National SAR Committee
Georeferencing Matrix:
Catastrophic Incident Search and Rescue (CIS).

Georeference System User	United States National Grid (USNG)	Latitude/Longitude DD-MM.mmm[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	Secondary	Primary	N/A
Land SAR Coordination	Primary	Secondary	N/A
Area organization and accountability[7]	Secondary	Tertiary	Primary

[1] During CIS operations (and to avoid confusion) Latitude and Longitude should be in one standard format: DD-MM.mmm. If required, use only 3 digits to the right of the decimal; 1 or 2 digits is acceptable. If required, allow 3 digits in the degrees field for longitude (i.e., DDD-MM.mmm). 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: Not Recommended: 09-00.300N 004-02.450W; Recommended: 9-0.3N 4-2.45W).

[2] GARS: Global Area Reference System.

[3] Land SAR Responders *must* 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.

[4] Aeronautical SAR Responders will use latitude and longitude for CIS 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 CIS operations geographically to federal, military, state, local and tribal leadership.

Section 3-7: Geo-referencing

Introduction

What is Geo-referencing?

Geo-referencing Methods

U.S. National Grid (USNG)

Latitude-Longitude

Global Area Reference System (GARS)

Geo-referencing Matrix

Introduction

In the aftermath of Hurricane Katrina, the review of the Federal, military, State, and local SAR response found that SAR agencies used different methods to communicate geographic information. This added confusion and complexity to an extremely large scale SAR operation.

Federal, State, Tribal, Territorial, local, and volunteer CISAR responders working together in a CISAR environment face numerous challenges, including those relating to a lack of geospatial awareness. Three issues were identified during the Hurricane Katrina response:

1. How do CISAR responders navigate when landmarks such as street signs and homes are blown away?
2. How do CISAR responders communicate position in a common language?
3. The final problem is CISAR resource de-confliction - the ability to ensure multiple assets are not inappropriately operating in the same area –a significant problem for CISAR responders.

Resource de-confliction is a matter of safety, particularly with aircraft, to ensure the likelihood of a mid-air collision is minimized. Additionally, resource de-confliction is a matter of efficient and effective use of limited resources so that all areas receive appropriate, available CISAR response assets.

What is Geo-referencing?

To geo-reference is to define location in physical space and is crucial to making aerial and satellite imagery useful for mapping. Geo-referencing explains how position data (e.g., Global Positioning System (GPS) locations) relate to imagery and to a physical location.

Different maps may use different projection systems. Geo-referencing tools contain methods to combine and overlay these maps with minimum distortion.

Using geo-referencing methods, data obtained from observation or surveying may be given a point of reference from topographic maps already available.

Note: No single map/chart projection or coordinate/grid system will be perfect for all

applications. In the case of projecting the earth's curved surface on a flat surface, distortion of one or more features will occur. The conventions for locating points on the earth's surface for purposes of nautical and aeronautical navigation (long distances on small scale charts) is generally best conducted using latitude and longitude (spherical coordinates). Locating points on large-scale maps and for ground navigation is generally best accomplished with Cartesian-style plane coordinates (i.e., USNG). Large scale-maps can treat the Earth's surface as a plane – taking advantage of that simple geometric shape and math – rather than a complex sphere. Properly constructed large-scale maps – such as topographic maps take curvature of the Earth into account. Simple linear increments (i.e., meters) of plane coordinates are significantly easier for large-scale map users to handle accurately at high precision in the field than the more complex angular increments of latitude and longitude (i.e., degrees).

Geo-Referencing Methods

Three geo-referencing methods are to be used for CISAR operations anywhere in the United States, as indicated in the National SAR Committee geo-referencing matrix located at the end of this Section.

U.S. National Grid (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.

Note: the USNG and the Military Grid Reference System (MGRS) are functionally equivalent when referenced to NAD 83 or WGS 84 datums.

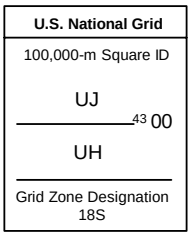
The coordinates are easily translated to distance, as they are actually in meters. Thus the distance between two coordinates can quickly be determined in the field.

Pages 85-86 explain how to find a position using USNG.

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.



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.

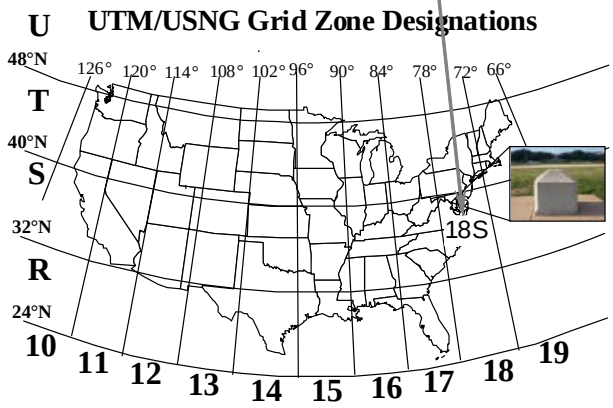
100,000-m Square Identification:

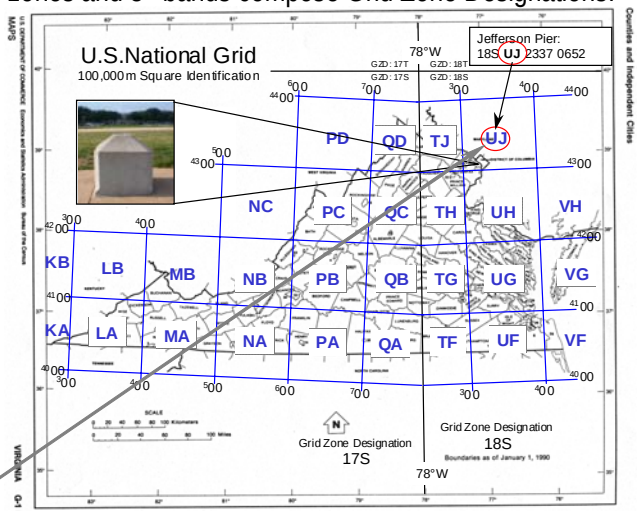
18S UJ 2337 0651

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

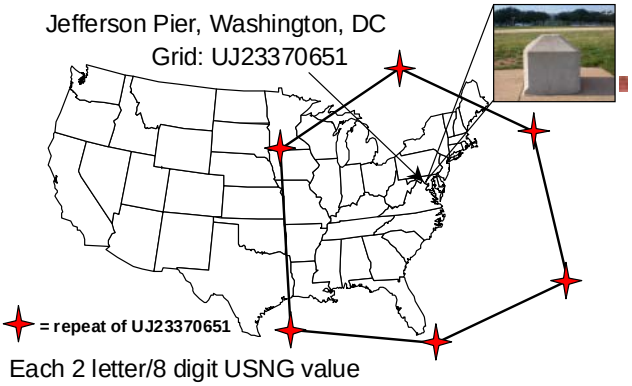




100,000-m Square Identifications Example: UJ

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.

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.

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.

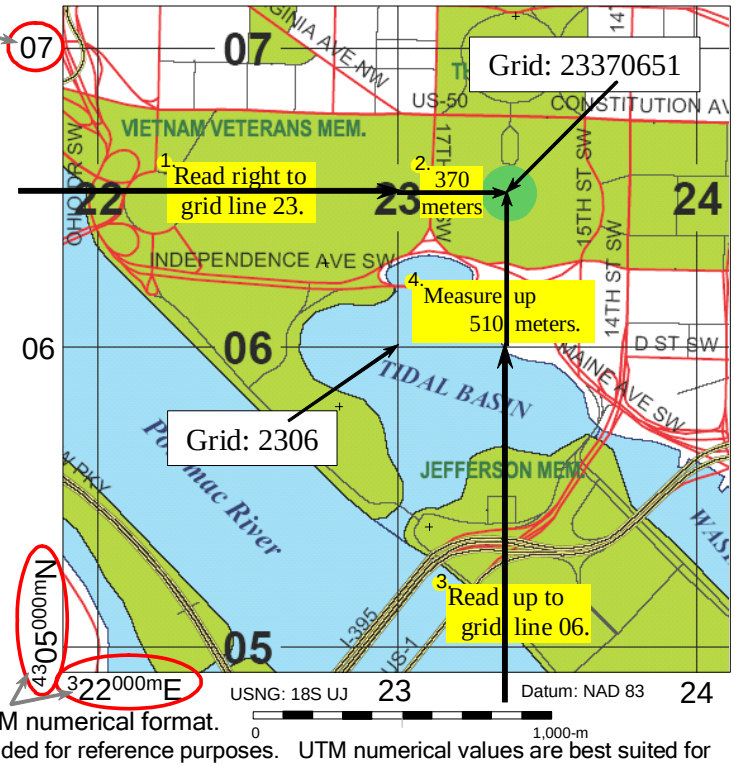
100,000-m Square Identification:

18S UJ 2337 0651

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

"Read right, then up."

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



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:

UTM numerical format.

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

Latitude-Longitude

Latitude and Longitude is used by aircraft and boats during CISAR operations. The Latitude-Longitude is a geographic coordinate system used for locating positions on the Earth's surface. Latitude and longitude are an angular measurement 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.

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").

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.

Global Area Reference System (GARS)

GARS is a standardized geospatial area reference system for military and civil SAR application, and is based on lines of longitude and latitude. GARS provides a common language between the components and simplifies communications.

How GARS works.

- GARS is a worldwide system that divides the earth's surface into 30-minute by 30-minute cells.
- Each cell is identified by a five-character designation. (ex. 006AG).
- The first three characters designate a 30-minute wide longitudinal band. Beginning with the 180-degree meridian and proceeding eastward, the bands are numbered from 001 to 720, so that 180 E to 179 30'W is band 001; 179 30'W to 179 00'W is band 002; and so on.

- The fourth and fifth characters designate a 30-minute wide latitudinal band. Beginning at the south pole and proceeding northward, the bands are lettered from AA to QZ (omitting I and O) so that 90 00'S to 89 30'S is band AA; 89 30'S to 89 00'S is band AB; and so on.
- Each 30-minute cell is divided into four 15-minute by 15-minute quadrants. The quadrants are numbered sequentially, from west to east, starting with the northernmost band. Specifically, the northwest quadrant is "1"; the northeast quadrant is "2"; the southwest quadrant is "3"; the southeast quadrant is "4".
- Each quadrant is identified by a six-character designation. (ex. 006AG3) The first five characters comprise the 30-minute cell designation. The sixth character is the quadrant number.
- Each 15-minute quadrant is divided into nine 5-minute by 5-minute areas. The areas are numbered sequentially, from west to east, starting with the northernmost band.
- The graphical representation of a 15-minute quadrant with numbered 5-minute by 5-minute areas resembles a telephone keypad.

Each 5-minute by 5-minute area or keypad "key" is identified by a seven-character designation. The first six characters comprise the 15-minute quadrant designation. The seventh character is the keypad "key" number. (ex.006AG39).

Figure 3-7-1 graphically depicts GARS; Figure 3-7-2 is an example GARS overlay.

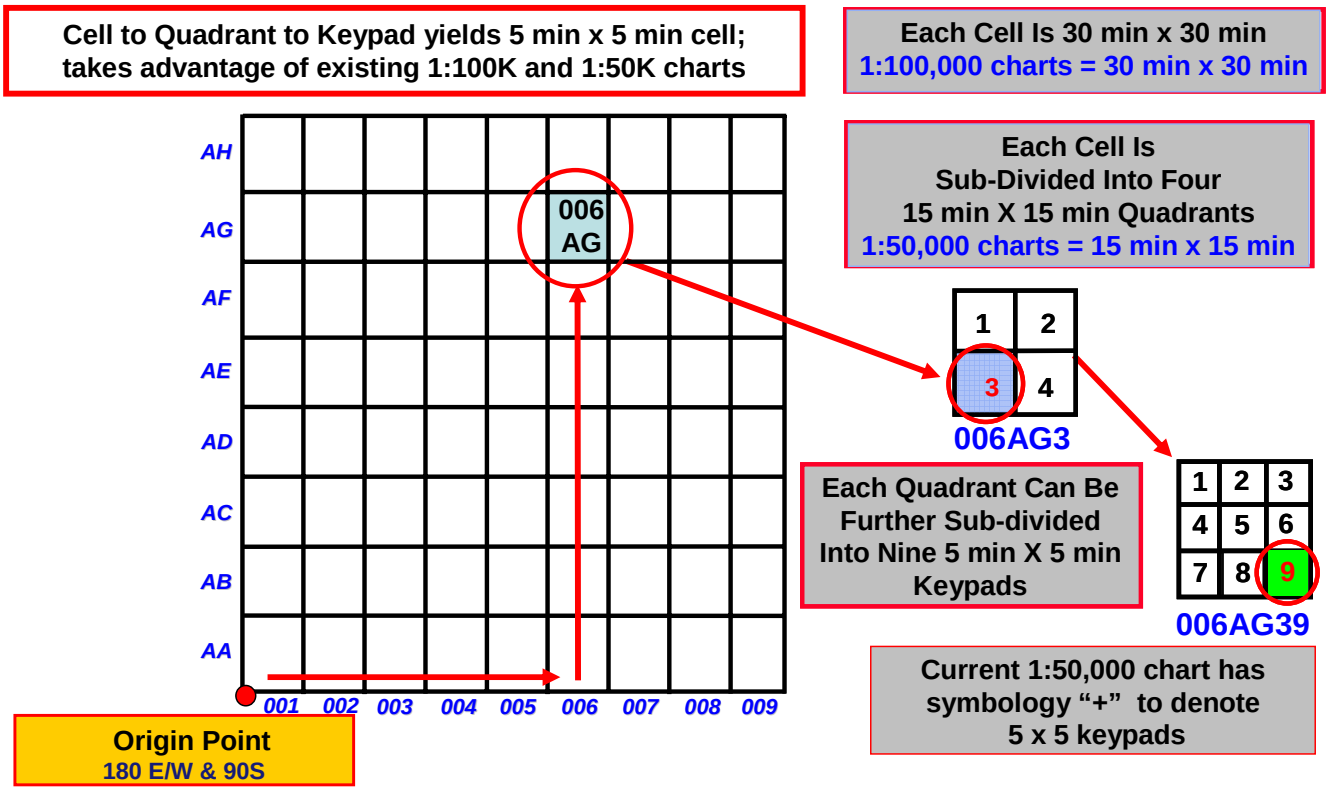


Figure 3-7-1

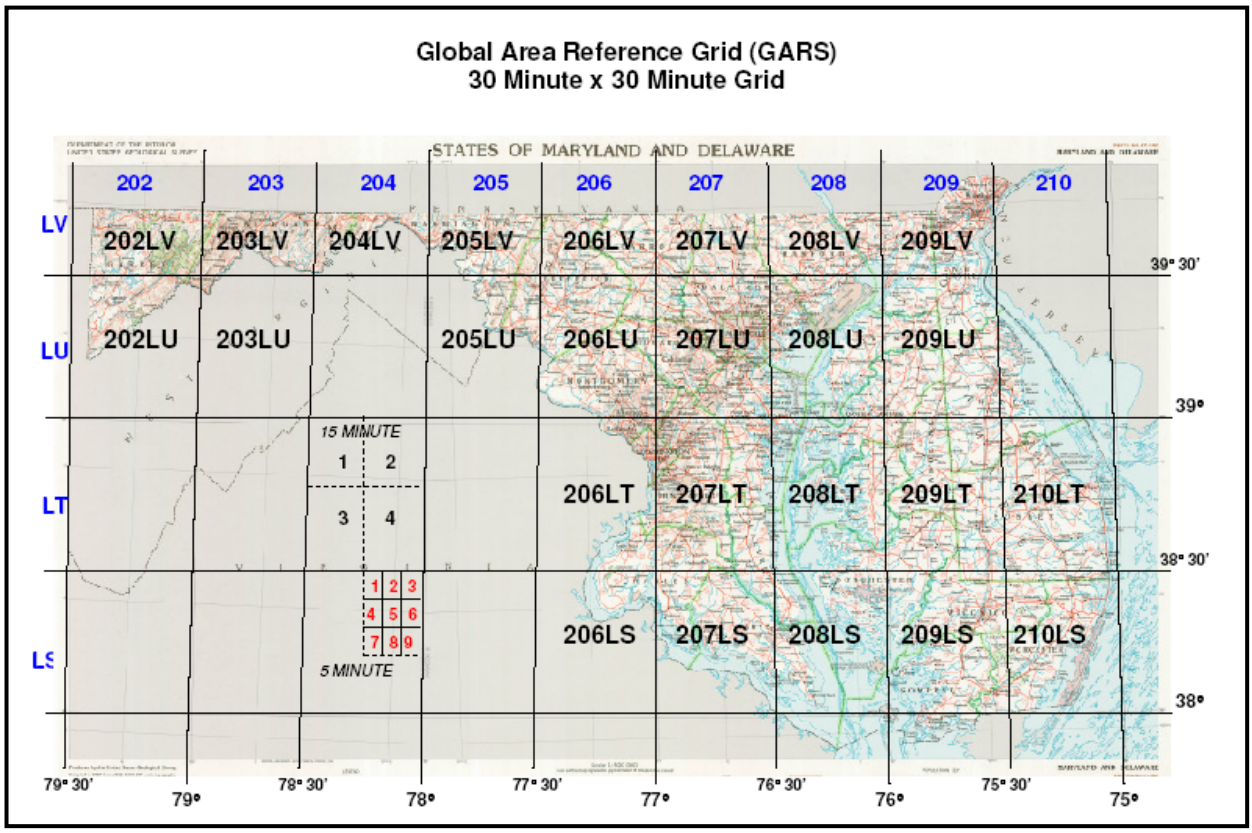


Figure 3-7-2

Geo-referencing matrix

A fundamental requirement for a geo-reference 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.

The geo-referencing matrix minimizes confusion and provides guidance on what geo-referencing system each CISAR responder should be using.

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

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Air Space Deconfliction[5]	N/A	Primary	N/A
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[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.