S.E.N.T.I.N.E.L.

Strategic **E**nvironment & **N**eural **T**errain **I**ntelligence **L**ogic

Technical Dossier: Final Implementation Logic
IIT BHU "Serve Smart" Hackathon

February 2, 2026

EXECUTIVE SUMMARY: THE LOGIC OF PRECISION

The Mission: To provide commanders with a visually accurate, mathematically grounded simulation of kinetic strikes on satellite/drone imagery without requiring manual calibration.
The Solution: S.E.N.T.I.N.E.L. utilizes a novel **"Hierarchy of Rulers"** computer vision approach. By identifying known military assets (Tanks, Warships, Aircraft), the system auto-calibrates the scale of the battlefield pixel-by-pixel, ensuring that a 90m Cruise Missile blast looks exactly correct relative to an 18m Fighter Jet.
Core Capabilities:

- **Auto-Scaling:** No manual zoom input needed. Uses detected objects as reference rulers.
- **Weighted Targeting:** Calculates impact points based on threat density.
- **Physics-Based Rendering:** Blast radii are drawn to exact real-world specifications.

1 SYSTEM ARCHITECTURE

1. PERCEPTION LAYER (YOLOv8)

- **Input:** Raw Recon Imagery (Satellite/Drone).
- **Model:** YOLOv8-Medium customized for military assets.
- **Classes:** Warship, Aircraft, Tank, Artillery, Truck, Soldier, Civilian.

2. CALIBRATION LAYER (The "Global Scale" Engine)

- Scans all detections to find the most reliable "Reference Object."
- Establishes a global `Pixels-Per-Meter (PPM)` ratio.

3. SIMULATION LAYER

- **Weapon Database:** Stores verified yield radii (e.g., 155mm Shell = 12m Radius).
- **Impact Logic:** Computes optimal strike coordinates.

4. VISUALIZATION LAYER (OpenCV HUD)

- Renders "Kill Zones" (Red) and "Shockwave Zones" (Orange) to scale.

2 MATHEMATICAL LOGIC: THE "HIERARCHY OF RULERS"

The core innovation is how S.E.N.T.I.N.E.L. understands size without metadata. It uses a strictly ranked priority list to choose the best reference object.

1. Priority Ranking Algorithm

We trust larger, standard rigid bodies more than organic or variable objects.

$$P(Warship) > P(Aircraft) > P(Tank) > P(Truck) > P(Soldier)$$

Reasoning: A soldier can be prone or standing (height varies), but an Aircraft's fuselage length is constant.

2. Scale Factor Calculation (S_{global})

Once the highest priority object (Obj_{ref}) is found:

$$S_{global} = \frac{L_{pixel}}{L_{real}}$$

Where:

- L_{pixel} = Max dimension of bounding box (pixels).
- L_{real} = Database length of object (meters) (e.g., Aircraft = 18.0m).

3. Blast Radius Rendering

To draw the weapon impact circle:

$$R_{draw} = R_{weapon} \times S_{global}$$

Where R_{weapon} is the specific radius from the `WEAPON_SYSTEMS` database (e.g., Tomahawk = 45m).

3 TARGETING LOGIC: WEIGHTED CENTER OF MASS

The system determines the strike point (I_x, I_y) not by random choice, but by **Threat Weight**.

ALGORITHM: IMPACT COORDINATES

$$I_x = \frac{\sum(x_i \cdot W_i)}{\sum W_i}, \quad I_y = \frac{\sum(y_i \cdot W_i)}{\sum W_i}$$

Where W_i is the threat weight of object i:

- **Warship:** 15.0
- **Tank:** 10.0
- **Soldier:** 2.0
- **Civilian:** 0.0 (Ignored in targeting)

4 VERIFIED WEAPON DATABASE

The system does not guess explosion sizes. It uses hard-coded military specifications:

WEAPON SYSTEM	TYPE	KILL RADIUS	VISUAL DIAMETER
Artillery (155mm)	Precision	12m	24m
Cruise Missile	Area	45m	90m
Hypersonic HGV	Kinetic	75m	150m
Ballistic (Jericho)	Strategic	120m	240m
Nuclear (Tactical)	Doomsday	600m	1200m

Note: Visual Diameter is what is drawn on screen (2 × Radius). This ensures an Artillery shell looks appropriately smaller than a Cruise Missile.

5 OUTPUT MANIFEST (THE HUD)

The Commander sees a simplified Heads-Up Display (HUD) constructed via OpenCV:

1. **Asset ID:** Every detected object gets a tracking ID (e.g., `T-01 TANK`).
2. **Inner Kill Zone (Red):** The area of total destruction (R_{weapon}).
3. **Outer Blast Zone (Faint):** The shockwave limit ($2.0 \times R_{weapon}$).
4. **Grid Reference:** MGRS-style coordinate mapping for every target.

TEAM ASHSUM
Ashirwad Sinha & Sumit Pandey