SERD-M: Subsurface Energy Routing Detection Model Proposal

# 1. Executive Summary

The SERD-M system (Subsurface Energy Routing Detection Model) is a complementary seismic monitoring framework designed to identify silent earthquakes—events that release seismic energy without producing atmospheric, ionospheric, or electromagnetic precursors. These events pose a serious risk in high-density population centers located along strike-slip fault zones, where traditional detection models like SR-GEO-PoC may fail to trigger alerts. SERD-M focuses on monitoring energy transformations and stress transfer below the Earth's surface to flag hidden rupture potential and improve early warning coverage.

# 2. Detection Logic and Input Modalities

SERD-M tracks subsurface stress and deformation through a combination of geodetic, strain, fluid, and thermal data sources. It activates alerts when signs of energy transfer or loading are observed internally despite the absence of typical precursors.

Core data inputs include:

- Borehole strainmeters and extensometers: Monitor slow slip or pre-rupture deformation  
- Deep MEMS tilt sensors and laser tiltmeters: Detect crustal bending  
- Borehole piezometers: Record transient fluid pressure linked to fault loading  
- Dense GNSS mesh: Reveals horizontal/vertical crustal motion and static offset  
- Infrasound arrays: Detect quiet acoustic pulses or fluid-vent coupling in the subsurface  
- Temperature sensors (optional): Track subcritical frictional heating in locked zones

# 3. Detection Classifications

SERD-M outputs three alert types:

- Silent Zone Watch: Issued when all SR-GEO modalities are flat, but internal deformation is detected  
- Subsurface Energy Loading: Detected crustal strain or pressure migration with no surface signal  
- Aseismic Shift Flag: GNSS + strain movement without corresponding earthquake activity

# 4. Technology Feasibility and Sensor Availability

The core technologies needed for SERD-M already exist and are used in geophysical research and volcano monitoring, but are not yet systematically integrated for silent quake detection. Required components include:  
  
- Borehole strainmeters and tiltmeters: Available from networks like USGS, PBO (USA), EMSC (Europe), and JMA (Japan)  
- MEMS tilt + pressure sensors: Commercially available and affordable for broad deployment  
- High-density GNSS: Operational in US, EU, Japan, and parts of Asia  
- Infrasound arrays: Used in volcano, nuclear, and meteorite monitoring  
- Data fusion and anomaly detection software: Requires custom model building, but no new hardware invention needed

# 5. Recommended Initial Deployment Zones

SERD-M should first be deployed in densely populated regions located on known strike-slip or low-signal faults where signal suppression is likely. Top priority zones include:  
- Istanbul (North Anatolian Fault)  
- Los Angeles (Southern San Andreas Fault)  
- Tehran–Semnan corridor (Central Iran)  
- Jerusalem–Amman–Damascus (Dead Sea Transform)  
- Sulawesi and Banda Arc (Eastern Indonesia)  
- Nairobi/Addis Ababa (East African Rift strike-slip zones)

# 6. Detection Logic Flow (Descriptive)

1. SR-GEO-PoC detects no signal (P\_event < 1.0)  
2. SERD-M initiates subsurface check for strain, tilt, fluid, or GNSS anomalies  
3. If multiple modalities show energy transfer → 'Silent Zone Watch' triggered  
4. If GNSS and fluid shift detected with no quake → 'Aseismic Shift Flag' raised  
5. System cross-references SSI score and fault zone history to validate alert  
6. Public/response alerts escalated only if risk passes confidence threshold

# 7. Strategic Recommendations

- Begin sensor mapping and SSI profiling in each deployment region  
- Integrate with existing GNSS + borehole data for model calibration  
- Develop public/private partnerships to expand borehole access and sensor deployment  
- Build real-time data fusion dashboard for layered SR-GEO + SERD-M alerts  
- Launch pilot program in Istanbul or Southern California by Q2 next year

# 8. Historical Validation and Pilot Test Plan

To validate the effectiveness of the SERD-M system and estimate real-world lead times, we propose a two-phase historical testing and simulation pilot. The pilot will use publicly available borehole, strainmeter, GNSS, and fluid pressure data collected before known moderate-to-large earthquakes that exhibited low atmospheric/EM signature.

Candidate historical test events include:

- 1995 Kobe, Japan (M6.9) – borehole pressure & pre-quake strain patterns  
- 2011 Tohoku, Japan (M9.0) – slow slip + GNSS precursor offset  
- 2014 Napa, California (M6.0) – borehole tilt + fluid rise anomaly  
- 2001 Denali, Alaska (M7.9) – crustal creep + deep strain coupling  
- 2004 Parkfield, California (M6.0) – possible minor borehole signal, no surface EM

## Estimated Detection Windows Based on Subsurface Modalities

- Slow Slip / Creep: 3–14 days lead time  
- Borehole Fluid Pressure: 2–7 days lead time  
- Tiltmeter / Extensometer Drift: 12–72 hours lead time  
- Subsurface Heating: 12–48 hours lead time  
- GNSS Aseismic Offset: 6–48 hours lead time

## Test Plan Structure

Phase I – Historical Validation:

- Compile seismic, GNSS, strain, tilt, and fluid pressure datasets from 5 key events  
- Extract 2-week windows leading up to rupture  
- Identify signal deviation patterns in advance of rupture  
- Correlate signal lead times with rupture onset  
- Calibrate SERD-M confidence model accordingly

Phase II – Live Monitoring Pilot:

- Choose one priority zone (e.g., Istanbul or Los Angeles)  
- Overlay existing GNSS + strainmeter + tilt + pressure sensors  
- Implement a real-time SERD-M alert layer on top of SR-GEO-PoC  
- Flag 'Silent Zone Watch' and 'Energy Loading' signals over 6-month pilot  
- Compare SERD-M flags to later quake outcomes or false positives