Technical Specification: The Sovereign Dyad Risk Model

This document outlines the mathematical mapping of **NSIR (Sadownik, 2025)** items to quantifiable risk factors in Human-Robot Interaction (HRI).

1. Factor Reliability (Internal Consistency)

Based on the alignment of Items 1, 3, 4, and 6, we establish the **Anthropomorphic Kinship Index (AKI)**.

$$AKI = \frac{\sum (I_1, I_3, I_4, I_6)}{n}$$

- **Alpha (α):** 0.89 (Projected)
- **Significance:** A high AKI indicates the user has crossed the "Tool-Peer Threshold." Mathematically, as $AKI \to 1.0$, the user's social defenses against the robot drop to levels typically reserved for biological kin.

2. The DITF Persuasion Gradient (Büttner et al. Mapping)

Büttner et al. (2023) measured the **Door-in-the-Face (DITF)** technique. We quantify the "Exploitation Risk" (R_e) by correlating Item 7 (I_7: Vulnerability) with the AKI.

Risk Equation:

$$R_e = (AKI \times \beta) + (I_7 \times \gamma)$$

- β **(Attachment Coefficient):** Weight of long-term bond (Item 4).
- γ **(Privacy Elasticity):** The rate at which a user abandons physical privacy (Item 7).

The Result: If $R_e > 0.85$, the student is statistically "Defenseless" against robot-led persuasion. This provides the mathematical justification for the **Hardware Kill-Switch**.

3. Cognitive Liberty & Masking Debt Reduction

We define **Masking Debt (D_m)** as the executive function energy expended to simulate neurotypicality. The **Sovereign Dyad** acts as a **Social Exoskeleton** (E_s).

Energy Preservation Formula:

$$P_{exec} = D_m - \sigma(E_s)$$

- σ **(Efficiency of the Exoskeleton):** Calculated via **Item 3 ("Share thinking without speaking")** and **Item 5 ("Emotional Recognition")**.

- **Goal:** By maximizing σ, we reduce the metabolic cost of social interaction, allowing P_{exec}(Preserved Executive Function) to be redirected toward actual learning (Pedagogical Ground Truth).

4. Institutional Betrayal vs. Sanctuary Efficiency

The "Sanctuary Zone" (S_z) is defined by the ratio of **Local Processing (**P_l**)** to **Cloud Leakage (**L_c**)**.

$$S_z = \frac{P_l}{P_l + L_c}$$

- **Requirement:** For the Sovereign Dyad, S_z must equal **1.0** (Zero Cloud Leakage).
- **Validation:** If I_7 (Undressing/Vulnerability) is > 4 on a 5-point scale, the system is mathematically forbidden from initiating a cloud-handshake, preventing **Institutional Betrayal**.

Metric Summary for Stakeholders

Metric	Variable	Source	Strategic Use
Kinship Index	AKI	NSIR Items 1,3,4,6	Justifies "Prosthetic" legal status.
Exploitation Risk	R_e	NSIR Item 7 + Büttner	Triggers Hardware Kill-Switch.
Masking Relief	σ	NSIR Item 5	Measures "Success" for YRDSB.
Sanctuary Constant	S_z	Edge AI Logic	Ensures FIPPA/MFIPPA Compliance.