



Colorado Statewide GIS Avalanche
Path Database.

By Douglas D. Scott
AVALANCHE MAPPING

- For many years the Swiss, Canadian and other snow scientists have been using GIS to monitor and document avalanche occurrences, snow profiles, and weather.
- The United States has had limited GIS use for this discipline. Until recently almost all avalanche and snowpit data observations were recorded on hard copy and did not have a digital spatial component.
- Current advances in technologies have made GIS affordable and reasonable to implement and distribute. This paper presents the techniques for building the avalanche atlas maps and geospatial databases, sourced from legacy and newly collected data for the State of Colorado and elsewhere in the West.

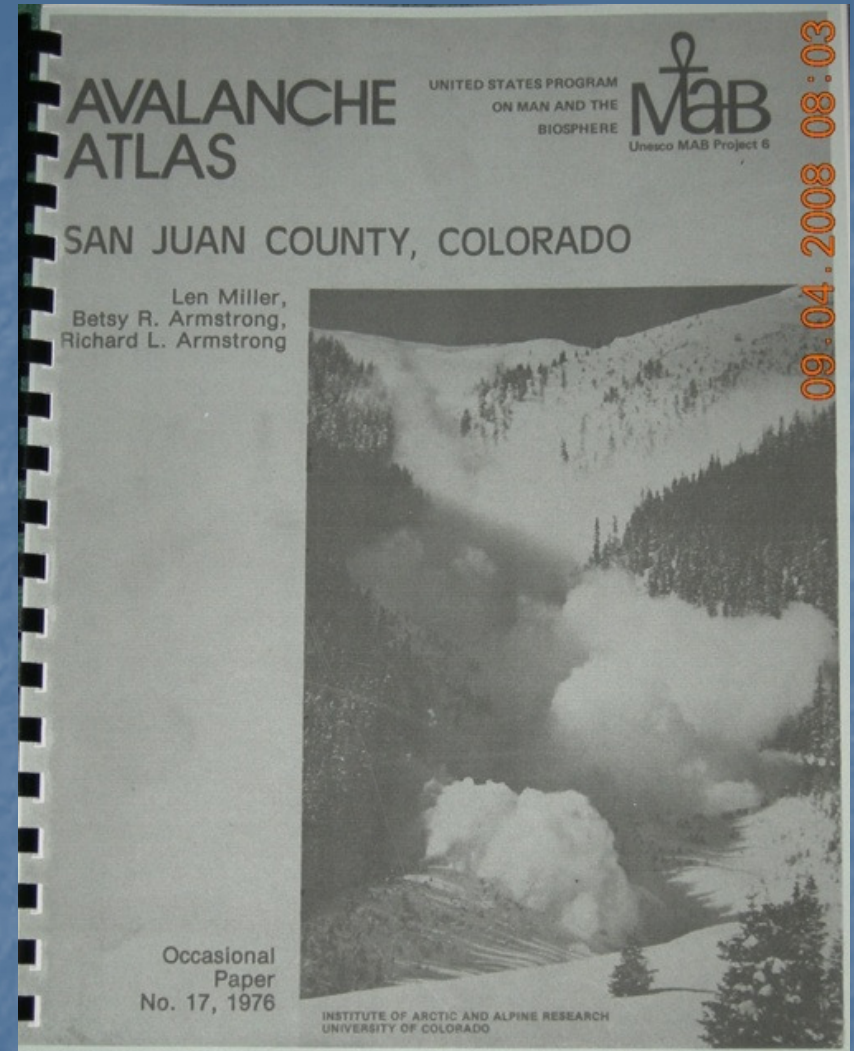
- These technology advances make it possible to bring observations and data into a GIS for referencing, modeling, and sharing.
- Historical avalanche path data is loaded into a database that can be related to the old hard copy snowpit and weather data.
- These data layers can be displayed over other GIS base layers such as DEM, DRG, DOQ, NAIP, soils/geology, and vegetation cover.
- Integration of real time weather and snow profile data can be added to this for analysis.
- Digital data collection tools can help load new data directly in to the GIS Database with little hand entry.

- The majority of the weather data is often in digital and can be linked or loaded to the avalanche and snowpit profile database as well.
- GIS base data layers such as DRG, DOQ and Satellite Imagery, provide visual information and the ability to identify avalanche terrain. These can also help in referencing the topography of the avalanche areas.
- High resolution DEMs allow various terrain analyses: mean slope, minimum slope, maximum slope, mean aspect, and curvature. When the avalanche path data is overlaid on the DEM it can be analyzed using neighbor modeling.

- Other important GIS data layers used in avalanche analysis are:
- Hydrographic (rivers, streams and lakes) data shows drainages where avalanches could be constricted by potential terrain traps.
- Geology and Vegetation layers are often combined with slope angles and curvature to help gauge friction parameters of destructive force from the various sizes of volume of the avalanche release.
- Tree ring data can help document and predict the frequency and sizes of avalanches along their tracks.
- Building, Zoning and Road data can define potential areas that will suffer destruction.

- Since 1950 avalanches have killed more people in Colorado than any other natural hazard, and in the United States, Colorado accounts for one-third of all avalanche deaths. This shows the need for better ways to store, deliver and represent Avalanche Information
- This past winter of 07-08 we had a fair amount of snow; it was a short but intense four month season, Highway 550 was closed for over fifteen days due to high avalanche hazard, mitigation and the struggle to regain the road. There were 111 natural avalanches that hit the road, they were 1' to 30' deep and covered 7,401' of highway. CDOT/CAIC triggered 178 slides that put debris 1' to 16' deep and covered 11,777' of road.














- Historical (legacy) data is used and developed into feature class reference layers in the GIS when the old hard copy hand drawn avalanche paths are digitized and loaded into a geodatabase.
- Colorado had many Avalanche atlas's and maps developed around the state in the 1970's. Most of the funded studies and data was developed during that era. Almost nothing was entered into GIS formats until the late 1990's/2000.



































- In 2004 the United States Snow and Avalanche Observational Guidelines were developed this is what Avalanche Mapping used as the template for the GIS geodatabase design. This was the first time the US has had any National standards.
- From this manual I developed a data dictionary and 3 GIS feature classes for observations. One for weather, one for the snow profile and one for the avalanche path. This geodatabase design was presented at the ESRI UC in 2007.



- For the Colorado Avalanche Information Center (CAIC) we took this a level further. We needed to break out the avalanche paths into subset layers in a Avalanche Data dataset for the different uses and applications. These are for CDOT Roads, County Roads, Ski Areas, Land Use, the Power Grid, Back Country and Accidents.

Contents		Preview	Description
Name	Type		
 AvAccidents2011	Personal Geodatabase		
 AvpathAccidents	Personal Geodatabase		
 AvPathBlank	Personal Geodatabase		
 BackCountryAvpaths	Personal Geodatabase		
 CDOTRdAvPaths	Personal Geodatabase		
 CntyRdAvpaths	Personal Geodatabase		
 ExplosivesUse	Personal Geodatabase		
 LandUseAvPaths	Personal Geodatabase		
 MapbookExtents	Personal Geodatabase		
 Obs1	Personal Geodatabase		
 Obs2	Personal Geodatabase		
 PowerGridAvPaths	Personal Geodatabase		
 SkiareaAvpaths	Personal Geodatabase		

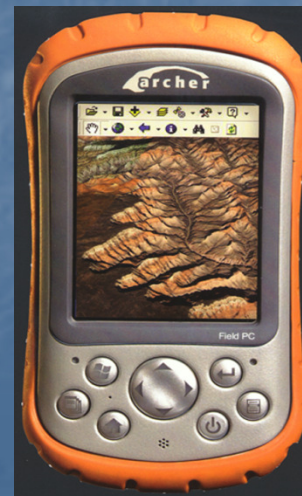
- Then we developed a detailed base data set. We have the mountain ranges of Colorado defined into 10 avalanche forecast zones based on their historical weather statistics. Also we have the weather stations across the state hyperlinked to the live weather feeds where we can see hourly updates. Other reference layers include snow machine and ski hut trails, roads with mile post , etc.

Contents	
Name	Type
 Above_7000ft	File Geodatabase Feature Class
 CDOT_Eng_Regions	File Geodatabase Feature Class
 CityBndy	File Geodatabase Feature Class
 CO_Cities	File Geodatabase Feature Class
 CO_Counties	File Geodatabase Feature Class
 CO_Mtn_Ranges	File Geodatabase Feature Class
 CO_Mtn_Summits	File Geodatabase Feature Class
 CO_Rds	File Geodatabase Feature Class
 COBndry	File Geodatabase Feature Class
 COWXStations	File Geodatabase Feature Class
 ESRIStreams	File Geodatabase Feature Class
 ForecastOfficeZones	File Geodatabase Feature Class
 ForestService_Rds	File Geodatabase Feature Class
 HIGHWAYS_2011	File Geodatabase Feature Class
 Huts_Yurts	File Geodatabase Feature Class
 HutYurt_Trails	File Geodatabase Feature Class
 Interstates	File Geodatabase Feature Class
 Local_Rds_2011	File Geodatabase Feature Class
 MILEPOINTS_2011	File Geodatabase Feature Class
 MILEPOSTS_GPS_2011	File Geodatabase Feature Class
 MjRivers	File Geodatabase Feature Class
 MtnHutTH	File Geodatabase Feature Class
 NHDWaterBodies	File Geodatabase Feature Class
 NWS_WXZones	File Geodatabase Feature Class
 PlaceNamesNonPop	File Geodatabase Feature Class
 PlaceNamesPopulated	File Geodatabase Feature Class
 Quad24K	File Geodatabase Feature Class
 Railroads	File Geodatabase Feature Class
 ROUTES_2011	File Geodatabase Feature Class
 Ski_Area_Bndry	File Geodatabase Feature Class
 SnowMachine	File Geodatabase Feature Class
 TenAvZones2011	File Geodatabase Feature Class

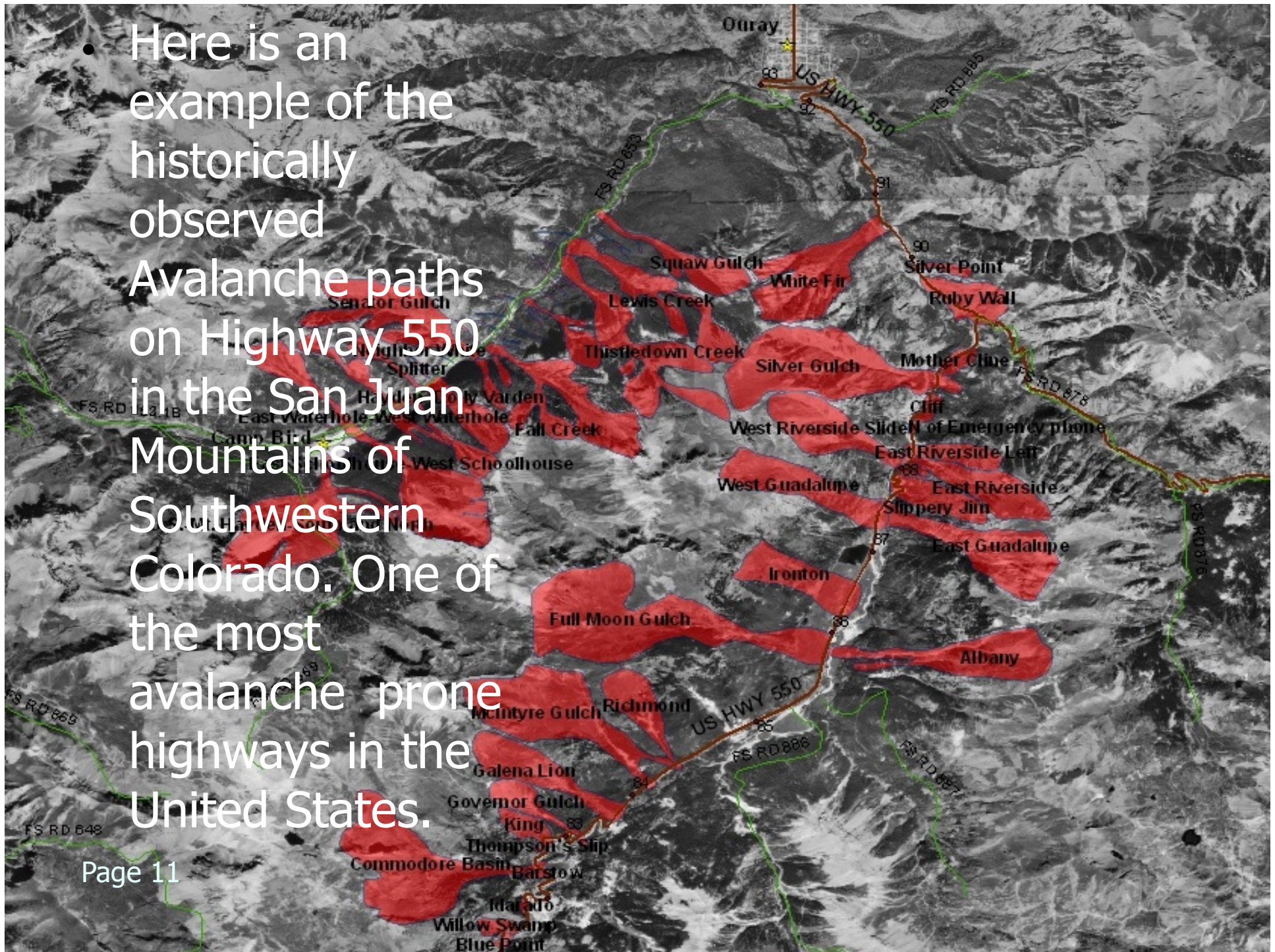
- The analyst can use the GIS to combine this historical and base data with real time weather and snow data of the area by using modern digital collection tools to assess the level of danger.
- The advent of pocket computers, mobile GIS/GPS software and laser rangefinders have made it possible to collect digital field data about weather, snow profiles and avalanche paths.

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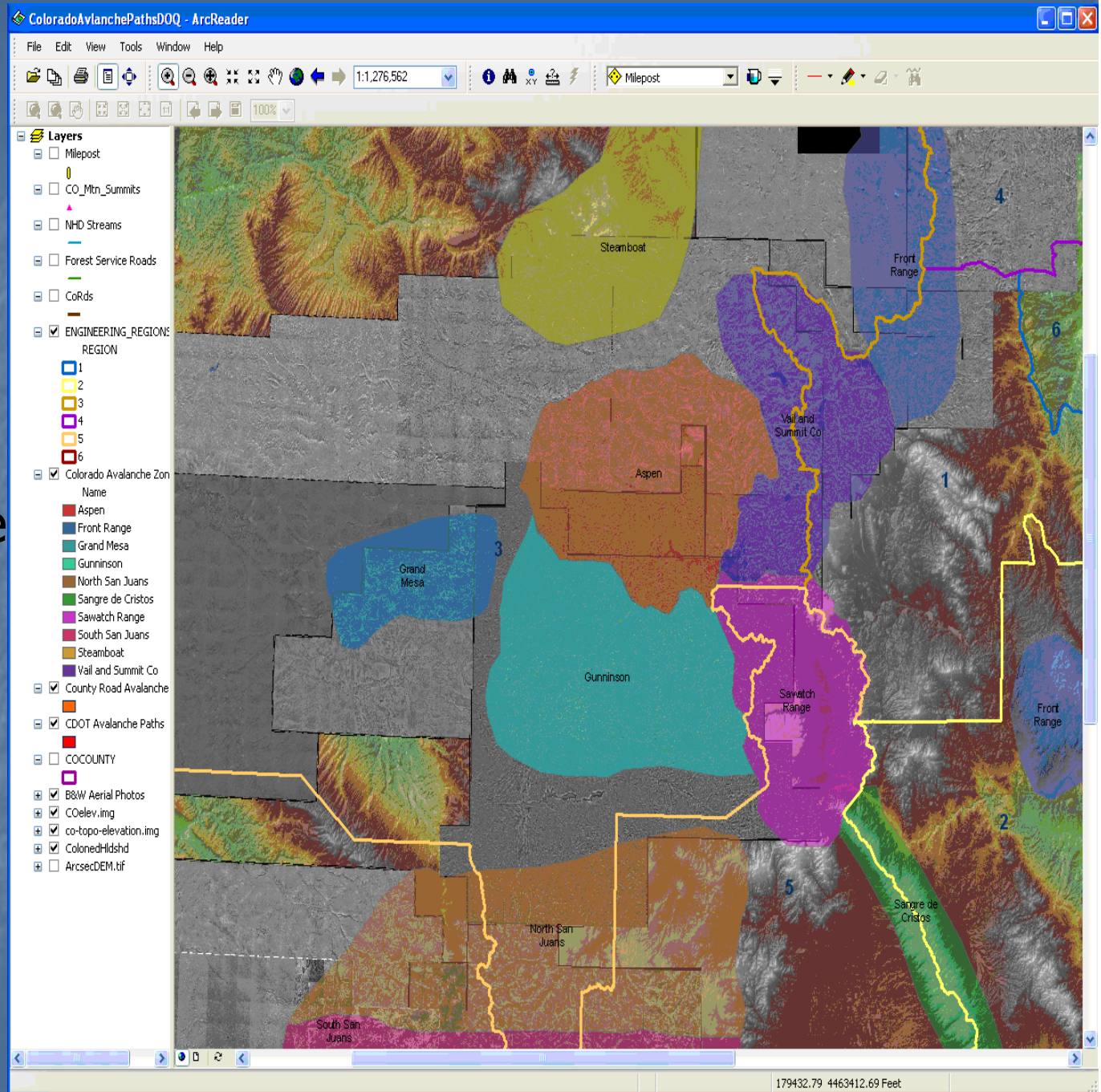
Snow Profile



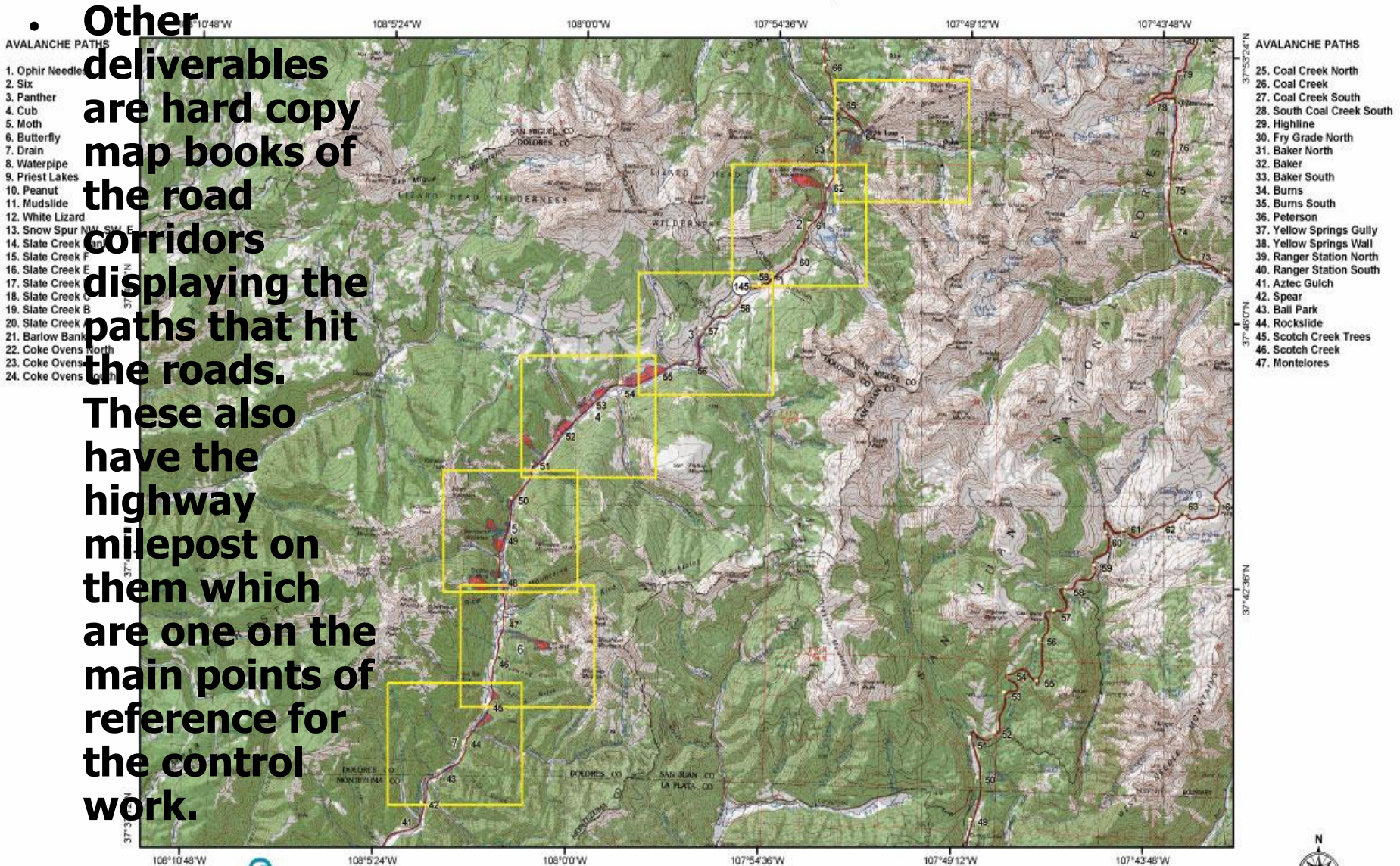
- Here is an example of the historically observed Avalanche paths on Highway 550 in the San Juan Mountains of Southwestern Colorado. One of the most avalanche prone highways in the United States.



- Current use plans by the CAIC for the Colorado Statewide Avalanche Database are to deliver an annual release of the avalanche database and mapping through the use of ArcReader in October of each year. Web Map technologies may be used in the near future.



AVALANCHE PATHS OF THE LIZARD HEAD PASS AREA, COLORADO. MAPBOOK INDEX



Other deliverables are hard copy map books of the road corridors displaying the paths that hit the roads. These also have the highway milepost on them which are one on the main points of reference for the control work.

- AVALANCHE PATHS**
1. Ophir Needle
 2. Six
 3. Panther
 4. Cub
 5. Moth
 6. Butterfly
 7. Drain
 8. Waterpipe
 9. Priest Lakes
 10. Peanut
 11. Mudslide
 12. White Lizard
 13. Snow Spur NW SW E
 14. Slate Creek NW
 15. Slate Creek E
 16. Slate Creek E
 17. Slate Creek C
 18. Slate Creek B
 19. Slate Creek B
 20. Slate Creek
 21. Barlow Bank
 22. Coke Ovens north
 23. Coke Ovens
 24. Coke Ovens

- AVALANCHE PATHS**
25. Coal Creek North
 26. Coal Creek
 27. Coal Creek South
 28. South Coal Creek South
 29. Highline
 30. Fry Grade North
 31. Baker North
 32. Baker
 33. Baker South
 34. Burns
 35. Burns South
 36. Peterson
 37. Yellow Springs Gully
 38. Yellow Springs Wall
 39. Ranger Station North
 40. Ranger Station South
 41. Aztec Gulch
 42. Spear
 43. Ball Park
 44. Rockslide
 45. Scotch Creek Trees
 46. Scotch Creek
 47. Montelores

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0 1 2 3 4 5 Miles

50 Foot Contour Intervals ORTOVOX

Data Sources: USGS 100K DRG's and DEM's. Avalanche data from CAIC/CDOT Avalanche Atlas. It does not represent all the possible avalanches that could occur.

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- **Another deliverable is the use of Mobile GIS/GPS technologies using of the Arcpad program. The Basedata, Geodatabase, and its domains have been setup to load to this and then updated with observations in the field. This gives us the ability to have near real time updates and post them back to the database for validation and forecasting and modeling. This also allows us to document with spatial coordinates our blast control work and mark dud explosives for retrieval.**



- In conclusion, it is apparent there are many benefits to using GIS and digital data technologies for avalanche and snow science. This presentation documented the various types of GIS layers and databases developed and used in avalanche mapping and documentation and their uses and deployment of the information for the CAIC/CDOT. The deliverables have been design so that even the none GIS users have access and the ability to utilize this information and data.

- Shooting an Avalanche on Highway 550



- St. Louis Avalanche Path in Ophir.



- Yellow Springs Avalanche Path in Ophir.



- Cement Fill Avalanche Path on Highway 550.



Photo By Jerry Roberts CAIC

- West Riverside Avalanche Path on Highway 550.



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