NENA Information Document for Synchronizing Geographic Information System Databases with MSAG & ALI

One Nation 9-1-1 One Number

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INFORMATION DOCUMENT

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NENA's Joint Data Technical/PSAP Operations & Next Generation Integration Committees have developed this document. Recommendations for changes to this document may be submitted via email to commleadership@nena.org or via mail to:

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1 Executive Overview

This document is the NENA information document for the synchronization of certain Geographic Information Systems (GIS) database layers with the Master Street Address Guide, the Automatic Location Information data, and optionally the site / structure locations. This document is meant to provide PSAP management, vendors, and other interested parties necessary guidelines for synchronizing GIS data with existing 9-1-1 databases. The synchronization process of the GIS data is most reliably accomplished by qualified, trained individuals or vendors that have received formal GIS training and instruction.

2 Introduction

2.1 Purpose and Scope of Document

This document is provided as a guide to synchronizing both the Master Street Address Guide (MSAG) and optionally the Automatic Location Information (ALI) databases to a Geographic Information System (GIS) geospatial database of road centerlines, site / structure locations, and related spatial databases. One must have a basic understanding of GIS concepts and MSAG data, or the resources available, in order to understand this document. The preferred method for performing the synchronization is using various database techniques. Emergency Service Zones, MSAG and Postal Community Names, and optionally the ALI data and address point data will all be used in the synchronization process. The synchronization of these databases will improve the accuracy of the GIS data, the MSAG, and optionally the ALI data, aid in meeting the requirements for Next Generation 9-1-1 (NG9-1-1) and improve the accuracy of the GIS data for Public Safety Answering Point (PSAP) map display for all types of calls. Once the corrections are made, the GIS road centerline file can then be used to validate addressing and to generate an up-to-date MSAG file for scrubbing service provider addresses.

2.2 Reason to Implement

Accurate and current data is of paramount importance to 9-1-1 entities. Having MSAG, ALI, and GIS datasets in agreement is crucial to providing telecommunicators the information they need to correctly verify the location of a caller and provide proper emergency response. Developing common datasets that follow a single standard will provide critical information to the PSAP and emergency responders and facilitate local, regional, and nationwide exchanging of data and information. As today's technology transitions to meet tomorrow's needs, the need for following a single set of standards is essential.

Comparing the MSAG and GIS databases will identify inconsistent naming conventions, inaccurate address information, improper ESN assignments to MSAG records, improper community assignments, improper exchange designations, and other discrepancies. The comparison process will also reveal fictitious data, incomplete information, and data that exist in only one database. It is important to note that errors or missing information can exist in both databases and other sources should be consulted as well to improve the overall accuracy and completeness of the data.

2.3 Document Terminology

The terms "shall", "must" and "required" are used throughout this document to indicate required parameters and to differentiate from those parameters that are recommendations. Recommendations are identified by the words "desirable" or "preferably".

2.4 Reason for Reissue

NENA reserves the right to modify this document. Upon revision, the reason(s) will be provided in the table below.

Version	Approval Date	Reason For Changes
Original	05/26/2009	Initial Document

2.5 Recommendation for Standards Development Work

This documents references existing NENA Standards and no further standards work is required at this time.

2.6 Cost Factors

Some of the cost factors to be considered, when undertaking the synchronization process, may include:
- Additional personnel
- Overtime
- Software
- Hardware
- Training (including seminars, conferences, webinars, podcast)
- Consultants
- Stress Management Classes
- Meetings among those involved
- Data availability
- Accuracy and completeness of existing data

2.7 Acronyms/Abbreviations/Definitions

Some acronyms/abbreviations used in this document have not yet been included in the master glossary. After initial approval of this document, they will be included. See NENA Master Glossary of 9-1-1 Terminology located on the NENA web site for a complete listing of terms used in NENA documents.

The following Acronyms/Abbreviations are used in this document:		
Acronym	*Description*	*** N)ew (U)pdate*
ALI	Automatic Location Identification	
ANI	Automatic Number Identification	

3   Synchronization of GIS, MSAG, and ALI data

Conflicting information between the MSAG, ALI and GIS databases becomes more prevalent without a constant effort to keep the systems synchronized. However, GIS data of any size will contain errors, and eliminating them all is an unrealistic expectation. The goal of this document is to develop a process that will consistently identify errors or discrepancies in the data and quickly correct those which are found. The longer GIS data goes without an update, the less accurate the information will become and the integrity of the data diminishes. The 9-1-1 Authority will always be the responsible party for the data, whether they use in-house staff to produce the data or obtain it from:
- Local GIS department(s) (i.e. government, law enforcement, fire department, utilities)
- Local City or County GIS departments
- Mapping Vendor
- GIS data provided from third parties
- The Addressing Authority(ies)

The amount of time to correct the data and eliminate errors cannot be estimated until an analysis of the discrepancies is performed.

Maintaining data integrity within the GIS, MSAG, and ALI requires high levels of coordination to resolve discrepancies. Synchronization of the MSAG, ALI, and GIS data requires coordination between the 9-1-1 Governing Authority database personnel, GIS personnel, Database Management Systems (DBMS), Postal Authority, the local Addressing Authority, Incumbent Local Exchange Carriers (ILEC's) and Competitive Local Exchange Carriers (CLEC's). This process requires specific procedures and a clear process to keep the information synchronized. It is important that the users of map data retain confidence in the data's accuracy. All GIS, MSAG, and ALI data must be continuously updated with the newest information and the updates made available to telecommunicators in a timely manner.

- The GIS and MSAG database synchronization process involves many important steps that are explained in detail throughout this document. Traditionally these two databases have been maintained separately; therefore understanding the current condition and maintenance processes of these existing databases is the important first step towards synchronization. From this understanding, an agency specific workflow can be implemented to consolidate and standardize the MSAG and GIS data. Once the MSAG and GIS databases are standardized, they need to be compared for accuracy and completeness. The synchronization of the GIS and the MSAG data could ultimately lead to a consolidated workflow and data maintenance process which would eliminate the need to maintain separate GIS and MSAG databases.

The basic steps in the synchronization process for GIS, MSAG, and optionally ALI data can be broken down into:
- Data Preparation
- Data Standardization
- Initial Corrections to the Databases
- Synchronization
- Discrepancy Reports
- Discrepancy Corrections
- Maintenance – The synchronization and correction of discrepancies should be done on a continuous basis.

As neither database is static in nature, the synchronization process will never yield a 100 percent match rate. The information in this document should be part of an ongoing and continuous process to ensure that the databases remain current and synchronized.
- It is recommended that a minimum match rate of **98%** be set prior to using the GIS data in the Emergency Routing Data Base (ERDB) or the Location to Service Translation (LoST) Protocol services.

There are many possible types of discrepancies and they all require research to find the resolutions that properly represent reality. Once this process is complete, the result is a consolidated, accurate, and complete 9-1-1 GIS database that is the central maintenance repository for addressing, mapping, and 9-1-1 database reporting.

3.1   Data Preparation

Standardization and quality control processing must take place on the GIS street centerline data and the MSAG data prior to comparing the two data sets for the synchronization process. This section describes the process for preparing the data in the GIS road centerlines and the MSAG data in order to compare the two data sets.

3.1.1 MSAG Standardization and Quality Control

The MSAG is a listing of all the road names and address ranges within a given area. Inconsistencies within the MSAG could translate into issues with the ALI data, how the call is routed, and could prevent a call from being properly located on the map.

A detailed comparison of the GIS street centerline data and the MSAG will identify many inconsistencies between the databases, including, but not limited to:
- Different road naming conventions
- Inaccurate address ranges
- Improper MSAG Community designations
- Improper Postal Community designations
- Improper Exchange designations
- Incorrect ESN assignments

- Incomplete or missing records
- Roads may be in the GIS that are not in the MSAG because the GIS roads do not have addressed structures associated with them.

Discrepancies between the GIS, the MSAG, and the ALI data can cause call routing and dispatching problems. Inaccuracies in the databases could lead to a delayed or improper response. By comparing GIS data to the MSAG, identifying the problems, creating discrepancy reports, and working to correct the discrepancies, these problems can be minimized.

Standardization is the process of agreeing on and utilizing a technical standard where uniform methods and criteria are used. This should be one of the first steps when comparing GIS and MSAG databases.

Standardization of the GIS road centerline data and the MSAG data should incorporate the following:
- N, S, E, W, NE, NW, SE, or SW are the only prefix and suffix directional abbreviations which are used, when a prefix and / or suffix directional is present.
- All punctuation should be avoided.
- Remove special characters (dash, underscore, apostrophe, quotes or any other special characters that could cause problems in any of the software or databases).
- Use only whole numbers in the house number fields (fractional house numbers belong in the House Number Suffix field).
- Use complete spelling of the legal street name assigned by the addressing authority (e.g. Saint Albans versus St Albans).
- Spell out the complete MSAG and Postal Community name.
- Prefix directional is only abbreviated when not part of the actual street name (North Dr would not be abbreviated to N Dr).
- Post directional abbreviated when they are not the actual street name. (Lone Pine Dr South would be abbreviated to Lone Pine Dr S, but Loop West Dr would not be abbreviated to Loop W Dr).
- Standardize street suffix according USPS Publication No. 28 – Appendix C1
  http://pe.usps.gov/cpim/ftp/pubs/Pub28/pub28.pdf

The Canadian Addressing Guide may be downloaded from the Canada Post / Postes Canada web site at URL:

English:
https://www.canadapost.ca/tools/pg/manual/PGaddress-e.asp

French:
https://www.canadapost.ca/tools/pg/manual/PGaddress-f.asp

Figure 1. Example of Street Suffix Standardization

Original					Standardized			
PD	STREET	SUFFIX	SD		PD	STREET	SUFFIX	SD
	North Elm	St			N	Elm	St	
N	Grand W Parkway				N	Grand	Pkwy	W
	Barton Trail					Barton	Trl	
	South Pasadena	Rd			S	Pasadena	Rd	
	Cana Road					Cana	Rd	
	Stockyard's	PKY				Stockyards	Pkwy	
	Oak Place					Oak	Pl	
	Market Plaza					Market	Plz	
	Rt 2					Route 2		
	W 9				W	9th		
	Av J					Avenue J		
	Ave B					Avenue B		
	Commerce					Commerce	St	
	St Albans	Ln				Saint Albans	Ln	
	M. D. Anderson	Blvd				M D Anderson	Blvd	
	Roosevelt Highway					Roosevelt	Hwy	
	west court street				W	Court	St	
	Co Rd 45					County Road 45**		
E	R. Jones Road				E	R Jones	Rd	

**Note: Check with your USPS Addressing Information Management System (AMS) to determine how they show a street name, CR 45 or County Road 45 for example. The proper AMS office can be located by providing a city and state, or just a zip code, to the locator service at: https://ribbs.usps.gov/locators/find-ams.cfm.

Additionally, you can enter an address into the USPS Zip Code Lookup service at: http://zip4.usps.com/zip4/welcome.jsp, and the USPS address will be returned.

While the local addressing authority may not follow the accepted standardized road naming conventions given in this document, it is important to remember that standardization must take place on the 9-1-1 databases to ensure interoperability and to allow exchanging of GIS data with other regional, tribal, state, and federal agencies. Every effort should be made to educate the local addressing authorities that standardization will improve quality, lower cost, and improve the level of services to the public.

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Figure 2. An example of using the Zip Code Lookup service to obtain the USPS street name

Pressing "Submit" returns the following:

The street naming conventions should be consistent in the **GIS street centerline, the MSAG and ALI** data. This should be done not only for the synchronization process, but also for day-to-day operations and data sharing. All MSAG, ALI, and GIS road naming conventions must be consistent.

The standardization process should take place in both the MSAG and the GIS databases. Since the number of changes to the databases may be quite high, all involved parties must agree to the number of changes that can be processed in a timely manner and reviewing the contractual obligations of the involved providers is suggested.

To begin the process of standardization the following steps are recommended:

- Request the MSAG from your Data Base Management System provider.
- Load the MSAG into a worksheet or database format, with each field being in a separate column.
- Save the MSAG file (e.g. Initial MSAG).
- Save another copy of the MSAG under a different name (e.g. Copy of MSAG).
- Open the copy of the MSAG (e.g. Copy of MSAG).
- Do not delete any records out of the original MSAG, only removing certain records from the "Copy of MSAG".
- Sort the data by MSAG COMMUNITY and delete any FX Records in the "Copy of MSAG" Make note of any records with a blank or incomplete MSAG COMMUNITY name as these will need to be resolved.
- If the MSAG contains Postal Community then sort by Postal Community and make note of any with missing or incomplete community names as these will need to be resolved.
- Sort the data by EXCHANGE and delete any wireless or VoIP records in the "Copy of MSAG".
- Sort the data by LOW and HIGH address ranges and delete any records with blank, zero, or missing LOW and/or HIGH address ranges in the "Copy of MSAG". Make note of the records with missing LOW and/or HIGH address ranges as these will need to be resolved.

If any of the MSAG records contains blank LOW and/or HIGH address ranges, MSAG or Postal Community Names, or ESN's that are not in your area, these records need to be checked carefully and either sent back to the DBMS provider with corrected information or reconciled.

Figure 3. Example of missing MSAG Community names

PD	STREET_NAME	SS	SD	LOW	HIGH	MSAG COMMUNITY	O/E	ESN	EXCH
	APPLEFORD			1100	1199			00093	ANK
	BARONRIDGE	DR		1000	1099			00093	4422
	BLUEBONNET	DR		1200	1499			00093	ANK

MSAG records entered to allow validation of FX, wireless or VoIP records not in the GIS should be deleted from the "Copy of MSAG". MSAG records that do not have a MSAG Community Name and / or a Postal Community name (if present in the MSAG), should be corrected to include the proper Community names completely spelled out. Figure 4 illustrates some of these types of MSAG records that need to be removed from the Copy of MSAG prior to comparing this information against the GIS street centerline data.

Figure 4. MSAG records to be removed from the "Copy of MSAG"

PD	STREET_NAME	SS	SD	LOW	HIGH	MSAG COMMUNITY	O/E	ESN	EXCH
	FOREIGN EXCHANGE	ST		1	1	TAYLOR		00093	
	FX - KIRBY	RD		500	500	TAYLOR	E	00093	5442
	FX -IFTWOOD	DR		207	207	TAYLOR		00093	5442
	FX - PINE	CIR		1111	1111	TAYLOR		00093	5442
	FX - WILLOW HILL	DR		4102	4102	TAYLOR		00093	HO1

	FX - WILLOW HILL	DR		4102	4102	TAYLOR		00093	ANK
	ANNAPOLIS	DR				SEABROOK		00093	ANK
	WIRELESS					TAYLOR		00093	WRLS
	1718 KIRBY BLVD - SW					TAYLOR		00093	WRLS
	1718 KIRBY BLVD - N					TAYLOR		00093	WRLS
	MOBILE WAY			2	2	LAKEVIEW		00093	WRLS

It is strongly recommended that the information in the Copy of MSAG be sent to the addressing entities for their review. The entities may have streets not shown on the MSAG or may have either renamed or extended a street and failed to forward proper notification or documentation.

Correcting the Initial MSAG Records

- Any changes that need to be made will have to be sent to the proper agencies to be corrected.
- Make note of any MSAG errors, but do not change anything in this MSAG copy (Copy of MSAG).
- Make a copy of the "Copy of MSAG" and name it "MSAG Changes".
- Open the "MSAG Changes" and add columns for New Prefix Direction, New Street Name, New Street Suffix, and New Street Suffix Direction, or other fields needing correction, similar to the example below. These fields will store the information that needs to be changed in the MSAG.
- Review each MSAG record for Prefix Directional, Street Name, Street Type, Post-Directional, and Community Name standardization.
- Review to make sure the proper information is in the correct field.

Again, in the First Pass we are only changing street names and ESN's. A very similar process will be used when we compare the MSAG and GIS data for MSAG Community, Postal Community, and Low and High address ranges later.

Note: Corrections to the MSAG data in your DBMS may differ from this process.

Figure 5. Example of Changes to MSAG table (not all fields are shown)

PD	STREET_NAME	ST_SUF	SD	LOW	HIGH	COMMUNITY	ESN	N_PD	N_STREET_NAME	N_ST_SUF	N_SD	N_ESN
	APPLEFORD			1100	1199	TAYLOR	093		APPLEFORD	DR		
	BARONRIDGE	DR		1000	1099	TAYLOR	093		BARON RIDGE	WAY		
	CHADBURY			800	899	TAYLOR	093		CHADBURY	RD		
	CORAL WAY	DR		1300	1322	TAYLOR	093		CORAL WAY	DR	S	
	CORAL WAY	CT		1500	1511	TAYLOR	093					112
	CRAGMORE	DR		1000	1199	TAYLOR	093		CRAIGMORE			
	CROWNWOOD	DR		4100	4299	TAYLOR	093	N	CROWNWOOD	LN		
	DARTMOUTH	DR		100	199	SEABROOK	093					112
	DELANEY			900	999	TAYLOR	093		DELAINEY	LN		

The 9-1-1 Authority should provide corrected and standardized information back to the respective agency for updating. The "MSAG Changes" document will be used to track and send changes to the

DBMS provider for updates and will contain corrections to the discrepancies for this process.
Submission of changes must be completed using agreed upon formats or interfaces.

3.1.2 GIS Data Standardization and Quality Control

Most of the information in this section for GIS centerline data is covered in NENA GIS Data
Collection and Maintenance Standards NENA 02-014, Issue 1, July 17, 2007. This document should
be referred to for recommended audits, quality control, quality assurance, and related information.
Parts of that document have been expanded on for the focus of this discussion.
The representation of a roadway in a GIS system is often referred to as a street centerline or an
addresses centerline, which represents the center of the road, not the right-of-way or the edge of the
property line. The attribute fields within the centerline data include high and low address ranges
along each segment of the road. The high and low addresses are further broken down into left and
right side address, so each centerline segment will have a left-side low address, a right-side low
address, a left-side high address and a right-side high address. Actual address ranges should be used.

Figure 6. GIS Data Model Version 2 – Street Centerlines

ATTRIBUTE NAME	USE R/O	TYPE	DATA DESCRIPTION
Low Address Left	R	N	Lowest address on left side of street in ascending order
High Address Left	R	N	Highest address on left side of street in ascending order
Low Address Right	R	N	Lowest address on right side of street in ascending order
High Address Right	R	N	Highest address on right side of street in ascending order
Prefix Directional	R	A	Leading street direction prefix. Valid Entries: N S E W NE NW SE SW
Street Name	R	A	Valid street name as assigned by local addressing authority
Street Suffix	R	A	Valid Street abbreviation, as defined by the US Postal Service Publication 28. (e.g. AVE)
Post Directional	R	A	Trailing street direction suffix. Valid Entries: N S E W NE NW SE SW
Road Class	R	A	http://www.fhwa.dot.gov/planning/fctoc.htm Highway Performance Monitoring System (HPMS) Functional Classifications: 1= Interstate 2= Other Freeways and Expressways 3= Other Principal Arterial 4= Minor Arterial 5= Major Collector 6= Minor Collector 7= Local

Not designated as a HPMS Functional Classification, but none the less an important road classification for 9-1-1: |

			8= Trails (Recreational trails)
One-way	R	A	One way road classification. B or Blank – travel in both directions allowed FT – One-way from FROM node to TO node (in direction of arc) TF – One way from TO node to FROM Node (The one-way fields may be different depending on the software used)
Postal Community Name Left	R	A	Postal Community Name as identified on the left side of the street[2]
Postal Community Name Right	R	A	Postal Community Name as identified on the right side of the street[2]
Postal Code/Zip Code Left	R	AN	Postal or Zip code as identified on the Left side of the street. Format: ANANAN or NNNNN
Postal Code/Zip Code Right	R	AN	Postal or Zip code as identified on the Right side of the street. Format: ANANAN or NNNNN
MSAG Community Name Left	R	A	Valid service community name as identified by the MSAG on the left side of the street
MSAG Community Name Right	R	A	Valid service community name as identified by the MSAG on the right side of the street
ESN Left	O	A	3-5 digit Emergency Service Number associated with street segment
ESN Right	O	A	3-5 digit Emergency Service Number associated with street segment
Segment ID	R	N	Unique Road Segment ID number
County Name Left	R	AN	County Name on the Left side of the street as given in FIPS 6-4 [1]
County Name Right	R	AN	County Name on the Right side of the street as given in FIPS 6-4 [1]
County Code Left	R	A	County Code on the Left side of the street as given in FIPS 6-4 [1]
County Code Right	R	A	County Code on the Right side of the street as given in FIPS 6-4 [1]
Source of Data	R	A	Agency that last updated the record
Date Updated	R	N	Date of last update Format: CCYY-MM-DD

Each street centerline segment should contain the low and high address values for the addresses assigned along that road centerline segment. In areas where there are no addresses assigned along a segment, a potential or probable range must be assigned.

If other applications using the GIS street centerline data require continuous addressing (e.g. 100 – 199 for one segment then 200-299 for the next with no "gaps" the in address ranges) it is strongly recommended that the NENA GIS Data Model fields for addressing be used to be reflect the actual address ranges of each street segment (e.g. 137 – 168 for one segment then 206 – 259 for the next segment) and another set of address fields be added to the GIS centerline data to accommodate any need for continuous address ranges. The use of actual address ranges is used to better reflect the address locations during geo-coding.

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Some of the "Mapped ALI" and / or Computer Aided Dispatch (CAD) systems will only load street centerline data that is has continuous address ranges, that is, without any gaps in the address values in the attribute fields. The use of actual address range values or potential address range values is dependent on how other applications or entities will be using the street centerline data. Other systems may allow only continuous, potential, address ranges. Check with the vendors of the different systems to understand their limitations.

Below is an example of the GIS street centerline data carrying both the actual address ranges in the first four columns shown and the potential address ranges in the next four columns. This allows the data set to use the actual address ranges for better geocoding of the location of addresses and the flexibility to use the potential address ranges with other applications that require continuous addressing.

Figure 7. Using actual and potential address ranges in same GIS street centerline database

Low Address Right	Low Address Left	High Address Right	High Address Left	LR_PA	LL_PA	HR_PA	HL_PA	Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left
12512	12513	12586	12587	12500	12501	12598	12599		BAY AREA	BLVD		069	070
12622	12623	12670	12671	12600	12601	12698	12699		BAY AREA	BLVD		069	070
1802	1803	1872	1873	1899	1801	1898	1899		CALYPSO COVE	CT		079	079
602	603	618	619	600	601	698	699		CORAL WAY	CT		093	093
408	409	427	428	400	401	498	499		CORAL WAY	DR		093	093

In Figure 8, 100 to 199 is the potential address range on the street segment, with the actual house location and addresses shown.

Figure 8. Potential address ranges along street segment
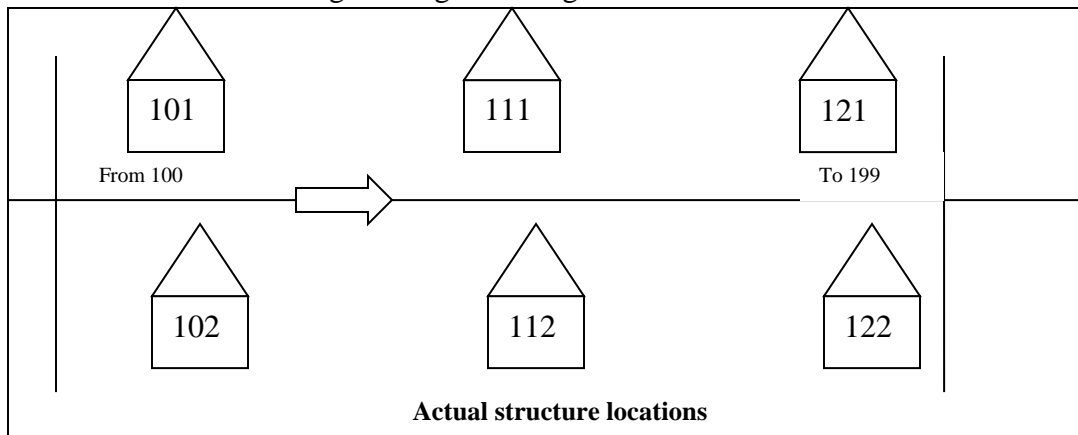
In Figure 9, where potential addressing is being used, an address is geocoded to the street centerline in the GIS data as a point, which is placed along the street segment to approximate the location of the address. In the case of potential addressing the address locations of 101, 102, 111, 112, 121, and 122 would all be displayed near the beginning address of 100 as indicated by the stars in the diagram.

Figure 9. Geocoded addresses (shown as stars) along street segment having potential address ranges
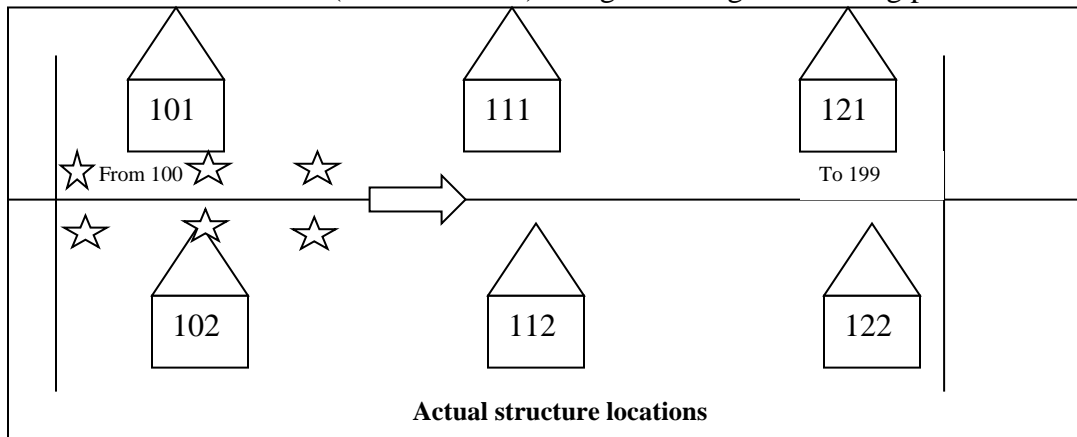
It is strongly recommended that actual addressing be used in the GIS street centerline. Using actual address ranges for the GIS street centerlines will improve the location accuracy of the geocoding process, and in Figure 9 the location of the geocoded point would be a closer approximation of the actual location of the structure. Close cooperation, coordination, and communication with the local addressing authority and the Postal Service will minimize the errors in the GIS street centerline data. The nuances of the local addressing system and available resources must be taken into consideration.

This document takes the approach that the GIS street centerline data should meet the following criteria:
- Is spatially accurate
- Attributes are accurate and complete and standardized (address ranges, ESN's, Communities, spelling, abbreviations)
- Meets or exceeds all related NENA Standards
- Contains the necessary attributes to be used by multiple applications and users
- Maintained on a continual basis
- Contains all the valid addressing information present in the MSAG after corrections to both datasets and MSAG records are made
- Matches the corrected MSAG to a **98** percent or higher rate.

Some recommended quality checks for attributes in the GIS street centerline data set include:

- All street names are present in the street centerline attributes

- Street names conform to the legal names as assigned by the addressing authority. (Some addressing authorities do not follow standard practices for street naming, and the legal street name may conflict with standardized naming conventions, but the 9-1-1 databases must be standardized to ensure synchronization and conformance in the NG 9-1-1 environment, e.g. Northeast J. L. Higg Pky should be standardized to NE J L Higg Pkwy and all punctuations should be removed.
- Incorrect, incomplete, missing, or inconsistent road names are corrected.
- Street Prefixes and Suffixes are properly abbreviated when they exist, according to NENA Standards
- All MSAG Communities are populated with the correct information, are fully spelled out, and are consistent
- All Postal Communities are populated with the correct information, are fully spelled out, and are consistent
- Lower address ranges are lower than the high address ranges
- Left and Right addressing is consistently either odd or even addresses
- No attribute information missing such as ESZ, MSAG Community, etc…
- No overlapping address ranges exist
- All line segments should be flowing (oriented) in the direction of increasing address ranges
- Wireline ESN's are all present and consistently coded in the GIS centerline data
- County ID's exist (FIPS-Code: 5 digit - 2 numbers for state, 3 for county)
- PSAP-ID's are all present https://www.fcc.gov/encyclopedia/9-1-1-master-psap-registry

Topology Elements
A topologically correct street centerline allows the systems to verify addresses and assign those addresses to specific agencies, cities, ESZ areas, districts, beats, units, etc. It is also vital for defining intersections, common place names, vehicle routing, premise and hazard data. To maintain proper topology the addressed centerline data and related area boundary layers must adhere to the following minimum topology requirements:

- Each centerline segment must share an exact begin or end node with another centerline segment.
- If segments intersect without begin or end nodes, (i.e. overpasses or underpasses) a street intersection is not established.
- For routing purposes and intersection lookup purposes, each intersection must be split.
- Centerline segments must be split (broken) at all true (grade-level) intersections.
- Line (road) segments shall be split at intersections and ESZ boundaries. Road segments can be split at city and country boundaries as well.
- Consider splitting at railroad tracks and streams for intersection searches.
- The centerline segments should be drawn in the direction of increasing addresses, which is not necessarily the same as the direction of travel.

Note: The above processes, and more, are described in detail in NENA 02-014.

3.2 Synchronization Process Overview

MSAG and GIS data synchronization should take place in different phases. Phase One will compare the GIS street centerline data to the MSAG. Phase Two will reverse the comparison process by comparing the MSAG to the GIS street centerline data. The process of creating and comparing these data sets is described in Section 2.2.1. An introduction to the concepts of this process is provided in this section.

Phase One – GIS street centerline compared to MSAG

In Phase One analysis, the MSAG data is the control dataset, and the GIS data is joined with the MSAG, to determine what records in the MSAG match the GIS street centerline data. The join process will also show what records in the MSAG are not in the GIS street centerline data. The join process requires a composite Unique Key in the MSAG and GIS data. The explanation and development process for the composite Unique Key are discussed in section 2.2.1.

An assumption cannot be made as to which discrepancies are correct or invalid. This process simply shows the discrepancies. A thorough investigation by local personnel will be required to determine if the MSAG, GIS, or both, require correction.

Figure 10. Example of GIS street centerline data ready to be joined (not all fields shown)

Low Address Right	Low Address Left	High Address Right	High Address Left	Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	MSAG Community Right	MSAG Community Left	Unique_Key
12512	12513	12586	12587		BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
12622	12623	12670	12671		BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
13522	13523	13536	13537		BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
1802	1803	1872	1873		CALYPSO COVE	CT		079	079	PASADENA	PASADENA	CALYPSO COVE CT 079
612	613	656	657		10TH	ST	S	080	080	SEABROOK	SEABROOK	10TH ST S 080
408	409	514	515		12TH	ST		080	080	SEABROOK	SEABROOK	12TH ST 080
4308	4309	2586	2587		ALBATROSS	DR		080	080	SEABROOK	SEABROOK	ALBATROSS DR 080
1768	1769	1820	1821		BIMINI	WAY		080	080	SEABROOK	SEABROOK	BIMINI WAY 080
2422	2423	2278	2279		BLUE CANOE	CT		080	080	SEABROOK	SEABROOK	BLUE CANOE CT 080
500	501	514	515		BLUE DOLPHIN	DR		080	080	SEABROOK	SEABROOK	BLUE DOLPHIN DR 080
1776	1777	1966	1967		CAPRI	DR		080	080	SEABROOK	SEABROOK	CAPRI LN 080
1740	1741	1846	1847		DOLPHIN	DR		080	080	SEABROOK	SEABROOK	DOLPHIN DR 080
606	607	652	653	N	FLAMINGO			080	080	SEABROOK	SEABROOK	N FLAMINGO 080
4520	4521	4628	4629	S	FLAMINGO			080	080	SEABROOK	SEABROOK	S FLAMINGO 080
1012	1013	1236	1237	W	FLAMINGO			080	080	SEABROOK	SEABROOK	W FLAMINGO 080
1008	1009	1086	1087	N	HERON	DR		080	080	SEABROOK	SEABROOK	N HERON DR 080
1151	1152	1266	1267	N	HERON	DR		080	080	SEABROOK	SEABROOK	N HERON DR 080
1332	1333	1460	1461	S	HERON	DR		080	080	SEABROOK	SEABROOK	S HERON DR 080
4900	4901	4998	4999	S	SURF OAKS			080	080	SEABROOK	SEABROOK	S SURF OAKS 080
1502	1503	1518	1519		CORAL WAY	CT		093	093	SEABROOK	SEABROOK	CORAL WAY CT 093
1306	1307	1322	1323		CORAL WAY	DR		093	093	SEABROOK	SEABROOK	CORAL WAY DR 093

Figure 11. Example of MSAG data ready to be joined (not all fields shown)

PS	ST_NAME	TYPE	SD	LOW	HIGH	MSAG_COMMU	O/E	ESN	Unique_Key
	BAY AREA	BLVD		12500	13598	LA PORTE	E	069	BAY AREA BLVD 069
	BAY AREA	BLVD		12501	13599	LA PORTE	O	070	BAY AREA BLVD 070
	CALYPSO COVE	CT		1800	1899	PASADENA	B	079	CALYPSO COVE CT 079
	BIMINI	WAY		1700	1899	SEABROOK	B	080	BIMINI WAY 080
	BLUE CANOE	CT		2400	2499	SEABROOK	B	080	BLUE CANOE CT 080
	BLUE DOLPHIN	DR		500	500	SEABROOK	E	080	BLUE DOLPHIN DR 080
	CAPRI	DR		1700	1999	SEABROOK	B	080	CAPRI DR 080
	DOLPHIN	DR		1700	1899	SEABROOK	B	080	DOLPHIN DR 080
N	FLAMINGO			600	699	SEABROOK	B	080	N FLAMINGO 080
S	FLAMINGO			4500	4699	SEABROOK	B	080	S FLAMINGO 080
W	FLAMINGO			1000	1299	SEABROOK	B	080	W FLAMINGO 080
N	HERON	DR		1000	1299	SEABROOK	B	080	N HERON DR 080
S	HERON	DR		1300	1499	SEABROOK	B	080	S HERON DR 080
S	SURF OAKS			4900	4999	SEABROOK	B	080	S SURF OAKS 080
	CORAL WAY	CT		1500	1511	TAYLOR	B	093	CORAL WAY CT 093
	CORAL WAY	DR		1300	1322	TAYLOR	B	093	CORAL WAY DR 093

In Figure 12, note that Bay Area Blvd in ESN 070 is in the MSAG but did not join to the GIS street centerline data because the Unique Key in the GIS data was built using ESN Right (069). When the left and right ESN's differ, care must be taken to ensure the MSAG and GIS data are correct. In this case the GIS Street centerline data does contain Bay Area Blvd with the left and right ESN's being correctly attributed.

Figure 12. Example of resulting GIS street centerline joined to the MSAG (not all fields shown)

MSAG_COMMU	O/E	ESN	Unique_Key	Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left
LA PORTE	E	069	BAY AREA BLVD 069		BAY AREA	BLVD		069	070
LA PORTE	O	070	BAY AREA BLVD 070						
PASADENA	B	079	CALYPSO COVE CT 079		CALYPSO COVE	CT		079	079
SEABROOK	B	080	BIMINI WAY 080		BIMINI	WAY		080	080
SEABROOK	B	080	BLUE CANOE CT 080		BLUE CANOE	CT		080	080
SEABROOK	E	080	BLUE DOLPHIN DR 080		BLUE DOLPHIN	DR		080	080
SEABROOK	B	080	CAPRI DR 080						
SEABROOK	B	080	DOLPHIN DR 080		DOLPHIN	DR		080	080
SEABROOK	B	080	N FLAMINGO 080	N	FLAMINGO			080	080
SEABROOK	B	080	S FLAMINGO 080	S	FLAMINGO			080	080
SEABROOK	B	080	W FLAMINGO 080	W	FLAMINGO			080	080
SEABROOK	B	080	N HERON DR 080	N	HERON	DR		080	080
SEABROOK	B	080	S HERON DR 080	S	HERON	DR		080	080
SEABROOK	B	080	S SURF OAKS 080	S	SURF OAKS			080	080
TAYLOR	B	093	CORAL WAY CT 093		CORAL WAY	CT		093	093
TAYLOR	B	093	CORAL WAY DR 093		CORAL WAY	DR		093	093

In the MSAG Capri Dr in ESN 080 did not join to any records in the GIS street centerline data. In the GIS data the street is Capri Ln in ESN 080. Since the street suffixes differ, the join process did not match the records.
The process of finding and correcting these discrepancies is described in Section 2.2.1.

<div align="center">

Phase Two – MSAG compared to GIS street centerline

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In the Phase Two analysis the GIS street centerline data is the control and the MSAG is joined with the GIS data to determine what records in the GIS data match the MSAG. The join process will also show records that exist in the GIS data that are not in the MSAG. The join process in Phase Two also requires a composite Unique Key as discussed in Section 2.2.1.

As stated above, investigation by local personnel is needed to determine if the GIS data, MSAG, or both require correction. For example, if there is a street with address ranges in the map that is not in the MSAG, then local personnel will need to determine if the GIS street centerline data is accurate, and whether or not the street officially does exist. If it is determined that the street actually exists, then the MSAG should be edited to accommodate the street name and address ranges.
Comparing the GIS data to the MSAG data will show the discrepancies between the MSAG and the GIS street centerline data, such as the street names or ESN's in the MSAG that do not match those in the GIS street centerline data.

Figure 13. Example of MSAG table joined to the GIS data

Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	Unique_Key	PS	ST_NAME	TYPE	SD	LOW	HIGH	MSAG_COMMU	O/E	ESN
BAY AREA	BLVD		069	070	BAY AREA BLVD 069		BAY AREA	BLVD		12500	13598	LA PORTE	E	069
CALYPSO COVE	CT		079	079	CALYPSO COVE CT 079		CALYPSO COVE	CT		1800	1899	PASADENA	B	079
10TH	ST	S	080	080	10TH ST S 080									
12TH	ST		080	080	12TH ST 080									
ALBATROSS	DR		080	080	ALBATROSS DR 080									
BIMINI	WAY		080	080	BIMINI WAY 080		BIMINI	WAY		1700	1899	SEABROOK	B	080
BLUE CANOE	CT		080	080	BLUE CANOE CT 080		BLUE CANOE	CT		2400	2499	SEABROOK	B	080
BLUE DOLPHIN	DR		080	080	BLUE DOLPHIN DR 080		BLUE DOLPHIN	DR		500	500	SEABROOK	E	080
CAPRI	LN		080	080	CAPRI LN 080									
DOLPHIN	DR		080	080	DOLPHIN DR 080		DOLPHIN	DR		1700	1899	SEABROOK	B	080
FLAMINGO			080	080	N FLAMINGO 080	N	FLAMINGO			600	699	SEABROOK	B	080
FLAMINGO			080	080	S FLAMINGO 080	S	FLAMINGO			4500	4699	SEABROOK	B	080
FLAMINGO			080	080	W FLAMINGO 080	W	FLAMINGO			1000	1299	SEABROOK	B	080
HERON	DR		080	080	N HERON DR 080	N	HERON	DR		1000	1299	SEABROOK	B	080
HERON	DR		080	080	N HERON DR 080	N	HERON	DR		1000	1299	SEABROOK	B	080
HERON	DR		080	080	S HERON DR 080	S	HERON	DR		1300	1499	SEABROOK	B	080
SURF OAKS			080	080	S SURF OAKS 080	S	SURF OAKS			4900	4999	SEABROOK	B	080
CORAL WAY	CT		093	093	CORAL WAY CT 093		CORAL WAY	CT		1500	1511	TAYLOR	B	093
CORAL WAY	DR		093	093	CORAL WAY DR 093		CORAL WAY	DR		1300	1322	TAYLOR	B	093

When the MSAG data is joined to the GIS street centerline data the streets in the MSAG data that are not in the GIS data, and those that are not an exact match, can be easily identified. In Figure 13 the GIS data contains a 10th St S, a 12th St, an Albatross Dr, and the previously discussed Capri Ln which are not in the MSAG data. The process of finding and correcting these discrepancies is described in Section 2.2.1 below.

3.2.1 Synchronization of GIS Street Centerline data to the MSAG

In order to synchronize the two data sets the first step is to do a comparison of the data. A common database technique found in all of today's GIS software packages and relational database management systems called a "join" will be used to compare the GIS street centerline data to the MSAG. A join combines records from two tables into a new table. The following examples use a special type of join, often referred to as an "inner join" or a "table join", which requires each record in the two tables to have a matching record in order for the join to occur. The matching record in this case is on a unique composite key of several of the attributes in each of the two tables.

Joining the MSAG records to the GIS street centerline data creates a database containing all the records in the GIS street centerline data and the records in the MSAG data that are an exact match of the unique key found in the GIS data as shown in Figure 13.
Figures 14 and 15 combine the Prefix Directional, Street Name, Street Suffix, Post Directional and the ESN of each record for both the MSAG and GIS data to create the unique composite key, or the unique key.

Conversely, if the GIS street centerline data was joined to the MSAG data, the resulting database would contain all of the records in the MSAG data and those records in the GIS data that were an exact match of the unique key found in the MSAG data as shown in Figure 12. These types of joins are known as a full outer join.

The use of the ESN in conjunction with the other attributes of the complete street name yields the most discrepancies. Other unique composite keys will be created by using the MSAG or Postal Community, in both the GIS and MSAG tables, in place of the ESN number used in these examples to further refine the synchronization process. Using the MSAG Community name and the Postal Community Name in place of the ESN will be discussed at the end of this section.

Figure 14. Unique Key field added to the MSAG Data (not all fields shown)

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN	E/O	Unique Key
	Kelly	Ct	S	111	B	Kelly Ct S 111
	Kelly	Ct	S	115	O	Kelly Ct S 115
S	Main			220	O	S Main 220
S	Main			226	E	S Main 226

S	Main			221	O	S Main 221

Figure 15. Unique Key added to the GIS Street Centerline Data (not all fields shown)

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN_L	Unique Key
	Kelly	Ct	S	111	Kelly Ct S 111
S	Main			220	S Main 220
S	Main			221	S Main 221
W	Adams	Ave		111	W Adams Ave 111

Notes on Joining the MSAG and GIS street centerline data:
- The GIS street centerlines contain a left and right ESN value. Care should be taken when the left and right ESN values differ as these may be streets that form the border of the ESN's, Postal Communities and / or MSAG Communities.
- These streets can be identified in the MSAG data by having an Even (E) or Odd (O) parity value in the E/O column of the MSAG. If the streets are completely within an ESN in the MSAG data then this column should contain a B for Both, assuming the MSAG data is correct.
- MSAG records that contain an Even (E) or an Odd (O) only range also require special consideration as they may form the boundary between two or more ESN's. These types of records should be carefully checked against the Left and Right ESN values in the GIS street centerline data.
- The GIS street centerline data and the MSAG data may store the ESN values differently. However, they must be the same length for the join process to work correctly. For example, the street name of SMITH ST with an ESN value of 00021 in the MSAG data, and a street name of SMITH ST with an ESN value of 021 in the GIS street centerline data will not allow the join process, since SMITH ST 00021 is not the same as SMITH ST 021.
- Many typical computer software applications for spreadsheets or databases allow the unique composite key in the MSAG to be created using the "concatenate" command, or similar function.
- It is recommended that both GIS and MSAG unique key fields be converted to uppercase in order for the Join process to work correctly, for example "Smith St" may not match "SMITH ST".
- All extra spaces need to be removed from the unique key, e.g. replacing two spaces with one space and removing leading and trailing spaces. In Figure 16 below there is an extra space before "Kelly" in the first Unique Key record and in the second Unique Key is an extra space between "Main" and "220". These must be removed prior to joining the two data sets for the join to work properly.

Figure 16. Unique Key having extra spaces

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN_L	Unique Key
	KELLY	CT	S	111	_KELLY_CT_S_111
S	MAIN			220	S_MAIN__220

All leading and trailing spaces must be removed from both the GIS street centerline data and the MSAG data unique key. When joining the MSAG and the GIS data together based on the unique key, the program may not recognize that "_Kelly" and "Kelly" are the same, since "_Kelly" has a space in front of the letter K. The same holds true for "S_Main __220" versus "S_Main_220", where there are two spaces between Main and 220.

These types of issues are illustrated in Figure 17, the "Centerline Unique Key Uncorrected, and figure 18, "Centerline Unique Key Corrected". Notice the leading, double, and trailing spaces in Figure 17, and the correction in Figure 18

Figure 17. Centerline Unique Key Uncorrected (not all fields shown)

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	MSAG Community Right	MSAG Community Left	Unique_Key
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	CALYPSO COVE	CT		079	079	PASADENA	PASADENA	CALYPSO COVE CT 079
	10TH	ST	S	080	080	SEABROOK	SEABROOK	10TH ST S 080
	12TH	ST		080	080	SEABROOK	SEABROOK	12TH ST 080
N	FLAMINGO			080	080	SEABROOK	SEABROOK	N FLAMINGO 080
S	FLAMINGO			080	080	SEABROOK	SEABROOK	S FLAMINGO 080
W	FLAMINGO			080	080	SEABROOK	SEABROOK	W FLAMINGO 080
N	HERON	DR		080	080	SEABROOK	SEABROOK	N HERON DR 080
S	SURF OAKS			080	080	SEABROOK	SEABROOK	S SURF OAKS 080
	CORAL WAY	CT		093	093	SEABROOK	SEABROOK	CORAL WAY CT 093
	CORAL WAY	DR		093	093	SEABROOK	SEABROOK	CORAL WAY DR 093

Figure 18. Centerline Unique Key Corrected (not all fields shown)

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	MSAG Community Right	MSAG Community Left	Unique_Key
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD 069
	CALYPSO COVE	CT		079	079	PASADENA	PASADENA	CALYPSO COVE CT 079
	10TH	ST	S	080	080	SEABROOK	SEABROOK	10TH ST S 080
	12TH	ST		080	080	SEABROOK	SEABROOK	12TH ST 080
N	FLAMINGO			080	080	SEABROOK	SEABROOK	N FLAMINGO 080
S	FLAMINGO			080	080	SEABROOK	SEABROOK	S FLAMINGO 080
W	FLAMINGO			080	080	SEABROOK	SEABROOK	W FLAMINGO 080
N	HERON	DR		080	080	SEABROOK	SEABROOK	N HERON DR 080
S	SURF OAKS			080	080	SEABROOK	SEABROOK	S SURF OAKS 080
	CORAL WAY	CT		093	093	SEABROOK	SEABROOK	CORAL WAY CT 093
	CORAL WAY	DR		093	093	SEABROOK	SEABROOK	CORAL WAY DR 093

Figure 19. GIS Street Centerline Joined to MSAG data

MSAG.Unique_Key	Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	Centerline Unique_Key
BAY AREA BLVD 069		BAY AREA	BLVD		069	070	BAY AREA BLVD 069
BAY AREA BLVD 070							
CALYPSO COVE CT 079		CALYPSO COVE	CT		079	079	CALYPSO COVE CT 079
BIMINI WAY 080		BIMINI	WAY		080	080	BIMINI WAY 080
BLUE CANOE CT 080		BLUE CANOE	CT		080	080	BLUE CANOE CT 080
BLUE DOLPHIN DR 080		BLUE DOLPHIN	DR		080	080	BLUE DOLPHIN DR 080
CAPRI DR 080							
DOLPHIN DR 080		DOLPHIN	DR		080	080	DOLPHIN DR 080
N FLAMINGO 080	N	FLAMINGO			080	080	N FLAMINGO 080
S FLAMINGO 080	S	FLAMINGO			080	080	S FLAMINGO 080
W FLAMINGO 080	W	FLAMINGO			080	080	W FLAMINGO 080
N HERON DR 080	N	HERON	DR		080	080	N HERON DR 080
S HERON DR 080	S	HERON	DR		080	080	S HERON DR 080
S SURF OAKS 080	S	SURF OAKS			080	080	S SURF OAKS 080
CORAL WAY CT 093		CORAL WAY	CT		093	093	CORAL WAY CT 093
CORAL WAY DR 093		CORAL WAY	DR		093	093	CORAL WAY DR 093

Figure 20. MSAG Joined to GIS Street Centerline

Centerline Unique_Key	PS	ST_NAME	TYPE	SD	LOW	HIGH	MSAG COMMUNITY	O/E	ESN
BAY AREA BLVD 069		BAY AREA	BLVD		12500	13598	LA PORTE	E	069
CALYPSO COVE CT 079		CALYPSO COVE	CT		1800	1899	PASADENA	B	079
10TH ST S 080									
12TH ST 080									
ALBATROSS DR 080									
BIMINI WAY 080		BIMINI	WAY		1700	1899	SEABROOK	B	080
BLUE CANOE CT 080		BLUE CANOE	CT		2400	2499	SEABROOK	B	080
BLUE DOLPHIN DR 080		BLUE DOLPHIN	DR		500	500	SEABROOK	E	080
CAPRI LN 080									
DOLPHIN DR 080		DOLPHIN	DR		1700	1899	SEABROOK	B	080
N FLAMINGO 080	N	FLAMINGO			600	699	SEABROOK	B	080
S FLAMINGO 080	S	FLAMINGO			4500	4699	SEABROOK	B	080
W FLAMINGO 080	W	FLAMINGO			1000	1299	SEABROOK	B	080
N HERON DR 080	N	HERON	DR		1000	1299	SEABROOK	B	080
N HERON DR 080	N	HERON	DR		1000	1299	SEABROOK	B	080
S HERON DR 080	S	HERON	DR		1300	1499	SEABROOK	B	080
S SURF OAKS 080	S	SURF OAKS			4900	4999	SEABROOK	B	080
CORAL WAY CT 093		CORAL WAY	CT		1500	1511	TAYLOR	B	093
CORAL WAY DR 093		CORAL WAY	DR		1300	1322	TAYLOR	B	093

The highlighted records in Figures 19 and 20 are the discrepancies between the MSAG and GIS data after both joins are performed. In Figure 19 the MSAG contains "Bay Area Blvd" in ESN 070 that is not in the joined street centerline data. There is also a discrepancy with the joined GIS data containing "Capri Dr" in ESN 080.
GIS street centerline data that contains different Left and Right side ESN's also requires special attention. In cases where the left and right ESN's differ in the GIS street centerline, the MSAG must be carefully consulted to ensure both datasets match.

In the case of "Bay Area Blvd" in Figure 19, the GIS data does contain a "Bay Area Blvd" that has a left side ESN of 069 and a right side ESN of 070, so the GIS data and MSAG data do agree with each other, but the ESN field used in creating the unique key only contained the ESN value of 069. The border streets and the records in the MSAG that have a different ESN on the odd side and even side require careful attention to determine if the GIS street centerline data and the MSAG data are in agreement.

Figure 19 shows "Capri Dr" in ESN 080, and Figure 20 shows "Capri Ln". This discrepancy must be carefully researched to determine the reason it does not match in both data sets.
Note: Different software will show the records that do not join to the other table as either blank or as a NULL value.

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Other join types are possible and may not include the unmatched records from either one or both original tables; care should be taken when dealing with different software vendors as the terminology of joins is not standardized.

Joining the GIS centerline data to the MSAG data, and then joining the MSAG data to the GIS centerline data will allow a determination to be made as to where the discrepancies exist. In the First Pass the ESN and street naming discrepancies will be identified.

Reasons why the two data sets do not properly join include, but are not limited to the following:

Figure 21. Common discrepancies found in the join process

Problem	Parent Data	Joined Data
Street Type missing	JONES RD	JONES
ESN's differ	00023	23
Street misspelled	JONES RD	JONEES RD
Post Directional transposed	JONES RD N	JONES RD N
Suffix Directional transposed	JONES RD N	JONES RD N
Community Names Differ	BURLINGTON	BURL
One Word vs. Two Word names	BLUEBONNET DR	BLUE BONNET DR
Incorrect Standardization	N LAKE DR	NORTH LAKE DR

Other Common Discrepancies:

- Street Names, Street Types, Pre and Post Direction
- Community Names with inconsistent spelling or with abbreviations in MSAG
- There will be streets segments in the GIS data that may not be in the MSAG such as unaddressed private roads, ramps, unaddressed connector streets, and proposed streets
- Improper ESN assignment

All MSAG records should be found in the GIS data, with the following exceptions: MSAG records for FX records, Test records, and VoIP and Wireless Shell records.

Synchronization between the MSAG and GIS must also apply to address ranges. The validation process for address ranges can be complex as the standard for applying ranges can vary between the MSAG and GIS data. As an example, the MSAG low to high ranges for a city street may be 100-399. The corresponding GIS street centerline data actual data ranges may be broken out by block ranges such as 110-159, 208-267, and 332-375. If the MSAG entry includes the low to high ranges for the corresponding street segments, the entry is considered validated.

Figure 22. Valid MSAG and GIS Street Centerline Ranges

PD	Name	Type	Low	High	ESN
			MSAG Data		
	SMITH	ST	100	399	00127
	MAIN		1	199	00067

PD	NAME	Type	LF_ADD	RT_ADD	ESN
			GIS Street Centerline Data		
	SMITH	ST	110	159	00127
	SMITH	ST	208	267	00127
	SMITH	ST	332	375	00127

Note: ALI databases must be verified to make sure that no addresses exist above the last address range of 375, shown in the GIS data. If there are ALI records, or other resources indicate addresses (permits, utility connections, tax records, etc. see NENA 02-013) above or below the address ranges in the GIS, then the GIS must be adjusted to accommodate these additional addresses.

Figure 23. Valid MSAG and GIS Street Centerline Address Ranges

PD	Name	Type	Low	High	ESN
			MSAG Data		
	MAIN		1	199	00067

PD	NAME	Type	LF_ADD	RT_ADD	ESN
			GIS Street Centerline Data		
	MAIN		1	73	00067
	MAIN		110	168	00067
	MAIN		192	197	00067

There are two levels of address range synchronization: Street Level and Block Level. The following examples explain the difference between the two levels, or types.

Street Level Synchronization
The example in Figure 24 below shows street level synchronization. The MSAG entry includes the low to high address range for Main Street. The GIS street centerline data has address range gaps between the low and high addresses, and is acceptable for "Street Level Synchronization".

This example does not qualify for block level synchronization because the MSAG entry includes addresses that are not in the GIS street centerline data.

One Nation 9-1-1 One Number

Figure 24. Example of Street Level Synchronization

MSAG Entry		
MAIN ST	100	333
GIS Street Centerline Ranges		
MAIN ST	100	121
MAIN ST	200	232
MAIN ST	300	333

Block Level Synchronization

Block level synchronization has individual MSAG entries that account for the corresponding address ranges in the GIS street centerline data. This level of synchronization is possible when the GIS street centerline data contains actual address ranges, and you MSAG contain individual range entries.

Figure 25. Example of Block Level Synchronization

MSAG Entry		
MAIN ST	100	121
MAIN ST	200	232
MAIN ST	300	333
GIS Street Centerline Data Ranges		
MAIN ST	100	121
MAIN ST	200	232
MAIN ST	300	333

Block level synchronization means the MSAG data and the GIS street centerline data are in complete agreement. However block level synchronization may not be achieved based on available resources and funding.

Although Street Level Synchronization is acceptable there may still be discrepancies in the GIS street centerline data. If the resources are not available to have a Block Level Synchronization, then it is recommended that the ALI data be geocoded against the GIS street centerline data, which is discussed in Section 2.2.2.

Comparing the MSAG address ranges to the GIS Street Centerline can be accomplished by manual methods as described in this document, third party software, custom coding using tools available in the GIS software, Structure Query Language (SQL) statements, or generating reports based on the summary of the minimum and maximum address range of each unique street segment in each ESN which can be accomplished with most GIS software.

Postal Community Code Validation

The process of using ESN in the Unique Key field can be repeated using the Postal Community, in place of the ESN, to validate the Postal Community.

Figure 26. GIS Street Centerline Data with Postal Communities

Prefix Directional	Street Name	Street Suffix	Post Directional	Postal Community Right	Postal Community Left	Unique_Key
	BAY AREA	BLVD		LA PORTE	PASADENA	BAY AREA BLVD LA PORTE
	CALYPSO COVE	CT		PASADENA	PASADENA	CALYPSO COVE CT PASADENA
	BIMINI	WAY		LA PORTE	PASADENA	BIMINI WAY LA PORTE
	BLUE CANOE	CT		SEABROOK	SEABROOK	BLUE CANOE CT SEABROOK
	BLUE DOLPHIN	DR		SEABROOK	SEABROOK	BLUE DOLPHIN DR SEABROOK
				SEABROOK	SEABROOK	SEABROOK
	DOLPHIN	DR		SEABROOK	SEABROOK	DOLPHIN DR SEABROOK
N	FLAMINGO			SEABROOK	SEABROOK	N FLAMINGO SEABROOK
S	FLAMINGO			SEABROOK	SEABROOK	S FLAMINGO SEABROOK
W	FLAMINGO			SEABROOK	SEABROOK	W FLAMINGO SEABROOK
N	HERON	DR		SEABROOK	SEABROOK	N HERON DR SEABROOK
S	HERON	DR		SEABROOK	SEABROOK	S HERON DR SEABROOK
S	SURF OAKS			TAYLOR	SEABROOK	S SURF OAKS TAYLOR
	CORAL WAY	CT		TAYLOR	TAYLOR	CORAL WAY CT TAYLOR
	CORAL WAY	DR		TAYLOR	TAYLOR	CORAL WAY DR TAYLOR

Figure 27. MSAG Data with Postal Communities

PS	ST_NAME	TYPE	SD	LOW	HIGH	POSTAL COMMUNITY	O/E	ESN	Unique_Key
	BAY AREA	BLVD		12500	13598	LA PORTE	E	069	BAY AREA BLVD LA PORTE
	BAY AREA	BLVD		12501	13599	PASADENA	O	070	BAY AREA BLVD PASADENA
	CALYPSO COVE	CT		1800	1899	PASADENA	B	079	CALYPSO COVE CT PASADENA
	BIMINI	WAY		1700	1899	SEABROOK	B	080	BIMINI WAY SEABROOK
	BLUE CANOE	CT		2400	2499	PASADENA	B	080	BLUE CANOE CT PASADENA
	BLUE DOLPHIN	DR		500	500	SEABROOK	E	080	BLUE DOLPHIN DR SEABROOK
	CAPRI	DR		1700	1999	SEABROOK	B	080	CAPRI DR SEABROOK
	DOLPHIN	DR		1700	1899	PASADENA	B	080	DOLPHIN DR PASADENA
N	FLAMINGO			600	699	SEABROOK	B	080	N FLAMINGO SEABROOK
S	FLAMINGO			4500	4699	SEABROOK	B	080	S FLAMINGO SEABROOK
W	FLAMINGO			1000	1299	SEABROOK	B	080	W FLAMINGO SEABROOK
N	HERON	DR		1000	1299	SEABROOK	B	080	N HERON DR SEABROOK
S	HERON	DR		1300	1499	SEABROOK	B	080	S HERON DR SEABROOK
S	SURF OAKS			4900	4999	SEABROOK	B	080	S SURF OAKS SEABROOK
	CORAL WAY	CT		1500	1511	TAYLOR	B	093	CORAL WAY CT TAYLOR
	CORAL WAY	DR		1300	1322	TAYLOR	B	093	CORAL WAY DR TAYLOR

MSAG Community Code validation

The above process of using ESN in the Unique Key field can be repeated using the MSAG Community, in place of the ESN, to validate the MSAG Community.

Figure 28. Example of GIS Street Centerline Data with MSAG Communities

Prefix Directional	Street Name	Street Suffix	Post Directional	ESN Right	ESN Left	MSAG Community Right	MSAG Community Left	Unique_Key
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD LA PORTE
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD LA PORTE
	BAY AREA	BLVD		069	070	LA PORT	PASADENA	BAY AREA BLVD LA PORTE
	CALYPSO COVE	CT		079	079	PASADENA	PASADENA	CALYPSO COVE CT PASADENA
	10TH	ST	S	080	080	SEABROOK	SEABROOK	10TH ST S SEABROOK
	12TH	ST		080	080	SEABROOK	SEABROOK	12TH ST SEABROOK
N	FLAMINGO			080	080	SEABROOK	SEABROOK	N FLAMINGO SEABROOK
S	FLAMINGO			080	080	SEABROOK	SEABROOK	S FLAMINGO SEABROOK
W	FLAMINGO			080	080	SEABROOK	SEABROOK	W FLAMINGO SEABROOK
N	HERON	DR		080	080	SEABROOK	SEABROOK	N HERON DR SEABROOK
S	SURF OAKS			080	080	SEABROOK	SEABROOK	S SURF OAKS SEABROOK
	CORAL WAY	CT		093	093	SEABROOK	SEABROOK	CORAL WAY CT SEABROOK
	CORAL WAY	DR		093	093	SEABROOK	SEABROOK	CORAL WAY DR SEABROOK

Figure 29. MSAG Data with MSAG Communities

PS	ST_NAME	TYPE	SD	LOW	HIGH	MSAG_COMMU	O/E	ESN	Unique_Key
	BAY AREA	BLVD		12500	13598	LA PORTE	E	069	BAY AREA BLVD LA PORTE
	BAY AREA	BLVD		12501	13599	LA PORTE	O	070	BAY AREA BLVD LA PORTE
	CALYPSO COVE	CT		1800	1899	PASADENA	B	079	CALYPSO COVE CT PASADENA
	BIMINI	WAY		1700	1899	SEABROOK	B	080	BIMINI WAY SEABROOK
	BLUE CANOE	CT		2400	2499	SEABROOK	B	080	BLUE CANOE CT SEABROOK
	BLUE DOLPHIN	DR		500	500	SEABROOK	E	080	BLUE DOLPHIN DR SEABROOK
	CAPRI	DR		1700	1999	SEABROOK	B	080	CAPRI DR SEABROOK
	DOLPHIN	DR		1700	1899	SEABROOK	B	080	DOLPHIN DR SEABROOK
N	FLAMINGO			600	699	SEABROOK	B	080	N FLAMINGO SEABROOK
S	FLAMINGO			4500	4699	SEABROOK	B	080	S FLAMINGO SEABROOK
W	FLAMINGO			1000	1299	SEABROOK	B	080	W FLAMINGO SEABROOK
N	HERON	DR		1000	1299	SEABROOK	B	080	N HERON DR SEABROOK

3.2.2 ALI database to GIS Street Centerline Data

The ALI database can be geocoded against the GIS street centerline data (and address points where used), as another quality assurance measure. This can be used as a confirmation that all ALI information will be properly located in the GIS street centerline data. The ALI will not contain all address in an area; therefore, the ALI cannot be considered the sole source for addresses. Typically if the MSAG and GIS street centerline databases have been synchronized, then all ALI records should geocode correctly to the GIS street centerline data. Comparing the ALI database to GIS street centerline data will find any remaining discrepancies between the ALI and GIS street centerline data.

Comparing the ALI database to GIS street centerline data is not an easy task, but can be accomplished by geocoding the ALI database to the GIS street centerline data. Geocoding is the process of assigning a geographic coordinate location by comparing tabular address information to geographic reference information.
In this case the ALI database is the table of addresses and the GIS street centerline data is the geographic reference. Geocoded addresses can be created by mathematically calculating the address location using the GIS street centerline with address ranges as the reference. There are many GIS software packages that provide robust geocoding and interactive reporting tools. While the ALI database to GIS comparison is a test to ensure that there are no discrepancies between the MSAG, ALI, and GIS database, this process also simulates the behavior of how 9-1-1 calls from the ALI database will plot to the GIS data. This is a proactive way to identify any inconsistencies and enhance the accuracy of all associated 9-1-1 databases.

An example of a report that may be created from this type of comparison is shown in Figure 33.

The geocoding of the ALI data against the GIS street centerline data will require knowledge of the GIS geocoding process for the particular GIS software being used. Discrepancies between the ALI data and the GIS data will need to be resolved with close coordination and review between the GIS and MSAG personnel. Corrections may be required of the GIS street centerline data, the MSAG data or both. After correcting any discrepancies there needs to be close coordination with the DBMS, Service Provider, the Telco's, and the Postal service to ensure there corrections are made to their data as well.

3.2.3 Site / Structure Location and ALI records Comparison

The objective is to insure that all ALI records and the attributes in the Site / Structure Location GIS data match and the information in the site / structure location layer are accurate as they should have been collected according to NENA 02-014 GIS Data Collection and Maintenance Standards. In order to do the comparison of the ALI records and the attributes in the Site / Structure Location Layer the following fields should be used:

ALI Records
    House Number
    House Number Suffix
    Prefix Directional
    Street Name
    Street Suffix
    Post Directional
    MSAG Community Name
    Postal Community Name
    ESN
    Zip Code
    Location

Site / Structure Location Layer
        House Number
        House Number Suffix
        Prefix Directional
        Street Name
        Street Suffix
        Post Directional
        MSAG Community Name
        Postal Community Name
        ESN
        Zip Code
        Location

Exclude Site / Structure Location data pertaining to Bridges, Billboards, Water Towers, and any other structures that would not be in the ALI database. Conversely the ALI records that should be excluded include VoIP and Wireless shell records, FX records, and Test Records.

A table of the required ALI data can be built with a Unique Key as shown below in Figure 30.

Figure 30. Example of the ALI Table with the Unique Key

123			APPLE	LN	W	DERRY	456	12345	BLDG A	123 APPLE LN W DERRY BLDG A 456 12345
144			APPLE	LN		DERRY	456	12345	STE 208	144 APPLE LN DERRY STE 208 456 12345
333		E	MARKET	ST		JACKSON CITY	444	54321	RM 222	333 E MARKET ST JACKSON CITY RM 222 444 54321
300		N	VALLEY VIEW	BLVD		JACKSON CITY	444	54321		300 N VALLEY VIEW BLVD JACKSON CITY 444 54321
41			MAIN	ST		JACKSON CITY	443	54321	UNIT 7	41 MAIN ST JACKSON CITY UNIT 7 443 54321
437			MAPLE	LN		BRADFORD	128	33333		437 MAPLE LN BRADFORD 128 33333
28		S	LOOP	RD		BRADFORD	128	33333		28 S LOOP RD BRADFORD 128 33333
228			CHESTNUT	ST		TAYLOR	340	21212		228 CHESTNUT ST TAYLOR 340 21212
221			CHESTNUT	ST		TAYLOR	340	21212		221 CHESTNUT ST TAYLOR 340 21212
84			MAIN	ST		TAYLOR	340	21212		84 MAIN ST TAYLOR 340 21212

The table of the GIS Site / Structure Locations will look similar to the one shown in Figure 31.

Figure 31. Example of a GIS Site / Structure Location Table with the Unique Key

144			APPLE	LN		DERRY	456	12345	STE 208	144 APPLE LN DERRY STE 208 456 12345
333			MARKET	ST		JACKSON CITY	444	54321	ROOM 222	333 MARKET ST JACKSON CITY ROOM 222 444 54321
300		N	VALLEYVIEW	BLVD		JACKSON CITY	444	54321		300 N VALLEYVIEW BLVD JACKSON CITY 444 54321
41			MAIN	ST		JACKSON CITY	443	54321		41 MAIN ST JACKSON CITY 443 54321
437			MAPLE	LN		BRADFORD	128	33333		437 MAPLE LN BRADFORD 128 33333
28		S	LOOP	RD		BRADFORD	128	33333		28 S LOOP RD BRADFORD 128 33333
221			CHESTNUT	ST		TAYLOR	340	21222		221 CHESTNUT ST TAYLOR 340 21222
84			MAIN	ST		TAYLOR	430	21212		84 MAIN ST TAYLOR 430 21212

Joining the GIS Site / Structure Location data to the ALI data will show the records that do match exactly, based on the Unique Key, those records that do not match will be shown as empty in the joined GIS Site / Structure Location part of the table, as shown in Figure 32.

The GIS Site / Structure Locations that did not match the ALI table Unique Key are shown as blank and highlighted in yellow. The records that did not join together are the discrepancies.

The reason the join did not occur is listed in the last column of Figure 32 and is only shown to clarify; this column is added to the table only to illustrate the reasons for the records not joining.

This type of join will also show records in the ALI data that do not exist in the GIS data.

Figure 32. Joined ALI and GIS Site / Structure Locations

ALI Table Joined with the GIS Site / Structure Location Table (not all fields shown)

MSAG Community	ESN	Zip Code	Location	Unique Key	Pre Dir.	Street Name	Street Suffix	MSAG Community	ESN	Zip Code	Location	Discrepancies
DERRY	456	12345	BLDG A	123 APPLE LN W DERRY BLDG A 456 12345	W	APPLE	LN	DERRY	456	12345	BLDG A	
DERRY	456	12345	STE 208	144 APPLE LN DERRY STE 208 456 12345		APPLE	LN	DERRY	456	12345	STE 208	
JACKSON CITY	444	54321	RM 222	333 E MARKET ST JACKSON CITY RM 222 444 54321								E Market St in ALI - Prefix Direction Differs
JACKSON CITY	444	54321		300 N VALLEY VIEW BLVD JACKSON CITY 444 54321								Valley View - 2 words in ALI, Valleyview in GIS
JACKSON CITY	443	54321	UNIT 7	41 MAIN ST JACKSON CITY UNIT 7 443 54321								Location information not in GIS data
BRADFORD	128	33333		437 MAPLE LN BRADFORD 128 33333		MAPLE	LN	BRADFORD	128	33333		
BRADFORD	128	33333		28 S LOOP RD BRADFORD 128 33333	S	LOOP	RD	BRADFORD	128	33333		
TAYLOR	340	21212		228 CHESTNUT ST TAYLOR 340 21212								Zip Codes differ
TAYLOR	340	21212		221 CHESTNUT ST TAYLOR 340 21212								ESN's differ

Joining the ALI table to the GIS Site / Structure Locations will show the discrepancies as well as site / structure locations in the GIS data that are not in the ALI data.

Some software packages allows one to create custom reports that allow near continuous reporting of discrepancies as shown in Figure 33.

Figure 33. Example of a custom report of discrepancies

Audit - ALI vs GIS Site Match

Audit Date: 01/01/2009 8:59:58 AM						
ANI	House No	House No Suffix	Street	Customer	Provider Name	MSAG Road Name Match
KNEENAH CO.						
COPSTOWN						
(555) 555-2130			BEAR HILL RD	GETCHA, GONNA	ABC PHONE CO	Yes
(555) 555-3928			BEAR HILL RD	NAT PARCEL CO	ABC PHONE CO	Yes
(555) 555-3512	197	A	BEAR HILL RD	CHEEPO USED CARS	ABC PHONE CO	Yes
(555) 555-3032	392		BEAR HILL RD	BOBS BOOKSHOP	ABC PHONE CO	Yes
(555) 555-3098	1236		BEAR HILL RD	MALONE, SUGAR	ABC PHONE CO	Yes
(555) 555-3620	1236		BEAR HILL ST	JIGGS, JIMMY	ABC PHONE CO	No
(555) 555-3920	1521		BEAR HILL ST	FACTORY OUTLET STORE	ABC PHONE CO	No
(555) 555-3026	66		CEMETERY	COPSTOWN MUNICIPAL OFFICE	AAA TELCO	Yes
(555) 555-3126	2339		CEMETERY	YOUNG, IAM	AAA TELCO	Yes
(555) 555-2139	42	C	CHELSEA RD	CHEEPO, YOUNG	AAA TELCO	Yes
(555) 555-3958	550		CHELSEA AVE	VACANT, NO-CALLBACK	AAA TELCO	No
(555) 555-3168	932		E HILL RD	LACARTE, M		Yes
(555) 555-3167	932		E HILL RD	CAPONE, A J	VERIZON	Yes
(555) 555-4608	3277		EAGLE PEAK RD	KILLROY, K. C.	ACME TELECOM	No
(555) 555-3102	1185		EAST ST	FERRIS, MAX A	VERIZON	Yes

3.2.4 Discrepancy Correction

Coordinate with the Service Provider and the 9-1-1 DBMS provider on the required changes. The Service Provider must correct the ALI data, and / or the 9-1-1 DBMS provider must make the necessary changes after notification, without the use of translations.

Coordinate with the Service Provider and / or the DBMS provider for a timeline for the changes. In order to effectively transition into NENA i3 you must make sure your GIS and MSAG data discrepancies are resolved.

Note: This is a time consuming, labor intensive project that will require a significant commitment. It is not something that can be quickly completed. Although if desired, it can be sent out to a reputable vendor to have them process the discrepancies.

4 Conclusions

Some of the aspects to consider when developing Standard Operating Procedures (SOP's) for synchronization include the following:

- Addressing Liaisons and Planning
- Addressing Review and Planning
- Road Naming Review
- Emergency Service Zone/Number Review
- USPS Coordination
- Master Street Address Guide
- Synchronization of all databases
- Documentation of EVERYTHING
- Creation of information about how the data was collected - **Metadata**
- Maintenance

It is important to be aware that the agency performing this process (presuming that it is not the addressing authority) CANNOT make the addressing authority change existing names. Part of this process is illustrating how to make the GIS data work with addressing inconsistencies, errors, and issues made in the past, and suggest that the corrections be made by the addressing authority.

5 References

Generally, the reference section of a document will be located at or near the end of the document, and will probably not be section 4 as it is in this Template. It will list all documents or other media used in development of this NENA OID. Some NENA OID's will also include an Exhibits Section, which will come after the References Section, if applicable. Some NENA Operations Information Documents will also contain an Appendix Section, which would come last, if applicable.

- NENA Data Standards for Local Exchange Carriers, ALI Service Providers & 9-1-1 Jurisdictions, NENA 02-011, Version 7

- NENA Data Standard*s* for the Provisioning and Maintenance of MSAG Files to VDBs and ERDBs, NENA 02-013, Version 3, June 7, 2008

- NENA GIS Data Collection and Maintenance Standards, NENA 02-014, Issue 1, July 17, 2007

- NENA Master Glossary of 9-1-1 Terminology revised, version 11, May 16, 2008

- NENA Standard Data Formats for ALI Data Exchange & GIS Mapping, NENA 02-010, Version 8.1, January 8, 2008

- NENA Wireless Maintenance Call Routing & TVW Standard, NENA 57-002, June 9, 2007

- NENA Wireless (Pre-XML) Static and Dynamic ALI Data Content Technical Information Document --- DEF Format V 2.1, NENA 02-501, Issue 1, October 16, 2006

- NENA Wireless Phase I & II Features and Functions Operational Information Document, NENA 57-501 Final 01/20/04

- NENA Wireless Phase I/II Planning and Implementation Checklist and Modules OID, NENA 57-502, May 24, 2004

- A Public Safety Answering Point Managers' Guide to Geographic Information Technology, a National Emergency Number Association White Paper, October 2002