

Hayabusa2 Outreach Activities and Its Public Response

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Keywords

science communication, strategy, social media

This report summarises the outreach activities and results related to Asteroid Explorer *Hayabusa2*, which conducted technologically challenging operations such as the release of rovers and a lander, touchdowns on the surface, and an impactor release to create an artificial crater in less than 10 months. Changes to the sequence of these operations after arriving at the target, the asteroid Ryugu, also posed a challenge for the outreach team. They had to quickly adjust the communication plan despite minimal resources. Thus, the team mapped out a strategy to share the scientific output and excitement of *Hayabusa2* with the public through the mass media. All media materials were prepared and provided under the Creative Commons Attribution 4.0. Frequent press briefings shared the mission status, operation schedule and risks, in addition to various aspects of the space mission, including engineering and scientific details. With materials provided by the outreach team, journalists and science reporters produced original content and published more than 67,000 online articles from *Hayabusa2*'s rendezvous with Ryugu to its return to Earth.

Introduction

*Hayabusa2*¹ is an asteroid sample-return mission operated by JAXA (Japan Aerospace Exploration Agency). Launched on 5 December 2014, it returned to Earth to deliver the material collected from its target, the asteroid Ryugu. Multiple technologically challenging operations were planned, including touchdowns, in which the spacecraft briefly landed on the surface of the asteroid to collect samples from Ryugu. The *Hayabusa2* operation team completed almost all of these operations.

The *Hayabusa2* mission was already popular when the project had the green light to proceed because of the success of its predecessor, *Hayabusa*, which overcame various issues including engine trouble and a fuel leak on return to Earth with material from the asteroid ITOKAWA. Annual JAXA surveys for Japanese citizens in 2018 - 2021 consistently show a high degree of public recognition of the *Hayabusa2* name. For example, the survey in 2019 shows more than 90% of the total 1350 questionnaire respondents knew the name of the *Hayabusa2* mission. In addition, the JAXA's advisory committee on public relations suggested to the *Hayabusa2* team and JAXA's PIOs (Public Information Officers²) about *Hayabusa2*

outreach activities: the Near Asteroid Operation Phase, the rendezvous at and departure period from the asteroid Ryugu, and its return to Earth might appeal to those not generally interested in scientific or technological media.

Hence, the goal for our outreach activities went beyond increasing public awareness of the mission. Instead, they aimed to improve the public's understanding of the space exploration mission and the risks, challenges, values, and difficulties of space science. The outreach team had many preparation tasks to achieve these goals, including preparing the press centre operation and producing and distributing visuals. In addition, the outreach team needed to develop backup plans for contingencies. Most of these tasks had to be completed before the arrival at Ryugu, when we had enough time to develop a practical and feasible implementation plan for the communication campaign. Although scientists and engineers can be reluctant about outreach activities (e.g., *Kassab, 2019*), this was not the case with *Hayabusa2*, which made public communication a priority. They posted status updates about the mission via Twitter for more than two years before its launch and accumulated more than 20,000 followers at its lift-off (see Figure 1 for the number of the *Hayabusa2* Twitter

followers). For more than two years, the *Hayabusa2* team also worked on EPO (education and public outreach) activities independent of JAXA's Public Relations Division. Therefore, the JAXA's outreach team coordinated the previous *Hayabusa2* team's outreach activities and started an outreach campaign by the time the spacecraft arrived at Ryugu.

This paper describes the strategy and implementation of the outreach activities of the *Hayabusa2* mission so far and summarises the results.

Mission Overview

Hayabusa2 is an asteroid explorer and sample-return mission. *Hayabusa2* aimed to collect a sample from the asteroid 162173 Ryugu and deliver it to Earth. Launched in December 2014, *Hayabusa2* took about three and half years to reach the target object and stayed about one-and-half years near the asteroid. Six years after its launch, *Hayabusa2* returned to Earth, having completed several missions at the asteroid Ryugu. When *Hayabusa2* reached Earth, a capsule containing a sample from Ryugu separated from the main spacecraft. Only the capsule landed on Earth. After the capsule separation, the main spacecraft continued on a fly-by orbit and headed off

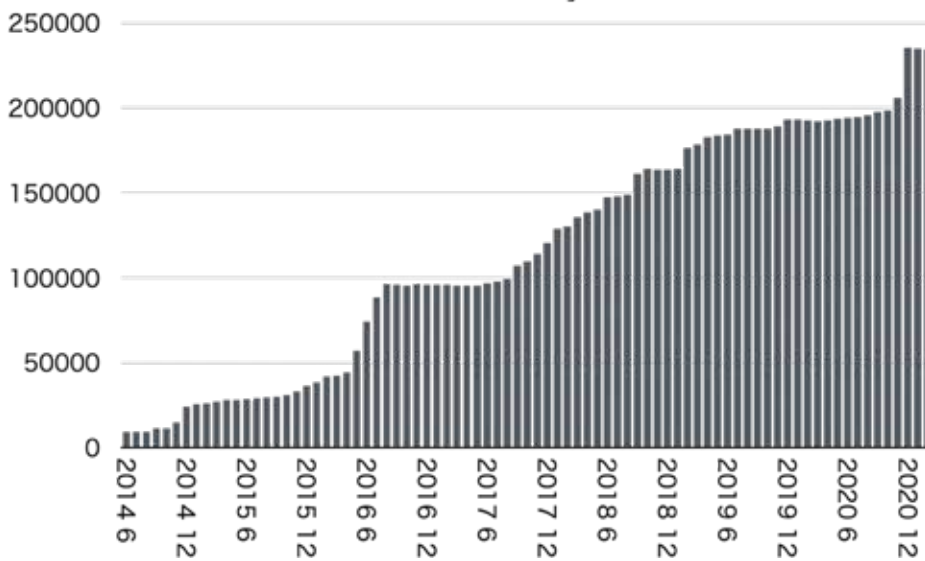


Figure 1. The number of followers of the Hayabusa2 Official Twitter account. Credit: The author

toward a new asteroid. Table 1 shows the timeline of several milestone events of the mission. The activities of the *Hayabusa2* mission during its near-asteroid phase (the period between arrival at Ryugu and departure from it) were described in detail in Tsuda *et al.* (2020). This article refers to the following as critical operations: rovers/lander releases, touchdowns, and Small Carry-on Impactor operations.

To maximise its scientific output, *Hayabusa2* was equipped with multiple instruments to be released. These included the MINERVA-II1 rovers, the MASCOT Lander, a small carry-on impactor, and target markers. The surface condition of Ryugu was utterly different from that expected and was found to be unexpectedly harsh. Facing the target, the *Hayabusa2* team decided to reconsider the strategy and change the order of the critical operations. The change in the order of the critical operations resulted in the change in our implementation plan of outreach activities. For example, video clips explaining the spacecraft's movement had to pause production until the *Hayabusa2* team specified the movement of the spacecraft and the target landing sites for the MINERVA-II1 rovers and the MASCOT lander. Human resources, including interpreters, a photographer, video crew and staff operating press centres, could be allocated only after the MINERVA-II1

rovers' and the MASCOT Lander's release schedule were determined.

Outreach Strategy

Our outreach campaign aimed to raise awareness of and increase the public's interest in engineering challenges and scientific discoveries of *Hayabusa2*. Through our outreach activities, we tried

to establish engagement with the public and make the public who engaged with *Hayabusa2* become its fans. Sashi (2012) mentioned:

a classic example of fans is provided by customers of professional sports teams who are loyal supporters of their teams in times of good and bad, delighted when they win, dejected when they lose, with trust and commitment characterising their enduring relationship with a team they regard as their own.

We tried to increase the number of *Hayabusa2* fans, like the fans of professional sports teams above, who advocate the *Hayabusa2* project even when unexpected incidents happen.

A marketing funnel model (e.g., Sellers, 2021) suggests that only a small part of people aware of a project or mission will engage with it. Thus, we should first direct as many people as possible to the mission status, its achievements and its scientific results. Only a fraction of people aware of *Hayabusa2* will be interested in and engage with the *Hayabusa2* mission, as the marketing funnel model suggests. A comprehensive strategic approach was necessary to communicate with the broadest audience possible. An essential aspect of the communication plan was to

Date	Operation
3rd December, 2014	Lift-off
3rd December, 2015	Earth Fly-by
28th June, 2018	Arrival at Ryugu
19th - 21st September, 2018	MINERVA-II1 Rover A & B Deployment
30th September - 4th October, 2018	MASCOT Deployment
20th - 22nd February, 2019	First Touchdown (TD1)
3rd - 6th April, 2019	Small Carry-on Impactor Operation (SCI)
9th - 11th July, 2019	Second Touchdown (TD2)
13th November 2019	Departure from Ryugu
5th December, 2020	Capsule separation
6th December, 2020	Capsule landing and capsule recovery operation

Table 1. Timeline of Hayabusa2 mission.

offer several feasible opportunities for the public to engage with the mission.

The outreach team tried to share the process, not only the engineering achievements or scientific results. We believed that sharing the process helped gauge public interest and publicly relayed the excitement of the *Hayabusa2* team. The outreach team constructed the outreach plan based on a policy that emphasised timely disclosure of updates about the *Hayabusa2* mission to share the process of the mission and humanising shared content, implementing it as follows: promptly releasing images, sharing risks, and sharing the mission's history-making moments.

We considered that the media could efficiently disseminate updated information about the mission and its discoveries to the public because the media published coverage reached wide audiences. Our plan met a need. It was apparent that the media were keen to obtain information regarding *Hayabusa2* and its mission status since JAXA's press room was over capacity each time JAXA held a press conference about *Hayabusa2*. Thus, we positioned the media as one of our important channels to communicate with the public.

We also expected social media to be an effective tool to communicate with the people attracted by *Hayabusa2*. Studies on customer engagement (e.g., *Thackeray et*

al., 2008; *Sashi*, 2012) suggest that social media greatly facilitates the establishment of a connection with a large number and wide variety of individuals and firms. Referring to these studies, the outreach team utilised social media to establish engagement with the public.

Prompt Image Release

The PIOs found that photographs and video clips of the *Hayabusa2* team members in the Operation Room were one of the key materials to be shared with the public. Before the rendezvous with Ryugu, domestic journalists often asked the PIOs if they could have a chance to take photos of the *Hayabusa2* team operating the spacecraft during the critical operations. The JAXA's advisory committee on public relations also recommended the PIOs make photos (and even more desirable, video clips) taken in the Operation Room available. Since the Operation Room is narrow, it did not seem realistic for media representatives to stay and take pictures. Therefore, we decided to share photos and video clips from a camera crew allocated by JAXA.

A consensus was necessary among the operation team members, PIOs, and security personnel to release Operation Room snapshots. A photographer and videographers filmed what happened in the operation room and the expressions of the team members (Figures 2 and 3).

To disclose some of these images, the operation team and the PIOs agreed in advance on several points. One example was the camera angle. The PIOs were prohibited from releasing photos containing staff members who were reluctant to share their image. Photos and video clips were reviewed according to JAXA's security guidelines, and the PIOs could distribute the photos and video clips that passed the review. The situation was more complicated for images taken using scientific instruments onboard *Hayabusa2* (see *Lorenzen*, 2016 for another example). We noticed a tension between those scientists who wished to keep all images from *Hayabusa2* proprietary and those who wanted to share them with the general public. These two opposing views about image release raise an essential and challenging debate in outreach. The *Hayabusa2* team took the middle ground and published quick-look and edited images. The edited images were not suitable for scientific quantitative discussion because the resolution was reduced or contrast altered for presentation purposes. Thus, more than 900 images, photographs and video clips were released and made downloadable from at least five official JAXA websites. These visuals were used in the media coverage and social media posts.

Optical Navigation Cameras revealed the first images of the asteroid's appearance and surface condition. The outreach team started releasing photos of Ryugu



Figure 2. A video director instructs a camera operator in the Operation Room. Credit: JAXA



Figure 3. Cameras were installed at the corners of the Operation Room to avoid hindering the *Hayabusa2* operators in their work. Credit: JAXA

when it still looked like a speck. As the spacecraft moved nearer to the asteroid and the apparent size of Ryugu gradually increased, its shape and surface got sharper with every photograph (Figure 4). Each new image with a simple caption was shared promptly with the engaged public. The images taken using CAM-H during the touchdown operation were another example³ of images released to the public. CAM-H is a small monitor camera, made possible by public donation, used to capture pictures. At the touchdown operation, CAM-H monitored changes in the surface before and after the touchdown. The *Hayabusa2* team arranged the data transmission sequence to download the images captured via CAM-H as early as possible. The effort helped maximise public excitement and maintain momentum when new images were released and viewed. Two hours after the touchdown, the team presented the images to the journalists at the press centre. Meanwhile, the PIOs distributed the images to the press using a cloud file-sharing service. The images were also posted on the official JAXA websites and Twitter. The *Hayabusa2* team created a time-lapse video clip from the images and released on YouTube within 12 hours. This was an excellent example of the collaboration between the public, the engineers who developed the camera, and the operations team, with their sequences of commands that enabled data transmission on such short timescales.

The images and videos were made available under a Creative Commons Attribution 4.0 licence. Sharing visuals under this licence enabled the press, publishers, researchers, science communicators, and researchers to use our visuals easily without troublesome deskwork to get permission to use them. In addition, the PIOs could save time and effort in responding to inquiries about using visuals. See also *Davis & Christensen (2009)* and *Christensen (2019)* for discussions about the conveniences of introducing Creative Commons licences.

Humanising Shared Content

The excitement generated by the space programs of many nations has increased public interest in recent decades (e.g., *Bauer et al., 2016*). To enhance public awareness of the findings and achievements of space

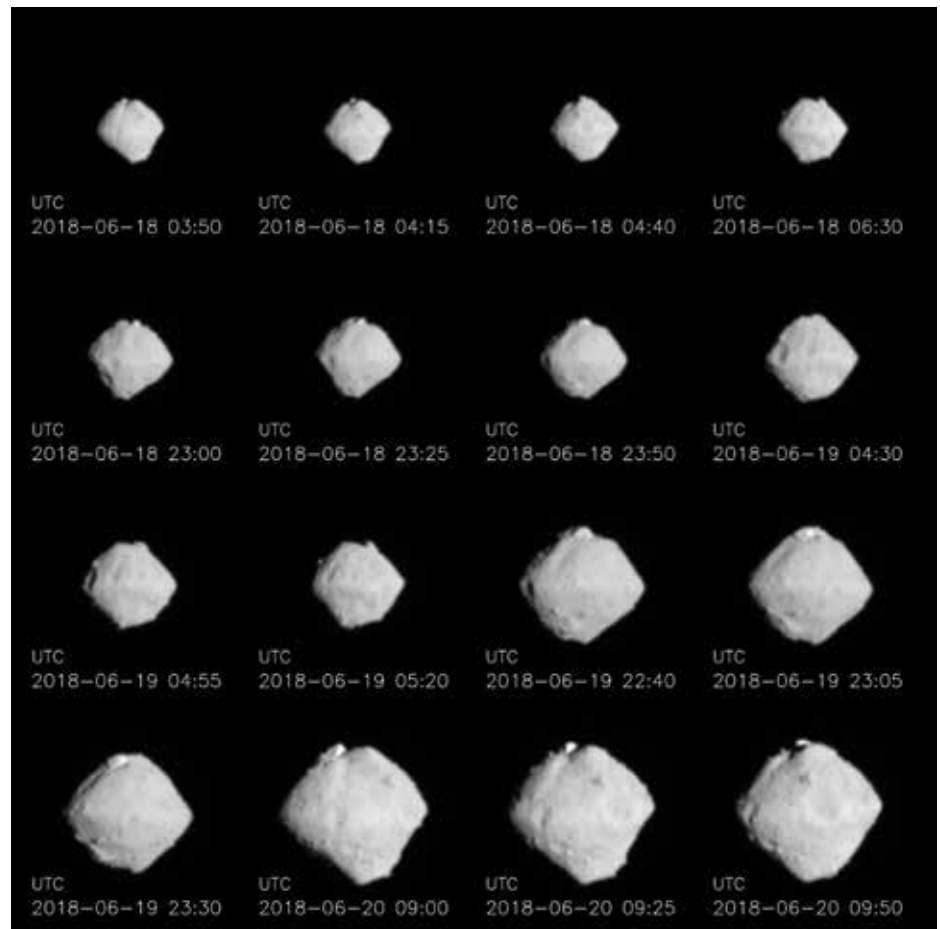


Figure 4. The asteroid Ryugu, taken by the Optical Navigation Camera onboard Hayabusa2 while the spacecraft was approaching Ryugu. Credit: JAXA, U. Tokyo, Kouchi U., Rikkyo U., CIT, Meiji U., Aizu U., AIST

exploration, one has to create a context that the audience can relate to and make them newsworthy (e.g., *Maran et al., 2000*).

The *Hayabusa2* mission has overarching scientific themes concerning the origins of the Solar System and potentially the origin of water and life on Earth. There is also the recognition that near-Earth objects have the potential risk of colliding with Earth. While these big questions fascinated some members of the public, they may have seemed relatively distant to the rest of the population, not as pressing as the issues of everyday life. Emphasising scientists and engineers who conduct the research or exploration seems to be one key element in increasing the probability of media coverage and public awareness (e.g., *Maran et al., 2000*). The outreach team spotlighted staff members to the public and ensured their visibility by presenting *Hayabusa2* on video and during the live

events. About 70 per cent of the footage released from the arrival at Ryugu to the departure contained the *Hayabusa2* team members. Scientists, operators, engineers and managers were featured intensively in JAXA internet broadcasts and videos, external TV interviews, documentaries and online channels. During interviews, tweets and press conferences, they discussed the facts and their passion for the mission.

The outreach team provided behind-the-scenes access through live-streamed events with opportunities for questions on our social media channels. The audiences were able to witness scientists and engineers nervously sitting through the nail-biting minutes when *Hayabusa2* dispatched rovers, conducted the touchdown operations and descended the Small Carry-on Impactor to create an artificial crater. Several key individuals involved in the mission, including the project

and engineering managers, became the faces of *Hayabusa2*. Comments posted on our YouTube programs show⁴ the public could relate to them because they showed their emotions and the human aspect of their work.

Preparing for an Off-nominal Situation

The Near Asteroid Operation Phase was full of risks and engineering challenges. When a camera on-board *Hayabusa2* captured the configuration of the Ryugu surface, the *Hayabusa2* team members found that the surface was almost entirely covered with boulders. Because of this, the team faced difficulties with the rover's safe landing and touchdown to collect samples while keeping the spacecraft in sound condition. Off-nominal events could occur during the Near Asteroid Operation Phase, and the PIOs had to prepare for them.

Decades of experience in space missions have demonstrated that unexpected events will occur during any mission. In preparation for such contingency, the PIOs regularly learn risk communication and media relations at outside experts' seminars and training. Based on our in-house experience and knowledge learnt at the seminars and training, the PIOs understood that presenting risks early helped control the public's expectations.

Because space science programs were funded by taxpayers and private donors and supported by politicians, the public's trust and credibility are vital, similarly to astronomy (West 2011). Building trust in risk management bodies was also a goal of recent risk communication (Frewer 2004). Sharing risks and benefits early and frequently with the public was essential to earn and maintain the public's trust and credibility (see Dawson, 2006 as an example of the risk communication strategy of NASA's *New Horizon* mission).

We took many opportunities to convey the potential risks of each critical operation together with the scientific and engineering significance that *Hayabusa2* addressed. We also explained how the *Hayabusa2* team assessed risks and took measures to reduce the probability of fatal situations of the spacecraft. Describing the risks with in-depth insight was aimed at tempering

public expectations. To share information about possible off-nominal situations, the team had to explain how the team analysed data, what they discussed, what problems existed, and how they tried to overcome them. In other words, the risk discussion also served to visualise the process of space exploration.

As Höppner et al. (2010) summarise in their report on risk communication, "transparency (includes openness, honesty and comprehensiveness) in communication appears to be the single most called for principle of good communication". In retrospect, our outreach activities, including communication to prepare for off-nominal situations, were consistent with this principle.

As mentioned above, there were many possible risks during the critical operations. Therefore, the outreach team assumed contingency, preparing for press release texts and planning operations of the press centre in emergencies.

Implementation and Results

Figure 5 shows the rough timeline of our outreach activities to prepare for the period from the rendezvous with Ryugu to the second touchdown, while Figure 1 demonstrates changes in the number of the *Hayabusa2* Twitter followers. The visibility of the mission reached a local maximum when the spacecraft launched; this was a chance to bolster awareness and engagement with the public. The next opportunity came one year after the lift-off, at the Earth fly-by. This was the start of the relatively long cruising phase.

Although the operations team had to guide the spacecraft carefully to the target, no drama occurred if there was no trouble for the spacecraft. Therefore, it was natural to assume that the public may lose interest. To avoid this and to maintain public interest, the *Hayabusa2* team held a press conference at least once every few months. Additionally, we held multiple press tours of the operations room during the cruising phase to explain the mission's progress in navigating the spacecraft to Ryugu.

Long-term engagement was key to *Hayabusa2*'s outreach activities. The

Hayabusa2 team kept updating the mission status, telling behind-the-scenes stories through the *Hayabusa2* official Twitter account and frequent (at least bi-monthly) public lectures and speeches during the cruising phase to the asteroid. The team also published manga (comic strips), which are available on the *Hayabusa2* website³ and relayed behind-the-scenes stories, making it easier for newcomers to understand space exploration and operations.

Twitter

The outreach team focused on Twitter for two reasons: first, the *Hayabusa2* official Twitter already accumulated more than 90,000 followers when the spacecraft rendezvoused with Ryugu, and became an important tool to communicate with the public; and second, at the time, Twitter was one of one of the most influential social network platforms in Japan⁴.

Figure 1 shows follower growth as a function of time on the *Hayabusa2* Twitter account. Since launching on 5 December 2014, followers gradually increased until the Earth fly-by on 5 December 2015. Followers remained steady, around 100,000, during the cruising phase and grew again before the arrival at the Ryugu. By the time the spacecraft arrived at Ryugu, Twitter was well-established as the direct channel to connect the *Hayabusa2* team and the public.

The team used Twitter to update the public on the status of *Hayabusa2* and provide schedules of outreach activities, including online and on-site public lectures. The team frequently tweeted on the mission's progress with snapshots from the Operation Room. Twitter contributed enormously to public communication during the critical operations. Some *Hayabusa2* team members concurrently contributed outreach activities and tweeted from the operation room. Thus, the tweets played an impactful role in sharing first-hand information about the mission and the operation team.

Naturally, tweets about *Hayabusa2* dramatically increased during the critical operations. Figure 6 shows the number of tweets and re-tweets about *Hayabusa2* before, during, and after the critical

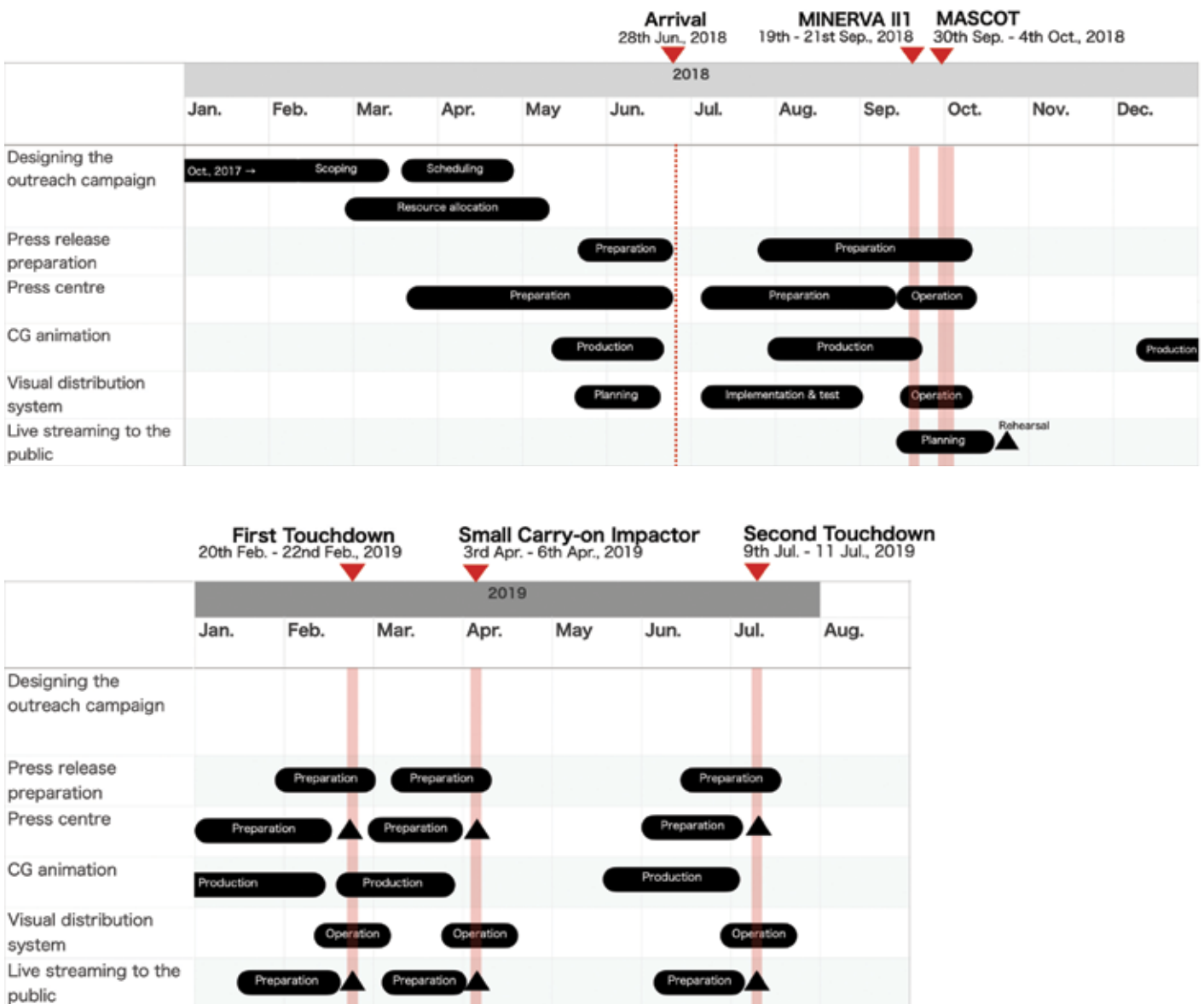


Figure 5. The rough timeline of our outreach activities to prepare for the period from the rendezvous with Ryugu to the second touchdown. Filled in black triangles in the “Press Centre” and “Live Streaming to the Public” rows show that the PIOs were running them. A filled-black triangle with the text “Rehearsal” means this live streaming was a test run. In “Scoping”, we discussed the aims of our outreach activities and decided on what we would and would not carry out. During “Scheduling”, we made a task list that described how long each task would take and estimated when we would start each task. Finally, in the “Planning” category, the PIOs worked on how to implement it. We made the necessary arrangements during the “Preparation” phases. Credit: The author

operations. The curve for each critical operation is normalised along the x-axis such that 0 represents the moment of the critical operation.

The distribution of tweets regarding the MINERVA-II1 Rovers A and B descent shows a somewhat flat distribution. The images taken by the rovers were released a couple of days after the descent and this delay contributed to the distribution’s long tail. Because people saw Ryugu’s surface so closely for the first time, and

the photos themselves were beautiful, the pictures gained as much attention as the operation to deploy the rovers. The images taken by the two rovers are still inserted into media articles as striking examples of the mission’s successful outcome (e.g., Gibney, 2018).

The second-largest number of tweets came with the first touchdown. Just after the spacecraft started approaching Ryugu, the team was forced to temporarily stop the operation due to some trouble. After

a five-hour behind the nominal schedule, the team finally fixed the problem and resumed the operation. Seeing incredible images taken by CAM-H, people tweeted congratulations when the touchdown was completed successfully and sent voices of surprise such as “Congratulations, another historic moment by JAXA. Thank you for sharing it with the world!”.

The most significant number of tweets was on Hayabusa2’s return to Earth. The peak corresponded to the day when it passed

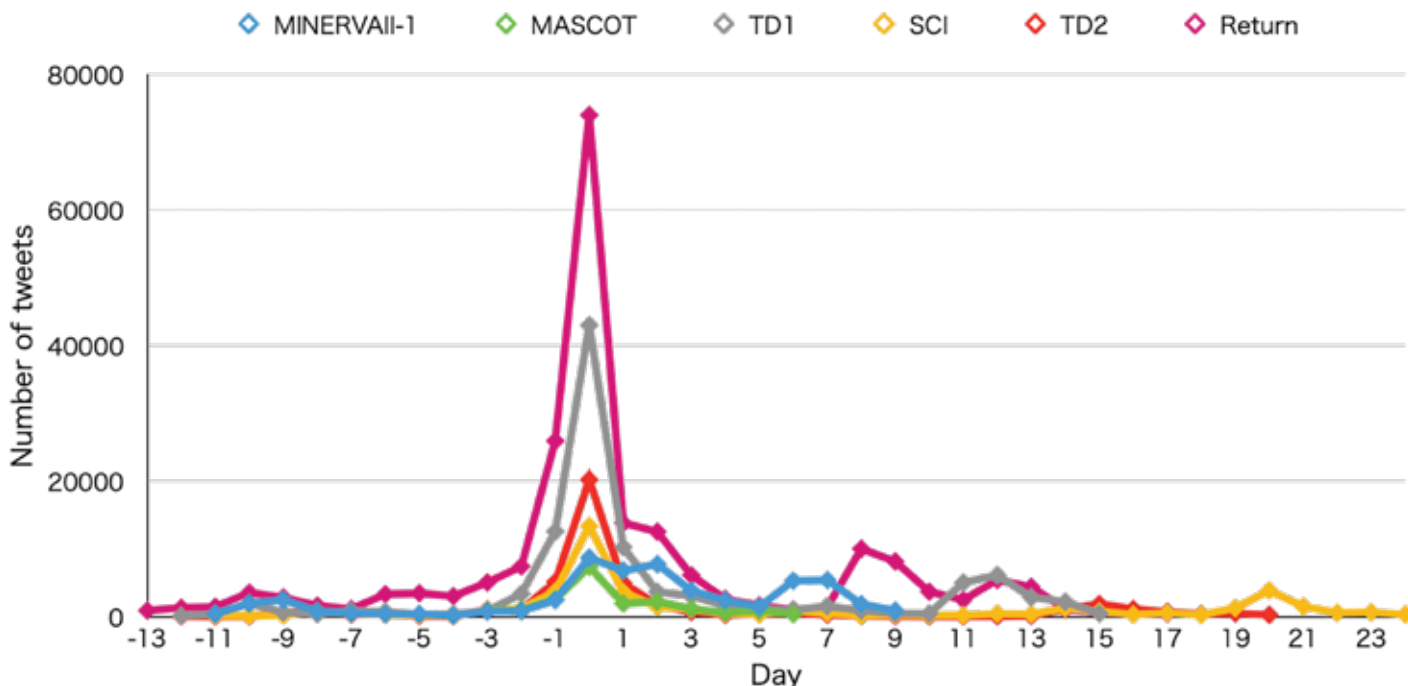


Figure 6. Number of tweets before and after each critical operation (peaks). We adjusted the peak of the number to zero on the x-axis. We counted re-tweets but excluded SPAM tweets. Note that the number of the vertical axis refers to the sum of tweets and re-tweets. Credit: The author

through Earth's atmosphere, streaming like a fireball, followed by the recovery operation of the landed capsule. These events happened between a Saturday and Sunday. Hence, the pinnacle is apparent in the two events. The related events occurred sequentially: the capsule's dispatch, the re-entry through the Earth's atmosphere, the capsule's landing, and its recovery. Analysing the hourly time variation of the number of tweets, we found that the number showed a peak corresponding to each event. Therefore, on a daily scale (Figure 6), the number was the summation of these tweets and became significantly high. Another peak appears almost one week after the recovery operation, which is about a press release on the confirmation of Ryugu's gas and sample collection.

The popularity of *Hayabusa2* had an unforeseen side effect. While analysing the Twitter data before and after its return to Earth, we found that many tweets were commercial. That is, we found many tweets that promoted products or services and embedded some words related to *Hayabusa2*. When these tweets are subtracted from the total number of tweets, the peak value decreases to approximately 62,000 (the original peak number was about 74,000). We speculate that these

tweets used the *Hayabusa2* name to obtain higher visibility of their offering. It seems natural that people working in advertising expected *Hayabusa2* to become a buzzword and tried to use it for publicity and promotion. This behaviour may reflect the success of the outreach activities of *Hayabusa2*.

Video Footage, YouTube and Livestream

We found video to be a powerful communication tool: it helped us understand complex movement, behaviour, and changes in attitudes about the spacecraft. Through video, people can share the feelings of the scientists, engineers, and team members and sometimes feel like they are participating in the mission. Further, video is a highly sought-after product: established newspaper publishing companies need video clips for their digital newspapers, the public and media often demand ready-to-use video clips, and user-friendly videos (and images) are required by science communicators working for museums and planetariums.

In response to this, the outreach team regularly produced computer graphic video clips to explain the movement of the spacecraft during a critical operation and digested videos of compiled images recorded in the Operation Room. Video clips were posted on YouTube, and downloadable versions were made available on JAXA's website⁵. We expected a small number of video clip views because we provided the footage as raw materials to be edited by professionals such as media members or video creators. We thought the number of views for professional use footage should be smaller than that target for a broader audience. Nevertheless, the number of views of each video clip was between 10,000 to 100,000 as of June 2022. There are many video clips for the general public with less than 10,000 on JAXA's YouTube channel. Considering this, we can judge that the *Hayabusa2*-related video release went well.

As we intended, domestic media outlets actually used the videos and inserted them into their news programmes. On the basis of the rich materials shared by multiple news outlets, the press treated reports on *Hayabusa2* as feature stories rather than straight news – news that impartially



Figure 7. Press conference of the first touchdown operation on 22nd February 2019. Credit: JAXA



Figure 8. Press conference of the first touchdown operation on 22nd February 2019. Credit: JAXA

reports only essential information about a story. Without JAXA's rich content and robust information, the *Hayabusa2* mission may have been considered a simple straight news clip with a short running time. Various materials enabled the press to create original coverage. For example, some news agencies reported from the point of view of science and engineering. Others focused on the mission's teamwork and collaboration with private companies. The public could obtain a deeper and broader understanding of the mission, thanks to the outreach team's content.

Live programming⁶ streamed during the first and second touchdown, the artificial crater creation operation, the capsule's release and the capsule's re-entry. The members of the *Hayabusa2* team wrote the plot for each live program together with a director from a production company which was interspersed with back-stage stories of challenge, struggle and the repeated trial of prototype, heart-warming episodes and more. These live programs helped familiarise the public with the space mission on a deeper level. Comments posted during the live streaming programmes show that the programmes earned an excellent reputation. Examples of response to the programmes can be found in the YouTube⁶ comments and the live chat section. They provided the audience with a unique experience to share in the excitement and breath-taking moments with the *Hayabusa2* team members.

Conventional Media

Popular newspapers with large circulations and five nationwide television networks comprise the media landscape in Japan. Although traditional newspaper readership is falling, newspapers remain influential and an excellent channel to disseminate the mission's information (e.g., *Reuters Institute for the Study of Journalism*, 2020). Television networks are powerful delivery mechanisms for stories about *Hayabusa2*. Therefore, exclusive opportunities are available to reporters from newspapers, news agencies and TV broadcasters. Freelance journalists were given the same opportunities because of their expertise in space science and experience reporting on space missions.

Frequent media events helped journalists to understand the mission deeply. Such media events included a monthly press conference. We also arranged a guided tour of the Operation Room and meet-and-greet events. During the Near Asteroid Operation Phase, press conferences increased in frequency to almost twice a month. These media events helped journalists get familiar with the *Hayabusa2* team and the space mission's operation. The connections the team fostered contributed to the long-term engagement with the media and *Hayabusa2*.

One such press conference occurred during the Near Asteroid Operation

Phase, when its first critical operations were underway. Due to space constraints, attendance was limited to only three representatives from each media outlet; even with this restriction, more than 100 media representatives attended each press conference. Figures 7 and 8 show a presentation by representatives of the *Hayabusa2* project and a photo session at the press centre, respectively. Although these were taken on the day when *Hayabusa2* completed the first touch-down operation, the situation at the press centre was similar to other events.

During the first critical operation at the Near Asteroid Operation Phase, two small rovers called MINERVA-II1 Rovers A and B were deployed. Although the press centre opened two hours before releasing the rovers, photos and video clips from the Operation Room were distributed one day before to registered media representatives with updates on the operation status. The outreach team tweeted the atmosphere of the operation team members and status updates more frequently during this time. These tweets and email notifications enabled media representatives and the public to know the ongoing mission status from wherever they were. Meanwhile, the PIOs answered media inquiries by phone. Thus, journalists could write articles with photos and video clips even before the press centre opened. Once the press centre opened, a member of *Hayabusa2* team and specialists in space engineering gave a briefing explaining the current status

of the operation, the daily schedule, and the atmosphere of the *Hayabusa2* operation team. Both the specialists and the PIOs stayed in the press centre to answer press questions whenever required.

Exclusive live video was streamed from the Operation Room to the press centre during the descent of the MINERVA-II1 rovers. We note that live streams became available to the public at the later critical operations, such as the touchdowns and the impactor operation to create an artificial crater. Photos and video clips were also provided to the media and are downloadable from JAXA's website.

Three and half hours later, after the successful deployment of the rovers, a press briefing began. The Project Manager of *Hayabusa2* and the other two specialists summarised the day's operation and provided status updates on the spacecraft and rover. A few hours after the press briefing was over, the first images arrived from the rovers. It was almost midnight in Japan. These first images (Figures 9 and 10) were released immediately and made the headlines. All the daily national newspapers and many local papers the following morning covered the rover deployment operation results. The articles included straight news reports, interviews and featured articles. Some newspapers even reported side stories about manufacturers that developed and provided parts of the MINERVA-II1 rovers.

A similar press centre operation and media communication strategy were repeated for each of the critical operations during the Near Asteroid Operation Phase (see Table 1 and Figure 5). Scientists of the *Hayabusa2* team and the PIOs answered inquiries from the media at any time when we held the press centre. In addition, we took as many questions as possible at each press conference (Figure 7). Because the PIOs received no complaints about a shortage of information or visuals, we understand that the media representatives were satisfied by the information provided by JAXA and our press centre operation. Thus, we conclude that our media communication strategy worked well.

Figure 11 shows the number of articles posted on news websites about *Hayabusa2*. We used the online news posts monitoring service by a company, Meltwater, to collect the data. In Figure 11, the peaks correspond to the critical operations. The total number of online news posts about *Hayabusa2* was the largest in Japan, but the news media in other countries, including the United States, Germany and France, also prominently featured the mission, as shown in Figure 12. These numbers would not have been possible if the articles were published only in scientific and technological media; the outreach team played a central role in publicising the mission. As a result, the *Hayabusa2* mission was a global news story with an audience of millions.

Amid the Covid-19 pandemic, the established media communication channels, such as in-person interviews and photographers surrounding the team members (Figure 8), were interrupted. The only activity media representatives could do in the press centre was to watch live streams of the operation. In particular, this impacted the press conferences when *Hayabusa2* returned to Earth. Although photos and video clips were still preferentially provided to the press, the volume of these materials decreased significantly compared with those of the critical operations during the Near Asteroid Operation Phase.

The team still tried to engage the media even during Covid-19. After the capsule's recovery, a virtual press conference was held by connecting the venue in Australia, where the capsule landed, and the venue in Japan via a network conference system. The PIOs knew the internet connection between the press centre in Australia and Japan was not fast enough to transmit video, so the press conference was originally planned to be audio-only. However, this plan was changed, and a video conference was ultimately adopted. The unavoidable result was that the speakers could not communicate well: the video transmission hampered the audio. Although the PIOs did their best to improve the communication after the first press conference, the measure was not enough. We understand that a video conference is visually attractive, but it is not very

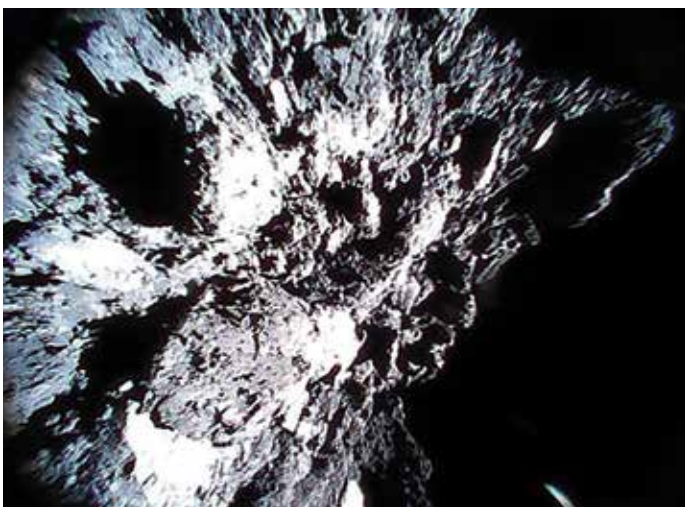


Figure 9. Image taken by the MINERVA-II1 Rover A. The surface of Ryugu is seen in detail. Credit: JAXA



Figure 10. Image taken by the MINERVA-II1 Rover A. Sunlight produced the white area on the right side. Rover A took this picture mid-hop. Credit: JAXA

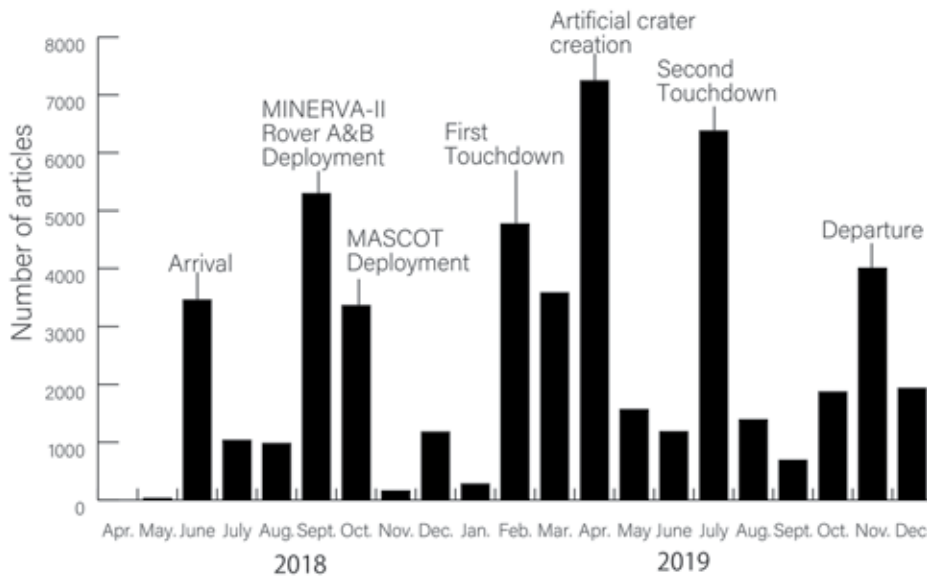


Figure 11. The number of articles on news websites about Hayabusa2 posted each month during the Near Asteroid Operation Phase. The number includes both inside and outside Japan. The data were collected using Meltwater. Credit: The author

meaningful if we cannot communicate. We should have considered the network's capacity from the outset.

The audience's reaction to the live stream of the virtual press conference⁶ was not as positive as prior press conferences. According to comments, the audience felt a shortage of information and inadequate preparation for the press conference, in part due to the slow network connection between the press centre in Australia and Japan.

Despite this setback, there was still ample media coverage of the capsule's return to Earth. Figure 13 shows the number of news articles from two days before the capsule's release from Hayabusa2 to two days after the capsule arrived back in Japan. The peak shows when the capsule's fireball was observed upon re-entry, and recovery. These two events occurred on the same day, and the peak in Figure 13 represents the summation of news coverage of these two events. In reviewing some of the articles, we found similar coverage. We compared the first 200 characters of each article to examine the variety and number of unique stories. This quick check revealed that the number of unique articles was almost one-third of the total. The same comparison for the news posts in Figure 11 shows that the number of unique articles was about half. Therefore, we conclude that a smaller variety of articles were

published when Hayabusa2 returned to Earth. Feature stories revealed diversity in their opening text. It seems the majority of articles about Hayabusa2's return were straight news stories simply providing facts, such as the return, the capsule's re-entry and the capsule's recovery. This limited information and material resulted in similar coverage among different news agencies.

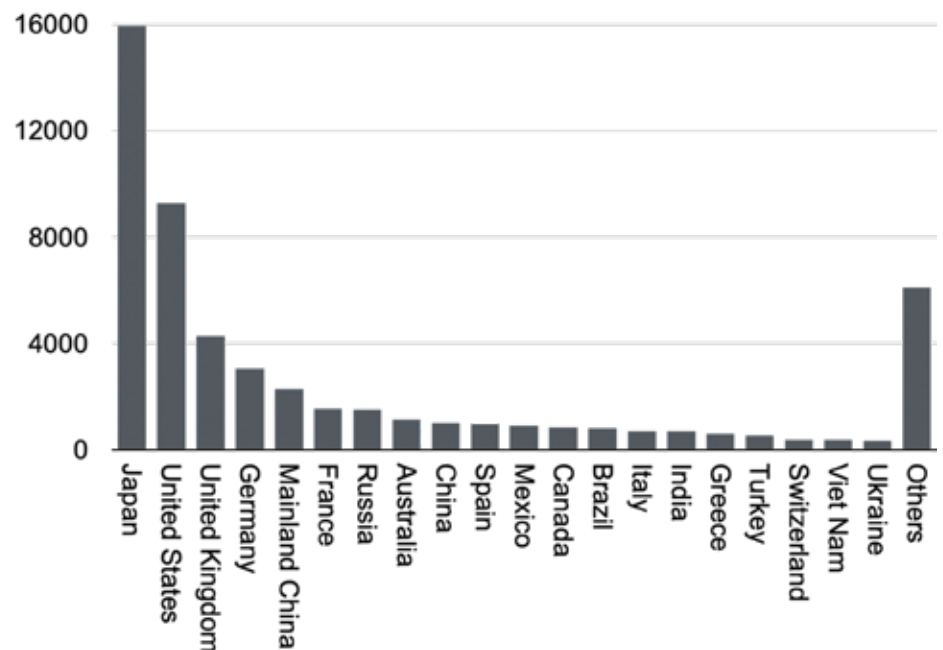


Figure 12. The number of news articles about Hayabusa2 aggregated by country. The data source was the same time period as Figure 4. The data were collected using Meltwater. Credit: The author

Lessons Learnt

In this section, we summarise the lessons learnt about Hayabusa2 outreach activities.

1. Importance of visuals' publication under open access licence

Through the Hayabusa2 outreach campaign, we have learnt the importance and effectiveness of material distribution under the Creative Commons Attribution 4.0. This licensing enabled the press, publishers, researchers and science communicators ease of use. Open access images and videos are essential for good communication with the public. People who wanted to use JAXA's visuals had to apply and obtain JAXA's permission until March 2018, when a new data policy on space science⁷ became effective. Although the older rule was not applied to usage for news, education and research, JAXA's PIOs knew that some hesitated to use JAXA's visuals because of the rule and tended to use visuals provided by the open access licence. The PIOs often heard complaints from the media, publishers and members of JAXA's advisory committee on public relations stating the procedure to obtain permission was troublesome or time-consuming. The new data policy is compatible with Creative Commons

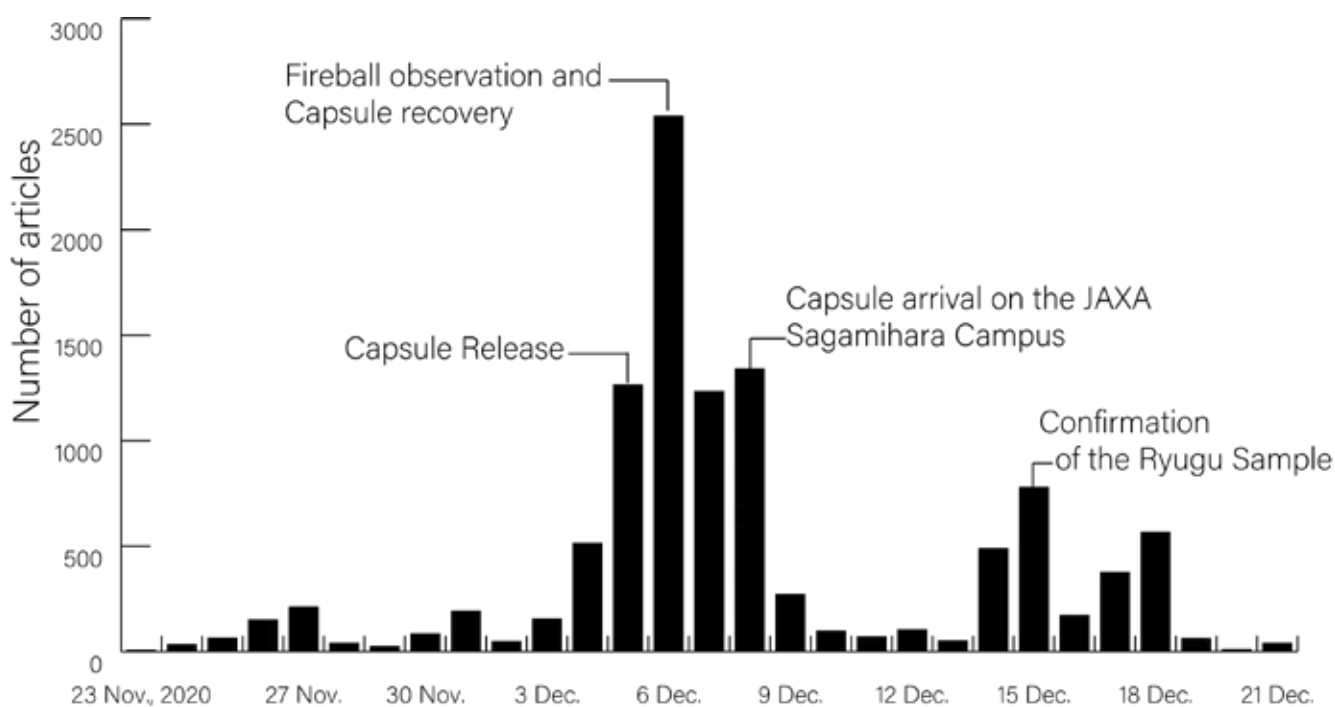


Figure 13. The number of articles published on news websites before and after the capsule release, when Hayabusa2 returned to Earth. The data were collected using Meltwater. Credit: The author

BY 4.0. The PIOs do not have to approve visuals' usage requests.

We also found that the demand for visual aids was higher prior to each critical operation than after: explanatory visuals should be made publicly available before events to allow maximum effectiveness.

As an example of these lessons, JAXA and NHK, Nippon Hoso Kyokai (Japan Broadcasting Corporation), worked together and created computer generated (CG) animations based on actual data from Hayabusa2. Unfortunately, the CGs were hardly used by the media except for NHK. The CG animations were not distributed under the Creative Commons Attribution 4.0 Licence. Aside from the fact that these animations were released two days after the touchdown operation (and as such, were likely released too late for broadcasters and news agencies), the press may have additionally perceived the permission procedure for these animations as too complex.

2. Utilise animations, which can enhance explanation and presentation of scientific and engineering issues

Although repeatedly emphasised, animations were an excellent tool to explain spacecraft movement. As the proverb says, a picture is worth a thousand words. With the aid of animations, scientists and the PIOs could explain complex topics such as the operational plan and the risks of critical operations more easily to the press and the public. By judging from the fact that the press inserted the animations into coverage, it seems that the press also considered that the animations helped viewers and readers to understand the contents of the coverage.

3. It is necessary to optimise an implementation plan according to the available resources

An outreach team should carefully confirm if a plan can be implemented, considering the available resources and the required infrastructure. As was the case for the virtual press conference, our outreach team sometimes faced high demand from managers or the public under limited resources. If the request is beyond the resources, it is wise to make compromises to optimise an implementation plan. Otherwise, the efforts of the outreach team could be wasted.

4. Be ready for any contingency

We took many opportunities to convey possible operations risks. The Hayabusa2 team also explained how the team assessed risks and took measures to reduce the probability of fatal situations in the spacecraft. We believe that describing the risks served to visualise space exploration. Similarly to the Hayabusa2 team assessing the risks and taking the appropriate measures, the outreach team assumed contingencies and planned communication activities in emergencies. Fortunately, Hayabusa2 was not exposed to a fatal situation. However, it is wise to assume and prepare for a contingency. Otherwise, we cannot handle the situation as prompt action is necessary during an emergency.

5. Social Media is a useful tool to disseminate information and encourage the public participation

We focused our social media efforts on Twitter. Throughout the outreach campaign, the outreach team recognised that Twitter was a handy tool to share information and the Hayabusa2 team's excitement with the public. Twitter also contributed to humanising the Hayabusa2

project. The *Hayabusa2* team members communicated their feelings and emotions, not only operational status, with the public via Twitter. We concentrated on Twitter because of the limitation of our resources, however employing more than one channel may have expanded the demographics of our user base.

We note that maintaining engagement is the next challenge for *Hayabusa2*'s science communicators, scientists, and engineers. After the release of the capsule from *Hayabusa2*, the number of Twitter followers began to decline on the *Hayabusa2* account.

6. *Choose carefully if exclusive treatment is offered to a specific media company*

During the Near Asteroid Operation Phase, we did not allow the media to enter the Operation Room because it was narrow with little space for cameras. As compensation, we frequently distributed video clips and snapshots taken by our contracted crew so that the media could use these as press materials.

The only exception was Japan's public broadcaster, NHK. JAXA decided on special treatment for the NHK crew. NHK was believed to produce excellent science programmes that appealed to a large segment of Japanese people. The crew was allowed to stay in the Operation Room and shoot as it produced special science programmes. Unfortunately, the special NHK programmes did not receive high ratings. The content was just a summary of previous coverage, although the video clips were exclusive to NHK. So far, there is no evidence to show NHK's special treatment had any impact on public engagement or awareness. Hence, it is wise to decide access based on a submitted proposal, not on a previous reputation.

7. *Seek as many perspectives as possible and prepare to respond to criticism and diverse concerns*

The capsule's recovery operation occurred amid the Covid-19 pandemic. Many people congratulated the success, but not all. Operators at a JAXA call centre received complaints about the capsule's recovery operation that approximately 100 staff members visited Australia by charter flights. They emphasised that

taxes should be directed to supporting people who were suffering from Covid-19. Since PIOs face a front-line of critics by the public, it is wise to note that not all people favourably received the mission. Although the *Hayabusa2* project manager explained, at press conferences, why the *Hayabusa2* team conducted the capsule recovery operation then, we admit that the agency-wide messaging seemed not strong and persuasive enough. We should have kept updating responses to queries and developing talking points as people's concerns changed or new issues arose. We should also have continuously researched inquiries to JAXA and public comments posted on SNSs or other platforms. If we had made these steady efforts, we should have elicited people's specific concerns, needs and interests. Then, we could have prepared for coordinated responses to them beforehand and shared the developed responses with all of the PIOs.

Conclusions

Various outreach activities of *Hayabusa2* were executed at different levels, from research to the whole of JAXA. The steady and long-term communication efforts by the *Hayabusa2* team members achieved global attention, resulting in many followers and intense engagement with the public. Also, the volume of information shared with the media and the public garnered interest and positive emotions for this incredible mission.

However, from a coordination point of view, it would have been helpful to have more time to develop the communication campaign so we could more effectively engage with the community. We used the *Hayabusa2* mission as an opportunity to interest people in space science. Further studies are necessary to check if our outreach activities contribute to strengthening engagement with our stakeholders that leads to the long-term advocacy of space science.

At JAXA, we are constantly learning and adapting based on our experiences. In addition, we have referred to lessons learnt and experiences from other astronomy and space science projects outside JAXA, which are also valuable. We hope that the learnings described here will inform how

future outreach teams engage with the public.

Notes

- ¹ More on *Hayabusa2*: <https://www.hayabusa2.jaxa.jp/en/>
- ² JAXA's PIOs are the staff that belong to JAXA's public relations section, while the *Hayabusa2* outreach team consists of a mixture of some of the *Hayabusa2* team members and JAXA's PIOs.
- ³ Images can be found at <https://www.hayabusa2.jaxa.jp/en/galleries/> while comic strips (only in Japanese) are available at https://www.hayabusa2.jaxa.jp/topics/kochihaya_comic/
- ⁴ Survey Report on Information and Communication Media Usage Time and Information Behavior, National Institute of Information and Communications Policy, Ministry of Internal Affairs and Communications, https://www.soumu.go.jp/main_content/000564529.pdf
- ⁵ Footage of *Hayabusa2*: <https://isas-gallery.jp/tag/hayabusa2>
- ⁶ Archive of live programs and press conferences: <https://www.youtube.com/playlist?list=PLHMAIn1-d750aDmJosNXtnBciQERQN4Sr>
- ⁷ ISAS Data Policy: <https://www.isas.jaxa.jp/en/researchers/data-policy/>

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Acknowledgement

The author appreciates anonymous referees for their thoughtful suggestions and comments. The author would like to acknowledge Kanako Toshioka, Takuya Ohkawa, Shiho Sakai, Jun Yamamoto, Sayaka Fukuda and Takayuki Tomobe (JAXA) for their assistance and communication work. The Hayabusa2 outreach activities could not be possible without them; they worked hard and enthusiastically to implement the activities successfully. The author is also grateful to Yutaka Iijima, Usami Masaaki (USA PRO Co., Ltd.) and Miyazaki Koji (VITS Inc.) for video and photo production.

Biography

Chisato Ikuta is an associate professor at the Institute of Space and Astronautical Science (ISAS) at the Japan Aerospace Exploration Agency (JAXA). She coordinated and led the public outreach campaign of the Hayabusa2 mission in the Near Asteroid Operation Phase.