Caltrans All Roads Linear Referencing System Fact Sheet

Overview

In 2012, the Federal Highway Administration unveiled a new requirement for State Departments of Transportation to develop and submit a linear referencing system (LRS) network for all public roads in their respective states known as the All Roads Network of Linear Referenced Data (ARNOLD). This ARNOLD requirement is an integral part of each state's federally mandated Highway Performance Monitoring System (HPMS) annual submittal. To meet the ARNOLD requirement, the Division of Research, Innovation and System Information (DRISI) has developed a representation of all roads in California using a combination of the Census Bureau's Topologically Integrated Geographic Encoding and Reference (TIGER) files and previously developed line work representing the State Highway System.

The Caltrans All Roads LRS dataset provides the base geometry for federally required Highway Performance Monitoring System (HPMS) business data, functionally classified roads for the California Roads System (CRS) (a requirement for federal funding of local agency projects), and the State Highway Network (SHN), which supports a wide range of internal Caltrans business needs.

The Caltrans All Roads LRS has several limitations and there are ongoing efforts to improve data quality and accuracy. Some known issues of the dataset are:

- Inclusion of an excessive number of minor roads, resulting in many "unnamed" routes
- Overlapping geometry
- Missing geometry (gaps)
- Insufficient accuracy of geometry
- Incorrect street names, resulting in incorrect route identifiers (LRS_KEY)
- Incomplete representation of dual carriageways
- Incomplete representation of roundabouts

Development

The geometry of the All Roads LRS was sourced from the TIGER-based dataset used for CRS mapping and maintained using ESRI ArcGIS Desktop. The geometry and attributes were transferred to and are currently maintained in Hexagon GeoMedia Pro desktop using Oracle as the data warehouse. Subsequently, accuracy of geometry has been improved and new streets added based on National Agriculture Imagery Program (NAIP) imagery (originally using 2012 vintage and updated to 2016).

The linear referencing system was created by assigning a unique "route identifier" (called LRS_KEY) and a sequence of "measures" to the All Roads geometry. Begin and end measures are based on the geometric length of each route segment in thousandths (0.001) of miles as calculated by Oracle (e.g. BEGIN_MEASURE = 25.204, END_MEASURE = 26.544). In general, for non-state highway routes, the LRS_KEY consists of a concatenation of County, Jurisdiction, Street name, Street name suffix, and

Carriageway fields (e.g. SAC_SAC_29TH ST_P). LRS_KEY for state highways is based on the Route number and Carriageway appended to "SHS" (e.g. SHS_099_P).

Linear Referencing Methods (LRMs)

The All Roads LRS supports two linear referencing methods: All Roads LRM and the State Highway LRM. The All Roads LRM is one and the same as the All Roads LRS, where the unique route identifier is LRS_KEY and the begin and end measures are those of the LRS.

The State Highway LRM is more complex. Caltrans identifies locations on the State Highway System using a combination of county, route, possibly a route suffix, a postmile (with a precision of three decimal places, or to the thousandth of a mile), possibly a postmile prefix, and possibly a postmile suffix. Postmiles along a route reset to 0.000 at county lines, and due to realignments and other modifications, postmiles on a route and within a county may overlap or have gaps; in these cases, postmile prefixes are applied to differentiate between postmiles with the same numeric value. Some examples of SHN county/route/postmiles are:

County	Route	Route Suffix	Postmile Prefix	Postmile	Postmile Suffix
FRE	99			23.304	
MEN	101	U		99.431	
SD	5		R	30.436	L

In GeoMedia/Oracle, the State Highway LRM is stored as an "event" table (TSN_ROUTE_SEGS) that references the All Roads LRS. The referenced source for this table is the Transportation System Network (TSN) database, which is the Department's system of record for the state highway system. Each record in this table includes the county, route, begin and end odometer from TSN, the corresponding All Roads LRS_KEY and begin and end measures.

Next Steps - All Roads LRS High Precision Project

Caltrans is in the process of updating the All Roads LRS dataset utilizing the latest available NAIP imagery as a reference to improve accuracy of the geometry. Work will be completed on a county-by-county basis for all 58 California counties. In this high precision project, all geometry will be reviewed at a maximum scale of 1:2500 and corrected at a scale range of 1:1200-2500. For comparison, ARNOLD requires a minimum scale of 1: 24,000. With Caltrans' more precise scale for scanning and editing, the resulting geometry and attribution will be more accurate. Edits will include:

1. Remove invalid and add missing dual carriageways
2. Check secondary LRS_KEY compliance with associated primary LRS_KEY
3. Assign names to unnamed streets and update associated records
4. Identify possible invalid geometry for Caltrans review
5. Identify and fix overlapping geometry
6. Add new geometry based on latest NAIP imagery
7. Use local agency GIS roads data as a reference
8. Add and update valid roundabouts

9. Ensure ramps connect to state highway network geometry
10. Resolve various errors with measures (e.g. overlaps and gaps) and calculated geometric lengths
11. Address errors identified by internal customers

All edits occur on FHWA Functional Classification (FC) 1 through 7 except the determination for dual carriageways for FC 7.

Functional Classification Legend		
▬	Interstate	1
▬	Other Freeways or Expressways	2
▬	Other Principal Arterial	3
▬	Minor Arterial	4
▬	Major Collector	5
▬	Minor Collector	6
▬	Local	7

The FHWA Functional Classification Guidelines can be found here.

The following is an example of an area that has experienced the All Roads LRS High Precision editing process.

Anticipated Timeline

A proof of concept project was completed in April 2019 that fully implemented two counties using the ESRI Roads and Highways (R&H) for ArcMap platform. The proof of concept project was conducted to ensure that all identified Caltrans LRS requirements were met before attempting a statewide conversion. The project included the full migration of two counties (with LRS requirements that are representative of all counties) from Hexagon GeoMedia to R&H.

A statewide migration to Roads and Highways for ArcGIS Pro is tentatively scheduled to be completed in December 2020. The statewide migration project will transition from the current platform to R&H. It is anticipated that the statewide migration project will take 12 months (January 2020 – December 2020).

During the statewide migration project, the All Roads LRS High Precision project will be suspended until the statewide migration project is completed. The All Roads LRS High Precision project (statewide) is anticipated to be completed in December 2022.

The estimated timeline (anticipated completion by Caltrans district) for the All Roads LRS High Precision project, is summarized below along with the anticipated R&H Statewide Migration Project.

1. District 4   – Completed October 2018
2. District 7   – Completed February 2019
3. District 12   – Completed March 2019
4. District 11   – Completed April 2019
5. District 8   – Completed July 2019
6. District 5   – Completed September 2019

R&H Statewide Migration Project (tentative January 2020 – December 2020) **

7. District 6 **   – October 2021
8. District 9 **   – October 2021
9. District 10 **   – February 2022
10. District 3 **   – July 2022
11. District 1 **   – September 2022
12. District 2 **   – December 2022

** Pending future funding

Summary

The Caltrans LRS is currently undergoing an update project (All Roads LRS High Precision Project) that was started in April 2017. Caltrans staff are using Hexagon GeoMedia to perform the edits and are tentatively planning a transition to ESRI Roads and Highways for ArcGIS Pro beginning in January 2020. During this period (January 2020 – December 2020) no edits will be performed on the data. Once the transition is completed, the update project will resume. The expected completion of the update project is December 2022. Upon completion, the Caltrans All Roads LRS will be in a maintenance update phase. Caltrans will explore sharing data with Local Agencies to continue updating the LRS. Caltrans will

be testing the use of change detection technology and other methods of making focused updates to the street geometry.

Item	Milestone	Begin Date	Expected Completion Date	Notes
1	All Roads High Precision Update Project	June 2017	December 2022	Project suspension between October 2019 - December 2020
2	Proof of Concept project - migrate two counties to ESRI Roads and Highways	June 2017	April 2019	N/A
3	Full transition to ESRI Roads and Highways	January 2020 (tentative)	December 2020 (tentative)	Completion of statewide migration
4	Resume All Roads High Precision Update Project (pending contract approval)	Resume January 2021	December 2022	N/A
5	All Roads Maintenance Phase	June 2023	N/A	Coordinate with Local Agencies for updates/data sharing