Regarding the:

Public Hearing in the Matter of the Issues on Emergency Medical Services Helicopter Operational Safety;

and

In support of the National Search and Rescue Committee's (NSARC) standardization of position information during Catastrophic Incident Search and Rescue (SAR) Operations;

The following information is provided.

ISSUES

1. Earth referenced coordinates should be harnessed on a consistent, nationwide basis as a supplement to street addresses in ground transportation and public safety operations.
2. How should diverse aeronautical and land based emergency responders effectively utilize positional information from external sources (the general public, other agencies, [both non-emergency and emergency], etc.) and communicate that position information accurately, effectively, and efficiently to first responders in forms they can understand and use?
3. This paper is a response to the Public Hearing concerning Helicopter safety during emergency response operations and identifies the issues that must be addressed concerning the use of Earth reference coordinates for emergency responders.

USE OF EARTH REFERENCE COORDINATES FOR PUBLIC SAFETY

Tangential and relevant to the NTSB study on Emergency Medical Services Helicopter Operations Safety is the issue of harnessing Earth reference coordinates in public safety and transportation in general. The use of Earth referenced coordinates – latitude and longitude in the case of aviation and maritime transportation industries - is a routine and well established convention in those industries.

Similar use of Earth reference coordinates in a standard and systematic manner is not the case in United States ground transportation and public safety.

One example of the problem is the September 2008 Search and Rescue (SAR) response to the crash of a Maryland State Police helicopter on an emergency medical services mission. The helicopter apparently had little problem locating the automobile accident site where its medical evacuation services were needed – navigating by what ever means until sighting the flashing lights of emergency vehicles on the ground. However, when the helicopter itself experienced an emergency, an inordinate amount of time passed before emergency responders on the ground were able to locate the crash site and assist the one survivor.

In that event, which resulted in several fatalities, one very seriously injured survivor remained without help for an extended length of time until found. This occurred in spite of the fact that the helicopter's flight had been monitored continuously, its last position was accurately known to a high degree of accuracy (on order of meters), and that position was provided to emergency responders reasonably quickly.

Even though the position information was provided in precise Earth referenced coordinates, the emergency responders were unable to correctly interpret or exploit the information, thereby substantially delaying the response.

A study of this issue will show that the systemic problem did not lie with the individuals using the coordinates that day – but with implementation of public safety policies in the United States surrounding the use of Earth reference coordinates.

STREET SIGNS?

An investigation would in all probability find that almost no-where in the United States does ground transportation or public safety (i.e. 9-1-1) operations exploit Earth referenced coordinates in a *nationally systematic manner* as a critical information resource. *The issue is cultural – one of human factors – not technical.* Earth referenced coordinates are a new information phenomena in ground public safety and transportation that has yet to be properly realized.

A component of the systemic problem has been that the 9-1-1 community only relies on street addresses for position descriptions, a critical component in referencing incident locations.

Fundamentally, street addresses have critical design flaws that too often surface in mid-event and interfere with delivering emergency services. Design flaws in street addressing can be evidenced by:

- A street address or street sign may not visible to the end user in the field. This can result because the street sign may not be readily posted, limited visibility (e.g. darkness), have been passed while driving, heavy traffic, driver workload, etc.
- The feature or place of interest has not been pre-registered in a geospatial database and associated with an Earth referenced coordinate.
- A street address is not adequate to the task – such as when a street address is associated with a very large parcel, campus, factory complex, large construction site, etc.
- Street signs have been removed by over pressure events, high winds, fire, underwater during flood, etc., and are no longer visible.

Alternatively, when street addresses are systematically used in conjunction with Earth referenced coordinates, end users then have two independent reference systems to cross reference. When a street address becomes ineffective as a means of identifying position, the Earth referenced coordinate is ready to fill the gap. Furthermore, modern digital systems marry an Earth referenced coordinate with a street address to provide a 'look up and locate capability' on a digital map when the end user queries a street address.

> *What has been missing from the US civil first responder community has been an appreciation that Earth referenced coordinates (without a street address) can be used directly, and easily to physically locate any surface location.* Unlike the aeronautical and maritime industries -- the ground transportation and public safety communities have not directly harnessed Earth referenced coordinates as an information tool.

For better than ten years, low-cost (<$125) consumer GPS receivers have provided position descriptions – as coordinates – accurate to <10-m of true position 95% of the time. Highly accurate and low cost GPS receivers could be used like a "street-sign-in-a-box" on the dashboard general public and emergency response vehicles where they are today widely seen. The caller need only read the coordinates – like a street sign – to the 9-1-1 operator.

CELL PHONES?

Since the mid-1990's 9-1-1 officials have worked diligently to develop a means across the nation to geo-locate callers using cell phones. The objective was to achieve the 'Phase II Wireless location capability' where a call could be located to within 100-m and preferably to within 10-m of true position. Given the technical and political challenges, this capability was years behind its mandated schedule for activation and some areas remain without this capability. Unfortunately 9-1-1 officials have not appreciated the life-saving technology less complex and costly solutions that could leverage direct use of coordinates as an interim solution for the public.

But even with the introduction of Phase II Wireless capabilities, 9-1-1 operators generally still do not have the policy, training, or technology (such as even a simple paper map with a proper grid or web based maps) to exploit highly descriptive geo-referenced position information.

GOOGLE EARTH

In the case of the Maryland state police helicopter crash, the coordinates of the crash site were improperly communicated in a Degrees-Minutes-Seconds (DD-MM-SS) latitude and longitude format as a string of undesignated numbers. Then, the problem was compounded when the string of numbers were entered into Google Earth (free), which interpreted the DD-MM-SS format as Degrees-Decimal-Degrees (DD.dddd) -

Google Earth's default coordinate format. This change in coordinate format incorrectly placed the helicopter crash site approximately 30 miles to the southeast of the exact position, thereby delaying emergency response personnel from rendering assistance.

Yet if a caller to Public Safety Access Points tried to provide such coordinates for their location they would be – and typically still are – rebuffed by the 9-1-1 operator who could only use a street address or similar mile post numbers. In the case of the larger 9-1-1 community, this relatively low tech use of Earth referenced coordinates can result in saving numerous lives by improving emergency response time.

The problem is the lack of use of Earth coordinates for policy reasons in ground transportation and emergency response operations.

GPS industry representatives have estimated that during this time an interim gap-filler Phase II capability for most location needs could be handled by a $50 GPS receiver. This fully automated (turn and turn off) dashboard mounted "street-sign-in-a-box" GPS receiver would need to do little more than display the current location as a standard coordinate. Drivers would read this coordinate to 9-1-1 operators in lieu of a conventional street address, and would be accurate to 10-m, 90% of the time.

EXAMPLES

The following case examples from the National Emergency Number Association web site and other sources illustrate how this could be used.

- Miami, Florida -- The story of a lady's drowning quickly gained national coverage after she dialed 9-1-1 on her wireless phone from her sinking car in a Miami, Florida canal. She could not escape the car. Being unable to see a conventional street sign, she could not tell 9-1-1 dispatchers by cell phone her location. After an extensive conversation, the woman perished before emergency help could reach her.
- Fort Lauderdale, Florida – A lady was forced to wait seven minutes and make three separate 9-1-1 calls from her cellular phone before help was dispatched after her daughter was impaled by a three-foot steel rod that had crashed through their windshield. The lady was forced to exit the interstate and find a major intersection in order to give the dispatchers her location.
- Day County, South Dakota – A lady spent <u>*40 hours*</u> in temperatures that dropped to -30° F when a blizzard stranded her in her pickup truck. Although she was able to dial 9-1-1, she was unable to tell her rescuers where she was. While the Day County Sheriff's office was eventually able to locate the car, it took them five hours to place the vehicle within a 35-mile radius.
- Rural Michigan – A lady was rear-ended and suffered minor damage while driving in rural Michigan. While no one was injured, she did call 9-1-1. She informed the dispatcher of her location and then waited 30 minutes for the cruiser to arrive. When he failed to materialize, she called again. The two roads that she had given to the dispatcher to help them locate her actually crossed twice, and the cruiser was looking at the wrong intersection.

- Washington, D.C. – In 2001, a visitor to the FDR Memorial suffered a heart attack. A passing police officer and the dispatcher could not agree on an appropriate address for the incident location at this large campus like memorial. Eventually an intersection several blocks away was selected. Because the FDR Memorial had not been associated with a street address in the D.C. 9-1-1 Computer Aided Dispatch (CAD) system, the ambulance was never able to find the incident. The victim was flown to a hospital by a U.S. Park Police helicopter.
- Arlington County, Virginia - In 2003, a motorcyclist was seriously injured after being thrown over the guardrails of an overpass. A pedestrian nearby immediately called 9-1-1 but had trouble determining an address for the incident. The caller did have a GPS receiver, and finally asked in frustration if the 9-1-1 operator could use a coordinate from it. The operator replied that no, they did not use that technology.

Even after Phase II Wireless location is achieved, the fundamental shortcomings of street addresses alone are not resolved as demonstrated below:

- Fairfax County, Virginia – A caller to 9-1-1 reported having been stung by a bee, and was beginning to have trouble breathing. The 9-1-1 operator, using Phase II Wirless location technology, could see clearly on the map where the caller was located, but had no actionable way of describing the caller's location in the 493 acre heavily wooded park to first responders.
- Dallas, Texas – In 2008, a motorcycle police officer escorting Senator Clinton during her presidential campaign had an accident. In the event, the officer's injuries were of such magnitude that emergency medical aid could not have saved him. Regardless, the dispatch of emergency medical services was delayed because the Houston Street viaduct did not have a valid address in the 9-1-1 CAD database. The first ambulance dispatched was not from the closest station; officers on scene flagged down another ambulance that was in the area to assist the injured officer.

The following examples provide two perspectives on the direct use of coordinates.

- By 2003 in Rhode Island, cell phones equipped with GPS chip sets could be rapidly located to within 15-m of true position. 9-1-1 organizations remained focused on conventional addresses, yet only about a fifth of the street addresses had been correlated to a coordinate. For incidents where the provided coordinate cannot be correlated to a street address there is no way to readily communicate a location to first responders who can only use street addresses to find places. As the Rhode Island 9-1-1 Director Ray LaBelle stated, "*If I give an ambulance driver latitude and longitude coordinates, he's going to tell me where to go."*
- "...In Iraq, Coalition Forces (particularly the U.S. Govt and U.S. Military) are using MGRS coordinates almost exclusively. They have GIS software and data that allows them to search for a particular address (building #, street # and house #) within the 9 districts of Baghdad and in a few other cities/regions of Iraq. The operators in the field will get intel about a person of interest being located at a

particular address. We will use the GIS sw/data to locate that address on a map or imagery of the city. Then, using our data, we can provide an MGRS coordinate for that location. The operator can then plug that coordinate into his GPS and (map and) easily navigate to the building of interest in order to do surveillance."[1] US Government person, December 2005.

NATIONAL SEARCH AND RESCUE COMMITTEE (NSARC)

In 2005, the failure to harness Earth referenced coordinates in ground transportation and public safety operations became truly evident during the Hurricane Katrina response. As a result, in 2007, the National Search and Rescue Committee (NSARC)[2] began developing guidance for Federal responders who conduct SAR operations in support of the State during Catastrophic Incidents.

As NSARC undertook this effort, it was quickly understood that one of the primary problems identified during large scale SAR operations was communicating position information that is easily understood by Federal, State, Tribal, Territorial, and local SAR responders working together to save lives. Because Catastrophic Incident SAR (CISAR) requires a multiagency, coordinated response from so many different SAR organizations, establishment of a standardized way to communicate position information became a critical issue to ensure SAR responder safety and facilitate effective SAR coordination and communication.

Communicating position information became one of the most important concerns addressed by NSARC in developing CISAR guidance.

Hurricane Katrina. Hurricane Katrina highlighted a number of these difficulties, including those relating to a lack of geospatial awareness. Talbot Brooks (Director, Center for Interdisciplinary Geospatial Information Technologies, Delta State University) described the problem:

> Two very difficult issues arose during Katrina: 1) How does one navigate when landmarks such as street signs and homes are blown away and 2) How do we communicate position in a common language.[3]

A third issue identified was SAR resource de-confliction to ensure multiple assets are not inappropriately operating in the same area. This is both a matter of safety, particularly with aircraft, so the likelihood of a mid-air collision is minimized, and a matter of efficient and effective use of limited resources so that all areas receive appropriate, available SAR assets.

[1] MGRS = Military Grid Reference System (Functionally equivalent to the U.S. National Grid).

[2] The National SAR Committee (NSARC) is comprised of the following Federal Departments and Agencies: Departments of Defense, Interior, Homeland Security, Commerce, and Transportation, the Federal Communications Commission, and the National Aeronautics and Space Administration (NSARC's website: www.uscg.mil/nsarc).

[3] Talbot Brooks, *Importance of USNG and Land Navigation* [article on-line]; available from: http://mississippi.deltastate.edu/.

It is important to understand that the same geo-referencing problems identified during Hurricane Katrina can also adversely impact any type of emergency response operation—whether small or large, frequent or infrequent. How should positional information be communicated? What's the "right" reference system that should be used? Is there only one reference system that satisfies the requirements of all Emergency Responders? How/when is positional information in one reference system converted to another? How is positional information received in non-standard formats converted to a standard reference system?

WHAT IS GEO-REFERENCING?

To geo-reference a position is to identify that position with a coordinate referenced to the figure of the Earth. Such standards based coordinates define a location in physical space. They are crucial to making ortho-imagery more than a pretty picture – but instead give an ortho-image the functionality of a map

Field users have several sources of geo-referencing information. An obvious source is the Global Positioning System and other Location Based Services (GPS/LBS). Geo-referencing techniques in turn are the means by which GPS/LBS positioning information is given practical application. While GPS may tell us where we are, by plotting that position through geo-referencing techniques on a map (digital or hard copy) – the map tells us where everything else is.

Another vital source of geo-referencing information is the grid or graticule on a properly designed map or chart. Field users can precisely determine their location through terrain association with a United States Geological Survey (USGS) topographic map or similar maps and charts. When these maps and charts depict a properly designed grid or graticule, users can precisely geo-reference any pencil-dot size location on the map with coordinates. The location of the pencil size dot can then be unambiguously communicated with coordinates to other interested parties such as a SAR team or 911 operator.

A key point for this discussion is for NTSB to recognize that standard, properly executed geo-referencing techniques and technologies are life-saving tools in transportation and transportation safety issues. Only recently have efforts been organized to recognize and implement these in a systematic way across the nation – a key point that NTSB should consider and help facilitate further implementation.

GEO-REFERENCING CONSIDERATIONS

NSARC identified some basic considerations concerning standardizing geo-referencing information that will be used during CISAR operations.

[Note: These same considerations are relevant for any emergency response operation.]

- NSARC should not try to impose a new position system standard on Federal, State, Tribal, Territorial, and local SAR responders. There are geo-referencing standards already in place; why change what SAR responders are already learning and being implemented in software and maps?
- A fundamental aspect to any geo-referencing system is the ability to easily interface between the Incident Command System, the land SAR responder (or maritime SAR responder), and the aeronautical SAR responder. Each has unique geo-referencing requirements. To effectively interface between each component is vital to a successful CISAR response.

  [Note: This is the same issue for SAR responders in any emergency response, as well as CISAR operations.]
- No single map/chart projection or coordinate/grid system will be perfect for all applications[4]. In the case of projecting the earth's curved surface on to a flat surface, distortion of one or more features will occur. For navigation and SAR applications, conformal projections have proven to be the most useful. For example, nautical charts use the standard Mercator projection, aeronautical sectional charts use the Lambert conformal projection, and recent large-scale topographic maps use the Transverse Mercator projection.
- For long distance navigation (i.e. aeronautical and nautical), depiction of large areas on a map (i.e. smaller-scale mapping) requires dealing with the curvature of the Earth – thus the spherical latitude and longitude format is best suited to the task. Typically such navigation does not require overly precise (< 1-nm) plotting on a small-scale map. Latitude and longitude also facilitates the use of nautical miles as a standard linear distance in aviation and nautical operations.
- Land operations generally require larger-scale mapping (i.e. smaller areas with more detail). Positions often need to be plotted in more detail (such as the difference between two houses). On large-scale maps the Earth begins to be depicted as a plane. This advantage can be taken in mapping – and geo-referencing – with the simplicity of plane geometry and Cartesian-style plane coordinates. Locating points to such high precision (<100 to >1 meter) is generally best accomplished using a grid like the US National Grid based on the Universal Transverse Mercator projection. This grid scales locations with linear increments (the meter) rather than the more complex angular increments of lat/long.
- *Precedence*: There should be an existing, historic precedent to the use of a geo-referencing system.

[4] Snyder, John P., 1984. *Projections Used by the U.S. Geological Survey*; Geological Survey Bulletin 1532; GPO, Wash, DC; p. 5

SAR responders should be familiar with and understand the geo-referencing system(s) to be used. In other words, there needs to be a *historic precedent* already in place for the use of a geo-referencing system for it to be considered. A universally accepted geo-referencing system will minimize a SAR response organization's funding, training, and system implementation.

- *National Standard*: The geo-referencing system should be a recognized national standard.
- *Simple to Use*: A geo-referencing system must be easy to use by SAR Responders (land, aeronautical and maritime).
- A geo-referencing system needs to be understandable and easy to use in a CISAR environment, where time is critical in the saving of lives, circumstances are difficult and hazardous to SAR responders, and where power or internet access is unavailable or intermittent.

GEO-REFERENCING SYSTEM REQUIREMENT

The following geo-referencing systems were determined to be the best way to communicate position information during a CISAR response, and by implication can be used for other emergency response operations:

- U.S. National Grid (USNG);
- Latitude and Longitude (expressed in degrees, minutes, and decimal minutes (DD-MM.mm); and
- Global Area Reference System (GARS). [5]

RATIONALE: USNG

The USNG is intended to create a more interoperable environment for developing location-based services within the United States and to increase the interoperability of location services appliances with printed map products by establishing a preferred nationally-consistent grid reference system. The USNG can be extended for use world-wide as a universal grid reference system, and can be easily plotted on USGS topographic maps by using a simple "read right, then up" method.

The coordinates are easily translated to distance, as they are actually in meters. Thus the distance between two coordinates can quickly be determined in the field.

NSARC adoption of the USNG for CISAR operations based on the following rationale:

- The USNG is the approved United States national standard (FGDC-STD-0911-2001). [6] As stated by the Federal Geographic Data Committee:

[5] GARS is a worldwide global area reference system used for battle-space deconfliction and synchronization as well as for large-area SAR efforts. GARS divides the world into 30-minute by 30-minute cells, further subdivides those cells into 15-minute by 15-minute quadrants which are further subdivided into 5- minute by 5-minute cells. GARS is an overlay area reference system based on Latitude and Longitude. GARS is currently used only for situation awareness of Senior Managers.

The objective of this standard is to create a more favorable environment for developing location-based services within the United States and to increase the interoperability of location services appliances with printed map products by establishing a nationally consistent grid reference system as the preferred grid for National Spatial Data Infrastructure (NSDI) applications. This standard defines the US National Grid. The U.S. National Grid is based on universally defined coordinate and grid systems and can, therefore, be easily extended for use world-wide as a universal grid reference system. [7]

- The USNG is already being adopted by several States as their primary geo-referencing system. [8]
- The USNG is the operational equivalent to the Military Grid Reference System (MGRS) and is the standard used by Department of Defense ground forces, who will be a significant CISAR responder. Chairman of the Joint Chiefs of Staff Instruction 3900.01C, *Position (Point and Area) Reference Procedures*, states:

  The Military Grid Reference System (MGRS). Ground units and ground combat operations shall be serviced with MGRS coordinates. To support homeland security and homeland defense, the federal Geographic Data Committee (FGDC) US National Grid (USNG) standard when referenced to North American Datum 1983 (NAD83) is operationally equivalent to and is an accepted substitute for MGRS coordinates referenced to WGS 84. [9]

- Global Positioning System receivers are now being manufactured with the ability to transition between USNG and latitude/longitude, providing ease of transition between both coordinate systems.
- The Federal Emergency Management Agency (FEMA) has adopted USNG as their standard point reference system. [10]
- Many United States Geological Survey (USGS) maps/charts of the United States land mass are routinely over-printed with USNG lines plus latitude and longitude tic marks in the margins.

Pages 11-12 explain how to find a position using USNG.

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[6] Federal Geographic Data Committee (FGDC), *United States National Grid* (Reston: December, 2001).
[7] Ibid., 1. Also note that the FGDC is comprised of the Departments of Agriculture, Commerce, Energy, Housing and Urban Development, Interior, State, and Transportation, the Environmental Protection Agency, the Federal Emergency Management Agency, the Library of Congress, the National Aeronautics and Space Administration, the National Archives and Records Administration, and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups.
[8] State SAR Coordinators Meeting, National Association for Search and Rescue (NASAR) Annual Conference, 31 May 2007.
[9] *Position (Point and Area) Reference Procedures*, CJCSI 3900.01C (30 June 2007): 2.
[10] FEMA Technical Services Division, Mitigation Directorate, *FEMA's Recommendation on the Proposed US National Grid*, FEMA letter of 26 April 2001 to Standards Coordinator, US Geological Survey; also FEMA Operations Group, *Operations Group Recommendation # SEA 07-03*, FEMA Memorandum of 14 Feb 2007.

US National Grid (USNG) Coordinates: *World wide context.*

Information Sheet 2/1 in this series. FGDC-STD-011-2001 From www.fgdc.gov/usng

The example below locates the Jefferson Pier at USNG: 18S UJ 23371 06519.

U.S. National Grid
100,000-m Square ID
UJ ${}^{43}00$
UH
Grid Zone Designation 18S

A USNG value has three components.

Some maps may give this leading information in a grid reference box.

Grid Zone Designation (GZD): 6° x 8° longitude zone / latitude band.

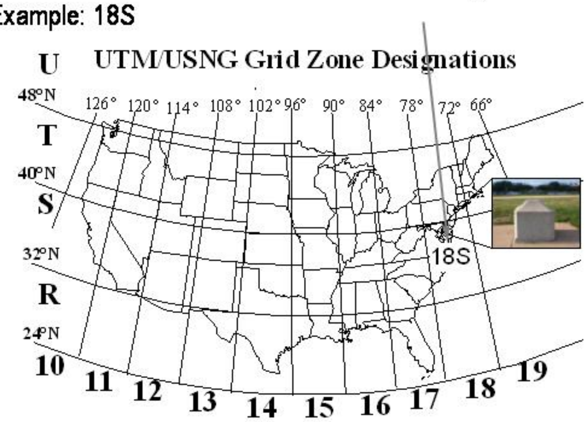
100,000-m Square Identification:

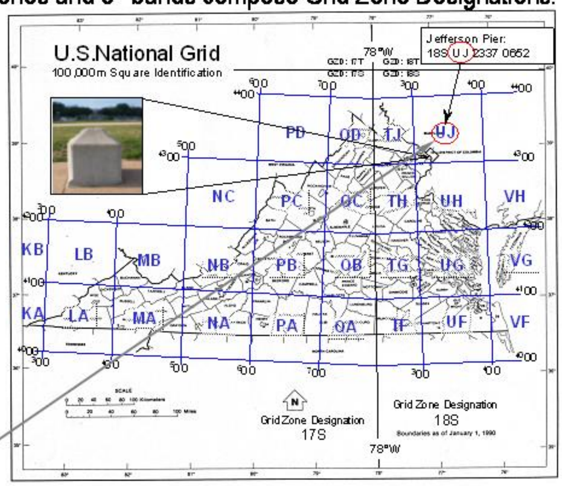
18S UJ 2337 0651

Grid Coordinates: Read ***right***, then ***up***.

"Read right, then up."

USNG values have three components as seen above. The Grid Zone Designation gives a USNG value world-wide context with 60 longitudinal zones each 6° wide. Zones 10 - 19 cover the conterminous U.S. as seen below left. UTM zones are divided into 8° latitudinal bands. Together these 6° zones and 8° bands compose Grid Zone Designations. Example: 18S





100,000-m Square Identifications
Example: UJ

GZDs are further subdivided into 100-km x 100-km squares with 100,000-m Square Identifications. In this example, the Jefferson Pier is located in UJ. These squares are organized and lettered so they do not repeat themselves but every 18°, which is approximately 1,000 miles in the mid-latitudes. The illustration at right depicts how far one must go before the letters UJ repeat. In the conterminous U.S. this ensures a given value such as UJ 2337 0651 is unique out of the entire state it is located in – as well as all surrounding states.

The Power of Truncated USNG Values

Each 2 letter/8 digit USNG value (10-m posting) in the outlined area is unique.

In general, people in a local community may use the grid coordinates alone – for example: 233 065. The same numbers recurs about every 60 miles but normally that will not cause a problem when the general location is understood. This is similar to the way you tell someone only the last digits of a phone number when the area code is obvious. If there is a possibility of confusion include the letter pair also – for example: UJ 233 065. A letter pair recurs about every 1000 miles so even in a disaster relief effort there should be no other point with those coordinates nearby. A complete USNG reference such as 18S UJ 233 065 is nationally and globally unique. Typically a GPS receiver or other electronic device requires a complete USNG reference since unlike a human it does not intuitively understand the general location from context. You should always give a complete USNG reference whenever abbreviated coordinates might not be clear or when listing them on letterhead, a business card or advertisement.

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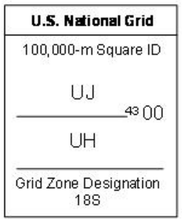
Reading US National Grid (USNG) Coordinates: *"Read right, then up."*

Information Sheet 2/2 in this series. FGDC-STD-011-2001 From www.fgdc.gov/usng

The example below locates the Jefferson Pier at USNG: 18S UJ 23371 06519.



A USNG value has three components.

Some maps may give this leading information in a grid reference box.

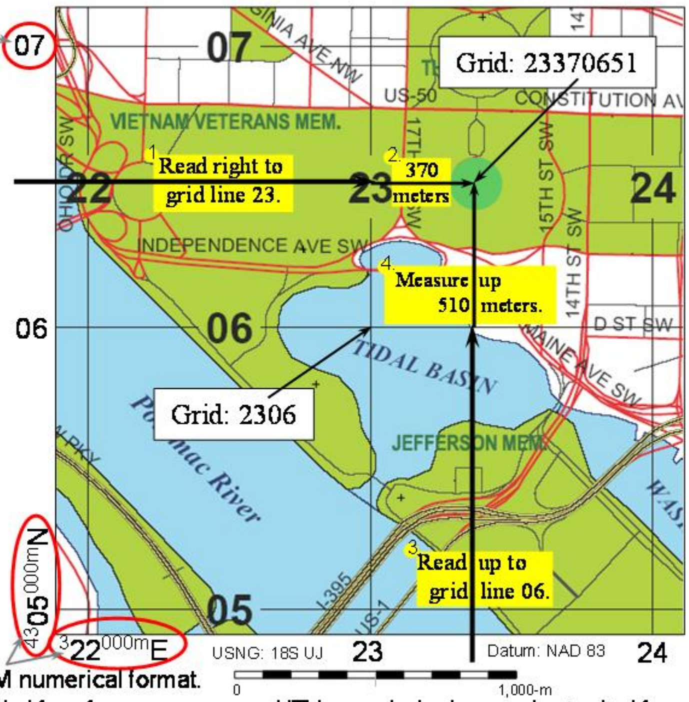
Grid Zone Designation (GZD):
6° x 8° longitude zone / latitude band.
100,000-m Square Identification:

18S UJ 2337 0651

Grid Coordinates:
Read *right*, then *up*.

"Read right, then up."

- Grid lines are identified by Principal Digits. Ignore the small superscript numbers like those in the lower left corner of this map.



UTM numerical format.

Reading USNG Grid Coordinates.

- Coordinates are always given as an even number of digits (i.e. 23370651).

- Separate coordinates in half (2337 0651) into the easting and northing components.

- [1] Read right to grid line 23. [2] Then measure right another 370 meters. (Think 23.37)

- [3] Read up to grid line 06. [4] Then measure up another 510 meters. (Think 06.51)

Grid:	Point of Interest:
228058	FDR Memorial:
231054	George Mason Memorial:
2338 0710	Zero Milestone:
2275 0628	DC War Memorial:
222065	Lincoln Memorial:

Ignore the small UTM superscript numbers that are provided for reference purposes. UTM numerical values are best suited for determining direction and distance as in surveying. USNG alpha-numeric values are best suited for position referencing because they can be given as only grid coordinates in a local area and with only the required precision for a particular task.

Users determine the required precision. These values represent a point position (southwest corner) for an area of refinement.

Four digits:	23 06	Locating a point within a 1,000-m square.
Six digits:	233 065	Locating a point within a 100-m square (football field size).
Eight digits:	2337 0651	Locating a point within a 10-m square (modest size home).
Ten digits:	23371 06519	Locating a point within a 1-m square (man hole size).

A modest size home can be found or identified in a local area with only an 8-digit grid.

Complete USNG value: 18S UJ 2337 0651 - Globally unique.
Without Grid Zone Designation (GZD): UJ 2337 0651 - Regional areas.
Without GZD and 100,000-m Square ID: 2337 0651 - Local areas.

This illustrates how nationally consistent USNG coordinates are optimized for local applications. They serve as a universal map index value in a phone or incident directory for field operation locations. Unlike classic atlas grids (i.e. B3), these can be used with any paper map or atlas depicting the national grid and in web map portals such as the Washington, DC GIS (http://dcgis.dc.gov).

They can also be used in consumer GPS receivers to directly guide you to the location. This is especially beneficial at night, in heavy traffic, or major disasters when street signs are missing.

Point of Interest	Street Address	USNG Grid: 18S UJ	Telephone: (202)
Subway Sandwich & Salads	2030 M St., NW	2256 0826	223-2587
Subway Sandwich & Salads	430 8th St., SE	2698 0567	547-8200
Subway Sandwich & Salads	3504 12th St., NE	2740 1120	526-5999
Subway Sandwich & Salads	1500 Benning Rd, NE	2815 0757	388-0421

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RATIONALE: LATITUDE AND LONGITUDE

Latitude and Longitude is:

- Used by aircraft and boats during CISAR operations;
- A geographic coordinate system used for locating positions on the Earth's surface; and
- Measured in:
  - Degrees (using the symbol, " ° ");
  - Minutes (using the apostrophe symbol, " ' "); and
  - Seconds (using the quotation symbol, " " ").

Lines of Latitude are horizontal lines shown running east-to-west on maps and are known as "Parallels," due to being parallel to the equator. Latitude is measured north and south ranging from 0° at the Equator to 90° at the poles (90° N for the North Pole and 90° S for the South Pole).

Lines of Longitude are vertical lines shown running north and south on maps and are known as "Meridians," intersecting at the poles. Longitude is measured east and west ranging from 0° at the prime meridian to +180° East and -180° West.

NSARC adopted the use of Latitude and Longitude CISAR operations based on the following rationale:

- Some would argue that the plotting of latitude and longitude on a chart, especially in small areas, would not be considered simple to use. However, the latitude/longitude coordinate system is universal, a de facto standard throughout the maritime and aeronautical communities, and is easy to use for any SAR responder with today's portable GPS receivers.
- Many SAR aircraft have avionics that can easily transition between latitude/longitude and USNG for interoperability between ground and airborne SAR responders. All aeronautical SAR responders do use latitude/longitude for navigation and can easily input area corner points for area reference and airspace deconfliction.
- Nautical charts, aeronautical sectionals, and USGS topographic maps have, at a minimum, latitude and longitude tic marks printed in the margins.

Standardized format. Latitude and Longitude can be read and written in three different formats:

- Degrees, Minutes, Decimal Minutes (DD° MM.mm');
- Degrees, Decimal Degrees (DD.DDDD°); and
- Degrees, Minutes, Seconds (DD° MM' SS").

For CISAR operations the following guidance applies when communicating position information using Latitude and Longitude.

Standard Latitude/Longitude format for CISAR operations

The standard Latitude/Longitude format for CISAR operations is Degrees, Decimal Minutes (DD° MM.mm').

Latitude is always read and written first noting "North" since the U.S. is North of the Equator. Longitude is always read and written last noting "West" since the U.S. is West of the Prime Meridian.

When speaking Latitude and Longitude coordinates for 39° 36.06'N by 76° 51.42'W. Latitude and longitude is stated as:

"Three nine degrees, three six decimal zero six minutes North by seven six degrees, five one decimal four two minutes West."

The words, "degrees," "minutes," and "decimal" must to be spoken.

[Note: This same criteria can be used to standardize any other emergency response, in addition to CISAR operations. Although this is the preferred format, emergency responders need to be able to recognize and understand the other formats and be able to translate from those formats to the preferred format described above.]

GEO-REFERENCING MATRIX

A fundamental requirement for a geo-referencing system is the ability to easily interface between the Incident Command, the land CISAR responder (or maritime CISAR responder) and the aeronautical CISAR responder. Because each has unique geo-referencing requirements, effective interface between each component is vital to a successful CISAR response.

As a result of the above information, NSARC created a geo-referencing matrix in order to minimize confusion and provide guidance on what geo-referencing system each CISAR responder should be using.

The geo-referencing matrix is provided on page 10 below. This matrix can be adopted for any emergency response operations.

Map Datum

North American Datum 1983 (NAD 83) and World Geodetic System 1984 (WGS 84) are equivalent at scales smaller than 1:5000.

National SAR Committee

CISAR Geo-referencing Matrix

Georeference System User	United States National Grid (USNG)	Latitude/Longitude DD-MM.mm[1]	GARS[2]
Land SAR Responder[3]	Primary	Secondary	N/A
Aeronautical SAR Responders[4]	Secondary	Primary	Tertiary
Air Space Deconfliction[5]	N/A	Primary	N/A
Land SAR Responder/ Aeronautical SAR Responder Interface.[6]	Primary	Secondary	N/A
Incident Command: Air SAR Coordination Land SAR Coordination	 Secondary Primary	 Primary Secondary	 N/A N/A
Area organization and accountability[7]	Secondary	Tertiary	Primary

[1] During CISAR operations (and to avoid confusion) Latitude and Longitude should be in one standard format: DD-MM.mm. If required, use up to 2 digits to the right of the decimal. If required, allow 3 digits in the degrees field for longitude (i.e., DDD-MM.mm). Do not use leading zeros to the left of the decimal for degrees or minutes that require fewer than the maximum number of possible digits to express their value. The minimum number of digits is always one, even if it is a zero. (Example: Recommended: 9-0.3N 4-2.45W; Not Recommended: 09-00.300N 004-02.45W).

[2] GARS: Global Area Reference System.

[3] Land SAR responders use U.S. National Grid; however, a good familiarity with latitude and longitude is necessary to ensure effective interface between Land and Aeronautical SAR responders (Note: Land SAR includes SAR on flooded terrain).

[4] Aeronautical SAR responders will use latitude and longitude for CISAR response. However, aeronautical SAR responders that work directly with Land SAR responders should understand the U.S. National Grid system for effective Land SAR/Aeronautical SAR interface.

[5] Air space deconfliction will *only* be implemented and managed using Latitude and Longitude.

[6] Aeronautical SAR responders working with Land SAR responders have the primary responsibility of coordinating SAR using USNG. However both groups must become familiar with both georeference systems.

[7] Describes the requirement for providing situational awareness of CISAR operations geographically to Federal, military, state, local and tribal leadership.

CONCLUSIONS

Emergency Responder confusion with respect to the interpretation and communication of positional data is a potentially life-threatening problem for the victim of a transportation-related accident.

This information is provided to identify the problems and a simple solution to communicating position. NSARC created the geo-referencing matrix to be used for a Federal, interagency SAR response to Catastrophic Incidents, but can be used for any emergency response operations. Combined with identifying a standardized way to communicate latitude and longitude, the confusion that often occurs due to inappropriate communication of position, or unfamiliarity with local landmarks can be mitigated.

RECOMMENDATIONS

1. The NTSB should routinely include at least a cursory examination of the emergency response in its investigations of transportation-related incidents; a more detailed investigation of the response may be appropriate when it appears the NTSB could make recommendations that could significantly improve response policies and procedures.
2. Emergency service providers, both public and private, should be:
   - Familiar with the USNG and latitude, longitude reference systems and their respective position data formats;
   - Capable of translating positions from one reference system to the other; and
   - Capable of accurately communicating position information from either reference system to other providers.
3. Maps at the appropriate scales and using appropriate projections, and/or electronic geographic information systems (GIS) with, as appropriate, either USNG grid lines or a latitude, longitude graticule overlaid on the map image, with the other reference system denoted by tic marks in the margin, should be made available to all emergency responders. Digital map display systems should display cursor location readout in both coordinate formats simultaneously.
4. Methods for converting positional information provided in other forms, ranging from street addresses to well-known landmarks and “points of interest” to range and bearing information from radar or aeronautical navigation aids, etc., into standard latitude, longitude and/or USNG coordinates should be provided at some level accessible to emergency responders 24/7.
5. Continue outreach and marketing in the use of the NSARC geo-referencing matrix for use by SAR emergency response personnel.
6. The NTSB explore the issues concerning the use of Earth coordinate reference systems use by emergency responders identified in this paper.

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