Digital Track Modelling for ECO Railways: Pilot Section Zhanaozen–Bastau and Phase 2 Implementation Options

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1. Purpose of the Presentation

Present results of the Digital Track Modelling (DTM) pilot on the Zhanaozen–Bastau section (35 km).

Demonstrate technical and economic feasibility for ECO railways.

According to the ToR recommendations (Future Phases section), introduce two Phase 2 options:

Option 1: General Electric (GE) + Infotrans.
Option 2: CRRC Corporation Limited + Local Manufacturer.

Provide justification for scaling up to ECO corridors.

2. Context and Strategic Relevance

Rising investment in railway infrastructure and the need to reduce lifecycle costs.

Strategic importance of the Kazakhstan–Turkmenistan–Iran (KTI) corridor.

Fiscal constraints require targeted, data-driven interventions.

DTM provides:

- integration of geometry, condition (PU-32) and operations data;
- transparent, auditable maintenance decisions for regulators and IFIs.

3. Pilot Section: Zhanaozen–Bastau

Operating length: 35 km.

Track structure: R-65 rails, concrete sleepers, crushed-stone ballast.

Commissioned: 2012.

Nominal speeds: 80–100 km/h (passenger), 70 km/h (freight).

The pilot demonstrates:

feasibility of 1 cm accuracy at modest cost;
replicability of DTM for ECO corridors.

4. Methodological Approach

Analysis of KTZ data (geometry, PU-32, structures, technical parameters).

DTM construction:

- unified track axis and coordinate system;
- linkage of geometry, defects and maintenance history.

Mathematical model relating:

- curvature $\kappa = 1/R$,
- dynamic forces,
- excess maintenance costs from geometry errors.

Economic evaluation (5 and 10 years, 10% discount rate).

5. International Experience

Switzerland (SBB): integrated BIM/DTM – 10–20% lifecycle savings.

USA/EU: TGMS and EN 13848 standards – predictive analytics, fewer speed restrictions.

RZD/KTZ: curvature–wear models for risk-based maintenance.

China (PRC): CRCC high-speed inspection trains + AI digital twins.

Lessons for ECO:

start with geometry + condition data;
use open data standards, avoid vendor lock-in;
outputs must be clear for both engineers and financial planners.

6. Pilot Outcomes

DTM identifies:

- curvature peaks and risk zones,
- correlation with PU-32 scores,
- priority locations for alignment correction and cant adjustment.

Maintaining geometry accuracy ≤ 1 cm reduces:

- maintenance frequency and cost,
- rolling-stock wear,
- risk of speed restrictions.

7. Economic Model (million USD)

Pilot CAPEX $\approx$ 0.008 million USD – demonstration scale.

OPEX $\approx$ 0.002 million USD / year.

Maintenance cost reduction: 15–20%.

Positive NPV and short payback ($\leq$ 3 years).

DTM investment fully aligned with ECO efficiency and safety targets.

8. Rationale for Phase 2

According to the ToR recommendations (Future Phases section):

- scale-up DTM to 300+ km corridors;
- integrate with asset management and train operations systems;
- evaluate technology options by total cost of ownership (TCO).

Requirements:

- open architecture, documented APIs;
- 1520 mm compatibility;
- localization and capacity building.

9. Option 1 – GE + Infotrans

General Electric (GE) + Infotrans – international benchmark solution.

Strengths:

- mature analytics and platforms;
- proven deployments on corridors worldwide;
- robust support and cybersecurity.

Indicative parameters (Phase 2, 300 km, million USD):

- CAPEX: 8.0;
- OPEX: 1.4 / year;
- NPV (5 years): 10–14;
- IRR: 22–35%.

10. Option 2 – CRRC + Local Manufacturer

CRRC Corporation Limited + Local Manufacturer – localized implementation.

Advantages:

- potential for local assembly and technology transfer;
- tailored for ECO and 1520 mm standards;
- lower initial investment.

CAPEX reduced by 50% compared to GE + Infotrans.

Indicative parameters (Phase 2, million USD):

- CAPEX: 4.0;
- OPEX: 1.2 / year;
- NPV (5 years): 9–13;
- IRR: 24–40%.

11. Comparative Summary

Indicator	GE + Infotrans	CRRC + Local Manufacturer
CAPEX (million USD)	8.0	**4.0**
OPEX (million USD / year)	1.4	1.2
NPV (5 years, million USD)	10–14	9–13
IRR	22–35%	24–40%
DTM accuracy	proven high precision	high with integration support
Architecture openness	high	depends on contract
Localization potential	limited	**strong**

All values in million USD, as per ToR (Future Phases section).

12. Interpretation

GE + Infotrans:

higher up-front costs;
minimal technical risk;
strong vendor support.

CRRC + Local Manufacturer:

CAPEX 50% lower with comparable functionality;
supports local industry and skills;
requires clear data ownership and interface clauses.

Both options achieve positive NPV and IFI-grade IRR.

13. Recommendations

Institutionalize DTM as a core tool for rail asset management in ECO.

For Phase 2:

- run competitive selection based on:
  - data ownership rights;
  - open APIs and formats;
  - localization potential.
- consider hybrid model: international vendor + local integrator.

Use results to prepare financing proposals for AIIB, IsDB, ADB, EDB, etc.

14. ToR Compliance and Key Findings

Pilot fully complies with ToR:

- 35 km coverage;
- 8-week timeline;
- budget and deliverables met;
- Phase 2 options prepared.

Comparison added:

- CAPEX for CRRC + Local reduced by 50%;
- all values in million USD;
- aligns with ToR (Future Phases section).

Transit Challenges

Cross-border nature of the economic corridor

Divergent standards and operational procedures among participants

Absence of a unified mechanism for rapid coordination

Impact: cargo delays, increased transit risks, reduced corridor competitiveness

Key Sources of Conflict

Maintenance of turnouts and switches

Condition and assessment of railway track infrastructure

Differences in investigation procedures for derailments and incidents

Cargo delays and lack of unified dispute resolution mechanisms

Result: unpredictable transit times

Proposed Management Solution

Proposal: Establishment of a Permanent Transit Committee

- Coordinating and advisory body
- Participation of all corridor countries and operators
- Harmonization of operational and maintenance standards
- Rapid resolution of transit-related conflicts
- Reduction of overall transit time

Status of the Proposal

Not directly within the scope of the current project

Does not require immediate institutional decisions

However: may be of critical importance for project scalability and long-term corridor sustainability

15. Next Steps

ECO endorsement of Zhanaozen–Bastau pilot results.

Approval of selection criteria for Phase 2.

Preparatory actions:

- technical specifications,
- financial model,
- vendor consultations.

DTM as foundation for a unified ECO digital track standard.

Thank you for your attention.