JRC TECHNICAL REPORT

Controls with Remote Sensing in the CAP2020+

Considerations for Member States who continue to operate CwRS On-the-Spot-Checks after 2023

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Executive summary

This document serves as a checklist for the MS who still plan to continue Controls with Remote Sensing (CwRS) as an On-the-Spot-Checks (OTSCs) regime from January 2023 onwards.

The new Common Agricultural Policy (CAP) regulation introduces a new delivery model based on delivering performance through a monitoring system, replacing the model based on compliance that has been in place in earlier CAP reforms. The EU based Common Technical Specifications (CTS) for OTSCs can no longer act as technical guidance and the provision of EU financed satellite imagery (Reg. (EU) No 1306/2013 (§.6b, §.21) and Reg. (EU) No. 908/2014 (§ 26.3) to the Member States (MS) will cease.

MSs will still have the possibility to set up and operate an OTSC-like, and obviously a CwRS-like, system as their national control system. Such operation will be under the full responsibility of the MS and could involve:

- Own financing of imagery for their checks (satellite and/or aerial);
- National procedures for running the check processes - the current CTS and Image Specifications offer a starting point but each MS/Region will become responsible for the definition, management, and assurance of the checks methods and image choices and to demonstrate that they are adequate and effective for their CAP checks.

This document is intended as a handover file (best practices compiling) of the parts of JRC's CTS knowledge and image provision experience, relevant for:

- substitution / adaptation of the CTS to their CAP OTSCs checks;
- coordination aspects;
- procurement of required services (aerial/satellite image acquisition, OTSC diagnosis, etc.). through tendering procedures;
- specification and validation of effective image profiles;
- verification of the fitness for purpose of newly launched sensors;
- procedures for identifying, ordering and accepting image delivery for control zones with specific acquisition windows (AWs);
- ensuring data storage and archiving;
- aspects of possible data re-use (e.g. licensing conditions, non-disclosure of 'personal information' …).

The different chapters of this document provide tips and technical advices for each of the points listed above.

Since the 90's the JRC has operated technological survey and provided technical support to DG AGRI and MS to help implementing the CAP. In mid-90's, the so-called CwRS was introduced thanks to the first availability of civil satellite imagery. The availability of free Sentinel data since 2017/2018, and a substantial IT evolution, has now made it possible to introduce new systems like the Checks by Monitoring (CbM) to answer to the community demand for fairer, more modern, more automated controls solutions.

It is therefore stressed that, as the Commission's guidance will not be provided anymore on OTSC (and CwRS)-like systems, such CbM-like controls methods are largely to be preferred in the new CAP in order to take maximum advantage of the new technologies that CwRS cannot benefit from.

1 Introduction

With the new CAP regulation that will enter into force in January 2023, the Commission will introduce a new delivery model based on delivering performance through a monitoring system. Thus, the model based on compliance in place since several CAP reforms will end. The EU based on-the-Spot Checks (OTSC) that was attached to the old model will cease together with the provision of EU financed satellite imagery (current Reg. (EU) No 1306/2013 (§.6b, §.21) and its Implementing Reg. (EU) No. 908/2014 (§ 26.3).

§.6b – " … Other expenditure, including technical assistance (b) the acquisition by the Commission of the satellite images required for the checks in accordance with Article 21; …"

§.21 – " … Acquisition of satellite images: …The Commission shall supply those satellite images free of charge to the control bodies or to suppliers of services authorised by those bodies to represent them. The Commission shall remain the owner of the satellite images and shall recover them on completion of the work"

§ 26.3 - "…The Commission shall supply free of charge to the authorized agents of the Member States the satellite images which it has acquired. Those agents must observe the provisions on copyright set out in the contracts with the suppliers and return the images on completion of the work".

Nevertheless, Member States (MS) may decide to continue to use an OTSCs like system, whether it is Controls with Remote Sensing (CwRS) or traditional, for their internal controls/assurance system (as part of the subsidiarity principle).

The end of financial support for provision of imagery for OTSCs, implies the end of the JRC technical support to the CwRS and its operation of image provision for the MS. This will occur after completion of the Campaign 2022.

Any MS that will continue with a CwRS like system, shall from their 2023 CAP checks:

1. Finance the imagery (satellite and/or aerial) for the checks themselves;
2. Set up procedures and relative management of the OTSC process themselves.

Note. This discussion concerns only CwRS as a MS controls option. The provision of imagery financed by the COM for the EC regulated Quality Assurance systems (e.g. LPIS QA) are not covered under this document, and will not end.

This document aims to share with MS Administrations any technical knowledge or best practice, acquired by the JRC through the years of image acquisition. This should ease the development and implementation of a national successor if deemed appropriate. The document aims, through an overview of the whole image acquisition workflow, to explain the underlying options and processes such as the technical requirements, the satellite image profiles and their updating, the planning, the procurement and contracting. The document ends with some recommendations.

In summary, the discussion in this document should help MS with their standalone management of the OTSCs image acquisition workflow. It describes the various complexities, interactions, and connected external activities. These serve as best practices but do no longer represent a Commission position, let alone a legally binding requirement. From 2023, any CwRS process as part of a control system will be under the full responsibility/subsidiarity of each MS.

2 Background

The CwRS were introduced in the 90's benefiting from the early developments of the earth observation (EO) technology (airborne aerial photography) but above all from the emergence of first civil (commercial) satellites. At that time, the initiative was motivated by the need to find an alternative solution to the physical farm checks and that could have a high anti-fraud deterrent effect. After some years of trials and developments with some MS, a methodology was set and since 1993, the EC DG Agriculture has promoted the use of CwRS as appropriate control system within the CAP.

The goal of the on-the-Spot Checks (OTSCs) was to obtain area measurements and eligibility checks from parcels of sampled holdings; the general setting of the CwRS method results from a compromise between different technological, financial and staff resources' constraints. The method was mainly based on the Computer Assisted Photo Interpretation (CAPI) of High Resolution (HR) satellite imagery acquired on 2 to 4 dates spread over the main crop growing seasons over some so-called 'control zones' selected to cover at least 5% of farm dossiers. The full coverage of a country, or the acquisition of tens of dates over a zone, was not technically and financially possible. Dossier sample size, control zones selection and number of dates were assessed and adjusted to reach a sufficient level of representativeness and reliability of results.

Even though maintaining the same basic principles, the CwRS methods have evolved along the years in order to adapt to the changing conditions of land eligibility conditions with the different CAP reforms and also benefiting from the ever growing availability of EO imagery. While in the early years, the CAPI work consisted in crop recognition only, the introduction of decoupled payments has seen the need to identify some landscape elements and land maintenance rules. With the growing introduction of 'greening' requirements, the need to identify more farming practices and quantify landscape elements have also been introduced. In parallel, the access to VHR imagery (<1m) from 2000 onwards has allowed for an evolution of measurements and management of parcels from 1/10.000 to 1/5.000. (See Figure 1)

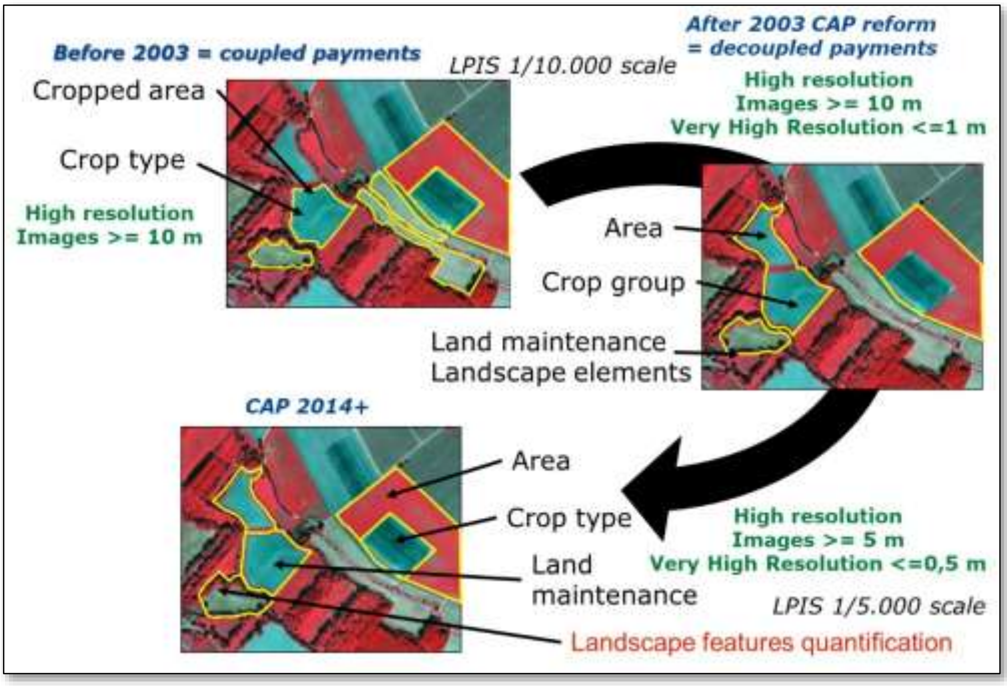


Figure 1 - Evolution of imagery characteristics jointly with their use in the frame of CAP OTSCs aligned with the different CAP reforms' land eligibility requirements.

The JRC as Commission service has always taken the leading role in these developments in order to ensure the technology uptake (e.g. arrival of new satellites), the transfer of innovations among MS and the compliance with evolving regulatory obligations. The main focus of the activity relates to clarifying concepts, assuring quality and respecting the equal treatment principle between MS.

For such purposes, since 1994, the Commission Services decided to centralize the satellite image acquisition (Council Regulation (EC) 165/94 and of the Commission Regulation (EC) 601/94). This task has been managed by the MARS Project at the JRC since 1999. The activity also involved the setting up of specifications, recommendations, performing Quality Controls (QC), auditing selected contractors, and evaluating new methods.

At present, years later, the satellite image acquisition process involves the control site definition within each MS, and a subsequent chain of image acquisition steps over the defined sites including feasibility with image providers (IPs), acquisition, validation, ordering, delivery and final archiving of the imagery (see Chapter 6.2.)

The recent (2015) introduction of free High Resolution Sentinel satellite data (optical and radar), with an unprecedented space and temporal coverage, has allowed the Commission (jointly with some MS) to launch an innovative procedure to substitute the CwRS method with the so-called CbM method. Available since 2018 by MSs, this procedure holds several advantages. Through its comprehensive territorial coverage without sampling, it also avoids risk management and guarantees fairness. It contributes to the reduction of the administrative burden for the paying agencies through the automatic nature of the processing and the possibility to avoid penalty procedures as farmers can modify their applications after an early warning (alert) and application modification.

Even as source for some CwRS methods, the use of free Sentinel data has allowed to reduce the number HR imagery purchased. These are the factors, together with other aspects of the new CAP delivery model, that have led to the Commission to stop promoting the CwRS method and consequently, to stop financing the provision of satellite imagery for such controls purpose.

As already stated, the OTCS methods are not fully banned from the next CAP programming period and MSs will still have the possibility of such solutions under their own full responsibility. What has disappeared is it common and compulsory nature of the process.

This report consists in describing the current JRC image acquisition activities to possibly help MS developing their proper in-house system, when and where it remains relevant. But to be clear, this document does not aim to promote a continuation of CwRS as a major control method, clearly, as the CbM design offers many advantages of new technologies that the CwRS cannot use.

In summary, the CwRS has developed through the years both as method, and in satellite sensor use, satisfying the evolution of the CAP 'compliance based' controls approach. But for the new CAP with its new 'performance based' delivery model, a CbM based method taking maximum advantage of new technologies is largely preferred. The new technology in the CbM design may also be considered a basis for the future Area Monitor System (AMS).

In principle the whole OTSCs workflow can be summarized as in Figure 2 below. The red shaded area is what the JRC did concerning the satellite image acquisition (and MS will need to do by themselves). The MSs will moreover be responsible for the adaptation of the Common Technical Specifications [ref i] governing their whole OTSCs workflow post-2023 (the sand coloured shaded area).

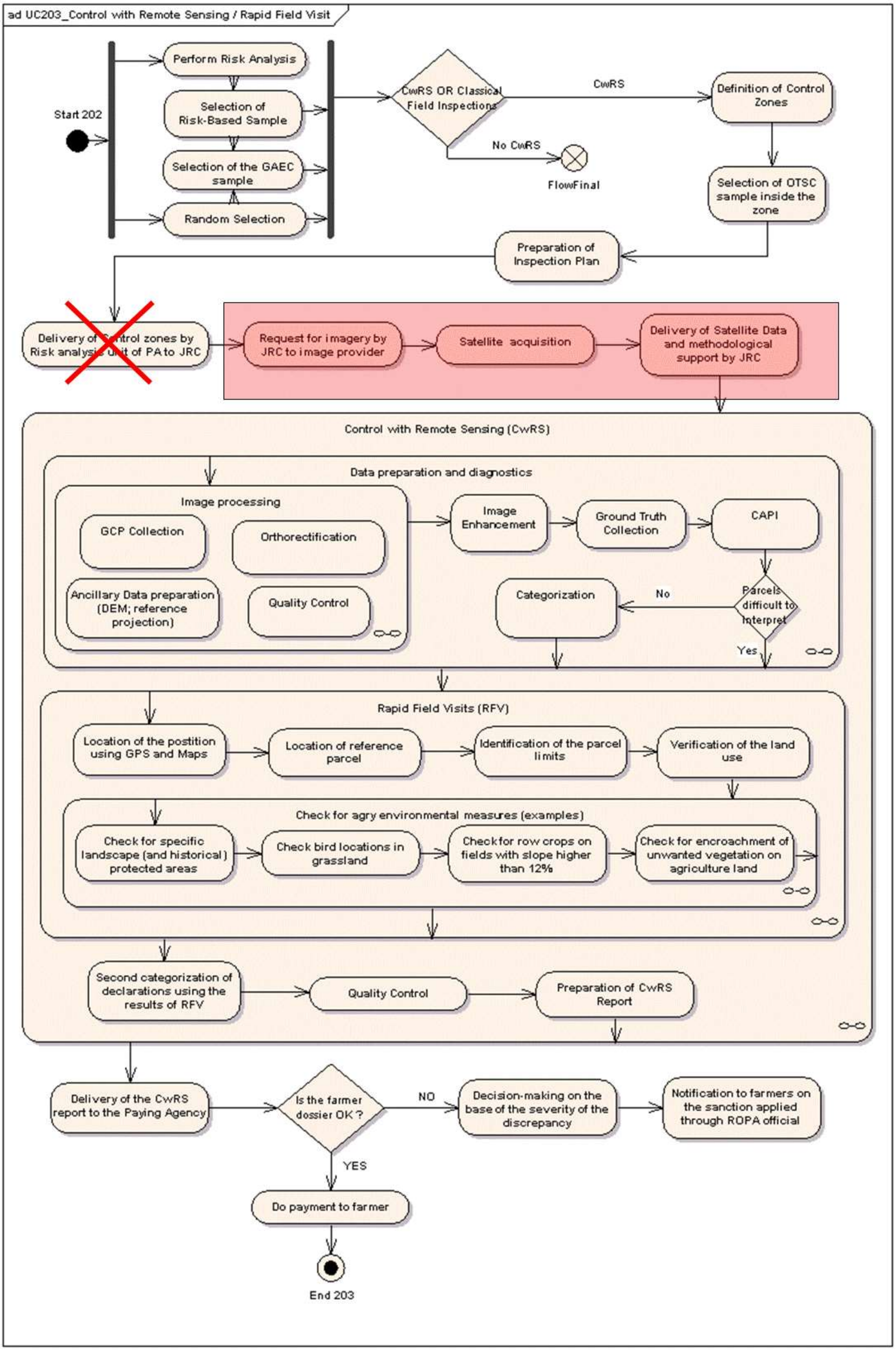


Figure 2 - the OTSCs workflow showing MS / JRC activity.

3 Defining the object of procurement

Necessary imagery will not always be freely available to a MS. If not, it will be mandatory to launch call for tenders for their supply and the associated services in support of the on-the-spot-checks (OTSCs). The supplies/services subject of these calls will have to include some minimum requirements for which the elements considered hereafter should be considered. Imagery refers to both satellite and aerial platforms. Although JRC has only acquired satellite imagery for the MS, technical specifications and procurement procedures for either platforms are similar, so image procurement is treated as one in this document.

The first and main purpose of the satellite images, is to allow the MS to carry out all or part of their CAP OTSCs up to conclusion. For these checks, at least one VHR image is needed to cover the full control zone. In addition to the VHR images used for the area measurement, the MS may use HR imagery (High High Resolution (HHR) profile see 3.1.2 below) to further support the checks, among others, of land cover type, of Good Agricultural and Environmental Conditions (GAECs), or of the 'greening' requirements such as crop diversification and measures related to the Ecological Focus Areas (EFAs) [ref i]

The different CAP checks methods used by the MS (see Figure 3) consists of fulfilling satellite image acquisition within one or more discrete multitemporal acquisition windows (AWs) over the zone. The AWs are defined to follow the crop cycle of the particular region, and are optimized for determining required agricultural practices, and therefore allow CwRS of autumn, spring and summer crops, with their relative land cover/GAEC/greening requirements.

Figure 3 - the CwRS approach used in the CAP on-the-spot-checks

The layout in time for the typical CAP checks AWs is described more in detail in Chapter 4, but the layout of this inspection source data may be:

1. VHR complemented with a Rapid Field Visits (RFVs),
2. the second main used one is the VHR complemented by n HR images,
3. In some areas the use of 2 VHR images (with no or fewer HR) have been preferred.

Earlier the COM also allowed the use of an autumn AW but this was discontinued as the free Copernicus Sentinel-2 (S2) imagery became available and well serves the purpose of checking any requirements during autumn or early winter (see Chapter 3.1.2).

In the recent years, the workflow management and in particular the communication between stakeholders has been performed by use of a web application Geomatics for the Common Agricultural Policy (G^4CAP), which is described in Chapter 6.1, and ref iii.

Each MS will become responsible for the definition, the management, the assurance of the checks methods and the image choices and to demonstrate that they are adequate and effective for their CAP checks

Decisions on above will lie as basis for national specifications for the procurement of any required services (aerial/satellite image acquisition, OTSC diagnosis, etc.) to be set up by the individual MS.

3.1 Technical Requirements of CwRS imagery - Catalogue of current image profiles

In 2014 the JRC introduced the so-called "profile" approach, or satellite sensor independent approach to define satellite imagery needs for the CwRS. Two main types of profiles were retained as necessary. These are then further subdivided [ref i, ii];

- One for VHR imagery suitable for the area measurement required for the regulatory COM requirement at 1:5.000 scale American Society for Photogrammetry and Remote Sensing (ASPRS) cartography standards;
- One for HR imagery allowing to perform the different requested land use/land cover related checks and checks of some CAP 'greening' obligations.

The approach holds advantages e.g. easier tendering procedures, less framework contracts (FMCs) (see Chapter 5.1), and also easier introduction of newly launched satellite sensors (see Chapter 3.2) into the fleet of the IP. New sensors that fit a particular profile are simply added to the catalogue after required benchmarking (see Chapter 3.2.2).

The profiles have specifications in terms of a quality level on spatial resolution, radiometric resolution, number of spectral bands, geolocation accuracy with absolute 1-D RMSE thresholds, elevation angle, programming type, processing levels, ease of processing via commercially off-the-shelf software (COTS SW), resampling types, cloud cover (CC) threshold over AOI, ratio of acquired Ground Sampling Distance (GSD) / delivered GSD, and ratio of the final ortho resolution to the delivered GSD etc.

Further details on the profiles and their subdivision used by COM are given in chapters below, but details can be found in Annex Chapter 14 and [ref ii].

The MS are responsible for the definition of the image requirements. The currently adopted solution by the COM with sensor independent profiles is strongly recommended.

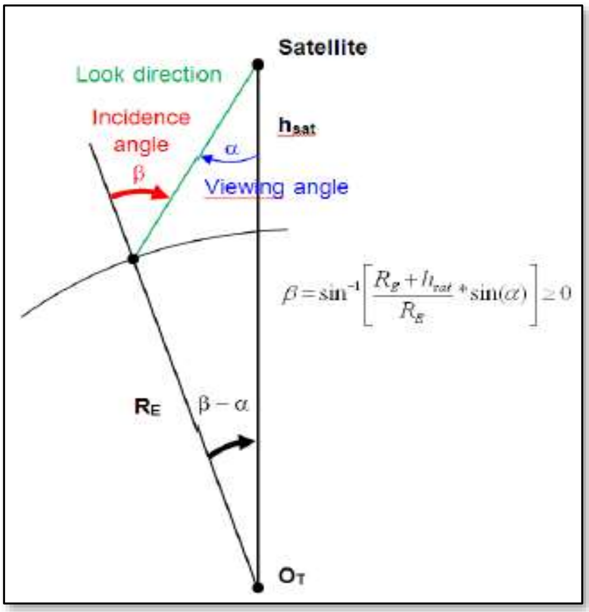
3.1.1 The VHR profiles

One particular parameter that is considered when defining profiles is the Ground Sampling Distance (GSD) which, for given optics and orbits, is dependent on the elevation angle (the lower the elevation angle, the higher the view or off-nadir angle, giving a coarser GSD). A coarser GSD affects measurement, and therefore the elevation angle (including the effect of the earth curvature) needs to be considered in the specification of the profile. To take an example, Figure 4 below illustrates the VHR profiles defined and where they position themselves, in relation to the curves of some sample VHR satellite sensors used.

The Equations 1 below [ref iv] gives the relation between the GSD and viewing angle (the angle α between nadir and look direction from the satellite) without taking account of the earth curvature (1) and taking account of the earth curvature (2). These equations consider the satellite altitude (h_{sat}), the Instantaneous Field of View (IFOV), and the earth radius (R_E).

$$GSD = h_{sat}.\tan(\alpha + IFOV) - h_{sat}.\tan(\alpha)$$, without taking into account the rotundity of the Earth.

$$GSD_c = R_E.\left[\frac{\left(1+\frac{h_{sat}}{R_E}\right).\cos(\alpha)}{\sqrt{1-\left(1+\frac{h_{sat}}{R_E}\right)^2.\sin^2(\alpha)}} - 1\right].IFOV$$, taking into account the rotundity of the Earth.



Equations 1 - Ground Sampling Distance (GSD) calculation without or with earth curvature.

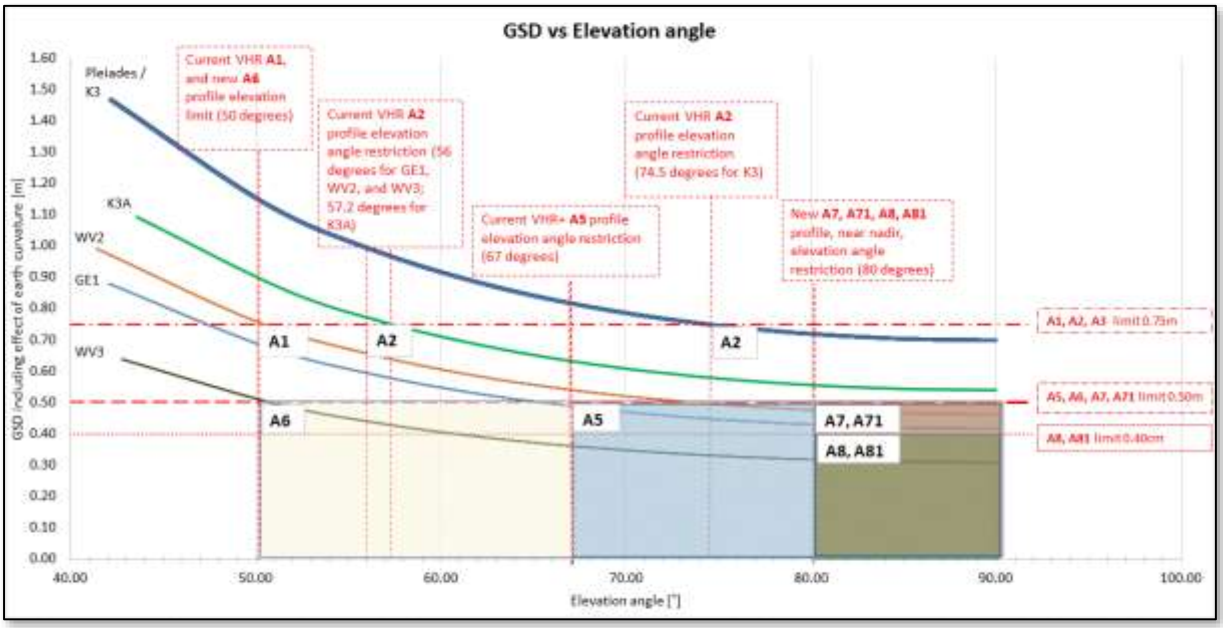


Figure 4 - Ground Sampling Distance (GSD) vs. elevation angle for the VHR profiles.

The most commonly used VHR profile defined by the COM is the A.1 "standard" with a GSD requirement of ≤ 75cm (see Annex Table 1) deemed suitable for the "standard" case. There are some specific profiles suitable for checks performed in terrain with challenging topography, or for the checks of particular features. The MS should consider which equivalent profiles to use for their particular agricultural landscape:

- Profile A.2 and A.5; were designed for control zones located in mountainous or complex topology areas applying further restrictions on acquisition angle in order to limit topographic distortion.
- Profile A.6; for controls of the Landscape Features (LF) that are included in the 'greening' of the CAP within the Ecological Focus Areas (EFAs).
- Profile A.7 and A.8; were introduced for the LPIS QA purpose (so not directly in the scope of these CwRS checks), but also for some 'near nadir' acquisition requirements (meaning these are the 'strictest' profiles

and have limits on the GSD, on the elevation angle, and on the output resampling). These strict profiles were applied only to targets where no interference with the planned capture of any other profile would occur since feasibility is particularly challenging.

3.1.2 The HHR profiles

As mentioned above since 2014, the JRC introduced the term "profile" where for the HR it was deemed necessary to have one main profile type defined, called the HHR profile. This is then subdivided in two more specific ones F.1, and F.2 (see Annex Table 2)

The term HR stands for High Resolution, but the profile is named HHR to emphasise the difference in resolution (< 3m) compared to earlier generation of SPOT, IRS, DMC etc. and now Copernicus S2 data (10-20m). It could be an idea for the MS to have both HR and HHR profiles types defined in their future management and definition of the checks methods and the image choices.

The COM financing of above coarse commercial HR imagery (10-20m) was discontinued with the CwRS Campaigns 2017/2018 as in fact the S2 data became available. These data, which are free of charge, are directly downloaded from external on-line cloud archives (e.g. ESA Copernicus Open Access Hub, Copernicus Data and Information Access Services (DIAS) Services, Amazon Web Services (AMS), USGS etc.), and may be used in any AW, but especially for autumn/winter, or HR imagery between the VHR windows (i.e. HRB1, HRB2) where both S2A/S2B are fully 'fit for purpose'.

Recently, PlanetScope DOVE imagery has been introduced in the HHR profile even if it does not include a panchromatic band. Its red-edge band is sometimes appreciated for some checks purposes, and some MS's are using it as a backup/archive solution if acquisitions initially expected from other sensors fails. It fits to the F1. MSP, and F2.MSP HHR profile. See [ref ii] for more details on this.

3.1.3 Processing levels

The above mentioned VHR and HHR profiles were defined with specific criteria set on levels of processing: geometric processing accuracies, on resampling kernels to be used, on image dynamic range adjustment (DRA) application, on Atmospheric Compensation algorithms use [ref vi], and on optimal ratio between satellite acquired GSD - delivered GSD - ortho GSD to maintain best information extraction.

The automatically ortho-rectified HHR profile F.2 can also be mentioned as a product making use of the Reference 3D [ref v] for the orthorectification process, which has been benchmarked for use.

3.2 Image Specifications

3.2.1 Image Specifications, and updating of profiles

The image acquisition is today governed by the "living" specifications for the imagery and for the image acquisition workflow [ref ii]. These are revised and updated for every campaign to fit CAP changes, to allow more efficient use of imagery in the controls, and a more efficient image acquisition. The specifications for geometric (and radiometric) benchmarking of a sensor are instead governed by a scientifically proven methodology [ref vii].

3.2.2 Benchmarking specifications today

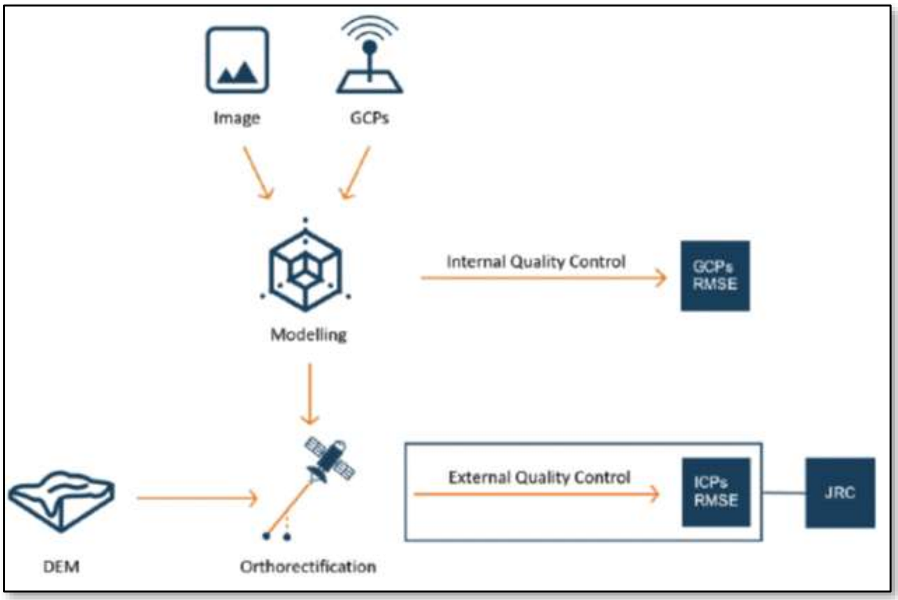


Figure 5 - Schematic figure of JRC and IP satellite benchmarking methodology (courtesy EUSI)

The geometry benchmark stems from 2014 when the "profile based" approach was introduced by the JRC. The IP was contractually requested to follow a clearly defined methodology, see Figure 5 above. If successful, the IP could add the sensor to his fleet of sensors used for image acquisition. The geometry benchmarking has been under the control of the JRC to keep the guarantee that sensors introduced met the technical specifications [ref ii, vii]. JRC will no longer perform such benchmarks.

From 2023 the responsibility for above mentioned image specifications and benchmarking documents will lie with the PA. It is strongly suggested to implement routines for their updating, and for the validation of new image profiles.

4 Planning considerations

Each year the COM was providing the so-called CTS [ref i]. Its aim was to describe the technical tasks that the MS Administrations are responsible for even if some parts may be entrusted to contractors. It provided technical guidance on how to perform OTSCs in general and much of the information provided concerned the implementation of the Controls with Remote Sensing (CwRS).

From 2023, MS administrations will have the full responsibility to define/adapt their OTSC strategies. Their planning preparations should reflect on following (non-exhaustive list):

- the geophysical/landscape particularities of the country;
- the different farm typologies;
- the resources (staff and budget availability);
- the typologies of the different payment schemes.

The MSs are responsible for the substitution / adaptation of the Common Technical Specifications to their CAP OTSCs checks post-2023.

As part of this they will have to define their image needs and ensure their efficient acquisition and sound use.

4.1 Autonomous sampling and zoning

The Common Technical Specifications (CTS) contains relevant information for the preparation of the On-The-Spot Checks (OTSCs) campaign especially for what concerns the selection criteria of dossier sampling and control zones by use of defined random and risk proportions. It cannot be repeated often enough, that it will be the full responsibility of MSs to make the decisions to set their methods and zones for their OTSCs.

4.2 Timing issues

Up to the introduction of S2 (2017/2018), it was unfeasible technically, but above all financially, to purchase and acquire tens of images over a considered zone. Indeed, one achievement of the "COM financed" CwRS process has been to find the right (optimal) balance between the minimum number of dates (images) necessary to discriminate the main types of crops (limiting the number of and need for RFVs) and to make this at a reasonable (cost efficient) budget (at least cheaper than classical farm check). Another achievement has been to manage the timing to obtain information from imagery prior to rapid field visits in case of doubt.

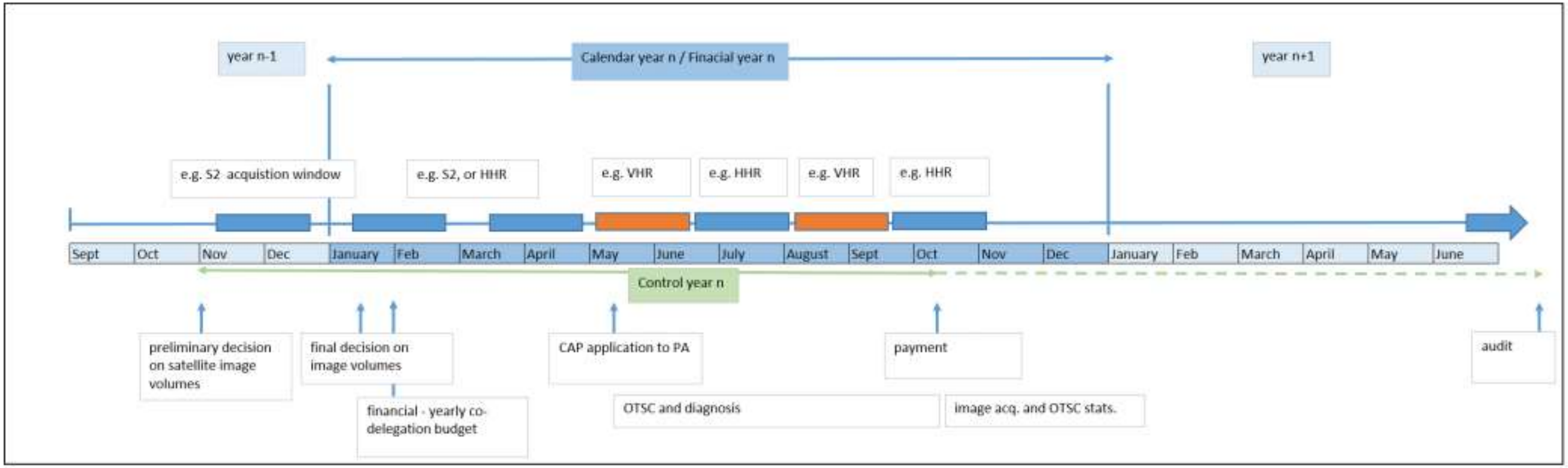
The combined understanding has led to definition of above mentioned image profiles, and the main AWs layout as shown in Figure 6. Each MSs obviously has adapted this according to the features to check and their phenology, and the manpower available etc.

Any image acquisition campaign (control year, or crop season) with its OTSC diagnosis and payment to farmer is spread over > 1 calendar year (or financial year). Preparations start before the crop season (in year n-1), COM financed image acquisition proceeds through the crop season (in year n), together with the diagnosis (parcel, payment group, and application level), payments, and relative statistics (of image use and OTSC statistics). The overlap of a Campaign (control, crop year) with a calendar year is of high relevance for the financial operations (Chapter 5).

The goal of the planning is that the acquisition of imagery falls in the predefined AW and that the captured image is received without delay. One should nevertheless allow for some flexibility in case some weather or other events induces a shift in the expected phenological cycles. Further details are provided in the Feasibility Chapter 6.3.2 (and in the image specifications [ref ii]).

The Figure 6 below summarizes the calendar through the year, and then two detailed extracts from G^{4}CAP (Figure 7, Figure 8) demonstrate how the crop cycle decides on the placement of the satellite AWs for the two main methods of placing the inspection source data (VHR only, and VHR plus 2 HHRs).

Figure 6 - Campaign year summary over time



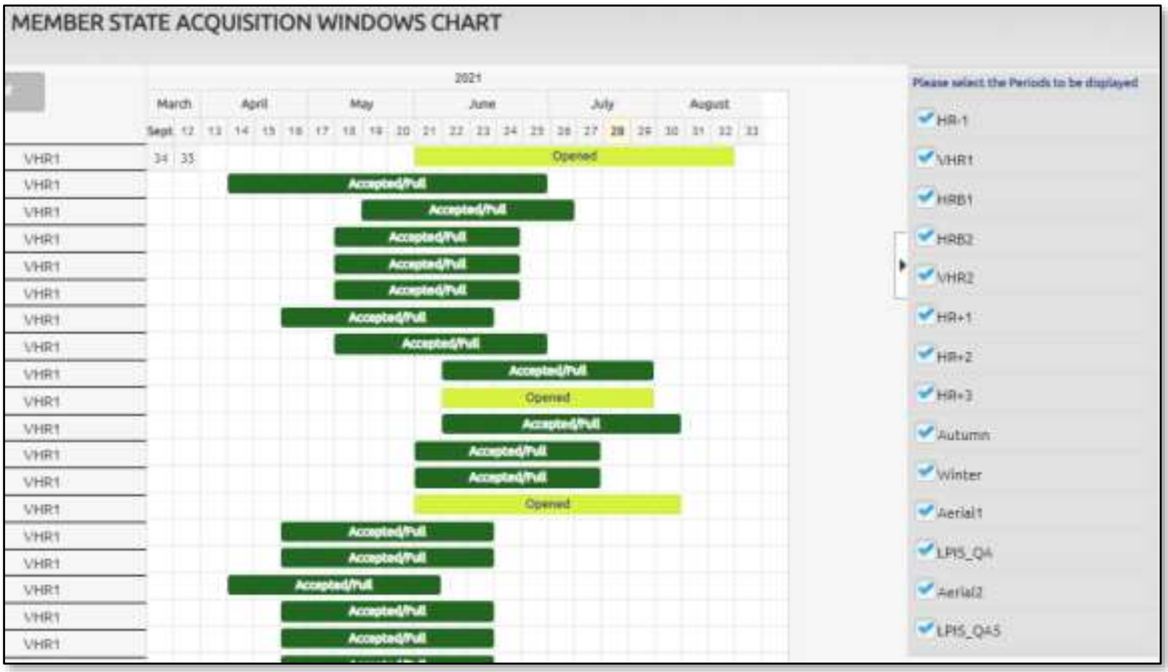


Figure 7 - AWs layout covering crop season in the case of [VHR only with RFV] (in dark green acquired satellite imagery, in light green VHR AWs still being programmed for acquisition by IP); (source G4CAP)

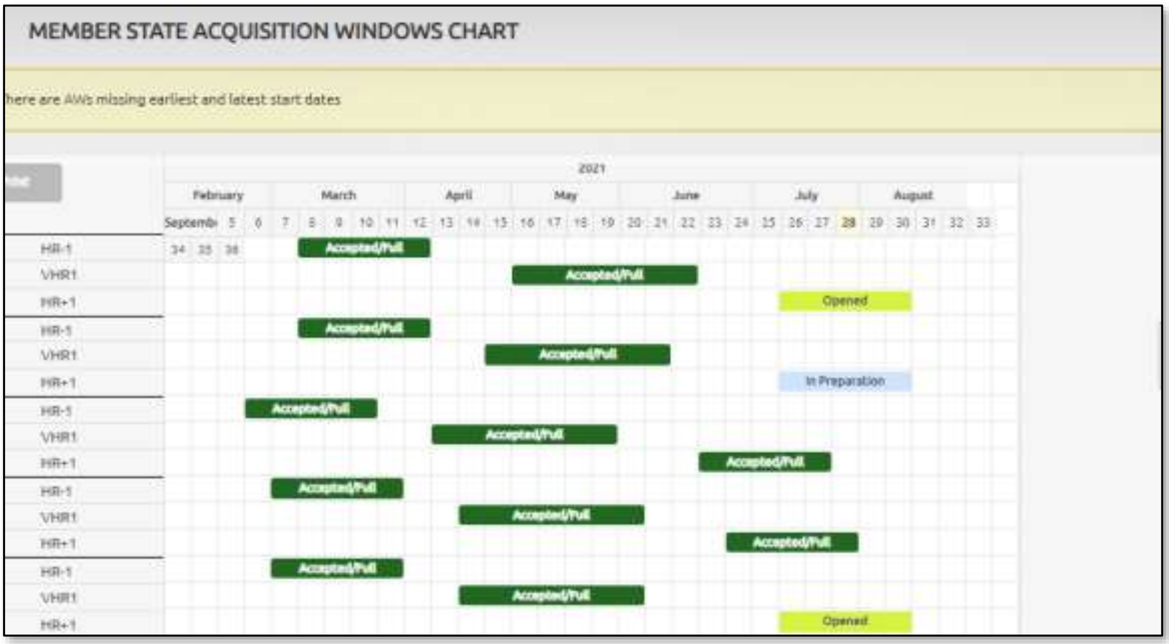


Figure 8 - AWs layout covering crop season in the case of [VHR + n HR] (in dark green acquired satellite imagery, in light green VHR AWs being programmed, and in light blue AWs still to be opened); (source G4CAP)

MS PAs should carefully coordinate all financial, contractual, and image collection workflow in order to timely receive imagery for the CwRS activities.

5 Procurement and contracting

5.1 Transfer to national budget and procurement

Today the COM budget allocated for the CwRS stems from a DG AGRI multiannual financial decision. The amount is revised every year according to a specific yearly work programme set up on the basis of the MS annual image requests (received in November year n-1). This budget amount is delegated to the JRC from DG AGRI in the beginning of the Campaign (year n) (see Figure 6 above).

This funding and provision of services by the Commission will stop by end of year 2022. MSs which will opt for keeping a CwRS-like system from 2023 and onwards, will have to finance and thus to set up FWCs or ad hoc contracts by themselves with the IPs and 'value adding contractors' well in time for the Campaign 2023.

The COM via the JRC has always set up FWCs according to the EU Financial Regulation [ref ix] for the image provision. A FWC lasts for normally 2-4 years, and allows definition of the supply and services framework and a total approx. financial envelope within which then specific contracts with detailed specifications are signed and progressively consume budget until ceiling is reached. These specific contracts accept the operational invoicing, and payments as the campaign progresses. The negative issue of making overarching FWCs is that they take some time (several months …) to set up, and obviously you need to know approximately your financial envelope for the FWC validity. The JRC experience is however positive, and the FWCs have worked efficiently once set up.

It needs to be mentioned that the COM FWCs need to deal with requests for all EU MS participating in the CwRS operations. The set up for individual MS should be of much simpler character, therefore it could be envisaged that simpler 'direct contracts', or even 'commercial off the shelf' (COTS) image buy could be used for the MS yearly imagery. This is a decision for the MS to take.

MSs which will opt for keeping a CwRS-like system from 2023 and onwards, will have to finance and thus to set up FWCs or ad hoc contracts by themselves well in time for the Campaign 2023.

Given the MS is a public body, image purchasing should follow EU or National Financial Regulations and rules in their tendering and purchase procedures.

Budget necessary for the MS controls operations should be carefully planned well in time for the Campaign start. Every year's allocated budget should be enough for (1) the satellite imagery needed for the controls, and (2) the subcontracting of the image preparation, OTSCs diagnosis, etc.

5.1.1 FWCs vis-à-vis image providers

The COM's FWCs with the IP (or operator) implement the profile framework approach detailed above (Chapter 3.1). The object of the procurement is therefore to supply satellite remote sensing VHR or HHR profile imagery according to defined image profiles and including associated planning/scheduling activity [ref viii and ref ix]. Normally, as mentioned above, these FWCs are set up for a validity of 2 + 2 years. A monthly "basket" of collected imagery conform to specifications is created, checked and brought to invoice and payment in line with to the specific contracts signed. In addition to the imagery, technical deliverables to the MS should accompany the monthly reporting in order to control the processes. Below follows a non-exhaustive list of such deliverables as used today by the JRC:

- Improved VHR, HHR Specifications
- Feasibility Result Reporting
- Final Campaign Technical Summary Report
- Final Campaign Financial Summary Report
- Sensor benchmarking Report/s

Sufficient resources need to be planned to manage the FWCs with associated SCs and financial cash-flow.

Today, in its FWC, the COM also sets up clear objectives. A main one is that the IP must reach a minimum of 95% success rate in image acquisition on time, and according to specifications, and another one also stipulates that the IP needs to have minimum two satellite sensors available and active.

The contracts set up by the MS should clearly define deliverables, with specifications and performance thresholds.

5.1.2 Contracts vis-à-vis executing contractors

These contracts exist in the current CAP framework, so the MS using them have already a good experience to deal with the contracting / subcontracting of selected services linked to their 'value adding' required in the CwRS operation. Examples (non-exhaustive) are image preparation (e.g. orthorectification), RFVs or OTSC diagnosis. Some MS perform these tasks in-house, other prefer outsourcing this activity.

5.1.3 Aspects on respecting common market provisions and public tendering.

The importance of adhering to EU or National Financial Regulations [ref ix] is here re-iterated. Moreover the contracts set up must comply with EU, National, or ad-hoc rules as follows. JRC is not a legal expert, but following aspects have surfaced during the JRC operations:

- **Confidentiality** - the technical management of the image acquisition for the CAP checks is a sensitive issue. The CwRS has a deterrent effect on CAP subsidy fraud and it is therefore of utmost importance that the areas to be controlled in the MS do not become known before or during the campaign (e.g. never shall a zone boundary coordinate file be sent without secure handling). Moreover, it is of utmost importance for the FW Contractor to act correctly, coherently, and transparently in the image provision, and image operations not to favour any of the stakeholders involved in the CAP checks.
- **Personal data** – any issue of General Data Protection Regulation (GDPR) [ref xii]
- Avoidance of **conflict of interest** that could compromise or could be perceived as compromising the impartial and objective performance.
- Clear **Collaboration agreements** e.g. between HHR, VHR IPs who need to cooperate, communicate and coordinate with each other, and with the MS Administrations (and their contractors) for an efficient running of the activities.

MS PAs are in their tendering suggested to carefully follow EU and/or National Financial Regulations, and moreover respect rules on: Confidentiality, Personal data, avoid conflict of interest, and set up necessary Collaboration agreements between relevant stakeholders.

5.2 Aerial versus VHR

The acquisition of aerial imagery for the checks has always been the responsibility of the MS. It is a well-established commercial market. COM's interest in any contract has been limited to stakeholder input in G^4CAP AWs management e.g. requesting a VHR satellite image is unnecessary where an aerial flight is planned, or managing the opening of an HHR AW after an aerial flight acquisition, etc.

If a PA (or their contractor/s) intend to acquire and/or ortho-rectify aerial digital imagery, they should refer to the Best Practice and Quality Checking of Ortho Imagery JRC guidelines [ref vii]. Responsibility to use best practice and to update such specifications lies with the MS.

Historically satellite VHR and aerial VHR have both been used. Both are effective, but experience possibly tends to show that satellite acquisition capacity is more efficient. Indeed experience shows that forecasted satellite image acquisitions have never been converted to aerial, but very often opposite requests were made by MSs.

Regarding pros and cons of the aerial option, the following can be said [ref i]:

Aerial pros:

- Aerial imagery allows covering of large areas (e.g. large administrative units such as full provinces) in a relatively limited period of time,
- Aerial imagery allows covering a large number of small zones in a given region fast
- The use of (natural colour in combination with false colour composites) imagery permits an easier identification of land cover, thus significantly reducing follow-up RFVs for crop identification
- Aerial flights carried out within the present state of the art: the use of GNSS and inertial navigation systems linked to the camera makes it possible to optimise the flight coverage and considerably reduce the costs of further processing.

Aerial cons:

- Aerial imagery may have restrictions over military zones and air traffic lanes.
- Cloud cover is not as restricting for aerial photography as for satellite imagery, but meteorological conditions are in any case affecting the radiometric quality of the images.
- The lead-time in the acquisition/processing of aerial imagery may be longer than that for satellite images.
- More influenced by a pandemic situations since flying might be restricted due to hygienic rules (e.g. COVID-19)

In any case:

- Aerial images acquisition must be organised sufficiently in advance, and the acquisition periods should be relatively early in the year.
- It is the responsibility of the MS to avoid a situation of acquisition of VHR satellite imagery contemporaneously to an aerial acquisition. See comment on stakeholder input in G^{4}CAP above in the beginning of this chapter.

There are pros, and cons in using aerial or satellite VHR imagery for the CwRS. MS should define which VHR source is most efficient for their checks, and to use updated specifications for their imagery, flight systems, image processing, and workflow management.

6 Behind the doors: Overview of G⁴CAP highlighting future MS responsibilities.

6.1 The G⁴CAP web application vs. own application

In order to request, acquire and deliver the CwRS images, workflow management and communication between stakeholders is today organised via a dedicated web application, the so-called G^4CAP [ref iii].

Geomatics for the Common Agricultural Policy (G^4CAP) is the main communication tool between the CwRS stakeholders during the campaign, making use of automatic e-mail exchange to synchronize actions between different actors. Figure 9 below details responsibilities among the actors within the system.

It is envisaged that MS that opt to continue with CwRS in 2023 will need to substitute a system like the JRC managed G^4CAP with a much simpler, but still efficient, in-house alternative (web application or other).

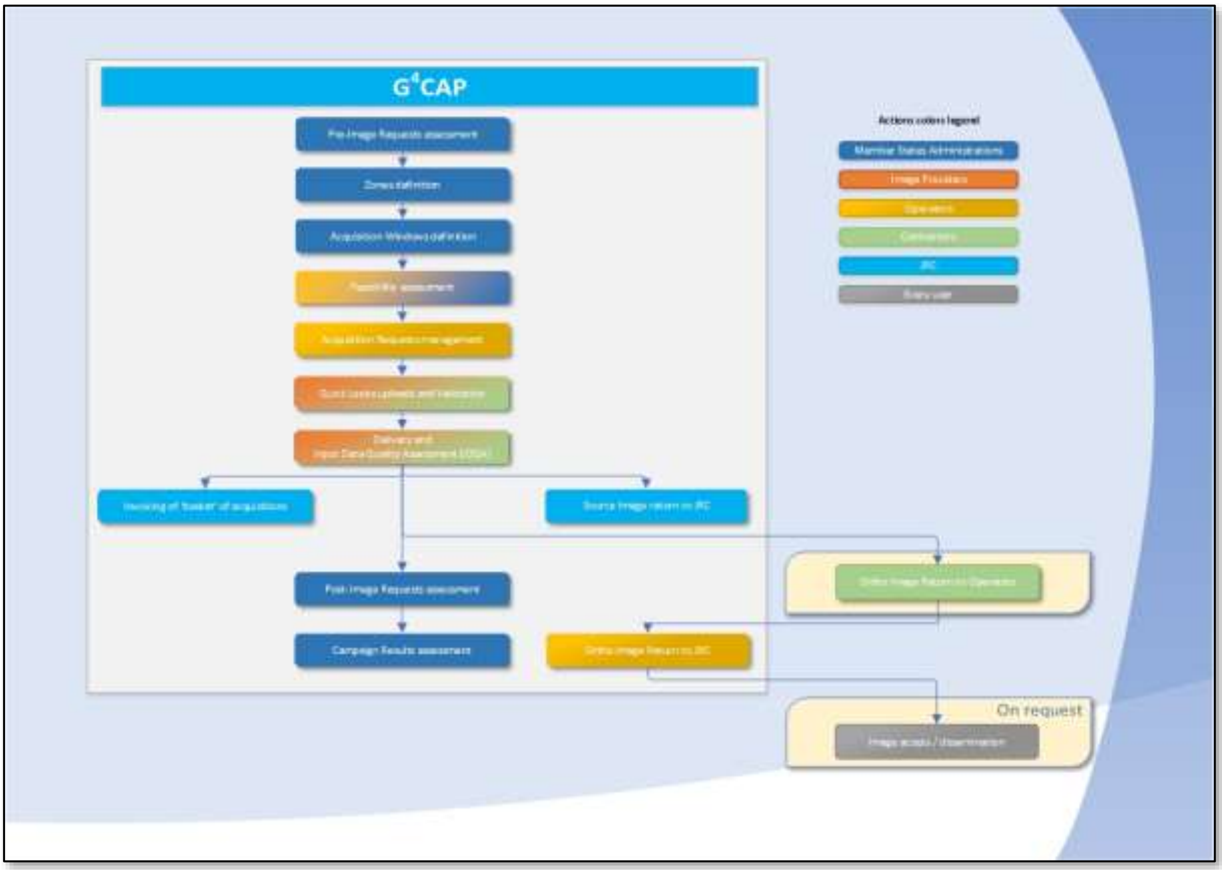


Figure 9 - The overall process, the stakeholders, and their interaction in G^4CAP

6.2 The workflow

The operational workflow of the image acquisition is shown in below schematic diagram (Figure 10). All actions with a blue coloured tag are handled by G^4CAP. The main activities which will likely fall under the MS responsibility, are described in more detail in the chapters to follow [ref ii, iii].

1. Image Requests and Feasibility => AWs
2. Image Acquisition - Image Validation
3. Delivery - Quality Control – Invoice
4. Data storage and archiving
5. Data use and sharing

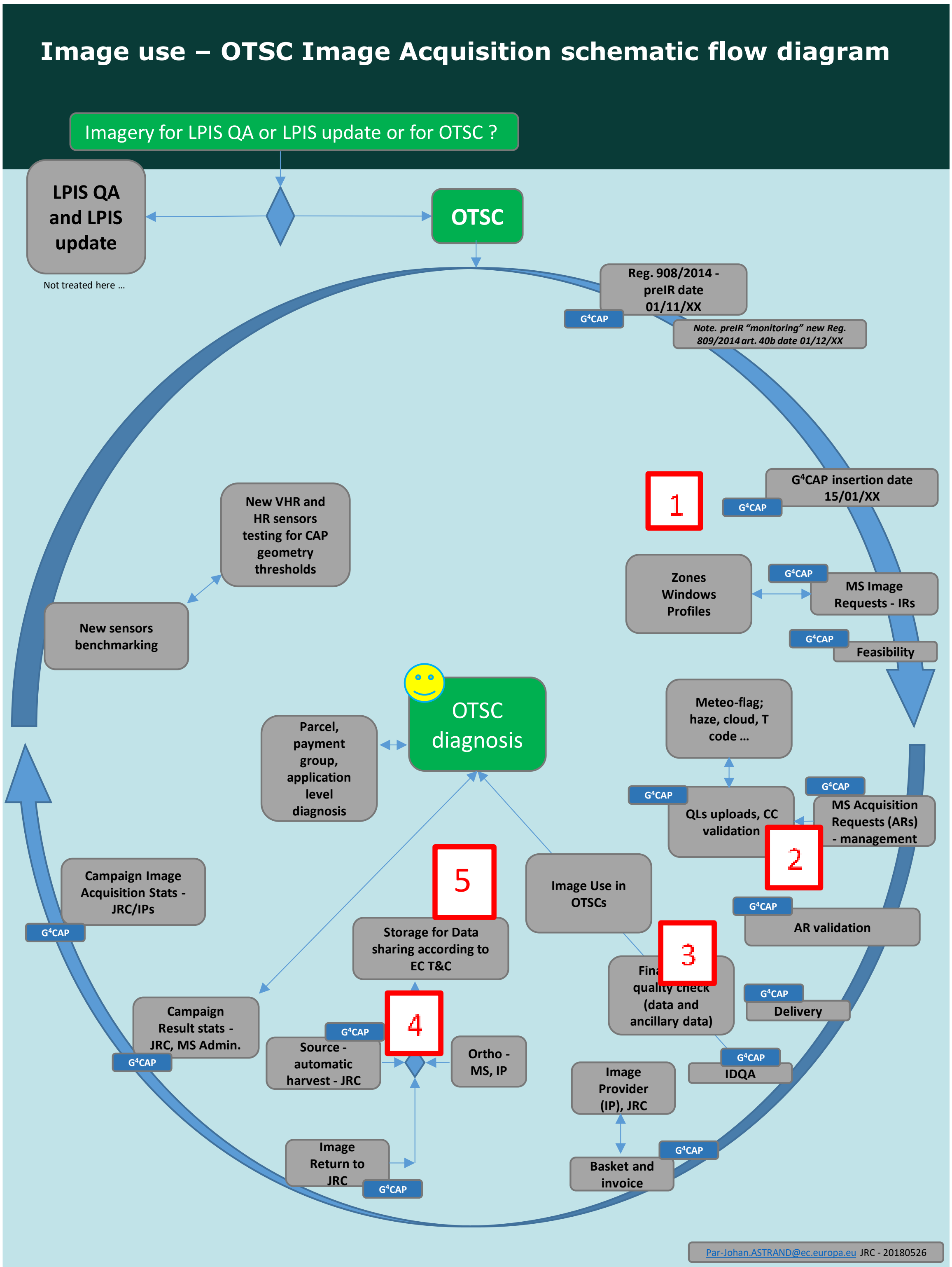


Figure 10 - The OTSCs image acquisition schematic flow diagram

6.3 Image Requests and Feasibility (1)

6.3.1 Image Requests

The current MS Image Request for the campaign is defined in two steps, as formalised with specific deadlines in the current CAP regulation. The two steps are introduced to allow the MS to project their desiderata and to allow distribution of the available budget among the MS. Such deadlines are absent from the new regulations and it will be the MS itself to decide on budget distribution within the MS itself.

1. pre-Image Requests (pre-IRs)
2. Final IR definition; ZONES, Acquisition Windows (AWs), SHAPES

Step (1) allows to preliminarily decide upon total volume (area, km2) of VHR and HR (HHR profile) satellite data necessary for the MS to perform its checks. It also serves to give a budget need indication of the imagery to be purchased for the campaign (see Chapter 5). This first step is based on following input:

- <u>the MS on-the-spot-checks (OTSCs) information</u> including # applications, total declared area, expected # of OTSCs, expected area of the OTSCs, # checks for 'greening' measures.
- <u>The MS CwRS information</u> including # CwRS applications, total area checked by CwRS, % of control zone used for the checks, expected total AOI area of CwRS zones, expected number of CwRS checks for 'greening', CwRS methods (see Figure 3) and for each method the # zones, and # periods (AWs). At last but importantly the type of profiles required for effective controls (Chapter 3.1) are also be specified.

The EC reminds the MS to pay attention to the effectiveness/efficiency aspects of the image request. It is expected that appropriate justifiable choices fitting the MS particular landscape and CAP OTSC controls scenario are made. Also, the EC encourages the maximum use of S2 data (see Chapter 3.1.2) wherever appropriate. Today, to possibly check the current eligibility criteria, MS should not need more than two HR (HHR profile) AWs in addition to these freely available S2 data, and as few MS as possible should need a second VHR AW.

Step (2) consists of giving final details of the image request. This step includes:

- Definition of final control zones (shape files). See Chapter 4.1 for selection of beneficiaries by random/risk procedures.
- Selection of contractor for each control zone
- Details of final image request for each control zone (EPSG code, type of delivery, AW, image profile, image mode (e.g. pansharpened, bundle, multispectral), earliest starting date, latest start date, dead period, and whether to allow AW extensions. The EC reminds the MS that in their AW definition use suitable dates and window lengths ('normally' for HHR a minimum of 4 weeks, and for VHR a minimum of 6 weeks) fitting to their crop cycles.

Reg. (EU) No 1306/2013 (§.6b, §.21) and its relative Implementing Reg. (EU) No. 908/2014 will no longer be in force. So, the regulatory 2-step image request procedure is no longer applicable and MS can merge the steps when and how appropriate.

However, the two steps procedure is useful since the first gives a budget indication, while the second gives detailed acquisition parameters necessary for the success of the image acquisition itself, and also a detailed prediction of the costs. This expense will lie with the MS Administration.

6.3.2 Feasibility

In order to assess whether a programming request will be successful within an Acquisition Window (AW), a so-called technical and competitive feasibility assessment is made. The IPs (or satellite operator) performs this assessment based on, among other parameters, assessments of satellite characteristics, zone size, zone shape, zone latitude, elevation angle, AW, programming priority level, cloud cover (CC), weather statistics and weather forecast and finally other competitive tasking requests. All tasking is for the CwRS normally placed at priority level.

Such feasibility assessment results in classes of success probability, typically:

A. GOOD (GREEN) - FEASIBLE WITHIN AW - approaching 100% probability (≥90%);
B. MEDIUM (YELLOW) - FEASIBLE WITHIN AW - ≥70% probability; may need EXTENSION - suggestions can be made to improve possibility of success;
C. LOW (RED) - NOT FEASIBLE WITHIN AW – with suggestions to make it feasible (e.g. AW extension with the suggestion of a new start/end date, change of profile allowing e.g., a less strict elevation angle, change of a sensor or acceptance of backup) (< 70%).

For the feasibility, G[4]CAP relies on an iterative process involving IP and MS to reach acceptable feasibility for an AW and profile. See Figure 11 below which shows this iterative process [ref ii, iii].

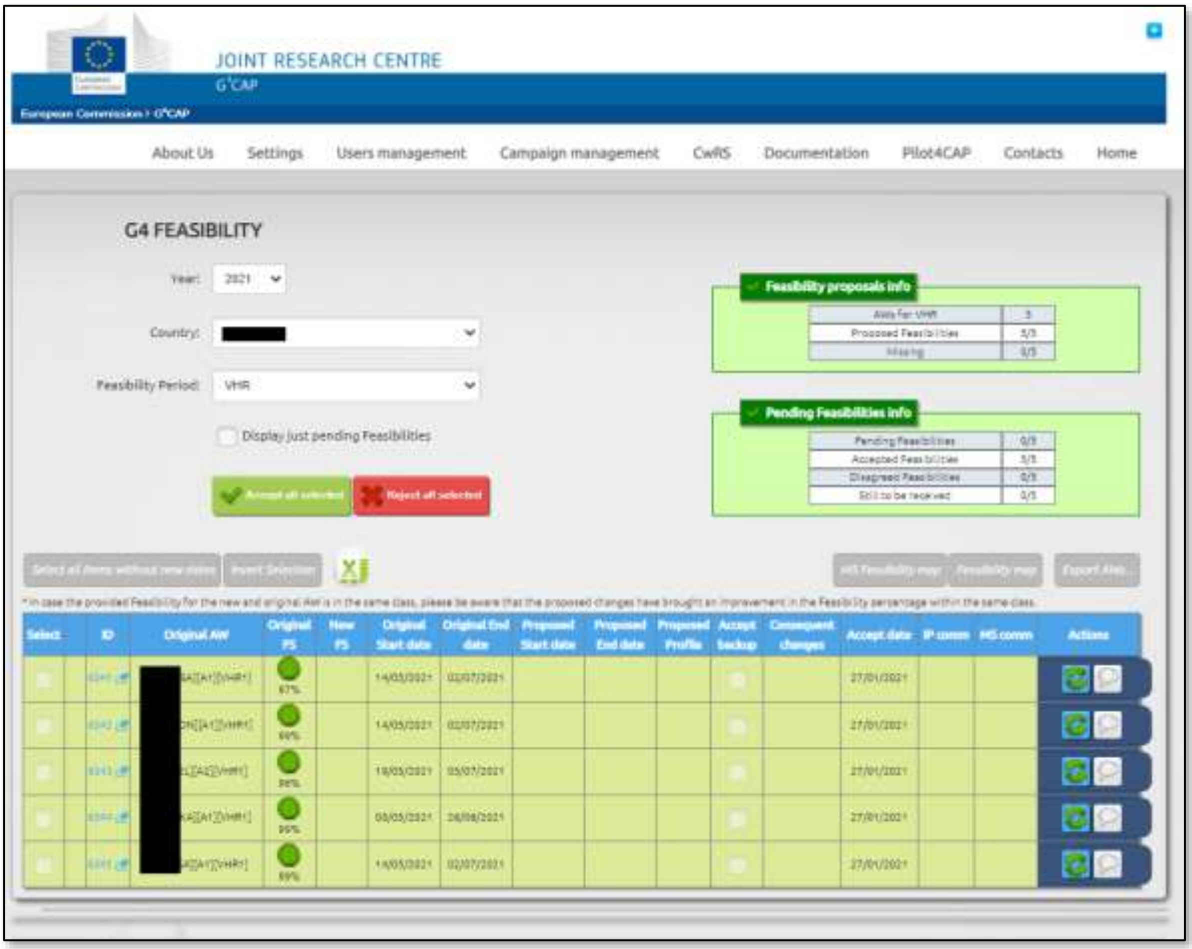


Figure 11 - G[4]CAP view of a sample feasibility; (source G4CAP)

There are two cases of AWs, and the feasibility assessment differs between the two.

6.3.2.1 The “normal” feasibility scenario (VHR AWs, HHR (HR-1) AWs)

The “normal” feasibility approach is followed for all VHR Acquisition Windows (AWs), and all HHR HR-1 windows, starting from initially requested AWs, and with no, or little, constraints stemming from a previous AW or a subsequent AW. The IP provides the MS with scenarios, labelled with possible success rates "Good", "Medium" or "Low", and also a “Black” option where acquisition is NOT feasible under those constraints. AW parameters are changed in iteration until the final feasibility agreement between MS, IP is validated by JRC.

6.3.2.2 The "sliding window" feasibility scenario

The "sliding window" approach is applied for the feasibility assessment of the HHR (HRB1, HRB2, HR+1, and any subsequent HR period), since their starting dates depend on the preceding VHR or aerial acquisitions being completed. According to this situation, the IP provides the MS with two scenarios, labelled with possible success rates "Good", "Medium", "Low", or "Black':

1. BEST CASE - From the earliest start date of window to the latest start date plus the window (4/6 week)
2. WORST CASE - From the latest start date of window plus the window (4/6 week)

The iterative process proceeds and normally results in a final feasibility agreement between MS, IP and validation by JRC. The situation is however further complicated if there is a delay of the preceding AW (e.g. due to an adverse meteorological situation resulting in a AW "shift"), which necessarily leads to further iterations, indeed also to keep the necessary and important "dead period" preventing imagery to be acquired too close to each other [ref ii].

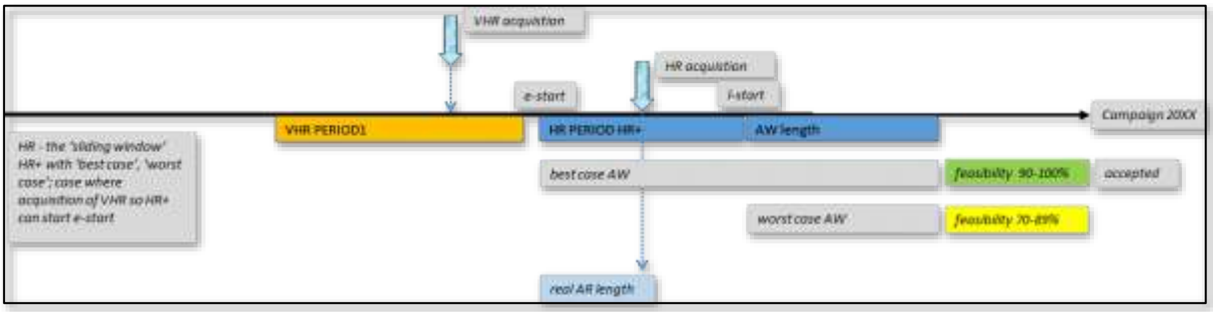


Figure 12 - The case of a sliding window in HHR AWs feasibility

In conclusion:

> The EC suggest to set up a very close communication channel with the IPs to account for feasibility, and analysis of the campaign. This experience will feed into the programming choices for subsequent campaign and will give input to the feasibility evaluation.

Due to the importance and volume of the pan-EU CwRS contracts, the IPs have always considered the requests for the CwRS as "priority tasking". Individual MS volumes will possibly not carry such weight vis-à-vis the IPs and MS should pay attention to this loss of scale while trying to ensure feasibility.

6.4 Image Acquisition – Image validation (2)

After the feasibility, as the AWs open, the campaign proceeds and delivers first a down-sampled browse images of the acquisition, a synthesis image or so-called Quick-Look (QL), uploaded within 2 days, and the full resolution imagery, within 6 days. A MS or its appointed contractor uses the QL to validate the image suitability, and, if validated, the contractual product is delivered, quality controlled, pre-processed and used in the subsequent OTSCs [ref i, ii]. All deadlines are set contractually in the FWC.

The pre-processing of the satellite imagery is either performed by IP before delivery (e.g. in the case of ortho rectified SPOT HHR imagery with Reference3D [ref v]), but most often by the MS contractor (Chapter 5.1.2). This produces 'ready to use' imagery for measurement, and CAPI where it is combined with the LPIS, GSAA and other relevant data for the OTSC diagnosis.

The process which is shown schematically in Figure 10 above, consists of:

- Creation of acquisitions requests (this is the actual implementation of the MS image requests explained in Chapter 6.3.1 above)

- QLs upload, see Figure 13 below. QLs of the collected imagery is shown to the MS, or its appointed contractor, within 2 working days of the acquisition [ref ii].

- Acquisition acceptance and validation, see Figure 14. The acceptance of the acquisition is made upon criteria set in the specifications [ref ii], typically on validated/proposed/retained cloud cover (CC) thresholds over the control zone, on elevation angle allowed (see Figure 4 above), or on backup sensor allowed, etc.

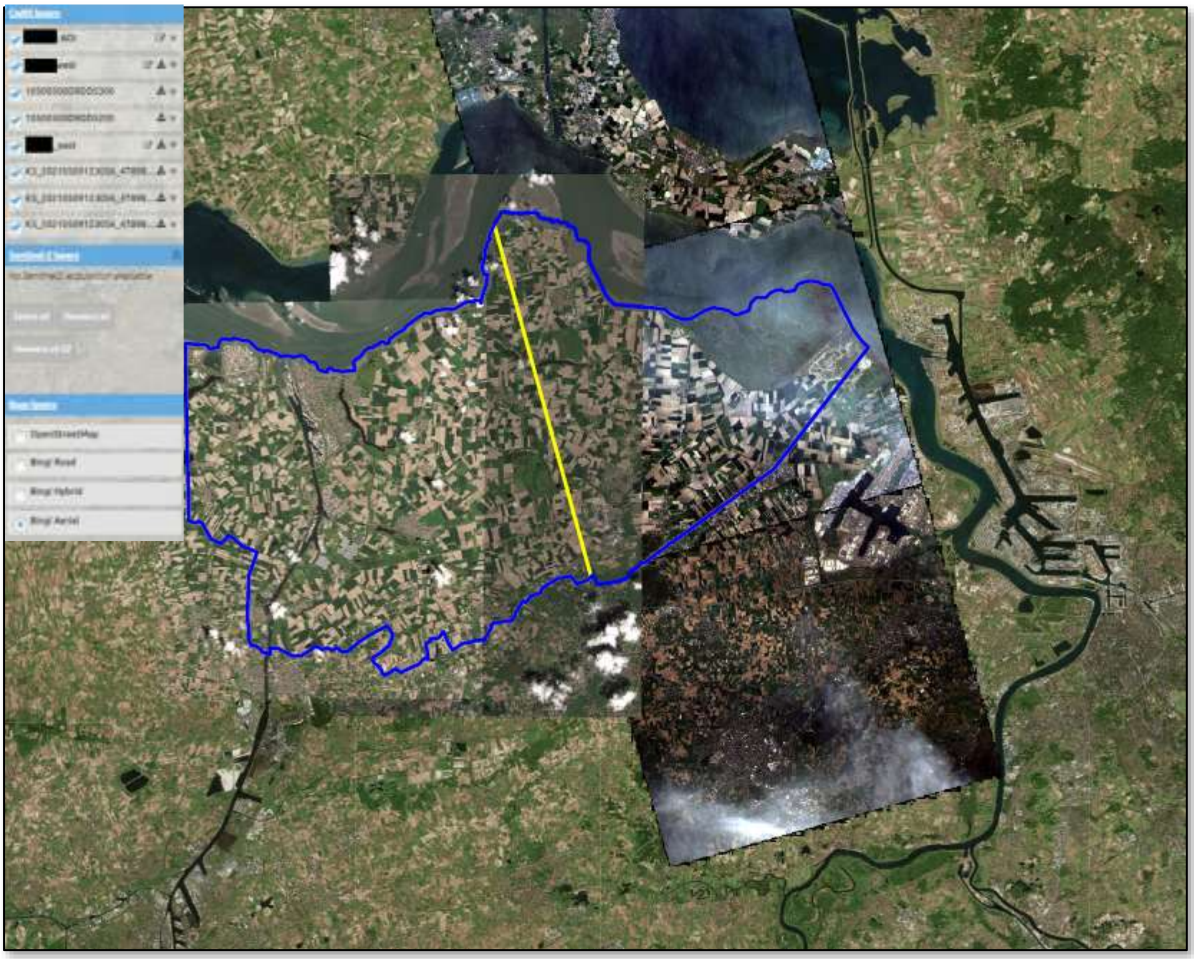


Figure 13 - G⁴CAP view, in its ad-hoc viewer, of typical uploaded cloudy QLs; (source G4CAP)

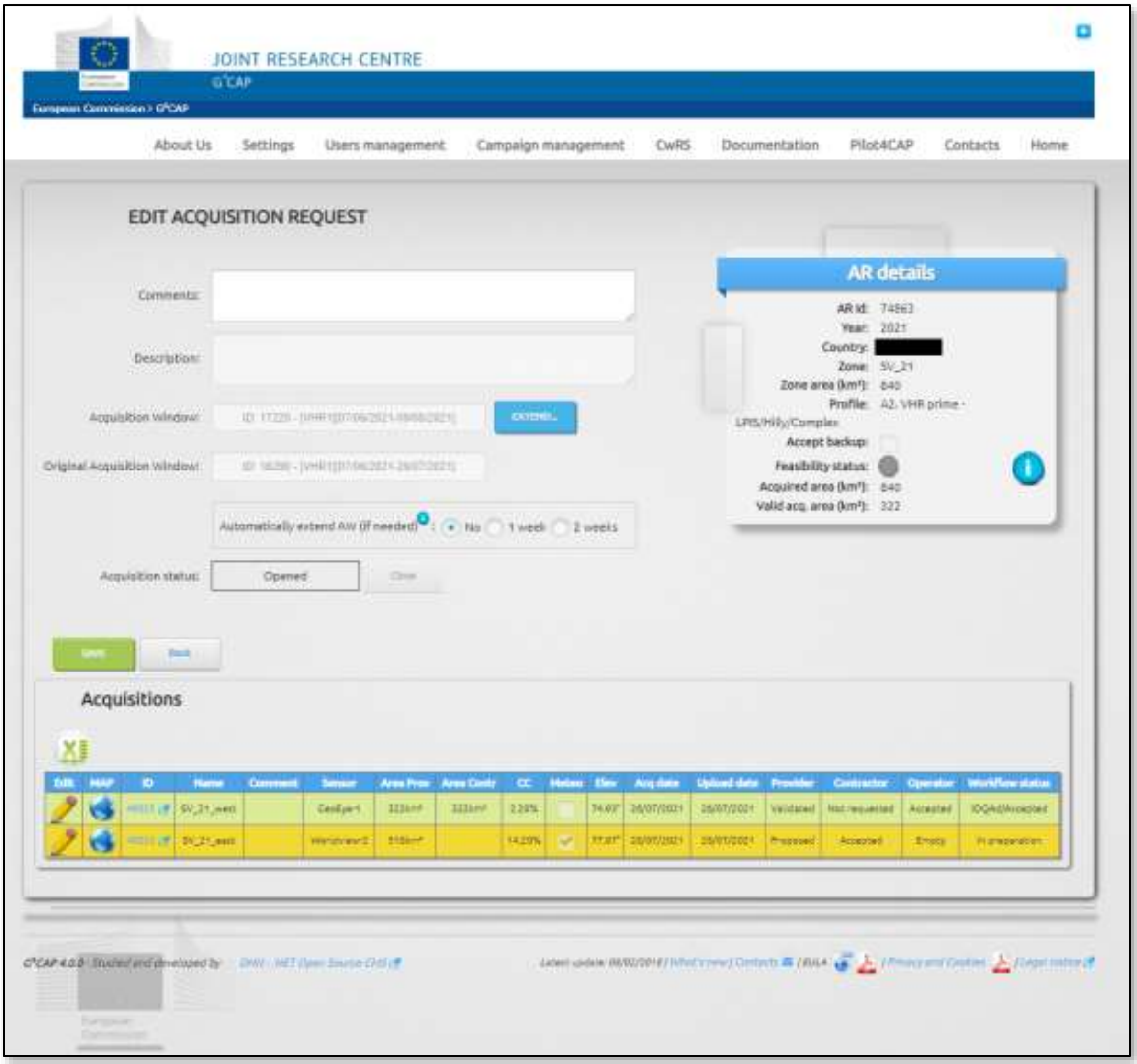


Figure 14 - G⁴CAP view of a typical ongoing acquisition acceptance; (source G⁴CAP)

It is suggested by the EC that the MS should set up Quality Control Records (QCRs) controlling the image acquisition workflow. These are a set of records that should be made available to the MS by the IP at any time during the image acquisition process and which give important information on the quality and performance of the service. The MS should define these carefully. The following are defined by the JRC, but the MS can add others: [ref viii]:

- List of zone and Acquisition Windows (AW) parameters as of specifications; at any time requested.
- Georeferenced Quick look (QL) (e.g. JPG, GeoTIFF etc.) over any AOI; positional accuracy < 100m RMSE; at any time requested.
- Documented Cloud Cover (CC) assessment over any AOI at any time requested; accuracy level requested - better than 1% definition.
- Document containing proven attempts the Image Provider (IP) made over each AOI; attempts remaining over AOI before an AW ends; statistics as to attempts made, re-tasking, adaptations due to weather conditions, etc. at any time requested.
- Campaign status logbook: day-to-day status of acquisitions at any time requested.
- Documented statistics of image delivery: QL upload, production start/end, dispatch, receipt dates, etc. at any time requested.
- Reporting of image quality according, with explanations of Input Data Quality Assessment (IDQA) PASS/FAIL, reasons, and iterations with MS Administrations (or their contractors); at any time requested.

- Documented statistics as to balance of sensors used in the Campaign at any time requested.
- Document giving outline of launch status of new satellite sensors; commissioning information; suggested 2 times / year, or as minimum in conjunction with the launch and commissioning of any new satellite sensor.

The JRC also suggests to set up routines for checking availability of S2 archive imagery and other suitable free of charge satellite imagery for the MS controls. In G[4]CAP a specific module called 'S2alert' is implemented, which alerts the MS whenever there is a suitable S2 acquisition over a specific programmed, or ad-hoc, AW and allows display of the QL (Figure 15 below) [ref iii]. Such services (more or less sophisticated) are now available from ESA or other S2 providers (see above Chapter 3.1.2).

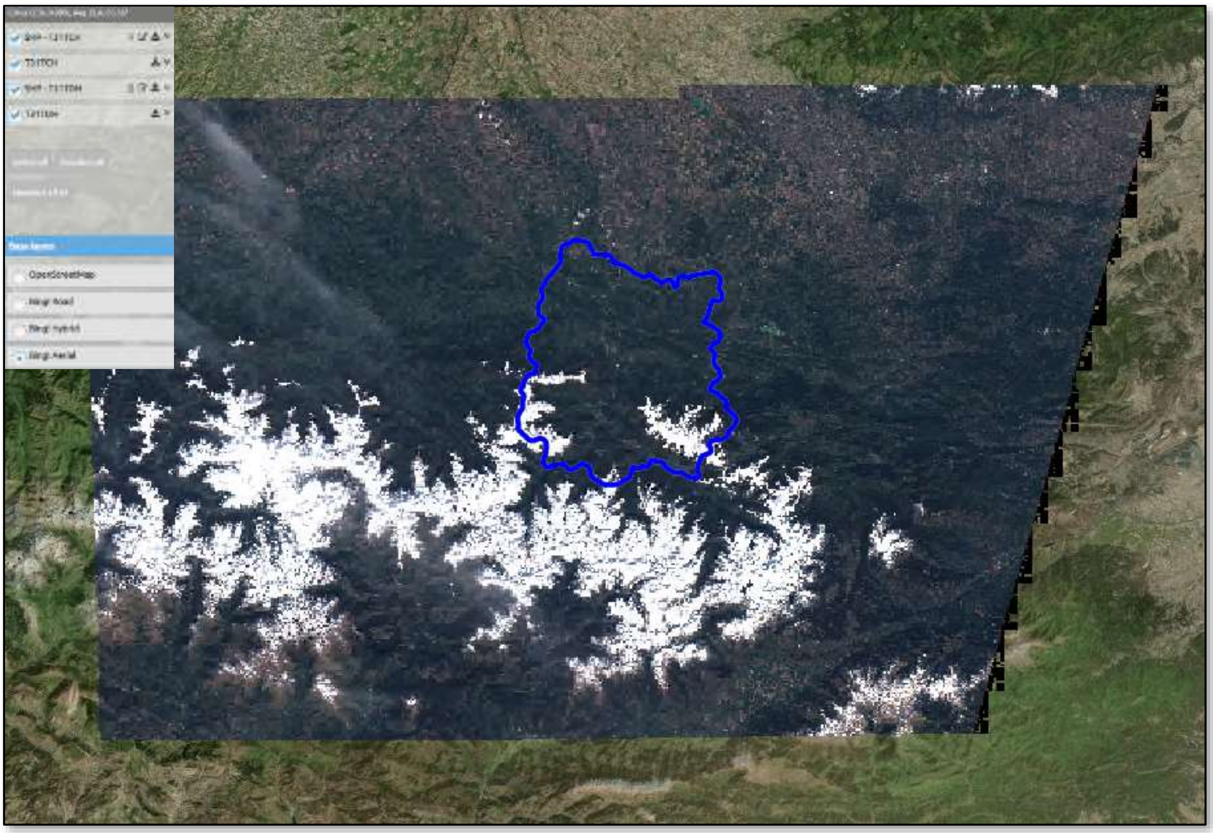


Figure 15 - G4CAP view of S2alert uploaded QL; (source G4CAP)

In conclusion:

Efficient satellite browse image validation routines should be set up by MS in order to initiate delivery of imagery in the predefined optimal time. It is also suggested to have Quality Control Records (QCRs) to be able to follow in detail the image acquisition quality and performance at any time. Good routines for following up availability of Sentinel-2 and other sensors are recommended.

6.5 Delivery, Quality Control (QC), Invoice (3)

The full resolution image that passed the IP's internally defined QA/QC process, arrives to the MS, or its appointed contractor, after a maximum of 6 calendar days. The image delivery is normally via FTP (push or pull), and upon download at MS premises it needs to pass through the MS's Input Data Quality Assessment (IDQA). Images that fail the IDQA will be rejected, and the acquisition is either re-processed by the IP or rejected. The IDQA needs to be done quickly to avoid operational delays. Figure 16 below shows a typical G[4]CAP TAB on an ongoing FTP delivery, and IDQA.

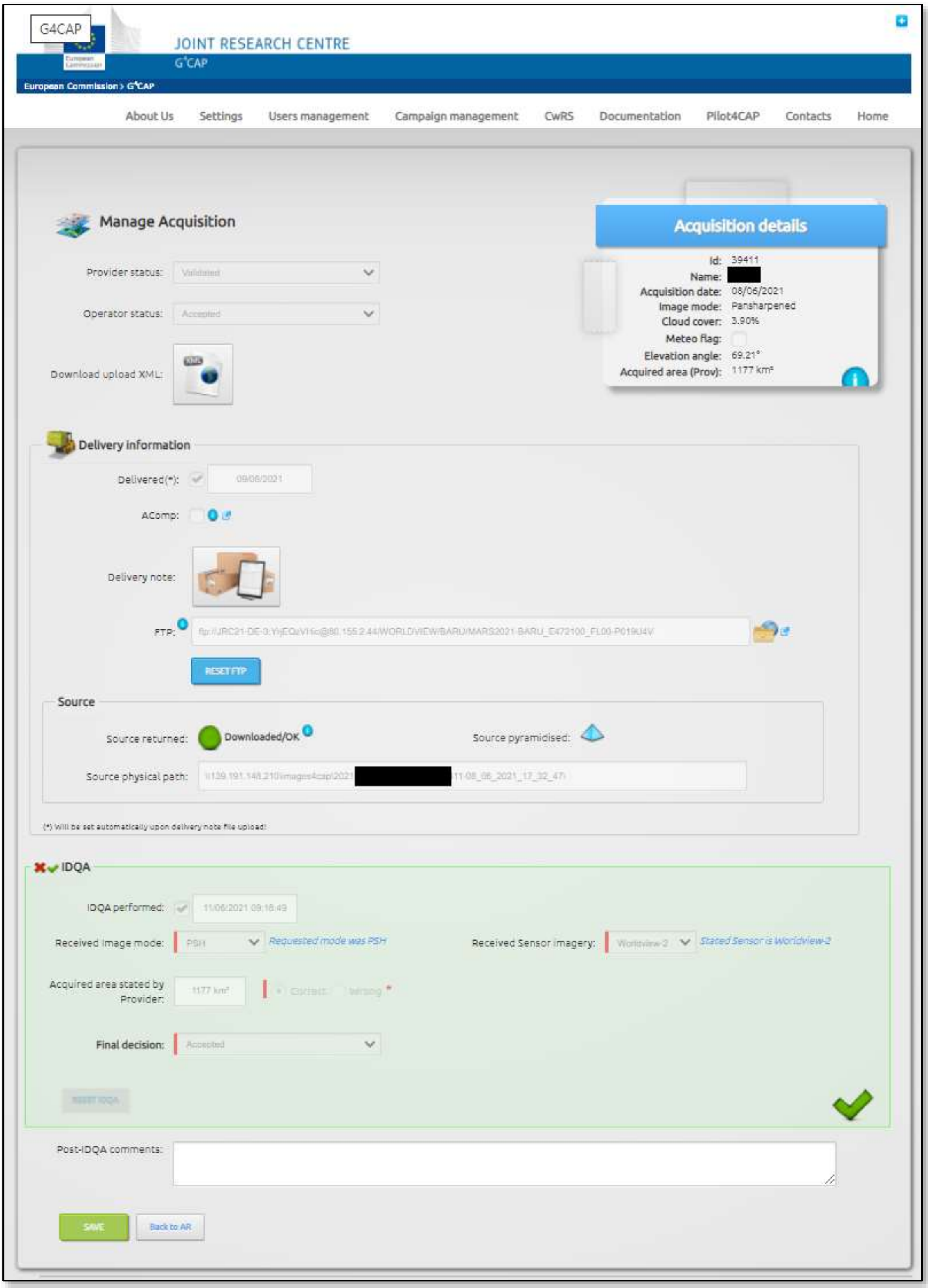


Figure 16 - G4CAP view of a typical ongoing acquisition delivery, and IDQA; (source G4CAP)

<u>The IPs internal QC includes</u>: assessment of issues such as data integrity, data completeness, cloud cover, haze or thin clouds, cloud shadows, fog, smoke, smog, snow, flares, etc. It also includes assessing the product geometry, radiometry, image characteristics (dropouts, etc.), the production parameters (resampling algorithm, bit depth), etc.

The MS Input Data Quality Assessment (IDQA) includes: a minimum suggested are the below parameters to be checked (Figure 17). After IDQA accept/pass the product is invoiceable (see below Chapter 6.5.1).

CODE	MEANING
DATAREAD	data readability of a source image
GEOMANC	ancillary information to allow ortho-correction (e.g. view angle, orbit RPC, etc.) is present and readable
GEOMGCP	imagery allows GCP placement
CAPIQVIS	image visual quality (haze, contrast, saturation, histogram)
CAPIQCC	cloud on parcel structure

Figure 17 - G^{4}CAP Input Data Quality Assessment (IDQA) parameters; (source G^{4}CAP)

A typical issue of multispectral bands misalignment discovered during IDQA is shown in Figure 18 below. Such issue may be resolved by IP by a re-processing.

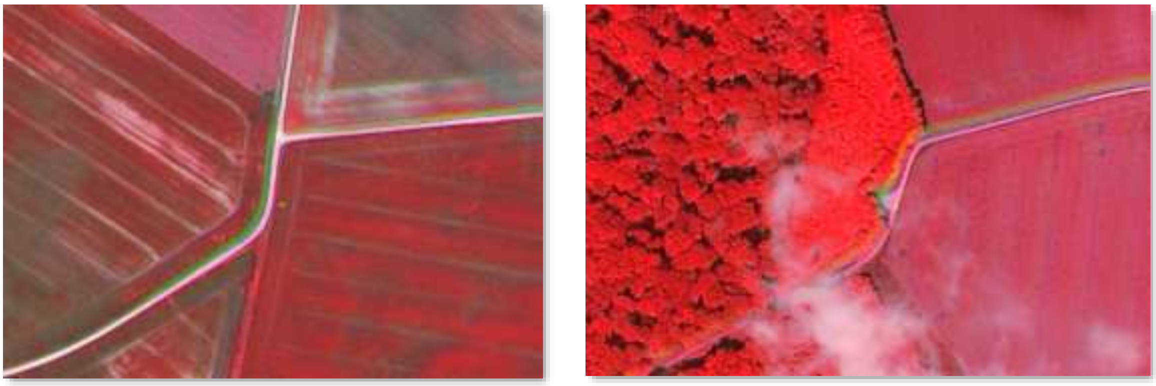


Figure 18 - RED band misalignment detected during image Quality Control (QC).

The EC suggest to set up a very close communication channel with the IPs during image acceptance and image delivery. Understanding the IPs internal Quality Control, setting up a fast and reliable FTP transfer, performing an efficient IDQA, are all guarantees for a successful image acquisition, and efficient image use.

6.5.1 Order/Invoice routines.

Ordering of the satellite imagery by JRC is typically done via framework and specific contracts set up with the IP/IPs (see Chapter 5.1.1). Orders are submitted as soon as the image requests are known, normally in a bulk order and triggered by the start of the acquisition request (AR) at AW opening (see above Figure 14).

After Input Data Quality Assessment (IDQA) completion any image can be invoiced, either by individual image or by grouping the acquired imagery. G^{4}CAP handles a so called 'monthly basket' which is sent to the IP allowing them to prepare a monthly invoice supported by the required reporting (deliverable/s). Figure 19 below shows a typical monthly basket.

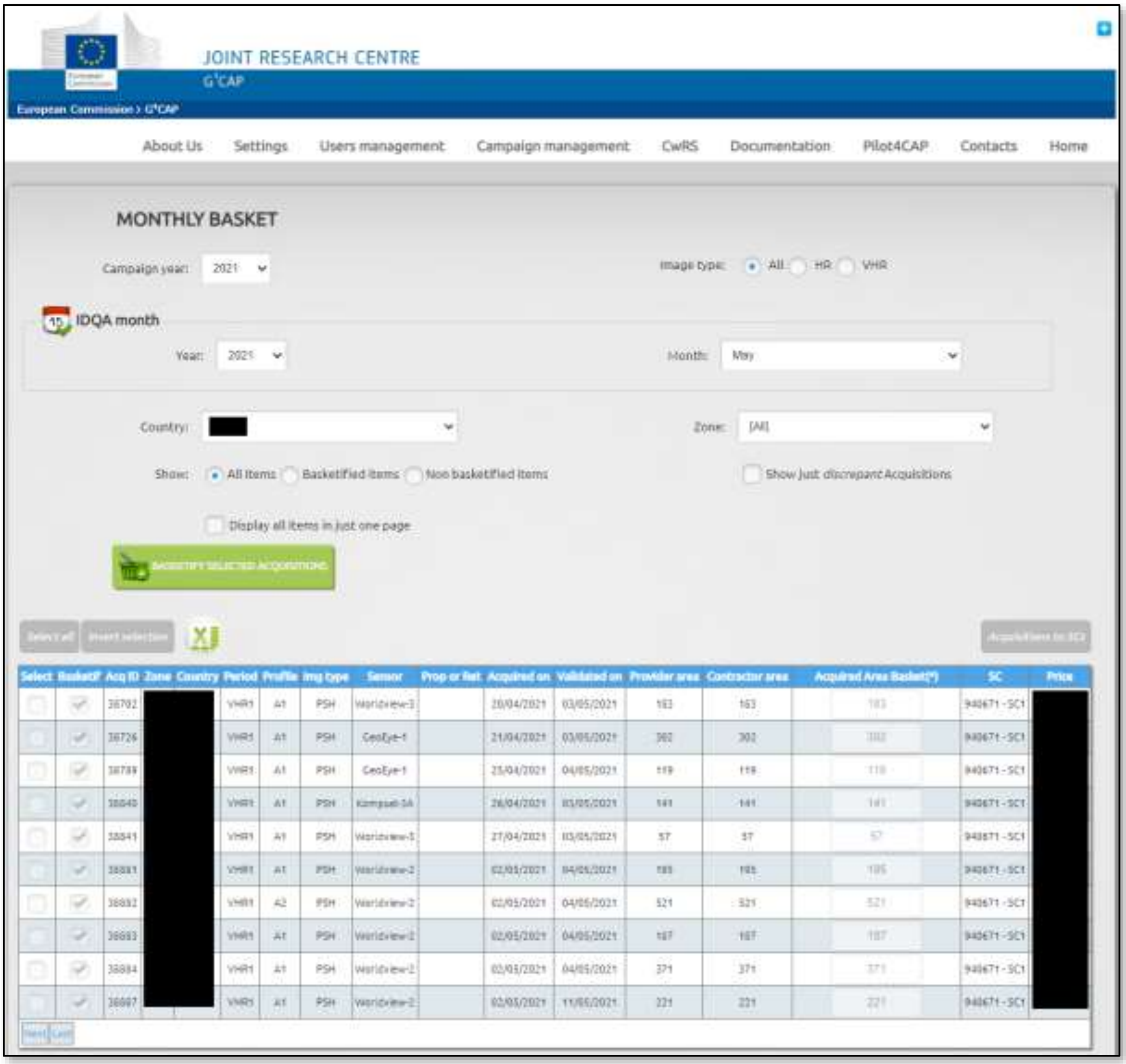


Figure 19 - G4CAP view of a 'monthly basket' ready for invoice by IP; (source G4CAP)

The JRC suggest to MS to closely follow up expenditure within one Campaign and also analyse the overall Campaign expenditure to facilitate forecast, cash flow, and follow-up.

6.6 Data storage and archiving (4)

All satellite datasets collected, and processed should be suitably stored together with their metadata, and routines for Long Term data Preservation (LTDP) need to be set up. The infrastructure is to be managed and maintained by the MS, or its appointed contractor, to allow for any audits, and/or MS re-use of the data.

6.7 Data use and sharing (5)

Each contract should hold licensing conditions governing the 'rights of use' of the imagery purchased, either by accepting the IP's proposed End-User License Agreement (EULA) [IP example in ref x], or by setting up ad-hoc licensing [JRC example in ref xi]. The latter involves a considerable legal effort but has allowed the COM to govern an efficient 'rights of use' policy. There is a need to consider data privacy and personal information governed by the EU legal framework of the General Data Protection Regulation (GDPR) [ref xii] in force since

May 2018. Digital data, including images, specifically created for controls purposes have a fair likelihood to be classified as personal data.

Data storage should be long term, should allow for data re-use conformal to Licensing Conditions, and should not enable any disclosure of 'personal information'.

6.8 Other – miscellaneous

6.8.1 Keeping statistics (of image acquisition and of OTSCs results)

It is good practice to produce and keep statistics (Figure 10) of both the campaigns image acquisition and of the CwRS results at final diagnosis level to facilitate analysis and improve methodologies efficiency and/or efficacy:

- e.g. statistics on image success, image use, and methods etc. (e.g. no. of zones, AWs, average AOI area, methods, profiles, modes, CC, elevation angles, sensor performances, providers performances, and feasibility accuracies and proposals' goodness etc.)
- e.g. details regarding applications (no. of applications, applications by scheme, by controls method, results at application level, group, and parcel level etc.).

6.8.2 Miscellaneous; consulting, IT services, technology watch …

The JRC reminds that a sound management of all above operations linked with the CwRS is of importance, and suitable choices of whether internal or outsourced IT systems and IT services, or other consulting services need to be made carefully by the MS.

MSs are also advised to do the necessary technological survey to seek for the adaptation, improvement of their methods (e.g. introduction of micro satellites constellation data, sampling and image acquisition based on unmanned aerial vehicles (UAVs), Remotely-piloted aircraft systems (RPAS), or High Altitude Platform Systems (HAPS) …).

7 Conclusions, Recommendations and way forwards

7.1 Conclusions and Recommendations

With the entry into force of the new CAP regulation in 2023 the legal basis for EU financed satellite imagery for the CAP checks as of Reg. (EU) No 1306/2013 (§.6b, §.21) and its relative Implementing Reg. (EU) No. 908/2014 (§ 26.3) will not be in force any longer. This document serves as a guideline for the MSs which decide to continue On-the-Spot-Checks (OTSCs) like methods after this date and set up an individual management of this process.

The key consequences are:

- Any MS that continues with CwRS shall from their 2023 years CAP checks:
    - Finance satellite imagery for the checks;
    - Set up procedures and relative management of the OTSC process.
- The currently provided COM Guidance documentation such as the CTS, or the Image Specifications will lose their official status and no longer be updated. Each MS will be responsible for definition, management, and assurance that its checks methods, and image choices, are adequate and effective (i.e. producing the intended or expected result) for their CAP checks.
- Each MS is from 2023 responsible for setting up the procurement of any required services (aerial/satellite image acquisition, OTSC diagnosis, etc.) to perform their checks

The main recommendations are:

- MS are suggested to carefully coordinate all financial, contractual, and image collection workflow in order to be ready for the necessary CwRS activities.
- MS must plan the budget timely and appropriately for (1) the satellite imagery needed for the controls and (2) the subcontracting of the image preparation, OTSCs diagnosis, etc.
- The image supply contracts set up by the MS must clearly define objectives, and contractual thresholds. As an example the COM defines the main one to be: “a minimum of 95% success rate of image supply on time, and according to specifications”. The MS needs moreover to control the supply and related services by use of efficient Quality Control Records (QCRs).
- The MS are responsible for the definition of the image requirements. The currently adopted solution by the COM with sensor independent profiles is strongly recommended. They should constitute a main element of the technical specification for the image provision contract.
- The image requests procedure may suitably divided in two steps where the first gives a price indication for the MS CwRS imagery, while the second gives detailed acquisition parameters necessary for the success of the image acquisition itself, and also a better prediction of the pricing. A price which is paid by the MS Administration and not by the EU.
- MS are suggested to set up a very close communication channel with the IPs for the image acquisition execution: planning, feasibility, acceptance and delivery.
- Data storage should be long term, and allow reasonable access
- MSs are advised to make necessary technological watch to seek for the adaptation, improvement of their methods (e.g. introduction of micro satellites constellation data, sampling and image acquisition based on UAV/RPAS fleets, etc.).

7.2 Way forward

Since the 90’s the JRC has operated technological survey and provided technical support to DG AGRI and MS to help implementing the CAP. In mid-90’s, the so-called CwRS was introduced thanks to the first availability of civil satellite imagery.

The availability of free Sentinel data since 2017/2018 has now made possible the introduction of a new systems (e.g. CbM, AMS) to answer to the community demand for fairer, more modern, and more automated solutions. It should therefore be re-iterated that such methods are largely preferred in order to take advantage of the new technologies that CwRS cannot.

8 References

i. The wiki cap URL in general contains reference material; Guidance documents, validations methods and JRC Common Technical Specifications (CTS) for the On-The-Spot Checks (OTSC) and area measurement according to Art. 24, 25, 26, 27, 30, 31, 34, 35, 36, 37, 38, 39, 40, 41 of Regulation (EU) No 809/2014 as amended by Regulation (EU) 2018/746; WikiCAP:
https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Main_Page
https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Guidance_CTS

ii. VHR, HHR Specifications. Require EU Login (contact author); see documentation page:
https://g4cap.jrc.ec.europa.eu/g4cap/

iii. G4CAP manual reference. Requires EU Login (contact author); see documentation page:
https://g4cap.jrc.ec.europa.eu/g4cap/

iv. SPOT Imagery User Guide; Airbus, Defence and Space *intelligence*; (Chapter C.1.2.1 p56, Chapter C.4.1 p 64): https://www.intelligence-airbusds.com/en/8718-user-guides

v. Reference3D is a global, geocoded database developed jointly by Spot Image and the French mapping and survey agency, IGN:
https://www.intelligence-airbusds.com/files/pmedia/public/r469_9_reference3d_product_description_201105.pdf

vi. Digital globe atmospheric compensation, white paper. Available online:
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vii. Best Practice and Quality Checking of Ortho Imagery; JRC Geometry Guidelines:
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viii. FWC – VHR, and HHR Tender specifications sample used by the COM:
https://etendering.ted.europa.eu/document/document-old-versions.html?docId=78157
https://etendering.ted.europa.eu/cft/cft-documents.html?cftId=4150&page=2

ix. FR - EU Financial Regulation - REGULATION (EU, Euratom) 2018/1046 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 July 2018 on the financial rules applicable to the general budget of the Union:
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1046&from=EN

x. Sample commercial licensing conditions (EULA):
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xii. General Data Protection Regulation (GDPR) - REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016, on the protection of natural persons with regard to the processing of personal data and on the free movement of such data:
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xiii. CbM; WikiCAP / DS-CDP-2017-03, DS-CDP-2018-17, DS-CDP-2018-18
https://marswiki.jrc.ec.europa.eu/wikicap/images/c/ce/JRC108353.pdf
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9 Acronyms

Abbreviation	Description
AL	Arable Land
AMS	Area Monitoring System
AOI	Area of Interest
AR	Acquisition Request
ASPRS	American Society for Photogrammetry and Remote Sensing (and Geospatial Information Society)
AW	Acquisition Window
AWS	Amazon Web Services
CAP	Common Agricultural Policy
CAPI	Computer Assisted Photo Interpretation
CbM	Checks by Monitoring
CC	Cloud Cover
CD	Crop diversification
CESTEM	Cubesat-Enabled Spatio-Temporal Enhancement Method
CIAS	Campaign Image Acquisition Statistics module of the Web application G^4CAP
COM	European Commission (EC)
COTS	commercially off-the-shelf
CTS	Common Technical Specifications (OTSCs)
CwRS	Controls with Remote Sensing
DIAS	Copernicus Data and Information Access Services
DN	Digital Number
DRA	dynamic range adjustment
ECA	European Court of Auditors
EFA	Ecological Focus Area
EO	Earth Observation
ESA	European Space Agency
EULA	End-User License Agreement
EU	European Union
FWC	Framework contract
FR	Financial Regulation
G^4CAP	Geomatics for the Common Agricultural Policy (see definition in Chapter 10)
GAEC	Good Agricultural and Environmental Conditions
GDPR	General Data Protection Regulation
GTCAP	Guidance and Tools for CAP implementation

Abbreviation	Description
GSAA	Geo-spatial aid application
GSD	Ground Sampling Distance
HAPS	High Altitude Platform System
HRB AW	HR image with acquisition window lying Between two VHR acquisition windows (e.g. HRB1, HRB2)
HHR	High-High Resolution image
HR	High Resolution image
IDQA	Input Data Quality Assessment
IFOV	Instantaneous Field of View
IP	Image Provider
IR	Image Request
JRC	Joint Research Centre of the EC
L2A	Level-2A (processing level of S2 data)
LC	Land Cover
LPIS QA	Land Parcel Identification System Quality Assurance
LTDP	Long Term Data Preservation;
LUT	Lookup table
MS	Member State
MSP	Multispectral (image)
OTSC	On-The-Spot Checks
PA	(MS or MS Regional) Paying Agency
PAN	Panchromatic
preIR	Campaign pre-Image Requests parameters which are filled in at the beginning of the Campaign in G⁴CAP
postIR	Campaign post-Image Requests, parameters which are filled in at the end of the Campaign in G⁴CAP
QA	Quality Assurance.
QC	Quality Control; aims to detect non-conformities in a product.
QL	Quick Look or down-sampled browse image
RFV	Rapid Field Visit
RP	Reference Parcel
RPAS	Remotely-piloted aircraft system
S1	Sentinel-1 (radar) satellite sensor
S2	Sentinel-2 (optical) satellite sensor
SC	Specific Contract

Abbreviation	Description
SW	Software
UAV	Unmanned aerial vehicle
VHR	Very High Resolution image

10 Definitions

Term	Description
DOVE	Triple-CubeSat miniature satellites built by Planet Labs, Inc., US; see PlanetScope below
G^4CAP	Web-based application used to manage the whole CAP OTSC CwRS Campaign workflow. It is the main communication tool between the CAP checks actors during the campaign, making use of automatic e-mail exchange to synchronize actions between different actors.
GSD	Ground Sampling Distance, the nominal size of one sensor pixel projected onto the imaged surface
PlanetScope	PlanetScope satellite constellation consists of multiple launches of groups of individual cubesats (DOVEs); Constellations: the classic DOVE, the next generation Dove-R, and the SuperDove.
Reference3D	Reference3D is a global, geocoded database developed jointly by Spot Image and the French mapping and survey agency, IGN. It can be used as an accurate source for producing orthoimages 100% automatically. Reference3D comprises three registerable layers of data: - a DTED level 2 DEM - an HRS orthoimage with a resolution of near five metres - a full layer of quality and traceability data, including 2 performance maps

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14 Annexes

14.1 VHR profiles

Image Profile ID	Description	Spatial resolution requirement (*)	Radiometric resolution (**) and spectral bands	Minimum Elevation Angle restriction (***)	Threshold abs. 1-D rmse to be proven in geometry benchmark	Cloud Cover (CC) over AOI	Acquisition programming	Resampling	Remarks	Example of sensors
A1. VHR prime - CwRS [std]	Pan+Multispectral (Bundle)	GSD ≤ 0.75m	PAN	> 58	x,y ≤ 2m	≤ 10%	Priority programming	Sensor dependent	Standard CwRS profile	WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
		GSD ≤ 3m	MSP (at least 4 bands)							
	Pan-sharpened	PAN GSD ≤ 0.75m MSP GSD ≤ 3m	At least 4 bands							
A11. VHR prime - CwRS [VHR+][8]	Pan+Multispectral (Bundle)	GSD ≤ 0.75m	PAN	> 58	x,y ≤ 2m	≤ 10%	Priority programming	0.50m		WV3, WV2, possibly others not benchmarked yet
		GSD ≤ 3m	MSP (at least 8 bands)					2m		
	Pan-sharpened	PAN GSD ≤ 0.75m MSP GSD ≤ 3m	At least 8 bands					0.50m		
A2. VHR prime - [Topographic] [less strict than A5]	Pan+Multispectral (Bundle)	GSD ≤ 0.75m	PAN	See paragraph below on off-nadir/elevation angle restrictions for the A2 profile (see also Appendix 1 to Technical Specifications)	x,y ≤ 2m	≤ 10%	Priority programming	Sensor dependent		WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
		GSD ≤ 3m	MSP (at least 4 bands)							
	Pan-sharpened	PAN GSD ≤ 0.75m MSP GSD ≤ 3m	At least 4 bands							
A3. VHR prime - CwRS [Pan only]	Pan	GSD ≤ 0.75m	PAN	> 58	x,y ≤ 2m	≤ 10%	Priority programming	Sensor dependent		WV3, WV2, GE1, WV1, possibly others not benchmarked yet
A4. VHR prime - CwRS [Stereo]	Pan+Multispectral (Bundle)	GSD ≤ 0.75m	PAN	According to IP specifications	x,y ≤ 2m	≤ 10%	Priority programming	Sensor dependent		WV3, WV2, GE1, possibly others not benchmarked yet
		GSD ≤ 3m	MSP (at least 4 bands)							
	Pan-sharpened	PAN GSD ≤ 0.75m MSP GSD ≤ 3m	At least 4 bands							
A5. VHR prime - CwRS [VHR+ Topographic]	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 67	x,y ≤ 2m	≤ 10%	Priority programming	0.40m		WV3, WV2, GE1, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 4 bands)	> 67				1.60m		
	Pan-sharpened	PAN GSD ≤ 0.50m MSP GSD ≤ 2m	At least 4 bands	> 67				0.40m		
A51. VHR prime - CwRS [VHR+ Topographic][8]	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 67	x,y ≤ 2m	≤ 10%	Priority programming	0.40m		WV3, WV2, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 8 bands)	> 67				1.60m		
	Pan-sharpened	PAN GSD ≤ 0.50 m MSP GSD ≤ 2m	At least 8 bands	> 67				0.40m		

Image Profile ID	Description	Spatial resolution requirement (*)	Radiometric resolution (**) and spectral bands	Minimum Elevation Angle restriction (***)	Threshold abs. 1-D rmse to be proven in geometry benchmark	Cloud Cover (CC) over AOI	Acquisition programming	Resampling	Remarks	Example of sensors
A6. VHR prime - CwRS [VHR_EFA_LF]	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 58	x,y ≤ 1.5m	≤ 10%	Priority programming	0.50m		WV3, WV2, GE1, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 4 bands)					2m		
	Pan-sharpened	PAN GSD ≤ 0.50m MSP GSD ≤ 2m	At least 4 bands					0.50m		
A61. VHR prime - CwRS [VHR_EFA_LF][8]	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 58	x,y ≤ 1.5m	≤ 10%	Priority programming	0.50m		WV3, WV2, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 8 bands)					2m		
	Pan-sharpened	PAN GSD ≤ 0.50m MS GSD ≤ 2m	At least 8 bands					0.50m		
A7. VHR prime - near nadir profile [VHR_NN_50]; LPIS	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 80	x,y ≤ 1.5m	Close to cloud free, haze free, better than ≤ 10%	Image Provider (IP) best programming, when sensor available	0.50m	longer acquisition window: typically March-August; AOI chosen by IP within large areas given by JRC	WV3, WV2, GE1, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 4 bands)	> 80				2m		
	Pan-sharpened	PAN GSD ≤ 0.50m MSP GSD ≤ 2m	At least 4 bands	> 80				0.50m		
A71. VHR prime - near nadir profile [VHR_NN_50]	Pan+Multispectral (Bundle)	GSD ≤ 0.50m	PAN	> 80	x,y ≤ 1.5m	≤ 10%	Priority programming	0.50m		WV3, WV2, GE1, possibly others not benchmarked yet
		GSD ≤ 2m	MSP (at least 4 bands)	> 80				2m		
	Pan-sharpened	PAN GSD ≤ 0.50m MSP GSD ≤ 2m	At least 4 bands	> 80				0.50m		
A8. VHR prime - near nadir profile [VHR_NN_40]; LPIS	Pan+Multispectral (Bundle)	GSD ≤ 0.40m	PAN	> 80	x,y ≤ 1.5m	Close to cloud free, haze free, better than ≤ 10%	Image Provider (IP) best programming, when sensor available	0.40m	longer acquisition window: typically March-August; AOI chosen by IP within large areas given by JRC	WV3, GE1, possibly others not benchmarked yet
		GSD ≤ 1.60m	MSP (at least 4 bands)	> 80				1.60m		
	Pan-sharpened	PAN GSD ≤ 0.40m MSP GSD ≤ 1.6m	At least 4 bands	> 80				0.40m		
A81 VHR prime - near nadir profile [VHR_NN_40]	Pan+Multispectral (Bundle)	GSD ≤ 0.40m	PAN	> 80	x/y ≤ 1.5m	≤ 10%	Priority programming	0.40m		WV3, GE1, possibly others not benchmarked yet
		GSD ≤ 1.60m	MS (at least 4 bands)	> 80				1.60m		
	Pan-sharpened	PAN GSD ≤ 0.40m MSP GSD ≤ 1.6m	At least 4 bands	> 80				0.40m		

Image Profile ID	Description	Spatial resolution requirement (*)	Radiometric resolution (**) and spectral bands	Minimum Elevation Angle restriction (***)	Threshold abs. 1-D rmse to be proven in geometry benchmark	Cloud Cover (CC) over AOI	Acquisition programming	Resampling	Remarks	Example of sensors
B. VHR archive	As any of above	As any of above	As any of above		As any of above	as any of above	Archive	Sensor dependent	Used for archive search for any profile	WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
	As any of above	As any of above	As any of above		As any of above	as any of above	Priority programming	Sensor dependent	Used for re-task for any profile	WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
	As any of above	As any of above	As any of above		As any of above	10% < CC ≤ 30%	Priority programming	Sensor dependent	Proposed for any profile	WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
C. VHR back up	Pan+Multispectral (Bundle)	GSD ≤ 3m	PAN		x,y ≤ 5.0m	≤ 10%	Priority programming	Sensor dependent	Back up for any profile	WV3, WV2, GE1, K3, K3A, possibly others not benchmarked yet
		GSD ≤ 12m	MSP (at least 3 bands)							
	Panchromatic	GSD ≤ 3m	PAN							
	Pan-sharpened	GSD ≤ 3m	At least 3 bands							

(*) GSD in both directions (across track, along track) including the effect of earth curvature should satisfy this criterion

(**) Dynamic range, minimum ≥ 11 bits/pixel

(***) Elevation angle of any uploaded strip of an acquisition should satisfy this criterion

Table 1 - VHR profiles adopted within the CAP CwRS checks

14.2 HHR profiles

Image Profile ID	Description (Image MODE)	Spatial Resolution (*) GSD	Radiometric resolution (**) and minimum spectral bands	abs. 1-D RMSE	Cloud Cover (CC) over AOI	Acquisition programming	Remarks	Example of sensors
F1. HHR prime - CwRS (HHR)	Bundle (PAN plus MSP bands), PSH	GSD ≤ 3m	PAN band plus 4 MSP bands including B, G, R, NIR	x,y ≤ 5m (reachable with off the shelf sw suite and performed by MS Administration or its contractor)	≤ 1% validated (profile F11) ≤ 5% proposed (profile F12) ≤ 20% retained (profile F13) archive (profile F14)	Priority programming (excluding F14)	for PSH mode the GSD of the PAN band is applied for GSD threshold	SPOT 6/7, Deimos-2, etc.
	MSP bands only	GSD ≤ 12m	4 bands including B, G, R, NIR	x,y ≤ 1.5 x GSD (reachable with off the shelf sw suite and performed by MS Administration or its contractor)			for MSP mode the GSD of the MSP band is applied for GSD threshold	SPOT 6/7, Planet Scope, Deimos-2, etc.
F2. HHR prime - CwRS (ORTHO)	Bundle (PAN plus MSP bands), PSH	GSD ≤ 3m	PAN band plus 4 MSP bands including B, G, R, NIR	x,y ≤ 5m (orthocorrected by image provider)	≤ 1% validated (profile F21) ≤ 5% proposed (profile F22) ≤ 20% retained (profile F23) archive (profile F14)	Priority programming (excluding F14)	for PSH mode the GSD of the PAN band is applied for GSD threshold	SPOT 6/7, Deimos-2, etc.
	MSP bands only	GSD ≤ 12m	4 bands including B, G, R, NIR	x,y ≤ 10m (orthocorrected by image provider)			for MSP mode the GSD of the MSP band is applied for GSD threshold	SPOT 6/7, Planet Scope, Deimos-2, etc.

(*) - the maximum GSD is calculated including the effect of the earths curvature

(**) - minimum 8 bits/pixel, preferably 11-12.

Table 2 - HHR Profiles adopted within the CAP CwRS checks

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