



HARVARD

School of Engineering
and Applied Sciences

Frank N. Keutsch

*Stonington Professor of Engineering and Atmospheric Science
Professor of Chemistry and Chemical Biology*

keutsch@seas.harvard.edu

**Harvard John A. Paulson School of Engineering and Applied Sciences
Department of Chemistry and Chemical Biology
Department of Earth and Planetary Sciences**

12 Oxford Street, Cambridge, MA 02138 USA
Phone: 617-495-1878 / Fax: 617-495-4902

December 9, 2020

Dear SCoPEX Advisory Committee,

In response to your written request, we submit a document that provides more information about the proposed platform test in Sweden in June 2021.

We appreciate the Committee's review of the platform test and will be happy to provide additional information on request.

Sincerely,

Frank Keutsch

Stonington Professor of Engineering and Atmospheric Science
Harvard John A. Paulson School of Engineering and Applied Sciences
Department of Chemistry and Chemical Biology
Department of Earth and Planetary Sciences

Request 1: Please provide the Advisory Committee with specifics about what you intend for the engineering test flight to accomplish. What are the specific parameters/characteristics for this test?

Response: On March 31, 2020, we shared a platform test description with the Advisory Committee. We have reattached the document here. Our top-level stretch goal would be to be able to maneuver the gondola back through the aerodynamic wake of the propellers and confirm this movement via a turbulence measurement. Specific engineering goals include tests of the power system, flight computer, propeller system, ascender, and altitude control. We would not release any aerosols, nor fly an aerosol injection/release system. We are happy to provide further detail if needed.

Request 2: Please provide the Advisory Committee with your reasons for shifting the launch to Sweden from a U.S. location.

Response: We have chosen to partner with Swedish Space Corporation (SCC) and fly in Sweden because of their availability for summer 2021, promising flight trajectories, and significant experience launching scientific balloons. We also looked at several US balloon operators, but because of COVID-19 and other logistical and scheduling challenges, there were no US based options that could provide a 2021 early-summer launch with a landing on land, and that had already secured launch equipment. (Landing on land is important because we need to recover and reuse our platform equipment. And launch equipment, such as a crane or bucket loader and balloon spool, is needed to safely get the payload off the ground. In fact, US based Raven Aerostar had to cancel our prior agreement many months ago because they could no longer obtain launch services, as we noted on our website at the time. Yet, Raven Aerostar will still be fabricating the balloon for SCoPEX, while Swedish Space Corporation will be managing the launch and flight operations of the balloon.)

We also needed to make sure we identified a partner who could successfully manage the needs of the SCoPEX balloon, as flight safety is of utmost importance to us. The experimental design for future SCoPEX science flights requires a balloon that will fly a 600 kg payload near an altitude of 20 km. This is a lower altitude than many other stratospheric balloon missions, and launch equipment for this weight class and balloon size is not readily available. We also require that the launch site have relatively low winds, the ability to fly a 4-6 hour flight, and the capability to land on land, as noted above. Swedish Space Corporation performed a trajectory analysis based on wind data from 2018 and 2019 and showed favorable trajectories with suitable landings for the entire summer season (April 15-September 15). For example, these projected landings are in extremely low population areas, which is important from a flight safety perspective.

Swedish Space Corporation is a global provider of advanced space services and has been launching scientific balloons for over 40 years. They have been launching balloons out of Esrange Space Center in Kiruna, Sweden since 1974 and they have also provided launches from outside Esrange since 2018. They will be an exceptional partner for SCoPEX. And we hope that the significant partnerships between Swedish Space Corporations and various US balloon operations could lead to enhanced international collaboration and future launches both from Esrange and within the US. Moreover, and perhaps most importantly, working in Sweden will enable us to increase international scientific collaboration around the SCoPEX experiment, which is critical to us. We have already begun to reach out to Swedish scientists, and we are in discussion with German scientists who have now expressed some interest in collaborating on this flight. We are looking forward to forming new partnerships that will enhance the diversity of perspectives studying SCoPEX and improve the science.

For a full list of all the balloon options we considered and engaged with, please see our Balloon Comparison Table in the private Appendix.

Request 3: Please provide the Advisory Committee with the likely location and planned date of the launch and/or location options being considered. Do you anticipate any delays and if so why and how long a delay?

Response: The engineering flight is planned for the second or third week of June 2021. The payload will launch from [Esrang Space Center](#) in Kiruna, Sweden. Esrang is located in northern Sweden above the Arctic Circle at 67° 53'N, long 21° 04'E, which is a remote location with extremely low air traffic in the vicinity. The facility was built by ESRO (European Space Research Organization) and inaugurated in 1966 as a sounding rocket launch facility. Since July 1972 Esrang Space Center has been managed by Swedish Space Corporation. Balloon activities at Esrang Space Center started in 1974 and the center has built up several dedicated balloon facilities.



Potential launch delays could result from:

1. The COVID-19 pandemic. Depending on the cause of the delay, this could be 1-2 months or unknown, particularly if option a is the cause:
 - a. Travel prohibitions or delays such as Sweden denying entry to our team.
 - b. Delays in shipping or procurement of parts; while the majority of components for the SCoPEX payload are already inhouse, there are items that still need to be ordered.
 - c. Delays because team members get sick.
2. Weather delays. These are possible but unlikely and would only cause a minor delay. The trajectory analysis shows that for a June launch there could be days where there are restricted launch hours. However, Swedish Space Corporation did not find any days in June 2018 or June 2019 that were completely unsuitable for a launch. With a two-week launch timeframe it is therefore unlikely that there will not be a launch window.
3. Engineering delays. Project management and planning has tried to mitigate these delays by mapping out dependencies and predicting lead times. However, if laboratory and subsystem tests reveal previously unknown flaws, component redesign or remanufacturing could cause delays on the order of 2-3 months.

Request: 4. Please provide the Advisory Committee with contact information for your primary liaison at Swedish Space Corporation (SSC).

Response: We have included the contact information for our primary contacts at Swedish Space Corporation in the private Appendix.

Request 5: Please provide the Advisory Committee with information on that company's leadership and track record for similar launches.

Response: Swedish Space Corporation is a private company owned by the Swedish Government and a global provider of advanced space services. They have been launching scientific balloons from the

Esrangle Space Center for over 40 years. In 2018 they also began supporting launches outside of Esrange. Since 2005, SSC has launched 18 large balloon payloads for US based experiments through a partnership with NASA/CSBF. Additionally, over the last 10 years SSC has been the complete launch provider for 50 missions with balloons over 10,000 m³. The SCoPEX balloon will be around 17,000 m³.

Swedish Space Corporation also abides by a formal [Code of Conduct](#), which outlines their commitment to business ethics, human rights, people and leadership, the environment, and regulatory compliance.

Request 6: Please provide the Advisory Committee with any additional information that is available about the timing of the launch.

Response: The SCoPEX payload and team will arrive at Esrange for a 3-week campaign on May 31, 2021. During the first week, the payload will be prepared and be readied for flight. After a Flight Readiness Review (FRR), the payload will then be ready for launch. The two-week launch window starts on June 8, 2021. The balloon will be launched in such wind conditions that it will fly at a low velocity at float altitude for the duration of the flight. After a 4-6 hour float period, the flight will be terminated. The payload and flight systems will be separated from the balloon envelope and descend to the ground at 4-6 m/s. The payload will be recovered after the flight and typically arrives back at Esrange within 24 hours.

Request 7: Please provide the Advisory Committee with any materials documenting a legal review by Harvard or the balloon launch company of the planned launch in Sweden to ensure it will be in compliance with applicable Swedish regulations.

Swedish Space Corporation will manage the overall permitting process for the SCoPEX balloon flight to ensure that it complies with all national and international regulations. Harvard's Office of the General Council will also work with the Advisory Committee if/when any additional legal reviews are needed. For example, the Committee has recently recommended that outside counsel participate in a legal review process. We will follow this advice, so Harvard's Office of General Council will help facilitate this process from the university side.

To provide more detail, the exact altitude and the corresponding potential trajectories will be selected by Swedish Space Corporation. The potential trajectories will likely encompass both Sweden and Finland and could include Norway. Swedish Space Corporation manages the permitting process for all of their flights out of Esrange and applies yearly for permission to fly stratospheric balloons from the Transport Authorities in Sweden, Norway, and Finland. Swedish Space Corporation will apply for these permits for the SCoPEX flight, and no problems are foreseen as they have received yearly permits since 1974 to fly in all three countries.

Swedish law and Swedish safety and security regulations apply to all activities at Esrange Space Center. Additionally, as part of Swedish Space Corporation's Code of Conduct, they are committed to abiding by the laws and regulations of all the nations in which they operate.