

**Forest Service Handbook
National Headquarters - Washington Office
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**Forest Service Handbook 7109.13a – Geometronics Handbook
Chapter - Zero Code**

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Approved by: Susan M. Super, Acting Service-wide Directive Manager

Date approved: March 5, 2003

Responsible Staff:

Explanation of changes: Following is an explanation of the changes throughout the directive by section.

7109.13a: This is a technical amendment that converts the format and style of this Forest Service Handbook (FSH) title (previously in “Applixware”) to the new FSH template using the agency’s current corporate word processing software. Where chapters were previously organized into more than one document, they are now merged into one chapter whenever possible.

Although some minor typographical and technical errors have been corrected, this amendment contains no changes to the substantive direction in this Handbook.

Table of Contents

02 - Objective	3
05 - Definitions	3
06 - References.....	7
06.1 - Geometronics References.....	7
06.2 - Aerial Photography, Photogrammetry, and Global Positioning System References....	7
06.3 - Other References	7
07 - Records Maintenance	9

02 - Objective

1. To prepare and revise maps and map-related products in a consistent, uniform manner.
2. To acquire new and purchase existing aerial photography.
3. To prepare geometronics-related development project proposals.
4. To support digital data collection for automated cartography and geographic information systems.

05 - Definitions

Area of Interest. The area within the perimeters of 7.5-minute (or 15-minute for Alaska) quadrangle units that embrace National Forests, Grasslands, Land Utilization Areas, Purchase Units, and adjacent lands of direct concern to the Forest Service. The limits should not extend more than one 7.5-minute (or one 15-minute for Alaska) quadrangle beyond the forest boundary.

Attribute. The quality or characteristics of a feature.

Base Series. The separation plates and layers that constitute the Primary/Single Edition Quadrangle, Secondary, and Regional Base Series used to produce Forest Service cartographic products (FSM 7142 and FSH 7109.13a, ch. 10).

Cartographic Feature Files (CFF). A data file containing the digital representation of all features except contours from a Primary Base Series/Single Edition Quadrangle map. Features are represented as line strings and points in ground coordinates with attribute information attached.

Compiled Map. A film or paper base that incorporates information collected from any source material.

Composite Map. A map made on photographic material by the combination of selected base layers and appropriate informational layers.

Correction Guide Package. The final assembly and collection of all appropriate map-related data accumulated from various sources to provide the GSC with the information necessary to construct or revise stable base separation plates for the Primary and Secondary Base Series.

Cultural Data (political). Political and administrative boundaries, names, and map legends.

Cultural Data (structural). Constructed features above, on, or below ground including roads, trails, buildings, canals, pipelines, and other similar features.

Data Base (computer). A set of data that is stored in a well defined, structured manner and that is possible to manipulate or query through use of a data base management system.

Data File (computer). A collection of data sets stored on a computer-compatible medium used generally as input data for computer programs.

Digital Elevation Model (DEM). A computer data file consisting of an organized collection of three axis (x,y,z) coordinates of the surface of a portion of the earth; the DEM meets accuracy, format, and content standards prescribed by the USGS.

Digital Terrain Model (DTM). A numeric, three-dimensional terrain representation.

Digitize. The process of converting spatial information into computer-recognizable characters locatable in a coordinate system.

Dilution of Precision (DOP). The ratio of the positioning accuracy to the measurement accuracy based on the effect of the satellite configuration. The DOP is the multiplicative factor that modifies ranging error. It is caused solely by the geometry between the user and the set of satellites used to determine the position.

- a. Position Dilution of Precision (PDOP). The multiplication factor that increases the error in the receiver's solution for position which is dependent on the geometry between the receiver location and the location of the satellites being used for position fix.
- b. Geometric Dilution of Precision (GDOP). Three position coordinates plus clock offset in the solution.
- c. Horizontal Dilution of Precision (HDOP). Two horizontal coordinates.
- d. Vertical Dilution of Precision (VDOP). Height only.
- e. Time Dilution of Precision (TDOP). Clock offset only.
- f. Horizontal and Time Dilution of Precision (HTDOP). Horizontal position and time.

Feature. An element that can be represented as a point, line, or polygon.

Forest Visitor Map. A product of the Family of Maps - Visitor Information Series map (FSM 7143.14 and FSH 7109.13a, sec. 13.4).

Functional Layer. A term used to describe data themes containing thematic or topical information such as soil, vegetation, fuel, and so forth. Layers must be spatially registered to the base plates and/or to other layers. Sometimes referred to as a functional layer.

Geographic Coordinate Data Base (GCDB). A data base being populated in cooperation with the Bureau of Land Management, U.S. Geological Survey, and Forest Service for the purpose of standardizing geographic coordinates for the Public Land Survey System (PLSS).

Geometronics. The science of recording, measuring, interpreting, handling, and displaying information about the earth and its resources. Geometronics combines the fields of cartography, remote sensing, geodesy, resource and engineering photogrammetry, and electronic data gathering and display.

Geographic Name. A name applied to a geographic feature. The feature can be any relatively permanent part of the natural or manmade landscape or seascape that has recognizable identity within a particular cultural context. The name is recognized and published on maps and other publications and is included as part of Geographic Names Information System (GNIS) (FSH 7109.14).

Global Positioning System (GPS). The NAVSTAR (NAVigation Satellite Time And Ranging) Global Positioning System is an all-weather, passive space-based radio positioning system developed by the U.S. Department of Defense (DOD). The system has the capability of providing highly accurate, three-dimensional position, velocity, direction, and time information to properly equipped users on a world-wide basis. The system consists of 21 satellites (with 3 spares) orbiting the Earth providing 24-hour, world-wide coverage of at least 4 visible satellites at any location.

Layer. A term used to describe film separates comprising essential base series information including culture, hydrography, hypsography, land net and status, and (optional) surface imagery. Sometimes referred to as base layer.

Level. A term used to describe a separation of map detail by categories such as color or symbol classification. The term is also used in Automated Cartography for basic categories of feature codes.

Mapping Unit. A block area of relatively common mapping needs covered by a contiguous group of Primary Base Series/Single Edition Quadrangle maps or a single Secondary Base Series sheet.

National Map Accuracy Standards (NMAS). Standards approved by the Office of Management and Budget that define acceptable horizontal and vertical map accuracy as the result of a 1940-41 interagency conference agreement. The standards are stated both under definitions and in appendix B of Definitions of Surveying and Associated Terms (FSM 7140.8).

Orthophoto. A differentially rectified and scaled reprojection of aerial imagery that minimizes detail displacement and that is suitable for geographically accurate measurements.

Project Map. A precise, detailed, large-scale map constructed for a specific use or project area.

Quadrangle. A map bounded by lines of latitude and longitude usually 7.5 or 15 minutes apart.

Remote Sensing. The detection and recording of reflected, scattered, and emitted energy of the electromagnetic spectrum. The most common form of remote sensing is aerial photography.

- a. Infrared Imagery. Imagery obtained by recording the wavelengths of the electromagnetic spectrum that are just beyond the visible red end of the spectrum (.7 to 1.0 micrometers approximately). These wavelengths are within the sensitivity range of photographic film systems.
- b. Photography, High Altitude. Aerial photography requiring the use of jet aircraft. High altitude photography is usually quadrangle-centered and obtained for quadrangle mapping and orthophoto production, but it may be used for unit planning. The photography must be of metric quality for use in stereo plotter compilation.
- c. Photography, High Resolution. Photography that allows for a high quantitative measure of detail. High resolution photography requires fine resolution film, cameras with high resolving power (not necessarily metric quality), and strict quality control.
- d. Photography, Mapping. Aerial photography obtained primarily for the purpose of constructing map manuscripts. It may also be used for controlling other photography used for photogrammetry. It must be metric.
- e. Photography, Metric. Photographs obtained with a precision camera in which the lens characteristics are calibrated and internal geometry meets rigid specifications useful for photogrammetric work. Photographer must use stable-base film.
- f. Photography, Resource. Aerial photography obtained for general resource use and mapping. The scale is determined according to the Utility Guide for Aerial Photography, and the photography must be of metric quality.
- g. Photography, Terrestrial. Photographs exposed from a camera station on the ground.
- h. Thermal (Infrared) Imagery. Obtained from the middle wavelengths of the infrared region of the electromagnetic spectrum (from 3 micrometers to 20 micrometers approximately). The thermal band most used extends from 8 to 13 micrometers and cannot be recorded directly on film base material.

06 - References

06.1 - Geometronics References

In addition to the two publications listed in FSM 7140.8 as references, use the "Dictionary of Scientific and Technical Terms," 5th ed., McGraw Hill Publishing Company, 1982; and the Topographic Instruction Manual, 4A3 July 1979, published by the U.S. Geological Survey, National Mapping Division for abbreviations for map text.

06.2 - Aerial Photography, Photogrammetry, and Global Positioning System References

Use the following references to supplement instructions in this handbook and to obtain additional information for proper selection and use of aerial photographic products and materials.

1. USDA Specifications for Aerial Photography, Section C, Agricultural Stabilization and Conservation Service/Aerial Photography Field Office, 2222 W. 2300 S., P.O. Box 30010, Salt Lake City, UT 84130-0010.
2. The American Society of Photogrammetry and Remote Sensing (ASPRS), 5410 Grosvenor Lane, Suite 210, Bethesda, MD 20814 (Telephone: (301) 493-0290). The following publications on Close Range Photogrammetry and Surveying are available through ASPRS at the previously listed address.
 - a. State-of-the-Art, Developing the Art of Application. 1985. Proceedings of a workshop held as part of the American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping 1984 Fall Convention, September 9-14, 1984. ISBN 0-937294-61-6,
 - b. Manual of Photogrammetry. 4th ed.; 1980.
 - c. Manual of Remote Sensing. 4th ed.; 1983.
3. Aldrich, Robert C. December 1979. Remote Sensing of Wildland Resources: A State-of-the-Art Review. Gen. Tech. Report RM-71. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, pp. 56.
4. USDA Forest Service, Engineering Staff. October 1985. Utility Guide for Aerial Photography. This publication contains criteria governing aerial photography emulsion and scale selection to satisfy specific requirements. Available from Regional Geometronics units.
5. U.S. Department of Interior, U.S. Geological Survey (USGS), National Mapping Division. February 1979. Analysis of Digital Terrain Profile Data. Earth Sciences Information Center, User Services Branch, USGS, 507 National Center, Reston, VA, 22092, pp. 5.

06.3 - Other References

The following publications are pertinent to geometronics activities:

1. Department of Commerce, U.S. Coast and Geodetic Survey. 1984. Standards and Specifications for Geodetic Control Networks. Federal Geodetic Control Committee, 1315 East West Highway, Silver Spring, MD, 20910, pp. 102.
2. Department of Commerce, U.S. Coast and Geodetic Survey. May 1988. Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Federal Geodetic Control Committee, 1315 East West Highway, Silver Spring, MD, 20910, pp. 48.
3. U.S. Department of Agriculture, Forest Service (USDA-FS). August 1985. "Land Surveying Guide," EM-7150-3. USDA-FS, Engineering Staff, P.O. Box 96090, Washington, DC, 20090-6090, pp. 228.
4. U.S. Department of Agriculture, Forest Service (USDA-FS). Current edition. "Cartographic Specifications and Symbols," EM-7140-24. USDA-FS, Engineering Staff, P.O. Box 96090, Washington, DC, 20090-6090, pp. 32.
5. U.S. Department of Agriculture, Forest Service (USDA-FS). September 1993. "Cartographic Feature Files: A Synopsis for the User," EM-7140-21. USDA-FS, Engineering Staff, P.O. Box 96090, Washington, DC, 20090-6090, pp.28.
6. Wells, David. December, 1986. Guide to GPS Positioning. University of New Brunswick Graphic Services: Fredericton, N.B., Canada, pp. 273.
7. Jeff Hurn. 1989. GPS, A Guide to the Next Utility. Trimble Navigation, 645 N. Mary Avenue, P.O. Box 3642, Sunnyvale, CA 94088-3642, pp. 76.
8. U.S. Department of Agriculture, Forest Service (USDA-FS). November 1986. "Corner Search, Perpetuation, & Recordation: A Training Guide," EM-7150-4. USDA-FS, Engineering Staff, P.O. Box 96090, Washington, DC, 20090-6090, pp.193.
9. U.S. Department of Interior, Bureau of Land Management (USDI-BLM). June 1991. Geographic Coordinates Data Base (GCDB) Data Collection Software User Documentation, User's Manual. Published in four volumes which include: Public Land Survey System Coordinate Computation System Point (PCCS) Vol. 1, User's Manual; Vol. 2, Program Reference; GCDB Measurement Management (GMM) Vol. 3 User's Manual; Vol. 4, Program Reference. USDI-BLM, Cadastral Survey, 1849 C Street NW, Washington, DC, 20240, pp. 280.
10. U.S. Department of Agriculture, Office of Governmental and Public Affairs (USDA-OGPA). May, 1980. USDA Visual Management Manual AD-791, Volume 1, Graphic Design. USDA-OG&PA, Design Division, 12th and Jefferson Drive, SW, Washington, DC, 20250, pp.210.
11. U.S. Department of Interior, U.S. Geological Survey (USGS), National Mapping Division. December, 1992. Standards for Digital Elevation Models. Earth Sciences Information Center, User Services Branch, USGS, 507 National Center, Reston, VA, 22092, pp. 80.
12. FSH 7109.14, Geographic Names Handbook.

13. FSH 2409.12, Timber Cruising Handbook.

07 - Records Maintenance

(See FSM 7141.2, FSH 6209.11). Maintain geometronics records as necessary to allow the extraction of data needed to respond to specific requests from within the Forest Service and from other agencies.

The following records are essential:

1. Inventory, accomplishment, and costs (maps and tables) of:
 - a. Aerial photography (include other remote sensing).
 - b. Base series and project mapping.
 - c. Control surveys.
2. Photogrammetric projects.
3. Agreements.
4. Program records (cost, progress, and personnel).
5. United States Board on Geographic Names (USBGN) decision lists. Maintain an atlas and a listing of all USBGN decisions affecting a Region. Also, include names decided upon or promulgated by other State and local government agencies.
6. Non-Forest Service sources. Maintain a file of status and index information produced by other Government and private agencies on:
 - a. Aerial photography. Agricultural Stabilization Conservation Service Monthly Progress Status Reports. Department of Agriculture Aerial Photography Comprehensive Listing and Regional indexes to aerial photo coverage.
 - b. Topographic mapping. U.S. Geological Survey State indexes and semi-annual status maps (1:5,000,000-scale, 7.5-minute and 15-minute formats).
 - c. National High-Altitude Photography Program and National Aerial Photography Program.