RoadEng® Optimal
Alignment Optimization Tools

Presenter
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Softree
Engineering an Easier Way

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Presentation Outline

- Introduction
- Background and Rationale
- Alignment Optimization
- Preliminary Results
- Conclusions

Softree

- Software applications for surveying, mapping and civil design.
- Based in Vancouver, B.C.
- 20+ years in business.
- 1500+ customers.
- Focus on engineering not CAD.

Introduction

Typical Clients

Private

- AMEC, AB, BC, NL
- Associated Engineering, BC, SK
- Canadian Projects Ltd.
- Focus Corporation, BC
- Golder Associates, ON
- McElhanney, BC, AB
- MDH Engineered Solutions
- Knight Piésold, BC, ON
- Civil Project Management
- ARA Engineering
- LEX Engineering
- Stewart Weir

Government

- Township of Central Frontenac, ON
- NWT Ministry of Transport
- Municipality of Chatham-Kent, ON
- County of Grande Prairie, AB
- BC Ministry of Transport
- Sturgeon County, AB
- Brazeau County, AB
- Canadian Army
- Yukon DOT
- County of Lanark, ON
- County of Dufferin, ON
- USDA FS

Education

- University of BC
- University of Alberta
- Université Laval
- University of Idaho
- University of Northern BC
- University of New Brunswick
- University of Helsinki
- Oregon State University
- University of California
- N.A.I.T.
- B.C.I.T.

... + 1500 more

Introduction

Typical Clients

Introduction

RoadEng® Optimal Research Project

- Automated and semi-automated tools to find the lowest cost alignment.
- Goal: reduce engineering and construction costs for corridor projects.
- 3 year research collaboration with the University of British Columbia.
- Patent pending.

RoadEng® Optimal Benefits

- Construction cost savings
  - Corridor based infrastructure is very expensive.
  - Earthwork costs are typically 30% of the total construction cost.
  - Small improvements in the alignment render large savings.
- Engineering cost savings
  - Interactive project cost metric.
  - Automatic alignment calculation.
  - These features speed the design cycle.
- Engineering Improvements
  - Freeing the engineer from worries about earthwork and meeting basic standards allows focus on other design enhancements.

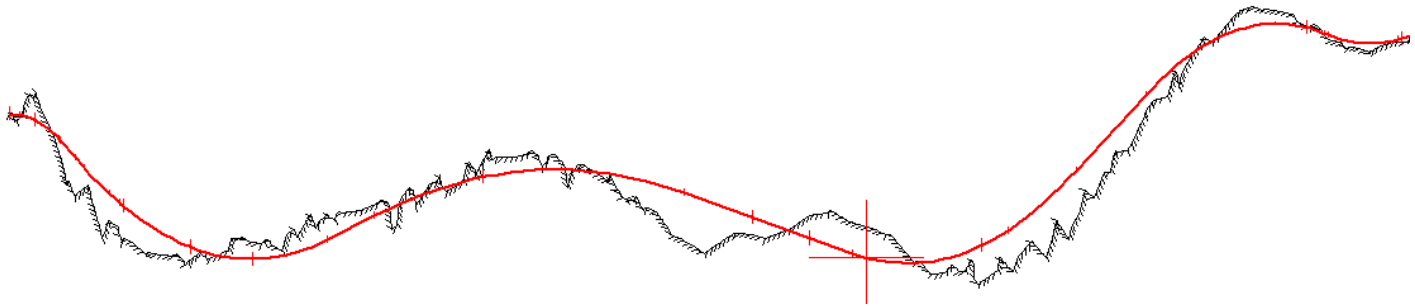
RoadEng® Optimal Current Status

- Version 1 – Vertical Alignment.
- Proof of concept stage.
- Seeking organizations to help with evaluation and testing.

Background and Rationale

The Vertical Alignment Problem

- Find minimal cost position of the alignment based on certain constraints such as design speed and maximum grade.



Background and Rationale

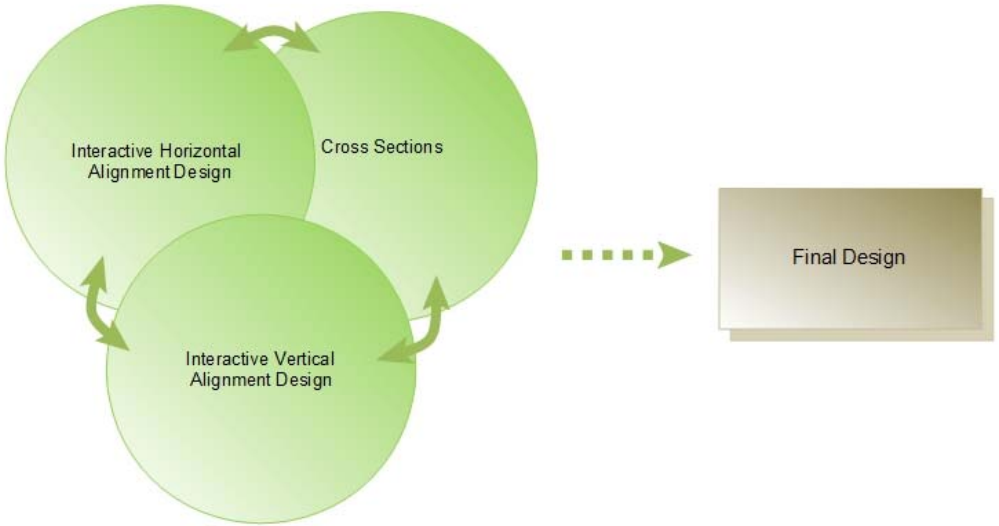
Why do we need optimization tools?

- Alignment design is critical for construction, maintenance and user benefit.
- Alignment design is a difficult problem.
- Current practices are essentially ‘trial and error’.

Background and Rationale

Finding the best solution without optimization

- Iterative procedure
  - Try an alignment position.
  - Check the design constraints.
  - Compare volumes.
  - Compare material movement.
  - Estimate net cost.
  - Accept result or repeat…



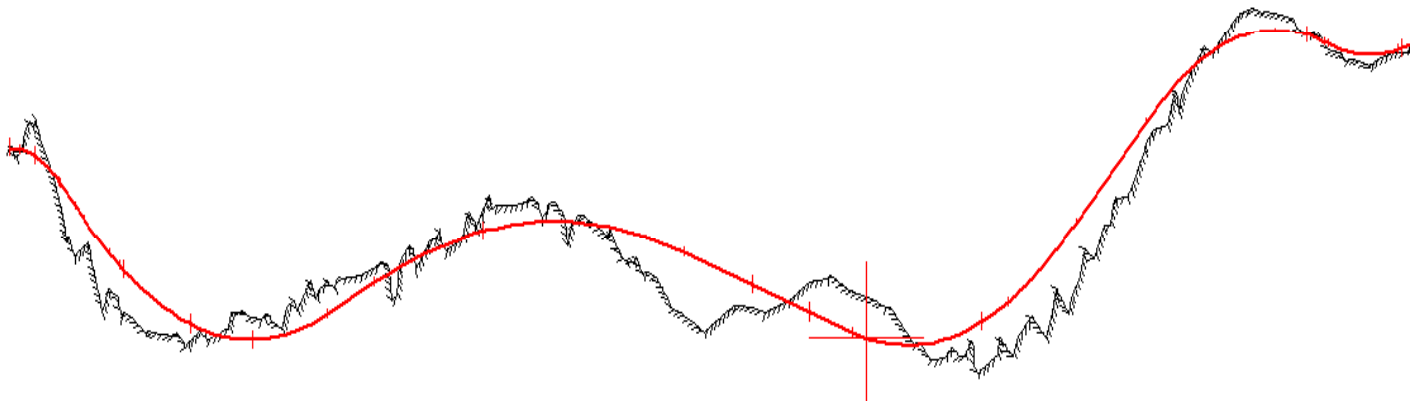
Does this procedure consistently arrive at the lowest cost solution?

Background and Rationale

Do trial and error methods lead to the best solution?

Two factors indicate this is not the case:

- Large number of possible solutions.
- Small alignment changes can result in significant cost differences.



Background and Rationale

Optimization hasn't worked before. Why will it work now?

Research on optimization dates back to the 1970's. However, it has yet to become an accepted engineering tool.

Enabling factors for current success:

- Softree's mathematical modeling of detailed design cross sections and design parameters such as super elevation transitions, ditches, widening etc.
- High powered MILP solvers available as open source or commercial software products.
- Improved computing power and availability of parallel processing.
- Large scale surveys of corridors (LiDAR).

Background and Rationale

Applications

- Preliminary alignment design and planning.
- Improving and fine tuning existing designs.
- Comparing and checking existing designs.

Benefits

- Reduced engineering time.
- Improved design.
- Reduced construction costs.

Background and Rationale

Project Considerations

The benefits of optimization depend on project type and resources.

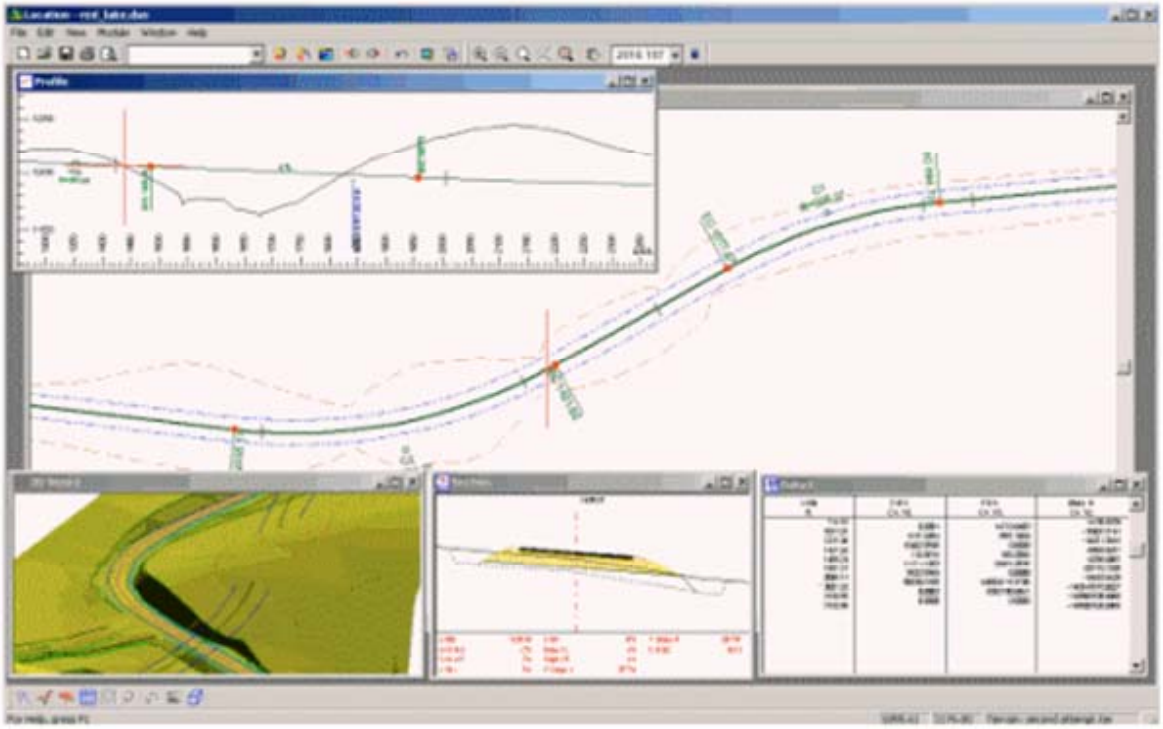
- Constraints
- Terrain Complexity
- Designer experience
- Road standard
- Project resources

Example:

novice designer + difficult terrain + tight timeline = ideal optimization project.

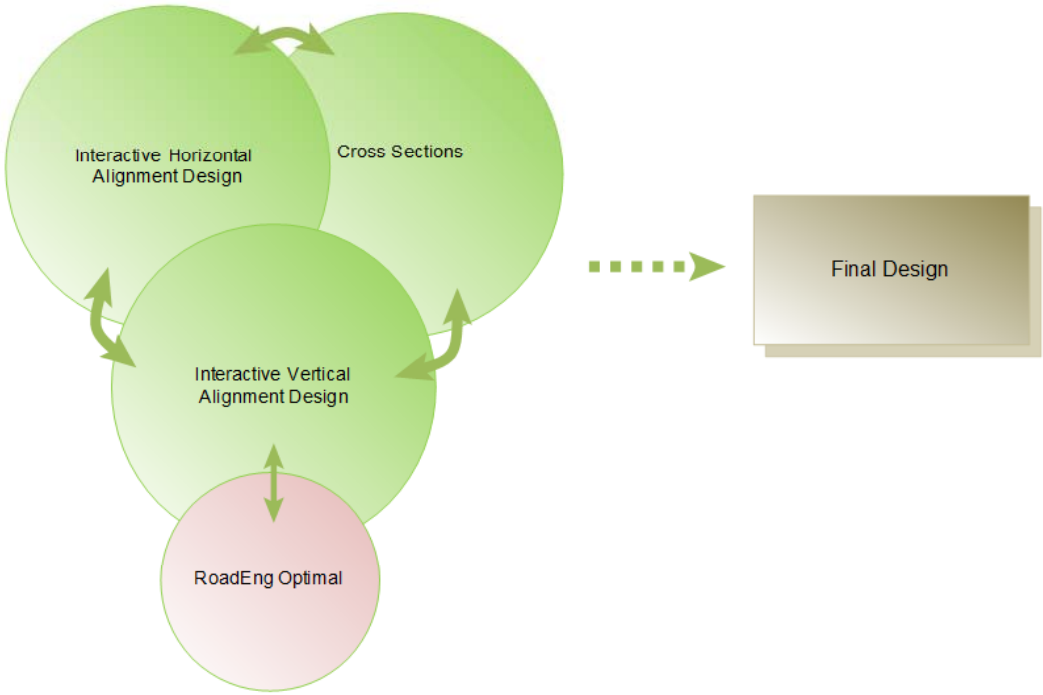
Alignment Optimization

Optimization Combined With Interactive Design



Alignment Optimization

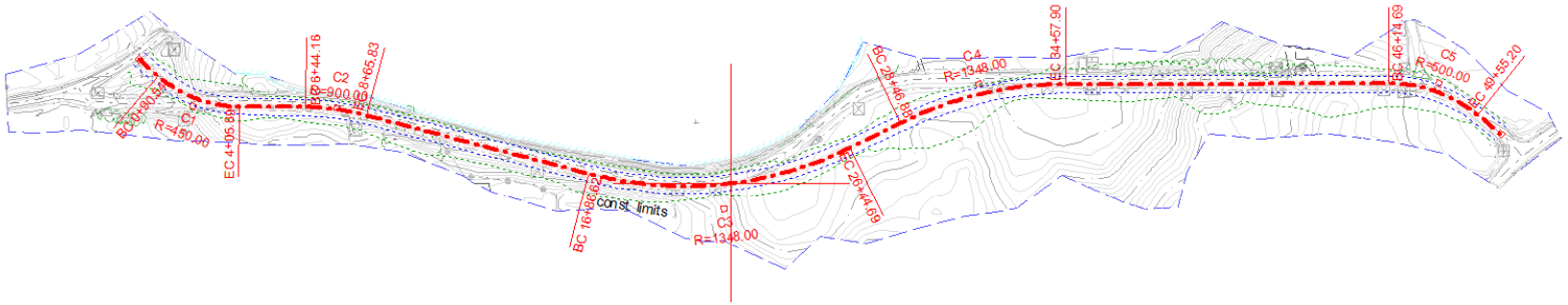
Design Process including *RoadEng Optimal*



Preliminary Results

County Road Case Study

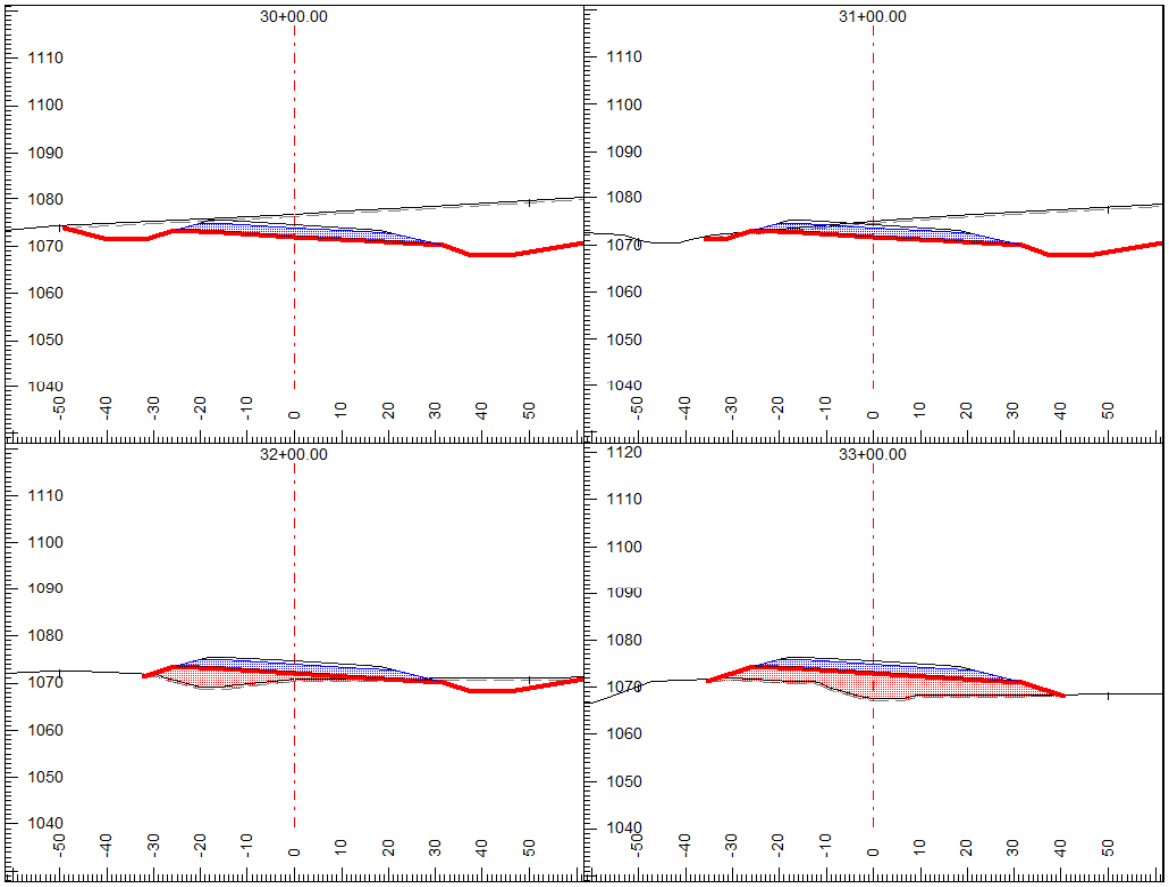
- **One mile realignment**



Preliminary Results

County Road Case Study

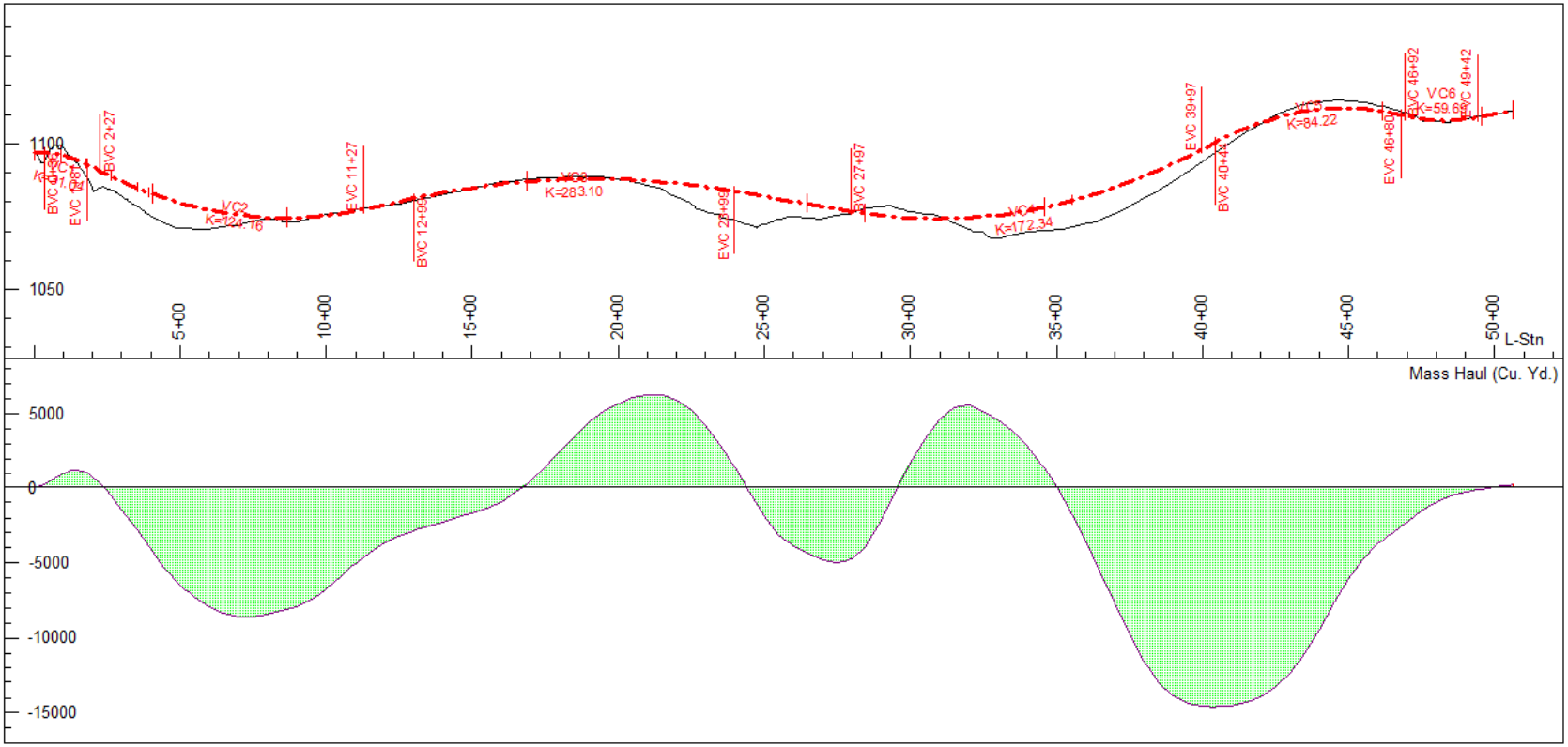
- **Real world cross section templates**



Preliminary Results

County Road Case Study

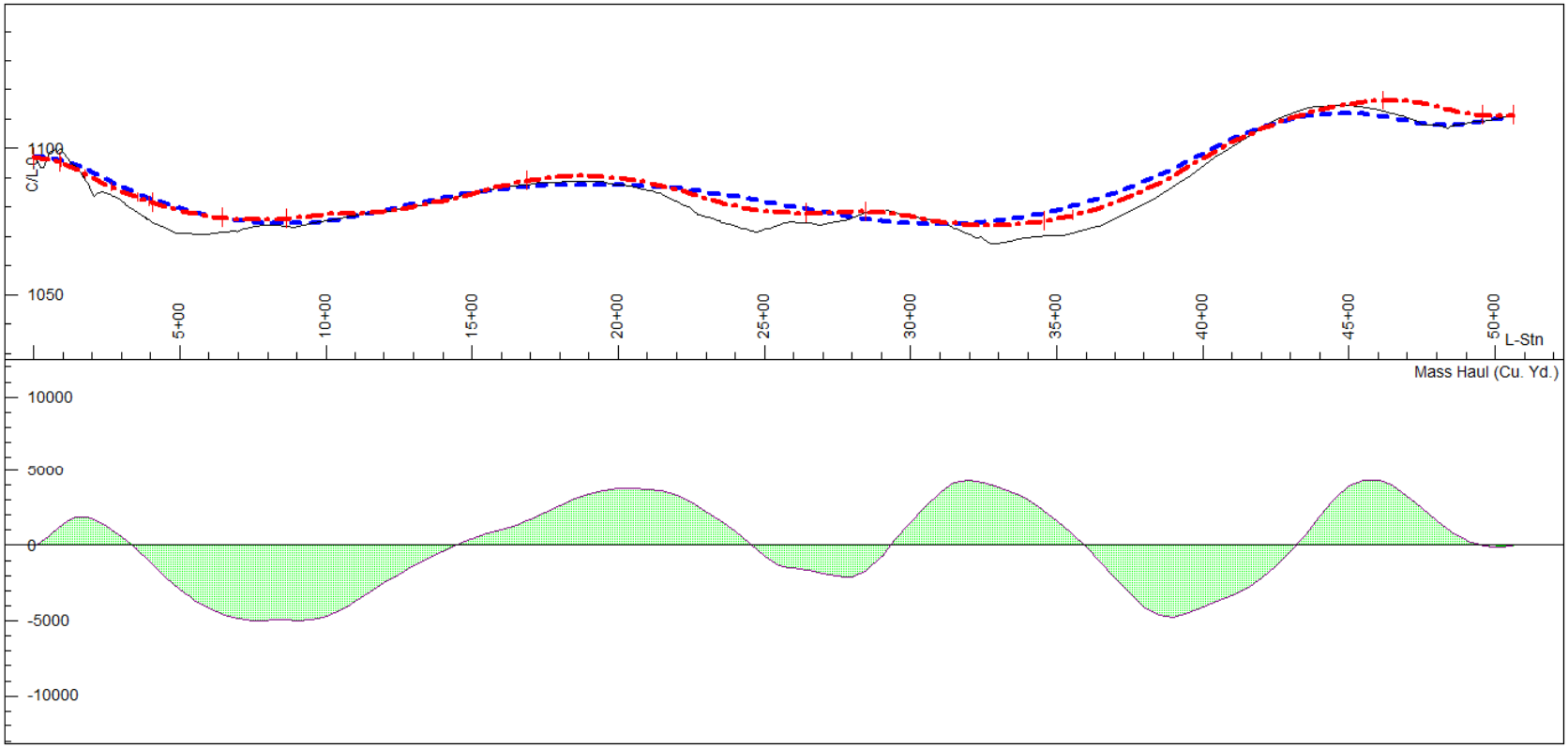
- **Human engineered alignment**
- **Cost = 609761**



Preliminary Results

County Road Case Study

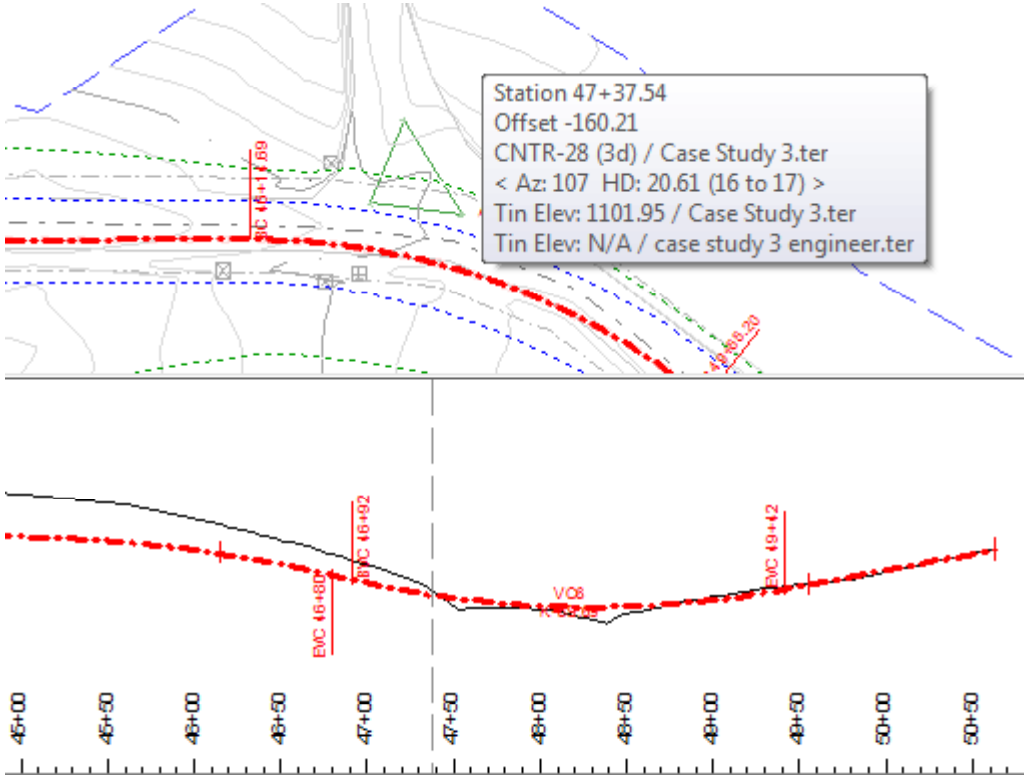
- Generate optimal alignment, first iteration
- 55 mph, less near ends
- Cost = 381811



Preliminary Results

County Road Case Study

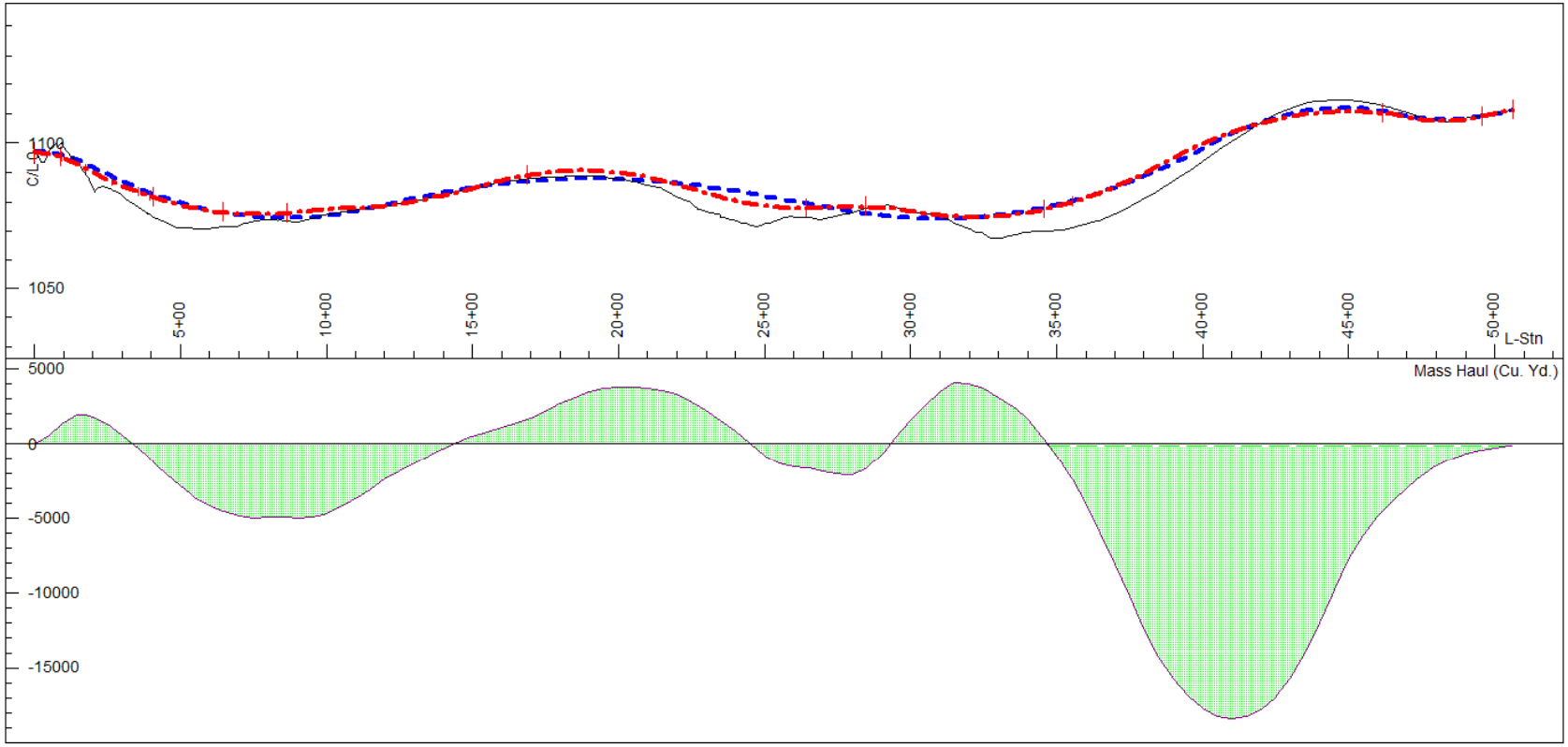
- **Intersection**



Preliminary Results

County Road Case Study

- Generate optimal alignment, second iteration
- With intersection constraint
- Cost = 535814



Preliminary Results

County Road Case Study

- **Numbers**

	Human Engineered	Iteration 1	Iteration 2
Movement cost	$213,988	$106,052	$184,756
Cut/Fill cost	$395,773	$275,759	$351,058
Total cost	**$609,761**	**$381,811**	**$535,814**
RoadEng Cut (Cu. Yds.)	43915	30499	38842
RoadEng Fill (Cu. Yds.)	43706	30520	38961
Net	209	-21	-119

Preliminary Results

Other case studies

Softree is working with several organizations to complete testing and evaluation. We expect the results of these studies to be available in the form of detailed case studies in the near future. The following table includes some rough preliminary results (see * comment below).

	Human Engineered Results $ CDN		**Optimized Results * $ CDN**	
	Excavation / Embankment	Material Movement	Excavation / Embankment	Material Movement
2 Lane Highway, Northern Canada	$1,017,000	$1,020,000	$686,000	$256,000
Rural County Road, Alberta, Canada	$125,000	$62,000	$136,000	$13,000
Rural County Road, Midwest, USA	$395,000	$213,000	$351,000	$184,000

* These preliminary tests have been carried out by Softree without full knowledge of the project. As such, the benefit of optimization is likely overstated as additional constraints have not been included.

Conclusions

Summary

- **RoadEng Optimal** can:
  - Provide an interactive single value cost metric to a design engineer.
  - Create an optimal (vertical) alignment based on given horizontal alignment, real world template cross sections, constraints and design standards.
- **RoadEng Optimal** will:
  - Reduce the cost of road construction (5-10%?).
  - Speed up engineering (and reduce the engineering cost).
  - Improve final design.

Conclusions

Partnership Proposal

- Softree is seeking industry or government organizations that can provide access to road design project information for analysis.
- The beta versions of **RoadEng Optimal** will be evaluated and tested using:
  - Completed projects.
  - Ongoing projects (not yet constructed or tendered).
- Organization engineers and technologists familiar with these projects will:
  - Help define project specifications and constraints.
  - Provide feedback as to the value of RoadEng Optimal and suggest possible enhancements and other applications.
- Softree will share any project improvements found by **RoadEng Optimal** and Softree technicians with the partner organization.
- Partner organizations will benefit from any design improvements for ongoing projects.