DOCUMENT

EO Level 1 Lessons Learned Meeting, ESA/ESRIN, 10-11 June 2013

Prepared by	**G. Davies**
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Table of contents:

1 INTRODUCTION

As a result of a recommendation at the Atmospheric Composition Validation and Evolution workshop held on 13-15 March 2013, representatives from the atmospheric composition and optical Level 1 communities participated in a meeting to discuss how to:

- Integrate the latest findings on level-1 into the upcoming reprocessing campaigns of ERS1/ERS-2/Envisat.
- Support:
  - Scientific Research
  - The EO Applications and Exploitation community
  - ESA programmes, in particular CCI, SEOM and LTDP
- Prepare for the Sentinels operations phase (and lessons learned for the future missions)

These objectives were facilitated through:

- The exchange of ideas between the different ESA EO instrument teams including an introduction to the approaches used by different communities
- Provision of L1 recommendations for the upcoming ERS/Envisat instrument reprocessing campaigns
- Formulation of lessons learned for calibration and in-flight characterisation including recommendations for future activities (for example QA constellation, S5p/S5 calibration, Sentinel B units)
- Consider the way forward for L1 activities

The participants are listed in Annex A and the agenda is included in Annex B. The presentations are available on the SPPA Web Pages (https://earth.esa.int/web/sppa/meetings-workshops/eo-level1-lessons-learned-workshop).

1.1 Acronyms and Abbreviations

This section controls the definition of all abbreviations and acronyms used within this document. Special attention has been paid to adopt abbreviations, acronyms and their definitions from international standards as ISO, ANSI or ECSS.

AATSR	Advanced Along Track Scanning Radiometer
ACVE	Atmospheric Composition Validation and Evolution
ATSR-1/2	Along Track Scanning Radiometer
CCD	Charge-Coupled Device
CCI	ESA Climate Change Initiative programme
CEOS	Committee on Earth Observation Satellites
DCC	Deep Convective Clouds
ECV	Essential Climate Variable
ECMWF	European Centre for Medium-Range Weather Forecasts
EM	Engineering Model

ENVISAT	Environmental Satellite
EO	Earth Observation
EPS	EUMETSAT Polar System
ERS	European Remote Sensing Satellites
ESL	Engineering Support Laboratory
FCDR	Fundamental Climate Data Record
FOV	Field of View
GOME	Global Ozone Monitoring Experiment
GOMOS	Global Ozone Monitoring by Occultation of Stars
LTDP	Long Term Data Preservation
MERIS	Medium Resolution Image Spectrometer
MetEOC	Metrology for Earth Observation and Climate
Metop	Polar orbiting meteorological satellites (space segment component of EUMETSAT Polar System (EPS))
MIP	Most Illuminated Pixel
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding
MTF	Modulation Transfer Function
NIR	Near-Infrared
NIST	National Institute of Standards and Technology
NMI	National Metrology Institute
NRT	Near Real Time
OLCI	Ocean and Land Colour Instrument
OMI	Ozone Monitoring Instrument
QM	Qualification Model
QWG	Quality Working Group
RUT	Radiometric Uncertainty Tool
SADE	Structure d'Accueil de Données d'Etalonnage
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Chartography
SFM	Steering Front Mechanism
SLSTR	Sea and Land Surface Temperature Radiometer
SWIR	Sort-Wave Infra-Red
TOA	Top-Of-Atmosphere
TROPOMI	TROPOspheric Monitoring Instrument
UVN	Ultra-violet/Visible/Near-Infrared
WGCV	Working Group on Calibration and Validation

2 PROCEEDINGS

The main points arising from the presentations and discussions are summarised below. Recommendations are identified when they arose in the meeting, and collected in Table 1 in section 4.

2.1 Day 1: 10 June 2013:

Bojan Bojkov (ESA) presented the objectives of the meeting, showing the importance of L1 for exploitation of data and programmes such as DUE and CCI. The evolution cycle for processors was shown, demonstrating the continuous improvement loop and importance of calibration and characterisation of sensor data.

Diego Loyola (DLR) presented the lessons learned from multi-sensor ECV generation. For GOME-type total ozone, this used GOME as the reference, correcting SCIAMACHY and GOME-2 for spatial and temporal biases and drifts. The approach for accurate L1 UVN products required for ECV generation was to generate the best possible L1 products for single sensors (using on-ground calibration, in-flight calibration, L1 algorithms, degradation, etc.), then to inter-calibrate the L1 from several sensors and create Fundamental Climate Data Records (FCDR) from various missions (i.e. GOME, SCIAMACHY, OMI, GOME-2/MetOp-A and GOME-2/MetOp-B). This required close interaction of L1, L2 and ECV teams (in particular, the close collaboration of the L1 and L2 teams was strongly recommended), extensive instrument and retrieval knowledge and implementation of L1 & L2 the ECV and L1 FCDR requirements included for Sentinel 5P, 4 and 5. *[Recommendation L1WG01-07: Close collaboration of the L1 and L2 teams is recommended in the definition and understanding of the characterisation and calibration activities and results.]* Knowledge of what has been done in calibration campaigns and access to this information are critical in this, such that the record of calibration needs to be good enough to recreate the process and to adjust the different instruments to each other. Having experts not involved in the original characterisation and calibration review the calibration documents was also considered useful. *[Recommendation L1WG-1-05: Traceability and completeness of characterisation and calibration information should be ensured, which could be partly fulfilled by having additional review of the documents by experts not involved in the characterisation and calibration.]* Several issues are known in the inter-comparison and improvements are expected still to come for GOME L1.

The approach to uncertainties was discussed, with it recognised that different users (e.g. NRT and climate monitoring) having different requirements for data quality (e.g. best orbit information is not available in NRT). The usefulness was agreed of having an instrument model for assessing sensitivities to uncertainty and also to guide in targeting key areas for characterisation, even if it can be a complex and difficult task which cannot model all parameters with equal effectiveness (e.g. polarisation). *[See recommendation L1WG01-08 in Nigel Fox's presentation.]*

J.M. "Thijs" Krijger presented SCIAMACHY/GOME experiences and lessons learned. Several calibration and characterisation issues arose in flight, which had not all been considered, with several that could not have been anticipated. SCIAMACHY was also not designed in such a way to facilitate calibration, which had possibly led to the omission of some measurements. Re-analysis of some on-ground as well as in-flight data is ongoing to further understand the behaviour in flight. Some lessons learnt included that a quick look of measurements during the on-ground calibration was important to detect anomalies early and before full analysis of the results. Identification of instrument characteristics that can only be measured on-ground should be a priority and redundant measurements are important so need to be part of the calibration planning. Opportunities for extra on-ground measurements should be taken when possible. Rapid access to thorough documentation and traceability of information are needed, with formal agreement proving time-consuming for the science institutes to get access to SCIAMACHY information. *Recommendation L1WG01-06: Easy, full and free access to characterisation and calibration information is needed throughout the mission, including pre-launch, in-flight and vicarious data. See also Rüdiger Lang's and Patrice Henry's presentations.]* It is also better value to ensure good documentation and traceability at the time of measurements rather than trying to reconstruct this later. Involvement of the scientists and expert users is also essential in the calibration, and the entity responsible for the operation of the instrument must have all the measurements, S/W and documentation from the on-ground calibration. On-ground characterisation, in-flight calibration and mission concept are interdependent and need to be treated as such contractually.

Nigel Fox (NPL) presented about ensuring traceability of Level 1 optical products. The definition of traceability being a property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty was emphasised. As an example of this, the Radiometric Uncertainty Tool (RUT) being developed for Sentinel-2 will allow users to generate uncertainty images associated with the orthorectified top-of-atmosphere (TOA) reflectance/radiance products, which are based on a radiometric model of the instrument and the ground processing, assessing the main uncertainty sources and their combination. Since the meeting recommended the systematic investigation of uncertainty sources for EO instruments, the development of the RUT is encouraged. *[Recommendation L1WG01-08: The systematic investigation of uncertainty sources for EO instruments should continue to be an important activity for past as well as active and future missions. For example, sensitivities to uncertainly sources can be investigated by development and use of an instrument model. See also Diego Loyola's presentation.]*

The EU FP7: Metrology for Earth Observation and Climate (MetEOC) project covering activities by NMIs was explained, http://www.emceoc.org, as an important European development. The role of pre-flight calibration (characterisation) was explained since it usually changes on launch. It confirms understanding, design and build of sensor and forms a baseline to help understand and correct post-launch changes. It also allows any measurements/science to have credibility as a starting point for accuracy claims and allows a linkage to internationally consistent physical units. At the pre-flight stage, reliable satellite data quality requires instrument design conformance, traceable sub-system characterisation/calibration and end-to-end calibration, maintenance/life-test of witness samples/sub-systems. Post-launch, it requires design/performance conformance through traceable calibration/validation of all key characteristics (or their harmonisation), on-board calibration/monitoring system, comparisons with physical parameter ("test site"), with reference data/method/instrument and with existing similar satellite instruments).

In summary, Pre- & post- launch calibration, characterisation & validation traceable to international agreed standards is a fundamental requirement with the strategy determined at the start of the mission concept by a clear link to requirements. The need for maintaining selected test sites was also recommended, as demonstrated by the implementation of the CEOS/WGCV/RadCalNet for vicarious calibration using high reflectance test sites. *[Recommendation L1WG01-09: Maintenance of instrumented test sites is recommended, as demonstrated by the implementation of the CEOS/WGCV/RadCalNet for vicarious calibration using high reflectance test sites.]* Internationally coordinated infrastructure/comparisons (CEOS) are very effective, by driving innovation, proving cost effective and as a learning opportunity, and the National Metrology Institutes are willing to help.

Ludovic Bourg (ACRI) presented in-flight lessons from MERIS and prelaunch calibration of OLCI. Radiometric calibration of MERIS was provided by an on-board diffuser plate, used as a secondary standard. The stability (ageing) of the diffuser plate is monitored by a second diffuser plate deployed 10 times less frequently and results show Diff-1 to have aged <2% which leads to an ageing of <0.2% for Diff-2. The instrument spectral characteristics are obtained from regular spectral calibration campaigns and a simple instrument spectral model with an accuracy of <0.2nm, and have shown the instrument to be stable to better than 0.1 nm over 10 years. The instrument degradation (trending) has been monitored and showed that Meris has degraded by < 5% in the blue and < 1 % in the NIR. OLCI, being the successor to MERIS, adopts similarity to MERIS, but includes lessons learnt from MERIS. Additional calibration sequences have been included, as well as all of the existing MERIS spectral calibration campaigns. The commonality between the two instruments means that a proven successful calibration strategy can be reused, while including refinements according to lessons learnt and will be embedded in the operational Sentinel environment. This approach gives confidence in the calibration of OLCI, but surprises cannot be excluded and vicarious validation is mandatory, as well as flexibility in adjusting the calibration approach,

Dave Smith (RAL) presented lessons learned from (A)ATSR and prelaunch calibration of SLSTR. The main calibration topics included: spectral response, infrared radiometry, solar channel radiometry, geometric calibration and polarisation. The AATSR Viscal diffuser aging has not followed the Barnes model, unlike ATSR-2. Results of solar channel comparisons with MERIS show good agreement, with outliers possibly caused by residual cloud contamination in MERIS data. GOME-2 and SCIAMACHY can be used for cross-comparisons. The major error sources in geometric calibration were also discussed, with the scan rotation angle in particular being variable around the scan and over time and this uncertainly will always be the main limitation on geolocation (for SLSTR, each pixel will have angular position). The co-registration between the two views is very important and work continues to improve this for reprocessing. The ATSR-2 record needs to take account of loss of pointing and its effects on Viscal illumination: filtering of bad measurements will be included in the next reprocessing.

Requirements for SLSTR calibration take into account history from previous ATSR instruments, but also have to include new activities arising from differences in the SLSTR instrument, e.g. Bands at 1375nm and 2250nm, significantly wider FOV – 1500km compared to 500km, nadir pixel is offset by -5 degrees, inclined view is in the opposite direction to (A)ATSR, there are multiple detectors per channel and the detectors not aligned to common field stop. There was concern at the meeting about what appears to be a short on-ground calibration plan which could jeopardise the mission objectives.

2.2 Day 2: 11 June 2013:

Patrice Henry (CNES) presented multi-sensor vicarious calibration activities at CNES. CNES has a lengthy background of in-orbit image quality monitoring of operational Earth observation systems, since the launch of SPOT1 in 1986, covering diverse missions with different resolution, different types of mission, different themes. The expertise covers skills in e.g. geometry, radiometry, MTF, polarized geometry and different tools (as generic as possible) to ensure user satisfaction. Concentrating in the presentation on radiometric calibration, different calibration methods over natural targets for visible and NIR optical sensors have been developed, including Rayleigh scattering over ocean, sun glint over ocean, deep convective clouds (DCC), stable African deserts, Antarctica (Dome C area), lunar calibration and autonomous calibration station (for high resolution). Most of these are used on an operational basis. The CNES calibration toolbox is a powerful tool for calibration. In conclusion, there is great interest for on-board calibration for operational mission, with the need for independent vicarious calibration for assessing on-board calibration or providing alternative calibration. Routine monitoring has to be performed according to written procedures and calibration effort needs to be sustained over the entire mission, with close links between operations and expert teams. There is a need for calibration with different approaches/methodologies and great interest for a multi-sensors calibration database. This approach was strongly supported at the meeting, and access to the SADE database by other space agencies was recognised as a very useful facility, as well as CNES' willingness to extend the database with other sensors' overpass data if made available to CNES. *[See recommendation L1WG01-06 in Thijs' Krijger's presentation.]*

Jürgen Fischer (FUB) presented experiences with spectral calibration of MERIS/OLCI. The individual accuracies of Fraunhofer and oxygen spectral calibration for MERIS were shown to be good, but an inconsistency was still to be solved, though some candidate ideas were being assessed (i.e. pressure and temperature dependence of O_2A absorption lines, spectroscopy of the O_2A band and an insufficient stray-light model). Compared to MERIS, recommendations for OLCI spectral calibration were to use an additional Fraunhofer Ca-line (1005 nm), use of H_2O absorption lines between 920 nm and 970 nm, analyse the camera boundaries, improve the spectral correction factor / "stray-light" correction and to perform Rayleigh correction above dark ocean surfaces. It was emphasised that continuous research into calibration is necessary to improve the quality of the existing MERIS dataset, and also to prepare for OLCI. *[Recommendation L1WG01-10: Continuous research into characterisation and calibration is necessary to improve the quality of existing datasets, and also to prepare for follow-on instruments.]*

Klaus Bramstedt (IUP), **Gaetan Perron** (ABB) and **Gilbert Barrot** (ACRI) presented instrument pointing issues on Envisat for SCIAMACHY, MIPAS and GOMOS respectively.

For SCIAMACHY, **Klaus Bramstedt** summarised the conclusions which were that precise pointing information derived for solar occultation was 27 m. The elevation angle offsets were: seasonal cycle ±127m, mean offset 249 m. Limited to NH only, different azimuth compared to SCIAMACHY limb. Additional information sources were lunar occultation (very limited) and GOMOS stellar occultation (Star tracker). The goal is to improve pointing also for SCIAMACHY limb and MIPAS. *[Recommendation L1WG01-11: It was recommended that investigation should continue into assessing if the better pointing information from SCIAMACHY activities can also be used to improve the AUX_FRA ADFs (restituted attitude files containing the best pointing/attitude information for Envisat).]* The AUX_FRA are used in the processing of data from SCIAMACHY, MIPAS and MERIS. The possibility of using high quality orbit files from altimetry should also be investigated to improve the pointing.

For MIPAS, **Gaetan Perron** explained that L2 can estimate the altitude information from retrieval and according to the community, this accurate to around 0.5 km. At the beginning, compared to L2, L1 reported altitudes had an orbital variation up to 1km, being similar to a platform pitch of 10mdeg and a roll of 60mdeg. After investigation, it was found that the alignment matrix of MIPAS was not taken into account in L1 and a patch to reduce the error was done in IPF5 through auxiliary data file and the difference compared to L2 is less than 0.5km and this is now in IPF7. Other minor improvements to include are an elevation mirror non-linearity correction (<250m); refraction model error due to approximation at low altitude was giving non-physical behaviour (<50m). Further suggestions for future work would be to try to use SCIAMACHY time series to estimate MIPAS seasonal variation more accurately instead of a simple bias (around -25mdeg); use precise orbit (~2m) and restituted attitude (orbital variation of ~500m); improve sideways (there is still a 2km offset in sideways compared to L2 which has not been a priority, since few measurements are done in sideways) and; improve atmospheric refraction calculation similar to GOMOS.

For GOMOS, **Gilbert Barrot** explained that the measurement principle was to programme the instrument to reach rendezvous points with stars (seen outside the atmosphere) with inputs on time, pointing angle and initial velocity. Then, the star was centred in the GOMOS telescope and tracked until the bottom of the atmosphere where the star is lost while its spectrum is measured. The MIP (Most Illuminated Pixel) is the star position on the CCD in detection mode and its variation in position seems to be seasonal and is an indicator of deviations from the expected ENVISAT platform attitude.

GOMOS needs an accurate platform position and attitude knowledge for the correct rendezvous time with the stars. The tracking of the star during measurement is performed by a star tracker which is used to correct the mirror velocity i.e. to accelerate or slow down the relative movement of the star image. The L1 processing uses the star as a reference target, not the pointing information provided by the sensor: the absolute pointing accuracy of GOMOS only relies on the well-known knowledge of Envisat's position and the star location. If the expected Envisat attitude is not correct, GOMOS misses the rendez-vous with the star (so this is more important for mission planning), and after measurement, the GOMOS star tracker and the Steering Front Mechanism (SFM) measured angles provide the pointing information. Comparing the theoretical and measured angles gives a difference of 300 m at 3000 km, with the source of this difference not yet fully understood.

The tangent point altitude is computed with 3D density grids (ECMWF) using a ray tracing model. The ECMWF error bar (a function of altitude) is used to determine the error in altitude accuracy at the tangent point. The pointing error of 100 m at 20 km is due to air density error, not to the Envisat attitude knowledge.

Rüdiger Lang (EUMETSAT) presented MetOp GOME-2 lessons learned. For the on-ground characterisation, it is critical to allow enough time, e.g. for repeat measurements for consistency checking (as reproducibility forms a key part of the uncertainty budget and allowing sufficient time for stabilisation of the instrument. It is also essential that all characterisation measurements are carried out in thermal vacuum and that the thermal environment including gradients is representative of the in-orbit situation. Procedures should be documented and reproducible with photo/video documentation, with close attention to frames of reference, coordinate systems & angles (e.g. GOME-2 flip of elevation angles diagnosed in orbit). All sources should be well commissioned prior to the start of measurement and radiometric calibration must be connected to standards e.g. NIST. All measurements and procedures must be traceable & under configuration control including software versions and documentation of which precise measurement is used in the generation of key data and data processing should be automated as far as possible. For slit function characterisation, requirements are needed from the data analysis activity before planning the measurements. All required supplementary calibration measurements (e.g. dark signal etc) need to be taken close to the time of each measurement. The importance of the on-ground characterisation was supported by the meeting and the comprehensive approach cited by Rüdiger Lang was strongly recommended, particularly in ensuring adequate time is allowed and included in the instrument development schedule. *[Recommendation L1WG01-12: The importance of the on-ground characterisation was emphasised, particularly in ensuring adequate time is allowed and included in the instrument development schedule.]*

For in-orbit Calibration & Performance Verification, consider taking necessary in-orbit calibration measurements adjacent to Sun measurements if possible, dark measurements should be taken under the same conditions as measurements. It is important to take many monitoring and calibration measurements early in instrument life, and to be aware of coatings etc. that will require time to stabilise and outgas, and of any temperature dependencies of output or aging issues in on-board. During any storage before launch, the instrument should typically be stored in a container over pressured using nitrogen, with regular reactivation (and monitoring measurements performed) and extreme attention to cleanliness required.

The key-issues from GOME-2 concern the instrument characterisation both on-ground and in-flight. Most issues concerning the applied algorithms are usually of transient importance or meanwhile have been solved. The responsible agencies should address instrument key-data issues throughout the programme (all phases) and lay open and respond to (potential) problems, limitations and uncertainties as soon as possible. They should also be responsive to user concerns on data quality and ensure there are close/short loop cycles between investigation and updates (which requires a certain/significant amount of in-house expertise to analyse, address and respond to issues). Ensuring traceability of information and completeness of characterisation documentation were recommended, as well as providing easy user access to the key characterisation information. *[See recommendation L1WG01-06 in Thijs' Krijger's presentation.]*

Users also have the responsibility to report back the problems they observe in a way which supports the investigations (i.e. fit quality indicators spectrally and angularly and temporarily resolved (e.g. in pre-defined target areas) and try to reduce/separate potential retrieval problems from level-2 problems. This also emphasises the need for close collaboration between the L1 and L2 teams. *[See recommendation L1WG01-07 in Diego Loyola's presentation.]*

Quintus Kleipool (KNMI) presented OMI and Sentinel-5 Precursor TROPOMI lessons learned. OMI issues were trying to be avoided on TROPOMI, including nonlinearity and gain. The TROPOMI challenges have included many lessons that have been dealt with, but there were still several remaining, including: challenging straylight performance; the complex but versatile electronics UVN; the novel SWIR detector and module; the lack of a QM/EM (which has an impact on the development of the L1 processor, specifically making the L01b reverse model difficult to define); agile software approach needed to allow for late changes; extensive planning and preparation for calibration needed; large software effort; on-ground calibration software must be developed beforehand; 2 axis turn/tilt cradle available, but no translate function, since very good knowledge of the attitude is needed; vacuum breaks were unavoidable and the tight schedule. Referring to the schedule, allowing enough time in the instrument development schedule for adequate on-ground characterisation was again recommended by the meeting. *[See recommendation L1WG01-12 in Rüdiger Lang's presentation.]*

3 CLOSING COMMENTS

The usefulness of the meeting was recognised by all participants in bringing together representatives from different instrument communities to discuss and share common characterisation and calibration topics and solutions. Such free and open information exchange and discussion about L1 topics is a valuable exercise and there was a consensus to build on the success of the meeting by forming a Level 1 Working Group (L1WG). *[Recommendation L1WG01-01: ESA to set up the L1WG, based on a 9-12 months cycle for meetings. Terms of Reference should be prepared.]* This would be moderated and facilitated by ESA and should meet on a 9-12 month cycle. Outputs would also be disseminated to instrument QWGs, particularly as input to reprocessing campaigns. *[Recommendation L1WG01-04: The L1WG should develop recommended best practice processes, based on review of existing practices e.g. from CEOS and issues arising from the WG meetings.]* Participation to the group should also include ESTEC, EUMETSAT and industry to provide further expertise and broaden the range of instruments and topics that can be covered (e.g. geometry topics which had not been addressed in detail at this meeting and to provide inputs to Sentinels and pre-launch characterisation activities). *[Recommendation L1WG01-02: In view of the Sentinel missions in particular, consider additional participants including ESTEC, EUMETSAT and industry, as appropriate to the topics to be discussed.] [Recommendation L1W01-03: Consideration should be given to more thematic workshops, e.g. pointing and geometry topics that had not been covered in depth at the meeting.]* The recommendation for free and open access to calibration data (including on-ground, in-flight and vicarious (e.g. the CNES database) data) *[recommendation L1WG01-06]* was also emphasised.

The recommendations defined during the meeting are tabulated in the next section. These will be treated as action items to be addressed by ESA.

4 RECOMMENDATIONS

The key recommendations arising from the meeting are summarised in the table below, and these will be or already are being considered by ESA.

Reference	Summary	Priority	Status
L1WG01-01	ESA to set up the L1WG, based on a 9-12 months cycle for meetings. Terms of Reference should be prepared	High	In progress – next meeting to be held by October 2014
L1WG01-02	In view of the Sentinel missions in particular, consider additional participants including ESTEC, EUMETSAT and industry, as appropriate to the topics to be discussed	Medium	In progress
L1WG01-03	Consideration should be given to more thematic workshops, e.g. pointing and geometry topics that had not been covered in depth at the meeting	High	In progress – agenda for next meeting to be prepared
L1WG01-04	The L1WG should develop recommended best practice processes, based on review of existing practices e.g. from CEOS and issues arising from the WG meetings	High	Initial best practice topics to be proposed in advance of next meeting
L1WG01-05	Traceability and completeness of characterisation and calibration information should be ensured, which could be partly fulfilled by having additional review of the documents by experts not involved in the characterisation and calibration	High	To be addressed
L1WG01-06	Easy, full and free access to characterisation and calibration	High	To be addressed

Reference	Summary	Priority	Status
	information is needed throughout the mission, including pre-launch, in-flight and vicarious data		
L1WG01-07	Close collaboration of the L1 and L2 teams is recommended in the definition and understanding of the characterisation and calibration activities and results	Medium	Already partly addressed through QWGs
L1WG01-08	The systematic investigation of uncertainty sources for EO instruments should continue to be an important activity for past as well as active and future missions. For example, sensitivities to uncertainly sources can be investigated by development and use of an instrument model	High	Radiometric Uncertainty Tool to be developed for Sentinels-2 and -3
L1WG01-09	Maintenance of instrumented test sites is recommended, as demonstrated by the implementation of the CEOS/WGCV/RadCalNet for vicarious calibration using high reflectance test sites	High	To be addressed
L1WG01-10	Continuous research into characterisation and calibration is necessary to improve the quality of existing datasets, and also to prepare for follow-on instruments	Medium	To be addressed
L1WG01-11	It was recommended that investigation should continue into assessing if better pointing information from SCIAMACHY investigations can also be used to improve the AUX_FRA ADFs (restituted attitude files containing the best pointing/attitude information for Envisat)	Low	To be addressed
L1WG01-12	The importance of the on-ground characterisation was emphasised, particularly in ensuring adequate time is allowed and included in the instrument development schedule	High	To be addressed

Table 1 – Summary of recommendations

ANNEX A – PARTICIPANTS

Name	Affiliation	Email address
Gilbert Barrot	ACRI	Gilbert.Barrot@acri-st.fr
Alasdhair Beaton	VEGA	Alasdhair.Beaton@vegaspace.com
Laurent Blanot	ACRI	Laurent.Blanot@acri-st.fr,
Bojan Bojkov	ESA	Bojan.Bojkov@esa.int
Ludovic Bourg	ACRIF	Ludovic.Bourg@acri-st.fr
Klaus Bramstedt	IUP	bram@iup.physik.uni-bremen.de
Alessandro Burini	Rhea	Alessandro.Burini@esa.int
Stefano Casadio	Serco	Stefano.Casadio@serco.com
Gareth Davies	VEGA (now at Serco)	gareth.davies2@serco.com
Angelika Dehn	ESA	Angelika.Dehn@esa.int
Steven Delwart	ESA	Steven.Delwart@esa.int
Thorsten Fehr	ESA	Thorsten.Fehr@esa.int
Nigel Fox	NPL	nigel.fox@npl.co.uk
Juergen Fischer	FU Berlin	juergen.fischer@wew.fu-berlin.de
Philippe Goryl	ESA	Philippe.Goryl@esa.int
Patrice Henry (via WebEx)	CNES	patrice.henry@cnes.fr
Rosario Iannone	Serco	RosarioQuirino.Iannone@serco.com
Quintus Kleipool	KNMI	quintus.kleipool@knmi.nl
Matthijs Krijger	SRON	J.M.Krijger@sron.nl
Antje Ludewig	KNMI	antje.ludewig@knmi.nl
Diego Loyola	DLR	diego.loyola@dlr.de
Guenter Lichtenberg	DLR	Guenter.Lichtenberg@dlr.de
Ruediger Lang	EUMETSAT	Ruediger.Lang@eumetsat.int
Gaetan Perron	ABB	gaetan.p.perron@ca.abb.com
Lidia SaavedraDeMiguel	Serco	Lidia.saavedrademiguel@serco.com
Ralph Snel	SRON	R.Snel@sron.nl
Dave Smith	RAL	Dave.Smith@stfc.ac.uk

ANNEX B – AGENDA

EO Level 1 lessons learned

ESA/ESRIN, June 10-11, 2013

Room Magellan

Monday June 10, 2013

13:45	Bojkov, B., Dehn A.	ESA	*Welcome and objectives of the meeting*
14:00	Loyola D., van Roozendael, M.	DLR, IASB	*Lessons learned from multi-sensor ECV generation*
14:45	Snel R., Lichtenberg G., Bramstedt	SRON, DLR, IUP	*SCIAMACHY/GOME experiences and lessons learned*
15:30		*Coffee break*	
16:00	Fox, Nigel	NPL	*Ensuring traceability of Level 1 optical products*
16:45	Bourg, L., Delwart S.	ACRI, ESA	*In-flight lessons from MERIS and prelaunch calibration of OLCI*
17:30	Smith, D.	RAL	*Lessons learned from (A)ATSR and prelaunch calibration of SLSTR*
18:15	*Discussion*		
19:00		*Close*	
20:30		*Non-hosted dinner in Frascati*	

Tuesday June 11, 2013

08:30	Henry, P.	CNES	*Multi-sensor vicarious calibration activities at CNES*
09:15	Fischer, J.	FUB	*Experiences with spectral calibration*
10:00	Bramstedt, K., Perron G., Barrot G.	IUP, ABB, ACRI	*Instrument pointing issues on Envisat*
10:30		*Coffee Break*	
11:00	Lang, R.	EUMETSAT	*MetOp GOME-2 lessons learned*
11:45	Kleipool Q., Veekind P.	KNMI	*OMI and TropOMI lessons learned*
12:30	*Discussion*		
13:30		*Close*	