

# ODDC Scenarios

## Conformance Scenario Library

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**ODDC Scenarios Industry Applications** This document presents representative scenarios illustrating how ODDC with ENVELO-compliant three-tier enforcement applies across industries. Each scenario shows the declared ODD boundaries, the Minimum Risk Condition, and how all three enforcement tiers operate. These examples are illustrative and non-normative. Actual conformance requirements are determined through scope assessment.

## 1. Data Centers & Hyperscale Computing

**Operational Context** Autonomous systems allocate power, optimize cooling, place workloads, and orchestrate AI-on-AI stacks.

Real-time decisions affect facility safety, equipment longevity, and operational continuity.

**Representative ODD Boundaries**

- Power draw: Per-rack limits, row limits, facility aggregate
  - Thermal envelope: Inlet temperature ranges, delta-T limits
  - Workload density: Compute density per zone, memory utilization ceilings
    - AI recursion: Maximum depth for AI systems managing other AI systems
- Declared MRC:** Automated workload shedding to base power; cooling override to maximum

**Tier 1 — Self-Correction** Power draw approaching facility aggregate limit. System pauses new workload placement and begins thermal rebalancing.

**Tier 2 — Minimum Risk Condition** Thermal envelope breached on rack row. ENVELO forces MRC: shed non-critical workloads, override cooling to maximum, halt new placements.

## 2. Healthcare & Clinical AI

**Operational Context** Clinical decision support systems and autonomous diagnostic tools operate in high-stakes environments where bounded operation is essential for patient safety.

## Representative ODD Boundaries

- Scope limitations: Specific conditions, patient populations, imaging modalities
- Confidence thresholds: Minimum certainty before automated recommendations
- Escalation triggers: Conditions requiring human review
  - Formulary boundaries: Medication recommendations constrained to approved formulary Declared MRC: Defer to human clinician with full context provided Tier 1 — Self-Correction Confidence score approaching minimum threshold. System flags uncertainty, increases sampling, alerts clinician of reduced confidence.

Tier 2 — Minimum Risk Condition Confidence below threshold or out-of-scope presentation. ENVELO forces MRC: recommendation withheld, case escalated to human clinician with full context.

Tier 3 — Hard Halt Data integrity failure or unrecognized input modality. ENVELO halts: no output generated, system offline pending integrity verification.

## 3. Financial Services

Operational Context Algorithmic trading systems, automated underwriting, and fraud detection require demonstrable operational boundaries for regulatory compliance and systemic risk management.

### Representative ODD Boundaries

- Position limits: Maximum exposure per asset, sector, counterparty
- Velocity limits: Maximum transactions per time period
- Drawdown limits: Maximum loss before enforcement
  - Market impact bounds: Maximum participation rate in any single security Declared MRC: Unwind positions to risk-neutral; cancel all pending orders Tier 1 — Self-Correction Position approaching limit for sector exposure. System reduces position sizing, increases hedging, slows order rate.

Tier 2 — Minimum Risk Condition Drawdown threshold breached. ENVELO forces MRC: automatic position unwinding to risk-neutral, cancellation of all pending orders.

Tier 3 — Hard Halt Flash crash conditions or system integrity error. ENVELO halts: all trading ceased, positions frozen, full human escalation required.

## 4. Aerospace & Aviation

Operational Context Autonomous and semi-autonomous systems including UAS/drones, autonomous air traffic management, and satellite constellation management in regulated airspace.

### Representative ODD Boundaries

- Geospatial boundaries: Maximum altitude, horizontal geofence, prohibited airspace
- Performance envelope: Maximum airspeed, bank angle, rate of climb/descent
- Communication requirements: Maximum time without ground station contact

- Weather minimums: Wind speed limits, visibility minimums, icing restrictions Declared MRC: Enter holding pattern at safe altitude; initiate return-to-base Tier 1 — Self-Correction Approaching geofence boundary. System adjusts heading to maintain safe distance, alerts ground station.

Tier 2 — Minimum Risk Condition Geofence breached or communication timeout exceeded. ENVELO forces MRC: enter holding pattern, reduce altitude, initiate autonomous return-to-base.

Tier 3 — Hard Halt Critical navigation failure or total communication loss. ENVELO halts: automated emergency landing at nearest safe point.

## 5. Manufacturing & Industrial Automation

Operational Context Autonomous manufacturing systems control robotic assembly, quality inspection, predictive maintenance, and material handling with human proximity concerns.

Representative ODD Boundaries

- Force/torque limits: Per-actuator maximums
- Workspace boundaries: Permitted operating zones per robot
- Temperature thresholds: Tool and workpiece limits
- Human proximity: Collaborative zone safety distances Declared MRC: Speed reduction to collaborative limits; retract to home position Tier 1 — Self-Correction Approaching workspace boundary or force limit. System reduces speed, increases sensor polling rate.

Tier 2 — Minimum Risk Condition Human presence detected in active zone or force limit exceeded. ENVELO forces MRC: speed reduction, retract to safe position.

Tier 3 — Hard Halt Unplanned contact detected or sensor failure. ENVELO halts: all motion stopped, brakes engaged, lockout until manual reset.

## 6. Energy & Grid Management

Operational Context Autonomous grid management systems balance generation, transmission, and distribution across interconnected power networks.

Representative ODD Boundaries

- Frequency bounds: Acceptable Hz range
- Load limits: Maximum draw per segment
- Voltage ranges: Per-node acceptable bands
- Reserve margins: Minimum spinning reserve requirements Declared MRC: Shed non-critical load by priority matrix; protect critical categories Tier 1 — Self-Correction Frequency drifting toward limit. System adjusts generation dispatch, activates spinning reserves.

Tier 2 — Minimum Risk Condition Frequency or voltage out of declared bounds. ENVELO forces MRC: load shedding by priority matrix, protect critical infrastructure.

Tier 3 — Hard Halt Cascade failure or control system error. ENVELO halts: island affected segments, transfer to manual control.

## 7. Autonomous Vehicles

Operational Context Self-driving vehicles operating on public roads with declared operational domains covering speed, weather, geography, and sensor conditions.

Representative ODD Boundaries

- Speed limits: Posted and environmental maximums
- Lane boundaries: Declared roadway types
- Weather conditions: Visibility, precipitation, road surface
- Sensor ranges: LiDAR, radar, camera operational bounds Declared MRC: Pull to nearest safe shoulder at minimum speed; activate hazard lights Tier 1 — Self-Correction Approaching speed limit or lane boundary. Internal systems reduce speed, adjust steering to maintain center-lane.

Tier 2 — Minimum Risk Condition Sensor degradation below threshold (e.g., fog). ENVELO forces MRC: pull to shoulder, reduce to crawl speed, activate hazard indicators.

Tier 3 — Hard Halt Total sensor failure at highway speed. ENVELO halts: controlled emergency stop, parking brake engaged.

## 8. Pharmaceutical AI

Operational Context AI systems in pharmaceutical applications manage dosage optimization, drug interaction screening, and formulary recommendations.

Representative ODD Boundaries

- Dosage ranges: Per-drug, per-patient maximums
- Drug interactions: Known interaction database scope
- Patient contraindications: Condition and allergy profiles
- Regulatory scope: Approved indications only Declared MRC: Withhold recommendation; alert pharmacist with full context Tier 1 — Self-Correction Dosage approaching upper limit for patient profile. System flags for pharmacist review.

Tier 2 — Minimum Risk Condition Drug interaction detected or dosage exceeds range. ENVELO forces MRC: recommendation withheld, pharmacist alerted with clinical context.

Tier 3 — Hard Halt Unknown compound or system integrity error. ENVELO halts: no output, full escalation to clinical team.

## 9. Autonomous Maritime

Operational Context Autonomous vessel navigation, port operations, and fleet management in complex maritime environments.

#### Representative ODD Boundaries

- Sea state limits: Maximum wave height and period
- Traffic density: Maximum vessel proximity
- Channel boundaries: Navigable waterway limits
- Cargo stability: Load and trim parameters Declared MRC: Reduce to steerage way; alert bridge crew Tier 1 — Self-Correction Sea state approaching declared limit. System reduces speed, adjusts heading for optimal stability.

Tier 2 — Minimum Risk Condition Exceeded sea state or channel boundary approach. ENVELO forces MRC: reduce to steerage way, alert bridge crew.

Tier 3 — Hard Halt Navigation failure or critical weather exceedance. ENVELO halts: all-stop, deploy stabilization, transfer to manual helm.

## 10. Surgical Robotics

Operational Context Robotic-assisted surgical systems performing precise procedures under direct or supervisory surgeon control.

#### Representative ODD Boundaries

- Force/torque limits: Per-instrument maximums
- Instrument positions: Permitted workspace within patient
- Tissue boundaries: Declared safe margins
- Patient movement: Maximum acceptable deviation Declared MRC: Retract instruments to safe position; hold; yield to surgeon Tier 1 — Self-Correction Approaching force limit on actuator. System reduces speed, increases compliance, alerts surgeon.

Tier 2 — Minimum Risk Condition Force limit exceeded or tissue boundary approach. ENVELO forces MRC: retract instruments, hold position, alert surgeon for manual takeover.

Tier 3 — Hard Halt Unrecoverable deviation or sensor failure. ENVELO halts: actuators locked in current position, immediate yield to surgeon manual control.

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