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# Earth Observation for SOS Children's Villages: Deployment of Cutting-Edge Technology to Support a Humanitarian NGO in Emergency Management

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**Abstract**

More than 1.5 million children and their families in over 130 countries around the world are currently receiving support from the humanitarian relief organization SOS Children's Villages International. The Department of Geo-Risks and Civil Security at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has been supporting the organization in the use of Earth Observation technology in order to develop a comprehensive emergency and disaster management concept. The study focused on disaster preparedness and early warning, emergency mapping, and humanitarian technologies as a whole. Pre-operational emergency mapping services, as well as automated services for satellite-based fire and flood information, were developed and tested. Our use case concentrates on the emergency mapping activation for tropical cyclone DINEO, which destroyed an SOS children's village in Mozambique in February 2017, and the related satellite-derived damage assessment.

## 1 Introduction

SOS Children's Villages was founded in post-World War II Austria in 1949. Today, the organization is active in 134 countries and territories, providing a range of services to children and families, including alternative care in SOS Children's Villages, youth programmes, family strengthening programmes, and emergency response (SOS Children's Villages International, 2015). In June 2016, SOS Children's Villages was involved in 25 emergency programmes around the world. One of the current focuses of the organization with regard to emergencies and disasters is to strengthen disaster resilience and preparedness, particularly in high-risk countries. A key part of this strategy is harnessing new technologies to improve both the speed and the efficiency of emergency response activities (Papp & Barclay, 2016).

The rising number (and partly the severity) of natural disasters (UNISDR, 2016), humanitarian emergency situations and threats to civil society increases the demand for timely and precise information on many different types of scenarios. Against this backdrop, Allianz SE and SOS Children's Villages have embarked on an ambitious global partnership to improve child safety around the world. As part of this initiative, Allianz and SOS Children's Villages have been working with DLR to use state-of-the-art Earth Observation technology in developing an emergency and disaster control concept (Voigt et al., 2016, Voigt et al., 2011) covering several hundred SOS Children's Villages worldwide. The partnership aims to improve information flows, and ultimately to secure the safety and well-being of the children and staff of SOS Children's Villages.

The study comprised two phases: an initial phase from January to July 2016, and a follow-up phase from October 2016 to March 2017. The study focused on an in-depth analysis for the technical optimization of work processes, and the development of pre-operational services in emergency and disaster management at SOS Children's Villages. It was split into three subject areas:

**Preparedness and early warning**

- Assessment of possible components of a preparedness and early warning system at various development stages (Jasani et al., 2009).
- Development and testing of pre-operational satellite-based fire and flood services (Twele et al., 2016; Plank et al., 2017).

**Emergency mapping**

- Assessment of a potential system for rapid provision of satellite imagery and situational awareness information of crisis-affected facilities to be used in emergency management (Voigt et al., 2016; Bello & Aina, 2014).
- Development and testing of pre-operational satellite-based emergency mapping services.

**Humanitarian technologies**

- Assessment of technological innovation approaches to improve and optimize the work of SOS Children's Villages, with a specific focus on emergency and disaster management. Recently, many humanitarian organizations have adopted strategies to further strengthen their capacities by making use of innovative technologies, for example in the fields of Earth Observation, logistics, incident management or telecommunications (IFRC, 2013).

## 2 Preparedness and Early Warning

Due to their diverse geographical location, many SOS Children's Villages are exposed to a range of natural and man-made risks or potential human crisis situations. A dedicated and tailored early warning system for SOS Children's Villages could assess the potential risks of natural disasters, such as earthquakes or floods, as well as of complex crises like armed conflict. Assessing and reacting to disaster risk, rather than focusing solely on response to disaster impacts, can facilitate improved disaster preparedness and ideally result in reduced damage (GFDRR, 2014). The aim was to develop pre-operational automatic services for fire and flood data layers. The resulting data layers were disseminated using DLR web services, which were based on the Open Geospatial Consortium (OGC)-conform Web Feature Service (WFS).

Three representative regions in western and central African countries (Sierra Leone, Niger and Central African Republic) were chosen for testing and demonstration of the early warning services to be developed. Each region included three SOS Children's Villages.

Sentinel-1 radar data was utilized for the preparation of the flood masks. Synthetic Aperture Radar (SAR) on board Sentinel-1 satellites operates in the C-band – a range which can be used for flood mapping irrespective of cloud cover. A global water mask was used in conjunction with the most recent satellite imagery to separate flood from river / standing water information. Deriving and processing the data to generate up-to-date flood mapping layers took approximately six hours. The complete processing chain is further described by Twele et al. (2016).

For the derivation of wildfire hotspot data, the SEVIRI sensor onboard the MSG-1/METEOSAT-8 satellite was utilized (compare EUMETSAT, 2007). The satellite is in a high geostationary orbit, synchronous to the planet's rotation. This geostationary location allows it to transmit temperature anomaly information for Europe and Africa every 15 minutes. Therefore, derived products could be delivered in near real-time (NRT).

The data was received, processed, analysed and published in the form of a standardized WFS, updated every 15 minutes regarding thermal anomalies and every six days regarding flood masks. The results were integrated into the client offered by DHL, Resilience360 (DHL, 2016), which has been serving as the decision-support platform at SOS Children's Villages. In addition to the automatically-processed sensor data, information and reports generated by local/regional staff are also regularly integrated into the platform.

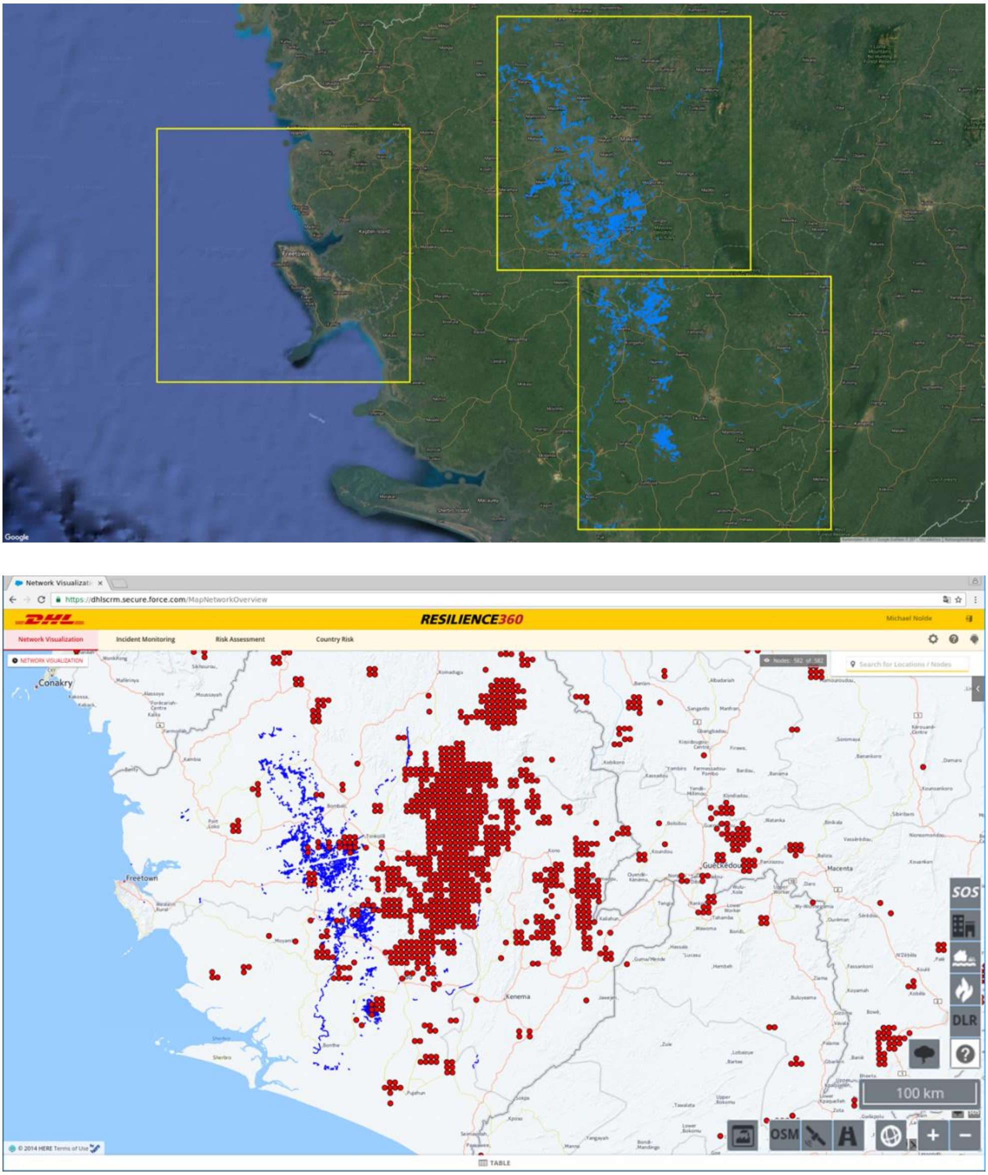


**Figure 1:** Flooding event in the area of Makeni, Sierra Leone (top: Visualization in QGIS; bottom: Flood and Fire Hotspot Service integrated into DHL Resilience360)

Both services delivered useful information for SOS Children's Villages. One challenge presented by the fire hotspot service is the number of hotspots transmitted, since no discrimination is made between short-term, low intensity fires and serious life-threatening events. Filtering methods need to be developed to obtain an accurate image of the situation. Regarding the flood service, there was no severe flood event during the test phase, so only minor flooding and normal water levels were shown.

## 3 Emergency Mapping

DLR helped to develop and run a pre-operational Emergency Mapping Service and to define its different components in order to give an overview of how an SOS Children's Villages Emergency Mapping Service could be set up (compare Schneiderhan et al., 2010; Voigt et al., 2006; Mahmood et al., 2002). The first step was to define the specific SOS Children's Villages requirements in the event of an emergency, and to show the technological framework for Earth Observation, as well as tailored satellite-based crisis information. Example products for the SOS Children's Village Harar, Ethiopia, served as demonstration material (see Figure 2).


**Figure 2:** SOS Children's Village, Harar, Ethiopia – Geographic Reference Map – Overview

In the second project phase, a pre-operational Emergency Mapping Service (EMMA) was developed and tested. The pre-operational EMMA was designed as a service for the rapid provision, processing and analysis of satellite imagery during disasters or crisis situations worldwide. The central elements of EMMA are service generation and provision, to include not only the production of mapping products in case of a crisis, but also quality control, internal verification, service evolution, access and long-term preservation of products, and training. With the inclusion of these elements, EMMA is comparable to existing operational emergency mapping services, e.g. Copernicus EMS (2017) and DLR's ZKI (2017).

In its test phase, EMMA was run on a 5 days/8 hours a week schedule. During this time, the pre-operational service was triggered by SOS Children's Villages for two natural disasters: 1) wild fires in Chile, January 2017, and 2) tropical cyclone DINEO passing over Mozambique, February 2017. During the two activations the entire service chain, including ordering, emergency product generation and delivery, as well as the usability for SOS Children's Villages, was successfully tested and evaluated.

In the case of Mozambique, the emergency products consisted of a damage assessment and a flood layer derived from reference (pre-disaster) and newly-acquired (post-disaster) satellite imagery. All crisis information and satellite images were provided via a WMS, including key infrastructure (e.g., hospitals) and points of interest for SOS Children's Villages (see Figure 3). Despite delays due to cloud cover and limitations due to the 5/8 service, the satellite-based crisis information could be used for supporting the damage assessment in the affected area. The provision of comprehensible crisis information for a large area was the main benefit for SOS Children's Villages' staff on site. Future adaptations should include performance improvements of the WMS related to its use in low-bandwidth environments.

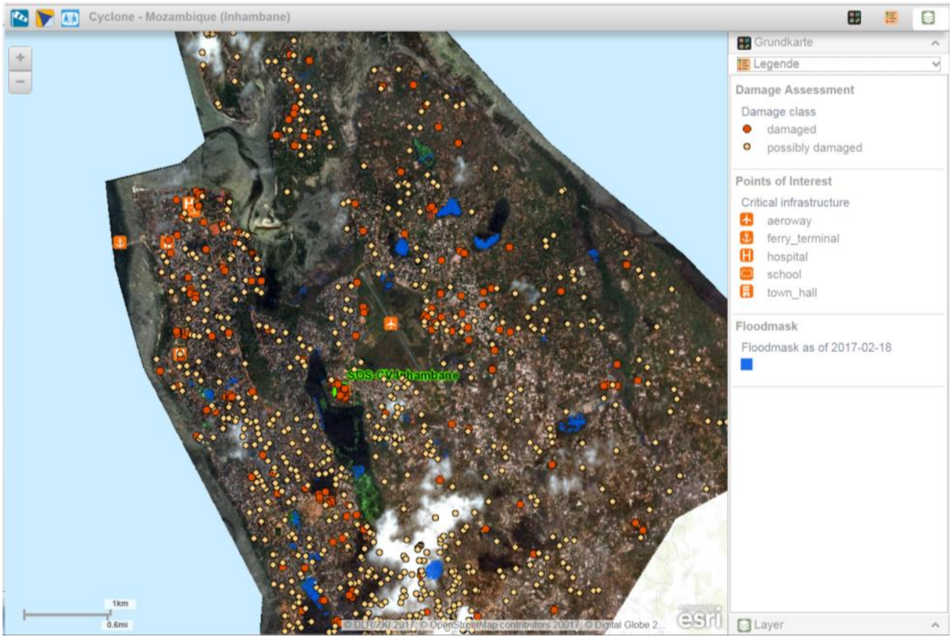


**Figure 3:** SOS Children's Village, Inhambane, Mozambique, affected by tropical cyclone DINEO; screenshot of DLR's WMS

## 4 Humanitarian Technologies

Management of crisis and emergency situations requires robust communications and information flows, as well as reliable technical infrastructure and tools. A large part of the relevant infrastructure, such as telecommunications and drinking water supply, relies on uninterrupted power supply. In many countries, the power supply is not reliable, and/or is often damaged during severe disaster situations. Solar and other renewable energy technologies represent an important basis for future improvements in the capacity of humanitarian organizations. There are many further examples where new technology can increase the efficiency and reliability of SOS Children's Villages' services, e.g. in the domain of Information Technology, water and sanitation, or technical communication.

Thus, SOS Children's Villages is scouting for and reviewing further innovative technology tools that can be used to improve and strengthen its relief management capacities across the board. As part of the collaboration among SOS Children's Villages, DLR and Allianz, DLR provided support for assessing, selecting and implementing new technological tools in the daily operational procedures within the mission of SOS Children's Villages – both for crisis and emergency preparedness and response, as well as in support of 'regular' SOS Children's Villages operations.

In the course of intensive working phases, exchange of information in workshops, telephone interviews, and discussions with experts from a number of technological fields at SOS Children's Villages from all around the world, the most relevant aspects to support SOS Children's Villages were identified as: a) bandwidth/connectivity, b) geo-spatial data and satellite information, and c) an incident management system. The work on scouting for useful technology tools could be further deepened on a selected subset of technology fields to then allow the elaboration of more concrete and practical suggestions for development and implementation.

# 5 Conclusion and outlook

In this study, we identified and discussed the technological needs and requirements to strengthen SOS Children's Villages' disaster management capacities, with a focus on disaster preparedness and emergency response. A set of innovative technologies was identified to support SOS Children's Villages in reducing damage and improving the effectiveness of managing disasters and crisis events. Two of these main technologies were further developed and implemented within SOS Children's Villages' operations during the second phase of the study: (1) a pre-operational satellite-based fire and flood service; (2) a pre-operational satellite-based emergency mapping service. Both services were tested in a real-life environment and demonstrated great potential to support the decision-making of SOS Children's Villages with regard to emergency response capacities in the short term, as well as over the long run. Since the added-value of new services depends strongly on a clear communication of strengths and limitations, the translation of early warnings into early action and the skill of the user, we recommend in-depth training based on realistic decision-making scenarios.

We conclude that probabilistic disaster risk information and analysis should be incorporated into the concept, which may, for instance, build on the global seasonal prediction of precipitation and temperature anomalies. In contrast to deterministic information, probabilistic information does not provide a single value for a predicted condition (e.g., extreme rainfall), but rather a probability that a certain event will happen. Based on the multi-model flexible forecasts developed at the International Institute for Climate and Society (Columbia University), users may pre-select probability thresholds so as to better modulate their information flow as appropriate to the region and potential risk.

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