

An Unprecedented Global Communications Campaign for the Event Horizon Telescope First Black Hole Image

Lars Lindberg Christensen
European Southern Observatory
lars@eso.org

Mislav Baloković
Center for Astrophysics | Harvard & Smithsonian
mislav.balokovic@cfa.harvard.edu

Mei-Yin Chou
Academia Sinica Institute of Astronomy and Astrophysics
cmy@asiaa.sinica.edu.tw

Suanna Crowley
HeadFort Consulting, LLC
suanna@myheadfort.com

Peter Edmonds
Center for Astrophysics | Harvard & Smithsonian
pedmonds@cfa.harvard.edu

Valeria Foncea
Joint ALMA Observatory
Valeria.Foncea@alma.cl

Masaaki Hiramatsu
National Astronomical Observatory of Japan
hiramatsu.masaaki@nao.ac.jp

Colin Hunter
Perimeter Institute for Theoretical Physics
chunter@perimeterinstitute.ca

Katharina Königstein
Radboud University
k.konigstein@astro.ru.nl

Sarah Leach
European Southern Observatory
reachingsarahleach@gmail.com

Nicolás Lira
Joint ALMA Observatory
Nicolas.Lira@alma.cl

Mariya Lyubanova
European Southern Observatory
mlyubeno@eso.org

Satoki Matsushita
Academia Sinica Institute of Astronomy and Astrophysics
satoki@asiaa.sinica.edu.tw

Harriet Parsons
East Asian Observatory
h.parsons@eaobservatory.org

Eduardo Ros
Max-Planck Institute für Radioastronomie
eros@mpifr-bonn.mpg.de

Oana Sandu
European Southern Observatory
osandu@partner.eso.org

Calum Turner
European Southern Observatory
calum.talkscience@outlook.com

Megan Watzke
Center for Astrophysics | Harvard & Smithsonian
mwatzke@cfa.harvard.edu

Karin Zacher
Institut de Radioastronomie de Millimétrie
zacher@iram.fr

Keywords
Event Horizon Telescope, media relations, black holes

An unprecedented coordinated campaign for the promotion and dissemination of the first black hole image obtained by the Event Horizon Telescope (EHT) collaboration was prepared in a period spanning more than six months prior to the publication of this result on 10 April 2019. This article describes this unusual campaign and its outcomes.

Due to the viral nature of the dissemination of this result, we believe it is reasonable to conclude that over half of the world's population now know that humankind has taken an image of a black hole. The potential global readership was on the order of billions, possibly as much as 4.5 billion. The result trended as number one on Twitter globally, reached the top spot on Google News, got its own Google Doodle, and was the most popular story ever published for many scientific organisations involved. The authors believe this has led to a significant boost for the EHT, for the involved observatories and organisations, for astronomy, for

science and for peaceful international collaboration.

Introduction

On 10 April 2019, the EHT Collaboration announced the first-ever image of a black hole, specifically M87* in the galaxy Messier 87. The data were obtained by sophisticated interferometry using eight radio telescopes:

- Atacama Large Millimeter/submillimeter Array (ALMA)
- Atacama Pathfinder Experiment (APEX)

- The IRAM 30-meter telescope
- The James Clerk Maxwell Telescope (JCMT)
- The Large Millimeter Telescope Alfonso Serrano (LMT)
- The Submillimeter Array (SMA)
- The Submillimeter Telescope (SMT)
- The South Pole Telescope (SPT)

Astrophysicist and author Ethan Siegel¹ from Forbes elegantly sums up the discovery itself:

The story of the Event Horizon Telescope is a remarkable example of high-risk, high-reward science. During the 2009 decadal review, their ambitious proposal



Figure 1. Some of the many newspaper front pages on 11 April 2019. Credit: Eduardo Ros

declared that there would be an image of a black hole by the end of the 2010s. A decade later, we actually have it. That's an incredible achievement.

It relied on computational advances, the construction and integration of a slew of radio telescope facilities, and the cooperation of the international community. Atomic clocks, new computers, correlators that could link up different observatories, and many other new technologies needed to be inserted into every one of the stations. You needed to get permission. And funding. And testing time. And, beyond that, permission to observe on all the different telescopes simultaneously.

But all of this happened, and wow, did it ever pay off. We are now living in the era of black hole astronomy, and the event horizon is there for us to image and

understand. This is just the beginning. Never has so much been gained by observing a region where nothing, not even light, can escape.

An unprecedented coordinated campaign between the involved institutions for the promotion of this high-profile science story began in October 2018, with weekly alignment video conferences amongst all layers of the collaboration (sometimes several a week). A big focus of the work was confidentiality since the result had one singular visual — the image of the black hole — which would essentially give away the entire story if leaked, possibly nullifying all the preparation. The excitement of the work was significant and the tension high while preparing to communicate the results widely and at the same time keeping sensitive information with big visual impact from leaking early.

After months of preparation, six coordinated press conferences began at 13:00 UTC:

- Brussels (English, with at least 12 satellite events²)
- Santiago (Spanish)
- Shanghai (Mandarin)
- Taipei (Mandarin)
- Tokyo (Japanese)
- Washington, D.C. (English)

At exactly 13:07 UTC the image was unveiled at all press conferences either through a state-of-the-art zoom video³ (produced by ESO) or through showing the black hole image. News of this result was covered in most major media around the world and went viral on social media. This led to unprecedented coverage.

The Preparation of the Campaign

In the summer of 2017, it became clear that although the recent EHT observing campaign of the previous spring could possibly generate groundbreaking science results, the collaboration had not yet developed a communications strategy to announce them. In July of that year, following substantive early conversations, support and encouragement from the National Science Foundation (NSF), the EHT Collaboration began working on a communications plan. With ongoing support from NSF, the communications plan centred on the existing EHT Outreach Working Group (OWG) in order to establish an inclusive, collaborative and representative approach that involved dozens of independent institutions. After nearly 18 months of plan development, on 1 October 2018, the OWG brought together media officers from the collaborating institutions to launch the unprecedented campaign for promotion and dissemination.

By October 2018 a group representing more than 100 communicators and communication-savvy scientists from the involved EHT institutions were meeting in weekly video conferences led by the EHT communications coordinator Mislav Baloković. A Teamwork⁴ site was set up by the Perimeter Institute to allow the group to collaborate. As the weeks went by the scientists in this ad-hoc

collaboration assumed a more and more leading role in the communications work, possibly due to the high stakes at play. In general, the excitement among all the collaborators was very high due to the potential impact of the result. The primary focus was on limiting access to the image and result to as few people as possible, and secondarily on the production of content. The OWG meetings established a framework for developing content, strategies and deadlines, as well as opportunities to share those products.

Starting in January 2019, parallel weekly meetings led by NSF focused specifically on coordinating the international press conferences, including precise logistical details. Managers of the press conferences, as well as some scientists and representatives from the relevant institutions, including EHT Director Sheperd Doeleman, participated. This burgeoning team did not have the benefit of an established formal, legal or administrative structure or any pre-existing leadership hierarchy (apart from the EHT science collaboration). Nevertheless, they proved capable of coming to agreement, and making and abiding by major decisions regarding the public announcements.

The European Southern Observatory (ESO) Public Information Officer Calum

Turner took the lead on writing up a joint core press release with allocated spaces for “localised” content and quotes that could highlight and promote the individual participating organisations and telescopes. This text was then jointly edited by the participating communicators and scientists over the course of several weeks. Collating and integrating the many comments was a herculean effort and allowed everyone in the collaboration to share their suggestions, concerns and views. Most of the press releases published, notably NSF, ESO, the East Asian organisations and the EHT Collaboration, respected the agreed format, but not all — mainly those from organisations who were not part of the above-mentioned group video conferences and hence were not aware of the substantial alignment efforts.

While this approach allowed a broad range of opinions to come together, it dramatically increased the coordination workload and would have benefitted from a more predefined approval structure. However, the level of coordination did allow for a very broad, constructive and collaborative approach, leading to many translations (including into Hawaiian, the first such case) and a common pool of impressive visuals (including a Japanese comic³). A set of in-depth scientist-led factsheets about the EHT and the history of the

science leading up to the result were unfortunately never finalised and published.

It was agreed to send out a media advisory announcing the press conferences on 1 April, despite some differing opinions among EHT partners about the form and timing of this communication. On the one hand, it was deemed necessary to give journalists time to reserve flights to participate in the press conferences. On the other hand, the long time period before making the major announcement increased the chances of information leaks. This risk was countered by the guideline that collaboration members completely avoid talking to the press before the press conferences, even on background. Some science journalists were sharply critical of this guideline because it seemed unusually restrictive, and there was also concern that competing journalists would receive access to embargoed information, based on experience with past announcements in astronomy. Other journalists accepted the challenge of using publicly available information and wrote templates of articles with the assumption that the project had succeeded. In the end, the lack of leaked information was an impressive achievement by the collaboration. The 10 days of advance notice gave journalists enough time to travel and prepare, and it created a sense of suspense in the media with lots of (sometimes tangential) rumours and interest which in itself generated additional visibility to EHT and its partners (anecdotally, about one-third of all media coverage was registered prior to the event for the Brussels press conference).

Such a coordinated public announcement of this scale had never been attempted before in astronomy. This coordination proved remarkably successful. The fact that there were no major leaks of information prior to the 10 April press conferences is demonstrated by the fact that even the media was surprised to learn that results were of M87*, not the widely anticipated Sgr A* observations.



Figure 2. The press conference in Brussels. Credit: European Research Council Executive Agency

Press Conferences

Brussels

The Brussels press conference (Figure 2) was held at the European Commission's (EC) Berlaymont building. Over 60 journalists attended the press conference in Brussels, while some 120 registered to follow it online. The YouTube live feed reached a peak of some 200 000 viewers. After the press conference, European Research Council (ERC) President Jean-Pierre Bourguignon and Nobel Laureate Brian Schmidt opened an EHT exhibition in the same venue.

According to the internal analysis by the ERC press service using Meltwater and Akio Spotter, the ERC has never had this kind of success before. The press conference in Brussels was broadcasted live by the EC audio-visual service. The press conference YouTube stream⁶ has now been seen by more than 3.1 million viewers and has had 13.6 million impressions, 72 000 shares, 62 900 interactions, 58 000 likes and 1600 comments. It quickly became the third most viewed video on the EUTube account. It was the top video for all black hole videos on YouTube on the day of the announcement. In terms of engagement, it was the most successful EUTube⁷ video ever.

More than 500 entities embedded the live stream on their websites. Le Monde hosted more than 2 hours 30 minutes of live streaming, which according to the Le Monde website⁸ became third best

live stream in the history of Le Monde and had a larger online audience than France's victory at the FIFA World Cup 2018 for football when more than 45 000 people connected. The live stream also appeared on Euronews, Le Figaro, Bloomberg, Sky, El Confidencial, Evening Standard, Agenzia ANSA, Science Alert, Le Soir, La Libre, CNET Magazine, Wired.it, T-online.de, Sputnik News, Observador.pt, Il Fatto Quotidiano, The Independent and BBC News.

At least 92 TV channels, including BBC News, Sky News, Deutsche Welle, TVS Slovenia, ARD and ARTE produced 648 TV reports using live satellite broadcast from the press conference or the audio-visual material prepared in advance by the ERC and Commission's AV service and distributed on the day of the announcement.

The result meant that science was solidly "put on the agenda" in Brussels, the European hotspot for politicians and news consumers in general, and also that science, possibly for the first time, proved itself to the sceptical Brussels press corps, which is an important cultural change at the EC.

Santiago

The press conference in Santiago (Figure 3) was hosted by the Joint ALMA Observatory (JAO) and ESO, and was introduced by the Atacama Large Millimeter/submillimeter Array (ALMA) Director, Sean Dougherty,

and ESO's Director General, Xavier Barcons. It featured presentations from researchers behind the result (ALMA's Violette Impellizzeri and MIT Haystack Observatory's Geoff Crew).

This event was intended for Spanish-speaking journalists from the local and international media. The conference was streamed online⁹ and on Facebook, YouTube and Twitter-Periscope (54 000 on Facebook, 155 000 viewers on Youtube, and more than 7000 on Twitter (incl. 2400 Live)). The event was attended by at least 35 journalists. The JAO website had 75 000 hits on 10 April and more than 18 000 at the beginning of the press conference. The JAO ALMA Instagram channel doubled from 25 000 to 53 000 followers and the result had at least 487 mentions in Chilean media.

Shanghai

The Shanghai press conference (Figure 4) was hosted by Shanghai Astronomical Observatory (SHAO) at 21:00 CST. Jinliang Hou, Deputy Director of SHAO, hosted the press conference with presentations by Zhiqiang Shen, Director of SHAO, and Rusen Lu, researcher and Head of the Max Planck Partner Group at SHAO. Suijian Xue, Deputy Director-General of The National Astronomy Observatory of China (NAOC) was also in attendance.

The event was covered by almost all of the major Chinese media broadcasters and popular media compa-



Figure 3. Attendees at the press conference in Santiago. Credit: F. Pizarro/ALMA (ESO/NAOJ/NRAO)



Figure 4 The Shanghai press conference. Credit: Shanghai Astronomical Observatory

nies including CCTV, People's Daily, XinhuaNet, China News, China News Week, Guangming Online, Sina Net, and Science and Technology Daily. Media tracking up to the end of April indicated that the video of the press conference has been watched over 50 million times, with over 5000 stories covering the press conference and 52 million interactions related to the press conference on various platforms (e.g. Weibo, People's Daily Online, XinhuaNet, CCTV website and Tiktok).

Alongside the press conference, SHAO produced a series of informative scientific interpretations and eight videos about the black hole. Media tracking up to 18 April indicated that these articles were read more than 1 million times on the social media platform WeChat and these videos were viewed 3.3 million times using TikTok and Xigua Video platform.

Taipei

The press conference in Taipei (Figure 5) was hosted by the Academia Sinica (AS) and the Ministry of Science and Technology (MOST) in Taiwan. It was introduced by the President of Academia Sinica, James Liao, and featured presentations from researchers Asada Keiichi and Masanori Nakamura. The conference was streamed online through Facebook and Youtube (956 000 viewers on Youtube and 620 000 on Facebook, which corresponds to about 7% of the Taiwanese population). The press

conference live stream has now been viewed more than 1.6 million times. There were more than 50 reports shown in Taiwanese media on 10 and 11 April. More impressively, the President of Taiwan, Ing-Wen Tsai, praised the success of the imaging of the black hole shadow on her Instagram account.

Tokyo

The Tokyo Press Conference (Figure 6) was held at the Tokyo Garden Terrace Kioi Conference facility. Although it was inconveniently late in the evening in Japan (22:00 JST), 61 journalists and 14 TV crews attended the event. The National Astronomical Observatory of Japan (NAOJ) live stream on YouTube¹⁰ and niconico¹¹ had about 85 000 views. The press release on the NAOJ website¹² had up until 30 April almost 300 000 pageviews. The major Japanese TV stations NHK and TV Asahi live-streamed the press conference on their app and Twitter account. The tweet by @ALMA_Japan of the image gained 960 000 impressions and 32 000 engagements, both the highest numbers achieved in the eight-year history of the account.

NAOJ produced a comic to introduce a brief history of radio interferometry and the EHT project in both Japanese and English. The comic was distributed through Twitter and the NAOJ website. The tweets of the comic (two posts) gained 680 000 impressions and 53 000 engagements in total. The comic was also distributed as a PDF and several

science centres in Japan posted it as a part of their exhibitions. A simple poster to show the result made by NAOJ (only in Japanese) was also widely used by science centres.

The result was mentioned in the regular press conferences of the Japanese Minister of Education, Culture, Sports, Science and Technology (MEXT) and the Chief Cabinet Secretary¹³.

Washington, D.C.

The Washington, D.C. press conference (Figure 7) was held at the National Press Club and featured NSF Director France Córdova, EHT Director Sheperd Doleman, and astronomers Dan Marrone, Avery Broderick and Sera Markoff. More than 56 reporters were in the room (roughly the same as in Brussels). Audiences included more than 735 000 viewers on YouTube and 520 000 on Facebook Live. The YouTube stream¹⁴ has now accumulated 1.3 million views, 22 000 likes, 758 comments, 5.3 million impressions, and 32 667 shares. The Facebook Live feed now has 716 000 views and 60 000 likes and reactions. Other press conferences streamed the Washington, D.C. press conference as the start of their programmes.

Following the press conference, NSF facilitated on-camera interviews with such outlets as NBC Nightly News, CBS Evening News and BBC News; calls with the New York Times, the Los Angeles Times and others; and in-depth



Figure 5. The journalists at the Taipei press conference. Credit: Academia Sinica



Figure 6. The press conference in Tokyo. Credit: NAOJ



Figure 7. The US press conference panellists. Credit: National Science Foundation

conversations with National Geographic, the Associated Press, Reuters, USA Today, Xinhua, The Washington Post and dozens of other leading outlets from across the globe (Figure 10). Through coordination with media officers at partnered U.S. research institutions, some of which streamed the Washington, D.C. event, regional press engagement was also strong — more than 145 U.S. broadcast affiliates aired reports that mentioned both EHT and NSF. Analytics identified a total of 400 broadcast news stories, with half mentioning NSF.

In the afternoon, the presenters gave a briefing sponsored by the House of Representatives Committee on Science, Space and Technology. Staff from both the House and Senate attended as well as committee Chairwoman Rep. Eddie Bernice Johnson (D-TX), Ranking Member Rep. Frank Lucas (R-OK) and Congressman Rep. Don Beyer (D-VA). In a separate press release, Rep. Lucas congratulated the EHT on its success. Later that evening, the Harvard-Smithsonian Center for Astrophysics hosted a reception at the Smithsonian's National Air and Space Museum for invited guests.

On 16 May 2019, Córdova and Doleman returned to Capitol Hill, this time accompanied by MIT Haystack Observatory

Director Colin Lonsdale and EHT scientist Katie Bouman, to testify on the science results before a full committee hearing of the House Committee on Science, Space, and Technology, which was also broadcast on the TV network C-SPAN.

Press Coverage

Naturally, the impact of a worldwide campaign of this magnitude is hard to measure. The viewership numbers are reported in the preceding summaries and the hundreds of front pages from around the world, some of which were collected by Eduardo Ros (Figure 1), clearly show the global penetration of the result and the viral nature of its coverage.

On 10 April, Rick Fienberg, the press officer for the American Astronomical Society (AAS) sent out around 20 press releases which were just a fraction of the total estimated 40-50 press releases produced.

Thousands of major news outlets reported on the story, which led to unprecedented coverage. According to news chief Ray Villard at Space Telescope Science Institute, the EHT image made 3500 online articles with a potential 4.5 billion readers (as an upper limit). The

Bennet Group in Hawaii reported a similar number of theoretical maximum readership for a narrower subset of the storyline: "Aggregate Readership: 4 673 590 910 for reflecting media results directly attributable to Bennet Group's collaboration with James Clerk Maxwell Telescope and Submillimeter Array". Cision Analytics identified more than 1000 news articles mentioning both EHT and NSF, with a theoretical maximum audience of up to 2.2 billion unique viewers. Such theoretical readership numbers are naturally only indicative and should be used with caution and significant caveats¹⁵.

Several of the people involved with EHT communication made what we nicknamed the "taxi-driver test": asking random laypeople about black holes (for instance, in taxis), which led to a perceived near-complete coverage in the awareness of the story among random people in the western world ($N \sim 100$).

The result reached the top spot on Google News (Figure 8) and Google Trends (Figure 9) show an interesting two-day peak with a relatively long tail of six to seven days of sustained interest.

Impact in Some Selected Cases

The collaboration's website¹⁶ received unprecedented traffic in the days leading up to the press conference, the day of the event itself, and the immediate period that followed. During March 2019 the website received roughly 600 visitors daily, but on 8 and 9 April, this surged to about 50 000 visitors per day, before spiking to 450 000 visitors on the day of the press conference. The two days immediately following the press conference saw 130 000 and 42 000 visitors per day to the site before declining as expected.

NSF

In anticipation of unprecedented public interest, NSF launched a special report page¹⁷ several weeks in advance of the EHT press conferences. This site featured stories about NSF black hole research, and, with EHT approval, teased the announcement by hosting a trailer for the Smithsonian Channel's documentary Black Hole Hunters. On 10 April, the NSF

page transformed to host the Washington, D.C. live stream and link to a media site with a wealth of custom visuals including an animation based on EHT modelling data, as well as interviews, B-roll, stills, backgrounders, and eventually even a downloadable poster. One of the new videos, an NSF montage featuring the EHT telescopes and data centres, aired during the core press conferences around the globe and served as B-roll for a number of broadcasts.

In addition to distinguished guests, including Director Kelvin Droegemeier of the White House Office of Science and Technology Policy, NSF invited a broad pool of EHT team members and experts to ensure journalists featured the broader EHT Collaboration in addition to the image.

ESO played a major role in developing the story and a rich set of visuals that were published together with the press release on the ESO website¹⁸: a total of 20 images and 13 videos, which

were shared with others throughout the collaboration. Though ESO is not a member of the EHT Collaboration, its contributions through ALMA and APEX were significant. A special ESO EHT landing page¹⁹ was set up and has so far had hundreds of thousands of views.

A check soon after the publication on the press clippings service Meltwater found 487 stories for “ESO + black hole” plus an additional unknown number for “European Southern Observatory + black hole”, which leads us to believe that between 13% and 20% of the articles worldwide mention ESO.

Despite undergoing significant hardware and software upgrades in the months before the release, the ESO web servers were somewhat saturated for around 60 minutes from 15:00 to 16:00 CEST (13:00 to 14:00 UTC) on 10 April (especially for low-bandwidth connections). Over the first six days after the release, ESO accumulated 36 million hits on its web pages and 1.1 million views of the press release itself. It is estimated

that the press release got at least seven times more visitors and traffic than the 2017 high-impact optical counterpart detection of gravitational waves (LIGO-Virgo) release²⁰.

Institut de Radioastronomie Millimétrique (IRAM)

IRAM, one of the thirteen EHT stakeholder institutes, reported similar outcomes. IRAM, a research institute in France, was mentioned in more than 400 online articles (mainly German and English-speaking) with about 182 million potential readers. Additionally, French-speaking media published about 400 articles (web, radio, TV, print press) mentioning “EHT” and “IRAM”. More than 100 written articles mentioning “IRAM” were published in Germany alone.

Radboud University

Radboud University in the Netherlands, another stakeholder in the EHT Collaboration, was mentioned in more than 4000 online articles peaking on 10 April with 1600 online articles, and the press release was picked up by the NRC Handelsblad, de Volkskrant, RTL 4 and NOS. The news reached the largest audience via the Algemeen Dagblad in the Netherlands — 6.8 million potential readers. In collaboration with Radboud astronomer Jordy Davelaar, among others, a video was produced in which the black hole was simulated. This video has been viewed almost 100 000 times on several YouTube channels²¹.

Chile

In Chile, the black hole image hit the front pages of the main media and with broad coverage on all the news shows broadcasted on open TV (TVN, MEGA, CHV, Canal 13). It is estimated from Meltwater (Search of “EHT + ALMA”) that at least 700 million theoretical readers received the news mentioning ALMA and the press clipping service LitoraPress calculated the ALMA coverage in Chilean media worth around USD \$1.8 million in Advertising Equivalent Value.

Japan

In Japan, all the daily national newspapers and many local papers covered the EHT result next morning. The embargo lifted at 22:07 JST in Japan — a somewhat disadvantageous hour and too late for some newspapers to include

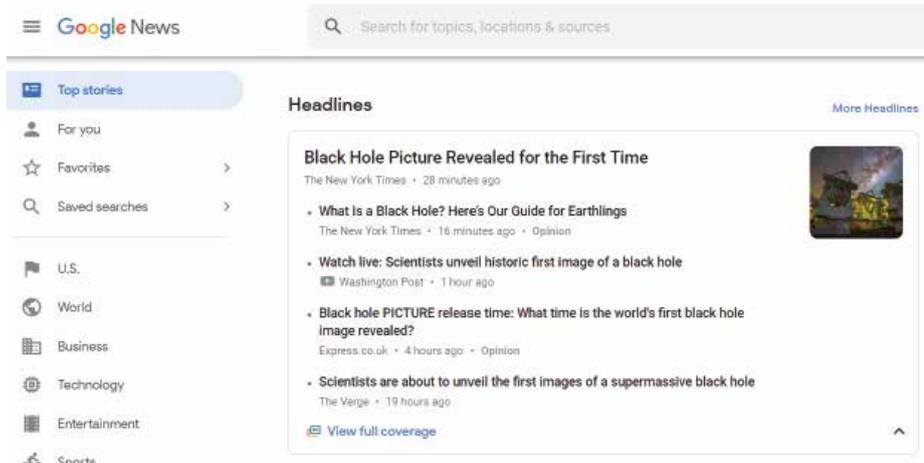


Figure 8. The image was the number one story headline on Google News on 10 April (higher than any political news). Credit: Google News

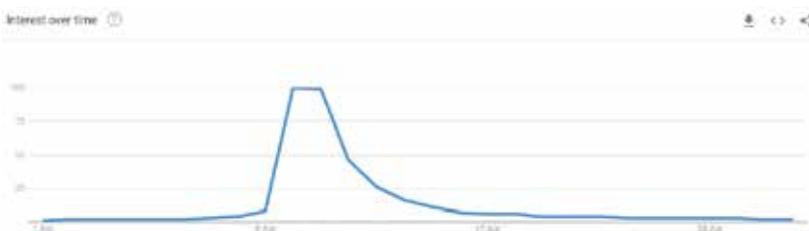


Figure 9. The Google Trend for “black hole” in April 2019. Credit: Google Trends

the EHT results in their morning issue (especially for the editions distributed to the countryside regions, where the readership is higher than in urban areas). Even in this situation, about 300 articles were published up to 30 April 2019. The articles include plain news reports, interviews with Japanese researchers focusing on personal aspects of the project, and editorial articles. Major Japanese TV news programmes and tabloid shows covered the EHT result and some programmes interviewed Mareki Honma, the leader of EHT-Japan team. Three TV stations followed Honma's work in the time from the observation campaign in April 2017 to the press conference two years later.

Canada

In Canada, every national newspaper and television news broadcast covered the EHT Collaboration announcement. The country's most prominent newspaper, The Globe and Mail, ran a long article and a video produced with EHT researcher Avery Broderick of Canada's Perimeter Institute. Canadian Prime Minister Justin Trudeau tweeted congratulations to Broderick and the EHT Collaboration. The Perimeter Institute released four new videos about the EHT on the day of the announcement and hosted a live webcast panel discussion

on the same day. This video content garnered nearly one million views²².

Taiwan

In Taiwan, all the national daily newspapers and TV news covered the EHT result on 10 and 11 April. The press conference was held at 21:00 CST in Taiwan, resulting in many journalists coming to interview the researchers over the following few days. There were more than 60 articles reporting the EHT news and Taiwanese contribution in April 2019. Four Taiwanese TV news programmes invited researchers to explain the EHT result.

Social Media Impact

Social media campaigns were coordinated with the aim of stimulating people's curiosity leading up to the event and inform them of the chance to follow any of the press conferences live, as well as to disseminate the image, the science results and the facilities which contributed to the science. As for the social media impact, it is hard to evaluate, but it was significant, possibly unprecedented, as made evident from the result reaching number one and number three on Twitter Trends (Figure 11).

Impact of Selected Social Media Campaigns

NSF

NSF proposed the idea of a "black hole blackout" to the EHT community to start three days before the event. All NSF social media pages went dark, posting only an all-black image and redacted text that gradually unveiled a message detailing the date and time of a "major announcement" and ultimately where to watch it (Figure 13). This drove excitement and anticipation including an incorrect theory that NSF had hidden the black hole image in the post.

Within the first week, the NSF Twitter campaign earned 8.1 million impressions, 58 600 retweets, 120 700 likes, 63 900 clicks on NSF links, and Twitter included NSF tweets in the official Twitter Moment news feed. Throughout the day on 10 April, NSF posted about the announcement, while the Facebook Live stream from the press conference reached 1.9 million people. NSF's tweet with the image²³ accumulated more

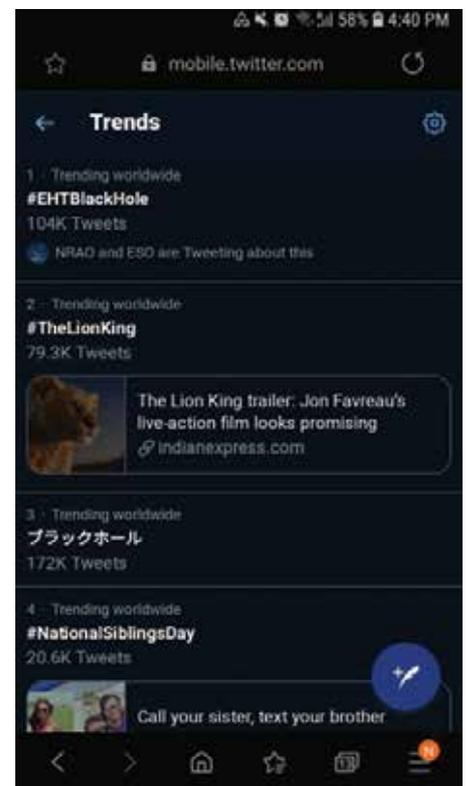
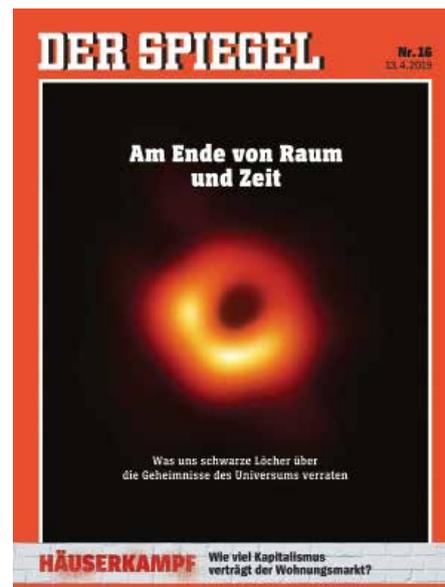


Figure 10. A few of the magazine covers of the black hole shadow image. Courtesy of DER SPIEGEL 16/2019³² and New Scientist

Figure 11. The #EHTBlackHole hashtag of the event was trending as number one while the Japanese word burakkuhooru (black hole) trended as number three on Twitter globally. Credit: Twitter

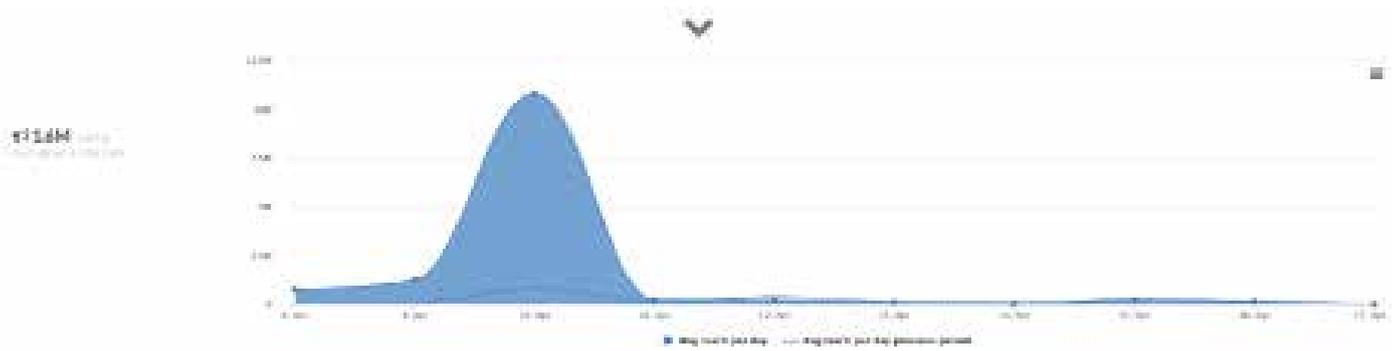


Figure 12. Average reach per day on ESO’s Facebook and Twitter for the period 8–16 April was 1.6 million, with a big peak on 10 April. The peak of the social media interest is 3-4 times slimmer than the Google Trend peak. Note the effect of the teasing campaign before 10 April, left. Credit: ESO

than 29 700 retweets and 53 400 likes within 12 hours, numbers which have almost doubled since then. Following the announcement, NSF gained 25 000 new Facebook followers and 40 000 new Instagram followers.

ESO started a teasing campaign on 7 April on Facebook, Twitter and Instagram, based on the initial idea from NSF and adapted to ESO channels (Figure 14). A message and key visual were gradually revealed during the period of 8–10 April. The teasing campaign was very successful, with comments showing that people were very eager to see the image.

On Twitter, ESO decided not to host a live stream but did live tweets instead. ESO posted 40 tweets during the day, focusing on explaining the scientific results, the EHT network of telescopes, the role of European facilities, ESO’s contribution to the results through the ALMA and APEX telescopes, the technology used, etc.

ESO’s Facebook and Twitter posts reached 10 779 709 people on 10 April and had an average reach during the period 8–16 April (Figure 12) of 1.6

million people per day (1.4 million higher than compared with the previous period). Similar to what happened to the JAO-ALMA Instagram followers, the ESO Instagram followers doubled from 28 038 to 55 545. The main post of the discovery reached 391 230 people and had 50 854 likes and 1059 comments. The impact on community growth was less significant on other channels (a 5% increase in Twitter followers and a 1% increase in Facebook friends). On ESO’s YouTube, the videos from the period 10–16 April had 1.05 million views. While

ESO’s social media had the most impact in Europe, the message reached every populated continent as well.

ESO and collaborators also hosted a Reddit Ask Me Anything Science session²⁵ with scientists from the entire collaboration, which accumulated an impressive 1600 comments on the thread.

EHT Collaboration
The Facebook page for the EHT Collaboration²⁶ went from less than 5000

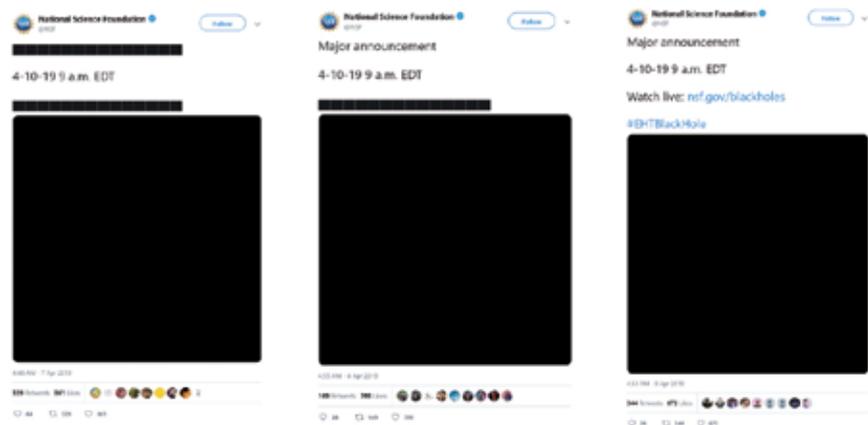


Figure 13. The NSF “black hole blackout” social media campaign. Credit Twitter/NSF

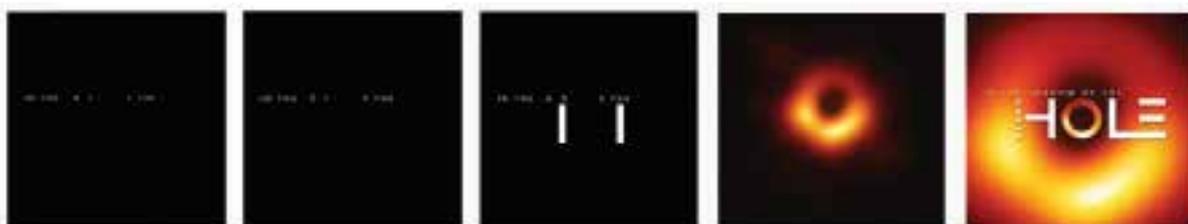


Figure 14. ESO’s five teaser posts, including the result post, on ESO’s Instagram account²⁴. Credit Instagram/ESO



Figure 15. Social media memes from 10 and 11 April 2019. Courtesy of the individual users

friends at the end of March to nearly 60 000 on the day of and immediately following the press conference. The top post on this Facebook account reached some four million users, leading to 21 000 likes, 23 000 shares and about 1200 comments.

Mirroring the reach of the ESO social media activity, the top tweet of the collaboration's Twitter account (@ehtlescope), using the #EHTBlackHole hashtag, has generated 1.4 million impressions, with over 65 000 retweets and 130 000 likes. The number of impressions in March averaged about 3000 per day, then increased to 43 000 from 1–9 April, 7.9 million on 10 April, 2.9 million on 11 April, about 250 000 from 12–18 April and 84 000 from 18–25 April. The number of followers was about 4500 at the time of the media advisory, about 6500 just before the announcement and about 61 000 on 11 April.

The European Commission

The EC's social media campaign used the full potential of the EC's Twitter, Facebook and Instagram accounts. The Commission's social media team shared related posts on all its accounts. The actions were among the most successful content an EU-institution has ever published:

- Twitter: Five tweets with a total of 2.7 million impressions and 240 000 engagements. The tweet of the image²⁷ was the most successful ever published by the EC.

- Instagram: More than 21 000 engagements and with a reach to 139 757 people. The EC's #RealBlackHole Instagram post was the most successful content of an EU social media Instagram account ever both in terms of engagement and in terms of reach.

- Facebook: The post with the image reached 1.5 million users

Memes

In addition to the impact seen on social media by prepared campaigns, another remarkable aspect of this result was the amount of memes and popular culture references that were shared on social media, demonstrating that the image not only had reached people far wider than seen for other results before, but also that people seemed to be as excited about the results as the scientific community, and engaged in co-creation, sharing heavily on social media. This popularity was enhanced by the simplicity of the image and its easy identification with a black hole, combined with the public's fascination with these objects.

Leaning into the "meme-ification" of the black hole image, NSF asked the public to share their favourite meme with #BlackHoleLooksLike through a popular blog post titled The best jokes about the first image of a black hole, which was posted on 12 April.

A few of the hundreds of examples of "exploitables" or "memes" are shown here (Figure 15).

Side Stories

Apart from memes, the viral dissemination of the black hole results led to several individual strands of storylines or "side-stories" that took on a significant life of their own. Examples include the following.

'Pōwehi

The first astronomy press release was translated into the Hawaiian language and M87* was bestowed the name 'Pōwehi ("embellished, fathomless dark creation") by Dr Larry Kimura, an associate professor of Hawaiian Language and Hawaiian Studies at the University of Hawai'i, Hilo²⁸. In Hawai'i, the success of this locally directed press releases was demonstrated when the state governor proclaimed 10 April as 'Pōwehi Day in Hawai'i.

Stock Photo Firestorm in China

In China, the stock image provider Visual China Group (VCG) set off a debate over copyright practices in China and beyond after claiming exclusive rights to the black hole photo. Shares for VCG (with around 500 MEUR in assets) plunged 27% on 12 April and had not recovered several months later. Internet regulators in Tianjin temporarily shut down the VCG website, calling for the company to end “illegal, rule-breaking practices”. VCG issued a public apology and the website remained closed for several weeks²⁹.

Katie Bouman

A viral story about EHT scientist Katie Bouman overtook social media following a tweet posted by MIT’s Computer Science and Artificial Intelligence Laboratory (@MIT_CSAIL) at 9:10 EDT on 10 April. This tweet was followed by further tweets from prominent STEM Twitter users that included a photo from Bouman’s Facebook page showing her reaction to a pre-announcement EHT image on her computer or comparison to Apollo 11 software engineer Margaret Hamilton. Bouman and other EHT researchers defended her after the emergence of sexist tweets caught her in a social media firestorm, necessitating issue management support to Bouman from the Smithsonian Astrophysical Observatory and HeadFort Consulting. This viral story was perhaps fed by a lack of appreciation for the size and complexity of the EHT collaboration as well as the knowledge that women’s contributions to science have often been neglected.

Respite from Brexit

British journalists and artisans found respite in the positive, benign, and, most importantly, peaceful international collaboration in the midst of deteriorating Brexit talks between Britain and Brussels, leading to humorous articles, tweets, and political comics in the media and online.

Japanese Products

Online in Japan, Kellogg’s and a Japanese candy company³⁰ used the science results in promotional tweets on Twitter, a dominating social media platform in Japan³¹. A company that creates virtual Youtube avatars, or VTubers, distributed a design file of an “eye” inspired by the EHT image.

Japanese Photo-Op Stand

Also in Japan, a tweet of a “photo-op stand” of the EHT image installed at the NAOJ Mizusawa VLBI Observatory led to a viral story in Japan and coverage from several newspapers. As a result, the observatory received nearly four times more visitors during the holiday season in early May compared to the year before.

Other Results

The EHT image was honoured with its own Google Doodle (Figure 22), was on Wikipedia’s front page (Figure 23) and was even featured in two xkcd comic strips (Figure 24).

Conclusions and Lessons Learned

Although it is hard to draw very solid conclusions from this complex campaign with its multitude of outcomes, some takeaways are nonetheless clear.

- The success of this campaign was made by a combination of an amazing result, a captivating and dramatic story build-up, an appealing main visual (the image) and a significant investment in excellent, accurate graphic design.

- Content is king. Naturally, the quality of the communication products, the teasing campaigns and the collective might of the dozens of “endorsing” world-leading organisations were important. But had the result and story behind it been weak, the impact would likely have been much lower.

- For a big collaboration with many involved organisations, it is natural and unavoidable to allow all participating organisations to issue their own press releases. Having a common core allowed us, in this case, to have the best of both worlds: to fully align our science messages and still allow for “localised” organisational content.

- Not unexpectedly, viral content generates unpredictable side stories that take on lives of their own and can help the visibility of the main storyline. A plan should be implemented for monitoring and responding to social

media coverage of significant results, especially concerning scientists with large numbers of followers or enhanced name recognition.

- A common strategy with regard to an embargo policy and how to deal with media requests must be defined and strictly followed by all partners. A detailed justification for this strategy should be provided — both for collaboration members and the media — including preventing accidental leaks and avoiding favouring of individual media outlets.

- Sharing material under the Creative Commons Attribution 4.0 License allows for the maximum wider reach with minimum effort (no need to approve usage requests). At the same time, attention has to be paid to third parties who take the visuals and re-use them without due credit (or by changing a license fee).

- The different cultures of the communicators and scientists in the campaign meant that important official factsheets about the project’s history as well as technical and scientific background were prepared, but not approved and published, preventing a more complete communication effort.

- Teasing on social media works well to generate attention, but it has to be balanced to not become too much.

- For complex storylines, it helps to have a team of (younger) scientists ready to answer questions in real-time on social media, and are available to give interviews and extra provide information in the following days. An exciting result will generate a lot of questions and engagement.

- When video streaming, a script for the camera people that clearly indicates where the focus should go is important. Within the camera field of view, the speakers should be combined with inset frames of the sides and the audience.

- When doing Facebook Live, it is worthwhile to research how to do Facebook cross-posting and to look into Twitter’s Media Studio to make the content easily available to partners.

- Social media ideas, tools, hashtags and messaging is best discussed well in advance. It is important to have some hashtags highlighting some of the individuals involved in the project (also to highlight diversity) and could have been done better in this case.

- It is very important to provide timely and effective media training to the scientists presenting at a press conference. Often, scientists prepare slides that are more appropriate for the scientific community and not a general audience.

- Due to the magnitude of the story, there were organisations involved in parts of the result who were not among the large group of communicators. Due to strict confidentiality, the conundrum of how to involve them and how much risk to assume was never resolved in a satisfactory way.

Only a true team effort can lead to a success as big as this. The value of international collaborations in science communication cannot be stressed enough for their benefits, especially for generating reach in the millions or even billions of readers.

Acknowledgements

The authors would like to acknowledge all the scientists, organisations, observatories and funding organisations who collectively made this historic result possible. We would like to thank Josh Chamot (NSF), Peter Kurczynski (NSF), and Denise Zannino (NSF) for their insights and assistance. A big thank-you also goes to the many scientists who were involved with the communication work and without whom this effort would not have been so successful: Luciano Rezzolla, Chi-kwan Chan, Hung-Yi Pu and several others.

Notes

¹ Ethan Siegel's article "10 Deep Lessons from Our First Image Of A Black Hole's Event Horizon": <https://www.forbes.com/sites/startswithabang/2019/04/11/10-deep-lessons-from-our-first-image-of-a-black-holes-event-horizon/#be8191e55e64>

² This included one held at the Danish National Space Center in Denmark. Denmark, a new member of the EHT, which will be involved in future EHT observations through the Greenland Telescope.

³ Zoom video produced by ESO: <https://www.eso.org/public/videos/eso1907c/>

⁴ Teamwork: <https://www.teamwork.com/>

⁵ Japanese comic produced by NAOJ: <https://www.nao.ac.jp/en/news/sp/20190410-eh/eh/images/eh-comic-en-20190410.pdf>

⁶ EC Youtube live stream of the press conference: <https://youtu.be/Dr20f19czeE>

⁷ EUtube: <https://www.youtube.com/user/eutube>

⁸ Live stream on Le Monde: https://www.lemonde.fr/sciences/live/2019/04/10/en-direct-suivez-la-diffusion-de-la-premiere-image-d-un-trou-noir_5448356_1650684.html

⁹ JAO-ALMA observatory website: www.alma-observatory.org

¹⁰ NAOJ Youtube live stream of the press conference: https://youtu.be/_QBQMT5vrJo

¹¹ NAOJ niconico live stream of the press conference: <https://live.nicovideo.jp/gate/lv319442680>

¹² NAOJ press release: <https://www.nao.ac.jp/news/science/2019/20190410-eh.html>

¹³ Video of the press conference of the Chief Cabinet Secretary of Japan: https://www.kantei.go.jp/jp/tyoukanpress/201904/11_a.html

¹⁴ NSF Youtube live stream of the press conference: <https://www.youtube.com/watch?v=l-nJi0Jy692w>

¹⁵ With some conviction, the authors believe that the readership is on the order of billions. A sanity-check of this number: the number of people living in absolute poverty dropped from ~1.9 billion in 1990 to 734 million in 2015 (https://en.wikipedia.org/wiki/Extreme_poverty). The literacy rate changed from 73% in 1990 to 87% in the present (~6.7 billion people who can read and write out of 7.7 billion, <https://ourworldindata.org/literacy>), and 56% of the world population now has access to the internet (~4.4 billion, <https://www.internet-worldstats.com/stats.htm>). In summary, an estimate of a few billion may be right, considering the huge impact of the news in large and populated regions such as China, Latin America, as well as Europe and North America, with a very high coverage rate.

¹⁶ EHT website: <http://eventhorizontelescope.org>

¹⁷ NSF black holes webpage: www.nsf.gov/blackholes

¹⁸ ESO press release: <https://www.eso.org/public/news/eso1907/>

¹⁹ ESO EHT webpage: <https://www.eso.org/public/science/event-horizon/>

²⁰ ESO 2017 LIGO-Virgo press release: <https://www.eso.org/public/news/eso1733/>

²¹ Videos include the following: <https://youtu.be/8S-DF6WZob8>, <https://www.youtube.com/watch?v=3NeIVjfuKQY>, <https://www.youtube.com/watch?v=0LsiYIH-bmI> and more.

²² Perimeter Institute's video playlist: <https://www.youtube.com/playlist?list=PLaLvSxP-pl1c2NsXZuwah9Ns7DqdAw2m8m>

²³ NSF's final "black hole blackout" tweet: <https://twitter.com/NSF/status/1115964620186030080>

²⁴ ESO's Instagram: <https://www.instagram.com/esoastronomy/?hl=en>

²⁵ Black hole Ask Me Anything on Reddit: https://www.reddit.com/r/askscience/comments/bbknk/askscience_ama_series_we_are_scientists_here_to/

²⁶ EHT Facebook page: <https://www.facebook.com/eh Telescope/>

²⁷ EC tweet of the black hole image: https://twitter.com/EU_Commission/status/1115964395782197248

²⁸ The release was directed by the East Asian Observatory which operates JCMT on Maunakea in collaboration with staff at 'Imiloa and Dr. Kimura.

²⁹ Although it is technically not against the Creative Commons Attribution licensing to distribute an image at a cost, stock photo agencies are not allowed to change the credit (as sometimes is seen) and are required to ensure that the Creative Commons message is distributed with the image as well.

³⁰ Japanese pineapple candy tweet: https://twitter.com/pain_ame/status/1115977781341380608

³¹ eMarketer article "Japan Is One of the World's Strongest Markets for Twitter": <https://www.emarketer.com/content/japan-is-one-of-the-strongest-markets-in-the-world-for-twitter>

³² Der Spiegel cover: <https://www.spiegel.de/spiegel/print/index-2019-16.html>

Biographies

Lars Lindberg Christensen is an award-winning astronomer, science communicator and manager. He is responsible for the communication for some of the world's most famous telescopes such as ESA's part of the Hubble Space Telescope and ESO's Extremely Large Telescope. He has authored a dozen popular science books translated into more than ten languages.

Mislav Baloković is a postdoctoral research fellow at the Center for Astrophysics | Harvard & Smithsonian, studying active galactic nuclei. He led and contributed to many small-scale public outreach projects, and currently co-coordinates outreach efforts of the Event Horizon Telescope Collaboration.

Mei-Yin Chou is the Education and Public Outreach (EPO) Project Scientist in Academia Sinica Institute of Astronomy and Astrophysics (ASIAA), Taiwan.

Suanna Selby Crowley, PhD, RPA, is a research scientist with an expertise in communications, digital media, fundraising, and applied anthropology. She has worked across the globe on projects that involve technology, the environment, and the role of women in science, and now leads HeadFort Consulting, LLC, based near Boston, MA.

Peter Edmonds has worked as the Chandra Press Scientist since 2003.

Valeria Fonca, a journalist and Master in Strategic Communication, is the EPO Officer of the ALMA Radio Telescope. She has an extensive television career doing reports on environmental, scientific and technological issues for the Chilean TV. In institutional communications, she has served at the UNDP and ESO-Chile.

Masaaki Hiramatsu is the East Asian ALMA Education and Public Outreach Officer and an assistant professor at NAOJ. He obtained a PhD in radio astronomy, then worked as an ALMA postdoc in Taiwan before starting his current post in 2011, just before the start of ALMA science observations.

Colin Hunter is the Director of Communications and Media at Perimeter Institute for Theoretical Physics in Waterloo, Ontario, Canada. The not-for-profit institute is the world's largest independent centre for theoretical physics research, training, and educational outreach.

Katharina Königstein has worked at Radboud University as Communication Specialist and Management Support and coordinated European science outreach efforts in her role as a program manager together with the other leading institutes. She has now taken this experience back to the industry and pursues her career in the IT-Service Management sector.

Sarah Leach is a science editor based in Leiden, the Netherlands. She has worked on astronomy communication, outreach, and education for many organisations and institutions, including the European Southern Observatory, Imperial College London, the California Academy of Sciences and the Chabot Space and Science Center.

Nicolás Lira is a Chilean journalist with previous studies in Physics in the Denis Diderot University in Paris, France. Currently, Nicolas is studying a Master Degree of Innovation at the Catholic University in Santiago, Chile. He has been working in outreach at ALMA since 2013.

Mariya Lyubenova is a faculty astronomer at ESO and head of the Media Relations Team at the Department of Communication. Before that Mariya worked as a researcher at the Max Planck Institute for Astronomy in Heidelberg, Germany and the Kapteyn Astronomical Institute of the University of Groningen, the Netherlands.

Satoki Matsushita received his PhD from the Graduate University of Advanced Studies in Japan, then spent postdoc periods at the Center for Astrophysics | Harvard & Smithsonian and the Academia Sinica, Institute of Astronomy and Astrophysics (ASIAA) working on starbursts and active galactic nuclei using submillimeter interferometers, and is now a Research Fellow at ASIAA.

Harriet Parsons is a Support Astronomer at the JCMT observatory operated by the East Asian Observatory. She obtained her PhD in Astrophysics at the University of Hertfordshire in 2011. Alongside her duties as a Support Astronomer and Head of Operations, she manages the expanding outreach efforts at the JCMT.

Eduardo Ros is a scientist at the MPI für Radioastronomie in Bonn, Germany, and professor for Astrophysics (on leave) at the University of Valencia, Spain. Event Horizon Telescope Board Executive Secretary and coordinator of its Observing Proposals and the Outreach Working Groups; also member of collaborations such as MOJAVE, TANAMI or Fermi/LAT.

Oana Sandu is a communication expert for science and technology with more than 11 years of experience. Among the brands she works for is the European Southern Observatory, where she handles community coordination (promotion, distribution and social media) and communication strategy.

Calum Turner is an astrophysics graduate and science communicator with a growing experience of sharing astronomy with the public and, until recently, he worked as the Public Information Officer at ESO. He is currently spending his time studying spacecraft engineering.

Megan Watzke is the public affairs officer for the Chandra X-ray Observatory, a position she has held since 2000. Her responsibilities include the dissemination of Chandra's science results to the public through press releases, press conferences, informal education and other activities.

Karin Zacher is a science and astronomy communicator. At IRAM, one of the world's leading institutes for radio astronomy, she is responsible for the communication of the most powerful radio telescopes in the Northern Hemisphere: the NOEMA Observatory and the IRAM 30-meter Telescope.