Automatic scheduling of satellite passages at the SOS-W

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Since the beginning of the operational phase of the SOS-W, the system is operated with an automated return detection mechanism facilitating the operation in terms of the amount of attention an observer has to spend while running the SLR system. To discharge the operator in terms of workload further, an automated scheduling algorithm for satellite passages has been implemented, enabling for the selection of satellites to observe and keeping track of already observed targets as well as the regular scheduling of calibration runs.
The scheduling algorithm works rapid enough to support the ILRS target list without any problem, can be even extended to hundreds of targets and paves the way for improving the autonomous operation of the SOS-W.

To illustrate why automatic scheduling of satellite passages is a desirable tool, figure 1 shows a two day schedule for currently 78 supported satellite missions for the SOS-W site. Allocating observation time at optimized intervals around rise time, transit time and set time is, besides satellite acquisition, found to be the most tedious job and further on, the benefits of automatic scheduling are:

- Regular scheduling of calibration runs
- Objective target selection
- Keeping track of intended and successful observations
- Being on time in initializing the SLR system for rapid LEO targets
- Making the most out of observing time

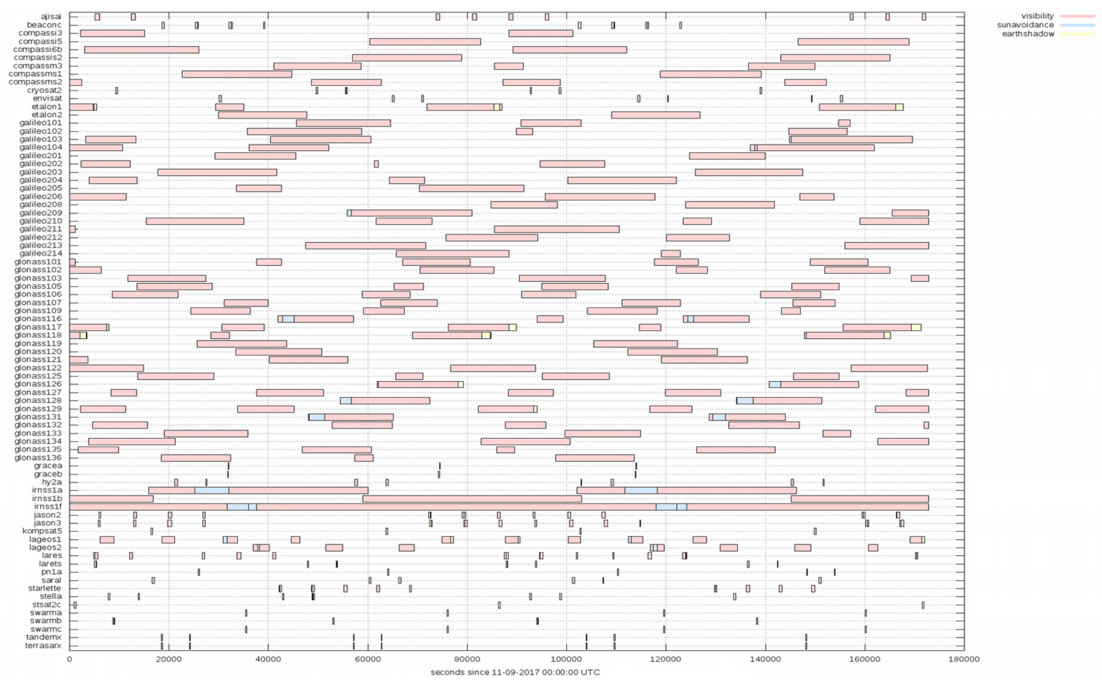

Figure 1: Two day satellite schedule for the SOS-W

For the definition of a scheduling algorithm to be adapted for a specific SLR system, several parameters were chosen to characterize the SLR system capabilities:

- A minimum observation time is defined to reflect pass switching and acquisition times of the SLR system. For the example of the SOS-W it is set to 60 seconds.
- The minimum elevation angle for which observations are scheduled is set to 20 degree
- Sun avoidance area is defined as a solid angle of 20 degree around the current sun position
- Earth shadow encounters are considered by the algorithm in order to schedule light curve measurements if requested.
- A target specific observation time is considered, which is currently defined as the normal point window for each satellite. For geodetic targets 2 normal point windows per observation session are allocated, making up 6 normal point intervals per pass.

It should be pointed out that the system performance in terms of mission coverage is heavily dependent on the minimum observation time, since it limits the time actually available for data acquisition.

In order to furnish an algorithm enabling for the above mentioned properties an empirical approach was chosen based on sorting the visible targets by their maximum speed in azimuth or elevation respectively as a first choice. Once a target is observed it is added to a so called expiration list, where a target specific expiration time is maintained preventing the target to be rescheduled for observation as long as it's expiration time has not vanished. Choosing one third of the specific target passage duration one ends up with observing sessions allocated around the desired pass segments . The complete algorithm can be cast into the following steps:

- If calibration is expired, schedule calibration run.
- Sort visible and not observed targets by speed in azimuth and elevation (whichever is higher). Allocate specific observation time for target with maximum speed.
- Check if intended observation session “shadows” LEO passages. Reduce intended target observation time or select first shadowed LEO passage if remaining observation time is too short.
- Add target to list with expiration time of one third of the passage. Targets in this list are not rescheduled until their expiration time has vanished or no other choice is available.
- Carry out observation.
- Select new target for advanced time.

Applying this algorithm to our example two day visibility schedule above one ends up with a nice distribution of observing sessions as shown in figure 2. The calibration is carried out on regular intervals and most of the GNSS passages are covered with three sessions per pass, except for those situations where the visibility conditions impose a work load too high for a single SLR system. Further illustration of the interleaving capabilities of the algorithm is given in figure 3 with a blow up of the two day schedule showing adjacent Jason2-Jason3 passages, where observing sessions of 1 minute duration are mutually allocated, and also nice interleaving of the Lares and Larets satellites.

In order to quantify the observation time required for the currently 78 satellite missions supported by the ILRS we simply add up the observation time required by each category (geodetic, GNSS, ...) for three segments per pass. Doing so one ends up with a required observing time of 1743 minutes per day, which is clearly exceeding the temporal limit of 1440 minutes per day. Thus for full support of the ILRS missions now and in the future it is well justified to operate two SLR systems on site just to provide the required observation time. On the other hand cloudy sky conditions and air craft safety shut offs are still the main factors corrupting the schedule and mission support giving ways to improve system performance with respect to these issues.

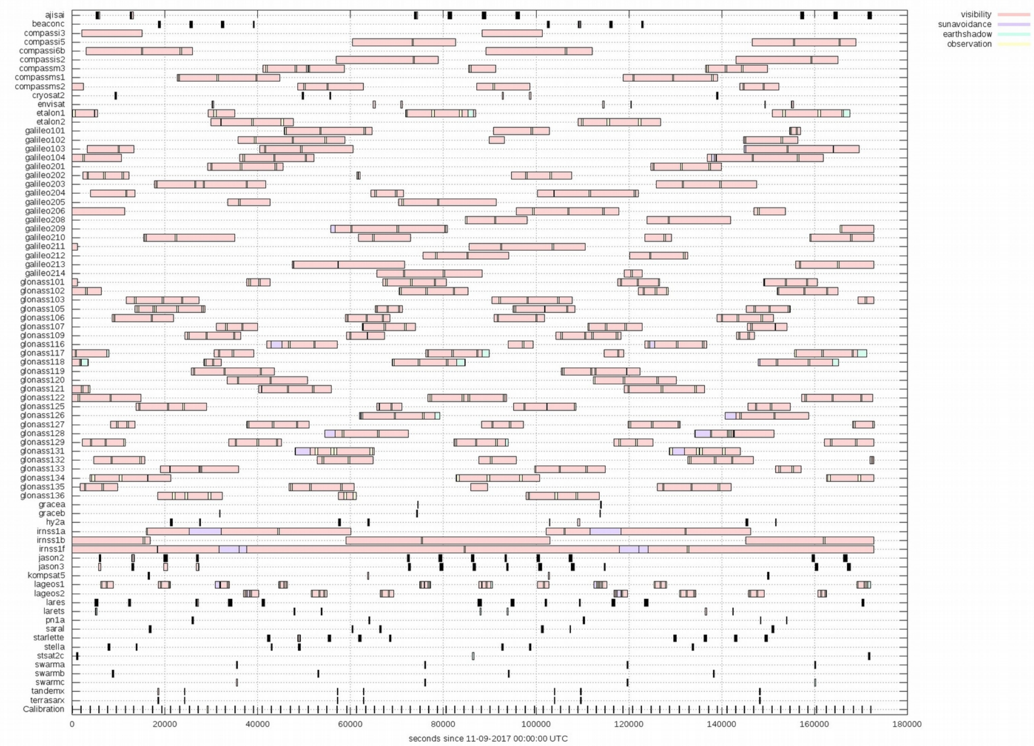

Figure 2: Two day satellite visibility at the SOS-W with allocated observing sessions of 1 minute minimum length.

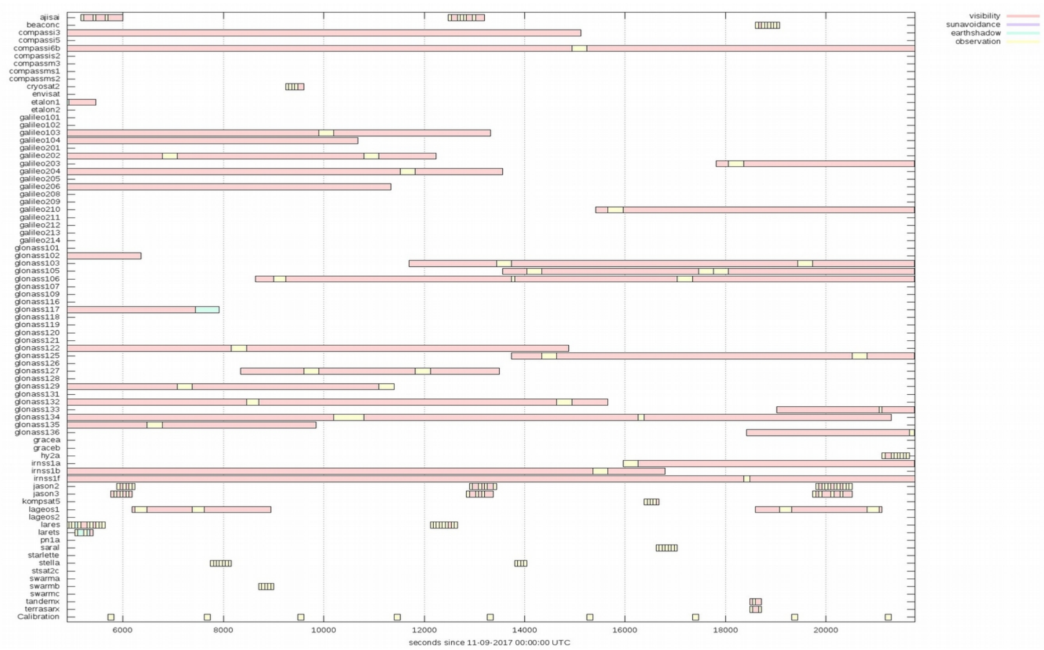

Figure 3: Blow up of the SOS-W visibility chart with nice interleaving for Jason-2 and Jason-3 as well as Lares and Larets.