DEVELOPMENT AND DISSEMINATION OF AN ISRAELI FIRST RESPONDERS ADDRESSES GEOSPATIAL DATASET FOR MANAGEMENT OF EMERGENCY EVENTS

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ABSTRACT:

At the last decades the awareness of the role of developing and improving the technological means in order to support better response during disasters such as earthquake and huge forest fire, became critical. Hence, the first responders agencies (Firefighters, police, Red Cross, municipality etc.) requires a geospatial dataset to manage, operate, coordinate and make their decisions based on a "common language" in order to navigate in real time, and to cooperate "on the field" in an appropriate way for saving life's.
Due to the event of huge forest fire in the Carmel Forest at the northern area in the state of Israel, the Survey of Israel promoted the development and dissemination of National First Responders Geospatial Dataset (NFRGD) to all of the first responder's agencies and municipalities.
In the State of Israel, there are more than 1.9 million buildings and 160,000 km of roads and unpaved roads, but only about 30% have an unequivocal name or official number. Since all emergency forces use navigation applications to locate, plan the route and arrive to the event area, most of the buildings and roads cannot be located by means of navigation, because there is no unique identification for them. In these cases, the forces will base their way to the event on prior acquaintance with the area of activity. This knowledge exists only in the local emergency and rescue forces. In huge events, when forces are being enlisted from other service areas to help, and they are not familiar with the local geography, they must work and communicate based on common spatial database.
The main challenges of the NFRGD development were:

1. Designing a product that will be generic to the whole of the First Responders agencies.
2. Dissemination of the dataset in frequency that enable the First Responders agencies IT to integrate the data set in their systems.
3. Overcome complex use cases due to the complexity of the reality representation in National Topographic Data Base.

This article will describe the methodology of the geo computation and algorithms, which implemented in the development of the NFRGD. The algorithms were characterized and developed by a joint team of representatives from the first responders, the chief scientist and systems analysts of the Survey of Israel (SOI).

INTRODUCTION

Background

Why do you need addresses? An address is a tool for establishing the governance (central or local). Through addresses it is possible to associate the citizens with their place of residence, as well as streamline the process of collecting taxes. Besides, Addresses are very crucial, as they can help emergency response teams to quickly identify the place to send rescue teams to the location.
Different places in the world have created unique address numbering methods. In Japan, the numbering is done by quarters and the house numbers are given according to the year the building was built. The older the building, the lower the number. In the United States, there is the Philadelphia system, which is numbered by blocks. In Latin America the numbering is according to the distance of the house from the center of the locality and in Europe it is customary for a number of buildings in odd/even system with odd numbers proceeding on one street side and even numbers on the other side. The European method, which sometimes called French system, was introduced in France in the 19th century and was later adopted in other European countries.

In Israel, the responsibility for providing street names and numbering the buildings lies with the municipal authority only, but there is no obligation to do so. In most rural localities, kibbutzim and moshavim (agriculture small settlements), and in minority localities, street and address names do not exist. Mainly, the odd/even system is the method of address numbering used in Israel.

Motivation

In the State of Israel, there are more than 1.9 million buildings and 160,000 km of roads and unpaved roads, but only about 30% have an unequivocal name or official number. Since all emergency forces use navigation applications to locate, plan the route and arrive to the event area, most buildings and roads have no way to be reached by means of navigation, because there is no unique identification for them, and the forces will base their way on prior acquaintance with the area of activity. This knowledge exists only in the local emergency and rescue forces.
In an emergency event, when several emergency agencies operate in parallel in the same area, it is very difficult to coordinate between them because each organization works in different systems, different reporting networks and different

databases characterized by a different level of currency and layers variation.
From the major emergency event at the Carmel Forest Fire in 2010, it was learned, that since it was attended by emergency and rescue forces from all around the country and they were reinforced by external forces, who had no prior knowledge of the incident area. Therefore, even if part of the forces had early familiarity with the area, for most of the forces, it was complicated to cooperate and they wasted time until they could become useful.
The NFRGD project aims to establish a common language among the first responders (emergency and rescue agencies) in the State of Israel based on geographical information systems utilizing a spatial data and cartography. The project involves all the national first responders: the Israel Police, the Home Front Command, a national fire brigade, Magen David Adom (Israel "Red Cross"), government ministries and local authorities.
On the technical level, the project based on a collection of complex algorithms for locating and uniquely numbering streets, intersections and buildings that do not have an official street name and/or address. The result of the project is a uniform spatial relational database containing a wide range of geographic information layers. At the same time, a uniform reporting network was built for the entire territory of the country, independent of any coordinate network. The database is maintained, managed and disseminated by the SOI in order to create uniformity (data integrity) and a common language between all government ministries, emergency and rescue bodies and local authorities.
The basic premise is that there is a wide range of users who must use the project product, and therefore there is a need for easy implementation of the data in a variety of systems and users with optimal usability.
The practical usage is based on the main idea, that each object on the NFRGD map hold its own unique number. Since the same version of the NFRGD is installed in the forces vehicles/airplanes terminals and control centers, they all communicate using the same numbering, referring the physical objects.

THE NFRGD TECHNICAL ENVIRONMENT

NFRGD spatial Database

The NFRGD project is based on an orthophoto with a resolution of 0.25 m per pixel and on the National Topographic Database (NTDB) as the common database of the project.
The NTDB was established in 1993 and is maintained by the Survey of Israel on an ongoing updating basis. The NTDB is the official topographic database of the Government of Israel. The database includes 25 layers of information on various topics, see Figure 1, that constitute a basic spatial infrastructure for all government ministries.
As part of the NFRGD project, a unique key is added to identify geographical entities in several layers from the database: roads, unpaved roads, buildings and addresses.

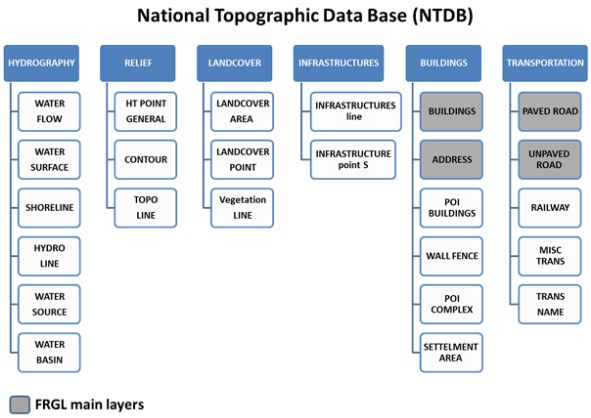


Figure 1. NTDB spatial layer structure.

NFRGD System architecture

The system is online and installed on an on - premise enterprise server. Development was performed with ASP.NET, C #, SQL HTML, CSS.
The spatial algorithm written in C# combines ESRI ARCGIS libraries and STORE PROCEDURES on SQL SERVER. Using STORE PROCEDURES streamlines the system running process because the system ran directly on the database.
In order to create secure access to the data, SDE is not accessed directly, but by means of an MVC (MODEL-VIEW-CONTROLLER), as shown in Figure 2. The user sends a request via BROWSER using HTTP to CONTROLLER and by transferring the request to MODEL, the operation is performed in the databases.
The database is MS SQL with SDE and the geographic engine is ESRI ARCGIS.
Using the SDE, complex geographical processes (GEO-PROCESSING) are applied on the geospatial layers that make up the project.
SQL SERVER contains two databases. One, a managing database, through which the processes, permissions and documentation (LOG) of the system are managed. The second, a spatial data storage, contains all the geographic layers that make up the project database and geographic auxiliary layers that are created during the system run.
Because the running process is long (several days in a nationwide deployment) breaks can happen during the run. Therefore, the system was developed so that it would be possible to continue the run from where it was stopped without compromising the processes performed and without compromising the data.

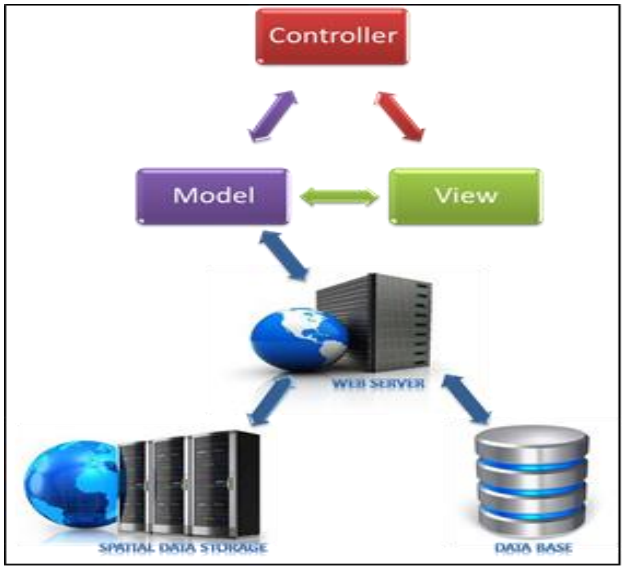


Figure 2. NFRGD system architecture

NFRGD algorithm

The purpose of the algorithm is to create temporary street names and temporary addresses for streets and buildings without an official name or number. The guideline in the development was that the users of the NFRGD have a wide range of capabilities and therefore there is an obligation to create an easy and simple database to understand and based on the familiar structure of an existing street numbering in Israel (the European method).
In the process of examining the existing situation, it was found that in the State of Israel there is no uniformity in the numbering of buildings on the streets and in fact each municipal authority determines the order of numbering of addresses for buildings (north-south, east-west).

NFRGD OPERATIONAL WORK METHODS

Work assumptions

In order to sustain the overall goal, the following assumptions were made:

1. The database includes all official addresses and road numbers and official street names, missing information in this data is completed using a number that will not be longer than 5 characters.
2. The NFRGD numbers are monolithic at the national level and divided according to municipal boundaries as defined in the Ministry of the Interior.
3. NFRGD numbers are kept for a long time and between versions, as long as there is no official street name / house number.
4. The existing methodology is maintained in house numbering as it exists in official addresses (European method - double-pair).
5. The junction layer will be created according to the road layer in each version, automatically.

NFRGD development work method

The project was developed in two phases. The first phase was intended for the "construction phase" and the second phase was intended for the project update phases. For each stage a unique algorithm was developed that expresses the basic principles.

As part of the project, information is added to the three existing layers in NTDB: roads, unpaved roads and buildings, while the address layer is used as a reference layer for finding buildings without an address.

Construction phase

In the initial phase, it was necessary to number all the roads, unpaved roads and buildings without official identification, as well as to create the layers of junctions and the reporting fishnet. This phase included the development and determination of the basic principles as well as the structure of the general algorithm. The algorithm is mainly based on the spatial identification number (UNIQUE ID)
The algorithm is divided into 3 steps according to the layers that were required to add the NFRGD numbers, as shown in Figure 3.

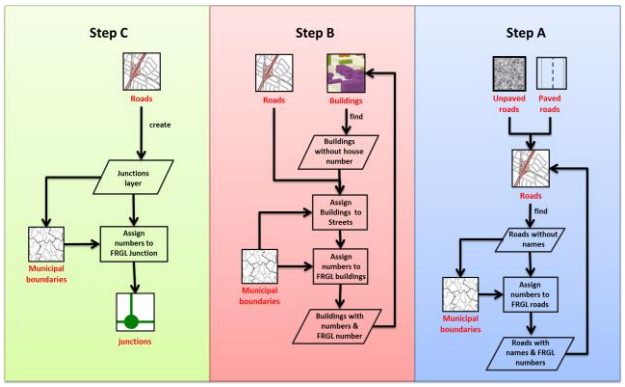


Figure 3. Construction phase steps

Step A – Road creation and numbering

The road layer is built for all sections that are without a street name or road number. The roads are based on the geographical location of each section, and the location and relation to the adjacent sections.
The creation of roads includes 2 stages:

1. Creating roads ("streets") according to the obtuse angle (180 dg') of the section's angels that make up a junction, to the extent that the sections have not yet been numbered in the current run.

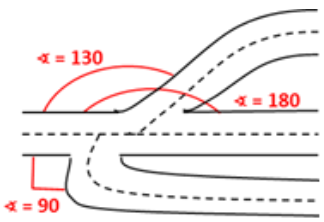


Figure 4. Creating roads.

2. Adding a NFRGD number to the roads found: The numbers will be given to each section that makes up the street. In order to enable to identify that the number is a NFRGD number, initial letter R (= ROAD) will be added to the number.

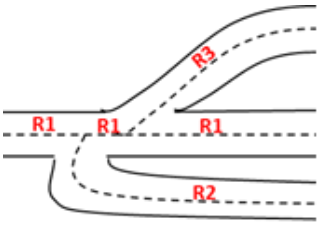
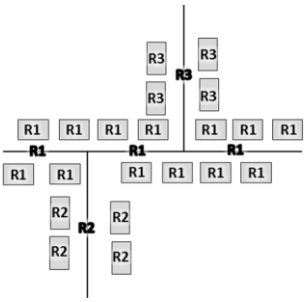


Figure 5. Adding NFRGD numbers.

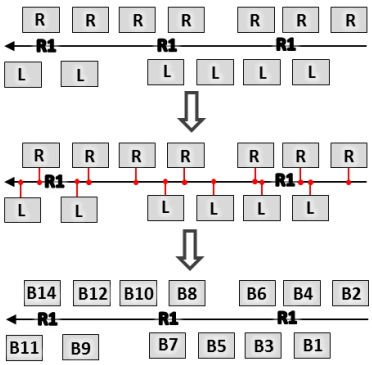
Step B – Numbering of buildings without an official address

Assigning NFRGD numbers to buildings consists of four stages:

1. Assign each building to the nearest road.



2. Assignment of buildings to a logical side (left or right): Any building that is associated with a logical road should be determined for it whether it is on the even or odd part of the road when the even side will always be the right side in the direction of digitization
3. Calculate the location of each building on the street in relation to the other buildings. The calculation is done by lowering a vertical to the road and giving a number to each of the meeting points between the road and the vertical.
4. Providing finite numbers (even and odd). Even numbers on the right and an odd numbers on the left.



In order to enable identifying the NFRGD numbers, an initial letter B (= BUILDING) will be added to the number.

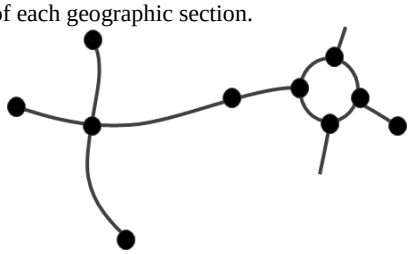
The end result is a numbering of the existing structures in official addresses or NFRGD addresses. Since an urban area is not uniform in terms of numbering, there will be a mix between official addresses and NFRGD addresses, as shown in Figure 6.

Figure 6. Buildings layer - a combination of official and NFRGD addresses.

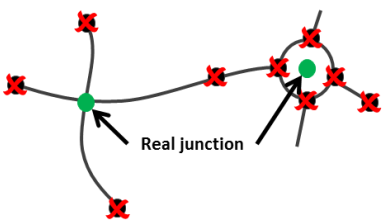
Step C – Create the junction layer and number according to the logical roads

The junction layer is based on the ROADS layer (the road and unpaved road layers). Each junction/intersection created receives a unique identification number at the level of the locality and according to the street to which it belongs. The junction layer is built in the process of building the logical roads. The process of creating nodes includes four stages:

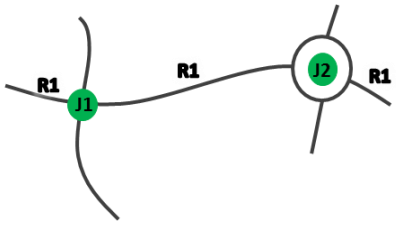
1. Creating a junction layer - consisting of the beginning and end of each geographic section.



2. Finding real junctions - nodes that consist of an encounter of at least 3 sections.



3. Creating nodes in the center of traffic circles and deleting the nodes created at the intersection of the sections with the traffic circle.
4. Numbering the nodes according to the logical roads. In order to be able to identify that the number is a NFRGD number, an initial letter J (= JUNCTION) will appear before the number.



The update phase

The NFRGD project is updated once a year in accordance with updates made into the National Topographic Database (NTDB). The basic assumption for the update phase is that NFRGD numbers need to be stabile maintained over time.
For the purpose of updating the numbering, another algorithm has been developed based on the basic principles that exist in the construction phase, as well as on additional principles created for the purpose of the updating phase:

1. The NFRGD number is associated with a geographical entity throughout its existence in NTDB.
2. Entity in which a minimal change has been made (for example: enlarging a structure, changing an alphanumeric information, changing a minimal character) - the number of NFRGD will not change.
3. A NFRGD number deleted from the NTDB will not be given to another geographical entity.
4. A structure deleted from the NTDB is transferred to a separate geographical layer.
5. If the municipal boundary changes, the geographical entity will be associated with the new locality and its number will be in accordance with the rules.

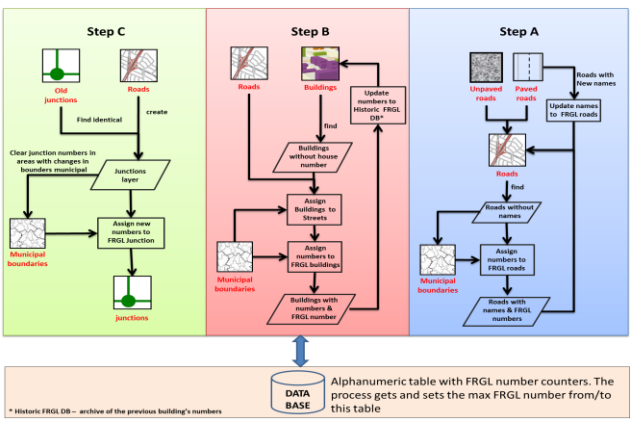
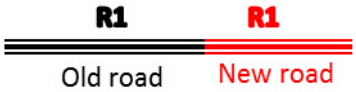


Figure 7. The update phase

Creating and numbering the logical roads
In updating the road numbers in the update phase, the location of the section that the number is taken into account in relation to the sections that have previously received NFRGD numbers. The goal is to create continuity, and uphold the principle that roads numbered with NFRGD numbers "behave" like officially named streets and roads:

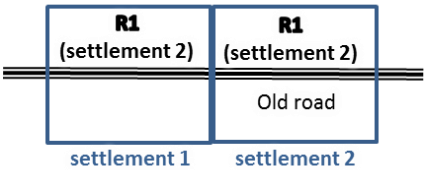
1. Sections that are a continuation of an existing road / unpaved road with NFRGD numbers will be numbered in the same numbering of the road they continue.



2. A section of road / unpaved road located between two sections who has already NFRGD number, will be numbered in one of the NFRGD numbers that connect to it.

3. A new section that does not constitute a continuation of an existing road / unpaved road, will be numbered with NFRGD number according to max + 1.

4. Preventing the transfer of sections that cross several localities between versions.



Numbering of buildings without an official address
The numbering of the buildings in the update phase maintains the principles that existed in the initial numbering phase (the construction phase). Any new structure added to the database or structure whose address has been deleted will be numbered in NFRGD in accordance with the numbering principles.

Create the junction layer and numbers according to the logical roads
The junction layer is created according to the roads in the new product version. After the junctions are created, a comparison is made between the new layer created and the old junction layer. When there is an overlap between the new and old node layer the number of the old junction will be given to the new junction. A new junction that does not overlap with an old junction will be numbered according to the numbering method during the construction phase, that is, numbering based on the logical roads.

Reporting fishnet
The layer was prepared using a Fishnet creation tool in ESRI's ARCGIS software. Each tile is 100X100 meters in size. Each tile was given a unique number at the national level with respect to its location in relation to the other tiles and in relation to the northwest corner of Israel. The reporting fishnet aimed to provide a solution for the fact that the emergency and rescue agencies work in different geographical coordinates. Using the reporting fishnet one can instantly focus on a small geographic area cell. In addition, data for each tile is entered as alphanumeric information in each of the project layers so that it is possible to know for each geographical entity in which tile it is located.

Project results

The product of the project is a uniform database based on the National Topographic Database (NTDB).
As part of the project, a temporary number was given for each road, unpaved road and building that are missing an official identification number, street name or house number, and a unique layer of junctions was created in which each junction was given a unique number.
The numbering within the framework of the project is unique at the national level and divided according to the boundaries of the localities as determined by the Ministry of the Interior.
The products of the project can be digitally displayed in different geographical and alphanumeric systems, as well as by printed maps, and by means of a unique symbology.
The integration of the NFRGD data into the systems of each of the first responders, as a routine update process, enables during an emergency event, to establish immediate cooperation between them, without the need to connect physically or using complicated data interfaces to their existing internal dedicated systems.

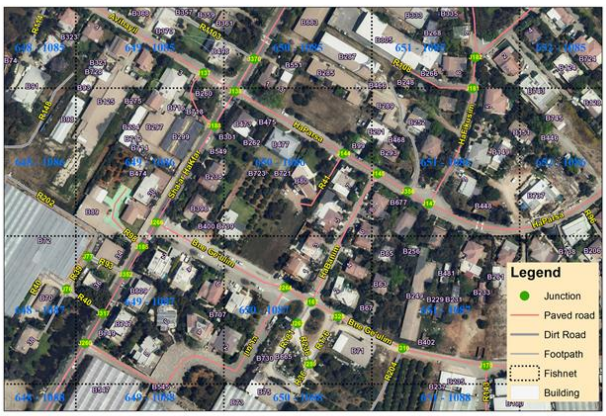


Figure 9. Final NFRGD product

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