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Accessible hybrid conferences are possible and affordable at large scale

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In August 2024, the International Astronomical Union General Assembly was held for the first time on the African continent, as a fully hybrid and open-access conference. This opportunity to approach such a traditional and historical event from a new perspective encouraged a spirit of innovation enabled by emerging technologies.

In a rapidly evolving world where gathering in person is increasingly challenging, hybrid meetings have become essential to keep communities connected. However, achieving meaningful hybrid interaction during a conference is currently far from trivial, as it combines all of the many requirements of an effective in-person meeting with those of an equally effective online meeting. Despite these obstacles, hybrid conferences ensure heightened accessibility, inclusivity and sustainability via the inclusion of the online component (see, for example, refs. 1–4); clearly, this is a challenge worth facing.

Within this context, a commitment was made to realizing a hybrid International Astronomical Union General Assembly (IAU GA) that was as inclusive as possible, guided by the principles and ambitions reflected in the Vision 2024 framework set up by the IAU GA National Organising Committee (NOC). Thus from the beginning stages of planning the IAU GA in Cape Town for August 2024, Vision 2024 provided the foundation for embedding and protecting hybrid elements in the conference (described more fully in a companion Comment[5]). In 2022, the NOC partnered with The Future of Meetings community of practice (TFOM[6]) to collaborate on designing and realizing a GA that aimed to set a good example for how hybrid might be feasibly achieved at all scales in astronomy and beyond.

With this Comment, we (representing the collective TFOM/NOC partnership) outline the experience of transforming the vision of a hybrid GA into a practical reality, emphasizing the pragmatic choices made to meet fundamental hybrid audience needs (see Box 1 for a definition of 'hybrid'), the aspects that showcase technical innovation in this space, and the challenges and lessons learned for future organizers to take into account when organizing hybrid conferences of this nature.

Hybrid by design at large scale

As noted in Box 1, our goal from the beginning and throughout the planning process was to achieve Level 3 hybrid for the GA. This meant that paid online attendees had to have agency: it was a requirement that they would be able to present their talks and posters, ask questions and interact with other attendees from wherever they were. This in turn strongly influenced decisions on and discussions with external suppliers. We also had a clear vision of 'open access', namely that the Level 2 experience would be freely available via livestream to anyone worldwide. We consequently chose the collection of tools, technologies and platforms for the GA considering what the experience would be for our three audience types: in-person participants, online participants and livestream viewers.

To achieve these goals, the following platforms were selected: Oxford Abstracts (registration, abstract submission, programme/content management, one-way communications), Slack (two-way asynchronous communications), Zoom (live interactive content), YouTube (livestreaming, recorded content) and Spatial (immersive interaction). These were chosen after considering a wide range of solutions with different costs and optimizing to balance minimum outlay for maximum benefit. We were able to make use of free versions of Slack and YouTube alongside paid licences for Oxford Abstracts and Zoom. Spatial was low cost for hosting and assets, with in-kind effort in building the spaces via the TFOM partnership.

We found it was important to select and work closely with audio-visual (AV) providers to guarantee that they would be able to effectively support the systems we had decided on (specifically in cases where linking to the physical venue was critical). Given that many large-scale conferences still consider 'fully hybrid' to be the provision of a livestream, we required an AV provider willing to help realize a more ambitious vision for an effective hybrid experience.

Unsurprisingly due to its wide usage in the academic community, Slack was a standout when it came to blending the experiences of the in-person and online attendees, as it is equally accessible from all modes of attendance. In retrospect, we could have made better use of the Slack space by, for example, making Slack channels the primary place for session discussion and questions, but overall, we found it to be a highly valuable platform for enabling hybrid interaction.

A virtual 3D conference venue was provided on the Spatial platform, accessible via a computer web browser, smartphone app, and virtual reality (VR) headset (see Box 2 for a detailed description of the experience). The venue consisted of multiple exhibit spaces, including a digital copy of the art exhibition hosted at the physical venue, plus rooms for formal and casual meet-ups. We actively sought to provide value-added experiences in Spatial that were online-first (that is, taking place online, but available to those attending in person via their personal devices). These included pre-conference networking, tours of exhibit spaces showcasing work from CSIRO's ASKAP radio telescope[7,8]

BOX 1

Defining 'hybrid'

It is worth addressing the definition of hybrid, to align expectations across organizers and participants. From our perspective, a meeting can be described as hybrid in format if it consists of two audiences: one attending in person (physically) and the other attending online (virtually), noting that variations on this simplified definition are possible (for example, inclusion of geographically distributed hubs).

Additionally, there is a spectrum of hybrid attendance and engagement that may be offered. Organizers should consider where it makes sense for their meeting to fit along this spectrum. We define these formats as:

- Level 0: no online attendance, the meeting takes place solely in person
- Level 1: asynchronous online access to recorded materials of in-person meeting
- Level 2: live passive online attendance (for example, online participants can only view and listen in as the meeting occurs in person)
- Level 3: live active online attendance (for example, online participants are able to present and interact, with dedicated online events and activities)
- Level 4: live fully blended attendance (for example, there is minimal difference between the two modes of attending)

In the current era of proactively seeking to increase accessibility, inclusivity and sustainability of interaction and collaboration, very few conferences would defensibly fall into the category of Level 0. Based on our observations to date, Level 4 largely remains an aspirational goal at the forefront of technology.

In designing and planning the 2024 IAU GA, our goal was to reach Level 3 as much as possible, opting for Level 2 or Level 1 in a small number of cases where Level 3 was not (for a good reason) feasible. While recognizing it as the ideal hybrid conference format, we determined that the IAU GA was not a suitable venue to push for highly experimental Level 4 hybrid.

and the Japan Aerospace Exploration Agency (JAXA), fireside chats, a networking lunch and social events. At set times during the GA, we also ran a VR booth in the physical exhibition hall with three Meta Quest headsets enabling in-person attendees to explore the Spatial venue, providing many with their first experience of VR (Fig. 1d).

Adopting a proactive approach for efficiency and innovation

Our technical goals for the hybrid format were driven by a desire to innovate beyond the conventional approach. Due to the high costs and limited ability to provide more than Level 1/2 hybrid solutions (among other reasons), the GA chose not to rely on a Professional Conference Organiser (PCO) company for administrative support and instead took on more of these tasks directly. Whilst this increased the workload for the organizing team, the resulting hands-on strategy enabled significant cost savings, with the added advantages of more direct communication channels and improved efficiency. An additional benefit of this model was the freedom to experiment with new Level 3/4 hybrid solutions in key areas.

An example of this was the hybrid poster set-up where online and in-person presenters and participants could interact freely in real time via Zoom (Fig. 1c). When it became clear that existing commercial providers could not realize this vision in a cost-effective way, a custom approach was devised that involved purchasing 100 sets of equipment, managed by the NOC and a dedicated set of volunteers. The physical set-up was fairly straightforward, incorporating digital screens, Raspberry Pis, mice, keyboards, webcams and ethernet connections. While this experimental approach was not without challenges, it successfully enabled hybrid posters in an unprecedented and innovative way. This approach also led to a sustained and lasting impact on the community: because the equipment sets were purchased outright rather than rented, they are being donated to schools across South Africa, bringing benefits to people well beyond the GA and facilitating educational opportunities that would have otherwise been inaccessible.

Where possible, we automated tasks to improve efficiency. This included, for example, the use of Python for generating web pages in bulk, scheduling detailed programme announcements via the Slack API, analysing user submissions to deliver networking matches and suggestions via email, analysis of registration and abstract data from Oxford Abstracts for decision-making purposes, generating a rotating poster schedule, and much more. It cannot be overstated how important and valuable it is for organizers to embrace the technological approaches available to make their lives easier, especially to reduce repetitive tasks and minimize the chance of error.

Lessons learned for conferences to come

Based on participant feedback and the general reception of the GA[5], the hybrid vision of the GA was both successfully realized and positively received, though with a number of areas for improvement. We outline some key lessons learned below, with the goal of aiding future organizers.

Although hybrid conferences are typically portrayed as adding high additional costs to conference budgets, this was not the case for the IAU GA. As an estimate, no more than 18% of the total conference costs can be in any way attributable to online attendees (including internet connection, hybrid poster setups, Zoom, and all AV costs). However, this is a substantial overestimate, as AV equipment is necessary for all participants, not just those online. When removing AV costs from the calculation, hybrid costs were only 3% of the budget — considering that online registration covered 6% of the total budget, it is likely that IAU more than broke even with its online registrations. We note that internet and hybrid poster costs also directly benefited in-person attendees, but we have attributed them solely to online attendees in the above estimate since the approach may have been different in a non-hybrid context.

Reflecting on the total number of online registrations, these were lower than initial expectations for the GA given its extensive hybrid access (though higher than reported from other hybrid meetings). Of the 2,648 registrations, 603 were online (~23%). This may be the result of several factors. Firstly, it is possible that the highly viewed open-access livestreams (> 20,000 views by > 10,000 unique viewers) were sufficient to meet the needs of many potential paying online attendees, especially when considering that it is difficult for much of the world to synchronously attend a UTC+2-focused programme. Another likely related factor is a general widespread perception (often based on negative experiences) that hybrid conferences cannot effectively meet the needs of online audiences. It is also possible that the online

BOX 2

A traveller's guide to the 2024 IAU GA Spatial venue

Whether you join the virtual venue from your browser, smartphone app, or on a VR headset, your journey through the 2024 IAU GA Spatial space begins in the Entry Hall. On your first visit, your avatar approaches the welcome desk to start the tutorial, where holograms will offer tips for navigating the virtual space, turning on your webcam and mic, interacting with other participants, and reminding you of the conference code of conduct. Once the tutorial is complete, the doors to the Main Hall swing open and the entire venue is yours to explore.

The Main Hall resembles the lobby of a large conference venue, featuring a digital twin of the physical IAU GA 2024 logo (Fig. 1a,b). Seating areas encourage people to gather and talk (with directional audio fall-off allowing many simultaneous conversations), including a cosy area around flaming logs for the 'fireside chats' where delegates had the chance to pose their questions to Nobel Prize winner Brian Schmidt and NASA Associate Chief Scientist Kartik Sheth (Fig. 1g). The livestreams from the social events, such as the #AfricaLookUp cultural exchange evening, were also shown on a large screen so people could watch together. From the Main Hall, portals led to a variety of other spaces, some similar to those in the physical venue and others wildly different.

The Exhibition Hall (originally designed for the 2024 Annual Science Meeting of the Astronomical Society of Australia, see ref. 9) features nine booths (including Astronomy Australia Limited, Astronomers for Planet Earth and SKAO, among others), with interactive videos and posters. The room is also the gateway to several unique experiences. One such experience is an exhibit for JAXA's asteroid and small body missions. Set on a space station surrounding a model of asteroid Ryugu, delegates can examine spacecraft, ride the Hayabusa2 mission mascot, Haya2-kun, and visit the asteroid's surface (Fig. 1f).

A different portal from the Exhibition Hall takes you to an exhibit dedicated to the CSIRO ASKAP radio telescope[7,8], where animated models showcase the antennas and technology that power this cutting-edge look at the radio sky (Fig. 1e). Set at a remote site in Western Australia to avoid interference from radio waves, very few people can visit ASKAP in person, but this virtual exhibit provides an unparalleled 360 degree view of the site from the ground and direct interaction with ASKAP technology.

A third exhibit reminds us of the impact of providing remote access to conferences, with an 1,868 m-tall climbable pillar representing the carbon used in bringing the in-person delegates to Cape Town towering over the 6 m-high block for the online delegates. Further exhibition halls also include the winning entries from the IAU Office of Astronomy for Education's astrophotography contest in the smartphone astrophotography category and a digitized version of the "Cosmic Echoes: a Shared Sky Indigenous Art exhibition", a mirror of the exhibit in the physical venue.

Designated meeting spaces allow users to upload and download material to a shared persistent space, making them ideal for ongoing and repeated meetings. These include offices for groups looking to brainstorm, a lecture hall, and a ballroom that was used for the Women in Astronomy and Young Astronomers networking socials.

registration rate was impacted by a mismatch in communications about the conference: when advertising the conference, organizers generally emphasized the benefits of in-person attendance, with less focus on the benefits and value of online attendance. An important consideration in the IAU GA case was that the online registration fees were a relatively high fraction of the in-person fee (50%), though online attendees made significant cost savings in avoiding the need to travel.

Engagement, especially for the value-added online-first activities, proved to be a challenge. We found that live turnout at science programme sessions and dedicated online events (for example, tours, high-profile guest speakers, watch parties, networking) was lower than anticipated. While clearer advertising further in advance and perhaps splitting the audience across fewer platforms may have improved engagement, this experience fits into a broader picture of difficulty with engaging online attendees (for more discussion on this topic, see ref. 9). That noted, those who participated online throughout the GA gave highly positive feedback and benefited from their active engagement, and the availability of accessible recordings has greatly increased the legacy reach of the GA.

Hybrid meetings have the great potential to effectively link people attending online and in person, but achieving the maximum benefit goes beyond providing platforms and tools. In particular, hybrid conferences at Level 3 and beyond require equivalent attention to both modes of attendance, finding ways to bridge the two wherever possible and ensuring there are dedicated events and activities for all attendees. We found we would have benefited from a larger fraction of the organizational effort focused on the online experience, both in defining the online events schedule and the overall execution of the hybrid programme. Additionally, future organizers should ensure that those in person (especially session chairs) are fully aware of and committed to the expectations of the hybrid model adopted, with more direct organizational oversight where possible. During the GA, it emerged that having in-person allies for online participants made a big difference in their experiences.

Our recommendation overall is to recognize that being progressive and innovative, while bringing huge benefits, requires adopting an experimental mindset, accepting the possibility of setbacks to be overcome and, in the case of hybrid, ensuring the needs of both online and in-person attendees are met. As such, we suggest choosing the right balance between experimentation and status quo that best suits the needs of their particular meeting, leveraging existing experience, precedent and advice.

Reflections on the legacy of the GA

In looking back at the IAU GA 2024 and what was achieved, this hybrid General Assembly was a culmination of many meaningful firsts[5]. We hope that the legacy of this GA will be widespread in impact and that future organizers will follow its example of accessibility, impact and sustainability. Similarly, we hope that hybrid offerings of this nature are increasingly the norm for attendees of all conferences, regardless

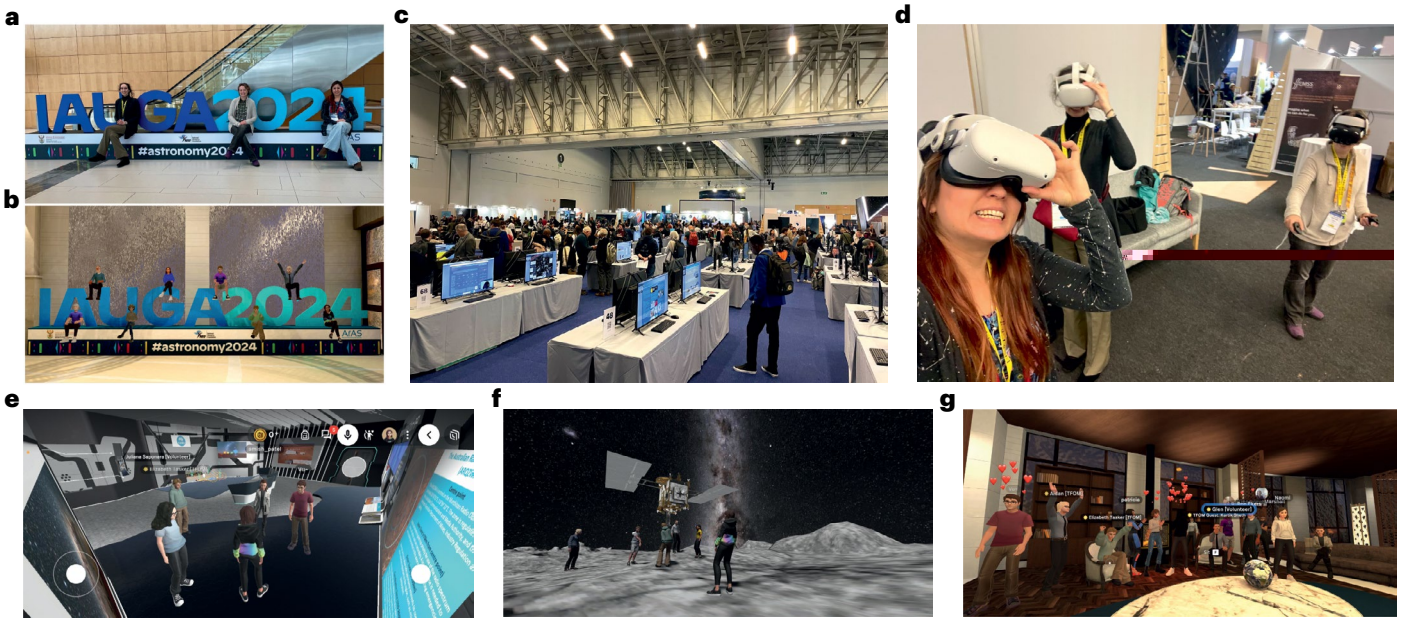

Fig. 1 | Representative images showcasing the hybrid and technological elements of the IAU GA. a,**b**, Digital twin image of the IAU GA 2024 logo, featuring the in-person TFOM representatives physically and the full team of TFOM IAU contributors (including those who attended online) in Spatial. **c**, Hybrid poster session featuring the custom setups devised by the NOC for the GA. **d**, The VR booth setup during the GA to offer in-person attendees access to the immersive Spatial venue. **e**,**f**, The online-first event program included tours of asteroid Ryugu and the CSIRO ASKAP exhibit. **g**, Group photo following a fireside chat with NASA Associate Chief Scientist Kartik Sheth in Spatial.

of scale. It is critical to recognize that the commitment early in the planning of the GA to the principles of a hybrid, open-access meeting was vital in realizing this vision, in that these principles then underpinned all planning decisions made.

We emphasize that hybrid meetings at all scales are feasible when approaching the meeting design with a view to pragmatically maximizing effectiveness and that the costs associated are firmly worth the benefits. The hybrid components of this meeting were significantly less than 5% of the total budget, yet enabled us to reach over 600 astronomers who could not attend in person and, via the YouTube streams, thousands of additional people who would have normally been unable to attend at all. Far from adding excessively to conference costs, the experience of the IAU GA demonstrates that hybrid can greatly increase reach (for instance, more than 10,000 unique viewers on YouTube) for a small fraction of the conference budget.

One of the great benefits of the IAU GA is how it connects people across various sub-fields of astronomy from many different countries, and there are many ways in which this was an exemplary case of the continued value of occasionally meeting in person. However, we must balance the costs of meetings with significant in-person components (versus what can be achieved solely or primarily online) carefully against their benefits. Critically, we must seek to bring these benefits to as wide an audience as possible, including those who cannot physically be present at meetings. As such, astronomy meetings should ultimately have virtual participation as a baseline.

Based on our experience with the IAU GA, hybrid conferences even at large scale can be affordable and impactful, bringing benefits to people well beyond the physical walls of an in-person conference venue. The parameter space to explore for improving both hybrid and online interaction remains vast with much potential for future innovation. It is our strong hope that future hybrid meetings, especially those of similar scale and nature to the IAU GA 2024, will push the boundaries even further, and reach greater heights when it comes to bringing science and knowledge to people all around the world.

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Competing interests

The authors declare no competing interests.