



U.S. Department
of Transportation
**Research and
Innovative Technology
Administration**

Report to Congress

Recapitalization Plan for the Nationwide Differential Global Positioning System (NDGPS)

June 2010

Recapitalization Plan for the Nationwide Differential Global Positioning System (NDGPS)

Executive Summary

The U.S. Department of Transportation (DOT) has developed a recapitalization plan to reduce technical, cost and programmatic risks of the DOT-funded inland segment of the Nationwide Differential Global Positioning System (NDGPS). The plan describes how the aging and obsolete equipment throughout the system should be recapitalized. Working closely with the U.S. Coast Guard, which operates the DOT inland portion of this national positioning, navigation and timing (PNT) utility, the Department has determined the cost and schedule requirements of an NDGPS recapitalization package.

DOT estimates that the total cost for recapitalizing the DOT-funded inland segment of NDGPS is approximately \$4,000,000.

Reporting Requirement

The FY 2009 Omnibus Appropriations Act (P.L. 111-8) includes the following requirement at p. 2113 of the Committee Print of the Joint Explanatory Statement accompanying Division I – Transportation, Housing and Urban Development, and Related Agencies Appropriations Act, 2009; Title I – Department of Transportation:

Nationwide Differential Global Positioning System.—The Secretary shall submit a recapitalization plan for the Nationwide Differential Global Positioning System within 90 days of the enactment of this Act to the House and Senate Committees on Appropriations.

Background

The DOT-funded terrestrial segment of NDGPS is one of three parts of a combined national positioning, navigation and timing utility, an enabling infrastructure technology system operated and maintained by the United States Coast Guard. The three segments are designated as (see Appendix A):

- 50 Maritime DGPS (MDGPS) sites funded, operated and maintained by the Coast Guard;
- Nine U.S. Army Corps of Engineers-funded and maintained sites, operated by the Coast Guard; and
- 29 inland NDGPS sites, funded through the DOT's Research and Innovative Technology Administration (RITA) and operated and maintained by the Coast Guard under a 1999 Memorandum of Agreement. RITA serves as inland NDGPS Program Manager, and chairs the interagency NDGPS Policy and Implementation Team. (See Appendix B).

The Department of Transportation and Related Agencies Appropriations Act, 1998 (P.L. 105-66, Title III, § 346) authorized the Secretary of Transportation to improve and expand the Coast Guard's Maritime DGPS into a Nationwide DGPS by adding an inland segment. At this time,

there are 29 DOT-sponsored sites in the NDGPS utility; the combined 87 sites provide 92 percent of the contiguous 48 states with single signal coverage, and 65 percent with dual coverage (and coverage to portions of Alaska, Hawaii and Puerto Rico). A map displaying existing combined NDGPS coverage is included in Appendix C.

The NDGPS coverage is achieved by using a medium frequency broadcast optimized for surface applications. The broadcast is a resilient signal that can travel across all types of difficult terrain including mountain ranges, canyons, and dense forest, and is sufficiently resistant to other obstructions (i.e., a line of sight is not required). The combined utility is an enabling technology, providing a highly reliable GPS integrity function to meet the growing requirements of surface users (transportation, precision agriculture, natural resources and environmental management, emergency management and response, fire management, and surveying and construction communities).

In addition to providing a real-time broadcast of differential corrections, the combined NDGPS utility provides a robust operational backbone to the U.S. Department of Commerce and other users for the following activities:

- National Oceanic and Atmospheric Administration's (NOAA) Continuously Operating Reference Station network that enables post-processing survey applications, Web-enabled location solutions, and maintenance of the National Spatial Reference System;
- NOAA's Earth System Research Laboratory for short-term severe weather and precipitation forecasts, and transportation safety research applications; and
- Ionospheric monitoring by NOAA's National Weather Service Space Weather Prediction Center.

Another current scientific application includes monitoring tectonic plate motions by members of the University NAVSTAR Consortium which receives some of its support from the National Science Foundation, the National Aeronautics and Space Administration, and the U.S. Geological Survey. These uses were re-validated through a user and system assessment of inland NDGPS.

More background on NDGPS may be found in the *2008 Federal Radionavigation Plan* and the March 2008 *NDGPS Assessment: Final Report*.

Requirements for Recapitalization

An important factor identified as a requirement for continuing NDGPS operations is recapitalizing aging and obsolete NDGPS equipment. The list of DOT-funded NDGPS sites requiring equipment recapitalization is available at Appendix D.

The Coast Guard has completed recapitalization of the Maritime DGPS sites. The DOT-sponsored inland NDGPS requires equipment upgrades to maintain interoperability with the Coast Guard's MDGPS technology, which through recapitalization has significantly increased reliability and reduced operations and maintenance costs and time. The interagency Policy and

Implementation Team determined that completing terrestrial NDGPS equipment recapitalization is important to reduce risks to this national PNT utility:

1. **Technical risk:** If recapitalization is not completed, there is an immediate risk of loss of service due to failure of aged and obsolete equipment; the risk increases with time and increased deferred maintenance.
2. **Cost risk:** The NDGPS equipment beyond serviceable life is being maintained at increased expense by purchasing/stocking expensive (and not always readily available) replacement parts (new or refurbished) for the old equipment.
3. **Programmatic risk:** Recapitalization is foundational to reducing operations and maintenance cost growth in the outyears, as the new Internet Protocol-based equipment allows 80 percent of trouble calls to be resolved remotely, without on-site technician service. For efficiency, the Coast Guard operates both Maritime and inland DGPS as a combined NDGPS. There are direct operational impacts to both segments of continuing to maintain two distinct operating systems if NDGPS recapitalization continues to be delayed. These impacts both increase total Federal costs of continuing current DGPS services, and decrease service reliability.

Transmitter Recapitalization

The Coast Guard is currently recapitalizing the broadcast transmitters at the MDGPS sites, with system fielding planned for completion by the end of FY2012. The DOT-funded NDGPS sites will also require transmitter recapitalization to maintain interoperability with Coast Guard operations. The current cost estimate for transmitter recapitalization is approximately \$100,000 per broadcast site.

Technical and Cost Benefits of Recapitalization

The Coast Guard has already demonstrated the technical and cost benefits of the recapitalized MDGPS sites, including:

- Simplified and less expensive installation and support.
- Implementation costs lower than the existing legacy design.
- Highly flexible open architecture, remotely configurable via a network.
- Unified software build (reference station and integrity monitor in one application).
- Ability to store and forward data (vs. broadcast only).
- Almost unlimited processor power.
- Elimination of legacy implementation errors.
- Enabling received network direct data feed to NOAA's National Geodetic Survey (NGS) for enhanced public access to position corrections.

NDGPS Recapitalization Work Package

The NDGPS recapitalization work package mirrors the work conducted by the Coast Guard to recapitalize the MDGPS sites. The recapitalization architecture design is transparent to present NDGPS users, and incorporates the following preferred, cost-saving design features:

- An open, IP-based architecture;
- Use of commercial off-the-shelf equipment;
- A flexible and upgradeable design to enable future requirements;
- Upgraded site communications to meet industry standard and increase speed; and
- Remote access for troubleshooting and maintenance, decreasing operational costs.

Because the existing reference station that provides DGPS corrections, and the integrity monitor that validates the integrity of DGPS corrections before broadcast, have both reached end of life (EOL) and can no longer be purchased, the recapitalization work includes significant hardware and software modifications.

Major hardware items to be replaced or added at each site include:

- Global Positioning System Receiver
- GPS Antennas
- Minimum-shift Keying Receiver
- MSK Modulator (Digital Signal Processing Board and DGPS Beacon Signal Generator)
- Computer
- Monitor/Keyboard/Video/Mouse Device
- Ethernet Network Switch

Minor hardware items to be replaced or added at each site include:

- Serial to Ethernet Converters
- Remote Controllable Power Manager
- Power Line Conditioner
- Uninterruptible Power Supply

A schematic of the recapitalized architecture is available at Appendix E.

Conclusion

The interagency NDGPS team concluded that recapitalizing the 29 DOT-funded NDGPS sites to maintain existing user services will cost approximately \$4,000,000. Because the Coast Guard has completed recapitalization on the MDGPS sites, technical risk of this change is low. The project timeline and order of site recapitalization is dependent upon Coast Guard workload, but will take no longer than 24 months from project initiation to completion.

The Department of Transportation remains committed to the continuing operations of the combined NDGPS as a national PNT utility, and will continue to work with our Federal agency partners, and with Congress to identify the resources needed for NDGPS recapitalization, operations and maintenance.

Questions

Please direct questions about this report to Timothy A. Klein, RITA's NDGPS Coordinator and Chair of the interagency NDGPS Policy and Implementation Team, at 202-366-0075; or Timothy.Klein@dot.gov.

Appendices: Appendix A: Nationwide DGPS (Map); September 2009

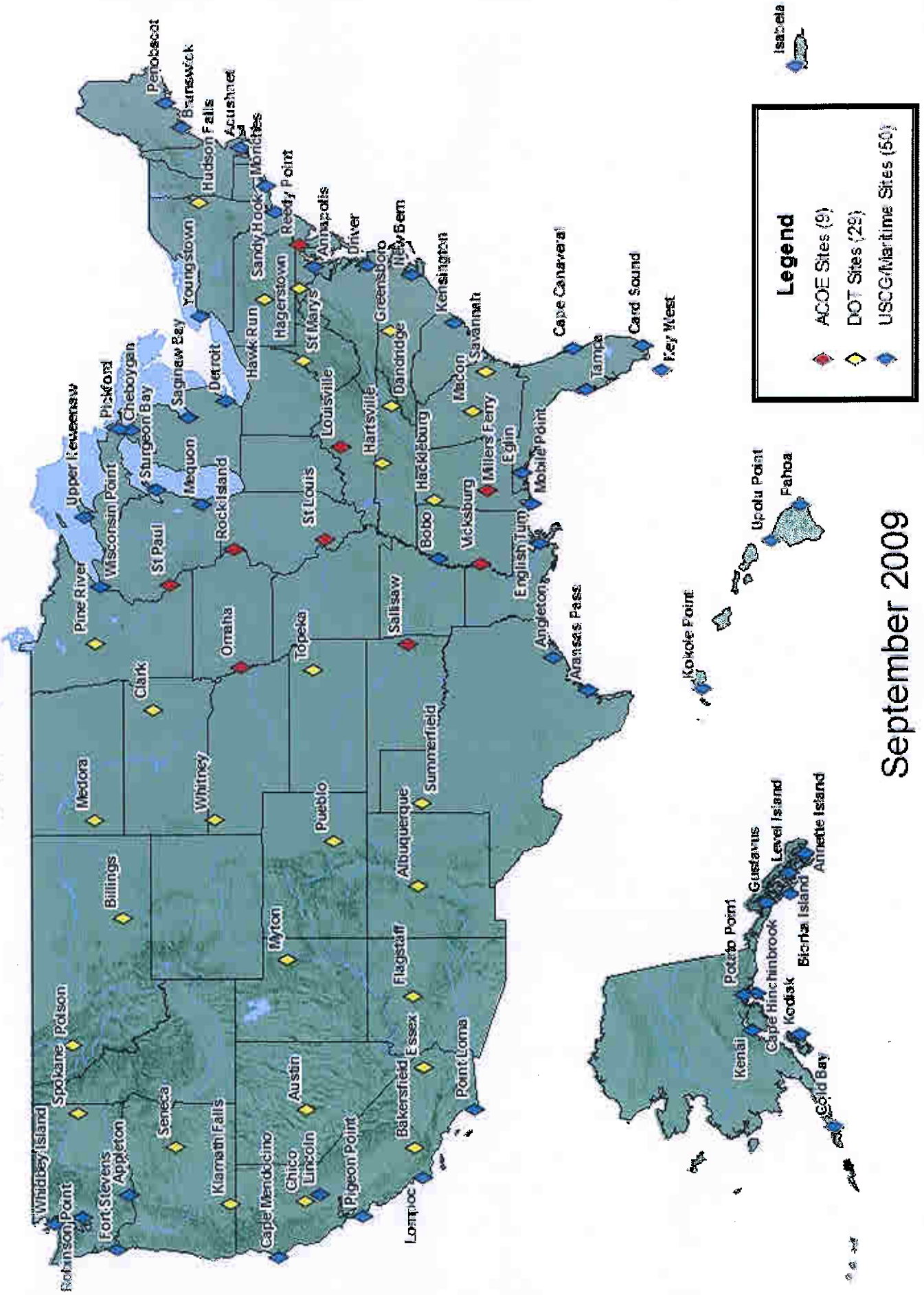
Appendix B: Nationwide Differential Global Positioning System (NDGPS) Policy and Implementation Team – Federal Agency Members

Appendix C: NDGPS Current Coverage Status (Map); September 2009

Appendix D: 29 DOT-Funded NDGPS Sites Requiring Recapitalization (Ordered by State)

Appendix E: DGPS Recapitalization Architecture

Nationwide DGPS



September 2009

Appendix B

Nationwide Differential Global Positioning System (NDGPS) Policy and Implementation Team

Federal Agency Members

Department of Agriculture

- U.S. Forest Service
- Natural Resources Conservation Service

Department of the Army

- Army Corps of Engineers

Department of Commerce

- National Oceanic and Atmospheric Administration
 - National Geodetic Survey
 - Earth System Research Laboratory
- National Weather Service
 - Space Weather Prediction Center

Department of Homeland Security

- United States Coast Guard
 - Command and Control Engineering Center (C2CEN)
 - Navigation Center (NAVCEN)
 - U.S. Coast Guard Headquarters/Electronic Navigation Branch (CG-54132)

Department of the Interior

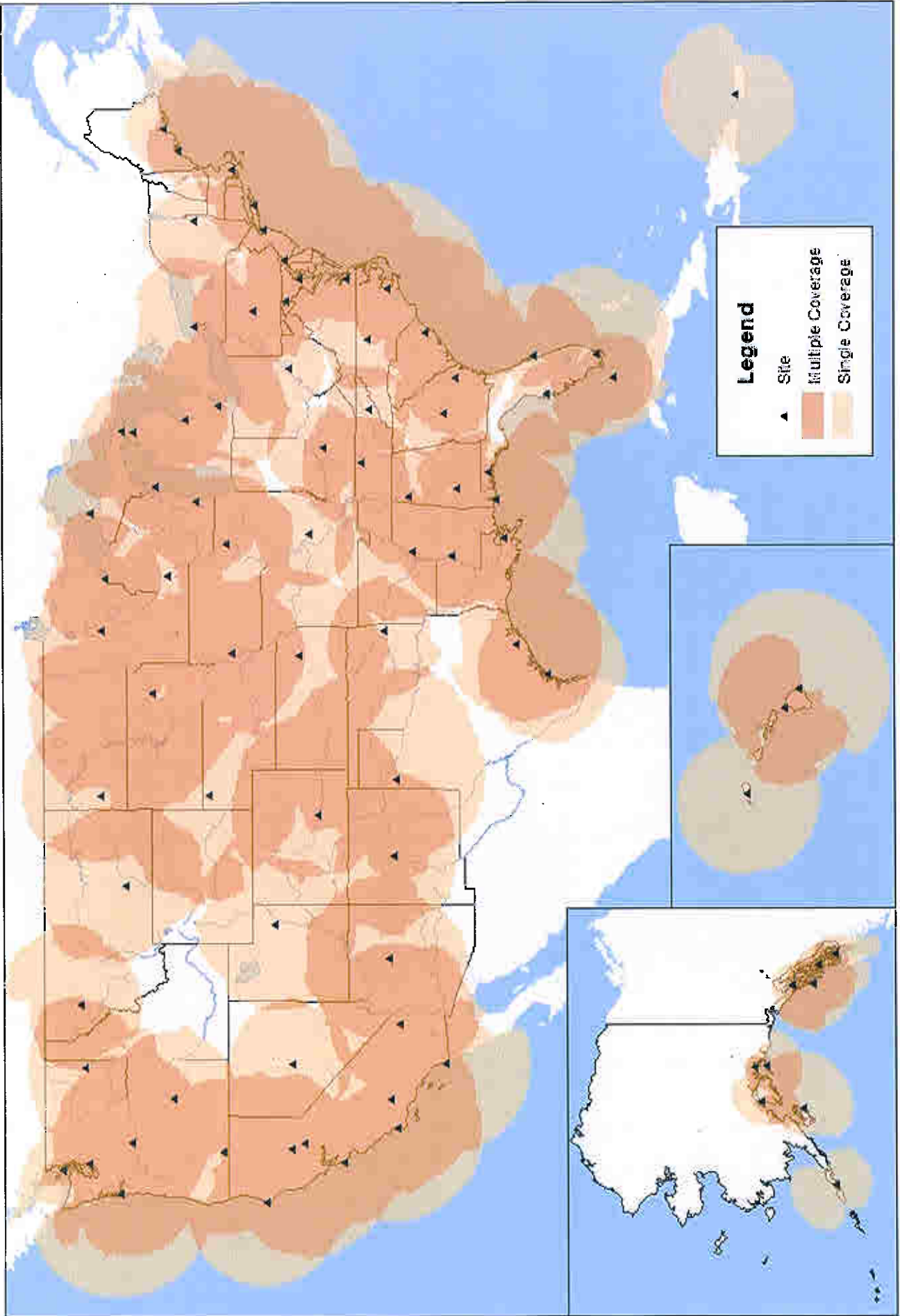
- Bureau of Land Management
- National Park Service
- U.S. Geological Survey

Department of Transportation

- Federal Highway Administration
- Federal Railroad Administration
- Research and Innovative Technology Administration (chair)
 - NDGPS Coordinator
 - Intelligent Transportation Systems (ITS) Joint Program Office
 - John A. Volpe National Transportation Systems Center

Appendix C: NDGPS Current Coverage Status (Map)

Nationwide DGPS



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Appendix D

Nationwide Differential Global Positioning System (NDGPS)

29 DOT-Funded NDGPS Sites Requiring Recapitalization (Ordered by State)

	<u>Site Name/Location</u>	<u>State</u>	<u>ID #</u>	<u>Coordinates</u>
1	Hackleburg	AL	825	34.2800 -87.8600
2	Flagstaff	AZ	876	35.2217 -111.8183
3	Bakersfield	CA	795	35.1322 -119.1086
4	Chico	CA	878	39.4333 -121.6656
5	Essex	CA	875	34.7519 -115.2306
6	Pueblo	CO	872	38.2872 -104.3472
7	Macon	GA	822	32.6969 -83.5603
8	Savannah	GA	818	32.1400 -81.7000
9	Topeka	KS	765	39.0444 -96.0389
10	Hagerstown	MD	834	39.5531 -77.7131
11	Pine River	MN	841	46.8642 -94.7211
12	Billings	MT	874	45.9722 -107.9964
13	Polson	MT	849	47.6628 -114.1147
14	Whitney	NE	859	42.7333 -103.3167
15	Austin	NV	798	39.3900 -117.3000
16	Albuquerque	NM	845	34.9572 -106.4928
17	Greensboro	NC	824	36.0686 -79.7447
18	Medora	ND	851	46.9100 -103.2700
19	Hudson Falls	NY	844	43.2703 -73.5386
20	Klamath Falls	OR	791	42.2883 -121.6706
21	Seneca	OR	773	44.1644 -119.0597
22	Hawk Run	PA	788	40.8786 -78.1803
23	Clark	SD	850	44.9342 -97.9606
24	Dandridge	TN	782	36.0203 -83.3042
25	Hartville	TN	858	36.3578 -86.0892
26	Summerfield	TX	823	34.6519 -102.5061
27	Myton	UT	873	40.1019 -110.0494
28	Spokane	WA	848	47.5194 -117.4233
29	St. Mary's	WV	843	39.2577 -81.0993

DGPS Recapitalization Architecture

