

Current Trends in Highway Design

Presented by

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Federal Lands Highway



Columbia, Missouri

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Computer Simulation of
CA 224, Bautista Canyon



Overview of Today's Topics



*Monarch Pass,
Colorado*
way

*Grading
with 4-Horse
Fresnos*

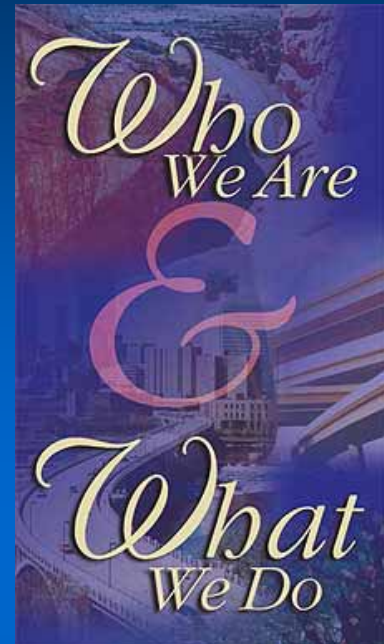
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Who is Federal Highway?

- Federal-aid Highway Programs
- Federal Lands Highway Programs
- Our Vital Few Priorities
 - *Safety*
 - *Congestion Mitigation*
 - *Environmental Stewardship and Streamlining*
- 52 Federal-aid Division Offices
- 3 Federal Lands Division Offices
- 4 Resource Center Offices



WWW.FHWA.DOT.GOV

FHWA FIELD OFFICES



Why Federal Lands Highway?

- Provide public road access to and within Federal Lands
- Provide engineering and technical services to the Federal land management agencies (FLMAs) and the transportation community
- Implement transportation technology
- Provide training and technical support

Federal Lands Highway Facts

- Federal Lands are 30% of the land in US
- Travel - tourism is the third largest industry in the US and is the largest employer
- There are over 500,000 miles of Federal land management agency roads
- Recreation is growing at a rate of 5% annually
- FLH administers the oldest road program (1914 - Forest Highway Program)

FLH Partners/Customers

- National Park Service
- Forest Service
- Fish and Wildlife Service
- Bureau of Indian Affairs
- Department of Defense

FLH Partners/Customers (cont'd)

- Native American Tribal Governments
- Other Agencies – BLM, BOR, COE
- State DOT's
- Local Governments – D.C., Towns, Counties
- FHWA Division Offices, Resource Center

Types of FLH Projects

- High Volume Urban Parkways
- Rural Parkways in National Parks
- Low Volume Rural Local Roads
- City Streets, Avenues, and Corridors
- Special-purpose Roads
- Scenic Overlooks and Parking Areas
- Pedestrian and Bicycle Facilities
- ATS: Alternative Transportation Systems
- ITS: Intelligent Transportation Systems

FLH's Perspective:

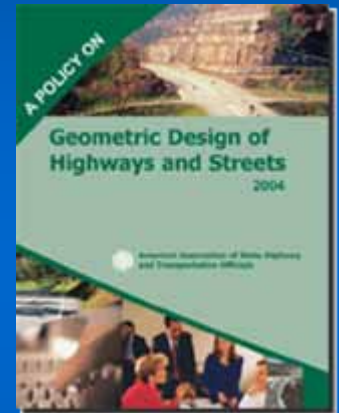
- Long-standing partnerships with FLMA's
 - Sensitivity to FLMA goals and values
 - Collaborative decision-making
 - Use expertise gained from partner agencies
 - Share complementary knowledge & skills
- National Perspective
 - Partner with many agencies and State DOT's
 - Broad geographical coverage
- Able to accommodate other agency standards
- Partners expect delivery of value and quality
- Retain Federal stewardship responsibility

Data and Performance

- Quality data and tools needed for effective engagement of stakeholders and public
- Understanding the basis for design criteria results in a higher level of performance
- Facilities in sensitive environments face higher demands for performance
- Analysis, engineering, and construction all need to be accomplished with ever higher levels of thinking, performance and quality

Performance Oriented Geometric Design Analysis

- Current design practice bases criteria on conditions, not performance
 - Functional Classification
 - ADT
 - Urban/Rural
 - Design Speed
- Compares existing versus recommended
 - Does not quantitatively characterize future performance
 - Does not evaluate the driving task
- Output of analysis is simply dimensions, not performance indicators



Performance Oriented Geometric Design Analysis

- Future trends will be to base design criteria on performance measures
 - Safety performance/consistency
 - Operational performance/reliability
 - Infrastructure performance/sustainability
 - Driver performance/human factors
- Compares predicted versus what is needed
 - Accurate prediction tools to characterize future performance
 - Considers the driving task and experiential values
- Output of analysis is performance indicators to support increasingly difficult decisions



Interactive Highway Safety Design Model (IHSDM)



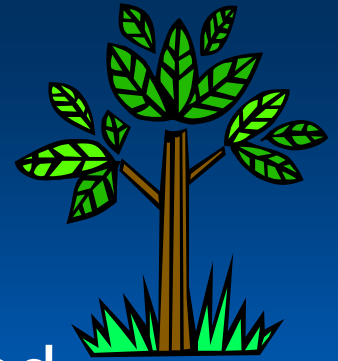
- Making Safety a Priority in Roadway Design
- Decision-support tool
- Five evaluation modules
 - Crash Prediction
 - Design Consistency
 - Intersection Review
 - Policy Review
 - Traffic Analysis
- Library of the research reports

Interactive Highway Safety Design Model (IHSDM)



- Download free-of-charge from <http://www.ihsdm.org>
- Quantitative analysis of expected safety and operational performance
- For two-lane rural highways
- Automated for CADD Design
- Compatible with GEOPAK and InRoads

CSS Approach



- Outcome satisfies the purpose and need
- Explores alternatives that equally address goals for safety, mobility, protection of the environment, and reflect community values
- Involves a collaborative, interdisciplinary approach, and effective use of resources
- Involves stakeholders, resource agencies and the public as a part of the design team
- Ensures that outcomes adequately address safety and mobility, and add long term value



Balanced
Goals



Why Does FLH Emphasize Context Sensitive Solutions?

- Enables FLH to achieve its vision

- FLH Vision:

Create the best transportation system *in balance with* the values of Federal and Tribal lands

FLH Approach to Delivery

- Facilitate early public involvement, integrated with scoping, to establish purpose and need
- Utilize an interagency, multi-disciplinary team based on identified needs, purpose and scope
- Maintain continuous communication and feedback among partners and stakeholders
- Collaborative decision-making with stakeholders
- Understand the context to guide alternatives which address mobility and safety needs

Recommended Practices

- Verify sound, factual basis for purpose and need
- Be flexible to consider alternative, corridor-specific design criteria that meets the need
- Understand basis for design criteria, and how it affects operational performance and safety risk
- Continuously adjust ever finer, the details that result in a more closer fit to the site conditions
- Follow proven processes that attend to the details affecting quality, across all disciplines
- Draw on lessons the road's history can teach

CSS is Data-intensive

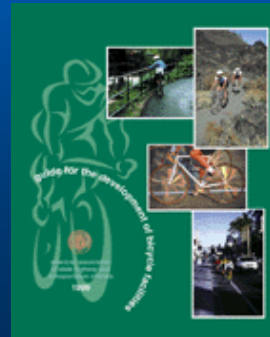
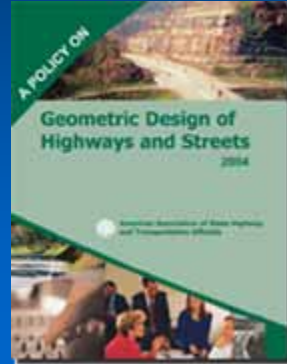
- Greater awareness/understanding of competing goals and values
- Knowledge of both the users' needs and the affected community (context)
- Accurate traffic and crash data to identify safety and mobility needs
- Safety-conscious scoping is emphasized to assure deficiencies are recognized and goals are achieved
- Precise surveys and mapping are needed to best fit local conditions

Leverage the Technology

- State-of-the-art interactive highway design and CAD software for quality and productivity
- Continuously upgrade workstations, plotters, servers and network to utilize latest tools
- Maximize integration of geospatial data from all sources (GIS, web, satellite, terrestrial)
- Interchange and share data and design information across all technical disciplines
- Use the survey, mapping, terrain and design modeling from planning through construction

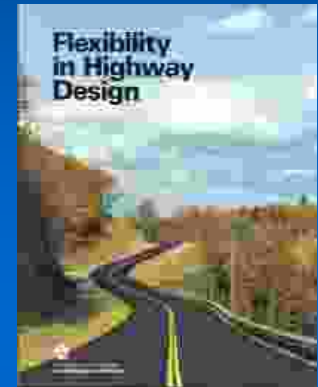
Highway Standards Used by FLH

- Generally...AASHTO Green Book
*“Policy on Geometric Design of
Highways and Streets”*
- Federal Land Agency Standards
- State or Local Design Standards
- Tribal Government Standards



CSS & Road Standards

- Purpose and Function of the Road
 - *Arterial?* - *Collector?* - *Local?*
 - *Special-Purpose?*
- Level of Traffic
 - *ADT?* - *Seasonal?* - *Design Vehicle?*
- Balance Design Speed & Roadway Width
 - *With Purpose & Function of Road*
 - *With Mobility and Safety Needs*
 - *With Community & Environmental Values*



FLH Design Techniques

● Curvilinear Alignment

- Lie lightly on the land
- Follow existing contours
- Flowing alignment, varying views
- Coordination of horizontal and vertical
- Spiral transitions at ends of curves
- Consistent, self-enforcing design speed
- Iterative reviews to optimize alignment







Natchez Trace Parkway



Voyageurs National Park, Minnesota



*Cherohala Skyway, North Carolina
National Scenic Byway*



Roadside Features

- Slope Treatments

- Rounded Top of Cut and Toe of Fill
- Warping at Transitions to Cut and Fill
- Roughening and Compounding
- Rock Sculpting and Ledinging
- Landscape Planting with Native Species

- Ditches

- Rounded, Vegetated
- Masonry Lined (Stone or Brick)
- Paved with Curbing

- Aesthetic Curbs and Pedestrian Sidewalks

- Fences and Appurtenances which Blend

*Rock Sculpturing
and Landscaping,
Mt. Lemmon, AZ*





Baltimore-Washington Parkway



Mountable Curbs, Baltimore-Washington Parkway, Maryland

Aesthetic Traffic Barriers

- Weathering Steel W-beam
- Etched Galvanized Steel W-beam
- Steel-backed Timber Beam Guardrail
- Steel-backed Timber Log Guardrail
- Simulated Stone Concrete Guardwall
- Natural Stone w/Concrete Core Wall
- Crash Tested and Approved

*Skyline Drive, Shenandoah
National Park, Virginia*





*Precast Artificial Stone Guardwall
Baltimore-Washington Parkway, Maryland*



Typical Steel-Backed Timber Guardrail, Blue Ridge Parkway



*Weathering Steel Guardrail,
George Washington Memorial Parkway, Virginia*

Structures that Blend

- Bridges
 - Type, Span, Shape, Formwork, Finishing
- Culverts
 - Shape, Material, End Treatment
- Retaining Walls
 - Aesthetic Facing, Color, Texture
- Natural Materials
 - Accents, Veneers, Facades



Yosemite, California



Stone Masonry Arch, Blue Ridge Parkway



Forehand Hollow Bridge, Natchez Trace Parkway



Double Arch Bridge, Natchez Trace Parkway, Tennessee



Lake Shore Drive, Lake Mead, NV





Great Smoky Mountain National Park, Tennessee



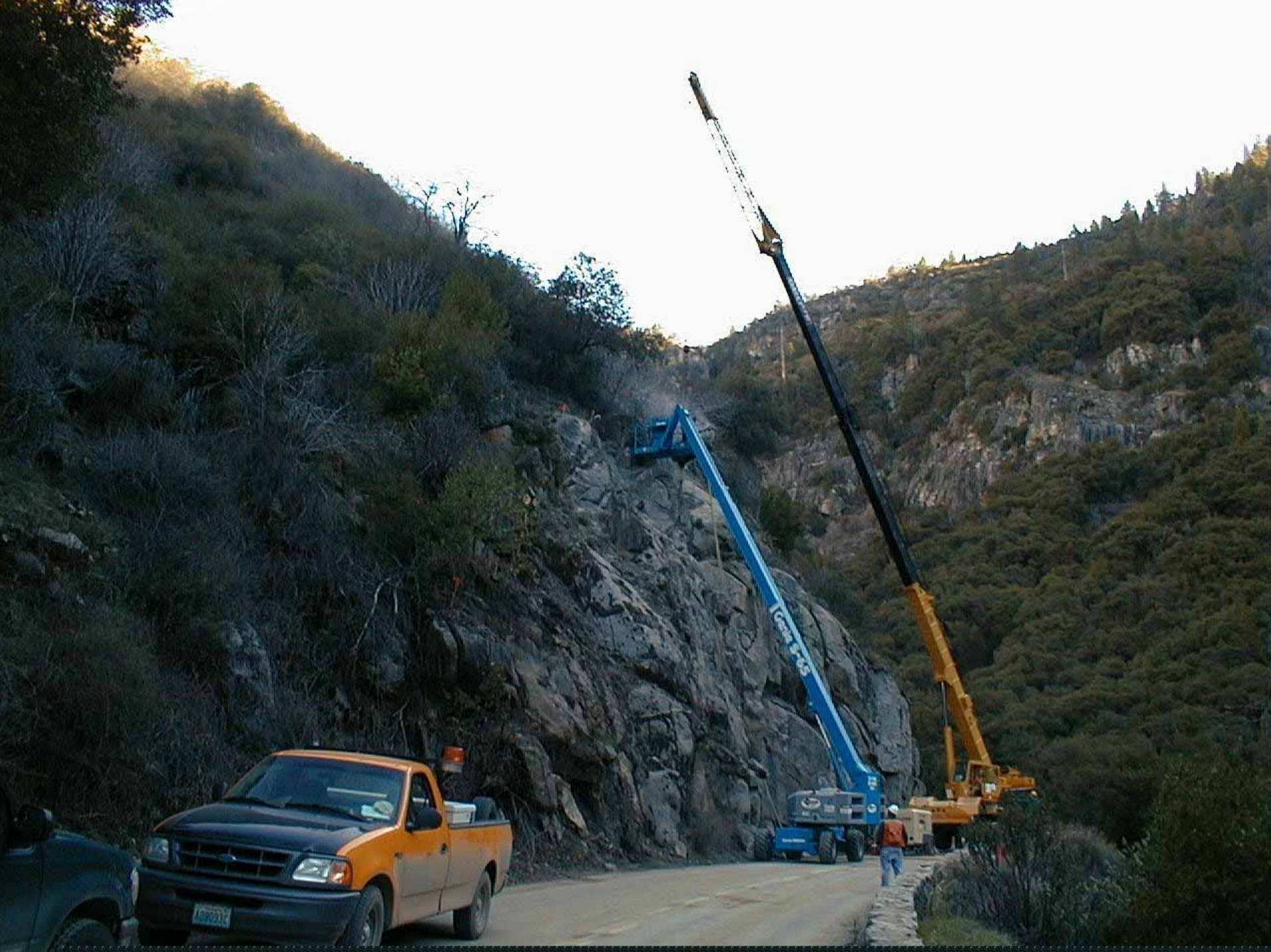


Environmental Enhancements

- Adjust roadway location away from critical and sensitive areas
- Restore drainage to original stream channels
- Replace existing culverts with natural bottom culverts for fish passage
- Add crossing structures sized for wildlife
- Restore existing barren slopes with native trees, shrubs and grasses
- Restore hydrology to natural conditions

CSS Construction Techniques







Foothills Parkway, Tennessee













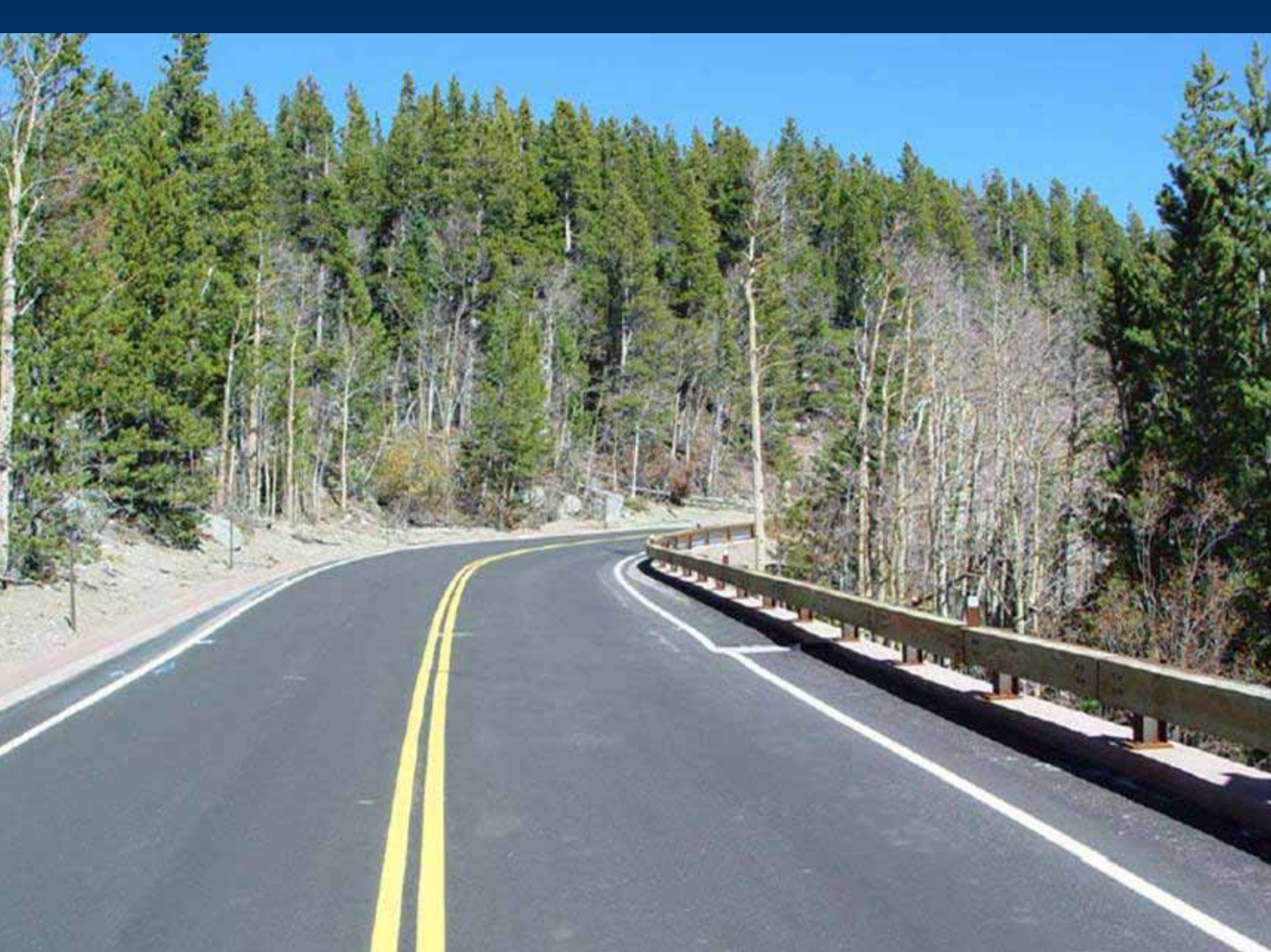




From Planning..... to Reality







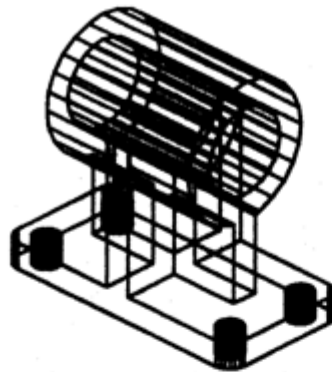
Visualization Applications

- Similar to the State DOTs, primarily 2D photo-simulations for public involvement and Environmental Documents
- For major (high cost/high visibility) projects, 3D models, limited animation, VHS and CD-Rom
- Some use of web-based access
- Limited planning applications (GIS)

Why Use Visualization?

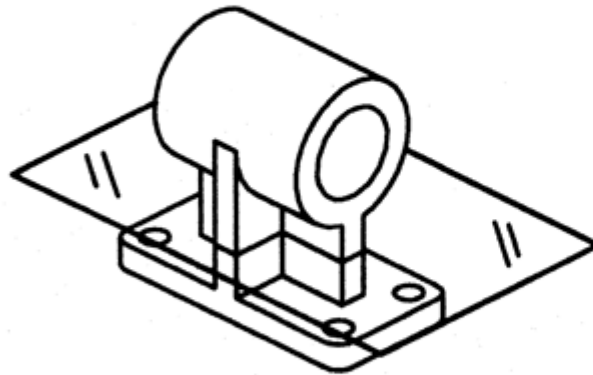
- Helps Context Sensitive Solutions
- Facilitates Involvement with Stakeholders and the Public
- Promotes Common Understanding
- Simulates the Proposed Facility
 - How it Looks (End Product)
 - How it Operates (Meets Needs)

Engineers Learn to Visualize in 2D

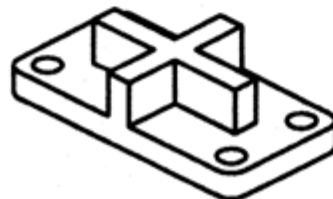


ROD
GUIDE

WIREFRAME MODEL

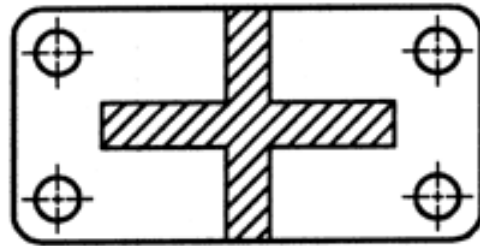


CUTTING PLANE
POSITIONED ON
SOLID MODEL



CUT SECTION OF
SOLID MODEL

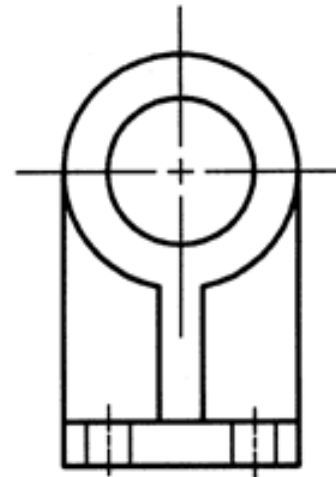
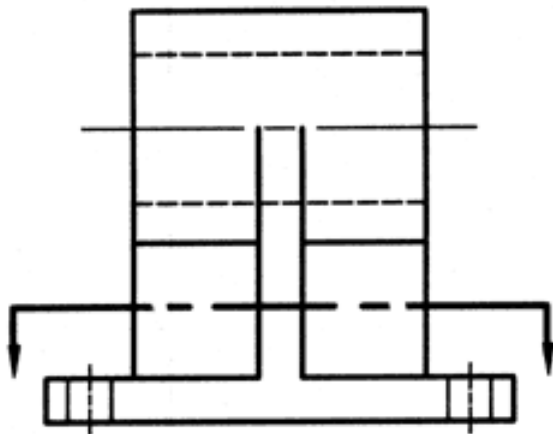
Engineers Learn to Visualize in 2D



RIB SECTION

ROD GUIDE

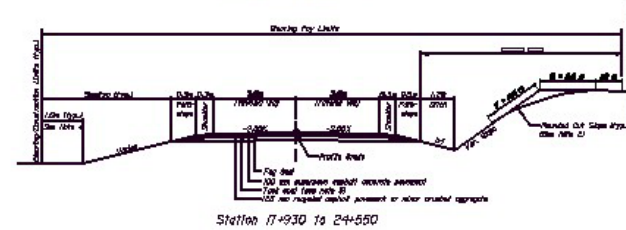
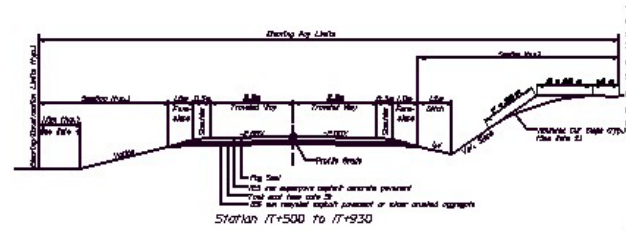
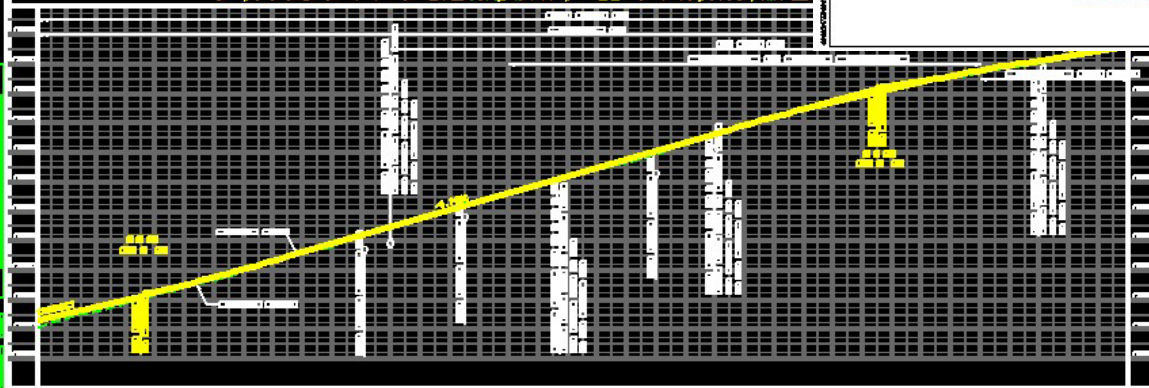
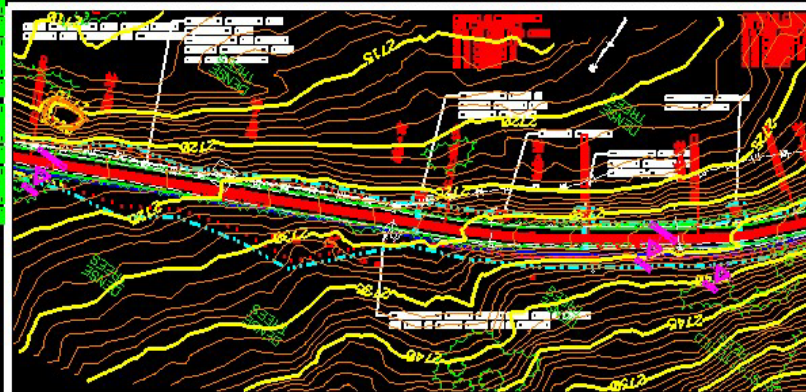
MTL.: CAST IRON



Stakeholders See Differently

- Engineer: Physical Requirements
“End Product” “Meets Criteria”
- Planner: Needs and Goals
- User: How I Operate On It
- Resident: How It Affects Me
- Community: Sense of Place, Environ.
Character, Heritage, Local Values
- Owner: Asset or Liability?

Engineers =



METHOD OF SUPERELEVATING ON CURVES

1. Distribute super-elevation in steps across or within 1/2 m (18 in) to achieve 10 percent and 10 percent in (10 percent) at the end of the curve.

NOTE:

1. The gradient and width of roadway, and the location and location of the roadway may be subject to the existing officer to ensure adequate drainage and stability.
2. Road 42 width and location that should not be changed (see Note 1) unless the 10 percent to the actual cut length and nature of the roadway.
3. Any curve widening as specified in the notes, the widening should not be made at any point, but should be made at the beginning and end of the curve.
4. When vehicle or lane plate are considered, make additional widening to 42 m.
5. Mass payment to the road with that and between 0.10.

| CURVE WIDENING | | |
|----------------|----------|----------|
| ROAD WIDTH | WIDENING | WIDENING |
| 10-15 | 0 | 0 |
| 15-20 | 0.5 | 0.5 |
| 20-25 | 1.0 | 1.0 |
| 25-30 | 1.5 | 1.5 |
| 30-35 | 2.0 | 2.0 |
| 35-40 | 2.5 | 2.5 |
| 40-45 | 3.0 | 3.0 |
| 45-50 | 3.5 | 3.5 |
| 50-55 | 4.0 | 4.0 |
| 55-60 | 4.5 | 4.5 |
| 60-65 | 5.0 | 5.0 |
| 65-70 | 5.5 | 5.5 |
| 70-75 | 6.0 | 6.0 |
| 75-80 | 6.5 | 6.5 |
| 80-85 | 7.0 | 7.0 |
| 85-90 | 7.5 | 7.5 |
| 90-95 | 8.0 | 8.0 |
| 95-100 | 8.5 | 8.5 |
| 100-105 | 9.0 | 9.0 |
| 105-110 | 9.5 | 9.5 |
| 110-115 | 10.0 | 10.0 |
| 115-120 | 10.5 | 10.5 |
| 120-125 | 11.0 | 11.0 |
| 125-130 | 11.5 | 11.5 |
| 130-135 | 12.0 | 12.0 |
| 135-140 | 12.5 | 12.5 |
| 140-145 | 13.0 | 13.0 |
| 145-150 | 13.5 | 13.5 |
| 150-155 | 14.0 | 14.0 |
| 155-160 | 14.5 | 14.5 |
| 160-165 | 15.0 | 15.0 |
| 165-170 | 15.5 | 15.5 |
| 170-175 | 16.0 | 16.0 |
| 175-180 | 16.5 | 16.5 |
| 180-185 | 17.0 | 17.0 |
| 185-190 | 17.5 | 17.5 |
| 190-195 | 18.0 | 18.0 |
| 195-200 | 18.5 | 18.5 |
| 200-205 | 19.0 | 19.0 |
| 205-210 | 19.5 | 19.5 |
| 210-215 | 20.0 | 20.0 |
| 215-220 | 20.5 | 20.5 |
| 220-225 | 21.0 | 21.0 |
| 225-230 | 21.5 | 21.5 |
| 230-235 | 22.0 | 22.0 |
| 235-240 | 22.5 | 22.5 |
| 240-245 | 23.0 | 23.0 |
| 245-250 | 23.5 | 23.5 |
| 250-255 | 24.0 | 24.0 |
| 255-260 | 24.5 | 24.5 |
| 260-265 | 25.0 | 25.0 |
| 265-270 | 25.5 | 25.5 |
| 270-275 | 26.0 | 26.0 |
| 275-280 | 26.5 | 26.5 |
| 280-285 | 27.0 | 27.0 |
| 285-290 | 27.5 | 27.5 |
| 290-295 | 28.0 | 28.0 |
| 295-300 | 28.5 | 28.5 |
| 300-305 | 29.0 | 29.0 |
| 305-310 | 29.5 | 29.5 |
| 310-315 | 30.0 | 30.0 |
| 315-320 | 30.5 | 30.5 |
| 320-325 | 31.0 | 31.0 |
| 325-330 | 31.5 | 31.5 |
| 330-335 | 32.0 | 32.0 |
| 335-340 | 32.5 | 32.5 |
| 340-345 | 33.0 | 33.0 |
| 345-350 | 33.5 | 33.5 |
| 350-355 | 34.0 | 34.0 |
| 355-360 | 34.5 | 34.5 |
| 360-365 | 35.0 | 35.0 |
| 365-370 | 35.5 | 35.5 |
| 370-375 | 36.0 | 36.0 |
| 375-380 | 36.5 | 36.5 |
| 380-385 | 37.0 | 37.0 |
| 385-390 | 37.5 | 37.5 |
| 390-395 | 38.0 | 38.0 |
| 395-400 | 38.5 | 38.5 |
| 400-405 | 39.0 | 39.0 |
| 405-410 | 39.5 | 39.5 |
| 410-415 | 40.0 | 40.0 |
| 415-420 | 40.5 | 40.5 |
| 420-425 | 41.0 | 41.0 |
| 425-430 | 41.5 | 41.5 |
| 430-435 | 42.0 | 42.0 |
| 435-440 | 42.5 | 42.5 |
| 440-445 | 43.0 | 43.0 |
| 445-450 | 43.5 | 43.5 |
| 450-455 | 44.0 | 44.0 |
| 455-460 | 44.5 | 44.5 |
| 460-465 | 45.0 | 45.0 |
| 465-470 | 45.5 | 45.5 |
| 470-475 | 46.0 | 46.0 |
| 475-480 | 46.5 | 46.5 |
| 480-485 | 47.0 | 47.0 |
| 485-490 | 47.5 | 47.5 |
| 490-495 | 48.0 | 48.0 |
| 495-500 | 48.5 | 48.5 |
| 500-505 | 49.0 | 49.0 |
| 505-510 | 49.5 | 49.5 |
| 510-515 | 50.0 | 50.0 |
| 515-520 | 50.5 | 50.5 |
| 520-525 | 51.0 | 51.0 |
| 525-530 | 51.5 | 51.5 |
| 530-535 | 52.0 | 52.0 |
| 535-540 | 52.5 | 52.5 |
| 540-545 | 53.0 | 53.0 |
| 545-550 | 53.5 | 53.5 |
| 550-555 | 54.0 | 54.0 |
| 555-560 | 54.5 | 54.5 |
| 560-565 | 55.0 | 55.0 |
| 565-570 | 55.5 | 55.5 |
| 570-575 | 56.0 | 56.0 |
| 575-580 | 56.5 | 56.5 |
| 580-585 | 57.0 | 57.0 |
| 585-590 | 57.5 | 57.5 |
| 590-595 | 58.0 | 58.0 |
| 595-600 | 58.5 | 58.5 |
| 600-605 | 59.0 | 59.0 |
| 605-610 | 59.5 | 59.5 |
| 610-615 | 60.0 | 60.0 |
| 615-620 | 60.5 | 60.5 |
| 620-625 | 61.0 | 61.0 |
| 625-630 | 61.5 | 61.5 |
| 630-635 | 62.0 | 62.0 |
| 635-640 | 62.5 | 62.5 |
| 640-645 | 63.0 | 63.0 |
| 645-650 | 63.5 | 63.5 |
| 650-655 | 64.0 | 64.0 |
| 655-660 | 64.5 | 64.5 |
| 660-665 | 65.0 | 65.0 |
| 665-670 | 65.5 | 65.5 |
| 670-675 | 66.0 | 66.0 |
| 675-680 | 66.5 | 66.5 |
| 680-685 | 67.0 | 67.0 |
| 685-690 | 67.5 | 67.5 |
| 690-695 | 68.0 | 68.0 |
| 695-700 | 68.5 | 68.5 |
| 700-705 | 69.0 | 69.0 |
| 705-710 | 69.5 | 69.5 |
| 710-715 | 70.0 | 70.0 |
| 715-720 | 70.5 | 70.5 |
| 720-725 | 71.0 | 71.0 |
| 725-730 | 71.5 | 71.5 |
| 730-735 | 72.0 | 72.0 |
| 735-740 | 72.5 | 72.5 |
| 740-745 | 73.0 | 73.0 |
| 745-750 | 73.5 | 73.5 |
| 750-755 | 74.0 | 74.0 |
| 755-760 | 74.5 | 74.5 |
| 760-765 | 75.0 | 75.0 |
| 765-770 | 75.5 | 75.5 |
| 770-775 | 76.0 | 76.0 |
| 775-780 | 76.5 | 76.5 |
| 780-785 | 77.0 | 77.0 |
| 785-790 | 77.5 | 77.5 |
| 790-795 | 78.0 | 78.0 |
| 795-800 | 78.5 | 78.5 |
| 800-805 | 79.0 | 79.0 |
| 805-810 | 79.5 | 79.5 |
| 810-815 | 80.0 | 80.0 |
| 815-820 | 80.5 | 80.5 |
| 820-825 | 81.0 | 81.0 |
| 825-830 | 81.5 | 81.5 |
| 830-835 | 82.0 | 82.0 |
| 835-840 | 82.5 | 82.5 |
| 840-845 | 83.0 | 83.0 |
| 845-850 | 83.5 | 83.5 |
| 850-855 | 84.0 | 84.0 |
| 855-860 | 84.5 | 84.5 |
| 860-865 | 85.0 | 85.0 |
| 865-870 | 85.5 | 85.5 |
| 870-875 | 86.0 | 86.0 |
| 875-880 | 86.5 | 86.5 |
| 880-885 | 87.0 | 87.0 |
| 885-890 | 87.5 | 87.5 |
| 890-895 | 88.0 | 88.0 |
| 895-900 | 88.5 | 88.5 |
| 900-905 | 89.0 | 89.0 |
| 905-910 | 89.5 | 89.5 |
| 910-915 | 90.0 | 90.0 |
| 915-920 | 90.5 | 90.5 |
| 920-925 | 91.0 | 91.0 |
| 925-930 | 91.5 | 91.5 |
| 930-935 | 92.0 | 92.0 |
| 935-940 | 92.5 | 92.5 |
| 940-945 | 93.0 | 93.0 |
| 945-950 | 93.5 | 93.5 |
| 950-955 | 94.0 | 94.0 |
| 955-960 | 94.5 | 94.5 |
| 960-965 | 95.0 | 95.0 |
| 965-970 | 95.5 | 95.5 |
| 970-975 | 96.0 | 96.0 |
| 975-980 | 96.5 | 96.5 |
| 980-985 | 97.0 | 97.0 |
| 985-990 | 97.5 | 97.5 |
| 990-995 | 98.0 | 98.0 |
| 995-1000 | 98.5 | 98.5 |

| NORMAL SLOPE RATIOS | | | |
|---------------------|------------|----------|------------|
| ROAD WIDTH | FILL SLOPE | WIDENING | EXIT SLOPE |
| 10-15 | 1:1 | 0.75 | 1:1 |
| 15-20 | 1:1 | 0.75 | 1:1 |
| 20-25 | 1:1 | 0.75 | 1:1 |
| 25-30 | 1:1 | 0.75 | 1:1 |
| 30-35 | 1:1 | 0.75 | 1:1 |
| 35-40 | 1:1 | 0.75 | 1:1 |
| 40-45 | 1:1 | 0.75 | 1:1 |
| 45-50 | 1:1 | 0.75 | 1:1 |
| 50-55 | 1:1 | 0.75 | 1:1 |
| 55-60 | 1:1 | 0.75 | 1:1 |
| 60-65 | 1:1 | 0.75 | 1:1 |
| 65-70 | 1:1 | 0.75 | 1:1 |
| 70-75 | 1:1 | 0.75 | 1:1 |
| 75-80 | 1:1 | 0.75 | 1:1 |
| 80-85 | 1:1 | 0.75 | 1:1 |
| 85-90 | 1:1 | 0.75 | 1:1 |
| 90-95 | 1:1 | 0.75 | 1:1 |
| 95-100 | 1:1 | 0.75 | 1:1 |
| 100-105 | 1:1 | 0.75 | 1:1 |
| 105-110 | 1:1 | 0.75 | 1:1 |
| 110-115 | 1:1 | 0.75 | 1:1 |
| 115-120 | 1:1 | 0.75 | 1:1 |
| 120-125 | 1:1 | 0.75 | 1:1 |
| 125-130 | 1:1 | 0.75 | 1:1 |
| 130-135 | 1:1 | 0.75 | 1:1 |
| 135-140 | 1:1 | 0.75 | 1:1 |
| 140-145 | 1:1 | 0.75 | 1:1 |
| 145-150 | 1:1 | 0.75 | 1:1 |
| 150-155 | 1:1 | 0.75 | 1:1 |
| 155-160 | 1:1 | 0.75 | 1:1 |
| 160-165 | 1:1 | 0.75 | 1:1 |
| 165-170 | 1:1 | 0.75 | 1:1 |
| 170-175 | 1:1 | 0.75 | 1:1 |
| 175-180 | 1:1 | 0.75 | 1:1 |
| 180-185 | 1:1 | 0.75 | 1:1 |
| 185-190 | 1:1 | 0.75 | 1:1 |
| 190-195 | 1:1 | 0.75 | 1:1 |
| 195-200 | 1:1 | 0.75 | 1:1 |
| 200-205 | 1:1 | 0.75 | 1:1 |
| 205-210 | 1:1 | 0.75 | 1:1 |
| 210-215 | 1:1 | 0.75 | 1:1 |
| 215-220 | 1:1 | 0.75 | 1:1 |
| 220-225 | 1:1 | 0.75 | 1:1 |
| 225-230 | 1:1 | 0.75 | 1:1 |
| 230-235 | 1:1 | 0.75 | 1:1 |
| 235-240 | 1:1 | 0.75 | 1:1 |
| 240-245 | 1:1 | 0.75 | 1:1 |
| 245-250 | 1:1 | 0.75 | 1:1 |
| 250-255 | 1:1 | 0.75 | 1:1 |
| 255-260 | 1:1 | 0.75 | 1:1 |
| 260-265 | 1:1 | 0.75 | 1:1 |
| 265-270 | 1:1 | 0.75 | 1:1 |
| 270-275 | 1:1 | 0.75 | 1:1 |
| 275-280 | 1:1 | 0.75 | 1:1 |
| 280-285 | 1:1 | 0.75 | 1:1 |
| 285-290 | 1:1 | 0.75 | 1:1 |
| 290-295 | 1:1 | 0.75 | 1:1 |
| 295-300 | 1:1 | 0.75 | 1:1 |
| 300-305 | 1:1 | 0.75 | 1:1 |
| 305-310 | 1:1 | 0.75 | 1:1 |
| 310-315 | 1:1 | 0.75 | 1:1 |
| 315-320 | 1:1 | 0.75 | 1:1 |
| 320-325 | 1:1 | 0.75 | 1:1 |
| 325-330 | 1:1 | 0.75 | 1:1 |
| 330-335 | 1:1 | 0.75 | 1:1 |
| 335-340 | 1:1 | 0.75 | 1:1 |
| 340-345 | 1:1 | 0.75 | 1:1 |
| 345-350 | 1:1 | 0.75 | 1:1 |
| 350-355 | 1:1 | 0.75 | 1:1 |
| 355-360 | 1:1 | 0.75 | 1:1 |
| 360-365 | 1:1 | 0.75 | 1:1 |
| 365-370 | 1:1 | 0.75 | 1:1 |
| 370-375 | 1:1 | 0.75 | 1:1 |
| 375-380 | 1:1 | 0.75 | 1:1 |
| 380-385 | 1:1 | 0.75 | 1:1 |
| 385-390 | 1:1 | 0.75 | 1:1 |
| 390-395 | 1:1 | 0.75 | 1:1 |
| 395-400 | 1:1 | 0.75 | 1:1 |
| 400-405 | 1:1 | 0.75 | 1:1 |
| 405-410 | 1:1 | 0.75 | 1:1 |
| 410-415 | 1:1 | 0.75 | 1:1 |
| 415-420 | 1:1 | 0.75 | 1:1 |
| 420-425 | 1:1 | 0.75 | 1:1 |
| 425-430 | 1:1 | 0.75 | 1:1 |
| 430-435 | 1:1 | 0.75 | 1:1 |
| 435-440 | 1:1 | 0.75 | 1:1 |
| 440-445 | 1:1 | 0.75 | 1:1 |
| 445-450 | 1:1 | 0.75 | 1:1 |
| 450-455 | 1:1 | 0.75 | 1:1 |
| 455-460 | 1:1 | 0.75 | 1:1 |
| 460-465 | 1:1 | 0.75 | 1:1 |
| 465-470 | 1:1 | 0.75 | 1:1 |
| 470-475 | 1:1 | 0.75 | 1:1 |
| 475-480 | 1:1 | 0.75 | 1:1 |
| 480-485 | 1:1 | 0.75 | 1:1 |
| 485-490 | 1:1 | 0.75 | 1:1 |
| 490-495 | 1:1 | 0.75 | 1:1 |
| 495-500 | 1:1 | 0.75 | 1:1 |
| 500-505 | 1:1 | 0.75 | 1:1 |
| 505-510 | 1:1 | 0.75 | 1:1</ |

Users =



Communication Challenges

● Engineers Speak

- Green Book
- Typical Section
- Pavement Materials
- Design Speed
- Crash Rate
- Constructability
- Plans and Profiles
- Cross Sections

● Users Speak

- Function, Fit
- Space to Drive
- Smoothness
- Comfortable Speed
- Feels Safe
- Barricades, Delays
- TV, Web, Pictures
- Perspective Views

Form versus Function

- Need to illustrate more than what it will look like, but imply how it will work
- Need to convey contextual value of the project to the user and community
- Need to enable analysis + feedback
- Visualization is only as effective as the understanding and communication it generates for the user or stakeholder

Realism is Necessary – But Not Sufficient

- Conveys Purpose and Need of the Project
 - *Shows what is Important? - User? - Community?*
 - *Safety? - Efficiency? - Environment?*
- Reflects Credibility of Your Work
 - *Is it Accurate? - Understandable? - Add Value?*
- Tailors Information with Audience
 - *Stakeholder: What the facility looks like*
 - *Community: What the facility changes*
 - *User: How well the facility works for me*

Planning & Public Involvement Visualization Applications



- Project Scoping
 - Purpose & Function of Road
 - Describe and Evaluate Alternatives that address needs, issues, and values
- Public Involvement and Communication
- Partner and Stakeholder Participation
- Collaborative Decision-making

Levels of Public Involvement

- Influencing
- Calming
- Informing
- Consulting
- Partnering
- Collaborating
- Citizen Control



What Level Is
Requested?

Levels of Interaction

- Imagination – The Engineer's Vision
- Simulation – Show and Tell to Others
- Evaluation – Feedback, Preference, Ranking of Input from Others
- Analysis – Interactive communication, clarification, multi-attribute scoring, consensus-building, collaboration

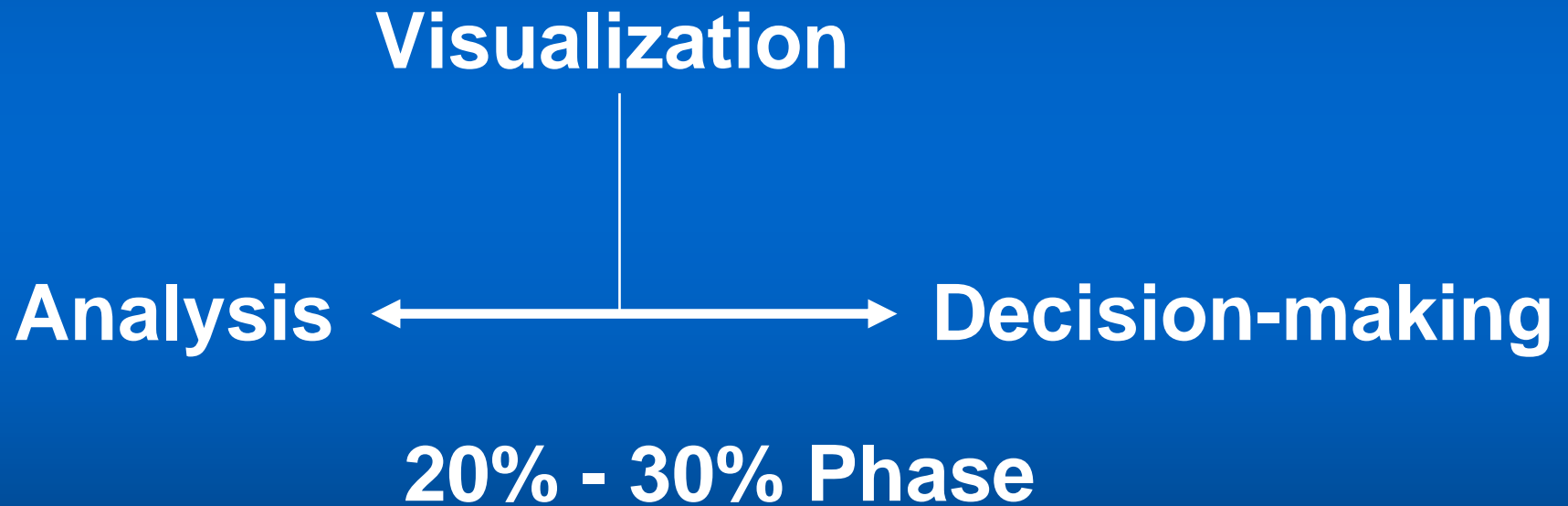
Levels of Decision-making

- Expert-based
- Stakeholder-based
- Community-based



What Level Is
Requested?

Where is Visualization Typically in the Process?



Visualization Technology

- 3D Perspective Views

- Intuitive and understandable
- Capability within GEOPAK software

- 3D Model Navigation

- Requires a large 3D digital model
- Enables any custom viewpoint
- Degrades with close-up view
- Limited fly-through and navigation capability without special software

Visualization Techniques

- Photo Simulations

- Shows single location, or aspect of the project
- Relatively simple, quick and inexpensive

- 360° Views

- Interactive, provides a context and scale
- Requires 12 photos, carefully aligned
- Requires Apple QuickTime Software

- Animation

- Allows a comprehensive corridor tour
- Provides a realistic video-like experience
- Requires a large, rendered, digital “model”

Visualization Products

- Hardcopy Graphics Presentation
 - Exhibit boards and posters
 - Brochures and flyers
 - Graphics and charts
- Electronic Presentation Products
 - Slide Presentations
 - Video CDs and DVDs
 - Interactive CDs
 - Project Web Sites

Example – Guanella Pass

- Diverse Stakeholders and Issues:
 - 2 National Forests & CDOT
 - 3 Owners (2 Counties & Town)
 - National Historic & Mining District
 - Scenic Byway
 - Adjacent to Wilderness Area
 - Private Landowners and Businesses
 - Controversial Corridor Management, Preservation vs. Improved Access

Example – Guanella Pass

Visualization used in the DEIS to show:

- Mobility Needs
- Safety Needs
- Community Values
- Natural Environment
- Proposed Alternative Design Solutions



Alternatives in DEIS

- Rehabilitate vs. Reconstruct
- Paving vs. Gravel
- Alternative Surface Types
 - Gravel w/Magnesium Chloride
 - Stabilized Gravel w/Admixtures
 - Recycled Asphalt Pavement
 - Macadam (penetration treatment)
 - Pavement w/Coarse Chip Seal

Visualization Applications

- Photo-simulations (before & after) on exhibit boards at public meetings
- Continuous videotape loop played on TV at public meetings
- Interactive CD-Rom included in DEIS document (live video, narration, maps, photo-simulations, 360 views, and animations of alternatives)
- Website with materials from CD-Rom



Before



After

Before



After



Reconstruct w/Gravel



Reconstruct w/Macadam











360 Views (before & after)

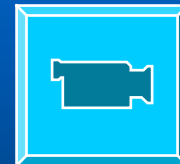
Switchback 360 View Before



Switchback 360 View After



Georgetown 360 View Before

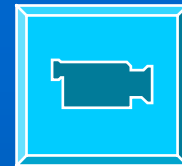


Georgetown 360 View After



Animation Excerpts from CD

Guanella Pass Movie Video Clip



How did Visualization add value?

- Identified true concerns
 - Rustic “backway” vs “parkway”
 - Impact of alternative alignments
- Need for aesthetic treatments
 - Retaining walls
 - Barrier rails
 - Curbs and ditches
- Showed the project could lay lightly

Example – Hoover Dam Bypass



Example – Hoover Dam Bypass (US 93 in AZ & NV)

- Diverse Stakeholders and Issues:
 - 2 State DOTs (owners)
 - BuRec, NPS, Hoover Dam, FHWA
 - National Historic Landmark
 - Adjacent Traditional Cultural Property
 - NAFTA Truck Route
 - Security of Hoover Dam
 - Safety, Congestion, Capacity Issues

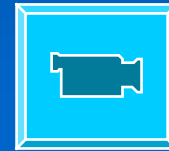
Visualization Applications

- Photo-montage of alternative corridor alignments
- Photo Simulations (before & after) at public meetings and in EIS
- Interactive Split-screen animation
- Website with photo simulations and fly-through animation

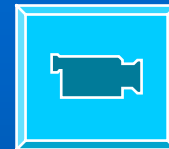


HDB Animation

HDB Split-Screen Video



Building HDB River Bridge



How did Visualization add value?

- Corridor Selection
- Relationship to Hoover Dam
- Scale of Colorado River Bridge vs Hoover Dam
- Bridge Type Selection
- Proximity to Traditional Cultural Property Site

Example – Beartooth Highway



Beartooth Highway

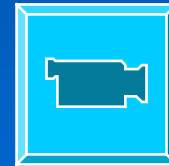
- Diverse Stakeholders and Issues:
 - 3 National Forests
 - 2 State DOTs (WY & MT)
 - Maintained by NPS
 - All-America Scenic Byway
 - Adjacent to Wilderness Area
 - Access to Yellowstone NP
 - Endangered Species, Wetlands, Historic Resources, Alpine Tundra

Visualization Applications

- Photo Simulations (before & after) on exhibit boards at public meetings
- Continuous Videotape Loop played on TV/VCR at public meetings
- Interactive CD-Rom included in all DEIS copies (live video narration, maps, photo-simulations, 360 views, and animations of alternatives)
- Website with materials from CD-Rom

360 Views (before & after)

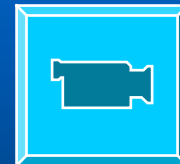
Beartooth Ravine 360 View Before



Beartooth Ravine 360 View After



Deadman's Curve 360 View Before

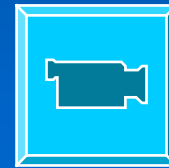


Deadman's Curve 360 View After



Animation Excerpts from CD

Beartooth Hwy Intro Video Clip



Beartooth Hwy Movie Video Clip



How did Visualization add value?

- Help resolve alternative alignment issues
 - Evaluation of new wetland impacts vs restoration opportunities
 - Illustrated pros/cons of alternative alignments vs perpetuation of existing alignment
- Bridge type selection
- Selection of aesthetic treatments
 - Retaining walls
 - Bridge rails design
 - Curbs and ditches
- Design major parking areas and pullouts

Emerging Technologies:

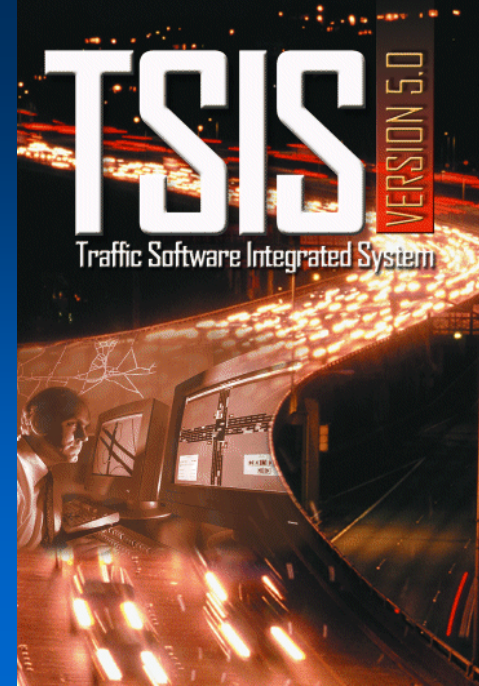


Traffic Operations

- Traffic Simulation Software
 - CORSIM
 - VISSIM
- Visualization Application

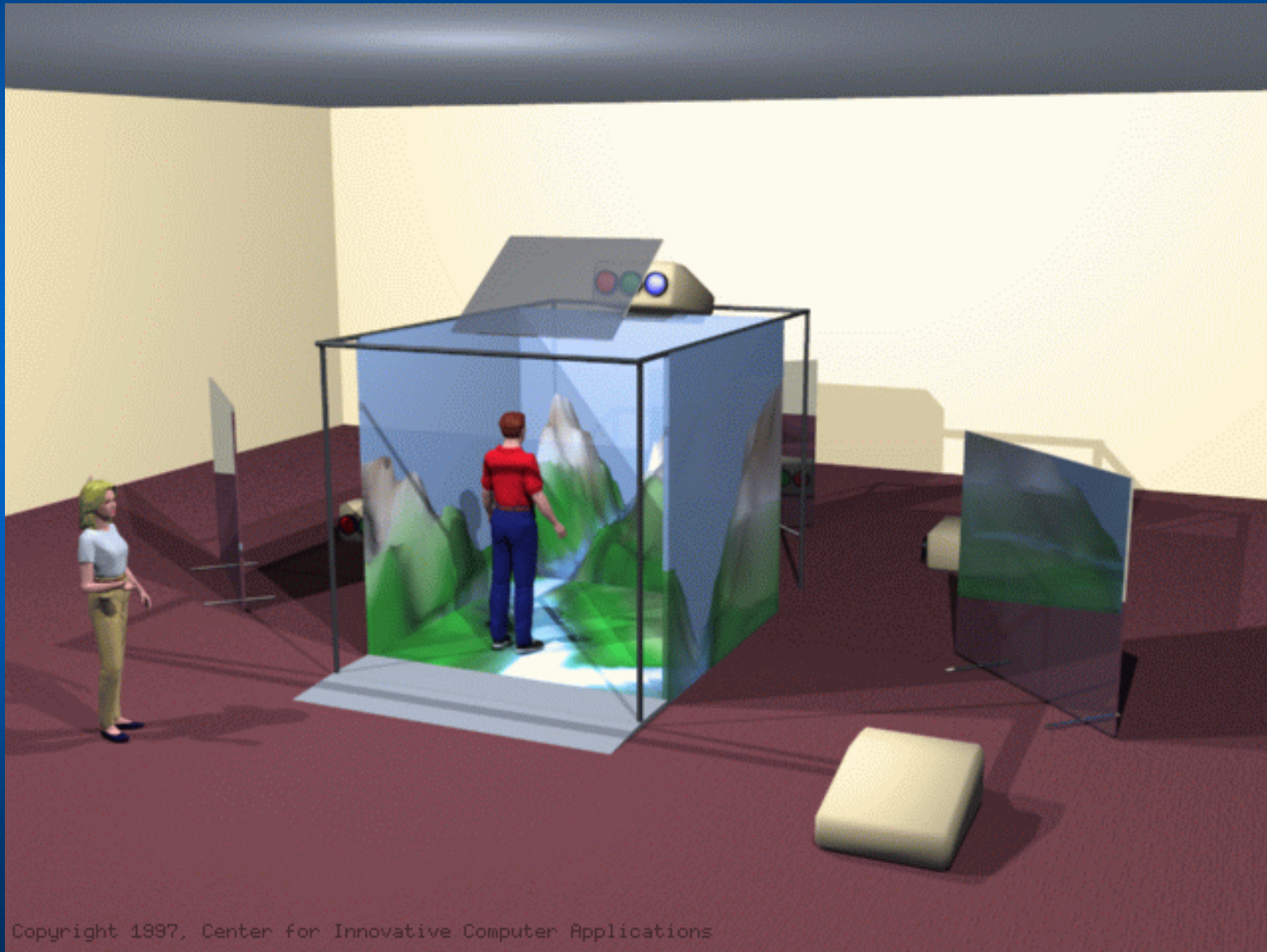
Vissim Video 1

Vissim Video 2



www.fhwa-tsis.com

CAVE Virtual Environment



CAVE Virtual Environment



Design Virtual Environment

- Immersive, stereoscopic environment
- Walk-in or Head-mounted displays
- Accurate size and scale
- Multi-participant, collaborative design
- Easily navigable

EVL U of IL Video



DVE GATech Video



Stake-less Construction Technology



Mobile Digital Highway Measurements



TURNER-FAIRBANK
HIGHWAY RESEARCH CENTER

ADVANCED RESEARCH PROJECT

Measurement Needs



Vehicle and Phase I Sensors



Future Added Sensors

- Sound Intensity Pressure Device (**SIPD**)
- Ground Penetrating Radar (**GPR**)
- **LIDAR**
- Infrared Sign Retro-Reflectivity (**IR**)
- Downward facing **Camera** for Pavements



Sensor

Infrared RetroReflectivity



Phase I

Stereoscopic Video



Inertial Navigation Unit

Enhanced NDGPS



DGPS



Monoscopic Video



Distance Measurement Instrument



Temperature Gage



Optical trigger



Scanning laser



1-D Accelerometer



3-D Accelerometer



Profiling laser



Texture laser



Sound Intensity Pressure



Ground Penetrating Radar



Application



Hardware condition



Hardware tracking



Trajectory of vehicle



Lane tracking



Position of Hardware



Linear Referencing



Vertical Profile



Horizontal Profile



Super-Elevation



Lane Definition



Pavement Surface

Phase I



Pavement thickness



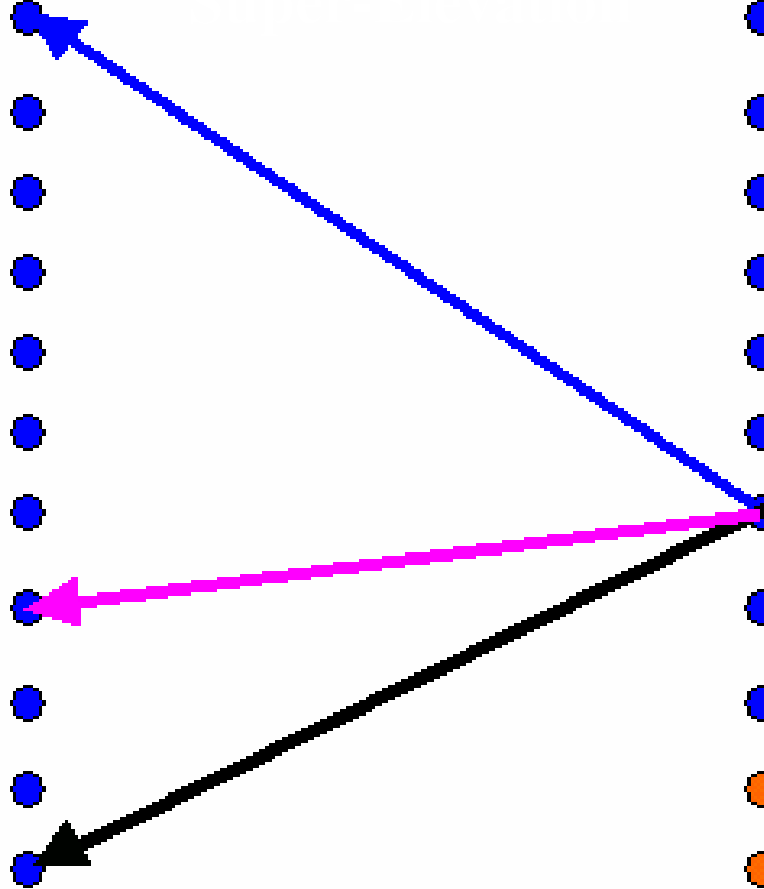
Base



Sub-Base



Underground Hardware



Sensor

Application

Infrared RetroReflectivity



Hardware condition

Phase I Stereoscopic Video



Hardware tracking

Inertial Navigation Unit



Trajectory of vehicle

Enhanced NDGPS



Lane tracking

DGPS



Position of Hardware

Monoscopic Video



Linear Referencing

Distance Measurement Instrument



Vertical Profile

Temperature Gage



Horizontal Profile

Optical trigger



Super-Elevation

Scanning laser



Lane Definition

1-D Accelerometer



Pavement Surface

Phase I

3-D Accelerometer



Pavement thickness

Profiling laser



Base

Texture laser



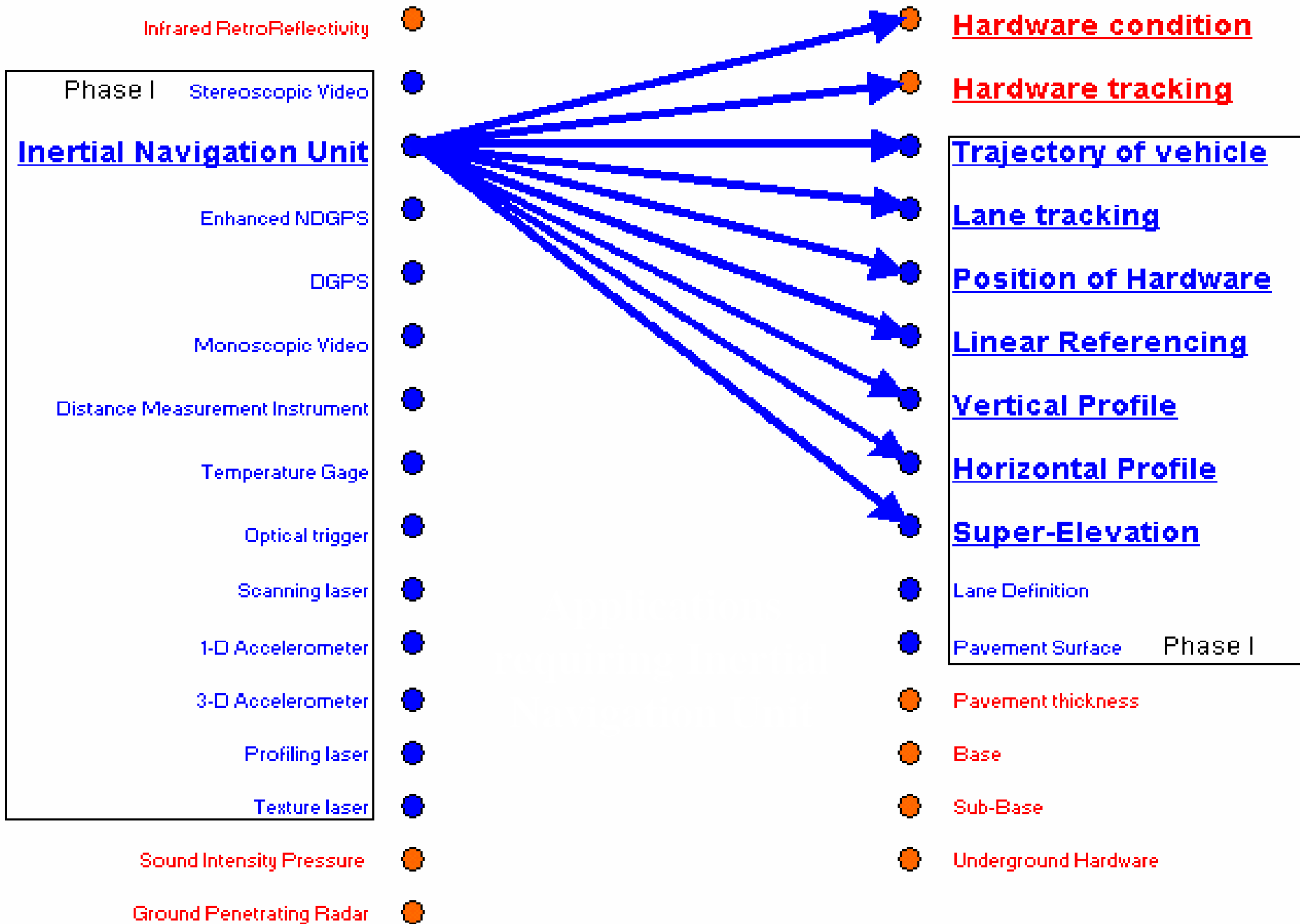
Sub-Base

Sound Intensity Pressure



Underground Hardware

Ground Penetrating Radar



Sensor

Application

Infrared RetroReflectivity

Phase I Stereoscopic Video

Inertial Navigation Unit

Enhanced NDGPS

DGPS

Monoscopic Video

Distance Measurement Instrument

Temperature Gage

Optical trigger

Scanning laser

1-D Accelerometer

3-D Accelerometer

Profiling laser

Texture laser

Sound Intensity Pressure

Ground Penetrating Radar

Hardware condition

Hardware tracking

Trajectory of vehicle Phase I

Lane tracking

Position of Hardware

Linear Referencing

Vertical Profile

Horizontal Profile

Super-Elevation

Lane Definition

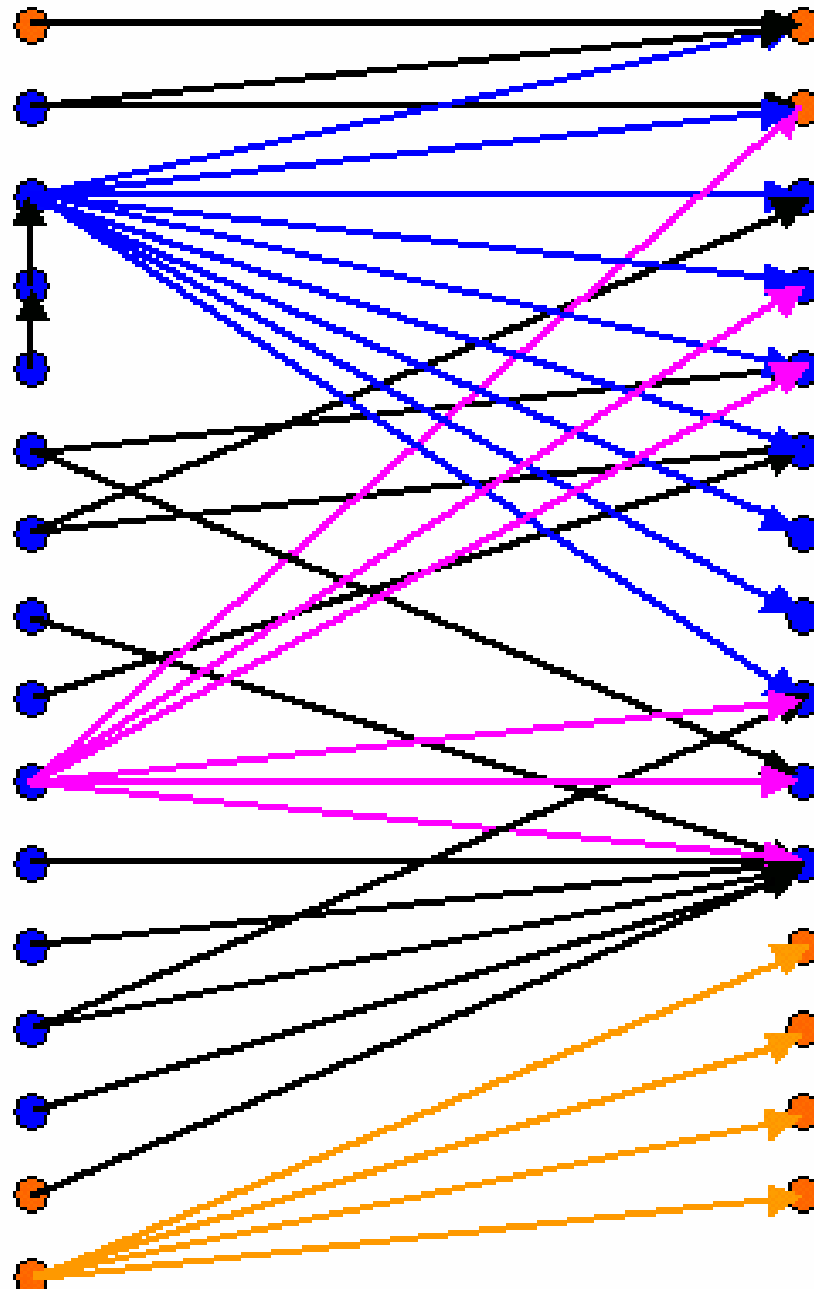
Pavement Surface

Pavement thickness

Base

Sub-Base

Underground Hardware



DHM SYSTEM

Case name **InitializeDLLs** Date **03-22-2004** Time **11:52:08** **DAQ** **Quit**

Sensor Check ●

| | |
|---------------|----------------|
| Geometry | Optical Trig. |
| Viden | Temperature |
| Profile | Inclinometers |
| NDGPS | Aux. Hor. Acc. |
| Aux. Geometry | DMI Pulsar |
| | Noise |

Put Bar Calibration

L: 0.00 C: 0.00 H: 0.00 C Offset: 0.000

DAQ System Selection

- ☐ Geometry
- ☐ HAGPS
- ☐ Video 5.0 FPS As Is
- ☐ Profile
- ☐ Scann
- ☐ NDGP
- ☐ Aux. C
- ☐ Optical
- ☐ Pvt. T
- ☐ Incline
- ☐ Aux.

Image Height
Capture Definition

Exclude Pixels

Speed (mph)
60



DHM DATA VIEWER



DHM STEREO IMAGING

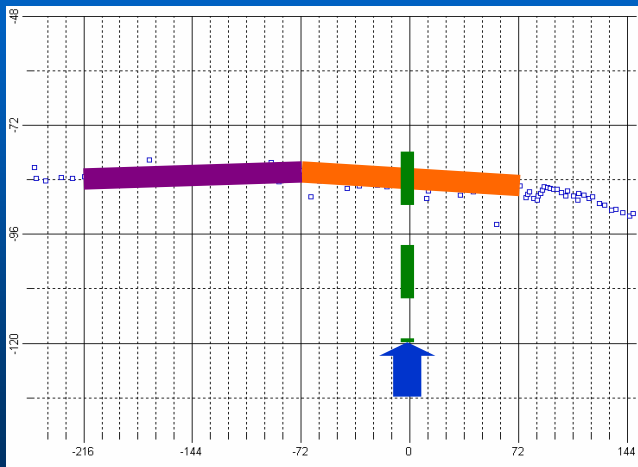
LEFT
CAMERA



RIGHT
CAMERA



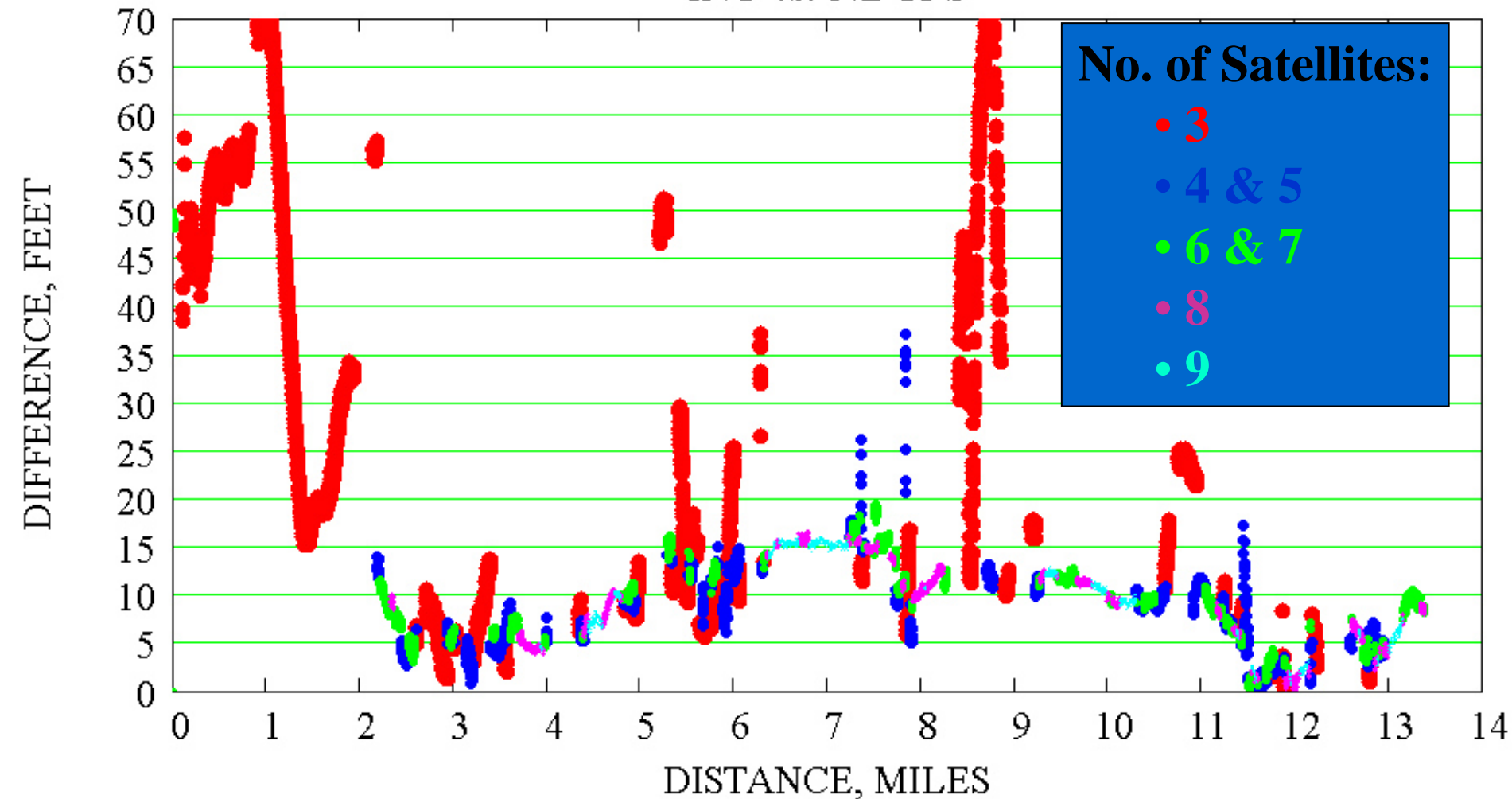
LANE ATTRIBUTES



- LANE MARKINGS
- LANE WIDTH

GPS RECEPTION

INU vs. NDGPS



Integrated GPS and Inertial

GPS Only

Advantages

- High accuracy position & velocity
- Moderate accuracy orientation (using multiple antennas)

Limitations

- Low bandwidth
- Satellite shading (dropouts)
- Slow ambiguity resolution

Inertial Only

Advantages

- Full 6 DOF solution
- High dynamic accuracy with broad bandwidth
- Self-contained (no dropouts)

Limitations

- Solution errors grow over time

Integrated Inertial/GPS/DMI

Advantages

- All inertial and GPS advantages
- DMI constrains noise and drift, and adds robustness

Limitations

- No significant limitations

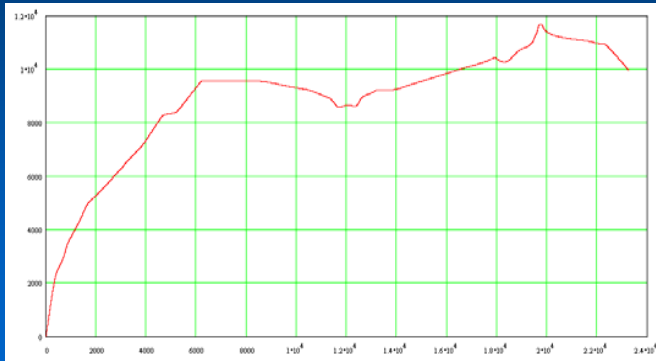
PHASE I APPLICATIONS

| APPLICATION | PARTICIPANT | | DATA ACQUISITION | | |
|-------------|-------------|--|------------------|----------------------|-------------------|
| | STATE | FEDERAL | DHM | Federal Lands RIP | Other |
| 1 | | Operations | | | As-built plans |
| 2 | | Infrastructure | | | As-built plans |
| 3 | | Highway Safety Information System | | | Static Laser |
| 4 | Penn DOT | Highway Driving Simulator | | | |
| 5 | VDOT | Interactive Highway Safety Design Module | | | Manual Survey |

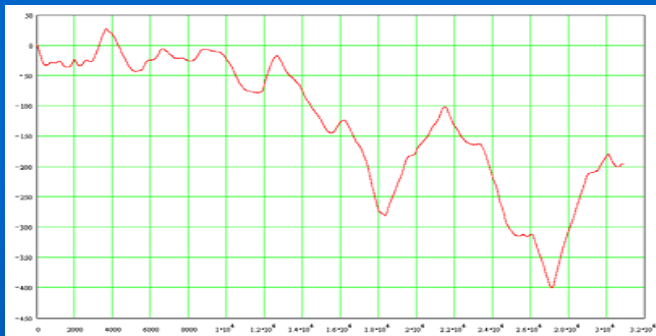
TYPES OF DATA

- VERTICAL AND HORIZONTAL ALIGNMENTS INCLUDING PC, PT, CURVE DATA
- SUPER ELEVATION
- LANE DEFINITION (MARKINGS AND EDGE)
- LINEAR REFERENCING
- ROADSIDE HARDWARE
- PAVEMENT SURFACE CONDITION

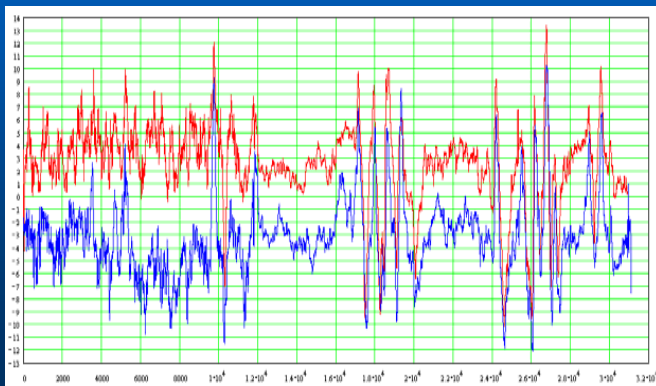
HIGHWAY GEOMETRICS



- HORIZONTAL ALIGNMENT

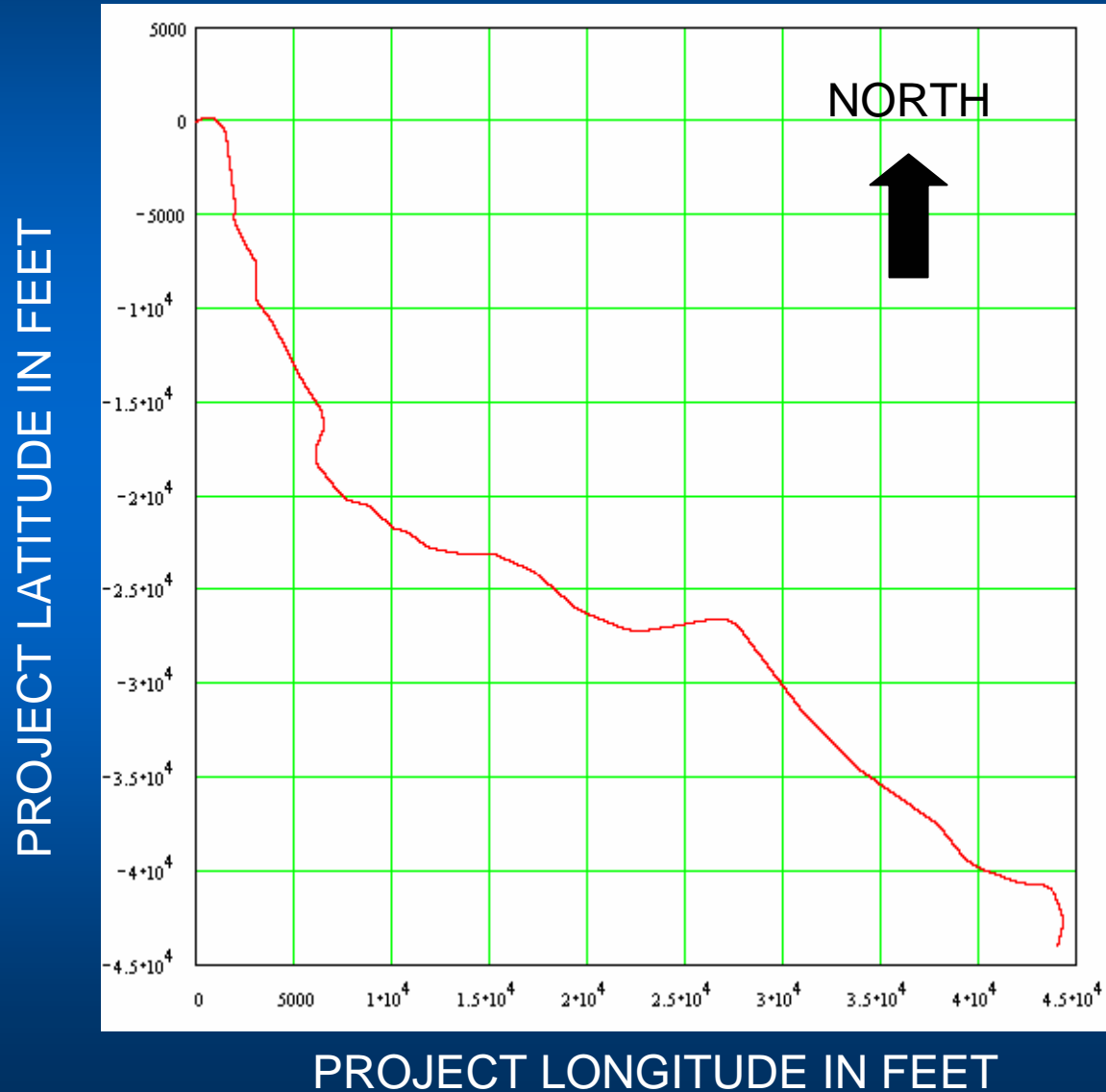


- VERTICAL ALIGNMENT

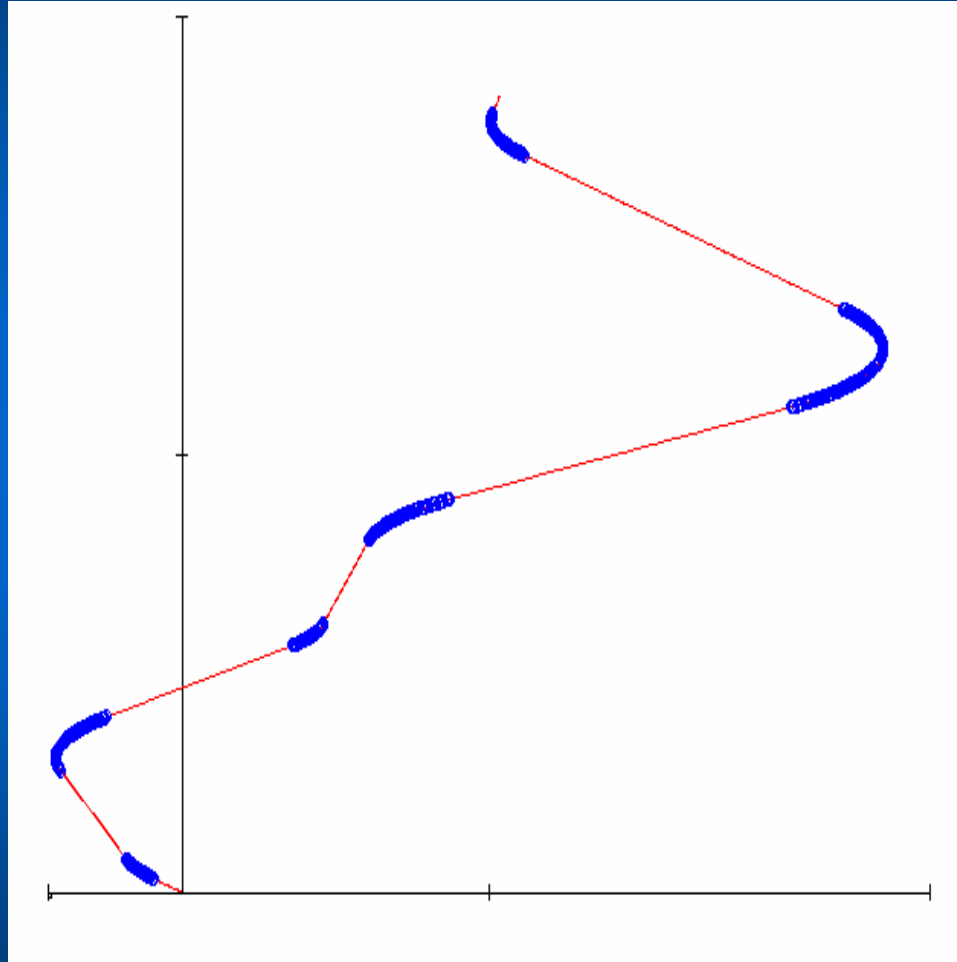


- SUPER-ELEVATION

PLAN VIEW

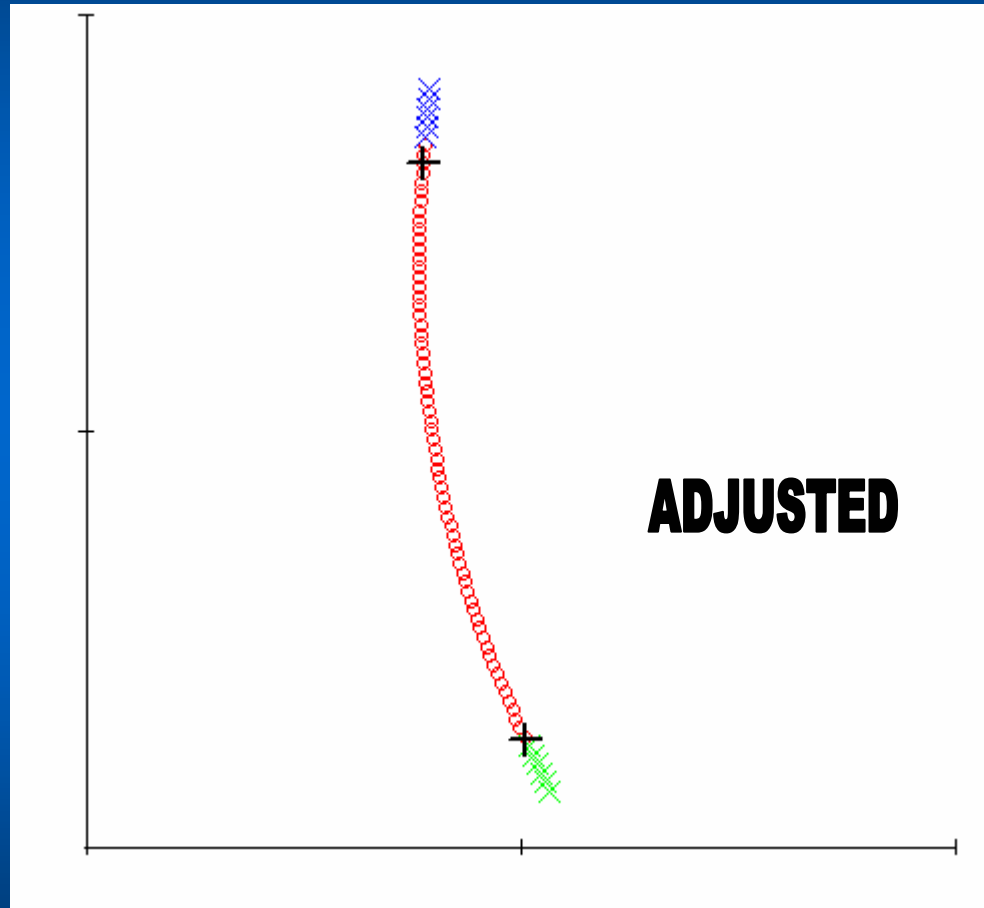


HORIZONTAL ALIGNMENT



Approximate PC = Point of Curvature and PT = Point of Tangency

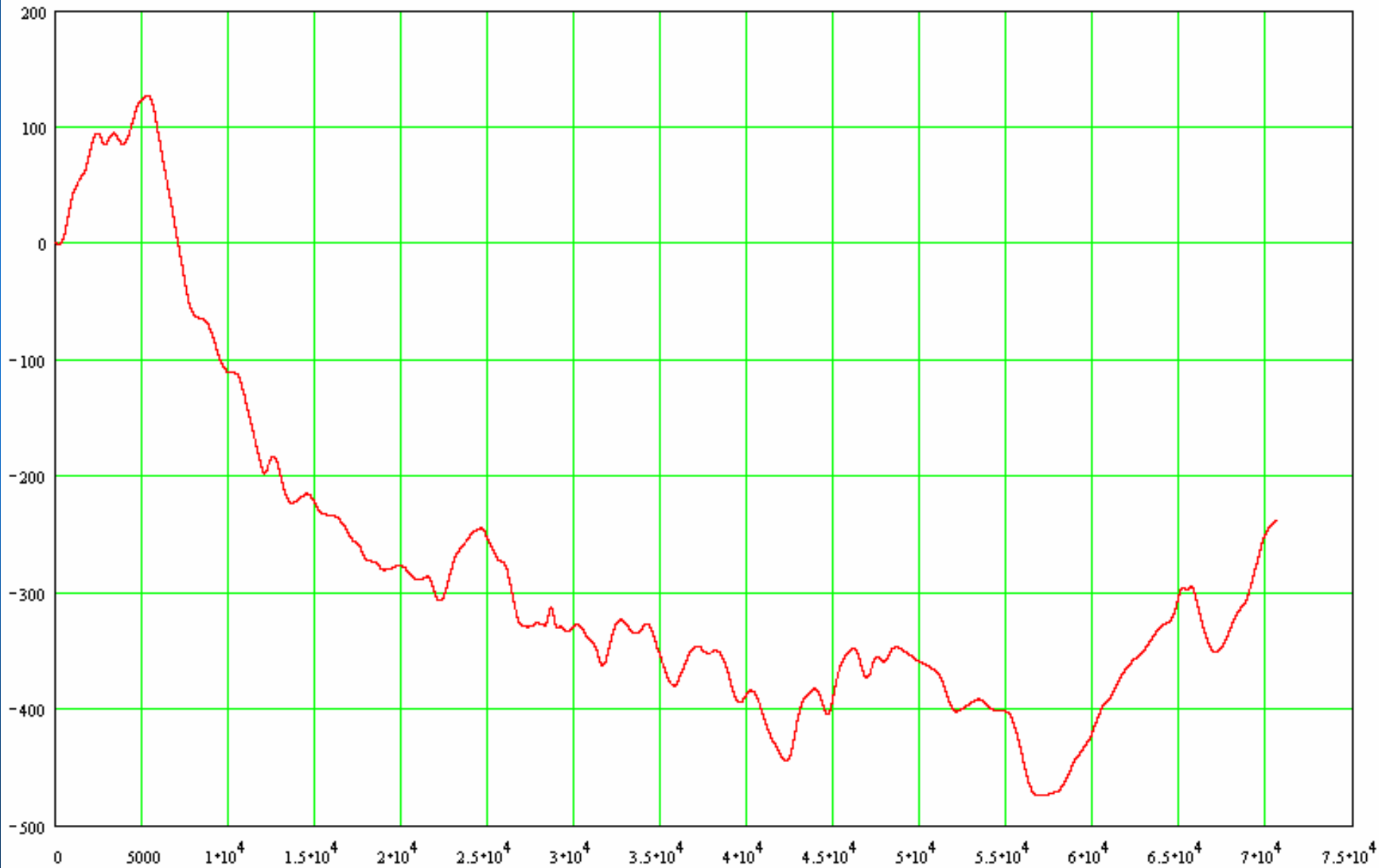
HORIZONTAL ALIGNMENT



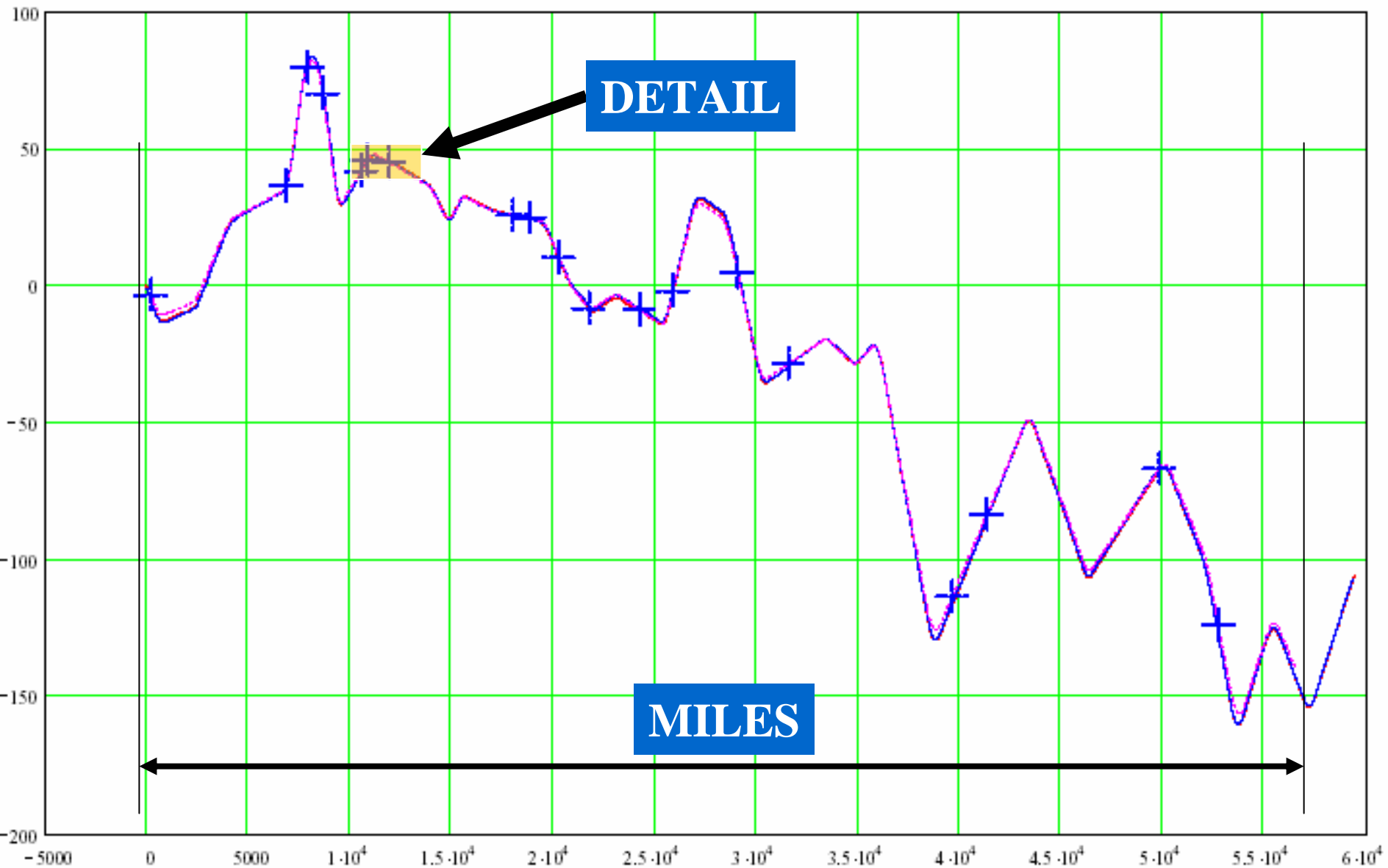
Refined PC = Point of Curvature and PT = Point of Tangency

ELEVATION VIEW

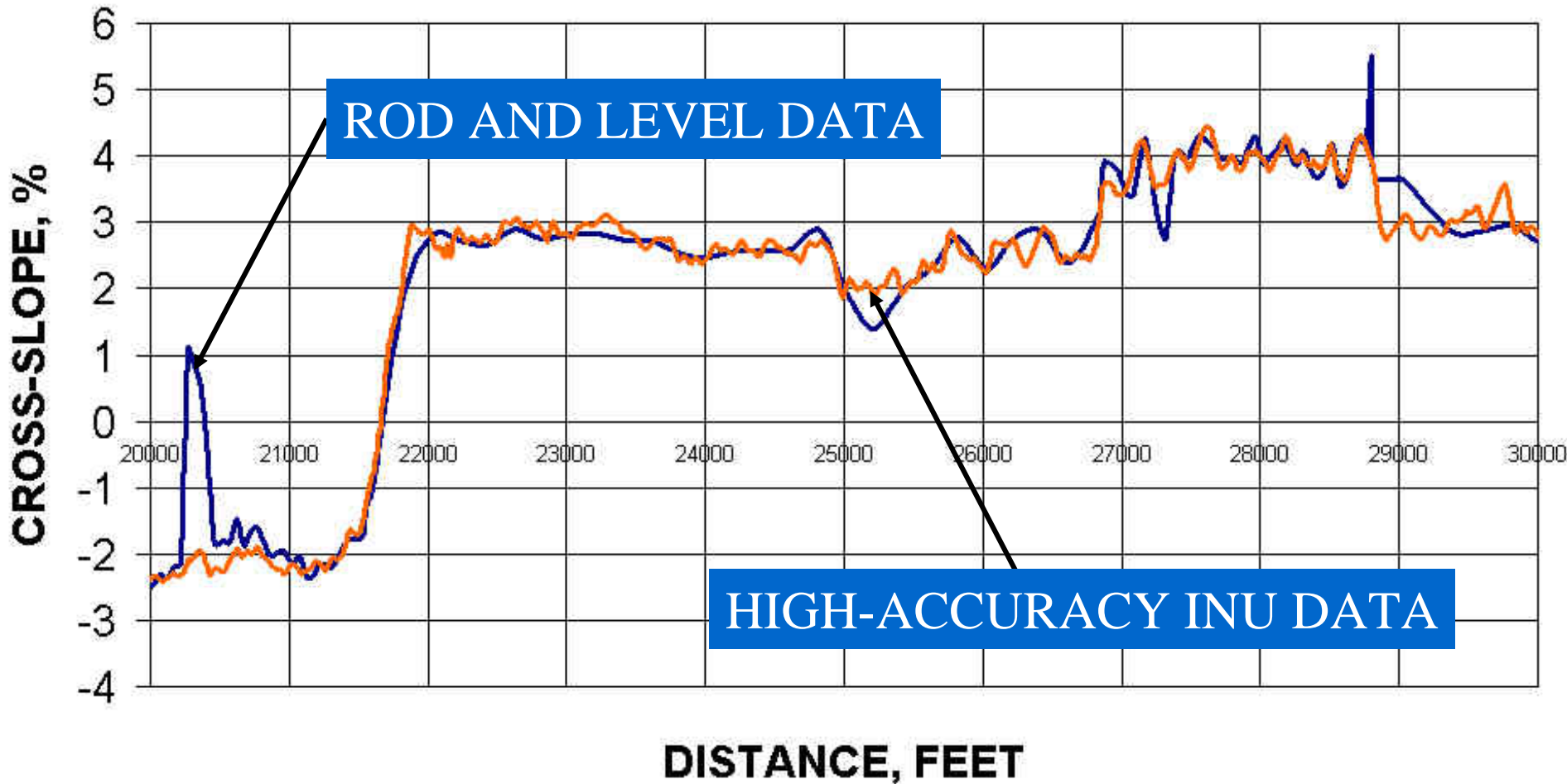
PROJECT ELEVATION IN FEET



VERTICAL ALIGNMENT

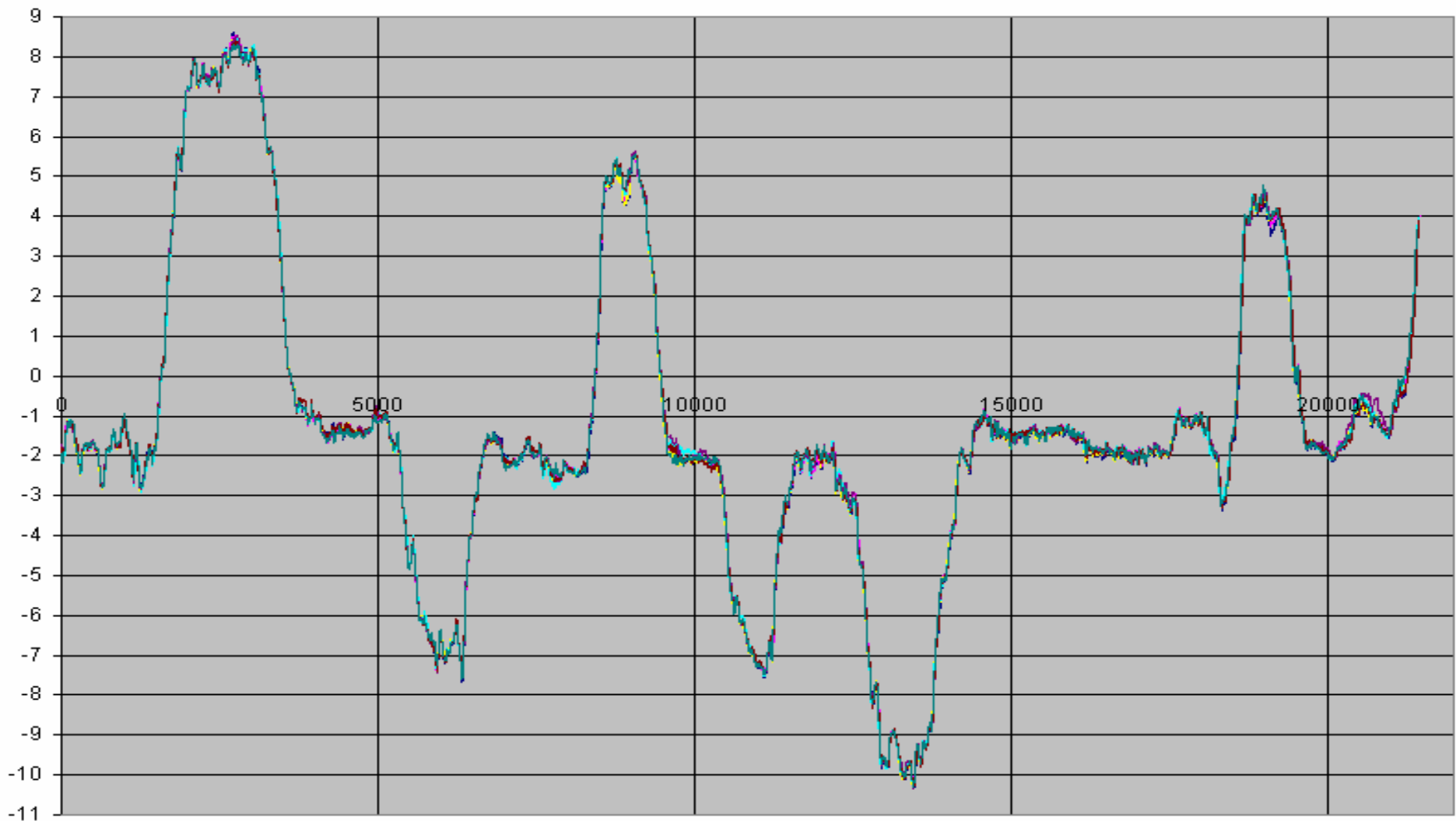


SUPER-ELEVATION



Comparison with rod and level data over 2 miles

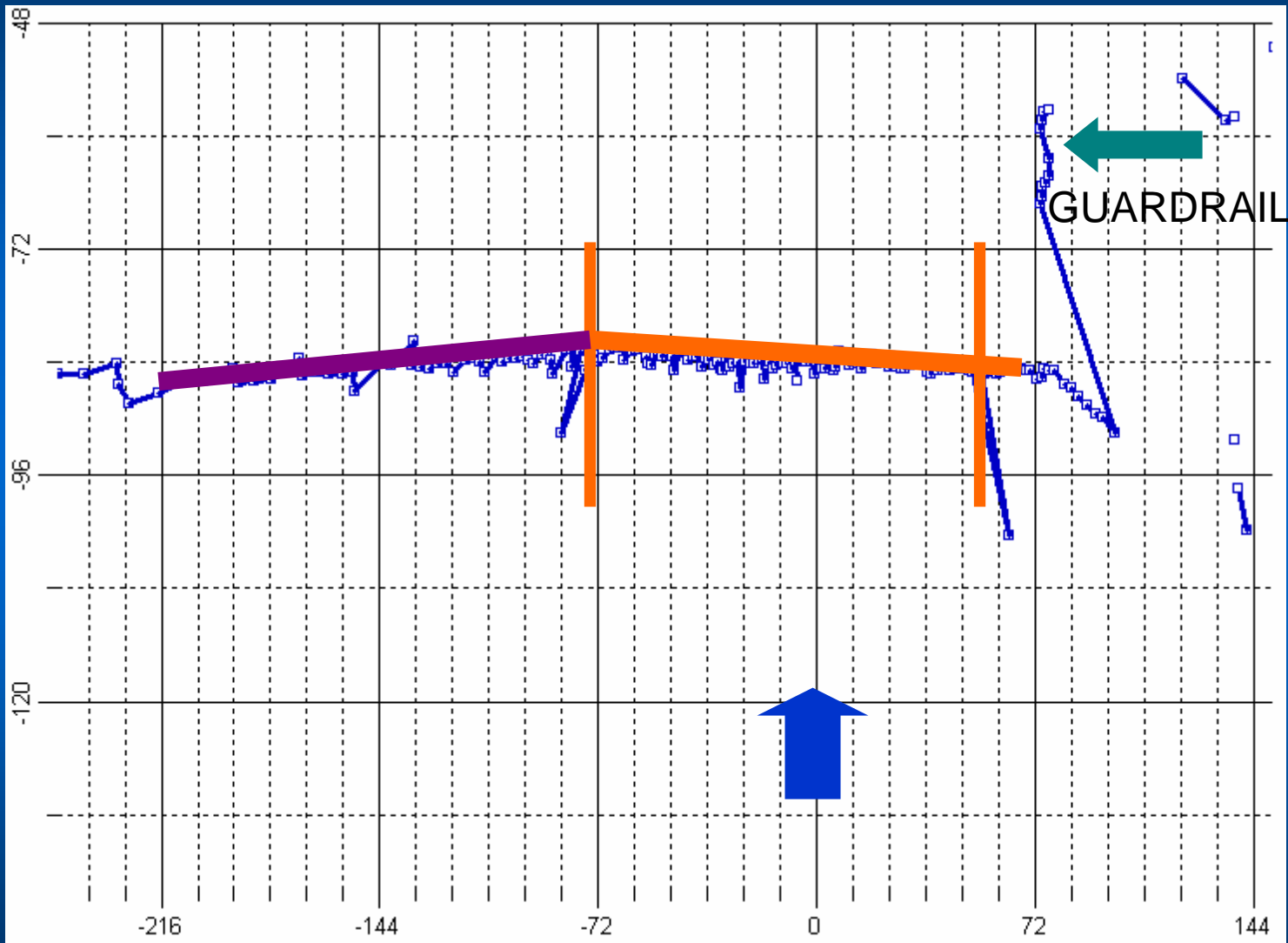
SUPER-ELEVATION



7 Runs Super-Imposed: Measured Precision = 0.02%

CROSS-SECTION SCANS

ELEVATION IN INCHES

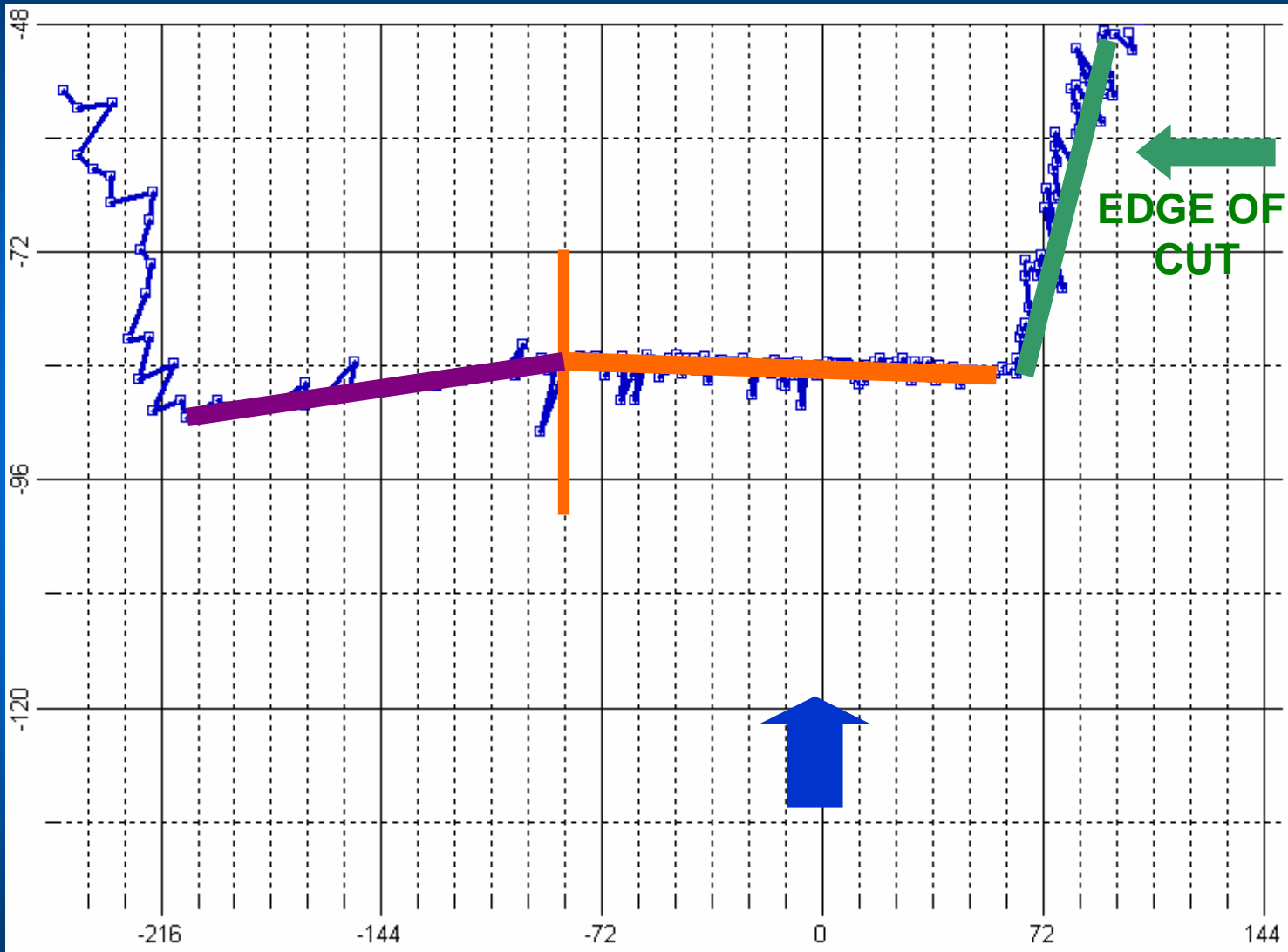


OFFSET FROM CENTERLINE OF VEHICLE IN INCHES

POSITION OF GUARD RAIL

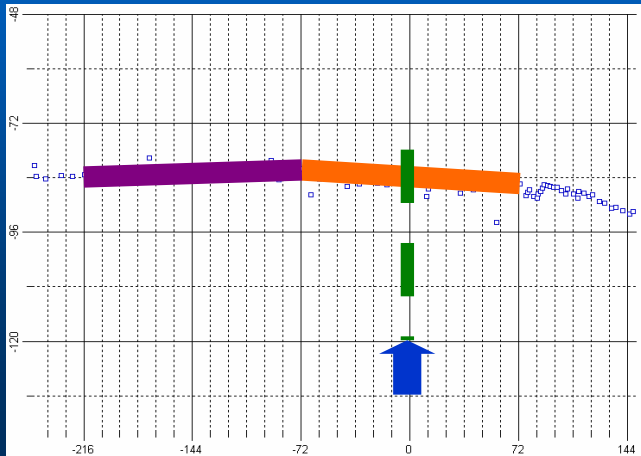
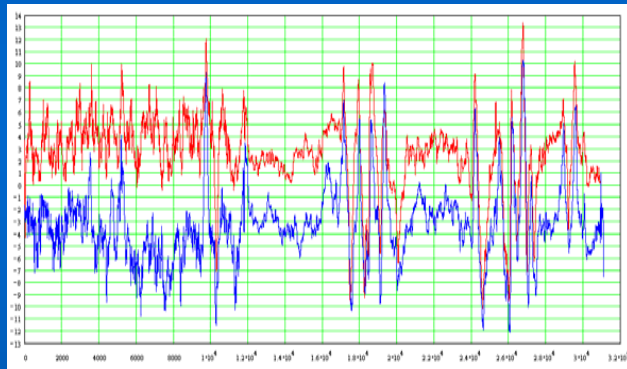
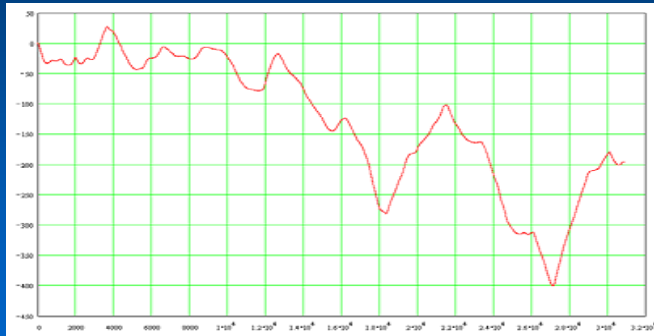
CROSS-SECTION SCANS

ELEVATION IN INCHES



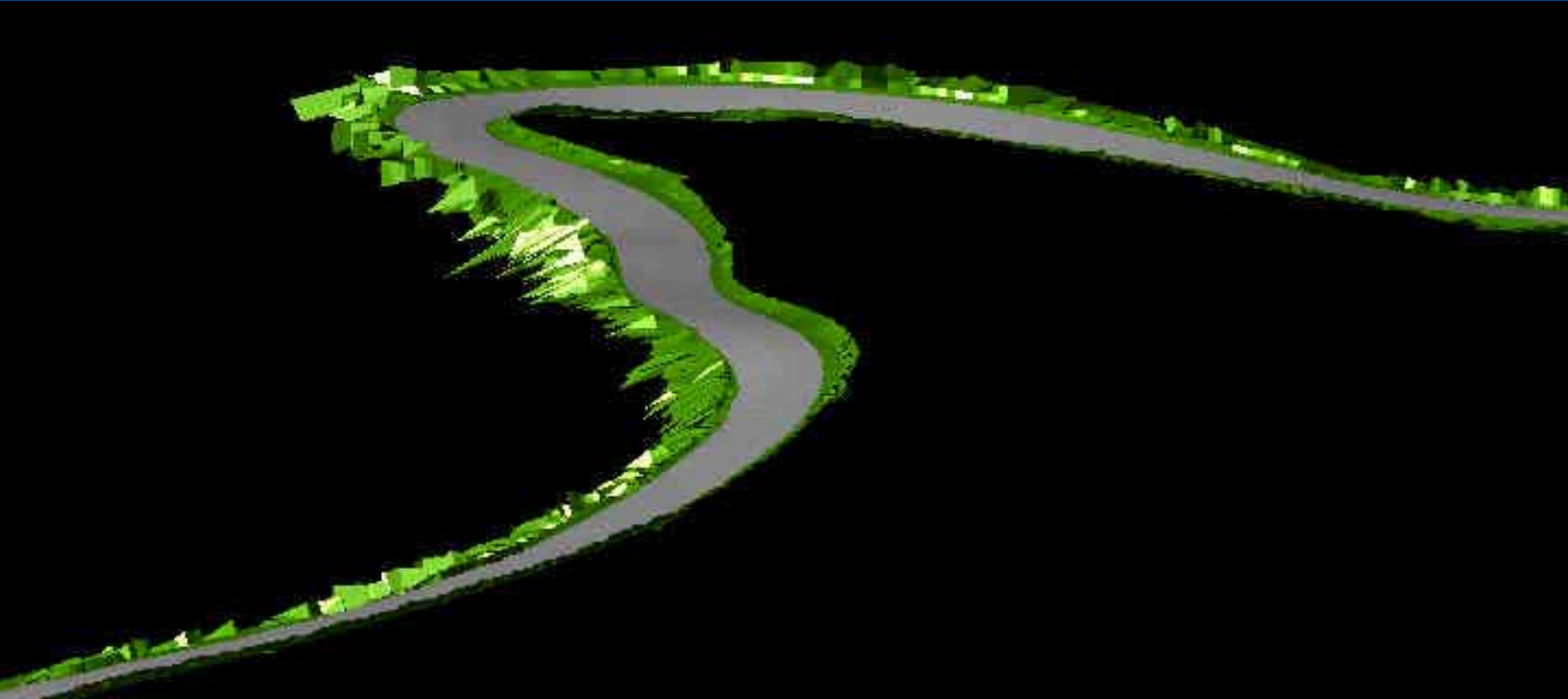
OFFSET FROM CENTERLINE OF VEHICLE IN INCHES

CROSS-SECTION PLOTS



- ESTABLISHMENT OF A CONTROL LINE FOR LINEAR REFERENCING
- MERGE OF ELEVATIONS AND CROSS-SLOPES
- SUPERIMPOSED CROSS-SECTIONAL SCANS

Visualization

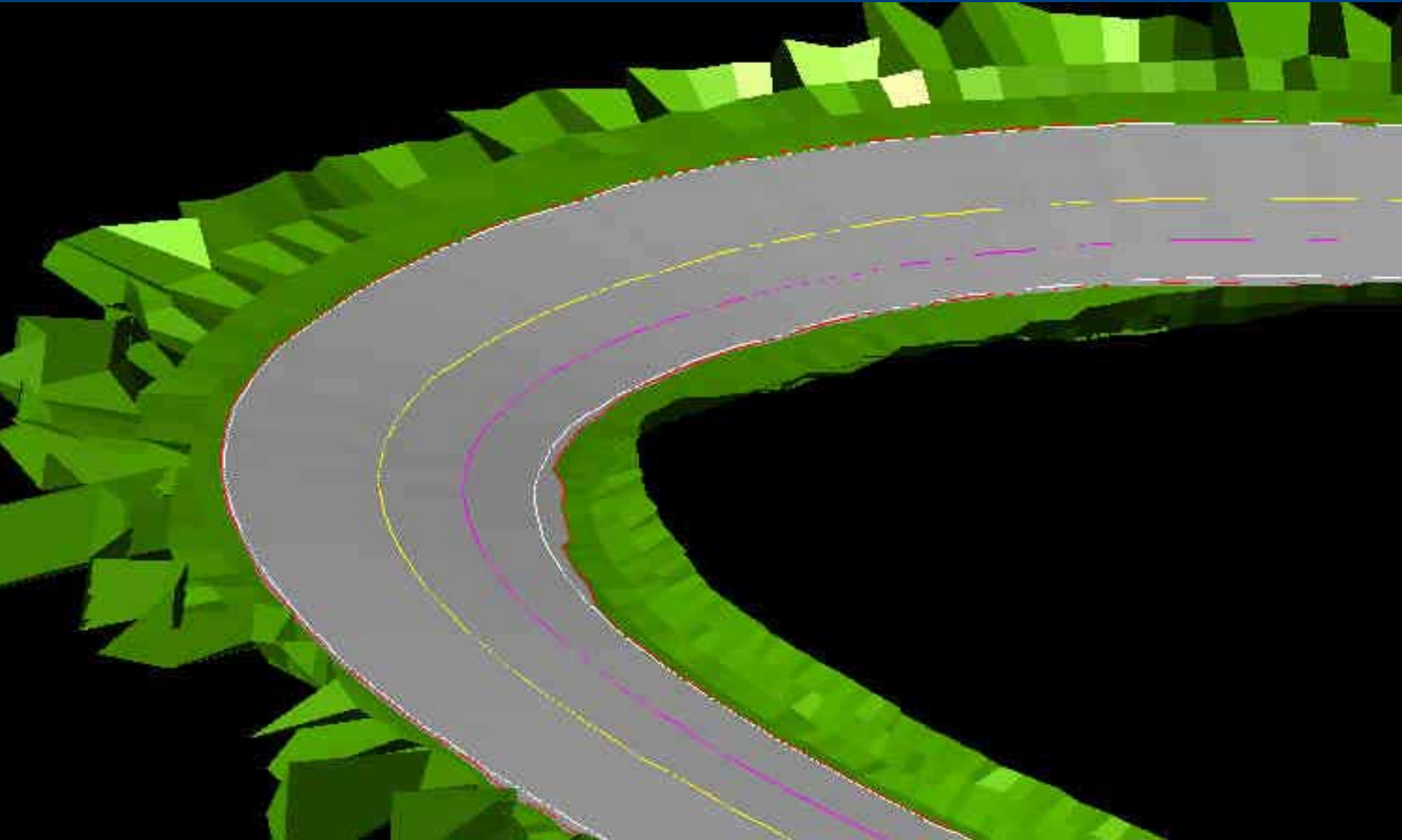


3-D RENDERING OF ROADWAY SURFACES

Superimpose Digital Imagery



Visualization



3-D RENDERING OF ROADWAY SURFACES

Superimpose Digital Imagery



Summary

- Federal Lands Highway uses
 - Performance oriented design and CSS
 - State of the art design technologies
- To deliver facilities which are
 - Technically feasible and responsible
 - In harmony with their environment
 - Reflect community and natural values
- That satisfy user and stakeholder needs
 - Safety
 - Mobility

For More Information

- Federal Lands CSS Web Site:

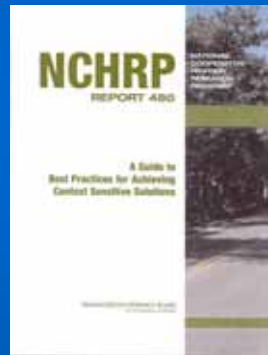
www.fhwa.dot.gov/csd/fed.htm

- NCHRP Report 480

*“A Guide to Best Practices for Achieving
Context Sensitive Solutions”*

- WWW.ContextSensitiveSolutions.Org

- WWW.TRBVIS.Org



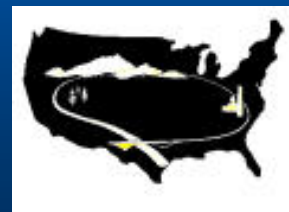
Thank You



Mark Taylor

Design Discipline Leader

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(720) 963-3607
mark.taylor@fhwa.dot.gov



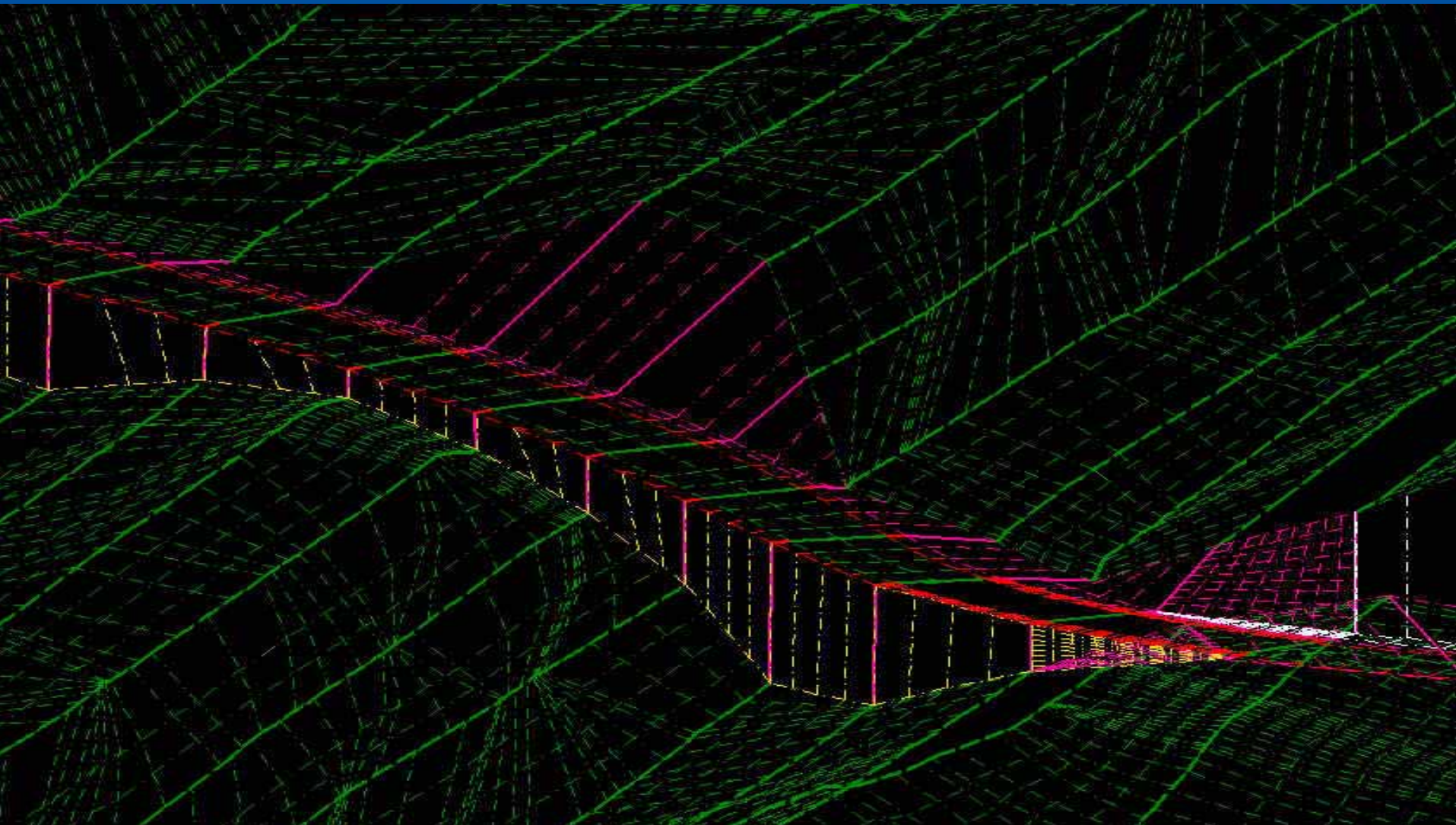
FEDERAL LANDS HIGHWAY

Photo-simulation Techniques

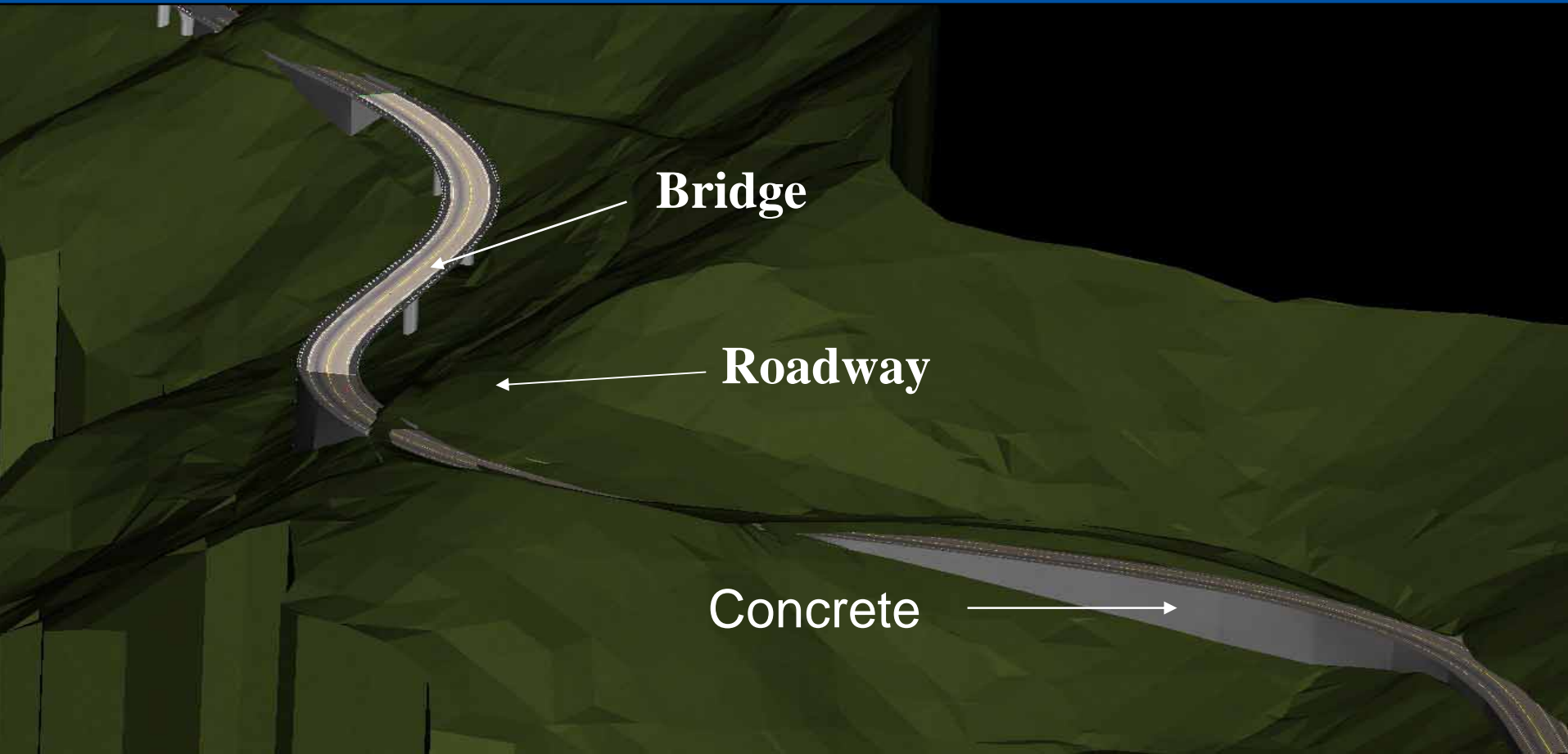
Data Furnished By Designer

- GEOPAK .gpk File
- Tin File
- Alignment Centerline Name
- Proposed Cross-Sections
- Roadway Criteria Files
- Structures TSL Info
- Structures Criteria Files

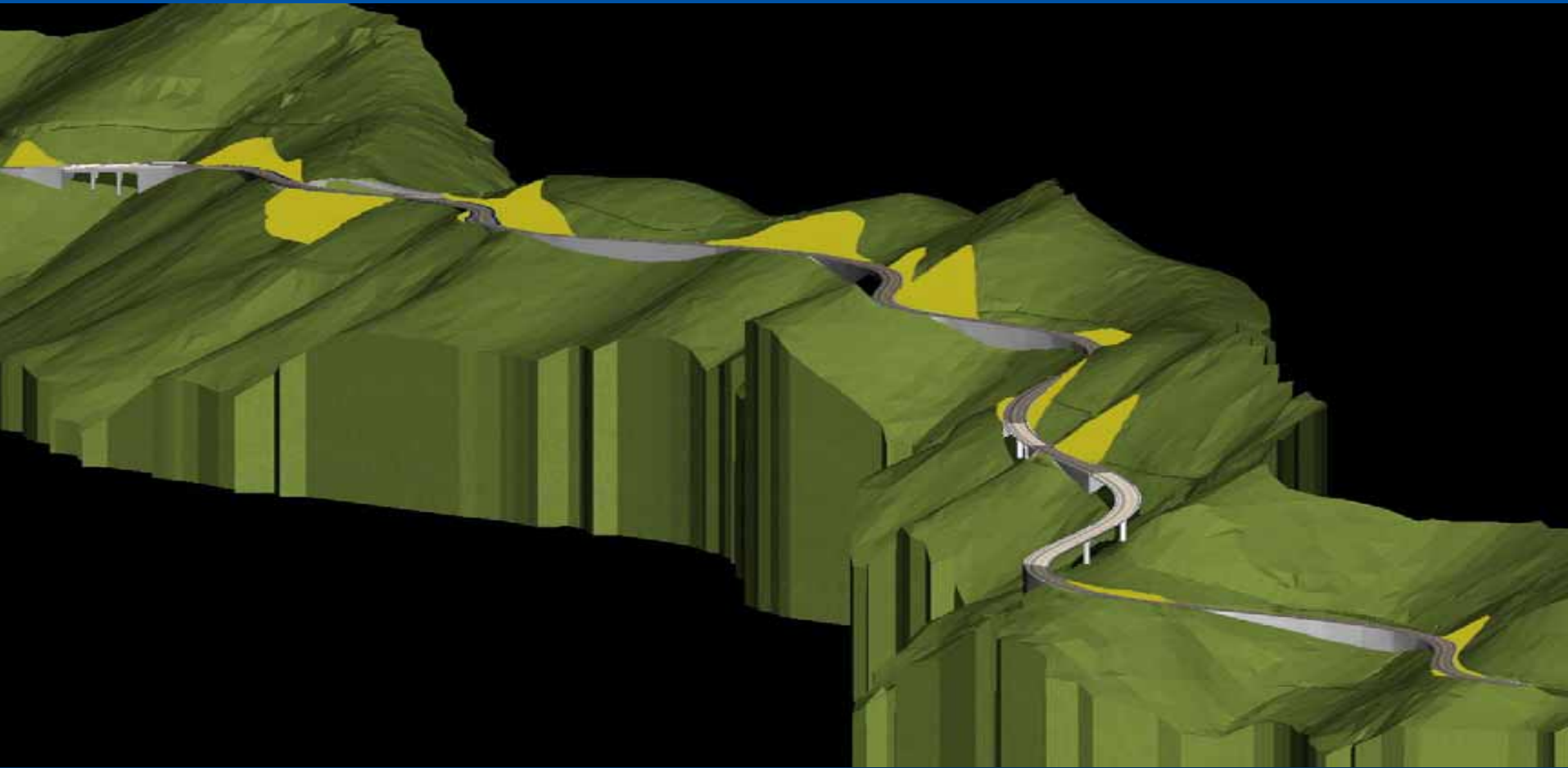
Run 3D Cross-Sections



Apply Surface Texture Materials



Apply Surface Texture Materials



Apply Lighting



Ray Trace Lighting
and Shadowing

Superimpose Photography



Photo Simulation Examples

8th Street Urban Street Improvements, Wash DC



8th Street Urban Street Improvements, Wash DC





