PDC 2025
Stellenbosch, Cape Town, South Africa

Please submit your abstract at `https://iaaspace.org/pdc`.

(please select the topic that best fits your abstract from the list below)
(you may also add a general comment - see end of this document)

- [x] **Ongoing and Upcoming Mission Highlights**
- [ ] **Apophis T-4 Years**
- [ ] **Hypothetical Asteroid Threat Exercise**
- [ ] **Key International and Political Developments**
- [ ] **Near-Earth Object (NEO) Discovery**
- [ ] **NEO Characterization**
- [ ] **Deflection & Disruption Modeling and Testing**
- [ ] **Space Mission & Campaign Design**
- [ ] **Earth Impact Effects & Consequences**
- [ ] **Disaster Management & Impact Response**
- [ ] **Public Education and Communication**
- [ ] **The Decision to Act: Political, Legal, Social, and Economic Aspects**

Science operation planning for Hayabusa2#'s flyby at Asteroid (98943) Torifune

Masatoshi Hirabayashi[a,1,*], Masahiko Hayakawa[b], Yuya Mimasu[b], Naru Hirata[c], Takuya Iwaki[b], Shun-ichi Kamata[d], Masanori Kanamaru[g], Kohei Kitazato[c], Toru Kouyama[e], Naoya Sakatani[b], Hiroki Senshu[f], Hiroshi Takeuchi[b], Satoshi Tanaka[b], Eri Tatsumi[b], Koki Yumoto[b], Masanao Abe[b], Masahiro Fujiwara[b], Moe Matsuoka[e], Tomokatsu Morota[g], Takanao Saiki[b], Yuri Shimaki[b], Sumito Shimomura[b], Yuichi Tsuda[b], Manabu Yamada[f], Yasuhiro Yokota[b], Makoto Yoshikawa[b], Hayabusa2# Team

[a] *Georgia Institute of Technology, Atlanta, GA, United States*
[b] *Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science, Kanagawa, Japan*
[c] *University of Aizu, Fukushima, Japan*
[d] *Hokkaido University, Hokkaido, Japan*
[e] *National Institute of Advanced Industrial Science and Technology, Tokyo, Japan*
[f] *Chiba Institute of Technology, Chiba, Japan*
[g] *University of Tokyo, Tokyo, Japan*

Keywords: Hayabusa2#, (98943) Torifune, Flyby, Small body mission, Planetary defense

---

Hayabusa2# is an extended mission of Hayabusa2 [1, 2], which will spend another decade conducting various scientific and engineering investigations highlighted by a flyby at Asteroid (98943) Torifune in 2026 and a rendezvous with Asteroid 1998 KY26 in 2031. Our space flight operations have continuously performed cruise science investigations of exoplanets, comets, and zodiacal light. Recently, the mission has also weighed our efforts more to plan flyby operation sequences at its target, (98943) Torifune, formerly 2001 CC21. Planned to be in July 2026, the flyby observation is an excellent opportunity to detail this asteroid geologically. Unlike a rendezvous observation, however, the flyby at an encounter speed of 5.3 km/s challenges detailed scientific observations. Regardless of the spacecraft's tight system constraints, maximizing scientific return is essential to address our science objectives.

*Corresponding author
Email address: thirabayashi@gatech.edu (Masatoshi Hirabayashi)

Hayabusa2 #'s science objective for the Torifune flyby is to determine the asteroid's taxonomy, shape, and morphological features as much as possible under extremely limited fast-flyby conditions to constrain its contribution to material transfer and demonstrate critical Planetary Defense technologies. The measurement requirements to achieve this objective specify the necessary performances of the onboard remote-sensing instruments: the Optical Navigation Camera Telescope (ONC-T), Thermal Infrared Imager (TIR), Near Infrared Spectrometer (NIRS3), and Laser Altimeter (LIDAR). Given highly tight constraints, while ONC-T and TIR will challenge their resolution limits, NIRS3 and LIDAR will attempt to detect at least one data sample.

The science operation planning divides science observation sequences into two phases. The first phase targets observations relatively far from Torifune 5 minutes before the closest approach (T-5 min to the CA). Because this phase actively controls the spacecraft via optical navigation, guidance, and control, science observations are expected to be limited and must meet zero conflicts with the planned system sequences using ONC-T for optical navigation. Limited scientific observation chances also challenge the simultaneous use of multiple remote-sensing instruments for science operations.

Conversely, the second phase can focus more on science investigations from T-5 min until the CA. This phase is planned to have more time for science observations. The primary discussion among the science team is about how to use the available time to maximize science return. The second phase also needs to determine the view geometry and CA timing for science observations based on Torifune's shape and rotational state. The mission's system team gave the science team flexibility regarding the timing and approach direction at the CA. We are currently identifying a sequential plan that can characterize the asteroid's geological and thermal conditions at most but can still satisfy the system constraints.

Considering all possible conditions, the Hayabusa2# team offers a holistic science observation plan for the Torifune flyby. This paper summarizes the current status of the mission's science operation planning.

References

[1] M. Hirabayashi, Y. Mimasu, N. Sakatani, S. Watanabe, Y. Tsuda, T. Saiki, S. Kikuchi, T. Kouyama, M. Yoshikawa, S. Tanaka, S. Nakazawa, Y. Takei, F. Terui, H. Takeuchi, A. Fujii, T. Iwata, K. Tsumura, S. Matsuura, Y. Shimaki, S. Urakawa, Y. Ishibashi, S. Hasegawa, M. Ishiguro, D. Kuroda, S. Okumura, S. Sugita, T. Okada, S. Kameda, S. Kamata, A. Higuchi, H. Senshu, H. Noda, K. Matsumoto, R. Suetsugu, T. Hirai, K. Kitazato, D. Farnocchia, S. Naidu, D. Tholen, C. Hergenrother, R. Whiteley, N. Moskovitz, P. Abell, Hayabusa2 extended mission: New voyage to rendezvous with a small asteroid rotating with a short period, Advances in Space Research 68 (2021) 1533–1555.

[2] Y. Mimasu, S. Kikuchi, Y. Takei, T. Saiki, S. ichiro Watanabe, S. Tanaka, M. Hirabayashi, N. Sakatani, T. Kouyama, M. Yoshikawa, S. Nakazawa, Y. Tsuda, Chapter 27 - Extended mission of Hayabusa2, in: M. Hirabayashi, Y. Tsuda (Eds.), Hayabusa2 Asteroid Sample Return Mission, Elsevier, 2022, pp. 557–571.