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The Role of GIS in the Response to the Terrorist Attacks of September 11 in New York City

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Synopsis

The primary goals of emergency management activities are to protect life, property, and the environment. Having the right data at the right time presented logically is critical in responding effectively to natural and human-generated hazards and taking appropriate actions. Most of the data required for emergency management are of a spatial nature and GIS provides a framework in which critical information can be gathered, centralized, synthesized, visualized, and shared. This paper describes the critical role that geographic data and GIS played in the response to the attacks of September 11 in New York City. Although the processes that generate the disaster might be different depending on the type of hazard (natural as well as man-made), the techniques to assess risk, evaluate damage, and assist response have much in common and can share and benefit from the lessons learned in New York City.

Keywords: WTC, 9/11, Emergency Response, NYC Disaster, GIS

1. Introduction

GIS and geographic information have been used for decades to help organizations collect and analyze data to make better decisions. It is said that any opposing opinions and skepticism anyone had about the effectiveness of GIS in New York City were erased after 9/11. This paper will examine the role of GIS and geographic data in the response to the attacks of September 11 in New York City.

2. The utilization of GIS for WTC

GIS was used mainly for the following four purposes in the response to the attacks of September 11 in New York City.:

1. To build base map products for damage assessment
2. To support recovery operations and prevention of secondary damage
3. To conduct three-dimensional analysis
4. To conduct plume analysis

2.1 Base Map products for damage assessment

Using GIS, officials can assess damages caused by a disaster and begin to evaluate the consequences in order to take appropriate actions. New York City's Emergency Operations Center (EOC), which was operated by the Mayor's Office of Emergency Management (OEM), had the geographic data, GIS software, and computer hardware they needed for any crisis in a state-of-the-art facility, housed within steel-framed, reinforced exterior walls designed to withstand 200-mile-an-hour winds. The EOC was only three and one-half years old, and was equipped with generators, backup generators, a water supply, and a ventilation system capable of filtering out 99 percent of airborne impurities with uninterruptible power supplies. It was located within walking distance of City Hall and most City agencies, and was designed to operate as a self-contained headquarters in a crisis. However, when the two World Trade Centers collapsed, the building (7 World Trade Center) that housed the EOC had also caught on fire and the building, along with the state-of-the-art equipment and data, had completely burnt down. Hence, at a time when the City needed the EOC's resources the most, those resources had to be regenerated practically from scratch.

Collecting and integrating GIS data for the EOC's mapping was a very complicated and overwhelming task. Data first had to be found and assembled from various departments and agencies, as well as from other government agencies outside the City, and from private vendors. As shown in the following figures, much effort was mad during the first week simply in trying to gather base map data from various organizations and to plot them.

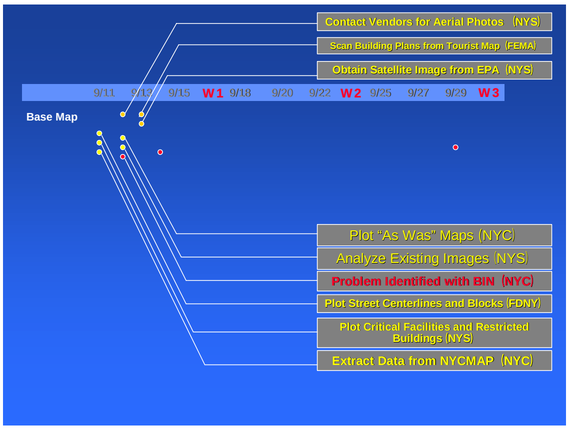

Fig. 1: GIS Related Activities – Base Map 1

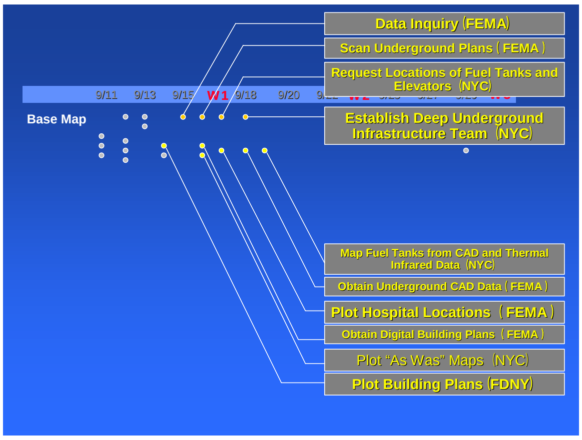

Fig. 2: GIS Related Activities – Base Map 2

During the first several days, the demand for images showing the extent of damages was so great that plotting aerial photographs and satellite images was all mapping center staffers could do to simply keep up with the request for maps. The first maps were based on aerial photographs from the New York State Emergency Management Office and satellite images from Space Imaging, which was the only reliable data available. Simple street maps were also created during the first several days with NYCMAP, the City's first accurate base map.

It is important to note that a problem was identified with building addressing and Building Identification Numbers (BIN) during the first week, causing difficulties in integrating data among various agencies.

Various data and maps were produced during the first two weeks to assess the situation and damages. As shown in Fig. 3 and Fig. 4, these assessments included Safety Map, which indicated unsafe areas that people working in the Ground Zero area had to be aware of; LIDAR based volumetric calculations; and maps showing damaged areas and utility outages.

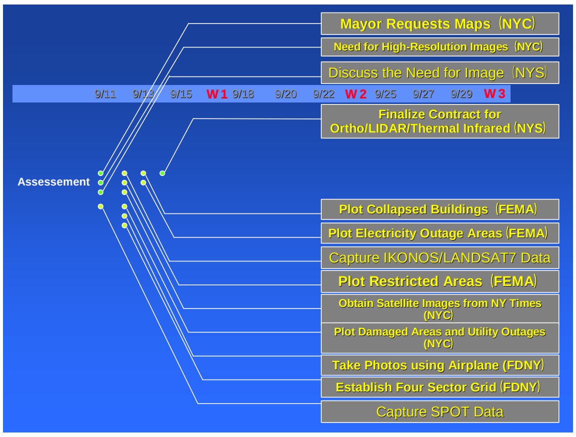

Fig. 3: GIS Related Activities – Damage Assessment 1

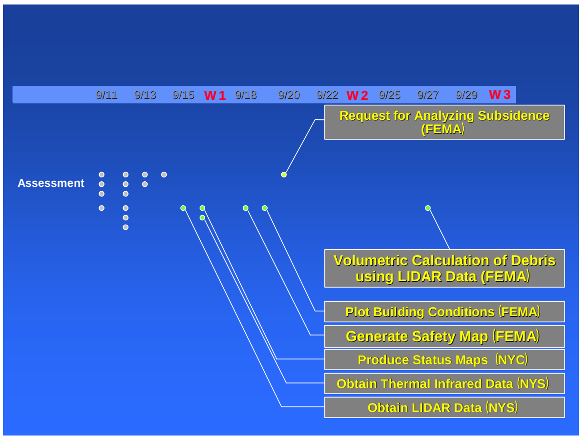

Fig. 4: GIS Related Activities – Damage Assessment 2

2.2 Support for recovery operations and prevention of secondary damage

GIS was also used to help stabilize the situation and reduce the probability of secondary damage (e.g., cordoning off affected areas to prevent further injury, looting, or other problems) as well as to speed up recovery operations (e.g., damage assessment). Hazard data (e.g., fire hazard areas, etc.) was viewed with other map data (e.g., streets, building plans, pipelines, power lines, etc.) to identify potential disaster hot spots. Data also came in from the field: command post locations, vehicle and pedestrian restrictions, utility outages, pedestrian and vehicle access zones, subway and bus line status, and river crossing access. This information was in high demand, and some were updated several times a day. This data became part of a growing list of standard map products, which in turn became a key component for public information, used by Mayor Rudolph Giuliani's office and posted on the New York City Web site.

OEM had implemented the Emergency Management Online Locator System (EMOLS), a Web-based, ArcIMS application that let New York City residents enter an address and see the location of the nearest emergency shelter in the event of some natural disaster such as a hurricane. This capability was easily pivoted, after the attacks, to allow residents to find out whether they lived in a restricted sector and whether they were subject to any utility outages.

Other maps were produced to help with the process of identifying damaged buildings, destroyed buildings, those in danger of collapse, and buildings needing cleanup. Daily updates of these maps were an important resource to provide to both residential and commercial tenants who were shut out of their buildings.

A 75-ft by 75-ft search grid was established to assign search and rescue crews to working areas, record the damage condition, document the findings and the date of discovery, and to track the progress of search and rescue effort. A device that allowed the firefighters to identify and bar code items found on the pile along with time, date and GPS location was used, and the information was compiled and depicted in the GIS database.

Fig. 5: 75-ft by 75-ft Search Grid

2.3 Three-dimensional analysis

Light detection and ranging (LIDAR)-based three-dimensional analysis maps of the debris field at Ground Zero was used to monitor shifts in the debris pile. LIDAR allowed emergency managers to see through the smoke and the debris piled up on top of buildings.

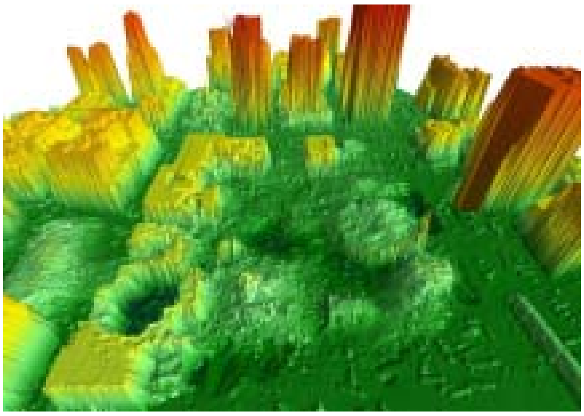

Fig. 6: LIDAR

2.4 Plume analysis

GIS was used to model the plume dispersion in order to track and monitor the effects of dispersal of particles into the atmosphere, and to determine exposure and risk.

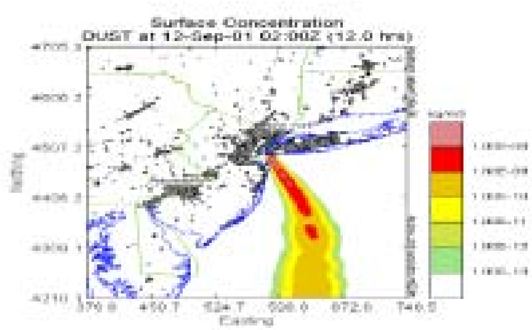

Fig. 7: Plume Analysis

3. Lessons Learned

3.1 Data

The capability to quickly and effectively access data that can minimize damage, and save lives is the key in disasters. The geographic information that organizations have today are the foundation on which to build strategies for a knowledge base that will enable organizations to create, publish, and access geographic and associated datasets for disasters. It is therefore critical to maintain and develop a solid and complete dataset for an effective emergency management.

3.2 Enterprise GIS and Security

GIS resources, and the expertise that builds them, are highly dispersed, so a distributed architecture to facilitate maintenance and sharing is preferable to extensive data replication and the maintenance of massive centralized repositories. Relying on the Internet, or secure Intranets or Extranets, to access data also has the direct advantage of keeping data resources dispersed and therefore potentially less vulnerable to a direct threat.

Devices such as mirror sites, remotely stored backup copies, permanent archiving, and sophisticated firewalls can further enhance security. Leaving these data resources in the hands of those who created them also increases the likelihood that data will be current and of high quality.

3.3 Risk assessment and planning

Disaster events such as terrorist attacks, wildfires, floods, epidemic spread, and hazardous material spills can be modeled and displayed in a GIS prior to an emergency. This will allow agencies to make comprehensive assessments and develop mitigation plans.

GIS can be used for consequence assessment and developing an emergency response plan also by integrating data on the location of schools, neighborhoods, key infrastructures, and emergency personnel. Analysis can identify transportation choke points near bridges or overpasses. GIS can help city and emergency managers plan for different scenarios and types of events and create the action plans needed to deploy personnel, vehicles, heavy equipment, fencing, and other important materials or resources.

3.4 Real-time data collection

GIS can also help manage data in real time, allowing emergency managers to make important decisions. Wireless technology allows for dynamic data exchange from field personnel back to the geodatabase. GIS integrates data on the fly, allowing emergency managers to visualize and analyze events as they unfold. GIS can assist by displaying the locations of emergency resources and tracking ongoing incidents throughout a larger geographic region. Selecting and routing emergency resources, equipment, and supplies can be accomplished using GIS.

GIS Internet applications can allow emergency managers to view the status of incidents, resources, and the overall situation from remote locations using a browser.

GIS can display "real-time monitoring" for an emergency early warning. Remote weather stations can provide current weather indexes based on location and surrounding areas. Wind direction, temperature, and relative humidity can be displayed by the reporting weather station. Wind information is vital in a chemical release or anticipating the direction of wildfire spread upon early report. Air quality, airborne pathogens, environmental health issues, radiation, and so forth, can all be monitored and displayed by location in a GIS. It is also possible to deliver this type of information and geographic display over the Internet for public information or the Intranet for organizational information delivery.

4. Conclusion

The response to the attacks of September 11 has demonstrated the critical role a GIS can play in the event of a disaster, and the significance of having solid geographic datasets. Analysis, preparation, and implementation of strategies will hinge not only on how information is collected and analyzed, but more important, on how it is coordinated and shared. The capability to build on existing data sets in the public and private sector, along with the knowledge and methodologies allows organizations to respond successfully in emergencies, and help reduce the cost and impact on society, and mitigate risk to human life, property, and the environment

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要 旨

ニューヨークでのテロ事件後GISが使われた主な目的はオーバレイ機能による迅速な状況把握、救援作業のサポートまた二次災害防止、3次元データによる視覚化･容積解析、及びプルーム･モデルによる空間解析の四つの点に集約される。ニューヨークで使用されたGIS分析の殆どはオーバレイ機能であった。有効にオーバレイ機能を行うには、充実した基図が

整備されている事が必須条件である。

キーワード: WTC, 9/11, 緊急対応, ニューヨークテロ事件, GIS

A-01

9・11 米国同時多発テロ事件における GIS の活用

○吉富　望

1．はじめに

災害が一度発生すると数多くの問題を同時に処理し、分析しなければばいけない。またそれと同時に、全てのもの、全ての命は救う事ができないという極めて厳しい現実に直面する事になる。僅か数秒という時間が人の生死を左右する中にあって、災害対応に携わる人々は複雑な問題を同時に扱い、また的確な判断を瞬時に下さねばならない緊迫した状況下に身を置くのである。GIS（地理情報システム）はそのような状況下で様々な問題を整理し、災害に対応する人々が正確な判断を下す事ができるフレームワークを提供する。

GIS は意思決定をいち早く行える環境を効果的に提供するツールとして、長年にわたって世界中の防災関係者の間で評価されてきた経緯がある。その有効性を多大に実証した事例として 2001 年に起こった 9・11 米国同時多発テロ事件がある。ニューヨーク世界貿易センターでの応急対応、また復旧・復興作業において GIS は必要不可欠なツールとして様々な役割を担い、ニューヨーク市や米国連邦緊急事態管理庁(FEMA)などを始め、多数の関連組織で使用された。テロ事件発生後、GIS の必要性や費用対効果に対する疑問の声がニューヨーク市では全く聞かれなくなったと言われているが、GIS が実際にどのように使用され、またその体験から何を学んだのかを明らかにして、今後の危機管理分野における GIS の活用について考えてみたい。

2．テロ事件における GIS の活用と今後の課題

ニューヨークでのテロ事件後 GIS が使われた主な目的は以下の四つの点に集約される。

1. オーバレイ機能による迅速な状況把握
2. 救援作業のサポートまた二次災害防止
3. 3 次元データによる視覚化・容積解析
4. プルーム・モデルによる空間解析

オーバレイ機能とは GIS に取り入れた複数のレイヤーを重ね合わせることにより、同一空間上における異なる情報・要因を相互間の空間的関係を基に比較、参照、また抽出する基本的な機能である。ニューヨークで使用された GIS 分析の殆どがこのオーバレイ機能であった。有効にオーバレイ機能を行うには、充実した基図が整備されている事が必須条件である。今後の課題として我々は既存の基図を整理するだけではなく、災害時において必要となるデータを注意深く検討し、基図として含むべきデータを見直す必要がある。特に、インフラ、ライフライン、地下鉄や地下街などの地下構造、また公共交通機関のネットワークなど、都市機能を支える基盤となるデータは、その有無の確認のみならず、精度、互換性、アクセス権限を明確にし、また異なる組織が使用可能な仕組みを構築する必要がある。

GIS は救援作業のサポートや二次災害防止において、救援隊員の作業エリアの割り当て、災害状況や危険物の有無に関する分析、また救援作業の進行状況や発見物・遺体などを記録するために利用された。ニューヨークの場合、75ft x 75ft の正方形からなるグリッドを被災地全域に規定し作業の効率化を図った。グリッドを用いた理由としては、一定の場所を従来の住所体系を用いて特定する事が被災地では極めて困難であることが挙げられる。現場での作業員から意思決定に携わる管理職まで、災害に対応する全ての人や組織が即座に理解でき、また伝達不良などを回避するための仕組みとしも、位置特定のための手法を事前に確立する事は極めて重要である。更に、危険物などを扱う施設は二次災害を防止するために、危険物の内容、保管場所、またそれが人体に及ぼす影響などの情報を事前にデータ化する必要がある。それに伴い、情報の所有権を保護する法的な手続き、またデータの独自仕様などに対応できる技術的な基盤も整備する必要がある。ニューヨークでは LIDAR（3 次元データ取得のための技術）や熱センサーを搭載した飛行機などを用いて上空からのデータも毎日取得されたが、測量会社などの民間企業との協議及び契約等を事前に行える制度も検討しなければばいけない。最後に、災害のサイクルを通して利用できる空間解析のモデルの整理や開発もまた重要な課題である。