IMPROVEMENTS OF 1D RIVER MATHEMATICAL MODELLING USING RIVER DATABASE

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***Abstract**: Since the beginning of civilization, flowing water have attracted people through the benefits offered (like transportation, fishing, irrigation, etc.) and convinced them to settle on their shores. Therefore the vast majorities of the cities are built on the shore of a river or close to it. The positioning of human settlements near flowing water come with the benefits mentioned above but also a huge disadvantage: floods. Over the centuries the approach of handling floods changed from reacting to them after they happened to preventing them. This transition was also encouraged by the fast development of modern technologies. These technological advancements facilitated the development of an efficient and elegant method of flood prevention, which is the creation of the mathematical model of the river and using it for numeric simulations in various scenarios. The mathematical model will make it easier to determine under which conditions a flood will occur, how big it will be, and what impact it will have on the surrounding area, enabling the optimal decision making for preventing it.*

***Keywords:** river modelling, 1D mathematical modelling, ISIS, MIKE 11 .*

1. Introduction

The development of the mathematical model of the river is a laborious process which has multiple stages and implies collecting multi-disciplinary data. (Figure 1).

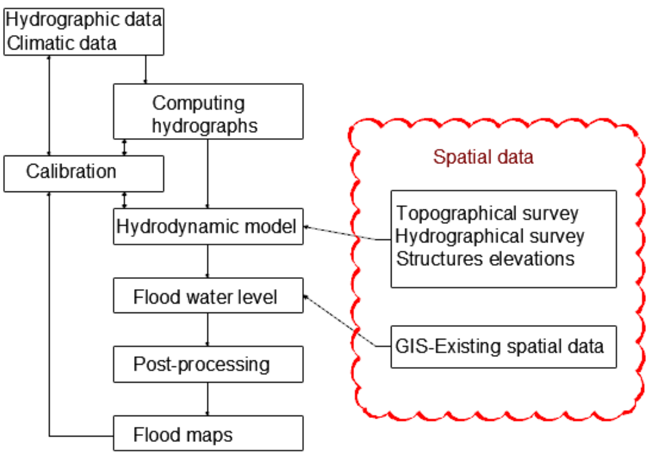

Fig.1 Development of the mathematical model of the river

The river model can be generated in two distinct ways, named after how the river route geometry is considered in plan, therefore the model can be 1D or 2D. This 2 types of modelling can be used individually but also together in order to validate and improve the obtained results. For the same reason, the 1D modelling is achieved by using at least 2 applications.

The 2D modelling requires: the generation of DTM of the targeted area (considering spatial data), which covers depending on the case the whole hydrographical pool, the entire floodplain or just a part of it. Collecting all this data can be done through multiple of geodetic methods but only a few will be used considering their efficiency in collecting a big quantity of geospatial data in a short period of time. Among these methods are: airborne LiDAR, aerial photogrammetry and hydrographical survey for the area covered in water.

1D modelling implies (considering spatial data) collecting punctual geospatial data along the river forming cross sections to the river axe. These cross sections will be presented under graphical representations but also in numerical representation in files compatible with the applications used for generating the 1D mathematical model.

Because of the different approach the geospatial data needed for the 1D modelling fits a classic method of data collection in which GPS and total station are used instead of airborne LiDAR and aerial photogrammetry which are the methods used for 2D modelling.

2. Collection and processing of spatial data necessary for 1D modelling

The cross sections specific to the rivers can be separated into simple cross sections and cross sections with structures. The cross sections are taken perpendicular on the longitudinal axe of the river and their density is chosen taking into account the terrain configuration and the importance of the area in which they are.

For the 1D mathematical modelling of the rivers are necessary and therefore required the following:

- Graphical cross sections and longitudinal sections,
- Numeric data compatible with modelling software. The most used are:
  - ISIS,
  - Mike 11,
  - Hec-Ras.

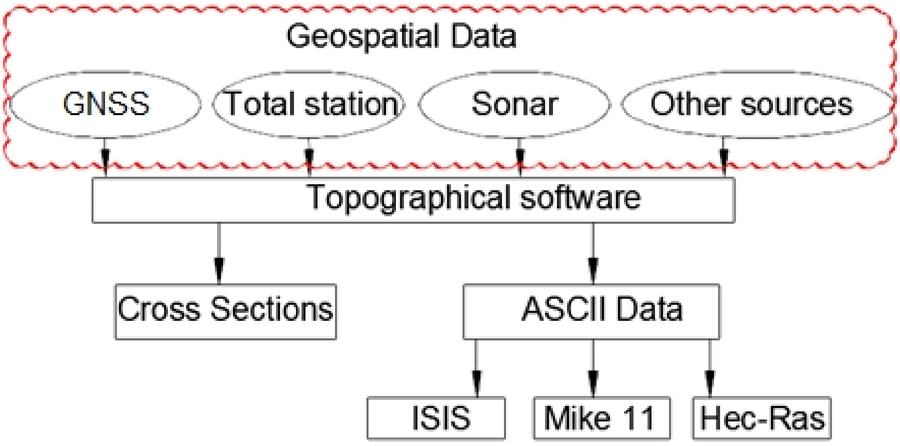

Fig.2 The current processing method

3. Disadvantages of the current processing method

After a proper analysis of the actual method used for data processing, presented above, it can be observed that it does not offer a high level of efficiency and at the same time it is prone to human errors. These drawbacks become more intolerable for big and very big projects that imply many manual operations. The low efficiency and high probability of human error is generated by:

- Manual processing of the graphical cross-sections and numeric file generation are done independently, therefore any modification or correction done in any of this data would not be reflected automatically in the rest of the file database;
- Processing of the graphical cross sections requires manual editing;
- Numeric file generation is not done automatically, most of the software used for geospatial data processing do not have this option. The ones that do have it, provide it only for one type of data which is not sufficient for these types of projects. Data for river modelling usually demand to use at least two mathematical modelling packages;
- The generation of numeric files for two or more mathematical 1D modelling software is done independently, introducing the possibility of using uncorrelated data.

Beside the disadvantages presented, the classic method of processing also has some advantages like:

- Input data flexibility,
- Flexibility of the exported data format. It offers the possibility to easily export the requested data into a new format specific to a new 1D mathematical modelling software used for rivers.

A few of the existing topographical data processing software that have the option to export data for the 1D mathematical modelling software solve a part of the problems of the current processing method but also have their share of issues:

- High cost, for licensing but also for the need to transition to a new system (hardware, software, user training),
- Export option for only one 1D mathematical modelling software,
- Reduced flexibility of exporting function. Defining a new format for exporting is not possible, in case a new modelling software is used.

4. River database

Analysing what was presented in the previous paragraphs, it can be observed that an improvement of the current method of data processing is necessary but also possible. This new method should:

- Be able to create and maintain a constant link between the data used for graphical cross-sections and numerical data throughout all the project's phases, in such a way that any modification that occurs in any component would be reflected in all the linked data,
- Permit automation of graphical data editing, therefore increasing the efficiency of the processing operation,
- Permit the automation of numeric data generation,
- Be able to create and maintain a link between the numerical data used in different modelling software, so that any modification would be automatically reflected in all the numeric files linked,
- Permit its implementation without extra licensing costs, equipment or user training,
- Have input data flexibility,
- Facilitate easy adding of a new type of export format in case of using a new 1D river mathematical modelling software, which could be very likely considering the fast evolution of IT.

In order to fulfil these requirements it has been considered as an ideal solution the creation of a database in which will be stored all the information regarding the river. The new method of processing spatial data is presented in Figure 3.

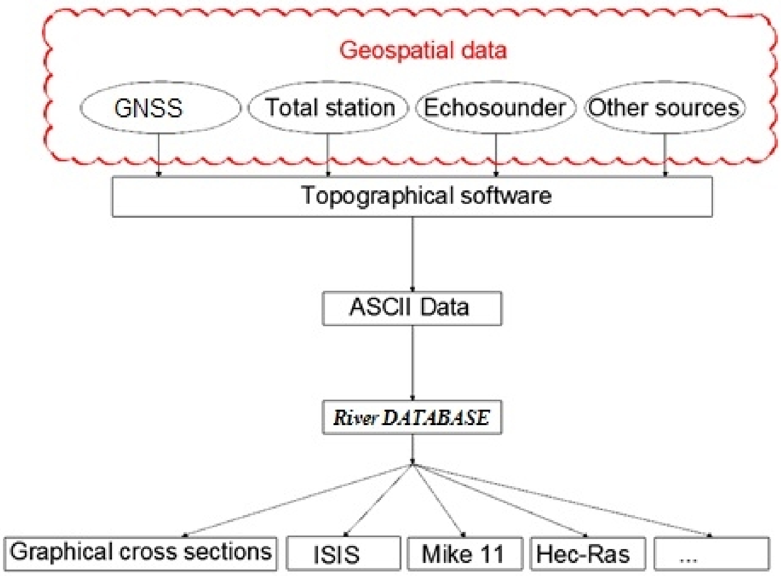

Fig.3 New processing method

Analysing the requirements for 1D river modelling with the help of the existing software (ISIS, Mike 11, Hec-Ras), extrapolating and developing these requirements to ensure compatibility with possible new 1D river modelling software, the following river database structure was defined:

- Planar geometry of the river,
- Planar geometry of the cross sections,
- River chainage, direct and reverse,
- Cross section identifier,
- Cross section positioning in direct and reverse mode,
- Shore positioning in cross-sections,
- Cross section point details:
  - Identifier,
  - x, y, z coordinates,
  - Normal and centre mode offset ,
  - Code,
  - Field notes.

Along with this strictly necessary structure, it is also mandatory to consider creating empty fields in the structure for an eventual extension of the database which could be generated for example by the development of a new format for numeric data used by a 1D river mathematical modelling.

5. Advantages of using a river database

Applying this new processing method through centralising all the river information has the following advantages:

- All information are stored one time and in the same place, hence, any adjustment of any database element would be reflected in all types of data linked to it, graphical or numerical,
- From same motivation as above, the export into CAD environment of the graphical cross sections could be done in a much more advanced form of processing consequently reducing manual editing effort and increasing productivity,
- Storing information in the database also eliminates possible errors that could occur due to manual and independent processing of data in ISIS, Mike 11 and Hec-Ras,
- The database containing all the existing information on the river could generate input data not only for the currently used platforms (ISIS, Mike11, Hec-Ras) but also for any other river mathematical modelling software, future or existing,
- The river database, being an independent product and allowing data generation for all existing and future modelling software, eliminates the necessity of new equipment acquisitions (software or hardware) hence lowering production expenses,
- Because the database contains all the input data in ASCII format it allows multiple party collaborations, even if different geospatial data processing software is used. This also increases productivity.

It can be observed that these advantages cover the requirements described above, confirming that this is the solution most suitable for perfecting the spatial data processing method for 1D river mathematical modelling.

6. Conclusions

Analysing the geospatial data collecting processing necessary for 1D river modelling and taking into account the objective of this research, the following conclusions can be drawn:

- Collecting data as well as their initial processing do not present any special technical problems, the techniques and methods used for collecting the data and for their processing are well established and are tested during the years,
- When collecting the data, the required accuracy must be considered. This is usually differentiated for simple cross sections and for the ones with structures, this plays an essential role in choosing the right equipment and data collection methods,
- The final processing of the data that enables their usage in 1D river mathematical modelling software implies a perfect understanding of their requirements. This processing has multiple independent stages, many of which

are manual processing that facilities the introduction of human errors. Also this type of processing needs time resulting into low efficiency,

- The final data processing that enables their usage in 1D river mathematical modelling software could be done through an alternative method, using a data base that would store all the information regarding the river. The utilisation of this data base allows a high automation of generating the final products eliminating in this way the possibility of human errors and increasing the efficiency by reducing the data processing time for this stage to only few minutes.

7. Abbreviation

ASCII	*American Standard Code for Information Interchange*
CAD	*Computer Aided Design*
GNSS	*Global Navigation Satellite Service*
GPS	*Global Positioning System*
IT	*Information Technology*
LiDAR	*Light Detection And Ranging*
DTM	*Digital Terrain Model*

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