Draft Failure Modes and Effects Analysis (FMEA)

System: O.R.B.I.T. End-of-Life Deorbit Module
Basis: Documented EDT missions, PMD literature, and adoption-failure analysis

Failure Mode	Cause (Observed / Expected)	Effect on Disposal	Why This Blocks Adoption	O.R.B.I.T. Mitigation
Single-point deployment failure	Single burn-wire or cutter fails after long dormancy	No tether deployment → no deorbit	Binary failure with no recovery possible	Dual independent restraint paths; either path alone initiates deployment
Loss of spacecraft power at EOL	Battery depletion, solar degradation, bus fault	Deployment command cannot be issued	PMD depends on healthy spacecraft at the moment of failure	Lifeboat electronics with internal battery independent of host
Avionics or OBC failure	Radiation damage, watchdog reset, software lock	Deployment logic never executed	Commands cannot be trusted years after launch	Hardware-backed trigger paths independent of primary processor
Loss of communications	Antenna failure, attitude loss	Ground command unavailable	Operator cannot intervene at EOL	Fully autonomous triggering (timer + heartbeat loss)
Partial deployment (jammed payout)	Reel jam, door obstruction, tether snag	Reduced or zero deorbit effectiveness	Failure may go undetected; no verification	Door-open + spool-payout sensing to verify physical deployment state
Silent deployment failure	Release event occurs without tether motion	Disposal assumed but does not occur	Regulators cannot verify PMD success	Explicit detection of “release without payout” classified as failure

Launch safing conflict	Design prioritizes launch safety over EOL reliability	Deployment inhibited indefinitely	Certification vs reliability tradeoff unresolved	Separate mechanical launch inhibit and electrical EOL inhibit
Attitude disturbance during deployment	Large drag surface or uncontrolled payout	Unstable spacecraft dynamics	Risk to mission and nearby objects	Compact tape tether, controlled payout, passive gravity-gradient bias
Dependence on continuous control	Active control required throughout deorbit	Failure mid-process aborts disposal	Disposal fails if system degrades over time	Passive post-deployment deorbit; performance degrades, not fails
Binary PMD behavior	All-or-nothing deployment logic	Total loss of disposal on single fault	Insurers and regulators reject binary systems	Designed for degraded performance rather than binary failure