Participatory Map Services Using Advanced Modelling

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SUMMARY

GIS Technology is ever advancing and is increasingly embedded in human society. Maps or map services are no longer the sole domain of GIS experts or a GIS department. Geospatial information is becoming the blood that flows through organisations and human society, enhancing data interoperability and communication between the various stake holders. Roles vary from actor to actor, and can include precise positioning, updating tabular states of geospatial objects, designing domain infrastructure and gaining insight in decision making processes. With crowd sourcing and volunteered geospatial information the era of participatory mapping has slowly emerged.

With a wide range of new GIS technologies available the sky seems to be the limit. However, there exist a downside as well: the rapid appearance of a new technology may make recently embedded technology obsolete. As financial resources are limited embracing progress can therefore be challenging. Organisations may become conservative in embedding new GIS technologies.

Modelling geospatial information processes may help organisations in their continuous struggle for progress in GIS technology. Although modelling geospatial information processes is not new, the GIS technology has developed gradually in the last years, making its scope to provide GIS solutions significantly wider. Information flows can be easily adjusted and the batch processing of geospatial information may provide for affordable GIS solutions. Advanced models may become the backbone of GIS Technology in organisations.

Moreover, additional information can easily be generated using advanced modelling of geospatial information processing on already existing geospatial datasets. Using catalogued measures new maps can be generated that I call regulation driven maps. Regulation driven maps can play an important role in providing information to, for example, stake holders that need insight in their situation.

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1. REGULATIVE MEASURES

For water management authorities governance and control can be a time consuming task. Take for instance berth governance and control. Several information sources might need to be consulted before a berth permit may be granted or extended. A minimum water depth profile for certain waterways might need to be maintained. Or a boat class dependent minimum sight distance might need to be respected. Both aspects need to be considered in order to prevent dangerous situations.

These aspects, quantified as regulative measures, can be found in catalogues and other kinds of reference material. Here *Rijkswaterstaat* (2011) has been used. Although these catalogued measures are available, a desired overview of the to be investigated area is not automatically obtained, resulting in a large investigation time.

Table 1 shows an example of catalogued measures. Here the minimum depth and width of a certain waterway class, here known as the CEMT class[1], for a fully loaded boat configuration is given.

Figure 1 shows an example of several merged catalogued measures that have been visualized as a minimum water depth profile. Although insightful, there is no direct relation with the area of interest. No direct relation with a berth position can be established.

The direct relation can be obtained by reproducing and mapping the catalogued measures. Additionally any desires and requirements of water management authorities can be taken into account as well. The resulting regulation driven maps give the desired insight of the to be investigated area.

Table 1 Minimum depth and width of waterway CEMT classes for a fully loaded standard boat configuration.

CEMT Class	Minimum Depth [m]	Minimum Width [m]
I	3.1	10.2
II	3.5	13.2
III	3.5	16.4
IV	3.9	19.0
Va	4.9	22.8
Vb	5.6	22.8

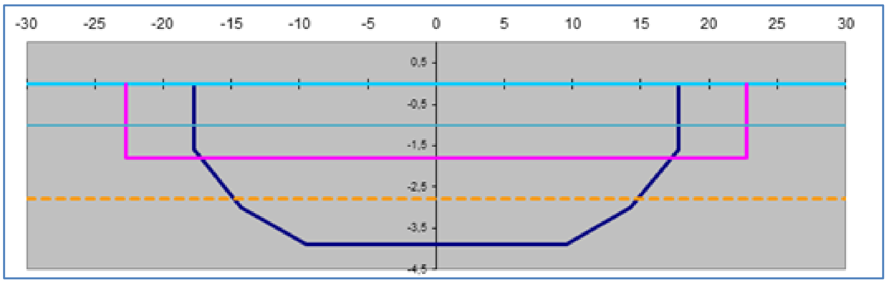

Figure 1 An example of a minimum water depth profile for a certain CEMT class. The different colours indicate different water depth requirements and guidelines.

2. THE ASSIGNMENT FOR MAPPING CATALOGUED MEASURES

For the mapping of regulative measures a water management authority in the Netherlands* issued several requirements and desires. Without going into full detail of the desired maps, the most important were these:

(1) results need to be reproducible;

(2) the tools need to be based on existing GIS layers;

(3) a low threshold in user knowledge and user experience is desired;

(4) the tools need to be adaptable as future modifications are foreseen;

(5) Resulting maps need to be accessible to the water management community.

3. REGULATION DRIVEN MAPS USING ADVANCED MODELS

The need to reproduce the results, i.e. specification (1), demands for an automatic or semi-automatic solution. Although a to be written algorithm would meet this specification, there exist other solutions as well that do not imply the writing of computer code, and that could satisfy specification (3) and (4) as well: Extract-Transform-Load (ETL) software has evolved from a pure format conversion tool to a tool in which advanced GIS models can be developed.

Unlike computer code, that needs programming skills and that is sensitive to syntax errors, the building stones of advanced models are already pre-programmed. Although for developing advanced models advanced levels of expertise are required as well, the building stones for the models itself are comprehensible for the non-experienced user. Models are therefore easier to share or to adjust.

* Due to legal restrictions the water management authority will remain anonymous.

Specification (2) can be met by simply making use of the GIS layers available. In order to be able to reproduce similar results the essential GIS layers are stated in the examples that will soon be discussed.

Specification (5) has been almost automatically met by disclosing the GIS layers to a central database and a visualization platform. By running the models according to a certain frequency, e.g. once in the month, maps are automatically updated such that resulting maps are always up-to-date. Using smart phone technology and cloud solutions the maps can be reviewed in the field as well. User profiling can improve data interoperability and communication even further.

A thorough discussion about user profiles is beyond the scope of this paper, but it is sufficient to imagine that resulting GIS layers can be implemented in organizations, and society, using the concept of user profiling. Experience from best practices indicate that in general two types of profiles need to be considered: profiles that associate with viewing rights and profiles that associate with editing rights. To prevent overloading the user with undesired information, as a rule of the thumb, the amount of viewable information needs to be minimized to the need of the user profile. For editing rights GIS experience, and eventually GIS user guidance, need to be taken into account.

4. GENERATING MINIMUM WATER DEPTH PROFILES

The following GIS layers had been essential in order to generate minimum water depth profiles: waterway axes from which a water depth profile can be computed, (potential) berth polygons, and the boundary of the area of interest.

The waterway axes and the berth polygons contain CEMT class parameters to obtain the catalogued measures. These layers, and the area of interest, are the foundations to reproduce the minimum water depth profiles. A depth resolution needed to be introduced too in order to keep the number of resulting depth layers limited.

In order to create water depth profiles, similar like the one in Figure 1, the concept of iterative buffering has been used. The number of buffers working on the waterway axes depend on the depth resolution, while the buffer amount depends on the corresponding CEMT class and the local steepness of the considered waterway profile. Additionally resulting buffers receive an attribute value equal to the corresponding water depth.

Except for the minimum water depth profiles along the waterway axes the berth need to be reachable as well. From requirements of the Water Management authority lanes for arriving and departing berths have been introduced as well. Corresponding to the berth type and the CEMT class lanes with corresponding water depth values have been added.

To acquire the minimum water depth solution the depth layers have been first superimposed on each other by copying any boundaries of overlaying polygons. This process results into a partitioning of the polygons while the water depth values are maintained. Polygons on top of each other will next be candidates to a selection process. By simply selecting the polygon with the deepest water depth value the minimum requirements in water depth will be met: only one planar filled layer remains. The minimum water depth profiles are finalized by clipping the remaining depth layers to the boundaries of the area of interest.

During the development of the model technical challenges occurred that were caused by the limits of the available computation power. The best depth resolution possible was by experience 5 cm for a relative smaller area of interest, and 10 cm for the whole governing area of the water management authority. In order to keep the amount of equations down the superimposing of water depth layers has been done in two steps. First the depth layers were grouped and superimposed on each other according to smaller areas of interest. After intermediate removal of any redundant water depth layers in a next phase all the remaining depth layers were superimposed on each other.

Figure 2 shows an area of resulting minimum water depth profile.

Notice that the minimum water depth profile can be compared to the real water depth using bathymetric data, resulting in water depth differences. By converting the GIS layer to a raster image and snapping the resulting raster image on the bathymetric raster image the difference can simply be computed by subtracting the values.

Figure 3 shows resulting water depth differences.

5. GENERATING LINES OF MINIMUM SIGHT

To generate lines of minimum sight only one GIS layer has been essential: the layer containing the waterway axes. This layer contains again the CEMT class parameters to obtain the catalogued measures for minimum sight.

In order to generate lines of minimum sight every 5 meters along the waterway axes a point has been created and extracted. From these points circular polygons can be created with a radius equal to the minimum sight.

By using the intersections of the edge of these circles with the waterway newly secondary coordinates can be extracted. Adding these coordinates to the coordinates we already had result into the desired lines of minimum sight.

Notice that in this scenario one-to-many relations occur. In general two intersections can be made: ahead of the center of the circle and behind the center of the circle. Only branches and boundary conditions may alter these one-to-many relations.

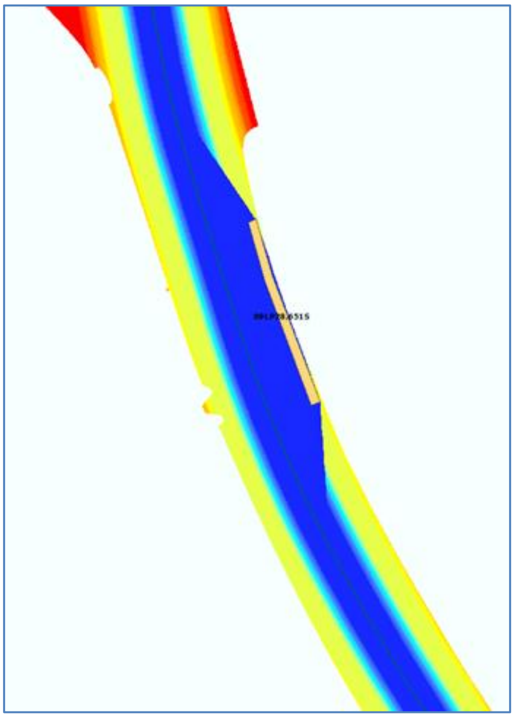

Figure 2 An example of mapped minimum water depth levels using catalogued measures. On the image the position of a berth and the water axis are visualized as well. Red shows a low minimum depth requirement, while blue shows a high minimum depth requirement. Notice that the lanes for the berth have discontinued the water depth profile locally.

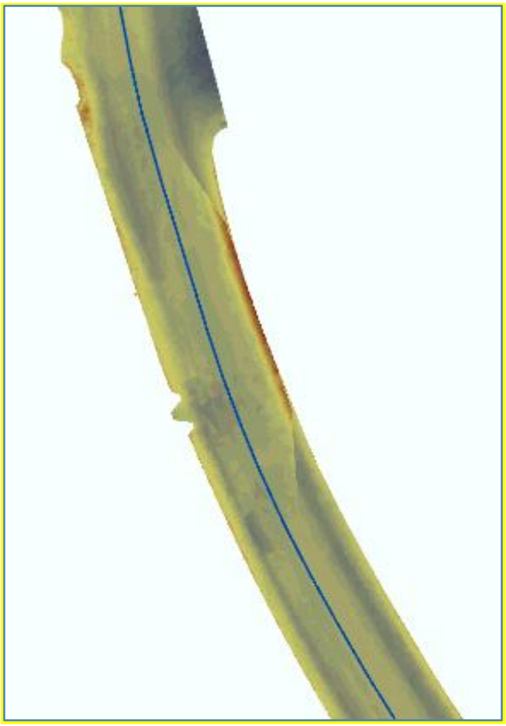

Figure 3 An example of water depth differences using catalogued measures. The different colours indicate different water depths differences. Red shows shortage and blue shows surplus in meeting the minimum water depth requirement.

From my dataset about 70000 lines of minimum sight could be generated in about two hours. As the number of lines are high and therefore heavy to load, it might be better to form polygons from the lines using the concepts of dilation and erosion[2]. By using a positive buffer, a dissolver and an equal but negative buffer, setting the buffer to an appropriate measure, 70000 lines could be transformed to only two major polygons.

Figure 4 shows a waterway and the waterway axis in blue and the areas of minimum sight in transparent purple on a background a composition of photogrammetric images. It can clearly be seen that the areas of minimum sight cross land that might contain objects to obstruct the view.

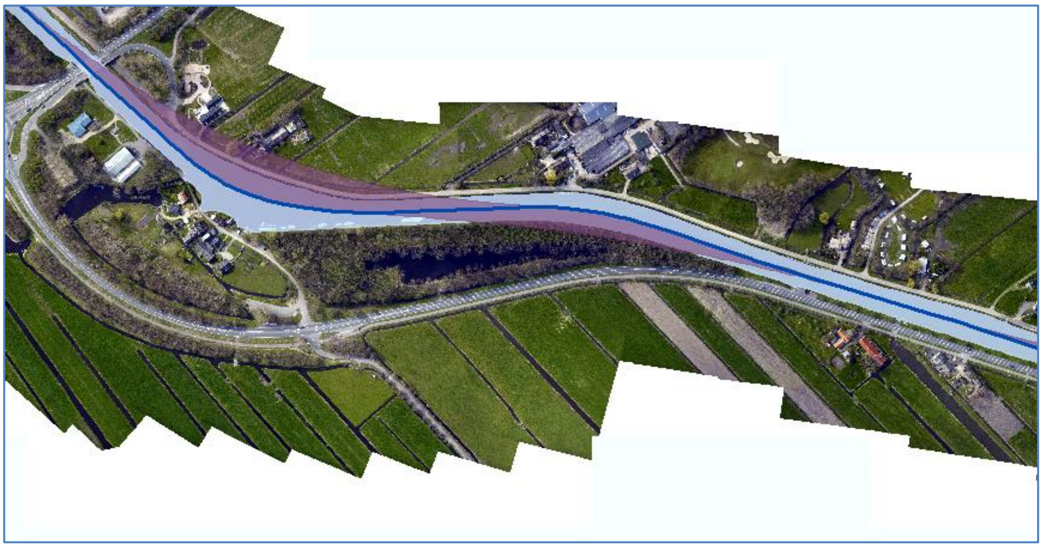

Figure 4 An example of areas of minimum sight. The waterway and waterway axis are shown and the areas of minimum sight are shown in a transparent purple. On the background a composition of aerial imagery is shown. It can clearly be seen that areas of minimum sight cross land that might contain objects to obstruct the view.

LOGICAL AND AUTOMATIC OBJECT CODING

The following GIS layers had been essential in order to generate minimum water depth profiles: waterway axes and 100-meter signs.

In order to code waterway objects such as mooring poles and bank constructions along the waterways, the position along the one-dimensional waterway axes can be used. In order to follow International standards concepts of the River Information Services[4] have been studied.

First the 100-meter signs, signs that indicate the distance along the waterway trajectories, are projected to the one-dimensional waterway axis. By transferring the trajectory code, the distance and the port or starboard position of the object with respect to the corresponding waterway axis, using the nearest neighbor principle, any object can be logically and automatically coded. In this case also acronyms have been introduced to further differentiate between the various object types.

A position slot for every 100 meters may not provide sufficient space for all the objects. By adding more position slots, introducing points every meter or any other reasonable measure, more position slots become available such that every object can be uniquely identified according to its position, port or starboard position and trajectory code.

About 23000 objects could be logically and automatically coded in 11 minutes.

6. CONCLUSIONS

Catalogued measures, found in all kinds of reference material, in conjunction with existing GIS layers, can be used to provide useful information that might shorten investigation time. Using the requirements and desires of a Water Management Authority advanced modelling has been successfully applied. The resulting regulation driven maps have been shared to a Water Management community.

Examples have shown that minimum water depth profiles, lines/areas of minimum sight and automatic object coding can be successfully generated. While ETL software in the past has mainly been used to convert data formats, the examples show that features like iterative buffering, minimization problems, one-to-many relations, concepts like erosion and dilation and automatic object coding can be well handled in the software.

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BIOGRAPHICAL NOTES

Jochgem Gunneman mastered his engineering degree in the field of Earth Observation in 2010 at the Delft University of Technology, the Netherlands. During his study he gained a solid background in mathematical modelling. His Thesis studied estimation and quality aspects in satellite radar remote sensing.

After his study he started working for the Dutch Cadaster where he became a Team Leader of a quality control unit. In the project historical boundaries were revealed and disclosed into GIS files for the purpose of shortening the investigation time in legal issues.

Next, as a Specialist in Geomatics at NEO, a Dutch company, he learned more about the acquisition of mutation signals using aerial imagery and automatic quality control using ETL software.

For the Province of South Holland he worked as a Specialist in GIS and Geomatics. He worked on several projects. Projects for making inventories of waterway objects using panorama imagery, geo-tagging of legal documents and restructuring tabular states of waterway banks based on the informational need of several departments were amongst them.

In June 2014 he started his own company: Gunneman GIS & Geomatics. The company is involved in the development of advanced models using ETL software and projects related to participatory map services. Some of the work of the company is presented here in this paper.

Future developments involve a business study in providing low cost and high quality (manual) GIS production services. By outsourcing both GIS production and quality control to separate parties production costs could in theory be further reduced.

Jochgem Gunneman is a member of the Dutch association *Geo-Informatie Nederland*, a member of the Dutch platform for freelancers and entrepreneurs in the *Ruimteschepper* and a member of the *FIG Young Surveyors Network*. He has been moderating a session for the Dutch network for Young Surveyors *Jong Geo* during a National fair and has contributed in the organization of the FIG Young Surveyors' event in Bulgaria.

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