Proba – V 9th Quality Working Group (QWG): Summary Report

The 9th Proba-V QWG took place in Brussels on 17th - 18th Apr, 2019

Partecipants:			
R. Biasutti – ESA	E. Tilmans – ESA	Christian Baijot– ESA	F. Niro – ESA
J. Vandenabeele – BELSPO	D. Clarijs –VITO	W. Dierckx –VITO	I. Benhadj – VITO
E. Swinnen – VITO	S. Sterckx – VITO	J. Leon Tavarez – VITO	C. Tote –VITO
E. Wolters – VITO	P.Defourny - UCLouvain	Q. Marissiaux-UCLouvain	K.Ruddick-RBINS
Y. Govaerts – Rayference	L. Gomez-Chova – Uni Valencia	E. De Grandis – SERCO	R. Lacaze – HYGEOS
C.Brockmann-Brockmann Consult	C. Henocq – ACRI		

Objectives of the meeting

The main discussion points for the QWG meeting #9 are recalled:

1. *Mission Status:* mission performances are excellent with no sign of degradation; the radiometric and geometric performances are within the requirements, though some minor anomalies need to be reviewed during the meeting, such as decompression errors and the calibration status, both the radiometry and the geometry will be reported and discussed.
2. *Mission extension:* during last QWG Meeting it was agreed to consider Apr 2020 as the end of the operational Vegetation mission, since by that time the impact of orbital drift in long term analysis will start to be significant and can potentially lead to spurious trend in global long-term applications. The mission will be continued beyond this date in a so-called "Experimental Phase" and several options were already discussed on how to use this phase for Cal/Val and science purposes. Among these options, there is the planning of special acquisition campaigns (yaw, MVA, Antarctica) and the launch of complementary Cubesat sensors. During the current meeting these options will be reviewed more in details and final recommendations from the QWG will be gathered.
3. *Algorithms Baseline for C2:* the development of the new NN cloud-screening algorithm for C2 is on-going in close collaboration between University of Valencia, VITO and Brockmann Consult. The implementation schedule is in-line to what proposed at the last QWG, in particular the 333m version of the NN is about to be completed and it will be delivered to Brockmann for validation in the next month. The NN will then be re-trained for the 100m and 1km dataset. The other main improvement in C2 will focus on the A/C and the used AOD; feedback from VITO on the usage of AOD climatology will be discussed during the current meeting. Finally, the final results on the implementation of a BRDF-correction method, to be deployed in the MEP, will be presented by VITO.
4. *Continuity:* the transition from Proba-V to Sentinel-3 for land applications is currently on going and the corresponding algorithms are being upgraded at CGLS. S-3A+B constellation is fully operational after the initial tandem phase, which was essential to cross-validate the twin satellites. Various improvements were recently implemented in the SYN-VGT processing chain and the latest results will be reviewed and discussed during this meeting.

Flight and Ground Segment Status

The overall performances of the platform and sensor are excellent and very stable with platform availability between 94.1% and 99.9% max for the last 5 months. All performance parameters are well within the requirements, the system is very stable with no sign of degradation.
The Flight Segment status is detailed:
•*LTDN prediction*: 09:59 AM are reached in April 2019 (10:00 AM S3 overpass time), 09:40 in Dec 2019 and 09:25 in June 2020;
• *Platform status*: the number of decompression errors has slightly increased and it is closely monitored. The operations to allow the automatic Antarctica imaging were performed and several activities were needed to fix problems linked to a wrong integration time and to reduce the memory overwriting. In December 2018 a new Extended Land Sea Mask was uploaded in order to restrain image acquisition of the Antarctica continent to the central camera so that to decrease the MMM memory usage. On February 2019, the automatic Antarctica imaging has been stopped;
• *AOCS performances*: all is nominal and the platform pointing performances are far better than the requirement;
• Power budget: the power situation is very stable with a power budget largely positive, no degradation of the solar arrays, battery and the power distribution system;

• *Thermal performances*: excellent thermal performances of radiator and optical bench. The increase of temperature of the optical bench associated to the last Antarctica acquisition seems bigger than the previous one (Antarctica campaign 2017-18) and this should be investigated;
• *Decompression Errors:* after the first yaw manoeuvre of July 2017, the number of decompression errors remains very low even if a slight increase is observed in February/March 2019 period. The status is closely monitored and it is proposed to plan additional yaw manoeuvre in case the number of decompression errors keep increasing during the coming months. One option could be to plan a yaw manoeuvre over Cal/Val site (e.g., RadCalNET site), to be used for science purposes. Final decision will be taken depending on the increasing trend observed in the coming weeks/months;
• *Masse Memory Module and Safe Mode:* the Safe Mode occurred during 24 December 2018 was induced by the saturation of the MMM. The automatic commanding in geodetic mode did not solve the problem, nor the manual platform reconfiguration procedures commanded in the night of the 25th and in the morning of 26th. During the morning of 26th it was decided to erase the MMM and reset the MMM pointers; this steps allowed to resume the nominal observation mode at 11:57 on the 26th of December. QinetiQ was able to reproduce the problem and to apply the related patch;
• *Ground Segment Status*: the satellite and ground segment operations are running nominally. The data downlink is shared between Kiruna, Alaska and Inuvik stations with 10 X-band passes per day. Due to the increased amount of data generated by the Antarctica imaging, an extra daily pass was added in from 13 to 30 December 2018.

Radiometric and Geometric calibration

The DCC and moon calibration shows a jump in calibration factor during the last winter for the NIR band, which correlates clearly with the increased temperature of about 6K. This increased temperature was linked to the disabling of the sunbathing mode implemented in order to plan the Antarctica acquisition. The reason for the temperature impact on the NIR band has been analysed using the pre-launch SRF measurements performed at different temperature. Despite the limited set of SRF measurements, this dependence can explain the variation of absolute calibration as a function of temperature for the NIR band. This relationship can also explain the apparent increase in the Red and NIR responsivity along the mission observed in the desert calibration. On the other hand, the uncertainty in the pre-launch characterization measurements does not allow to derive an accurate model to correct for this temperature dependence of the SRF. The analysis of the last yaw manoeuvre was completed and the final results presented, showing a remarkable improvement in the SWIR PRNU characterization. The derived equalization coefficients for the two yaw campaigns (2017 and 2018) are in good agreement, and lead to significant improvement of the PRNU. Question was raised whether to apply these coefficients already in the processing or wait for the C2 reprocessing. It is agreed to apply them already with current NRT processing. A transient anomaly was observed during 19-21 Sep 2018 with ALE exceeding 500m. QinetiQ performed the investigation on the issue and the problem was identified in a noise event in the GPS measurements. No other issues were observed since then. It is stressed that the affected data was removed from the archive and the users were warned about this geometric issue. A question was raised whether to implement an automatic monitoring of the GPS accuracy so that to automatically flag these measurements. The long-term ALE shows a slight trend with time, though the mean value remains well within the requirements. Indeed, no ICP update was implemented since Sep 2016, demonstrating the excellent and stable performance. Inter-band geometric accuracy trends were presented and discussed. A question was raised on the need to discriminate this analysis for the different cameras.

Mission Extension

The operational vegetation mission will be extended until end of April 2020, after this date the mission will enter an "Experimental Phase" of limited duration (2 years). During this phase, the objective of the mission will be twofold: to perform special acquisitions (yaw, MVA) over target sites for science and Cal/Val applications and to test the use of Cubesat IODs and to verify and validate the possibility to exploit them in synergy with Proba-V and Sentinels mission for fused products.
Concerning the special acquisition the QWG agreed on the need to plan a new MVA and yaw manoeuvre. An additional night-time acquisition will be tested to verify the ability of mapping night light signal. With respect to the IODs proposal, the QWG was concerned by the lack of a consistent long-term strategy and by the technical challenges associated to some of the proposed sensors. The QWG strongly suggested refocusing the strategy on a single-sensor proposal with a clear way forward for the deployment of a constellation.

Algorithm Baseline Definition for C2

The implementation of the **NN cloud algorithm** is on-going in line with the proposed schedule; the 333m chain was already tested and verified and it is ready for validation, the training of the NN at 100m and 1km is on-going. Overall, the new cloud mask for C2 is expected to bring significant improvements, by correcting the current C1 over-detection and by providing more accurate cloud mask at 100m. Concerning the **atmospheric correction**, the QWG endorsed the proposal from VITO to abandon the current AOT image-based retrieval and move toward the use of ancillary data (e.g., from CAMS or climatology). This decision is in line with the one being adopted by the C3S. In this respect, the choice of the best AOT ancillary dataset will be based on an inter-comparison exercise, which is currently on going within C3S. In the frame of C3S a significant

upgrade of SMAC processing scheme is also under development. It is suggested that this recent SMAC version should be considered for implementation in C2.
The **BRDF correction** was implemented with the goal of deploying this tool as on-demand processing service within the MEP. The results demonstrated that the VJB method is globally good despite an increased "noise" observed at high latitude, mostly linked to a cloud issue in C1 observed at the same latitude. An outlier detection method based on IQR range was applied to create the clean reflectance time series, which were then used to retrieve the VJB parameters. The performance of the BRDF correction using the VJB method is assessed demonstrating good results, though the latitudinal pattern during wintertime is still visible, owing to the known issue of the cloud mask for C1. Considering that this pattern will disappear in C2 reprocessed dataset, thanks to the improved cloud mask scheme, it is agreed to conclude the development of this BRDF module, which can then be considered ready for implementation in the MEP.
The **Proba-V SNAP Toolbox** updates are presented: concerning the Antarctica data, the reader issue with netCDF was fixed with the upgrade to SNAP 7 whereas the problem in decoding the Antarctica Polar Stereographic coordinates still remains unsolved; the S2 cloud shadow algorithm was introduced in the previous QWG as a most accurate approach for estimating cloud shadow. The processor is fully implemented within SNAP (part of IdePix for S2) while its implementation in Proba-V is foreseen by October 2019. The ESA SEOM S3 project was described during the previous QWG, the purpose is to develop and validate a new algorithm for retrieving several key snow parameters from Sentinel-3 optical satellite data. The investigation on a potential transfer of the algorithm to Proba-V, discussed in the previous QWG, is on-going and aims to analyse the algorithm requirements against the Proba-V spectral coverage and radiometric suitability.
The **L1C SYN Tool** will generate the L1C SYN products as required by CGLS and C3S services and will be implemented as plug-in in SNAP S3 Toolbox. Looking at the roadmap, three versions of the tool will be foreseen: the first already delivered in an engineering phase on January 2019, the V2 will be delivered in April/May 2019 and when finalized will published on SNAP, the delivery of V3 is planned in December 2019.

User Feedback and Continuity

The feedback from the Copernicus global Land Service on Proba-V data and an overview of the CGLS products portfolio are presented. The availability of Proba-V data is good allowing reliable and sustained operations at CGLS. The expectations for the mission extension are discussed. Considering the need for a smooth transition to Sentinel-3, CGLS strongly recommends to extend the Proba-V operational mission until end of April 2020.
The strategy for the transition to S-3 is presented. The work started during November 2018 and the plan is to complete the transition to S3 by November 2019. The approach is to reuse as much as possible to current CGLS processing chain, using as input the S3 combined dataset (OLCI+SLSTR), re-projected to a common grid with the SYN-L1c tool. The schedule of the CGLS transition is highly dependent on the availability of the SYN-L1c. The V1 of the tool was provided by end of Jan 2019, the V2 is expected at the end of April 2019. The V2 is designed to support operational processing; it is therefore suited for CGLS products timeliness requirements and it solves all performances issues of V1.

A feedback from C3S on the use of Proba-V data is provided by VITO: the main objective of the C3S service is the generation of multi-sensors long-term climate data record for a variety of ECVs. A consortium primed by VITO will be responsible for the generation of the following terrestrial ECVs: LAI, fAPAR, Surface Albedo, Land Cover, Fire Radiative Power and Fire Burnt Areas. Proba-V archive data will be used by C3S for: Surface Albedo, LAI, FAPAR, and Land Cover. Use of S-3 data is also foreseen, in particular for fire ECVs. The C3S strategy is to build upon the algorithms and approaches developed in the frame of CCI and to focus on harmonisation both across-sensors and across CDRs. The CISAR@MEP project's objectives and approach are also presented and the new project called SPAR@MEP is introduced and described: the aim is to derive a consistent Spot-Proba-V Aerosol and surface Reflectance long-term data record in the MEP. The projects deliverables will consist on a Long Term Data Record (1998-2018) of AOT and BRF at 1Km of resolution over selected key macro regions around AERONET stations and on a global processing of about 5 years at a spatial resolution suitable for climate studies (e.g., 5km). The target processing facility will be the Proba-V MEP. The radiometric accuracy and multi-temporal stability of the considered long-term data record, which was acquired with three different radiometers (SPOT-4, SPOT-5 and Proba-V), should be carefully assessed as a first verification step for the project. Furthermore, the processing performances should be significantly improved in order to sustain the mission reprocessing. To this end, the current plan is to exploit multi-cores CPU, or, alternatively, the GPU technology. Both parallel processing with CPU multi-cores and GPU servers are available on the MEP to support this project.
UCL presented the status of a project recently started on the use of the full Proba-V 100 m archive for the generation of multi-years global land cover map at 100m. The project will build upon the algorithm developed in the frame of CCI LC and it will go beyond that by improving the classification approach and the validation scheme, in particular by testing the use of innovative machine learning approaches for pixel classification. The main objective is to demonstrate the added value of 100m resolution for global daily mapping. This spatial scale is in fact considered the best compromise between the traditional coarse resolution sensors, such as S-3 @300m and the S-2/L-8 decametric scale sensors. The advantage over S-3 is the capability to reach the field scale required to map complex agricultural fields and fragmented landscape, such as in sparse vegetated or urban areas. Furthermore, the 100m dataset significantly lower the bar for the global analysis of time series, allowing overcoming the technical challenges associated with handling 10m data at global scale. Some remaining issues with

cloud and cloud shadow masks were then presented, which impact accuracy of pixel classification, in particular over urban areas, which are often mis-classified as clouds. It is agreed that this list should be provided to UV in order to improve NN training for 100m.

The transition from Proba-V to S-3 for land applications is currently on going and the corresponding algorithms are being upgraded at CGLS. The CGLS approach is to solve the sensor specific processing within a pre-processing module, while the biophysical retrieval approaches should remain identical. At the moment the pre-processing module strongly depends on the availability of the S3 SYN-L1c tool, which was recently upgraded to V2 in order to meet the performances requirements of the CGLS. The transition to S-3 at CGLS is expected by end of 2019. In terms of S-3 SYN-VGT products consistency, significant progresses were recently made, in particular in the AOT retrieval, leading to more realistic AOT and surface reflectances products. A cross comparison of SYN-VGT TOA reflectances with Proba-V shows overall good agreement for all bands, except the SWIR, where a clear bias is observed in the same order of magnitude of the SLSTR SWIR radiometric bias. Some remaining inconsistencies in the SYN-VGT and Proba-V processing scheme, were identified by VITO and are under investigation by ACRI. Solution of these inconsistencies will lead to enhanced consistency and smooth transition to S-3. Overall, both VITO and CGLS strongly endorsed the need for planning a S-3 SYN-VGT reprocessing, starting at least since the beginning of S-3A+B operations, using the latest IPF baseline, in order to allow for a comprehensive long-term cross-sensors calibration and validation until the end of Proba-V operational phase.