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Assets mapping products in support of preparedness and prevention measures (examples from Germany, Italy and France)

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Extended Abstract:

Introduction

The development of assets mapping services and products has quite a history in Europe's Copernicus programme (called GMES until December 2012 [Global Monitoring for Environment and Security]). In pursuit of a coordinated continuation of this groundwork, the work in IncREO (Increasing Resilience through Earth Observation, running from 01/2013-12/2014) is following up developments made in the thematic services domain of the SAFER project (Services and Applications for Emergency Response; 01/2009-03/2012) – focussing now on further development and refinement. This latter objective is achieved by the technical implementation of the concepts for HiRAM (High-Resolution Assets Map) and AM+ (Assets Map Plus). By providing assets mapping solutions suited for the regional and local scales, HiRAM and AM+ differentiate from the already pre-IncREO well-advanced solution at country level (e.g. BEAM product; Basic European Assets Map) which is meant to complete an assets mapping portfolio covering different end user needs in terms of scale and level of accuracy. These needs have been derived from numerous consultations with stakeholders from the disaster management and civil protection domains being in charge of preparedness and prevention measures. For example, all assets mapping products are suited to support the (potential / actual) estimation of material damage, affected population and the planning of evacuation measures in case of a natural disaster. In this context the test areas chosen in IncREO are Dresden (Germany), Alpago communities (Veneto, Italy) and La Rochelle (France). The related natural disaster is flood concerning Dresden (Elbe River) and La Rochelle (Atlantic). Alpago in Italy is a multi-hazard site which is in addition to flood also prone to earthquake, landslide and avalanches. As to the map content the HiRAM product shows monetary values in EUR related to the "residential buildings" assets per inhabited building. In combination with disaster extent information as for example an area's susceptibilities to landslides and avalanches the HiRAM product supports the estimation of potential and / or actual damage of inhabited buildings in case of a disaster occurring. The HiRAM production is based on a set of layers related to building footprint, land cover, network information (road, water) and selected so-called elements at risk. The "residential building asset" information can sometimes be obtained from official statistics and cadastral data for the building typology, for example. A way of determining the number of a building's storeys is the use of a tri-stereo data-based Digital Elevation Model. In contrast, the AM+ shows the number of inhabitants per "asset" (here the building volume) and – as a result of a routing analysis performed additionally – an indication about the traffic hold-up to be expected in case of evacuation for the occurrence of a natural disaster. For this routing

analysis the underlying assumption is the number of cars per road segment in the area affected by a landslide for example.

Starting point

The relationship between the three mentioned assets mapping products is given in Figure 1. From bottom to top the level of detail per product increases whereas from top to bottom the transferability of the product to another area decreases. These constraints have been tackled in the frame of IncREO. Furthermore, especially for the products HiRAM and AM+ the topics of "elements at risk" (critical infrastructure), potential economic damage and "population to be evacuated" in case of natural disasters have become subjects of the final map products.

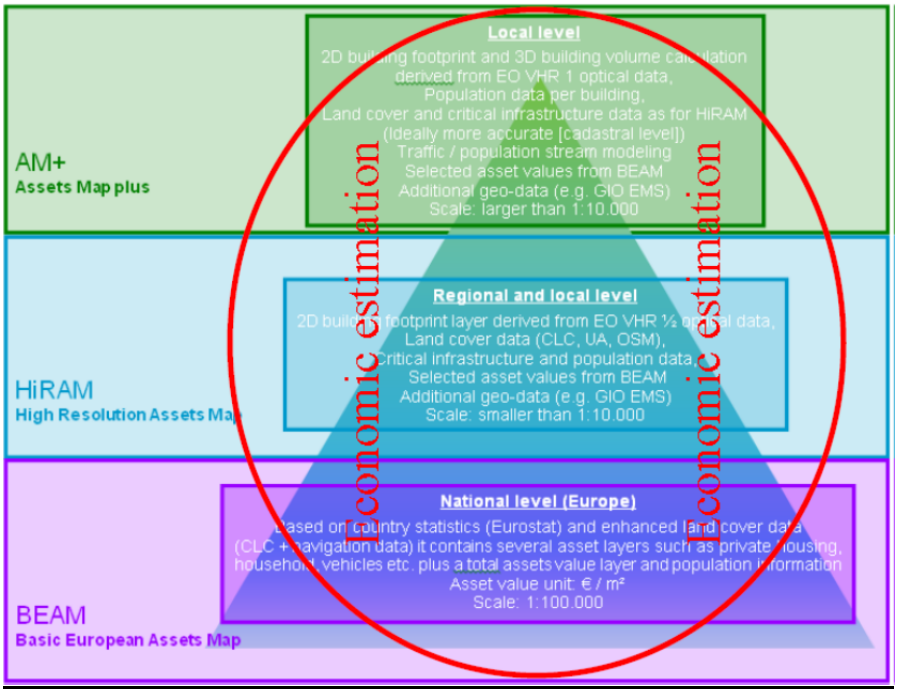

Figure 1: Assets mapping pyramid as created in SAFER and further developed in IncREO.

Data

From a global point of view, the products HiRAM and AM+ refer to the same type of information, providing for a given area key information such as population and economic figures as well as information about inhabited buildings. Obviously, the AM+ product, being based on VHR1[1] EO[2] data (i.e. a resolution better 1m) leads to a more detailed product.

The HiRAM product is a "layer stack" of various sources available at medium scale. It provides mainly information about land use, residential building assets, transportation infrastructures and elements at risk. According to the use cases drawn up, the data used are as follows:

- Background: CORINE Land Cover 2006 data[3] for Alpago, Italy and La Rochelle, France and Urban Atlas data[4] for Dresden, Germany, respectively

[1] Very High Resolution
[2] Earth Observation
[3] http://sia.eionet.europa.eu/CLC2006
[4] http://www.eea.europa.eu/data-and-maps/data/urban-atlas

- Building footprints: Derived from OpenStreetMap[5] or other available databases such as the database compiled in the framework of the CHANGES project[6] for the use case Alpago or the BD TOPO database[7] for the use case of La Rochelle.
- Assets values: The already available assets values from the BEAM product[8] such as private housing assets in EUR per sq. m have been used to calculate the monetary value per inhabited building proportionally to the 2D/3D footprint area of the building and with reference to the total value from the corresponding BEAM polygon. Where more accurate house prices from other databases are available, these figures have been used instead.
- Disaster extent: The spatial extent information has been taken either from other sources (CHANGES database for Alpago) or delineated manually using satellite imagery (Dresden) or simulated (Rochelle)
- Population figures: Adopted from official sources such as Insee[9] for La Rochelle

The AM+ product is a layer stack of more or less the same type of information but usually available at a larger scale than for the HiRAM product, displaying thus a more accurate background and a more accurate representation of the population's distribution. This degree of higher accuracy is mainly achieved by the use of a Data Surface Model (DSM; here derived from tri-stereo Pleiades satellite imagery) in combination with a recent satellite building-derived building footprint of this area. This combination allows for a better estimation of inhabitants per residential building. Optionally and depending on the spatial extent of the natural disaster, a routing analysis can be performed as well. This routing analysis is applied to identify the areas to be evacuated first for the chosen disaster scenario.

Material and Method

Provided that the user required data are available, the HiRAM production is – to put it simply – rather the result of clever GIS operations until the users' requirements are met. Such a product example is given in Figure 2 where the HiRAM product has been combined with the flood extent as observed on 5 June 2013 in the district of Cossebaude in Dresden, Germany.

[5] http://www.openstreetmap.org/#map=5/51.500/-0.100
[6] https://horatius.irpi.pd.cnr.it/changes/
[7] http://professionnels.ign.fr/bdtopo
[8] Basic European Assets Map © geomer/Airbus DS Geo (Infoterra GmbH)
[9] www.insee.fr

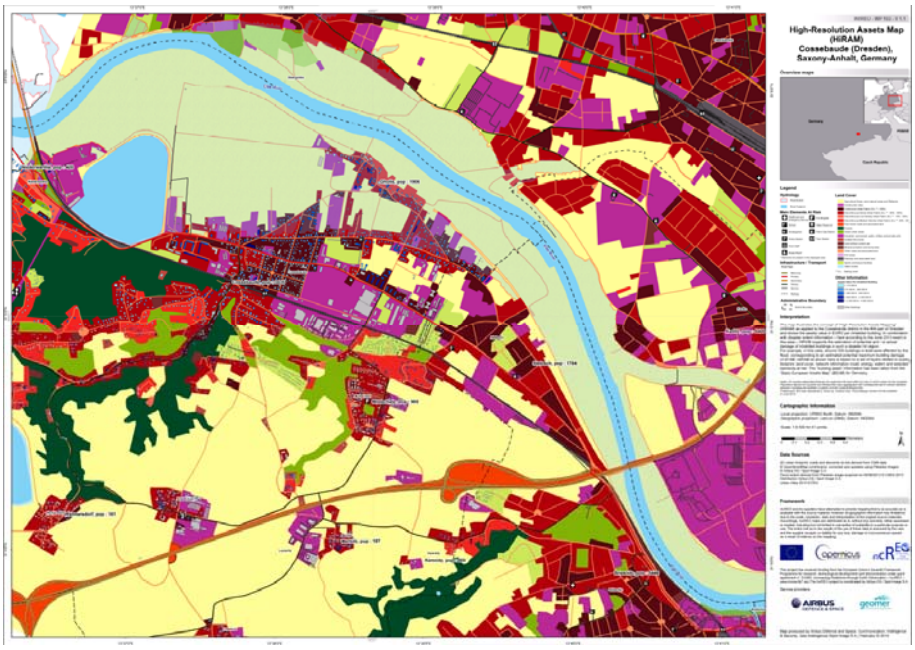

Figure 2: HiRAM product Dresden, Germany.

A bit more sophisticated is the production of the AM+ where the focus is put on in the following sections.

The AM+ product is meant to provide more detailed information about the population distribution in a disaster-prone or a disaster-affected region. For its creation the main idea followed is that the population of residential buildings is proportional to the building volume. Depending on the area of study population functions have to be parameterized and adjusted since the population dynamics are not the same in mountainous, rural or urban areas. Of course, census data can be implemented (if available) but sometimes it can get a quite time-consuming exercise to obtain these data from local sources. Technically, the former mentioned DSM and building footprint are used to derive the building volume which is then weighted using an average height per storey. In case building height information is already available and accessible – as for instance via BD TOPO data for La Rochelle in France – the building volume is directly taken from the source data.

The “routing analysis” is another feature of the AM+ product and is running on ArcGIS © ESRI and is based on functions consolidated in a processing chain designed using the ModelBuilder. The processing chain also requires the Network Analyst extension to work properly. In view of offering a solution without software constraints, the workflow has also been designed to be executed using public domain GIS software.

The basic idea of the routing analysis is to estimate the number of cars required to estimate the population of the area of interest to safe spots in case of a disaster. Assuming the disaster extent is known (historical/recent events, local knowledge, simulation) it is then possible to determine which residential buildings’ population is to be evacuated first to designated safe spots. The result of the routing analysis is a layer providing the estimated total amount of cars per road segment in case of evacuation (Figure 3) with the number of cars directly related to the population living in the buildings affected by the disaster.

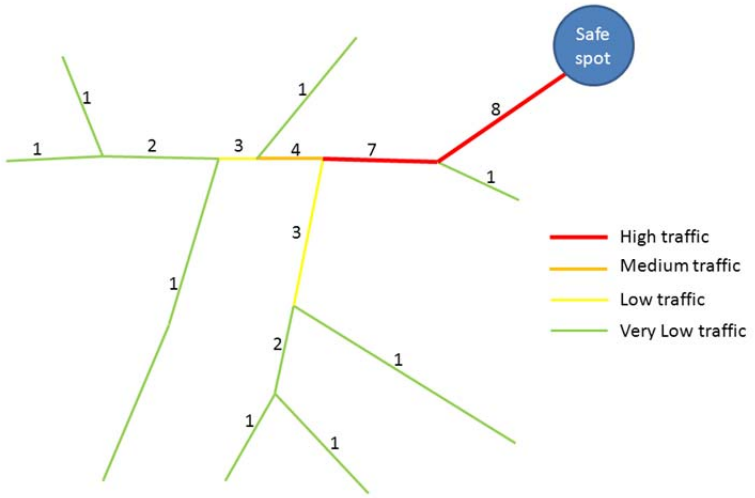

Figure 3: Output layer from the routing analysis. For each road segment the total number of car is estimated to determine the traffic intensity.

An overview of the whole workflow including software used for the AM+ production is given in Figure 4. The process of map production is for the time being automated as much as possible using a common map template within the IncREO project. A potential further development could be to fully integrate selected ArcGIS capabilities allowing for a completely automated atlas creation and generation of multiple maps on demand, respectively.

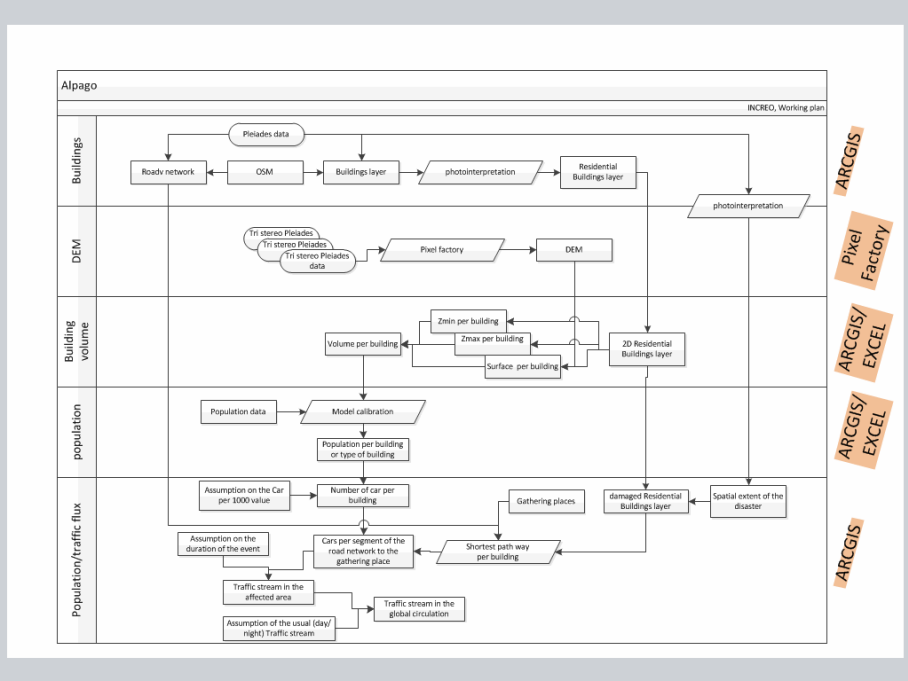

Figure 4: Workflow and software used for the production of AM+. Using the building footprint (Building) and the terrain information (DEM), the volume of the residential buildings is calculated (Building volume). Population census data (if available) is then used to calibrate the model. The routing analysis is performed as a last step (Population/traffic flux).

Results

The HiRAM and AM+ products for the Alpago region, for example, have been validated by the users during a workshop (WS) held in October 2014 (Fig. 5). During this event it had

been presented how the feedback and recommendations received during the first WS in May 2014 had been implemented. Users approved the update done and acknowledged that the products delivered to them provide a valuable support for their daily routines concerning disaster prevention and preparedness.

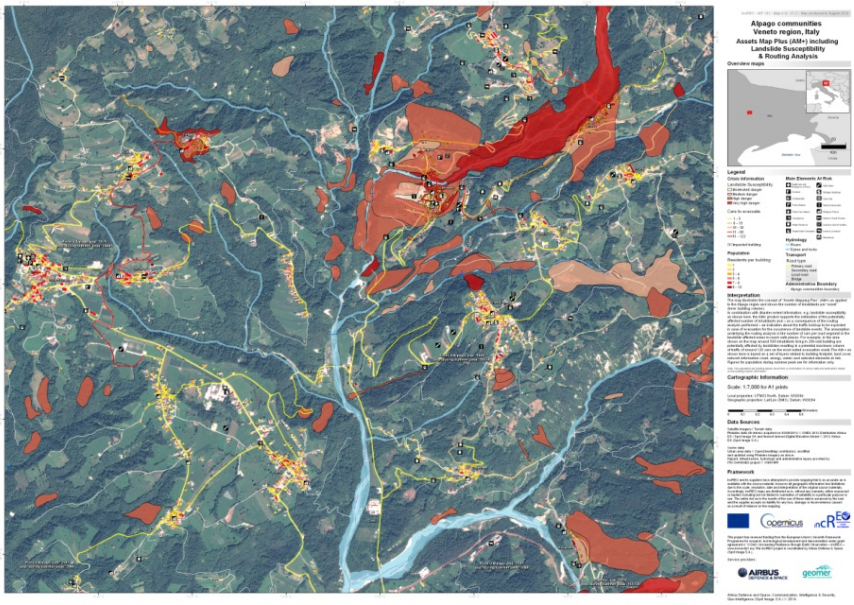

Figure 5: The AM + prototype product as validated by the Alpago region users in October 2014.

The validation of the HiRAM and AM+ products of La Rochelle as delivered to the French Civil Protection in October 2014 is still pending. This is expected to be completed soon and will be announced accordingly on the project's website at www.increo-fp7.eu. The products referred to above (and others) are already available for download in pdf and tif/jpg formats in the project's "Products" section (http://www.increo-fp7.eu/products/).