ANALYSIS OF THE HUNGARIAN HYDROCARBON INDUSTRY'S ACCIDENTS AND THEIR DEMONSTRATION WITH GIS

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ABSTRACT

From its beginning until today the Hungarian hydrocarbon industry has suffered more than seventy bigger accidents where intervention of the fire service and thorough examination was required. In the article the author presents the short analysis of accidents that were collected, systemized, and entered into database during the research, and their integration into the Geographic Information System (GIS). Based on the finished database, with the extended list of the locations' GPS coordinates, the accidents will be entered into the ArcMap application. The publication of the accidents will be done with the help of Arcgis Viewer for Flex – Application Builder program. Following the GIS placement of accidents, testing, drawing conclusions and summarization are the main goals. The next step will be the preparation for assigning the database to the Disaster Management Decision Support Geographic Information System. Following the international publication, the long-term goal is the connection of each country's files of dangerous industrial activities that were collected by researchers into one common database.

KEYWORDS: disaster management, hydrocarbon industry, analysis, GIS

1. Introduction

Based on the author's hypothesis the hydrocarbon processing plants are among the most dangerous plants in Hungary and also in the world, making them safer is the main subject of his research. During hydrocarbon processing among others the biggest problem is caused by pyrophoric phenomena, that happens because of the oxidative reactions that occur inside technological equipment, influencing the rate of production, the processing and storage of hydrocarbon products in a negative way (Tóth, 2018a).

Some parts of Hungarian industry are outdated, the average age of the plants is high. Owners spend little on the replacement of technological equipment other than the repair of the occasional malfunctions because they are trying to maximize the profit. The instrumentation of the technological equipment and the supply of control-supervision systems for the progresses is good. From 2012, changes in legislation will require the operator of all hazardous plants in Hungary to protect the environment and the population. Disaster management was given the tool of law from the lawmaker to defend the environment with the means of law enforcement. From what is written above it shows that sooner or later inevitable accidents will happen unless the operator and the authorities

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prepare together. The study makes it clear that efficient preparing can be done by learning from the mistakes of the past and utilizing the technologies of the future.

2. The Author's Research and Related Publications

During hydrocarbon processing in the past years both on the Hungarian and on the international levels the focus was on efficiently putting out fires, foam cannons, flooding, and the usage of fire-fighting robots, however according to the author proper preparation and efficient prevention can be the most important safety improving factors. The author thinks that in order to make the progresses of hydrocarbon processing safer the present tools of disaster management should be improved. Preparing the population – for extraordinary situations, safety challenges, risks – is among the given dangerous industrial plant's and the disaster management's most important tasks and that it should be done in cooperation (Tóth, 2018b). My co-authors and I have examined the significant Hungarian industrial disasters from the viewpoint of planning and handling (Tóth, Muhoray & Péllérdi, 2019). Prescient plants that were prepared for every possible outcome, that reduced malfunctions with planned maintenance, and whose well-prepared management did the periodic preparation of the population together with the disaster management, and also informed the population in cases of accidents, have proved themselves already.

With the improvement of infocommunication technologies the possibilities of informing the population have widened. In the past decades the flow of information was slow and distorted, in the age of infocommunication the publicity has an increasingly important role. The exchange of information within communities has become simpler and faster. While in the past time and distance were important in giving/receiving information today these factors are not providing a challenge anymore because the internet has stepped over the physical boundaries. Social media has become a relevant part of this rapid flow of information. Based on the experience in handling previous crises I conclude that it is beneficial to assign the tasks in advance in the crisis communication plan. Such as the methods of efficiently informing and reassuring the population, communication policies and relationships with the press. Following a certain accident not only the professional activities should be analysed but also the communication related to the event. The review and analysis of finished tasks and future impacts should be done (Tóth, 2017).

3. Creating a Database for Hydrocarbon Industrial Accidents

During my research focusing on hydrocarbon processing accidents and modifying the disaster management methods and making them more accurate, I examined and systematised the Hungarian and foreign hydrocarbon processing accidents including some bitumen processing accidents. I found the causes of explosions and fires, the technological shortcomings, and I made suggestions to prevent them. With my co-authors we examined the natural disasters' effect on the hydrocarbon processing industry (Tóth & Siposné, 2017), human influence and terrorism, and the complex disaster management task system related to underground gas storages (Endrődi & Tóth, 2019). Following the study of possible improvement of the fire analysis related to hydrocarbon processing accidents (Tóth, Bleszity, & Restás 2020), the author organized a database of more than 70 systematic damage events discovered from the beginning of the Hungarian oil industry to the present day (Tóth, Siposné & Endrődi, 2020).

3.1. Database Definition, and Structure

The principles of ordering things in the database are the following:

●putting the entered accidents in chronological order;

●settlement and location, and cause of occurrence column;

●injury or death and property damage field;

●last column is the exact source.

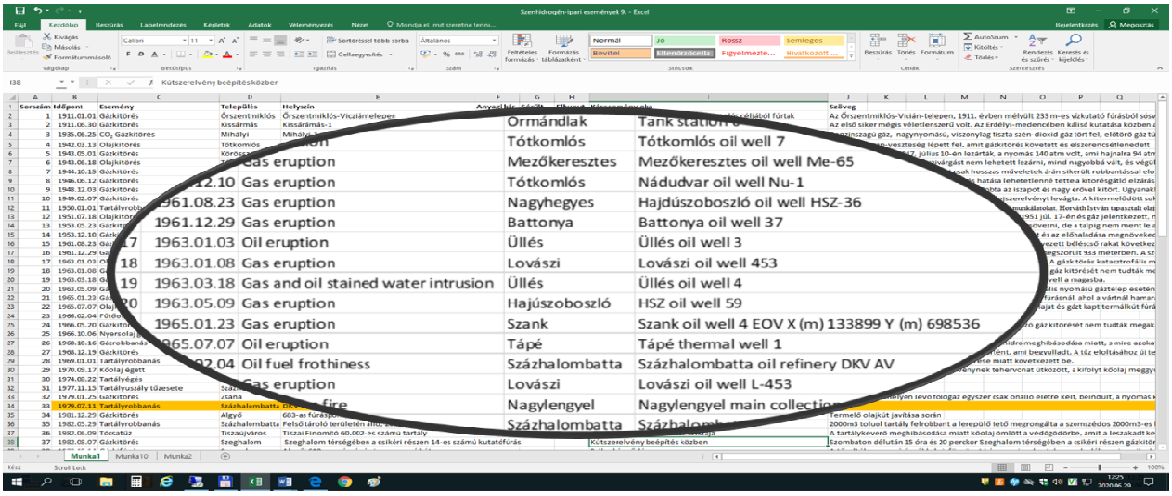

Figure no. 1: *The database of hydrocarbon accidents in an Excel spreadsheet*
(Source: Author)

After ordering the database graphic representation of the accidents and queries based on different parameters has become available (Figure no. 2). The results are suitable for drawing conclusions. According to the database the most common and most dangerous type of accident in the hydrocarbon industry is gas eruption occurring during hydrocarbon mining, but further analysis has found that fortunately it last happened in the 2000s.

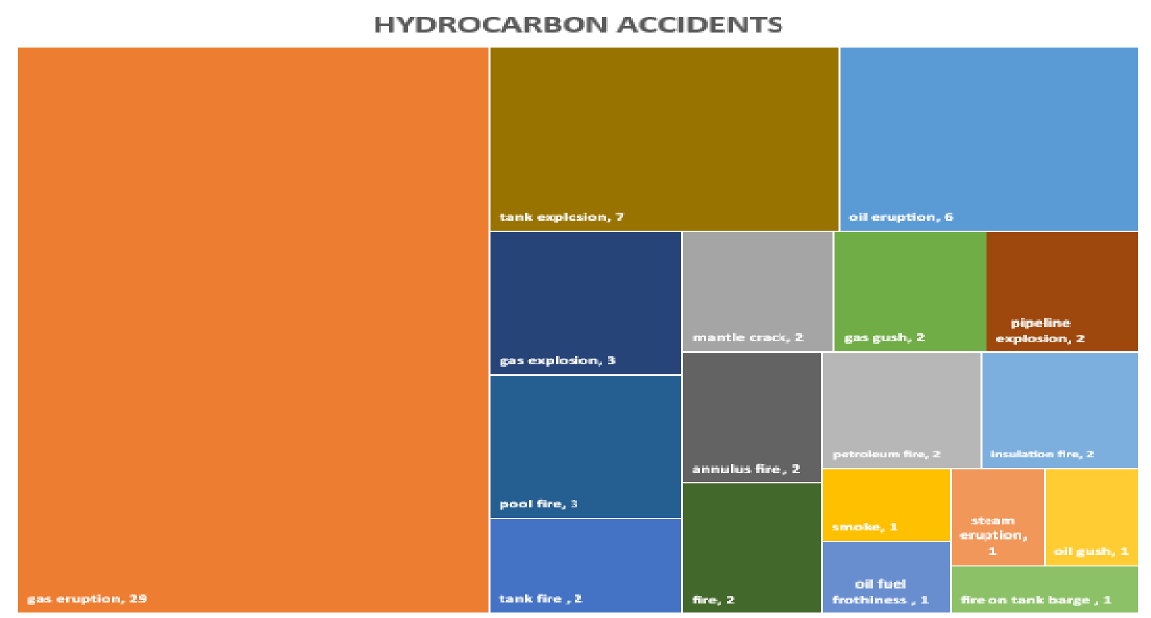

Figure no. 2: *Displaying hydrocarbon accidents that have happened in Hungary*
(Source: Author)

4. The Disaster Management's Decision Support System

The disaster management's important pillar and area of expertise is the protection of the population which back in the 90s was an independent organization that used different GIS and from 2002 decision support systems. The one currently used is called Decision Support Map (DÖMI), which shows the data relevant to the operations on a transparent, fast, user friendly map interface. Information about the ongoing events, series of actions, and feedback are constantly updated from the PAJZS alarm system database.

The operation control duties are helped by several tools, such as the status indicator which shows the current status of every vehicle (can be alarmed, is currently at a fire, out of storage, has no manpower, out of use, etc.) on the data collector machine which collects the important service information (fire signal, alarm, phone and radio traffic, etc.).

Collecting data can play a major role in the post factum analysis of fires, but also as evidence in criminal law or in civil lawsuits. Databases are important: list of street names, maps, limitations, information about dangers, fire-fighting plans; their maintenance is a responsible work which is only efficient using computers, that also creates the possibility of the automatic alarm system using this data.

At the operation control duties, a computer driven alarm system and the Decision Support Geographic Information System with the help of the developed software are helping making the decisions about the operation control and their proper documentation. The PAJZS MINI operation control support system helps with the communication. At the fire service duties industrial cameras are useful e.g. to automatically operate storage doors (Cziva & Duruc, 2016).

5. GIS Adaptation

The application of disaster management's GIS system's data, tools, and services provided efficient assistance in organizing the defence plans for several cases of disaster, and in evaluating real dangers. Over the years achievements of GIS systems have become part of fire service, industrial safety, and population defence specializations' daily work (MIA, NDGD, 2017).

No	Time	Category	Event	Location	X_coordinate	Y_coordinate	Injured	Deceased	Reason	Description
11.	1950.01.01	Tank explosion	Tank explosion	Ormándlak tank station 6	46,7482160	16,7648760	1	1	Welding	Welding work was ordered on a half- filled natural gas tank
18.	1963.01.08	Gas eruption	Gas eruption	Lovászi oil well 453	46,5513430	16,5577680			Malfunction of the eruption inhibitory	The eruption inhibitory could not prevent the eruption of an exertion gas placed on the upper level
19.	1963.03.18	Gas eruption	Gas and oil stained water intrusion	Üllés oil well 4	46,3478500	19,8543710			Drilling over-pressured layers	Gas mixed with oil and water shot in the air in an approximately 40 metre height
26.	1968.10.16	Gas explosion	Gas explosion	Százhalombatta DKV AV-II oil refinery	47,2944569	18,8712725	2+16	8	Technological error	Hydrocarbon gas ignition, light hydrocarbon gases ignited when they reached the tube furnace
27.	1968.12.19	Gas eruption	Gas eruption	Algyő oil well 168	46,3163619	20,1843040			Gas eruption ignited	To put out the fire new technology was developed, that was used successfully in Kuwait following the Gulf War
28.	1969.01.01	Tank explosion	CO_2 Tank explosion	Répcelak Carbonic Acid Production Company	47,3554907	16,9259427	6+13	9	Brittle fracture next to welding seam	The explosion has occurred because of the tank's brittle fracture. Storage tank explosion on Carbonic acid producing company's site in Répcelak

Figure no. 3: *Some highlighted hydrocarbon accidents converted to the Arcmap application*
(Source: Author)

After entering the GPS coordinates of the locations of accidents into the database the extended data was gathered with the Arcmap app. With the help of the ArcToolbox and ArcCatalog programs we displayed the map function with the online map Arcgis Viewer for Flex – Application Builder in the GIS system of the disaster management (Tóth, 2020). In the later parts of the study the data will be available to outside users.

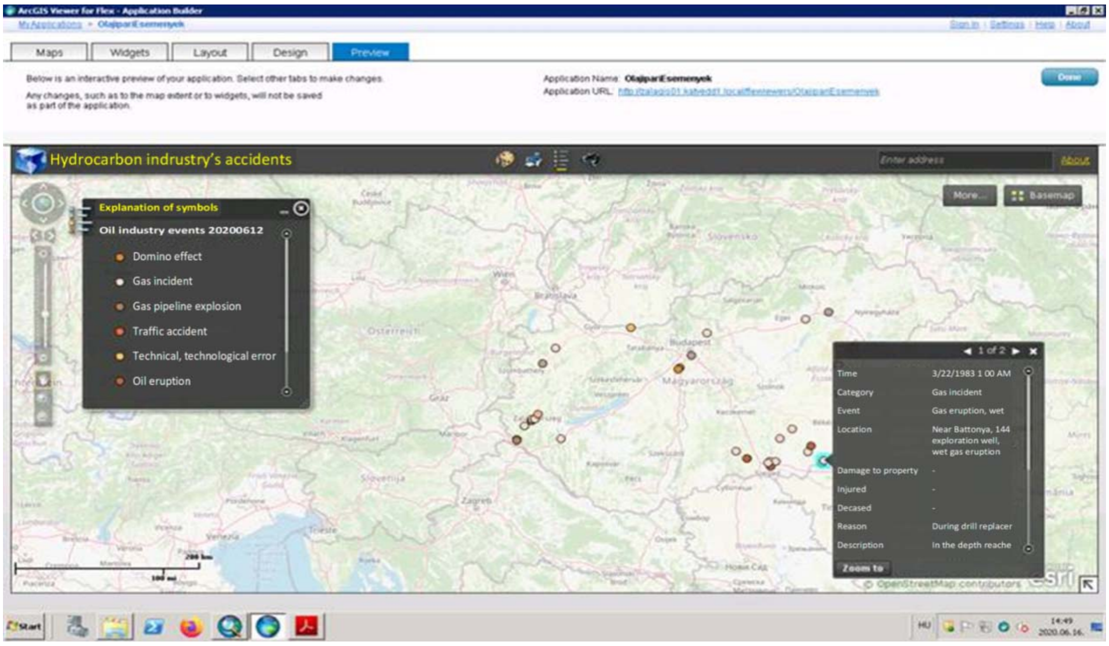

Figure no. 4: *The preview of the raw interface, before defining colours, subtitles, figures* (Source: Author)

ArcGIS is a user-friendly program that is used by a significant fraction of GIS users. The Environmental System Research Institute (ESRI) software has a long history in the GIS field (Dobos, Hegedűs, Lénárt & Tamás, 2003).

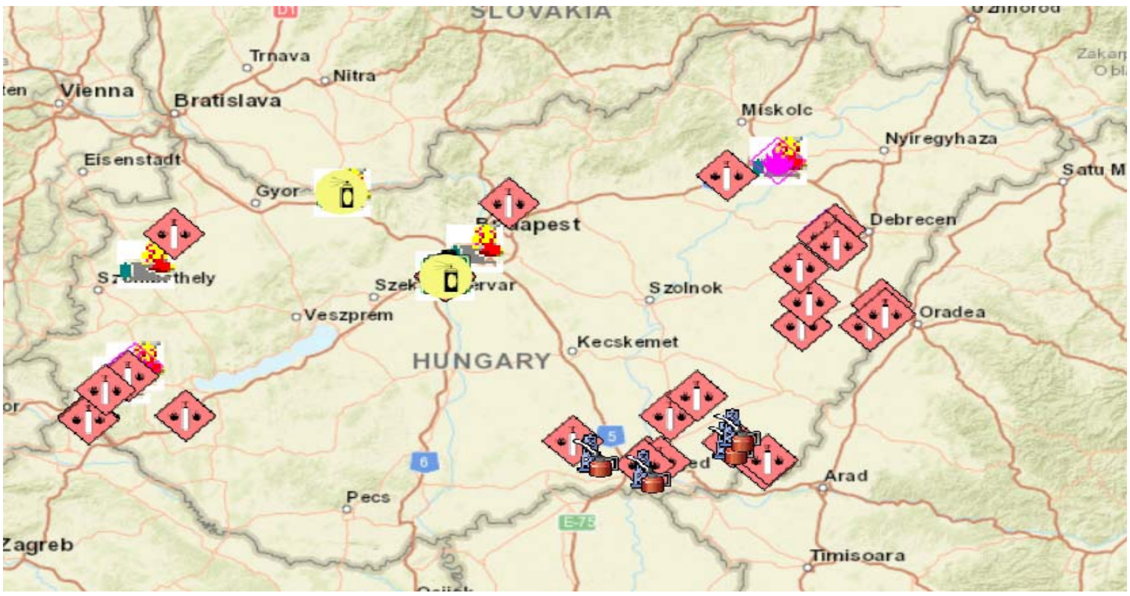

Figure no. 5: *The finished interface displaying all 7 layers at once* (Source: Author)

In the database of hydrocarbon processing the entered events were ordered in 7 categories and were placed on the map based on these (layers) (Figure no. 5):

- Technical error (insulation fire, oil fuel frothiness);
- Transport accident (petroleum tank truck collision, tank barge fire);
- Oil eruption (petroleum eruption during hydrocarbon mining);
- Domino effect (chain reactions caused by power outage, changes in gas mixture);
- Gas incident (gas and steam eruptions occurring during hydrocarbon mining);
- Pool fire, fire case (torn mixing engine, gasket error);
- Tank fires (fire cases of hydrocarbon storage tanks).

Transparency of the layers is adjustable, their visibility can be turned off, therefore all events can be looked at once, or each of them separately but multiple categories can be set visible on the user's demand. To every category there is a notation connected, for example for the oil eruption an oil rig with a pictogram of a manual oiler in front.

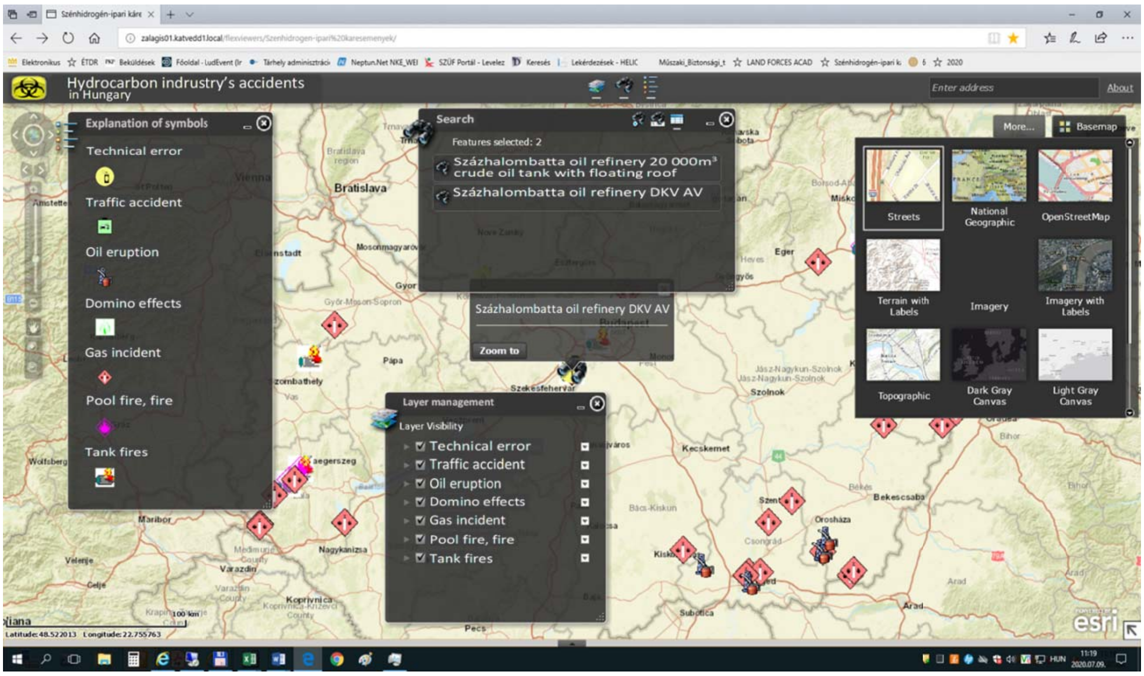

Figure no. 6: *The functions of the website: notation, layer handling, base map and the search bar*
(Source: Author)

On the interface events can be made visible on 10 base maps:

- Streets;
- National geographic;
- Open Street Map;
- Terrain with Labels;
- Imagery;
- Imagery with Labels;
- Topographic;
- Dark Gray Canvas;
- Light Gray Canvas;
- Oceans.

The functions of the website: "Search" based on quality, name, opportunity to mark things out e.g. finding the accident in a marked out square shape or any polygon shape. On the Streets map (Figure no. 6) I first tested the search function with the word “oil”, then on the Terrain with Labels map I searched for petroleum and natural gas eruptions that occurred during hydrocarbon mining in the Southern Great Plain. Both searches resulted in successful displays on the chosen map.

Inquiring an event on a settlement gives you all the events related to the settlement in chronological order. We can navigate by clicking on the arrows and we can get information about the accidents. There were 17 accidents entered related to Hungary’s largest refinery, the “Dunai Finomító”. From the description of a given accident the circumstances of its occurrence can be determined, which can serve as a basis for later studies, drawing their conclusions rises the safety levels of hydrocarbon processing.

According to the author the display of accidents in the same place should be improved because the app places different events’ pictograms on top of each other.

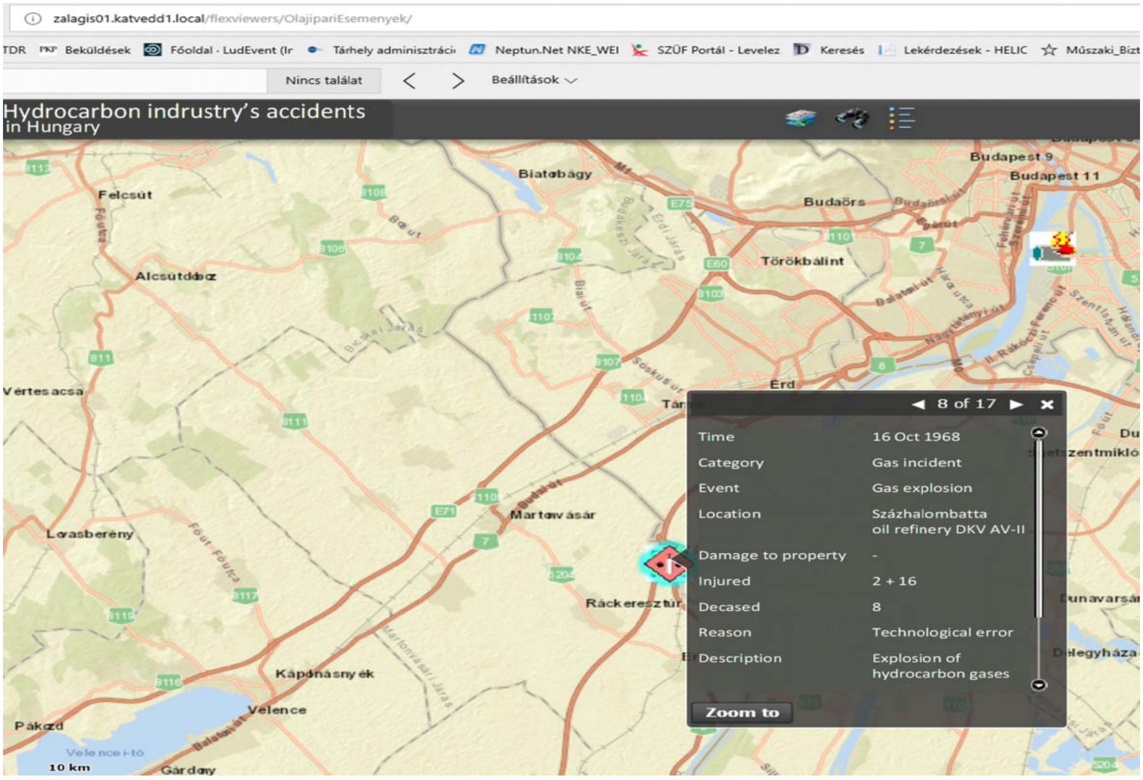

Figure no. 7: *Display of all events (17) related to a single plant*
(Source: Author)

6. Conclusions

With the collected hydrocarbon industry accidents that were gathered through years of research, and by recognizing and analysing the past mistakes the author is trying to achieve a reduced risk of such accidents occurring, paving the way for safe, accident-free dangerous industry activities. In the shown database the previously entered accidents were completed with GPS coordinates, and following the GIS publication they were made available through the disaster management’s internal system. The wide range examination of events, queries, analysis, drawing conclusions and summary on different levels are the next steps that can prepare the connection of the hydrocarbon accident interface with the Disaster Management Decision Support GIS System. To succeed in the aforementioned areas, it is necessary to create a database of the Hungarian plants, and factories in the future and place that on a GIS interface. The long-term goal is the creation of an international database which requires a unified safety-based point of view. In the dangerous industry and hydrocarbon industry areas researchers are able to create a common database by submitting their own country's data which would be available on a "Disaster map" online interface for the users and the researchers. I ask for my fellow researchers' cooperation in order to achieve the long-term goal.

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