# AIUB SPACE SAFETY EXPERT CENTRE VALIDATION AND QUALIFICATION PROCEDURE FOR SENSORS ACQUIRING LIGHT CURVE OBSERVATIONS

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## ABSTRACT

This contribution presents the Validation and Qualification (V&Q) procedure for Light Curve (LC) observations with passive optical sensors. Our primary goal is to present our current vision of the procedure, solicit input and feedback from the community to improve the V&Q process.

## 1 INTRODUCTION

The light curves (LC) play an important role in the study of attitude state and nature of artificial objects in Earth orbit. Such objects cover the entire parameter space from massive defunct satellites to tiny space debris. Apart from the generic space traffic management, the study of attitude motion of specific candidate space debris targets is increasingly becoming important for the active space debris removal missions. Combined analysis of light curves acquired by several observing stations will lead to major enhancement in the knowledge about such objects. Temporal coverage of the data could be improved by avoiding instances of incremental weather affecting particular sensor locations. On the other hand, observing the same object simultaneously with several stations under different geometries sets more stringent constraints on the attitude state. This leads to the necessity of having common standards for light curves data acquisition and comparison. An important milestone in that direction is establishment of a Validation and Qualification (V&Q) procedure for the sensors providing light curves. Since the acquisition of a LC constitutes a more complex parameter space compared to tracking (follow-up) observations, different levels of V&Q are considered. These levels are based on the sensor's capabilities such as flux/magnitude calibration (relative vs. standard), flux limit for object detection (limiting magnitude), orbital regimes, temporal resolution, and spectral coverage. To test these capabilities, the V&Q procedure is relying on observing stellar fields, "standard" objects (geodetic and radar calibration spheres for which LC will be predominantly affected by the geometry of the pass), and objects with well-known/monitored simple light curves. In this contribution we are presenting the current V&Q procedure that is testing the capabilities of the sensors to deliver quality LC data on a timely and efficient manner, utilizing standard formats and techniques. Different levels of V&Q are presented and the possibilities to compare data from sensors with different levels of qualification are briefly outlined. Since we are at the initial stages of utilizing the procedure, we are aiming to present it to the broader community, soliciting discussion and feedback from both sensor operators and potential users of the data users. The main goal is to optimize and improve the V&Q procedure, such that it aptly reflects the sensor capabilities, and the resulting data meets the needs and requirements of the community.

## 2 QUALIFICATION PROCEDURE

The V&Q procedure consists of two parts. During the validation the goal is to ensure that we are able to reliably send planning and retrieve observation data with the sensor. The communication interfaces and data formats are established and one observing night is carried out at the end. If issues that require attention are identified, those could be addressed before the qualification. Three observing nights are planned during the qualification part in order to ensure that the sensor is capable of reliably delivering observations matching the established specifications. The V&Q procedure is outlined below:

1) Point at a star/stellar field and take one hour of data to ensure the stability of the observing system by taking series of exposures with the same exposure time. The results from the measurements of the magnitudes/fluxes from the stars should be identical within the uncertainty of the photometry.

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Ideally for those we could use the Landolt and/or Stetson standards that have Northern, Equatorial and Southern fields, well distributed in RA. Hence, there is a good range of possibilities for any geographical location of the sensor. This observation will be carried out once per night during the entire duration of the V&Q and will test the stability of the sensor photometry in minutes to (tens of) days timescales.

For every night with such data set received, we could also derive the photometry Zero Point (ZP) of the sensor and its stability. Zero Point is a proxy of the sensor sensitivity and how faint objects we could target with the sensor. On the other hand, the ZP stability will also illustrate the ability of the sensor operator to judge on the weather conditions.

We could also use any stellar field by utilizing the Gaia catalog to obtain the stellar magnitudes in the Gaia photometric system.

2) Utilizing the same field take series of exposures with varying exposure time. This will show us how the errors of photometry are evolving for the particular sensor as a function of the stellar flux/magnitude. This measurement we do twice during the V&Q procedure to ensure the validity of the results. Ideally one measurement during the validation and one more at the beginning of the qualification part.

For both measurements outlined above we request that data is acquired with the same detector setup as utilized for the routine photometry observations and that the same calibrations are utilized.

3) Tracking observations in different orbital regimes (LEO/ HEO/GEO) with the following “standard” objects.

## 3 STANDARD OBJECTS

Tracking observations in different orbital regimes LEO/HEO/GEO with the following “standard” objects:

- Radar calibration spheres
- Geodetic spheres
- GPS satellites with well known variability patterns
- GEO satellites with well known light curves

One possibility worth mentioning is to consider using LEDSAT as a standard object.

For future operations, we could consider getting several such objects on different orbits to be used as a potential “standard constellation”.

In such way we are covering both the photometry properties of the system and the ability of the sensor to track objects in a certain orbital regime(s). These are going to be listed in the V&Q document/certificate to be presented to the sensor operator.

If more information is needed, you have suggestions or need sensor V&Q, please contact Peter Pessev.

## 4 SUMMARY AND CONCLUSIONS

The initial steps towards defining and testing a V&Q procedure for passive optical sensors LC observations have been presented. The procedure is going to be extensively tested in near future, utilizing the sensors at the Zimmerwald observatory.