Report on the ESA–ESO Conference

Science Operations 2013: Working Together in Support of Science

held at ESAC, Madrid, Spain, 10–13 September 2013

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This first conference aimed at establishing closer communication and synergy of ground- and space-based operations for astronomy and Solar System science is summarised by the two chairs. The main topics covered the organisation and management of science operations, science and instrument planning, instrument handling and calibration, data processing and archiving, and support services.

Continuing the effort of establishing new synergies between space- and ground-based astronomical facilities, back in 2012 the European Space Agency (ESA) and ESO thought that it would be worthwhile to bring their communities together and compare their operational methodologies, processes, procedures and interfaces. The authors were tasked with defining and structuring the broad content of the meeting. The objective of the resulting conference — Science Operations 2013 — was clear, i.e., to present and discuss the various approaches to science operations in spacecraft missions and ground-based facilities for astronomy and Solar System science. Through a more direct comparison of operational approaches, the meeting was also intended to improve our current processes and use of resources, as well as to foster innovations and establish/intensify collaborations.

With the contributions of the Programme Organising Committee (see Table 1), which included representatives of both space- and ground-based facilities (mostly European), all details of the content of the programme were discussed and finalised once all abstract submissions had been received. Thanks to a broad range of contributions, the programme[1] took shape and was naturally arranged following the chronology of project phases, from initial concept developments to legacy products. The following aspects were addressed:

– Science operations organisation and management
– Science and instrument planning
– Instrument handling and calibration
– Science data processing
– Community support and services
– Science data archiving and product generation.

With approximately 150 attendees (see Figure), the meeting took place at ESAC (European Space Astronomy Centre; ESA's establishment for science operations), near Madrid, and ran over a total of three days, with a full programme of oral contributions and a parallel poster session.

Science operations

The welcome presentations were given by Martin Kessler (ESA, Head of ESA Science Operations Department) and Andreas Kaufer (ESO, Director of Operations), who summarised the highlights and challenges of ESA and ESO science operations at large, respectively. The programme then started with the most extensive session of the entire meeting, on science operations. This session was intended to provide overview presentations on science operations schemes for a wide spectrum of projects and was organised following a timeline, from past, or ongoing, to future missions. In the end, it ranged from operational overviews of ground-based facilities (Isaac Newton Group, ESO Very Large Telescope [VLT], Gemini and the Atacama Large Millimeter/submillimeter Array [ALMA]) and space missions (Herschel, Planck — High Frequency Instrument [HFI], Picard, Gaia, the Laser Interferometer Space Antenna and the James Webb Space Telescope), to lessons-learned type presentations, where critical evaluations of how things had gone for a given (part of a) mission were presented (e.g., INTEGRAL) or how a successful operational model was evolved for the succeeding mission (e.g., from SOlar Heliospheric Observatory [SOHO] to Solar Orbiter). An interesting presentation, falling between ground and space, was the one about the Stratospheric Observatory for Infrared Astronomy (SOFIA), with all the challenges an airborne observatory has to face.

An aspect that emerged early from this first session was the comparison of operational set-ups between ground-based observatories (self-contained and operating multiple telescopes on the same site) and the more decentralised schemes

Table 1. Composition of the Programme Organising Committee.

Member	Affiliation
Paola Andreani	ALMA Europe (ESO ARC, Germany)
David Barrado	Calar Alto Observatory, Spain (now Centro de Astrobiologia [CAB], Spain)
Chris Benn	Isaac Newton Group of Telescopes (ING, Spain)
Françoise Genova	Centre de Données Astronomiques de Strasbourg (CDS, France)
Paolo Giommi	Agenzia Spaziale Italiana (ASI, Italy)
Nick Hanowski (Chair)	ESA (ESAC, Spain)
Danny Lennon	ESA (ESAC, Spain)
Thierry Levoir	Centre National d'Etudes Spatiales (CNES, France)
Roberto Neri	Institut de Radioastronomie Millimétrique (IRAM, France)
Francesca Primas (co-Chair)	ESO (Germany)
Wolfgang Schmidt	Kiepenheuer-Institut für Sonnenphysik (KIS, Germany)
Tilman Spohn	Deutsches Zentrum für Luft-und Raumfahrt (DLR, Germany)
Mike Watson	XMM-Newton Science Survey Centre (XMM-SSC, United Kingdom)

of space missions, where operations are often distributed and typically involve numerous institutes in several different countries. The closest ground-based approach to this is probably the set-up of the European ALMA Regional Centre (ARC) nodes, where different participating member countries provide operational support via a dedicated node or expertise centre to specific operational tasks and phases. The session also included presentations on the organisation of operational centres that serve multi-mission purposes or are working in close collaboration with each other (e.g., the Centre d’Opérations des Missions Scientifiques for the French Instrument Mars Operation Centre [COMS/FIMOC] facility), and on some sociological aspects that surfaced in the following sessions (e.g., best practices in the collaboration between astronomers and engineers). In addition, an overview of the challenges in setting up a new mission, with all its technical, financial and operational constraints (such as closing the loop on the lessons learned, the balance between conservative *vs*. daring approaches) was provided.

Instrument handling

The next session on instrument handling was actually split into two sub-sessions: “Planning and Scheduling” and “Calibrations and Operations”.

The first part included a mix of talks — some focusing on how the use of an instrument is planned and its science is scheduled (with Herschel as an example), others focusing on the implementation of the most efficient use of telescope/instrument science time. It is clear that this latter is a challenging task that both communities face and has the same ultimate goal: to ensure reliable long-term scheduling (where “long” can refer to a full observability season or shorter periods of time) for which a robust but flexible short-term scheduling can provide the operators/observers with the best trade-off between observations, external conditions, minimisation of idle time, time criticality constraints, etc. In this group of presentations, it was interesting to learn the details of how telescope scheduling is currently carried out at ESO (for the La Silla Paranal and Atacama Pathfinder EXperiment [APEX] facilities) and the exploratory investigations carried out by two independent projects.

The Cherenkov Telescope Array (CTA), is planned to begin construction next year and represents the next generation of ground-based very high energy γ-ray instrumentation. For their final scheduler, the CTA is investigating the application of neural networks (specifically a guarded discrete stochastic neural network) coupled with constraint propagation techniques. The other ongoing investigation presented at the meeting is related to one of the ESA M3 mission candidates currently being assessed, the Exoplanet Characterisation Observatory (EChO). The complexity of the multi-dimensional space (target visibility, time and duration of events, number of events to be observed, target priority), combined with the huge number of possible combinations that have to be looked through to find the optimal solution, makes the scheduling exercise impossible for human planners and motivated the EChO team to look into genetic algorithms. This approach tries to reproduce the evolution of a problem/environment by combining all potential solutions using different types of operators (selection, combination and mutation). Preliminary results look promising, showing higher operational efficiencies than more standard (heuristic) approaches.

The second part of this session, covered best practices in calibrating a given facility/instrument and some operational challenges. The VLT Quality Control Loop and how it has evolved over the years was presented in detail, as well as the challenges that our ALMA colleagues are facing in calibrating all the antennas. More on the operational side, one presentation described the “evolutionary transfer” of the successful operational model behind the Planck low-frequency instrument (LFI) to the Euclid near-infrared spectrometer and photometer (NISP). Another nice presentation, touching upon lessons learned and operational evolution, focused on laser guide star (LGS) operations at the Keck Observatory. Again, the challenges presented in this talk were found to be common with other observatories that offer LGS-supported observations.

Science data processing and conservation

Of the three remaining sessions, two focused on different aspects related to science data, respectively Science Data Processing and Science Data Archiving & Data Legacies. Since they both deal with data, we will summarise the content of both sessions together, leaving the summary of the fifth session for the end of this report. There were of course notable differences in the main focus of these two sessions, namely the basic processing principles applied to science data and their operational implementations on the one side, data archiving/archives and their content at the other end. A few talks dealt with several data-related aspects (e.g., combining multi-frequency, multi-messenger, multi-temporal data or archive, grid, interactive and pipeline processing). Otherwise, we learned how back-end operations are, or will be, implemented (respectively at ESO’s La Silla Paranal Observatory and for the Euclid mission) and what is, and will be, the raw and processed content of current and future archives (from ground- to space-based facilities/missions, like ESO, ALMA, INTEGRAL, VENUS-EXPRESS, HEAVENS).

The highlights here were probably the major infrastructure developments that have taken place in recent years to serve large and complex datasets (Astro-WISE, ESO Advanced Data Products and its new Phase 3 interface, the MUSE–WISE [Wide-field Infrared Survey Explorer] set-up to handle massive MUSE-IFU [integral field unit] datasets and the ESA Multi-Mission Archive). This is a clear and prompt response to the shift that we have witnessed (and are still seeing) within the astronomical community and the way the top scientific questions are posed and tackled. The trend is to deeper and bigger, with large teams proposing public survey (hence legacy) projects that combine efforts in order to collect huge data volumes and tackle the most ambitious scientific quests. These are not projects that can be managed and handled by a few individuals; they are gigantic efforts that require dedicated infrastructure and data centres, able to process huge amounts of data, making them available to the community at large in almost real time. In turn, this also brings more

requests from the community to enhance the content of the more standard data archives. Because of this overwhelming data flow, archive architectures are evolving (e.g., at ESA), independent data centres are being set up (e.g., the European University Institute Data Centre at the Royal Observatory of Belgium) and interoperability among different archives remains an important item on the agenda of future efforts.

Community and user support

The final session to be reviewed here is the one on Community and User Support. This was a session heavily dominated by presentations (seven out of ten) on tools and user-support schemes implemented at ground-based (as opposed to space-based) facilities. ALMA and VLT/I user support implementations were compared in detail, including the main sets of tools that are provided to the users to prepare their observations. All other contributions were geared more towards user services for data processing, handling and distribution. We learned about the challenges that the APEX facility had to overcome in making the data available rapidly (i.e., within two days) to its users via the ESO Archive and which services and interfaces the AGILE Science Data Centre at the Italian Space Agency provides to its user community (especially in terms of web-based tools for quick-look and online data analysis).

At the end of the day, what really counts is how successful a facility/mission is or has been. This is rather challenging to assess: it clearly relies on a variety of — if not all — the operational aspects that were scrutinised during the meeting, from the call for ideas and conception of a new mission/instrument to the detailed definition and implementation of ancillary tools/interfaces that make the new facility as user-friendly as possible. Yet, the loop needs somehow to be closed so that we can measure the research output of a facility/observatory/mission as one of the possible indicators of success. One such attempt was presented in the presentation on the ESO telescope bibliography telbib, aimed at correlating scientific productivity to the amount of time invested in science observation. A huge but very rewarding effort!

Towards a follow-on conference

As the first attempt in gathering people involved in science operations at large, the success of the meeting was not guaranteed from the start. However, a large majority of the attendees agreed in declaring this event a success and something worth pursuing further. Overall, more open discussions on specific operational topics would have been beneficial; on the other hand this meeting provided a very detailed overview of all ongoing and future projects, both ground- and space-based (though mostly European). This, now common, understanding is essential for further exploration of synergies. There was a clear push from the audience in continuing this forum and we hope that the next such meeting will be able to take advantage of what we all learned this time, so that it can foster more concrete innovative developments and strengthen collaborative efforts.

Links

[1] Conference website and programme: http://www.sciops.esa.int/sciops2013

Announcement of the ESO Workshop

Herbig Ae/Be stars: The missing link in star formation

7–11 April 2014, ESO Vitacura, Santiago, Chile

This workshop on Herbig Ae/Be stars is dedicated to the formation and pre-main sequence (PMS) evolution of intermediate-mass stars. These stars bridge the transition between the distinctly different scenarios for the formation of low- and high-mass stars. Over the past 20 years, new instruments have opened up the milli- and sub-milliarcsecond spatial scales where the disc physics takes place and planetary formation processes occur. ALMA will complement spatially, and advance spectrally at high resolution, the connection between the inner discs and the outer, dusty discs as observed by space-based observatories. The workshop aims to elucidate the evolution of the circumstellar material from the formation phases, during the star's PMS contraction, and into the dispersal and debris phases. Topics include stellar interiors and surface physics accretion and ejection processes, evolution of the discs and the connection with debris discs and planet formation.

The workshop format will consist of invited reviews, contributed talks and posters. There will be ample time for discussions. The conference venue has the capacity for 100–120 participants.

The ESO 2014 Herbig AeBe workshop will commemorate of the life and works of George H. Herbig (2 January 2 1920 – 12 October 2013). George Herbig pioneered the field of star formation, especially that of young stars and their nebulous surroundings. His legacy includes the identification and first description of the Herbig Ae/Be stars and the Herbig–Haro objects.

Full details can be found on the workshop web page:
http://www.eso.org/sci/meetings/2014/haebe2014.html
or by e-mail to: haebe2014@eso.org

The abstract and registration deadline is 31 January 2014.