Long term support on instrument anomalies, calibration and on-ground processing; EnviSat RA-2 Individual Echoes algorithm design; EnviSat Radar Altimeter Individual Echoes and S-band – RAIES, Calibration of the RA-2 S-band range against Ku-band range, using data over the salar de Uyuni; and participates or leads projects with other space agencies (e.g. Cross calibration of data from ERS-1, ERS-2, EnviSat RA-2, TOPEX, ICESat and CryoSat on salar de Uyuni, Bolivia for NASA; isardSAT expert support for altimeter instrument monitoring, within the CLS/CNES SALP project). ▪ She is also leading (a) the EnviSat RA-2 L1b ESL activities with ESA, (b) the CryoSat-1/2 SIRAL Calibration activities using an ESA transponder; (c) the Level 1b part of the REAPER project (Reprocessing of Altimeter Products for ERS, “a la EnviSat”) with ESA; (d) the Sentinel-3 SRAL L0 and L1b GPP development, under CLS (under TAS) contract; and (e) participates in the instrumental work package of the Sea Level Climate Change Initiative project, and (f) the SALP project with CNES though CLS; and finally (g) she is leading the development of the Jason-CS L1b prototype with ESA (Astrium).
Nationality	<ul style="list-style-type: none"> ▪ Catalan
Languages	<ul style="list-style-type: none"> ▪ Spanish, English

Name	▪ Bernat Martinez
Current Position	▪ Algorithm System and Architectural engineer at isardSAT
Role in the project	▪ S-3 SRAL user Handbook
Degree	▪ MSc in Telecommunication Engineering from the Universitat Politècnica de Catalunya in 2001
Experience	<ul style="list-style-type: none"> ▪ Since 2000, he has been working in several IT companies (Alcatel, JDS UniPhase, Indra Systems) as a Analyst and Project Manager in the telecommunications market (CRM, Contact Center, Work Force management, Billing Systems). He has been involved in several projects with several customers (France Telecom, Telecom Italia, Turk Telekom, Telecom Sweden). ▪ Bernat joined isardSAT in January 2009. He initiated his tasks in the Level 1b Re-Processing of the ERS data (ESA REAPER project) and he runs all technical aspects since beginning 2010. He has been involved in the development of Sentinel-3 L0 and L1b Ground Processor Prototype since the beginning of the project as a responsible of the coordination of the System architecture and Algorithmic development, as well as performing the Project Management tasks. He is currently managing the system and architectural aspects of the Jason-CS L1b prototype development.
Nationality	▪ Spanish
Languages	▪ Spanish, English

5. APPENDIX 1: WPDs

WPD Title		WP 1100		
WP Title:	Case Studies	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent: Consolidated final list of case studies		Issue Date: 4 Jan 2012		
Start Event:	KOM	Planned Start Date: T0		
End Event:	PM1	Planned End Date: T0 + 1		
WP Manager:	S. Lavender			
Objectives: <i>To define "typical user" case studies covering the GMES services</i>				
Inputs:				
<ul style="list-style-type: none"> ▪ Proposal submitted by the consortium ▪ Minutes of KOM 				
Activities:				
<ul style="list-style-type: none"> ▪ Consolidate a final list of case studies on the basis of those presented in the consortium's proposal ▪ Take into account the points raised by ESA and agreed to at the negotiation/KOM ▪ Ensure that the proposed case studies cover the maximum extent of potential users of the Sentinel products ▪ Compile a case study report 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-1: Case Study Report (T0 + 2 weeks), updated at T0 + 8 m and T0 + 9 m 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
120	-	-	-	-



Work Package Description		WP 1200		
WP Title:	User requirements	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):	ARRAY			
Major Constituent:	User requirements derived from the case studies	Issue Date: 4 Jan 2012		
Start Event:	KOM	Planned Start Date: T0		
End Event:	DWM	Planned End Date: T0 + 2 m		
WP Manager:	S. Lavender			
Objectives: <i>To derive "user requirements" for the justification of the Sentinel User Handbook content</i>				
Inputs:				
<ul style="list-style-type: none"> ▪ SOW ▪ Proposal submitted by the consortium ▪ Minutes of KOM ▪ Case study report when available 				
Activities:				
<u>ARGANS</u>				
<ul style="list-style-type: none"> ▪ Derive user requirements from the case studies; to be used for the justification of the Handbook detailed structure 				
<u>ARRAY</u>				
<ul style="list-style-type: none"> ▪ Provide input on case studies and user requirements ▪ Assessment of user requirements more specifically linked to S-1 mission and products ▪ Provide input on Handbook structure from the perspective of S-1 Handbook 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-2: Sentinel User Requirements Document (draft version to be delivered at T0+1 m, release at T0+2 m), updated at T0+8 m and T0+9 m 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
40	-	32	-	-



Work Package Description		WP 1300
WP Title:	Sentinel Handbook Architecture	Sheet: 1 of 1
Leader:	ARGANS	Issue Ref: 1
Participant(s):		
Major Constituent:	Detailed Handbook wiki structure	Issue Date: 4 Jan 2012
Start Event:	KOM	Planned Start Date: T0
End Event:	DWM	Planned End Date: T0 + 2 m
WP Manager:	S. Emsley	
Objectives: <i>To propose a detailed Sentinel User Handbook wiki structure</i>		
Inputs: <ul style="list-style-type: none">▪ SOW▪ Proposal submitted by the consortium▪ Minutes of KOM▪ Sentinel User Requirements Document (when available)		
Activities: <p><u>ARGANS</u></p> <ul style="list-style-type: none">▪ Propose a detailed Handbook wiki structure based on (and including as a minimum):<ul style="list-style-type: none">✓ Presentation of the Sentinels and the objectives of the missions✓ Description of available and foreseen services fed by Sentinel data✓ Detailed description of the mission, spacecraft and instruments down to unit and component level if appropriate✓ Detailed description of instrument performances✓ Detailed description of instrument calibration and on-ground characterization✓ Executive overview of all key technical documents; identification of web links✓ Executive overview of the data access; identification of web links✓ Executive overview of the exploitation tools; identification of web links✓ Data products - format and content – linked to the Exploitation Tools▪ Justify the proposed wiki structure, content and user-friendliness from the user requirements▪ Justify the proposed “book” structure from the user requirements and how it is printable▪ Discuss the suitability of the ESA provided wiki development environment and justify the evolutions▪ List and define the required extent of the multimedia requirements needed for the content▪ Write the Sentinel User Handbook wiki and “book” TNs		

Work Package Description
WP 1300
Outputs:

- DEL-3: Sentinel User Handbook wiki structure description Document (T0+2 m), updated at T0+8 m and T0+9 m
- DEL-4: Sentinel User Handbook wiki structure justification Document (T0+2 m), updated at T0+8 m and T0+9 m
- DEL-5: Sentinel User Handbook “book” structure description Document (T0+2 m), updated at T0+8 m and T0+9 m
- DEL-6: Sentinel User Handbook “book” structure justification Document (T0+2 m), updated at T0+8 m and T0+9 m
- DEL-7: TN about the suitability of the User Handbook wiki development environment (T0+2 m), updated at T0+9 m
- DEL-8: TN about the multimedia requirements for the Sentinel User Handbook Wiki (T0+2 m), updated at T0+9 m

Number of hours allocated to the WP

ARGANS	ACRI-ST	ARRAY	BC	isardSAT
248	-	-	-	-



Work Package Description		WP 1400		
WP Title:	GSCDA Critical Analysis	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent: Interface between the GSCDA web site structure with the Sentinel User Handbook		Issue Date: 4 Jan 2012		
Start Event:	PM1	Planned Start Date: T0 + 1		
End Event:	DWM	Planned End Date: T0 + 2		
WP Manager:	S. Emsley			
Objectives: <i>To perform a critical analysis of the ESA's GSCDA web site</i>				
Inputs:				
<ul style="list-style-type: none"> ▪ GSCDA web site access 				
Activities:				
<u>ARGANS</u>				
<ul style="list-style-type: none"> ▪ Analyse the GSCDA web site structure ▪ Provide justified recommendations in order to “elegantly” interface with the Sentinel User Handbook ▪ Provide a web site map showing the interfaces with the Sentinel User Handbook 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-9: Critical Analysis of ESA's GSCDA web site document (T0 + 2), updated at T0 + 9 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
64	-	-	-	-



Work Package Description		WP 2100		
WP Title:	Sentinel User Handbook introduction	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):	Consultants			
Major Constituent:	Sentinel User Handbook introductory chapter	Issue Date: 4 Jan 2012		
Start Event:	DWM	Planned Start Date: T0 + 2		
End Event:	SCM	Planned End Date: T0 + 8		
WP Manager:	S. Lavender			
Objectives:	<i>To develop the Sentinel User Handbook introductory chapter</i>			
Inputs:	<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Outcomes of DWM 			
Activities:	<p><u>ARGANS</u></p> <ul style="list-style-type: none"> ▪ Organise, coordinate and collate the consultants inputs <ul style="list-style-type: none"> ✓ Organise interviews, teleconferences etc if required ▪ Collate inputs from existing documentation supplied by ESA or available on the internet <p><u>Consultants</u></p> <ul style="list-style-type: none"> ▪ Provide Sentinel User Handbook introductory chapter contribution answering to the question: "What can the Sentinels do for you and how?" ▪ Provide recommendations about the wiki structure and content 			
Outputs:	<ul style="list-style-type: none"> ▪ Contribution to DEL-10, DEL-12 and DEL-14 (Introductory chapter and "high-level" information) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
64	-	-	-	-



Work Package Description		WP 2200		
WP Title:	Sentinel-1 Products Handbook	Sheet: 1 of 1		
Leader:	ARRAY	Issue Ref: 1		
Participant(s):				
Major Constituent: Sentinel-1 part of the User Product Handbook		Issue Date: 4 Jan 2012		
Start Event:	DWM	Planned Start Date: T0 + 2		
End Event:	-	Planned End Date: T0 + 8		
WP Manager:	R. Jha			
Objectives: <i>To develop the detailed content of the Sentinel User Product Handbook (Sentinel-1 part)</i>				
Inputs:				
<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Sentinel-1 documentation (CFI) 				
Activities:				
<u>ARRAY</u>				
<ul style="list-style-type: none"> ▪ Develop the detailed content of the Sentinel User Product Handbook (Sentinel-1 part) on the basis of the Sentinel User Product Handbook wiki and “book” structure <ul style="list-style-type: none"> ✓ Detailed description of the S-1 spacecraft and instruments down to unit and component level if appropriate ✓ Detailed description of S-1 instrument performances ✓ Detailed description of S-1 instrument calibration and on-ground characterization ✓ Executive overview of all S-1 key technical documents ✓ Executive overview of the S-1 data access ✓ Executive overview of the S-1 exploitation tools (NEST) ✓ S-1 products description in terms of products definition, products format, etc. 				
Outputs:				
<ul style="list-style-type: none"> ▪ Contribution to DEL-10, DEL-12 and DEL-14 (S-1 related information) 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	630	-	-



Work Package Description		WP 2300		
WP Title:	Sentinel-2 Products Handbook	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent: Sentinel-2 part of the User Product Handbook		Issue Date: 4 Jan 2012		
Start Event:	DWM	Planned Start Date: T0 + 2		
End Event:	-	Planned End Date: T0 + 8		
WP Manager:	J. Jackson			
Objectives:	<i>To develop the detailed content of the Sentinel User Product Handbook (Sentinel-2 part)</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Sentinel-2 documentation (CFI) 				
Activities:				
<u>ARGANS</u>				
<ul style="list-style-type: none"> ▪ Develop the detailed content of the Sentinel User Product Handbook (S-2 part) on the basis of the Sentinel User Product Handbook wiki and “book” structure <ul style="list-style-type: none"> ✓ Detailed description of the S-2 spacecraft and instruments down to unit and component level if appropriate ✓ Detailed description of S-2 instrument performances ✓ Detailed description of S-2 instrument calibration and on-ground characterization ✓ Executive overview of all S-2 key technical documents ✓ Executive overview of the S-2 data access ✓ Executive overview of the S-2 exploitation tools (BEAM) ✓ S-2 products description in terms of products definition, products format, etc. 				
Outputs:				
<ul style="list-style-type: none"> ▪ Contribution to DEL-10, DEL-12 and DEL-14 (S-2 related information) 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
344	-	-	-	-



Work Package Description		WP 2410		
WP Title:	Sentinel-3 OLCI, SLSTR and SYN Products Handbook	Sheet: 1 of 1		
Leader:	ACRI-ST	Issue Ref: 1		
Participant(s):				
Major Constituent: Sentinel-3 optical products part of the User Product Handbook		Issue Date: 4 Jan 2012		
Start Event:	DWM	Planned Start Date: T0 + 2		
End Event:	-	Planned End Date: T0 + 8		
WP Manager:	P. Garnesson			
Objectives:	<i>To develop the detailed content of the Sentinel User Product Handbook (Sentinel-3 OLCI, SLSTR and SYN part)</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Sentinel-3 documentation (CFI) 				
Activities:				
<u>ACRI-ST</u>				
<ul style="list-style-type: none"> ▪ To develop the detailed content of the Sentinel User Product Handbook (S-3 OLCI, SLSTR and SYN part) on the basis of the Sentinel User Product Handbook wiki and “book” structure <ul style="list-style-type: none"> ✓ Detailed description of the S-3 spacecraft and OLCI, SLSTR and SYN instruments down to unit and component level if appropriate ✓ Detailed description of S-3 OLCI, SLSTR and SYN instrument performances ✓ Detailed description of S-3 OLCI, SLSTR and SYN instrument calibration and on-ground characterization ✓ Executive overview of all S-3 OLCI, SLSTR and SYN key technical documents ✓ Executive overview of the S-3 OLCI, SLSTR and SYN data access ✓ Executive overview of the S-3 OLCI, SLSTR and SYN exploitation tools (BEAM) ✓ S-3 OLCI, SLSTR and SYN products description in terms of products definition, products format, etc. 				
Outputs:				
<ul style="list-style-type: none"> ▪ Contribution to DEL-10, DEL-12 and DEL-14 (OLCI, SLSTR, SYN S-3 related information) 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	671	-	-	-

Work Package Description				WP 2420	
WP Title: Sentinel-3 SRAL Products Handbook			Sheet: 1 of 1		
Leader: isardSAT			Issue Ref: 1		
Participant(s):					
Major Constituent: Sentinel-3 SRAL part of the User Product Handbook				Issue Date: 4 Jan 2012	
Start Event: DWM		Planned Start Date: T0 + 2			
End Event: -		Planned End Date: T0 + 8			
WP Manager: M. Roca					
Objectives: <i>To develop the detailed content of the Sentinel User Product Handbook (Sentinel-3 SRAL part)</i>					
Inputs:					
<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Sentinel-3 documentation (CFI) 					
Activities:					
<u>isardSAT</u>					
<ul style="list-style-type: none"> ▪ To develop the detailed content of the Sentinel User Product Handbook (S-3 SRAL part) on the basis of the Sentinel User Product Handbook wiki and “book” structure <ul style="list-style-type: none"> ✓ Detailed description of the S-3 spacecraft and SRAL instruments down to unit and component level if appropriate ✓ Detailed description of S-3 SRAL instrument performances ✓ Detailed description of S-3 SRAL instrument calibration and on-ground characterization ✓ Executive overview of all S-3 SRAL key technical documents ✓ Executive overview of the S-3 SRAL data access ✓ S-3 SRAL products description in terms of products definition, products format, etc. 					
Outputs:					
<ul style="list-style-type: none"> ▪ Contribution to DEL-10, DEL-12 and DEL-14 (SRAL S-3 related information) 					
Number of hours allocated to the WP					
ARGANS	ACRI-ST	ARRAY	BC	isardSAT	
-	-	-	-	220	



Work Package Description		WP 2500		
WP Title:	Links with stakeholders	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent: Sentinel Stakeholders consultation meeting		Issue Date: 4 Jan 2012		
Start Event:	-	Planned Start Date: T0 + 6		
End Event:	SCM	Planned End Date: T0 + 8		
WP Manager:	S. Lavender			
Objectives:	<i>To organise the Sentinel Stakeholders consultation meeting</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ Phase 1 deliverables (last version) ▪ Sentinel User Handbook (iss=draft) 				
Activities:				
<u>ARGANS</u>				
<ul style="list-style-type: none"> ▪ Prepare the Sentinel Stakeholders consultation meeting <ul style="list-style-type: none"> ✓ Organise the meeting ✓ Prepare a presentation of the Sentinel User Handbook wiki including justifications based on case studies and associated user requirements ▪ Participate to the Sentinel Stakeholders consultation meeting (presentation, minutes etc) ▪ Support the Sentinel Stakeholders recommendations report 				
Outputs:				
<ul style="list-style-type: none"> ▪ Minutes of SCM ▪ Contribution to DEL-11 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
72	-	-	-	-



Work Package Description		WP 3100		
WP Title:	Detailed Analysis of Recommendations	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent:	Stakeholder recommended updates to the User Product Handbook	Issue Date: 4 Jan 2012		
Start Event:	SCM	Planned Start Date: T0 + 8		
End Event:	-	Planned End Date: T0 + 9		
WP Manager:	S. Lavender			
Objectives:	<i>To support the preparation of stakeholders' recommendations report and perform an analysis of these recommendations</i>			
Inputs:	<ul style="list-style-type: none"> ▪ Minutes of SCM 			
Activities:	<p><u>ARGANS tasks</u></p> <ul style="list-style-type: none"> ▪ Review the following deliverables linked to the Sentinel Stakeholder's comments: <ul style="list-style-type: none"> ✓ DEL-1: Case Study Report ✓ DEL-2: Sentinel User Requirements Document ✓ DEL-3: Sentinel User Handbook wiki structure description Document ✓ DEL-10: Sentinel User Handbook draft 			
Outputs:	<ul style="list-style-type: none"> ▪ DEL-11: Sentinel Stakeholder's Recommendations Report & Analysis (T0+9) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
64	-	-	-	-



Work Package Description		WP 3210		
WP Title:	Implementation of Sentinel-1 recommendations	Sheet: 1 of 1		
Leader:	ARRAY	Issue Ref: 1		
Participant(s):				
Major Constituent:	Sentinel-1 updates to the User Product Handbook	Issue Date: 4 Jan 2012		
Start Event:	SCM	Planned Start Date: T0 + 9		
End Event:	AM	Planned End Date: T0 + 12		
WP Manager:	R. Jha			
Objectives:	<i>To update the Sentinel User Handbook wiki (Sentinel-1-related chapters)</i>			
Inputs:	<ul style="list-style-type: none"> ▪ DEL-10: Sentinel User Handbook draft ▪ Phase 1 deliverables (updated version) ▪ DEL-11: Sentinel Stakeholder's Recommendations Report & Analysis ▪ Updated Sentinel-1 documentation 			
Activities:	<u>ARRAY</u> <ul style="list-style-type: none"> ▪ Complete and update the Sentinel User Handbook wiki and "book" content including stakeholders' recommendations related to S-1 			
Outputs:	<ul style="list-style-type: none"> ▪ Contribution to DEL-12: Sentinel User Handbook, issue 1 – S-1 chapters (T0+12m) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	184	-	-



Work Package Description				WP 3220	
WP Title:		Implementation of Sentinel-2 recommendations		Sheet: 1 of 1	
Leader:		ARGANS		Issue Ref: 1	
Participant(s):					
Major Constituent: Sentinel-2 updates to the User Product Handbook				Issue Date: 4 Jan 2012	
Start Event:		SCM	Planned Start Date: T0 + 9		
End Event:		AM	Planned End Date: T0 + 12		
WP Manager:		J. Jackson			
Objectives:		<i>To update the Sentinel User Handbook wiki (Sentinel-2 chapters)</i>			
Inputs:					
<ul style="list-style-type: none"> ▪ DEL-10: Sentinel User Handbook draft ▪ Phase 1 deliverables (updated version) ▪ DEL-11: Sentinel Stakeholder's Recommendations Report & Analysis ▪ Updated Sentinel-2 documentation (CFI) 					
Activities:					
<u>ARGANS tasks</u>					
<ul style="list-style-type: none"> ▪ Complete and update the Sentinel User Handbook wiki and "book" content including stakeholders' recommendations related to S-2 					
Outputs:					
<ul style="list-style-type: none"> ▪ Contribution to DEL-12: Sentinel User Handbook, issue 1 – S-2 chapters (T0+12m) 					
Number of hours allocated to the WP					
ARGANS	ACRI-ST	ARRAY	BC	isardSAT	
136	-	-	-	-	



Work Package Description		WP 3231		
WP Title:	Implementation of Sentinel-3 OLCI, SLSTR and SYN Recommendations	Sheet: 1 of 1		
Leader:	ACRI-ST	Issue Ref: 1		
Participant(s):				
Major Constituent:	Sentinel-3 optical updates to the User Product Handbook	Issue Date: 4 Jan 2012		
Start Event:	SCM	Planned Start Date: T0 + 9		
End Event:	AM	Planned End Date: T0 + 12		
WP Manager:	P. Garnesson			
Objectives:	<i>To update the Sentinel User Handbook wiki (OLCI, SLSTR, SYN Sentinel-3 chapters)</i>			
Inputs:	<ul style="list-style-type: none"> ▪ DEL-10: Sentinel User Handbook draft ▪ Phase 1 deliverables (updated version) ▪ DEL-11: Sentinel Stakeholder's Recommendations Report & Analysis ▪ Updated Sentinel-3 documentation (CFI) 			
Activities:	<u>ACRI-ST tasks</u> <ul style="list-style-type: none"> ▪ Complete and update the Sentinel User Handbook wiki and "book" content including stakeholders' recommendations related to OLCI, SLSTR, SYN S-3 			
Outputs:	<ul style="list-style-type: none"> ▪ Contribution to DEL-12: Sentinel User Handbook, issue 1 – OLCI, SLSTR, SYN S-3 chapters (T0+12m) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	242	-	-	-



Work Package Description		WP 3232		
WP Title:	Implementation of Sentinel-3 SRAL Recommendations	Sheet: 1 of 1		
Leader:	isardSAT	Issue Ref: 1		
Participant(s):				
Major Constituent:	Sentinel-3 SRAL updates to the User Product Handbook	Issue Date: 4 Jan 2012		
Start Event:	SCM	Planned Start Date: T0 + 9		
End Event:	AM	Planned End Date: T0 + 12		
WP Manager:	M. Roca			
Objectives:	<i>To update the Sentinel User Handbook wiki (SRAL Sentinel-3 chapters)</i>			
Inputs:	<ul style="list-style-type: none"> ▪ DEL-10: Sentinel User Handbook draft ▪ Phase 1 deliverables (updated version) ▪ DEL-11: Sentinel Stakeholder's Recommendations Report & Analysis ▪ Updated Sentinel-3 documentation (CFI) 			
Activities:	<u>isardSAT tasks</u> <ul style="list-style-type: none"> ▪ Complete and update the Sentinel User Handbook wiki and "book" content including stakeholders' recommendations related to SRAL S-3 			
Outputs:	<ul style="list-style-type: none"> ▪ Contribution to DEL-12: Sentinel User Handbook, issue 1 – SRAL S-3 chapters (T0+12m) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	-	-	100



Work Package Description		WP 4100		
WP Title:	Deployment of Sentinel Handbook in GSCDA	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent:	Deployment of the Sentinel User Handbook within the GSCDA website	Issue Date: 4 Jan 2012		
Start Event:	AM	Planned Start Date: T0 + 12		
End Event:	-	Planned End Date: T0 + 14		
WP Manager:	S. Emsley			
Objectives:	<i>To deploy the Sentinel Handbook in GSCDA</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ DEL-12: Sentinel User Handbook issue 1 				
Activities:				
<u>ARGANS tasks</u>				
<ul style="list-style-type: none"> ▪ Deployment of the Sentinel User Handbook into ESA's GSCDA website 				
Outputs:				
<ul style="list-style-type: none"> ▪ Sentinel User Handbook, issue 1, deployed in GSCDA 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
128	-	-	-	-



Work Package Description		WP 4200		
WP Title:	Maintenance of the Handbook	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):	ACRI-ST, ARRAY, isardSAT			
Major Constituent:	Maintenance of the Handbook	Issue Date: 4 Jan 2012		
Start Event:	AM	Planned Start Date: T0 + 12		
End Event:	FP	Planned End Date: T0 + 18		
WP Manager:	S. Lavender			
Objectives:	<i>To update as needed the content of the Sentinel User Handbook</i>			
Inputs:	<ul style="list-style-type: none"> ▪ DEL-12: Sentinel User Handbook issue 1 ▪ Updated documentation of Sentinel-1, Sentinel-2 and Sentinel-3 			
Activities:	<p><u>ARGANS tasks</u></p> <ul style="list-style-type: none"> ▪ Coordinate the update of contents of the Handbook accordingly to update or revised information provided by ESA ▪ Ensure, if needed, the maintenance of the wiki ▪ Update, if needed, the contents (if necessary) in chapter(s) related to BEAM <p><u>ACRI-ST tasks</u></p> <ul style="list-style-type: none"> ▪ Update, if needed, the contents in all chapters related to OLCI, SLSTR and SYN S-3 <p><u>ARRAY tasks</u></p> <ul style="list-style-type: none"> ▪ Update, if needed, the contents in all chapters related to S-1 ▪ Update, if needed, the contents (if necessary) in chapter(s) related to NEST <p><u>isardSAT tasks</u></p> <ul style="list-style-type: none"> ▪ Update, if needed, the contents in all chapters related to SRAL S-3 			
Outputs:	<ul style="list-style-type: none"> ▪ DEL-14: Sentinel User Handbook issue 1.1 (T0+18m) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
64	156	113	-	52

Work Package Description		WP 5110		
WP Title:	Development of Sentinel-1 products readers for NEST	Sheet: 1 of 1		
Leader:	ARRAY	Issue Ref: 1		
Participant(s):				
Major Constituent: Sentinel-1 products readers		Issue Date: 4 Jan 2012		
Start Event:	PM2	Planned Start Date: T0 + 5		
End Event:	-	Planned End Date: T0 + 9		
WP Manager:	R. Jha			
Objectives:	<i>To develop Sentinel-1 products readers to allow ingestion of these products in NEST</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ NEST toolbox description ▪ Sentinel-1 simulated products ▪ ECSS-ST-Q-80C 				
Activities:				
<u>ARRAY tasks (the global coordination of the Exploitation Tools activities (WP5000) is ensured by BC)</u>				
<ul style="list-style-type: none"> ▪ Develop data readers for the following Sentinel 1 products: SAR L0; L1 SLC; L1 GRD; L2 OCN ▪ Define, document and implement a software product assurance programme based on ECSS-ST-Q-80C ▪ Ensure that the installation and de-installation of the data readers will be done through the NEST module manager ▪ Code the S-1 readers as Java plug-ins in order to ensure that the S-1 data readers will run on every platform where the Java VM is available (Windows, Mac OS, Linux and other Unix system) ▪ Enable the saving of these products in the internal BEAM-DIMAP format ▪ Adapt the existing NEST SLC debursting and detection tool to the S-1 SLC products ▪ Allow the user to operate all data readers from within the visualisation tool interface of NEST and from the command-line ▪ Allow the user to read the whole data product or only parts of the product, e.g. selected Measurement Datasets; user-defined region of interest ▪ Assess the functional performance of NEST by using simulated S-1 products ▪ Identify the main performance bottlenecks shall be identified and mitigated 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-17: Sentinel-1 data readers for NEST, 1st delivery (T0+9 m) 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	578	-	-

Work Package Description		WP 5120		
WP Title:	Development of Sentinel-2 & Sentinel-3 products readers for BEAM	Sheet: 1 of 1		
Leader:	BC	Issue Ref: 1		
Participant(s):	Sentinel-2 and -3 products readers			
Major Constituent:	-	Issue Date: 4 Jan 2012		
Start Event:	PM2	Planned Start Date: T0 + 5		
End Event:	-	Planned End Date: T0 + 9		
WP Manager:	N. Fomferra			
Objectives:	<i>To develop Sentinel-2 and Sentinel-3 products readers to allow ingestion of these products in BEAM</i>			
Inputs:	<ul style="list-style-type: none"> ▪ BEAM toolbox description ▪ Sentinel-2 and Sentinel-3 simulated products ▪ ECSS-ST-Q-80C 			
Activities:	<p><u>BC tasks</u></p> <ul style="list-style-type: none"> ▪ Coordinate the Exploitation Tools activities (WP5000) ▪ Develop data readers for the following S-2 (MSI L1B & MSI L1C) and S-3 products (OLCI L1, OLCI Water Color L2, OLCI Land L2, SLSTR L1, SLSTR Water L2, SLSTR Land L2 & SYN/VGT L2) ▪ Develop a data reader for the ingestion of the L2A output products as generated with ACP ▪ Define, document and implement a software product assurance programme based on ECSS-ST-Q-80C ▪ Ensure the installation and de-installation of the data readers is through the BEAM module manager ▪ Code the S-2&S-3 readers as Java plug-ins in order to ensure that the data readers will run on every platform where the Java VM is available (Windows, Mac OS, Linux and other Unix systems) ▪ Enable the saving of these products in the internal BEAM-DIMAP format ▪ Allow the user to operate all data readers from within the visualisation tool interface and the command-line ▪ Allow the user to read the whole data product or only parts of the product, e.g. selected Measurement Datasets; user-defined region of interest ▪ Assess the functional performance of BEAM by using simulated S-2&S-3 products ▪ Identify the main performance bottlenecks shall be identified and mitigated 			
Outputs:	<ul style="list-style-type: none"> ▪ DEL-18: Sentinel-2 data readers for BEAM, 1st delivery (T0+9 m) ▪ DEL-19: Sentinel-3 data readers for BEAM, 1st delivery (T0+9 m) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	-	630	-

Work Package Description		WP 5200		
WP Title:	Integration of Sentinel-2 ACP into BEAM	Sheet: 1 of 1		
Leader:	BC	Issue Ref: 1		
Participant(s):				
Major Constituent: Integration of Sentinel-2 ACP into BEAM		Issue Date: 4 Jan 2012		
Start Event:	AM	Planned Start Date: T0 + 12		
End Event:	PM4	Planned End Date: T0 + 15		
WP Manager:	N. Fomferra			
Objectives:	<i>Integrate the ACP into BEAM</i>			
Inputs:				
<ul style="list-style-type: none"> ▪ Atmospheric Correction Processor (ESA CFI) ▪ BEAM toolbox description ▪ ECSS-ST-Q-80C ▪ Sentinel-2 simulated data ▪ Technical proposal (about technical solutions for the integration) 				
Activities:				
<u>BC tasks</u>				
<ul style="list-style-type: none"> ▪ Integrate the ACP into BEAM ▪ Ensure that ACP integrated in BEAM will run on every platform where the Java VM is available (Windows, Mac OS, Linux and other Unix system) ▪ Verify that the integrated processor generates same output as the native Python code <ul style="list-style-type: none"> ✓ To deliver a test report 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-20: Integrated Sentinel-2 Atmospheric Correction Processor, 1st delivery ▪ Test report on the integrated ACP 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	-	435	-

Work Package Description		WP 5300		
WP Title:	Software Maintenance	Sheet: 1 of 1		
Leader:	BC	Issue Ref: 1		
Participant(s):	ARRAY			
Major Constituent:	Sentinel-1, -2 and -3 Readers Maintenance	Issue Date: 4 Jan 2012		
Start Event:	-	Planned Start Date: T0 + 9		
End Event:	FP	Planned End Date: T0 + 18		
WP Manager:	N. Fomferra			
Objectives:	To maintain S/W developed in WP 5200			
Inputs:	<ul style="list-style-type: none"> ▪ Output from WP5200 ▪ Change and evolutions (if any) 			
Activities:	<p><u>ARRAY</u></p> <ul style="list-style-type: none"> ▪ Maintain the S-1 reader for NEST <p><u>BC tasks</u></p> <ul style="list-style-type: none"> ▪ Maintain the S-2 and S-3 readers for BEAM ▪ Maintain the ACP integrated in BEAM 			
Outputs:	<ul style="list-style-type: none"> ▪ DEL-21: Final delivery of all S/W items (S-2 and S-3 readers, ACP) 			
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
-	-	50	119	-



Work Package Description		WP 6000		
WP Title:	Management	Sheet: 1 of 1		
Leader:	ARGANS	Issue Ref: 1		
Participant(s):				
Major Constituent: Project Management		Issue Date: 4 Jan 2012		
Start Event:	KOM	Planned Start Date: T0		
End Event:	FP	Planned End Date: T0 + 18		
WP Manager:	S. Lavender			
Objectives:	Manage and control all project activities of all sub-contractors			
Inputs:				
<ul style="list-style-type: none"> ▪ ITT and SOW ▪ Proposal prepared by ARGANS and the subcontractors ▪ Minutes of Negotiation Meeting ▪ Contract signed with ESA 				
Activities:				
<u>ARGANS tasks</u>				
<ul style="list-style-type: none"> ▪ Keep control of the work progress according to the work and financial plan ▪ Control that deliverables suit the customer needs and expectations ▪ Detect any problem / deviation from the planning or conflicts of any kind ▪ Prepare and organise the meetings and the reviews ▪ Maintain the Action Items List ▪ Production of monthly progress reports ▪ Management of the sub-contractors (issuing contracts and checking the milestone payments are authorised according to the milestones and deliverables) 				
Outputs:				
<ul style="list-style-type: none"> ▪ DEL-15: Monthly Progress Reports ▪ DEL-16: Presentation Hands-Out ▪ Minutes of Meetings 				
Number of hours allocated to the WP				
ARGANS	ACRI-ST	ARRAY	BC	isardSAT
287	-	-	-	-