TECHNOLOGY EVOLUTION OF RAISED-RELIEF MAPS

History, Modern Methods, & Design Considerations
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“Flat” methods of presenting terrain can be very effective – as shown in the samples below. But at times using a 3D model greatly eases interpretation of complex terrain, particularly for the untrained eye.
The original National Park Service 2D flat map of Glacier Bay National Park is shown at right. Summit very effectively converted this map to a raised-relief format shown below.

Notice on the raised-relief map how easy it is to quickly understand and interpret the complex and rugged terrain.
Summit is a leading designer and manufacturer of thermoformed raised-relief maps for National Parks and recreation areas, government/military, corporations, and individuals.

Up to 50” x 35” 3D area
Up to 3” – 4” of relief

**Key Technology** -- 3D printed thermoform terrain molds – extreme resolution and accuracy with economical cost.

**Key Advantage** – low cost 3D map production once design/tooling is complete.
Sampling of products:

At left, the National Park Service Denali map, converted to 3D raised-relief map format.

At right, a raised-relief map of a private property in North Carolina.
Sampling of products:

At right, a raised-relief map of Kabul, Afghanistan and the surrounding area, produced for the US Army.

At left, a large raised-relief map of the Arctic Circle, modeling the ocean bathymetry as well as the land topography.
Some Early Raised-Relief Maps and Terrain Models

Raised-relief maps have been around for a long long time, starting with models made in the dirt and sand. Handcrafted maps became things of beauty over the past couple of hundred years. The model shown below looks remarkably similar to modern raised-relief maps.

Gettysburg Battlefield
Ambrose Lehman
1886
Raised-Relief Map History

Size…Some very large terrain models have been produced for public display.

A 50,000 sq ft terrain model of Yellowstone National Park, with working geysers, was built for the Panama-Pacific International Exposition in 1915.
Materials… even concrete has been used for terrain modeling.

The Great Polish Map of Scotland is a 40m by 50m relief map sculpted in concrete.

Barony Castle Hotel Eddleston, Scotland
Military applications have long driven the development of raised-relief maps and models. The USMC uses improvised sand terrain models even today.

Below, USMC sand table classroom training

Above, USMC sand terrain model being used in the field.
Military applications have resulted in innovative new materials and approaches to 3D maps. The 3-foot square rubber raised relief map of the Normandy beach was used to brief troops aboard ship prior to the invasion.
Cut contour line sheets stacked together, and sometimes covered in plaster, clay or paper, have long been used for terrain modeling.
These four methods are the most common means of producing raised-relief maps and terrain models today:

- CNC milling/routing
- 3D printing
- Computer-cut & stacked contour sheets
- Thermoformed plastic sheets
CNC routing (subtractive manufacturing) and ink-jet printing (ref: Solid Terrain Modeling Inc.)

Pros:
- high resolution
- very accurate

Cons:
- high per-map production cost
Raised-Relief Map
Manufacturing Methods

Full color 3D Printing (additive manufacturing, stereolithography) – Z Corporation/HP.

Pros:
- high resolution
- very accurate

Cons:
- high per map production cost
Raised-Relief Map Manufacturing Methods

Cut/stacked contour sheets.

Pros:
- lower cost
- artistically attractive.

Cons:
- low resolution
Raised-Relief Map Manufacturing Methods

Printed & thermoformed plastic sheets – Summit Terragraphics and Hubbard Scientific/AEP.

Pros:
- high print image quality
- accurate terrain modeling
- lowest per map production cost

Cons:
- significant tooling costs
- image registration challenging at times
Typical Work Flow for a Summit Terragraphics Raised-Relief Map Project

**Client Requirements**
- Extent, Scale, Format

**Source/Generate Map Image**
- Earth-imagery base layer
- Color-illustrated base layer
- Vector graphic overlays

**Collect/Process Elevation Data**
- NED, SRTM, Lidar, ...

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**Construct Terrain**
- Thermoform Mold
- 3D printing/composite lamination

**Print & Review Map**
- Wide-format digital printing on flat vinyl sheet

**Print & Review**
- Adjust graphics as needed

**Thermoform Prototype Raised-Relief Map**

**Print & Thermoform Production Raised-Relief Maps**

2 Weeks

2 - 4 Weeks

1 Week

1 - 2 Weeks
Horizontal Scale: Summit Terragraphics has worked across a wide range, from 1:4,000 (Torrey Pines, to right) to 1:5,700,000 (Arctic Circle, below) to 1:33,000,000 (Mini US map). Most of Summit’s projects are between 1:50,000 and 1:500,000.
Raised-Relief Map Design Considerations

Vertical Scale and Exaggeration: Summit Terragraphics has worked across a wide range.

- from .80x (private ranch, shown at right)
- to 15x (Arctic Circle)
- to 35x (mini US map)
The optimal vertical scale and exaggeration are dependent on both terrain geometry and scale. The data points plotted below show the vertical exaggeration selected for a variety of map projects.
Raised-Relief Map Design Considerations

Hill shading must be used cautiously. The shadowing in natural aerial imagery, and artificial shaded relief effects – can lead to problems if not closely registered and properly lighted during display.
Summit’s White Mountains 4,000-Footers 3D Map

23.5” x 20” 3D format
1:125,000 horizontal scale
2x vertical exaggeration
1.0” vertical relief (main map)
Custom elevation color-ramp base layer*
Carefully designed vector-graphic overlays*

* Map illustration created by Benchmark Maps