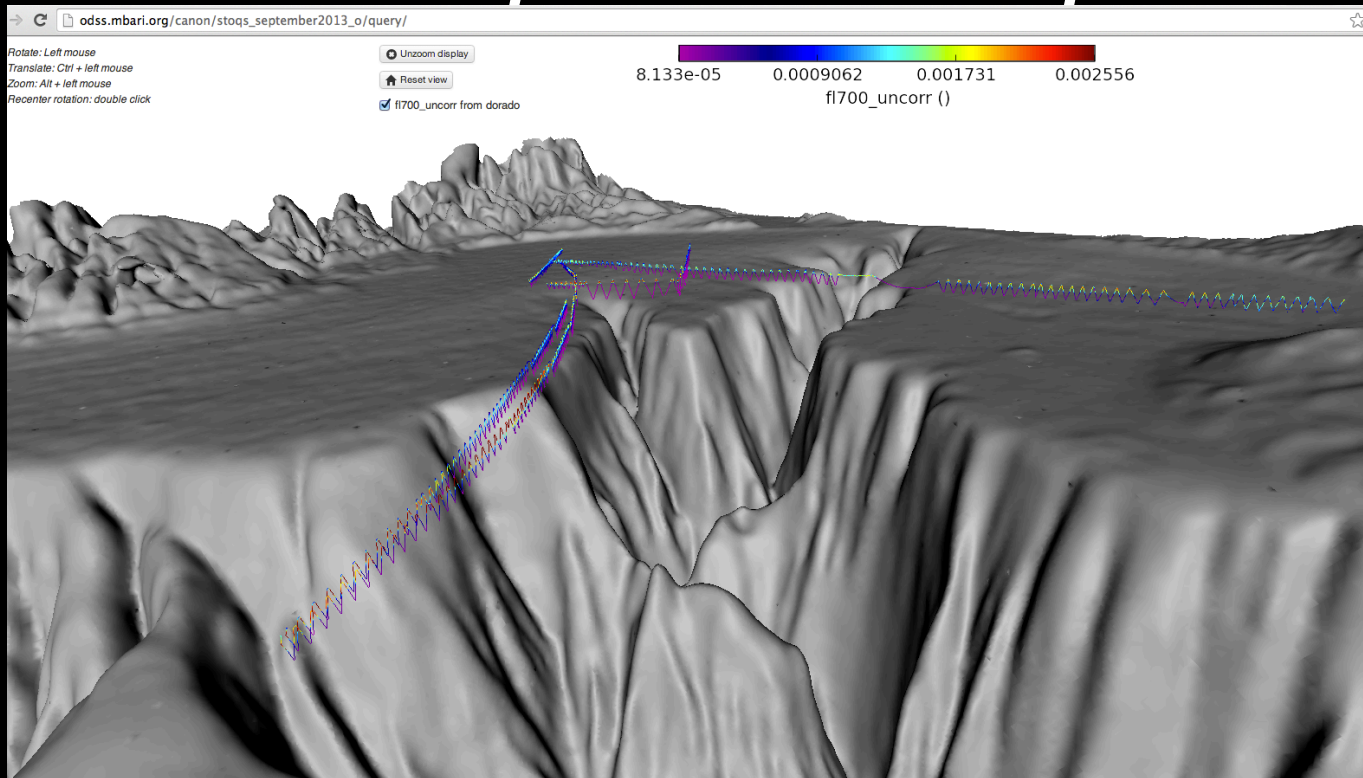# *X3D Geospatial Component*

Mike McCann

Monterey Bay Aquarium Research Institute

Web3D Emerging Technology Showcase

Virginia Tech Research Center

25 March 2014

X3D Geospatial

- All the benefits of X3D:
  - Rich computer graphics capabilities
  - Runtime environment
  - Built for the web
- Geospatial accuracy (ellipsoids, geoids, etc.)
- True mapping of 3D Geospatial coordinates to X3D's Cartesian X, Y, Z coordinates
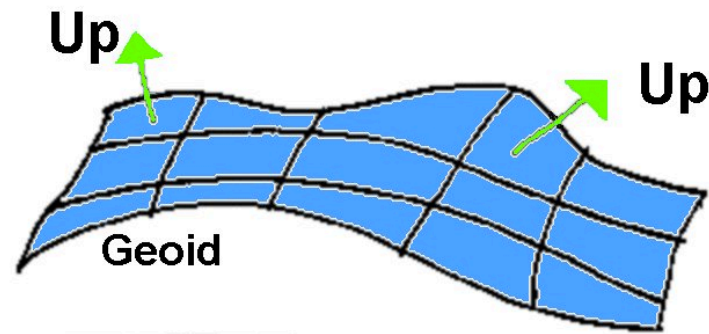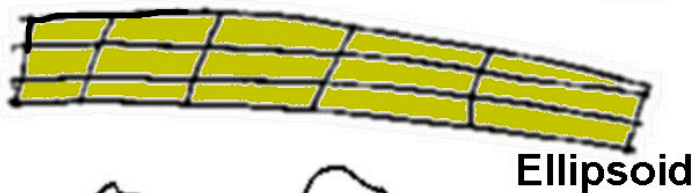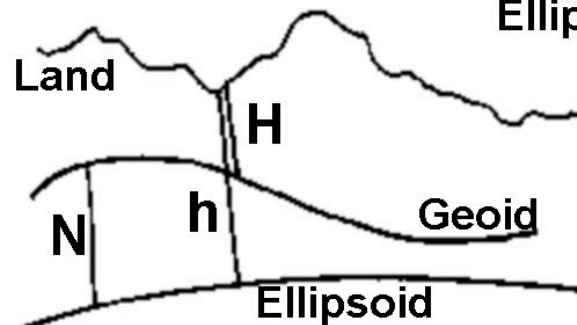
Geographic & Geocentric
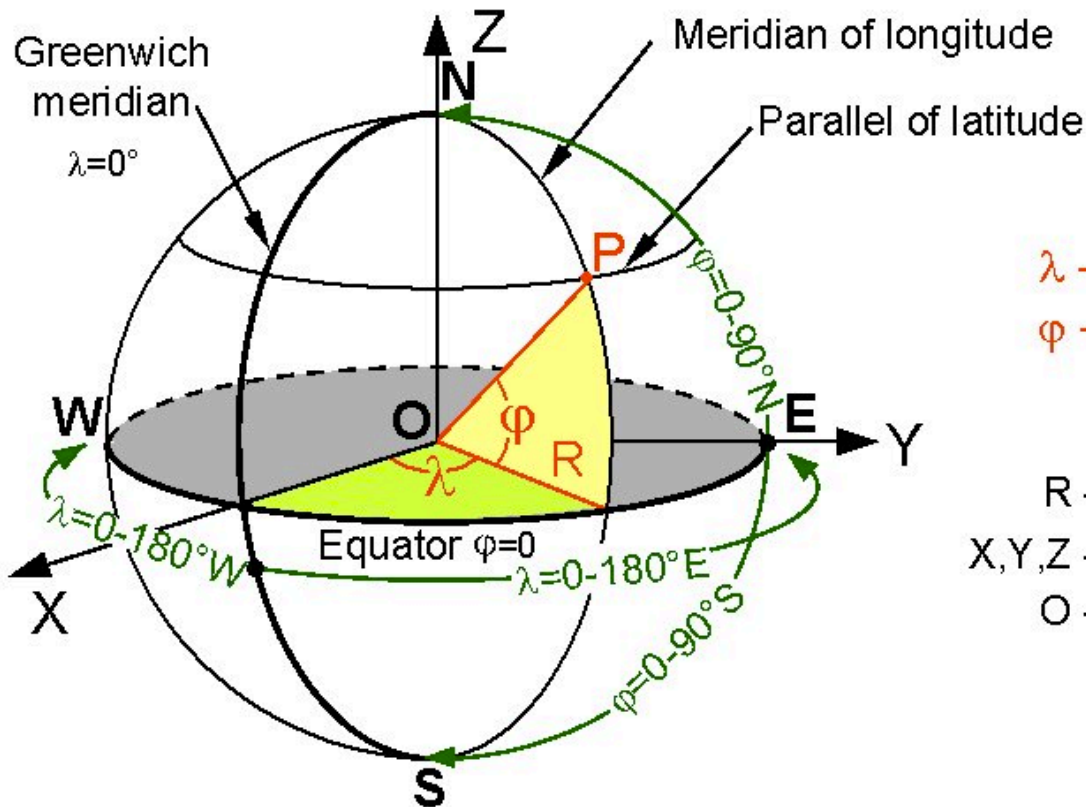
Geodesy

H orthometric or msl height

h ellipsoidal height

N geoid undulation or geoid seperation

$$h = H + N$$

Geoid - Ellisoid Diagram
Two and Three Dimensions

Geodesy
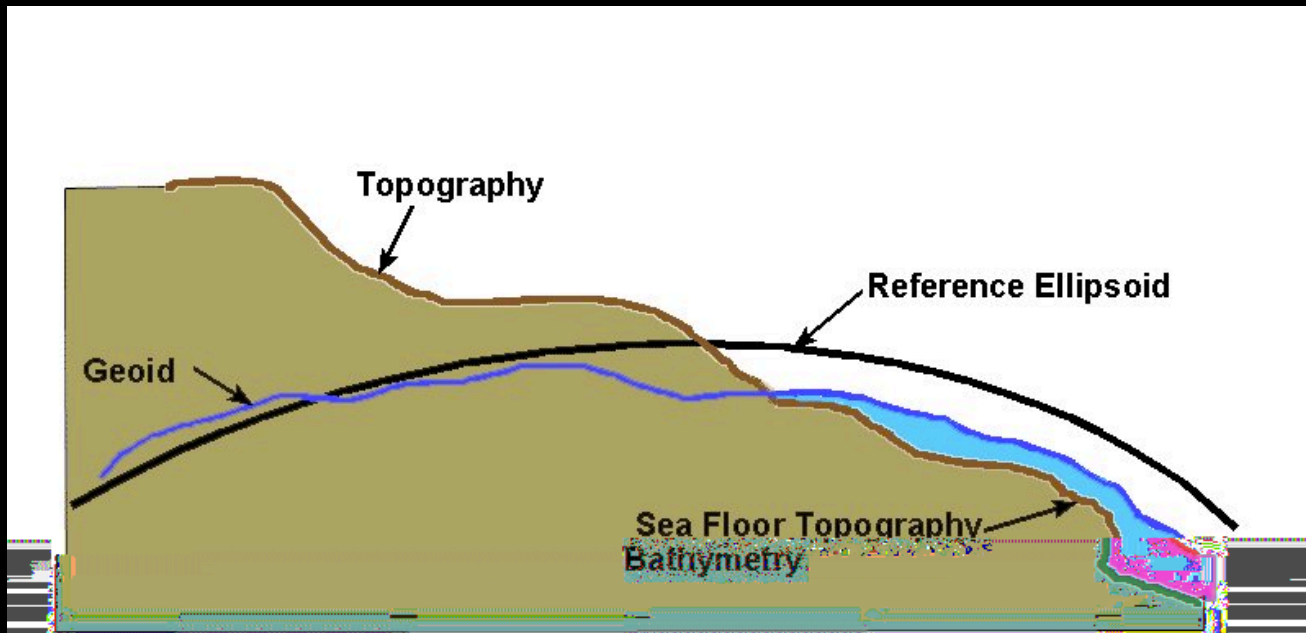
Three Surfaces of Geodesy

GeoCoordinate Examples

```
# GEO lat 21.3… deg, long -157.86… deg, 0 m elevation, WGS84

<GeoCoordinate
    geoSystem="'GD'"
    point="21.316258 -157.886202 0.0"
</GeoCoordinate>

# UTM zone 11, 4361550.1 n, 310385.2 e, 1000 m elevation

<GeoCoordinate
    geoSystem="'UTM', 'Z11'"
    point="4361550.1 310385.2 1000"
</GeoCoordinate>
```

(All coordinates translated internally to geocentric)

Simplicity of Use

- X3D Geo nodes are built out of GeoCoordinate nodes just as regular Geometry nodes are built out of Coordinate nodes

- GeoCoordinates may be specified in WGS84 Lat/Lon, UTM Easting/Northings, or GeoCentric x/y/z coordinates

- Nodes like GeoElevationGrid work just like ElevationGrid but with GeoCoordinates

GeoSpatial Node overview

1. **GeoCoordinate** - Build geometry with geographic coordinates

2. **GeoElevationGrid** - Define height field with geographic coordinates

3. **GeoLocation** - Georeference a vanilla X3D model

GeoSpatial Node overview (cont.)

4. **GeoLOD** - Multi-resolution terrain level of detail management

5. **GeoMetadata** - Dublin Core element style Information about the data

6. **GeoOrigin** - Used to increase the precision within the scene (deprecated)

GeoSpatial Node overview (cont.)

7. GeoPositionInterpolator - Animate objects within the geographic coordinate system

8. GeoProximitySensor - Provides geographic coordinates of viewer's position

9. GeoTouchSensor - Return geographic coordinates of an object

GeoSpatial Node overview (cont.)

10. **GeoTransform** - Translate and rotate GeoCoordinate built geometry orthometricly, *i.e.* relative to local tangent plane of ellipsoid or geoid

11. **GeoVeiwpoint** - Specify viewpoint in geographic coordinates

Extending X3DOM

- Javascript library for plugin-free 3D Web
- Some support for Geospatial:
  - GeoCoordinate
  - GeoElevationGrid
  - ...
- POPGeometry and BinaryGeometry
  - Not (yet) part of X3D Specification
  - Can be used for detailed terrain rendering

More detail into the Geo nodes

- The building blocks of GeoSpatial worlds

GeoCoordinate (1 of 11)

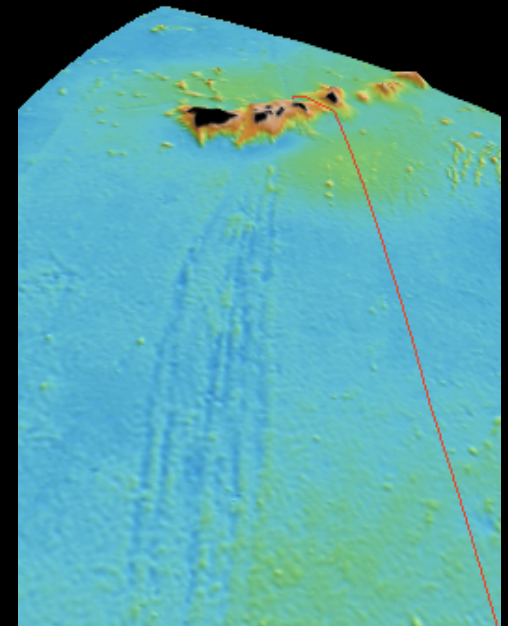- Purpose
  - Specify a list of geographic coordinates
- Usage
  - Can use a GeoCoordinate node anywhere an X3D Coordinate node can go, e.g. PointSet, IndexedFaceSet, or IndexedLineSet.
- Uses
  - Build models in terms of lat/long or UTM. For example, a road line segment, a GPS track, or 3-D model from GPS-recorded points or model simulation

```
<Shape>
    <IndexedLineSet colorPerVertex="false"
      coordIndex="0 1 2 . . ."
        <GeoCoordinate
            point="21.316258 -157.886202 0.0,
              21.316262 -157.8862 0.0,
              21.31626 -157.886193 0.0, . . ."
            geoSystem="&quot;GD&quot;">
            <GeoOrigin USE="ORIGIN"/>
        </GeoCoordinate>
        <Color color="1.0 0.0 0.0"/>
    </IndexedLineSet>
</Shape>
```

GeoElevationGrid (2 of 11)

- Purpose
  - Define a height field using geographic coordinates
- Usage
  - Can use a GeoElevationGrid node anywhere an X3D ElevationGrid can go, e.g. from the geometry field of a Shape node.
- Uses
  - Create terrain models for local or large areas (automatically introduces correct degree of earth curvature)

GeoElevationGrid (2 of 11)

```
<Shape>
    <Appearance>
        <ImageTexture
          url="&quot;NEPacific50.jpg&quot;"/>
    </Appearance>
    <GeoElevationGrid
        geoGridOrigin="15.0 -165.0 0.0"
        height="-5416.0, -5496.0, …
        xDimension="113" xSpacing="0.5380962885"
        zDimension="66" zSpacing="0.5415395186"
        yScale="10.0"/>
        <TextureCoordinate
          point="0.0 0.0, 0.00892857 0.0, ... />
    </GeoElevationGrid>
</Shape>
```
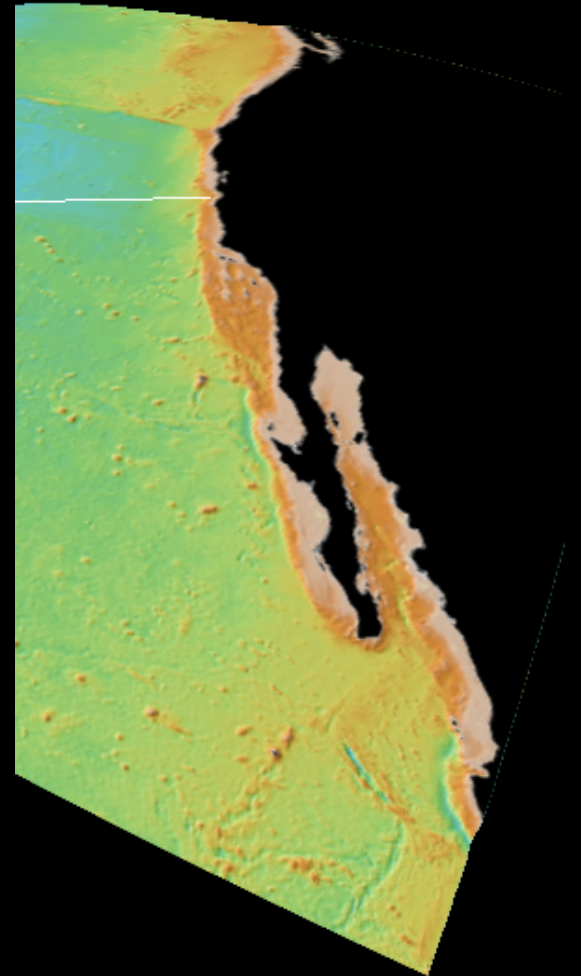
GeoLocation (3 of 11)

- Purpose
  - Georeference a vanilla X3D model onto the surface of the earth
- Usage
  - The GeoLocation node is a grouping node that affects the location of its children. It also sets the orientation so that +Y is up for that location.
- Uses
  - Place a non-georeferenced model at its correct location and orientation, place an X3D Viewpoint or ElevationGrid at a geographic location.

```
<GeoLocation
    containerField="children"
    geoSystem="&quot;GD&quot;"
    geoCoords="37.45855
          -122.172997 6.5">
    <inline url="building.x3dv" />
</GeoLocation>
```

GeoLOD (4 of 11)

- Purpose
  - Level of detail management for multi-resolution terrains
- Usage
  - The GeoLOD node is a grouping node that switches between two resolution levels of a quad-tree based upon distance from a point.
- Uses
  - Build massive tiled, multi-resolution terrain models where the browser progressively loads higher resolution detail as you fly into the terrain.

```
GeoLOD {
    center 36.5 -122.4 -2054.4
    child1Url "../../trees/2/
    p0p0.x3dv"
    child2Url "../../trees/2/
    p1p0.x3dv"
    child3Url "../../trees/2/
    p0p1.x3dv"
    child4Url "../../trees/2/
    p1p1.x3dv"
    geoOrigin USE ORIGIN
    geoSystem "GD"
    range 72673.5
    rootNode Shape {
     appearance Appearance {
        texture ImageTexture {
            url "../../images/1/
              p0p0.jpg"
        }
     }
    }
    ..
```
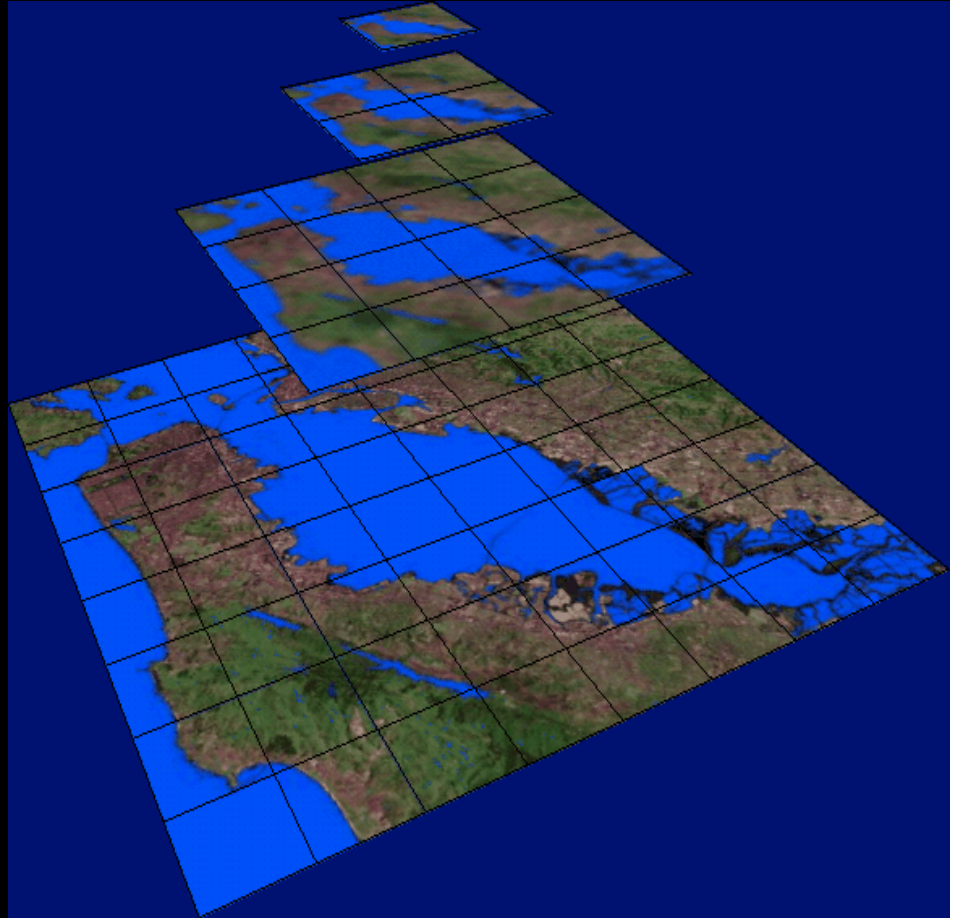
GeoMetadata (5 of 11)

- Purpose
  - Include a generic subset of metadata about the geographic data
- Usage
  - Can be thought of as a WorldInfo node, but specifically designed for describing geographic information.
- Uses

  - Provide a subset of metadata information about one or more geographic elements in a scene, and provide links to full metadata and source files.

# GeoMetadata (5 of 11)

```
GeoMetadata {
  summary [
    "title", "SAN FRANCISCO NORTH, CA"
    "description", "DEM GENERATED FROM 1/24,000 DLG-
  SOURCE"
    "coordinate-system", "UTM Z10"
    "extent", "555060.99 4177990.30 543974.53 4191924.61"
    "resolution", "30"
    "originator", "United States Geological Survey (USGS)"
    "data-format", "USGS 7.5 min DEM"
  ]
  data USE GEOEG
  url "sanfranciscon.dem"
}
```

GeoOrigin (6 of 11)

- Purpose
  - Specify a local coordinate system for increased floating point precision
- Usage
  - You can use a GeoOrigin node only as the value for a geoOrigin field in another X3D node. Only one GeoOrigin per scene. Use DEF/USE to provide the same GeoOrigin node to all GeoVRML nodes.
- Uses
  - Remove floating point rounding artifacts for ground-level models such as quantization of vertices and camera jitter during navigation

```
<GeoOrigin DEF="ORIGIN"
   containerField="children"
   geoSystem="&quot;GD&quot;"
   geoCoords="30.0 -5.0 0.0"/>

<GeoCoordinate
   geoSystem="&quot;GD&quot;"
   point="31.31834 -5.886202
   0.0"
        <GeoOrigin
   USE="ORIGIN"/>
</GeoCoordinate>
```
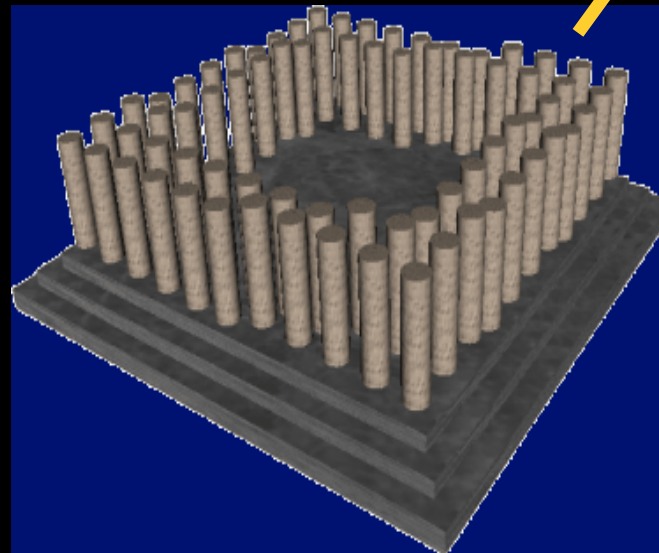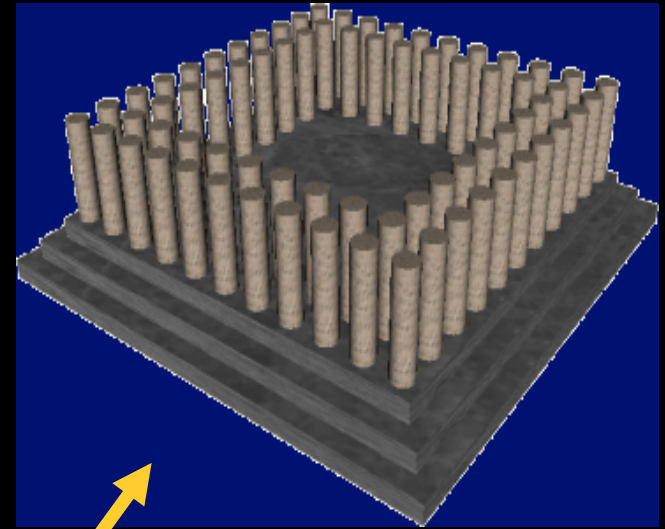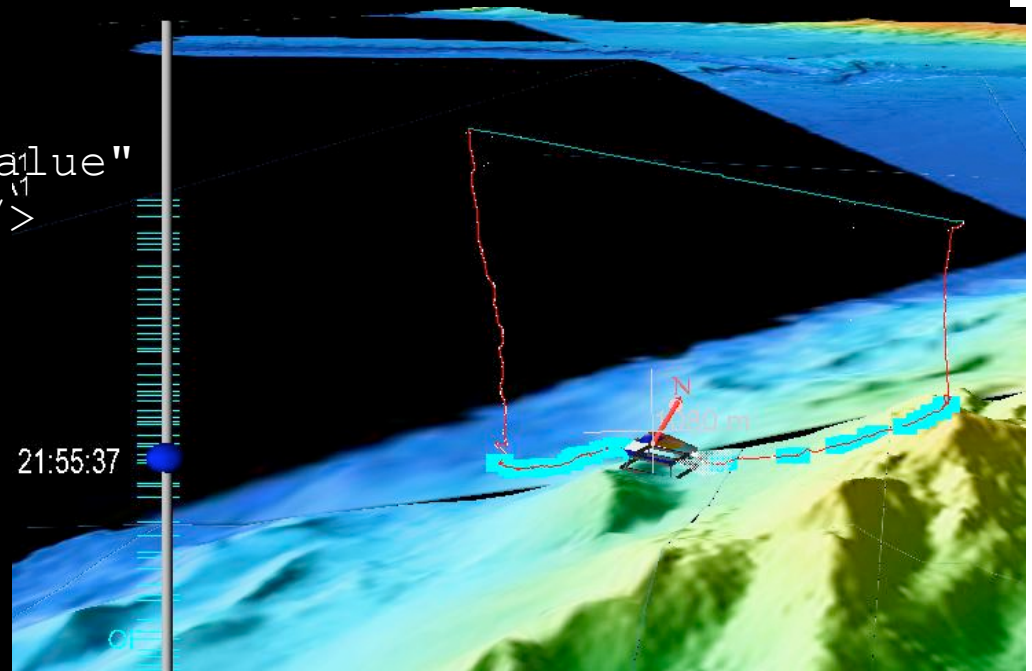
- Purpose
  - Animate objects within a geographic coordinate system
- Usage
  - Can use a GeoPositionInterpolator node anywhere that a X3D PositionInterpolator node can go.
- Uses
  - Perform fly-throughs of X3D content by animating the camera, animate objects based upon GPS data or key frame locations.

```
<GeoPositionInterpolator
 DEF="ROV_Pos_Interpolator">
  <IS>
   <connect nodeField="key"
   protoField="rovKeys"/>
   <connect nodeField="keyValue"
   protoField="rovLocation"/>
  </IS>
  <GeoOrigin USE="ORIGIN"/>
</GeoPositionInterpolator>
```


21:55:37

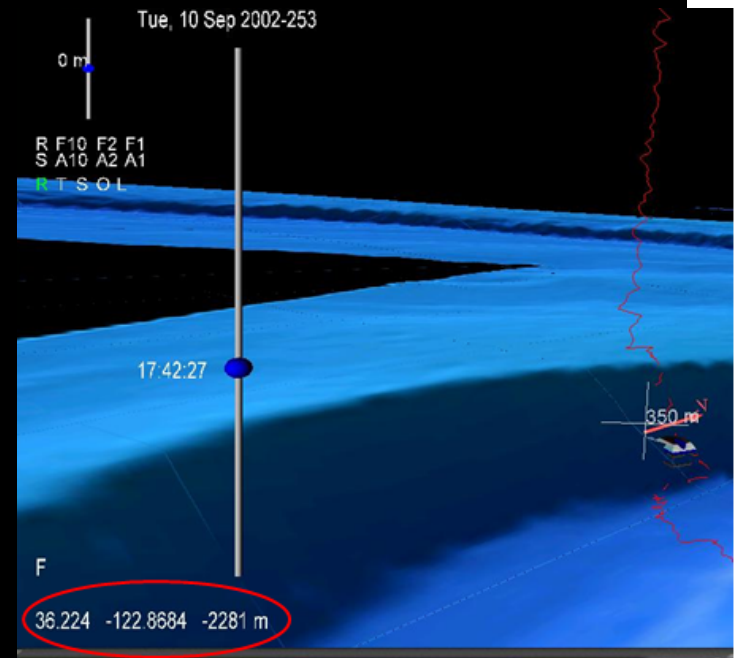# GeoProximitySensor (8 of 11)

- Purpose
  - Report geographic location of the viewer's position
- Usage
  - Can use a GeoProximitySensor node anywhere that an X3D ProximitySensor node can go.
- Uses
  - Specify proximity sensors in GeoSpatial reference frame.

  - Route GeoCoordinate values of viewpoint location

```
DEF PROX GeoProximitySensor {
 geoOrigin USE ORIGIN
 geoSystem [ "GD" ]
 geoCenter IS diveMidpoint
 size 1.e6 1.e6 1.e6
}
 .
 .
 .

ROUTE PROX.geoCoord_changed TO
   PROX_script.set_geoCoord
ROUTE PROX_script.locationString TO
   DepthDisplay.set_string
```
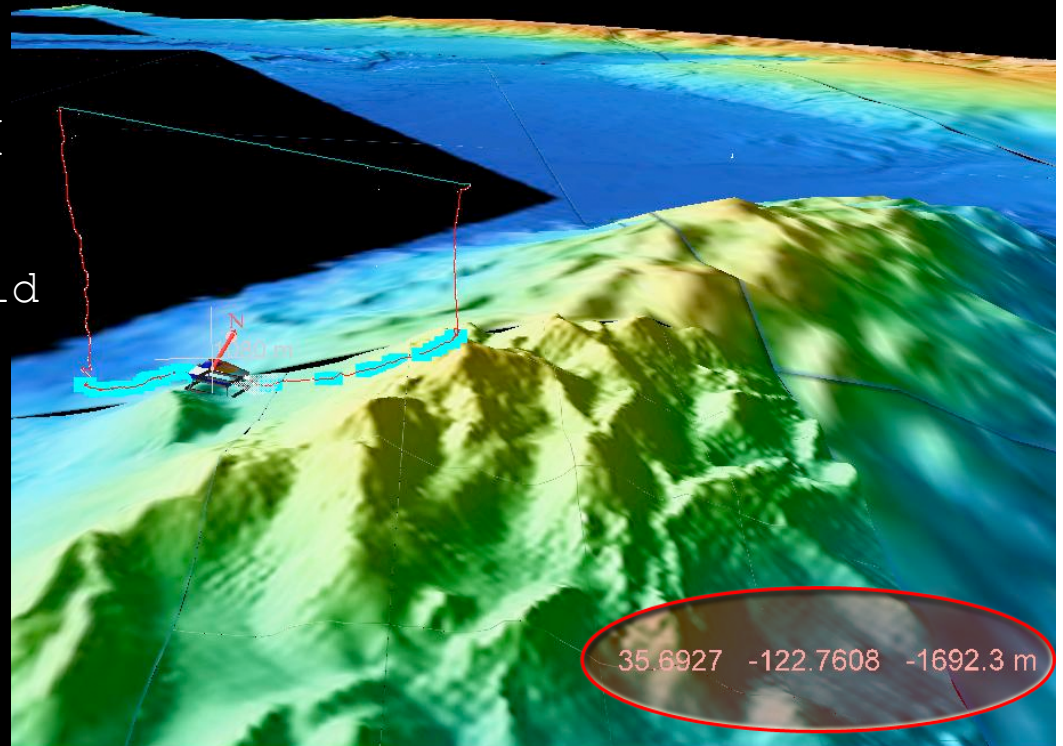
GeoTouchSensor (9 of 11)

- Purpose
  - Report geographic location of the mouse position on an object
- Usage

  - Can use a GeoTouchSensor node anywhere that an X3D Touch Sensor node can go.

- Uses
  - Route GeoCoordinate values of mouse position and act on mouse clicks.

GeoTouchSensor (9 of 11)


```
Group {
 children [
  DEF GTS GeoTouchSensor {
   geoOrigin USE ORIGIN
  }
  geometry GeoElevationGrid
  {
    . . .
  }
 ]
}
.
.
.

ROUTE GTS.hitGeoCoord_changed TO
   TEXTSCRIPT.set_value
```
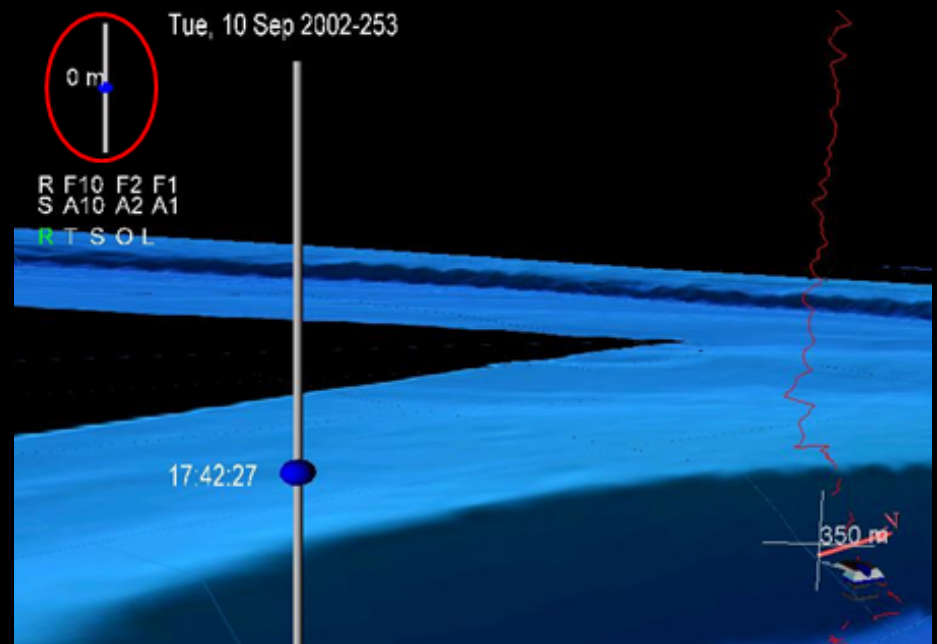
- Purpose
  - Translate and rotate GeoCoordinate geometry relative to ellipsoidal tangent plane
- Usage
  - Grouping node like Transform, but for GeoCoordinate geometry
- Uses
  - For Shape nodes built of GeoCoordinates GeoTransform provides translation and rotation routable attributes for moving GeoCoordinate constructed geometry relative to a local tangent plane on the globe.

GeoTransform (10 of 11)

```
DEF DiveLocation GeoTransform {
 geoOrigin USE ORIGIN
 geoCenter IS diveMidpoint
 children [
 Transform {
  children [
   DEF ROVTrackShape Shape {
    geometry IndexedLineSet {
     coord GeoCoordinate {
     geoOrigin USE ORIGIN
     point IS rovLocation
    }
   ]
  }
 ]
}
.

ROUTE DepthSliderEvents.translation_changed TO
   DiveLocation.set_translation
```

GeoViewpoint (11 of 11)

- Purpose
  - Specify a viewpoint using geographic coordinates
- Usage

  - Can use a GeoViewpoint anywhere an X3D Viewpoint node can go. The viewpoint orientation is relative to the up vector at that location.

- Uses
  - Place the camera at a geographic coordinate, setup sensible navigation options such as height-based velocity and near/far clipping planes.

```
GeoViewpoint {
    position "51.5 -0.1 1000000"
    orientation 1 0 0 -1.57
    geoSystem "GD"
    navType "EXAMINE"
    description "View1"
    headlight TRUE
    jump TRUE
}
```