British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

Multi-satellite tracking at SGF Herstmonceux

Strategies to exploit clear spells

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Advantages and Disadvantages

Each station has to work within these to maximise their science contribution

Herstmonceux

+ historically well supported, system components are relatively new (kHz laser), or refurbished (telescope drives).

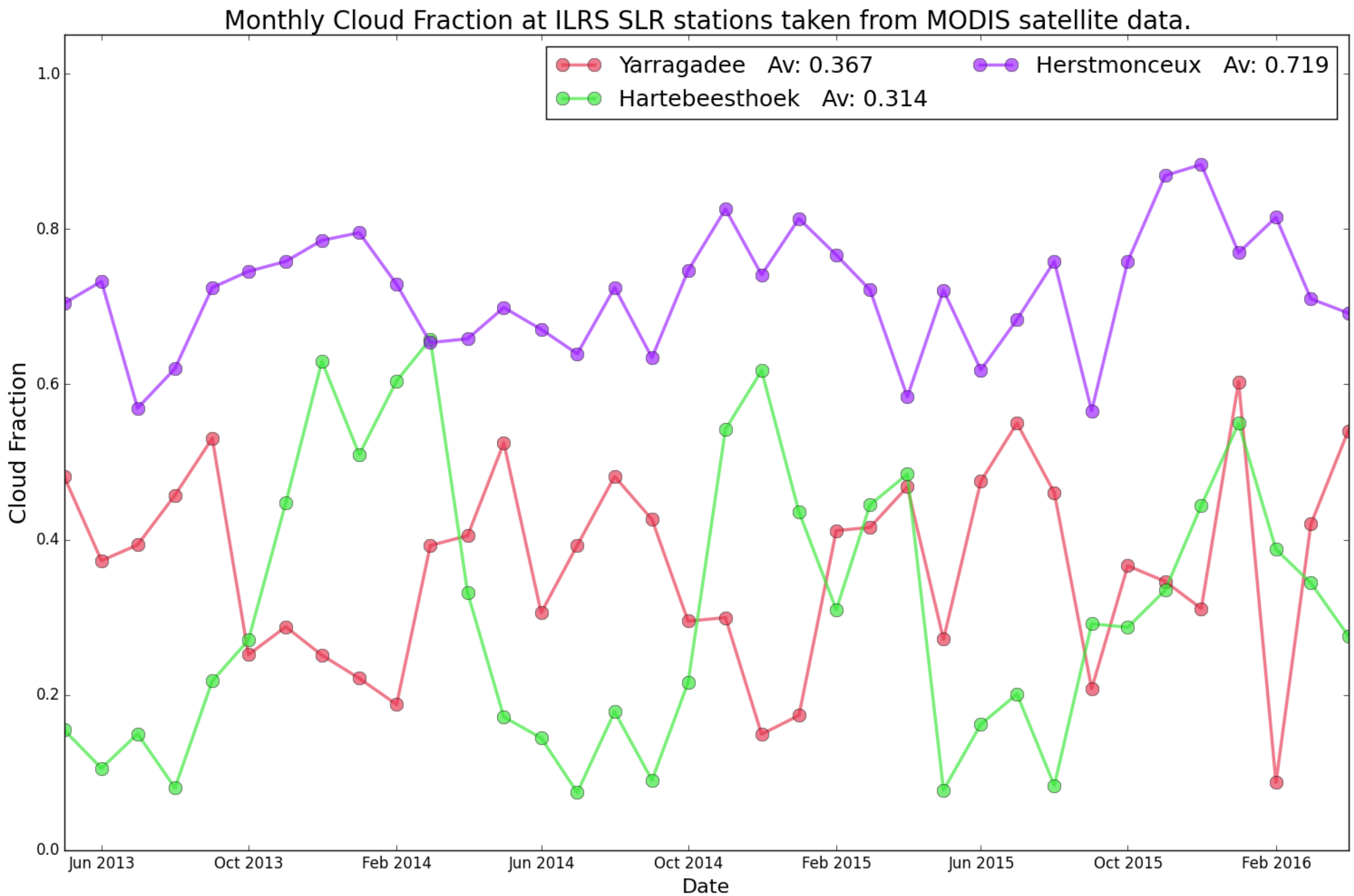
+ highly trained and long standing team of observers.

+ freedom to innovate, improve and build tools to help.

+ able to set our own priorities. Our funding body is content for us to track the full complement of ILRS targets.

- the weather, only 35% of scheduled time is worked.

- funding restrictions limit spending on overtime/observing.



MODIS satellite cloud fraction data for three stations over 3 years.

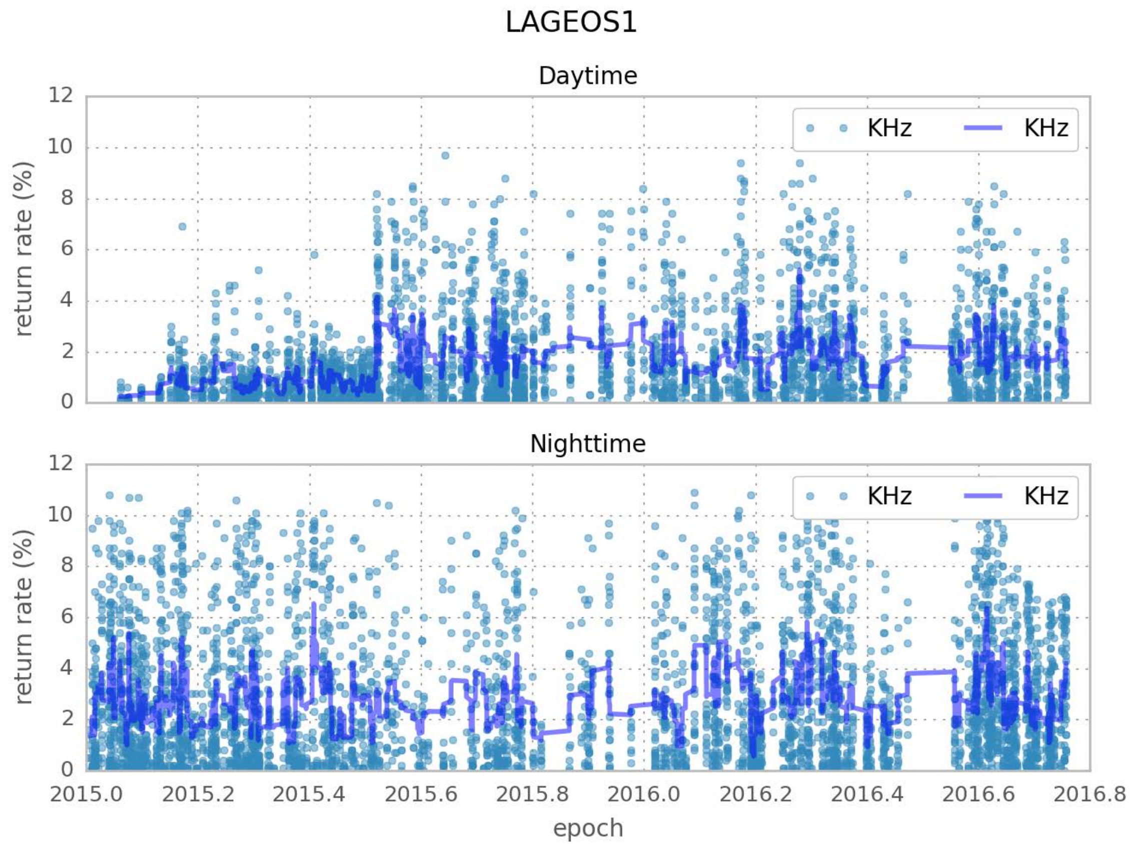
- Herstmonceux is typical northern Europe, Atlantic influence gives few stable periods, clear sky tends to come in short bursts.
- Yarragadee reasonable sky throughout the year.
- Hartebeesthoek has a very clear seasonal effect.

Flexible scheduling process

- A month in advance listing of all LEO and LAGEOS passes from TLE’s, all GNSS tracked but excluded for clarity at this stage.
- Two duties per day are formed by editing this list, keeping in mind satellite priority and available funds.
- Natural gaps in satellite passes used to shorten shifts. Much reduced at weekends.
- Each observer decides if the sky is good enough to work, only attends in clear weather.
- This process means we can exploit short clear spells with high density of priority satellites.

Factors in efficient observing

- The aim is to achieve the highest quantity of high accuracy normal points possible.
- Fast switching between satellites is limited for us by mount slew speed, but needs to be quick enough to interleave Jason satellites for example.
- The current upgraded kHz laser allows less time on each satellite to gain the required number of points. This is particularly important for GNSS tracking.
- Not a new process since kHz, we worked the same way at 10Hz, it’s just faster now.
- Recent daytime blocking filter upgrade, better transmission, large improvement in daytime GNSS.



Lageos1 NP return rate day and night before and after filter upgrade.

Very close to night-time performance post upgrade.

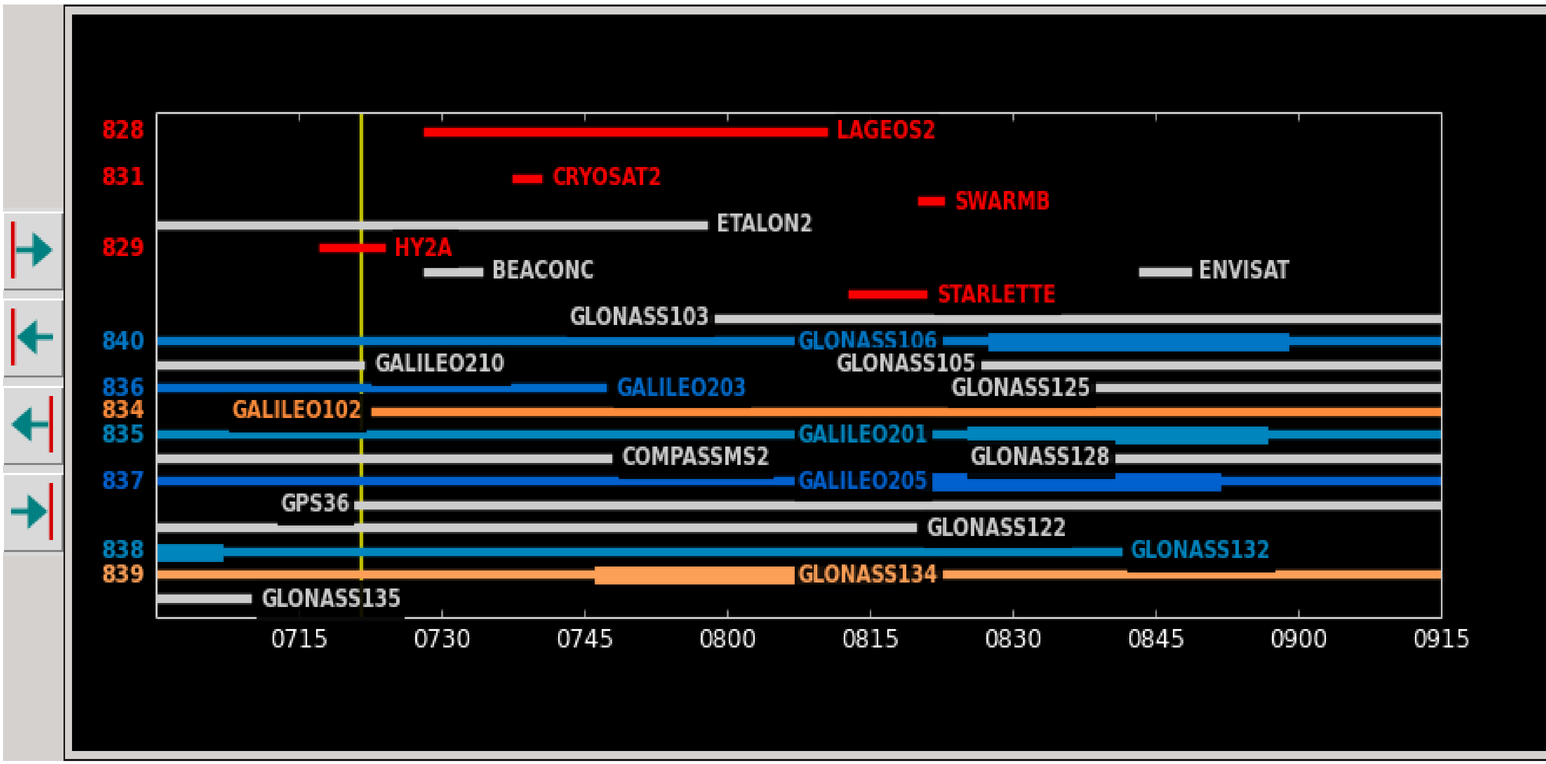
It is the improvement in the ability to track GNSS in daytime that is most significant.

Good example of a change that is focused on improving the most difficult tracking.

Real time display and tools

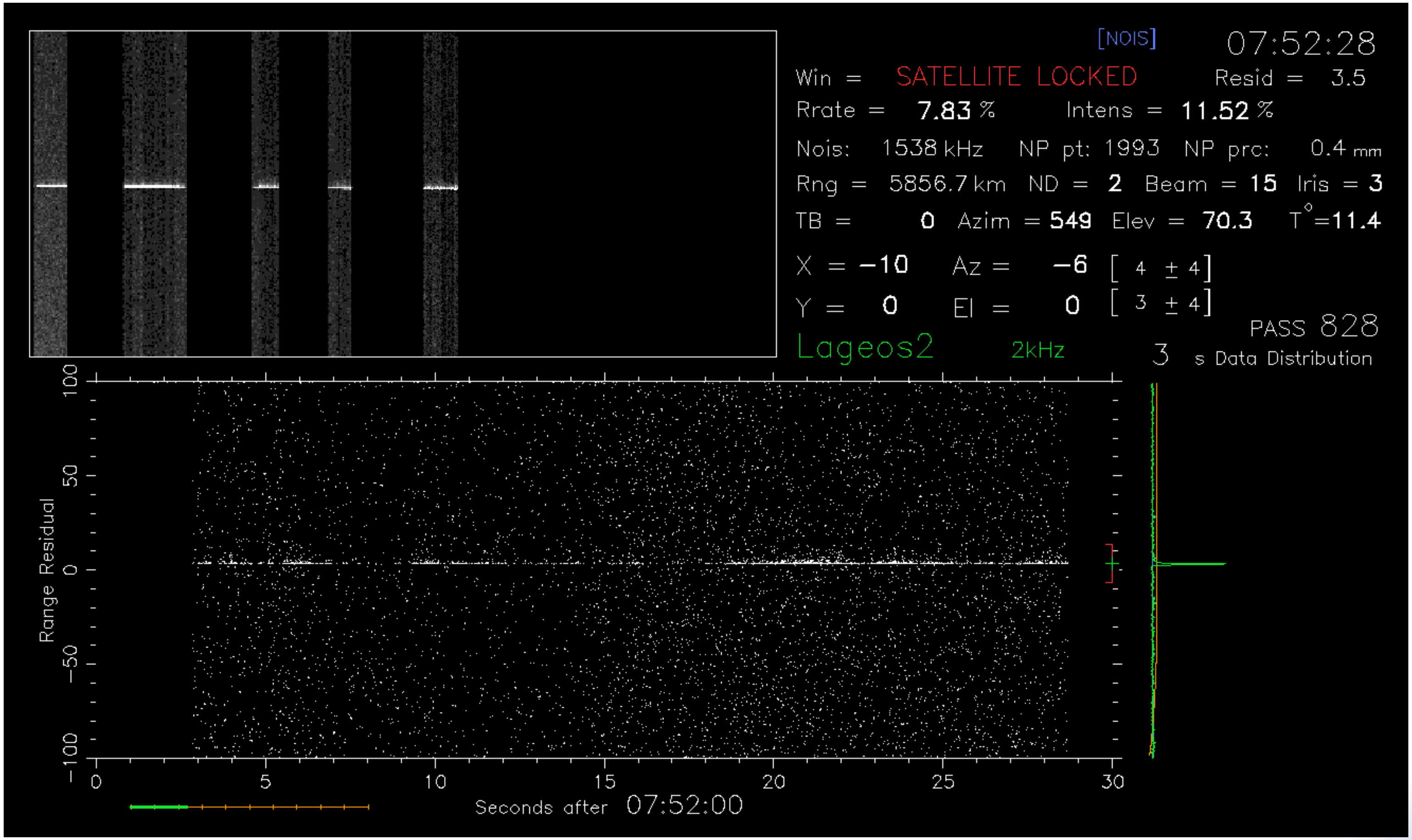
- Observer is given information to help them make good decisions on what to track and when.
- The schedule of upcoming and current passes is available, along with detailed pass listing and information, shadow times for example.
- Audible alarm system is available for warning that a pass is about to start.
- During tracking, the display shows the track (or lack of), and current return rate, pointing offsets etc.
- Number of points in current NP and real time estimate of precision is displayed.
- Observer can move on once 1mm NP precision or 1000 points is obtained.

Real time schedule display.



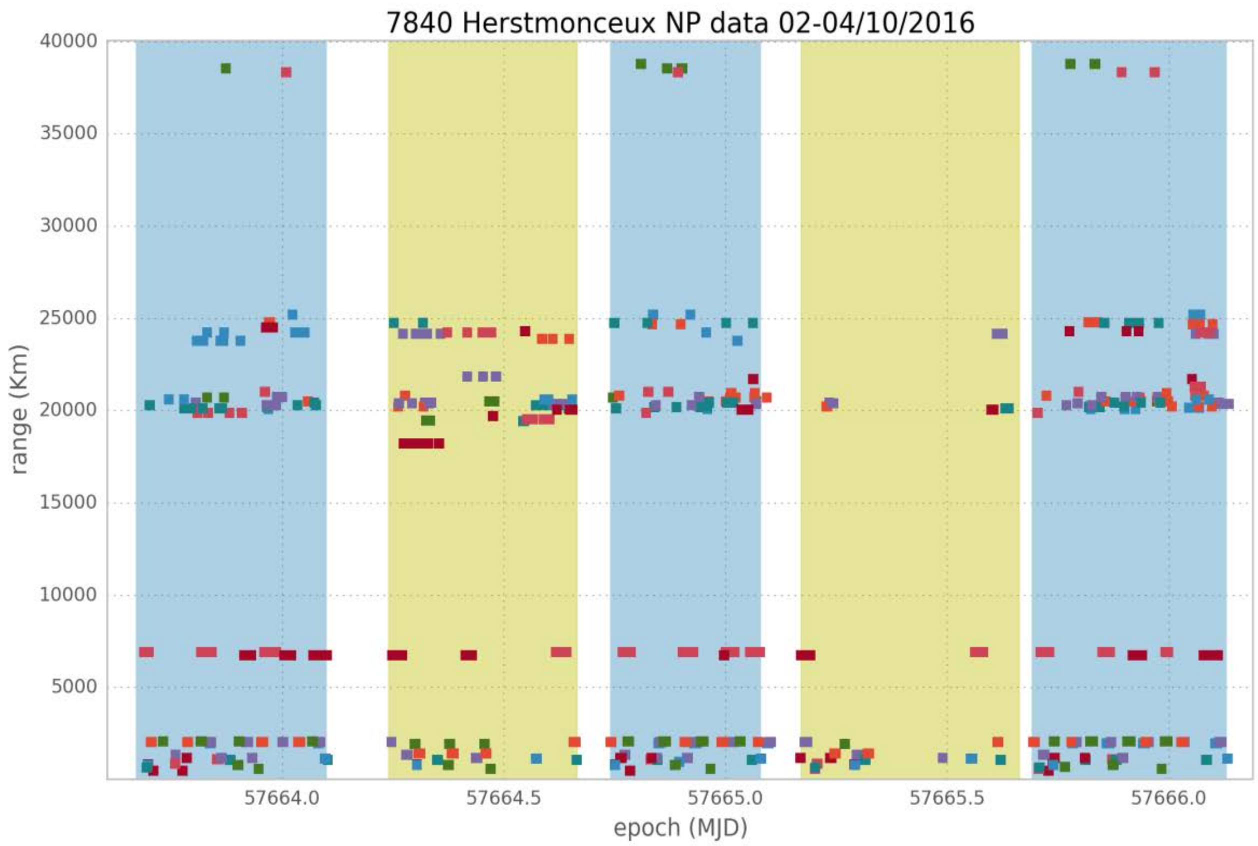
Screenshot of observers information screen. Visual guide aids planning.
Priority order from top to bottom, kept simple, LAGEOS then LEO’s, then GNSS based on number of recent passes.
Different colours have been used effectively here to highlight a more intense tracking requirement.

Real time display



Current points in the NP are shown, along with approximate precision.
At this point we are set to switch to a GNSS satellite.
Good conditions needed for this in daytime, but routine at night.

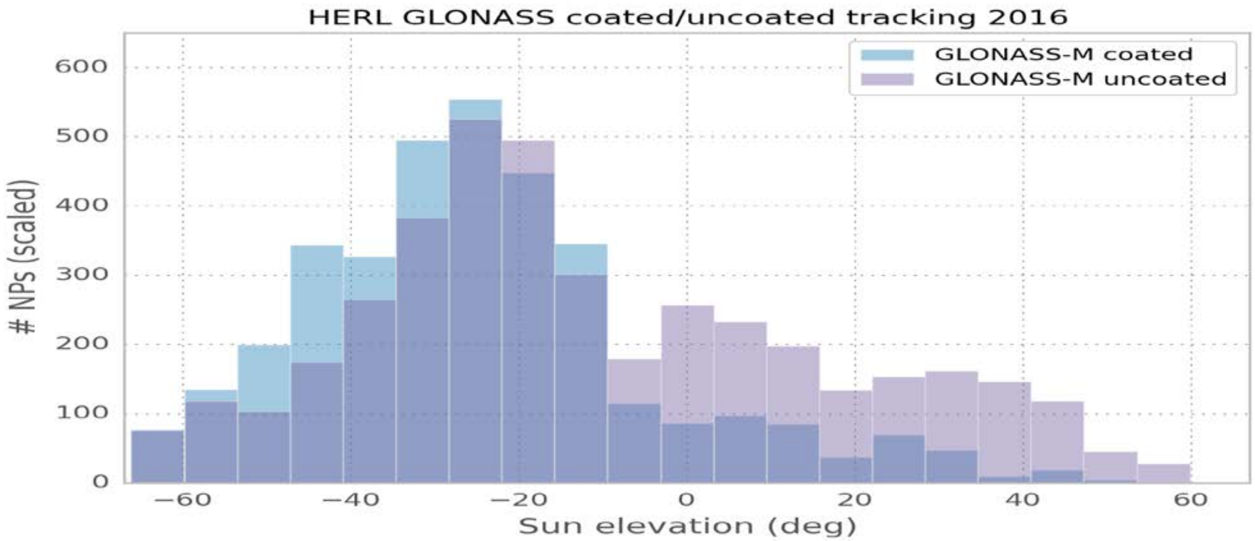
Recent NP data.



NP plotted against satellite mean range for a few days last week.
Night shifts in blue, days in yellow, white gaps unscheduled.
Example of the density of tracking that is possible in good conditions.
GEO range the next challenge for us in daytime.

Importance of a good LRR array

- Solid daytime returns for kHz stations needed.
- Latest uncoated GLONASS arrays offer good performance.
- In contrast to GALILEO where the array size has been reduced for latest satellites.
- Excessive difficultly (failures) reduces observer ambition: there are always other less time wasteful GNSS satellites to attempt.



Increasing numbers of targets, a challenge.

- In particular increasing numbers of GNSS satellites represent a challenge for observing.
- SLR systems are increasingly finding funding routes in non-traditional areas as well, for example debris, SST.
- We currently feel there is capacity still for more satellites, given the capabilities described. But recognise that a limit may be reached.
- This limit entirely dependant on tracking density required.
- Input from mission operators is critical.
- We could observe whole constellations but prioritise within them, for example as in ILRS GNSS campaigns.
- Or only track a subset of satellites.
- Or have flexible scheduling, station by station or network.
- Better to have the ‘problem’ of too much demand.

Thank you.