Real time hazard triage: how GIS and mobile computers can help save homes

J. J. Coil
Sedona Fire District, Sedona, Arizona, United States of America

Abstract

The Complete Hazard Assessment Reporting System (CHARS) can be the most valuable piece of technology available to the fire manager. CHARS can also assist the Fire Chief in protecting and improving the survivability of homes and other structures in the wildland urban interface. This system uses ArcGIS, a mobile field computer, database, and Active Server Page to create a living document from all at-risk sectors of a community. Armed with this tool, fire managers will be able to more effectively assess risks to a community and infrastructure, establish specific mitigation/protection plans, identify and evacuate at-risk populations, and safely and quickly direct suppression and rescue efforts.

CHARS will enable the fire protection agency to build a database with input from the private homeowner, fire department personnel, and other public entities. With this system homeowners can advise the fire department of improvements they have made to their property and view their individual and community hazard assessment. The fire fighters can access and update data over the Internet, through mobile computer terminals, from a laptop hard drive, or through a network for preplanning and fire fighting. An Incident command team can use the previously collected information as a valuable visual aid in familiarizing themselves with the values threatened or for strategic planning. They can also use CHARS to build upon the information collected during preplanning. Or, if they are assigned to an incident with no previous home site or infrastructure assessment, they can complete these and have them added to a map in a fraction of the time.

Main Paper

The hazard most commonly faced by incident management teams (IMTs) and the one that may benefit the most from the rapid and accurate collection of critical information and our ability to display it on a map is wildland fire. The need for timely and accurate information about the defensibility of structures within a community threatened by wildfire cannot be overstated. The ability to safely and quickly deploy limited suppression resources effectively, disengage to a safe location when necessary, and reenter effected areas to continue with suppression efforts may make the difference in the number of homes lost or saved. Knowing the roof classification, the availability of defensible space, building construction, hazard materials present, potential effectiveness of mitigation measures, and the ability to locate and access threatened structures with the appropriate equipment and resources is essential to reducing the risk to the firefighters and public. Information regarding the locations and access to structures, their particular attributes, and having that information displayed on a map accurately and timely is crucial. Armed with the information gathered and displayed on a map, those responsible for tactical decisions can better determine the most effective use of resources, the location of safety zones, water sources, and other information critical to the suppression effort.

The Complete Hazard Assessment Reporting System (CHARS) can be the most valuable piece of technology available to the fire manager. CHARS can also assist the Fire Chief in protecting and improving the survivability of homes and other structures in the wildland urban interface. This system uses ArcGIS, a mobile field computer, database, and an active server page to create a living document from all at-risk sectors of a community. Using CHARS, the fire managers will be able to more effectively assess risks to a community and infrastructure, establish specific mitigation/protection plans, identify and evacuate at-risk populations, and safely and timely direct suppression and rescue efforts.

CHARS will enable the fire protection agency to build a database with input from the private homeowner, fire department personnel, and other public entities. With this system homeowners can advise the fire department of risk reducing steps they have taken on their property and view their individual and community hazard assessment. The firefighters can access and update data over the Internet, through mobile computer terminals, from a laptop, desktop PC, or through a network for preplanning and firefighting. An incident command team can use the previously collected information as a valuable visual aid in familiarizing themselves with the values threatened or for strategic planning. Or, if the IMT is assigned to an incident with no previous home site or infrastructure assessment, the team can complete the home site assessments and have them added to a map in a fraction of the time. Without adequate preplanning of hazards and values at within a community, we cannot ensure that the best strategic and tactical decisions have been made.

Intelligence gathering is an essential part of any wildfire response, and the ability to gather accurate, concise intelligence on an incident is the purpose of the Complete Hazard Assessment and Recording system (CHARS). CHARS was initially designed specifically for wildfire preplanning and response but has developed into a true multi-hazard triage tool that can increase the effectiveness of any agency's response. Simply put, CHARS is a force multiplier. It increases safety and productivity and potentially reduces the dollar loss by more effectively utilizing information from different locations and quickly gathering additional information specific to the threat currently being encountered.

As with any intelligence gathering effort, the first step is to determine what type of information must be gathered. By working with the individual agencies to design custom forms specific to their need, CHARS can adapt to a multitude of different individual agency needs. The form illustrated below was used to develop the computerized form for the Sedona Fire District to use in the pre-fire planning and triaging of structures within the urban interface. Forms also exist for post-incident damage assessments, infrastructure vulnerability assessments, swiftwater hazard identification, and hurricane vulnerability, or any other threat.

1. Street signs and Address numbering
    a. Present 1___
    b. Not Present 10___
2. Ingress/Egress
    a. Two or more Primary Roads 1___
    b. One road, turn around possible 3___

c. One way in, one way out 5___

3. Width of Primary Road
   a. 20 feet or more 1___
   b. Less than 20 feet 3___
4. Accessibility
   a. Road grade 5% or less 1___
   b. Road grade more than 5% 3___
5. Fuel types within 100 feet of residence
   a. Light (Fuel Model 1,2,3,8) 1___
   b. Medium (Fuel Model 5,6,9) 5___
   c. Heavy (Fuel Model 4 or 10) 10___
6. Predominant Slope
   a. 8% or Less 1___
   b. More than 8% but less than 20% 4___
   c. More than 20% but less than 30% 7___
   d. 30% or more. 10___
7. Roofing Material
   a. Noncombustible (Tile, Metal) 1___
   b. Combustible (Asphalt Shingle, Rolled Roofing) 5___
   c. Non-rated (Untreated shake shingles) 10___
8. Building Construction Material
   a. Non Combustible siding and deck 1___
   b. Non Combustible siding/combustible deck 5___
   c. Combustible siding and deck. 10___
9. Utilities (electric and gas)
   a. All underground utilities 1___
   b. One above/one underground 3___
   c. All above ground 5___
10. Additional Corrections
   a. Fuel on or under deck 2___
   b. Branches within 10 feet of roof 5___
   c. Continuous vegetation within 30 feet of structure 5___
   d. Non-maintained wood siding or deck 5___
   e. No screens on vents or chimneys 2___
   f. Propane tank/ heating oil within 20 feet of structure 5___
   g. Woodpile within 20feet of structure 5___
11. Livestock Present (Circle One) Yes No

Low Hazard 1-39_____ High Hazard 60-74 _____
Moderate Hazard 40-59_____ Extreme Hazard 75+_____

When the form is created, it is loaded onto a GPS enabled mobile computer such as Trimble's GeoXT. The Trimble GeoXT has proven itself a valuable and effective platform for the rapid mapping of hazards, improvements, or structures. With its sub-meter accuracy GPS, rugged housing and daylight readable touch screen, the GeoXT is well suited for the rigors of field use. ESRI's ArcPad is loaded into the GeoXT along with any other information about the area to be

triaged. This usually includes roads, water sources, and political boundaries. Instruction is then provided to the crews collecting the information. Individuals with some computer knowledge can be ready to begin triaging structures in an hour.

This method of triaging has a number of advantages over filling out paper forms including:

1. **Speed**: The average structure protection specialist can complete about 100-200 structure triages in a 12-hour operational period.
2. **Accuracy**: Since the information is stored in the memory of the mobile computer and downloaded at the fire station or base camp, the chances for error are greatly reduced. When using a paper form and a standard GPS, the coordinates must be read from the GPS, transferred to the form, and then transferred back to a spreadsheet if the information is to be displayed on a map. These accuracy problems are in addition to the potential for errors when different GPS systems are set to different map datum or coordinate systems.

3. **Display of information**: With Geographical Information System (GIS) quickly becoming the method of choice for fire agencies to analyze and present data, compatibility and standardization are paramount. CHARS utilizes ESRI products to gather and display the information. In October 2001, ESRI received a blanket purchasing agreement for the U.S. Department of Agriculture. ESRI soon entered into a similar agreement with the U.S. Department of Interior. Through these agreements ESRI has provided these agencies with more product for their money and ensured that they will be the standard for GIS within the federal government, thereby enabling data from different private and government sources to be used. To assure the pressing need for standardization of efficient and accurate geospatial information is met, CHARS is using ESRI products. For instance, last year on the Biscuit Fire, we triaged the area around Galice in the Rogue River Valley. During the home site assessments, residents were asked if they planned to leave in the event of an evacuation order. Their response was noted on the form along with the number and type of onsite livestock. This information was then projected onto a map allowing logistics to easily determine resources necessary to remove the livestock from the area if the fire reached our evacuation trigger points.
4. **Data maintenance**: After determining the location of the structures using GPS enabled hardware such as Trimble GeoXT ($5,000), a pocket PC ($600) can maintain the data cost effectively. A pocket PC such as a Compaq Ipaq can be loaded with all of the structure and road information allowing the individual responsible for data maintenance to use dead reckoning in locating the homes. This allows for about an 80 percent savings over buying additional GeoXT's for data maintenance. Of course, with the addition of new structures or improvements it will be necessary to locate them using a GPS.

After initial instruction, the crews fielded to conduct home site triage are given a pin based mapping system to begin data collection gathered for that area, county, state, and local government and possible local utility companies. The crew would also carry a number of other items to aid in the collection and to receive "buy in" from the public. A typical data collection packet would contain the following assessment tools plus other items to gain public "buy in":

1. Pin-based mapping system with proper application and step-by-step instruction and troubleshooting guide
2. Handouts explaining how the project can benefit the public and what "your fire department" will be doing with the information collected. This should also include the dates/locations of Firewise workshops and cleanups planned for the neighborhood along with a statement explaining what other agencies will be doing to assist with the problems, an example being the Forest Service planning to perform mechanical thinning or prescribed fire on federal land adjacent to the private property.
3. Handouts explaining Firewise landscaping, the historical role of fire in a particular ecosystem, and how homeowners can update their triage rating by providing input over Internet to their fire department. This information would be used to update their triage rating and track how much time the homeowner spent to make those improvements. This information could be validated and, with the homeowner's permission, could also be used to provide the funds necessary for grants requiring a dollar match.
4. Digital Camera
5. Consideration should be given to the fact that some seasonal residents may not be home at the time of the triage. A method of notifying the homeowner of the above information should be developed providing them with the necessary information. This method must be safely designed so as not to advertise to potential criminals that the house is unoccupied.
6. Any other case specific information to aid the homeowner in understanding the importance of completing corrective action. An example would be information about the beetle infestation/drought problem the southwest is facing and the proper method to identify and remove infected trees.
7. A list of contractors in the area who can be contacted to complete the necessary work if the homeowner wishes to pay to have the work done.

After the data collection is complete, the information will be incorporated into a GIS map. A form showing the total hazard rating, suggestions on corrective action, links to Firewise on the department's website, and an additional reminder about Firewise meeting and cleanup dates will be provided to the homeowners. Any digital photos would also be included in this document. Digital photos would be used to locate obscure utilities, water transfer switching or valving, and difficult access/egress. From this HTML document, the digital photos could be accessed by a simple mouse click.

Other types of preplanning data to be collected could include helispots, helicopter dip sites, drafting locations, safety zones, areas in which fixed wing or rotary aircraft would be ineffective for suppression, established locations where the public could shelter in the event of a fire. All of these items could be marked onto the map and would have separate applications developed for recording the necessary data. Also, if an agency has mobile computer terminals (MCT) in the apparatus, this information could be converted into an HTML format and stored on the MCTs. This would minimize the special training necessary to retrieve such data in the event of an incident. If the product were placed on the MCT in an ArcView format, then whoever retrieved

the data would need the expertise in ArcView. The chances of the data being used in the event of an incident increase by minimizing the special computer training necessary to retrieve it.

Once a fire department has completed the triage and provided the information to the public, the homeowner, fire department, or whoever else may have pertinent information, can update the database.

The following are examples of typical information that can be displayed on the map:

1. Roof classification—shake shingle, class A, B, C
2. Access—type of engine able to access residence (type 1-6/4x4)
3. Signage—home visibly addressed
4. Special hazards—above ground power/propane
5. Livestock—number and type
6. Building construction type—wood frame/log/non-combustible
7. Additional considerations
    - Inadequate defensible space
    - Wood pile 20 feet
    - Open eves/no screens on vents
    - Fuel model at interface
    - Spark arrester on chimney
    - Branches overhanging roof
8. Another benefit this system provides is the ability to quickly determine and display if a homes hazard rating could be reduced with fuels reduction effort. If a home is a high hazard based on its location and construction type then sending crews to that location to do work would be useless.

With CHARS a form can be customized dependent upon the needs of the agency and hazard presented or preplanned. These sources include both public and private entities. Utility companies can provide information on buildings with active accounts, most likely occupied. County assessors or building departments can provide parcel data to assist with locating homes in rural areas. Access, bridge ratings, vegetation types, water source, and street locations can also be incorporated into the system. If this system is first utilized during an incident, the depth and scope of the initial data collection may be dictated by fire behavior and spread. If the system is in place prior to a wildfire threatening the urban interface, it can provide a greater degree of utility. This type of preplanning could be used to show progress on fuels reduction efforts within the interface and identify residents who have taken steps to reduce their risk. If grants are available, this information can also be used to illustrate the need for funding for fuels reductions, Firewise education, or additional staffing.

Data can then be stored, accessed, and updated from a variety of locations determinable upon a mitigation prevention effort or during and actual incident. For example, if the CHARS system were in place, the information would most likely be stored in a database at a central server location, thus accommodating and inviting all users to contribute information and reap each other's benefits. Again, the system is designed to be a living document with each person collecting data or reporting to the system stores and updates information in an ongoing process, ensuring current data availability 24/7/365.

If the data collection is taking place at an incident, then the information would most likely be stored on a laptop PC, provided to the planning section, and transferred to the effected agencies at the incident's conclusion. This would allow the effected community, who may not have had any ongoing mitigation efforts, to build upon the work of the IMT. The primary purpose of the intelligence gathering efforts of the structure protection components of the IMT is to prevent or minimize structure damage associated with the incident. An extension of that responsibility is to make every reasonable effort to assist the effected communities in laying the foundation for a comprehensive hazard reduction effort. With CHARS this effort would not only relate to the hazard they are currently facing but would also be expanded to include the potential hazards. It is obvious this system's implementation well before the incident's onset would provide the greatest benefit, allowing for the necessary mitigation efforts to be identified and realized prior to wildland fire threatening the community. However, if that were not possible, the ability to provide a community with a foundation for future fuels reduction, road improvement, water system upgrade, or similar necessary changes would likely be of great benefit to all parties involved. This groundwork allows the policy makers and community leaders to capitalize on the heightened awareness generated by the incident.

Regardless of the method or timing for implementation, the information can benefit numerous entities.

1. Homeowners benefits: Through an interactive website the homeowner can view his hazard rating and those of his neighbors. The homeowner can also access his risk assessment to see what he can do to decrease a potential threat(s) to his home. Information on Firewise landscaping and construction techniques would also be available at this location. After the work is completed, the homeowner could report the changes back to the fire department via the website and in some situations could provide the fire department with the necessary information to use the homeowner's property improvement as in-kind funding for matching grants.
2. Operations: During an incident those responsible for making critical operations decisions would benefit by having accurate, timely data catered to the needs of the incident or the specific hazard being mitigated.
3. Local agencies: The information collected can be used as the foundation for grant request and can be used to prioritize fuels reduction within the wildland urban interface. Furthermore, the more accurate maps and information on home locations can be beneficial during other calls for assistance.

It is important to recognize that the CHARS system is only one piece of the overall picture. If an incident is not appropriately staffed with qualified personnel, necessary equipment, and needed support, then rapid, accurate gathering of critical intelligence will not change the outcome. Thomas Jefferson said, "Plans are useless but planning is essential." This statement illustrates the urgency of having a plan that does not just exist on paper as a snapshot of a moment in the past, but one that is capable of providing operational personnel with the most current intelligence possible.