US007792331B2

(12) **United States Patent**
Balaga et al.

(10) **Patent No.: US 7,792,331 B2**
(45) **Date of Patent: Sep. 7, 2010**

(54) **COMPOSITION OF RASTER AND VECTOR GRAPHICS IN GEOGRAPHIC INFORMATION SYSTEMS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 978 days.

(21) Appl. No.: **10/880,940**

(22) Filed: **Jun. 29, 2004**

(65) **Prior Publication Data**

US 2005/0285876 A1 Dec. 29, 2005

(51) **Int. Cl.**
G06K 9/00 (2006.01)
G06K 9/32 (2006.01)
G09C 5/00 (2006.01)

(52) **U.S. Cl.** **382/113**; 382/293; 382/294; 345/629; 345/632

(58) **Field of Classification Search** 345/629, 345/632; 382/113, 293, 294
See application file for complete search history.

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Assistant Examiner—Michael A Newman
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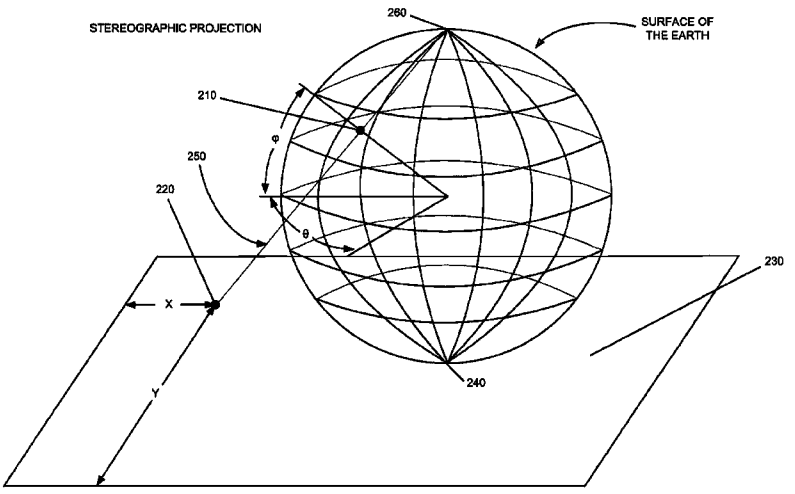
(57) **ABSTRACT**

A method for editing composite geographical images, including importing a raster geographical map file, the raster file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including geographical information identifying vector objects, rendering a two-dimensional raster image including transforming linear coordinates to geographical coordinates according to the inverse of a prescribed second projection that transforms geographical coordinates to linear coordinates, and re-projecting the geographical coordinates to linear coordinates according to the first projection, rendering a two-dimensional vector image including projecting the vector objects according to the prescribed second projection, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image. A system and a computer readable storage medium are also described and claimed.

34 Claims, 23 Drawing Sheets



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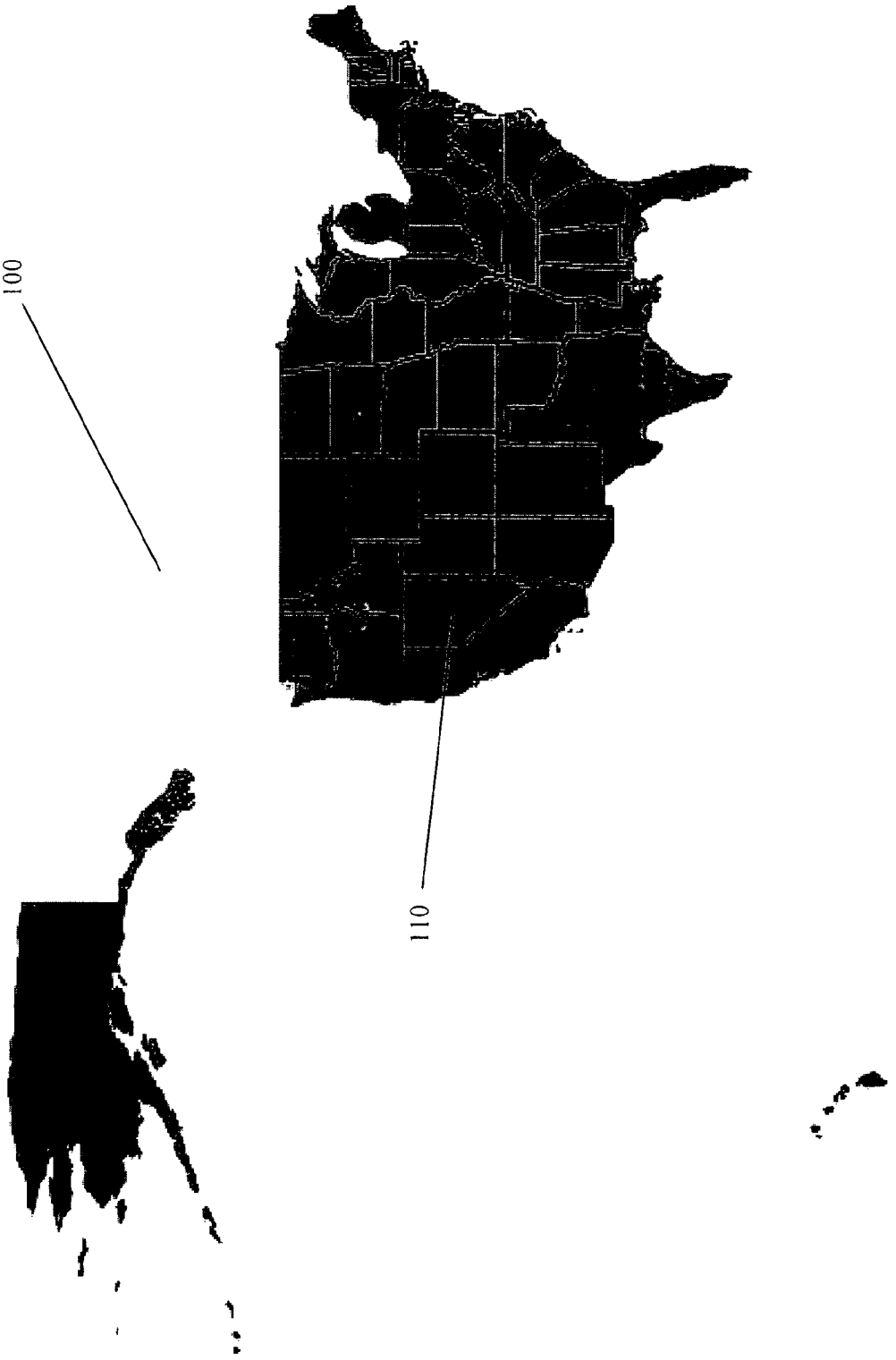
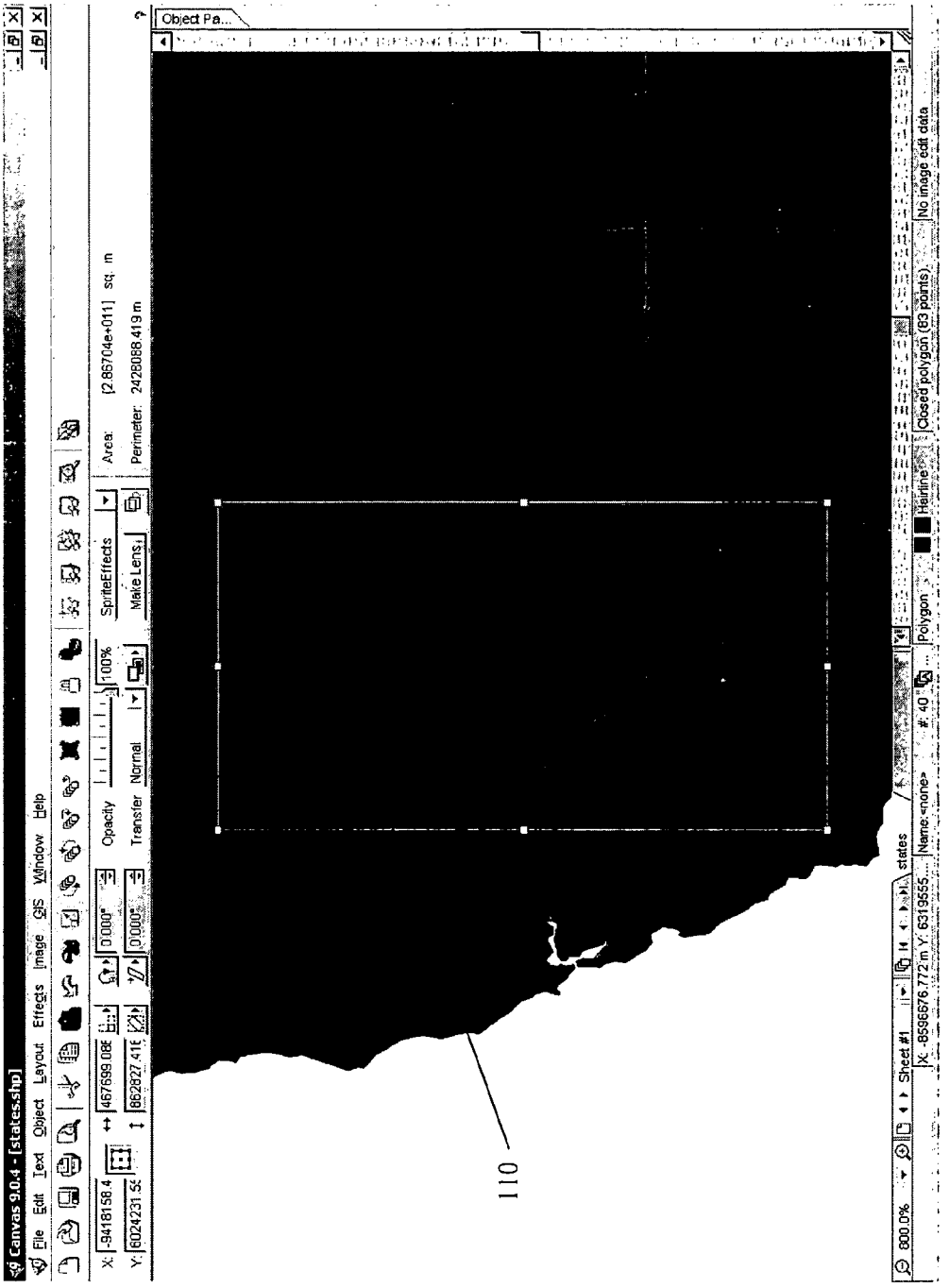


FIG. 1A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Perimeter: 2428088.419 m
SpriteEffects
Make Lens
Opacity
Transfer Normal
100%
Sheet #1
states
Polygon
Hairline
Closed polygon (83 points)
No image edit data
800.0%
110

FIG. 1B

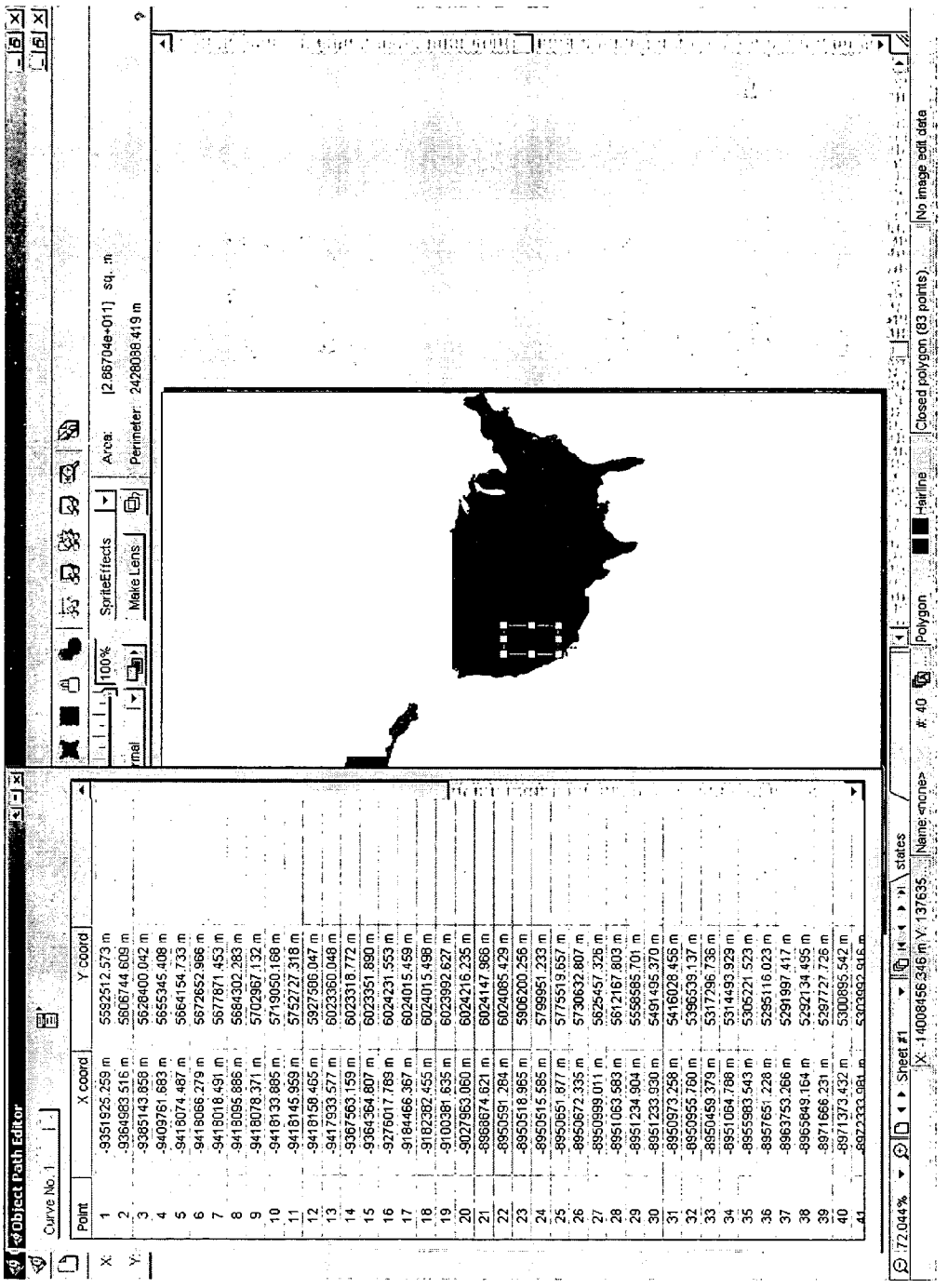
Object Path Editor
Curve No. 1
Point
X coord
Y coord
SpriteEffects
Make Lens
Area: [2.867904e+011] sq. m
Perimeter: 2428038.419 m
Polygon
Hairline
Closed polygon (83 points)
No image edit data
states
Name: <none>
40
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FIG. 1C

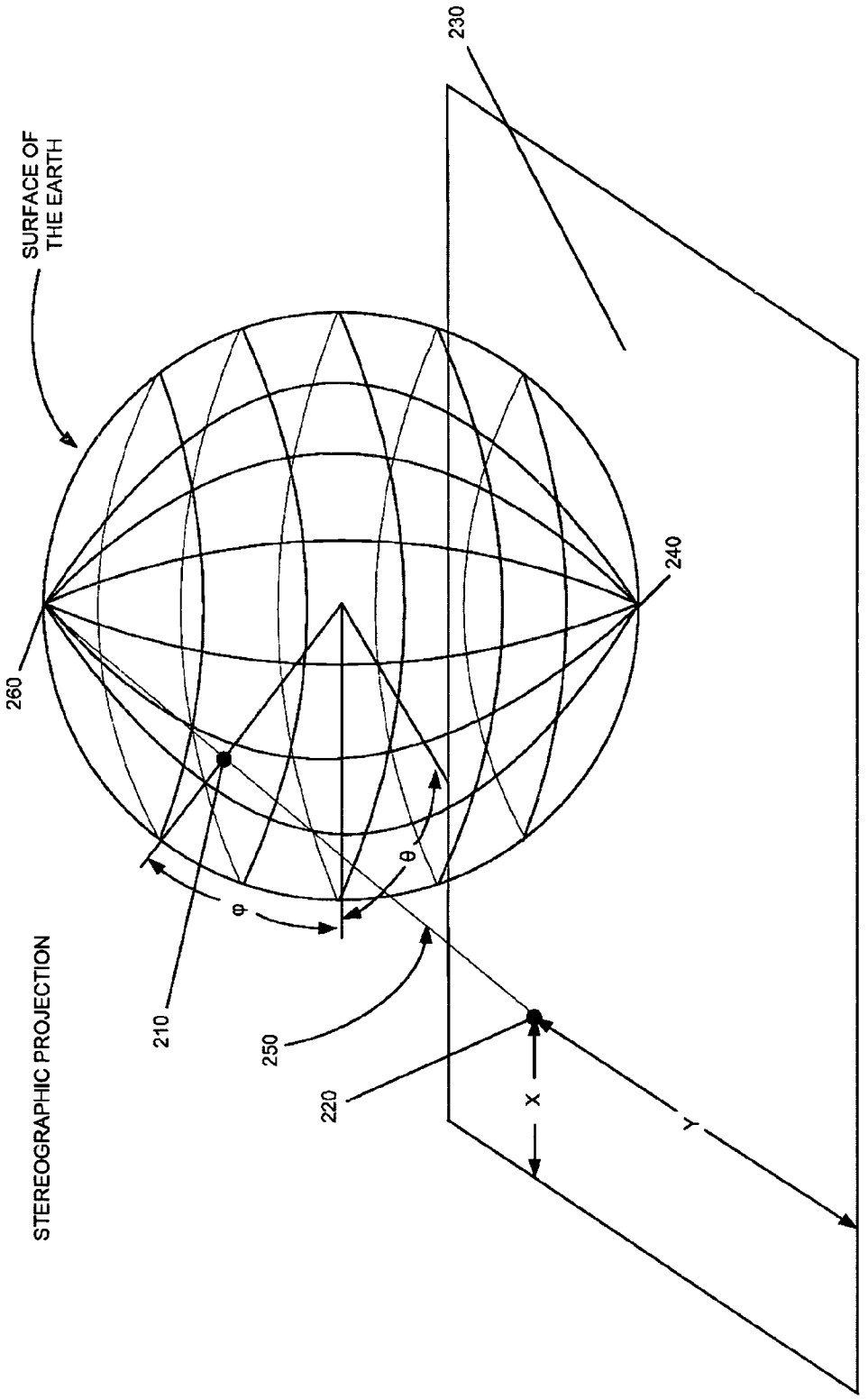

230
SURFACE OF THE EARTH
240
260
θ
φ
210
250
220
X
Y
STEREOGRAPHIC PROJECTION

FIG. 2

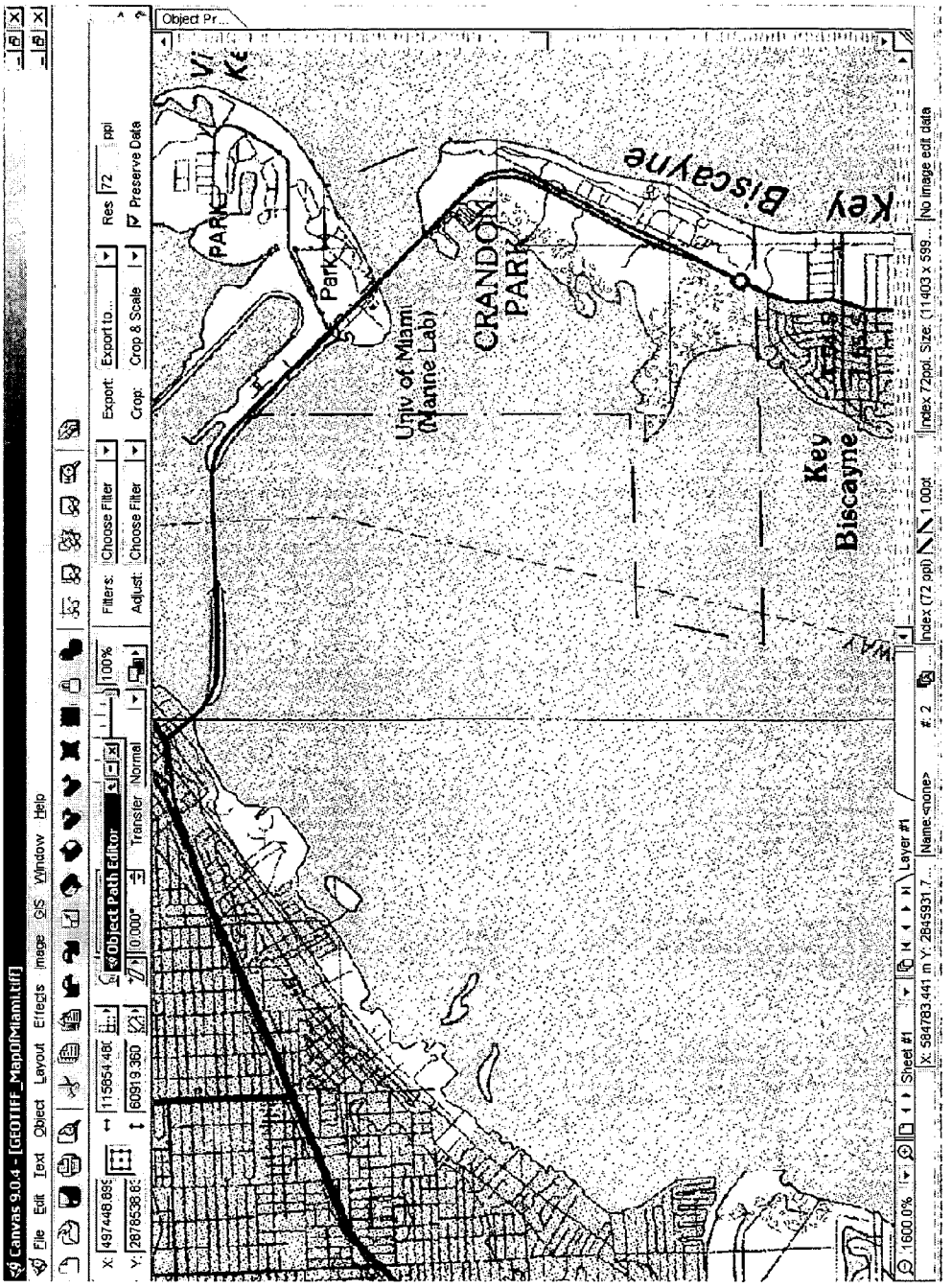
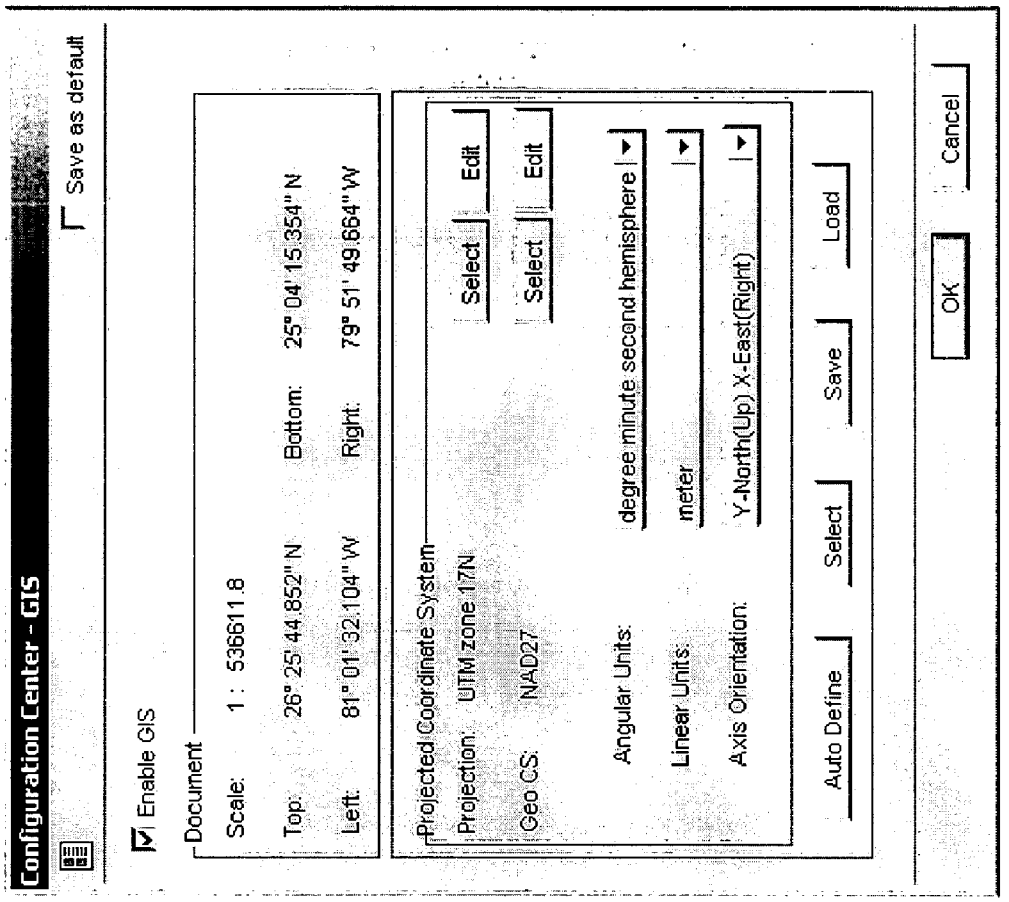

Canvas 9.0.4 - [GEO1TIFF_MapOfMiami.tif]
File Edit Text Object Layout Effects Image GIS Window Help
Object Path Editor
Filters: Choose Filter
Export: Export to...
Crop: Crop & Scale
Preserve Data
Adjust: Choose Filter
Transfer Normal
Object Pr...
PARK
Univ of Miami (Marine Lab)
CRANDON PARK
Key Biscayne
Sheet #1
Layer #1
No Image edit data

FIG. 3A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Save as default
Enable GIS
Document
Scale: 1 : 536611.8
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Bottom: 25° 04' 15.354" N
Left: 81° 01' 32.104" W
Right: 79° 51' 49.664" W
Projected Coordinate System
Projection: UTM zone 17N
Select
Edit
Geo CS: NAD27
Select
Edit
Angular Units: degree minute second hemisphere
Linear Units: meter
Axis Orientation: Y-North(Up) X-East(Right)
Auto Define
Select
Save
Load
OK
Cancel

FIG. 3B

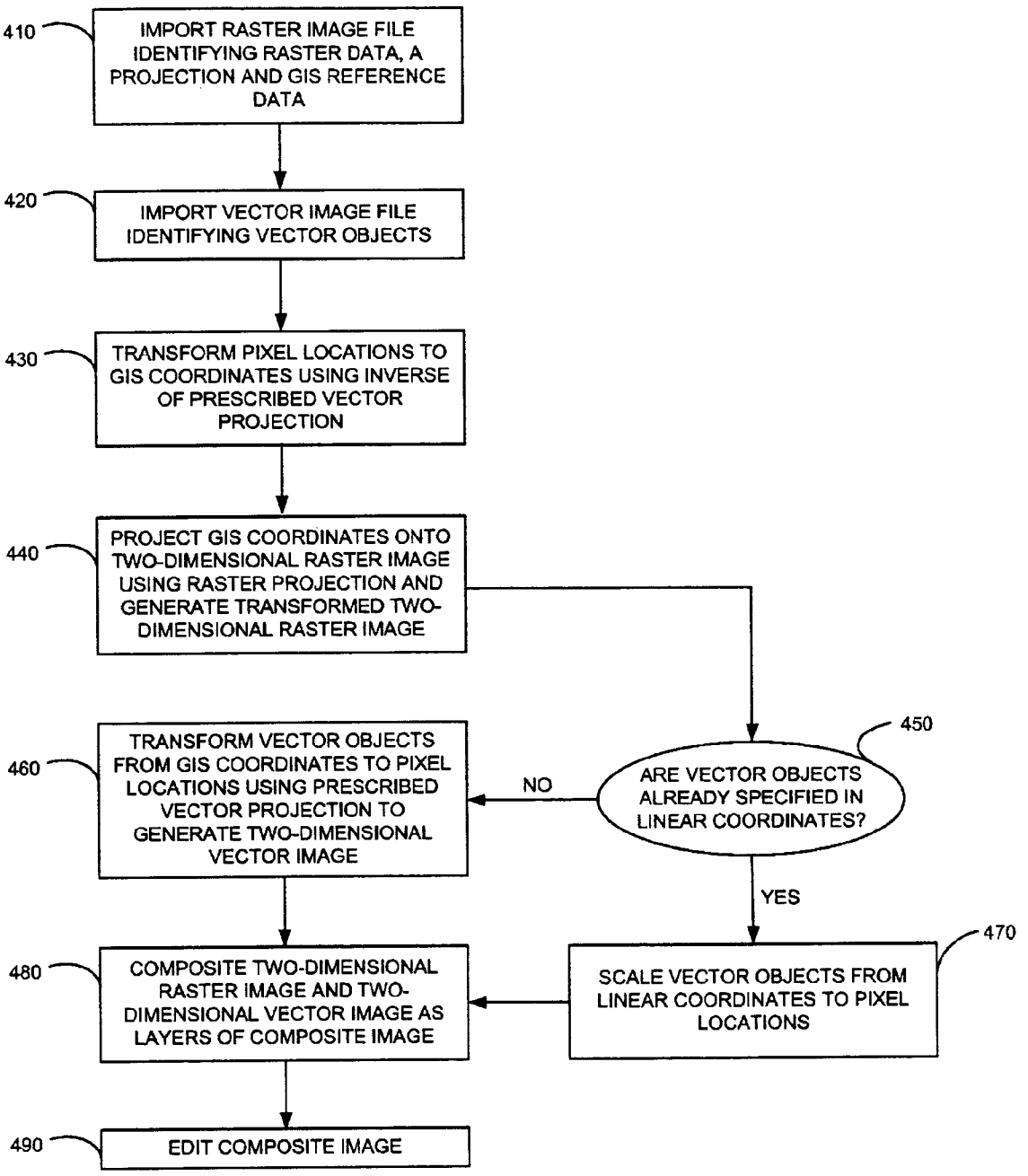

410
IMPORT RASTER IMAGE FILE IDENTIFYING RASTER DATA, A PROJECTION AND GIS REFERENCE DATA
420
IMPORT VECTOR IMAGE FILE IDENTIFYING VECTOR OBJECTS
430
TRANSFORM PIXEL LOCATIONS TO GIS COORDINATES USING INVERSE OF PRESCRIBED VECTOR PROJECTION
440
PROJECT GIS COORDINATES ONTO TWO-DIMENSIONAL RASTER IMAGE USING RASTER PROJECTION AND GENERATE TRANSFORMED TWO-DIMENSIONAL RASTER IMAGE
450
ARE VECTOR OBJECTS ALREADY SPECIFIED IN LINEAR COORDINATES?
NO
YES
460
TRANSFORM VECTOR OBJECTS FROM GIS COORDINATES TO PIXEL LOCATIONS USING PRESCRIBED VECTOR PROJECTION TO GENERATE TWO-DIMENSIONAL VECTOR IMAGE
470
SCALE VECTOR OBJECTS FROM LINEAR COORDINATES TO PIXEL LOCATIONS
480
COMPOSITE TWO-DIMENSIONAL RASTER IMAGE AND TWO-DIMENSIONAL VECTOR IMAGE AS LAYERS OF COMPOSITE IMAGE
490
EDIT COMPOSITE IMAGE

FIG. 4

FIG. 5A

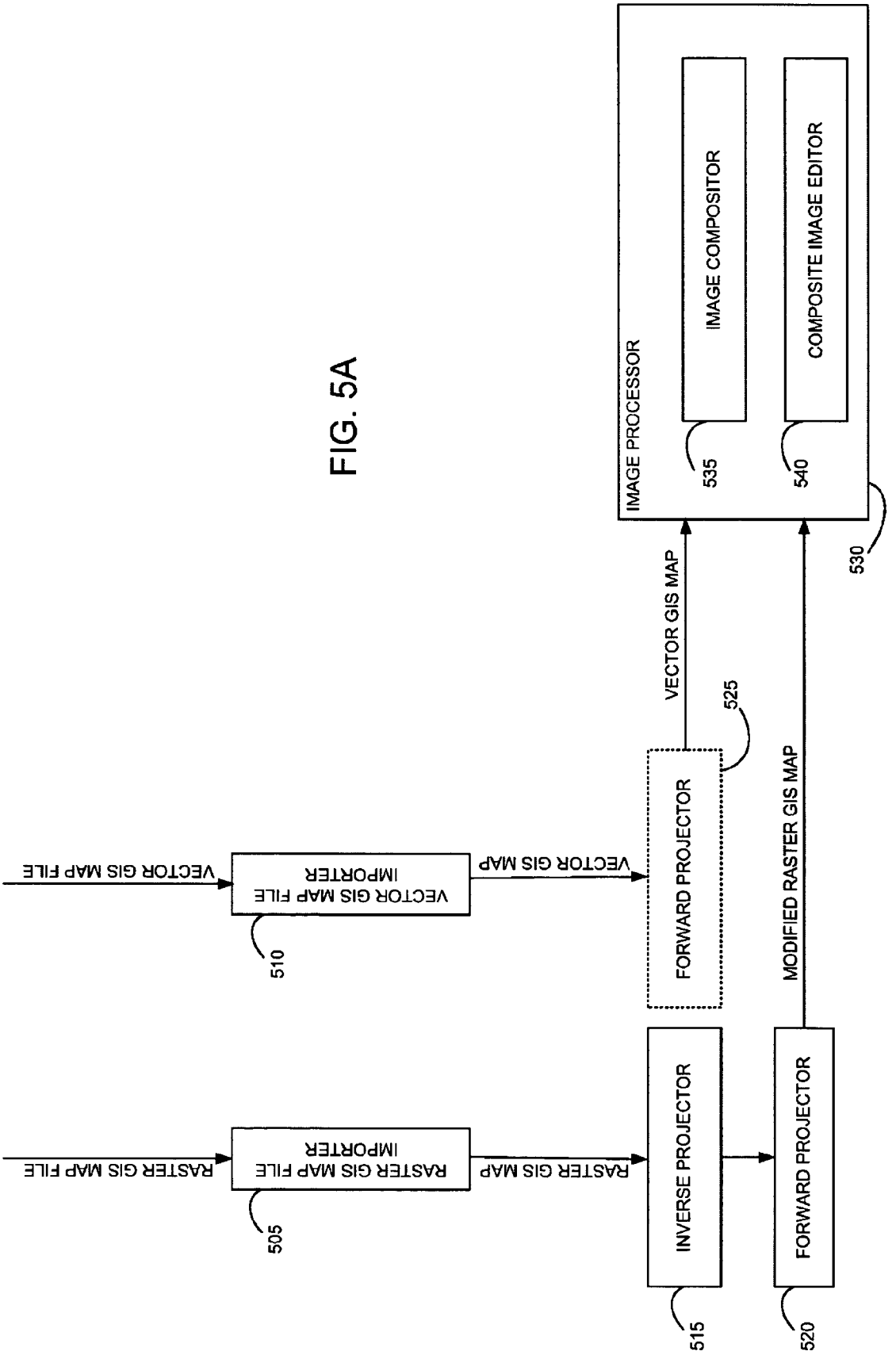


IMAGE PROCESSOR
IMAGE COMPOSITOR
COMPOSITE IMAGE EDITOR
535
540
530
VECTOR GIS MAP
525
FORWARD PROJECTOR
MODIFIED RASTER GIS MAP
VECTOR GIS MAP FILE
VECTOR GIS MAP FILE IMPORTER
VECTOR GIS MAP
510
RASTER GIS MAP FILE
RASTER GIS MAP FILE IMPORTER
RASTER GIS MAP
505
INVERSE PROJECTOR
FORWARD PROJECTOR
515
520

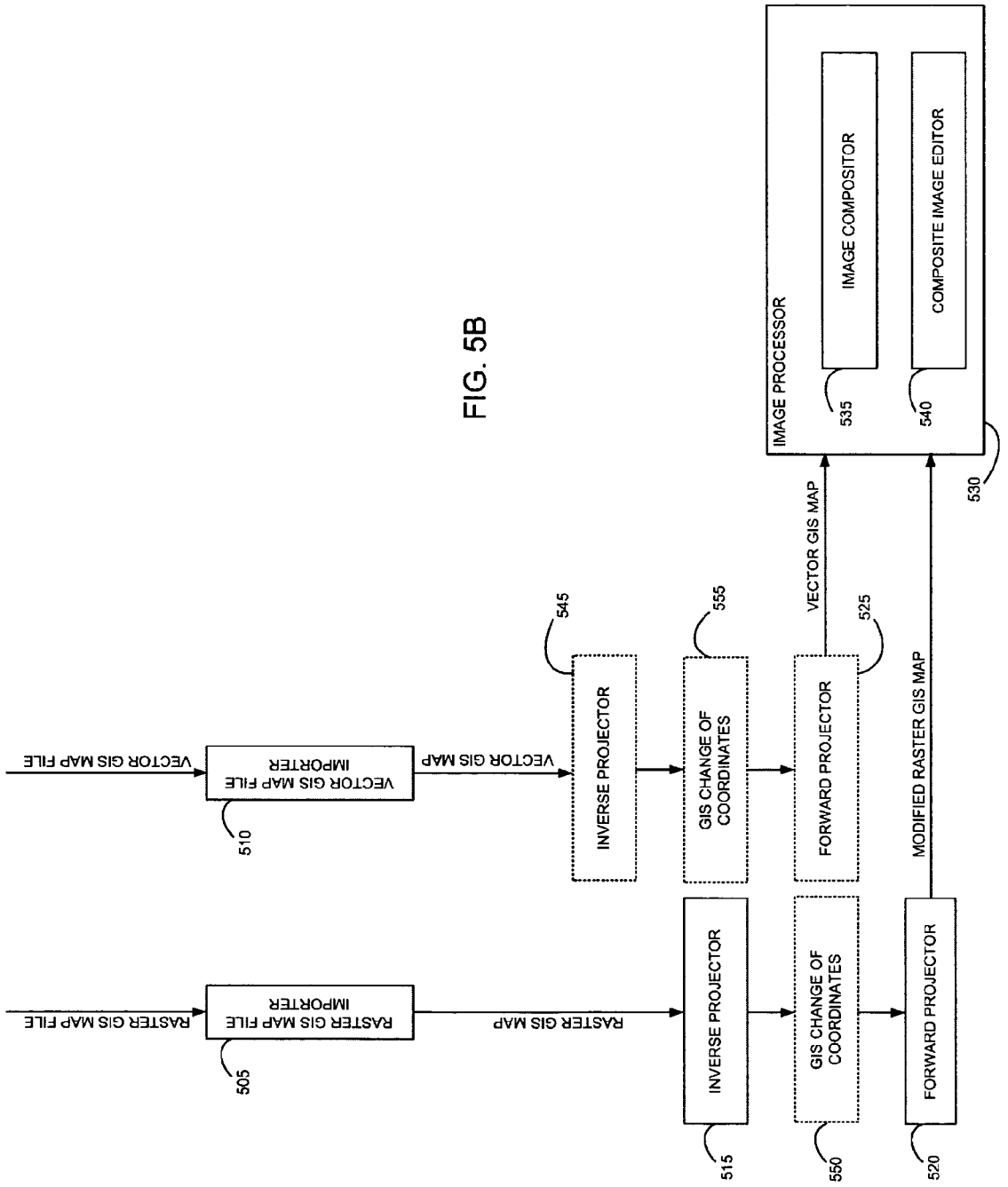
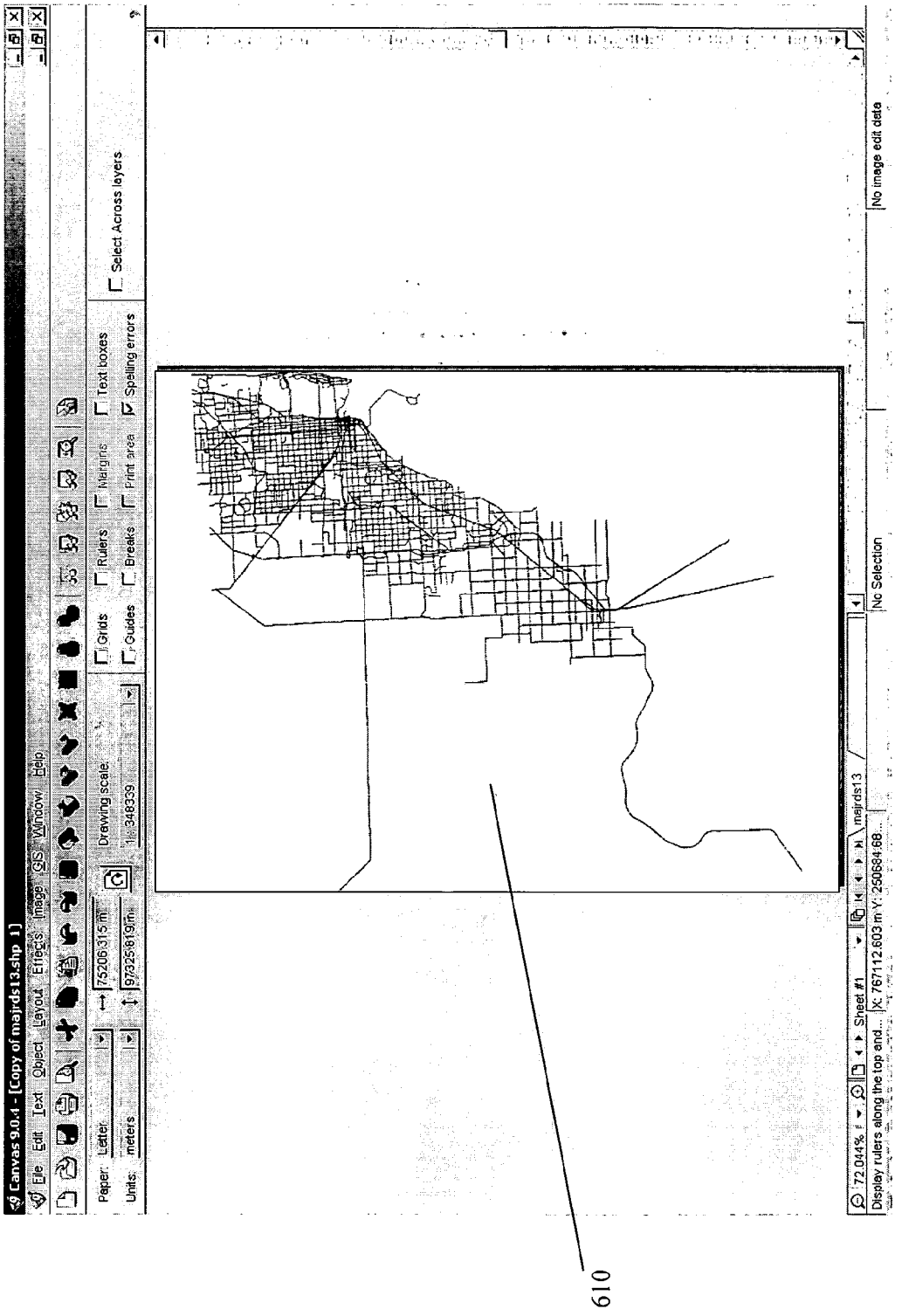


IMAGE PROCESSOR
IMAGE COMPOSITOR
COMPOSITE IMAGE EDITOR
535
540
530
VECTOR GIS MAP
MODIFIED RASTER GIS MAP
545
555
525
INVERSE PROJECTOR
GIS CHANGE OF COORDINATES
FORWARD PROJECTOR
VECTOR GIS MAP
VECTOR GIS MAP FILE IMPORTER
VECTOR GIS MAP FILE
510
RASTER GIS MAP
INVERSE PROJECTOR
GIS CHANGE OF COORDINATES
FORWARD PROJECTOR
RASTER GIS MAP FILE IMPORTER
RASTER GIS MAP FILE
505
515
550
520

FIG. 5B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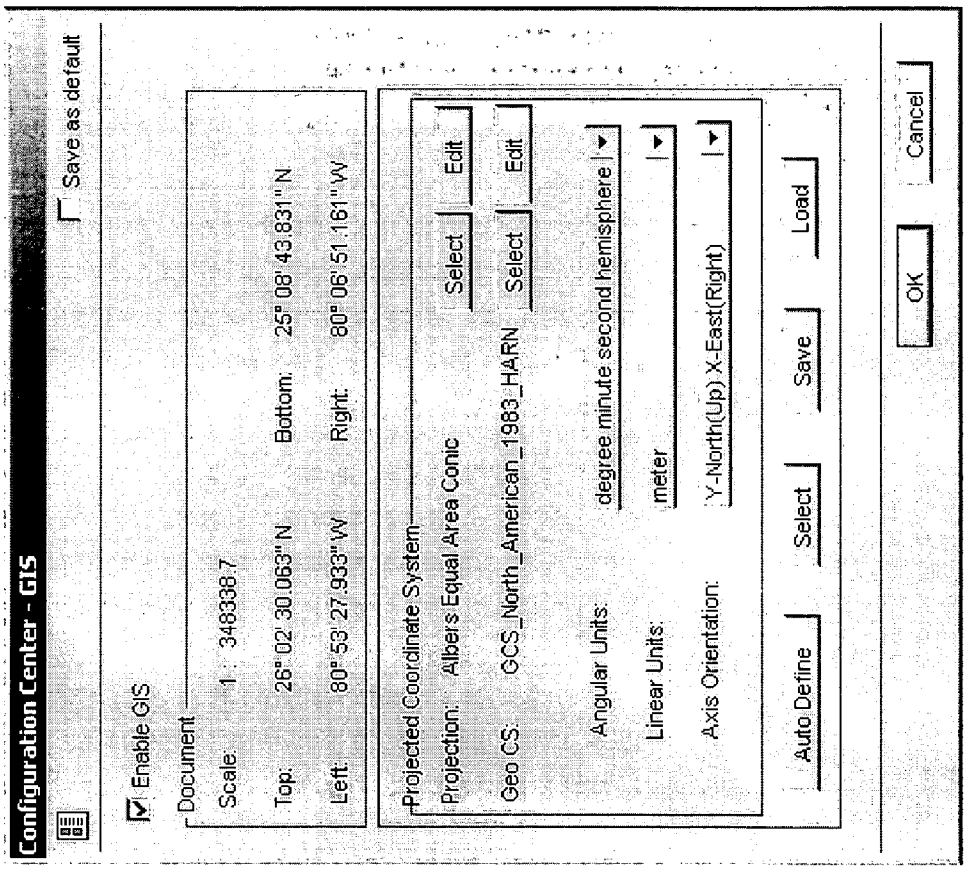
Units: meters
Drawing scale
1in=346339
Grids
Guides
Rulers
Breaks
Margins
Print area
Text boxes
Spelling errors
Select Across layers
No image edit data
No Selection
Sheet #1
majrds13
Display rulers along the top and...
X: 767112.603 m Y: 250684.68...
610

FIG. 6A


Configuration Center - GIS
Enable GIS
Save as default
Document
Scale: 1 : 348338.7
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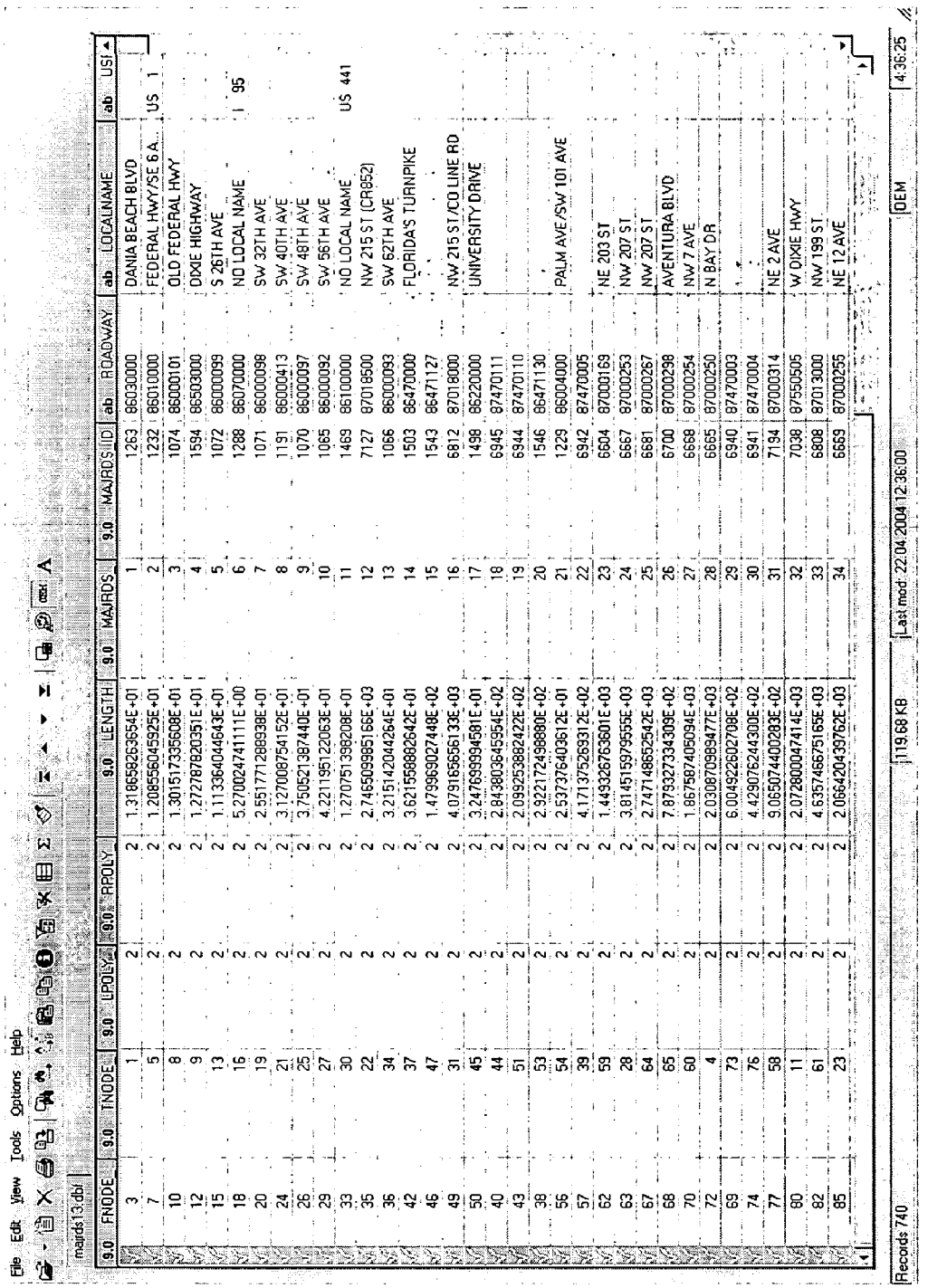
Bottom: 25° 08' 43.831" N
Left: 80° 53' 27.933" W
Right: 80° 06' 51.161" W
Projected Coordinate System
Projection: Albers Equal Area Conic
Select
Edit
Geo CS: GCS_North_American_1983_HARN
Select
Edit
Angular Units: degree minute second hemisphere
Linear Units: meter
Axis Orientation: Y-North(Up) X-East(Right)
Auto Define
Select
Save
Load
OK
Cancel

FIG. 6B


File Edit View Tools Options Help
majrds13.dbf
FNODE TNODE LPOLY RPOLY LENGTH MAJRDS MAJRDS_ID RDAWAY LOCALNAME
DANIA BEACH BLVD
FEDERAL HWY/SE 6 A
OLD FEDERAL HWY
DIXIE HIGHWAY
S 26TH AVE
NO LOCAL NAME
SW 32TH AVE
SW 40TH AVE
SW 48TH AVE
SW 56TH AVE
NO LOCAL NAME
NW 215 ST (CR852)
SW 62TH AVE
FLORIDA'S TURNPIKE
NW 215 ST/CO LINE RD
UNIVERSITY DRIVE
PALM AVE/SW 101 AVE
NE 203 ST
NW 207 ST
NW 207 ST
AVENTURA BLVD
NW 7 AVE
N BAY DR
NE 2 AVE
W DIXIE HWY
NW 199 ST
NE 12 AVE
Records 740
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OEM
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FIG. 6C

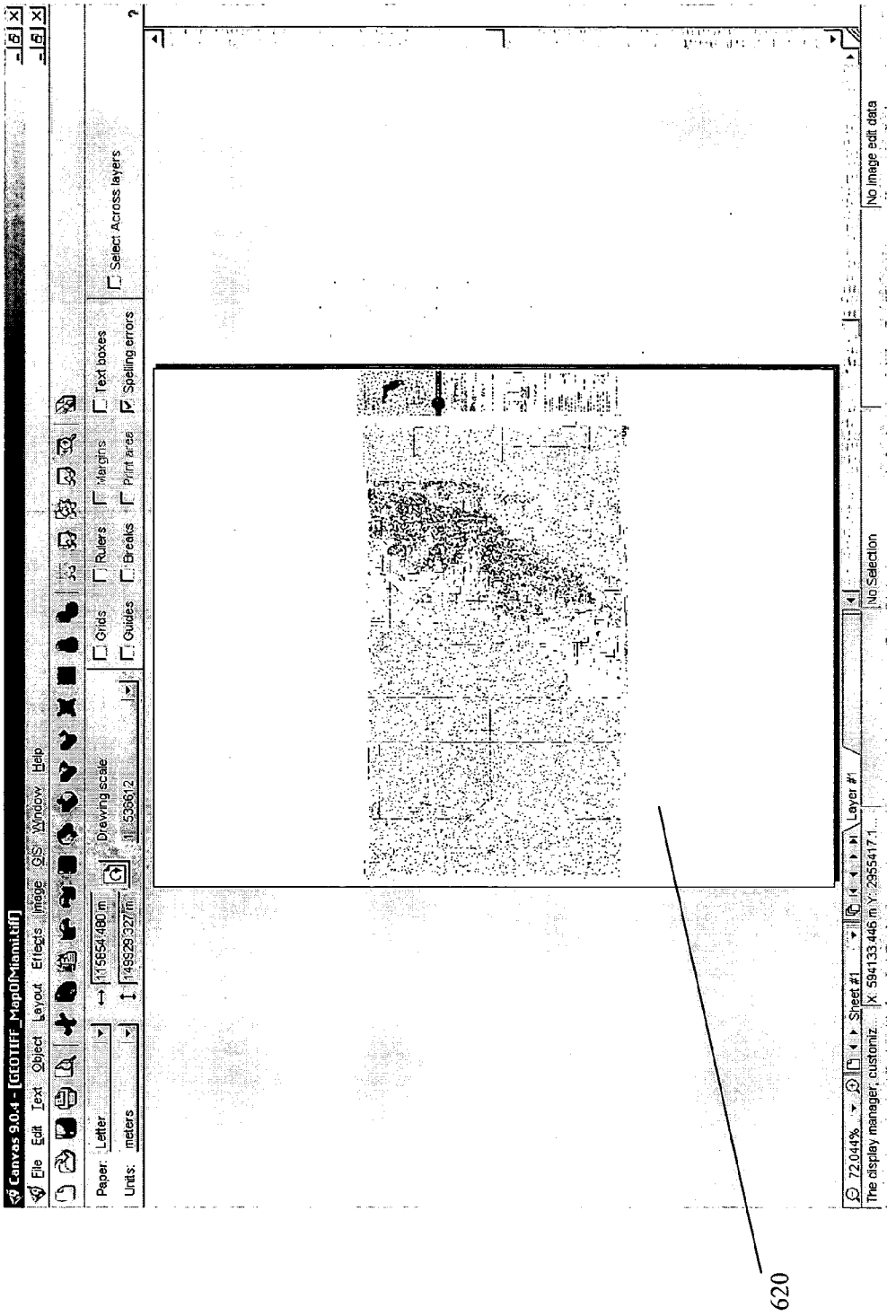


FIG. 6D

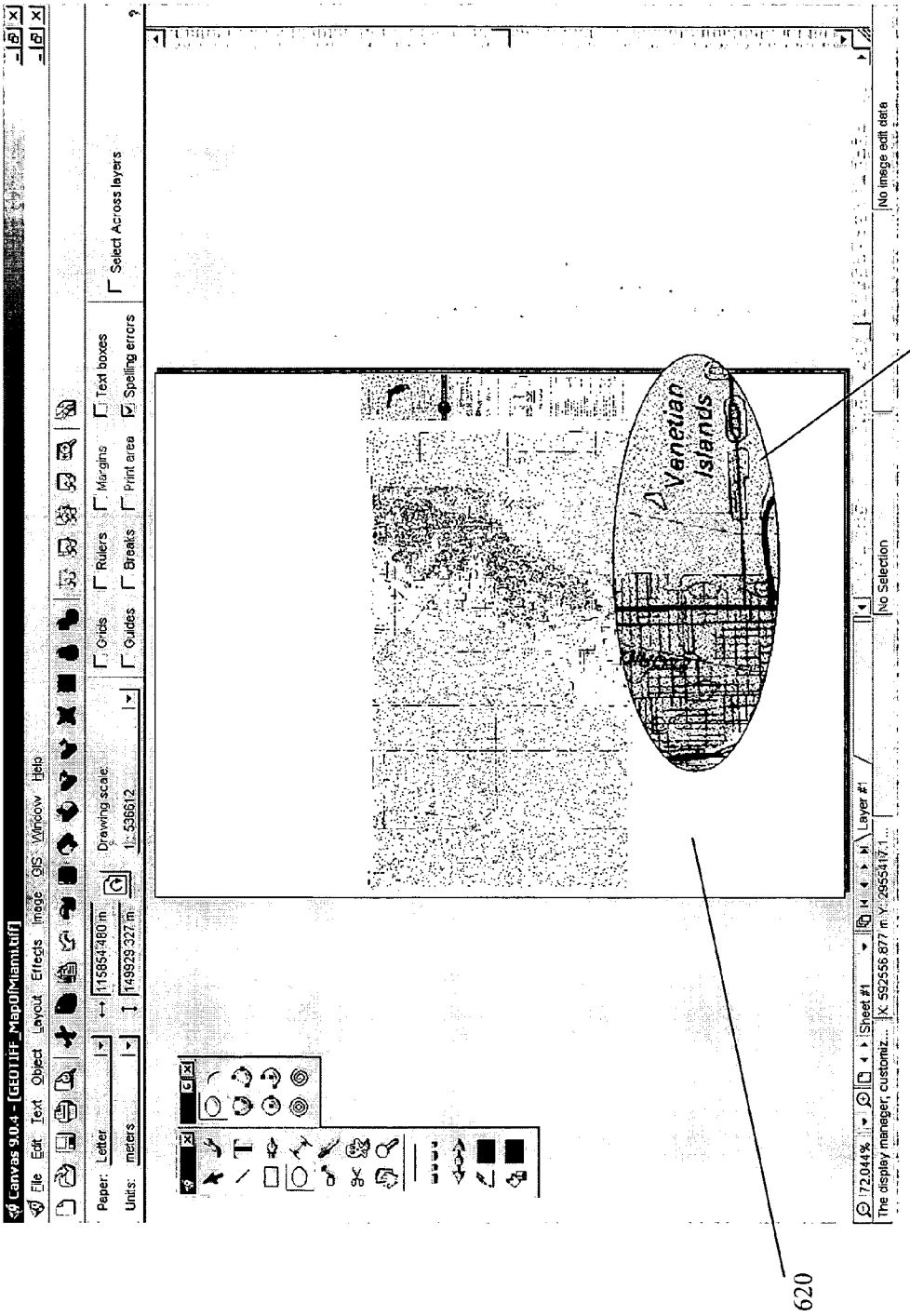


FIG. 6E

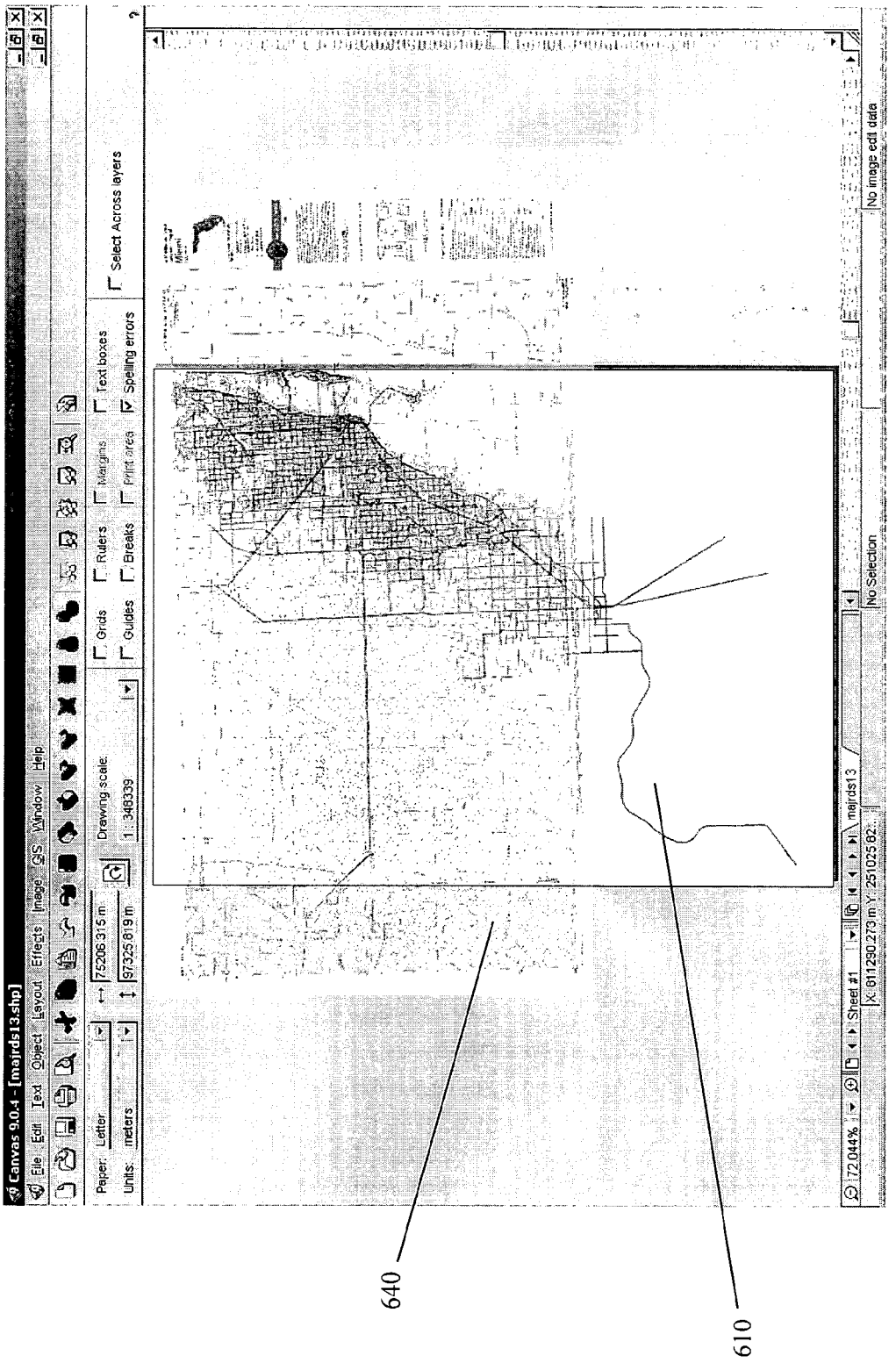
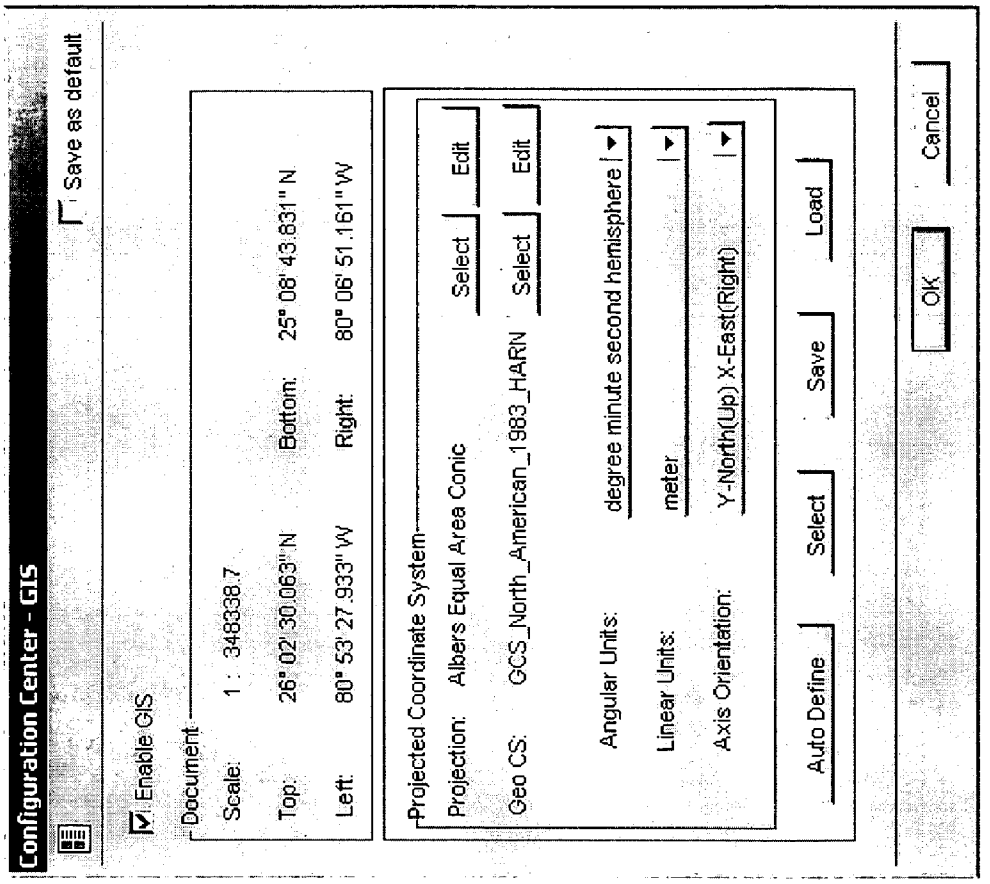


FIG. 6F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Bottom: 25° 08' 43.831" N
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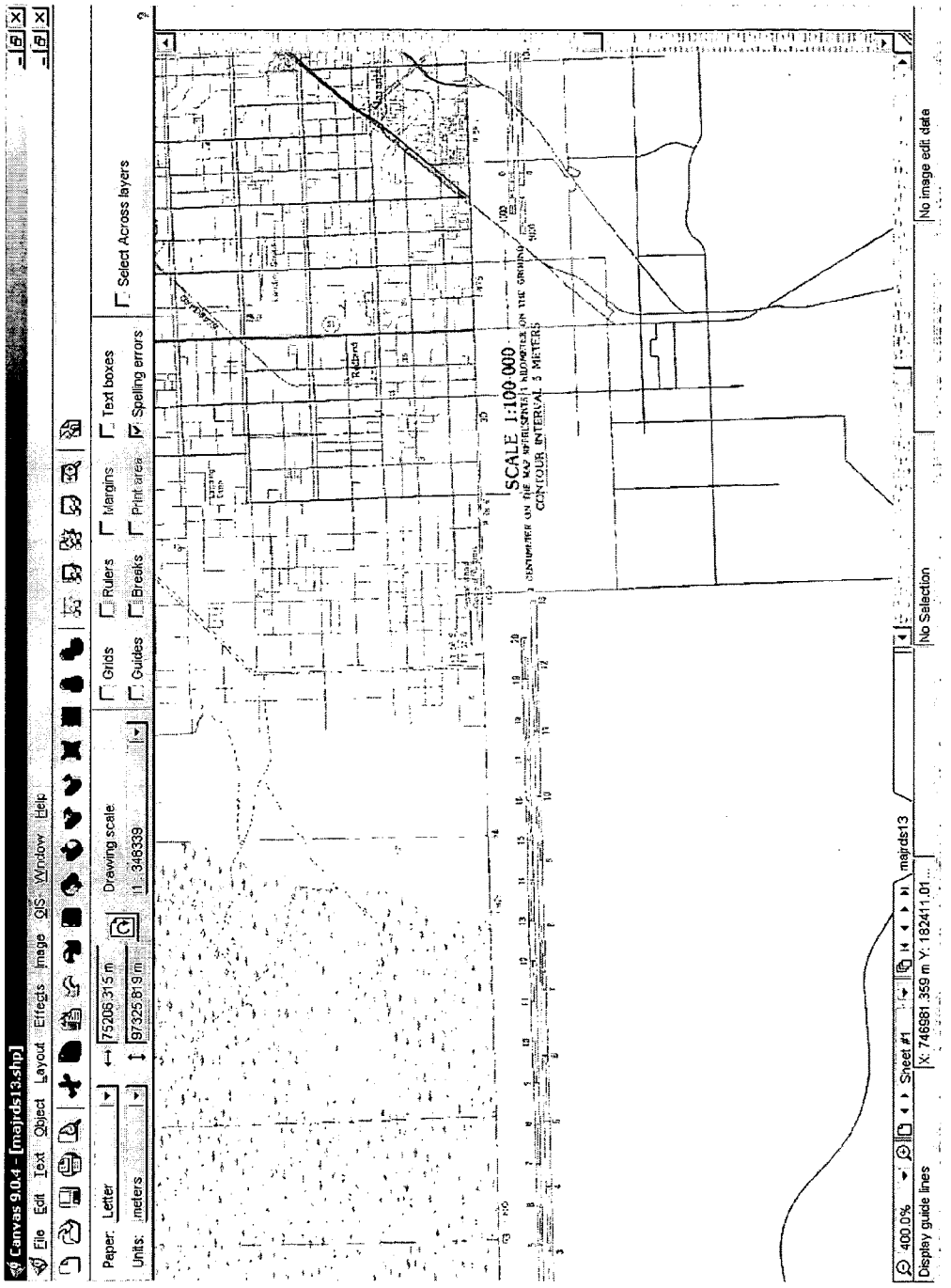
Right: 80° 06' 51.161" W
Projected Coordinate System
Projection: Albers Equal Area Conic
Select
Edit
Geo CS: GCS_North_American_1983_HARN
Select
Edit
Angular Units: degree minute second hemisphere
Linear Units: meter
Axis Orientation: Y-North(Up) X-East(Right)
Auto Define
Select
Save
Load
OK
Cancel

FIG. 6G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Units: meters
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97325.819 m
Drawing scale
1: 346339
Grids
Guides
Rulers
Breaks
Margins
Print area
Text boxes
Spelling errors
Select Across layers
SCALE 1:100 000
CONTOUR INTERVAL 5 METERS
majrds13
Sheet #1
No Selection
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Display guide lines
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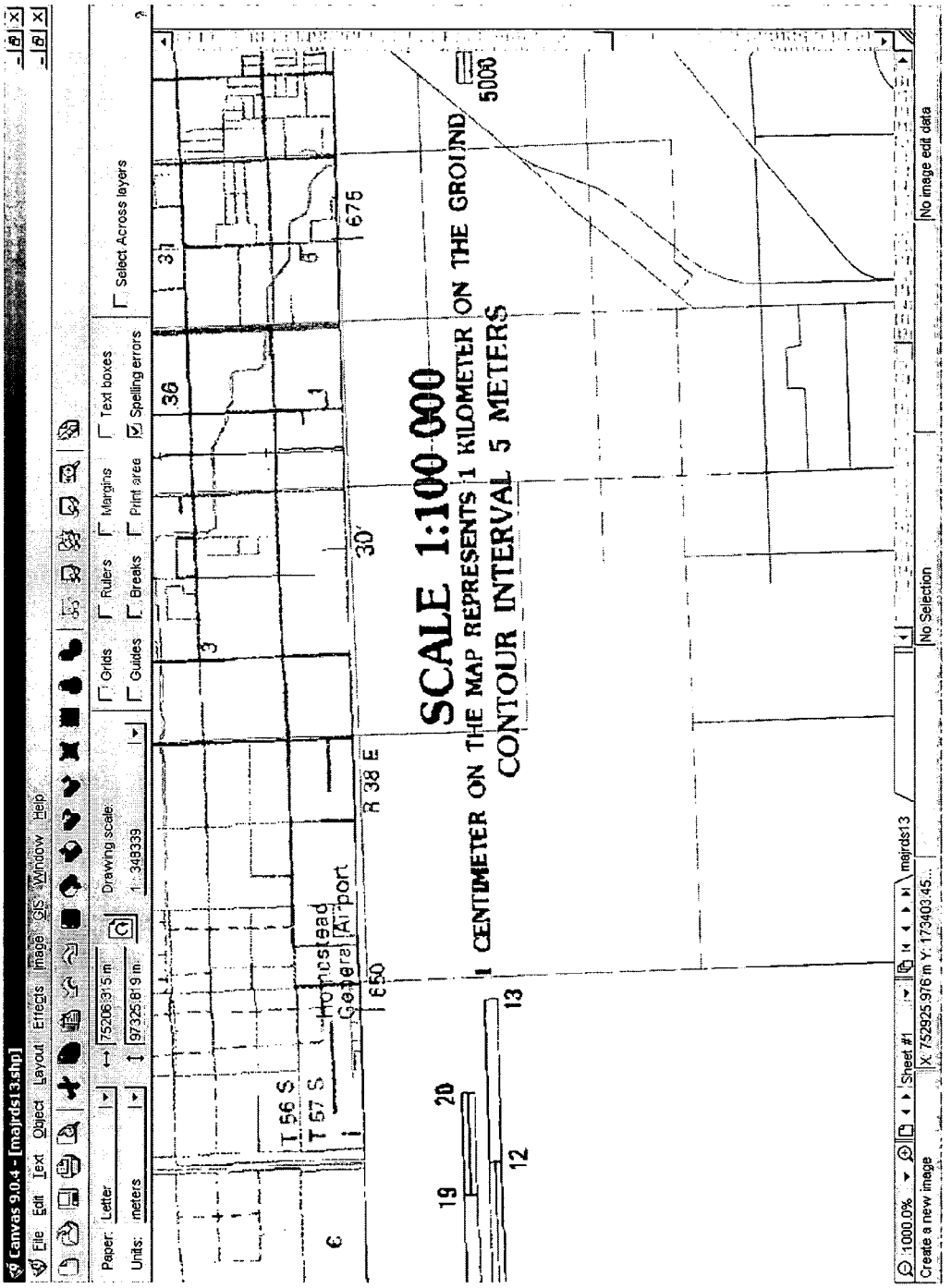
FIG. 6H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Paper: Letter
Units: meters
Drawing scale
1 : 348339
Grids Rulers Margins Text boxes
Guides Breaks Print area Spelling errors
Select Across layers
SCALE 1:100 000
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND
CONTOUR INTERVAL 5 METERS
T 56 S
T 57 S
R 38 E
Homestead
General Airport
675
650
30
36
31
6
1
3
19
20
12
13
majrds13
Sheet #1
No Selection
No image edit data
Create a new image

FIG. 6I

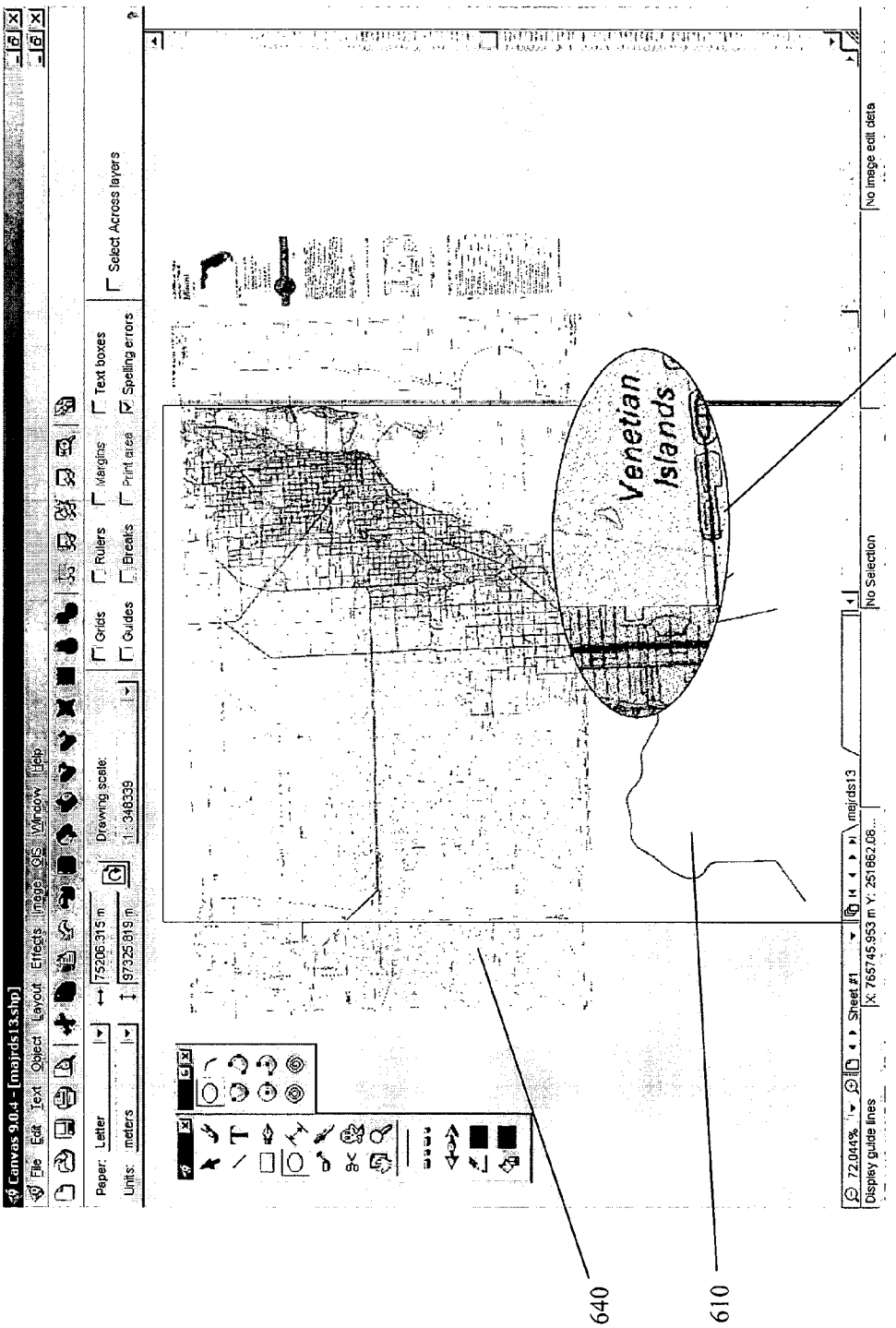
Canvas 9.0.4 - [majrds13.sbp]
File Edit Text Object Layout Effects Image GIS Window Help
Paper: Letter
Units: meters
Drawing scale:
Grids
Rulers
Margins
Text boxes
Guides
Breaks
Print area
Spelling errors
Select Across layers
Venetian Islands
640
610
630

FIG. 6J

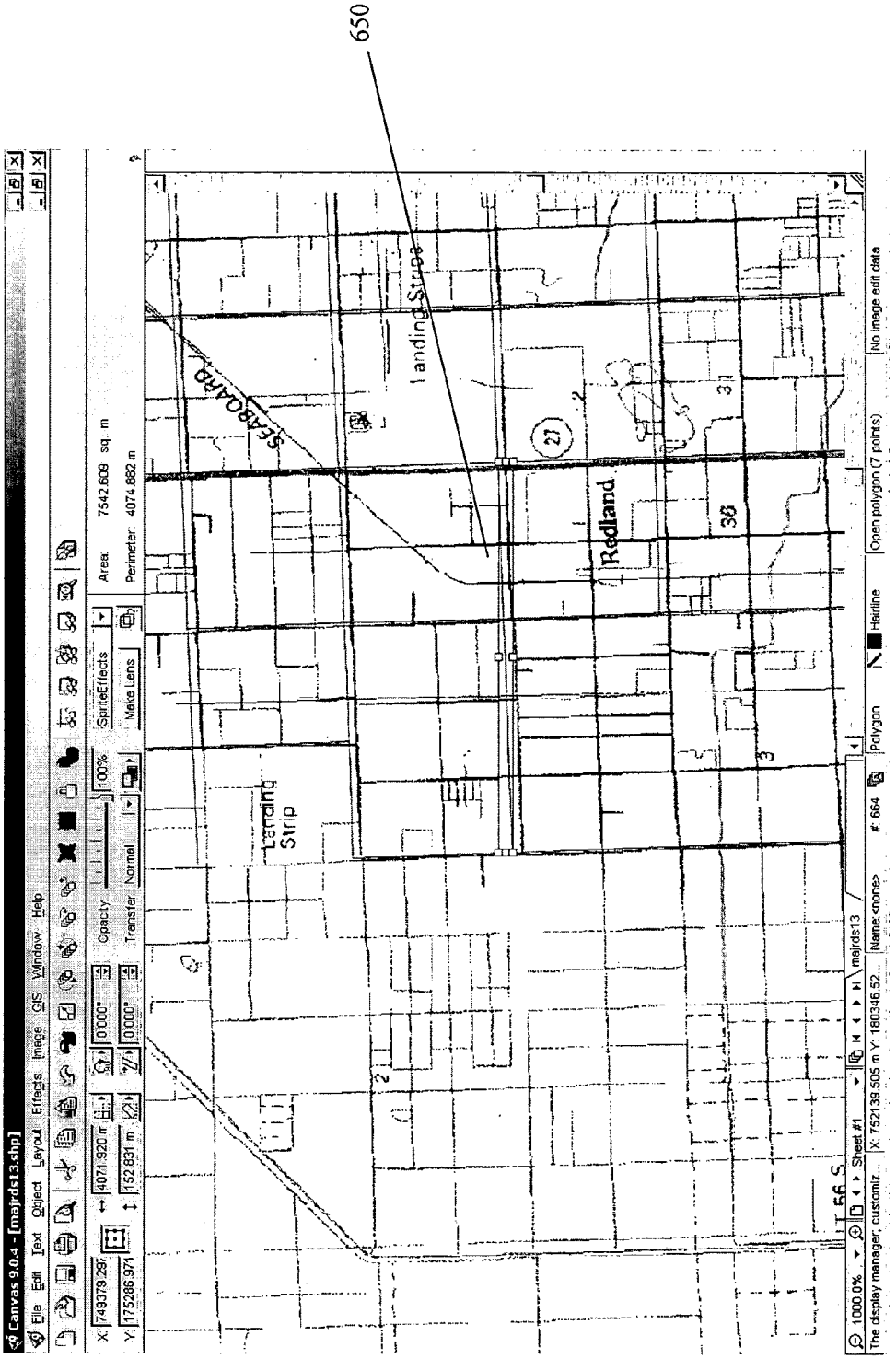
650
Canvas 9.0.4 - [majrds13.shp]
File Edit Text Object Layout Effects Image GIS Window Help
Landing Strip
Redland
SEABOARD
Landing Strip
majrds13

FIG. 6K

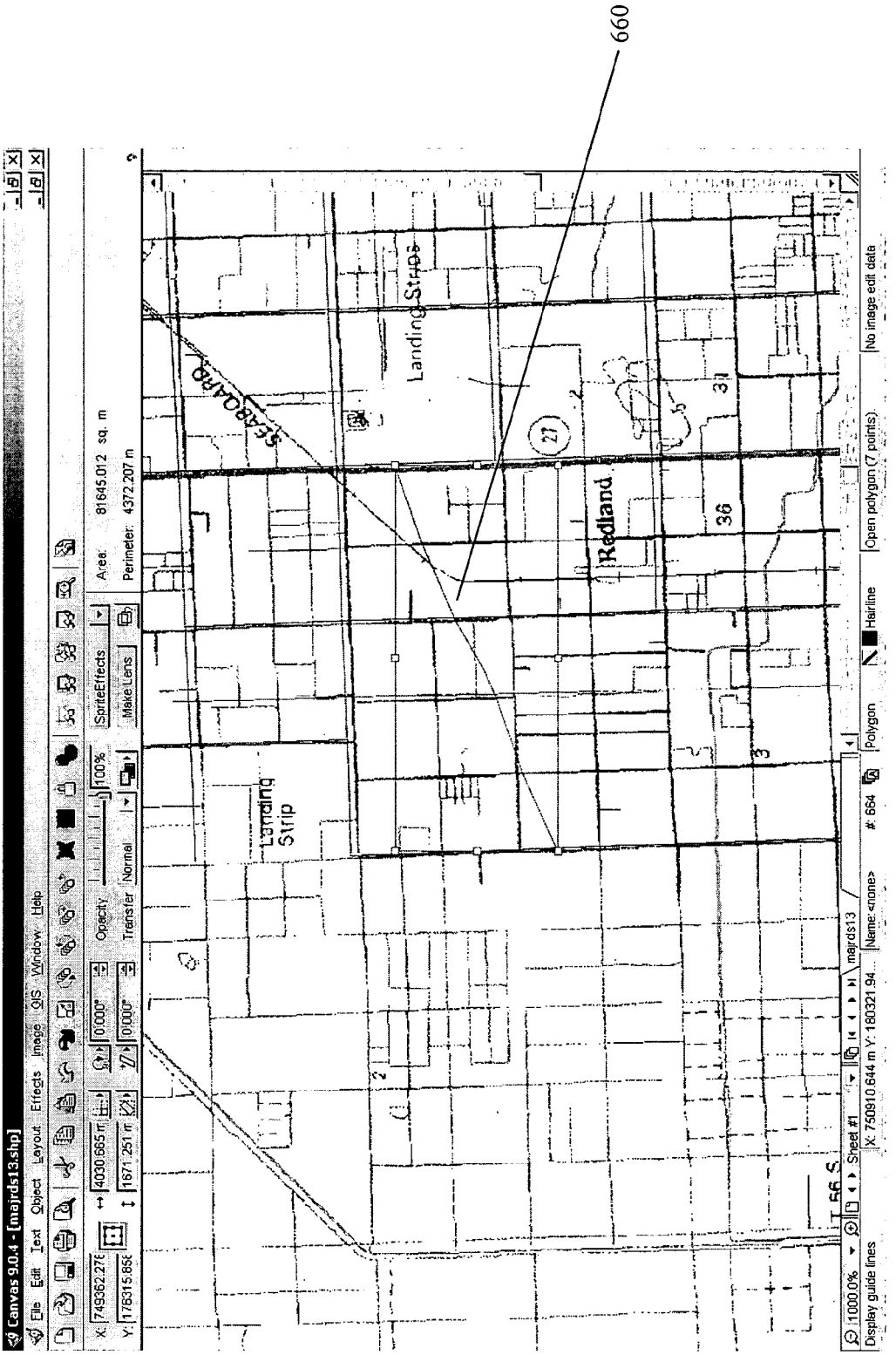
660
Canvas 9.0.4 - [majrds13.shp]
File Edit Text Object Layout Effects Image GIS Window Help
Landing Strip
Redland
Landing Strips
Area: 81645.012 sq. m
Perimeter: 4372.207 m
Open polygon (7 points)
No image edit data
Display guide lines
majrds13
Polygon
Hairline

FIG. 6L

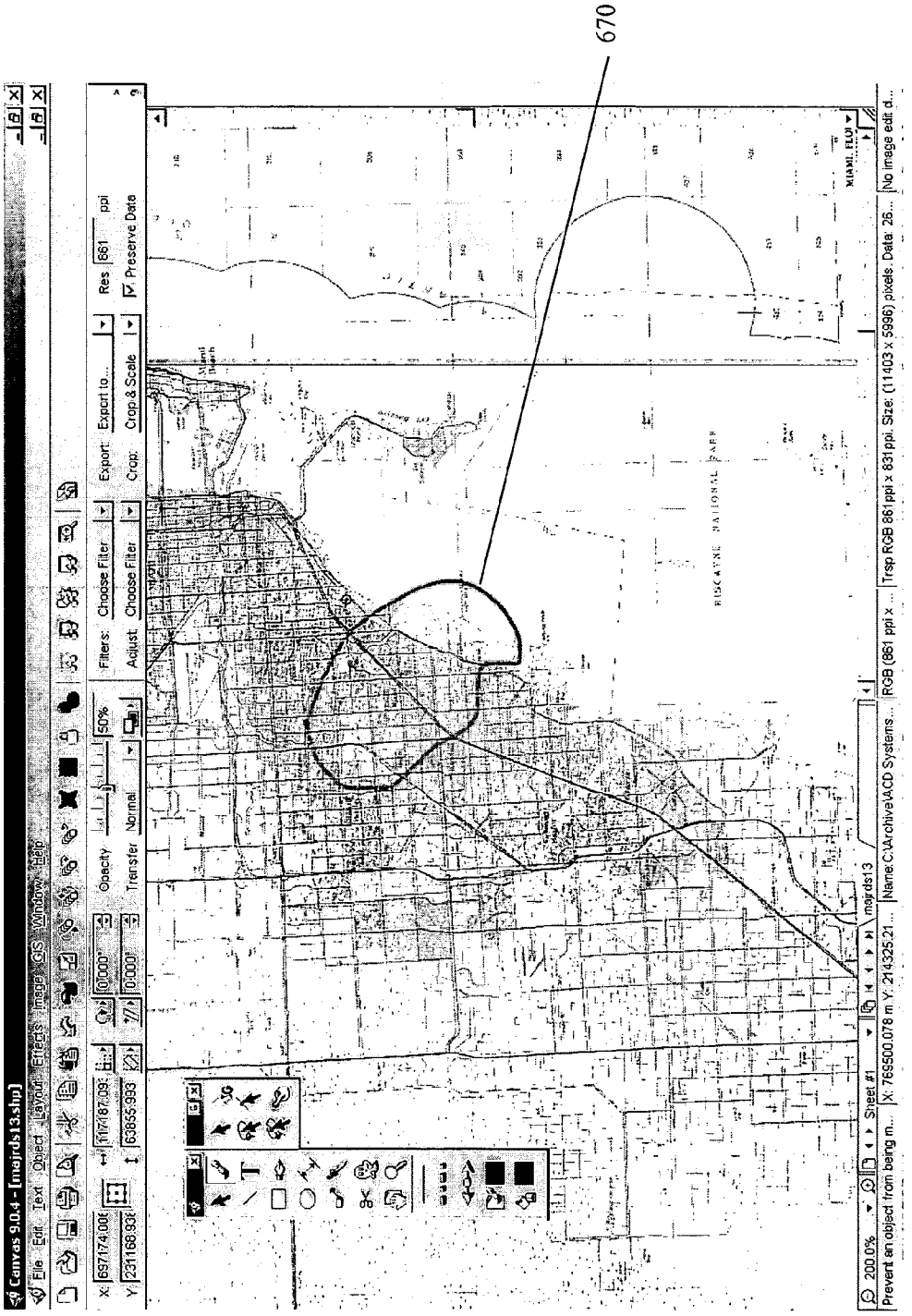

FIG. 6M

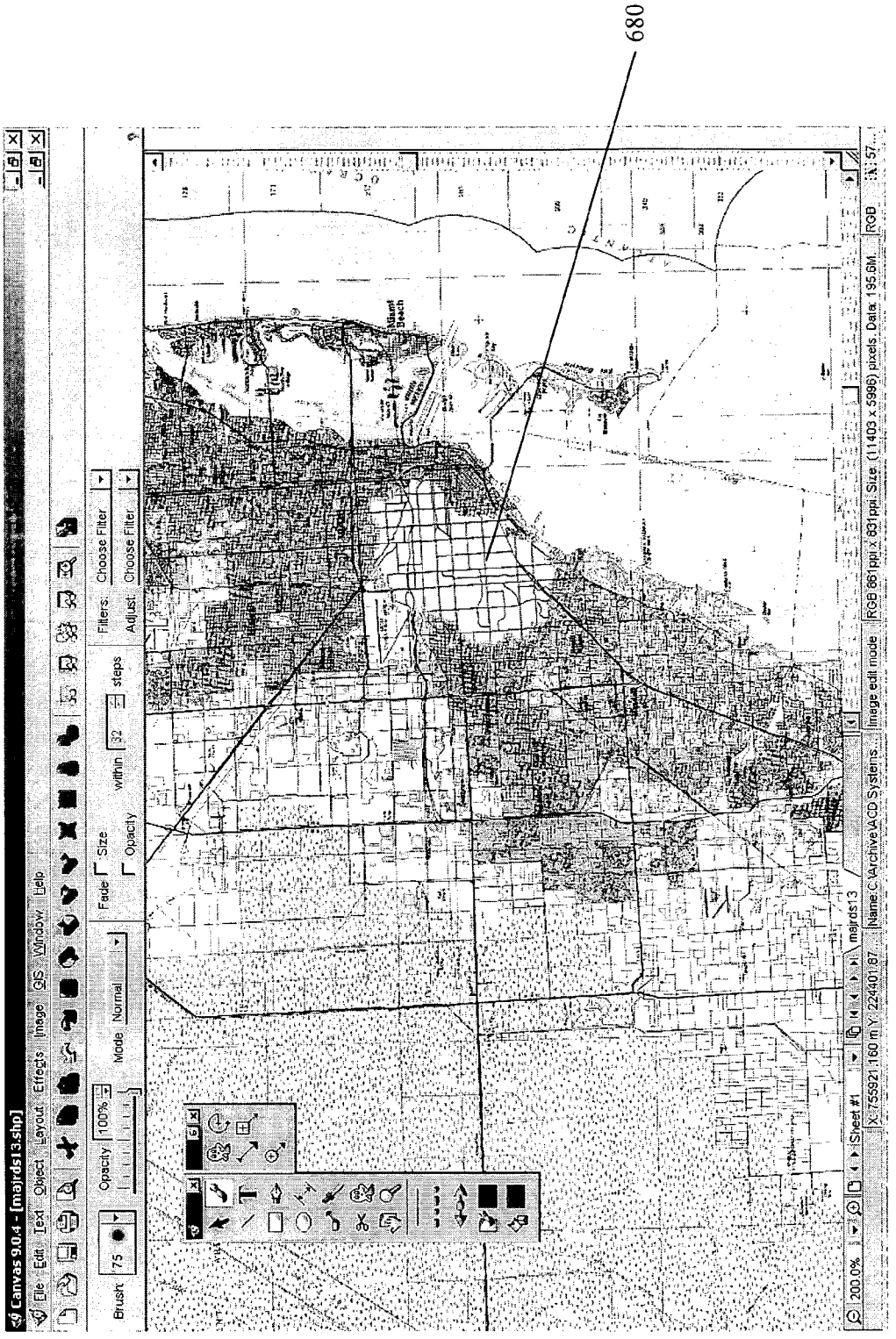

FIG. 6N

COMPOSITION OF RASTER AND VECTOR GRAPHICS IN GEOGRAPHIC INFORMATION SYSTEMS

FIELD OF THE INVENTION

The present invention relates to geographical information systems (GIS), and in particular to vector and raster GIS images.

BACKGROUND OF THE INVENTION

Conventional digital images are represented in either vector or raster formats. Vector formats are used to store lists of vector primitives, which may overlap and obscure or partially obscure one another. The vector primitives themselves generally consist of geometrical primitives including points, curves and areas. Points and curves generally have colors associated therewith, and areas generally have both a fill color and a boundary color. Curves include inter alia lines, pieced together line segments, circles, ellipses and Bezier curves. Graphics software generally provides tools for generating such curves.

Vector primitives are resolution independent, and can be scaled to any desired display screen. Thus a line or a circle, for example, can be rendered within an arbitrary display region by locating the endpoints of the line or the center and radius of the circle, and then rendering the line or the circle accordingly.

Familiar examples of vector images include flowcharts, block diagrams and other synthetic images produced by graphics software applications.

Raster formats are used to store arrays of pixel color values, the color values specifying a color for each pixel location within a rectangular array of pixels. Raster images are generally resolution dependent, and the information in a raster image file only suffices to identify color values for a fixed resolution. Raster images can be scaled down in size by down-sampling such as by averaging, and scaled up by up-sampling such as by interpolation. However, up-sampled color values in general are artificial, and often destroy the true nature of an image.

Familiar examples of raster images include image images acquired by a digital camera or scanner.

Image compositing involves generation of complex images by overlaying simpler images on top of one another. For example, a composite image may include a layer for a background, layers for various sprites, and a layer for text. Layers are generally arranged one on top of another. Each layer may obscure or partially obscure layers below it, or may be transparent and allow the lower layers to appear through it. Image compositing software applications generally enable a user to apply a variety of versatile editing effects to a composite image. Thus a user may edit each of the layers, add or remove layers, navigate through a composite image by zooming in and out and moving up, down, left and right, rotate and scale a composite image, apply brush strokes and other artistic effects, and apply image processing filters including calorimetric and geometrical transformations.

One of the many challenges of image compositing is the overlaying of raster and vector images. Since vector images are generally resolution independent, conventional digital compositing systems scale a vector image to the pixel dimensions of a raster image, when overlaying one upon the other.

In geographic information systems (GIS), image formats are used to represent maps of portions of the surface of the Earth. Such portions are three-dimensional in nature, and are

generally projected onto a two-dimensional view plane for rendering. Coordinates of vector objects and of pixel locations are not arbitrarily set in GIS images, but correspond to locations of points on the surface of the Earth. As such, compositing of vector and raster GIS images poses additional alignment challenges, beyond those of conventional compositing. Further challenges arise with editing of such composite vector+raster GIS images.

Conventional digital image applications provide only limited viewing capability for composite vector+raster GIS images, and do not provide editing capability therefor.

There is thus a need for an image processing method and system that enables versatile editing of composite vector+raster GIS images.

SUMMARY OF THE INVENTION

The present invention provides a method and system for compositing vector and raster GIS images as layers of a composite image, and for editing the resultant composite vector+raster image. Using the present invention, software or hardware or a combination of software and hardware can be manufactured to enable a user to import vector GIS images and raster GIS images into a composite image, and maintain accurate geographical alignment therebetween. The user can modify the composite vector+raster image in many ways, including inter alia

- applying opacity masks;
- importing non-GIS layers such as text and brush strokes;
- applying image processing filters such as sharpening and blurring filters;
- applying geometrical transformations such as scaling, rotation and reflection;
- applying calorimetric transformations such as visualization tools; and
- magnifying a portion of the composite image within a desired lens-shaped region.

There is thus provided in accordance with a preferred embodiment of the present invention a method for editing composite geographical images, including importing a raster geographical map file, the raster file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including geographical information identifying vector objects, rendering a two-dimensional raster image including transforming linear coordinates to geographical coordinates according to the inverse of a prescribed second projection that transforms geographical coordinates to linear coordinates, and re-projecting the geographical coordinates to linear coordinates according to the first projection, rendering a two-dimensional vector image including projecting the vector objects according to the prescribed second projection, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is further provided in accordance with a preferred embodiment of the present invention a GIS system for editing composite geographical images, including a raster image file adaptor, for importing a geographical map file, the file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, a vector image file adaptor, for importing a geographical map file, the file including geographical information identifying vector objects, a raster map projector operatively coupled to

the raster image file adaptor for transforming linear coordinates to geographical coordinates using the inverse of a prescribed second projection that transforms geographical coordinates to linear coordinates, and for projecting geographical coordinates to linear coordinates using the first projection, a vector map projector operatively coupled to the vector image file adaptor for projecting vector objects to a two-dimensional vector image, using the prescribed second projection, and an image editor operatively coupled to the raster map projector and the vector map projector for compositing a two-dimensional raster image and a two-dimensional vector image as layers of a composite image, and for editing the composite image.

There is yet further provided in accordance with a preferred embodiment of the present invention a method for editing composite geographical images, including importing a raster geographical map file, the raster file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including two-dimensional vector objects corresponding to a second projection, rendering a two-dimensional raster image including transforming linear coordinates to geographical coordinates according to the inverse of the second projection that transforms geographical coordinates to linear coordinates, and re-projecting the geographical coordinates to linear coordinates according to the first projection, rendering a two-dimensional vector image comprising rasterizing the two-dimensional vector objects, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is moreover provided in accordance with a preferred embodiment of the present invention a GIS system for editing composite geographical images, including a raster image file adaptor, for importing a geographical map file, the file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, a vector image file adaptor, for importing a geographical map file, the file including two-dimensional vector objects corresponding to a second projection, a raster map projector operatively coupled to the raster image file adaptor for transforming linear coordinates to geographical coordinates including an inverse projector for transforming geographical coordinates to linear coordinates according to the inverse of a prescribed second projection, and a forward projector for projecting geographical coordinates to linear coordinates, according to the first projection, a vector map rasterizer operatively coupled to the vector image file adaptor for rasterizing two-dimensional vector objects, and an image editor operatively coupled to the raster map projector and the vector map projector including an image compositor for compositing a two-dimensional raster image and a two-dimensional vector image as layers of a composite image, and an image editor for editing the composite image.

There is additionally provided in accordance with a preferred embodiment of the present invention a method for editing composite geographical images, including importing a raster geographical map file, the raster file including a two-dimensional raster image, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including information identifying two-dimensional vector objects, rendering a two-dimensional vector image including inverse projecting the two-dimensional vector objects according to a prescribed second projection, projecting the resulting inverse-projected vector objects according to the first projection, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is further provided in accordance with a preferred embodiment of the present invention a GIS system for editing composite geographical images, including a raster image file adaptor, for importing a geographical map file, the file including a two-dimensional raster image, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, a vector image file adaptor, for importing a geographical map file, the file including information identifying two-dimensional vector objects, a vector map projector operatively coupled to the vector image file adaptor including an inverse projector for inverse projecting the two-dimensional vector objects according to a prescribed second projection, and a forward vector projector for projecting the resulting inverse-projected vector objects according to the first projection, and an image editor operatively coupled to the raster map projector and the vector map projector including an image compositor for compositing a two-dimensional raster image and a two-dimensional vector image as layers of a composite image, and an image editor for editing the composite image.

There is yet further provided in accordance with a preferred embodiment of the present invention a method for editing composite geographical images, including importing a raster geographical map file, the raster file including geographical information identifying raster image data and global positioning reference data, importing a vector geographical map file, the vector file including geographical information identifying vector objects with globally positioned edit paths, aligning the raster image data and the vector objects so that the global positioning reference data and the globally positioned edit paths are in alignment, compositing the aligned raster image data and vector objects as layers of a composite image, and editing the composite image.

There is moreover provided in accordance with a preferred embodiment of the present invention a GIS system for editing composite geographical images, including a raster image file adaptor for importing a raster geographical map file, the raster file including geographical information identifying raster image data and global positioning reference data, a vector image file adaptor for importing a vector geographical map file, the vector file including geographical information identifying vector objects with globally positioned edit paths, a global position aligner operatively coupled with the raster image file adaptor and the vector image file adaptor, for aligning the raster image data and the vector objects so that the global positioning reference data and the globally positioned edit paths are in alignment, and an image processor operatively coupled with the global position aligner, for compositing the aligned raster image data and vector objects as layers of a composite image, and for editing the resulting composite image.

There is additionally provided in accordance with a preferred embodiment of the present invention a computer-readable storage medium storing program code for causing a computer to perform the steps of importing a raster geographical map file, the raster file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including geographical information identifying vector objects, rendering a two-

dimensional raster image including transforming linear coordinates to geographical coordinates according to the inverse of a prescribed second projection that transforms geographical coordinates to linear coordinates, and re-projecting the geographical coordinates to linear coordinates according to the first projection, rendering a two-dimensional vector image including projecting the vector objects according to the prescribed second projection, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is additionally provided in accordance with a preferred embodiment of the present invention a computer-readable storage medium storing program code for causing a computer to perform the steps of importing a raster geographical map file, the raster file including geographical information identifying raster image data, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including two-dimensional vector objects corresponding to a second projection, rendering a two-dimensional raster image including transforming linear coordinates to geographical coordinates according to the inverse of the second projection that transforms geographical coordinates to linear coordinates, and re-projecting the geographical coordinates to linear coordinates according to the first projection, rendering a two-dimensional vector image comprising rasterizing the two-dimensional vector objects, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is additionally provided in accordance with a preferred embodiment of the present invention a computer-readable storage medium storing program code for causing a computer to perform the steps of importing a raster geographical map file, the raster file including a two-dimensional raster image, global positioning reference data and a first projection that transforms geographical coordinates to linear coordinates, importing a vector geographical map file, the vector file including information identifying two-dimensional vector objects, rendering a two-dimensional vector image including inverse projecting the two-dimensional vector objects according to a prescribed second projection, projecting the resulting inverse-projected vector objects according to the first projection, compositing the two-dimensional image raster image and the two-dimensional vector image as layers of a composite image, and editing the composite image.

There is further provided in accordance with a preferred embodiment of the present invention a computer-readable storage medium storing program code for causing a computer to perform the steps of importing a raster geographical map file, the raster file including geographical information identifying raster image data and global positioning reference data, importing a vector geographical map file, the vector file including geographical information identifying vector objects with globally positioned edit paths, aligning the raster image data and the vector objects so that the global positioning reference data and the globally positioned edit paths are in alignment, compositing the aligned raster image data and vector objects as layers of a composite image, and editing the composite image.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood and appreciated from the following detailed description, taken in conjunction with the drawings in which:

FIG. **1**A is an illustrative vector image for the United States, corresponding to a vector image file;

FIG. **1**B is an expanded view of FIG. **1**A showing the State of Nevada;

FIG. **1**C is a portion of the edit path for the boundary of the State of Nevada illustrated in FIG. **1**B;

FIG. **2** is a simplified illustration of a projection from the surface of the Earth to a two-dimensional plane;

FIG. **3**A is a raster image of a portion of the city of Miami, Fla., corresponding to a raster image file;

FIG. **3**B is an information panel for the image in FIG. **3**A;

FIG. **4** is simplified flowchart of a method for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention;

FIG. **5**A is a simplified block diagram of a GIS system for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention;

FIG. **5**B is a simplified block diagram of a more versatile GIS system for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention; and

FIGS. **6**A-**6**N are views of a composite GIS image including a vector layer and a raster layer, processed in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention concerns composition of vector and raster graphics within geographical information systems (GIS). GIS images are generally of two types: vector images comprised of vector objects such as points, lines and areas, and raster images comprised of arrays of pixel color values.

The present invention is preferably implemented within a conventional computing device including a central processing unit, memory units for storing programs and data, input devices including a mouse and keyboard, and an output display device. Preferably, the central processing unit, memory units, and device drivers for the mouse, keyboard and display are coupled communicatively together using a conventional data bus. It may be appreciated, however, from the description hereinbelow, that the present invention may also be implemented within non-conventional computing devices, as long as such devices include processing means, program and data storage means, and input and display means that inter-communicate. The present invention can be implemented within a standalone computer, or within one or more networked computers.

Vector GIS Images

Reference is now made to FIG. **1**, which is an illustrative vector image for the United States, corresponding to a GIS shape file. The shape file rendered in FIG. **1** includes 51 polygonal objects, one polygon for each of the 50 states, and a polygon for the District of Columbia. Each polygon is represented as a piecewise linear path, referred to as an "edit path." The State of Nevada, for example, indicated by numeral **110** in FIG. **1**A, is shown enlarged in FIG. **1**B. As can be seen in FIG. **1**B, the border of the State includes line segments connected one to another. The southeastern part of the border is rugged, and is represented by many short line

segments. A total of 83 line segments are used to render the border of Nevada. Thus the edit path of Nevada includes 84 (x, y) coordinates, wherein the 84^{th} coordinate is the same of the 1^{st} coordinate, and the n^{th} line segment connects the n^{th} point with the $(n+1)^{st}$ point. FIG. **1**C shows a portion of the edit path for the State of Nevada shown in FIG. **1**B.

Each of the (x, y) coordinates, referred to as "global linear coordinates," used to represent borders of states, corresponds uniquely to a longitude and a latitude (θ, ϕ) on the surface of the Earth, referred to as "geographical coordinates." A projection, such as a stereographic projection, denoted by Π, is used to project coordinates on the surface of the Earth, (θ, ϕ), to coordinates in a plane, (x, y), referred to as global coordinates. That is, the projection transforms geographical coordinates to global linear coordinates; Π: (θ, ϕ)→(x, y).

Reference is now made to FIG. **2**, which is a simplified illustration of a projection from the surface of the Earth to a two-dimensional plane. The projection illustrated in FIG. **2** is a conventional stereographic azimuthal projection, which transforms each point **210** on the surface of the Earth to a unique point **220** on a plane **230** tangent to the Earth at the South Pole **240**, the unique point **220** corresponding to the intersection of a line **250** connecting the North Pole **260** to the point **210** with the tangent plane **230**. Point **210** with geographical coordinates (θ, ϕ) on the surface of the Earth is projected to point **220** with global linear coordinates (x, y).

Similarly, a scaling transformation, denoted by Σ, transforms global coordinates to local coordinates; Σ: (x, y)→(i, j). The local coordinates correspond to pixel coordinates within a view plane. Pixel data in the view plane is rendered on a display screen or printed onto a page of paper.

Generally, the local coordinates (i, j) span only a relatively small portion of the Earth, such as the United States or the State of Nevada. The local coordinates themselves form a rectangular array, since rendered maps are generally rectangular. However, the geographical coordinates corresponding to such rectangular array generally do not form a rectangular array, but instead are warped. Thus, if R denotes a rectangular region in (x, y) space, then Π^1 (R) is generally not a rectangular region in (θ, ϕ) space. The notation Π^1 denotes the inverse transformation to Π; i.e., referring to FIG. **2**, the transformation that maps point **220** with global linear coordinates (x, y) back to point **210** with geographical coordinates (θ, ϕ).

The scaling transformation Σ generally loses global positioning information. That is, after global points (x, y) are scaled to local points (i, j), the local points cannot thereafter be scaled back to the global points. In order to retain the global positioning information two or more reference points are required, such as the global positions of two points (i**1**, j**1**) and (i**2**, j**2**), where i**1**≠i**2** and j**1**≠j**2**.

Raster GIS Images

Shown in FIG. **3**A is a raster image of a portion of the city of Miami, Fla., corresponding to a GEO-TIF file. The GEO-TIF file rendered in FIG. **3**A contains pixel data c(i, j) for a rectangular array of pixel locations (i, j), where c denotes a color vector, such as a three-dimensional RGB color, c(i, j)=(r(i, j), j), b(i, j)), where r, g and b are 8-bit integers. Thus, a GEO-TIF image corresponds to an already projected portion on the surface of the Earth. Generally, a GEO-TIF file includes (i) a description of the projection used to transform geographical coordinates to global linear coordinates; and (ii) reference point information for at least two local points (i, j).

Shown in FIG. **3**B is an information panel for the image in FIG. **3**A. As shown in the panel, the projection used for rendering the map in FIG. **3**A is "UTM Zone 17N"; and the reference point information specifies the top-most latitude of FIG. **2**A as 26° 25' 44.852" N, the bottom-most latitude as 25° 4' 15.354" N, the left-most longitude as 81° 1' 32.104" W and the right-most longitude as 79° 51' 49.664" W. Using the given projection and the given reference information, the local coordinates for the map of Miami can be converted back to geographical coordinates.

Composite Vector+Raster GIS Images

It may thus be appreciated that shape files and GEO-TIF files represent two general types of map formats for geographical images—vector and raster. Shape file data may correspond to geographical coordinates or global linear coordinates, and GEO-TIF file data generally corresponds to local linear coordinates. As such, overlaying vector maps and raster maps in such a way that the resulting composite image can be further edited, is difficult.

In a preferred embodiment, the present invention overcomes the difficulty of editing composite images having both vector and raster layers, by warping the layers one to another. Specifically, the layers are referred to a common projection, so that they can be overlaid while maintaining geographical alignment. Thus, if a GEO-TIF file specifies a first projection, Π_1, and if a shape file specified in terms of geographical coordinates is to be rendered using a second projection, Π_2, and a scaling transformation Σ, then the pixel coordinates of the GEO-TIF file are mapped to transformed coordinates by applying $\Pi_1\ \Pi_2^{-1}\ \Sigma^1$: (i**2**, j**2**)→(i**1**, j**1**). The color value of pixel (i**1**, j**1**) for the GEO-TIF image is assigned to pixel (i**2**, j**2**) for the composite image. The composite image can then be interactively edited.

Reference is now made to FIG. **4**, which is a simplified flowchart of a method for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention. At step **410** a raster image file is imported, such as a GEO-TIF file. Preferably, the raster image file identifies raster image data, a first projection from the surface of the Earth to a two-dimensional plane, and reference GIS positioning data. At step **420** a vector image file is imported, such as a shape file, specified in terms of geographical coordinates or in terms of linear coordinates. Preferably, the vector image file identifies vector objects, such as points, curves and areas, using GIS coordinates for edit paths. At step **430** pixel locations for a to-be-transformed raster image within a display plane are inverse projected to GIS coordinates, using the inverse of a prescribed second projection. At step **440** the GIS coordinates are projected to linear coordinates within the raster image data, using the first projection from the surface of the Earth to a two-dimensional view plane.

The color value at the linear coordinates within the raster image data is then assigned to the pixel locations of the to-be-transformed image, thereby generating the modified raster image. The modified raster image corresponds to the original raster image based on the second projection instead of the first projection.

At step **450** a determination is made as to whether the vector objects are already specified in terms of linear coordinates within the vector image file. If not, then at step **460** the vector objects are projected to a two-dimensional vector image, using the prescribed second projection from the surface of the Earth to the two-dimensional view plane, thus generating a two-dimensional vector image. If so, then at step **470** the vector objects only require scaling from global linear coordinates to local linear coordinates, in order to generate the two-dimensional vector image.

At step **480** the two-dimensional raster image and the two-dimensional vector image are composited as layers of a composite image. Finally, at step **490** the composite image is edited.

Reference is now made to FIG. **5**A, which is a simplified block diagram of a GIS system for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention. Shown in FIG. **5** is a raster GIS map file importer **505**, which reads a raster GIS map file and generates raster image data therefrom. Preferably, GIS map file importer **505** also identifies a first projection associated with the raster image data, and reference GIS positioning information also associated with the raster image data. Similarly, a vector GIS map file importer **510** reads a vector GIS map file and generates vector data therefrom. Preferably, vector GIS map file importer **510** identifies vector objects such as points, curves and areas, specified using either GIS or linear coordinates.

In accordance with a preferred embodiment of the present invention, the raster map data identified by raster GIS map file importer **505** is transformed to modified raster map data, by an inverse projector **515** that inverts raster pixel coordinates within a view plane to GIS coordinates using the inverse of a specified second projection, followed by a forward image projector **520** that projects the GIS coordinates to modified pixel coordinates using a prescribed vector projection. That is, using the notation hereinabove, inverse raster image projector **515** applies the transformation $\Pi_2^{-1}\Sigma^1$: (i**2**, j**2**)→(θ,ϕ), and forward projector **520** applies the transformation Π_1:(θ, ϕ)→(i**1**, j**1**). Modified raster map data is generated by assigning color values at location (i**1**, j**1**) from the imported raster map data to location (i**2**, j**2**) for the modified raster data.

The modified raster map data corresponds to a two-dimensional raster image within the view plane.

Similarly, a forward projector **525** projects the vector objects onto the view plane using the prescribed vector projection, to generate a two-dimensional vector image within the view plane. Forward projector **525** is drawn using dotted lines, to indicate that it is required if the vector GIS map file is specified in terms of GIS coordinates, and is not required if the vector GIS map file is specified in terms of linear coordinates.

The two-dimensional raster image and the two-dimensional vector image are transmitted to an image processor **530**. Image processor **530** includes an image compositor **535** that composites the two two-dimensional images as layers of a composite vector+raster image, and a composite image editor **540** that edits the resulting composite image. The composite vector+raster image is aligned so that vector objects are displayed at their correct locations within the raster image.

Reference is now made to FIG. **5**B, which is a simplified block diagram of a more versatile GIS system for editing composite raster and vector geographical images, in accordance with a preferred embodiment of the present invention. The system shown in FIG. **5**B is flexible enough to accommodate a scenario in which both a raster GIS map file and a vector GIS map file are re-projected using a third projection. That is, the raster GIS map data is based on a first projection, the vector GIS map data is specified in linear coordinates based on a second projection, and the composite image is to be rendered using yet a third projection. This situation can arise, for example, when three or more map files are composited.

In general, if n map files, $F_1, F_2, \ldots, F_n$ correspond to respective projections $P_1, P_2, \ldots, P_n$, and if a composite target image is to be rendered with respect to a projection P, then the map data in each file F_t is inverse projected using projection P_t and then forward projected using projection P. Thus, as shown in FIG. **5**B, both the raster map data and the vector map data are inverse projected back to geographical coordinates, using respective modules **515** and **545**, and then projected forward to linear coordinates with the third projection, using module **525**. Modules **525** and **545** are shown in dotted lines, indicating that one or both of them may not be required, as in the simpler system shown in FIG. **5**A.

Moreover, as shown in FIG. **5**B, modules **550** and **555** for change of GIS coordinates are operative to convert geographical data from one geographical coordinate system to another. It may be appreciated that multiple geographical coordinates systems exist for the surface of the Earth. The raster map data and vector map data may correspond to different geographical coordinate systems. Modules **550** and **555** are shown in dotted lines, since they may not be required.

Reference is now made to FIGS. **6**A-**6**N, which are views of a composite GIS image including a vector layer and a raster layer, processed in accordance with a preferred embodiment of the present invention. Shown in FIG. **6**A is a vector GIS map **610** corresponding to a shape file for the major roads in Miami, Fla. The shape file for FIG. **6**A includes 740 roads, each road preferably represented as an edit path including a series of points connected by line segments. As shown in FIG. **6**B, road map **610** displayed in FIG. **6**A is rendered using an "Albers Equal Area Conic Projection", to transform GIS coordinates to linear coordinates.

The data for the shape file of FIG. **6**A is stored in three files, as follows:

majrds.shp	The shape data for the lines segments of the roads
majrds.dbf	A database file containing metadata for the roads
majrds.prj	A description of the projection used for the shape file

Shown in FIG. **6**C is a portion of the metadata from majrds.dbf. The file majrds.prj contains the following text:

```
PROJCS["Custom",
    GEOGCS["GCS_North_American_1983_HARN",
        DATUM["D_North_American_1983",
            SPHEROID["GRS_1980",6378137,298.257222101]],
        PRIMEM["Greenwich",0],
        UNIT["Degree",0.0174532925199433]],
    PROJECTION["Albers"],
    PARAMETER["False_Easting",400000],
    PARAMETER["False_Northing",0],
    PARAMETER["Central_Meridian",-84],
    PARAMETER["Standard_Parallel_1",24],
    PARAMETER["Standard_Parallel_2",31.5],
    PARAMETER["Central_Parallel",24],
    UNIT["Meter",1]]
```

Specifically, the projection file indicates that the shape file majrds.shp uses a two-dimensional Cartesian coordinate system obtained by projecting the GCS_North_American_1983_HARN geographical coordinate system with D_North_American coordinates, based on an ellipsoid having a semi-major radius equal to 6378137 meters and an inverse flattening of 298.257; using angular units named "degree" with a conversion factor of 0.0174532925199433 to radians. The projection is an Albers projection with parameters False_Easting=400000, False_Northing=0, central meridian=−84, first standard parallel=24, second standard parallel=31.5, central parallel=24, using linear units named "meter" with a conversion factor of 1 to meters.

In general, coordinate systems for GIS images are specified using the following Backus-Naur Form, or variants thereof:

CS (coordinate system)=GeoCS (geographic)|ProjCS (projected)

GeoCS=Datum, Axis Orientation, Angular Unit

Datum=Ellipsoid, Prime Meridian

Prime Meridian=offset from Greenwich

Ellipsoid=semi-major axis, semi-minor axis (or flattening, inverse flattening)

ProjCS=GeoCS, Projection method & parameters, Axis Orientation, Linear Unit

Projection method=Albers, Mercator, etc.

Shown in FIG. **6**D is a raster GIS map **620** corresponding to a GEO-TIF file for Miami. The GEO-TIF file is a 22.6 MB file which contains data for an 11403×5996 pixel color image, corresponding to 195.6 MB of uncompressed pixel data. Map **620** in FIG. **6**D has been projected using the "UTM Zone 17" projection shown in FIG. **3**B. The image displayed in FIG. **6**D has been scaled to fit within the screen, and can be magnified to view more detail, as in FIG. **3**A. Shown in FIG. **6**E is an oval shaped lens **630** that is used as a magnifying glass to examine the map in more detail. Within lens **630** is a 20:1 magnified portion of the map that includes the Venetian Islands.

As shown in FIG. **6**F, the GEO-TIF map **620** of FIG. **6**D has been imported into the road map of FIG. **6**A to form a two-layer composite vector+raster image. The two-layer composite image is generated in accordance with a preferred embodiment of the present invention using the method described in FIG. **4**. The layer for the GEO-TIF map has been rendered at an opacity level of 50%, to enable the road map to be seen underneath. It is noted that the map of Miami **640** in FIG. **6**F is not identical to the map **620** shown in FIG. **6**D. The former has been re-projected to match the "Albers Equal Area Conic Projection", as indicated in FIG. **6**G.

FIGS. **6**H and **6**I are 4:1 and 10:1 magnifications of the composite image displayed in FIG. **6**F, respectively, showing the accuracy of the alignment between the vector GIS map **610** and the raster GIS map **640**. FIG. **6**J shows lens **630** with a 20:1 portion of the composite map that includes the Venetian Islands. Comparing the content of lens **630** in FIG. **6**J with the content in FIG. **6**E further shows the ability to process the composite vector+raster image, in accordance with a preferred embodiment of the present invention, and further shows the accuracy of the alignment.

FIGS. **6**K and **6**L show the ability to edit the composite vector+raster image, in accordance with a preferred embodiment of the present invention. Specifically, as shown in FIG. **6**K, one of the line objects **650** in the road map of FIG. **6**A, corresponding to one of the major roads, is selected and moved to a new location **660** shown in FIG. **6**L.

FIG. **6**M shows a paint brush stroke **670** applied to the composite image of FIG. **6**F, in accordance with a preferred embodiment of the present invention.

In FIG. **6**N, the opacity level of GEO-TIF map **640** has been set to 100%, so that vector map **610** is obscured. A portion **680** of map **640** has been cut out using an opacity mask to ghost out map **640** using brush strokes, in accordance with a preferred embodiment of the present invention. As can be seen in FIG. **6**N, the opacity mask exposes a portion of vector map **610**.

In reading the above description, persons skilled in the art will realize that there are many apparent variations that can be applied to the methods and systems described. Thus, the description above teaches a preferred embodiment for alignment of a raster image with a vector image, by re-projecting the raster image using a second projection, instead of a projection originally used to generate the raster image. In an alternate embodiment the raster image may be maintained, and the vector image may be projected using the same projection that was used to generate the raster image. More generally, the decision of which embodiment to use can be based on the order in which a user imports the vector and raster images. Thus, when a user first opens a vector image and subsequently imports a raster image, as in FIG. **6**E, the preferred embodiment of re-projecting the raster image is used; and when the user first opens a raster image and subsequently imports a vector image, the alternate embodiment is used.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made to the specific exemplary embodiments without departing from the broader spirit and scope of the invention as set forth in the appended claims. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A non-transitory computer-readable storage medium storing program code for causing a computer to perform a method of:

importing a plurality of raster geographical map files, each raster file including geographical information identifying raster image data comprising color values for a plurality of pixel locations (i**1**, j**1**), global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to one another, and a first projection that transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

importing a vector geographical map file, the vector file including geographical information identifying vector objects;

for each of the plurality of raster files and their corresponding first projections, rendering a corresponding planar raster image comprising, for each pixel location (i**2**, j**2**) from a plurality of pixel locations (i**2**, j**2**):

transforming planar Cartesian coordinates (x**2**, y**2**) corresponding to the pixel location (i**2**, j**2**), to geographical longitude-latitude coordinates (θ, ϕ) according to the inverse of a prescribed second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

re-projecting the resulting geographical longitude-latitude coordinates (θ,ϕ) to planar Cartesian coordinates (x**1**,y**1**) according to the first projection; and

assigning a color value for the pixel location (i**2**, j**2**) according to the color value for the pixel location (i**1**, j**1**) corresponding to planar Cartesian coordinates (x**1**, y**1**), of the raster geographical map file;

rendering a planar vector image comprising color values for the plurality of pixel locations (i**2**, j**2**), comprising projecting substantially all of the vector objects according to the prescribed second projection; and

compositing the plurality of rendered planar raster images and the rendered planar vector image as layers of a composite image.

2. The non-transitory computer-readable storage medium of claim **1** further comprising applying a change of coordinate transformation to change coordinates from a first geographical longitude-latitude coordinate system (θ**1**, ϕ**1**), associated within the raster geographical information corresponding to at least one of the raster files, to a second geographical lon-

gitude-latitude coordinate system (θ2, φ2), associated with the vector geographical information.

3. The non-transitory computer-readable storage medium of claim 1 wherein said rendering a planar vector image further comprises rasterizing the projected vector objects.

4. The non-transitory computer-readable storage medium of claim 1 wherein the global positioning reference data includes top and bottom latitudes, and left and right longitudes.

5. The non-transitory computer-readable storage medium of claim 1 wherein the vector objects include curves represented as at least one line segment.

6. The non-transitory computer-readable storage medium of claim 1 wherein the vector objects include areas represented as polygons with piecewise linear boundaries.

7. The non-transitory computer-readable storage medium of claim 1 further comprising modifying an opacity of the planar raster image within at least one raster layer of the composite image.

8. The non-transitory computer-readable storage medium of claim 1 further modifying an opacity of the planar vector image within the vector layer of the composite image.

9. The non-transitory computer-readable storage medium of claim 1 further comprising masking a portion of the planar raster image with an opacity mask within at least one raster layer of the composite image.

10. The non-transitory computer-readable storage medium of claim 1 further comprising masking a portion of the planar vector image with an opacity mask within the vector layer of the composite image.

11. The non-transitory computer-readable storage medium of claim 1 further comprising modifying a projected vector object within the vector layer of the composite image.

12. The non-transitory computer-readable storage medium of claim 1 further comprising magnifying a lens-shaped portion of the composite image.

13. A GIS system for editing composite geographical images, comprising:

a raster image file adaptor, for importing a plurality of raster geographical map files, each file including geographical information identifying raster image data comprising color values for a plurality of pixel locations (i1, j1), global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to one another, and a first projection that transforms geographical longitude-latitude coordinates (θ, φ) to planar Cartesian coordinates (x, y);

a vector image file adaptor, for importing a vector geographical map file, the file including geographical information identifying vector objects;

a raster map projector operatively coupled to said raster image file adaptor for rendering, for each of the plurality of raster files and their corresponding first projections, a corresponding planar raster image comprising color values for a plurality of pixel locations (i2, j2), comprising:

an inverse projector for transforming planar Cartesian coordinates (x2, y2) corresponding to the pixel locations (i2, j2), to geographical longitude-latitude coordinates (θ, φ) according to the inverse of a prescribed second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, φ) to linear coordinates (x, y), and wherein the second projection is different than the first projection; and

a forward projector for projecting the resulting geographical longitude-latitude coordinates (θ,φ) to planar Cartesian coordinates (x1,y1), according to the first projection;

wherein the raster map projector assigns color values for the pixel locations (i2, j2) of the planar raster image according to the color values for pixel locations (i1, j1) corresponding to planar Cartesian coordinates (x1, y1), of the raster geographical map file;

a vector map projector operatively coupled to said vector image file adaptor for rendering a planar vector image comprising color values for the plurality of pixel locations (i2, j2), comprising a forward vector projector for projecting vector objects to a planar vector image, according to the prescribed second projection; and

an image compositor for compositing the plurality of rendered planar raster images and the rendered planar vector image as layers of a composite image.

14. The GIS system of claim 13 wherein said raster map projector further comprises a change of coordinate transformer for changing coordinates from a first geographical longitude-latitude coordinate system (θ1, φ1), associated within the raster geographical information corresponding to at least one of the raster files, to a second geographical longitude-latitude coordinate system (θ2, φ2), associated with the vector geographical information.

15. The GIS system of claim 13 wherein said vector map projector further comprises a vector rasterizer for rasterizing the projected vector objects.

16. The GIS system of claim 13 wherein the global positioning reference data includes top and bottom latitudes, and left and right longitudes.

17. The GIS system of claim 13 wherein the vector objects include curves represented as at least one line segment.

18. The GIS system of claim 13 wherein the vector objects include areas represented as polygons with piecewise linear boundaries.

19. The GIS system of claim 13 further comprising a composite image editor for modifying an opacity of the planar raster image within at least one raster layer of the composite image.

20. The GIS system of claim 13 further comprising a composite image editor for modifying an opacity of the planar vector image within the vector layer of the composite image.

21. The GIS system of claim 13 further comprising a composite image editor for masking a portion of the planar raster image with an opacity mask within at least one raster layer of the composite image.

22. The GIS system of claim 13 further comprising a composite image editor for masking a portion of the planar vector image with an opacity mask within the vector layer of the composite image.

23. The GIS system of claim 13 further comprising a composite image editor for modifying a projected vector object within the vector layer of the composite image.

24. The GIS system of claim 13 further comprising a composite image editor for magnifying a lens-shaped portion of the composite image.

25. A non-transitory computer-readable storage medium storing program code for causing a computer to perform a method of:

importing a plurality of raster geographical map files, each raster file including geographical information identifying raster image data comprising color values for a plurality of pixel locations (i1, j1), global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to

one another, and a first projection that transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

importing a vector geographical map file, the vector file including planar vector objects corresponding to a second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y), and wherein the second projection is different than the first projection;

for each of the plurality of raster files and their corresponding first projections, rendering a corresponding planar raster image comprising, for each pixel location (i**2**, j**2**) from a plurality of pixel locations (i**2**, j**2**):

transforming planar Cartesian coordinates (x**2**, y**2**) corresponding to the pixel location (i**2**, j**2**), to geographical longitude-latitude coordinates (θ, ϕ) according to the inverse of the second projection;

re-projecting the geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x**1**, y**1**) according to the first projection; and

assigning a color value for the pixel location (i**2**, j**2**) of the planar raster image according to the color value for the pixel location (i**1**, j**1**) corresponding to planar Cartesian coordinates (x**1**, y**1**), of the raster geographical map file;

rendering a planar vector image comprising rasterizing the planar vector objects; and

compositing the plurality of rendered planar raster images and the rendered planar vector image as layers of a composite image.

26. A GIS system for editing composite geographical images, comprising:

a raster image file adaptor, for importing a plurality of raster geographical map files, each file including geographical information identifying raster image data comprising color values for a plurality of pixel locations (i**1**, j**1**), global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to one another, and a first projection that transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

a vector image file adaptor, for importing a vector geographical map file, the file including planar vector objects corresponding to a second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y), and wherein the second projection is different than the first projection;

a raster map projector operatively coupled to said raster image file adaptor for rendering, for each of the plurality of raster files and their corresponding first projections, a corresponding planar raster image comprising color values for a plurality of pixel locations (i**2**, j**2**), comprising:

an inverse projector for transforming planar Cartesian coordinates (x**2**, y**2**) corresponding to the pixel locations (i**2**, j**2**), to geographical longitude-latitude coordinates (θ, ϕ) according to the inverse of the second projection; and

a forward projector for projecting the resulting geographical longitude-latitude coordinates (θ,ϕ) to planar Cartesian coordinates (x**1**,y**1**), according to the first projection;

wherein the raster map projector assigns color values for the pixel locations (i**2**, j**2**) of the planar raster image according to the color values for pixel locations (i**1**, j**1**) corresponding to planar Cartesian coordinates (x**1**, y**1**), of the raster geographical map file;

a vector map rasterizer operatively coupled to said vector image file adaptor for rendering a planar vector image, comprising rasterizing planar vector objects; and

an image compositor for compositing the plurality of rendered planar raster images and the rendered planar vector image as layers of a composite image.

27. A non-transitory computer-readable storage medium storing program code for causing a computer to perform a method of:

importing a plurality of raster geographical map files, each raster file including a planar raster image comprising color values for a plurality of pixel locations (i, j), global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to one another;

importing a first projection that transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

importing a vector geographical map file, the vector file including information identifying planar vector objects;

rendering a planar vector image, comprising:

inverse projecting the planar vector objects according to a prescribed second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

projecting the resulting inverse-projected vector objects according to the first projection; and

assigning color values for the pixel locations (i, j) of the planar vector image according to the color values of corresponding vector objects of the vector geographical map file; and

compositing the plurality of planar raster images and the rendered planar vector image as layers of a composite image.

28. A GIS system for editing composite geographical images, comprising:

a raster image file adaptor, for importing a plurality of geographical map files, each file including a planar raster image comprising color values for a plurality of pixel locations (i, j), and global positioning reference data for identifying pixel locations (i, j) and planar Cartesian coordinates (x, y) that correspond to one another, and for importing a first projection that transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y);

a vector image file adaptor, for importing a geographical map file, the file including information identifying planar vector objects;

a vector map projector operatively coupled to said vector image file adaptor for rendering a planar vector image comprising color values for the plurality of pixel locations (i, j), comprising:

an inverse projector for inverse projecting the planar vector objects according to a prescribed second projection, wherein the second projection also transforms geographical longitude-latitude coordinates (θ, ϕ) to planar Cartesian coordinates (x, y); and

a forward vector projector for projecting the resulting inverse-projected vector objects according to the first projection, wherein the vector map projector assigns color values for the pixel locations (i, j) of the planar

vector image according to the color values of corresponding vector objects of the vector geographical map file; and

an image compositor for compositing the plurality of planar raster images and the rendered planar vector image as layers of a composite image.

29. The non-transitory computer-readable storage medium of claim **1** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

30. The GIS system of claim **13** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

31. The non-transitory computer-readable storage medium of claim **25** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

32. The GIS system of claim **26** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

33. The non-transitory computer-readable storage medium of claim **27** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

34. The GIS system of claim **28** wherein the first and second projections are stereographic projections, which project coordinates (θ, ϕ) on the surface of the earth to planar Cartesian coordinates (x, y).

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