Summary of Available Terrain Data

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This report provides the results of a study into the type and availability of digital terrain and elevation data that could be used as input to terrain rendering software providing a real-time flight simulator integrated with a Geographic Information System (GIS).

1 Data for terrain rendering

Computer rendering of a terrain can be done using satellite image data to provide the basic picture of the terrain, overlaid onto polygons created from digital elevation data, to provide a three-dimensional view. This provides the basic images onto which geographic information system (GIS) data can be overlaid.

Terrain rendering requires orthophotoquad quality satellite images, which have been processed to include corrections for elevation, angle, and inaccuracies in calculating the coordinates of the area in the satellite images. This precision and elevation corrected data is then placed into standard map quadrants, giving what is basically a two dimensional digital "photographic map". This can be done using either Landsat or SPOT satellite data, at 30m or 20m resolution respectively, for any part of the world. This processing requires the use of a digital elevation model. SPOT data is available in stereo-image pairs which allow the elevation data to be computed. For Landsat data, US Geological Survey elevation data is used for the US, and the customer needs to provide the elevation data for areas outside the US.

Note that satellite data is very expensive. For example, the cheapest Landsat data is $2500 per "scene". Only about 10 scenes are needed to cover New York state, however over 400 scenes would be required for the entire US, which would cost over a million dollars. SPOT satellite data is almost 10 times more expensive.

Digital elevation data for all areas of the USA can be obtained very inexpensively from the US Geological Survey (USGS). Currently the entire US is available at 60m resolution, and soon will be available at 30m resolution (currently only 50% of the US is available at this higher resolution). This data is in the public domain, so can be repackaged and resold.

High resolution (90m) digital elevation data for the entire world has been put together by the US Defense Mapping Agency, but it is not available to the general public. The only existing public domain digital elevation data for the entire world is at very coarse (1 km) resolution (which is the same resolution as is available for Mars!). High resolution (better than 100m) data is available from the mapping agencies of certain countries, e.g. Canada, Mexico, Britain, Japan.

Digital elevation and satellite image data for the whole of Mars (at 1 km resolution) and parts of Venus (at higher resolution) is also available from NASA missions, and is in the public domain.

Other public domain data from USGS, such as Digital Line Graph data, Land Use and Land Cover data, and a Geographic Names database, could be integrated into the system to provide added educational GIS content such as highways, railroads, canals, rivers, lakes, state and county boundaries, forests and agricultural areas, and names of all these features plus towns, mountains, and other geographic objects.

Integrating and overlaying different types of data, especially data using different mapping conventions, is a non-trivial task. Software to do this is available from various commercial GIS companies, including ERDAS.

The USGS data is in the public domain and can be repackaged and resold. The satellite data can be resold as long as it is processed in such a way that the raw data cannot be extracted from the final product, which would be the case for terrain rendering.

2 Available Data

Some government data such as US Geological Survey and US Census Bureau is in the public domain and can be repackaged and resold. For most other sources, the data can be resold as long as it is processed enough so that the original data could not be extracted by the user.

Digital Elevation Model (DEM) data

1" = 1 arc-second ≈ 30m
1' = 1 arc-minute ≈ 1 mile

WORLD

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Data: The Digital Chart of the World
From: US Defense Mapping Agency
Resolution: ~ 1 km (from 1:1M scale map) except Antarctica (1:2M)
Source: Digitized 1:1M and 1:2M scale maps
Area covered: World
Format: VPF and VRF
Size: 600 MB for elevation data
Cost: $200 for 4 CDs covering different continents
Notes:
1000' contour lines rather than grid data.
Available from USGS. Also includes DLG and other data.
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Data: ETOPO5
From: US Defense Mapping Agency
Resolution: ~ 6 mile (5')
Area covered: World
Format: 2 byte binary integers
Cost: included in Global Relief Data CD-ROM
Size: 18.6 MB
Notes:
Available from National Geophysical Data Center and Global Resource
Information Database (GRID). Included in Global Relief Data CD-ROM.
The resolution of the gridded data varies from true 5-minute for the
ocean floors, the U.S.A., Europe, Japan, and Australia to 1 degree in
data-deficient parts of Asia, South America, northern Canada, and Africa.
Also includes some land use and land cover data.
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Data: Digital Terrain Elevation Data Level 1 (DTED-1)
From: US Defence Mapping Agency
Resolution: 90m (3") and 30m (1")
Area covered: World (only parts of 90m DTED-1 has been declassified)
Format: DTED-1
Size: ~ 3MB per 1x1 degree quad, ~ 60 Gbytes for whole world
Notes:
This data is classified, and not available to the general public,
except through repackaged USGS 90m data for the USA.


From: SPOT Image Corporation and ESRI
Resolution: 10m
Area covered: World (customized for requested area)
Format: ARC/INFO-compatible format
Cost: approx $10,000 per 60x60km scene (SPOT), available on tape or CD-ROM.
      Quarter-scene is also available.
Size: unknown
Notes:
Available from SPOT, Environmental Systems Research Institute (ESRI).
10m DEMs are available for any location in the world via SPOT
stereoscopic satellite imagery. The DEM data may not be available for the
entire scene.
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UNITED STATES

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Data: 1 degree DEM
From: U.S. Geological Survey (USGS)
Resolution: 90m (3")
Source: Digitized 1:250,000 scale maps
Area covered: Entire US
Format: ASCII, WGS 84
Cost: Free via ftp, or $1500 for 6 CDs
Size: ~940 1 degree square quadrants x 10 MB per quad  ~= 10 Gbytes
      for whole US (stored as ASCII - binary would be factor 3-4 smaller)
Notes:
This data is reformatted DTED-1 data for the US.


Data: 30' and 15' DEM
From: U.S. Geological Survey (USGS)
Resolution: 60m (2")
Source: Digitized 1:100,000 scale maps
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Area covered: Entire US
Format: ASCII
Cost: $90 base charge + $7 per 30' quad (for more than 5 quads)
Size: ~18,000 15' square quads x 1 MB per quad  ~= 18 Gbytes
      for whole US (stored as ASCII - binary would be factor 3-4 smaller)
Notes:
A 30' DEM quad consists of four 15' DEM quads. 30' DEM is available for
conterminous US and Hawaii. 15' Alaska DEMs have varying longitudinal
cell size.


Data: 7.5' DEM
From: U.S. Geological Survey (USGS)
Resolution: 30m (1")
Source: Digitized 1:24,000 scale maps
Area covered: Only about 50% of US available so far
Format: ASCII
Cost: $90 base charge + $7 per quad (for more than 5 quads)
Size: ~54,000 7.5' square quads x 1 MB per quad  ~= 50 Gbytes
      for whole US (stored as ASCII - binary would be factor 3-4 smaller)
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OTHER COUNTRIES

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Country: Austria
Resolution: 50m
From: Bundesamt fuer Eichund Vermessungswesen (BEV)
      (The Austrian National Mapping Agency)

Country: Canada
Resolution: 93m
From: Communications Data Services, Inc., under contract from
      Energy Mines & Resources Canada.

Country: Finland
Resolution: 25m
From: National Land Survey of Finland

Country: France
Resolution: 100m
From: Institut Geographique National (IGN)

Country: Japan
Resolution: 50m
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From: Geological Survey Institute

Country: Mexico
Resolution: 93m
From: Communications Data Services, Inc.

Country: Norway
Resolution: 100m
From: Norwegian Mapping Authority

Country: Taiwan
Source: DTED-1 data
Resolution: 90m
From: Todd Rothermel, Martin Marietta

Country: UK
Resolution: 50m
From: Ordnance Survey

OTHER PLANETS

Planet: Mars
Resolution: 1 km
From: NASA JPL, distributed by USGS
Size: ~ 700 MBytes

Satellite image orthophotoquad data

WORLD

Data: SPOTView Thematic Mapper
From: SPOT
Resolution: 20m
Area covered: World (customized for requested area)
Cost: $2500 per 60x60km scene (SPOT) on tape or CD-ROM (70c per square km).
$1000 without orthophotoquad corrections. Quarter-scene is also available.
Notes:
This is SPOT image data with corrections made to convert the images to orthophotoquad standards. SPOT can create its own DEM data for elevation

corrections, using stereo-pairs.

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Data:  Landsat Thematic Mapper
From: Earth Observation Satellite Co. (EOSAT)
Resolution: 30m
Area covered: World
Cost: $6250 per 185x170km scene (20c per square km).
      $4400 without orthophotoquad corrections.
      $2500 for "Best of the US", using existing older images
            without orthophotoquad corrections (8c per square km).
      For the cheapest data, coverage of New York state (about 10
      scenes) would cost around $25K, coverage of the entire US
      (about 435 scenes) would cost around $1M. There are no bulk
      or educational discounts.
Notes:
This is Landsat data with corrections made to convert the images to
orthophotoquad standards. USGS DEMs are used for the US, the customer
must provide their own DEM for areas outside the US.
Much cheaper data is available from the "Best of the US" package of
pre-selected older images. These are not precision or elevation corrected
to orthophotoquad standard, however software is available (e.g. from
ERDAS) to do elevation correction. For large areas this would be most
cost effective.
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UNITED STATES

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Data: U.S. Geological Survey (USGS) orthophotoquads
From: USGS
Source: Black and white aerial photographs
Resolution: unknown
Area covered: Very small sections of the U.S.
Cost: unknown
Notes:
This is a new USGS program that aims to digitize standard format 20,000'
black and white aerial photographs and convert them to orthophotoquads.
Very little data is available yet. This is not very useful unless USGS
starts to do the same thing for color aerial photos.
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OTHER PLANETS

Planet: Mars
Resolution: 1 km
From: Planetary Data System from NASA JPL
Cost: Free via ftp
Size: ~ 700 MBytes

Planet: Venus (not entire planet)
Resolution: better than 1 km
From: Planetary Data System from NASA JPL
Cost: Free via ftp

Digital Line Graph (DLG) data

WORLD

Data: The Digital Chart of the World
From: US Defense Mapping Agency
Resolution: ~ 1 km (1:1M scale) except Antarctica (1:2M)
Area covered: World
Format: VPF and VRF
Size: 600 MB
Cost: $200 for 4 CDs covering different continents
Notes:
Available from USGS.
Composed of 17 thematic vector layers which include political boundaries, coastlines, cities, transportation networks, hydrography, landcover, hypsography and place names.

UNITED STATES

From: U.S. Geological Survey (USGS)
Resolution: 2.5 km (digitized USGS 1:2M scale maps)
Area covered: entire US
Format: DLG-3
Cost: Free via ftp, $32 for CD
Notes:
Highways, railways, boundaries (states, counties, forests and parks), streams and waterways.

From: U.S. Geological Survey (USGS)
Resolution: 120m (digitized USGS 1:100,000 scale maps)
Area covered: entire US excluding Alaska
Format: DLG-3
Cost: $32 for each of 14 regional CDs
Notes:
Highways, railways, boundaries (states, counties, forests and parks),
streams and waterways.

From: U.S. Geological Survey (USGS)
Resolution: 30m (digitized USGS 1:24,000 scale maps)
Area covered: only parts of US are currently available
Format: DLG-3
Cost: unknown
Notes:
Highways, railways, boundaries (states, counties, forests and parks),
streams and waterways.

From: American Digital Cartography
Resolution: 30m (digitized USGS 1:24,000 scale maps)
Area covered: entire US (customized on request)
Cost: unknown
Notes:
Highways, railways, boundaries (states, counties, forests and parks),
streams and waterways, and elevation contours,

Data: Topologically Integrated Geographic Encoding and Referencing (TIGER)
From: U.S. Census Bureau
Resolution: street level for roads
Area covered: entire US
Cost: The entire database costs $50,000 for tapes or $15,000 for CD-ROM.
The owner has unlimited right to modify and resell the information.
Notes:
Provides references and positions of all streets, boundaries and waterways.
Apparently this data has numerous mistakes, however it should be good
enough for educational GIS applications.
ETAK Digital Maps produces EtakMap, a cleaned-up and refined version of
the TIGER data.

Land Use and Land Cover (LULC) data

UNITED STATES

From: U.S. Geological Survey (USGS)
Resolution: 10-40 acre (from 1:250,000 scale maps)
Area covered: Most of the conterminous United States and Hawaii
Cost: Free via ftp, or $32 for one CD-ROM
Notes:
Classified into 92 categories of land use (human activity such as residential, agricultural, etc) and land cover (vegetation, water, etc).

Geographic Names Information System (GNIS)

UNITED STATES

From: U.S. Geological Survey (USGS)
Area covered: Entire U.S.
Format: ASCII
Cost: minimal - cost of tapes and handling
Notes:
List of over 2 million geographic place names in the US, with positions.

3 Some categories of available digital GIS data

Digital Elevation Model (DEM) data

Elevation (height) data for points on a rectangular grid, generally obtained by digitizing standard maps and interpolating to grid points. Elevation data is sometimes also available as digitized map contour lines, but DEM data is much better for terrain rendering applications, since it allows very simple construction of polygons.

Digital Line Graph (DLG) data

Vector (line segment) data showing cartographic features, such as roads, railways, waterways (streams, lakes, etc), and political boundaries.

Satellite terrain data

Satellite images of the entire earth's surface in a number of spectral bands, generally blue, green, red, and infrared. This data can be combined to create true color images. Data is available from the US Landsat, French SPOT, and Indian IRS satellites.

Orthophotoquads

Satellite images or digitized aerial photographs that are corrected for angle of sight and elevation skew, and inaccuracies in the estimation of the area being mapped, and then aligned into standard map quadrants, so that the image is basically turned into a digital "photographic map". This processing step increases the cost of the data.

Land Use Land Cover (LULC) data

Areas are classified into 92 categories of land use (human activity such as residential, agricultural, etc) and land cover (vegetation, water, etc).

Geographic Names Information System (GNIS)

List of geographic place names with positions.