Innovative Approaches to Modeling GPS/GNSS Construction Data with Oracle Spatial and Graph

Tracy McLane, Bechtel GIS Manager

Oracle BIWA with Oracle Spatial Summit 2015

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Speaker Bio

- **Tracy McLane** is currently the **GIS Manager** for the Bechtel Infrastructure Global Business Unit (GBU), where she also serves as the **GIS Technical Discipline Lead** for the company. She is responsible for the development of the **GIS Technical Center of Excellence for Bechtel** and has implemented an Enterprise GIS database and centralized GIS Knowledge Bank for the Bechtel GIS user community. Tracy was named as one of ten **Bechtel Distinguished Scientists in the Bechtel Distinguished Engineers and Scientists (BDES) program** in 2012, and currently serves as the **Vice Chairman** on the **Oracle Spatial Special Interest Group (SIG) Board of Directors** in the Independent Oracle Users Group (IOUG).

- Ms. McLane has worked in the GIS industry for more than 20 years, and has provided GIS support for each of Bechtel’s Global Business Units (GBUs) during her 16+ years with the company. Ms. McLane’s previous GIS experience includes work at the Tennessee Valley Authority and the U. S. Department of Energy Bechtel Savannah River Site before taking her current position with Bechtel in March of 2007.

- Ms. McLane holds a Masters of Science degree in Geography from the University of Tennessee in Knoxville, Tennessee and a Bachelor of Arts degree in International Business from Eckerd College in Saint Petersburg, Florida.
OVERVIEW

- **Company:** Bechtel
  - Top U.S. construction contractor by *Engineering News-Record (ENR)* for 15 straight years
  - Bechtel has worked on more than 25,000 projects in 160 countries on all seven continents.
  - Bechtel has some 40 offices and 53,000 employees in nearly 40 countries.
  - Signature Projects: Hoover Dam, English Channel Tunnel, Hong Kong International Airport, Ivanpah Solar Energy Site

- **System:** BecGIS
  - Internal users for multiple Global Business Units (GBUs)
  - Development and Production Environments
  - GIS Architecture on Bechtel Network

CHALLENGES / OPPORTUNITIES

- GIS Data Configuration Management Processes
- Spatial Data Content Sharing and the User Experience
- Scalable, Multi-Tiered Data Security
- Integration of Disparate Data
- Effective Spatial Data Process Workflows
- Data Integrity and Documentation of Accuracies

SOLUTIONS

- Oracle Database 10g Enterprise Edition (migrating to 12c)
  - Spatial Option with GeoRaster, Network Data Model
  - Partitioning
  - Oracle PL/SQL

RESULTS

- Consolidation of field data collection and other spatial data in a centralized repository
- More effective Big Data handling and processing
- Improved data accuracies and field verification, making basis for construction activities more reliable
Objectives

To show how innovative approaches to Oracle Spatial and Graph database design and spatial analysis, in conjunction with GPS/GNSS mapping and survey data, can improve data processing efficiencies, streamline process workflows and document data quality parameters for engineering design and construction, using the examples below:

• Big Data Analysis
  • Analysis of GPS/GNSS Geomagnetic Effects and Data Collection Parameters

• Oracle Spatial Survey Geometry Creation
  • 3-Dimensional Geometry Creation from Feature-coded Survey Data
  • 3-Dimensional Surface Modeling from Construction Survey Data

• “Select Distinct” Spatial Analysis for 3D Subsurface Point Data

• Oracle Spatial Database Design for GPS/GNSS Construction Spatial Quantities and Quality Reporting Tool (SQ2RT)
Big Data –
Analysis of GPS/GNSS Geomagnetic Effects and Data Collection Parameters
GPS/GNSS Accuracies by Device Classification

Factors that Affect GPS/GNSS Accuracy

- Multipath Interferences
- Number of Available Satellites
- Satellite Positioning
- Duration of Observation
- Space Weather
Space Weather Indicator: KP Index

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Source: http://www.swpc.noaa.gov/info/Kindex.html
### Space Weather Parameters

#### Dilution of Precision Parameters

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<th>COLUMN_NAME</th>
<th>COLUMN_TYPE</th>
<th>DESCRIPTION</th>
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<tr>
<td>DOP_DATE</td>
<td>Date/Time</td>
<td>The date of the DOP reading, in Coordinate Universal Time (UTC)</td>
</tr>
<tr>
<td>DOP_TIME **</td>
<td>Date/Time</td>
<td>The timestamp of the DOP reading, in Coordinate Universal Time (UTC)</td>
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<td>GDOP</td>
<td>Double</td>
<td>The geometric dilution of precision</td>
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<tr>
<td>TDOP</td>
<td>Double</td>
<td>The time dilution of precision</td>
</tr>
<tr>
<td>PDOP</td>
<td>Double</td>
<td>The positional dilution of precision</td>
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<tr>
<td>HDOP</td>
<td>Double</td>
<td>The horizontal dilution of precision</td>
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<td>VDOP</td>
<td>Double</td>
<td>The vertical dilution of precision</td>
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<td>GPS</td>
<td>Long Integer</td>
<td>The number of GPS satellites visible to the point of observation</td>
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<td>The number of GLONASS satellites visible to the point of observation</td>
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<td>The number of GALILEO satellites visible to the point of observation</td>
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<td>The number of COMPASS satellites visible to the point of observation</td>
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<td>FILE_NAME</td>
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### KP Index Parameter

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<td>KPI_INDEX</td>
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<td>The planetary Kp value as collected on a three-hour interval basis.</td>
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<td>The date/timestamp of the space weather KPI data</td>
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<td>Date/Time</td>
<td>The starting time of the three-hour interval for the KPI observation</td>
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<tr>
<td>OBS_ETIME</td>
<td>Date/Time</td>
<td>The ending time of the three-hour interval for the KPI observation</td>
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<tr>
<td>OBS_DESC</td>
<td>Text(20)</td>
<td>The period of the day of the observation (&quot;Period 1&quot; for first three-hour interval, etc.)</td>
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<td>SOURCE_FILE</td>
<td>Text(60)</td>
<td>The source .GIF image of the KPI value chart from which the data was extracted</td>
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### Observation Time Conversions

- **Local Date and Time Stamp:** November 2012 8:15 AM PST
- **UTC Date and Time Stamp:** November 11, 2012 1:15 AM UTC
- **Concatenated Time Stamp:** YYYYY + MM + DD + HH + MM + SS
  
  2012 + 11 + 11 + 07 + 01 + 15

- **Identifier for KP Indices:**
  2012 + 11 + 11 + 07 + 00 + 00**

- **Identifier for DOP Parameters:**
  2012 + 11 + 11 + 07 + 01 + 00*
Joining and Filtering of Space Weather Parameters

update utelepyl set utelepyl.insert_kpi = (select clgenkpi.kp_index from clgenkpi where utelepyl.insert_id > clgenkpi.from_time and utelepyl2.insert_id < clgenkpi.to_time);

Big Data – Analysis of GPS/GNSS Geomagnetic Effects and Data Collection Parameters

Oracle Spatial Geometry Creation -

• 3-Dimensional Geometry Creation from Feature-coded Survey Data
• 3-Dimensional Surface Modeling from Construction Survey Data
Geometry Creation from Feature-Coded Survey Data

For construction environments, development of a geodetic control dataset to tie down design features is essential for minimizing grid-to-ground issues and datum referencing issues that construction personnel experience in the field at a job site.

The example below creates a single 3-dimensional survey point feature from feature-coded survey point data, which can be run in batch using PL/SQL:

```sql
INSERT INTO SPOT_ELEVATION_POINT
(OBJECTID, DATALINK,SPT_ELE_ID, META_ID,MEDIA_ID,SPOT_TYP_D, ELEVATION,ELEV_U_D,FEAT_DESC, FILE_NAME,USER_FLAG,FEAT_NAME, FEAT_CODE,SHAPE)
VALUES
(11771,'2000','11771', 'ESCD-LF-000020-2014', 'CJB 210601','ELEVATION',2613.972,'M', 'Bechtel Survey Location-INFOGRAFIA INTERFERENCIAS SECTOR TORRE 511 EB4-1, EB4-2','004 23-06-14, T LEV EB4-1, EB4-2 TORRE 511 DC.xlsx','1','PUNTOS DE RELLENO', '200',SDO_GEOMETRY
(3001,32719, SDO_POINT_TYPE
(475524.598,7322276.875,2613.972),null,null));```
Modeling Geometries from Survey Data

Due to cost and schedule limitations for field collection, it is often beneficial to use field data to model other more detailed geometry features using a sample of field survey point data and the Oracle Spatial SDO_GEOMETRY function.

The example below creates a linear 3-dimensional pipeline feature from feature-coded survey point data, which can be run in batch using PL/SQL:

```
INSERT INTO PIPELINE_LINE
  (OBJECTID, FEAT_NAME, FEAT_CODE, SHAPE)
VALUES
  (2,'Bechtel Survey Location','906',
  SDO_GEOMETRY(3002, 32719, null,
  SDO_ELEM_INFO_ARRAY(1,2,1),
  SDO_ORDINATE_ARRAY (
    452962.39,7334378.237,1516.462,
    452989.24,7334357.069,1517.341,
    453015.778,7334336.737,1517.861,
    453042.731,7334315.67,1518.677,
    453070.143,7334294.362,1519.574,
    453096.341,7334273.967,1520.216,
    453122.154,7334254.268,1520.905,
    453147.967,7334234.478,1521.392,
    453174.639,7334214.097,1521.569,
    453201.704,7334192.756,1522.8,
    453228.9,7334172.249,1523.623,
    453255.021,7334151.973,1524.126)));```

Oracle Spatial Database Design -
Construction Spatial Quantities and Quality Reporting Tool (SQ2RT)
GPS/GNSS Field Data Collection Process Diagram

Spatial Views for Assigning Field Collection Features to a Geographic Index Tile

This SQL example creates an Oracle Spatial view using SDO_INTERSECTION to assign field geometry features to a geographic index. When combined with other geographic indices, these attributes can be joined back to the spatial features and commodity information in a spatial view and be used as “GROUP BY” columns for summarizing quantity statistics:

```sql
CREATE OR REPLACE VIEW VGIS_AN_FIELD_COLLECT_PT_GEO1
AS SELECT
input.OBJECTID OBJECTID,
input.FEAT_NAME FEAT_NAME,
input.FEAT_DESC FEAT_DESC,
target.GEOG1_INDEX TILE_CODE,
target.FEAT_NAME TILE_NAME,
SDO_GEOM.SDO_CENTROID(input.shape,0.001).SDO_POINT.X COORD_X,
SDO_GEOM.SDO_CENTROID(input.shape,0.001).SDO_POINT.Y COORD_Y,
SDO_GEOM.SDO_INTERSECTION(input.shape, target.shape, 0.005) SHAPE
FROM
SCPX.VGIS_IM_FIELD_COLLECT_PT input,
VGIS_GD_MAP_INDEX_AREA_GEO1 target
WHERE
SDO_GEOM.SDO_AREA(SDO_GEOM.SDO_INTERSECTION(input.shape, target.shape, 0.005),0.005) is not null;
```
Creation of Oracle Spatial Database Design for Field Data Collection Quantities

The example below creates an Oracle Spatial view of 3-dimensional field collection points with decoded domain assignments and other field attribution:

CREATE OR REPLACE VIEW vgis_im_field_collect_pt AS SELECT
field_collection_point.objectid objectid,
field_collection_point.g_point_id feature_id,
field_collection_point.meta_id meta_id,
DECODE (field_collection_point.geo1_d, d_geo1.domainvalu, d_geo1.domaindesc, 'UNKNOWN') geog1_index,
DECODE (field_collection_point.fld_wkr_d, d_fldwkr.domainvalu, d_fldwkr.domaindesc, 'UNKNOWN') field_worker,
DECODE (field_collection_point.actv_typ_d, d_actgen.domainvalu,d_actgen.domaindesc,'UNKNOWN') activity,
DECODE (field_collection_point.material_d, d_genmat.domainvalu, d_genmat.domaindesc, 'UNKNOWN') material,
DECODE (field_collection_point.wrk_stat_d, d_wrkstt.domainvalu, d_wrkstt.domaindesc, 'UNKNOWN') work_status,
SUBSTR (field_collection_point.geo2_d,1,6)||'.'||field_collection_point.feat_code scope_id,
field_collection_point.feat_code feat_code,
field_collection_point.feat_name feat_name,
field_collection_point.feat_desc feat_desc,
field_collection_point.feat_num feat_num,
field_collection_point.field_time field_time,
field_collection_point.photo_link photo_link,
field_collection_point.remarks field_notes,
SDO_GEOM.SDO_CENTROID(shape,0.001).SDO_POINT.X coord_x,
SDO_GEOM.SDO_CENTROID(shape,0.001).SDO_POINT.Y coord_y,
SDO_GEOM.SDO_CENTROID(shape,0.001).SDO_POINT.Z coord_z,
field_collection_point.date_last date_updated,
field_collection_point.horz_dat_d horiz_datum,
field_collection_point.horz_u_d horiz_units,
field_collection_point.vert_dat_d vertical_datum,
field_collection_point.vert_u_d vertical_units,
field_collection_point.projectn_d projection_type,
field_collection_point.projectn_n projection_name,
field_collection_point.file_name file_name,
field_collection_point.file_ver file_ver,
field_collection_point.file_rev file_rev,
field_collection_point.narrative narrative,
field_collection_point.shape shape,
field_collection_point.se_anno_cad_data se_anno_cad_data
FROM
field_collection_point,d_fldwkr, d_actgen, d_genmat, d_wrkstt, d_geo1
WHERE
field_collection_point.meta_id = 'SCPX-IM-000003-2014' AND
field_collection_point.objectid = 1 AND
field_collection_point.geo1_d = d_geo1.domainvalu(+) AND
field_collection_point.fld_wkr_d = d_fldwkr.domainvalu(+) AND
field_collection_point.actv_typ_d = d_actgen.domainvalu(+) AND
field_collection_point.material_d = d_genmat.domainvalu(+) AND
field_collection_point.wrk_stat_d = d_wrkstt.domainvalu(+) ;

Source: Tracy McLane, Yongmin Yan and Kevin Saso.
Field Quantity Summaries with Spatial Views

The example below creates an Oracle Spatial view that tabulates the quantities metrics and summarizes them by field collection commodity and geographic indices:

```sql
CREATE OR REPLACE VIEW vtbl_im_field_collect_pt_qnt
AS SELECT DISTINCT
  vgis_im_field_collect_pt.project_id project_id,
  vgis_im_field_collect_pt.meta_id meta_id,
  vgis_im_field_collect_pt.map_tile map_tile,
  vgis_im_field_collect_pt.geog1_index geog1_index,
  vgis_im_field_collect_pt.scope_id scope_id,
  vgis_im_field_collect_pt.feat_code feat_code,
  vgis_im_field_collect_pt.feat_name feat_name,
  vgis_im_field_collect_pt.feat_desc feat_desc,
  vgis_im_field_collect_pt.activity activity,
  vgis_im_field_collect_pt.material material,
  SUM(vgis_im_field_collect_pt.feat_num) feat_num,
  COUNT(vgis_im_field_collect_pt.feat_code) total
FROM
  vgis_im_field_collect_pt
GROUP BY
  vgis_im_field_collect_pt.project_id,
  vgis_im_field_collect_pt.meta_id,
  vgis_im_field_collect_pt.map_tile,
  vgis_im_field_collect_pt.geog1_index,
  vgis_im_field_collect_pt.geog2_index,
  vgis_im_field_collect_pt.geog3_index,
  vgis_im_field_collect_pt.geog4_index,
  vgis_im_field_collect_pt.geog5_index,
  vgis_im_field_collect_pt.scope_id,
  vgis_im_field_collect_pt.feat_code,
  vgis_im_field_collect_pt.feat_name,
  vgis_im_field_collect_pt.feat_desc,
  vgis_im_field_collect_pt.material;
```
### Spatial Field Collection Quantities Web Reporting

#### Cover Sheet / Work Orders / T&M - Daily Report

Work order read from saved report. Work order created from BGCIS.

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<th>ERP #</th>
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#### Work Pay Item

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Subsurface Investigation As-Built Survey Data – Dynamic Spatial Locations from Potentiometric Pick Data

1) CREATE OR REPLACE VIEW VGIS_HY_WELL_PT_FILTER
   SELECT
   WELL_ID, SDO_GEOM.SDO_CENTROID(shape,0.001).SDO_POINT.X, SDO_GEOM.SDO_CENTROID(shape,0.001).SDO_POINT.Y, shape, se_anno_cad_data, AQUIFER_SAMPLE_POINT.OBJECTID
   FROM
   AQUIFER_SAMPLE_POINT;

2) CREATE OR REPLACE VIEW VTBBL_HY_WELL_LUT
   SELECT
   WELL_ID WELL_NAME, MAX(SE_SDO_ROWID) SE_SDO_ROWID
   FROM
   VGIS_HY_AQUIF_PT_FILTER
   GROUP BY
   WELL_ID;

3) CREATE OR REPLACE VIEW VTBBL_HY_AQUIF_PT_UNIQUE
   SELECT vtbl_hy_well_lut.well_name, vgis_hy_aquif_pt_filter.shape, vgis_hy_aquif_pt_filter.SE_SDO_ROWID, vgis_hy_aquif_pt_filter.SE_ANNO_CAD_DATA
   FROM
   VGIS_HY_AQUIF_PT_FILTER, VTBBL_HY_WELL_LUT
   WHERE
   vtbl_hy_well_lut.se_sdo_rowid= vgis_hy_aquif_pt_filter.se_sdo_rowid(+);

Equivalent of a Spatial “Select Distinct” using both spatial and basic Oracle functions
Future Conceptual Model of Bechtel Enterprise GIS Data Center Architecture

Source: Concept integrated from the Bechtel GIS Design Guide on Spatial Data Management and information on emerging technologies at the Oracle Openworld 2014 Conference (T. McLane)
Key Takeaways

• Effective Enterprise Database Design should include the Use of Oracle Spatial Functions and Spatial Views to:
  • Improve the Ability to Work with Big Data
  • Ensure Data Integrity with Quality Parameter Integration
  • Summarize and Report Field Construction Quantity Metrics
  • Streamline Data Processing Workflows

• Oracle Spatial Geometry Creation from Field Survey Data can:
  • Improve the Accuracies of Construction GIS Features
  • Minimize Grid-to-Ground Issues in Engineering Drawings and BIM Models
Questions?
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Bechtel GIS Manager

tjmclane@bechtel.com