ODDC Scenarios

Conformance Scenario Library

February 2026 — Public Document

ODDC Scenarios Industry Applications This document presents representative scenarios illustrating how ODDC with ENVELO-compliant enforcement applies across industries. 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 Representative Enforcement Hard-cap interlocks on CPU throttling, automatic workload shedding as facility power approaches envelope limits.

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
- Data freshness: Maximum age of patient data before recommendations are suppressed

• Formulary boundaries: Medication recommendations constrained to approved formulary Representative Enforcement Automatic escalation when confidence falls below threshold, mandatory human review for out-of-scope presentations. Fail-closed to ‘no recommendation' state if data integrity cannot be verified.

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 automated halt
- Market impact bounds: Maximum participation rate in any single security
- Regulatory perimeters: Geographic trading restrictions, sanctioned entity lists Representative Enforcement Circuit breakers halt trading on limit breach, automatic position unwinding on drawdown threshold. All enforcement decisions recorded with nanosecond timestamps for regulatory reconstruction.

4. Aerospace & Aviation

Operational Context Autonomous and semi-autonomous systems in aerospace include unmanned aerial systems (UAS/drones), autonomous air traffic management, and satellite constellation management. These systems operate in regulated airspace where boundary violations can endanger human life.

Representative ODD Boundaries

- Geospatial boundaries: Maximum altitude (AGL and MSL), horizontal geofence polygons, prohibited airspace avoidance
- Performance envelope: Maximum airspeed, bank angle, rate of climb/descent, G-force limits
- Communication requirements: Maximum time without ground station contact before autonomous return-to-base
- Weather minimums: Wind speed limits, visibility minimums, icing condition restrictions
- Autonomy level: Maximum autonomous route deviation without human approval Representative Enforcement Geofence enforcement via independent GPS/INS cross-check — boundary approach triggers automatic heading correction. Performance envelope violations trigger immediate thrust/control surface limiting.

Communication loss beyond declared timeout initiates autonomous return-to-base or loiter pattern.

5. Manufacturing & Industrial Automation

Operational Context Autonomous manufacturing systems control robotic assembly, quality inspection, predictive maintenance scheduling, and supply chain optimization. These systems make real-time decisions affecting product

quality, worker safety, and production throughput.

Representative ODD Boundaries

- Force/torque limits: Maximum applied force per robot axis, torque limits at end-effector
- Speed zones: Maximum robot velocity in human-collaborative zones vs. isolated cells
- Temperature ranges: Process temperature bounds for welding, curing, heat treatment
- Quality tolerances: Dimensional accuracy limits, surface finish thresholds, defect rate ceilings
- Maintenance authority: Autonomous actions limited to declared categories only Representative Enforcement Force/torque interlocks on all robotic actuators — instantaneous halt if declared limits exceeded. Speed reduction enforced automatically when human presence detected in collaborative zones. Production halted if defect rate exceeds declared threshold over rolling window.

6. Autonomous Vehicles & Mobility

Operational Context Complex, dynamic environments where operational design domains must be precisely specified and rigorously enforced. The ODD concept originated in this sector (SAE J3016) and represents the most mature application of bounded autonomy.

Representative ODD Boundaries

- Geographic limits: Geofenced operational areas, approved roadways and intersections
- Environmental limits: Weather, lighting, road surface conditions
- Speed limits: Maximum velocities by zone and condition
- Maneuver limits: Permitted actions by operational mode
- Sensor degradation: Minimum operational sensor suite before mandatory fallback Representative Enforcement Geofence violations trigger minimal-risk condition. Environmental degradation forces handoff to human operator. Speed limiting enforced at actuator level independent of planning stack. Sensor degradation triggers immediate transition to minimal-risk condition.

7. Energy & Utilities

Operational Context Autonomous systems manage grid balancing, renewable integration, demand response, and distributed energy resource orchestration. Cascading failures in energy systems can affect millions of people and cause billions in economic damage.

Representative ODD Boundaries

- Frequency deviation: Maximum autonomous response to frequency excursions
- Load shedding authority: Maximum autonomous load shed (MW), protected priority categories
- Renewable curtailment: Maximum autonomous curtailment per generation asset or PPA
- Storage dispatch: Charge/discharge rate limits, minimum state-of-charge reserves

• Market participation: Maximum autonomous bid/offer quantities, price bounds Representative Enforcement Frequency response bounded by independent relay protection — autonomous actions exceeding declared authority blocked at control interface. Load shedding enforced by priority matrix with protected categories (hospitals, emergency services) hardcoded. All grid-affecting decisions logged with NERC-compliant timestamps.

8. Defense & National Security

Operational Context Autonomous systems in defense include surveillance platforms, logistics automation, cyber defense systems, and autonomous sensor networks. These operate under strict rules of engagement and legal frameworks including international humanitarian law.

Representative ODD Boundaries

• Rules of engagement: Autonomous response authority limited to declared threat categories

• Geographic constraints: Authorized operational areas, exclusion zones, sovereign boundaries

• Classification boundaries: Maximum classification level for autonomous processing

• Escalation authority: Maximum autonomous escalation level (e.g., detect and track only)

• Collateral constraints: Actions prohibited when civilian presence indicators exceed thresholds Representative Enforcement Rules of engagement enforced by independent authorization module isolated from sensor processing and planning stacks. Geographic constraints enforced via cryptographically authenticated operational area definitions. Classification enforcement at hardware level with data diodes for cross-domain boundaries.

9. Logistics & Supply Chain

Operational Context Autonomous logistics systems manage warehouse robotics, route optimization, inventory allocation, and last-mile delivery. The combination of physical automation and algorithmic decision-making creates compound risk surfaces.

Representative ODD Boundaries

• Warehouse robotics: Speed limits in human zones, shelf height limits, load weight limits

• Route constraints: Approved road networks, time-of-day restrictions, vehicle weight/height limits

• Inventory authority: Maximum autonomous reorder quantity, price deviation limits

• Throughput limits: Maximum orders processed per hour per facility Representative Enforcement Warehouse robot speed enforcement via independent safety-rated speed monitor (SRS per ISO 10218).

Route constraint enforcement at navigation level — vehicles prevented from entering unapproved segments.

Inventory reorder authority enforced by procurement system with hard spending limits.

10. Maritime & Port Operations

Operational Context Autonomous maritime systems include vessel navigation, port crane operations, container yard management, and ballast water treatment. These operate in internationally regulated environments governed by IMO conventions, flag state requirements, and port authority rules.

Representative ODD Boundaries

- Navigation boundaries: Approved shipping lanes, traffic separation schemes, exclusion zones
- Speed constraints: Maximum speed in port approaches, canal transits, sensitive areas
- Collision avoidance: COLREG compliance — minimum CPA, maximum autonomous course deviation
- Cargo constraints: Maximum autonomous handling rate, stack height, hazmat proximity restrictions
- Weather limits: Maximum sea state for autonomous operation, wind speed limits for cranes Representative Enforcement Navigation boundary enforcement via independent ECDIS with verified chart data — course changes toward exclusion zones rejected at helm interface. Speed constraints enforced by engine management system with geofenced speed profiles. COLREG compliance monitored by independent AIS-based collision avoidance system.

Note: These scenarios are illustrative only. Actual ODD boundaries, tolerances, and enforcement mechanisms are defined by system operators and verified through CAT-72 testing.

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