

Collaborative Mapping and Emergency Routing for Disaster Logistics – Case Studies from the Haiti Earthquake and the UN Portal for Afrika

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Summary

For planning the humanitarian operations of the UN the information about the actual condition of the streets is very important, as well as up-to-date information about hindrances and danger areas. Based on the services behind the OpenRouteService.org (ORS) platform dedicated Web portals for supporting the disaster logistics of the UN have been developed. While ORS uses data from OpenStreetMap in one special portal for Afrika the data from the United Nations Spatial Data Infrastructure for Transportation (UN SDI-T) was deployed (ITHACA 2008a, b). This data needed special processing in order to make it usable for routing in the first place. In general recent geographic information is of high importance in disaster management, but in particular in developing countries the availability and access to geodata is still often quite limited. In order to improve the situation and have spatial data ready for planning and managing humanitarian actions the UN SDI has been initiated. It is fed from several sources and has therefore a varying quality. But recently another data source becomes more and more relevant for such activities. These are the user-generated datasets from communities of volunteers that organize themselves through Web 2.0 approaches. This „Volunteered Geographic Information“ (GOODCHILD 2007) can play an increasing role in disaster management as the use case of Haiti has showed. Such information – in particular the prominent OpenStreetMap data has been used to realize Emergency Routing Services with highly up-to-date data.

An important feature of ORS for the disaster management operation was to consider blocked areas or streets when routing. The OGC (Open Geospatial Consortium) standard implemented in ORS, the Open Location Services Route Service (OpenLS), defines so called „AvoidAreas“, which can be used to realize such functionality – even in an interoperable way. The portal allows UN staff to define and upload spatial data that represent those AvoidAreas into a geodatabase through the Web using the WFS-T (OGC Web Feature Service – Transactional). Further OGC services include a WMS or the OpenLS geocoder. This portal is a follow-up of a first prototype that was actually used during the UN emergency operation in Haiti after hurricane „Ike“. Based on those real experiences the UNJLC planned to set up a portal to support in future operations.

Within this paper we present the realized portal based on OGC standards, experiences with the data available for Afrika in the UN SDI-T and the functionality that were realized within the emergency routing service based on the technology deployed at OpenRouteService.org. We also introduce the OpenStreetMap (OSM) solution for Haiti and compare the

differences and explain the lessons learned. From that we draw conclusions about the need to integrate and synchronize community-based approaches into humanitarian actions carried out by official humanitarian organisations. This includes the need to harmonize the data schemes of e.g. the UN Spatial Data Infrastructure for Transportation and approaches such as OpenStreetMap.

1 The Case of Africa: A Geoportal for the UN Joint Logistics Cluster

The UN Joint Logistics Cluster (UNJLC) is mandated by the UN Inter-Agency Standing Committee (IASC) to complement and co-ordinate the logistics capabilities of co-operating humanitarian agencies during large-scale complex emergencies and natural disasters. The UNJLC defines and implements the UN SDI-T which constitutes the transport-related branch of the United Nations Spatial Data Infrastructure (UNSDI). As explained above the availability of geodata that can be used for planning the logistics of humanitarian actions is often still quite restricted in particular in less developed countries.

The UN tries its best to set up a SDI but because of the general lack of sufficient accessible data the data of the UN-SDI-T consists of very heterogeneous sources and therefore has varying quality (figure 1). In order to make the data usable for route planning in the first place, both automatic procedures and a lot of checking and editing by hand was necessary. The data even included topological errors etc. in spite of being a database for transportation planning. The reason is that the collection and integration of the data only started a few years ago and data sources included (to a few percent) even non-geometric sources such as interviews, reports or measurements even without GPS. For example there are no logical relationship between point-objects such as bridges and obstacles included in the database. This means that those relationships needed to be established through spatial queries. This is problematic because of the heterogeneity of the different data sources with their differing accuracy and scale. There is a strong need for further homogenization and data quality control of this data. Within the work of P. Singler (SINGLER et al. 2009) it was possible to derive a topologically correct, routable street network from this data. This was used as input for the route service.

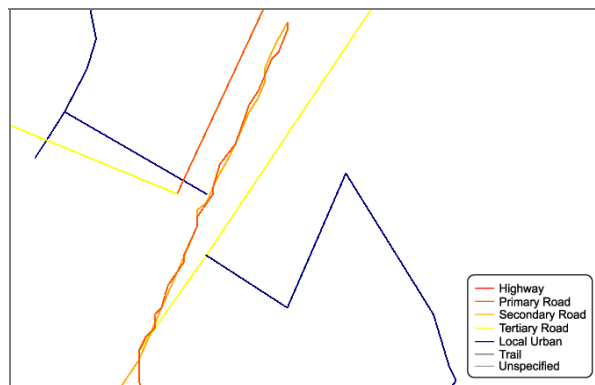


Fig. 1:
Example of “heterogeneous”
UN-SDI-T data (Africa)

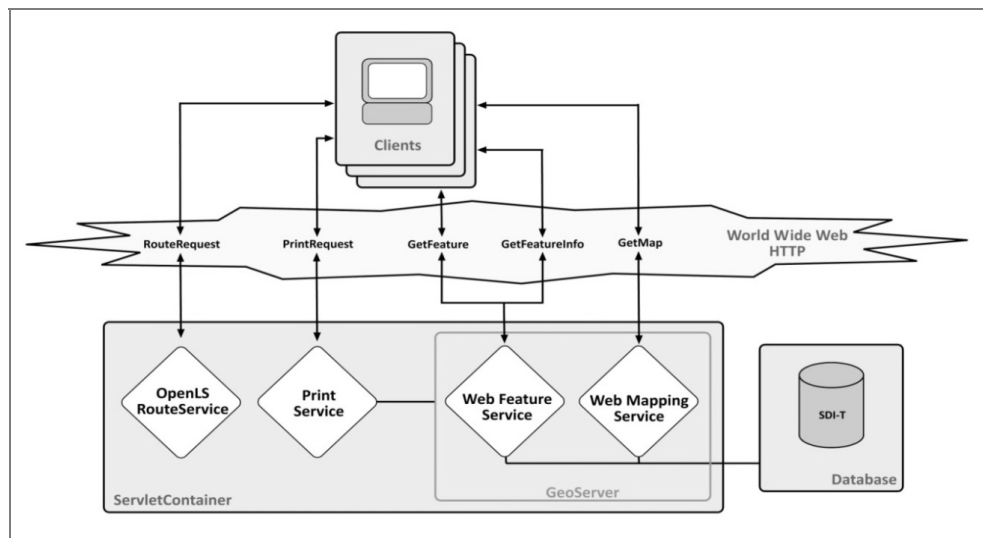


Fig. 2: OGC Service Architecture of the WFP-Africa GeoPortal

The architecture of the realized portal can be seen from figure 2. It is mostly based on the typical OGC web services (WMS, WFS), but includes also the OpenLS Route Service and a new, dedicated Print Service. This is a not-standardized service. It was introduced due to the needs of the humanitarian organisations to get printable planning maps (as high resolution pdf) for the field work with a specific layout and legend etc. This could not easily be realized through WMS with SLD.

The functionality of the Geoportal for Africa includes the possibility to calculate streets (figure 3). The route service implementation has been adapted from OpenRouteService.org to support the new data structures. Earlier versions had even been extended for a 3D context (NEIS et al. 2007). Similar to OpenRouteService.org it is possible to define so called “AvoidAreas” interactively on the map within the portal. But in contrast to ORS, these are being saved to a spatial database for further use by the users of the portal. It is also possible to attach attributes, e.g. in order to specify the grade of the obstacle in order to be able to handle different types of vehicles and different – even temporary – conditions of the roads. For example a non-paved road may become muddy after heavy rain and may only be accessible by All-Wheel Drives of a certain type. Another example is that even after flooding some specialized vehicles may still be able to pass the road if the flooding does not exceed a certain height. This means that it is necessary to be able to add further metadata attributes to the „AvoidAreas“ and specific combinations of those need to be considered for different types of vehicles from bikes to heavy trucks with/without trailers when routing (figure 4).

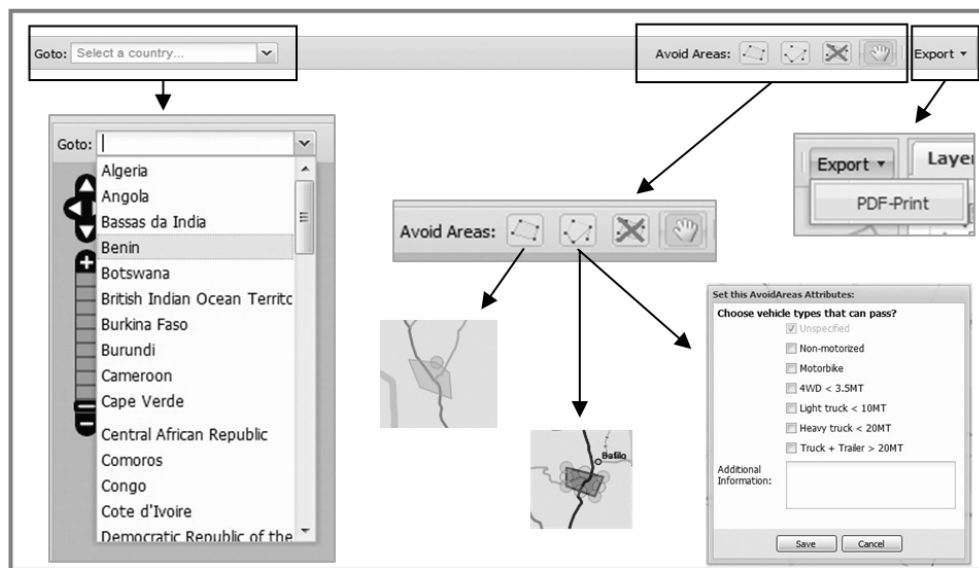


Fig. 3: Some major **functionality** in the UN WFP Geoportal for Africa

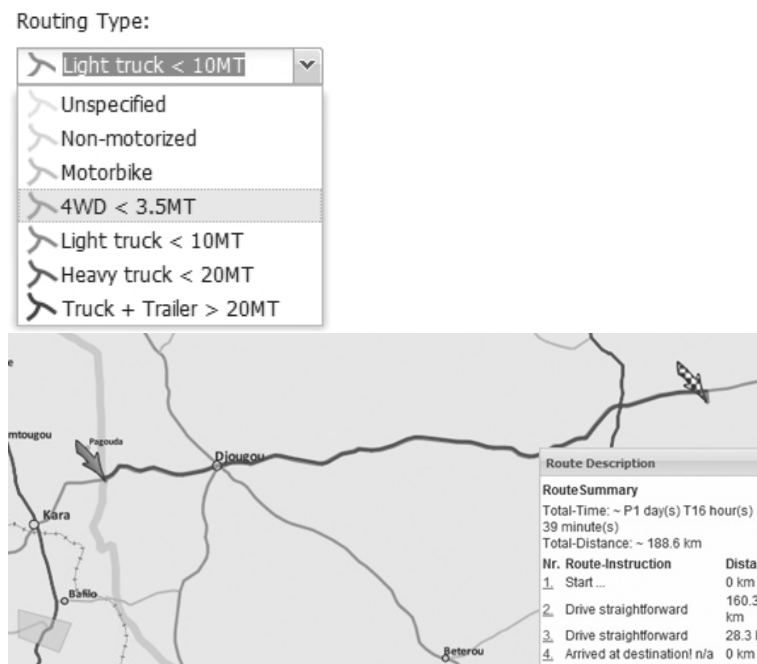


Fig. 4: Emergency Route Service for Africa in the WFP Geoportal based on UN SDI-T data.

2 The Haiti Case: From Hurricane IKE to the Earthquake 2010

The first real application of the new Emergency Route Service was not happening in Africa though. Oddly enough an earthquake hit Haiti in January 2010. Only two days after the Haiti earthquake the team of the Chair of GIScience of the University of Heidelberg published a new Emergency Route Service. This version is online at <http://openls.geog.uni-heidelberg.de/osm-haiti/>. This service uses the free geodata of OpenStreetMap. The Route service is updated every hour in order to reflect the OSM community's great effort to map Haiti as fast as possible. In only a few days the data mapped through a collaborative effort of the OSM community and helpers worldwide has grown by a magnitude. This was possible because a set of recent satellite and aerial images were provided for digitizing the infrastructure and current situation.

Already during the Hurricane IKE disaster an online emergency route planner had been realized (SCHMITZ et al 2009). This was initiated by a request by the UN Logistics Cell that later lead to the development of the UN Africa routing portal. In 2008 OSM was not yet that well known and the data was still very sparse, in particular in less developed countries such as Haiti. Therefore additional data sources for the street network were needed. After some days a quite rough street network was found that was usable for routing between the towns. It did not provide much detailed information about the street network within the cities, though. This means the main difference between the Hurricane Ike version and the Earthquake 2010 version was the data set used. As in the case of the earthquake 2010 OpenStreetMap was used; it was also possible to publish the portal publicly for everybody interested. This was not possible in the Hurricane Ike version due to data license restrictions. This meant that only selected organizations had access to that version. Another difference was related to the functionality offered. In 2010 this functionality was even much more reduced compared to the Hurricane Ike version. The Hurricane Ike version included for example some special functionality for uploading and storing shape-files with already digitized AvoidAreas that should be considered when routing. Additional services such as the Accessibility Analysis Service (AAS) were available that allowed to calculate isochrones based on the street network from a selected location (NEIS & ZIPF 2007). Due to the quite sparse data set this was not really very useful in 2008. In 2010 we did not have the resources to add this service again. In order to increase the usability for non-expert users the web interface and functionally offered remained as simple as possible.

The choice to use OpenStreetMap was based on our experience with OpenRouteService and the speed of the growth of the OpenStreetMap data in general. Also quality assessments of OSM data have been conducted (ZIELSTRA & ZIPF 2010). Already one day after the earthquake it became clear to us that the OSM community would become very active and that there would be a substantial free geodata set in a short time. This meant we did not reactivate the old version from hurricane Ike, but Pascal Neis installed and extended a completely new version based on OpenStreetMap. Next to some efforts to adapt the user interface, the main task was automating the data update process for the route service. This was necessary in order to keep up to date with the fast growing OSM data set. Fortunately the colleagues from Geofabrik Karlsruhe (F. Ramm) provided a very frequent OSM data extract for download, which was more comfortable for handling and sped up the development process as it freed us from caring for this task as well.

The success of the collaborative mapping effort would not have been possible without the institutions owning satellite images providing these images to the public and humanitarian organisations and further giving allowance to use these images for deriving data for OpenStreetMap. The typical way how OSM data is being generated is that volunteers map the area with GPS by walking, biking or driving through the area. This was of course not possible in the Haiti case. Here almost all of the data was derived from satellite images. These are typically not available in other regions for this purpose because of the open licence of the derived vector data, which is not compatible with the licence of the image data. But in case of disasters, individual and relevant images were released to the public and explicit allowance was given to use those images for the purpose of digitizing data for OSM from them. Figures 5 and 6 illustrate the achieved results.

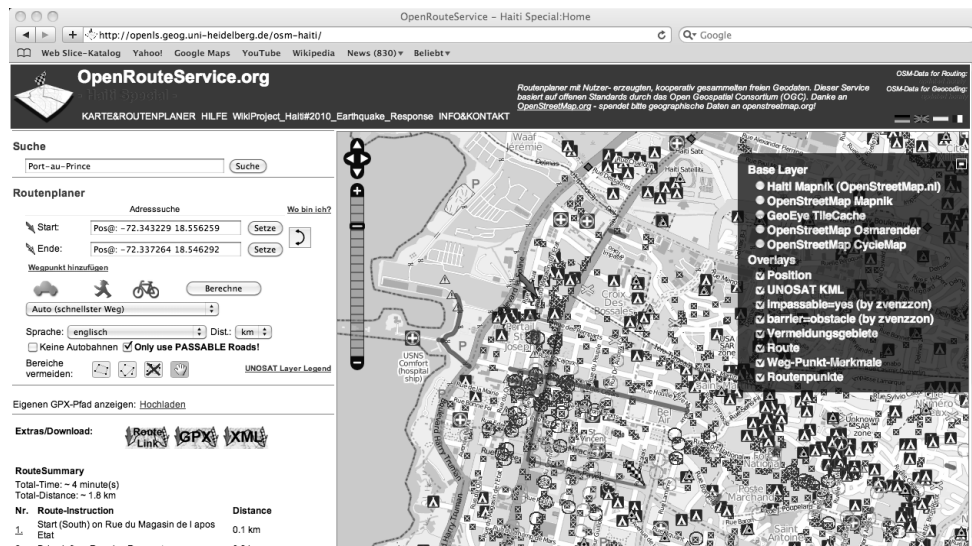


Fig. 5: Web User Interface of OpenRouteService for Haiti and Dominican Republic (the map shows Port-au-Prince with mapped **refugee camps**, **destroyed houses** etc.)

One of the activists within the OSM community who initiated the OSM disaster relief effort was Mikel Maron. He sent a mail to the OSM mailing list asking for support for Haiti already on January 12, 2010 and also spread the news on January 14 that the data provider GeoEye has allowed to use their images for mapping for OSM. This was done on Twitter (<https://twitter.com/mikel/status/7755676201>) – quite typical for the use of new social media and web 2.0 technology for coordinating communities of volunteers. This is in particular true for the case of disasters, where these media often provide relevant information much earlier than the more conventional sources of news and information. The same day another provider – DigitalGlobe – opened their images for OSM mappers. This meant that there were several high-resolution images available as data sources for OSM only after two days and the list of further sources grew continuously – including post-disaster images that allowed mapping the extent of the disaster.

Cmp. http://wiki.openstreetmap.org/wiki/WikiProject_Haiti/Imagery_and_data_sources.

The growth of the OSM data set can be visualized using some maps of the capital Port-Au-Prince before the earthquake, two days after the earthquake and how it looks now (fig. 7).

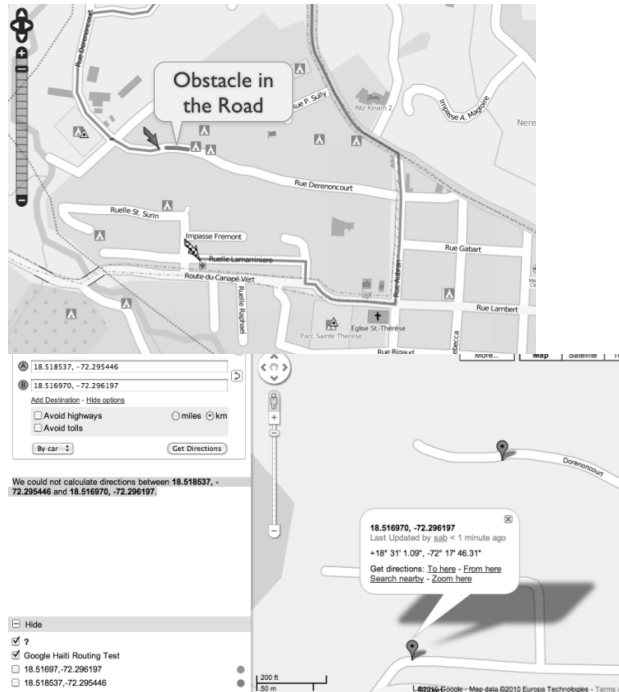


Fig. 6: Result of Routing in Haiti after the earthquake in OpenRouteService (left) ORS supports obstacles and Google (right) (routing failed). (In 2008 after Hurricane Ike Google did not support routing in Haiti at all.)



Fig. 7: Maps from OSM data showing the capital Port-Au-Prince before the earthquake, two days after the earthquake, and what it looks like now

Additionally the data became richer through a set of data donations from different sources. This includes maps of destroyed houses from disaster management organisations or data on health infrastructure. A list of data imports can be found here: http://wiki.openstreetmap.org/wiki/WikiProject_Haiti/VectorAndMapData. The following graphs show the increase in the number of places for geocoding as well as route segments within one week after the earthquake (figure 8).

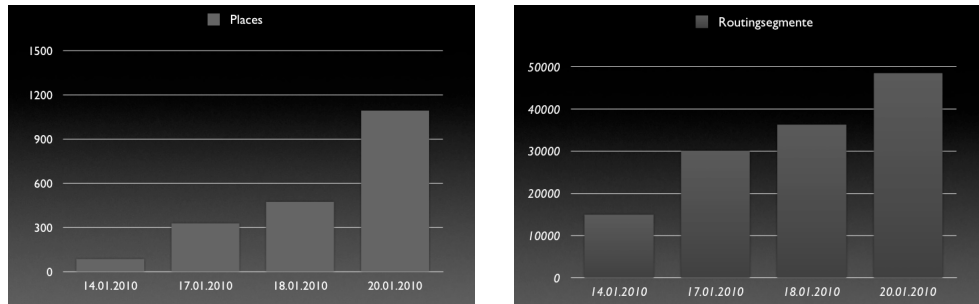


Fig. 8: Increase of OSM data in Haiti after the earthquake
<http://www.slideshare.net/jokru/crisismapping-in>

3 An OSM Tagging Scheme for Humanitarian Actions?

Mapping geometry is obviously not enough. Geodata needs attributes in order to be usable in application in a sensible way. For example in the case of routing applications different street types are needed or attributes describing what types of vehicles can drive on that particular street. We have seen this already in the Africa Geoportal and the UN SDI-T provides an elaborate data schema for this purpose. The goal is to standardize that schema for the UN worldwide in order to increase the interoperability of the data within the UN institutions and other humanitarian organisations. But OSM, on the other hand, did not provide such a standardized schema for attributes related to disasters. In contrast, they use an open list of “tags” that describe attributes. During the mapping effort it became clear that additional tags were needed and mappers started discussing those. Fortunately also people that were aware of the UN SDI-T schema were among the discussants and fed in their experience with such issues. The Humanitarian OSM Team (H.O.T.) needs to be mentioned here in particular: http://wiki.openstreetmap.org/wiki/Humanitarian_OSM_Team. As a result a range of new OSM tags were introduced for adding information on a wide range of topics related to disasters. A respective proposal can be found here: http://wiki.openstreetmap.org/wiki/Humanitarian_OSM_Tags/Humanitarian_Data_Model.

Some examples are shown below. Also here the OSM principle of using the simplest approach has been followed. People do only map what they do understand and what does not mean too much overhead. This avoids sophisticated but overly complex data schemes, as these do not work in crowdsourcing with volunteers. These new tags allowed generating specialized maps (e.g. <http://haiti.openstreetmap.nl>) and applications. In particular Open-RouteService Haiti has been extended to support the tag „impassable“ after it was introduced and used by mappers for Haiti. This allowed introducing a new option in addition to

the already mentioned AvoidAreas. This even could be seen as a replacement for the option to save the digitized AvoidAreas (as in the case of the Africa Geoportal or ORS Haiti IKE 2008). Now OSM itself could be the database for this kind of information. But this needs further discussion as it is currently unclear how to handle dynamic situations where attributes change fast and frequently. In the Haiti earthquake case this was easily solved as only the latest version was of interest and the data was updated so frequently. But this is not a general solution. Of course proposals exist, but the question again is, which one is simple enough to work for a Web2.0 community of volunteers.

Examples of relevant tags:

earthquake:damage: collapsed_building ; earthquake:damage: spontaneous_camp;

earthquake:damage: damaged_infrastructure earthquake:damage: landslide

tourism: camp_site ; refugee: yes

Way Finding & Routing: impassable: yes

4 Conclusions

Volunteered information being collected by non-professionals and distributed through social media and Web 2.0 technology has been realized as a new source of information, in particular in the case of disasters. This is also true for geodata as the OpenStreetMap case shows. The Haiti disaster is only the most prominent example for that. This means that this kind of data collection and data source or even technical data infrastructure become an alternative to classical spatial data infrastructures. This leads to the need to discuss how these worlds can be integrated so that we get the best of both: actuality, richness and openness on the one hand, and reliability and semantic structure on the other. Through the experiences with Haiti we see that both players move towards each other and try to work on a solution. Future work will include discussions how to set up future infrastructures and applications for supporting disaster management (such as an emergency routing portal) that can make the best of all relevant data sources. In particular in the field relief workers just need data that works with their equipment – and that is actually true also for OSM, that has been provided in different download formats, e.g. also for use in GPS devices. E.g. a photo showing the Fairfax County Urban Search & Rescue Team using OSM on their GPS devices in Haiti on 22.01.2010 can be found at

http://1.bp.blogspot.com/_GxwMnMY7RgE/S3U_5wBOMSI/AAAAAAAAE8w/ileiANeg1YE/s1600-h/OpenStreetMap_on_a_Garmin_in_Haiti.JPG.

This is gratitude for all mappers that contribute to the project.

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