ALTO HSR CITIZEN RESEARCH INITIATIVE

Engineering Complexity Rubric

A ten-dimension scoring framework for the worldwide database of high-speed rail projects

Methodology brief

This brief defines a ten-dimension rubric for classifying the engineering complexity of high-speed rail corridors. Each dimension is defined against five descriptor levels (Minimal, Low, Moderate, High, Extreme) and carries a weight reflecting its typical role in capital-cost dispersion; weights sum to 100. Dimensions are scored on a granular integer scale from 1 to their weight. Two composite indices are reported: a Peak Severity index, which captures engineering capability at the most demanding locations; and an Exposure-Adjusted index, which scales each dimension by the fraction of corridor length at which the peak severity is present. Both composites are scored out of 100 and placed into one of four complexity categories. The rubric is designed for evidence-based application across the worldwide HSR database maintained by the Initiative, to support reference-class forecasting and cross-project benchmarking.

Version 1.0 • April 2026

1. Purpose and scope

The worldwide database of high-speed rail corridors maintained by the Initiative compiles capital cost, ridership, journey time, and operational performance data across more than forty commissioned or under-construction projects. Meaningful comparison across this database requires an explicit framework for engineering complexity: corridors that differ in length, climate, geology, and network context are not directly comparable on a dollars-per-kilometre basis, yet unadjusted comparisons are routinely used in business cases to justify cost estimates.

This rubric provides a reproducible method for positioning any corridor on an engineering complexity spectrum, independent of its cost or ridership outcomes. The primary uses are:

- Reference-class construction: identifying projects whose engineering complexity is genuinely comparable to a proposed corridor, so that cost and schedule forecasts are grounded in relevant precedent rather than headline numbers.
- Risk stratification: surfacing the dimensions on which a corridor differs materially from its nominated reference class, so that residual risk can be costed and scheduled explicitly.
- Benchmarking: comparing proposed corridors against historical outcomes in the same complexity band, to test whether stated cost, schedule, and performance assumptions are plausible.

The rubric is not a substitute for detailed engineering assessment. It is a classification instrument, to be applied at desk-study level from publicly available information, and refined as project documentation becomes available.

2. Structure of the rubric

The rubric comprises ten dimensions, each scored on a five-point scale. The dimensions are grouped into four natural clusters:

Ground and climate

Dimensions 1–4 address the physical environment the corridor must cross: subgrade and soil conditions, bedrock and excavation, hydrology and hydrogeology, and climatic regime. These dimensions are largely fixed by geography and cannot be engineered away.

Geometry and hazard

Dimensions 5–6 address the interaction between the alignment and the terrain: topographic relief and alignment geometry, and seismic and geohazard exposure. These dimensions reflect both what the landscape requires and what the chosen design speed permits.

Environment and community

Dimensions 7–8 address the environmental, heritage, and rights-based constraints the corridor encounters: ecological and protected-area footprint, and heritage, archaeological, and Indigenous-rights constraints.

Delivery and integration

Dimensions 9–10 address the corridor as an infrastructure project: corridor integration and land acquisition (the right-of-way question), and urban engineering content (the engineering burden imposed by urban segments).

Each dimension is independent. A corridor may score low on ground conditions but high on ecological constraints, or low on climate but high on seismic exposure. The composite score captures the cumulative engineering burden; the dimension profile identifies where that burden concentrates.

3. Scoring scale and composite

Each dimension is defined against five descriptor levels:

- **Minimal** — routine, well within established practice
- **Low** — standard engineering with limited attention required
- **Moderate** — established mitigation approaches apply
- **High** — non-routine engineering, elevated risk and cost dispersion
- **Extreme** — frontier engineering, few or no directly comparable precedents

Dimension weights

Not all dimensions exert equal influence on capital cost and schedule risk. The weighted rubric assigns each dimension a maximum contribution reflecting the magnitude of its typical cost impact across the reference class. Weights sum to 100, so the composite is read directly as a score out of 100.

#	Dimension	Weight
D1	Subgrade and soil conditions	**10**
D2	Bedrock and excavation character	**15**
D3	Hydrological and hydrogeological setting	**10**
D4	Climatic regime	**15**
D5	Topographic relief and alignment geometry	**15**
D6	Seismic and geohazard exposure	**5**
D7	Ecological and protected-area footprint	**5**
D8	Heritage, archaeological, and Indigenous-rights constraints	**5**

#	Dimension	Weight
D9	Corridor integration and land acquisition	5
D10	Urban engineering content	15
	TOTAL	100

The four cost-dominant dimensions each carry a weight of 15: Bedrock and excavation character, Climatic regime, Topographic relief, and Urban engineering content. Subgrade and Hydrology carry 10 each. The remaining four dimensions — Seismic and geohazard exposure, Ecological footprint, Heritage and Indigenous-rights constraints, and Corridor integration and land acquisition — each carry 5.

Granular scoring

Each dimension is scored as an integer on a scale from 1 to its weight. A dimension with weight 15 is scored 1–15; a dimension with weight 10 is scored 1–10; a dimension with weight 5 is scored 1–5. The integer score is the dimension's direct contribution to the composite; the composite is the sum of the ten contributions and ranges from 10 (all dimensions minimal) to 100 (all dimensions extreme).

Descriptor levels map proportionally onto the granular scale. On a weight-15 dimension, Minimal corresponds to 3, Low to 6, Moderate to 9, High to 12, and Extreme to 15; on a weight-10 dimension, the mapping is 2, 4, 6, 8, 10; on a weight-5 dimension, 1, 2, 3, 4, 5. Intermediate integer scores record cases where corridor conditions straddle two descriptor levels. For example, a bedrock dimension with documented karst plus a shield–sedimentary boundary crossing but without full Extreme-scale tunnelling requirements may be scored 13 (above High, below Extreme) rather than being forced to the coarser 12 or 15.

The composite is binned into four categories:

Score band	Category	Interpretation
20 – 40	**Low**	Routine engineering within established international practice. Capital cost and schedule estimable with reference-class precedent.
41 – 60	**Moderate**	Standard HSR engineering with discrete challenges requiring design attention. Typical of most commissioned European and East Asian HSR lines on favourable corridors.

Score band	Category	Interpretation
61 – 80	**High**	Multiple dimensions at elevated complexity. Capital cost dispersion wide; reference-class forecasting essential. Risk of significant cost and schedule overrun absent strong governance.
81 – 100	**Extreme**	Frontier engineering on several dimensions simultaneously. Few or no directly comparable precedents. Risk register dominated by interaction effects between dimensions; independent peer review and reference-class forecasting are mandatory.

Weighting rationale. The weights reflect the empirical role of each dimension in capital-cost dispersion across the worldwide HSR reference class. Bedrock, climate, topography, and urban engineering are the dimensions on which observed cost outcomes vary most strongly. Any alternative weighting scheme is permissible in applications where the weighting above does not match the policy question at hand, provided the alternative weights are declared at the point of application, sum to 100, and are applied consistently across all corridors in the comparison.

Peak Severity and Exposure-Adjusted indices

For most corridors, the engineering conditions captured by a dimension are not uniformly distributed along the alignment. Subgrade sensitivity may be present across 70% of corridor length; a hard-rock shield crossing may occupy only 5%; urban engineering content may appear only at terminal approaches. The rubric supports two complementary indices to reflect this:

The Peak Severity composite is the sum of the granular dimension scores. It treats each dimension as fully present when the peak severity appears anywhere on the alignment. This index characterises the engineering capability the corridor must provide at its most demanding locations — the capability-for-the-worst-segment reading.

The Exposure-Adjusted composite scales each dimension's contribution by the fraction of corridor length at which the peak severity is present. It characterises the aggregate engineering burden distributed across the whole corridor. The contribution formula for each dimension is:

$$contribution_i = granular_i \times [\ \alpha + (1 - \alpha) \times exposure_i\ ]$$

where i indexes the ten dimensions, $granular_i$ is the integer score on the weighted scale (1 to weight), $exposure_i$ is the fraction of corridor length at or near peak severity (0.0 to 1.0), and α is the design-severity parameter. The default value is $\alpha = 0.75$, which preserves peak-severity dominance while allowing exposure fraction to modify the contribution downward where severity is localised. At $\alpha = 1.0$ the Exposure-Adjusted composite equals the Peak Severity composite; at $\alpha = 0$ it becomes a pure length-weighted index.

Both indices should be reported when exposure fractions are known with reasonable precision. The two indices answer different questions and are not substitutes: a corridor with high Peak Severity but low Exposure-Adjusted score has concentrated complexity; a corridor with high scores on both has distributed complexity. Capital-cost and schedule forecasting both indices have their uses; the design-capability case for peer review and reference-class forecasting is driven by Peak Severity, while the corridor-scale cost envelope is informed by the Exposure-Adjusted composite.

When exposure fractions cannot be estimated from available evidence, the Peak Severity composite alone should be reported, with an explicit note that exposure adjustment has not been performed.

4. The ten dimensions

Each dimension below is defined by its scope, the evidence sources typically consulted for scoring, and five explicit level descriptors. Scoring should cite specific evidence and record the rater's judgement where descriptors straddle a corridor's actual conditions.

Dimension 1. Subgrade and soil conditions

Engineering behaviour of the soils supporting the track structure, including sensitivity, compressibility, liquefaction potential, and long-term settlement characteristics. This dimension captures the subgrade the corridor must cross, irrespective of bedrock.

Evidence sources. Regional surficial-geology mapping; published geotechnical investigations; soil-sensitivity indices (St); organic-deposit inventories; liquefaction-susceptibility maps.

1	**Minimal**	Uniformly stable granular or residual soils on competent bedrock. Bearing capacity exceeds requirements with minimal preparation. Settlement predictable and within tolerances using standard compaction.
2	**Low**	Predominantly competent soils with localised zones of moderate compressibility. Conventional preloading, surcharge, or light stabilisation adequate. No quick or sensitive clays present along alignment.
3	**Moderate**	Mixed conditions including normally-consolidated clays, silts, and organic pockets requiring targeted ground improvement (stone columns, wick drains, cement stabilisation) across a minority of the corridor.
4	**High**	Significant reaches of soft or sensitive clay (10–30% of corridor), peat deposits, or liquefiable soils requiring extensive ground improvement, deep soil mixing, or piled transition structures. Long-term settlement a primary design driver.
5	**Extreme**	Extensive quick or highly sensitive clays (St > 8), thick peat sequences, or deep liquefiable deposits across more than 30% of the corridor. Examples include Champlain Sea (Leda) clays, Scandinavian quick clays, or liquefiable alluvium in seismic zones. Subgrade treatment may dominate capital cost and construction schedule.

Dimension 2. Bedrock and excavation character

Rock-mass behaviour in cuttings, tunnels, and foundation excavations. Includes lithology, weathering, structural discontinuities, and the presence of karst or fault systems that govern excavation method and support requirements.

Evidence sources. Bedrock geology maps; rock-quality designation (RQD) data; karst inventories; fault and shear-zone mapping; regional tunnelling precedents.

1	**Minimal**	No rock excavation required, or thin competent sedimentary cover removed by conventional means. Foundations bear on soil.
2	**Low**	Limited rock excavation in competent, uniform sedimentary or igneous rock. No karst, no major fault zones. Standard drill-and-blast or mechanical methods sufficient.
3	**Moderate**	Mixed-face conditions across a moderate fraction of the corridor. Some weathered rock, minor fault zones, or discrete tunnel segments through competent rock requiring routine support.
4	**High**	Substantial rock excavation, long hard-rock tunnels, or corridors crossing the boundary between distinct geological provinces (e.g., sedimentary basin / crystalline shield). Discrete karst features or major fault zones requiring grouting, probing, or realignment.
5	**Extreme**	Extensive karst terrain with documented sinkhole activity and cavernous aquifers; long hard-rock tunnels through highly variable shield or fold-belt rock; corridors that must traverse active-fault structures or extreme rock-stress environments. Ground-risk a dominant cost and programme driver.

Dimension 3. Hydrological and hydrogeological setting

Surface-water and groundwater conditions along the corridor, including major crossings, wetland traversal, aquifer sensitivity, and dewatering demands during construction and operation.

Evidence sources. Watershed maps; wetland inventories (provincial, Ramsar); aquifer vulnerability mapping; sole-source aquifer designations; Ministry or Agency flood-plain mapping.

1	**Minimal**	Arid or well-drained terrain with no significant watercourse crossings. No wetlands. Groundwater deep and not a construction consideration.
2	**Low**	Small-stream crossings only. Minor wetland fringes. Groundwater present but manageable with conventional dewatering. No protected aquifers.

3	**Moderate**	Multiple stream crossings and moderate wetland traversal. Shallow groundwater requiring planned dewatering. Corridor passes through recharge areas but not designated source-water zones.
4	**High**	Several major river crossings, substantial wetland complexes, shallow regional aquifer under the alignment, or proximity to protected watersheds. Hydrological modelling and dewatering management a significant design task.
5	**Extreme**	Multiple major river crossings combined with karst or sole-source aquifers; extensive wetlands of international significance; corridor traversing multiple watersheds with sensitive drinking-water supplies. Hydrogeological protection measures integral to alignment and construction methods.

Dimension 4. Climatic regime

Thermal, precipitation, and loading conditions that govern structural, track, and overhead-line design. Continental and cold-climate corridors face exposure regimes that maritime and subtropical corridors do not.

Evidence sources. Environment and Climate Change Canada (or national equivalent) climate normals; freeze-thaw cycle counts; design snow and ice loading standards; historical temperature extremes.

1	**Minimal**	Temperate maritime or subtropical. Annual temperature range below 25°C. Negligible freeze-thaw. No design snow or ice loading.
2	**Low**	Temperate continental. Annual range 25–45°C. Limited freeze-thaw cycles. Modest snow loading within standard European or US norms.
3	**Moderate**	Cold-temperate. Annual range 45–60°C. Regular freeze-thaw (30–80 cycles/year). Design snow loading and ice accretion significant but within established precedent.
4	**High**	Continental cold. Annual range 60–75°C. More than 80 freeze-thaw cycles/year. Deep frost penetration (>1.5 m). Substantial ice and snow loading on overhead contact system and structures.
5	**Extreme**	Severe continental. Annual range above 75°C, sustained temperatures below −30°C, more than 100 freeze-thaw cycles/year, and frost penetration exceeding 2 m. Thermal cycling governs rail and catenary design. Few operational precedents globally; Harbin–Dalian is the principal case study.

Dimension 5. Topographic relief and alignment geometry

Vertical and horizontal constraints imposed on the alignment by terrain. Captured through tunnel and viaduct percentages, ruling gradient, and whether the corridor can achieve the curvature required by the nominated design speed without compromise.

Evidence sources. Digital elevation models; published alignment drawings and profile diagrams; tunnel and bridge inventories.

1	**Minimal**	Level plain or gently rolling terrain. Fewer than 5% tunnel and viaduct combined. Gradients below 1%. Geometry achievable at nominated design speed with comfortable margins.
2	**Low**	Rolling terrain with occasional river valleys. 5–15% tunnel and viaduct. Gradients up to 1.5%. Minor curvature compromises at design speed.
3	**Moderate**	Moderate relief including foothills or escarpments. 15–25% tunnel and viaduct. Gradients up to 2%. Some segments require speed reductions.
4	**High**	Substantial relief, including rising terrain or crossing of highland provinces. 25–40% tunnel and viaduct. Gradients up to 2.5–3%. Achievable design speed constrained by geometry on multiple segments.
5	**Extreme**	Mountain crossings, deeply incised valleys, or fold-belt traversal. More than 40% tunnel and viaduct. Ruling gradients above 3%. Corridor requires sustained deviation from straight-line alignment; design speed strongly geometry-limited.

Dimension 6. Seismic and geohazard exposure

Earthquake ground motion, active-fault proximity, landslide and slope-stability hazards, karst subsidence, and permafrost degradation hazards that govern structural design and risk to operations.

Evidence sources. National seismic hazard maps (PGA, 475-year return period); active-fault databases; landslide inventories; permafrost maps; karst subsidence records.

1	**Minimal**	Stable cratonic interior. PGA < 0.05 g. No active faults within tens of kilometres. Negligible landslide or subsidence hazard.
2	**Low**	Low-seismicity interior. PGA 0.05–0.10 g. No active-fault crossings. Isolated slope-stability issues at scale of individual cuttings.
3	**Moderate**	Moderate seismicity. PGA 0.10–0.20 g, no active-fault crossings on the direct alignment, or limited discrete geohazards (sensitive clay slopes, minor karst, isolated landslide terrain) requiring specific mitigation.

4	**High**	Active-margin setting. PGA 0.20–0.40 g, one or more known fault crossings, or significant exposure to landslide, karst subsidence, or permafrost degradation along extended reaches.
5	**Extreme**	High-seismicity margin (PGA > 0.40 g) with multiple active-fault crossings; or extensive permafrost requiring cold-climate geotechnical design; or pervasive landslide and karst subsidence risk. Geohazard design a dominant engineering and cost driver. Japan, Taiwan, California and Harbin–Dalian occupy this tier.

Dimension 7. Ecological and protected-area footprint

Sensitivity of the natural environment traversed, captured through listed species, critical habitat, protected-area designations, and wetland or ecosystem significance.

Evidence sources. Species-at-risk registries (SARA, IUCN, state equivalents); protected-area GIS layers; biosphere-reserve and Ramsar designations; critical-habitat orders.

1	**Minimal**	Previously disturbed or intensively managed land throughout. No listed species, no protected areas, no designated wetlands of significance.
2	**Low**	Primarily agricultural or second-growth corridor. Isolated habitat for common species. No critical habitat, no protected areas traversed.
3	**Moderate**	Mosaic landscape with habitat for several regionally listed species. Minor wetland crossings. Protected-area boundaries approached but not crossed.
4	**High**	Multiple federally or internationally listed species affected, including species with designated critical habitat. Corridor crosses or adjoins provincial or state protected areas. Substantial wetland complex traversed.
5	**Extreme**	Multiple species with legal critical-habitat designations; corridor crosses biosphere reserves, national parks, or equivalent; traverses wetlands of international significance or supports habitat for species whose range is already highly restricted. Ecological constraints integral to alignment selection.

Dimension 8. Heritage, archaeological, and Indigenous-rights constraints

Cultural-heritage resources, archaeological potential, burial and cemetery sites, and Indigenous territorial rights, including treaty and title lands where free, prior and informed consent is required under UNDRIP or comparable frameworks.

Evidence sources. Provincial and national heritage registers; archaeological potential mapping; cemetery inventories; treaty and title-territory boundaries; Indigenous consultation records.

1	**Minimal**	Previously disturbed corridor with no registered heritage sites. Archaeological potential assessed and cleared. No Indigenous territorial claims on the alignment.
2	**Low**	Limited heritage or archaeological sensitivity, addressable through standard assessment and mitigation. Indigenous consultation limited to notification where required by statute.
3	**Moderate**	Several registered heritage sites, moderate archaeological potential, or corridor crossing traditional territory requiring substantive consultation beyond statutory minima.
4	**High**	Substantial heritage footprint, including registered cemeteries, listed structures, or cultural landscapes. Corridor crosses treaty territory or land subject to unresolved claims, triggering formal consent processes.
5	**Extreme**	Dense heritage and archaeological resources, including burial sites requiring exhumation or in-situ protection; corridor crosses multiple Indigenous territories with unresolved title claims or consent requirements; risk of rights-based legal challenge to the project as a whole.

Dimension 9. Corridor integration and land acquisition

Degree to which the project uses existing transport corridors versus greenfield alignment, density and fragmentation of affected land, and scale of property acquisition or expropriation.

Evidence sources. Cadastral mapping; existing rail and highway corridor inventories; expropriation records from comparable projects; land-use classification.

1	**Minimal**	Full use of existing rail corridor with compatible geometry. Negligible new acquisition; construction within existing right-of-way.
2	**Low**	Predominantly existing corridor with limited widening or short deviations. A few hundred property impacts, mostly partial takings.
3	**Moderate**	Mixed corridor with meaningful new greenfield segments. Several hundred to low thousands of property interests affected, including some full residential or farm takings.
4	**High**	Majority greenfield alignment through fragmented rural and exurban landscape. Thousands of property interests affected. Farm severance and access restoration substantial.
5	**Extreme**	Long greenfield alignment through densely settled rural and urban landscapes, or through actively farmed land with complex drainage, access, and tenure patterns. Tens of thousands of property interests; project timeline and cost dominated by land acquisition and expropriation.

Dimension 10. Urban engineering content

Engineering complexity arising from urban segments of the corridor, including urban tunnelling, new-build or substantially rebuilt station construction, scale of utility relocation, and construction-logistics constraints from adjacent buildings, transport infrastructure, and high-value property. Urban segments impose engineering and construction burdens of an order distinct from rural and exurban segments of the same alignment and warrant explicit scoring, separate from the corridor-reuse question captured in Dimension 9.

Evidence sources. Corridor alignment drawings showing urban approach configurations; published station plans and urban transportation studies; urban tunnel length data; municipal utility and transportation network inventories; existing rail infrastructure inventories at termini.

1	**Minimal**	Corridor terminates at existing stations with no urban tunnelling or new station construction. All urban approaches use existing shared corridor with no modification beyond track and systems upgrades.
2	**Low**	Short urban approaches, under roughly 10 km total across the corridor, using predominantly existing rail corridor. Station reconstruction limited to platform extensions and basic infrastructure upgrades. Limited utility conflicts resolved through routine relocation.
3	**Moderate**	Urban approach segments requiring new at-grade or elevated construction on or adjacent to existing corridors. Station rebuilds within existing footprint at one or more termini. Localised utility conflicts requiring coordinated relocation but no system-level reconstruction.
4	**High**	Significant urban tunnelling or elevated viaduct on one or more approaches. New or substantially rebuilt stations at one or more urban termini. Major utility relocations including system-level conflicts. Construction-logistics constraints from adjacent buildings and transport infrastructure. Property acquisition includes mid-rise and heritage structures.
5	**Extreme**	Major new urban tunnelling through dense urban cores. New underground or multi-level stations in heritage urban districts. Extensive utility relocations with system-level reconstruction. Severe construction-logistics constraints from adjacent heritage buildings, metros, commuter rail, and major roads. Property acquisition in high-value urban density with complex heritage or commercial tenure.

5. Application guidance

Evidence standards

Scores should be supported by documented evidence: published geology maps, project design documents, environmental assessment registries, heritage inventories, and peer-reviewed literature. Where scoring straddles two descriptors, the higher score is assigned if any of the contributing conditions are present at a material scale along the alignment.

Treatment of data gaps

Where evidence is absent or insufficient to score a dimension, the score is recorded as "not yet assessed" and excluded from the composite, with the number of scored dimensions stated alongside the total. Composite totals derived from fewer than eight scored dimensions are not assigned to complexity bands.

Length normalisation

The rubric scores the character of the corridor, not its extent. A 50 km corridor crossing karst terrain scores the same on Dimension 2 as a 500 km corridor crossing the same terrain for the same proportion of its length. Length is tracked separately in the database and combined with the complexity score for cost and schedule forecasting.

Rater protocol

Each corridor is scored by a primary rater against documented evidence, then independently reviewed by a second rater. Discrepancies of more than one point on any dimension are resolved by evidence review, not averaging. The final score sheet records the evidence cited for each dimension, any dissent, and the date of the assessment.

Revision triggers

Scores are revised when new evidence becomes available (for example, when detailed geotechnical investigation is published), when the alignment is materially changed, or when the design-speed regime is altered. Version history is retained in the database alongside the current score.

6. Illustrative application

The table below applies the rubric to thirteen reference corridors drawn from the worldwide database. The scores are based on publicly documented engineering characteristics and are provided to demonstrate how the rubric operates across diverse contexts; final database entries are subject to independent review and evidence citation per dimension.

Note on the table. The per-dimension columns (D1–D10) show descriptor-level scores on the five-point scale (1 = Minimal to 5 = Extreme). The Total column is the weighted composite out of 100, computed as the sum of (descriptor-level ÷ 5) × dimension weight across the ten dimensions. Where evidence supports a granular refinement between adjacent descriptor levels (for example, 13/15 on a Bedrock dimension straddling High and Extreme), the granular integer is used directly in the composite; the illustrative scores below use proportional rescaling except where noted.

Corridor	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Total	Band
TGV Sud-Est Paris–Lyon (France, 1981)	2	2	2	2	3	2	2	2	3	2	**44**	**Moderate**
Madrid–Sevilla AVE (Spain, 1992)	2	3	2	2	3	2	2	2	3	3	**50**	**Moderate**
Beijing–Shanghai HSR (China, 2011)	3	2	3	3	2	3	2	2	4	4	**56**	**Moderate**
Nürnberg–Ingolstadt (Germany, 2006)	2	4	3	2	4	1	3	2	3	3	**58**	**Moderate**
HS1 London–Channel Tunnel (UK, 2007)	2	3	3	2	3	2	3	3	4	5	**61**	**High**
Köln–Rhein/Main (Germany, 2002)	2	4	2	2	5	1	3	2	3	4	**62**	**High**
HS2 Phase 1 (UK, under construction)	3	3	3	2	3	1	4	3	4	5	**63**	**High**
Taipei–Kaohsiung THSR (Taiwan, 2007)	3	3	3	2	4	5	3	3	4	3	**63**	**High**
Ostlänken (Sweden, under construction)	4	4	3	3	3	2	3	2	4	3	**64**	**High**
Wendlingen–Ulm (Germany, 2022)	3	5	2	2	5	1	2	2	3	4	**66**	**High**

Corridor	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Total	Band
Tokaido Shinkansen (Japan, 1964)	3	3	3	2	4	5	3	3	4	4	**66**	High
Harbin–Dalian HSR (China, 2012)	4	3	3	5	3	3	3	2	4	3	**68**	High
California HSR (under construction)	4	4	3	3	4	5	4	3	4	4	**75**	High

Reading the table. The table shows the descriptor-level scores for each dimension (1–5) and the weighted composite out of 100. No corridor in the illustrative set scores in the Extreme band (81–100) on its ten-dimension weighted total. Corridors occupying the High band (61–80) generally combine severe exposure on two or three cost-dominant dimensions (seismic and climate for Harbin–Dalian; seismic and geotechnical for California HSR; topography and bedrock for Wendlingen–Ulm and Köln–Rhein/Main) with elevated but not extreme scores across the remaining dimensions. HS1 illustrates the distinct profile of an urban-engineering-dominant corridor: short in length, limited on ground and climate dimensions, but Level 5 on urban engineering content owing to central-London tunnelling and the St Pancras reconstruction. Ostlänken illustrates the sensitive-clay + shield-bedrock + continental-cold profile most directly comparable to the geotechnical and climatic setting of eastern Ontario. This pattern is informative: frontier-engineering projects are characterised less by uniform extremity than by the simultaneous presence of several high-complexity dimensions that interact in design, construction, and operations.

7. Using the rubric with reference-class forecasting

The rubric integrates directly with reference-class forecasting of capital cost and schedule. The procedure is:

1. Score the proposed corridor against the ten dimensions.
2. Identify database corridors within the same complexity band, then filter by profile similarity (for example, corridors with elevated scores on the same dimensions).
3. Extract capital cost, schedule, and ridership outcome distributions from the filtered reference class, normalised by length and for inflation.
4. Compare the proponent's forecast against the reference-class distribution. Forecasts in the lower tail relative to the reference class warrant explicit justification.
5. Where the proposed corridor exhibits dimensional extremes without database precedent, apply an uplift consistent with observed outcomes on the most complex dimension-matched comparators.

This procedure addresses the principal failure mode of infrastructure forecasting identified in the Flyvbjerg reference-class literature: anchoring forecasts on favourable comparators while omitting the corridors whose complexity profile matches the proposed project. Explicit scoring against the ten dimensions makes the comparator-selection step auditable.

8. Limitations

Four limitations are inherent to any complexity rubric of this kind and are noted here for transparency.

First, the rubric assumes linear aggregation across dimensions, whereas in practice complexity on several dimensions simultaneously can produce interaction effects larger than the sum of individual exposures. The composite score should be read alongside the dimension profile, not as a substitute for it.

Second, some dimensions have long-tailed consequences that a five-point scale cannot fully capture. A score of 5 on seismic exposure encompasses a wide range of conditions from active-margin interior sites to plate-boundary crossings; where such distinctions matter, dimension-specific sub-rubrics are warranted.

Third, the rubric does not score governance, procurement, or institutional-capacity factors that strongly influence delivery outcomes. These are assessed separately in the Initiative's governance assessment framework and should be combined with engineering complexity scores when forecasting project performance.

Fourth, the illustrative application is a demonstration, not a reference publication. Final database entries are produced by evidence-reviewed scoring with citations per dimension and independent review; they are not interchangeable with the illustrative scores in this document.