Niger Delta Flooding: Monitoring, Forecasting & Emergency Response Support from SPDC

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SUMMARY

In September and October 2012, Nigeria was affected by widespread and unprecedented flooding. As this flooding began to impact SPDC host communities and facilities in the Niger Delta, the SPDC Geomatics team was asked to assist in the Company's response to the emergency. Satellite radar images were acquired from Radarsat-2 and the COSMO SkyMed constellation to estimate the extent of flooding across the Niger Delta. The first image was made available within twelve hours of the request. The radar images enabled mapping of the extent of water bodies through cloud cover and at night, and proved to be suitable for the detection of flood water in partially vegetated and open areas.

Over a period of one month 14 satellite radar images were analysed, with the support of imagery vendors, to generate flood extent maps for internal and external stakeholders. Two approaches were evaluated; change detection using radar images acquired before and during the flooding, and direct mapping from threshold images. The latter approach proved to be a simpler and more accurate way to identify flood-impacted areas. This information was integrated with data from water level gauges and digital elevation data to predict other likely areas of impact as flood waters continued to rise. The maps produced by the Geomatics Team highlighted key oil/gas infrastructure and the locations of communities. Photographs from helicopter over-flights were subsequently used to evaluate and confirm the accuracy of the flood mapping.

The work by the Geomatics Team supported not only internal stakeholders, but also SPDC'S delivery of relief materials to impacted communities. The work also supported the Red Cross and other NGOs' (Non-Governmental Organisations) response to the disaster.

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1. INTRODUCTION

In September and October 2012, Nigeria was affected by widespread flooding, attributed to heavy rainfall and the failure of the major Lagdo Dam in Northern Cameroon. Nigeria's National Emergency Management Agency (NEMA) estimated that the floods claimed 363 lives and displaced 2.1 million people in different parts of the country.

By October 5, SPDC operations began feeling the impact and the company's Western Delta Emergency Response Team (ERT) was activated. The SPDC Geomatics Team supports the ERT and was asked to provide information to assess the extent and impact of flooding. This information was not only required by SPDC for management of safe shut-downs and evacuation of its personnel but also by third parties such as NGOs and Government agencies. Some of the driving forces behind this satellite-based approach to flood monitoring and emergency response strategy include:

1. The need for knowledge at a regional scale of the position and extent of flood water across the Niger Delta in relation to SPDC facilities and active locations (e.g. well-sites with drilling rigs)
2. The need for assessment of present and future vulnerable SPDC assets within or near the flood-affected areas.
3. Support the Nigerian Government and relief organisations with accurate and timely information to enable effective support to flood-affected people, communities and the environment.
4. The need to obtain accurate, frequent regional information on flooding patterns across the Niger Delta.

Information was requested by SPDC onshore assets so they could evaluate potential risk to facilities and enable shut-down in a controlled manner or if safe to continue operations. This article summarises the approach which was taken and some learning points.

2. INITIAL RESPONSE

Geomatics was first contacted to provide support on activation of the ERT. The first reports of flooding in the SPDC operational area of the Niger Delta indicated that the impact was restricted to a small area adjacent to the River Niger, but this was quickly revised to an area of approximately

3400 sq km. This represents approximately 10% of the area of SPDC's onshore operations, but several flow-stations and other infrastructure were at risk. After some discussion between the ERT Commander and Geomatics, MDA Geospatial Services were contacted on their emergency hotline (24/7) and asked to provide radar tasking feasibility reports. Radarsat-2 makes two passes over Nigeria at approximately 6am and 6pm local time on most days and the first available and suitable acquisition opportunity was October 9, in the afternoon.

2.1 Satellite Radar Remote Sensing

SPDC is currently implementing satellite radar imaging for oil spill monitoring offshore and coincidentally an image had been acquired on October 5th which included the impacted areas. Comparison between this image and a previous scene from the same sensor, acquired in the same mode, demonstrated that the flood waters were visible in the radar imagery. The imagery provided an initial indication of the extent of the flooding, which was more widespread than initially reported.

On October 6, the ERT Commander and Chief Surveyor authorised urgent tasking of radar imagery, and E-Geos were contacted on their 24/7 hotline to provide additional support. They responded immediately, offering an acquisition attempt the following day, which was successfully achieved.

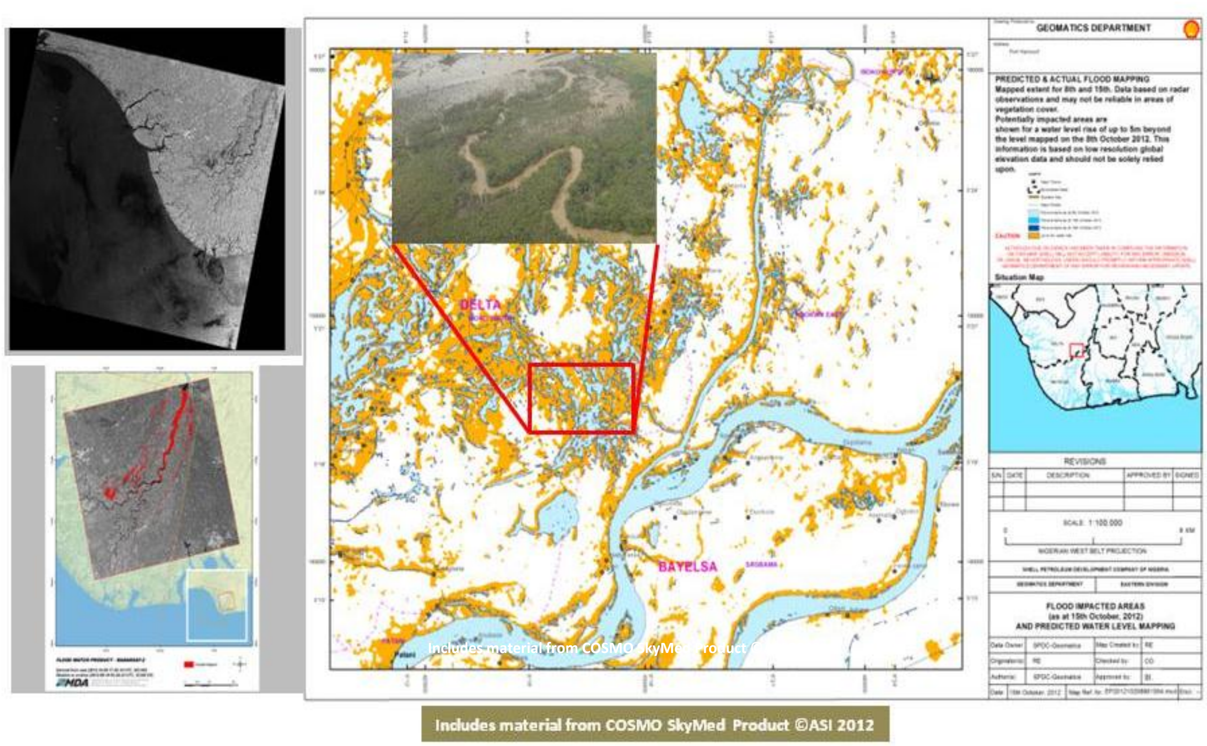

Figure 1 : Example of flood extent and prediction maps produced for key locations.

Two approaches were taken to map the extent of flooding from the satellite radar images. MDA piloted change detection, utilising dual-polarisation Radarsat images, acquired before and during the flooding. E-Geos favoured thresholding of images. Thresholding identified the darkest areas in the imagery, which represent water and other highly reflective areas. The change detection approach assisted in elimination of false positives, but tended to under-estimate the extent of flood water. The thresholding results were more accurate. The vendor results were typically received within two hours of acquisition. After download by file transfer protocol (FTP), each interpretation was checked and updated as appropriate, and maps of the extent of flooding were produced and distributed by email.

Figure 2: SPDC facility cut-off by flooding, first identified from radar-derived mapping.

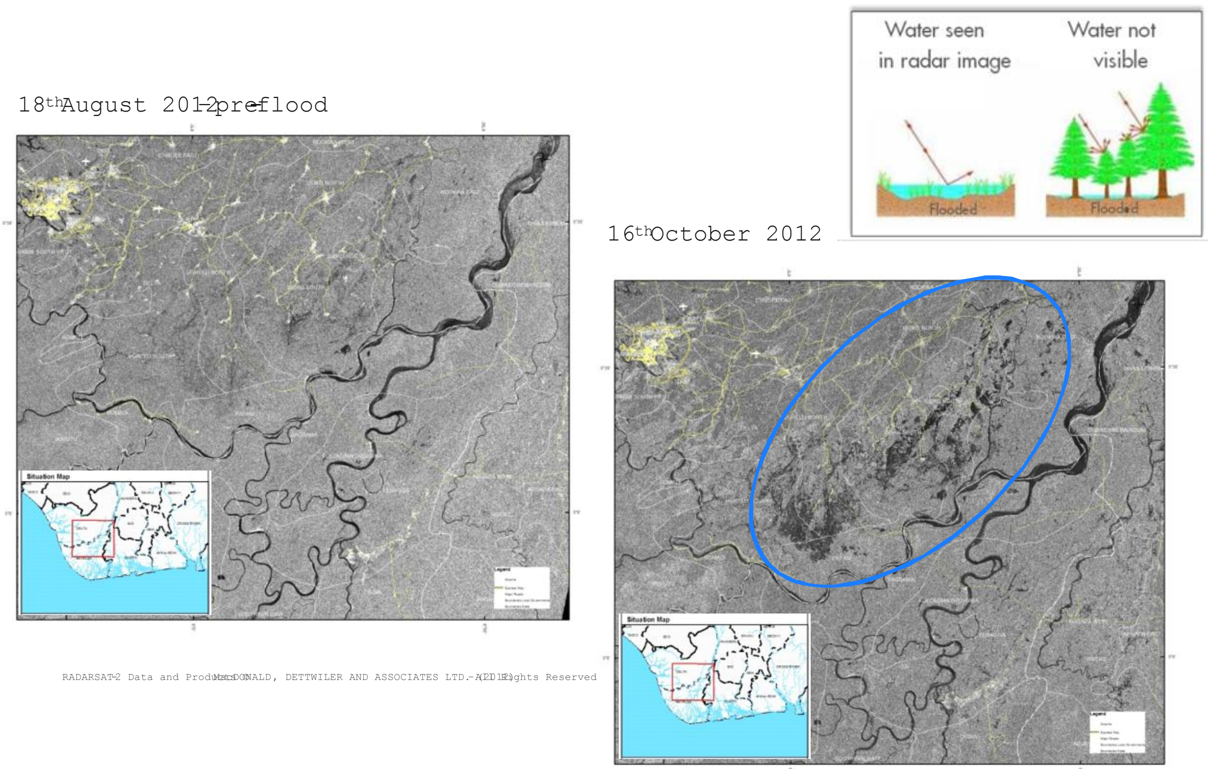

Figure 3: Identifying flood water in radar images, using images acquired before and during the flooding.

This information was also integrated with data from water level gauges and digital elevation data to predict additional areas of impact as flood waters continued to rise. The maps produced by the team included key infrastructure and the locations of communities. Two map series were produced. Internal stakeholders received maps by email, including the location of facilities and infrastructure, and other key locations (e.g. mobile drilling rigs). External stakeholders, including the Nigerian Red Cross, received similar maps, but without the SPDC asset information being included.

2.2 In-situ Flood Level Mapping

In order to complement the radar-based flood mapping and prediction, in-situ flood level mapping was quickly contemplated. An emergency decision to mobilise and setup water level gauges was approved and set up by the SPDC Geomatics operations team along Nun River close to Gbaran. This served to complement radar imagery-based mapping and flood prediction. The data from gauges was valuable in fine-tuning the prediction model generated from the satellite radar imagery.

3. THE SPDC RESPONSE

Radar-based, in-situ flood mapping and Geographical Information Systems (GIS) formed the bases of SPDC's emergency response strategy. After the mapping and prediction of flood extents were performed, flood maps were integrated with GIS data showing the location of active work sites and facilities. A number of work sites and facilities unaware of an impending flood had to be quickly demobilised and safely evacuated before the flood's ingress, including several coastal facilities e.g Forcados Terminal and flow-station. This saved SPDC considerable costs that would have been incurred if there was a full-scale emergency with numerous uncontrolled facility shut-downs. A key factor was advice from the Geomatics Team on the effects of tide and current counter-acting the effects of the flooding.

SPDC responded to a national disaster by supporting NGOs such as the Red Cross, other NGOs and Government agencies involved in the relief effort with flood extent and prediction maps to aid disaster management.

4. IMPROVING THE RESPONSE

The initial satellite tasking was based on the original area of interest, and proved to be inadequate to capture all of SPDC's impacted and at-risk facilities. During October and early November, 14 radar images were acquired, initially on a daily basis then at a reduced frequency after the flooding had peaked. The imagery and interpretation were delivered from both vendors by file transfer protocol(FTP). Both vendors adhered to strict file-naming conventions for the radar images, but flooded area interpretations, which were delivered as shape-files, were not consistently named. There was also some inconsistency in the results delivered by both vendors, necessitating additional quality control and checks against the source imagery by SPDC analysts.

The workflow used to ensure adequate satellite image coverage started with reviewing the imagery already acquired, and the extent of the flooding. Then, using acquisition opportunity data from MDA and E-Geos, tasking for the next three or four days was reviewed and confirmed, balancing activity between the two vendors to ensure adequate coverage. Two overlapping time series were effectively created. The MDA coverage from Radarsat 2 used a range of beam modes, and choice was limited by acquisition opportunities, whereas the E-Geos constellation of four satellites offered more acquisition opportunities and was able to provide a more consistent time series. Frequent telephone and e-mail communication was essential throughout the month, to manage acquisitions and avoid unnecessary tasking.

When the Geomatics flood mapping capabilities became public knowledge, it was important to provide regular updates, delivered internally and externally. The maps were always accompanied by a brief note describing their content and the origin of the information. These communications reflected all of the information available to the Geomatics Team. For example, the first radar map that indicated the flood water was receding was supported by information from water level gauges, and observations from helicopter over-flights.

5. CONCLUSIONS

The flood extent and prediction maps provided by the Geomatics team contributed to the managed shut-down of at-risk facilities, saving significant operational impact and costs, and avoiding unnecessary loss of production.

In Geomatics, the Geo-information Management team worked seamlessly with colleagues in Onshore and Offshore Survey Operations, and other disciplines in order to integrate information from all available sources, including satellite radar imagery, hand-held aerial photos, water level gauges and reports from field crews, in order to support SPDC's response to the flooding disaster in the Niger Delta.

The contribution of the Geomatics Team is widely recognised. Phillip Mshelbila, then General Manager, Sustainable Development & Community Relations in SPDC, stated that the maps "…have helped tremendously to demonstrate our support for the relief and recovery effort using our specific capabilities. Feedback from the Red Cross and NGOs has been very positive and appreciative."

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