Who, What, When, and Where in the Construction Industry

Abstract

Who, What, When, and Where are the questions that a reporter answers, and also the essential pieces of information supporting safe and effective construction work sites, and a good way to keep the owner of the site advised of progress and other issues.

In the construction industry, a Supervisor may need to know when and where to schedule crane services or how to react to personnel casualty. Consulting Engineers may need to understand an unexpected impediment to work. The Owners may need to see the job in summary so that they understand what has been accomplished.

This paper addresses a temporal and spatial information system that facilitates visualization and understanding of the construction environment and the project in near real-time via the web. It is of value for job planning and monitoring; and for cataloging, retrieving, and viewing the data and information (video, voice, images, sonar, text, and …) pertinent to the job.

Introduction

As kids, finishing breakfast on a summer morning in 1964, there were some very important questions that needed to be answered:

What will the day look like?
Where are my friends?
Where are our bikes, lacrosse sticks, and other things we would need for the day's activities?
and
What do we want to do and where shall we do it?

Then when we all congregated at our hang-out, we had to get in a full day of play before heading home for dinner with Dad and Mom and the rest of the family.

In July 2004 as adults, not much has changed. Breakfast still includes an orange and, although seemingly more complicated, play (a.k.a. work) is still play. It needs to be thought through, accomplished efficiently and safely, and it should be archived so that the people who made it all possible can hear about it later.

Back in the day, we listened to the radio for the weather, got together on the lawn, decided what to do, maybe checked a map, grabbed our bikes and some stuff and off we went. During the day we kept an eye to the sky and one occasionally on the clock. Memories were made to be talked about.

Today, we have some neat tools to use as we navigate our day and record our activities and findings. We use these same tools to get a quick start on the next day's work and also to tell our friends and partners what we have been up too.

The Temporal and Spatial Information System

Ambiente (the Environment) is a temporal and spatial information system implemented to facilitate data and information integration for nearly immediate viewing. It leads one to a fused characterization of a geographic location and also conveys the time varying aspects of that location. Classic geospatial data such as terrain, hydrography, and cultural features form the stage on which weather, water, people, vehicles, and all other things move or may be anticipated to move. Ambiente facilitates a view of this dynamic stage as time marches on. Ambiente also catalogs the temporal and spatial information so that it may be used again in a post analysis of data and events.

Some of the specific types of data that may facilitate a view of the civil engineering and construction industry are considered to be in three categories:

1. Data and Information that may form a view of the geospatial background, also called Foundation Data and Information:
   - Land and Water Characteristics (terrain elevation data, ground/soil composition, land cover or land use information, water resources (lakes, rivers, and streams), etc.).
   - Infrastructure (roads, bridges, water and sewage lines, storm drains, utility and telephone cable runs, buildings, etc.).
   - Named Infrastructure of significance to the audience viewing the stage (named buildings, loading docks, job sites and layout facilities, portions of the infrastructure that are the job, etc.).
   - Orienting Environment. These are the climatological weather and harbor/near shore water conditions (average monthly or seasonal views).
   - Orienting Imagery. These are the types of imagery which provide a visual context to the slowly changing geospatial background data noted above. These may be overhead images of a feature or large area or other pictures of a feature or a vista.
   - Orienting Information. These are information such as newspapers, brochures, and other types of documents which provide important information about the background area and/or features.

2. Data and Information that may form a view of the dynamic background:
   - Dynamic Environment. These are the weather (current conditions and forecasts, and climatology) and harbor/nearshore water conditions. This type of data refers to near real-time observations such as: point weather and water level reports, weather satellite and radar imagery, and numerical analyses and forecasts.
   - Dynamic Orienting Imagery. These are the types of imagery which provide a visual context to the dynamic aspects of the area. This may include a seasonal or daily view (snapshot) of the area or specific locations.

3. Data and Information that may form a view of the dynamic operations:
   - Operational Elements. These are the people and the equipment involved in the job. It is also the data and information that they generate as a part of the job.
   - Other Considerations. These are the other moment to moment factors which may influence the progress of the job and those that should be captured for post analysis. Some of these dynamic factors may be reports of road closures, traffic camera views, and reports, and/or derived models of flooding or disruptive weather (i.e. winds or lightning).

Others examples may include video and still images of the job. Also, the expert information provided by workers and supervisors on the job are an important piece to capture..

The result of the data and information fusion in Ambiente is an omniscient, bird's-eye view of the job to support information flow and access. This user-friendly fusion of data also enhances decision-making and the real-time reaction to events that leads to safe and effective construction work sites. It is also good way to keep corporate managers and the owner of the job advised of progress and other issues concerning the job. Archived in an easy to retrieve scheme, it also provides the deliverable for the owner that describes the job and highlights important data and information.

In disseminating this data and information on the job, it is valuable to have it via Internet, accessible and viewed via a standard web browser. Any authorized users may view the job either from home, the office, or on-site. By using a portable computer or a tablet PC with a wireless phone card, it is possible to view the job from almost anywhere.

An Architecture for Ambiente

The high-level architecture for Ambiente as it may be implemented by a small business consists of virtual data and information (meaning established and maintained by the data steward and sourced from the stewards); source mining and access tools; format, datum, and projection tools; temporary storage for use; user catalog tools; user access tools; dissemination networks; and the visualization tool for the user. Each of these categories may be considered a segment of the larger system. Figure 1 demonstrates the conceptual framework.

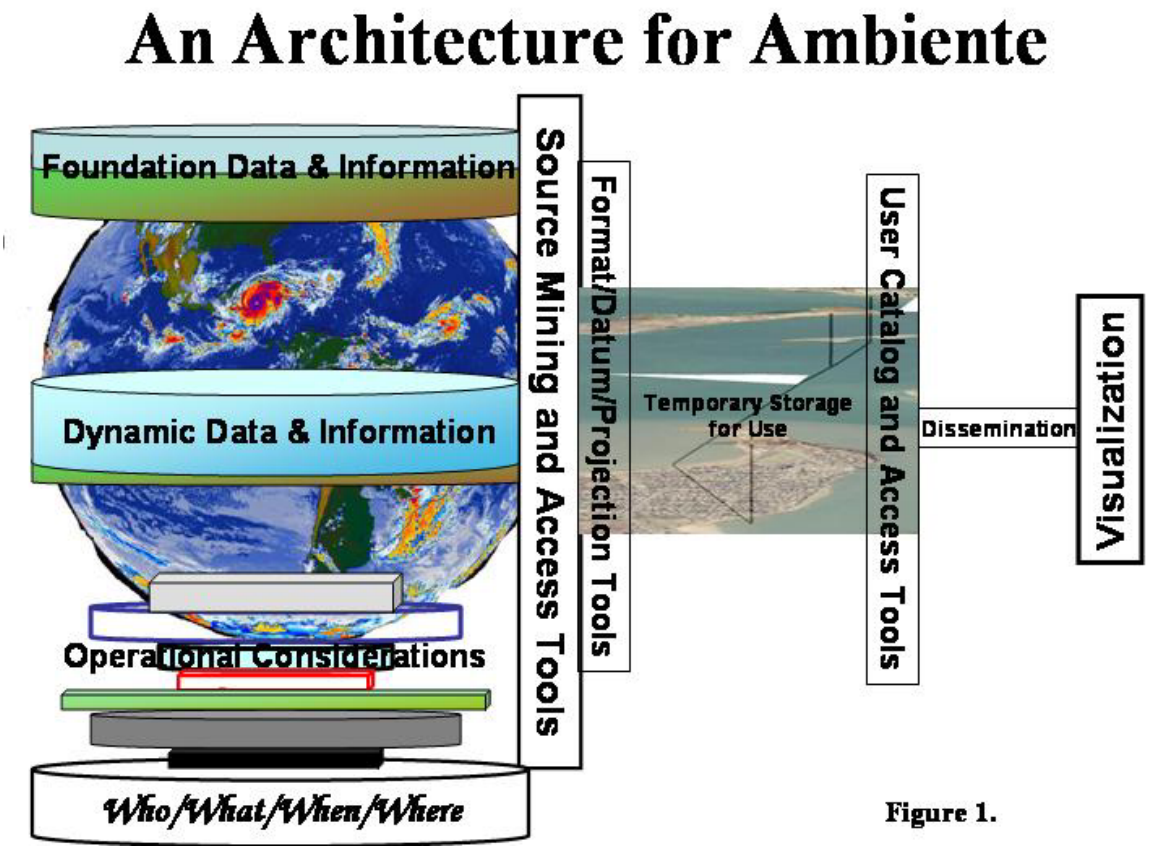


Figure 1.

A recent implementation of the Data and Information Segment for a sewer inspection project in Austin, TX included:

- image and geographic infrastructure data from the US Geological Survey (USGS) and State of Texas
- real-time and modeled environmental data from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), NOAA National Environmental Satellite Data and Information Service (NESDIS), USGS, and the State of Texas
- local area road condition bulletins from TV and radio news stations
- other information deemed significant to operating personnel.

The Mining and Access and the Format/Datum/Projection Segments for this project were a set of manual activities and custom automated scripts that prepared the data for temporary storage (facilitated in a WAN that included the Internet). The Temporary Storage Segment was based primarily in the ESRI family of ArcGIS products. The Visualization Segment was a web-based portal consisting of an ArcIMS interface embedded into a distributed access webpage.

An Implementation of Ambiente for Civil Engineering and Construction

For a civil engineering and construction industry implementation, Ambiente may be set-up to support job planning, people and resource tracking, and to capture and catalog job related information and data. It functions as a resource tracking and visualization tool for the individuals involved with day-to-day operations and as a planning, event, and data capture and cataloging tool to build deliverables for the customer.

This type of implementation allows for the essential pieces of information to be contained in a simple web portal (Figure 2). Included in the data and information stream may be lists of emergency and routine phone numbers, company policy and procedure documentation, local (and home base) news reports and other items of interest, equipment and personnel records, equipment and job order forms with links to tracking reports, area maps and address locators, the foundation feature data of the area, orienting imagery, dynamic weather analyses and forecasts and person and equipment locating data.

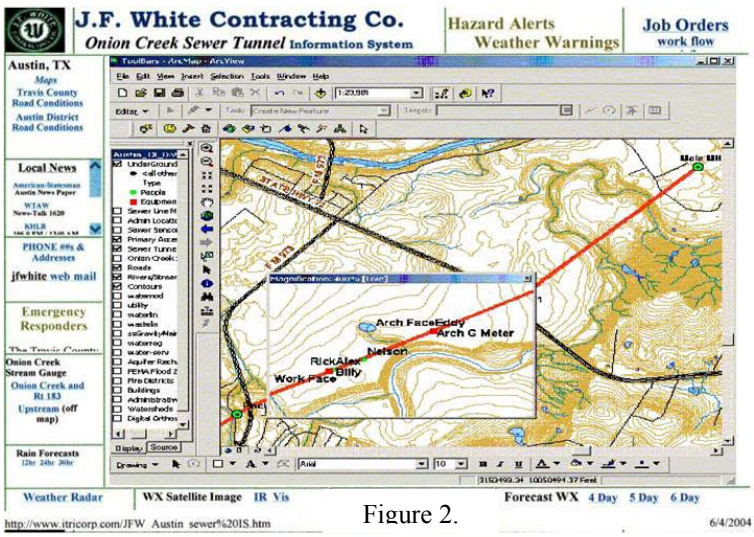


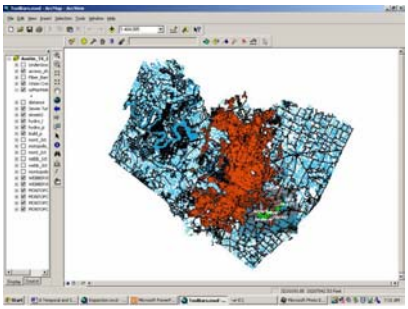
Figure 2.

This portal is available as an internet resource and may be updated by an operator interfacing the Ambiente application or by a person providing type and location information by voice communication with the operator or in an automated mode which is implemented in a web-enabled phone, very small personal computing device, and/or personal computer. Additionally,

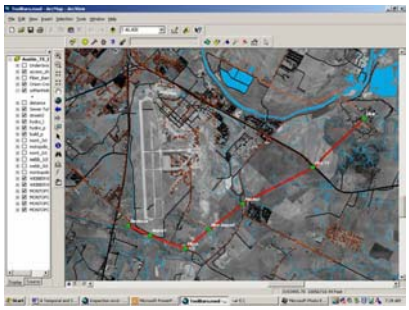
data and information in the form of text, photographs, voice reporting, and video and sonar data may become part of the temporal and spatial data and information holdings.

Using the System

The initial set-up of the system is no different than any set-up of a geographic information



system. Based on the job location and the geographic expanse of the job area of interest, the system operator and job supervisor determine the geographic area and the pertinent foundation and dynamic data types. The operator then locates all



available data resources and then builds and loads the relevant layers and the geographic scene.

Next, the system operator, by interacting with a custom toolbar designed to operate with the GIS,

will access a database and set-up job-specific information. This will include persons (name, job description and special qualifications) and significant resources and equipment (including serial numbers) on the job along with job-related geographic site locations. During the job, the operator may re-enter the database to add, remove, or edit people, resources, or locations in the job-specific database.

The system is now ready to log significant events; map people, equipment, and significant features; and link to the data or information about that feature as they occur. In the view depicted by Figure 3, an operator is tracking the work-face location in a sewer tunnel (red line feature) and the locations of the personnel working in the sewer tunnel (see magnification). To the left of the geographic depiction are continuously-updated, real-time O2, H2S, CO, and LEL (explosive gas) measurements that are observed at the work-face by an instrument mounted at the work-face and interfaced via the temporal and spatial GIS.

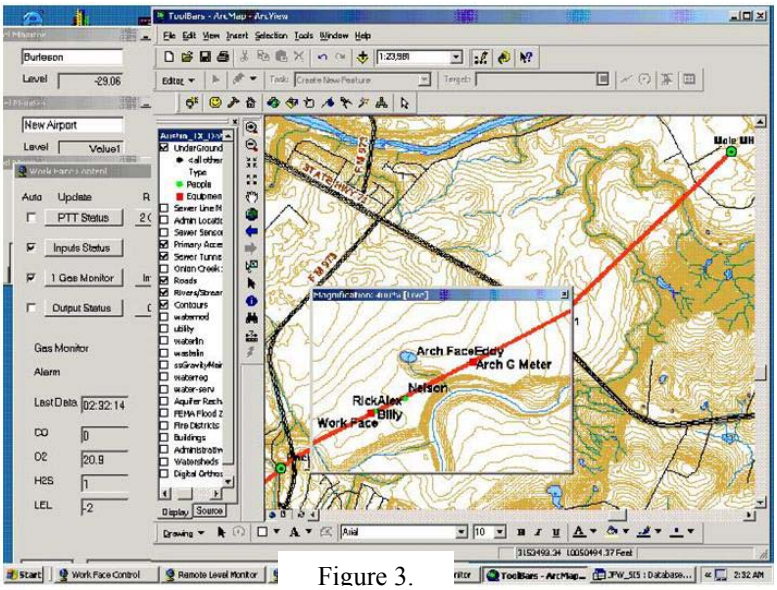


Figure 3.

If the system will be used to record and map the data and findings of an inspection, additional inspection related information are added to the job database. These include the types of inspection data (video, sonar, text, pictures) and standard phrases that an inspector may use to call attention to a feature of interest. When used in the Inspection Mode one of the deliverables to the customer may be map of the infrastructure that is annotated with labeled icons that indicate

comments and the supporting data at the location of the notation. When the user opens the icon it takes them to the data (see figure 4). In the Inspection Mode view the operator (may be a client or the owner of the infrastructure) is reviewing the data and information collected during an inspection. The person has opened the data (in this case a photograph) associated with an icon that indicated a significant feature found during the inspection.

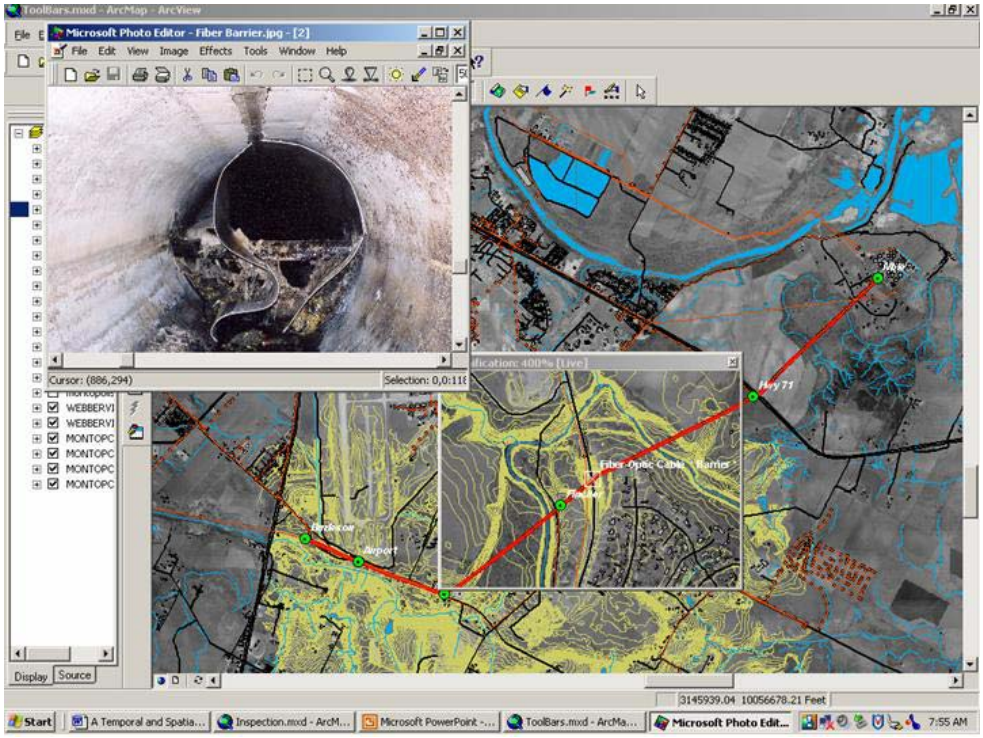


Figure 4.

Use Case/Conclusion

In November 2002, the Vice President of J.F. White Contracting Company's Diving Services Division asked for an automated way to keep track of who was beneath the surface and where they were so that if something happened, the dive supervisor would have a better picture of the event and thus could respond quickly and effectively. Itri Corporation modified a version of Ambiente that was being developed for an agricultural application and the first version of the J.F. White Job-Site and Inspection Information System (JSIIS) was implemented as a safety tool for construction diving shift supervisors.

In 2003, the City of Austin, Texas awarded J.F. White Contracting Company under direction of the Diving Services Division a contract to remove dislodged Schlegel liner (plastic tunnel liner) which threatened to completely block the Onion Creek wastewater tunnel. City officials declared the liner removal to be an emergency project and established an independent review committee to evaluate proposals submitted by the three lowest bidders. J.F. White did not offer the lowest bid price but developed the most comprehensive safety program and most effective procedures for this tunnel work.

The Onion Creek job included:

- Manned entry into the sewer tunnel to investigate the potential cause of the blockage in the system and to gain more detailed knowledge of the tunnel.
- Design, fabrication, and installation of a forty-foot high bulkhead and sewage bypass pumping system.
- Removal of approximately five miles of Schlegal liner and various types of debris in the tunnel.
- Remediation of tunnel wall defects.
- Final inspection by the consulting engineer of the five mile stretch of sewer tunnel for the City of Austin.

During May-July 2003, JSIIS tied to a fiber optic line installed in the tunnel and was used to monitor personnel and equipment to ensure safety and track job progress.

The job was completed without incident and by the early completion date. J.F. White's excellence in design, safety, and project performance provided the client an effective solution for extreme confined space penetrations. In their post report of the job to company stakeholders, J.F. White stated the following highlights:

- Bypass pumped 32 million gallons of wastewater per day.
- Installed fiber optic controls and safety system.
- Utilized GIS for monitoring personnel and inspection data.
- Achieved early completion goal without safety incidents.

Acknowledgments

The author acknowledges the vision of Mr. James Clark, Vice President, Diving Services Division, JF White Contracting Company. Mr. Clark, a believer in applying emerging technologies to solve difficult problems, quickly understood the value of a temporal and spatial information system applied as a tool to increase the effectiveness of job site supervisors and in keeping his people safe on-the-job.

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