On the Road: Transportation Programs Driving Regional Tribal Mapping Project

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Overview

- Introductions
- Tribal Mapping Project Overview
- GIS development and RIFDS
- Practical applications
- Questions
Rocky Mountain Tribal Mapping Project

Rocky Mountain Tribal Transportation Association
The Survey Grade Accuracy World Meets GIS and LiDAR
(A Planning and Design Tool)

- Survey grade accuracy in GIS system
- Coordinates and associates all surveying, engineering, and GIS projects onto one simple mathematical base
- DOTs, Land Departments, Irrigation, Tribal Housing, DNR, Forestry, Utilities and all others involved with development and mapping will be able to put all data onto one common survey grade base map.
- ACEC 2013, 2015, and 2017 Engineering Excellence Honor Award to the Blackfeet Nation, Crow Nation, Fort Belknap Indian Community, Fort Peck, and Wind River Reservations
Phase 1: 100% Complete: The purpose is to merge the survey grade accuracy world with the GIS world. The Low Distortion Projection (LDP) will allow anyone doing surveying, engineering, and GIS development to coordinate and associate all projects onto one simple mathematical base. The group received the "ACEC 2013 Engineering Excellence Award" for phase 1.

Phase 2: Priority switch, see phase 4: 1. For QC purposes control points, including High Accuracy Reference Network (HARN) points for Fort Peck were established. National Geodetic Survey (NGS) no longer maintains passive control, replaced by OPUS-DB solutions that depend on CORS. Because of NGS change the tribal mapping team has added Phase 4, CORS to the mapping project. With CORS we will be able to do same control work in 5 hours versus 100+ hours.


Phase 4 (95% complete): Tribal Continuously Operating Reference Stations (CORS): Objective: 1. Foundation for all GPS users (surveyors and GIS data collectors) 2. Enhance quality and production of survey grade GPS data 3. Technology is similar to cell towers, the closer the CORS the better the speed and accuracy of the data collected. 4. Enhance the Montana Height Modernization Program for reservation lands (see executive summary) 5. Create state of the art foundation for geodetic cts to supplement outdated NGS Ctl Mark program. The group received the "ACEC 2015 Engineering Excellence Award" for phase 4.

Phase 5 (100% complete): Tribal Real Time Network (RTN). The purpose of the RTN is: 1. establish catalyst for GPS users to georeference data 2. standardized infrastructure for machine controlled equipment including intelligent compaction. Benefits include: 1. need for user to establish permanent/permanent-base station eliminated 2. RTN can monitor its own QC 3. Loss of one station does not result in failure of system 4. and best of all "All users of the system are using a common, established reference coordinate frame", surveying and mapping has been standardized. The group received the "ACEC 2013 Engineering Excellence Award" for phase 5.

Phase 6: Phase 7: GIS Foundation: The group received the "ACEC 2017 Engineering Excellence Award" for phase 7.

Phase 8: LiDAR, 1 Foot Contours, 6" Pixel, Orthorectified Photogrammetry: The group received the "ACEC 2013 Engineering Excellence Award" for phase 8.

Phase 9: Legislative Adoption: Tribal Adoption, State Adoption 2017 Legislation: The group received the "ACEC 2015 Engineering Excellence Award" for phase 9.

Intermountain GIS Conference - Mapping Updates: Informing Professional Survey and GIS Communities: The group received the "ACEC 2017 Engineering Excellence Award" for phase 9.

Rocky Mountain Mapping Project
Phase 1: Coordinate Systems

Example: Blackfeet Coordinate System
Low Distortion Projections Locations
Phase 3

Handbook & User Guide

Free Downloads
Rocky Mountain Tribal Leaders Website
www.rmtlc.org
Resources ➔ Mapping & Surveying

or

Montana Association of Registered Land Surveyors (MARLS) http://marls.com/
Resources ➔ RMTCRS Information
Rocky Mountain Tribal Coordinate Reference System
Embed in the Software

esri

Leica

Trimble

AUTOdesk
Phase 4
Continuously Operating Reference Station (CORS)
Continental United States with Proposed MDT & Tribal CORS
Fort Peck
Poplar, MT CORS
Blackfeet CORS
Phase 4: CORS
Real Time Network (RTN) Phase 5

City of Seattle
Phase 5 – Real Time Network

RTN = Real Time Network
Phase 5 – Real Time N
RTN = Real Time Network
RTN: Current Status

Where is the system located?

State Agency:
1. State Library
2. MDT

Pilot Project:
1. Washington State
2. FarmTech: Choteau, MT  [http://farmtech.us/](http://farmtech.us/)
What program?

1. Leica Spider?
2. Trimble?
3. Topcon?
4. Geo++?

* needs to be universal
Phase 6
Survey Grade GIS Layer

Objective: Create a highly accurate and comprehensive survey grade GIS system based on GPS data.
Phase 2
Establish Passive Control Networks

Objective: Establish ground based control points for project control and quality assurance.
Phase 6d = Phase 2: Tribal Control

Use NGS, MDT, Section Corners, and ¼ Corners
Phase 6d = Phase 2: Tribal Control
Phase 2
Control Networks Passive Control
Phase 6

Data Collection

a) Survey Procedure Handbook – Done
b) Roads – Ownership, Condition, Type
c) Tribal Control Points
d) NGS Benchmarks (Prep 2022 NAV-D datum)
e) PLSS Collection Section, ¼ Corners
f) Utility Asbuilts
g) ROW, Easements, Plats to Data Base

Fort Peck CORS
Phase 6e: PLSS
Phase 6e: PLSS

Map 1.
Blackfeet Nation Survey Control Enhancement - Proposed Project Extent

- Proposed Collection Corners
- Existing Mapping Control (MSDI)

PLSS Townships (MSDI)

PLSS Sections (MSDI)

Tribal Boundary

Existing Mapping Control: 71
Proposed Collection Corners: 132*
Intersecting Townships: 81
Intersecting Sections: 2,619

*Additional collection may be necessary due to parallels and meanders

Source: ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA-USGS, AeroGRID, IGN, and the GIS User Community. MSDI.
Phase 6 – Data Collection

1. Survey Procedure Handbook

2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV-D datum)
5. PLSS Collection Section, ¼ Corners
6. Water Asbuilts
7. ROW, Easements, Plats to Data Base
Phase 6

Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type (RIFDS)
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV–D datum)
5. PLSS Collection Section, ¼ Corners
6. Water Asbuilts
7. ROW, Easements, Plats to Data Base
Phase 6
Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV-D datum)
5. PLSS Collection Section, ¼ Corners
6. GIS Data Platform
7. Water Asbuilts
8. ROW, Easements, Plats to Data Base
Phase 6 – Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV-D datum)
5. PLSS Collection Section, ¼ Corners
6. Water Asbuilt
7. ROW, Easements, Plats to Data Base
Phase 6 – Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV–D datum)

5. PLSS Collection Section, ¼ Corners

6. Water Asbuilds
7. ROW, Easements, Plats to Data Base
10 acres
Entire Townships
Bureau of Indians Land Surveyor (BILS)  
BLM – Thomas Laakso
Phase 6
Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV-D datum)
5. PLSS Collection Section, ¼ Corners

6. Water & Sewer Asbuilts

7. ROW, Easements, Plats to Data Base
Phase 6
Data Collection

1. Survey Procedure Handbook
2. Roads – Ownership, Condition, Type
3. Tribal Control Points
4. NGS Benchmarks (Prep 2022 NAV-D datum)
5. PLSS Collection Section, ¼ Corners
6. Water & Sewer Asbuilts

7. ROW, Easements, Plats to Data Base
ROW Map
Phase 7: GIS Foundation

Data source
- Street data
- Buildings data
- Vegetation data
- Integrated data

Data layers
GIS
DATA COLLECTION Everyone Benefits

In 5, 10, 15, 20 years...
In 5, 10, 15, 20 years... the survey and engineering data produced/colllected will be easily retrievable!

- ROW’s
- Easements
- Land Surveys
- Land Corners
- Utility Asbuilts
  - Water & Sewer Lines
  - Gas Lines
  - Power Lines
- Irrigations Structures
- Topographic Surveys

Who collects the data?
1) Engineers
2) Surveyors
Phase 7
GIS Foundation
Phase 8

LiDAR & Orthorectified – Photogrammetry

Objective: Obtain highly accurate topographic mapping and orthorectified aerial photography for use in planning and design projects.
Pulses vs. Returns (Point Clouds)

Lidar pulses

Lidar returns

Courtesy of USGS - Stoker
5. Accuracy Assessments

In order to verify the quality of the final ground surface, data from the ground survey conducted in the area was compared to the LiDAR ground surface. Northern Engineering and Consulting, Inc. provided 12 static GPS control points and 390 real-time kinematic (RTK) GPS measurements. The check points were distributed among multiple flight swaths. To assess the absolute accuracy, the coordinates of the RTK ground points were compared to the closest laser ground points. The table below lists the results summarized by land cover type.

<table>
<thead>
<tr>
<th>RTK Surface Type</th>
<th>RTK Survey Sample Size</th>
<th>Root Mean Square Error</th>
<th>Minimum dZ</th>
<th>Maximum dZ</th>
<th>Average Dz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Surface</td>
<td>121</td>
<td>0.189 ft.</td>
<td>-0.452 ft.</td>
<td>+0.412 ft.</td>
<td>+0.005 ft.</td>
</tr>
<tr>
<td>Short Grass</td>
<td>94</td>
<td>0.187 ft.</td>
<td>-0.415 ft.</td>
<td>+0.451 ft.</td>
<td>+0.005 ft.</td>
</tr>
<tr>
<td>Medium Grass</td>
<td>102</td>
<td>0.271 ft.</td>
<td>-0.385 ft.</td>
<td>+0.596 ft.</td>
<td>+0.140 ft.</td>
</tr>
<tr>
<td>Tall Grass</td>
<td>73</td>
<td>0.120 ft.</td>
<td>-0.142 ft.</td>
<td>+0.296 ft.</td>
<td>+0.057 ft.</td>
</tr>
</tbody>
</table>
Contour Maps – 1 Foot
Aerial Photos
Site conditions:
Other LiDAR Benefits: (4) Waste Water Lagoon
LiDAR & Ortho-rectified Photos

- With LiDAR you can design more efficiently:
  - plans can be taken to 30% without field surveys
  - permission to survey eliminated in some cases
  - hydraulic studies can be done without addition field surveys
  - water pipe sizing and water tower elevations can be designed using elevation data from LiDAR
Many Glacier Road
Phase 9: Legislative Action

- Legislative Action
  - Tribal Adoption
  - County Adoption
  - State Adoption
Various low distortion projection coordinate systems adopted by government agencies in the coterminous United States.
What is it and what can it do?

- A geographic information system (GIS) is a framework for gathering, managing, and analyzing data. ESRI

Explore, manage, visualize and analyze
GIS

What is it and what can it do?

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- Explore, manage, visualize and analyze
Needs

- A comprehensive Geographic Information System to manage and share spatially related data amongst Tribal departments and interests to improve the management, maintenance, and utilization of Tribal assets
- To create a process and strategy to accomplish this
- To create a training mechanism to enable tribes to implement the process and strategy
So why start with the Road Information Field Data System?

- The current system provided by the BIA does not provide an easily accessible visual representation of the inventory
- Being able to easily identify routes for maintenance projects, such as snow removal, is a priority for Tribal Transportation Departments
- Accuracy of data catalogued in RIFDS impacts funding through the Tribal Transportation Program (TTP)
Where to begin?

- Identify the current processes in place for cataloging Routes in RIFDS and how to access this information:
  - RIFDS training
  - Other colleagues and Tribal members with previous training and experience to identify challenges and places for improvement
  - Cooperation and communication with BIA TTP representatives
  - Cooperation and communication with end users who need RIFDS information to complete their daily tasks
Challenges Identified in Current Process:

- Visualization and identification of Routes difficult
  - Most efficient current strategy for many is to consult strip maps, narratives, and the legacy knowledge of those previously involved in submitting Routes
  - Access to RIFDS is limited and gaining access is a complicated and lengthy process, a lapse in authorization can seriously impact a Tribes ability to see and update their data
  - When former Tribal, BIA, and consultant depart, their extensive personal knowledge goes with them
  - Challenges in visualizing and tracking Routes without a spatial context leads to duplicates, overlaps, ghost trails, proposed projects since abandoned, and unintentional omissions from the system.
RIFDS
Strip Maps
Strip Maps
Strip Maps
So How Do We Improve the Process?

- Streamline the data evaluation process by creating a value-added system to improve the efficiency of data collection, attachment creation, and data input, all while creating a Geographic Information System to visualize and improve utility for end users of the information.
For each tribe, the first step is to evaluate what data is currently available:

- What is currently in a Tribal GIS?
  - Surveyed roads?
  - GPS’d roads?
  - Digitized roads?

- What is available through RIFDS?
  - Accuracy of strip maps?
  - Accuracy and presence of coordinates for section nodes?

- What is available publicly?
  - Quality and completeness of State data?
  - Quality and completeness of Census data?
  - Quality and completeness of USGS data?
Once Data Needs were Established, the rest were developed.

- A full circle approach to streamline both RIFDS entry and GIS incorporation
Vision

Getting the Data

INPUT RIFDS
Bulk uploads & other required attachments

INPUT GIS
Attribute Data to attach to GIS

PROCESSING Database

FIELD Data Dictionaries

OUTPUT GIS
Data Driven pages to Stripmaps
Sync to ArcGIS Online

OUTPUT
Database fed forms feed Inventory Data Sheets, Narratives, Attribute Tables & Bulk Input Tables
In addition to the tools described above customized additional interfaces were created to improve the ease of sharing and training, including:

- Pre-programmed queries & formulas
- Layer symbologies
- Labeling preferences
Calculate Field

#### GeoProcessing

**Calculate Field**

**Parameters**
- **ROUTE1**
- **Field Name**: RIFDS_CODE
- **Expression Type**: Python 1

**Expression**

RIFDS_CODE = calcSec(1, SECTION_NUMBER)

**Code Block**

```python
def calcSec(SECTION_NUMBER):
    if len(SECTION_NUMBER) == 1:
        return "\A\A + SECTION_NUMBER"
    elif len(SECTION_NUMBER) == 2:
        return "\A\A + SECTION_NUMBER"
    else:
        return SECTION_NUMBER
```

---

**Expression is valid**
Layer Symbology
Strip map from map series
With the creation of templates and approach, a training system was possible to bring in Tribal members to begin implementation of the system and science

Fort Belknap was the first too participate in this process with my colleague Dawn Chandler joining me for on the job training in Billings

As a result of this, the Fort Belknap roads are online
Outcomes

- Blackfeet, Fort Belknap, Fort Peck, and Wind River Tribes are in various stages of development of GIS for their TTP programs
- The final products will be hosted online
- Online hosting and sharing through ArcGIS Online:
  - Enables integration of other sources of data (federal, state, other Tribal) to create a more complete picture of Tribal assets for Leaders and decision makers.
- Enable Tribal & Departmental control of data accessibility and security settings
Next Steps

- **Error tracking & repair**
  - Utilization of new information to update existing registered Routes, including but not limited too:
    - Elimination of improper or duplicate Routes
    - Update of appropriate lengths
    - Update of nodes
    - Input of unintentionally omitted Routes

- **Continued training**
  - Training for launching and managing ArcGIS Online
  - Continued collaborative development as future challenges are addressed
TTP Project Explorer
Fire Hydrant Locate

Hydrant 10

Name   Hydrant 10
East   591342.551595
Nor   486800.506439

Zoom to  Get Directions
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