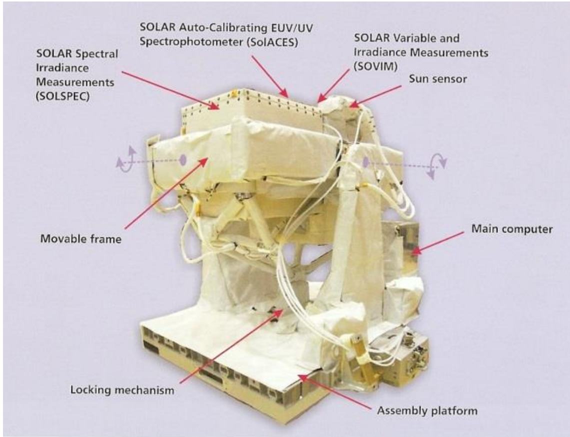
Nine Years of SOLAR Experiment Operations on ISS

B.USOC ISS Experience



On February 15, 2017 ground control in the Belgium User Support Center (B.USOC) switched off the SOLAR experiment package that had been continuously observing the Sun from the International Space Station (ISS) for nine years. SOLAR was delivered with the installation of the Columbus laboratory to the ISS in February 2008. SOLAR was mounted on the Columbus rigid external platform on a “Coarse Pointing Device” (movable frame) and consisted of three instruments, SOVIM, SOLACES and SOLSPEC. [1]

SOLAR has been measuring most of the radiation emitted by our Sun across the electromagnetic spectrum. “Built to run for only 18 months, it was still working as of today– exceeding all expectations” said Astrid Orr, ESA’s project scientist after shut-down and securing the SOLAR instruments after 9 years of continuous operations.

SpaceOps News (SoN) had the opportunity to talk to Astrid Orr (Project Scientist, ESA) and Alice Michel (ISS Operations, B.USOC) about the scientific achievements and B.USOC’s unique ground operations experience.

SoN: What were the overall goals of SOLAR - and why was Columbus the appropriate opportunity?

Astrid Orr: The goals were to obtain the highest possible accurate absolute measurement of the solar irradiance which basically is the determination of the solar constant at different wavelengths and to measure with highest possible precision the variability of the solar irradiance.

During its mission lifetime SOLAR mainly measured the absolute solar broad-band spectral irradiance from 180 nm to 3000 nm, the EUV/UV solar spectral irradiance between 17 nm and 220 nm.

Why Columbus? Columbus/ISS enabled observations from above the atmosphere which is an absolute necessity for studying the Sun because Earth’s atmosphere absorbs or deflects much of the light the Sun emits. As a location in space, ISS/Columbus was perhaps easier to access than developing a dedicated satellite. Initially the scientists were interested in retrieving the payload at the end of the mission in order to verify the calibration on Earth.

Otherwise, the ISS was actually not the best location for a solar observatory, due to Sun visibility constraints and tracking limitations (beta angle geometry).

The launch of Columbus offered a unique opportunity for science payloads readily available to be launched together with Columbus.

SoN: The original duration of the experiment was planned to last 18 months, it finally became 9 years. Had the solar-cycle something to do with it or were the achieved measurements so surprising that new insights were expected by the extensions?

Astrid Orr: The scientists wished the mission could be extended in duration so that the development of solar cycle # 24 could be followed, at least until its maximum (approximately in 2016). The current solar cycle seems to have some unexpected features given its very slow development. One has to go back approximately 100 years to find a similar cycle (solar cycle #13).

Furthermore there are other solar observatories in space taking somewhat similar data. The ISS/SOLAR data were systematically compared with data from other observatories, for calibration purposes. This type of calibration and comparison is interesting to all scientists concerned, in

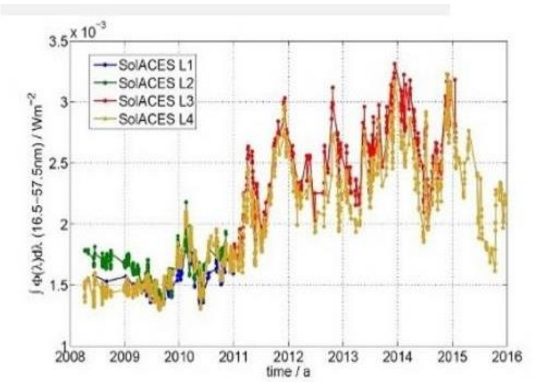
particular if one is trying to achieve “absolute” measurements. So it's nice to keep a mission going while it is delivering unique data.
Finally the data from SOLAR was also used as input for climate modelling. Therefore it was interesting to keep SOLAR operating as long as possible because climate modelling is an on-going activity (you don't just do it once).

SoN: Would the already existing data together with the SOLAR experimental data suggest even more refined experiments to be conducted or is the achieved level of detail sufficient to fulfil the originally established goals?

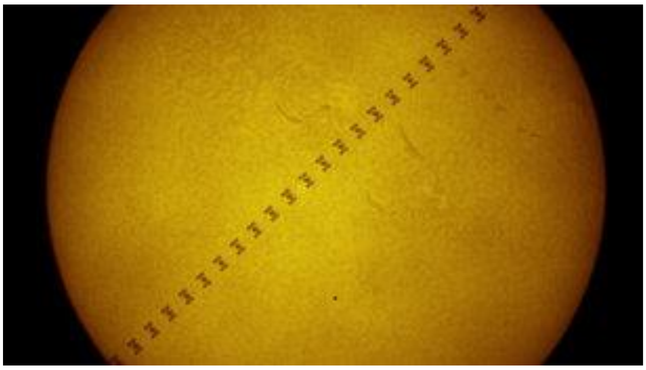
Astrid Orr: The goal was rather to continuously monitor the Sun with high (absolute) accuracy. It was not planned to just take a few selected measurements and then stop. The monitoring needs to be continuous because the Sun is a highly dynamic system and this type of monitoring will have to be continued by other missions. Ideally, for best possible calibration purposes, there should be no time gaps in between missions.

SoN: Did the gathered SOLAR data set reveal any immediate surprises which must definitively be followed up with a follow-on experiment - if yes, how big are the chances for an additional experiment on the ISS?

Astrid Orr: As mentioned above, the current solar cycle seems to have shown some unexpected features. However SOLAR was, of course, not the only mission to observe this.
One can’t really talk about a data set which needs to be followed-up by another experiment or by a new measurements. SOLAR was monitoring the Sun like the other solar observatories currently engaged in Sun observations. The novelty of SOLAR was the level of absolute accuracy that the scientists wished to achieve, and have in part achieved.
I am not sure if an additional solar experiment will be developed for the ISS. As mentioned above, the ISS is perhaps not the ideal platform for a solar observatory because it does not easily allow for uninterrupted monitoring. Also the ISS environment (spacecraft traffic, venting etc.) negatively affects the sensitivity of some of types of detectors which can be very sensitive to external contamination.



Spectral measurements in various wavelengths [2]


Space Station in front of the Sun as seen from Earth [ESA]

As mentioned in the introduction SpaceOps News also had the opportunity to talk to Alice Michel (B.USOC ISS Operations Manager) about the so far unprecedented long-term experience of operating an ISS experiment over 9 years. It should be remembered that the ISS/Columbus operations concept followed a so called “telescience” approach which, contrary to the shuttle/spacelab operations concept, offered the experimenters and scientists to stay at their home bases (User Support Operations Control Centers-USOC’s) and perform all the operations remotely from there i.e., being able to perform operations of their experiments within an allocated resource envelope (envelope planning). During spacelab missions the experimenters had to come to the spacelab control center and stay there for the duration of the mission (usually 14 days) to plan and operate their experiments in realtime in direct coordination with the spacelab operations teams.

For Columbus this was considered not practicable and the Columbus Control Center (Col-CC) at DLR Oberpfaffenhofen had to provide the planned and finally established 7 European USOC’s with the

appropriate data interconnections (voice, video telemetry and command data) to realize this ‘telescience’ concept.
Now, 9 years of operations of the SOLAR experiment offer a very good opportunity to analyze and judge how good this novel concept worked. The following questions could be discussed with Alice Michel, involved in SOLAR operations at B.USOC since the very beginning:

SoN: Was the Col-CC support as planned and expected?

Alice Michel: At the beginning of the 9 years the cooperation was very eager and positive but with no real experience on both sides. For both, Col-CC and B.USOC the experience of operating as part of the international ISS operations organization was new, and naturally the operations concept as well as the Col-CC support had to evolve from the original planned concept. In particular the planning cycle was very cumbersome and restricted because all experiment commands had to be included in the OSTPV (on-board short term plan viewer) with frequent daily rescheduling cycles because of unforeseen ISS events or changes of the science planning. Later, with growing experience and confidence the mode of operations moved a to a more realistic ‘telescience’ concept allowing realtime commanding from the B.USOC during an allotted command window.
Another problem turned out to be the operations shift coverage: at the beginning of the SOLAR experiment – which was also more or less the beginning of Columbus operations (launch: February 7th, 2008), Col-CC operators had to cover 24/7 shifts and that was expected from B.USOC as well. Because of experiment physical constraints the Sun could only be observed 10 to 12 days per month (while the Beta Angle was in between -24 and +24 degrees). After having gained experience with the experiment Col-CC could take over experiment status monitoring during those non-activity times and relieve the B.USOC personnel from shift-burden, which was highly appreciated. B.USOC in turn developed a notification tool (TYNA) for off-shift operator information (automatic calling or using SMS technology) supported by web-based monitoring parameters and anomaly information.

SoN: Was the science data return as expected?

Alice Michel: The data return was very satisfactory i.e., close to 100%, the few outage periods could be recovered by data recalls from the Col-CC or from NASA.

SoN: Any particular event you would like to recall?

Alice Michel: Because of mechanical constraints the SOLAR experiment was limited in view angles. On behalf of the experimenters B.USOC suggested to enhance the view periods for the benefit of the SOLAR scientists by maneuvering the whole space station into a more favorable position. At the beginning this was deemed to be impossible but through the skills of the NASA team in charge of the ISS attiude and the solidarity of the other experiments which were affected by the maneuvering B.USOC was able to “move” the ISS 5 times during the 9 years, thus enhancing the scientific SOLAR data return significantly, allowing the Sun to be observed over a whole rotation continuously.

SoN: How did you manage to maintain the operations team’s proficiency and integrity over such a long (unplanned) time period?

Alice Michel: Good question! Indeed this was and still is a challenge. In parallel to SOLAR, the operations team conducted other experiments onboard the station. The first year of the mission was pretty tough, we were understaffed to support continuously 24/7 operations, we were lucky most of us adapted to the new work in shifts, and no one got sick. New members joined the team throughout the years, and inevitably some left us to seek other challenges, but one of our main lessons learned resides in the recruitment process. Our operators are engineers, mathematician, physicians, sometimes even with a PhD, and along the mission we seek to build a heterogeneous team not only in term of educational background. We realized the benefit of diversity within the team. Different profiles (age, civil status, personality …) imply different interests and preferences. Heterogeneity was converted into an asset. For instance, shifts were assigned based on operators preferences, operators do shifts that suits their personal life better. Similarly for the off-line work, methodic and perfectionist profile will do operational products development, whereas leader profile will do more coordination and management. Also the coordinators roles are assigned alternately to the team members, to allow continuous improvement and new challenges possible for the whole personnel.

This way we try to maintain an enthusiastic and happy operations team, always seeking for improvement to increase the science return.

20% of of B.USOC personnel is coming from the Royal Belgian Institute for Space Aeronautics (a Belgian federal scientific research institute), and 80% from Space Applications Services, working together as an integrated team.

In summary, after initial difficulties and with growing confidence in the operations teams and the reliability in the operations system the Col-CC telescience concept proved to be very flexible and can be considered to become the standard for space laboratories science operations.

Astrid and Alice, thank you for the open discussion, SoN wishes you and your teams further success for B.USOC and any follow on experiments.

References:
[1] Top image left "SOLAR Experiment Package" taken from "How Columbus learnt to Fly" ESA book SP1321, July 2013, Thomas Uhlig, Alexander Nitsch, Joachim Kehr

[2] Solar Cycle Progression in SOLACES Data http://isssolac.esac.esa.int/iss-solaces/index.html

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