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ALTO HSR CITIZEN RESEARCH INITIATIVE

# Engineering Complexity and Community Friction

## Joint Predictors of High-Speed Rail Cost

*A multivariate reference-class analysis of 16 international HSR projects,  
with cost predictions for the ALTO corridor and the HPR alternative*

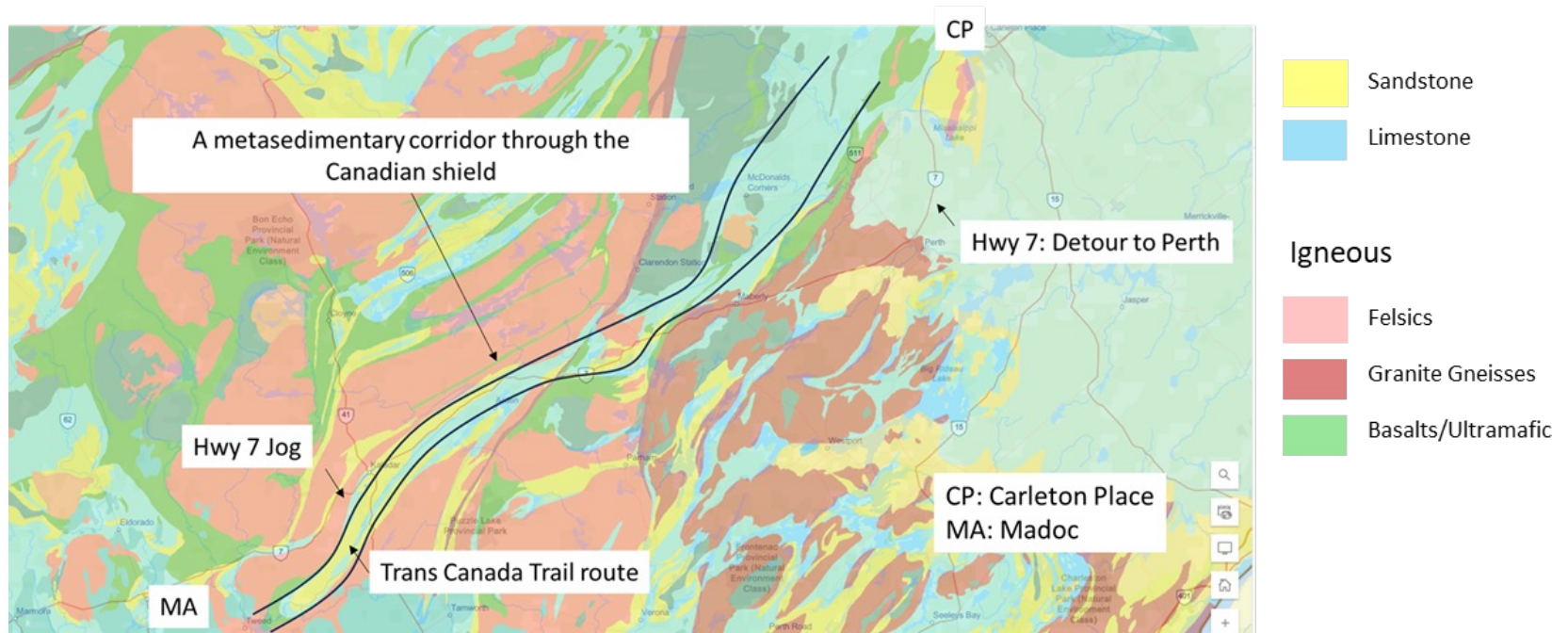
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Briefing deck · April 2026

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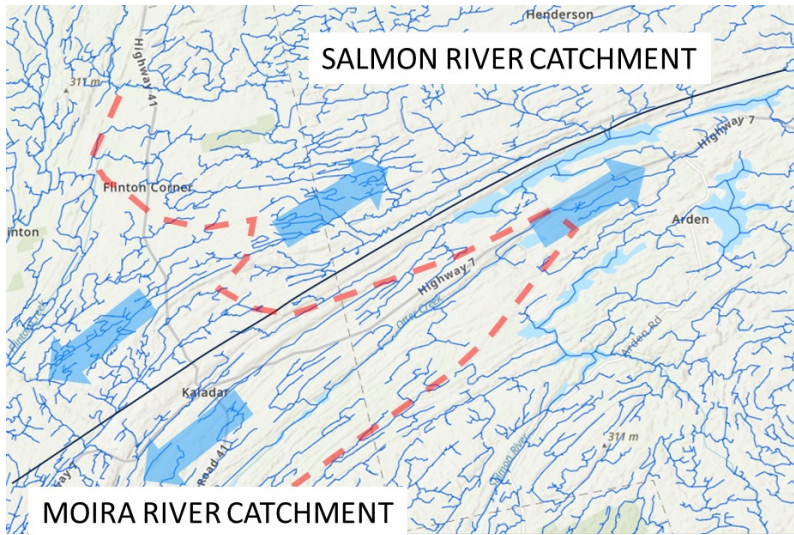
## GEOTECHNICAL BACKGROUND

# A six-dimension weighted index for engineering complexity

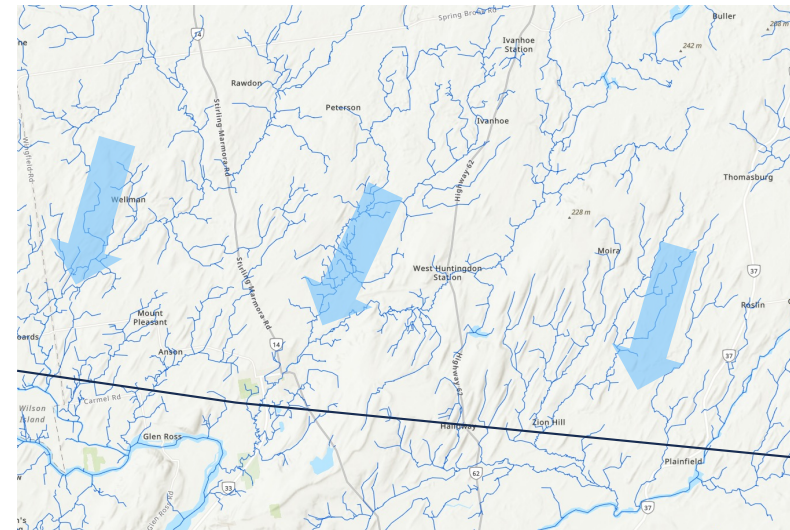


HYDROLOGICAL BACKGROUND

# 3-5,000 Billion litres of Water Cross the Railway








Northern Route



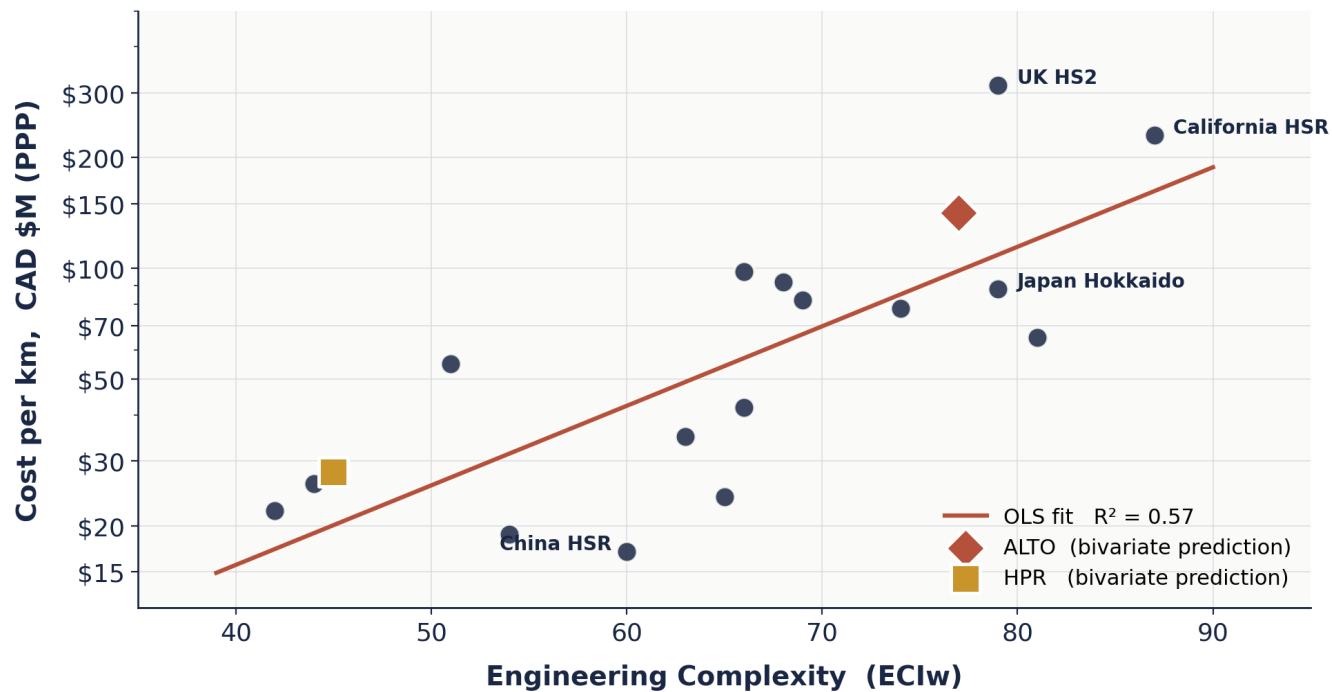
Southern Route

# The Engineering Complexity Index (ECI)

A six-dimension weighted index for engineering complexity

DIMENSION	WEIGHT	1 — ROUTINE	3 — MODERATE	5 — EXTREME
Geotechnical conditions	20 	Competent uniform ground, shallow stable bedrock	Mixed conditions, moderate settlement potential	Karst, sensitive marine clays, liquefaction, shear zones
Major structures	20 	Minimal — at-grade with small culverts	Short bridges, one grade separation cluster	Long viaducts, deep or long tunnels, major river bridges
Topography and alignment	20 	Flat, straight, generous curve radii	Rolling, some grade or curve compromises	Mountainous or constrained; grades and radii at spec limits
Hydrology and drainage	15 	Few minor crossings, simple culverts	Several regulated watercourses, some floodplain	Major river crossings, wetland complexes, altered groundwater
Infrastructure interfaces	15 	Greenfield, few conflicts	Several road, rail, or utility crossings	Dense urban interfaces, live rail, buried utilities
Climate and environmental loading	10 	Temperate, low freeze-thaw, stable	Cold climate, moderate frost heave, snow loading	Severe freeze-thaw, permafrost-adjacent, extreme swing

# Cost rises with engineering complexity — but with wide scatter



$R^2$

# 0.57

*of cross-project variance in log-cost explained by ECIw alone*

### Takeaway

Engineering complexity is a real cost driver, but leaves 43 % of variance unexplained — notably the anglophone premium (HS2, HS1, California).

$$\log_{10}(\text{cost CAD M / km}) = 0.0173 \cdot \text{ECIw} + 0.666$$

*n = 20 HSR reference projects · cost in 2026 PPP Canadian dollars*

ALTO HSR CITIZEN RESEARCH INITIATIVE

# The ALTO Community Friction Index (CFI)

*Key figures from the April 2026 research note*

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Briefing deck · April 2026

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THE FACE OF COMMUNITY FRICTION

# What does Community Friction Look like?



# Five factors that make up the CFI

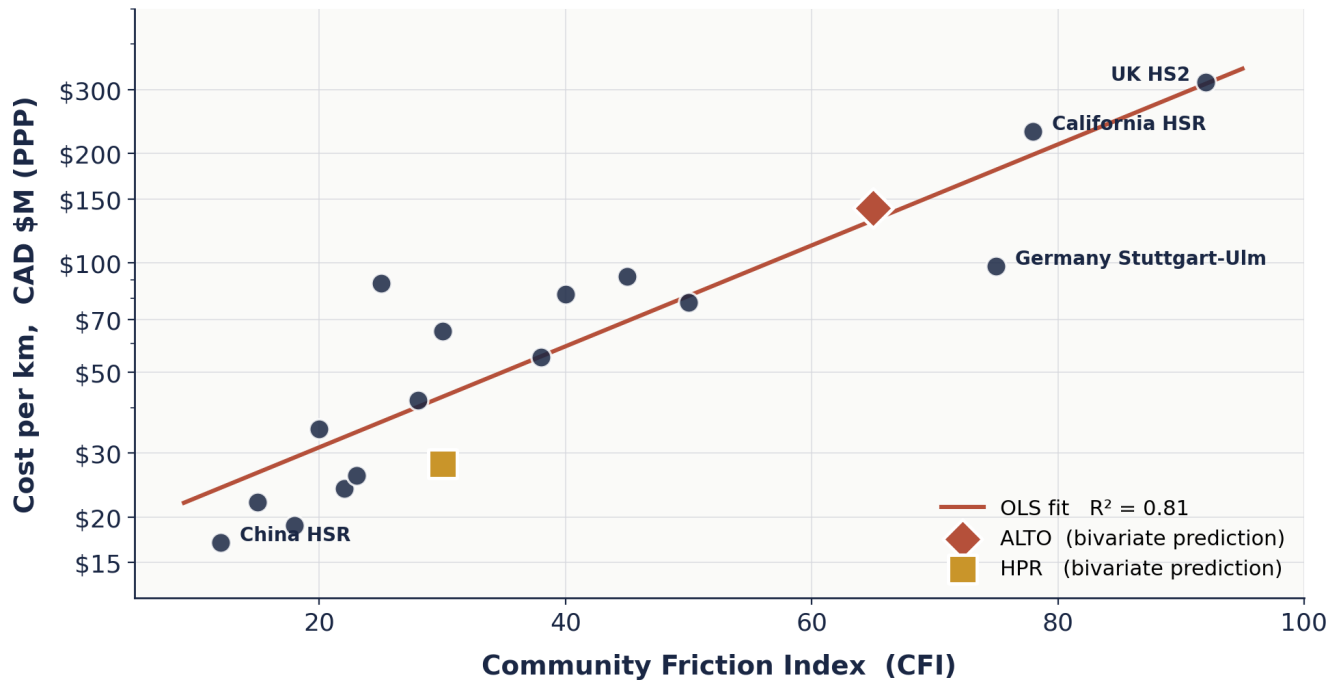
Each component scored 0-20 from the documented record · Five components sum to the aggregate CFI (0-100)

<b>1</b>	<b>Public opposition intensity</b> <i>Scale, organisation, and reach of grassroots opposition.</i>	MEASURED BY Consultation record · community groups · media coverage · public mobilisation
<b>2</b>	<b>Legal challenges filed</b> <i>Formal legal and quasi-legal activity against the project.</i>	MEASURED BY ATI requests · tribunal applications · judicial review · injunctions · s. 35 litigation
<b>3</b>	<b>Forced route changes</b> <i>Cumulative scope, alignment, or category changes under pressure.</i>	MEASURED BY Realignments · station relocations · speed downgrades · phase cancellations
<b>4</b>	<b>Environmental / NGO opposition</b> <i>Intensity of environmental and NGO engagement with the project.</i>	MEASURED BY EA submissions · species-at-risk triggers · regulator intervention · stop-work orders
<b>5</b>	<b>Political traction</b> <i>Inter-party, inter-governmental, or intra-caucus political contest.</i>	MEASURED BY Parliamentary inquiries · committee hearings · election-issue status · intergovernmental dispute

5 components × 0-20 sub-scale = **Aggregate CFI (0-100)**

UNIVARIATE FIT · COMMUNITY FRICTION

# Community friction is the stronger single predictor of HSR cost: PEOPLE ARE HARDER THAN ROCK!



$R^2$

**0.81**

*of cross-project variance in log-cost explained by CFI alone*

### Takeaway

CFI alone explains more variance than any engineering-only model. Sociopolitical cost pathways are independently measurable.

$$\log_{10}(\text{cost CAD M / km}) = 0.0139 \cdot \text{CFI} + 1.216 \quad n = 16 \text{ HSR reference projects} \cdot \text{cost in 2026 PPP Canadian dollars}$$

# A housing analogy: two factors, one price

*A house's price is driven by both its size and its location — a rail corridor's cost is driven by both its engineering complexity and its community friction*



**"Location, location, location"** is the fundamental real estate principle that a property's desirability, value, and appreciation are primarily determined by its position, rather than the house itself.

**Takeaway** Neither dimension alone tells the whole story. Size without location under-explains price; ECI without CFI under-explains HSR cost. Together, they capture 90 % of cross-project variance.

## HOUSE PRICE

*depends on two independent dimensions*

### Size

square footage · bedrooms · bathrooms

### Location

waterfront · proximity to schools ·  
proximity to HSR tracks

## ALTO COST PER KM

*depends on two independent dimensions*

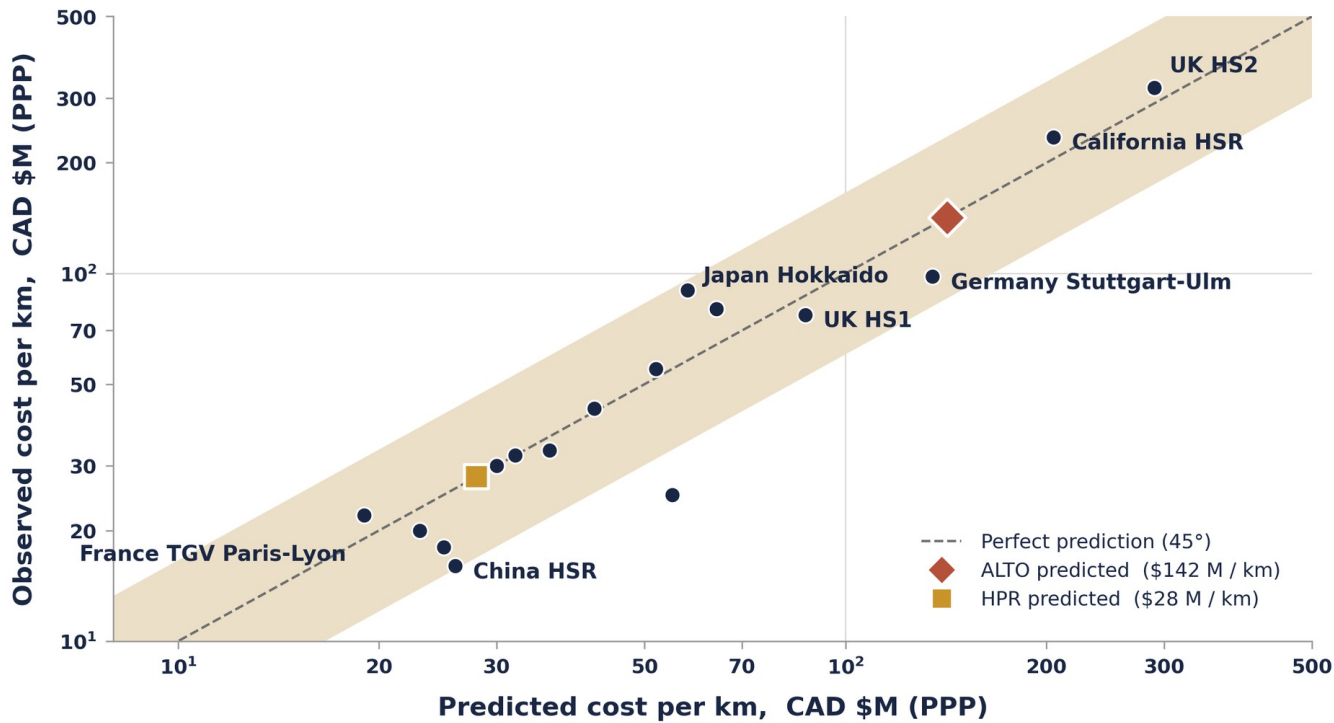
### Engineering complexity **ECI**

geotechnical · structures · topography

### Community friction **CFI**

consultation · land tenure ·  
environmental · cost-scope · political

# Together, ECIw and CFI explain 90 % of cross-project cost variance: How much will ALTO Cost?



R<sup>2</sup>

**0.90**

bivariate model · adj R<sup>2</sup> = 0.88  
 F(2, 13) = 56.9, p < 10<sup>-6</sup>

**Coefficients**

ECIw    p = 0.006    β = 0.35

CFI    p < 0.001    β = 0.70

Year    p = 0.83    (not sig.)

$$\text{Log}_{10}(\text{Predicted Cost per km}) = 0.0101 \cdot \text{ECIw} + 0.0108 \cdot \text{CFI} + 0.671$$

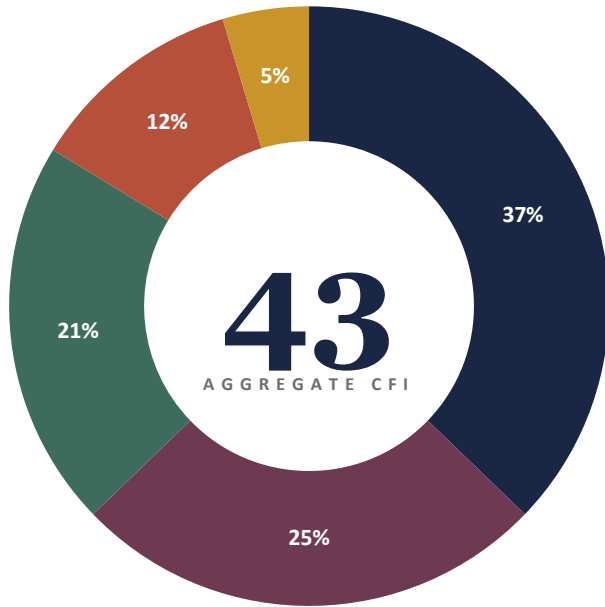
adj R<sup>2</sup> = 0.88 · completion year adds nothing once both indices are controlled for



# Current CFI: 43

Post-Bill C-15 baseline, April 2026 · Two points below the High threshold

Moderate band · 25 to 45



## Principal evidence by component

### Public · 16

Cross-sector coalition; parliamentary testimony on ALTO-specific C-15 provisions.

### Political · 11

Senate pre-study across 10 committees; 82 report-stage amendments.

### Environmental · 9

Coordinated NGO objections; SARA engaged as primary statutory protection.

### Legal · 5

Coordinated ATI programme across HICC, TC, PSPC, VIA Rail.

### Route · 2

Pre-consultation; C-15 s. 98 CTA deeming suppresses this component.

# Eight drivers of friction intensification

Repeatable conditions that move a project up the regression line · Multiple conditions together push scores into Very high and Extreme bands

1

## Tokenistic or premature consultation

Announcing a preferred corridor before genuine engagement converts stakeholders into adversaries. HS2 and California HSR both followed this pattern.

2

## Route through farmland and established communities

Linear severance of agricultural land and rural properties generates durable opposition. Rural communities have the cohesion and time to sustain multi-year campaigns.

3

## No Transparency in corridor selection methodology

Where the technical basis for alignment is not disclosed, communities fill the vacuum with worst-case assumptions. ATI requests escalate; political risk multiplies.

4

## Expansive or novel expropriation frameworks

Exceptional acquisition powers granted before environmental approval are experienced as an inversion of due process, attracting civil-liberties solidarity.

5

## Business case credibility gaps

BCR visibly below standard appraisal thresholds gives opponents a legitimising narrative that attracts fiscal-conservative allies (Flyvbjerg et al., 2002).

6

## Species-at-risk and ecological conflicts

SARA listings confer standing on environmental organisations and generate mandatory consultation obligations incompatible with project schedules.

7

## Station location and community bypass

Remote interchange stations remove potential beneficiaries from the supporter base, creating a durable perception that the project serves external logic.

8

## Delay and cost overrun signals

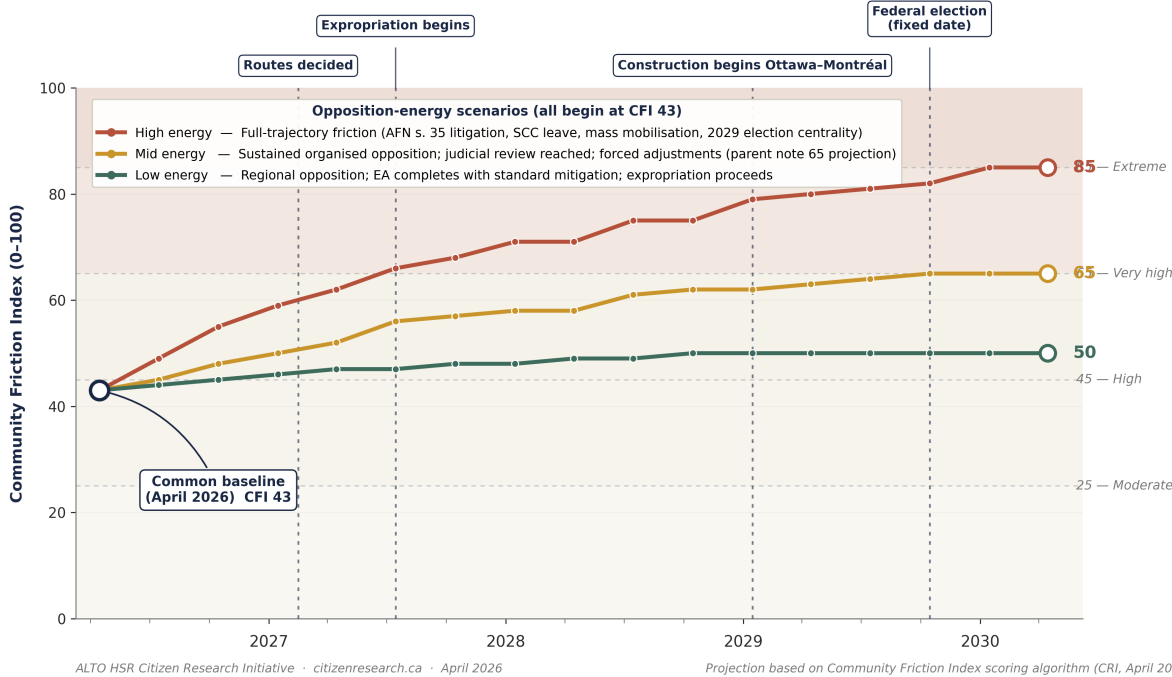
Each rescaling event increases friction. HS2 truncations and California HSR rebaselining both reset scores upward with every announcement.

# Four-year trajectory: three scenarios

All three begin at CFI 43 · Mid-energy endpoint (65) matches the parent note projection

## ALTO Community Friction Index: Three-Scenario Trajectory

April 2026 - April 2030 · Common post-Bill C-15 baseline; scenarios diverge by opposition intensity



### HIGH · CFI 85

Extreme border

AFN s. 35 litigation, SCC leave, mass mobilisation, 2029 election centrality.

### MID · CFI 65

Very high border

Sustained organised opposition; judicial review reached; forced adjustments.

### LOW · CFI 50

High band

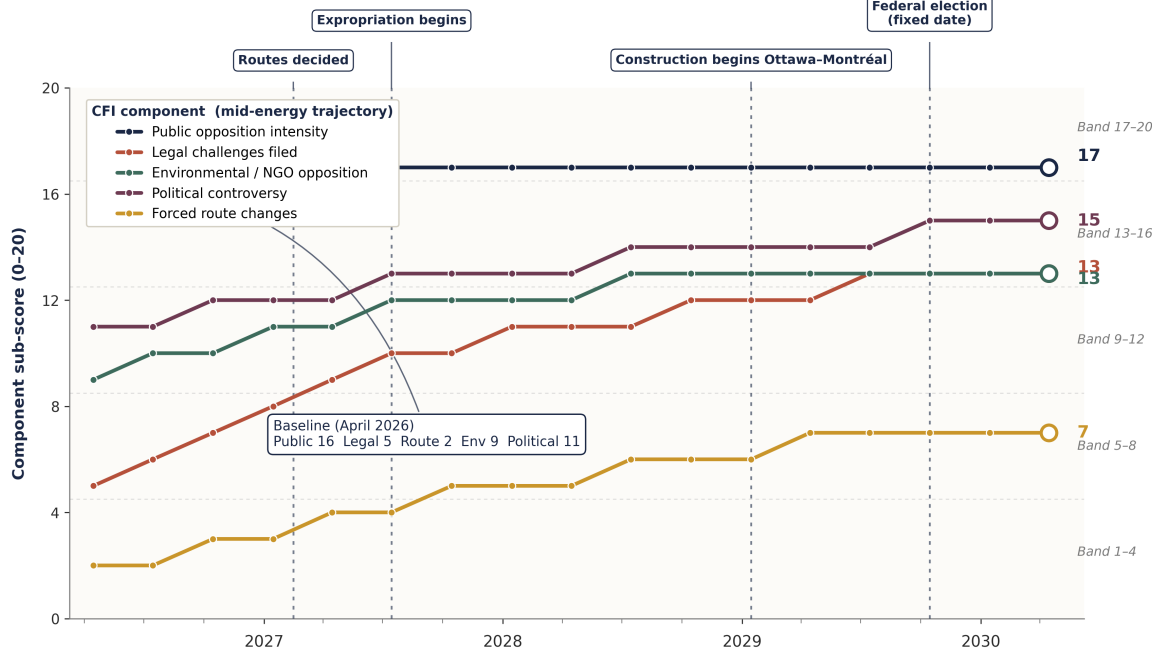
Regional opposition; EA completes with standard mitigation.

# Mid-energy: what drives the trajectory

Five component sub-scores sum to 43 → 65 · Legal challenges do most of the work

## ALTO CFI Mid-Energy Scenario: Component Trajectories

April 2026 - April 2030 · Five component sub-scores sum to the mid-energy aggregate (43 → 65)



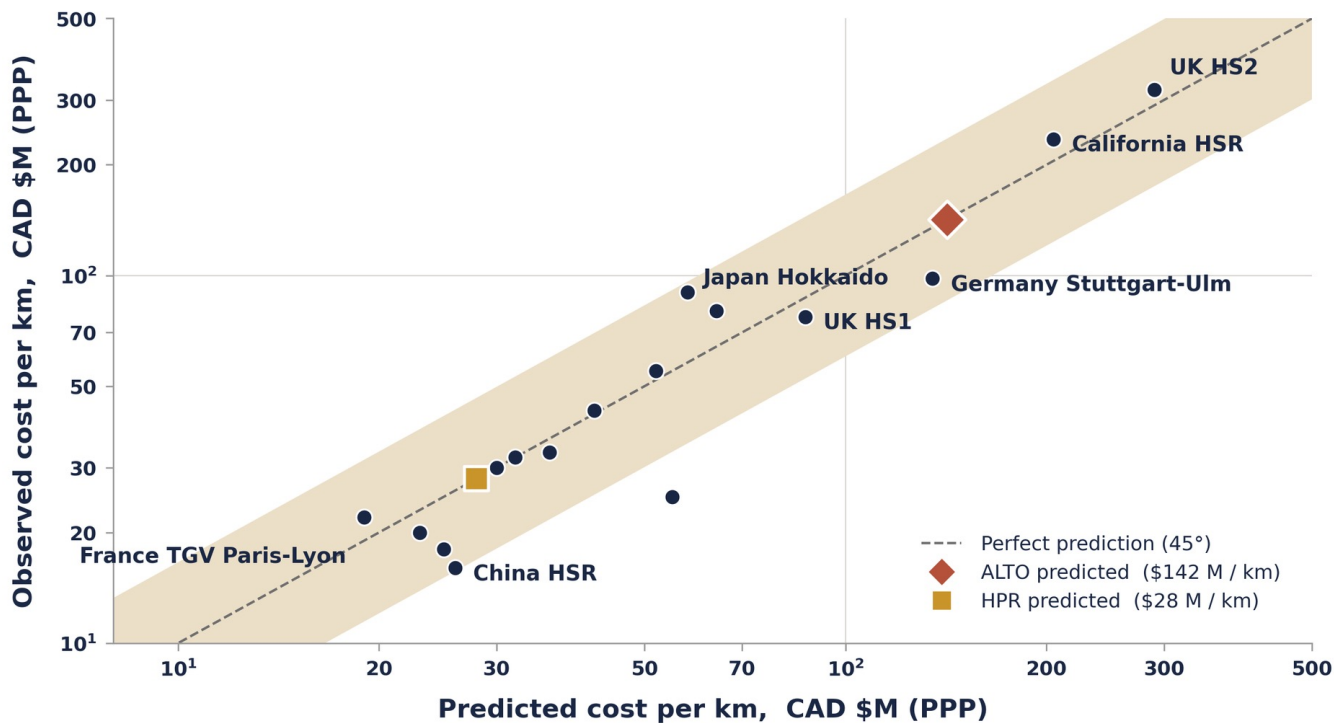
ALTO HSR Citizen Research Initiative · citizenresearch.ca · April 2026

Projection based on Community Friction Index scoring algorithm (CRI, April 2026)

## Reading the decomposition

- **Legal +8**  
 Steepest riser. C-15 closes parliamentary channels; litigation is primary pressure point.
- **Political +4**  
 Dampened through 2027-28 (majority insulation); bumps at October 2029 election.
- **Environmental +4**  
 Plateaus at 13. Higher indicators require SARA stop-work or Indigenous parallel action.
- **Route +5**  
 Slowest riser. s. 98 CTA deeming caps this component by statute.
- **Public +1**  
 Near-flat: mid-energy assumes organised but non-mass-mobilisation opposition.

# Together, ECIw and CFI explain 90 % of cross-project cost variance: How much will ALTO Cost?



R<sup>2</sup>

**0.90**

bivariate model · adj R<sup>2</sup> = 0.88  
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**Coefficients**

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$\text{Log}_{10}(\text{Predicted Cost per km}) = 0.0101 \cdot \text{ECIw} + 0.0108 \cdot \text{CFI} + 0.671 \text{ CAD \$M(PPP)}$     adj R<sup>2</sup> = 0.88 · completion year omitted

# ALTO's \$75 B declared cost lies at the lower 2.5 percentile of the reference-class prediction

The model's central estimate is \$143 B; the proponent's own figure coincides with the bottom edge of the 95 % prediction interval



95 % PREDICTION INTERVAL · log-normal, symmetric in log space

\$76 B · lower 2.5%

ALTO declared \$75 B falls at this boundary

\$143 B · central (50%)

joint EClw + CFI model prediction

upper 2.5% · \$264 B

upper prediction bound

**Takeaway** The proponent's own cost estimate coincides with the most extreme lower-bound outcome the reference-class model treats as plausible — roughly a 1-in-40 probability the corridor actually comes in at or below \$75 B.

# ALTO at the consultation deadline

*Communications-heavy staffing and missing project materials at the April 24 deadline*

## DISCLOSED STAFFING ALLOCATION

36

communications staff

2

environmental scientists

42

land negotiation staff

10

environmental & regulatory

### NO CREDIBLE MATERIALS YET PUBLISHED

construction costs · schedules · ridership forecasts · revenue models ·  
operating costs · risk and opportunity analysis · Cadence consortium  
agreement

### LEADERSHIP TURNOVER AND PUBLIC SCRUTINY

Air Canada CEO Michael Rousseau has announced retirement by  
September.

ALTO representatives reported to be departing amid backlash and sharper  
public questioning.

Residents, media and municipal bodies pressing for substantive answers.

**Takeaway** The public-facing footprint of the project outsizes its technical and environmental capacity — with the core deliverables of a credible consultation still absent at the deadline.

# ALTO costs five times more than HPR



The predicted cost gap is roughly half engineering, half community friction — not a function of timing

ALTO predicted cost

**\$142 B**

central · +/- 2SD \$76 – 264 B · over 1,000 km

ECIw = 77 · CFI = 65




HPR (200km/h 401 Corridor) predicted cost

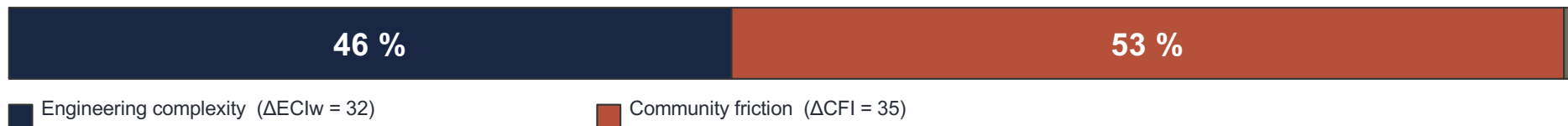
**\$28 B**

central · 95 % PI \$15 – 54 B · over 1,000 km

ECIw = 45 · CFI = 30



## Decomposition of the 5.0x cost gap



CONCLUSION · REFERENCE-CLASS COST PREDICTION

# ALTO's predicted cost is \$143 billion

Joint ECIw + CFI model explains 90% of cross-project variance · 95% prediction interval \$76 – 264 B over 1,000 km



ALTO DECLARED COST

**\$75 B**

Lower 2.5% bound — a 1-in-40 outcome at the bottom edge of the 95% PI.

UPPER 2.5% BOUND

**\$264 B**

Upper 2.5% bound — a 1-in-40 outcome at the top edge of the 95% PI.

*The proponent's declared \$75 B coincides with the lowest outcome the reference-class model treats as plausible.*