SVOM Science Ground Segment

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Introduction

The Space-based multi-band astronomical Variable Object Monitor (SVOM) is a collaborative mission by China and France to detect, localize, and study of ~60 Gamma Ray Bursts (GRBs) per year. Currently SVOM is being transformed into a time-domain orbital observatory, planned to be launched to a low inclination, low earth orbit in 2021, with a life of 3-5 years.

There are three observing programs for SVOM, the Core Program for GRB observations, the General Program for proposal-driven observation to fill the gaps between GRB observations, and a Target of Opportunity (ToO) Program dedicated to Nominal ToOs (including revisit of GRBs) and Exceptional ToOs.

SVOM has four on-board instruments to detect GRBs and to follow-up within minutes autonomously. ÉCLAIRs is dedicated to GRB trigger and localization, having a large field of view (FoV) which can detect GRBs in the hard X-ray energy band with an accuracy of 12 arcmin (provided by CNES, IRAP, CEA, APC); the Gamma Ray Monitor (GRM) measures gamma-ray in high energy band (by IHEP); the Visible Telescope (VT) is an optical telescope dedicated to pin-point (1 arcsec) and follow-up observe (by XIOPM). Micro-Channel X-ray Telescope (MXT) follows-up in soft X-ray band (by CNES, CEA, LAL, UL, MPE).

SVOM has dedicated ground based instruments: the Chinese Ground Follow-up Telescope (C-GFT) with a wavelength range of 400-1000nm and FoV of 26’x26’; the French ground follow-up telescope (F-GFT), 400-1700nm, 25’x25’; and an array of ground wide angle cameras (GWAC), 400-900nm, 5000 Square degrees.

Science Ground Segment

The SVOM Science Ground Segment (SGS) consists of a Chinese Science Center (CSC), a French Science Center (FSC), a Mission Center, a backend Space Science Data Center, a VHF network, C-GFT, F-GFT, GWAC, and Instrument Centers of ÉCLAIRs and MXT with a French Payload Operations Center.

During operations SVOM always points to the anti-solar direction, so that both the spacecraft and the dedicated ground instruments are always ready to slew into position quickly to start follow-ups when ÉCLAIRs detects a GRB in the dark side of the sky (T0).

For the Core Program, at T0 + 22 sec, the alert message is sent to a VHF network, which relays the alert to the FSC in 5 seconds. FSC processes and validates the alert and sends the first alert notices to the VOEvent network, the GCN, and dedicated ground telescopes -- F-GFT, C-GFT and GWAC -- in 5 seconds. In 5 min the GFTs will return position results with 0.5 arcsec accuracy and photometric redshift indicators. GWAC will provide data from T0 - 5 min. Refined measurements are gained both from repeated follow-ups and from analysis of on-board data transmitted via X-band telemetry within several hours.

An On-alert Burst Advocate is responsible for validating the burst, identifying possible untriggered bursts from telemetry data, issuing Notices and Circulars, coordinating follow-ups with external instruments such as large aperture telescopes around the world, assembling data products, and publishing. An on-shift BA and a stand-by BA are ready to step when new GRB happens.

For the SVOM General Program, the PIs issue call for proposal once a year for ÉCLAIRs, VT, MXT, and ground instruments. Observers write and submit proposal with tools supported by the Science Centers. A TAC evaluates, selects and allocates time, and form a one-year Pre-Planned Target (PPT) list. PPTs are executed by the Mission Center, subject to interruption and re-scheduling due to Core and ToO activities. Once observed, data are processed in standard pipeline and released to observer.

The SVOM ToO Program plans to observe one ToO per day initially and ramp up to up to 5 per day in later stages of the mission. There are several types of ToOs: Nominal ones are observed in 48 hours, including GRB revisits, pre-planned, and unplanned General Program targets; Exceptional and Multi-messenger ToOs are selected once a month on average, and are observed in 24 hours after trigger, for exceptional astrophysical events and search for EM counterpart to multi-messenger alerts, respectively.

The overall development approach is designed in recognition of significant risk in SGS readiness if a “Water Fall” development scheme is adopted, where a full functional system only come into existence at the end of Satellite/System development. To mitigate the risk, the Science Centers are to follow an iterative approach to develop in Phase B, C, D, respectively.  The goal is that by the time of launch, the SGS will be highly mature. It will have been used by its users for years using simulation data, ground instrument data, and payload testing data during development phases. There will be a smooth, seamless transition between mission phases.

Conclusion and remarks

SVOM ground segment is being designed to offer guaranteed follow-up capabilities, quick reaction time, a flexible architecture, and essential infrastructure to meet the requirements of SVOM observation programs as time-domain astronomy enters a rapidly expanding period.

Coordination with the time-domain astronomy community will be needed for SVOM SGS to provide better services, for example, to form a pool of follow-up telescopes implementing a standard interface (data, control, condition) and ready to observe with little human negotiation; put in place automated event brokers/aggregators to provide not only all available data of a given position, but also all scheduled observation of that position in a given time window in near future; to implement a platform to connect BAs, IS/IEs (Instr. Scientists and Experts), proposal observers, and anyone who has observed the target.