IVS NEWSLETTER

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New Generations

A VLBI pioneer has passed, but his legacy lives on, for instance, in the technology used in VGOS and in the continuation of a successful workshop series. A new generation of students learned about VLBI and VGOS in the triennial VLBI Training School. The VGOS observing plan gets an update, while BKG and TUM renew their nuptial vows. And TUM is co-organizing GM2026.

GM2026: Linking the Celestial and Terrestrial Realms

Dirk Behrend, NVI, Inc./NASA GSFC

Preparations are underway for the next big IVS event. On April 12, 2026, the 14th IVS General Meeting (GM2026) will kick off with an icebreaker reception at Hotel Garmischer Hof in Garmisch-Partenkirchen, Germany. On the subsequent five days, the main event as well as several splinter meetings will be held in the *Congress House of Garmisch-Partenkirchen*, while the Analysis Workshop is planned to take place up the Zugspitze mountain in the *Environmental Research Station Schneefernerhaus*. More details can be found on the meeting website for *GM2026*. The meeting will be held under the theme "Linking the Celestial and Terrestrial Realms." This is in recognition of the fact that the VLBI technique uniquely connects the realms of Earth and Space—observing the same cosmic radio sources to understand both the distant universe and the dynamics of the Earth. This linkage will be featured in a dedicated session; "Session 6: Crossroads VLBI" uniquely addresses the possible integration of astronomical and geodetic VLBI.

Registration and abstract submission for the event are now open. The abstract submission deadline is January 30, 2026. Early-bird registration ends on February 1, 2026, while regular registration closes on March 1, 2026. Make sure to not miss these deadlines. We hope to see many of you in Gamisch for GM2026. Safe travels!

Inside this issue

IVTW2025: Charting a New Blueprint for VLBI Technology

Xuan He and Yidan Huang
Shanghai Astronomical Observatory

The International VLBI Technical Workshop (IVTW2025) was held from October 21–25, 2025, at Chalmers University of Technology in Gothenburg, Sweden. In the afternoon of October 21, we enjoyed a guided tour of the clean room and laboratories on the Chalmers campus, where highly sensitive cryogenic/superconducting mixer receivers are under development, with frequency coverage ranging from several GHz to 1.2 THz. Following the tour, we attended the icebreaker event at Chalmers' Wijkanders restaurant, where we reconnected with old friends and had the opportunity to meet new people.

The official program began on October 22 with a welcome address delivered by John Conway. It was then followed by a moment of silence in memory of Alan Whitney, proposed by Chet Ruszczyk, to honor the legacy of the VLBI pioneer who was the initiator of both the IVTW and the former International e-VLBI Workshop.

As a pivotal international event in the VLBI technology sector, IVTW epitomizes the forefront, innovation-driven trajectory of VLBI development. This year's meeting comprehensively addressed four key cutting-edge topics:

- Station Upgrades and Technology—encompassing the renewal and development of frontend, backend, recording systems, and data transmissions;
- Data Processing and Imaging—covering the latest advances in correlation techniques and image processing methods;
- Future Space VLBI Missions—exploring potential mission planning and associated challenges;
- RFI Mitigation Strategies—focusing on RFI monitoring, suppression, and other countermeasures.

Participants of the IVTW2025 in the Veras Gräsmatta facility of Chalmers University of Technology.

The technical presentations at this workshop were particularly noteworthy. New station or network construction plans and status reports were presented for various research objectives. Breakthroughs and innovations were showcased in next-generation receivers and data recording and acquisition systems. Artificial Intelligence was frequently referenced throughout the sessions, with many peers exploring its applications in data processing—potentially heralding a technological revolution.

VGOS was one of hot topics throughout the meeting. The agenda featured a series of talks covering the new VGOS station at Bosscha Observatory, new VGOS frequency sequence tests, preparations for GENESIS observations, fully automated UT1 correlation, source flux density monitoring, and RFI measurements. We also presented preliminary phase delay measurements between two VGOS antennas over a 6-km baseline in Shanghai.

An interactive voting session was organized to stimulate discussion by identifying the most important challenges in VLBI, which spanned receivers, backends, data transfer, correlation, image processing, calibration, and coordination. The results showed that coordination and data transfer garnered the most votes.

Xuan He, Jiangying Gan, and Kaho Hashimoto (left to right) discussing data correlation.

Active discussions during coffee breaks.

A site visit to the Onsala Space Observatory, located 45 km from the Chalmers campus, was a valuable addition to our itinerary. At its scenic coastal site, we experienced the station's unique windy environment and toured its two VGOS antennas, known as the Onsala Twin Telescopes (OTT).

Another highlight was an unforgettable dinner held at Universeum (Gothenburg's science center and zoo/aquarium). Walking through the rainforest, the event was set against a striking backdrop of the aquarium's lovely animals and magnificent white soft corals, which fostered a wonderful atmosphere for both scholarly discussion and the building of friendships.

During the meeting, we talked with Kaho Hashimoto from the GSI correlator, sharing experiences in handling VGOS Intensive observation data and discussing technical developments for an automated UT1 data processing pipeline. It was also very helpful to have a discussion with Simone Bernhart from the BONN correlator about sampling delay issues, obtaining prior phases for post-processing, and resolving SNR_RATIOS issues in the correlation report.

Site visit to the Onsala Space Observatory.

The workshop successfully bridged the past and future, honoring our pioneers while charting a clear technology roadmap focused on AI, high-speed networks, and advanced hardware. As such, we are committed to deepening collaboration with international partners, recognizing that VLBI is, by its very nature, a globally interdependent endeavor.

Finally, we extend our sincere gratitude to Chalmers University of Technology and the Onsala Space Observatory for their meticulous organization and hospitality. We look forward to the next gathering of our VLBI community.

Impressions from the Universeum: a lovely bird and white soft corals.

2026 Meetings

2–4 March 2026	Reference Frames for Applications in Geosciences (REFAG2026), Munich, Germany
5–6 March 2026	GGOS/IERS Unified Analysis Workshop (UAW2026), Munich, Germany
12–17 April 2026	14th IVS General Meeting, Garmisch-Partenkirchen, Germany
3–8 May 2026	EGU General Assembly 2026, Vienna, Austria
28 Sep – 1 Oct 2026	Tracking and Investigating Geodynamics and Earth Rotation (TIGER), Gävle, Sweden
5–7 October 2026	GGOS Days 2026, Gävle, Sweden
7–11 December 2026	AGU Annual Meeting (AGU26), San Francisco, CA, USA

Board Games at Onsala

Dirk Behrend, NVI, Inc./NASA GSFC

Onsala Space Observatory was the venue for the 53rd IVS Directing Board meeting on 25 October 2025. Sandwiched between two major meetings in Gothenburg, Sweden, the agenda of the meeting sported some interesting topics—chief among them was a reverse brainstorming game. IVS Chair Rüdiger Haas conceived an exercise to break through mental blocks and to uncover new ideas for solving IVS-related problems. After mentally exacerbating existing weaknesses ("anti-solution"), Board member subgroups flipped the script in a second step to reverse the anti-solutions. The written record of the musings from the seven subgroups were collected to do some solution mining. History will be rewritten, once Rüdiger has evaluated the board game results.

IVS Directing Board during its 53rd meeting on October 25, 2025, at Onsala Space Observatory.

Beyond this playfulness, the board also tended to more serious matters. Gino Tuccari attended his last board meeting as IVS Technology Coordinator before his retirement in January 2026. The board decided to issue an open call to find a successor to Gino; the call was planned to be issued in December 2025. IVS Analysis Coordinator Benedikt Soja sent a list of topics from the VLBI perspective to be addressed at the GGOS/IERS Unified Analysis Workshop 2026 (UAW2026). He planned on contacting potential IVS analysis representatives to attend the UAW2026 in Munich, Germany, 5–6 March 2026 (participation is by invitation only). The next EVGA meeting will be held in the first half of June 2027 in Helsinki, Finland.

Chet Ruszczyk had prepared an outline for an IVS technical paper for publication in the journal "Sensors." The writing of the paper will be a collaborative effort using Overleaf LaTeX. Lucia McCallum and Susana García Espada reported on the progress of a pilot project to provide station feedback and benchmarking using publicly available data and reports. A presentation about the project is planned for the upcoming IVS General Meeting. It is foreseen that stations can voluntarily opt in to be part of the project. The board felt that there was a need to implement the VEX2 standard in support of the GENESIS mission. A task force was formed to compile an inventory of station and correlator needs and to look into possible implementation routes for VEX2. The suggested members of the task force include Matthias Schartner, Alexander Neidhardt, Phillip Haftings, Jamie McCallum, and Chet Ruszczyk.

The next Board meeting will be held in conjunction with the IVS General Meeting in Garmisch-Partenkirchen, Germany, on 17 April 2026.

Next-Generation VLBI Meets New Generation of Students

Gönenç Moğol, NVI, Inc./NASA GSFC

The 5th IVS Training School on VLBI for Geodesy and Astrometry took place between October 26–28, 2025, at Chalmers University of Technology and Onsala Space Observatory in Gothenburg, Sweden. The excitement for this year's school was high, not only because of the riveting material the teachers had prepared for us, but also because this year's IVS Training School was the first school to be in person since the COVID-19 pandemic.

The central theme of the VLBI school was to convey how a VLBI observation takes place throughout the entire process. After an introductory session by Rüdiger Haas

Lucia McCallum doing VLBI by numbers.

explaining the use and necessity of geodetic VLBI, we started with the very beginning of a VLBI observation: the radio sources. Patrick Charlot explained the standard unified model for the active galactic nuclei (AGN) and how the radio emission is created within them. He further instructed on the big variety of AGNs and how they might

Students touring Onsala Space Observatory during the scheduled test session.

influence geodetic VLBI observations. After the lunch break, it was time to crunch some numbers! In an interactive exercise session, Lucia McCallum walked us through how the signal-to-noise ratio is influenced by source intensity and telescope sensitivity. She artfully weaved her outreach visuals into her exercise session, making the interactive session captivating and memorable. At the conclusion of the first day, Matthias Schartner taught us the fundamentals of scheduling a VLBI session. Accompanied by his stunning and instructive animations, we learned about the optimization problem at the heart of geodetic scheduling. After the theoretical introduction, we had the opportunity to learn and play with the scheduling software VieSched++. With the help of his detailed instructions, we scheduled an Intensive session that was going to be observed the next day.

On the next day, we took a bus and after driving through beautiful landscapes and rustic towns, we arrived at the Onsala Space

Rüdiger Haas explaining control room activities.

Observatory. Since we had scheduled the VLBI observation the previous day, it was time to learn about the actual equipment that does the observation. Franz Kirsten introduced us to the anatomy of an antenna, the design of the antenna dish, as well as different designs of feedhorns used at the observatory. He walked us through the entire signal chain: from the signal's arrival at the feed until its sampling and digitization. In the next lecture, Rüdiger Haas taught how VLBI antennas are calibrated. As with any scientific equipment, if there's no calibration, there's no measurement; so, we learned about the measurement of antenna gain and cable delay as well as how phase calibration tones are used to determine the phase of the incoming signal. Equipped with the knowledge of antenna hardware and calibration, we were ready to start the observation. Lim Chin Chuan from the Onsala group showed us how the twin antennas are set up for an observation. He then hit start, initiating the choreographed dance of the twins. During the observation, we had the opportunity to tour the observatory and see the twin antennas move and observe.

Once the radio source emissions are converted into bits, how are they stored on hard drives and how does the data get from A to B? This was the central question of the captivating lecture given by Marjolein Verkouter. She introduced two types of recorders used at VLBI stations and how they differ in hardware and software design. Subsequently, she explained how data can be transported from stations to correlators and what software tools are available to deal with scattered data. In a demonstration led by Simone Bernhart, she transported the data from Onsala Space Observatory to the Bonn Correlator and showcased the software tools like jive5ab and m5copy, which were discussed by Marjolein in the previous lecture. At the conclusion of the day, Alva Kinman discussed her PhD dissertation work and how she uses the short baseline of the twin telescopes to monitor the flux of radio sources.

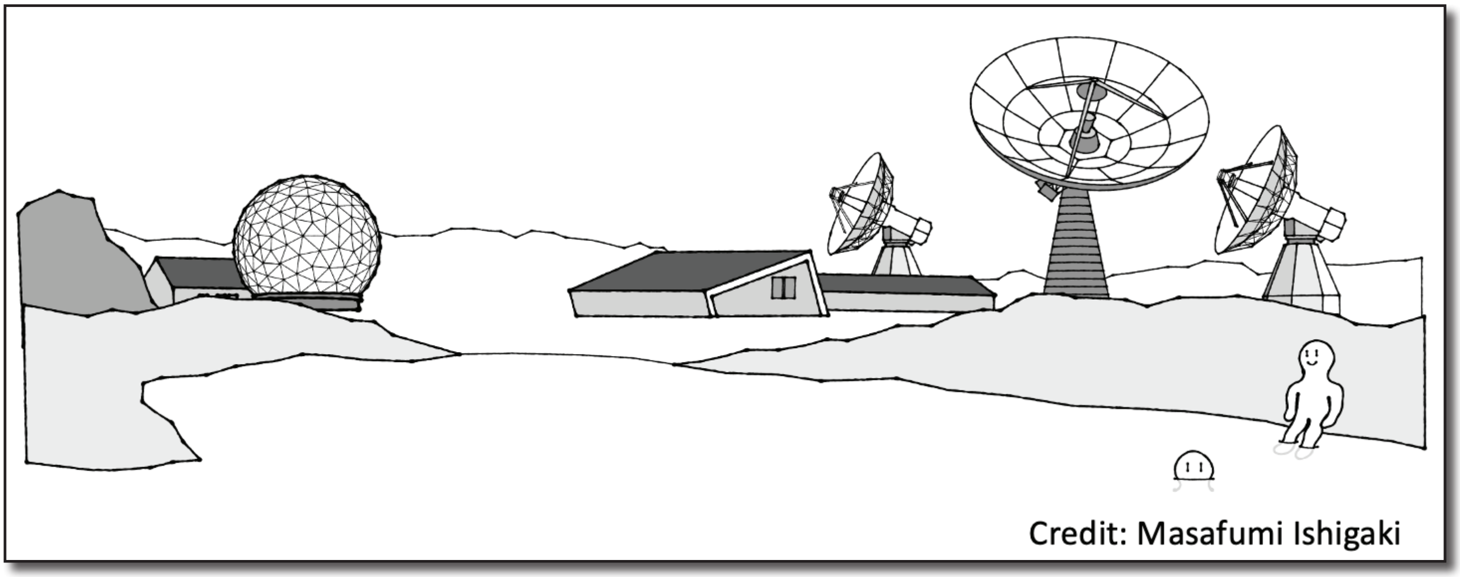
The final day of the VLBI school started with a thorough and engaging lecture by Simone Bernhart about the correlation and fringe-fitting of raw VLBI data. Following her lecture, Simone demonstrated the cor-

Participants of the 5th IVS Training School.

relation and fringe fitting process with the data we took the day before. Subsequently, we learned about modeling the correlated delay data. First, we started with the geophysical variables that affect the delay. Lucia McCallum explained how plate tectonics, planets, atmospheric loading, and tides influence the delay. Then, we continued with the modeling of the signal through the atmosphere. Nataliya Zubko explained how the ionospheric and tropospheric delays are calculated and accounted for in the analysis. Finally, we learned how the delay data can be used to extract geodetic variables like earth orientation parameters. Hana Krásná gave the theoretical introduction, followed by two exercise sessions by Tobias Nilsson, where we analyzed the data with his guidance.

Simone Bernhart addressing correlation and fringe fitting.

The IVS Training School is a unique opportunity to learn how a geodetic VLBI observation comes together from the very start until the very end. On behalf of the students, I sincerely thank all the teachers and organizers, who clearly have spent a lot of time and effort to teach us in a clear, understandable, yet fun way.



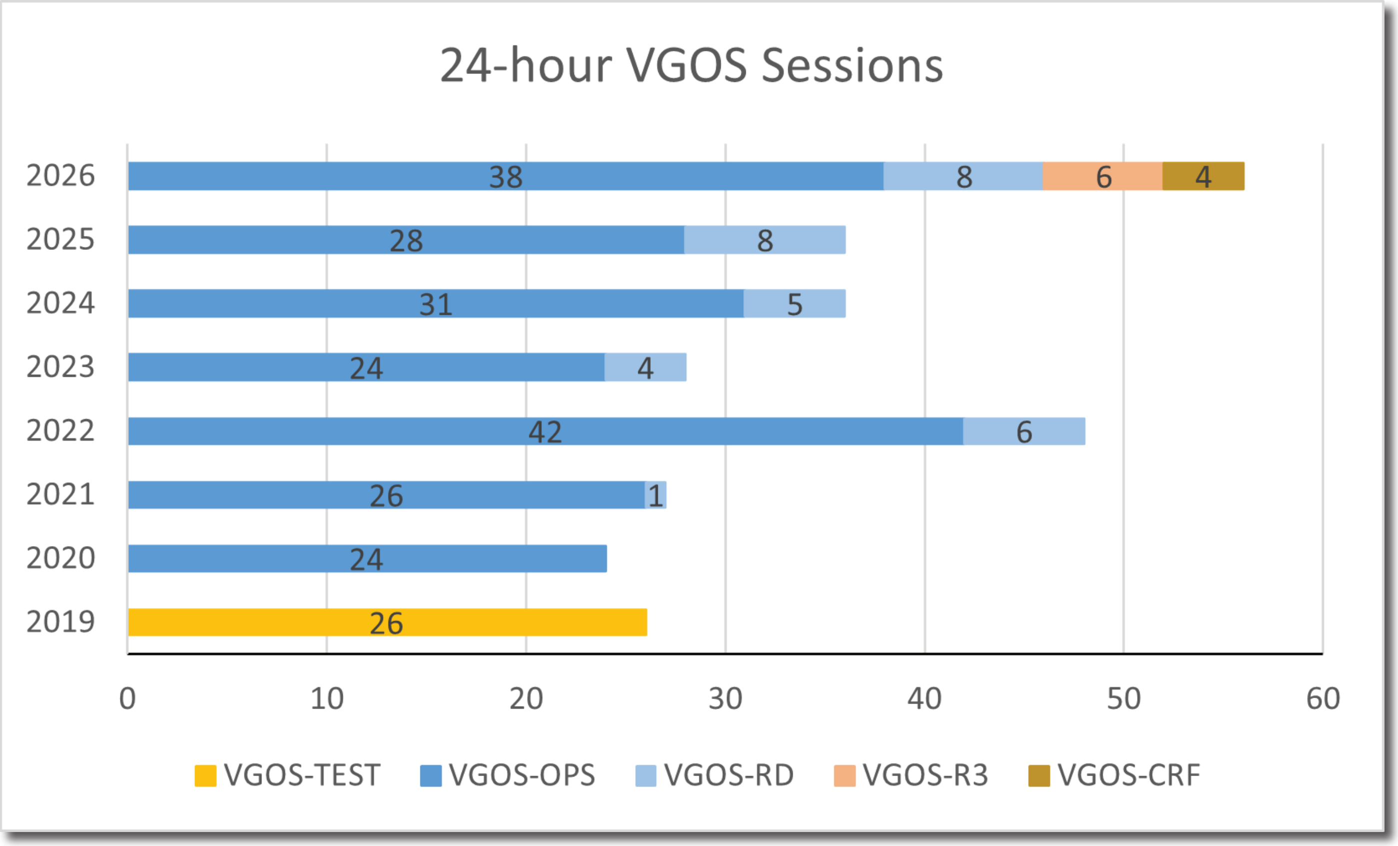
Onsala Space Observatory (illustration by Masafumi Ishigaki)

VGOS Observing Plan for 2026

Lucia McCallum, UTAS, and Dirk Behrend, NVI, Inc./NASA GSFC

The VLBI Global Observing System (VGOS) was declared operational at the beginning of 2020 (see, e.g., IVS Newsletter Issue #59) with a fledgling VGOS network of 8 to 10 stations located exclusively in the northern hemisphere. VGOS started to provide geodetic and astrometric results and to contribute to IVS products. The network size increased over time to 12 stations in 2023 and to 16 stations in 2025, including several stations in the southern hemisphere further improving data quality. It is anticipated that in 2026 the network will grow to some 22 stations.

In the early years of VGOS operations, the observing cadence for 24-hour sessions was typically every other week. This was mostly mandated by the number of correlators that could process VGOS data. Until 2019, only Haystack Observatory was able to handle VGOS correlation. Since then, four to five additional correlators (BONN, WASH, VIEN, WETZ, SHAO) have gradually taken on correlating 24-hour sessions. In 2022 weekly observing was implemented but had to be halted due to a growing backlog in processing sessions: the turnaround time for 24-hour VGOS sessions (end of observing to vgosDB creation) exceeded two months.



Number of 24-hour VGOS sessions for the period 2019–2026 by observing year. The VGOS-OPS series was started in 2020 succeeding the VGOS-TEST sessions observed in 2019.

Data transport and storage as well as correlator time were the main resources that limited the observing program. After going back to a fortnightly observing scheme in 2023, the last two observing years saw three VGOS 24-hour sessions per month. With the turnaround time gently decreasing (to currently 30+ days) and data storage/transport capacities increasing, it was time to re-evaluate the VGOS program and perhaps inch closer to the VGOS goals of continuous observing and fast turnaround.

The Observing Program Committee (OPC) looked into the next steps for the VGOS program also considering the ongoing network growth. Early ideas were communicated through the various IVS groups and feedback from the community was considered in the final strategy. The plan for 2026 foresees some 56 VGOS 24-hour sessions to be observed on Wednesdays (52 sessions) and Thursdays (4 sessions). That is, we will exceed weekly observing for the first time in VGOS history! The VGOS-OPS sessions will be capped at 200 TB but will retain all available stations for a global network. Further, a rapid-turnaround session series will be introduced: the new VGOS-R3 series will mimic the legacy S/X IVS-R1 and IVS-R4 series and consist of VGOS stations that have a proven record of fast data transport to the BONN correlator. For both the VGOS-OPS and VGOS-R3 series data transfer limits will be introduced: the transfer target will be 14 days for the VGOS-OPS and 5 days for the VGOS-R3. In addition, there will be four VGOS-CRF sessions (one per quarter) and eight VGOS-RD sessions. In total, the VGOS plan comprises the following sessions: VGOS-OPS (38), VGOS-R3 (6), VGOS-CRF (4), and VGOS-RD (4+4).

The *2026 master observing schedule* also brings an operational change for the 24-hour VGOS sessions mentioned above: their session start time will be 0:00 UT in all instances. This means that there will be no 30-min gap between adjacent sessions, which is the standard for the legacy S/X program, and that any changeover time needed for stations between sessions will be incorporated into the way the observing schedules are written. There will be four back-to-back sessions in 2026, and the OPC will work with the stations and the schedulers to enable a smooth changeover.

The prospect of a growing VGOS network is exciting. Yet all IVS entities need to think about future correlation facilities. The available correlator time was one of the main restricting factors when generating this plan, and we would like to thank the VGOS correlators in stepping up and agreeing to additional days for 2026. We also hope that a more regular observing cadence helps to bring more routine operations into VGOS processing, ultimately leading to less issues with the data as well as improved results.

Wettzell Collaboration Reaffirmed: Federal Agency and University Sign Agreement for Continued Cooperation

Alexander Neidhardt, TU Munich

Just as Earth parameters must be regularly updated to account for plate tectonics and variations in Earth rotation, contractual arrangements also need occasional adjustments to reflect new circumstances. Such an update took place on November 12, 2025, at the Technical University of Munich (TUM), where Prof. Dr. Paul Becker, President of the Federal Agency for Cartography and Geodesy (BKG), and Prof. Dr. Thomas Hofmann, President of TUM, signed a new campus agreement governing the continued joint operation of the Geodetic Observatory Wettzell.

President Prof. Dr. Paul Becker (BKG) and President Prof. Dr. Thomas Hofmann (TUM) signing the new campus agreement. (Credit: U. Meyer, TUM Pressesprecher)

The roots of this collaboration reach far back. From 1970 to 1986, the German Research Foundation funded a special Collaborative Research Center in satellite geodesy (SFB 78). Spaceflight and satellite technologies were still in their infancy at the time, but their immense potential—especially for Earth measurement and mapping—quickly became apparent. The emerging field of satellite geodesy laid the groundwork for the first satellite laser observations at a small station in the Bavarian Forest, the predecessor of today's Geodetic Observatory Wettzell. The site was selected due to the flight-restricted zone along the former "Iron Curtain" near the Czech border, which minimized risks posed by the non-eye-safe laser systems used in those early days.

On July 1, 1983, the Technical University of Munich, the central administration of the German Geodetic Research Institute (DGFI) in Munich, and the Institut für Angewandte Geodäsie (IfAG) in Frankfurt signed an agreement to ensure the long-term continuation of the work initiated by the research center. Their goal was to collaborate as a newly formed "Satellite Geodesy Research Group." During this period, the large radio telescope—still in operation today—was constructed. The group's mission included data acquisition, instrumentation development, scientific analysis, and participation in national and international research programs and services.

Since then, the partnership has flourished, achieving global importance in geodesy. Over time, the IfAG evolved into the Federal Agency for Cartography and Geodesy, which today provides national geospatial infrastructure services. DGFI Munich became part of the Technical University of Munich. Meanwhile, the broader context also changed: the German government recognized the crucial role of geodata—and particularly the infrastructure at Wettzell. The observatory was designated as a "critical infrastructure," and BKG assumed the role of a security authority. This status brings heightened requirements for protection, operations, and mission execution. At the same time, TUM has undergone remarkable development and is now ranked among Europe's top universities with a global reputation, accompanied by rigorous standards for research excellence. The original 1983 agreement no longer reflected these realities.

The leadership team (left to right): PD Dr. Alexander Neidhardt, Dr. Thomas Klügel, Dr. Johannes Bouman, President Prof. Dr. Thomas Hofmann, President Prof. Dr. Paul Becker, M.Eng. Christian Plötz, Prof. Dr. Roland Pail, and Prof. Dr. Urs Hugentobler. (Credit: U. Meyer, TUM Pressesprecher)

Because this "extraordinary collaboration between a federal agency and a university," as President Becker described it, was considered essential to uphold, the contractual framework has now been modernized to address today's expectations and evolving security challenges. The new campus agreement defines requirements for security and confidentiality, usage rights, mutual obligations, liabilities, and more. This ensures continued joint operations in which governmental services and scientific research can thrive side by side.

President Hofmann expressed clear enthusiasm for the renewed foundation of cooperation and promised to visit Wettzell again soon, noting that he was "deeply impressed by both the achievements and the remarkable team spirit on site."

The IVS Directing Board at Wettzell in 2023

Remembering Alan Whitney

Colin Lonsdale
MIT Haystack Observatory

Alan Whitney

The entire IVS community and MIT Haystack Observatory fondly remember Dr. Alan R. Whitney, former principal research scientist, associate director, and interim director of Haystack, who died on September 28, 2025, at age 81.

Whitney was a key contributor to the development of innovative technologies to advance the powerful radio science technique of VLBI. He ascended to the rank of MIT Principal Research Scientist, served for many years as Associate Director of the observatory, and in 2007–2008 took the reins as interim Observatory Director.

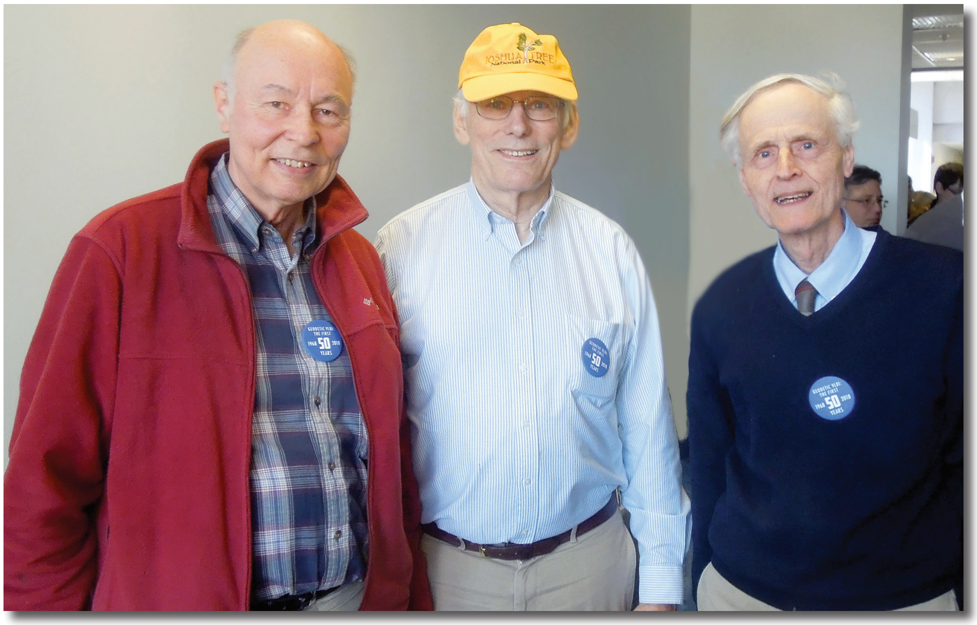
In the late 1960s, as part of his PhD work he was heavily involved in the pioneering development of VLBI, an extraordinary technique that yielded direct measurements of continental drift, and information on distant radio sources at unprecedented angular resolution. A landmark paper led by Whitney demonstrated the presence of apparent superluminal motion of radio sources, which was explained as highly relativistic motion aligned toward the Earth. He spent the rest of his long and productive career pushing forward VLBI technology to ever greater heights and ever more impactful scientific capabilities.

The early days of VLBI demanded heroic and grueling efforts, traveling the world with exotic devices in hand-carried luggage, mounting and dismounting thousands of magnetic tapes every couple of minutes for hours on end, troubleshooting complex and sensitive instrumentation, writing highly specialized software for the mainframe computers of the day, and Whitney was fully engaged on all these fronts. In a quest for higher-capacity data recording and greatly increased sensitivity, Honeywell high-speed instrumentation tape drives were adapted to create the Haystack Mark III (MkIII) VLBI recording system. This was accompanied by a custom-built hardware data processing system known as the MkIII correlator, capable of handling the massively increased data volume captured by the recorders. By the early 1980s, the Mark III (MkIII) recording and correlation systems, whose development was led by Whitney, were established as the state of the art in VLBI technology, and a standard around which the global VLBI community coalesced.

Over the next 3 decades, these systems were refined, streamlined, incrementally enhanced in various ways, and replaced with newer technologies, all under the guidance and leadership of Whitney as a gifted technologist and skillful manager. The MkIII recording system was augmented to store an order of magnitude more data on each tape, and a variant of this system was delivered to the National Radio Astronomy Observatory (NRAO) as a key component of the new Very Long Baseline Array (VLBA). Data formats and the end-to-end control language for VLBI experiments were standardized. A new correlator, the Mark IV (MkIV), was developed, requiring the management of a complex US-European collaboration involving custom chip fabrication, integration of European-designed station units, and extensive supporting software architecture.

By early recognition of a technological trend the form of a rapid and sustained rise in hard disk capacities and speed, Whitney led the transition to VLBI disk-based recording via development of the Mk5 system. This opened the door to VLBI bandwidths (and hence sensitivities) growing with Moore's Law after 2 decades of slow growth limited by the mechanical properties of instrumentation tape drives. This was a profound shift enabling major improvements in sensitivity and the scientific reach of VLBI as a technique. Mk5 systems were quickly adopted and retrofitted into the VLBA.

In the latter part of his illustrious career, Whitney continued to innovate, pushing the technical boundaries of VLBI. A key advance was the Mark 6 (Mk6) recording system, capable of yet faster recording, higher sensitivity, and more robustness. The Mk6 recorders' provided an essential capability allowing the creation of the Event Horizon Telescope (EHT), which famously yielded the first image of the shadow of a black hole. These recorders are now used to routinely record data roughly 100,000 times faster than the computer tapes used at the start of his career during the dawn of the VLBI technique.



Alan Whitney with Jim Moran and Alan Rogers

Whitney engaged with the development project for the international Murchison Widefield Array in Australia, and assumed the role of project director from 2008 until groups in Australia took over the construction phase of the project a few years later. Until his full retirement in 2012, Whitney continued to provide invaluable technical insights and support to the VLBI group at Haystack. In 2020, Whitney was a co-recipient of the 2020 Breakthrough Prize in Fundamental Physics awarded to the Event Horizon Telescope Collaboration.

Alan Whitney was a top-notch technologist with a broad perspective that allowed him to guide the development and refinement of the VLBI technique. His dedication was a source of inspiration to many in the IVS and beyond. He was widely admired for the clarity of his thought, the sharpness of his intellect, and his genial and friendly nature. He will be missed.

A version of this article *was published in MIT News in October.*

The IVS Newsletter is published three times annually, in April, August, and December. Contributed articles, pictures, cartoons, and feedback are welcome at any time.

Please send contributions to the General Editors; the deadline is one month before the publication date. The editors reserve the right to edit contributions.

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