Development of GIS Database and Analysis of the Alaska/Canada Railroad Link (Alaska Segment)

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Introduction

The United States government and the government of Canada had reached in an agreement in 2005 to carry out the feasibility study for the extension of the Alaska Railroad to the Canadian Railroad system. The University of Alaska Fairbanks had received the responsibility to carry out different studies, including the Geographic Information System (GIS) database development. GIS is a form of advanced technology that is highly capable of capturing, storing, retrieving, editing, analyzing, comparing, and displaying spatial information. The five fundamental essential components of a GIS are data acquisition, preprocessing, data management, manipulation and analysis, and product generation (Star and Estes, 1990). An important feature of a GIS is the ability to generate new information by the integration of existing diverse data sets sharing a compatible reference system (Goodchild, 1993). This chapter presents the different types of data collection of the Alaska portion and the development of the GIS database and the preliminary processing & analysis as an important and inherent part of the Engineering and Technical Analysis of the project. The study area comprises of the USGS quadrangles Big Delta, Mount Hayes, Tanacross, Nabesna, and Skagway.

The data collected are topographic maps, aerial photographs, satellite imagery, Digital Elevation Models (DEMs), geologic maps, land status maps, permafrost distribution maps, mineral resource data files, seismic data, existing highway maps, and hydrographic drainage network data which covers the entire area for the alternate routes in the interior Alaska and the Skagway-Whitepass section in the Southeast Alaska (Figure **1). The scanned USGS topographic maps after mosaicing for the study area has been as the base map for the whole GIS database development and analysis. All the data were collected exploring different sources contingent upon their availability but all the aerial photographs and some of the landsat imageries have been converted into digital system from the existing photographs. The figures of the Skagway-Whitepass section has not been shown in this chapter since the HDR Inc. has prepared a separate report for that section.
All other kinds of data, including these data have now been integrated by the Gartner Lee Ltd. and made available on the following URL:
https://geoportal.gartnerlee.com/universityAlaskaFairbanks/login.aspx

The entire database of the project will be brought to the University of Alaska Fairbanks at the end of this project. A GIS server will be established at the University and all the data will be regularly maintained and updated by the University.

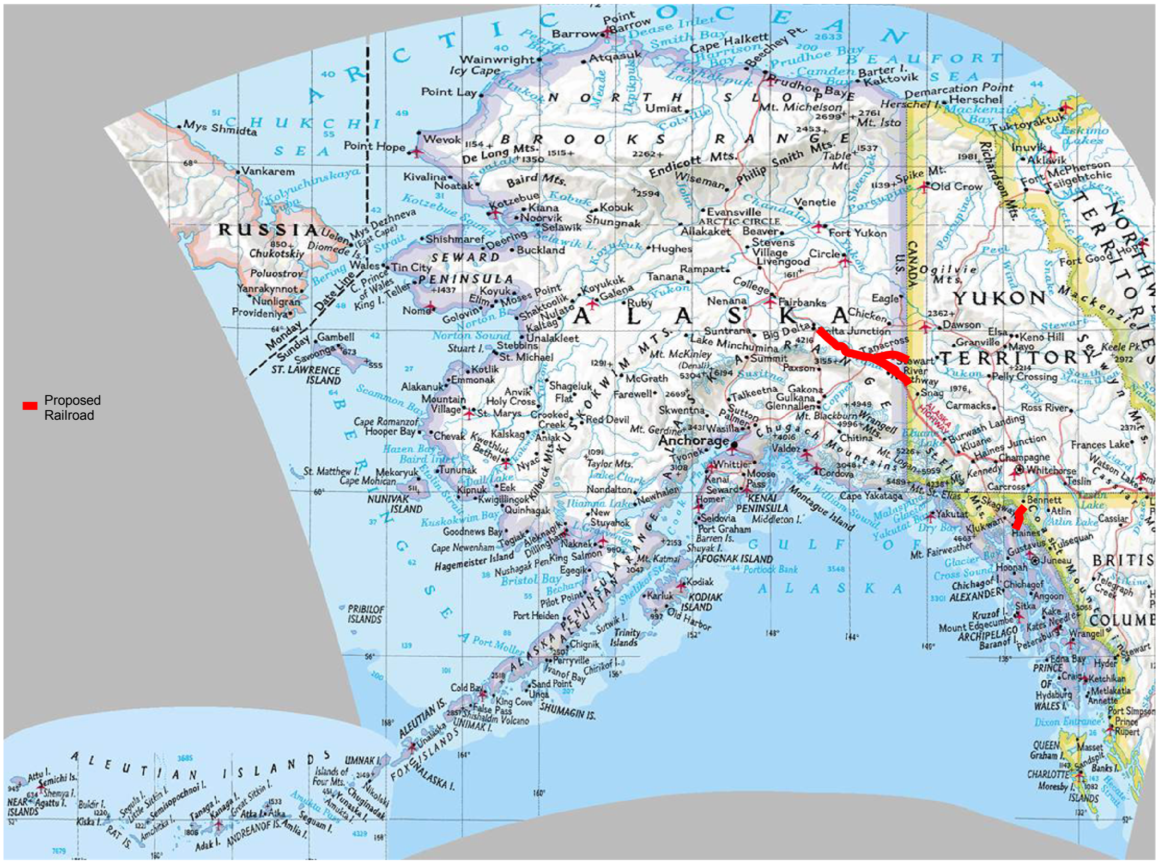

Figure 1. General Location of the Proposed Railroad within the Alaska segment.

Data Collection

The Study Area in Alaska covers the entire length of the Alaska Highway and the Ladue River from Delta Junction to the Alaska Canada Border and Skagway to White Pass following the existing old railroad.

Data sources of GIS database development for the project of Engineering Economic Analysis of the Synergistic Effects of a Multi-Modal Transportation Corridor on the Development of North Slope Natural Gas (Alaska/Canada Railroad Link) for the Alaska Portion include United States Geological Survey (USGS); Alaska Geospatial Data Clearinghouse (AGDC), Alaska Division of Forest, Department of Nature Resources (DNR); All Topo Maps, National Geographic, Department of Mining and Geological Engineering and GeoData Center, Geophysical Institute at the University of Alaska Fairbanks (UAF). Projection and georeference are handled carefully so that all the maps have consistent coordinate systems and map display. The georeference project system of the collected data varies from dataset to dataset. The most common used georeference system in the Alaska Canada Railroad Link Project is UTM NAD27 which is also the georeference system for GIS products of this project. However, there are very handy tools available in any GIS software to convert the projection system from one to another as per requirement.

The details of the data types, their sources and the processing carried out have been discussed below:

1. Topographic Map or Base Map: The USGS scanned topographic maps for Alaska State was purchased from www.igage.com with All Topo Maps and All Topo Viewer and the National Geographic (www.nationalgeographic.com/maps). There are three different scales of the topomaps available e.g. 1:250K, 1:63K, and 1:24K. For the consistency of data and the availability for the whole area, 1:63K topomap has been chosen as a base map keeping in mind that the data for the Canada portion are also available in 1:50K. The 1:24 K data would have been better detailed, however, it is available only for the Urban Areas like Fairbanks. The detailed description of the USGS scanned topomaps, georeferencing information and all the metadata can be found on the website:
http://topomaps.usgs.gov/drg/drg_overview.html

The raster maps have been exported in GIS/CAD Supporting format Geotiff file using All Topo Viewer. The collars of the every sheet of the maps have been trimmed and mosaiced in a seamless map using the Global Mapper Software (www.globalmapper.com). The maps have been mosaiced in for each quadrangle and for the entire corridor in one file format. The georeferenced map so produced in Geotiff format had been provided to Thomas Engineering as a Base map to draw the railroad alignment on it in a single file (Figure 2). It was an amazing achievement instead of using different sets of maps in terms of clarity, data accuracy, consistency and efficiency for the further products and analysis. One map covers the area from Delta Junction to the Alaska Canada Border along both the Alaska Highway Route and the Ladue River Route. The other file covers the Skagway White Pass Area.

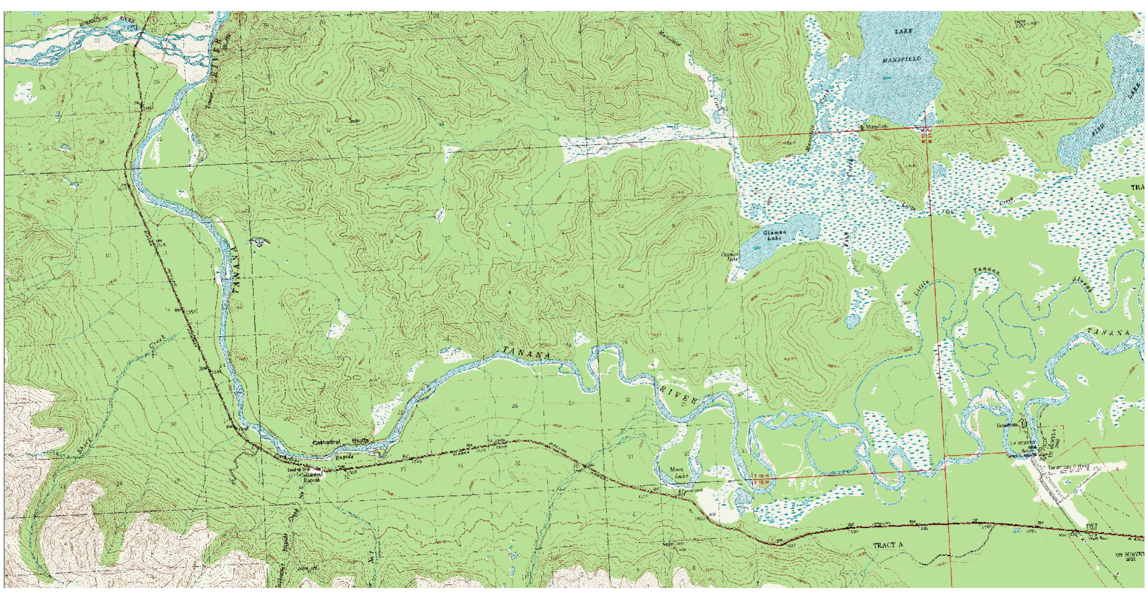

Figure 2a. Zoomed view of the topographic basemap.

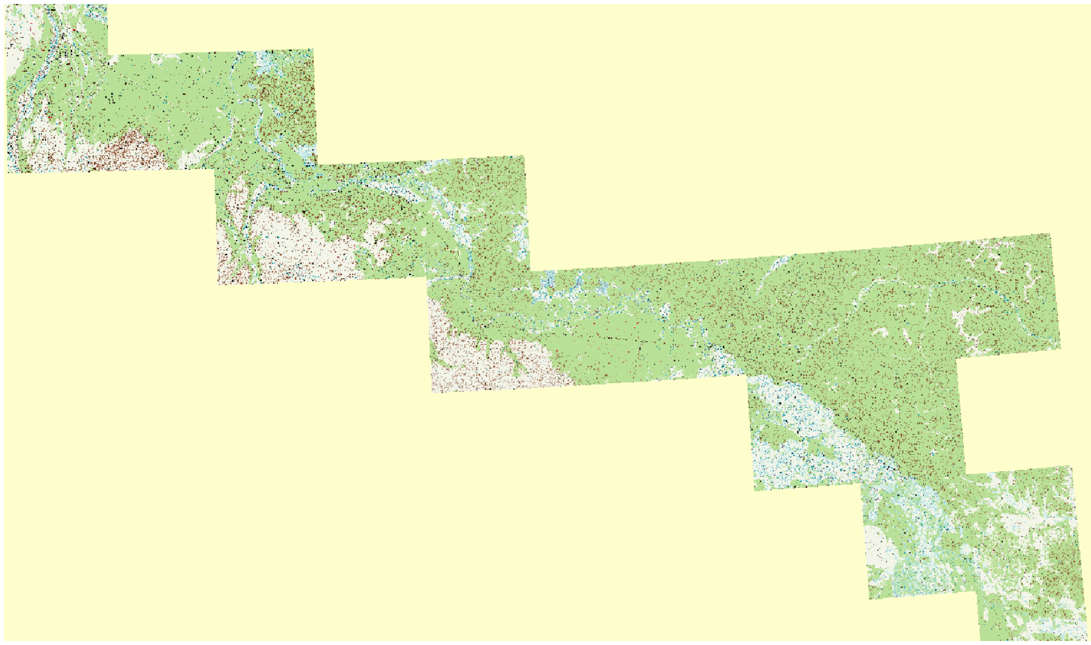

Figure 2b. The mosaiced topographic base map for the entire corridor

2. DEM data: The 15-Minute Alaska DEMs correspond to the USGS 1:63K-scale topographic map series for Alaska (http://edc.usgs.gov/products/elevation/dem.html). The data has been downloaded from USGS Alaska Geospatial Data Clearinghouse (www.agdc.usgs.gov/data) which requires some preprocessing to make it workable in ArcGIS. They were expressed in the Geographic Coordinates (latitude/longitude) and were referenced to either NAD 27 or NAD83. Gobal Mapper software was used as a comprehensive tool to display it and convert it into ASCII format and the referencing in the UTM NAD27 so that all the elevation information, the spatial information and the scale of the original data would be preserved and consistent to the basemap. The very beautiful colored view shade also has been produced in Geotiff format which contains only the spatial reference without elevation information (Figure 3). The DEM data has been mosaiced in the same aerial extent and forms as topomap so that a separate parallel layer of the DEM could be overlaid on the Base Topomap. The detailed information of the DEM data can be found in the following link:
http://edc.usgs.gov/products/elevation/dem.html

3. Mineral Resources Data: These data were collected from the following USGS website for the Alaska Resources Data Files: http://ardf.wr.usgs.gov/quadmap.html

The data has been organized by two lettered quadrangle names as shown in Figure 4. The quadrangle maps are available in 1:250,000 scale. If we click on the particular quadrangle we can browse the entire mineral resources data file in different formats. The exact equivalent of the U.S.G.S. Open-File Report for a quadrangle can be viewed and printed with the browser by clicking on the link of the "pdf" format. The data can also be downloaded in a "csv" format that can be used with a variety of data base and spreadsheet programs. The mineral resource data files are also available in "txt" format that can be downloaded and used with a variety of word-processing software. The same data is also available in the formats compatible to FileMaker Pro software.

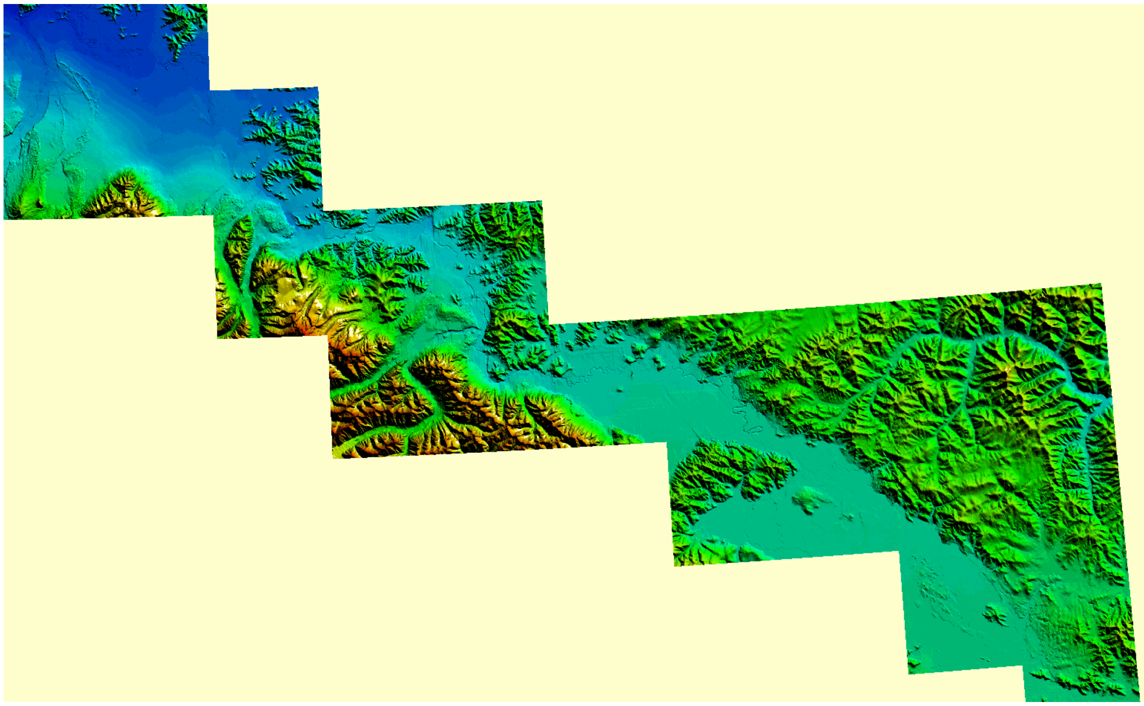

Figure 3. Digital Elevation Model (DEM) for the entire corridor.

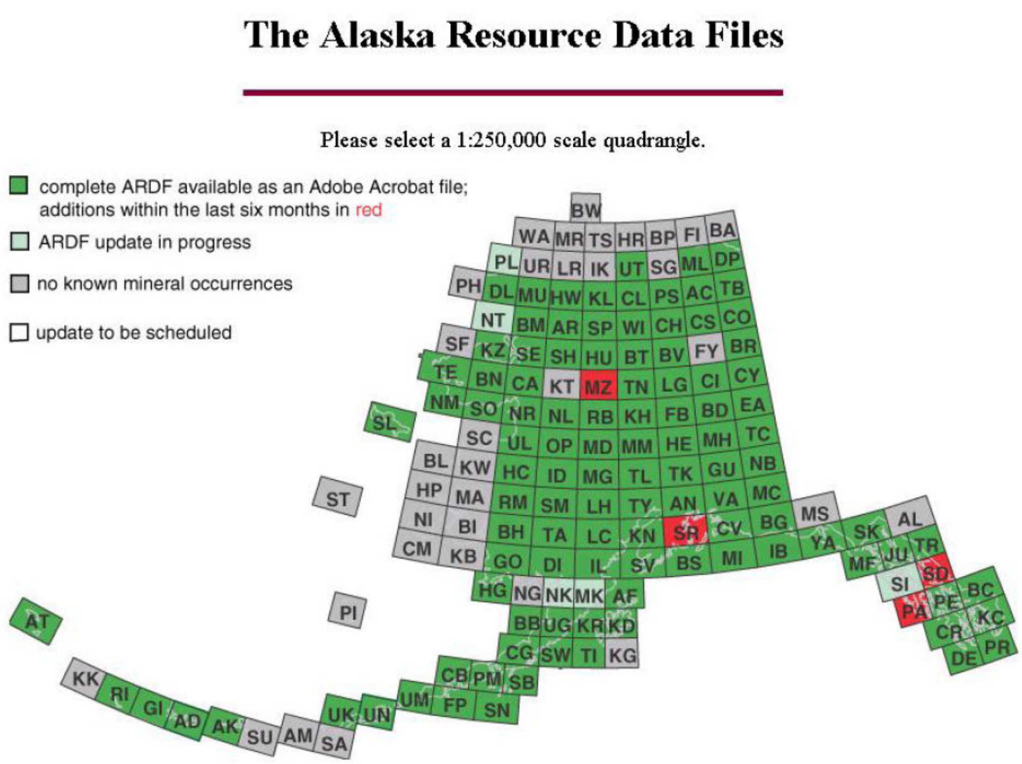

Figure 4. The Alaska resources data file index.

4. Land Status Data: These data were collected from the State Division of Lands. The land status is data is down to the township level subdivision level in some area (Figure 5).

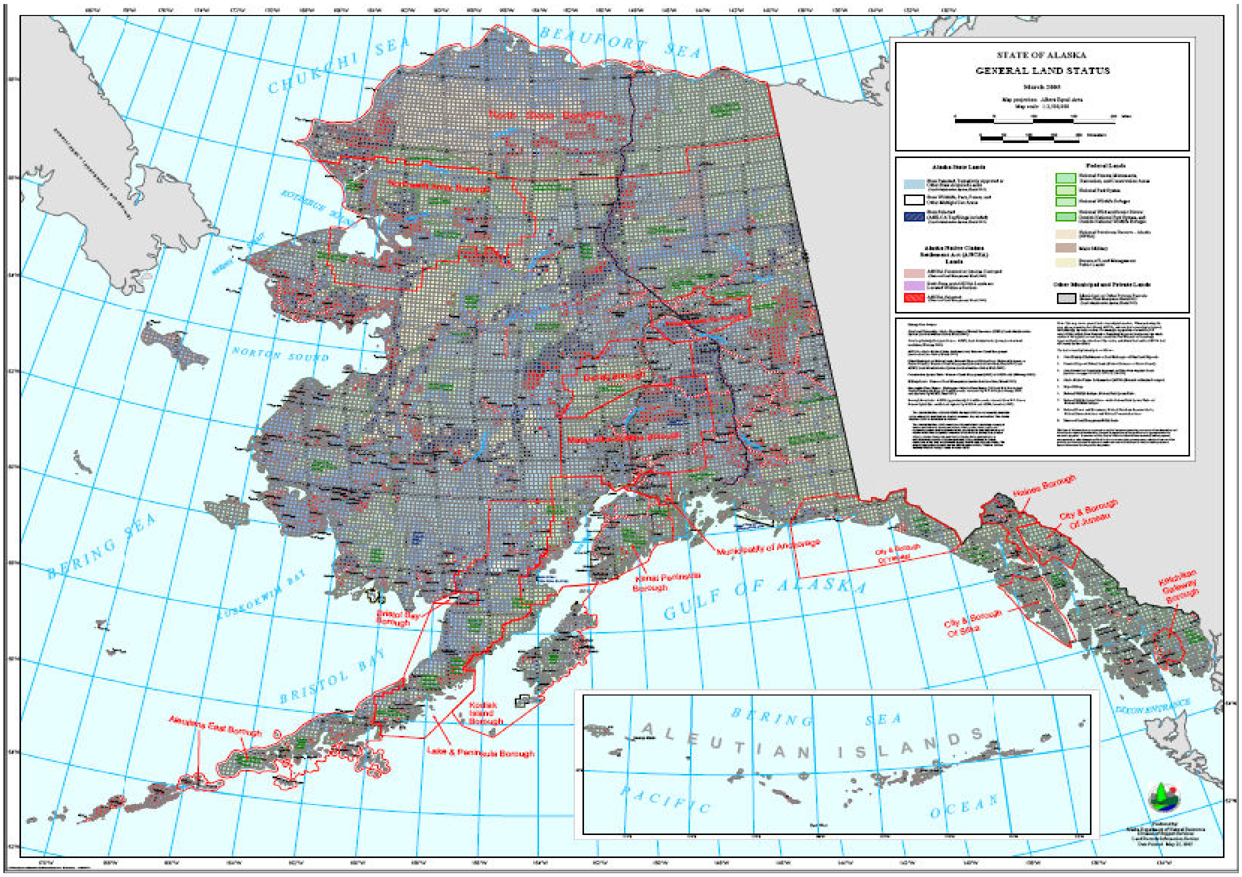

Figure 5. Land status map of Alaska.

5. Geologic Map: The geologic map of the Central Alaska was collected from the USGS open file report from: http://geopubs.wr.usgs.gov/open-file/of98-133-a/. The maps are available in pdf, eps, and the arc graphics format. The database files are available in the file formats consisting of .CSV, .DBF, .FP3, .FP5, .PDF, .TAB, and .XLS. The reports are available in the text format the MS-Word file and the tables are available in the MS-Excel and in the pdf format as in combined. Aeromagnetic and Bouguer gravity maps and data are available as the geophysics files. The metadata for the entire data is available in the above link. The map and associated digital databases are the result of a compilation and reinterpretation of published and unpublished 1:250,000- and limited 1:125,000- and 1:63,360-scale mapping. The map of the Interior Alaska has been shown in Figure 6.

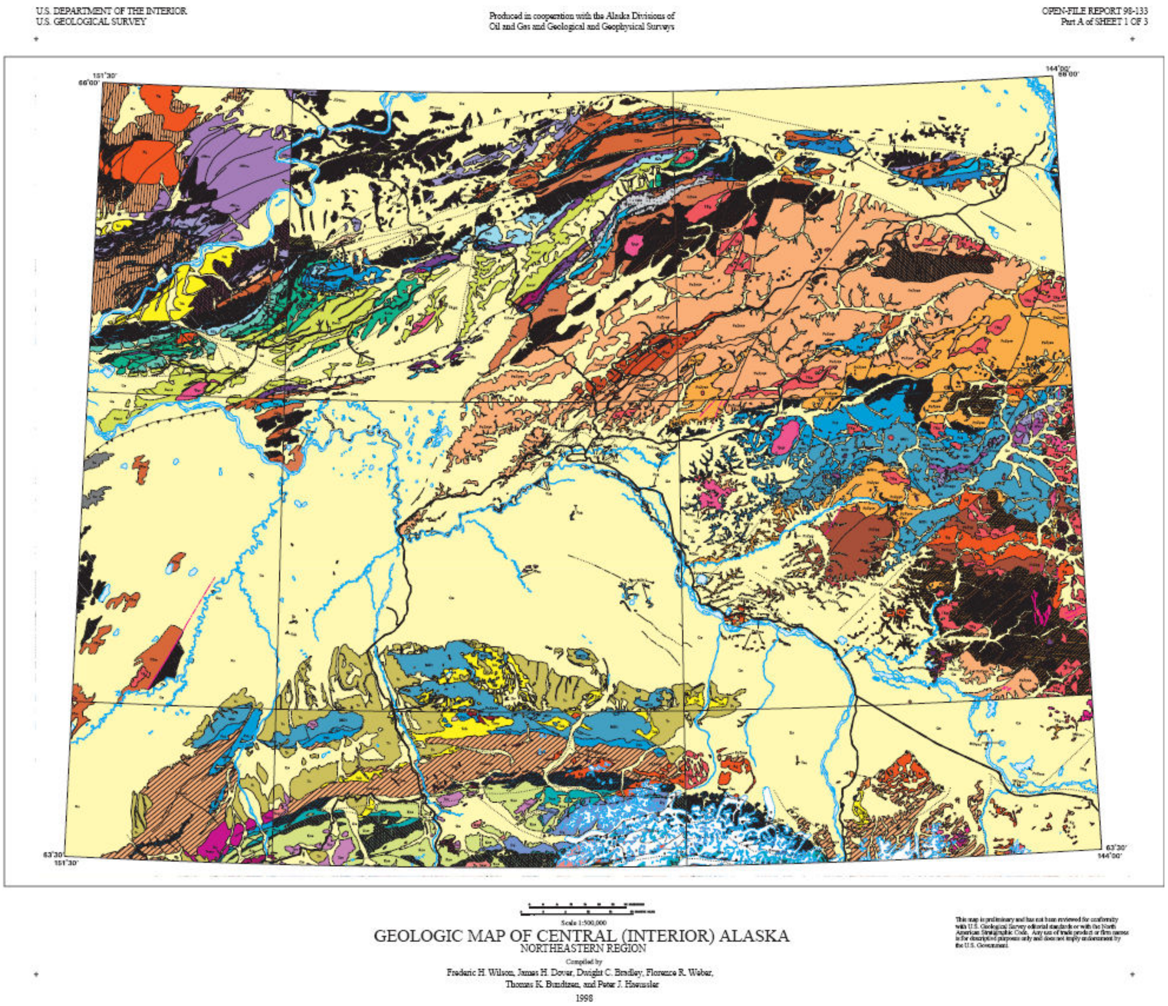

Figure 6. Geologic map of interior Alaska.

6. Permafrost Distribution Map: These were collected from National Snow and Ice Data Center. The map was originally organized by the US. Geological Survey EROS Alaska Field Office. The digital permafrost map of Alaska was originally published in December 10, 1996. The permafrost distribution as shown in Figure 7 has been downloaded from the following link:
http://efotg.nrcs.usda.gov/references/public/ak/permafrost8_02.pdf

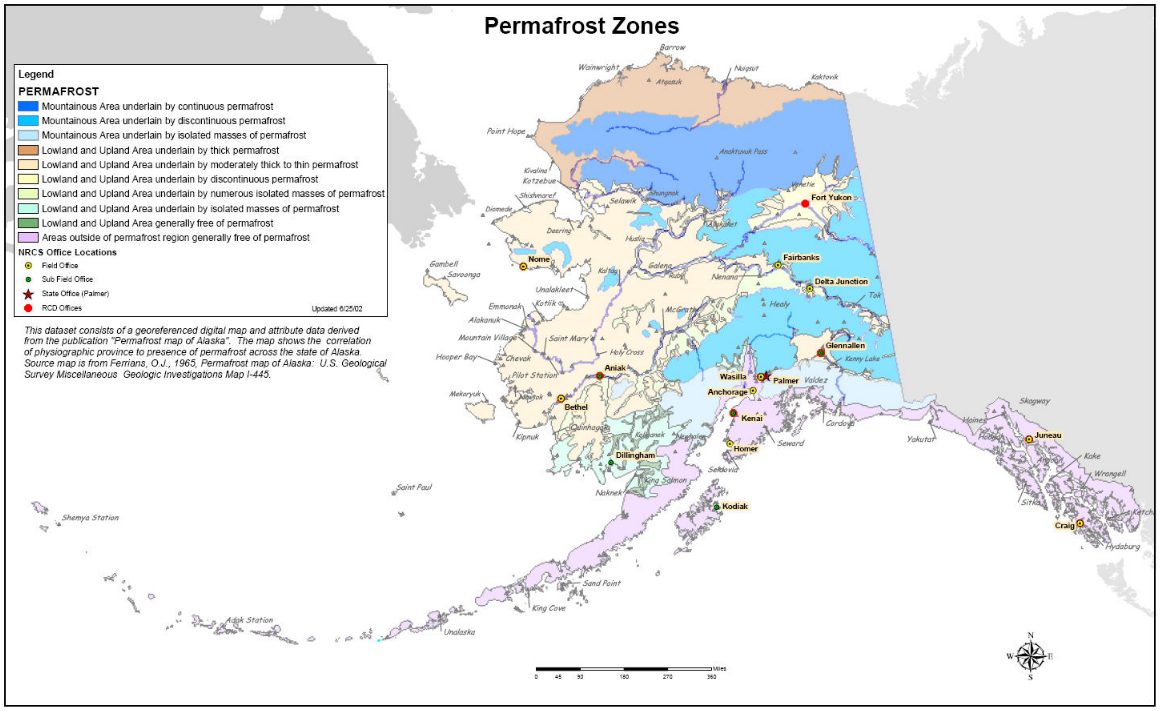

Figure 7. Permafrost distribution map of Alaska.

7. Seismic Data: these data were collected from Alaska Earthquake Information Center (AEIC), Geophysical Institute, University of Alaska Fairbanks. The data was collected based on the following two query criteria.

Query 1

```
Selection of events from the AEIC database with:
52.0 <= latitude <= 71.0
-168 <= longitude >= -130.0
0.0 <= depth <= 350.0
01/01/1898 <= date <= 02/09/2006
magnitude >= 4.0
Selected 5240 events.
```

Query 2

```
Selection of events from the AEIC database with:
     52.0 <= latitude <= 71.0
     -168 <= longitude >= -130.0
<= depth <= 350.0
     01/01/1898 <= date <= 02/09/2006
     magnitude >= 2.0
Selected 81366 events.
```

The seismicity map of Alaska as shown in Figure 8a has been downloaded from the link:
http://earthquake.usgs.gov/regional/states/alaska/seismicity.php
The map of the past earthquakes in Alaska as shown in Figure 8b has been downloaded from the link below:
http://geopubs.wr.usgs.gov/open-file/of95-624/of95-624.pdf

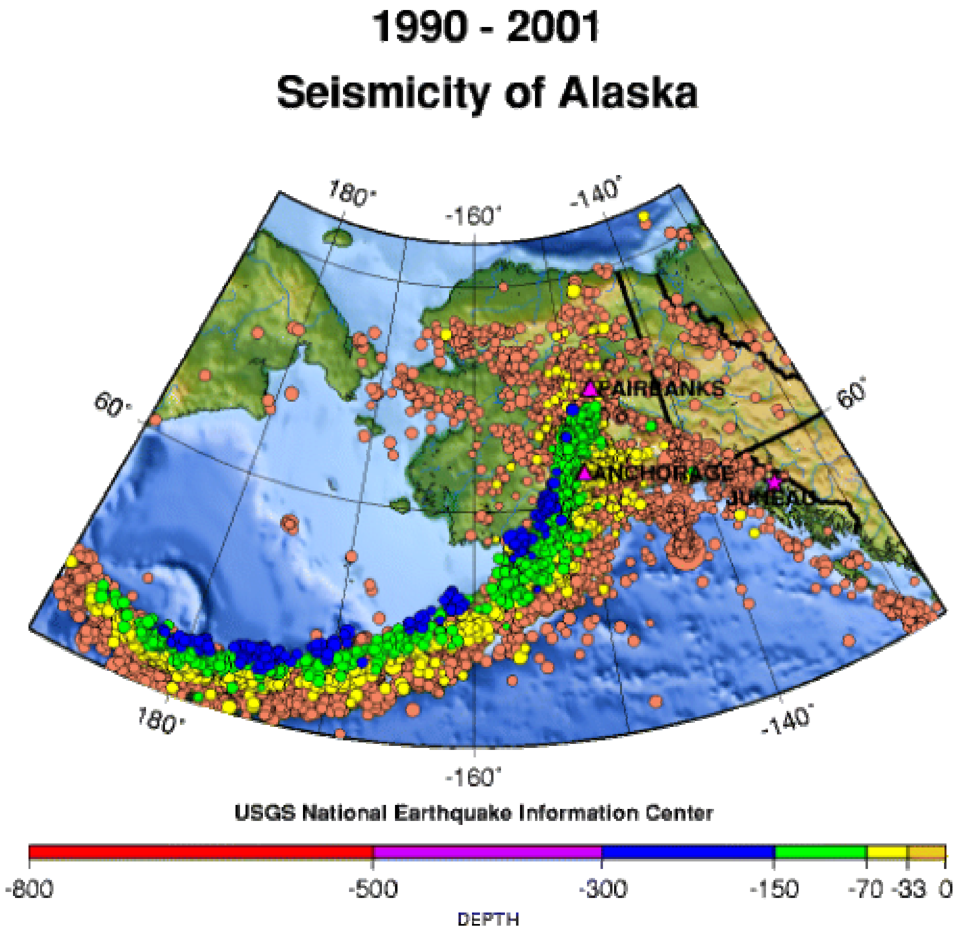

Figure 8a. Seismicity map of Alaska.

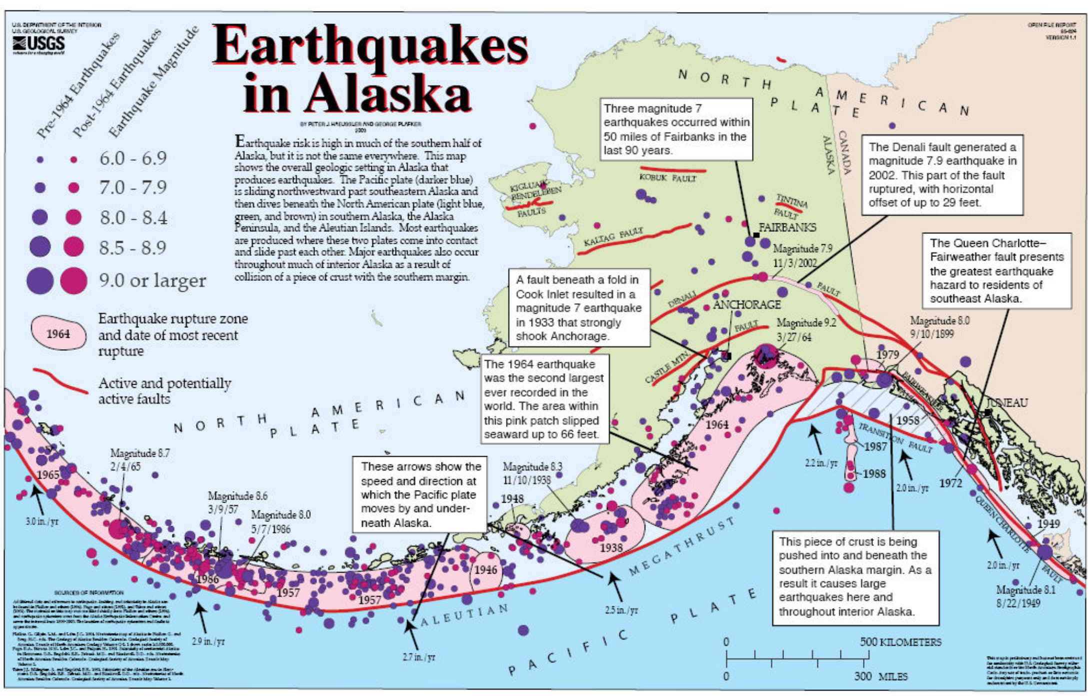

Figure 8b. Map of the past Earthquakes triggered in Alaska.

8. Hydrographic Data: The drainage network data were collected from the Alaska Geospatial data Claringhouse and converted into shape files as polygon, line and point features using Global Mapper. The projection system is UTM and the spheroid is NAD27. This covers the entire drainage network and the lakes and ponds existing in the study area. The watershed for every drainage crossing seen on the basemap along the proposed route have been digitized and saved in shape file so that it could be a very useful data for the hydrologic and hydraulic analysis for the bridge design purpose (Figure 9).

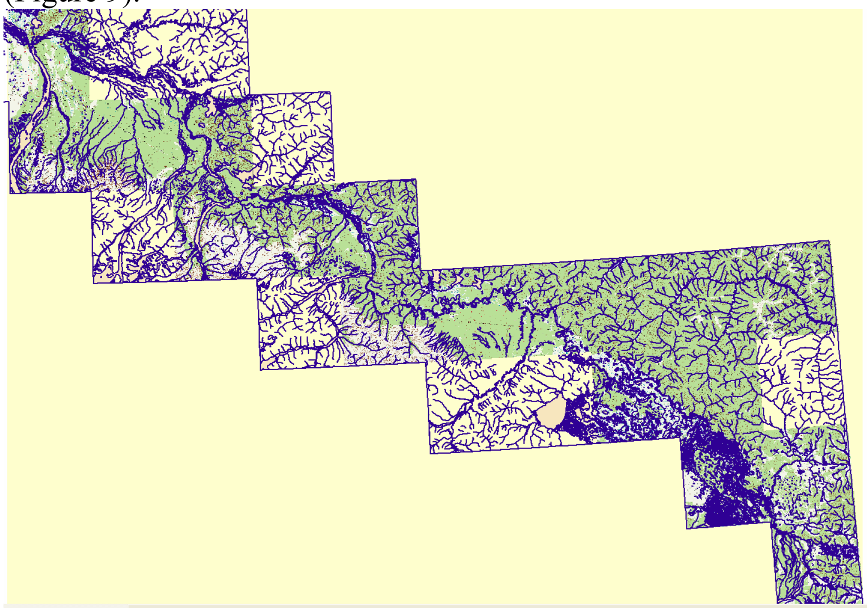

Figure 9. Hydrographic map of the entire corridor.

9. Highway data: Some part of the map of the Alaska Highway was collected from the USGS Alaska Geospatial Data Claringhouse and the remaining part was digitized from the topo basemap (Figure 10) .

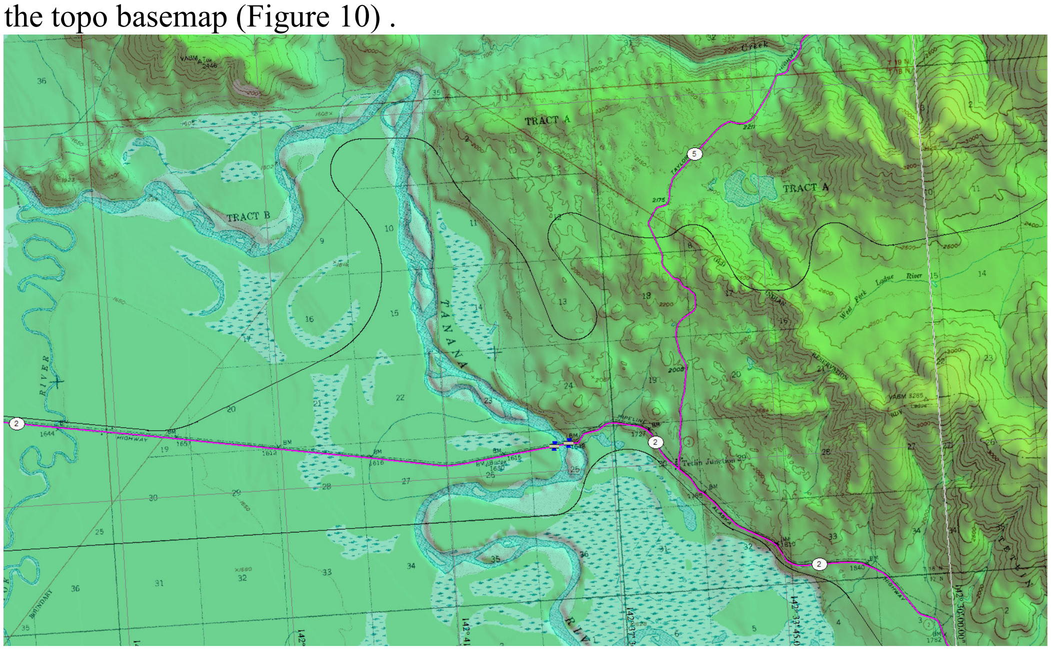

Figure 10. Map showing the Highway (pink) and the proposed railroads (black).

The satellite imageries and aerial photographs usually prove to be of most value during the planning and reconnaissance stages of a project. The information such imageries provide not only can be transferred to the base map or in the GIS database and be checked during feildwork but also help in effective and efficient planning of the fieldwork (Bell, 2004).

10. Aerial Photographs: The stereo pair aerial photographs of the late 70s and the early 80s available in the University of Alaska Fairbanks have been digitized to cover the study area (Figure 11). They were of 10”X10” size scanned at 100% and 400 dpi color. This covers the entire study area. They will be soon georeferenced mosaiced and converted into geodatabase. However, currently they are available in file based system. These aerial photographs were taken by NASA’s High Altitude Aircraft Program using an advanced multispectral scanner system and an array of high resolution camera configuration. The aircrafts were flown at the height of 65,000 ft. The scale of the photographs was focused to make compatible with the inch to a mile (1:63K) scale. Normally the aerial photographs have 60% overlap on the consecutive prints on the same run and adjacent runs have a 20% overlap or sidelap.

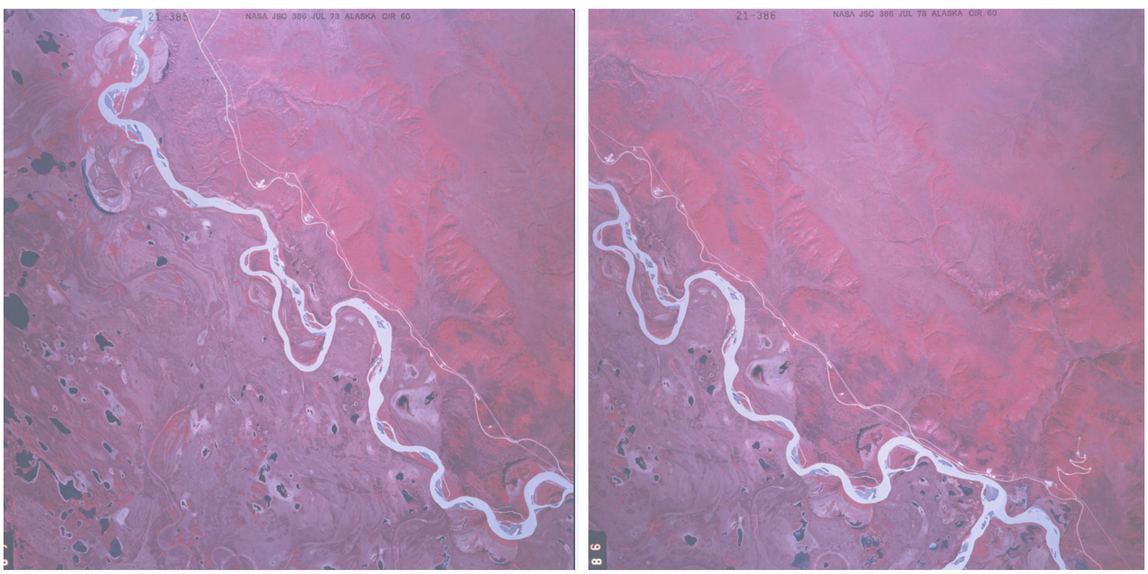

Figure 11. Maps showing a stereo pairs of the aerial photographs.

11. Satellite Imagery: The Landsat 1,2,3,4,5, and 7 Enhanced Thematic Mapper (ETM)+ scenes have been collected to cover the entire study area (Figure 12). The landsat 1,2,3 of the 70s have four bands 4 (Green), 5(Red), 6(Far Red), 7(Near Infra-red) for the area from Delta Junction to the border and a good image was not available for the Skagway Whitepass area. The landsat 1 and 2 have no panchromatic band. The image size of the landsats 1-3 is 185kmX185km and 4-5 is 185kmX170km. The approximate scale is 1:1,000,000 and the resolution of the landsats 1-3 is 79mX57m and 4-5 is 60mX60m. The scanners used in the landsats 1-5 are Multispectral Scanner (MSS). The altitude of the landsat 1-3 was 920km and 4-5 was 705 km approximately. Land sat 4,5 images of the 80s have been also scanned but they consists of the only one band in the near infra-

red region. The Land sat4, 5, and 7 ETM+ imageries of 90s and 00s have been directly downloaded from the Geographic Information Network of Alaska (GINA) website. These scenes consist of all 9 bands including the two bands of the thermal band 6 and a panchromatic band 8.
The salient features of the landsat 1-7 have been listed below:
Source: http://earthshots.usgs.gov/Help-GardenCity/Landsatstable

Landsat satellites, 1972-2000

	Launch	Decommission	Alt.	Angle	Revisit	Sensors	Data rate
1	23 Jul 1972	6 Jan 1978	917 km	99.6	18 days	MSS, RBV	15 Mbps
2	22 Jan 1975	25 Feb 1982	917 km	99.2	18 days	MSS, RBV	15 Mbps
3	5 Mar 1978	31 Mar 1983	917 km	99.1	18 days	MSS, RBV	15 Mbps
4	16 Jul 1982	* Aug 1993	705 km	98.9	16 days	MSS, TM	85 Mbps
5	1 Mar 1984		705 km	98.9	16 days	MSS, TM	85 Mbps
6	5 Oct 1993	** Oct 1993	(705 km)		(16 days)	(ETM)	(85 Mbps)
7	15 Apr 1999		705 km	98.2	16 days	ETM+	150 Mbps

```
           1972            1980                1990                2000
             | . . | . . . . | . . . . | . . . . | . . . . | . . . . | . . .
.
Landsat 1   -----------
Landsat 2        ---------------
Landsat 3              -----------
Landsat 4                       ----------------------
Landsat 5                          ----------------------------------->
Landsat 6                                            -
Landsat 7                                                       ---->
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* Landsat 4's data transmission stopped in August 1993.
** Landsat 6 crashed at launch.

The aerial photographs and satellite imageries so collected saved dozens of thousands of dollars for the project and a good database for the detailed analysis of the project.

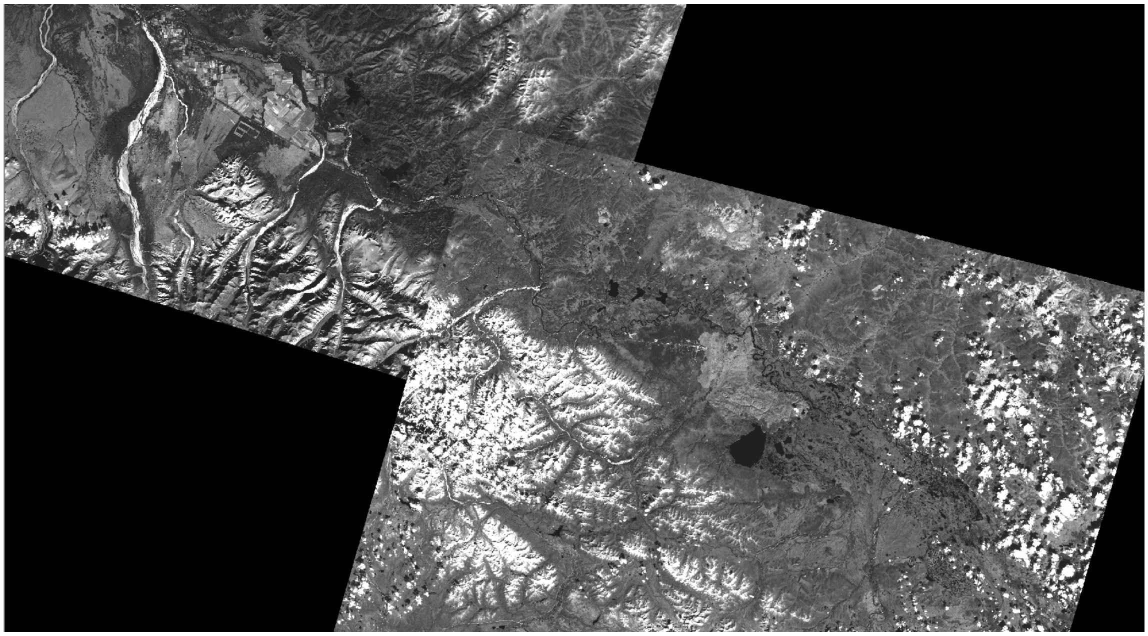

Figure 12. The mosaiced landsat 7 ETM+ imagery (band 7) covering the entire corridor.

12. The AutoCAD drawings for the railroad alignment alternates produced by the Thomas Engineering were georeferenced and converted into shape files for the GIS use and further analysis (Figure 13). The drawings alongwith the basemap on the background have been converted into pdf format with adequate resolution for the readability of the map for the users not using AutoCAD or GIS.

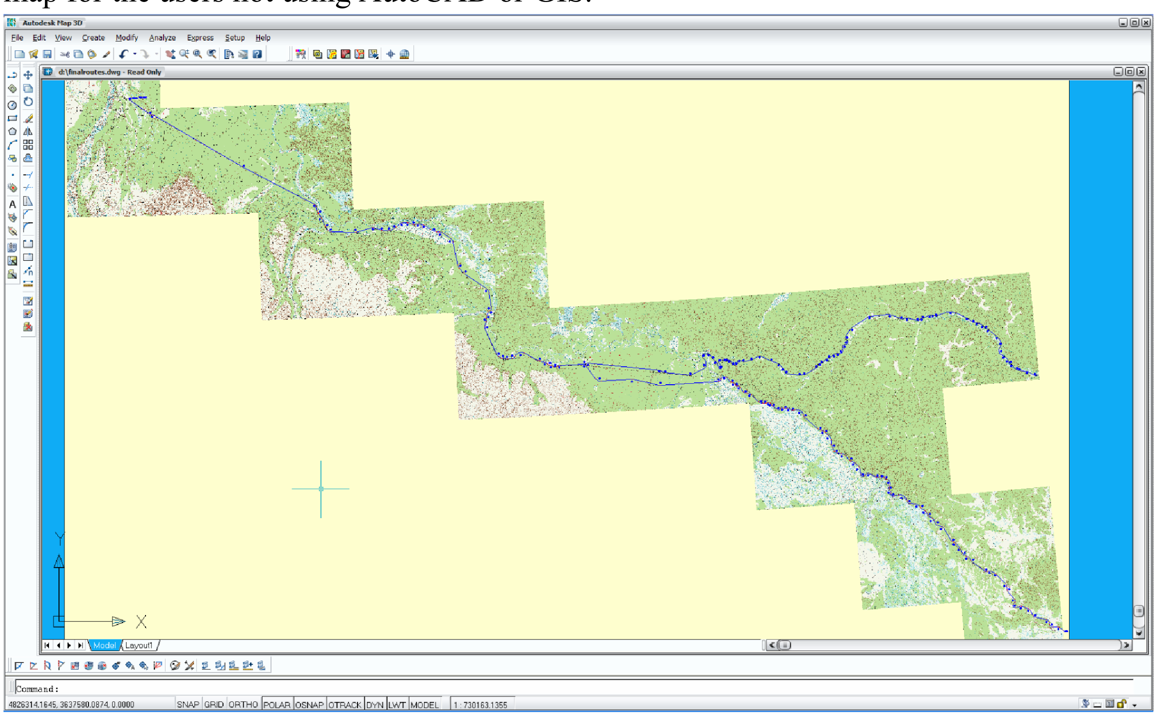

Figure 13. The map of the final alternate routes for the proposed railroad.

13. Bibliographic Data

Comprehensive bibliographic data for the BigDelta, Fairbanks, Livengood, Mount Hayes, Tanacross, Nabesna, and Skagway quadrangles have been collected from different sources. An annotated bibliography also has been prepared for Alaska Railroad that includes the extension from Eileson AFB to Delta Junction (Fairbanks and Big Delta quadrangles).

Development and Management of GIS Database

A considerable amount of data in various formats, such as image, digital, text, and tabular, is collected, complied, and integrated. Generally the DEM, topomap and the hydrographic data have been put into four different forms such as in its original form *.gz format of every inch to mile quadrangles, *.tiff (raster) and *.shp (vector) format for each inch to mile quadrangles, mosaiced into quarter million quadrangle and mosaiced for the entire corridor in a single file. The satellite imageries also have mosaiced ito single file matching the corresponding bands. So far the aerial photographs are in *tiff file. However, they are being converted into database so that a large area can be browsed in a single click. The coverages (such as shape files) are put into a database. Creating the database is critical for the entire GIS task. The database has been developed to store, display, and disseminate the information. Relational structures are developed to allow interactive linkages between graphic and tabular data, so that to facilitate information query, management, analysis and utilization. The proposed railroad route drawn by Thomas Engineering has been converted into GIS format and put into the geodatabase. UTM NAD 27 is the major projection system adopted for the GIS database so far in this project since the most of the original datasets were obtained in the same projection system.

TOPSAR DEM

A high resolution DEM (TOPSAR DEM) is produced by the Alaska SAR Facility (ASF) at the University of Alaska Fairbanks based on the NASA aero-SAR images and the GPS ground survey data. The TOPSAR DEM only covers a limited area of the entire study site due to the availability of the NASA aero-SAR images and the limitation of the distribution of ground GPS survey points. The georeference system used in the TOPSAR DEM is UTM WGS84 (or NAD83), which coincides with the georeference system for other GIS products of this project. The claimed resolutions are 1 meter in vertical dimension and 5 meter in horizontal dimension. Figure 14a shows hill shade view of the terrace generated from the TOPSAR DEM. Figure 14b is the terrain profile of A-B line shown in Figure 14a.

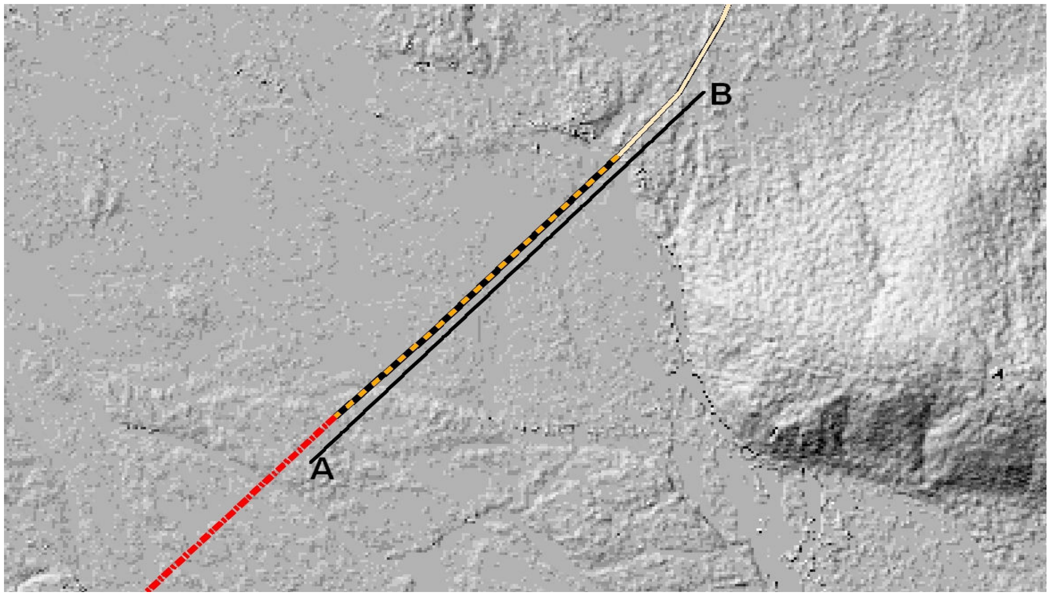

Figure 14a. Hill shade view of the terrace generated from the TOPSAR DEM.

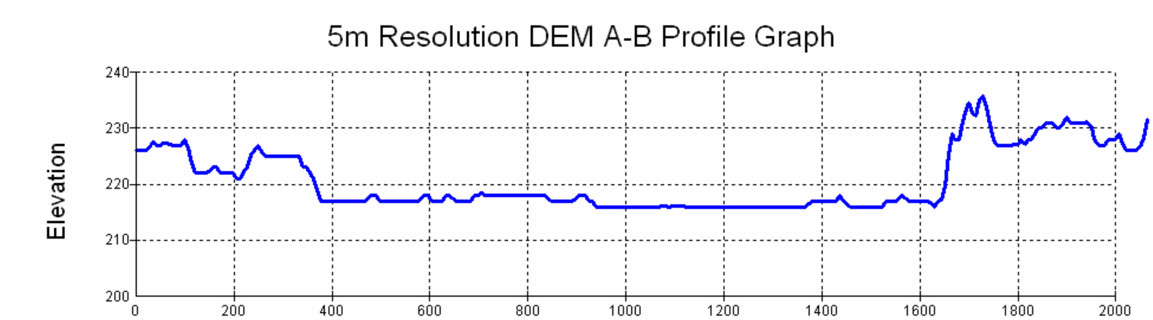

Figure 14b. Terrain profile of A-B section in Figure 14a generated from the TOPSARDEM.

Summary

A comprehensive and huge database comprising of the Topo base map, Aerial photographs, Geologic Map, Satellite imageries, Mineral resource data, Land status data, Seismic data, Permafrost distribution map, Hydrographic drainage network data, Road network of the Alaska Highway, the new rail route alignment map have been created collecting from different sources and put in GIS database system. The data was very helpful to come up with the alternate feasible routes in Alaska. The GIS database so prepared provides the backbone for the further technical analysis and detailed fieldwork and design of the proposed Alaska Canada Railroad route.

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http://edc.usgs.gov/products/elevation/dem.html

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http://www.igage.com

http://www.nationalgeographic.com/maps

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