Satellite Imagery for Disaster Resilience

Increasing natural hazards and complex emergencies require optimizations in the Swiss civil protection system. Joining the EU's Copernicus program could ensure satellite imagery access for disaster risk reduction, helping to save lives.

By Jurgena Kamberaj

In 1972, the Apollo 17 crew captured an iconic photograph of Earth from space, known as the Blue Marble. This image provided a groundbreaking perspective of our planet, revealing its blue oceans, white clouds, and vast landmasses. By capturing the South Pole ice cap for the first time and a cyclone in the Bay of Bengal, the image marked an important milestone in Earth science and Earth Observation (EO).

Since the Blue Marble photo, geospatial data, and especially satellite imagery, has found diverse applications across industries and sectors, most notably in disaster response and crisis management. In Switzerland, the Rapid Mapping Service (RMS) of the Federal Office of Topography swisstopo, utilizes satellite imagery to aid authorities in documenting damage following an event caused by natural hazards. However, Switzerland faces significant constraints in using satellite imagery for disaster management because it does not have its own EO satellites. A promising solution to this challenge is the Swiss participation in Copernicus, the EO component of the EU Space Programme.

Switzerland has a history of enhancing its crisis management systems after disasters have occurred, such as with the establishment of the RMS following floods in 2005. Yet, with the unpredictable nature of complex emergencies, the civil protection system needs a forward-thinking shift. A pivotal change would be to fully leverage RMS throughout the disaster management cycle before another major event strikes. This approach should prioritize the promotion of training and testing of the RMS during minor emergencies and the strengthening of institutional engagement, which can enhance emergency response strategies, especially at the cantonal level.

Spatial Data for Crisis Management

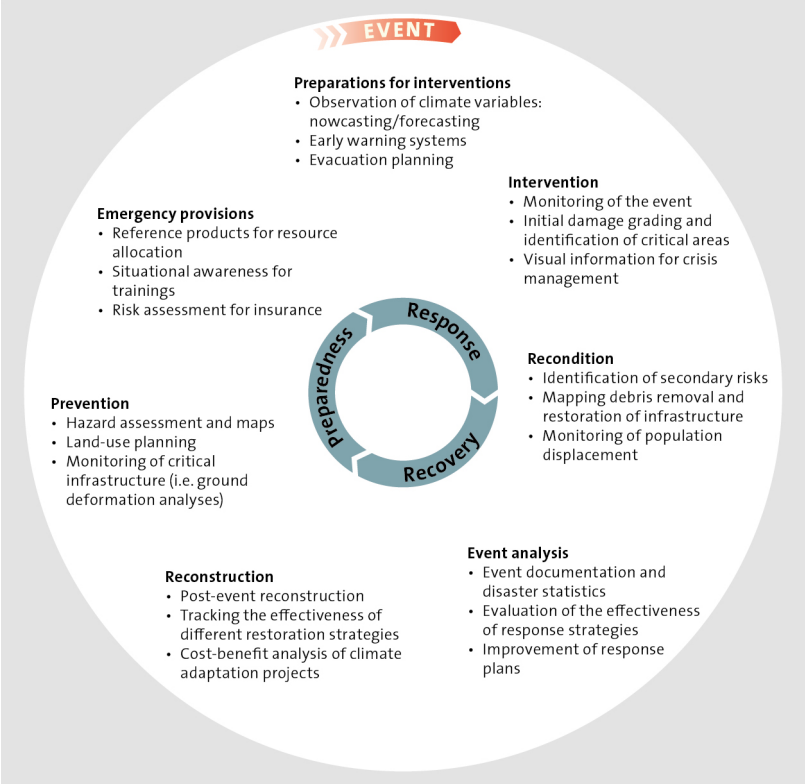
Satellite imagery offers accurate and reliable spatial information during emergencies, enabling effective prevention, preparedness, response, and reconstruction efforts (see graphic). In situations where ground-based data is limited, satellite imagery complements on-site or other geospatial information. For instance, images captured through

Key Points

- Satellite imagery has proven crucial to the management of disasters and complex crises, assisting in preparedness, response, and recovery efforts and enhancing the protection of populations against hazards.
- Despite the effectiveness of the Swiss Rapid Mapping Service, Switzerland's lack of a national Earth Observation program hinders its ability to leverage satellite imagery for disaster risk reduction.
- Swiss authorities could secure swift and reliable access to satellite data through engagement with initiatives such as the EU's Copernicus program. The effective use of this data requires training, institutional awareness, and its integration throughout all phases of crisis management.

different satellites aided Swiss crisis authorities in detecting avalanche activity when aerial surveillance was unavailable in 2018.[1]

There are many ways in which satellite imagery is impactful for disaster risk reduction, one of which is the role it plays in the early detection of natural hazards. When integrated with statistical data, geospatial imagery can also facilitate the identification of population concentrations, leading to more efficient evacuation strategies. During a disaster, crisis authorities rely on satellite images to accurately identify the areas affected. In Rouen, France, high-resolution satellite observations were used to detect and measure hazardous emissions after a fire broke out in a chemical plant in 2019. Furthermore, satellite imagery can support post-disaster reconstruction efforts and bridge data gaps related to disaster losses and statistics.



Incorporation of satellite imagery into the "Integrated Risk Management" of the Federal Office for Civil Protection, 2019. (modified by author)

The Swiss Context

Switzerland, with its distinct topography, is highly vulnerable to natural hazards, such as floods, landslides, avalanches, and forest fires. These are expected to become more frequent and severe due to climate change. As a result of the country's increasing urbanization, disasters caused by natural hazards can significantly affect congested populated areas. In fact, in 2021 and 2022 alone, geological and hydrological hazard events resulted in one fatality and around 500 million Swiss Francs in damages, according to the Swiss Federal Institute for Forest, Snow and Landscape Research (*"Unwetterschäden in der Schweiz"* report published annually).

Furthermore, any disaster entails cascading effects that can undermine the response efforts of authorities and severely impair the resilience and recovery of local communities over time. For instance, severe drought conditions and prolonged heat waves can endanger human health and exert significant stress on vegetation, potentially leading to wildfires and a reduction in agriculture and food supplies. Reduced water availability can compromise electricity generation, which can in turn cause supply-chain disruptions and lead to substantial socio-economic consequences.

As a result of these multifaceted challenges, Switzerland needs to complement its existing emergency response strategies with innovative and dynamic disaster management instruments that are swift, effective, and adaptable. This proactive approach calls for the integration of technological solutions such as satellite services to ensure the safety and resilience of the population, as is explicitly stated in the 2021 Security Policy report of Switzerland. Furthermore, the newly released Swiss Space Policy emphasizes the importance of securing access to space-based services and data as a solution to preparedness for critical challenges, including disaster response.

Swisstopo's RMS has already integrated satellite imagery into its operations. When a natural hazard event occurs in Switzerland, the RMS compiles and provides geodata, such as aerial or satellite images, primarily for documentations. The service requires coordination between multiple federal offices, cantonal agencies, and other relevant actors, led by the Federal Office for the Environment (FOEN), together with the National Emergency Operations Center (NEOC).[2] Moreover, the service can be activated by requests from federal offices, cantonal agencies, and the corresponding management bodies.

Since its establishment, the RMS has been utilized seven times for natural hazards, including forest fires, floods, avalanches, rockslides, and drought, successfully acquiring image data from various airborne and satellite platforms. Swisstopo currently collaborates with the Swiss Air Force for aerial imagery, leading to greater recognition of RMS's role among Swiss authorities. However, there are still areas that require improvement to make the service a more powerful instrument for crisis management. Current shortcomings include its limited access to satellite imagery data, the confinement of its use to natural hazards and

event documentation, an inadequate awareness of its capabilities among potential users, and restricted possibilities for collaboration and training.

Pathways for Swift Access to Satellite Imagery

The utilization of satellite imagery can greatly improve crisis and disaster response, but its effectiveness can be compromised if timely access to the data is not guaranteed. Switzerland does not operate its own EO satellites and instead relies on imagery and geodata from various operators. While several pathways exist that could ensure swift access to such imagery, each has its own limitations. However, the EU's Copernicus program appears a particularly promising option for securing on-demand, direct, swift, reliable, and cost-effective satellite imagery.

Switzerland's primary approach to obtaining on-demand satellite imagery is through commercial providers like Airbus or DigitalGlobe. Factors such as cost, speed of data delivery, and technical specifications, like spatial resolution, are evaluated before selecting a provider. However, Switzerland must also consider issues related to confidentiality and the potential disclosure of sensitive information when dealing with private providers.

An alternative approach is swift access to satellite data through bilateral agreements with national space missions, like the French National Centre for Space Studies (CNES) or the German Aerospace Center (DLR). However, this approach has not been widely explored, mainly due to constraints in satellite resources, or potential delays in data delivery driven by the national interests of the providing countries. Notably, the Swiss agreement with the French *Composante Spatiale Optique (CSO)* constellation might enhance access to satellite imagery, but its primary application is in the field of intelligence and security policy.

An additional possibility is engagement with international initiatives like the International Charter on Space and Major Disasters (the Charter) which is intended to provide on-demand satellite imagery for disaster relief free of charge. However, the past use of this avenue has come with its own challenges. For Example, Switzerland's activations of the Charter in 2005 and 2021 encountered difficulties due to data compatibility issues.

The final option for Switzerland to gain access to satellite imagery is through participation in Copernicus, which provides a variety of geodata and information in fields including environmental monitoring. This agreement can bridge the gaps resulting from Switzerland's lack of its own EO infrastructure. Accession to the program has also garnered support from Swiss policymakers, solidified by extensive deliberations in both chambers of parliament. This led to the Federal Council's decision in January 2022 to seek participation in Copernicus.

It is worth noting that Switzerland is already engaged in Copernicus through its membership of the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Despite this, Switzerland currently faces limitations in accessing specific services within Copernicus, especially the Copernicus Emergency Management Service (CEMS). This service provides on-demand mapping and early warning and monitoring that can support decision-makers' activities throughout all stages of the disaster risk management cycle (see graphic). The activation process is fast, as the service is supported by a wide constellation of satellites and sensors in different orbits. Authorized users have already utilized the services to handle large-scale emergencies, including the 2021 floods in Western Europe and the 2022 wildfires in Southern and Central Europe.

Joining Copernicus would present Switzerland with a unique opportunity to gain insights from a program specifically tailored to provide policymakers with data for informed decision-making and to respond effectively to emergencies. Moreover, Switzerland can assess its technological, regulatory, and logistical readiness against Copernicus's other participants. Thus, this strategic move could also unlock economic prospects for Swiss-based enterprises, industries, academics, and researchers.

Further Reading

Pietro Checcato et al., ***The 2023 COPERNICUS Emergency Management Service On-Demand Mapping - Fire Workshop March 7-8,*** *JRC-EU Commission* 2023.
Findings from the discussion on Copernicus CEMS for forest fires, gathered from the contributions of past activations from Copernicus participants.

Veronika Gstaiger et al., ***Aus dem All und aus der Luft frisch auf den (Lage-) Tisch: Der Nutzen von Luft-und Satellitendaten für die Lageerfassung,*** *DLR,* 2022.
Insights on the valuable contribution of aerial and satellite images in enhancing situational awareness during the 2021 floods in western Germany.

G. Le Cozannet et al., ***Space-Based Earth Observations for Disaster Risk Management,*** Surveys in Geophysics, 2020.
An overview of space-based EO initiatives, and strategies to integrate satellite data into the different phases of the disaster risk management cycle.

However, since the decision of the Federal Council to seek participation in Copernicus, progress in the technical negotiations has been slow, particularly due to stalled talks with the EU concerning the overarching institutional framework for future relations. Nonetheless, Swiss participation in Copernicus remains viable. This is because a bilateral agreement mirroring existing participation models, such as the Galileo Satellite System, could facilitate the process. It is also worth noting that Switzerland might access CEMS by participating in the EU Civil Protection Mechanism, a prospect heightened by the National Council's recent motion approval.[3]

Progressing Forward

While Switzerland's potential involvement in Copernicus continues to be explored through ongoing negotiations, Swiss authorities can simultaneously implement strategic measures to maximize the benefits of the RMS. This could involve promoting the use of satellite images throughout the whole disaster management cycle and encouraging the training and testing of the RMS during small-scale emergencies.

The effectiveness of satellite imagery in civil protection relies heavily on the awareness and understanding of its potential. Yet, the RMS remains underexplored and underutilized, especially at the cantonal level, and its use is often limited to event documentation despite its potential application in comprehensive event management. For instance, during the Bitsch forest fire in the canton of Valais in July 2023, authorities missed the opportunity to test the RMS' capabilities in support of firefighting activities. The integration of satellite imagery with weather and ground data could have enhanced situational awareness and communication among response teams, authorities, and citizens- facilitating decision-making and resource allocation.

Furthermore, the real-time testing of the RMS during the Bitsch forest fire could have familiarized users with command chains and procedures, a pivotal aspect in minimizing data delivery delays. Proactive testing and training within the RMS should also encompass a broader range of threats, including technological and societal hazards. Recent events like the 2019 industrial accident in Rouen demonstrate how satellite imagery has become a reliable source of timely information for emergency relief operations, including disasters triggered by technological, epidemic, or man-made threats.

Besides expanding the use of the RMS in Switzerland and implementing training and preventive testing programs, it is essential to consolidate and strengthen engagement within institutions and between them, both domestically and internationally. A pivotal initial step is to identify and consolidate stakeholders that could be included in dialogues regarding crisis mapping in Switzerland, as suggested in a 2013 CSS report.[4] Workshops can promote understanding of satellite imagery's role in disaster management and unite cantonal and federal experts from civil protection, military, academia, and business for better integration into their daily operations.

Beyond stakeholder workshops, it is important that key players within the RMS, including swisstopo, FOEN, and NEOC, commit to regular meetings and interactions. Regular consultations, coordinated efforts, and aligned objectives are crucial to unlocking the full potential of the RMS in Switzerland and ensuring prompt and efficient responses during emergencies. Internationally, Switzerland should increase consultation with neighboring countries, like Germany and France, which have their own national space programs but also actively use the Copernicus CEMS.

In conclusion, regardless of the outcome of the Copernicus negotiations, proactively strengthening the RMS is paramount. This strategy aligns with Switzerland's 2021 Security Policy, which prioritizes foresight in enhancing civil protection and building resilience. The RMS, though created in response to past disasters, needs consistent refinement to become a valuable instrument for crisis authorities. Switzerland should not await another crisis to dictate necessary changes.

Selected Sources

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2. Federal Department of Defence, Civil Protection and Sport (DDPS), Hochwasser im Sommer 2021: Klassisches Rapid Mapping und neue Möglichkeiten, 2022.
3. Bundesversammlung, Motion Matter Michel. Für einen Beitritt der Schweiz zum EU-Katastrophenschutzverfahren.
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