FHWA OFFICE OF OPERATIONS PEER EXCHANGE WORKSHOP

INNOVATIVE CONTRACTING AND ACCELERATED CONSTRUCTION TECHNIQUES FOR WORK ZONE SAFETY AND MOBILITY

ABC AHP Decision Tool

Pool Funded Study, TPF 5(221)

June 5-6, 2012

Denver, Colorado

Accelerated Bridge Construction (ABC) Analytic Hierarchy Process (AHP) Decision Tool

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Outline

- Overview - Pool funded study TPF 5(221)
- Goals and objectives
- Criteria commonly used in project decisions
- AHP for multi-level and multi-criteria
- Tool Validation - Case Studies
- Deployment Plan

FHWA-sponsored pool funded study, TPF 5(221), Technical Advisory Committee

State	Members and Titles
Oregon	Benjamin Tang, P.E., Br Preservation Manager Steve Soltesz, Research Coordinator Dawn Mach, Bridge Fin. Analyst Holly Winston, Sr. Local Bridge Standards Engineer
FHWA	Mary F. Huie, Highways for LIFE, Program Coordinator Tim Rogers, P.E., Division Bridge Engineer Nat Coley, Asset Manager
California	Paul Chung, Sr. Bridge Engineer
Iowa	Ahmad Abu-Hawash, Chief Structural Engineer
Minnesota	Kevin Western, Bridge Design Engineer
Montana	David Johnson, Bridge design Engineer
Texas	Courtney Holle, Transportation Engineer
Utah	Daniel Hsiao, P.E., S.E., Sr. Project Manager
Washington	Bijan Khaleghi, Design Engineer DeWayne Wilson, Bridge Management Engineer

Overall Project Objective

Develop a decision tool:

- To help analyze different alternatives and multi-criteria
- To determine which construction approach for a specific bridge project is preferred
- To compare conventional and accelerated construction approaches.

Project Goals and Target Users

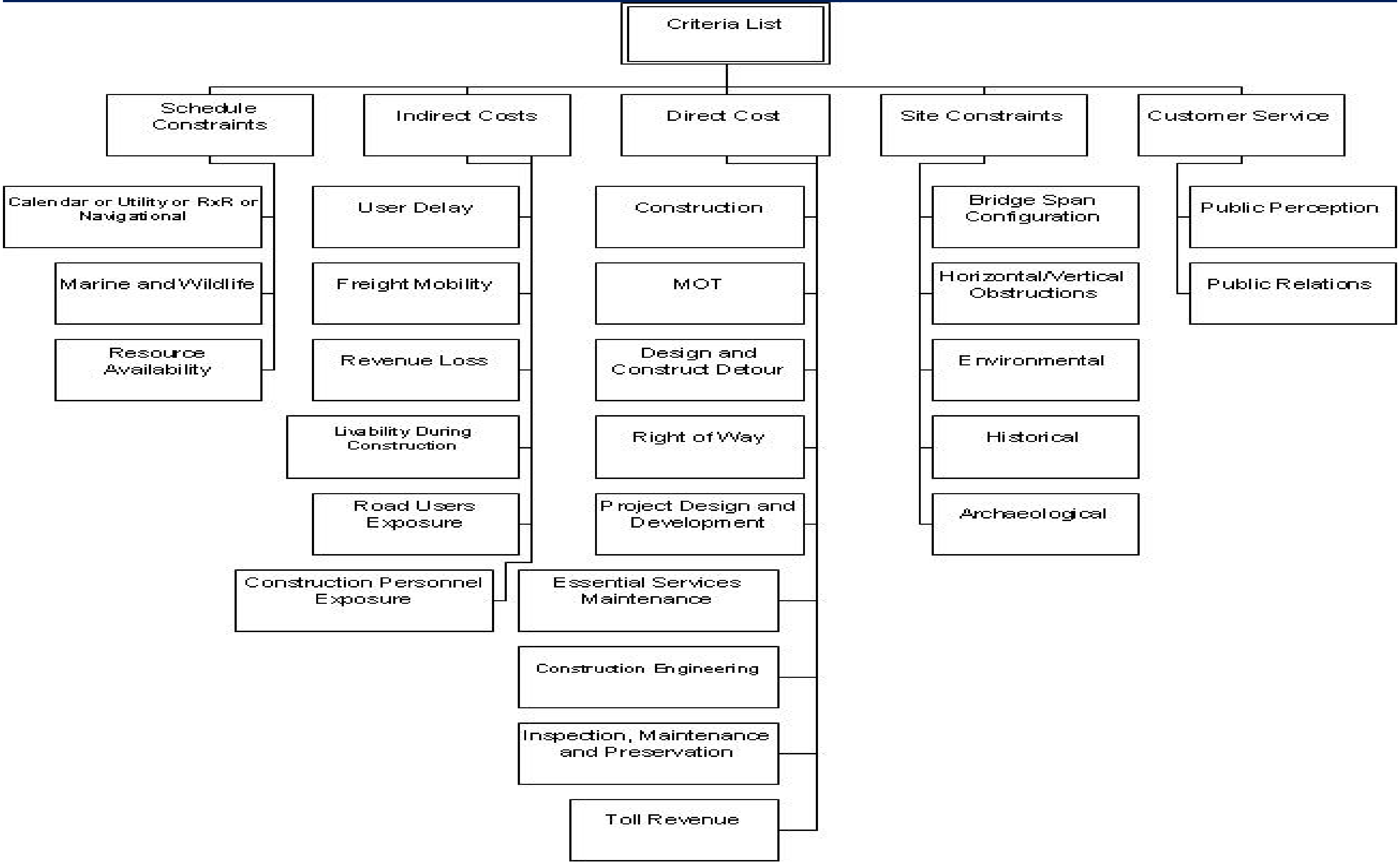
Goals of Project

- Bring ABC to ordinary (bread and butter) bridges
- Create a tool that can communicate decision rationale
- Assists users in making ABC a standard practice

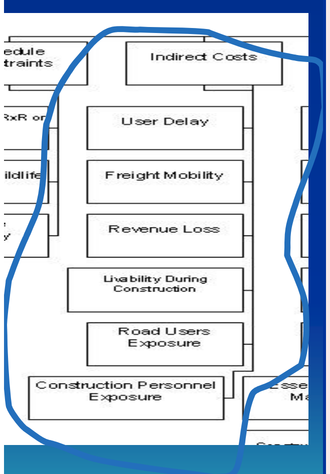
Target User Population

- Project managers
- Engineers
- Project owners
- Program planners

Criteria Organization



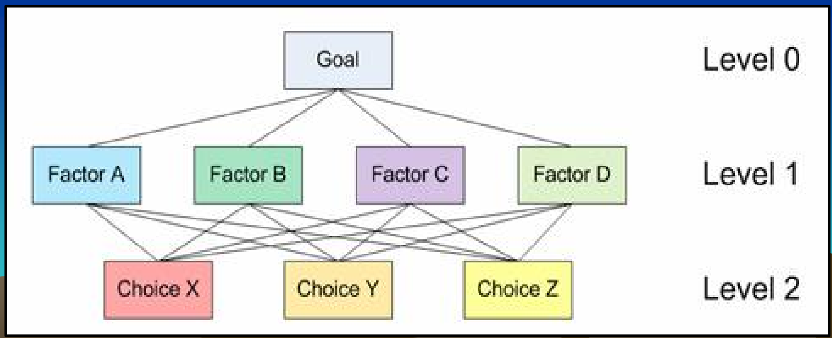
Defining Criteria (Example)



Criteria	Sub-Criteria	Definitions
Indirect Costs	User Delay	This factor captures costs of user delay at a project site due to reduced speeds and/or off-site detour routes.
	Freight Mobility	This factor captures costs of freight delay at a project site due to reduced speeds and/or off-site detour routes.
	Revenue Loss	This factor captures lost revenues due to limited access to local business resulting from limited or more difficult access stemming from the construction activity.
	Livability During Construction	This factor captures the impact to the communities resulting from construction activities. Examples include noise, air quality, and limited access.
	Road Users Exposure	This factor captures the safety risks associated with user exposure to the construction zone.
	Construction Personnel Exposure	This factor captures the safety risks associated with worker exposure to construction zone.

Approach to Multi-Criteria Decision-Making

- AHP (Analytic Hierarchy Process) is a decision-making technique designed to select the best alternative from a set of alternatives evaluated against several criteria.
- The decision maker performs pair-wise comparisons that are used to develop an overall priority ranking for each alternative.



Analytic Hierarchy Process (AHP)

Developed by Prof. Thomas Saaty, Wharton School of Business (McGraw-Hill, NY, 1980)

1. Develop Decision Hierarchy
2. Construct Comparison Matrices (linear algebra)
3. Calculate Eigenvector and Eigen values
4. Check Consistency of Matrices
5. Evaluate and Compare Alternatives for Criteria and Decision making
6. Conduct a sensitivity analysis of the model

Software Demo
Comparing any two alternates

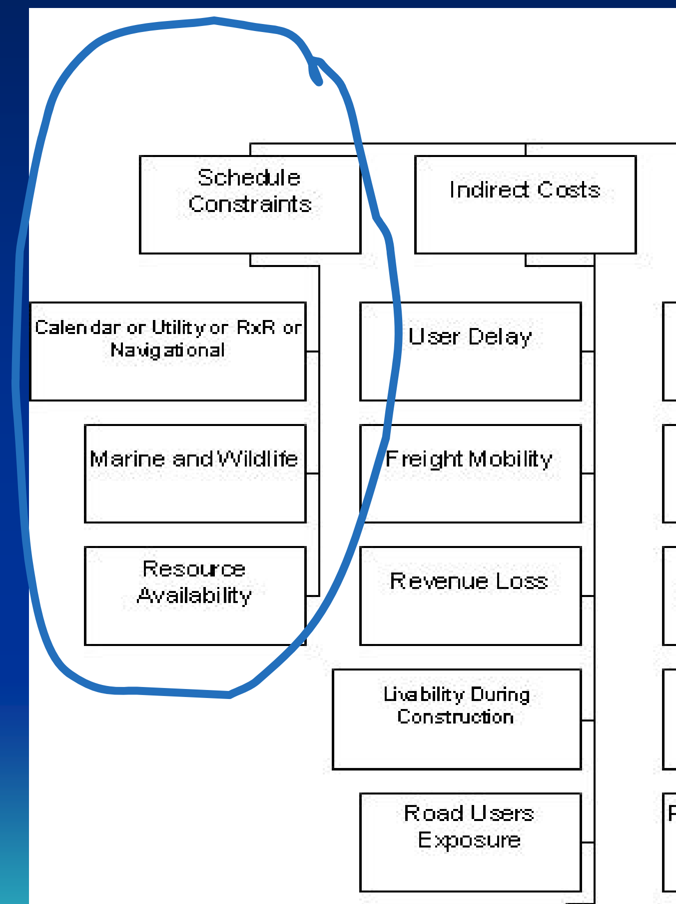
- Working across the tabs from left to right
- Changing/removing default criteria
- Setting label for alternates
- Entering values in pair-wise comparisons
- Processing input or calculating utility values
- Reporting on the results
- Saving your project entries

ABC AHP Software

- Default criteria and sub-criteria developed by sponsoring state members
- ABC AHP developed by Oregon State University under TPF 5(221)
- Microsoft Studio Visual .NET 4.0 or later
- Supports Windows (i.e. MS XP, Vista, 7)
- Software interface – tabular design
- User can add/change any criteria

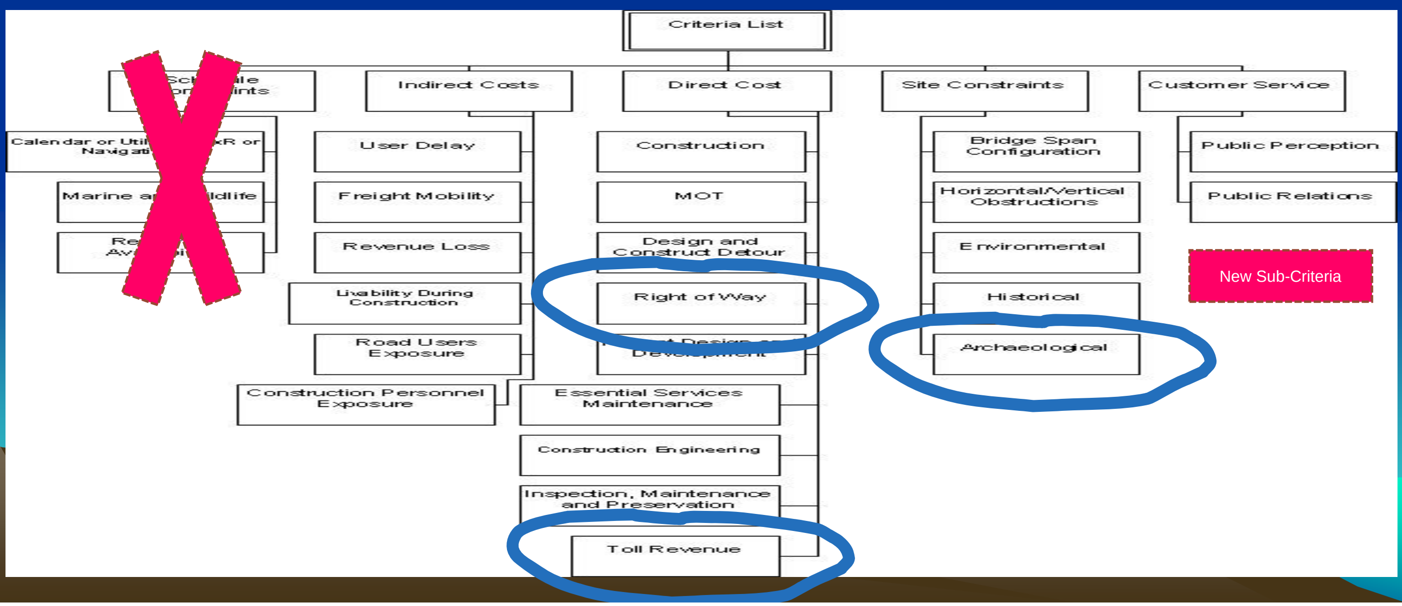
AHP Analysis Details

- The hierarchy organizes the decision-making process
  - The factors affecting the decision, i.e. criteria and sub-criteria, progress in gradual steps from general, in the upper levels of the hierarchy, to the particular, in the lower levels of the hierarchy



AHP Analysis Details – cont.

- A decision maker can insert or eliminate levels and elements as necessary to sharpen the focus on one or more parts of the analysis. Less important criteria and sub-criteria can be dropped from further consideration.



AHP Analysis Details - cont.

- Comparisons between criteria and between sub-criteria are performed using data from actual measurements or using a qualitative scale.

* A comment field was added to allow user to capture key comments

AHP Analysis Details - cont.

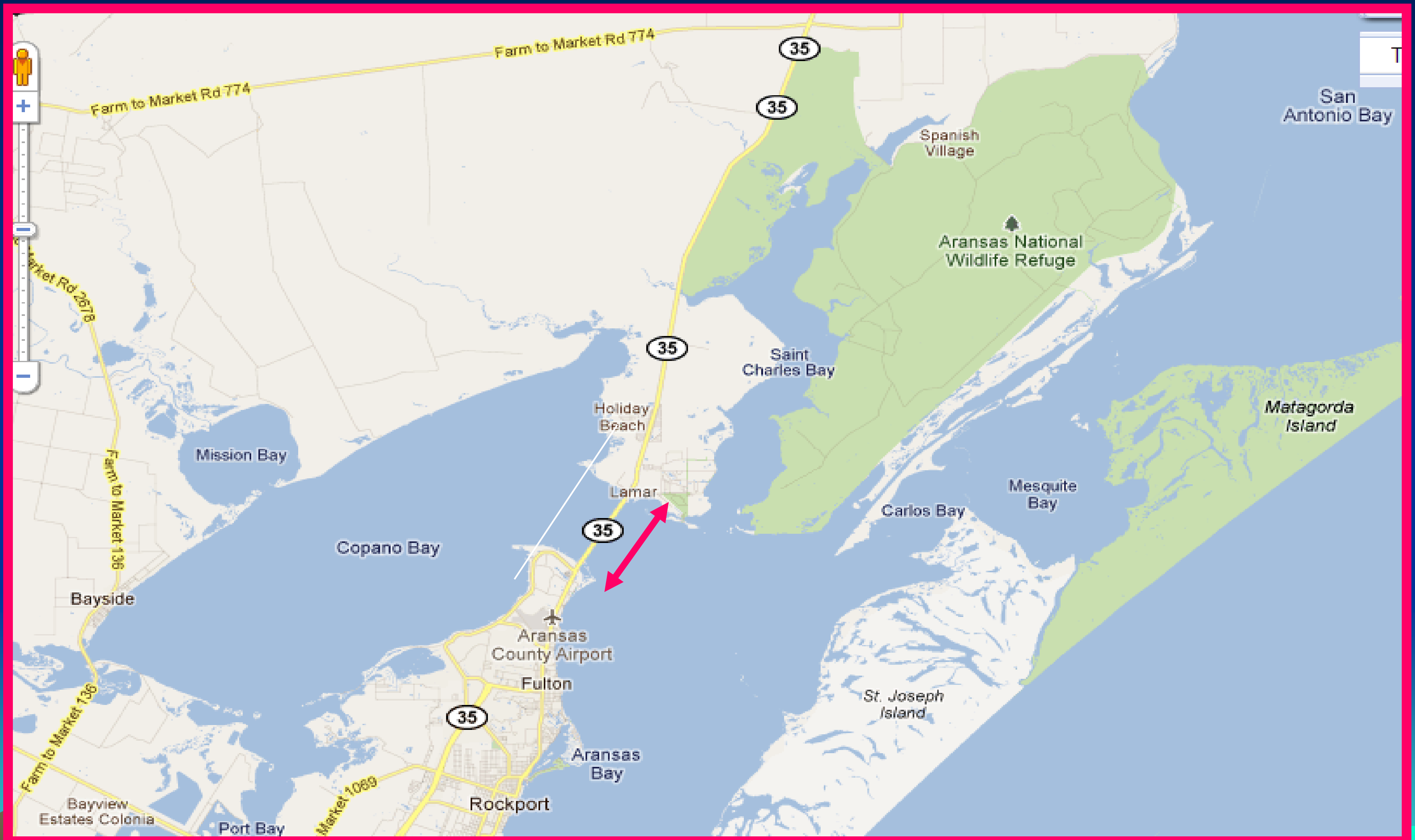
- Comparisons are also used to assess the extent to which one alternative satisfies a criteria over another alternative.

* A comment field was added to allow user to capture key comments

Case Studies

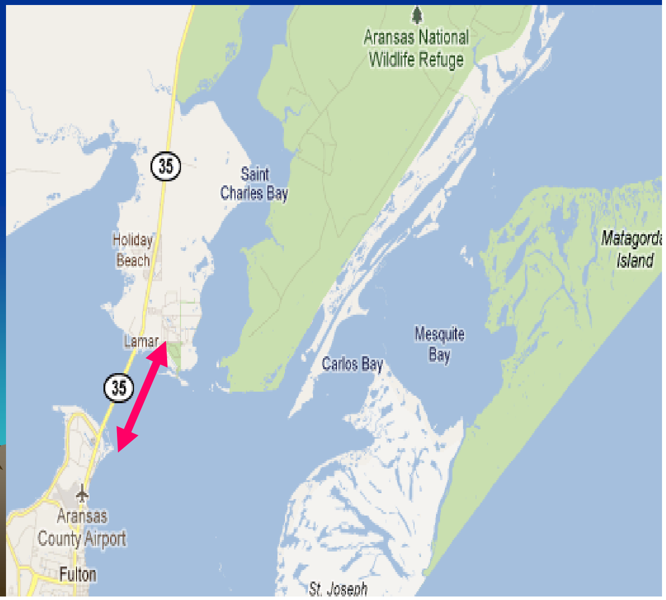
- Copano Bay, TX
- Sabula, IA
- Others

Copano Bay, Fulton/Lamar, TX



Copano Bay Bridge, TX

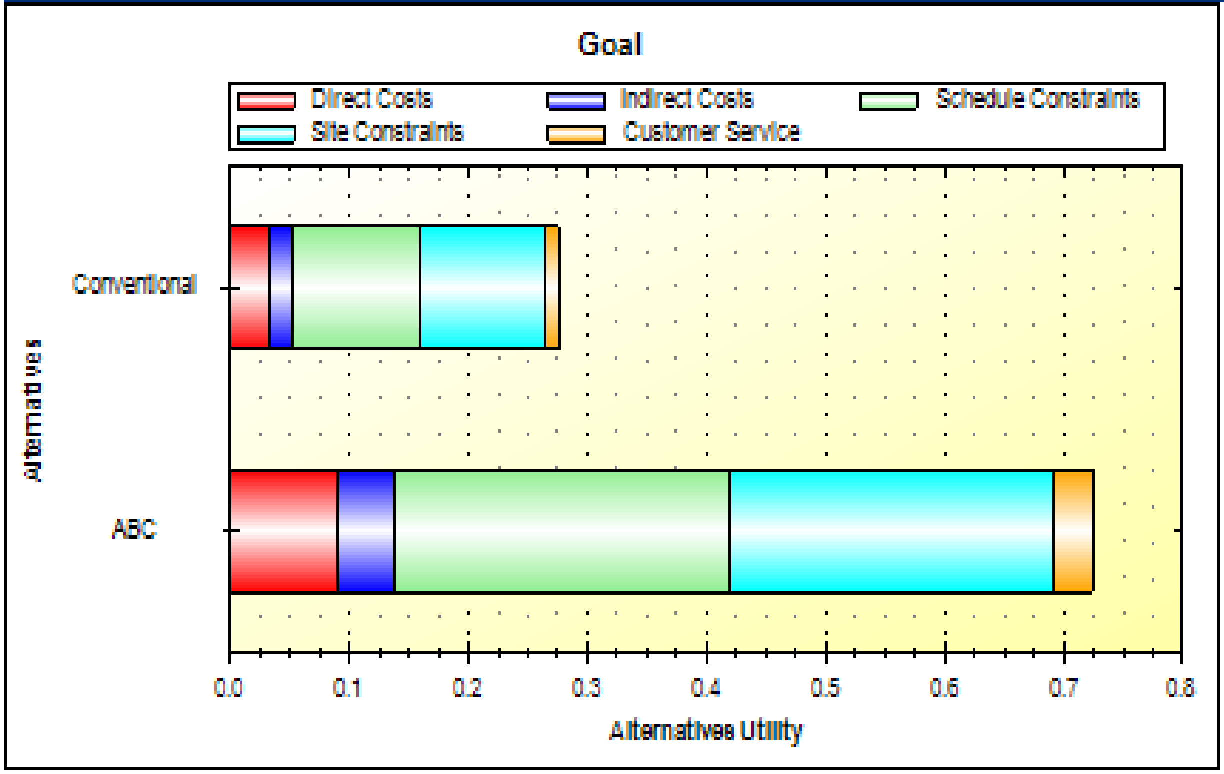
- Carries SR 35-Gulf Intracoastal Waterway
- 11,010 ft long, 129 ft wide, 75 ft tall
- 100, 120 and 150 PS, PC girders
- Approaches -CIP bent caps on trestle piles
- Main navigational structure - CIP pile caps, tall columns and bent caps
- Oyster bays and migratory birds
- High tourist traffic/bird watchers



ABC versus Conventional

- ABC Alternate: use of precast bent caps
- Conventional: cast-in-place bent caps

Alternative Utility - ABC: 0.720 and Conventional: 0.280



Criteria Utility Contributions

Direct Costs:

ABC: 8.9 Conv.: 3.5

Indirect Costs:

ABC: 4 Conv.: 1.6

Schedule Constraints:

ABC: 27.7 Conv.: 10.7

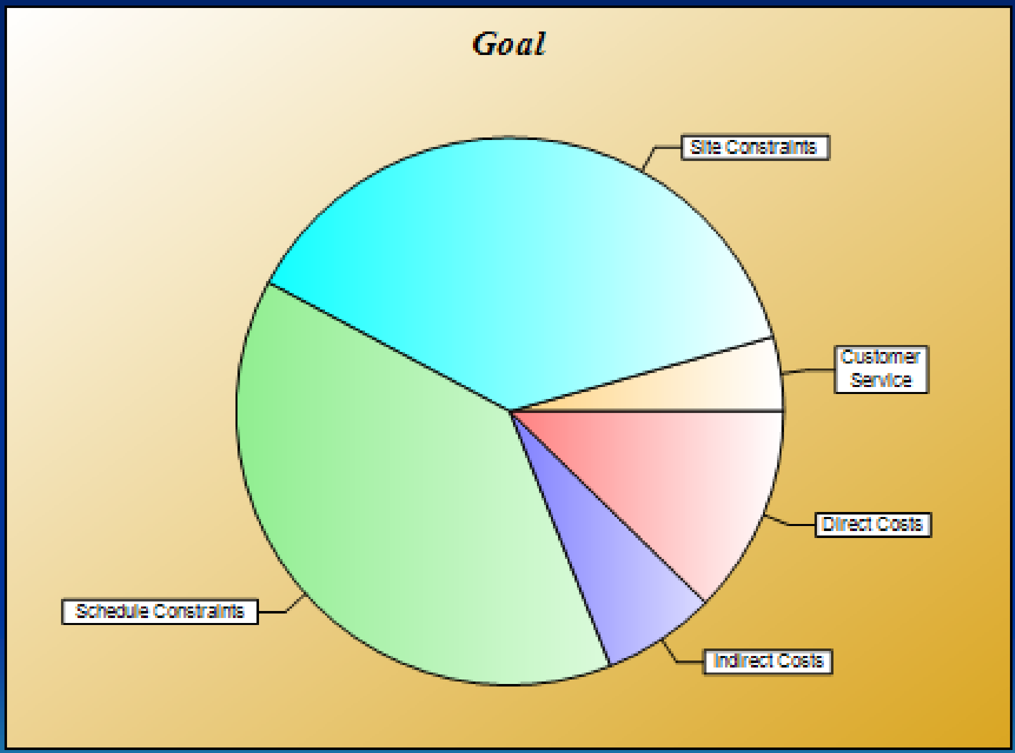
Site Constraints:

ABC: 27.8 Conv.: 10.8

Customer Service:

ABC: 3.6 Conv.: 1.4

Copano Bay – ABC preference AHP- Synthesized Criteria weights



Main Criteria contributions

Schedule Constraints:38.8%

Indirect Costs: 6.7%

Direct Costs: 12.3%

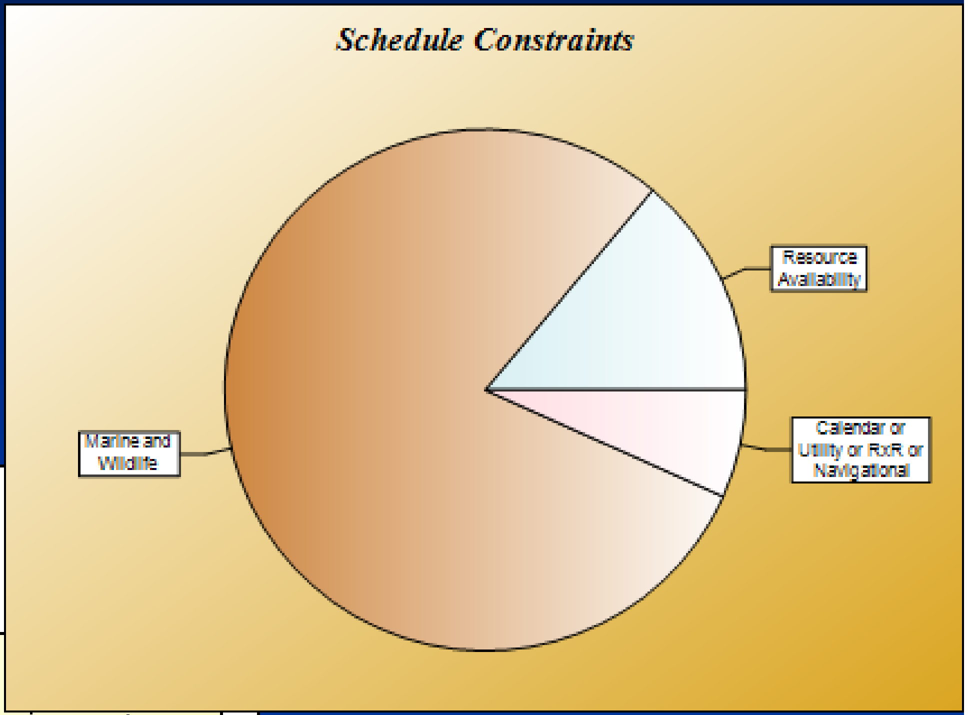
Site Constraints: 37.8%

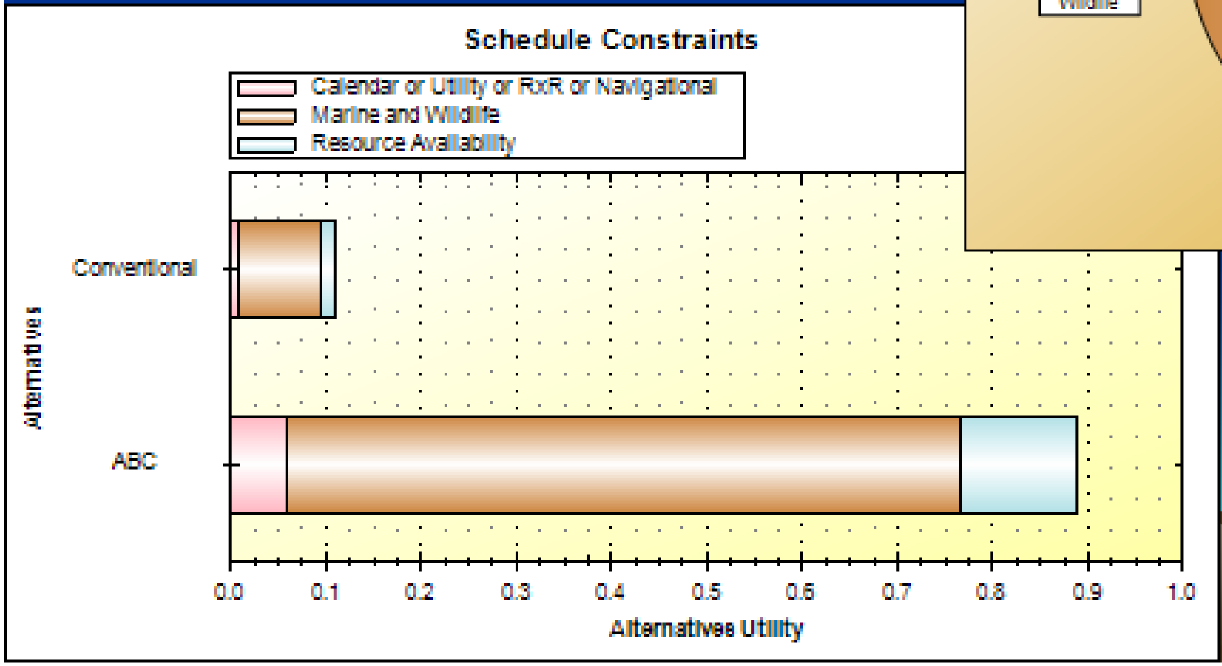
Customer Service: 4.4%

Schedule Constraints 38.8%

ABC top most favorable sub-criteria:

• Marine and wildlife

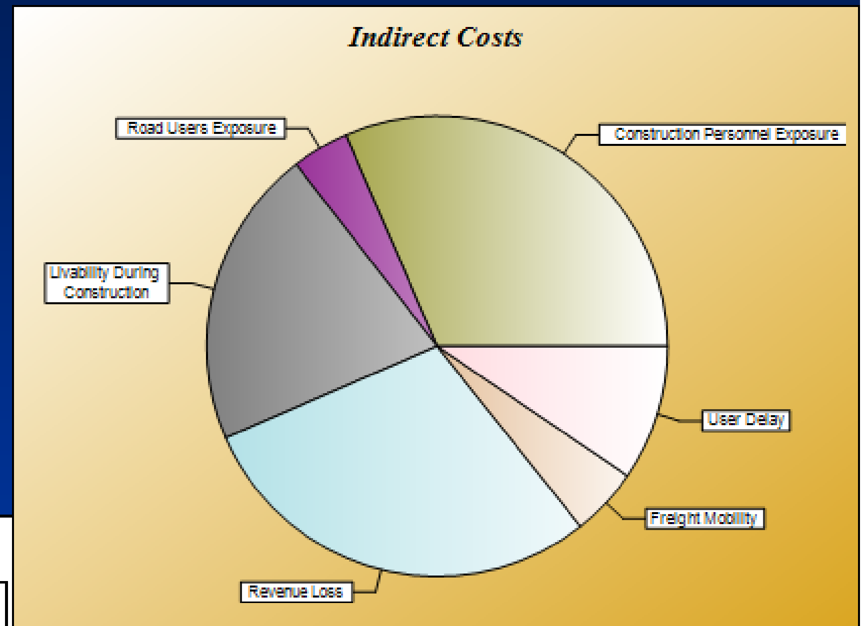


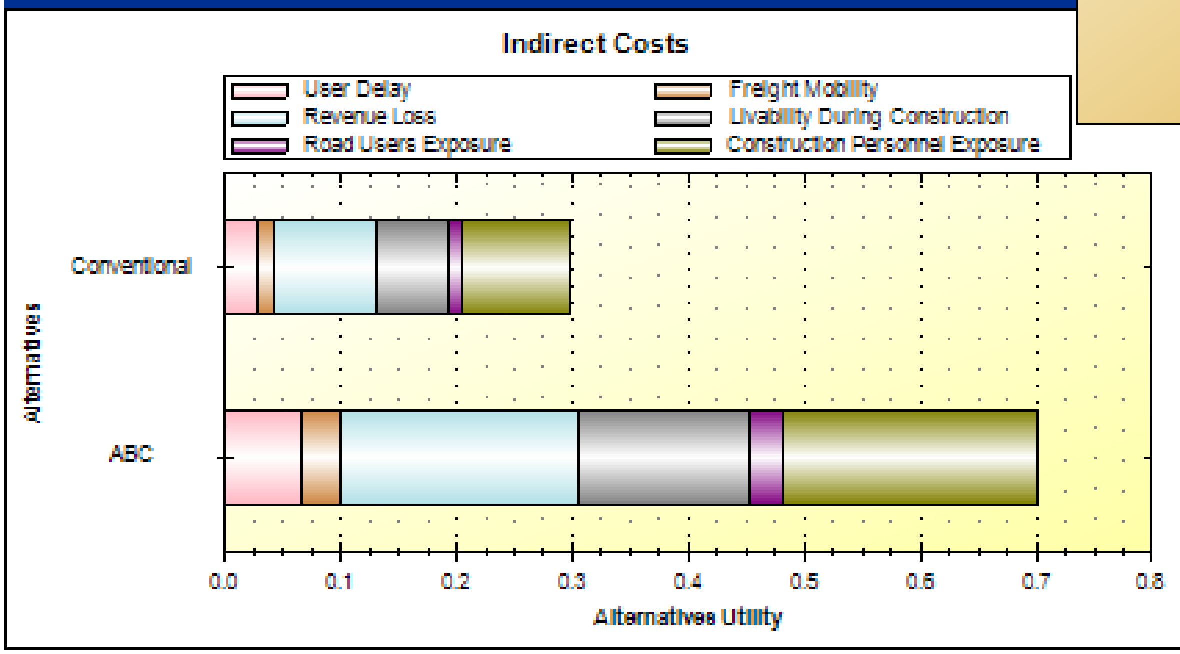


Indirect Costs – 6.7%

ABC top 3 favorable criteria:

- Construction Personnel Exposure
- Revenue loss
- Livability during Construction

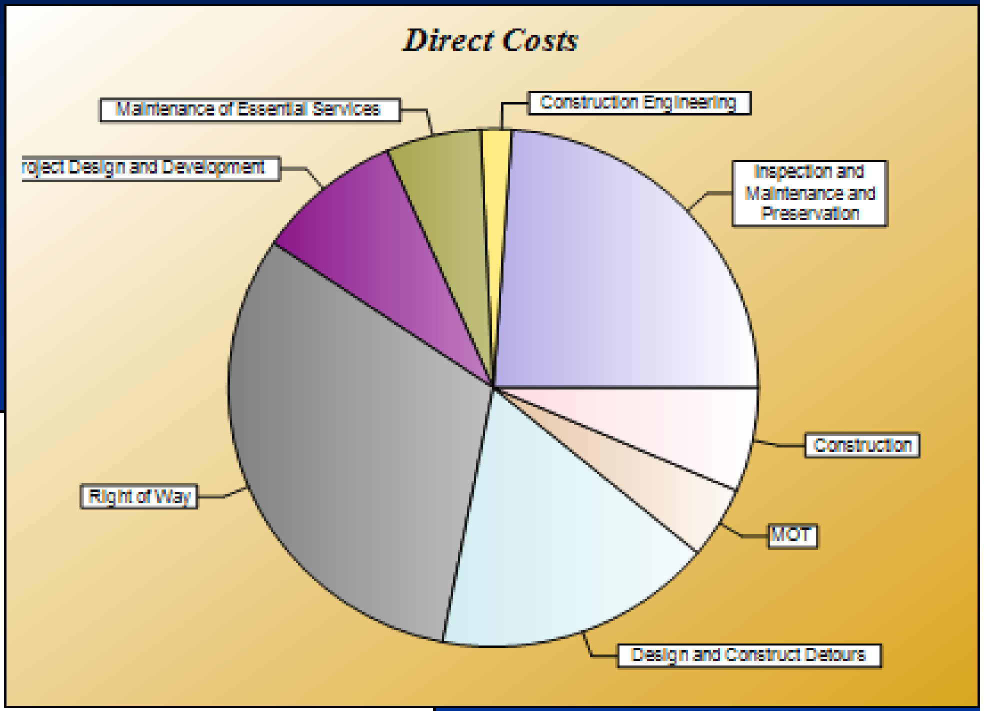


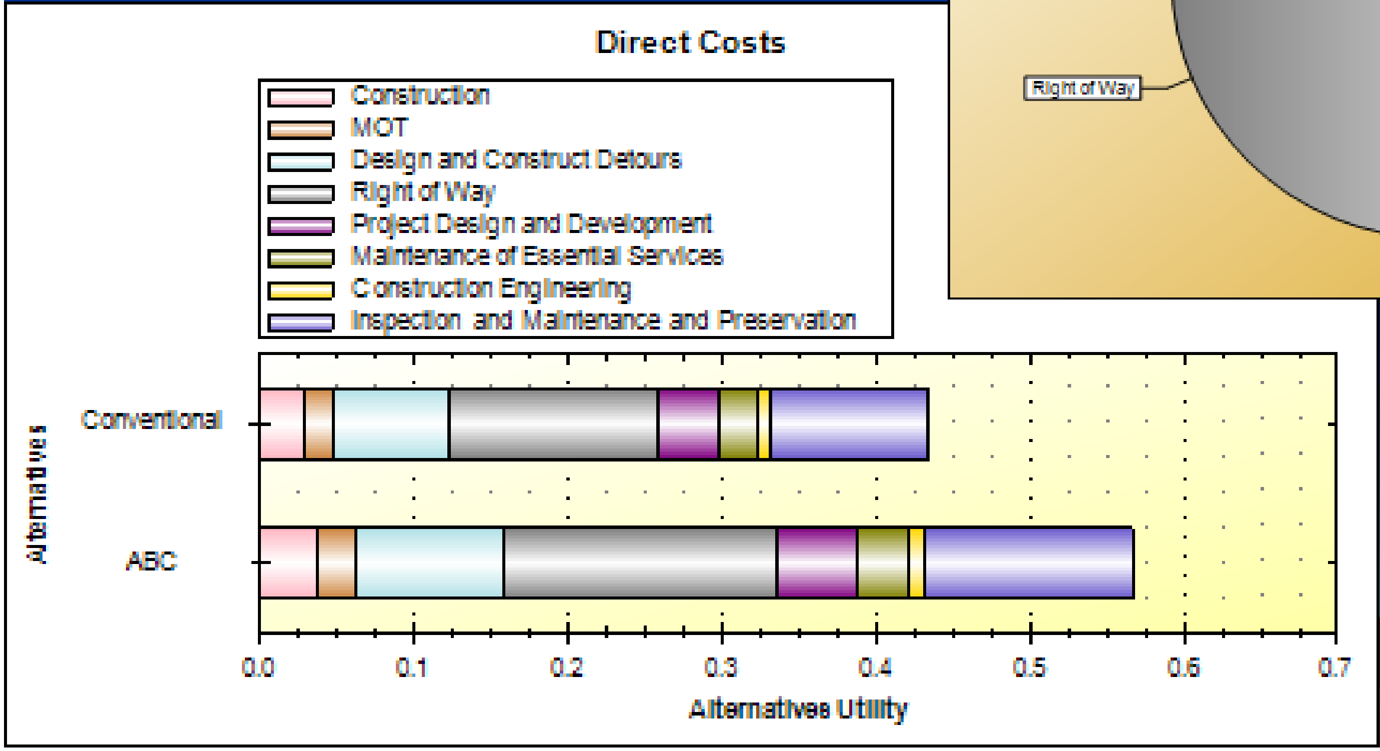


Direct costs – 12.3%

ABC top 3 favorable sub-criteria:

- ROW
- Inspection Maintenance and Preservation
- Design and Construct Detours

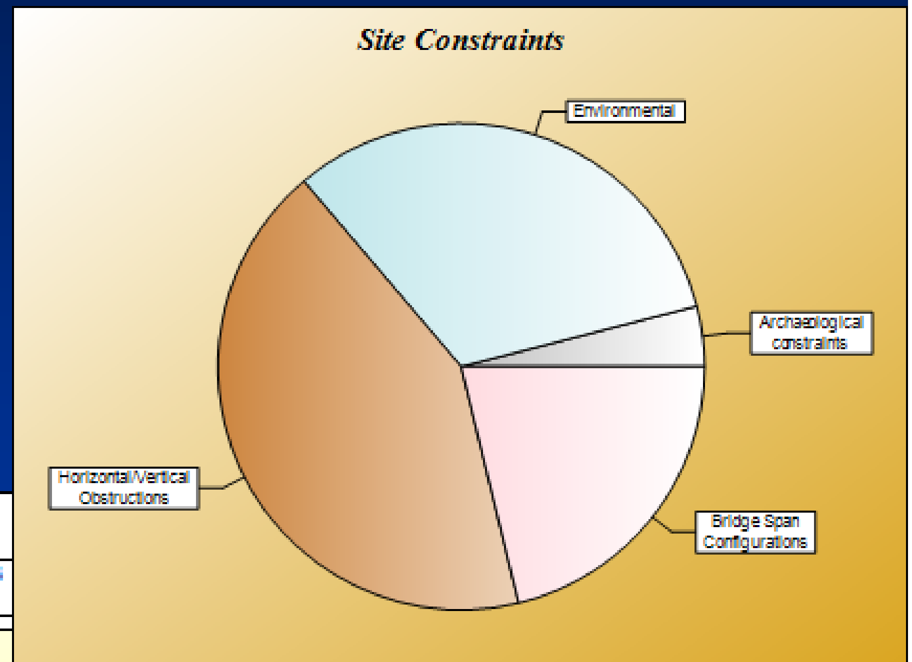


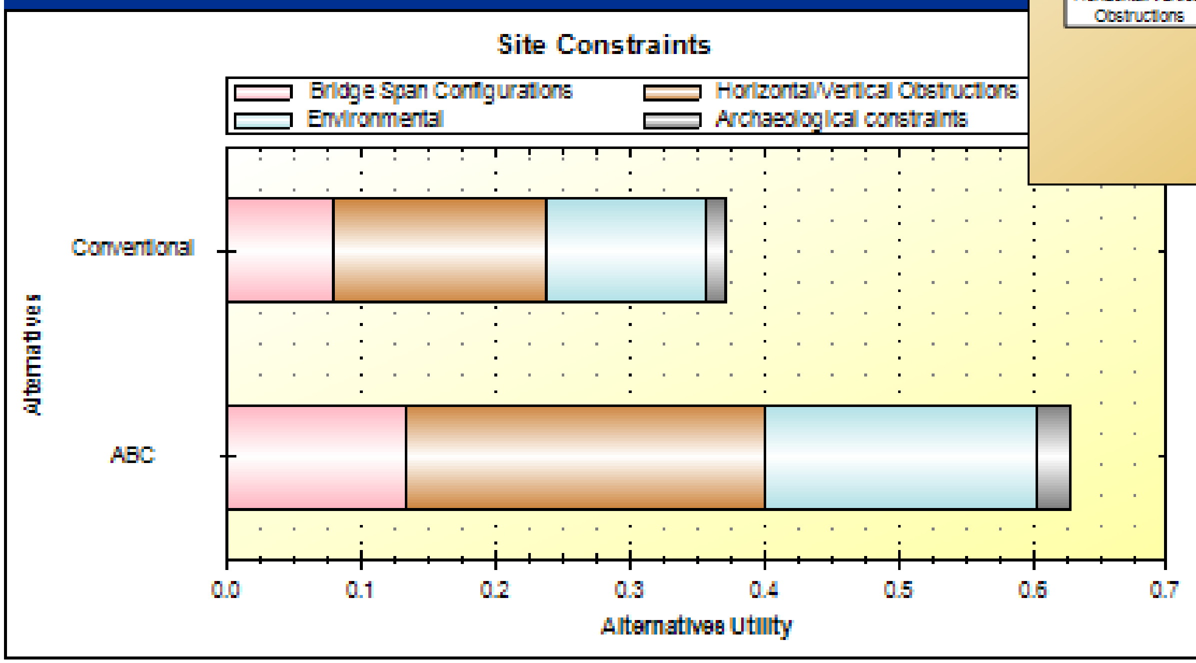


Site Constraints 37.8%

ABC top 3 favorable criteria:

- Horizontal/Vertical Obstructions
- Environment
- Bridge span configurations

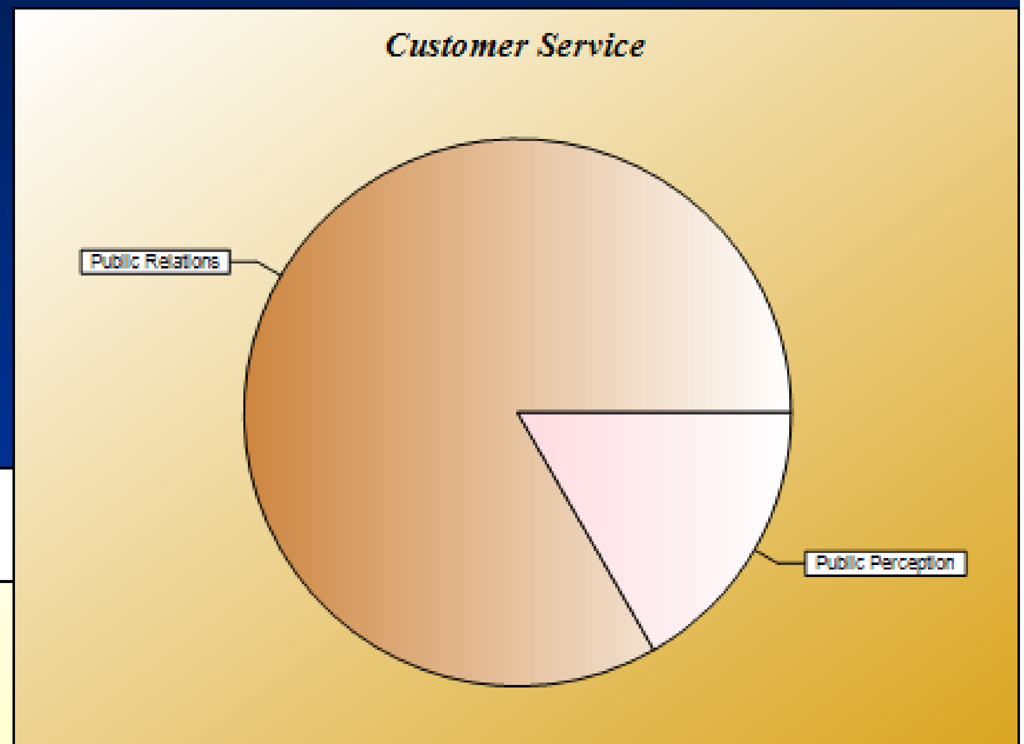


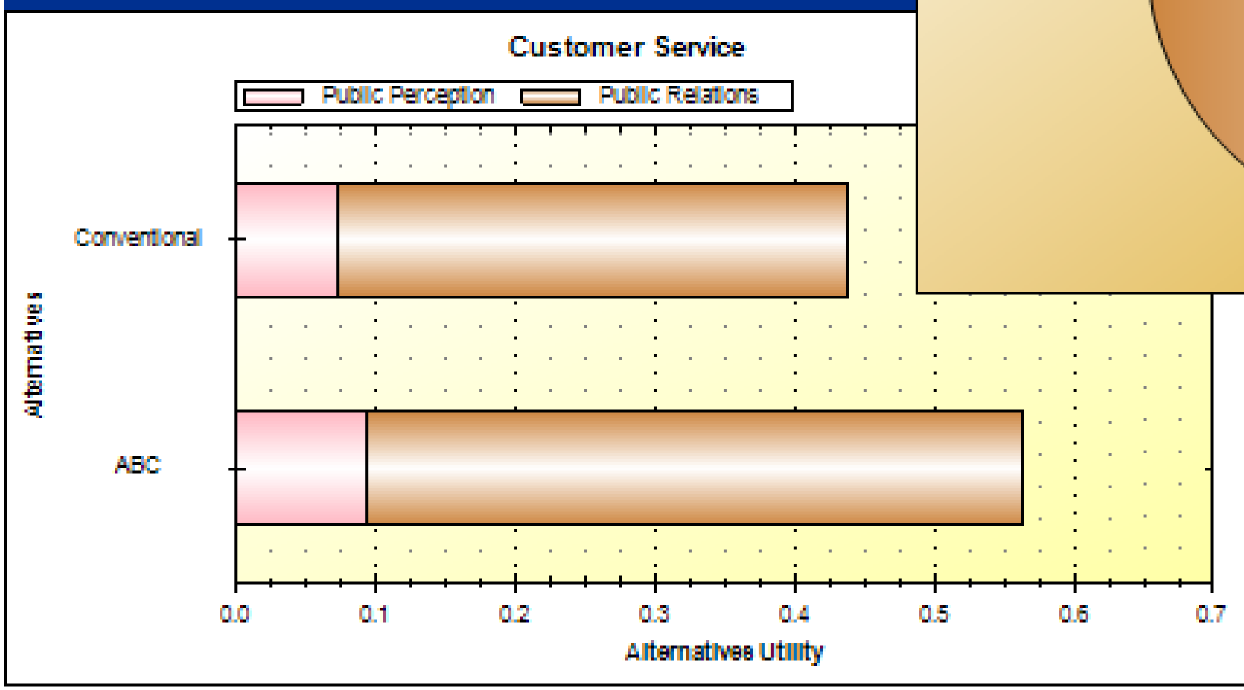


Customer Service 4.4%

ABC top most favorable criteria:

• Public relations





Sensitivity Testing – Copano Bay Alternative Utility Values

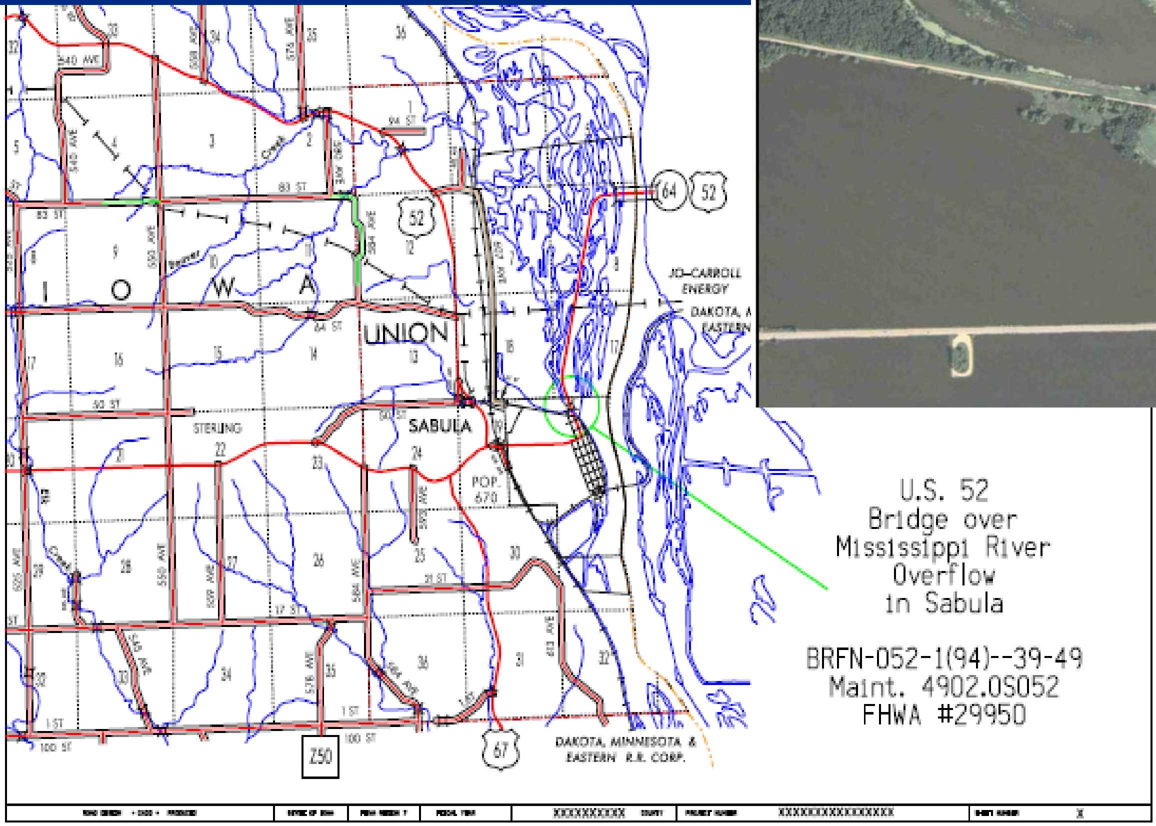
Case Ref: PCC/CIP - 0.720/0.280 = 2.57

No Schedule Constraints	No Indirect Costs	No Direct Costs	No Site Constraints	No Customer Service
ABC: Pre- 0.608	cast bent 0.713	caps 0.733	0.759	0.737
CIP: CIP 0.392	0.287	0.267	0.241	0.263
ABC/CIP 1.55	2.48	2.75	3.15	2.80

Sabula Project, IA

Alternate A: Same Alignment
with Detour (ABC)

Alt. B: Shifted Alignment (Conv.)



Steel Truss Bridge

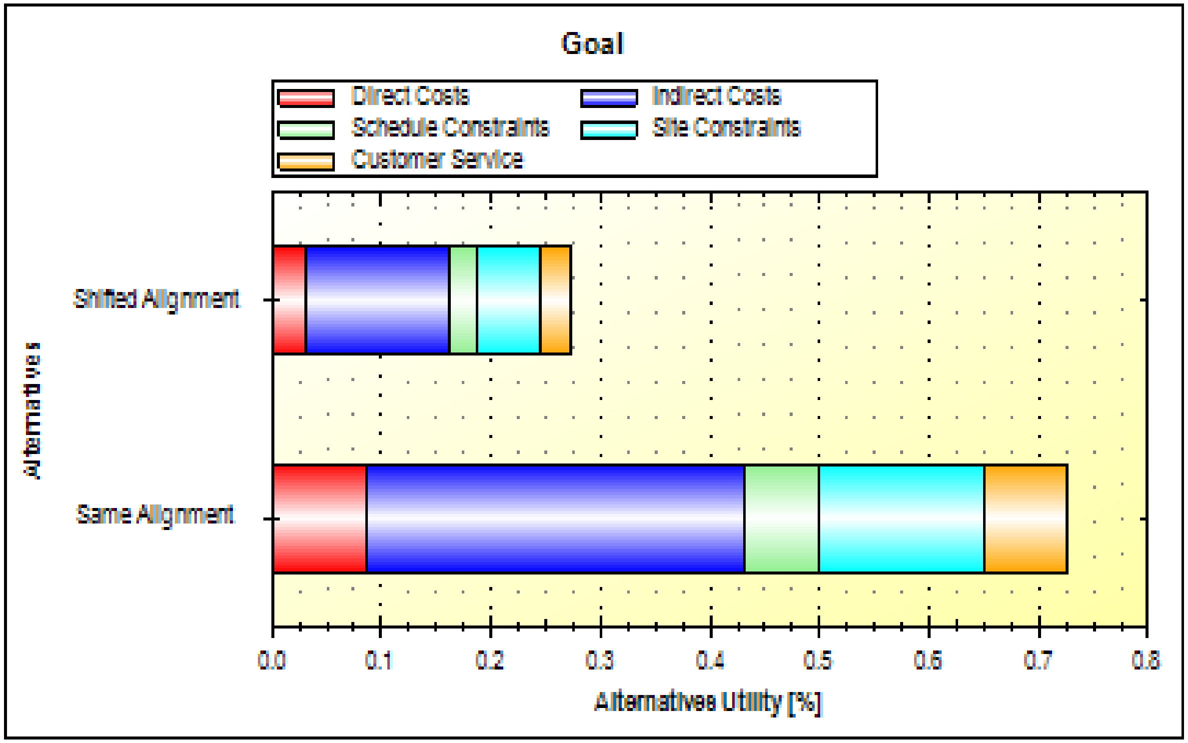
342-ft Long X 20-ft

SD and FO – narrow, heavy corrosion, scour hole 50' downstream, vehicle collision impact on portals

Sabula: ABC versus Conventional

- ABC Alternate: same alignment with detour
- Conventional: shifted alignment

Alternative Utility - ABC: 0.728 and Conventional: 0.272



Criteria Utility Contributions

Direct Costs:
ABC: 8.6% Conv.: 3.2%

Indirect Costs:
ABC: 34.5% Conv.: 13%

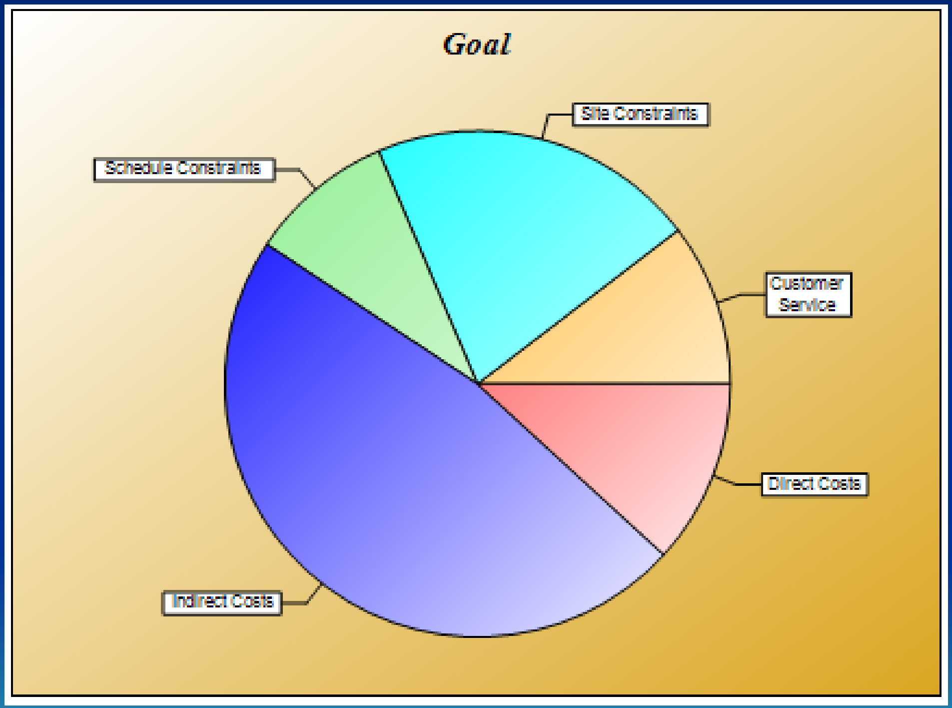
Schedule Constraints:
ABC: 6.8% Conv.: 2.5%

Site Constraints:
ABC: 15.3% Conv.: 5.7%

Customer Service:
ABC: 7.6% Conv.: 2.8%

Σ: 72.8% 27.2%

Sabula, IA – ABC preference
AHP- Synthesized Criteria weights



Main Criteria contributions

Schedule Constraints: 9.3%

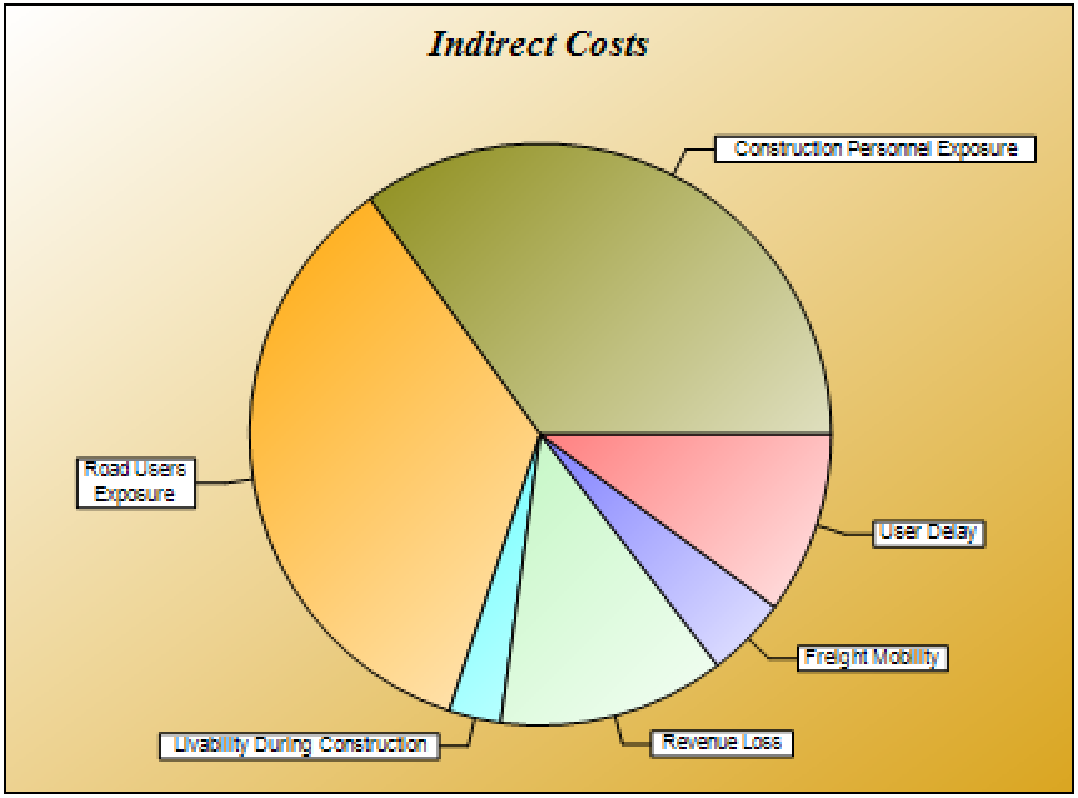
<u>Indirect Costs: 47.5%</u>

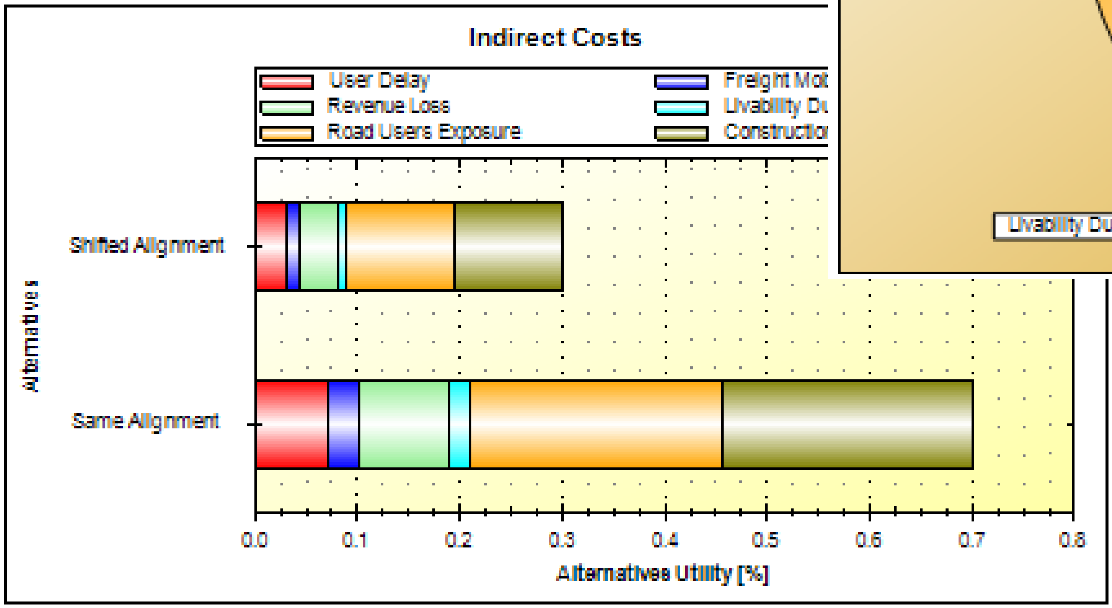
Direct Costs: 11.8%

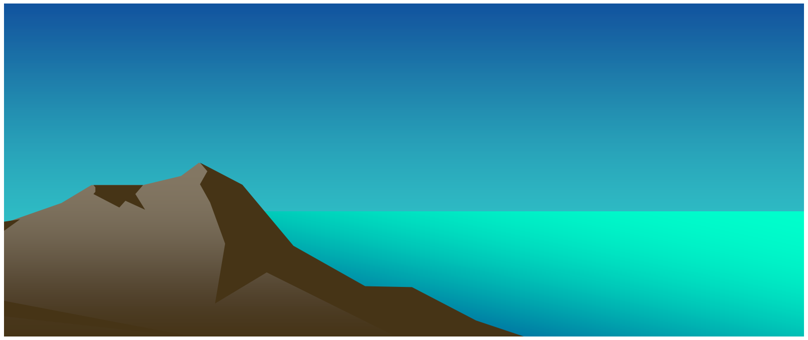
<u>Site Constraints: 21%</u>

Customer Service: 10.4%

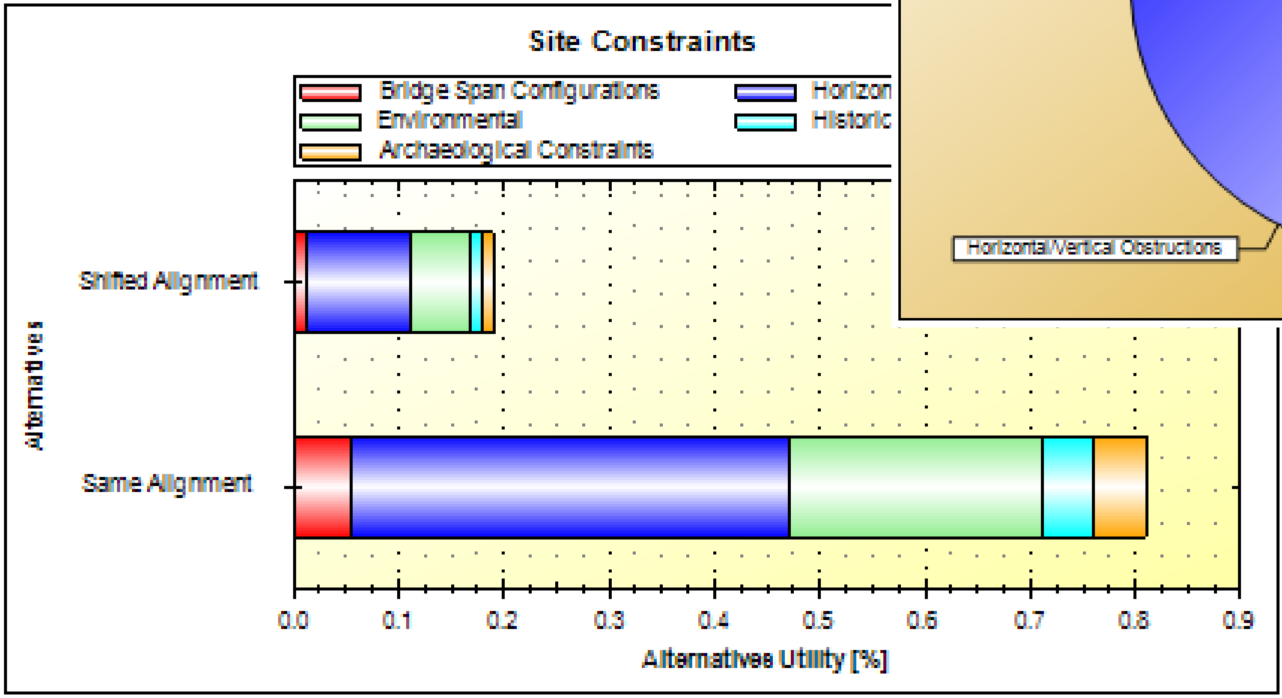
Sabula: Indirect Costs

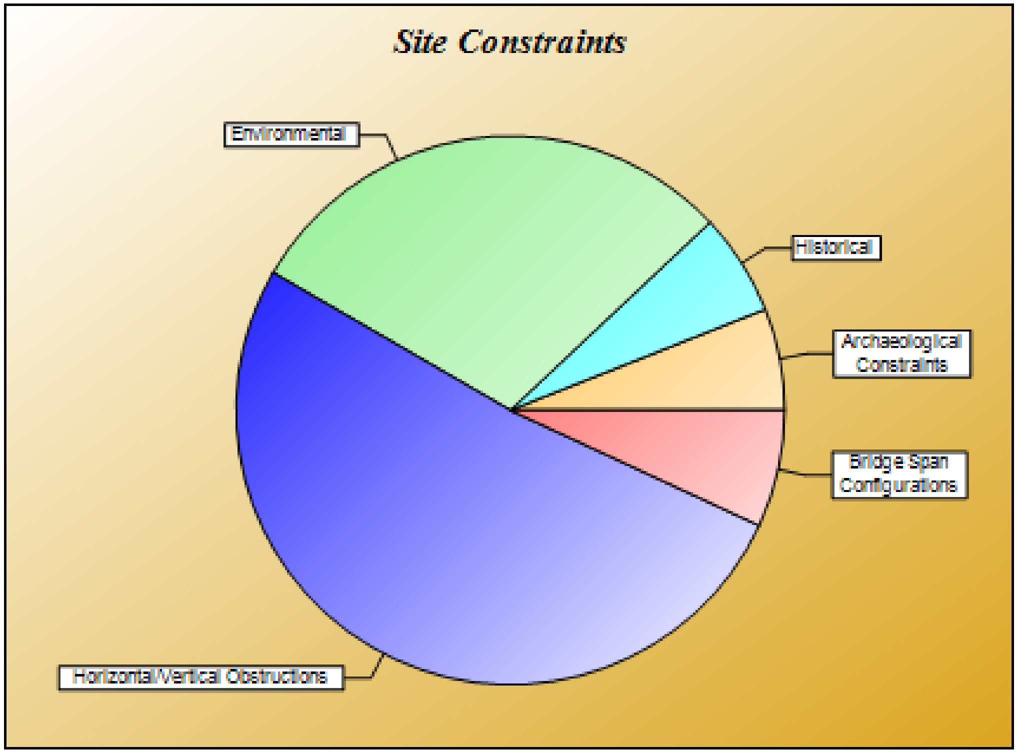


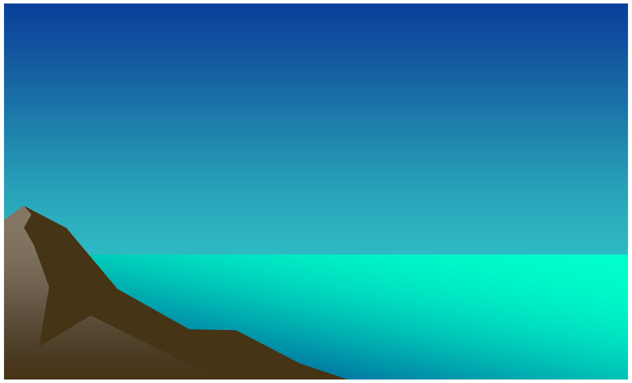




Sabula: Site Constraints





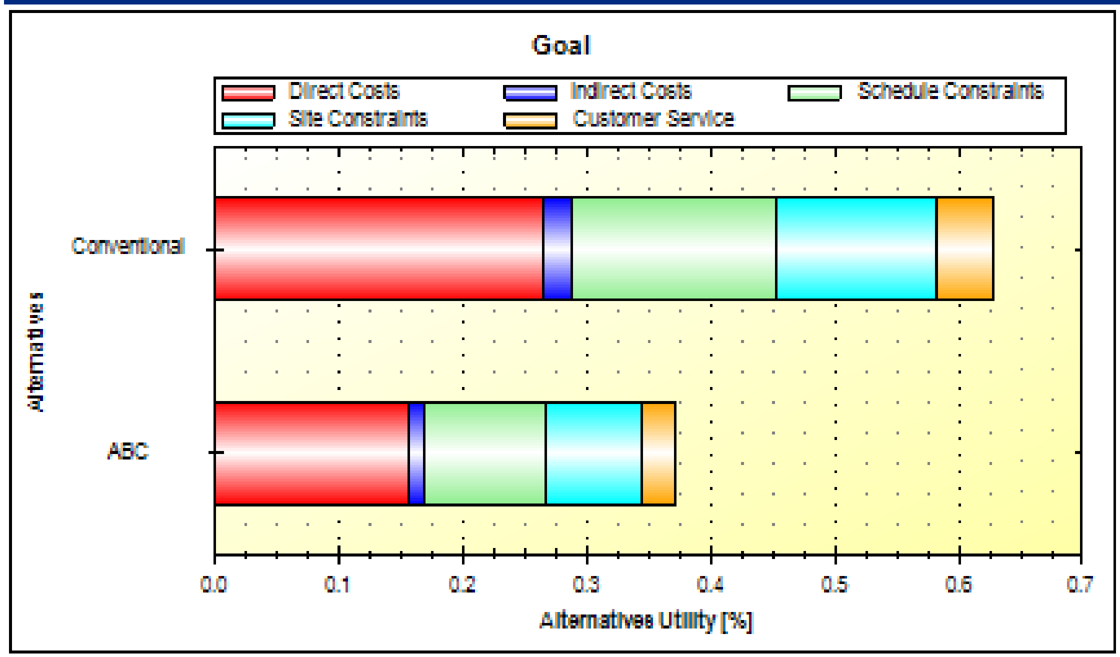


Clear Creek – Local agency project

- Existing Bridge length: 29-ft steel girders on concrete abutments
- The bridge is on a rural local road.
- ADT: 90
- Detour length: 1 mile
- The new bridge will be 80-100 ft in length

Clear Creek Bridge Project

- Conv.: 0.629 (1.7X)
- ABC: 0.371



Criteria Utility Contribution

Direct Cost:

ABC- 15.7% Conv - 26.5%

Schedule constraints:

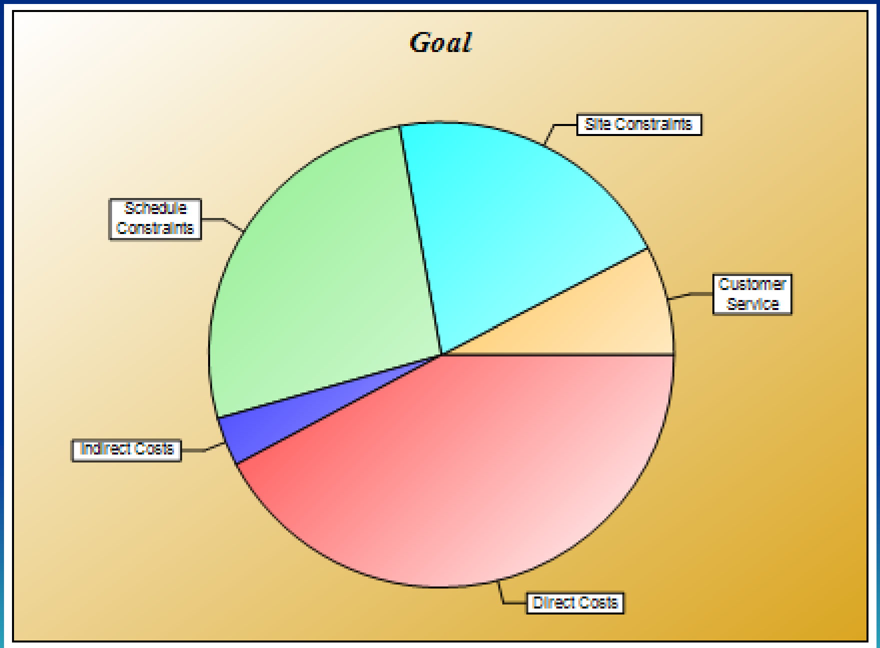
ABC – 9.8% Conv – 16.7%

Site constraints:

ABC – 7.5% Conv – 12.8%

Clear Creek Bridge Project

- Conv. - 0.629   (1.7X)
- ABC – 0.371

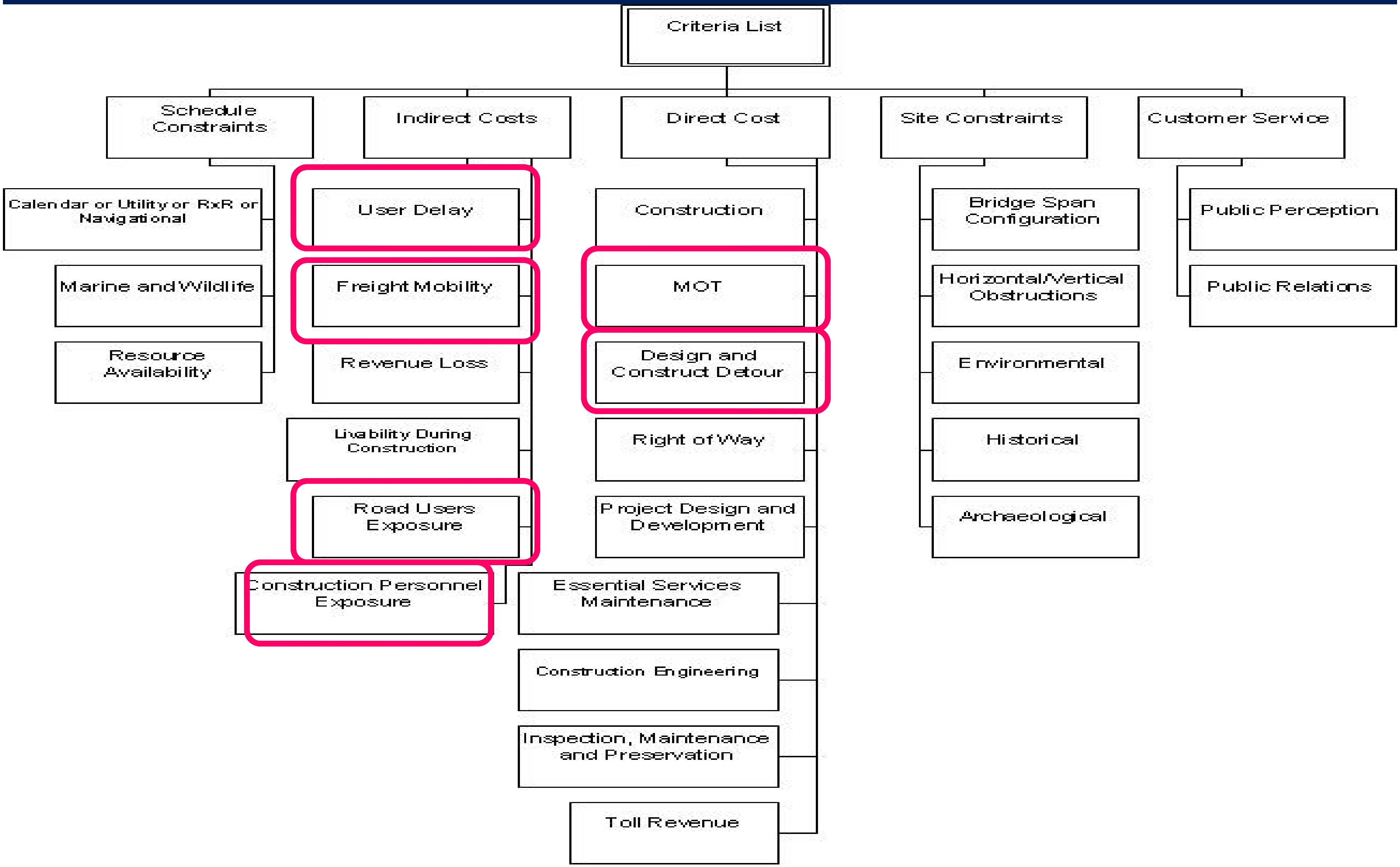


- Main Criteria Contribution
- Direct costs: 42.2%
- Indirect costs: 3.4%
- Schedule constraints: 26.5%
- Site constraints: 20.3%
- Customer service: 7.6%

A list of other projects used

- Elk Creek Bridge, OR
- Grand Mound Project, WA
- I-405 Temple Ave, Long Beach, CA
- Keg Creek Bridge, IA
- Millport Slough Bridge, OR
- Pistol River (2)
- Rte 710 Bridge Widening, CA
- SR 16 EB Nalley Valley I/C, WA

Traffic Cost Impact on Criteria



Maintenance of Traffic and User Delay Costs (HYRISK)

Detour Mileage Cost (DMC):

- Duration (days) X Length (km) X Cost/Length X ADT
- Cost per KM vehicle driven of detour: $0.27
- ADT
- ADTT as a percentage of ADT
- Time cost per person/hr: $16.31
- Occupancy rate per vehicle: 1.56 in Oregon
- Time cost per hour per truck: $29.50
- Speed of Travel: km/hr

MOT and UDC: Sample Project

- Project Br # 00138
- Duration: 365 days
- Detour length: 26 km
- Speed: 64 km/hr (40 mph)
- ADT 330
- ADTT: 10% of ADT (0.10)

Detour Mileage Cost (DMC): $845,600

Detour Time Cost (DTC): $1.265 M

Total Community Cost Associated with Bridge Closure: $2.11 M

Do the Math…

- Detour Mileage Cost: D*L*CpL*ADT: (365*26*$0.27*330) = $845,559.00
- Detour Time Cost: (24.38 min extra/veh)

  (365 days * 24.38/60 (hr) * 330 daily traffic* {(1.56*$16.31)*0.9 veh + ($29.50*0.1 truck)}) = $1,264,876.00

Total Delay Cost: $0.845M + $1.265 M=$2.11 M

Summary

- The AHP Decision making - effective technique to select the best option from a given set of alternatives evaluated against several criteria and sub-criteria
- Breaks down a multi-dimensional decision matrix into a pair-wise comparison
- Provides a formalized and apparent decision process with quantifiable values contributed by each criteria
- Create conversation among decision makers

Deployment Plan & Proposal

- FHWA preparing software Sect 508 compliance
- ODOT's technical support when needed
- FHWA to promote its adoption and develop training
- Several webinars (FHWA EDC, NHI and FIU)
- Provided training to ODOT users (3-hr sessions)
- Presentation at Regional conferences
- ODOT Pilot projects – 3 currently in progress

Questions

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