Scheduling and Commanding Message Standard usage in telescope tasking activities for NEO and SST; supporting preparation of the observation plans according to standard via NOAS SCM Editor

Artur Białkowski[(1)], Piotr Duźniak[(2)], Toni Santana-Ros[(3)], Andrzej Adamczyk[(4)], Grzegorz Taberski[(5)], Karolina Pieniowska[(6)], Joanna Baksalary[(7)], Rafał Renk[(8)], Julia Matysiak[(9)], Tomasz Kwiatkowski[(10)], Krzysztof Kamiński[(11)], Przemysław Bartczak[(12)]

[(1)] *GMV, Hrubieszowska 2, 01-209 Warsaw, Poland, Email: abialkowski@gmv.com*
[(2)] *GMV, Hrubieszowska 2, 01-209 Warsaw, Poland, Email: pduzniak@gmv.com*
[(3)] *ESOC, Robert-Bosch-Str. 5, D-64293 Darmstadt, Germany, Email: toni.santana-ros@esa.int*
[(4)] *ITTI, Rubież 46, 61-612 Poznań, Poland, Email: andrzej.adamczyk@itti.com.pl*
[(5)] *ITTI, Rubież 46, 61-612 Poznań, Poland, Email: grzegorz.taberski@itti.com.pl*
[(6)] *ITTI, Rubież 46, 61-612 Poznań, Poland, Email: karolina.pieniowska@itti.com.pl*
[(7)] *Adam Mickiewicz University, Faculty of Physics, Poznań, Poland, Email: joanna.baksalary@amu.edu.pl*
[(8)] *Adam Mickiewicz University, Faculty of Physics, Poznań, Poland, Email: rafal.renk@amu.edu.pl*
[(9)] *Astronomical Observatory of Adam Mickiewicz University, Poznań, Email: julmat2@amu.edu.pl*
[(10)] *Astronomical Observatory of Adam Mickiewicz University, Poznań, Email: tkastr@vesta.astro.amu.edu.pl*
[(11)] *Astronomical Observatory of Adam Mickiewicz University, Poznań, Email: kkastr@gmail.com*
[(12)] *Astronomical Observatory of Adam Mickiewicz University, Poznań, Email: przebar@amu.edu.pl*

ABSTRACT

SCM [1], Scheduling and Commanding Message, is a new standard for tasking telescopes for NEO and SST purposes based on XML structure on which one of the commit

tees of CEN/CENELEC's is currently working. The standard itself is still under development, and in this paper a first operational usage is presented as part of three activities for ESA in the scope of NEO and SST.

On the one hand, the P3-NEO-XII activity within the ESA's SSA program is devoted to the development of a so-called NEO Data Processing Chain from raw images from telescopes, particularly the new Fly-eye telescope. On the other hand, the POLTELSST activity within the Polish Incentive Scheme Program is devoted to the qualification of Polish telescopes for SST purposes.

NOAS (NEO and SST Observation Assistant Service) SCM Editor is a desktop application realizing a comprehensive creation of an observational plan, supporting SCM creation.

1 INTRODUCTION

Planning observation tasks and preparation of the observation plan is a common set of tasks performed by observers and owners of the various types of sensors (e.g. telescopes, radars, lasers etc.). In their daily work they use wide range of software applications and standards associated with them. In many cases, people who defines observation tasks are not responsible for performing them in further stage. Because of that, one common standard which defines observation tasks with their constraints and describes the plan to be performed on the particular sensor is needed. During the course of work ESA has proposed one common standard of XML files which could be used to fulfil those two aims. It has been named SCM which stands for "Scheduling and Commanding Message". This document is a standard for NEO&SST observations and includes also specification of constrains under which they should be performed. The standard also allows for commanding tasks for sensors using one common protocol independent of senor provider.

The content of this publication is twofold. The first part describes the set of projects connected with observation of NEO & SST objects and usage of the SCM standard in them. The second part provides an insight into the NOAS SCM Editor which is a software package simplifying preparation of SCM files. Furthermore, an exemplary set of use cases presenting the use of this editor and the proposed further actions have been presented.

2 SCM STANDARD IN NEO&SST RELATED PROJECTS

The following section presents the description of SCM usage in two ESA funded projects.

2.1 P3-NEO-XII data processing chain

The "Scheduling and Commanding Messages" (SCM) specifies a standard format for observing system commanding and scheduling. It consists of following segments:

- Header – general info about message
- Metadata – more detailed info about originator of message, and links to other messages
- Command – observation block used to specify

an action for observatory

- ScheduleRequest – block used to specify observation for a scheduler

The main goal in P3-NEO-XII project is to make messages simple, and give more control to a telescope. Thus ScheduleRequest has been chosen over Command block. The main difference is that Command block specifies absolute times at which telescope should take a picture. This requires to take under consideration telescope-specific nuances (as slew rate) or environmental parameters (moon proximity, weather).

ScheduleRequest allows to specify only object's designator and its ephemerides over scheduled time. Exact timing is not necessary, the epoch can be chosen by observatory according to its knowledge about current conditions. Due to that, with improving infrastructure and new functionalities, an observatory can boost probability of a picture being valid, without any additional customer actions.

SCM Header information contains following tags:

- Creation date: date time of message generation
- Originator: this tag allows receiver to recognize from where message comes from, in this project it is marked as "SSA P3-NEO-XII"
- Target system: Identificator of observatory which shall conduct observations
- Mode: specifies whether the message is a direct input for control computer, or for a scheduler. In NEO project it is "request" mode, which makes the message designed for scheduler computer.
- Overlapping flag: flag to mark whether overlapping with pre-existing plan exists, in the project it is set to "false".
- Message ID: unique string that identifies the message from given operator.
- State: Shows whether observation has been completed (1) or not (0), useful for robotic OS networks, in the project it is set to (0).
- Fail count: number of failed attempts to execute the request, in the project it is set to (0) as it is an original message.

Metadata block is skipped, as it is not needed for the automatic reception.

SCM standard supports special structures and additional blocks that can ease the creation of a message and compress the volume of XML file. In the P3-NEO-XII project, "commonData' block is used. Every segment included there will be repeated in all 'ScheduleRequest" blocks. It is planned to include the camera name tag. Some observatories have common designator, and choice of specific telescope is made by additionally naming a

target camera. Observatory's scheduler will read common data block and attach camera name for every schedule request available. It is designed to include requests for the same camera in a given SCM message.

After the common data block, "ScheduleRequest" blocks follows. Each block provides information about one target object, such as its ephemerides.

P3-NEO-XII system is using images from the NEO Survey Telescope as an input. It processes them to determine the position of all discovered asteroids and submits the data to the Minor Planet Centre. Special emphasis is given to potentially new NEOs. (Near Earth Object – any small Solar System Body which orbit is in Earth proximity)

Whenever a new NEO is detected and confirmed by an operator, a follow-up observation is scheduled.

Upon new asteroid confirmation, OrbitCalculator, a P3-NEO-XII project's subsystem, is responsible for calculating the ephemerides for re-observation and attaching them to SCM message.

Calculations are based on a statistical approach, where only sky coordinates at given epoch can be calculated. Initially, the message was designed for Orbital Elements submission. Thanks to SCM's flexibility, object's information could be changed. Instead of orbital parameters, list of Right Ascension, Declination, Date Time values is included in the SCM.

The scheduling computer of an observatory is responsible for proper execution of a task. It is interpreting the schedule request, and generating commands for a telescope with exact observation timing and pointing. The only information available is a set of points on a sky where asteroid is foreseen to be. Time separation between them can be changed by the operator. The scheduling computer shall interpolate that data and create continuous function of time, so not only "sidereal" observation can be executed, but also "ephemerides". Using the interpolated function, the scheduler is creating commands to keep telescope's FOV centered at object during exposure. The type of tracking can be requested by the user and is set in "trackRate" segment.

Time constraint, when the telescope is meant to take a picture, is not strict. A photo is requested to be taken during local night time. It is up to scheduler to choose the best epoch, based on weather forecast, light conditions etc. It is a good approach, as often the telescope has up-to-date data and is aware of all nuances that can affect measurement. In P3-NEO-XII project, time constraints are spanned over the night, but can be changed by the

operator when requested."dateTimeConstraint" block is used.

Target designator is obtained from other parts of the system, where it is tied to its images. The type of target is set to "NEO". Target's type has an effect on origin that is chosen for coordinate system. In case of NEO and orbital parameters, it would be the center of the Sun. In current implementation, it has no effect on pointing coordinates – they are by default topocentric EME2000.

Finally, the Schedule request contains following segments:

- Target segment: Object information provided
    - Target type: set to "NEO"
    - Name: provided is temporary designator of an object existing in P3-NEO-XII system
    - Ephemerides
        - Ephemerides are provided as a Ra list, Dec list and DateTime list (in CSV format). Coordinates and times are connected by their order in a list.
    - Track rate type: it can be "sidereal" (during exposure star background is not moving) or "ephemerides" (camera is following the object). In a project it can be chosen by user.
    - Constraints: define additional conditions that scheduler have to meet.
        - Date Time Start / Date Time End: these are the start and end epochs of schedule. These are set to cover most of a night, so scheduler has more space to select the right epoch for observation.

Once all parameters are prepared, they are written to Java objects and serialized to XML. It is then passed to other part of system, which is responsible for sending the message to the correct recipient. All executions from NEO confirmation to XML sending happen automatically.

Thanks to the standardized approach, every telescope implementing the SCM standard shall be able to digest SCM messages generated by NEO Data Processing Chain. The 'Scheduling" block allows to offset observatory's technical details from customer.

Table 1 SCM message example generated by P3-NEO-XII system

```
<?xml version="1.0" encoding="UTF-8"?>
<SCM xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:noNamespaceSchemaLocation="http://sanaregistry.org/r/
ndmxml/ndmxml-1.0-master.xsd" id="ESA_SCM" version="1.0">
    <header>
```

```
        <CREATION_DATE>2018-12-
14T13:05:03.105</CREATION_DATE>
        <ORIGINATOR>SSA P3-NEO-XII</ORIGINATOR>
        <TARGET_SYSTEM>target-system</TARGET_SYSTEM>
        <MODE>request</MODE>
        <OVERLAPPING_FLAG>false</OVERLAPPING_FLAG>
        <MESSAGE_ID>message-id</MESSAGE_ID>
        <STATE>0</STATE>
        <FAIL_COUNT>0</FAIL_COUNT>
    </header>
    <commonData>
        <camera>
            <NAME>camera-name</NAME>
        </camera>
    </commonData>
    <scheduleRequest>
        <target>
            <TARGET_TYPE>NEO</TARGET_TYPE>
            <NAME>target1</NAME>
            <ephemerides>
                <raDecList>
                    <RA>5.729578,8.594367,11.459156</RA>
                    <DEC>8.594367,11.459156,14.323945</DEC>
                    <DATE_TIME>2018-12-12T10:00:00.000,2018-12-
12T10:10:00.000,2018-12-12T10:20:00.000</DATE_TIME>
                </raDecList>
            </ephemerides>
            <trackRate>
                <TRACK_RATE_TYPE>ephemerides</TRACK_RATE_T
YPE>
            </trackRate>
        </target>
        <constraints>
            <dateTimeConstraint>
                <DATE_TIME_START>2011-12-
03T10:15:30.000</DATE_TIME_START>
                <DATE_TIME_END>2011-12-
03T12:15:30.000</DATE_TIME_END>
            </dateTimeConstraint>
        </constraints>
    </scheduleRequest>
    <scheduleRequest>
        <target>
            <TARGET_TYPE>NEO</TARGET_TYPE>
            <NAME>target2</NAME>
            <ephemerides>
                <raDecList>
                    <RA>-5.729578,-8.594367,-11.459156</RA>
                    <DEC>8.594367,11.459156,14.323945</DEC>
                    <DATE_TIME>2018-12-12T10:00:00.000,2018-12-
12T10:10:00.000,2018-12-12T10:20:00.000</DATE_TIME>
                </raDecList>
            </ephemerides>
            <trackRate>
                <TRACK_RATE_TYPE>ephemerides</TRACK_RATE_T
YPE>
            </trackRate>
        </target>
        <constraints>
            <dateTimeConstraint>
                <DATE_TIME_START>2011-12-
03T10:15:30.000</DATE_TIME_START>
                <DATE_TIME_END>2011-12-
03T12:15:30.000</DATE_TIME_END>
            </dateTimeConstraint>
        </constraints>
    </scheduleRequest>
</SCM>
```

2.2 POLTELSST

In the POLTELSST project – Qualification of the Polish telescopes for Space Surveillance and tracking (SST)

purposes, SCM is used as optical sensors scheduling standard.

POLTELSST project has a goal to qualify a number of Polish telescopes in order to connect them to EUSST network. Telescopes are performing test observations, and basing on provided photometric and astrometric data, biases and accuracy are measured. There are 2 campaigns conducted, where second campaign is designated for final validation, after any errors from first one are corrected.

Because telescopes are operated by different companies, their interfaces vary. Thus SCM standard is a good solution to unify the message exchange.

Each telescope has to observe specific objects. The plan contains GPS satellites as reference objects with well-known positons for bias calculation, geostationary satellites for orbits calculation, and few more with correct brightness for photometric data analysis.

The task to generate a tracking plan for each telescope is handled by GMV's planning and tasking application. Because telescopes haven't got yet their scheduling computers prepared, receiving SCM "Schedule" requests will not work as intended by SCM standard. SCMs are received by custom infrastructure created in each telescope's facility, and the effort of tasking is shifted to customer. Thus observation plan is pre-processed, where measurement is scheduled only at times of greatest observability. Observatory parameters are ingested by the planning and tasking application, and observation windows are prepared, taking under consideration Moon position, angle with horizon, angle with Sun, etc. The planning and tasking software produces several slots, where each slot is a 15-minutes period where the best observability is available for a given object. Slots are distributed in a way that each object will have a chance to be observed during a night. Within those 15 minutes, 10 observations (photos) shall be conducted by the telescope. Information is being sent as "SheduleRequest", where each slot is one block.
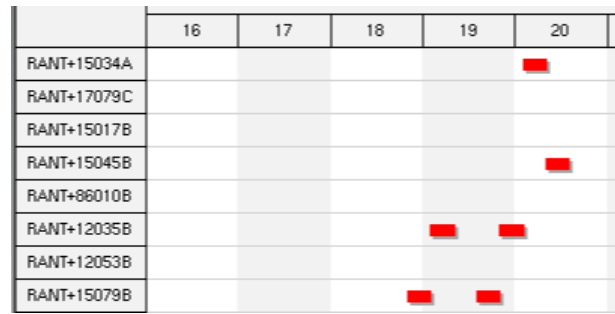

Figure 1 Generated observability slots in POLTELSST project

The planning and tasking software generates output files that have to be translated to SCM XML file.

One observation night in POLTELSST has tracking and survey slots. For each night two SCM files are prepared – one for tracking and one for survey.

During survey, telescope shall observe part of a sky at 2 epochs in a night, where then detection of objects will be conducted. Surveys have separate construct in SCM message, and they are being sent as separate files. SCM standard contains fields for predefined survey plans that are scanning the sky in different ways. For POLTELSST the option of custom plan has been chosen and the specify survey strategy to follow was decided with telescope operators separately beforehand.

The header in SCM messages differs from the one in P3-NEO-XII project in few places:

- Target system is specified as "POLTELSST". Because messages are not received by scheduler computer, this customization has been allowed for the project purposes. The exact telescope name is carried by camera "NAME" tag. It has been confirmed by observatories operators.
- commonData block contains camera name and target type designator. One SCM is always prepared for the same telescope and "SST" object.

A few tags inside scheduleRequest are common for tracking and survey operations. Those are BLOCK_ID, TARGET_TYPE and constraints – all described below.

Each tracking SCM file contains more than one ScheduleRequest tag. Each tag is identified by its unique BLOCK_ID. In case of the POLTELSST project, the BLOCK_ID is an id generated by the planning and tasking software. This approach help us to identify potential problems. In both actions, the TARGET_TYPE is SST, copied during interpretation from "commonData" block. For tracking observations this tag also contains:

- Object name (target/NAME) which keeps observed object ID and Cospar or Norad number.
- The ephemerides which are provided in CCSDS OEM format. The OEM type and relative path to file is defined (SCM and OEM files are downloaded by telescope from the same ftp folder).
- constrains – both time and exposure – time constrains are the slots for tracking (exact start and end time). Exposure constrain contains, as was agreed internally in the consortium, the minimum exposures number equally separated in the time slot (usually value is 10).

Survey SCM also uses scheduleRequest with minor modifications. Ephemerides are not needed, and object ID is unnecessary. Besides above mentioned common tags, in survey is one more tag SURVEY_STRATEGY_TYPE to define a survey strategy.

Table 2 Survey strategy additional tag

```
<surveyStrategy>
<SURVEY_STRATEGY_TYPE>4</SURVEY_STRATEGY_TYPE>
</surveyStrategy>
```

Also there are some use changes in the constraints tag. For survey operations dateTimeConstraint tag contains the time boundaries for the whole survey period – in our case two slots for 2 hours. During this time the sensors should perform the survey strategy which is code in the SURVEY_STRATEGY_TYPE tag. This tag contains the integer value defining the strategy. In POLTELSST type "4" is in use, what means "other strategy". In the scope of this project the sensors are qualified for SST purposes including survey. To fulfil the requirements we defined the special simple strategy for survey. The strategy for survey was agreed with the sensors' owners individually. This solution lets to customize the options to verify survey capabilities.

In total, POLTELSST generated 140 tracking messages and 140 survey messages in first campaign that were successfully received by observatory facilities.

Table 3 SCM tracking message in POLTELSST

```
<?xml version="1.0" encoding="UTF-8"?>
<SCM xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://sanaregistry.org/r/ndmxml/n
dmxml-1.0-master.xsd" id="ESA_SCM" version="1.0">
    <header>
      <CREATION_DATE>2018-12-
04T16:43:26.224</CREATION_DATE>
      <ORIGINATOR>GMV</ORIGINATOR>
      <TARGET_SYSTEM>POLTELSST</TARGET_SYSTEM>
```

```
      <MODE>request</MODE>
      <OVERLAPPING_FLAG>false</OVERLAPPING_FLAG>
      <MESSAGE_ID>RANT-20183381643260</MESSAGE_ID>
      <STATE>0</STATE>
      <FAIL_COUNT>0</FAIL_COUNT>
   </header>
   <commonData>
      <camera>
        <NAME>RANT</NAME>
      </camera>
      <target>
        <TARGET_TYPE>SST</TARGET_TYPE>
      </target>
   </commonData>
   <scheduleRequest>
      <metadata>
        <BLOCK_ID>RANT-000013</BLOCK_ID>
      </metadata>
      <target>
        <NAME>15079B</NAME>
        <ephemerides>
           <EPHEMERIDES_TYPE>OEM</EPHEMERIDES_TYPE>
<URI>./20181204T090334_15079B_S20181204T165000_E20181205
T170000.oem</URI>
        </ephemerides>
      </target>
      <constraints>
        <dateTimeConstraint>
           <DATE_TIME_START>2018-12-
04T18:50:00.000</DATE_TIME_START>
           <DATE_TIME_END>2018-12-
04T19:05:00.000</DATE_TIME_END>
        </dateTimeConstraint>
        <exposureConstraint>
           <EXPOSURE_COUNT>10</EXPOSURE_COUNT>
        </exposureConstraint>
      </constraints>
   </scheduleRequest>
   <scheduleRequest>
      <metadata>
        <BLOCK_ID>RANT-000014</BLOCK_ID>
      </metadata>
      <target>
        <NAME>12035B</NAME>
        <ephemerides>
           <EPHEMERIDES_TYPE>OEM</EPHEMERIDES_TYPE>
<URI>./20181204T090333_12035B_S20181204T165000_E20181205
T170000.oem</URI>
        </ephemerides>
      </target>
      <constraints>
        <dateTimeConstraint>
           <DATE_TIME_START>2018-12-
04T19:05:00.000</DATE_TIME_START>
           <DATE_TIME_END>2018-12-
04T19:20:00.000</DATE_TIME_END>
        </dateTimeConstraint>
        <exposureConstraint>
           <EXPOSURE_COUNT>10</EXPOSURE_COUNT>
        </exposureConstraint>
      </constraints>
   </scheduleRequest>
</SCM>
```

3   NOAS SCM EDITOR

3.1   Functionalities

NOAS (NEO and SST Observation Assistant Service) SCM Editor is a desktop application realizing a comprehensive creation of an observational plan.

Observation plans are prepared according to SCM (Scheduling and Commanding Message) standard established and promoted by ESA. Result of this creation is a file containing all necessary information to perform an astronomical observation.

Preparation of an observational plan using NOAS SCM Editor can be realized in one of two ways: simplified path using Wizard and extended path using Editor. Wizard is a creator dedicated for people not experienced in SCM standard. It helps to fill all fields required to prepare a valid observation plan. Another option – manual editing is dedicated for professionals, who knows well SCM format. The result of both ways could be further review and adapt using several views such as:

- Edit View providing a possibility to change previously prepared file and extend it with a new content,
- Graph View which presents on a Gantt chart the observation plan represented by the SCM file,
- Text view displaying the observation plan in a form of XML file compliant with SCM standard.

Besides that, NOAS SCM Editor is supported by the Validator which takes care of correctness of created SCM files by showing what should be done in order to meet the requirements of the SCM standard. Furthermore NOAS SCM Editor is integrated with a set computation libraries which provides a possibility to create an observation plan and assess its feasibility taking into account set of constraints (e.g. time, location, etc.). In particular the following options are supported: GEO-filtering, TOPO-filtering and Scheduling. GEO-filtering rejects objects which are not observable from any place on Earth. TOPO-filtering is considering all necessary astronomical constraints which needs to be met during observation from a certain site. Finally the Scheduling results in observation plan which contains non-overlapping set of observations tasks optionally with an additional requirements considering their execution.

The major functions of NOAS are the following: 1) metadata editing, 2) request editing, 3) request validation, 4) observation scheduling, 5) request translation. Metadata editing provides metadata as dictionaries, indexes and referenced information e.g. SCM scheme file and telescope dedicated XSLT files. A user inputs telescopes' parameters (e.g. type, focal length, aperture, FOV, geographical location) and resulting instrument constraints (e.g. magnitude range). Request editor is to create telescope requests in the SCM format. These requests may contain one or more target objects. A user

indicates objects using their numbers and names and a telescope which the request is addressed to, while other information is filled automatically. A module fills up the lacking data in the request. Request Validator checks the validity of the request as for its format and parameters' constraints. The first stage of validation is based on standard proceeding based on the SCM syntax. The second stage is to check whether given values in the request exceed the parameters' constraints. In case of invalidity the specific feedback will be returned to a user. Observation Scheduling is for suggesting a sub-list of requested target objects to a user. The sub-list is the optimal object sequence of observations and it contains the targets of a good visibility assuming the given observation place and allocated observation time window. Request Translation serves to prepare observations' request for a specific instrument. It translates SCM request to the format or operation protocol of a given telescope controller. The functions were tested by connecting to the 0.7m RBT located in Arizona owned by Astronomical Observatory of Adam Mickiewicz University in Poznan.

NOAS is available for Windows, Linux and Mac OS. The installation of the system is simple and does not require any additional instructions. After launching the application a user can select one from three available options which are: *set workspace* (the workspace where NOAS will save all files), *create new project* (after setting up the workspace, you can create your first project) and *create new file* (creating files with the wizard). A user can also close the window and go directly to the NOAS SCM editor main view.
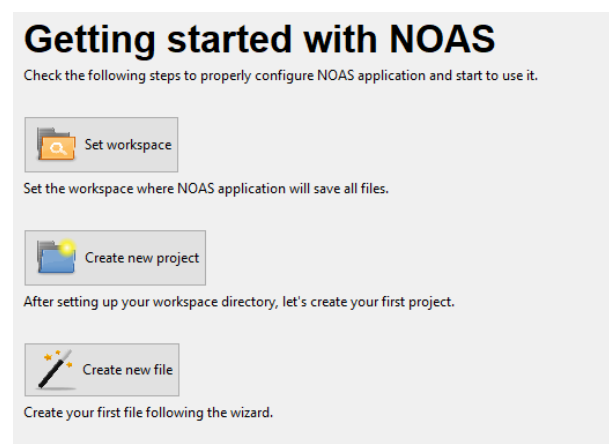

Figure 2 Welcome view

The main view of NOAS SCM Editor is divided into four major parts: 1) *Tool*, 2) *Projects* 3) *Library* and 4) *Editor,* 5) *Processing Section.*
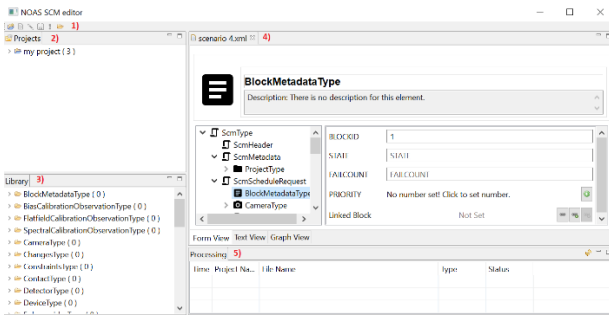
Figure 3 NOAS SCM editor main view

In the upper left corner of the view there is a toolbar with five functionalities. It enables convenient and direct access to creating new project, creating new SCM files, saving the files in workspace and validating selected ones.

In the project tab all the information about the project are stored and displayed. Here, a user can created new projects, add directories and create new SCM files.

Library tab stores parts of SCM files that could be reused in the editor tab. Library contains a set of directories correlated with the SCM file structure elements.

In each directory only one type of element can be stored (e.g. CameraType directory can store only SCM elements containing CameraType objects). A user can add new elements to Library from the Edit tab or create and edit them directly in the Library tab. When adding in the edit tab, a form that has to be filled in appears.

The Editor enables modifying the SCM files or their elements stored in the library. The editor tab is composed of two main parts: 1) a tree like structure which represents the nodes of the SCM file and enables users to manage them (create and delete), 2) a form which represents the content of the selected node and enables editing. The SCM tree enables adding and deleting elements from the structure. It is connected to the library which enables using already added elements or saving often used elements.

A user can switch from Form View to Text View or Graph View. Text view shows a structure of the SCM File displayed in an XML file structure. Graph View presents objects and the duration of each observation task on a timeline.
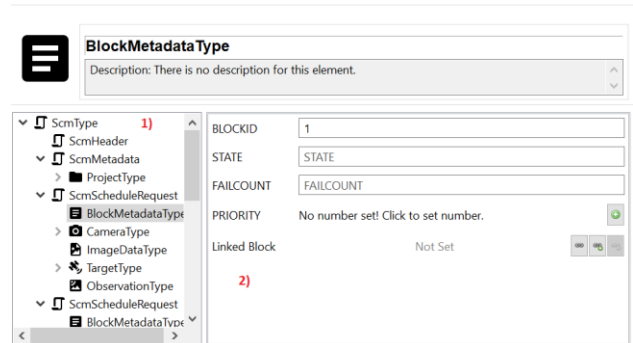

Figure 4 Editor tab

Processing tab indicates the status of files sent. The status displayed can be: received, ready to send, waiting for result, failure. There is a refresh button for updating the information.

3.2 Sample use case scenario

The following part will discuss a sample use case scenario for scheduling a 3x3 survey pattern of unfiltered observation, 60 seconds each, with the pattern repeated cyclically 4 times. The first step will be to create a new SCM File by selecting *New Scm File wizard* in the Projects tab. Then a user has to enter the name of the file and choose observation type from the list (Observation request, GEO-filtering, TOPO-filtering or Scheduling). In this case the Scheduling should be selected.

Figure 5 New Scm File Wizard

In the next step a user can insert his personal details and select if the person is the principal investigator. This step is optional.

The third page shows a list of two object types: SST and NEO. For the needs of the current case, the SST has to be selected. After selecting type of object a user has to select type of action – Survey or Follow-up. In this case it is

Survey. The next step requires the camera details, that are the following: Name, Binding X Factor, Binding Y Factor, Sensitivity, Position Angle, Filter Wheel Name and Filter Type. Then, the sensor parameters should be chosen or a new sensor should be added. The form contains the following Sensor data: Name, LambdaSign, PhiSign, Elevation, Astrometric lim. magnitude, Altitude lower limit, Altitude upper limit, Max non-sid tracking rate, Settling time, Max slewing rate, Meridian flip (yes or no).
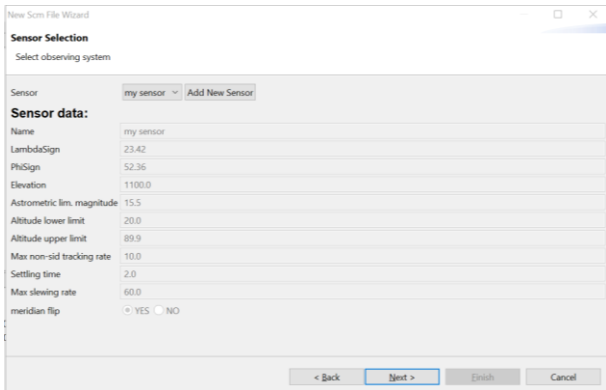

Figure 6 Wizard- Sensor data

The next form is the Observation time – the start and end dates and hours. Then a user has to select the survey strategy (type 1, 2 or 3), which in this case will be survey strategy type 1. Then the information about chosen survey strategy has to be entered.
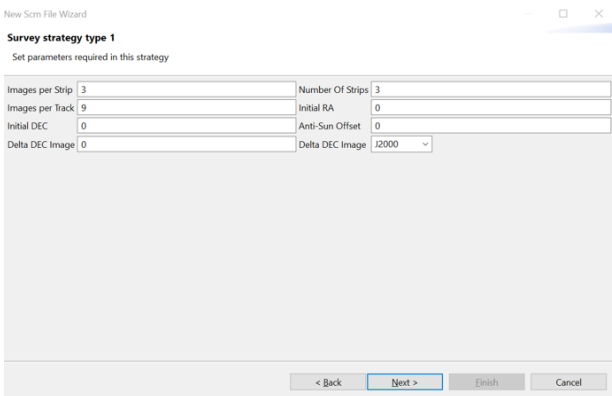

Figure 7 Wizard- Survey strategy details
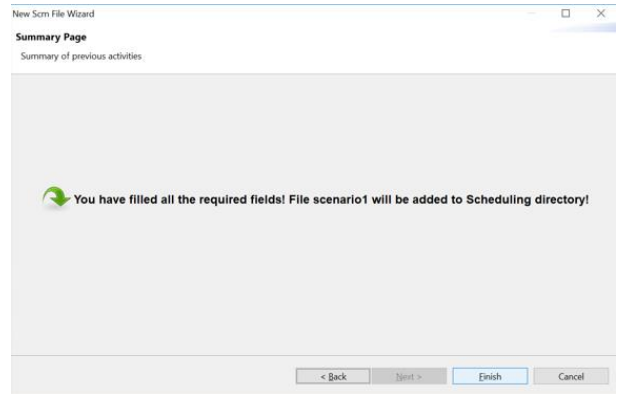
The process ends with Summary Page.

Figure 8 Wizard- Summary page

To set exposure time and exposure count a user should edit exposure in the form of ScmScheduleRequest as shown on the print screen:
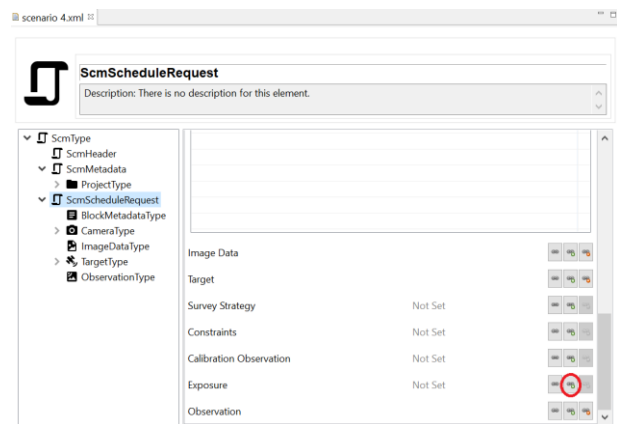

Figure 9 ScmScheduleRequest

In order to set 60 seconds exposure time a user has to enter this value in the *value* field. It is also possible to set the exposure count in the appropriate field.

Figure 10 ExposureType window

Text view for the presented example is shows in the below figure.
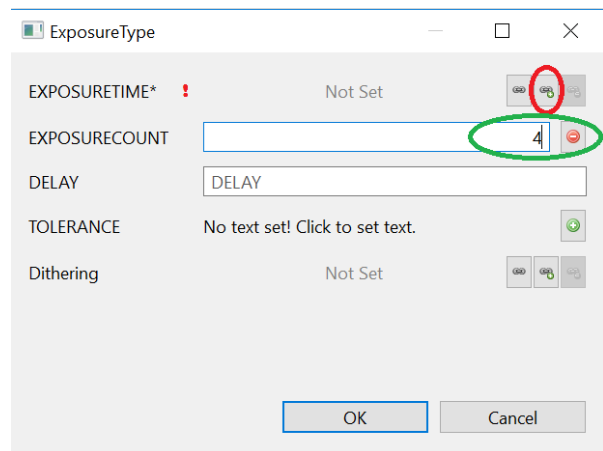
```
scenario 4.xml
<?xml version="1.0" encoding="ASCII"?>
<scm xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
 <header>
  <CREATION_DATE>2018-12-27T12:57:21.207+01:00</CREATION_DATE>
  <MODE>request</MODE>
  <OVERLAPPING_FLAG>false</OVERLAPPING_FLAG>
  <STATE>0</STATE>
  <FAIL_COUNT>0</FAIL_COUNT>
 </header>
 <metadata>
  <project>
   <PROJECT_ID>my project</PROJECT_ID>
   <contact>
    <NAME>John</NAME>
    <USERNAME>Spencer</USERNAME>
    <INSTITUTION xsi:nil="true"/>
    <EMAIL xsi:nil="true"/>
    <TELEPHONE xsi:nil="true"/>
    <FAX xsi:nil="true"/>
    <PRINCIPAL_INVESTIGATOR>true</PRINCIPAL_INVESTIGATOR>
   </contact>
  </project>
 </metadata>

Form View  Text View  Graph View
```

Figure 11 Text view for the presented example

Table 4 SCM XML text file for presented example

```
<?xml version="1.0" encoding="ASCII"?>
<scm xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
 <header>
  <CREATION_DATE>2019-01-08T12:16:25.228+01:00</CREATION_DATE>
  <MODE>request</MODE>
  <OVERLAPPING_FLAG>false</OVERLAPPING_FLAG>
  <STATE>0</STATE>
  <FAIL_COUNT>0</FAIL_COUNT>
 </header>
 <metadata>
  <project>
   <PROJECT_ID>my project</PROJECT_ID>
   <contact>
    <NAME>John</NAME>
    <USERNAME>Spencer</USERNAME>
    <INSTITUTION xsi:nil="true"/>
    <EMAIL xsi:nil="true"/>
    <TELEPHONE xsi:nil="true"/>
    <FAX xsi:nil="true"/>

<PRINCIPAL_INVESTIGATOR>true</PRINCIPAL_INVESTIGATOR>
   </contact>
  </project>
 </metadata>
 <scheduleRequest>
  <blockMetadata>
   <BLOCK_ID>0</BLOCK_ID>
  </blockMetadata>
  <camera>
   <NAME>my camera</NAME>
   <detector>
    <binning>
     <X_FACTOR>1</X_FACTOR>
     <Y_FACTOR>1</Y_FACTOR>
    </binning>
    <SENSITIVITY>1.0</SENSITIVITY>
    <POSITION_ANGLE>23.2</POSITION_ANGLE>
   </detector>
```

```
   <filterWheel>
    <filter>
     <NAME>filter wheel</NAME>
     <FILTER_TYPE>clear</FILTER_TYPE>
    </filter>
   </filterWheel>
  </camera>
  <imageData/>
  <surveyStrategy xsi:type="surveyStrategyVerticalStripType">

<SURVEY_STRATEGY_TYPE>1</SURVEY_STRATEGY_TYPE>
   <IMAGES_PER_TRACK>3</IMAGES_PER_TRACK>
   <IMAGES_PER_STRIP>3</IMAGES_PER_STRIP>
   <NUMBER_OF_STRIPS>3</NUMBER_OF_STRIPS>
   <INITIAL_RA>0.0</INITIAL_RA>
   <INITIAL_DEC>0.0</INITIAL_DEC>
   <DELTA_DEC_IMAGE>0.0</DELTA_DEC_IMAGE>
   <ANTI_SUN_OFFSET>0.0</ANTI_SUN_OFFSET>
   <REFERENCE_FRAME>J2000</REFERENCE_FRAME>
  </surveyStrategy>
  <exposure>
   <EXPOSURE_TIME units="s">60.0</EXPOSURE_TIME>
   <EXPOSURE_COUNT>4</EXPOSURE_COUNT>
  </exposure>
  <observation>
   <DATE_TIME_START>2019-01-08T12:17:19.494+01:00</DATE_TIME_START>
   <DATE_TIME_END>2019-01-09T12:17:19.494+01:00</DATE_TIME_END>
  </observation>
 </scheduleRequest>
</scm>
```

4   CONCLUSION

The SCM establishes a common language for exchanging information on planning, scheduling, and executing observations of celestial objects. In the end this will:

a) Facilitate interoperability and enable consistent warning between data originators who supply celestial observations and the entities or researchers who use it; and

b) Facilitate the automation of observation processes;

SCM is flexible in delivering pointing information for telescope. It covers standarized formats, as for example OEM which has been used in POLTELSST project, and implements its own definition. P3-NEO-XII used the possibility to include orbital elements or topocentric Ra Dec pointing.

The other advantage of SCM standard is a variety of predefined tags, so there are already available features (like changing the origin of Orbital Elements, to provide them for Sun-centric orbits).

Thanks to scheduling request, the task of selecting right observation epoch can be offloaded to observatory. Observation site has to have ability to fulfil the task, but is automated systems this easies the job of ordering measurements.

Furthermore with the support of the dedicated software tools like NOAS SCM Editor this standard becomes more usable for NEO and SST observers.

5 REFERENCES

1. P. Maier (December 2015) Proposal for a Telescope Commanding and Scheduling Data Standard, ESTEC 2015 - https://indico.esa.int/event/124/attachments/711/773/ESA-SSA-NEO-TN-0012_1_1_Telescope_standard_2015-12-22.pdf