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The National Map
US Topo

National Geospatial Program
The National Map

US Topo Product Standard

Techniques and Methods 11–B2

U.S. Department of the Interior
U.S. Geological Survey

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U.S. Department of the Interior
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U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

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Contents

Figures

Plate

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)/ World Geodetic System of 1984 (WGS84).

Altitude, as used in this report, refers to distance above the vertical datum

A U.S. Survey Foot is defined as: 1 meter = 39.37 inches. 1 meter = 3.280833333 U.S. Survey Feet (see *http://www.ngs.noaa.gov/faq.shtml*)

US Topo Product Standard

By Michael J. Cooley, Larry R. Davis, Kristin A. Fishburn, Helmut Lestinsky, and Laurence R. Moore

Introduction

This document defines a U.S. Geological Survey (USGS) digital topographic map. This map series, named "US Topo," is modeled on what is referred to as the standard USGS 7.5-minute (1:24,000-scale) topographic map series that was created during the period from 1947 to approximately 1992. The US Topo map product has the same extent, scale, and general layout as the older standard topographic maps. However, unlike the previous maps, US Topo maps are published using Adobe Systems Inc. Portable Document Format (PDF) with a geospatial extension that is called Georeferenced PDF (GeoPDF), patented by TerraGo Technologies. In addition, the US Topo map products incorporate an orthorectified image (hereinafter referred to as "orthoimage") along with data that were included in the standard 7.5-minute topographic maps. US Topo maps are intended to serve conventional map users by providing Geographic Information System (GIS) information in symbolized form in the customary topographic map layout. The maps are not intended for GIS analysis applications.

A full-size style sheet template (Appendix B) in PDF that defines the placement of map elements, marginalia, and font sizes and styles accompanies this standard. The GeoPDF US Topo maps are fashioned to conform to this style sheet so that a user can print out a map at the 1:24,000-scale using the dimensions of the traditional standard 7.5-minute quadrangle. Symbology and type specifications for feature content are published separately. In addition, the GeoPDF design allows for custom printing, so that a user may zoom in and out, turn layers on and off, and view or print any combination of layers or any map portion at any desired scale.

Background

When the USGS topographic mapping program was redefined in late 2008, the end product was specifically defined as a GeoPDF file. The PDF was chosen as the electronic format because it is accessible to computer users who are not GIS specialists, and it is relatively easy to print. The GeoPDF geospatial extension provides the end user with a PDF map that is georeferenced and that is built with multiple data layers that can be turned on and off to support different views of the map.

The first maps for the new US Topo program (*http://nationalmap.gov/ustopo/*) were created by the USGS in 2009. About 13,000 maps were created consisting of: a map collar; projection line and grids; orthoimage; and limited cartographic feature detail that included roads, geographic names, and limited annotation. Contour lines, hydrography, and other standard topographic map content were not included. These products are referred to as "Digital Map – Beta" (always specified with quotes).

Late in 2009, the USGS began publishing maps that integrated contours and hydrographic features into the maps, and the product was rebranded as US Topo. By the end of October 2010, the program had published over 32,000 maps in GeoPDF (both US Topo and "Digital Map – Beta"). In 2012, the USGS will begin to replace "Digital Map – Beta" products with US Topo maps. However, "Digital Map – Beta" products will continue to be available through the USGS Store (*http://store.usgs.gov*) as legacy maps.

Applicability

US Topo maps integrate an orthoimage, which is a significant enhancement to the original USGS topographic maps regarding currency and completeness. These products are built on standard coordinate systems, include full United States (U.S.) National grid lines and are particularly useful for emergency first-response operations. These maps can also be used by traditional topographic map users, such as resource managers, planners, and recreational users who continue to have a need for the symbolized feature data contained in the 7.5-minute maps.

Maintenance

Map content is composed of an orthoimage and significant features and layers from the following geographic themes: transportation, names, elevation, hydrography, and boundaries. It is the objective of the USGS to expand the content of the US Topo over time to include additional features and layers from these themes, as well as from other themes such as structures and land cover. This will result in a product that becomes progressively more robust to support emerging consumer requirements.

The US Topo program will provide coverage on a three-year production cycle (following the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP, http://www.apfo.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai), acquisition cycle) for the lower 48 conterminous United States, Hawaii, the Virgin Islands, and Puerto Rico. The USGS plans to initiate limited production for Alaska in 2013. The Pacific Rim Island territories and (or) protectorates will be factored into the program in 2015 or later.

The National Geospatial Program (NGP) of the USGS maintains standards for *The National Map* (*http://nationalmap.gov/*) and US Topo products. Submit questions and comments concerning this document to the U.S. Geological Survey US Topo Feedback website at *http://nationalmap.gov/ustopo/ustopo_feedback.html*.

Product Overview

The philosophy of the US Topo product design is as follows:

- The basic layout of the standard USGS 7.5-minute topographic maps has value. Maps with standard cell extent, full map collars, and standard grids are useful, in part, because of their standardized format and layout. For these advantages to persist, the layout and design of the US Topo products must conform to editorial standards that echo the traditional USGS 7.5-minute maps.
- In the emergency response and national security communities, there is a need for general purpose maps that can be easily printed at a standard map scale.
- Similarly, there is need for a National map series that can be used *without* specialized GIS software and expertise.
- A topographic line map with the addition of an orthoimage is an invaluable tool, particularly when provided in a digital format that allows the user to turn features and layers on and off, and to print at a standard map scale as well as at any desired scale.

The utility of turning layers on and off is demonstrated by the following three figures. The first illustrates the US Topo with all layers turned on (fig. 1). Figure 2 has the contour layer turned off, and figure 3 has the orthoimage layer turned off.

Files and Formats

The product defined by this standard is a layered GeoPDF, with an attached metadata file in Extensible Markup Language (XML) format conforming to the Federal Geographic Data Committee Metadata Content Standard (FGDC, available at *http://www.fgdc.gov/*). A full-sized style sheet in PDF accompanies this standard and defines the placement of map elements, marginalia, and font sizes and styles.

The physical format of the US Topo product is GeoPDF, a patented format with implementation rights held by TerraGo Technologies. This standard is therefore driven in part by the capabilities of specific commercial software systems. Adobe released the PDF specifications to be published by the International Organization for Standardization. The document is now available as ISO 32000-1 (see *http://www.iso.org/iso/pressrelease.htm?refid=Ref1141)*. TerraGo Technologies extends the PDF with the GeoPDF geospatial extension. The Open Geospatial Consortium (OGC) has published a Best Practices specification that documents the TerraGo Technologies geo-registration technique (see *http://www.opengeospatial.org/standards/bp*).

Adobe Reader software is one option to view the US Topo and may be downloaded for free at *http://get.adobe.com/reader/*. Adobe Acrobat software may be used in lieu of Adobe Reader, if available. For full geospatial functionality, the TerraGo Toolbar is available. This is a plug-in for either Adobe Reader or Acrobat. This plug-in is also available for free and may be downloaded from *http://usgs.terragotech.com/home/*.

Scale, Extent, Projection, Datum, Coordinate System, and Grids

This standard defines the US Topo product at a scale of 1:24,000. The USGS has also produced maps at other scales (for example 1:20,000, 1:25,000, 1:48,000, 1:50,000 1:62,500, 1:63,360, and 1:100,000). This standard does not prohibit other scales, but it does not completely define maps at other scales. Future enhancements to the standard may include such definitions.

All maps are cast on the North American Datum of 1983 (NAD 83) or on the World Geodetic System of 1984 (WGS 84). The two datums are equivalent at this scale. See Appendix A for further discussion about the relationship between NAD83 and WGS84. Vertical control used for elevation data is the North American Vertical Datum of 1988 (NAVD88). All maps are projected to the Transverse Mercator projection with Universal Transverse Mercator (UTM) parameters.

Geographic coordinate labels are shown outside the projection line. The full latitude and longitude values in degrees-minutes-seconds (DMS) format are shown at the corners of the projection. The 2.5-minute values are shown at every 2.5-minute tick. Fonts, type sizes, and placement guidelines are defined in detail in the associated style sheet (Appendix B).

All maps include a 1,000-meter UTM grid drawn and labeled in conformance with the U.S. National Grid (USNG, available at *http://www.fgdc.gov/usng*) standard, including a USNG grid reference box. As dictated by the USNG standard, full UTM values are shown for the first grid lines in from the northwest and southeast corners of the projection and truncated values are shown for the rest of the grid lines. The USNG standard has several options for representing the

Figure 1. Browse Image of a US Topo GeoPDF. All layers on.

Figure 2. Browse image of a US Topo GeoPDF. Contour layer off.

Figure 3. Browse image of a US Topo GeoPDF. Orthoimage layer off.

1,000-meter grid labels. US Topo maps use the following options:

- Except for the corner coordinates that show full UTM values, grid lines are labeled with the USNG principal digits in Univers 57 Condensed size 10 type: the preceding UTM digits in Univers 57 condensed size 6 superscript type, and the post digits are not shown (for example, $^{2}41$ or $^{35}58$) (see fig. 4, and the style sheet Appendix B).
- If the map includes two 100,000-meter zones, the zone letters are printed in both margins. If the map includes a corner between four 100,000-meter zones, the zone letters are printed in the margins and also at the intersection in the interior of the map. There are only two cases of multiple 100,000-meter zones that can occur on a 7.5-minute on-grid map.

State Plane Coordinate System of 1983 (SPCS83) ticks and labels are normally shown, although not required. SPCS83 values are always shown with units of U.S. Survey Feet.

Data Quality

Components of data quality include currency, consistency, completeness, and accuracy. The US Topo program uses interpreted cartographic point, line, and area features taken from databases maintained or approved by the USGS. These source databases are multi-purpose GIS databases, and are not necessarily complete or consistent in the same sense that is represented on standard topographic maps. The databases are often compiled from multiple primary and secondary sources and have no single currency date. US Topo maps therefore have different characteristics regarding currency, consistency, and completeness compared to the standard USGS topographic maps. The data tend to be more current than on a standard 7.5-minute legacy map, but may be less consistent between maps and between regions because of variations in data collection between different sources. Accuracy— both positional accuracy and attribute accuracy— of the data is the responsibility of the organization that produced the source data. The overall quality of the cartographic data depends

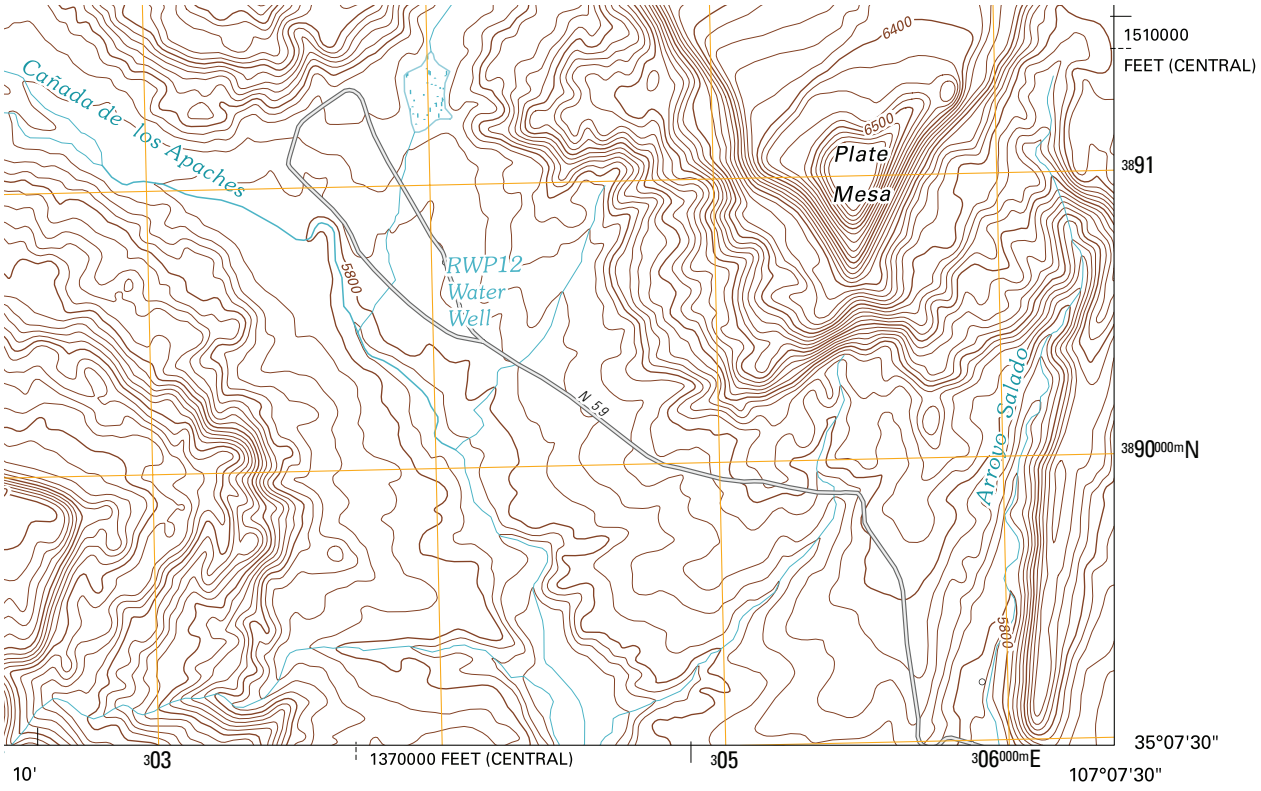

Figure 4. Detail of southeast corner of Arch Mesa, New Mex., US Topo quadrangle showing correct style for geographic and USNG coordinate values.

directly on the quality of the source GIS databases. To ensure readability, the USGS cartographically edits the data used in the US Topo where necessary. The XML metadata file attached to each map includes data quality statements in the Data Quality and Accuracy Information section and in the Data Source and Process Information section.

See Appendix A for a more detailed discussion on data completeness and consistency.

Projection Line Orientation and Page Size

The orientation of the projection line to the internal coordinate system of the US Topo image space is equivalent to those traditionally used on standard USGS topographic maps. The central meridian of the quadrangle (not to be confused with the central meridian of the projection zone) is set parallel to the left and right edges of the image file. The west and east edges of the projection line is therefore almost, but not exactly, parallel to the left and right edges of the image file (or to the edges of the paper on a rectangular paper plot).

This standard does not define a constant page size for trimming the US Topo printed at the full-size 1:24,000-scale. First, the 7.5-minute quadrangle width varies with latitude. Second, while quadrangle height does not vary with latitude, the text in the map collar may vary in content. The GeoPDF is constructed so that the width of the margins is always nearly equal. Because the GeoPDF provides for custom printing, the user may trim the printed map as required.

Off-Grid and Oversized Maps

Approximately 400 of the standard printed USGS 7.5-minute topographic maps did not precisely match the domain of a standard 7.5-minute cell. Exceptions included extensions beyond the projection line for things like a finger of land mass, extending the projection line to match a state boundary, or shifting of the entire projection line to center the quadrangle over an island.

USGS cell-based digital products, such as Digital Line Graphs (DLG) and Digital Elevation Models (DEM), did not allow for such exceptions. These products only had the geographic domain of an on-grid 7.5-minute cell.

US Topo maps conform to the latter convention, and all maps precisely fit the standard 7.5-minute cell grid. See Appendix A for further discussion about oversize and off-grid maps.

Map Collar

The map collar (or map margin) is defined as the area outside the projection line, including all text, diagrams, and other information that appears in this area, except for data related to cartographic coordinate systems, which are logically associated with the projection line and grids.

The general layout of the US Topo map collar is similar to that of standard 7.5-minute topographic maps. Precise content, positions, colors, fonts, and line weights for the collar are defined by the style sheet (Appendix B) that accompanies this standard. The following information is shown in the collar (see Appendix B):

- USGS Visual Identity logo.
- U.S. Department of Interior and Bureau identifier.
- The National Map Visual Identity logo.
- U.S. Forest Service logo, for cells containing National Forest land.
- Title block, upper right.
- Title block, lower right.
- Map generation date, lower right. This is the year the map product was created, not the date of any source material.
- Feature symbology legend.
- Map credit legend, consisting of the following:
  - The note “Produced by the United States Geological Survey.”
  - If applicable, the name of the cooperating Federal or State agency, Commonwealth, or Country is also shown.
  - The map projection, horizontal datum, UTM grid spacing, UTM zone, and State Plane zone.
  - A list of data layers with sources and currency dates.
- Quadrangle location diagram.
- Adjoining quadrangle diagram.
- Map scale note, with scale expressed as a representative fraction.
- Bar scales.
- Contour interval and Vertical Datum notes.
- Accuracy statement. An accuracy statement is shown only when all data displayed in the map interior are USGS data that have been accepted as part of a quality assurance program.
- US Topo Standard version statement.
- Metadata version statement. Metadata is formatted per the FGDC Metadata Content Standard. The XML metadata file attached to each GeoPDF contains standardized language that is determined by the source data used. Metadata file versions are maintained for

production use and the content of these files is not defined by this standard.

- North arrow and declination diagram.
- USNG grid reference box. The grid reference box is logically associated with grids and coordinate systems, but is positioned in the map collar area.

Map Interior—Data Sources, File Size and Resolution

All geospatial content is taken from National geospatial databases under the stewardship of USGS data programs. This normally means data owned and hosted by the USGS. It also includes data sources owned and hosted by other organizations, provided that these sources have been approved for use by the USGS. The US Topo product is freely distributable, but this does not necessarily mean that all the data in the product are public domain as this standard does not preclude the use of licensed data. All source information and any relevant license information is documented in the product metadata and map collar.

The US Topo map program produces a GeoPDF product that supports high quality printing and has a manageable file size for storage, view, and manipulation in its native digital format. These requirements have to take into account the size of the data sources that are integrated, ground sample distance (GSD), image bit depth, spatial resolution, and file compression. See Appendix A for a more detailed discussion of these concepts. The following sections discuss the goals and requirements for the data sources used in the US Topo product, and for the file size and resolution of the GeoPDF.

Interpreted Cartographic Features

The maps are assembled in layered GeoPDF, and include significant features and layers that are included in the standard USGS 7.5-minute maps in the data themes of: transportation, geographic names, elevation, hydrography, and boundaries. The USGS intends to expand the content of the US Topo products over time, adding additional features from the stated themes, as well as from themes such as structures and land cover. Examples of the features that are included in the US Topo are as follows:

- Roads
- Airports
- National boundaries
- Contours
- Coastline
- Lake/pond
- Stream/river
- Geographic names

This list is a sample, and is not intended to be all-inclusive. The details of the content, symbology and labeling are outside the scope of this standard, and are published separately.

The U.S. Board on Geographic Names (BGN, *http://geonames.usgs.gov/*) is the official Federal Government body established in 1947 by Public Law to maintain uniform geographic name usage throughout the Federal Government. The USGS developed the Geographic Names and Information System (GNIS, *http://geonames.usgs.gov/pls/gnispublic/*) in support of the BGN as the official repository of domestic geographic names data. The GNIS is the primary source for applying geographic names to Federal electronic and printed products, and it comprises a subset of all feature names that might be shown on the US Topo. See Appendix A for further discussion on Geographic Names.

Orthoimage

An orthoimage is a required layer in every US Topo product. The normal image source is the NAIP, though the program manager can opt to use other recent orthoimagery.

Orthoimagery requirements at 1:24,000-scale are as follows:

- One-meter ground sample distance (GSD).
- Bit depth of 8-bits.
- Currency within three years of the map publication date.

Image sources with a coarser GSD and smaller bit depths are not used in the US Topo. Image sources with a finer GSD and larger bit depths are resampled and (or) converted as necessary. These requirements support the balancing of digital file performance versus high quality printing.

File Size and Resolution

The objective is to produce a GeoPDF with a file size of approximately 20 Megabytes (MB). This is an ideal rather than a hard requirement because the data sources and orthoimage character vary between quadrangles. This file size is small enough for optimal performance and large enough to maintain high quality printing. The goal is to produce the US Topo maps with a spatial resolution of 600 pixels per inch (PPI) because this corresponds to 1-meter GSD at 1:24,000-scale, a favorable resolution for high quality printing.

Digital File Organization

Standard 7.5-minute topographic maps were designed for ease of use by a person viewing a paper map. The US Topo is still intended primarily for viewing (not for advanced GIS analysis), but the GeoPDF allows the user to view the map in softcopy and to print it out at the default scale of 1:24,000, or any desired scale for viewing on paper.

Startup Conditions

Specifying software behavior is unusual for a USGS product standard, but is used in this case because of the tight coupling between GeoPDF, the commercial software tools that can read a GeoPDF, and this product standard. The following startup behaviors depend on the Adobe Reader or Acrobat software and the TerraGo Toolbar extension, which is controlled by TerraGo Technologies, Inc. Therefore, these requirements are considered provisional.

When the GeoPDF file opens in a current version of Adobe Reader or Acrobat that has the TerraGo Toolbar installed, the following actions are displayed:

- The map is fit to the view page.
- The folder structure is collapsed, showing only top-level folders and layers.

Layers

The GeoPDF file contains, at a minimum, the following folders and layers:

- Map collar
  - Map elements
- Map frame
  - Projection and grids
    - Projection coordinate values
    - Geographic and grid ticks
    - Projection line mask
    - Grid lines
- Images
  - Orthoimage

"Map collar", "Map frame", and "Images" must be folders and must minimally contain the listed subfolders and layers. The folders and layers listed above are present in every GeoPDF file, and use the same names as shown here. The "Map frame" folder also contains other folders and layers for the cartographic features included in the US Topo, as depicted in fig. 5.

Compliant with this standard, additional data folders and layers may be added as the product develops. Each folder or layer may be turned on or off by the user. All data in the file belongs to a folder or layer. Therefore, it is possible to remove everything from the display.

Cartographic content may be trimmed precisely to the 7.5-minute cell extent, or may include data that slightly extends beyond the neat line. These data, if present, are hidden by a mask layer in the "Map collar" folder.

Companion Data Files in Open Formats

Although the GeoPDF extension is published as an Open Geospatial Consortium Best Practices document (Demmy and Reed, 2011), it is a proprietary format, and commercial software from TerraGo Technologies remains the dominant implementation. It is unusual for the USGS to use a proprietary format as the exclusive distribution format of a geospatial product; it is optimal to distribute content equivalent data products in formats that are open and GIS-compatible. However, the technical problems behind defining such companion products are complex enough that the USGS has decided to defer this issue. At this time, GeoPDF is the only digital distribution format for this product.

No directly comparable GIS product is currently being produced, but most data used to make US Topo maps are available in GIS formats from *The National Map* and other open sources, and most are downloadable free of charge (a significant exception is commercial road data in products created starting in mid-2010).

Metadata Files

An FGDC-compliant metadata file in XML format is attached to each US Topo product. The metadata file contains the same information as the map collar, plus additional information as required by the FGDC metadata content standard. The benefit of duplicating collar information is that the XML file can be parsed by software (see Product Overview section for map collar content).

File Names

US Topo GeoPDF files are named using the following convention:

state_cellname_timestamp_XX_geo.pdf

For example: CO_Golden_20101005_TM_geo.pdf

Where:

- *state* is the 2-letter abbreviation of the cell primary State.
- *cellname* is the name for this standard cell. If the cell name consists of multiple words, words are delimited with the underbar (_) character, not spaces.

- *timestamp* is the system-generated date of PDF file creation. Its primary purpose is to make each file name unique, regardless of how many instances of the same product are created for one cell. The timestamp string is a concatenation of year-month-day, where year has four digits and the other two fields have exactly two digits (padded with zeros as necessary). No delimiters are used in the timestamp, so December 4, 2009 is expressed as 20091204.
- *XX* is a string literal to indicate the map type. OM (Ortho Map) was used for maps published without contours in 2009. In 2010 publication of maps with contours began, and the type was changed to TM (Topographic Map). No domain of values for this string is specified by this standard.
- *geo* is a string literal that indicates the PDF is georeferenced.

No requirements are specified for letter case; file names may use any combination of uppercase and lowercase letters.

Because the metadata file is bundled with the GeoPDF as a file attachment, a naming convention for the metadata file is not dictated.

A naming convention is also not dictated for transfer or distribution files. For example, a zip file of one or more US Topo files need not conform to any particular naming convention.

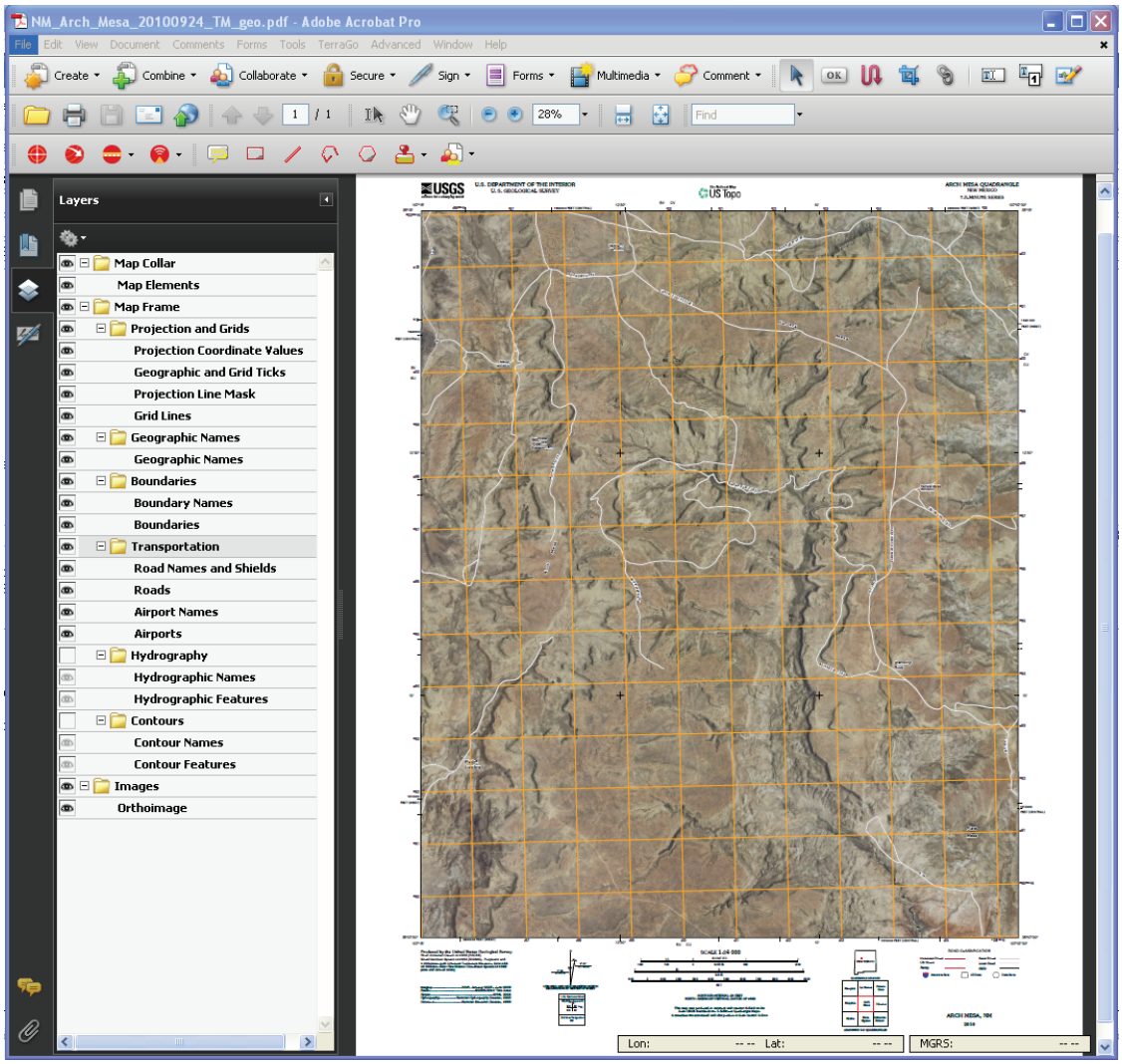

Figure 5. Image of the US Topo depicting folders and layers. Contour and hydrographic layers off.

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Glossary

National Geospatial Program (NGP, *http://www.usgs.gov/ngpo/*)—An administrative unit of the U.S. Geological Survey responsible for mapping and Geographic Information System (GIS) activities. The NGP is under the USGS Core Science Systems.

Metadata Information (*http://geology.usgs.gov/tools/metadata/*)—An information set about a map or other geospatial product that describes how the product was made, the sources of data, and other relevant information. The Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Metadata (version 2.0), FGDC–STD–001–1998, defines content and organization of metadata files.

7.5-minute standard cell—Geographic quadrangle that aligns with 7.5-minute increments of latitude and longitude. These cells, their official names, and other attributes are stored in the Geographic Cell Names Database (GCNDB), a part of the Geographic Names Information System (GNIS).

USGS Mapping Program—An umbrella term that encompasses most of the activities of the NGP, including all aspects of The National Map and the National Atlas.

U.S. National Grid (USNG)—The official grid coordinate system of the U.S. Government. See *http://www.fgdc.gov/usng/* for information and specifications.

Useful Websites

http://geology.usgs.gov/tools/metadata/—This site provides useful information about how to implement the FGDC metadata standard.

http://geonames.usgs.gov/ —The USGS home page for the U.S. Board on Geographic Names.

http://get.adobe.com/reader/ —Free Adobe Reader software may be downloaded from this site.

http://nationalmap.gov/— USGS home page for *The National Map.*

http://nationalmap.gov/ustopo/— USGS home page for the US Topo maps.

http://nationalmap.gov/ustopo/ustopo_feedback.html—Submit feedback for the US Topo via this site.

http://store.usgs.gov/ —USGS products may be downloaded from this site.

http://usgs.terragotech.com/home/ —Free TerraGo toolbar extension may be downloaded from this site.

http://www.apfo.usda.gov/FSA/—Home page for the U.S. Department of Agriculture's Farm Service Agency.

http://www.fgdc.gov/—Home page for the Federal Geographic Data Committee.

http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/—The FGDC Content Standard for Digital Geospatial Metadata may be downloaded from this site.

http://www.fgdc.gov/usng/—FGDC site for the United States National Grid standard.

http://www.iso.org/ —Home page for the International Organization for Standardization.

http://www.ngs.noaa.gov/—Home page for the U.S. National Oceanic and Atmospheric Administration, National Geodetic Survey.

http://www.opengeospatial.org/—Home page for the Open Geospatial Consortium.

http://www.usgs.gov/ngpo/ —Home page for the USGS National Geospatial Program.

http://www.usgs.gov/pubprod/reference.html#standards/ —Home page for USGS Maps, Imagery, and Publications.

Acronyms

BGN	Board on Geographic Names
DEM	Digital Elevation Model
DLG	Digital Line Graph
FGDC	Federal Geographic Data Committee
GCNDB	Geographic Cell Names Database (part of GNIS)
GeoPDF	Portable Document Format with georeferenced extension
GIS	Geographic Information System
GNIS	Geographic Names Information System
GSD	Ground Sample Distance
ISO	International Organization for Standardization
MB	Megabyte
NAD83	North American Datum of 1983
NAIP	National Agriculture Imagery Program
NAVD88	North American Vertical Datum of 1988
NGP	National Geospatial Program
OGC	Open Geospatial Consortium
PDF	Portable Document Format
PPI	Pixels per inch
SPCS83	State Plane Coordinate System of 1983
URL	Uniform Resource Locator (or Internet address)
USGS	United States Geological Survey
USNG	United States National Grid
UTM	Universal Transverse Mercator
WGS84	World Geodetic System of 1984
XML	Extensible Markup Language

Appendix A: Notes and Discussion Issues

This appendix contains additional discussion about several of the design decisions for the US Topo product.

Datums: NAD 83 and WGS 84

The following is from the Federal Register: August 15, 1995 (v. 60, no.157), "Use of the NAD 83/WGS 84 Datum Tag on Mapping Products." This article is online, but must be searched for from the Federal Register main page, *http://origin.www.gpoaccess.gov/fr/*.

> SUMMARY: The Office of National Geodetic Survey, redefined and readjusted the North American Datum of 1927 (NAD 27), creating the North American Datum of 1983 (NAD 83). The World Geodetic System of 1984 (WGS 84) was defined by the Defense Mapping Agency (DMA). The interagency Federal Geodetic Control Subcommittee (FGCS) at its meeting on December 7, 1994, recommended that
>
> > **"**All maps and charts produced for North America, at scales of 1:5,000 or smaller, that are based on either the North American Datum of 1983 (NAD 83) or the World Geodetic System of 1984 (WGS 84), should have the horizontal datum labeled as NAD 83/WGS 84.**"**
>
> SUPPLEMENTARY INFORMATION: The following supplementary information was reviewed by FGCS membership. A Federal Register notice published on June 29, 1979 (44 FR 37969), by the National Oceanic and Atmospheric Administration (NOAA) provided notification of the establishment of a new Datum (NAD 83) to which the geographic and plane coordinate values for the National Network of Horizontal Geodetic Control would be referenced. A Federal Register notice published on June 14, 1989 (54 FR 25318), by NOAA affirmed NAD 83 as the official horizontal datum for all future U.S. surveying and mapping activities performed or financed by the Federal Government. Furthermore, this notice said that to the extent practicable and feasible, all Federal agencies using coordinate information should provide for an orderly transition to NAD 83. Both NAD 83 and WGS 84 were originally defined (in words) to be geocentric and oriented as the Bureau International de l'Heure (BIH) Terrestrial System. In principle, the three-dimensional coordinates of a single physical point should therefore be the same in both NAD 83 and WGS 84 systems; in practice, small differences are sometimes found. The original intent was that both systems would use the Geodetic Reference System of 1980 (GRS 80) as a reference ellipsoid. As it happened, the WGS 84 ellipsoid differs very slightly from GRS 80. The difference is 0.0001 meters in the semi-minor axis. Effective January 2, 1994, the WGS 84 reference system was realigned to be compatible with the International Earth Rotation Service's Terrestrial Reference Frame (ITRF).

Data Completeness and Consistency

Feature completeness means that for some predefined feature set, if a feature exists in the real world, it is shown on the map. Consistency means that the same feature set is used everywhere. Completeness and consistency are extremely difficult to maintain over continental areas. The standard 7.5-minute topographic maps were impressively complete and consistent at the time of publication, but at a huge cost in both time and money. The results were possible only because the maps were compiled from primary sources such as new aerial photography, specialized field work, contact with local sources, and official survey plats.

General-purpose National-series maps of the present and the foreseeable future are not compiled from primary sources, and do not aspire to the same levels of completeness and consistency. Raising all datasets to a high level of completeness and consistency would be prohibitively expensive, while lowering content guidelines to a level where completeness and consistency are achieved inexpensively would make most maps artificially low in quality.

For any given small area (such as a city or county), the "best available" data are often very good, but data between cities and counties may be inconsistent. The use of secondary, best-available sources can (somewhat paradoxically) result in high quality maps that may be less complete relative to any specific content standard and less consistent relative to each other than legacy standard topographic maps. Consistency even within a single map can be problematic because local data sources follow political units, not 7.5-minute cells.

New models may be needed to express these realities in map content standards. Pending such developments, and pending the development of more mature National geospatial databases, it is the intention of the USGS to strike a reasonable balance between these factors.

Off-Grid and Oversized Maps

The policy of not allowing oversize or off-grid maps has several implications:

- The development and maintenance of map production software and procedures is simpler. This is the primary reason the current standard dictates only on-grid, standard size products. Building production systems to accommodate the special cases of off-grid

products is difficult and the number of cells involved is small.

- Softcopy map users will probably not be significantly inconvenienced by this policy, and may consider the higher level of regularity and standardization to be a benefit.
- The primary effect of this policy is to users who rely on paper maps. There will be some instances of maps that are covered almost completely by water, and instances of small island chains broken up into several pieces. Users who print their own maps will use more ink and paper to print very little additional information in these cases.

Image GSD, Bit Depth, Resolution and Compression

The goal in US Topo production is to construct a GeoPDF that strikes a balance between manageable file size and high quality printing. The orthoimage source has the greatest effect on file size. Government-procured orthoimagery is typically collected at a GSD between 6 inches and 1 meter. Though source orthoimagery may be collected at higher resolution, this standard calls for the orthoimage layer of the US Topo to be 1-meter GSD. This resolution was chosen for the US Topo because 1-meter GSD at 1:24,000 corresponds to 600 PPI, which is an appropriate resolution for high quality printing.

Bit depth represents the precision with which colors are specified in an image. For example, an 8-bit image stores 8 bits per pixel per primary color channel (RGB: red, green, and blue), or 256 intensity values for each primary color. Higher bit depth results in a larger file size. An 8-bit image is a true-color image that is deemed appropriate for high quality printing.

An 8-bit 7.5-minute orthoimage cell at 300 PPI contains approximately 35 million pixels, equating to over 100 MB of RGB image data. The same tile at 600 PPI (1 meter) is four times as large. Given this hefty potential file size, lossy compression (elimination of data) is required to produce a 7.5-minute GeoPDF containing 1-meter orthoimagery with a file size of approximately 20 MB. Compression is a tradeoff between quality and file size, as higher compression ratios result in smaller file sizes but lower quality images. The 20 MB file size is optimal for maintaining high quality for printing, and is a manageable file size for storage, viewing, and manipulation of the GeoPDF.

Note that compression is achieved with built-in features of commercial software for which precise algorithms are proprietary. Displaying and printing requires decompressing the data, which is done automatically by the Adobe Reader software, but the memory management of decompression is implementation-dependent.

Geographic and Cultural Features, their Names and Labels

The U.S. Board on Geographic Names (BGN) publication *Principles, Policies, and Procedures: Domestic Geographic Names*, states (page 5):

> "It is the policy of the Federal Government that only official domestic geographic names are to be used on Federal maps and in other publications. An official name is one in which the written form of that name and its application to the appropriate place, feature, or area are approved by the U.S. Board on Geographic Names or the appropriate administrative agency…By law, the Board is responsible for all geographic names except those applying to offices or establishments of Federal agencies…Practically, however, the Board decides primarily on the names of natural features of the land, unincorporated localities, and populated places in the United States, and its territories and outlying areas…"

Principle IV (p. 10–12) explains that names falling within the scope of other authorities (Federal agencies, State and local governments and associated entities, Native American Tribes, and structures on private property) are only the subject of BGN decisions when the Board decides that it is necessary to settle a conflict between the different authorities. "Independent of whether decisions are rendered, the Board may include such names in lists it issues from time to time, as part of its responsibility to promulgate standard names for U.S. Government use."

The document continues on page 5:

> "Because of their use as an authoritative graphic reference, it is particularly important that all names published on the base series maps and charts be recorded and agree in written form and application with GNIS name records."

Appendix B: 1:24,000-Scale US Topo Style Sheet

The US Topo Map style sheet is part of the US Topo Product Standard, and published as a map sheet that is included with this publication.

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