CHAPTER 2 – SPATIAL DATA SCIENCES AND TOOLS

Surveying and mapping exists within, and is greatly influenced by, a larger context of spatial data science. This broad subject area includes technologies such as information management, remote sensing, geographic information systems (GIS), the Internet, and other communication technologies. To look only at the specifics of surveying and mapping applications would ignore the significance of this rapidly changing context. Central Federal Lands Highway Division, like most other design services organizations, is asked to provide answers to complicated issues with increasingly faster turnaround, and to incorporate into them the data and analysis from a wide range of sources. The availability of off-the-shelf data sources such as stock aerial imagery and pre-packaged digital terrain data offers faster turnaround for decision makers. It also demands increased knowledge and understanding of geodetic datum, map projections, and relative accuracies for those who are charged with assembling this information. Continuing education and training programs then become an important component for any organization serious about implementing advanced technologies.

Free and inexpensive data sources were identified as one of the most valuable resources available to augment conventional surveying and mapping data collection. This value is not only from the reduced cost of the data, but more importantly from the time savings afforded. Some of the possible sources of available surveying and mapping data are listed in the following Table 1.

Table 1. Possible sources of data.

Data Type	URL	Approx. Cost
USGS Digital Ortho Quads Black and white ortho imagery, 1 meter pixels, 1:12,000 plotting scale	http://wgsc.wr.usgs.gov/doq/	Inter-Agency Agreement
USGS Digital Elevation Models 10-30 meter posting, 7 meter RMS	http://edc.usgs.gov/products/elevation/dem.html	Inter-Agency Agreement
BLM Public Lands Survey, GCDB Shape files (ESRI) of Public Lands Survey System, Sections, Township and Range	http://www.lsi.blm.gov/lsis/map.htm	Free
Airphoto USA Orthophoto Annual color ortho imagery, 0.5-1.0 meter pixels, predominantly metropolitan areas, available from various vendors and distributors, county-wide data bundles	http://www.airphotousa.com/	$50/Sq. Mi.
Satellite Data Largest of several vendors: True color and multi-spectral imagery up to 1 meter resolution, Digital Elevation Models, 12 meter posting, 7 meter RMS	http://www.spaceimaging.com/	Min 100Km^2 GSA Pricing

Digital ortho imagery is enthusiastically embraced for project planning and design at CFLHD. Standard products for every new photogrammetic mapping project are black and white, ortho-rectified imagery, at a resolution of 1 meter pixel size. Image files are referenced into plan and profile sheets, and are often used for various exhibits and site studies. One of the unique applications CFLHD has employed to distribute aerial imagery to a wider range of audiences is an Internet application called Terra Explorer by Skyline Software Sytems http://www.skylinesoft.com/. Terra Explorer provides an on-line interface to 3-D ortho imagery where users are able to view a project from any angle, or fly through a project zooming in and

out at will. The Skyline Software site has stock imagery of many major cities and prominent landmarks. A more powerful tool available through the site is the ability to have unique project data converted to the Terra Explorer file formats and posted for access by others on a project team. Similar applications to Terra Explorer have been developed for specific CFLHD projects and distributed to decision makers on interactive CD ROM (see: Bear Tooth Highway , WY04, US Route 212, for an example).

Remote sensing is a common theme for much of what is included in this study. These technologies are particularly appealing to the Federal Lands Highway Divisions as by nature they can afford "don't touch" capability needed to successfully work within the sensitive, and sometimes hazardous, areas encountered. The following is a list of remote sensing applications and their contrasting characteristics:

Table 2. Characteristics of remote sensing applications.

REMOTE SENSING TECHNOLOGY	CHARACTERISTICS
Satellite Imagery	Relatively large coverage areas >10^2 Km Up to 1 meter resolution Available in visible light and beyond visible spectrum Current data can be costly $1,000 and up
Aerial Photography	Stock data available for urban areas at low price Project specific missions are common Familiar data products, topography ortho imagery USGS Ortho Quads by inter-agency agreement
Light Detection and Ranging (LiDAR)	Design-level DTM data (1 meter contours) Mass points only, no breaklines or imagery Very dense point spacing (3 meters or less) May or may not penetrate vegetation
Synthetic Aperture Radar (InSAR)	Satellite based or high-level aircraft Uses radio wave signal Planning-level DTM data Multiple passes for accurate change detection (<10cm)
Reflectorless Survey Total Station	Laser measures discrete points (e.g. radio tower) Survey accuracy (<5cm) Beam diffraction (e.g. around corners, narrow angles)
Laser Scanning	Very dense point cloud (10cm or less) Extreme point accuracies possible (5mm) View angle not favorable for ground topography Sophisticated software for mapping geometric objects