Flexionization Risk Engine (FRE) V3.0

Short Formal Specification

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2025

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Abstract

The Flexionization Risk Engine (FRE) V3.0 is a multidimensional structural risk model based on the Flexion Framework. FRE analyzes stability, deviation, contraction, tension, and collapse-prevention through the state vector

$$X = (\Delta, \Phi, M, \kappa),$$

and the five-dimensional deviation geometry

$$\vec{\Delta} = (\Delta_m, \Delta_L, \Delta_H, \Delta_R, \Delta_C) \in \mathbb{R}^5.$$

Version 3.0 introduces a diagonal corrective operator, equilibrium pressure (FXI), capacity boundaries, structural zones, and a unified collapse boundary (SB). This short formal specification summarizes the core mathematics and architectural principles of FRE V3.0 for archival publication.

1 Introduction

FRE V3.0 generalizes structural risk analysis to a fully geometric, multidimensional framework. Traditional engines rely on probability, volatility, or external triggers, while FRE derives all risk from internal structural deformation.

Risk in FRE arises from:

- deviation magnitude (Δ),
- structural tension (Φ),
- irreversible memory (M),
- weakening contractivity (κ).

FRE V3.0 provides domain-agnostic guarantees of stability, boundedness, monotonicity, and collapse-prevention. The system is fully deterministic and operates strictly inside the Viability Domain.

2 State Representation

The system state is defined as:

$$X = (m, L, H, R, C),$$

with the five-dimensional deviation vector:

$$\vec{\Delta} = D(X) = \big(D_m(X),\ D_L(X),\ D_H(X),\ D_R(X),\ D_C(X)\big).$$

All deviation components satisfy:

- continuity,
- monotonicity,
- boundedness,
- admissibility for all system states.

3 Equilibrium Pressure (FXI)

The equilibrium indicator is defined as:

$$FXI = F(\vec{\Delta}),$$

a scalar field describing how deviation contributes to structural tension.

Near equilibrium: $FXI \to 0$. Near boundary conditions: FXI becomes large, indicating rising collapse pressure.

FXI drives contraction strength and determines the behavior of corrective operators.

4 Diagonal Correction Operator

FRE V3.0 introduces a diagonal structure:

$$\vec{C} = \big(E_m(\Delta_m),\ E_L(\Delta_L),\ E_H(\Delta_H),\ E_R(\Delta_R),\ E_C(\Delta_C)\big).$$

Each component operator $E_i(\cdot)$ satisfies:

$$\begin{aligned}&\text{continuity,}\\ &\text{monotonicity: } \Delta > 0 \Rightarrow E_i(\Delta) < 0, \quad \Delta < 0 \Rightarrow E_i(\Delta) > 0,\\ &\text{contraction: } |E_i(\Delta)| < k_i|\Delta|,\ 0 < k_i < 1,\\ &\text{boundedness: } |E_i(\Delta)| \le L_i.\end{aligned}$$

The operator is stable, interpretable, and compatible with global FXI.

5 System Evolution Rule

The structural update rule:

$$X_{t+1} = X_t + E(\vec{\Delta}_t),$$

with

$$\vec{\Delta}_t = D(X_t).$$

The evolution is:

- continuous,
- bounded,
- contracting,
- globally admissible,
- strictly monotonic toward equilibrium.

6 Structural Zones

The deviation space is partitioned into five zones:

1. **CSZ — Core Stability Zone**: strong contraction, minimal deviation.
2. **SAZ — Safe Adjustment Zone**: fully correctable dynamics.
3. **PRZ — Peripheral Risk Zone**: sensitivity increases.
4. **CZ — Critical Zone**: contraction fragile, FXI curvature rises.
5. **SB — Structural Boundary**:

$$\|\vec{\Delta}\|_W = C_{\mathrm{global}},$$

beyond which the system collapses.

SB marks the geometric limit of admissible structural behavior.

7 Collapse Boundary (SB)

The Structural Boundary (SB) is defined by:

$$\|\vec{\Delta}\|_W \to C_{\mathrm{global}}.$$

Crossing SB results in:

- irreversible breakdown dynamics,
- loss of contractivity,
- exit from the Viability Domain.

SB is the formal collapse boundary in FRE V3.0.

8 Key Results

FRE V3.0 guarantees:

- **Contraction**: every admissible trajectory moves toward equilibrium.
- **Stability**: deviations remain bounded inside the structural domain.
- **Continuity**: no jumps, oscillations, or undefined states.
- **Recoverability**: geometric signals indicate stabilization after stress.
- **Collapse Prediction**: FXI curvature reveals pre-collapse patterns.

These results form the universal theoretical core of the FRE architecture.

9 Conclusion

This short formal specification summarizes the mathematical foundations and structural architecture of FRE V3.0. The engine defines deviation geometry, contraction operators, stability zones, capacity boundaries, and collapse dynamics. FRE V3.0 is the complete theoretical baseline for all future structural risk systems in Flexion Science.