USING GIS AND REMOTE SENSING TO ASSESS AVALANCHE HAZARDS FOR NEW ROAD CORRIDORS IN ALASKA.

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ABSTRACT: As part of HDR's Chignik Connectors Project (a road system connecting the three communities of Chignik), assessment and mapping of potential avalanche hazard areas to coincide with the transportation planning for consideration and design of route alternatives to connect the three villages of Chignik. GIS/Remote Sensing data, techniques and procedures were used for the modeling and analysis of potential avalanche hazards in this proposed new road corridor in rural Alaska. Combinations of terrain modeling, satellite imagery interpretation and weather statistics were used to locate areas prone to avalanche activity. This was used to help determine the road design and routing. It also demonstrated the hazard existed and that there is a need to have a budget for avalanche control and mitigation. The poster session will explain the steps taken to develop and deliver the project.

KEYWORDS: Avalanche Hazard Assessment, Alaska, Transportation, GIS, Terrain Modeling, and Remote Sensing.

1. INTRODUCTION

As part of HDR's Chignik Connectors Project (a road system connecting the three communities of Chignik), assessment and mapping of potential avalanche hazard areas was required to coincide with the transportation planning for consideration and design of route alternatives to connect the three villages of Chignik. The avalanche hazards required identification so that the road design could avoid these areas if possible and where it could not be avoided mitigation plans and designs could be implemented.

2. STUDY AREA:

The project area is the Southwest Alaska region where the towns of Chignik, Chignik Lagoon, and Chignik Lake are located. The study area is the mountains and valleys that surround these towns and the possible road corridors that could connect them.

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3. ASSUMPTIONS:

There is potential avalanche activity along the proposed road corridor that would require observation and mitigation.

4. METHODOLOGY:

The methodology used to make these determinations is GIS analysis of remotely sensed data by an avalanche safety specialist. Standards and procedures include: Analysis of USGS digital elevation models to ascertain approximate slope angle and aspect. Analysis of USGS topographic maps of the area to analyze the contour intervals of the areas of concern. Analysis of aerial photography (summer) to observe vegetation damage along the study area. Analysis of Ikonos satellite imagery (winter) to observe the snow pack characteristics such as; cornice build up, avalanche debris, terrain traps, and possible run out zones. Analysis of wind data from the FAA's Cold Bay weather station to find the average winter wind direction. Analysis of mountain snow pack averages from the NRCS National Water and Climate Center. The publication:
"**Guidelines for Snow Avalanche Risk Determination and Mapping in Canada"** [1]

by the Canadian Avalanche Association in 2002, is considered the North American manual on this topic at this time.

5. HARDWARE/SOFTWARE

A Pentium 4, 3G workstation with 1.5G of ram was used for the primary hardware. The GIS software used was ESRI ArcGIS ArcINFO version 9 with the Spatial Analyst and 3D Analyst extensions, as well as ArcINFO command line GRID. Excel was used to calculate the wind statistics.

6. DATA SOURCES:

Data was gathered from these sources:

1. The NRCS Data Gateway: http://datagateway.nrcs.usda.gov/
2. National Geographic Alaska Topo Series.
3. The USGS NED Dataset: http://gisdata.usgs.net/
4. The Alaska State Geospatial Clearing House: http://www.asgdc.state.ak.us/
5. National Resource Conservation Service's, Alaska Snow, Water and Climates Services Website: http://www.ambcs.org/aksnow/snow_map.htm
6. National Weather Service, Alaska-Pacific River Forecast Center: http://aprfc.arh.noaa.gov/data/stations/climate.php?site=pacd
7. Space Imaging Satellite Imagery. http://www.geoeye.com/

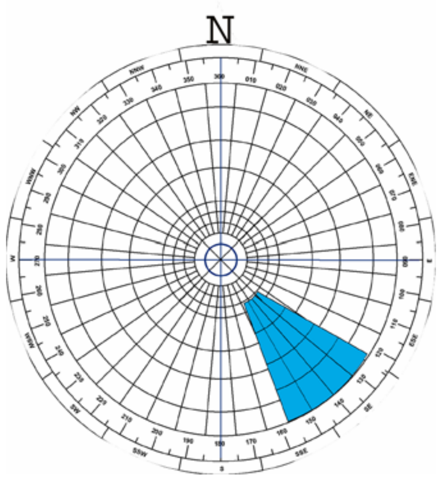
7. TECHNIQUES:

1. An ArcGIS project was built using the converted to GIS Engineering CAD data for the purposed road alignments and given a 2500ft wide buffer. This map project included a 30 Meter DEM hill shade created in Spatial Analyst,

7. TECHNIQUES CONTINUED:

1.cont. digital topographic maps, aerial photos, gis layers showing the villages, existing airstrips, streams and water bodies.

2. The daily wind direction data was acquired from the National Weather Service Alaska Pacific River Forecast Center Observation System (ASOS) located at the Cold Bay Airport, Alaska. Data was extracted from the annual records for 2000, 2001, 2002, 2003, 2004, and 2005 for the months November through April. These months were assumed to represent the winter season during which snow deposition and the resulting 'wind loading' would occur. Daily records for the winter months were aggregated and counted. Percentages were calculated for each unique record resulting in 36 unique values shown below. The most frequent (12.7% of total counts) wind direction counted was 140º for the period of record (2000 thru 2006). This information was used to generate a "Wind Rose".



3. Based on the predominant wind direction the 30 Meter DEM was modeled in ArcGIS Spatial Analyst to extract the wind loading aspects, which correlated to this. These were shaded and brought into ArcGIS. Also the DEM was modeled to were slope angles which were broken into under

25 degrees, 25-60 degrees, over 60 degrees. Both topographic map and DEM generated contours were inspected to verify these slope angles. These two GIS layers (Slope and Aspect) were then overlaid and a GIS polygon layer was generated to show where the areas of wind loading and avalanche hazard angles intersected.

4. Once this layer was created it was placed over the Space Imaging Satellite Imagery (1 meter resolution) that was captured in March 2003 along with the road corridor buffer layer. Based on these areas, close inspection of the imagery was done by zooming in and this pointed to areas that indeed had avalanche activity in the form of debris, also there was large cornice build ups which have the ability to break and cause avalanches.

8. FINDINGS AND CONCLUSIONS:

Based on the study of the data mentioned above, areas that displayed avalanche activity or could possibly avalanche and affect the potential road corridor were identified and mapped with GIS polygons. There was definite avalanche activity observed on the Ikonos satellite image. This is by no means a representation of all the areas that could avalanche. Snow and avalanche conditions change rapidly and with the data that is available there is no way to guarantee that all potential avalanche areas were identified. The following are descriptions of the figures illustrating the analysis of the project area:

Map 1: The proposed road alignment buffered by 1250 feet to either side over an Ikonos satellite image taken on March 6, 2003.
Map 2: Proposed 2500' road corridor over a digital topographic map (DRG) with hill shade enhancement.
Map 3: Proposed 2500' road corridor over an aerial photo flown in July of 2005.
Figure 4: Proposed 2500' road corridor over digital elevation model (DEM) processed to drive slope that has been overlaid on a DEM hill shade.
Map 5: Proposed 2500' road corridor on a DRG that has a DEM overlaid that is processed to display terrain aspects. This was analyzed and compared to the historical wind data collected at the National Weather Service, Alaska-Pacific River Forecast Center's Automated Surface Observation System (ASOS) located at the Cold Bay Airport, Alaska. Data was extracted from the annual records for 2000, 2001, 2002, 2003, 2004, and 2005 for the months November through April. This wind data was averaged to find the predominant wind direction for the winter months. The resulting wind rose illustrates that direction and the aspect DEM was symbolized to display this. It shows that the predominant wind loading would be on the West and Northwest aspects making these areas prone to avalanche activity.
Map 6: Proposed 2500' road corridor a digital topographic map with then areas of combined steep slopes and leeward wind aspects. The resulting analysis of Figures 4 and 5 and provided the information to create steep slope and aspect polygons to symbolize areas that have potential avalanche hazard.
Map 7: Proposed 2500' road corridor on the Ikonos satellite image with the potential and observed avalanche areas overlaid on it. Figure numbers of zoomed in areas of avalanche activity area labeled on this as well.
Maps 8 - 12: A zoomed in look on the proposed road 2500' road corridor and avalanche activity area on the Ikonos satellite image.
These images are too large to be included in this paper and will be displayed in the poster.

9. RECOMMENDATIONS AND ACTION ITEMS:

Recommendations are that further analysis by ground truth methods would be required to create a more accurate study. There is avalanche activity in the areas around the proposed road corridor and the AKDOT should have a plan for observation and mitigation.

References:

[1]Canadian Avalanche Association
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Phone: (250) 837-2435 Fax: (250) 837-4624
http://www.avalanche.ca/shop/items.html