

Engineering Assessment Process



Engineering Assessment Process: Keys to a Solid Engineer's Report

Brad Steckler, P.E.

89th Annual Purdue Road School

March 26, 2003

Engineering Assessment Section
Environment, Planning, and Engineering Division; INDOT

Engineering Assessment Process

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INDOT's project-development process includes an early phase called Engineering Assessment. It involves conceptualizing and evaluating alternatives with respect to their engineering and transportation merits. An account of the process for each project is presented in an Engineer's Report.

What this Session Presents

1. Outline of the Engineering Assessment process
2. Its role in overall project development
3. Keys to generating a concise, defensible, and functional Engineer's Report...some often-confused concepts, some useful web sites
4. Some case studies
5. An informal survey of attitudes (if time available)

What's Not Presented

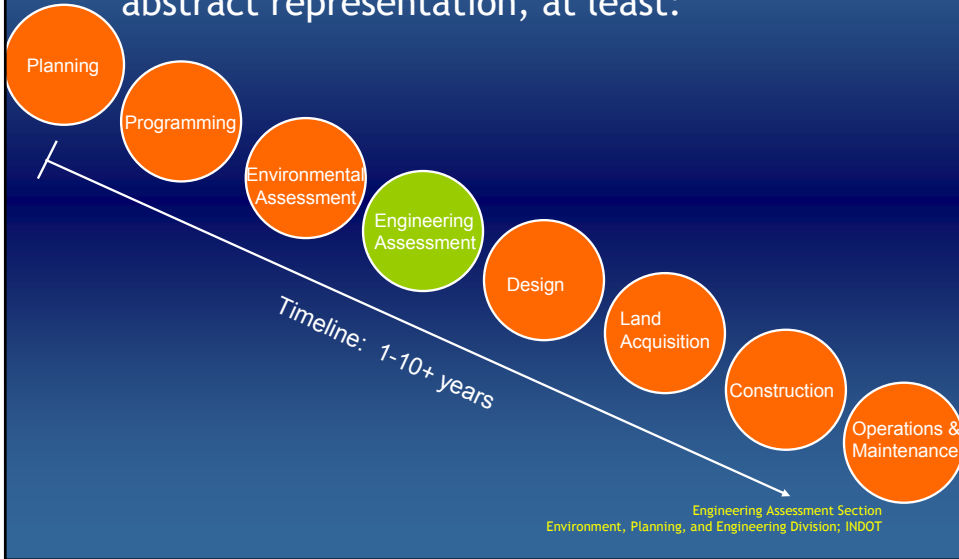
Other functions of the Engineering Assessment Section of INDOT, including...

- Interchange Justification studies
- Interstate “mini-scopes”
- Abbreviated engineer’s reports
- Special assignments (“related duties as required”)

Engineering Assessment Process

- Establish effective and efficient solutions to highway transportation problems. Effectiveness measures how well a plan meets the project objectives. A measure of economic return on investment, efficiency is a function of project cost.
- The Engineering Assessment process normally involves the development and comparison of alternatives, determination of the recommended course-of-action, and documentation. This phase of project life succeeds planning and precedes final design. Engineering Assessment complements related and at times concurrent phases of project development, including environmental review.
- The goals:
 - ◆ Ensure comprehensive consideration of reasonable improvement options,
 - ◆ Integrate engineering/transportation and environmental objectives, and
 - ◆ Effect recognition of a cost-effective, satisfactory course of action.

INDOT's project-development road map...an abstract representation, at least:



Project Report

INDOT FULL PROJECT LISTING

DATE: 3/25/2003 DED # 0700430

PROJECT MILEPOST EST/ACT START * EST/ACT FINISH

PROJECT MILEPOST	EST/ACT START	EST/ACT FINISH
Project Started	05/15/1997	05/15/1997
Engineering Assessment	03/24/2000	09/10/1998
Final Environ. Document Approval	09/15/2001	09/10/1998
Authorize Funds For Design	09/10/1998	09/10/1998
Start Plan Development	03/15/2001	03/15/2001

PROJECT MILEPOST	EST/ACT START	EST/ACT FINISH	PERSON RESPONSIBLE	PHONE	UPDATED DATE	UPDATED BY
Design Start	05/15/2000	05/15/2000	317232137	317232137	05/05/2000	
Design Approval	05/15/2000	05/15/2000	317232137	317232137	05/05/2000	
Final Environ. Document Approval	09/15/2001	09/15/2001	317232137	317232137	09/05/2000	
Authorize Funds For Design	09/10/1998	09/10/1998	317232137	317232137	09/05/2000	
Start Plan Development	03/15/2001	03/15/2001	317232137	317232137	03/05/2000	DOORMAN
Design Start	05/15/2000	05/15/2000	317232137	317232137	05/05/2000	DOORMAN
Design Approval	05/15/2000	05/15/2000	317232137	317232137	05/05/2000	
Final Environ. Document Approval	09/15/2001	09/15/2001	317232137	317232137	09/05/2000	
Authorize Funds For Design	09/10/1998	09/10/1998	317232137	317232137	09/05/2000	
Start Plan Development	03/15/2001	03/15/2001	317232137	317232137	03/05/2000	

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What's in a Name?

“Scoping” or “scope of work” has other, precise meanings in the field, in environmental coordination with resource agencies and in consultant contracts.

“Pre-Engineering”? The process involves application of a broad range of civil engineering principles as a means to solve a transportation problem.

Project Types Typically Having an Engineering Assessment Phase/Engineer's Report:

- New Road Construction, Road Reconstruction (4R)
- New Interchange Construction, Interchange Reconstruction
- New Bridge Construction, Bridge Replacement
- Small (Drainage) Structure Replacement
- Drainage Correction
- Road Rehabilitation
- Intersection Improvement
- Sight Distance Improvement
- Curve Correction
- Added Travel Lanes
- Landslide Correction
- New Rest Area Construction, Rest Area Modernization
- Railroad Crossing Reconstruction
- Others

Project Types Typically Not Having an Engineering Assessment Phase/Engineer's Report (a matter of substantive alternatives' analysis):

- Road Resurfacing (non-3R or non-4R standards)
- Shoulder Rehabilitation
- Bridge Rehabilitation
- Traffic Signal Installation/Replacement/Modernization
- Signing, Lighting, Pavement Markings
- Landscaping, Enhancement
- Guardrail Repair or Installation
- Access Control
- Roadside Work
- Erosion Control
- Environmental Mitigation
- Maintenance Activities
- Feasibility/Planning/Corridor Studies
- ITS
- Local-Jurisdiction Projects
- Transit projects
- Others

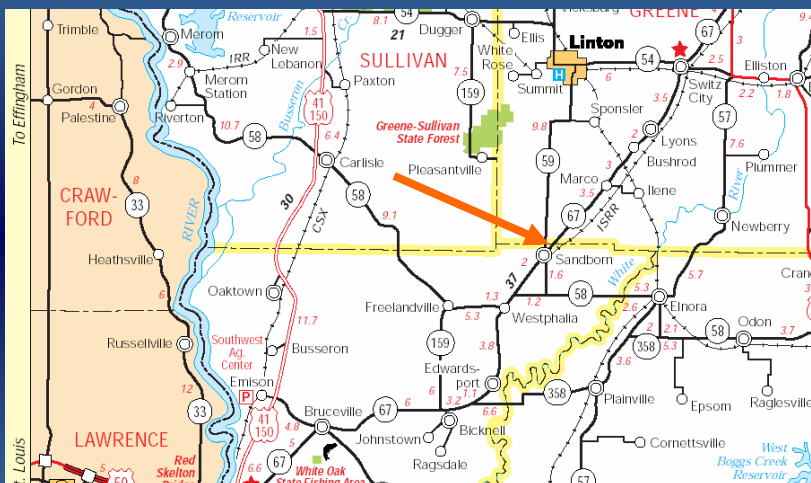
Two Case Studies...the Spectrum

1. Small Structure Replacement
2. I-80/I-94 (Borman Expressway)

SR 67 @ Unnamed Tributary to Hill Ditch

Knox County

Small Drainage Structure Replacement Project



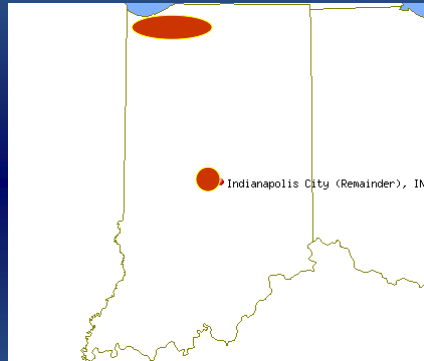
- 12' span by 6' rise box culvert, built in 1932, widened in 1950's
- Six-page Engineer's Report, plus appendices
- Need and Purpose: The primary need for the improvement is based on the deteriorating conditions present in this aging structure. The moderate silt buildup present under the north portion of the structure reduces the hydraulic capacity of this structure and the scour present causes the south abutment footing to be potentially vulnerable. The purpose of this project is to replace this deteriorating small structure, while providing a hydraulically adequate structure.
- 3R rural arterial design class
- Construction cost: \$380,000

I-80/I-94 (Borman Expressway)

Lake County

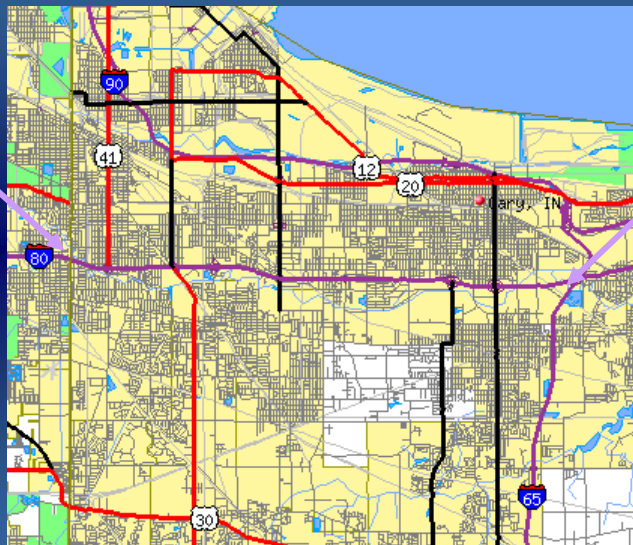
Pavement Replacement, Added Travel Lanes, Interchange Reconstruction

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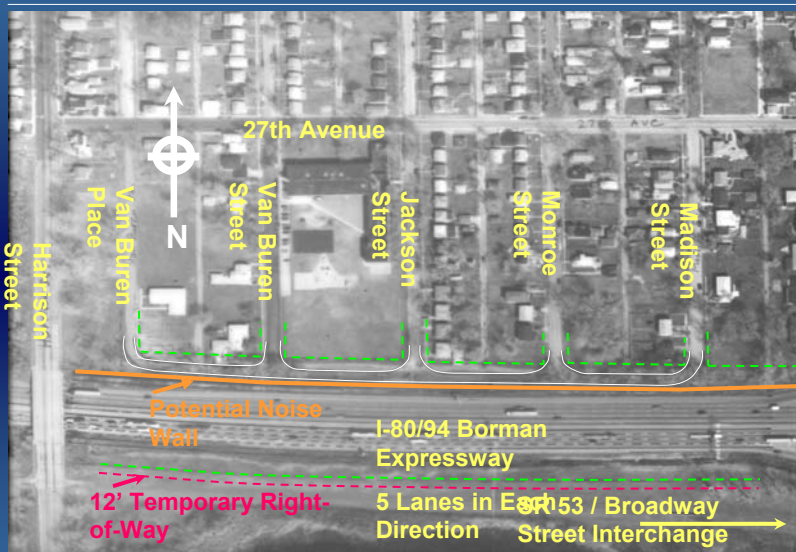
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Project Purpose is to Improve...

- Function
- Capacity
- Safety
- Operation
- Pavement Condition
- Bridge Condition
- Drainage



Engineering Assessment Process

- Time of Crash Analysis January 1995 to March 1999 (4 yrs, 3 mos)
- Property Damage-Only Crashes 5,221 reported
- Personal Injury Crashes 1,328 reported
- Fatal (at the scene) Crashes 23 reported
- Total Crashes 6,572 reported
- Total Crash Rate 12.75 crashes per 1,000,000 entering vehicles
- Total Fatality Rate 4.46 fatalities per 100,000,000 entering vehicles
- A crash of any kind has been reported per every 14'11" length of the Borman, or, every 5 hours-36 minutes.
- A fatality has has been reported per every 0.81 mile length of the Borman, or every 68 days.

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User Costs and Agency Benefits

Year 2006 Existing Configuration Cost	\$295,760,000
Year 2024 Existing Configuration Cost	\$488,620,000
Year 2006 Proposed Configuration Cost	\$247,420,000
Year 2024 Proposed Configuration Cost	\$314,620,000
2006—2024 Existing Cumulative Cost	\$4,291,090,000
2006—2024 Proposed Cumulative Cost	\$3,187,100,000
User Benefits (Existing minus Proposed)	\$1,103,990,000
User Benefits (Discounted to Year 2001)	\$905,290,000

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- Project Costs

Section 1—Overhead Bridges	\$10,010,000
Section 2—West Borman + Bi-State	\$67,440,000
Section 3—Central Borman	\$74,910,000
Section 4—Borman / I-65	\$90,570,000
Total Borman Project Cost	\$242,930,000

Engineering Economic Analysis

Net Present Value **\$662,360,000**

Benefit-Cost Ratio **3.73**

Run the Numbers

- Annual consultant budget (routine work): \$600,000-\$800,000
- Five consulting firms “on call” for routine work w/r/t engineering assessment tasks
- INDOT resources: 15-person staff of engineers, engineering assistants, draftspersons
- Cost per Engineer’s Report (routine projects): \$9,000
- Projects per year (routine): 150-200
- Share of out-sourced vs. in-house projects: 50/50
- Projects’ value per year (routine projects): \$400-\$600 million

Steps in the Engineering Assessment Process:

1. Verify or determine project’s essential need and purpose
2. Collect basic data
3. Conduct on-site inspection
4. Select design criteria
5. Analyze data
6. Refine project’s need and purpose
7. Develop alternative improvement plans
8. Evaluate alternatives
9. Identify a provisional recommendation
10. Write Engineer’s Report

Note: See Chapter 5 of the Indiana Design Manual.

Checks through the process:

- Environmental assessment
- Contacts with other offices
- Involvement of officials and public
- Consistency with other projects and plans

Task 1: Establish Need and Purpose

- “Need” = deficiencies.
- “Purpose” = broad measures to address those deficiencies.

Task 2: Gather Information

- Project application (schedule)
- Prior planning studies, environmental documents
- Related projects
- Existing road and bridge plans
- Bridge inspection reports
- Aerial & GIS images
- Traffic data
- Crash (accident) history
- Road & pavement history
- Preliminary pavement design
- Preliminary hydraulic recommendations
- Geotechnical report

Task 3: Field Inspection

- Lead time
- Requisite parties
- Be prepared
- Observe...but be brief and safe
- Revisit need and purpose
- Social, economic, and environmental issues
- Feasible alternatives, tentative preferences
- Traffic maintenance and constructability
- Project schedule
- Measurements, still photos, video
- Prepare minutes of on-site meeting/inspection
- Follow-up

Task 4: Select fundamental design class & criteria

- 3R or 4R (alternatives)
- Design speed
- Rural or urban function
- Rural or urban cross section
- Roadway (travel lanes and shoulders) and roadside (ditches or border) dimensions

Task 5: Analyze Conditions

- Crash analysis
- Traffic capacity analysis
- Alignments, sight distances, cross-section dimensions, small structure and bridge status, hydraulics & geotechnical circumstances

Steps in Crash Analysis

1. Reduce records
2. Evaluate sheer crash events (clustering)
3. Develop crash rates
4. Compare crash rates
5. Advanced statistical analysis
6. Linking crash events to existing conditions
7. Countermeasures (Task 7)

Traffic Capacity Analysis

- Highway Capacity Manual or Software
- Other tools
- Simulation
- Analyze base, intermediate, and design years
- Peak periods
- No-build and build alternatives (Task 7)
- Check reasonableness of results
- Recognize limitations in precision and sensitive to quality of input variables/assumptions/default values

Task 6: Refine Project's Need and Purpose Statement

- Are the problems initially identified truly evident
- Are alternatives sufficient to address need and purpose
- Should the project advance, be deferred, or be deleted

Task 7: Develop Alternatives

- Draw up reasonable alternatives addressing need and purpose
- Detail to level allowing informed comparison and sufficient explanation of scale of work to downstream phases
- Secure findings on environmental consequences from project's environmental analysis
- Estimate costs

- Task 8: Evaluate Alternatives
 - Informal analysis
 - Engineering economic analysis
 - Cost-effectiveness analysis

Note: See Chapter 5, pages 5-2(20) to 5-2(24).

Informal Analysis

Judgments regarding optimal improvement strategy rely principally on “standard” practice. Most projects may fittingly be addressed in this manner.

Engineering Economic Analysis

Limited to user and agency components having a tangible dollar value, in a life-cycle approach. Engineering Economic Analysis is referenced by other names, including traditional benefit-cost analysis. Applicable in projects having no appreciable non-user or environmental consequences. Less frequently applied than Informal Analysis, but more so than Cost-Effectiveness Analysis.

Cost-Effectiveness Analysis

Blends objective and subjective reasoning along with qualitative measures into the decision. More comprehensive form of "B-C analysis." Applicable to projects having multiple objectives, demanding accounting of non-user and external consequences. A host of methods are available, of varying degrees of complexity.

Task 9: Make a Recommendation

- Consideration includes level of satisfaction of need and purpose, efficiency, and impacts
- Consensus building of various interests, the nature of which is project-dependent

Task 10: Write Engineer's Report

- Purpose of Report
- Project Location
- Project Need and Purpose
- Existing Facility
- Related Projects and Plans
- Traffic Data and Capacity Analysis
- Crash (accident) Data and Analysis
- Alternatives
- Protocol for Later Revisions
- Appendices
 - Maps and Drawings
 - Data and Supplemental Analyses
 - Other

Two More Case Studies

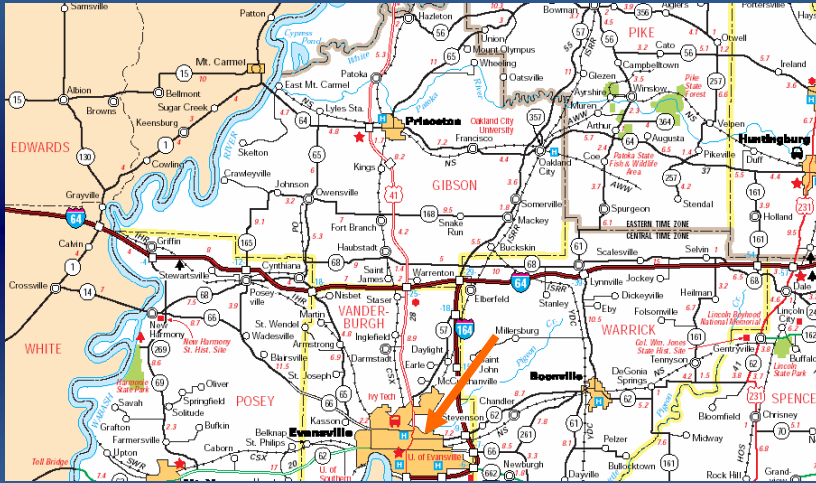
1. SR 62 & Oak Hill Road
2. SR 51 & SR 130

SR 62 @ Oak Hill Road

Evansville

Intersection Improvement

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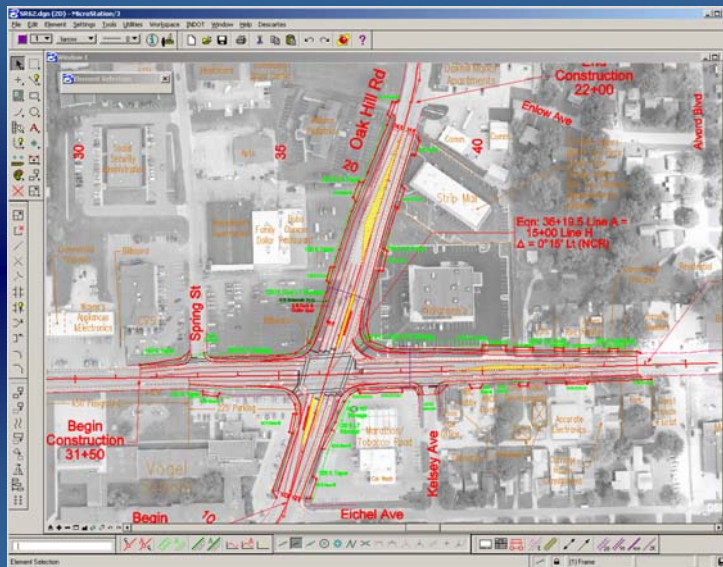
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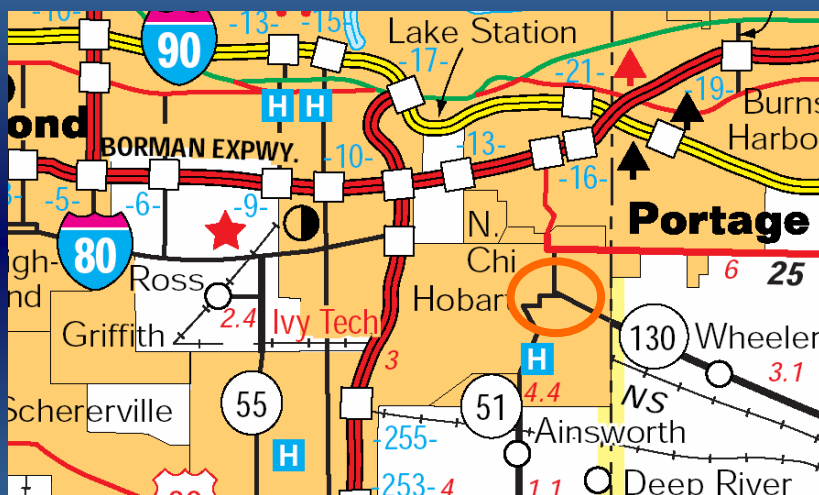


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SR 51 @ SR 130

Hobart, Lake County

Intersection Improvement and Median/Left-Turn-Lane Construction

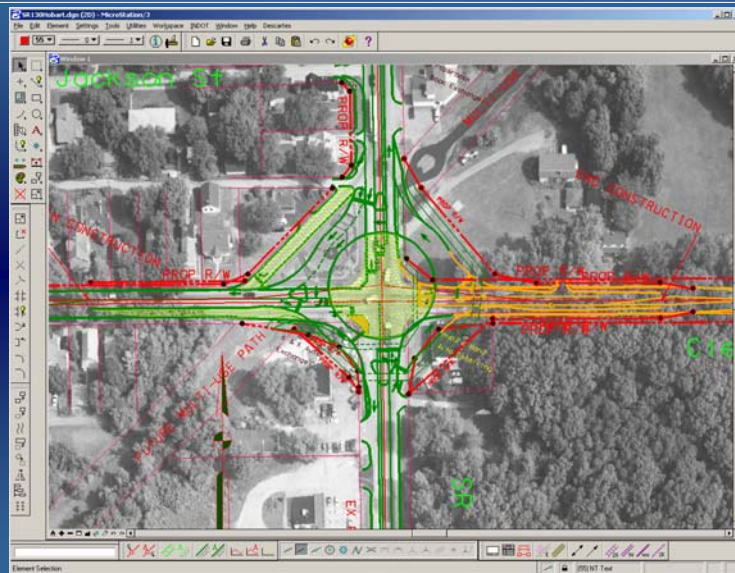


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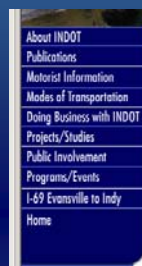
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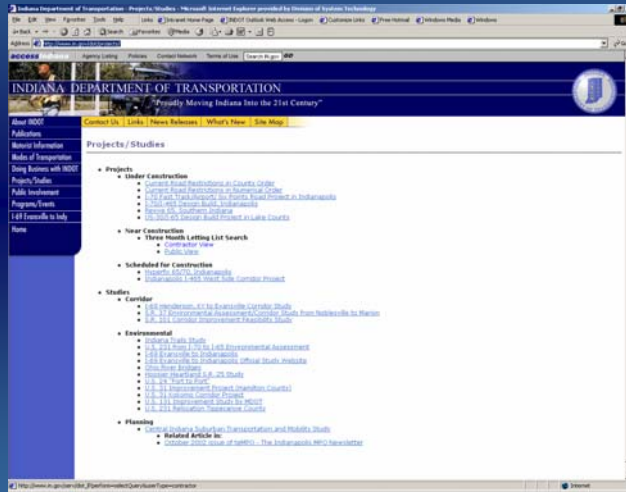
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Useful web sites

- <http://www.in.gov/dot/>



<http://www.in.gov/dot/projects/>



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<http://www.in.gov/dot/pubs/>



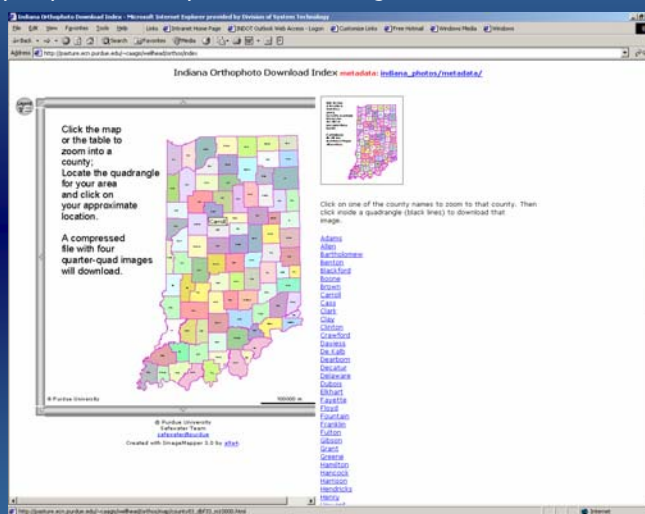
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<http://intranet.indot.state.in.us/maps/GISMaps.asp>



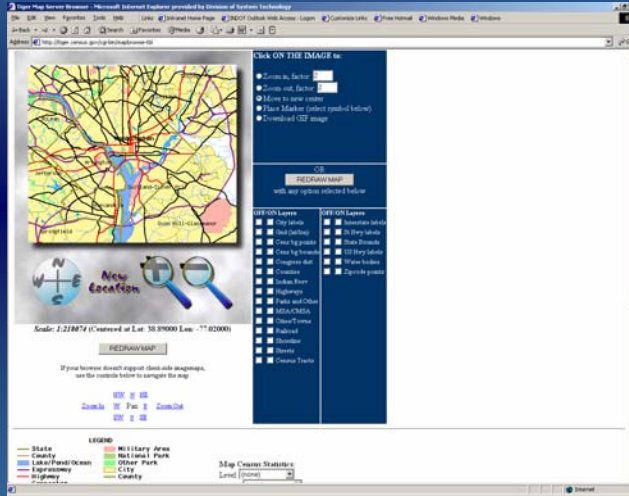
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- <http://pasture.ecn.purdue.edu/~caagis/wellhead/orthos/index>



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http://tiger.census.gov/cgi-bin/mapbrowse-tbl



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http://www.fhwa.dot.gov/



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<http://www.fra.dot.gov/site/index.htm>



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Commonly Misunderstood...

- 4R/3R network vs. 4R/3R standards
- Functional class vs. design class
- B/C ratio w/r/t ranking
- Design speed vs. operating speed vs. posted speed
- Roadway vs. Roadside
- Intersection Approach, Exit, Leg
- Freeway vs. expressway
- Full, partial, and no (drive permit) access control vs. L.A. R/W and non-L.A. R/W
- Skew vs. Intersection Angle
- Usable vs. paved vs. effective usable shoulders
- Distinction between design consultant and design consultant reviewer
- The power and limitations of traffic capacity analysis and traffic simulation
- TIP vs. STIP
- How projects are programmed
- How and when to engage the public and local public officials
- Too little detail vs. too much detail
- NHS vs. Statewide Mobility Corridors vs. Regional Corridors vs. Local Access Corridors
- Opportunity cost of capital
- While you're at it...
- Long Range Plan element vs. project
- Meaning/function of MPO's
- Who oversees what process/phase
- Relationship of environmental phase to other phases (planning, engineering assessment, design)
- NEPA, such terms as 4f, 6f, Section 106
- How to fill out a travel voucher

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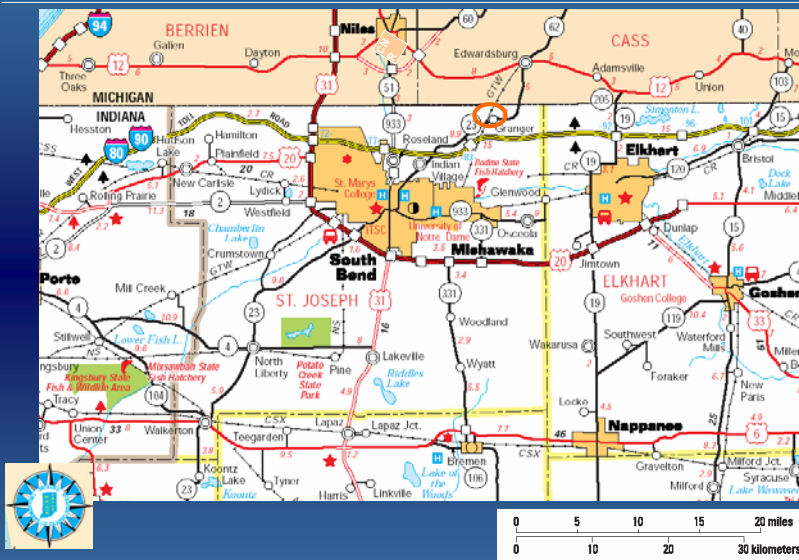
A Final Case Study

SR 23 @ Canadian National RR

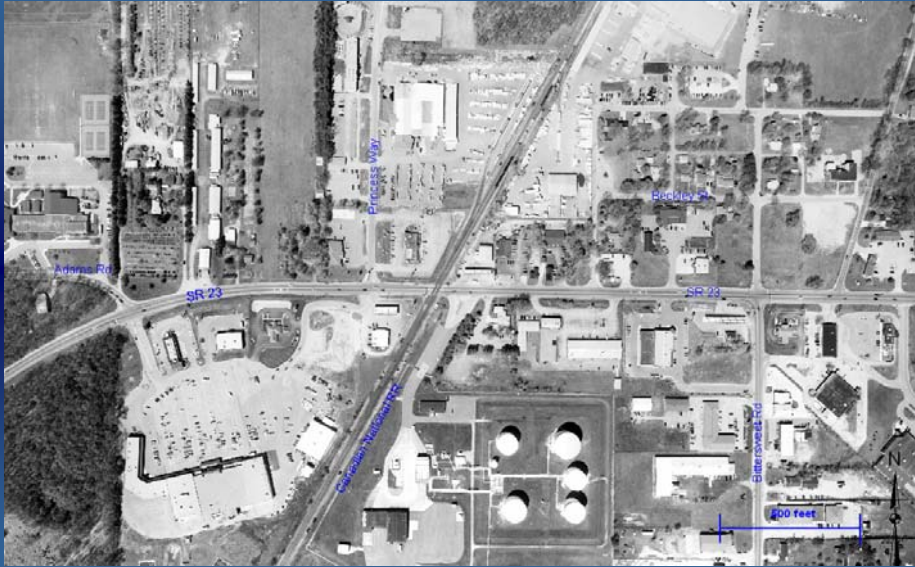
Grade Separation/Capacity Expansion

Granger, St. Joseph County

Programmed cost: \$5 million



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Build Alternatives

1. Widen present SR 23 to 4 lanes
2. Construct a highway bridge over the RR
3. Construct a RR bridge over the highway, elevate the RR
4. Relocate SR 23 one block north
5. Relocate SR 23 off-alignment (out of town)
6. Construct a RR bridge over the highway, depress SR 23
7. Other options

Alternate One:

Widen SR 23 on the present alignment to four lanes.

- **Acquire Additional 10 - 20 ft. of Right-of-Way Each Side**
- **0 Business Relocations - 30 Additional Properties Affected**
- **0 Residential Relocations - 5 Properties Affected**
- Advantages: Least impact on residents and businesses.
- Disadvantages: Provide short term relief but congestion will likely return in the future.

- **Cost = approximately \$4 million**

Alternate Four:

Construct bridge to take SR 23 over railroad on alignment one block north.

- **6 Business Relocations - 10 Additional Properties Affected**
- **13 Residential Relocations - 12 Additional Properties Affected**
- Advantages:
 - Can be built with little disruption to traffic.
 - Low direct impact on businesses.
- Disadvantages:
 - High impact on residences.
 - Negative indirect business impacts due to loss of thru traffic.
- **Cost = approximately \$21 million**

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Areas of Attention

- Efficiency in transportation investments: spending limited funds in the most effective manner
- Cost (time) controls for engineering assessment/engineer's reports
- Maintaining balance in work out-sourced and work carried out by in-house staff
- Consistency in level of effort/detail/precision
- Continued enhancement with respect to integrating bicyclist/pedestrian movements within road projects
- Attention to intellectual/human-resource issues
- Safety records and analysis
- Signing as a factor in alternatives' development
- Reconciling local street infrastructure investments with those of the state-jurisdictional highway network
- Implementing the 2000-2025 Long Range Plan, including the future of the rural Interstate System in Indiana

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