

P S E M A · H O M E L A N D D E F E N S E I N S T I T U T E

Private-Sector Lifelines in the Arctic

Predicting and Assessing Risk to Critical Infrastructure

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TABLE OF CONTENTS

Executive Summary	6
Key Findings	8
Cluster 1: Fuel as the Master Dependency	8
Cluster 2: Maritime and Aviation Sustainment Limits.....	9
Cluster 3: Seasonal and Inventory Asymmetry.....	9
Cluster 4: Communications and Cyber-Physical Convergence.....	10
Cluster 5: Workforce as Critical Dependency	10
Cluster 6: Medical and Pharmaceutical Cascades.....	11
Cluster 7: Cascade Dynamics and Paper Redundancies	11
Cluster 8: Threat Scenarios and Governance Architecture	13
Bottom Line	14
Strategic Implications.....	15
Introduction and Strategic Context.....	15
Doctrinal and Strategic Grounding	16
Scope and Boundaries	16
Analytical Framework.....	17
Research Sponsor and Institutional Context	17
Research Foundation.....	19
Methodology	19
Limits, Boundaries, and What This Methodology Cannot Deliver.....	21
Scenario Development.....	23
Framework Overview.....	23
Primary Disruption: West Coast Port Degradation	25
Early-Phase Stressors: Days 0-14, the Primary Analytical Focus.....	26
Concurrent Arctic Escalation.....	28
Real-Time Analog: Maritime Chokepoint Disruption and the Compression of Fuel Reserves	29
Arctic Sustainment Modes and Lifeline Constraints	31
Scenario Conditions and Constraints.....	34
<i>Infrastructure and Transportation Constraints.....</i>	<i>34</i>
<i>Communications and Information Constraints</i>	<i>35</i>
<i>Medical and Health System Constraints.....</i>	<i>35</i>
<i>Governance and Coordination Constraints.....</i>	<i>35</i>
<i>Seasonal and Asymmetry and the Berlin Airlift Anchor</i>	<i>36</i>
<i>Workforce Digital Dependency</i>	<i>37</i>
Scenario Stressors to Be Modeled	28

Targeted Dependency Mapping	40
Framework: Five Layers of Arctic Dependency	40
<i>Layer 1: National Supply Pathways Feeding the Arctic</i>	41
<i>Layer 2: In-Theater Arctic Lifeline Systems</i>	45
<i>Layer 3: Mission-Dependent Community Infrastructure</i>	47
<i>Layer 4: Workforce as a Cross-Cutting Dependency</i>	49
<i>Layer 5: Communications as the Coordination Spine</i>	50
Critical Dependencies Being Mapped	52
<i>Fuel and Energy Systems</i>	52
<i>Food and Essential Commodities</i>	54
<i>Medical and Pharmaceutical Supply Chains</i>	55
<i>Transportation and Logistics Nodes</i>	57
Cross-Sector Chokepoints Identified	58
<i>Communications Systems: SATCOM and Commercial Telecom</i> <i>with Limited Redundancy</i>	58
<i>Maritime Gateways: West Coast Ports as Primary Entry Point</i>	59
<i>Port of Alaska / Anchorage Hub: Central Consolidation Node</i>	59
<i>ALCAN Highway: Key Overland Redundancy with Limited Surge Capacity</i> ...	60
<i>Airfields: Critical but Constrained for High-Priority Sustainment</i>	60
<i>Electric Power: The Cook Inlet Depletion Trajectory</i>	61
<i>Coordination Architecture as a Cross-Sector Chokepoint</i>	61
<i>Cross-Border Interdependencies and Sovereignty Constraints</i>	61
<i>UNCLOS Article 234 and the Conversion of Cooperative Redundancy</i> <i>into Contested Access</i>	62
<i>Alaska Native and Tribal Community Considerations as Risk Amplifier</i>	64
Focused Risk and Vulnerability Assessment	65
Analytical Approach.....	65
<i>Representative Cascade: Port Throughout Degradation</i>	65
Time-Phased Degradation: Days 0–14	66
<i>Days 0-3: Disruption Recognition and System Strain</i>	66
<i>Days 3-7: Inventory Drawdown and Early Allocation</i>	66
<i>Days 7-14: Resource Scarcity and System Convergence</i>	67
Cascading Failure Analysis: From Trigger to Governance	69
<i>Transportation and Logistics Vulnerabilities</i>	69
<i>Fuel and Energy Vulnerabilities</i>	69
<i>Food and Essential Commodity Vulnerabilities</i>	70
<i>Communications Vulnerabilities</i>	71
<i>Medical and Pharmaceutical Vulnerabilities</i>	71
<i>Workforce and Community Dependency Vulnerabilities</i>	72
Cross-Border Interdependencies as Risk Amplifiers	73
Alaska Native and Tribal Community Dependency as a Risk Amplifier	74
Mission Impact Assessment	75
Cascading Impact Narratives	75
<i>Days 0-3: Throughput Degradation and First-Cycle Retail Signal</i>	75
<i>Days 3-7: Inventory Drawdown, Allocation Friction, and</i> <i>Household Decisions</i>	76
<i>Days 7-14: Convergency, Workforce Degradation, and Mission Impact</i>	77

Civilian-Military Convergence.....	80
The Reinforcement Mechanism	80
Arctic Sustainment Modes and Redundancy Reality Check	82
The Substitution Inventory: Paper Versus Operational	82
<i>Maritime Substitution: Alternate West Coast and Southcentral Port</i>	<i>82</i>
<i>Aviation Substitution for Maritime Cargo</i>	<i>83</i>
<i>Overland (ALCAN) Substitution: Cross-Border Surge Capacity</i>	<i>84</i>
<i>Northern Sea Route: Adversarial-Subject Pathway.....</i>	<i>84</i>
<i>Backup Fuel Supplies and Storage.....</i>	<i>85</i>
<i>Satellite Communications as Backup to Terrestrial Infrastructure.....</i>	<i>85</i>
<i>Pharmaceutical Resupply Through Alternative Disruption.....</i>	<i>86</i>
<i>State Emergency Feeding Operations</i>	<i>86</i>
<i>Public-Private Coordination Architecture.....</i>	<i>87</i>
<i>Civilian-Versus-Military Competition Across All Modes.....</i>	<i>87</i>
The Pattern: Paper Redundancy as Systemic, Not Incidental	88
Institutional Coordination as Risk Amplifier.....	89
The Jones Act Waiver Framework: Pre-Staging as the Determining Variable	90
The FEMA Public-Private Partnership Maturity Model: Where Arctic	
Jurisdictions Currently Sit	90
<i>The Permanent Coordinating-Entity Gap</i>	<i>91</i>
Contested Logistics: The Doctrinal Frame.....	92
Convergent Conclusion: Why Coordination Is the Risk Amplifier.....	93
Preliminary Mitigation and Cost–Benefit Prioritization.....	95
Implication for Mitigation Strategy.....	95
Prioritization Framework	96
Mitigation Prioritization Criteria	98
Priority Mitigation Categories	99
<i>Fuel and Energy Resilience</i>	<i>100</i>
<i>Coordination Architecture & Public-Private Partnership Development.....</i>	<i>101</i>
<i>Port and Maritime Throughput Resilience.....</i>	<i>103</i>
<i>Communications and Data Resilience</i>	<i>104</i>
<i>Workforce & Maintenance Capacity.....</i>	<i>105</i>
<i>Multi-Modal Logistics Redundancy.....</i>	<i>107</i>
<i>Food & Critical Supply Buffering.....</i>	<i>108</i>
Integrated Prioritization (Final Ranking)	110
Strategic Takeaways.....	110
<i>There Is No Single-Point Solution.....</i>	<i>110</i>
<i>Early-Phase (Days 0-14) Is Decisive.....</i>	<i>111</i>
<i>Infrastructure Alone is Insufficient.....</i>	<i>111</i>
<i>The Highest Return-on-Investment Mitigation Options Are Not Always</i>	
<i>The Most Capital-Intensive.....</i>	<i>111</i>
<i>Arctic Resilience Is a Specific Application of Institutional</i>	
<i>Coordination Doctrine</i>	<i>112</i>
<i>The Paper-Redundancy Gap Is a Planning-Compliance Failure, Not an</i>	
<i>Engineering Problem</i>	<i>112</i>
Integrated Prioritization.....	112

Stakeholder Engagement	113
Sectors Engaged.....	113
<i>Energy and Fuel.....</i>	113
<i>Transportation and Logistics.....</i>	114
<i>Food and Retail Distribution.....</i>	114
<i>Communications and Data Systems</i>	115
<i>Medical Supply, Cold Chain, and Medical Evacuation</i>	115
<i>Warehousing and Distribution Nodes</i>	115
<i>Workforce and Maintenance Operators.....</i>	116
<i>Emergency Management and Coordination Entities</i>	116
Cross-Sector Assumption Misalignments	118
Engagement Findings Carried Forward.....	118
Question Architecture.....	119
Synthesized Findings	119
<i>Failure Pathway Findings.....</i>	119
<i>Throughput and Capacity Findings.....</i>	120
<i>Resource Competition and Prioritization Findings</i>	121
<i>Substitution and Operational Reality Findings</i>	122
<i>Governance and Authority Gap Findings</i>	123
<i>Cross-Sector Patterns and Integration with Analytical Findings.....</i>	124
Recommendations	126
Near-Term Recommendations (0–12 Months)	128
Mid-Term Recommendations (12–36 Months).....	132
Long-Term Recommendations (36 Months or More)	134
From Recommendations to Implementation.....	136
The Coordination Gap This Research Has Identified	136
The PSEMA Network as Connective Infrastructure	137
Why a Sector-Neutral Intermediary Is The Architecture Required, and Why PSEMA Fits It	138
Connection Points: How PSEMA Connects to the External Partners	141
Continuation Availability.....	143
Conclusion	145
Appendices	
Appendix A: Glossary of Key Terms	
Appendix B: Reference List	
Appendix C: List of Acronyms	
Appendix D: Methodology and Limitations	
Appendix E: Stakeholder Engagement Detail	
Appendix F: Historical Precedents Reference	
Appendix G: Legal and Policy Authority Index	
Appendix H: Recommendations by Index	

EXECUTIVE SUMMARY

This report examines the privately operated physical lifeline systems that sustain Arctic homeland defense and concludes that the resilience of NORAD and USNORTHCOM's mission in the North is structurally dependent on commercial fuel, food, transportation, communications, and medical supply networks that lie largely outside Department of Defense control. Through analysis of a dual-theater disruption scenario involving West Coast port degradation and concurrent Arctic escalation, the research demonstrates that these lifeline systems operate with limited inventory buffers, narrow substitution margins, and concentrated chokepoints whose disruption cascades non-linearly into installation-level mission impact. The findings show that failure pathways move faster than existing planning frameworks assume, that paper redundancy frequently does not translate into operational redundancy under Arctic conditions, and that the Days 0–14 window of a crisis is decisive for whether private-sector lifeline degradation can be arrested before it becomes mission-limiting.

The central finding of this research is both straightforward and consequential: Arctic homeland defense depends on a web of privately operated lifeline systems that are not designed for the stress conditions a dual-theater disruption would impose. When they fail, they fail faster than planners assume, cascade more broadly than frameworks anticipate, and leave decision-makers operating without adequate situational awareness during the window when choices are most consequential.

This final report presents the completed findings of *Private-Sector Lifelines in the Arctic: Predicting and Assessing Risk to Critical Infrastructure*, a research effort commissioned by the Homeland Defense Institute in support of NORAD and USNORTHCOM's Arctic mission assurance mission. The research examines privately operated physical lifeline systems, fuel and energy, food and cold-chain distribution, multi-modal transportation, communications, and medical and pharmaceutical supply, as defense critical infrastructure dependencies whose failure cascades directly degrade force generation, sustainment, and mobility in the Arctic theater. The analysis is grounded in DoD Directive 3020.40 (Mission Assurance) and NSM-22 (Critical Infrastructure Security and Resilience), which recognize that military readiness is inseparable from civilian critical infrastructure, a dependence that intensifies in the Arctic where lifeline systems are sparse, fragile, and geographically constrained [69; 80].

The research is analytically distinct from its companion study, *Continuity of Society in the North: Multi-Modal Resiliency in Arctic Defense*, which examines the human-systems dimension of Arctic mission assurance, military families, the civilian and contractor workforce, tribal and Alaska Native communities, and the governance architecture that connects them. The two projects share a common dual-theater scenario, West Coast port degradation across Days 0–14 concurrent with Arctic escalation across Days 10–45, but maintain distinct analytical lenses. Where the companion study traces what happens to people because of system failures, this research traces what happens to the systems themselves, how failure pathways move through interdependent

infrastructure, and what those system effects mean for the installations and missions that depend on them.

Five completed deliverables form the analytical backbone of this final report: Scenario Development; Targeted Dependency Mapping; Focused Risk and Vulnerability Assessment; Preliminary Mitigation and Cost–Benefit Prioritization; and Stakeholder Engagement. Together with the Interim Report submitted in March 2026, these deliverables establish the dual-theater operating environment, map the structural chokepoints and no-fail nodes across national supply pathways and in-theater lifeline systems, identify the failure cascades most likely to become mission-limiting within the first fourteen days, evaluate high-impact resilience options against realistic throughput parameters, and validate findings through structured engagement with private-sector operators, government partners, tribal entities, and academic institutions across the lifeline sectors examined.

Throughout, the analytical posture is consistent. Arguments lead; research corroborates. Vulnerabilities are framed in operational terms, what fails first, how fast, with what cascading effect, and at what point intervention is no longer feasible. The objective is not to catalogue Arctic problems. It is to give NORAD, USNORTHCOM, the Homeland Defense Institute, and their interagency and private-sector partners an evidence-based foundation for the investment, coordination, and policy decisions that close the gap between paper redundancy and operational redundancy in Arctic mission assurance.

KEY FINDINGS

The findings below are organized into eight analytical clusters that correspond to the structure of the Final Report. Each cluster groups related failure modes, dependencies, or governance conditions that share an underlying logic, allowing the reader to move from the master dependency (fuel) through the lifeline architecture, into the cascade dynamics that connect them, and finally to the governance and coordination conditions that determine whether intact infrastructure can actually be coordinated under stress. Findings are intentionally additive: each contributes a distinctive analytical observation that is not reducible to the others in its cluster.

Cluster 1: Fuel as the Master Dependency

Fuel is the master dependency in the Arctic operating environment.

Fuel disruption does not stay in the energy sector. It simultaneously disables transportation, heating, power generation, and aviation, all of which depend on imported fuel products with limited regional storage and no rapid resupply alternative when maritime supply is degraded. Every other system failure mode identified in this research is accelerated when fuel availability is constrained. Fuel is not one vulnerability among several. It is the foundational dependency whose degradation initiates cascades across the entire lifeline architecture.

In-state refining capacity is structurally concentrated and operationally singular.

Alaska's in-state refining capacity is distributed across a small number of facilities operating under thin margins and tightly coupled to a single crude source. The structural significance is not absolute volume but concentration: there is no parallel refining architecture in-state that can absorb the loss of a single facility, and any disruption to refined product output cascades immediately into aviation, ground transportation, heating, and power generation. Refining concentration converts what elsewhere would be a sectoral disruption into a statewide lifeline event. [71]

Maritime fuel resupply depends on the small number of named commercial carriers.

The maritime fuel chain that feeds western and northern Alaskan communities depends on a sole or near-sole commercial avgas importer and a small number of fuel and freight carriers that together constitute the operational backbone of seasonal resupply. This is not a redundancy gap that can be closed through additional federal coordination; the underlying market structure is consolidated, the assets are specialized (ice-class, shallow-draft, fuel-rated), and there is no substitution path that does not require the same vessels under a different flag. Sole-source maritime fuel dependency is a structural feature of the Arctic operating environment, not a planning gap.

Cluster 2: Maritime and Aviation Sustainment Limits

West Coast maritime gateways are no-fail nodes with no rapid substitute.

The Port of Alaska is the single intermodal hub through which most of Alaska's freight, fuel, and population-supporting supply flows from the Pacific Northwest gateway complex. Peer-reviewed computable general equilibrium modeling of a compound disruption at the twin ports of Los Angeles and Long Beach, the same port complex degraded in this research's dual-theater scenario, finds GDP losses propagating well beyond the port region through commercial supply-chain transmission, with no rerouting alternative available at sufficient scale within a fourteen-day window. Those figures exclude Alaska entirely; Arctic mission-assurance consequences are additive, not captured within existing national loss models.

Aviation cannot replace maritime sustainment at scale.

Airlift is routinely cited in contingency planning as the alternative when maritime routes are disrupted. The RAND Plan Blue 21 wargame documents directly that this assumption is operationally wrong at scale. The historical record (Operation Vittles, 1948–1949) confirms that air-only sustainment requires conditions that do not apply in the Arctic dual-theater scenario, and that even under those conditions falls short of full substitution. Arctic airfields are simultaneously constrained by weather, fuel, maintenance capacity, and crew availability. Replacing one week of Port of Alaska cargo throughput by air would require the equivalent of seven hundred wide-body 747 cargo landings, a figure that does not account for fuel, de-icing, crew, or runway capacity, and that makes the substitution argument operationally implausible. Competition between operational aviation, medical evacuation, and logistics use of limited airfield capacity is immediate and zero-sum. [26]

The Jones Act framework adds friction to maritime substitution under stress.

Cabotage requirements under the Jones Act constrain the universe of vessels available for emergency Alaska resupply to U.S.-flagged, U.S.-built, U.S.-crewed bottoms. Waivers are available but are administratively scoped, time-limited, and require demonstration of national defense necessity through a process that was not designed for the compressed timelines of an Arctic-Pacific dual-theater event. The Jones Act is not the cause of the maritime substitution gap, but its waiver architecture is a friction point that adds time to a window in which time is the binding constraint.

Cluster 3: Seasonal and Inventory Asymmetry

Seasonal asymmetry compresses winter failure timelines from weeks to days.

The vulnerability is not uniform across the calendar year. Alaska's downstream distribution network serving western and northern communities is seasonal and ice-constrained. A West Coast port disruption occurring between October and April operates against already-depleted reserve margins with no barge resupply option available, compressing the time from port degradation to critical shortage from weeks to days because depleted reserves cannot be replenished until thaw. The scenario examined in

this research must be assessed against both dimensions: a national chokepoint failure and a seasonal logistics closure occurring simultaneously.

Commercial inventory buffers in Alaska are measured in days, not weeks.

Just-in-time architecture produces a structural fragility under disruption: community-level shortages appear within days. Planning frameworks built around multi-week adjustment periods before shortages become visible are working from an incorrect baseline. The Days 0–14 window must be planned for as a period of near-complete supply constraint at the community level, with the implication that any intervention designed to take effect after Day 14 arrives too late for the populations whose sustainment determines whether the installation workforce can report.

Cluster 4: Communications and Cyber-Physical Convergence

Communications failure is a force degrader for every other failure mode.

Communications degradation does not produce a single system failure. It eliminates the visibility into logistics status, infrastructure performance, and resource availability that every other response system depends on. Communications degradation is adversarial-exploitable: documented gray-zone tactics targeting both terrestrial and space-segment communications make this a force degrader, not a passive failure mode. Commercial satellite operators may alter service availability during crises, with no governance framework currently requiring them to maintain service. When communications degrade, intact physical infrastructure cannot be coordinated, supply decisions cannot be made, and the entire lifeline architecture operates blind.

Cyber-physical convergence in lifeline systems extends the attack surface beyond traditional defense.

The privately operated lifeline systems on which Arctic mission assurance depends are increasingly cyber-physical: supervisory control, fuel terminal automation, refinery process control, electrical grid management, satellite ground stations, and logistics dispatching all depend on networked control systems with varying levels of defensive hardening. A kinetic disruption to a fuel terminal and a cyber disruption to its control system are not separate scenarios; they are convergent vectors against the same operational outcome. Mission assurance planning that addresses only physical infrastructure or only cyber infrastructure underestimates the actual threat surface.

Cluster 5: Workforce as Critical Dependency

The civilian and contractor workforce is a critical but under-modeled dependency.

Installation sustainment depends on a civilian workforce that lives in communities experiencing the same disruptions as the installation. That workforce is not modeled in most mission assurance frameworks as a constraint, yet its availability is directly tied to the household-level food, fuel, and service access that supply chain disruption degrades within the first seven days. Workforce degradation reduces the functionality of otherwise

intact infrastructure. This is the failure mode that planning frameworks most consistently miss.

Workforce thinness compounds with seasonal labor dependency in specific sectors.

Several lifeline sectors central to the Arctic operating environment, seafood processing, maritime crewing, aviation maintenance, fuel terminal operations, depend on a workforce that is both numerically small and seasonally mobile. A disruption that occurs during a labor turnover window, or that prevents the inbound movement of seasonal workers, compounds the workforce constraint identified in Finding 11 with a labor-supply shock that has no rapid substitute. The implication is that workforce sustainment is not only a household-level problem but also a labor-market sequencing problem that planning frameworks rarely surface.

Cluster 6: Medical and Pharmaceutical Cascades

Medical evacuation capacity competes directly with logistics aviation under stress.

Arctic medical evacuation depends on the same constrained airfield, fuel, weather-window, and crew resources that logistics aviation requires under a dual-theater disruption. Under normal conditions, these systems coexist without significant competition. Under the scenario examined in this research, they become directly competitive: every airframe and airfield slot allocated to logistics surge is one not available for medical evacuation, and the resulting allocation decisions are made without a pre-defined adjudication mechanism. The civil–military adjudication gap in medical evacuation prioritization is a Day 0 problem, not a Day 14 problem.

Pharmaceutical cold-chain dependency creates a population-level failure mode within the first week.

A substantial fraction of the population in Alaska depends on temperature-controlled pharmaceuticals (insulin, biologics, refrigerated antibiotics, dialysis-related medications) whose supply chain depends on continuous power, refrigerated transport, and timely resupply. Disruption to any one of these components produces a population-level health consequence within days, not weeks. The cold-chain failure mode is structurally similar to the food cold-chain but operates on a shorter clinical timeline, and it concentrates risk in populations that are already disproportionately remote from acute-care capacity.

Cluster 7: Cascade Dynamics and Paper Redundancies

Cascading failures occur faster than planning assumes, and non-linearly.

The representative failure cascade, port throughput degradation, then delayed cargo, then inventory drawdown, then aviation surge, then fuel constraints, then medical evacuation limitations, then workforce degradation, is not a worst-case scenario. It is the operationally expected trajectory under the dual-theater disruption conditions the scenario models. Each link accelerates the next. Non-linear escalation occurs once key thresholds are reached, points at which sustainment assumptions fail, and the self-

reinforcing character of the cascade takes over. The critical planning implication is that the window for effective intervention closes faster than linear degradation models suggest.

Paper redundancies consistently fail to materialize under Arctic stress conditions.

Alternate routes are constrained by weather, ice, crew availability, and throughput limits. Backup fuel supplies exist on paper but are often already committed or seasonally inaccessible. Satellite communications alternatives provide limited bandwidth with intermittent reliability. The most analytically significant finding of this research is the gap between the redundancies embedded in planning documents and the redundancies that actually function under Arctic disruption conditions. Closing that gap is the organizing challenge that the recommendations and the PSEMA network framing are designed to address.

Canadian sovereignty makes the ALCAN Highway a paper redundancy at scale.

The Alaska–Canada Highway is the principal overland surge route into Alaska and is cited in nearly every contingency planning document as the alternative when maritime routes are degraded. In practice, ALCAN surge capacity is constrained by Canadian sovereignty over the corridor, by weather and winter road conditions that limit heavy commercial movement for a substantial portion of the year, and by infrastructure chokepoints (fuel availability, driver hours-of-service, customs throughput) that have no rapid surge mechanism. ALCAN is a genuine redundancy at low intensity and a paper redundancy at the volumes contemplated under a dual-theater disruption.

Distributed microgrid architecture is a partial structural protection against statewide cascade.

The approximately 150 standalone microgrids that serve western, northern, and interior Alaskan communities represent a distributed electrical architecture that is not vulnerable to a single statewide grid failure of the kind that would affect a comparably populated CONUS region. The microgrid architecture is a structural asset for resilience. The same architecture, however, concentrates fuel dependency: each microgrid is reliant on imported diesel or aviation fuel, and the failure mode that would collapse multiple microgrids simultaneously is the fuel supply chain disruption identified in Cluster 1. Distributed power architecture is a partial protection, not a comprehensive one, and its protection is fuel-bounded.

Cluster 8: Threat Scenarios and Governance Architecture

Most-likely and most-dangerous threat scenarios diverge, requiring distinct planning postures.

HDI's Research Focus Area framing requests assessment of both most-likely and most-dangerous Arctic threats. These two categories diverge in the Arctic operating environment and require different planning postures. The most-likely disruption profile is a compound natural-hazard event (severe winter weather, seismic activity, volcanic ash) coinciding with an unrelated commercial supply chain disruption, a scenario that is functionally indistinguishable from the dual-theater scenario in its lifeline consequences. The most-dangerous profile is an adversary-initiated dual-theater event with deliberate targeting of no-fail nodes identified in this research. Planning that addresses only one category leaves the other unaddressed.

Institutional coordination is a risk amplifier, not a passive backdrop.

The absence of pre-defined adjudication mechanisms for civilian and military claims on scarce fuel, food, transportation, and medical capacity is the most consequential governance gap surfaced in the research. The Jones Act waiver framework, the FEMA Public-Private Partnership maturity model, and the contested-logistics literature converge on the same conclusion: coordination architectures designed for predictable, single-incident response degrade under simultaneous, multi-theater stress. Building the resolution architecture before the crisis is a high-return, low-capital priority that no infrastructure investment can substitute for.

A sustained, trust-based intermediary is missing from the DoD–private sector–nongovernmental coordination architecture.

Across every lifeline sector examined, the same structural weakness recurs: there is no operationally-tested, sector-neutral intermediary positioned to translate between defense mission requirements and the privately operated systems that sustain them. Existing partnership frameworks are episodic, transactional, or limited to incident response. The connective infrastructure that Arctic mission assurance requires, non-attribution, sector-neutral, operationally credible, does not currently exist within the federal architecture. This finding shapes the recommendations in this report and the framing of the PSEMA network as connective infrastructure for the path forward.

Coordination architecture is itself a paper redundancy when it has not been exercised.

The federal Public-Private Partnership maturity model characterizes private-public partnership capacity along a Basic, Intermediate, Advanced continuum. Most Arctic jurisdictions relevant to this research currently operate at the Basic or low-Intermediate tier, with episodic engagement and resource commitments not formalized through charters or tested through exercises. Coordination frameworks that exist on paper but have not been exercised, formalized through charter, or integrated into lifeline operator business processes do not meaningfully reduce risk during Days 0–14. This is a direct application of the paper-redundancy principle to the governance layer.

Bottom Line

Arctic homeland defense cannot be sustained against the dual-theater disruption scenario this research models without three things that do not currently exist at adequate scale: pre-positioned reserves of fuel, food, pharmaceuticals, and critical materiel sufficient to bridge the Days 0–14 window; multi-layer communications redundancy that does not depend on any single commercial provider or terrestrial pathway; and a pre-defined civil–military coordination architecture, exercised against realistic Arctic disruption conditions, with private-sector cargo prioritization agreements in place before the crisis. Each of these is a preparatory investment whose return is realized before disruption occurs. None can be substituted for during the window when the failures they are designed to prevent are already underway.

The recommendations developed in this report are organized to support exactly that preparatory posture, across near-term, mid-term, and long-term horizons, with explicit identification of which external partners, the Homeland Defense Institute, NORAD/USNORTHCOM, Alaska DHS&EM, FEMA, CISA, tribal governments and Alaska Native organizations, academic institutions, and the PSEMA network, carry which lines of effort. The closing PSEMA Network section articulates the connective infrastructure that this research identifies as essential to making any of these recommendations operationally executable.

STRATEGIC IMPLICATIONS

Arctic mission assurance is constrained by lifeline fragility, not force capability. The lifeline systems on which Arctic homeland defense depends were not designed for the disruption scenario this research models; they were designed for normal operating conditions, and they are thin at every margin, in storage capacity, redundancy, workforce, coordination architecture, and the time available before failures cascade across sectors. Under dual-theater disruption, those margins compress from weeks to days, and in some cases to hours.

Closing the gap requires investments that are pre-positioned, pre-coordinated, and pre-authorized to take effect inside the Days 0–14 window. It requires throughput preservation, not infrastructure protection alone. It requires upstream cascade prevention rather than downstream symptom mitigation. And it requires engaging commercial operators as mission partners, not as regulated entities or contracted vendors. The institutional scaffolding exists, the doctrinal rationale is established, and the analytic foundation has been built. What remains is the deliberate alignment of investment, policy, and coordination commitment to the conditions, geographic, climatic, and operational, that make the Arctic both the most demanding and the most consequential environment for homeland defense mission assurance.

Introduction and Strategic Context

The question at the center of this research is not abstract. If an adversary simultaneously degrades major West Coast port capacity and forces rapid military mobilization through constrained Arctic corridors, which privately operated systems fail first, how fast do the effects cascade, and where do the planning assumptions embedded in current defense strategy break down?

That question matters because Arctic homeland defense cannot be separated from the commercial infrastructure that sustains it. Military installations in Alaska depend on fuel that arrives by barge from Pacific Northwest refineries, food that moves through a handful of maritime gateways, communications systems running on commercial satellite and fiber infrastructure, and a civilian workforce whose stability is inseparable from access to basic services. None of that infrastructure was designed for dual-theater disruption, none of it is owned or controlled by DoD, and almost none of it has been systematically mapped against the specific failure conditions this research examines.

Throughout this report, business-critical infrastructure refers to the privately operated physical lifeline systems on which Arctic homeland defense depends: fuel infrastructure, food and cold-chain distribution, transportation networks, communications systems, and medical and pharmaceutical supply. These systems are owned and operated outside Department of Defense authority but are essential to the projection, sustainment, and recovery of military forces in the Arctic theater. The term is used in preference to "private-sector infrastructure" or "commercial infrastructure" because it specifies operational

function, the systems on which mission and community sustainment depend simultaneously, rather than ownership category alone.

Doctrinal and Strategic Grounding

The institutional grounding for treating commercial Arctic systems as defense-relevant is established in current doctrine and policy. DoD Directive 3020.40, *Mission Assurance*, defines roles and responsibilities for the protection of DoD's critical assets and infrastructures and explicitly recognizes that military facilities and missions depend on civilian systems including energy grids and transportation networks [69]. National Security Memorandum 22, issued in April 2024, defines Defense Critical Infrastructure to include both DoD and non-DoD networked assets and facilities essential to project, support, and sustain military forces and operations worldwide; non-DoD-owned defense critical infrastructure consists of assets from relevant critical infrastructure sectors and subsectors, including as defined by statute [80].

The Navy's 2021 Strategic Blueprint for the Arctic establishes that effective Arctic operations are logistics- and access-defined rather than capability-defined, with sea lines of communication, chokepoint security, and self-sustaining force posture treated as the binding constraints on operational viability [73]. The Blueprint does not assume that resilient supporting infrastructure exists; it assumes operations must continue in a degraded environment, a posture directly consistent with the analytical premise of this research.

The contested-logistics literature developed since 2022, Unified Pacific Wargame Series outputs, Army contested-logistics modernization, and Naval Postgraduate School theses on supply chain resilience, establishes that sustainment is the pacing function in modern conflict, not maneuver, with the homeland increasingly understood as a strategic support area rather than a sanctuary [48; 58; 64]. Together, these frames bring privately operated lifeline systems formally within the mission assurance scope and reframe commercial Arctic logistics as adversarially exploitable rather than environmentally constrained.

Scope and Boundaries

This research is bounded in three deliberate ways that should be transparent to the reader. First, the analytical focus is on the Days 0–14 disruption window. Longer-horizon analysis, recovery dynamics, structural reconstitution, and multi-month sustainment modeling, is out of scope for this engagement and identified as a follow-on research priority. Second, the geographic frame is Alaska, the ALCAN corridor, and the West Coast maritime gateways serving Alaska. Greenland and Canadian Arctic interests are referenced where they directly affect Alaska sustainment, but a full North American Arctic treatment is outside this scope. Third, the analysis is unclassified and operates from publicly available sources, supplemented by structured stakeholder engagement conducted under non-attribution protocols. Where classified context would refine specific findings, the report identifies the boundary and recommends the appropriate follow-on framework.

Within those bounds, the research is intended to be operationally usable. The dependency mapping identifies specific nodes. The risk assessment identifies specific failure thresholds. The mitigation prioritization identifies specific investment categories ranked against five operational criteria. The recommendations identify specific actions, specific external partners, and specific time horizons. The intent is not to characterize Arctic vulnerability in general terms; it is to provide the foundation for command-level decisions about where preparatory investment is most consequential, and which coordination architectures must be built before the next disruption requires them to exist.

Analytical Framework

The research employs a five-deliverable architecture, with each deliverable building on the analytical foundation established by the prior step. The architecture is sequential by design: scenario before dependency, dependency before risk, risk before mitigation, and mitigation refined by stakeholder validation. This sequencing ensures that conclusions at each layer rest on the layer below, and that the integrated picture presented in this final report is internally consistent rather than assembled from independent strands.

Research Sponsor and Institutional Context

This research is sponsored by the Private Sector Emergency Management Association (PSEMA) under federal commission from the Homeland Defense Institute. Reviewers of this report and stakeholders engaging with its findings may not be familiar with PSEMA. The institutional architecture, membership composition, and operational posture that produced this research are summarized here to ground the analysis that follows in the organizational context that generated it.

PSEMA is a 501(c)(6) professional association, with an affiliated 501(c)(3) PSEMA Foundation, founded to close a structural gap in the national emergency management architecture: the absence of a sustained, sector-neutral, non-attribution venue through which private-sector lifeline operators, federal and state emergency management authorities, tribal governments and Alaska Native organizations, military commands, and academic institutions could engage one another on the operational realities that determine whether disaster response, continuity of operations, and homeland defense missions succeed or fail. PSEMA was established to fill that gap, and its institutional architecture is built around the engagement model the gap requires.

Mission and Vision. PSEMA's mission is to advance the integration of private-sector capability into emergency management and homeland defense by convening cross-sector practitioners, producing operationally grounded analytical products, and sustaining the trust-based relationships that crisis coordination depends on. PSEMA's vision is a national resilience architecture in which the privately operated systems that sustain American communities and defense operations, energy, fuel, food, transportation, communications, medical supply, warehousing, and the workforce that operates them, are integrated into preparedness, response, and recovery as full partners rather than as transactional vendors engaged at the point of disruption.

Membership Composition. PSEMA's membership and affiliated partner network span the lifeline sectors examined in this research and the partner categories that surround them. Member and partner organizations include energy and fuel providers; transportation, logistics, and supply chain operators across maritime, rail, trucking, and aviation modes; telecommunications and technology firms; food distribution, retail, and humanitarian feeding organizations; medical and pharmaceutical providers; engineering and infrastructure resilience consultancies; insurance and reinsurance partners; tribal and Alaska Native organizations; humanitarian and disaster-relief nonprofits; and emergency management consultancies and continuity practitioners. Federal, state, and academic partners participate alongside private-sector members through structured engagement protocols. The cross-sector composition is not incidental; it is the structural condition that makes the cross-sector translation function operationally feasible.

Operational Posture. Three features define PSEMA's operational posture and distinguish it from sector-specific trade associations, single-domain consultancies, and federal advisory committees. First, PSEMA operates under non-attribution protocols that enable candid practitioner engagement on system vulnerabilities, operational limits, and decision realities that attributed forums constrain. Second, PSEMA is sector-neutral, not anchored in any single lifeline category, which positions it to facilitate the cross-sector coordination that cascading disruption requires. Third, PSEMA's engagement is sustained across pre-incident, incident, and post-incident periods rather than activated transactionally during a disruption, producing the institutional memory and relationship continuity that operational coordination under stress depends on.

Relationship to This Research. PSEMA's research engagement with the Homeland Defense Institute on this project and its companion study draws directly on the cross-sector membership and engagement architecture described above. The dependency mapping, cascading risk pathways, and mitigation analysis presented in this report reflect practitioner insight gathered through PSEMA's standing engagement protocols, supplemented by literature review, federal policy analysis, and structured stakeholder validation. The non-attribution methodology applied throughout this research is the same methodology under which PSEMA's broader practitioner engagement operates, and it is the methodology that makes the operational realities documented in this report accessible to the analytical record at all. The recommendations developed in this report identify multiple external partners across every line of effort, and the connective infrastructure under which those recommendations become operationally executable is the subject of the From Recommendations to Implementation section. The institutional, methodological, and relational foundations developed here are the foundations that section builds on.

RESEARCH FOUNDATION

The deliverables in this report were developed through three lines of work that together give the analysis its operational and evidentiary grounding. Literature review was the primary source of information for this research, providing the analytical depth that the compressed performance window did not permit through stakeholder engagement alone. Literature review was supplemented by a limited set of structured stakeholder calls with private-sector operators and government partners, a SurveyMonkey-distributed Stakeholder Input Survey, and strategic conversations with current and former NORAD and USNORTHCOM leadership. The methodological objective was not comprehensive coverage of every Arctic infrastructure question; it was the construction of a coherent analytical foundation capable of supporting specific, decision-grade recommendations within the time and resource constraints of the engagement.

Methodology

The research was conducted along three coordinated lines of work, each documented separately and integrated by analytical synthesis. The full methodological foundation, source inventory, mental-models foundation, strategic conversations protocol, and stakeholder engagement instrument detail, is documented in Appendix D. The Stakeholder Input Survey instrument is documented in Appendix E.

The first and primary line of work was an extensive literature review spanning Arctic infrastructure and supply chain vulnerability, DoD mission assurance doctrine and critical infrastructure interdependency frameworks, Alaska-specific logistics and energy systems, civil–military coordination under disruption conditions, and the governance architecture of tribal, municipal, state, federal, and military authorities in Alaska. Given the three-month performance window, literature review carried the analytical weight of the research, providing the specificity of failure timelines, the precision of the dependency mapping, and the identification of cascading risk pathways that are consistent across multiple independent sources. The full inventory of sources with citation IDs is documented in Appendix B.

The literature record converges on four conditions that ground the scenario architecture. The Arctic has shifted from managed cooperation to active great-power competition, and the U.S. icebreaker fleet is critically under-sized against operational requirement. Adversarial gray-zone tactics, GPS jamming, maritime area closures, and interference with undersea telecommunications cables, are documented active practice rather than hypothetical risk. Alaska's dual-use infrastructure architecture concentrates statewide sustainment at the Port of Alaska as a no-fail node, with no viable substitute available within the Days 0–14 window. The unclassified record on Alaska's commercial supply chain is operationally precise and characterizes the just-in-time architecture, the seasonal asymmetry, and the inventory thresholds that the dependency mapping develops in detail. [8 13]

The second line of work was a series of strategic conversations with current and former NORAD and USNORTHCOM leadership. These conversations informed the analytical scope of the research by validating the dual-theater scenario as operationally relevant, confirming that the dependency gaps under examination are recognized at the command level, and identifying the civilian workforce, commercial cargo prioritization, and civil–military governance gaps as research areas consequential for mission-assurance planning. Input from these conversations is reflected in the analytical framing of the deliverables that follow.

The third line of work was structured stakeholder engagement conducted primarily through a SurveyMonkey-distributed Stakeholder Input Survey, supplemented by limited informal conversations with select members of the PSEMA network. The Stakeholder Input Survey served as the principal instrument and consisted of fifteen items combining closed-ended ranking, multi-select, and open-ended response formats. The survey used a core question architecture calibrated to the dual-theater disruption scenario and oriented toward surfacing governance friction, family, and workforce sustainment thresholds, civil–military coordination gaps, and the early-phase decision points where authority structures are most likely to strain.

Supplemental input was gathered through a small number of informal, non-attributed conversations with select PSEMA network members; these exchanges were not conducted as formal structured interviews but provided contextual validation of assumptions and dependencies surfaced through the survey and literature reviews. The engagement window was reopened with an extended response deadline to encourage adequate representation; survey response was nonetheless limited by the three-month performance window, and the analysis presented in this report reflects responses received through the extended deadline.

Three engagement principles govern the stakeholder methodology and apply throughout. First, the engagement is system-of-systems by design: the question architecture surfaces cross-domain interdependencies, the relationships between governance structures, family readiness, workforce sustainment, and tribal community resilience, rather than domain-specific perspectives. Second, the engagement is structured rather than open-ended: a standardized question framework asked across all participants enables comparative analysis across domains and surfaces practitioner-vs-analytical divergences in operationally consequential terms. Third, all input is aggregated and non-attributed by default, with no proprietary or sensitive data required and qualitative thresholds and operational insights treated as sufficient. Participation does not imply endorsement of findings. Tribal engagement was conducted under explicit sovereignty, consent, and reciprocity protocols, and tribal input is governed by those protocols rather than by the default aggregation framework.

Limits, Boundaries, and What This Methodology Cannot Deliver

The methodology is bounded by the three-month engagement window, the data accessible under non-attribution protocols, and the unclassified frame of the work. Three categories of limits warrant explicit acknowledgement and shape the recommendations developed in the final phase of the report.

First, the research does not produce decision-grade quantification of failure thresholds at the precision that command-level investment and pre-positioning decisions ultimately require. The Days 0–14 analytical frame is established with rigor, and the directional findings, that inventory buffers are measured in days, that cascading failure initiates within the first seventy-two hours, that governance friction compounds degradation, are sound. Translating those directional findings into time-to-failure parameters expressed in hours and days, by commodity, location, and disruption condition, is identified as a follow-on research priority.

Second, the research operates from publicly available sources supplemented by limited structured stakeholder engagement under non-attribution protocols. Where classified context, proprietary commercial data, or installation-specific operational information would refine specific findings, the report identifies the boundary and recommends the appropriate follow-on framework. The intent is not to claim more than the methodology supports; it is to be transparent about what the methodology does and does not deliver.

Third, the research is engagement-window-bounded, and the stakeholder engagement component is bounded further by response rate, sector coverage, and self-selection within that window. The three-month performance period was sufficient to construct the analytical foundation, validate it against literature and stakeholder input, and identify the most consequential mitigation and recommendation priorities. It was not sufficient to fully operationalize the recommendations, conduct exercise-based validation of paper coordination architectures, or pilot the integrated Arctic logistics testbed concept that the long-term recommendations identify. Within the engagement component specifically, structured stakeholder calls were limited to a small select group, and survey response was concentrated in the operations, continuity, and emergency management end of the lifeline architecture rather than in upstream lifeline operators. Direct fuel and energy operator participation, direct maritime and port operator participation, and direct communications and telecommunications provider participation are below the levels that sector-specific quantitative claims would require.

Tribal and Alaska Native organizational engagement did not occur within the engagement window and is identified as a priority for future research, with the sovereignty, consent, and reciprocity framing that institutional participation on terms tribal governments determine requires. Survey participation was self-selected; respondents who chose to engage are systematically more disposed toward cross-sector coordination than the sector population as a whole, which is a relevant consideration when interpreting the strength of the joint government-industry coordination consensus. The non-attributed aggregation approach protects respondent confidentiality and was a precondition for candid engagement, but it limits the specificity with which individual findings can be

sourced. Engagement findings are therefore treated throughout this report as directional validation of the analytical record and as identification of practitioner-vs-analytical divergences worth carrying forward, not as the basis for sector-specific quantitative claims in under-represented categories.

Key Insight: These limits are not deficiencies in the research; they are boundaries of what can be accomplished within the engagement frame. The recommendations and the PSEMA Network section of this report are constructed to identify what should happen next, by whom, on what timeline, and with what coordination architecture, so that the foundation laid here can be extended into the operationally executable architecture that Arctic mission assurance requires.

The five deliverables that follow build on this methodological foundation in sequence; the dual-theater disruption scenario that grounds all subsequent analysis is developed in the Scenario Framework section that opens the analytical body of this report.

SCENARIO DEVELOPMENT

The Scenario Development deliverable establishes the operating environment against which all subsequent analysis is conducted. It is designed for a broader audience than most defense research, not only DoD planners and logistics analysts, but installation and garrison leadership, private-sector lifeline operators, state and local emergency management partners, tribal governments and Alaska Native organizations, elected officials and civilian policymakers, and the nonprofit and community organizations that support both installations and the populations surrounding them. Understanding the scenario, and why it was constructed as it was, is essential context for everything that follows.

Framework Overview

This research employs a dual-theater disruption scenario to evaluate the limits of U.S. Arctic sustainment capacity under sustained stress. The scenario reflects the central research question: how do interdependencies between defense installations and privately operated lifeline networks influence mission assurance when both are disrupted at scale, particularly during the first Days 0–14 of disruption?

The dual-theater disruption scenario that grounds all subsequent analysis, West Coast port degradation across Days 0–14 concurrent with Arctic escalation across Days 10–45, is developed in full in the Scenario Framework section that opens the analytical body of this report.

The research focuses on how interdependencies between defense installations and privately operated lifeline networks influence mission assurance and sustainment capacity during the first zero to fourteen days of disruption, when formal mitigation options are limited and the decisions made under incomplete information set the trajectory of everything that follows.

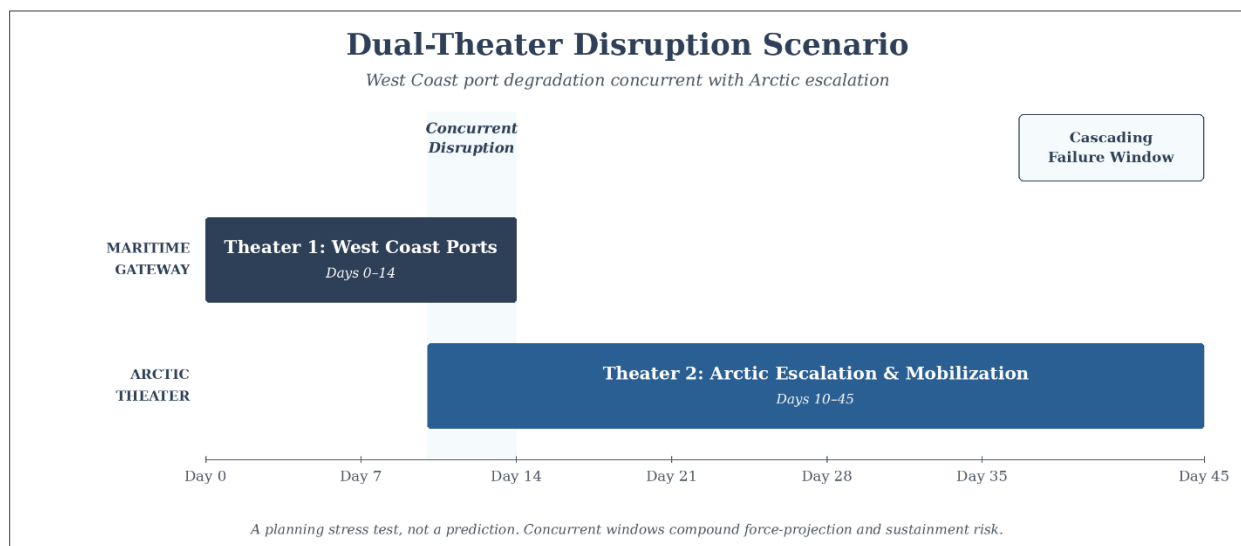
This Scenario Framework is the canonical home for the dual-theater scenario architecture. Subsequent sections, Dependency Mapping, Risk Assessment, Cascading Impact Narratives, and the Mitigation Options framework, reference the operative phase or window only, and rely on this section for the full scenario specification. The two-phase architecture is summarized as: Days 0–14 West Coast port degradation as the early-phase analytical focus, and Days 10–45 concurrent Arctic escalation as the extension window during which mitigation timelines must be evaluated.

The scenario simultaneously stresses two interdependent systems. The first is the CONUS-to-Alaska supply chain supporting fuel and fuel additives, food distribution and cold-chain commodities, pharmaceuticals and medical supplies, telecommunications equipment, and the logistics materiel that defense operations and civilian communities depend on. The second is the in-theater Arctic lifeline system that sustains installations, defense contractors, military families and dependents, and the civilian communities whose stability underwrites operational readiness.

The scenario explicitly incorporates the Arctic-specific realities that make disruptions here qualitatively different from their lower-latitude analogs. Sparse infrastructure and long resupply distances [25]. Severe and prolonged weather conditions. Limited redundancy across fuel, food, power, and communications [26]. Reliance on shared civilian–military systems with no dedicated military alternatives at scale. Jurisdictional complexity involving tribal, municipal, state, federal, and military authorities with different legal bases, different priorities, and no predefined coordination architecture for simultaneous stress [19; 45]. Concentrated dependence on Pacific Northwest maritime gateways with no equivalent substitute [49].

These constraints compress decision timelines and magnify early impacts on supply chains and workforce availability in ways that planning frameworks built around installation self-sufficiency assumptions do not capture. Just-in-time architecture (Glossary; developed in Dependency Mapping) is the structural condition under which the Days 0-14 timeline operates.

Key Insight: Early-phase disruption is driven less by catastrophic system failure and more by the rapid degradation of logistics reliability, commercial supply continuity, and the workforce availability that depends on both.



*Concurrent West Coast port degradation and Arctic escalation
 Scenario framework establishes a planning stress test, not a prediction.*

Primary Disruption: West Coast Port Degradation (Days 0-14)

The scenario begins with a coordinated, non-kinetic disruption of major West Coast maritime hubs, the Seattle/Tacoma port complex, which serves as the primary gateway for Alaska-bound containerized cargo, and the Port of Los Angeles/Long Beach. The disruption is compound in character: cyber intrusions targeting terminal operating systems, interference with navigation and cargo-handling systems, and labor safety stand-downs triggered by operational instability. No single failure shuts ports down completely. Throughput degrades. Predictability erodes. Confidence collapses. For Alaska-bound supply chains, the effect is immediate.

The Port of Alaska is the single node through which the majority of Alaska's commercial and defense sustainment flows, handling approximately half of all inbound freight and fuel for nearly the entire state's population. When the Seattle/Tacoma gateway degrades, that concentration means disruption is not distributed gradually across the state. It arrives statewide, immediately, at a single point with no equivalent substitute.

That vulnerability is not uniform across the calendar year. Alaska's downstream distribution network serving western and northern communities is seasonal and ice-constrained. A West Coast port disruption occurring between October and April operates against already-depleted community reserve margins, with no barge resupply option available to offset shortages. For households dependent on bulk seasonal delivery, that compression means the interval between port degradation and critical food or fuel shortage is measured in days, not weeks. The scenario examined in this research must be assessed against both dimensions: a national chokepoint failure and a seasonal logistics closure occurring simultaneously, and landing on communities with the least buffer to absorb either.

The scenario's analytical premise does not require this specific disruption mechanism to hold. Open-source seismic-science analysis of the Cascadia Subduction Zone documents a parallel disruption pathway in which a magnitude 8.0–9.2 full-margin rupture would simultaneously degrade the Ports of Seattle, Tacoma, and Portland; sever Pacific Northwest overland transportation corridors; damage fuel storage and distribution infrastructure including the Puget Sound refineries that process the majority of jet fuel and diesel consumed in Alaska; and generate tsunami inundation across critical intermodal nodes [43]. The non-kinetic disruption modeled here, and the seismic disruption documented in the geological record produce structurally analogous downstream effects on the Alaska supply system; the analytical conclusions of this scenario hold under either pathway.

Immediate Impacts: First 72 Hours

Within the first 72 hours, the effects arrive at the supply chain and workforce level before installation-level impacts become visible. Delays in Alaska-bound shipments of fuel, food, pharmaceuticals, telecommunications equipment, and logistics materiel begin immediately as maritime scheduling reliability erodes. DoD and defense-contractor supply flows routed through West Coast gateways are disrupted. Early backlogs form across container terminals, rail yards, and intermodal transfer points.

Rerouting toward Gulf and East Coast ports stresses rail and trucking capacity in ways that compound the original disruption and extend restoration timelines. Commercial operators, port authorities, and government agencies have limited visibility into recovery sequencing, alternative routing feasibility, or which sectors will be prioritized first in cargo allocation decisions.

The national economic consequence of compound West Coast port disruption, documented in peer-reviewed computable general equilibrium modeling [49], is not primarily a financial indicator in this context. It is a proxy for the speed and breadth of supply chain disruption: food and agricultural flows are among the first affected, and no short-term rerouting exists at the scale Alaska requires.

Early-Phase Stressors: Days 0–14, the Primary Analytical Focus

State emergency management planning in Alaska explicitly recognizes that outside assistance to affected communities may require 24 hours or more to arrive, establishing an early-phase response gap that local and tribal resources alone must absorb. This is not a planning estimate produced by the present research; it is an assumption embedded in Alaska's own operational doctrine, confirming that the Days 0–14 analytical window reflects an operational reality already recognized by state practitioners rather than an externally imposed construct.

Three integrated conditions shape what happens inside that early-phase window, and together they account for why disruption that would degrade gradually in a CONUS context degrades acutely in an Arctic context.

Just-in-Time Fragility Expresses Itself at the Household Level. The 2023 Alaska Supply Chain Baseline Assessment, prepared by Dewberry under the FEMA SCAN Pacific Partnership Project, identifies that commercial inventory buffers for essential goods in Alaska are limited, with food distribution systems commonly estimated at 6–10 days of available supply under normal operating conditions. [26]

Alaska imports upwards of 95 percent of its food, with approximately 95 percent arriving by sea, 4 percent by refrigerated truck up the ALCAN, and 1 percent by air cargo. Food departing the Port of Tacoma arrives at the Port of Alaska in three days and reaches retail shelves on the fourth day; ships arrive on Sundays and Thursdays; the state has no major warehousing capacity. Alaska is, by design, a just-in-time food retail state. What matters for this research is that the 6–10 day inventory window is not an abstract supply chain metric. It is the actual decision horizon within which families, workforce members, and community caregivers must decide about feeding, heating, medical access, and whether to remain in place. In the Arctic, that dependence is not a planning edge case; it is the defining operational condition. [4; 38; 44]

External Dependency with Limited Local Substitution. Fuel, food, medical supplies, and consumer goods are overwhelmingly imported, and the population's capacity to substitute local production for disrupted external supply is bounded. Subsistence systems are resilient and operationally significant, as the Alaska Federation

of Natives' community resilience documentation confirms [[2]], and they extend survival timelines and reduce immediate dependence on external supply flows for the communities that practice them. But subsistence systems are not scalable to offset prolonged commercial disruption at the statewide population level, and the populations most dependent on external commercial supply, the military, the civilian and contractor workforce, and urban populations, have the least access to subsistence substitution. This differential is the analytical basis for the differential vulnerability assessment this research applies across the three populations examined.

Annual petroleum throughput at the Port of Alaska is at a volume for which no alternative routing or delivery mechanism exists within the Days 0–14 window; the infrastructure substitution analysis is examined in the companion study. When that flow is interrupted, the downstream effect is not a gradual reduction in availability; it is an immediate drawdown against fixed reserves with no replacement mechanism on the timescale of the disruption. The dual-theater disruption scenario used in this research is structurally consistent with the simultaneity problem the 2025 National Defense Strategy identifies as a primary planning challenge across the Arctic and Western Hemisphere. The doctrinal frame within which this scenario is analytically significant is developed in the Institutional Coordination section. [70]

Workforce Attrition as Early-Phase Condition. The workforce that sustains transport, processing, logistics, healthcare, and community services in Alaska is heavily dependent on seasonal, imported, and transient labor whose availability is directly affected by the same disruption conditions the scenario produces. Workforce absenteeism driven by childcare, eldercare, household sustainment needs, and subsistence requirements begins within the first week, with simultaneous stress on healthcare, public safety, social services, schools, and emergency response organizations. Workforce attrition under these conditions is therefore not a downstream consequence of the scenario; it is an early-phase condition that propagates into installation support functions, community services, and the civilian sustainment capacity that both populations and installations depend on. The generational digital-dependency vulnerability documented in the Scenario Conditions section compounds this dynamic in the population segment most needed for surge capacity. The contractor workforce that installations rely on for maintenance, logistics, food service, transportation, and support operations is drawn from the same communities experiencing these stressors, which is why installation-level workforce disruption and community-level workforce disruption cannot be analytically separated.

Across households and families, the first fourteen days produce reduced availability of food, heating fuel, medications, and essential household goods. Price volatility, panic purchasing, and rationing behavior emerge in local markets as supply predictability erodes. Families with limited local storage, limited transportation options, or limited income flexibility face these conditions with the least capacity to absorb them. Delays in childcare supplies, medical items, and household necessities destabilize the daily routines that support both family wellbeing and workforce participation.

Across installations and garrisons, civilian workforce disruptions affecting base operations and support services begin within the first week. Increased demand on installation support services from families and dependents intensifies simultaneously. Garrison leaders face growing pressure to balance mission requirements with household and community support concerns, a tension that early-phase uncertainty and limited information make harder to resolve, not easier. Early decisions made under that uncertainty set conditions for prolonged strain even if logistics flows partially recover later.

Key Insight: Supply chain and workforce instability emerge before installation-level impacts are fully visible, making early commercial system stress a leading indicator of broader operational degradation.

Concurrent Arctic Escalation (Days 10-45)

As West Coast logistics remain impaired, Arctic operational requirements increase. Elevated air and maritime activity, expanded surveillance and domain-awareness missions, sustained operations at Arctic and sub-Arctic installations, and increased demand for logistics support, fuel, mobility, and installation services all impose greater demands on systems already stressed by the primary disruption. Arctic Edge 2025 is operationally instructive on this point: the exercise was conducted concurrently with an INDOPACOM exercise, generating real competing demand signals across shared sustainment resources and confirming that multi-theater concurrent operational tempo is not a planning hypothesis but a documented exercise condition [67].

Under these conditions, readiness depends directly on the resilience of commercial systems that sustain operations: fuel delivery and distribution, food supply continuity, pharmaceutical and medical resupply, telecommunications infrastructure, and the civilian and contractor workforce sustaining installation operations. RAND Plan Blue 21 is directly applicable: logistics capacity falls below operational demand, coordination speed falls below disruption speed, and civilian system resilience falls below military dependency, creating conditions where the cumulative failure arrives faster and cuts deeper than any individual system failure would predict [46].

The scenario assumes no open kinetic conflict but sustained pressure on systems with limited surge capacity, limited redundancy, and high dependence on commercial infrastructure that was not designed for these conditions. The critical analytical insight is that increased operational demand does not merely add to existing civilian system strain; it amplifies it, accelerating competition for limited resources across military and community systems in ways that governance frameworks are not currently designed to manage.

The Arctic escalation pathway is further shaped by the absence of functional security dialogue mechanisms. Open-source analysis documents that military security dialogue between Russia and other Arctic states has been suspended since 2014, and that no pan-Arctic mechanism exists for managing submarine telecommunications cable security [8; 13; 14; 45]. The Ted Stevens Center's 2025 High North Security Dialogue documents that Arctic security increasingly requires integrated military, civilian, and private-sector

approaches, with infrastructure resilience and domain awareness as foundational enablers and Russia identified as the primary near-term threat layered against Chinese long-term systemic competition [60]. The absence of deconfliction mechanisms means that misperceptions or accidental incidents are harder to de-escalate, compressing the time available before military and civilian systems must adapt to a degraded or contested environment. The Northern Sea Route represents a potential maritime rerouting option that could be closed or degraded by adversarial action under UNCLOS Article 234 claims at the moment of greatest need, eliminating a pathway that otherwise appears as an alternative in benign planning models [49].

Key Insight: Increased operational demand amplifies existing commercial system strain, accelerating competition for scarce fuel, cargo capacity, and workforce availability across military and civilian systems simultaneously.

Real-Time Analog: Maritime Chokepoint Disruption and the Compression of Fuel Reserves

The dual-theater scenario this research models is a stress test, not a prediction. Its construction is deliberately conservative: a coordinated non-kinetic disruption of West Coast maritime gateways concurrent with an Arctic escalation requiring rapid northern mobilization. The scenario does not depend on the events of any specific contemporary conflict for its validity. It does, however, gain analytical confidence when the patterns it models are observable in current real-world maritime disruption, and the current Strait of Hormuz situation supplies a structurally analogous case at the time of this report.

Following the outbreak of U.S.–Iran hostilities in late February 2026, Iranian forces declared the Strait of Hormuz closed and asserted regulatory control over transit through the Persian Gulf Strait Authority. Pre-conflict transit averaged approximately 3,000 vessels per month carrying roughly twenty percent of the world’s seaborne oil trade and a comparable share of liquefied natural gas. [39] Within weeks, monthly transits had fallen to under ten percent of that level, with daily open transits reaching near zero by early May. War-risk insurance premiums tripled within days of escalation. Importing countries dependent on Persian Gulf throughput, Japan, South Korea, India, and others, began drawing down strategic reserves on timelines compressed against initial planning assumptions. The International Energy Agency coordinated a release of 400 million barrels from member-state reserves. The Federal Reserve Bank of Dallas modeled the disruption as a potential reduction of global GDP growth of 0.2 to 1.3 percentage points depending on duration. These figures are consequential precisely because they describe a system that, in pre-conflict equilibrium, was characterized as resilient and redundant [20; 47].

The structural lesson for Arctic mission assurance is not that the Hormuz situation predicts a similar Arctic event. It is that the operational characteristics of maritime chokepoint disruption documented in real time match the operational characteristics this scenario models in three specific ways. First, the disruption is not a single event but a regulatory and kinetic compound, combining declared closures, vessel seizures, insurance-market repricing, and route reassignment under coastal-state authority.

Second, the timeline from full-throughput to near-zero throughput is measured in days and weeks, not months. Third, the cascading impact on dependent national fuel systems is governed by inventory buffers and conservation policy decisions, not by upstream production capacity, which is the same structural condition Alaska faces with respect to its in-state fuel inventory and refining dependency on CONUS sources.

Concurrent with Hormuz, additional fuel-dependent national systems are demonstrating the same pattern at the consuming end. Cuba, whose energy system depends on imported crude and has been subject to U.S. blockade actions since early 2026, has exhausted diesel and fuel-oil reserves to the point that the national energy minister publicly acknowledged in mid-May 2026 that the country has effectively run out, with blackouts of up to twenty hours per day and emergency conservation measures including a four-day workweek, school closures, suspended jet-fuel service, and prioritized fuel allocation to essential services only [52]. Allied LNG dependencies in Europe have shifted observable volume toward Russian Arctic LNG sources, with Yamal cargoes accounting for an outsized share of EU import volume during the Hormuz disruption window, a pattern that demonstrates how rapidly substitution chains reform under chokepoint stress and how those substitutions can carry strategic costs that exceed the immediate supply gain [39].

The relevance of these patterns to the Arctic scenario is direct and bounded. Alaska's fuel position differs from Cuba's in scale, governance, and proximate cause, and the comparison is therefore not equivalent. What the Cuban and broader chokepoint-affected cases establish is that the conditions under which fuel reserves move from operational to critical are not speculative. Conservation-measure rollouts, prioritization decisions across essential services, blackout sequencing, and the political consequences of those choices are being implemented in real time across multiple national systems during the same window in which this research has been conducted. The Days 0–14 window the scenario models is not an analytical abstraction. It is the duration over which observable national fuel-dependent systems transition from constrained to acutely degraded under conditions consistent with, and in some respects less severe than the dual-theater scenario this research examines.

The analog also reinforces the UNCLOS argument developed in the Dependency Mapping section. The Strait of Hormuz crisis is, at its operational core, an exercise of coastal-state regulatory authority over a maritime chokepoint by a state whose interests under disruption do not align with the sustainment requirements of dependent importers. The legal instrument differs from UNCLOS Article 234, Iran has not ratified UNCLOS, and the asserted authority over the Strait is grounded in territorial-waters claims rather than ice-covered-area provisions, but the structural logic is the same. A coastal state asserting unilateral regulatory authority over a transit corridor, in conditions where downstream substitutes are physically constrained or politically unavailable, eliminates redundancy on timelines that substitution-limit modeling does not adequately anticipate. The lesson for Arctic planning is to treat consent-dependent redundancy as a planning placeholder rather than as available capacity, regardless of the specific legal instrument under which the consent operates.

Maritime Chokepoint Disruption: Observed Analog and Modeled Scenario

Three structural parallels between the 2026 Strait of Hormuz disruption and the dual-theater Arctic scenario

STRAIT OF HORMUZ

Observed in real time, Feb–May 2026

PARALLEL 1 — DISRUPTION IS A REGULATORY AND KINETIC COMPOUND, NOT A SINGLE EVENT

OBSERVED COMPONENTS

- Declared closure of the Strait under Persian Gulf Strait Authority
- Vessel seizures and coastal-state transit control
- War-risk insurance premiums tripled within days
- Route reassignment and carrier withdrawal
- IEA coordinated release of 400M barrels from reserves

MODELED EQUIVALENTS

- Non-kinetic degradation of West Coast port operations
- Concurrent Arctic escalation forcing rerouted lift
- Insurance and carrier repricing on Arctic transits
- UNCLOS Art. 234 consent-dependent NSR alternatives
- Compressed draw on Alaska in-state fuel inventory

PARALLEL 2 — FULL-THROUGHPUT TO NEAR-ZERO IN DAYS AND WEEKS, NOT MONTHS

HORMUZ — OBSERVED TRANSIT VOLUME

FULL THROUGHPUT

Pre-conflict

~3,000 vessels/mo

Day 7

Week 3

<10% of pre-conflict

Early May

near-zero daily transits

NEAR-ZERO

~90 days

Modeled Days 0–14 window for Alaska maps directly to Hormuz Days 0–21: the duration over which dependent systems shift from constrained to acutely degraded.

PARALLEL 3 — CASCADE IS GOVERNED BY INVENTORY BUFFERS AND CONSERVATION DECISIONS, NOT UPSTREAM PRODUCTION

CUBA

May 2026

Diesel and fuel-oil reserves exhausted; national minister acknowledged

Blackouts up to 20 hrs/day

4-day workweek, school closures, suspended jet-fuel service, essential-only fuel allocation

EU LNG SUBSTITUTION

Hormuz disruption window

Observable volume shift toward Russian Arctic LNG (Yamal cargoes)

Substitution chains reform rapidly under chokepoint stress, often at strategic cost exceeding the immediate supply gain

DEMAND-SIDE CASCADE — IMPLICATIONS FOR ALASKA

- Alaska's position is governed by in-state inventory buffers and refining dependency on CONUS sources, not by upstream production capacity.
- Conservation-measure rollouts, prioritization across essential services, and blackout sequencing are documented operational tools, not speculative levers.
- Consent-dependent redundancy (UNCLOS Art. 234, NSR alternatives) functions as a planning placeholder, not as available capacity.

BOTTOM LINE

The Days 0–14 window the scenario models is not an analytical abstraction. It is the duration over which observable national fuel-dependent systems transition from constrained to acutely degraded under conditions consistent with — and in some respects less severe than — the dual-theater scenario examined.

ALASKA / DUAL-THEATER

Modeled scenario, Days 0–14 window

The 2026 Strait of Hormuz disruption mirrors the dual-theater scenario across three structural parallels, confirming the Days 0–14 window as observable operational reality, not analytical abstraction.

Arctic Sustainment Modes and Lifeline Constraints

The Arctic Sustainment Modes framework characterizes how each mode behaves under disruption and surfaces the structural relationships among modes that determine whether substitution is operationally feasible. The underlying infrastructure baseline, throughput, icebreaker capacity, port architecture, and seasonal logistics, is documented in the Scenario Conditions and Constraints section that follows; this section establishes the analytical framework the research applies to that baseline.

Lifeline Sectors and Mission-Control Functions

Stressor domains, onset windows, and household-visible conditions under Arctic dual-theater disruption.

Mode	Capacity & Fuel Profile	Seasonal & Weather Constraints	Cross-Border & Governance Constraint
Maritime: Pacific Northwest to Port of Alaska	Capacity: Primary mode, ~50% of all inbound freight and fuel for ~90% of population; >1.47M tons petroleum annually; no operationally available substitute within Days 0–14. Fuel: Vessel bunker fuel; low marginal sensitivity at this throughput.	Seasonality: Year-round at the Port of Alaska intermodal hub; West Coast gateway congestion is the binding seasonality. Weather: Moderate at gateway; high when combined with West Coast port congestion or storm closure.	U.S. domestic. West Coast port and labor disruption is the operative constraint.
Maritime: Western and Northern Alaska barge resupply	Capacity: Bulk fuel and bulk goods to rural communities; primary delivery mode for off-road Western and Northern Alaska. Fuel: Diesel; depleted reserves cannot be replenished by any other mode until breakup.	Seasonality: Late fall delivery cycle, before sea ice and river ice; closed from ice-in to spring breakup. Weather: High; ice and seasonal storms are governing constraints.	U.S. domestic.
Aviation: fixed-wing	Capacity: Critical-but-capacity-limited tier; replacing one week of Port of Alaska cargo by air would require approximately 700 wide-body sorties (Berlin Airlift Anchor establishes this is not a feasible substitute at scale). Fuel: Aviation gasoline for the bush plane network flows through a single importer at the Port of Alaska, single-supplier, single-node dependency.	Seasonality: Year-round; airfield availability constrained by weather, fuel, maintenance, and crew. Weather: High; Arctic weather, geomagnetic events, and polar route disruption all reduce sortie completion.	Polar overflight permissions where applicable.

Overland: ALCAN Highway	Capacity: Constrained-redundancy tier; ~350 vehicles per day operating throughput against 12,000–15,000 vehicles per day theoretical lane capacity (paper-redundancy gap of an order of magnitude). Fuel: Diesel for trucking; fuel availability along corridor is itself a constraint under disruption.	Seasonality: Year-round in principle; winter closures, weather events, and avalanche conditions produce intermittent unavailability. Weather: High at winter; route geometry (1,387 miles) and weather closure cadence are governing constraints.	Approximately 1,200 miles of Canadian transit; sovereign decision points U.S. planning cannot resolve unilaterally.
In-state final-mile: trucking and rail (Alaska Railroad)	Capacity: Downstream amplifier mode; throughput determined entirely by upstream maritime, aviation, and ALCAN inputs (not an independent sustainment mode); Alaska Railroad emergency freight activation requires pre-scripted winter-operations pathway and rail-to-port integration at Seward. Fuel: Diesel; in-state trucking is workforce-constrained and fuel-constrained simultaneously.	Seasonality: Year-round; degraded by snow, ice, and seasonal access at distribution endpoints. Weather: Moderate at urban network; high at rural and remote distribution endpoints.	U.S. domestic.

No single mode is independently sufficient under the scenario timeline [73]. The seasonal asymmetry is severe: the modes that carry the greatest peak capacity (maritime through the Port of Alaska intermodal hub and rural barge resupply) are also the modes most compressed by winter conditions and gateway congestion, while the modes available year-round (aviation and ALCAN) carry categorically lower peak capacity.

The Arctic Edge 2025 exercise series, conducted across Alaska under USARAK and USNORTHCOM with joint, interagency, and allied participation, confirms that expeditionary logistics, port operations, and transportation brigade activities are the binding chokepoints on Arctic force flow under exercise conditions, and that infrastructure availability cannot be assumed but must be opened, secured, or restored under degraded conditions [67]. This asymmetry is the operative constraint on Arctic sustainment, not the absolute capacity of any single mode.

Scenario Conditions and Constraints

The scenario incorporates conditions and constraints that define the operating environment for all subsequent deliverables. These are not hypothetical additions; they are the documented realities of Arctic logistics and infrastructure under disruption. The Ted Stevens Center's 2025 High North Security Dialogue convened operators, planners, and Arctic-nation representatives to assess shared concerns, and its proceedings reinforce that infrastructure fragility, communications gaps, and cross-border dependencies are recognized across the Arctic security community as the defining constraints on near-term homeland defense operations [60].

Independent Arctic policy analysis converges on the same conclusion: the operating assumption that the Arctic remains a low-tension cooperative theater is no longer sustainable, and homeland defense planning must increasingly account for strategic competition as the governing condition [8].

Infrastructure and Transportation Constraints

Alaska's transportation architecture is defined by centralization and constraint simultaneously. The Denali Commission establishes that the state operates as a distributed, fragile supply chain system with few redundancies: no continental rail connection, approximately 75 percent of communities inaccessible by road, infrastructure costs two to ten times the Lower 48 baseline, and seasonal logistics cycles with no buffer for sustained disruption [25].

The Port of Alaska's role as the primary consolidation node for approximately 50 percent of all inbound freight and fuel, serving approximately 90 percent of the state's population, means that West Coast gateway disruption is not a partial constraint. It is a statewide supply event concentrated at a single intermodal hub [44]. The macroeconomic stakes are documented: peer-reviewed computable general equilibrium modeling of a compound disruption at the Los Angeles–Long Beach port complex finds GDP losses propagating well beyond the port region through commercial supply-chain transmission to Rest-of-U.S. economic activity, with food and agricultural supply chains among the first and most immediately affected, and no rerouting alternative available at sufficient scale within the early-phase window [49]. The GAO confirms there is no deep-draft port within 800 miles of the Bering Strait, the Nome deepening project remains in design phase. The U.S. icebreaker fleet is critically short of the eight to nine vessels identified as necessary, and GAO has documented that Coast Guard Arctic operations face information gaps and capability shortfalls that further constrain what maritime access can realistically be surged during contested-environment scenarios [34; 37; 59; 68; 75; 77].

The icebreaker capacity constraint that shapes maritime access can be stated specifically. A 2023 Coast Guard fleet mix analysis determined that eight to nine polar icebreakers are needed to meet Arctic mission requirements; the current operational fleet is two vessels, with a third, the converted commercial vessel *Storis*, anticipated home-ported in Alaska by summer 2026. The Polar Security Cutter program has experienced significant cost growth and schedule delay [21; 68]. For scenario purposes, the operating assumption is

that icebreaker-enabled maritime access during Days 0–14 cannot be surged beyond currently deployed capacity.

Communications and Information Constraints

The Ted Stevens Center's 2023 Arctic Communications Workshop Report documents fragmented and non-interoperable communications systems across agencies and communities, bandwidth limitations constraining real-time coordination, lack of redundancy creating high vulnerability to single-point failures, and insufficient infrastructure in remote communities [58]. For the populations examined in this research, communications degradation is not merely a coordination problem. It eliminates the information access that households depend on to make decisions, increases anxiety and the spread of misinformation, disrupts the digital channels that family readiness programs rely on, and isolates rural and tribal communities from the state and federal coordination structures responsible for their support. Allied partners are pursuing parallel polar satellite communications investments, including Canada's Enhanced Satellite Communications Project, Polar, which is intended to extend assured military communications coverage into the high north, but these investments operate on independent timelines and are not currently integrated into a unified Arctic communications architecture [35].

GAO has separately documented that Coast Guard Arctic communications and domain awareness gaps compound these structural constraints, meaning that the federal entity with the broadest Arctic operational footprint operates with the same information limitations the commercial lifeline systems do [77].

Defense reporting in early 2025 has confirmed that closing the Arctic high north communications gap remains an unresolved priority across DoD and partner-nation discussions, reinforcing that the structural baseline this assessment describes is not a legacy condition awaiting routine modernization but an active capability gap with current operational consequences [11].

Medical and Health System Constraints

Limited healthcare capacity, medevac delays driven by weather and distance, and vulnerable pharmaceutical supply chains create a system operating near its limits before disruption begins. The tribal infrastructure baseline (developed in Dependency Mapping as a risk amplifier) sets entry conditions in which baseline sanitation and water-system stress increase healthcare demand precisely when capacity is most constrained. Pharmaceutical cold-chain disruption is among the earliest consequential failure modes when maritime logistics degrade, with no substitution options and resupply cycles that cannot be compressed [74; 76].

Governance and Coordination Constraints

Overlapping tribal, municipal, state, federal, and military authorities with differing legal bases, different priorities, and no predefined coordination architecture for simultaneous stress create friction at the moments when speed is most operationally critical. The National Academies' report on Indigenous disaster preparedness documents that confusion about tribal authority worsens outcomes, and that tribes exercise real

governmental powers in emergencies that outside agencies frequently misunderstand or ignore. The State of Alaska Emergency Operations Plan (EOP) confirms that no single agency controls all infrastructure or response capabilities, that resource scarcity and competing demands are expected, and that pre-established agreements with private sector and voluntary organizations are critical for effective response, agreements that are rarely in place with the specificity that early-phase conditions require [54]. The governance gap that matters most for the analysis that follows is not the absence of frameworks but the gap between codified authority structures and the operational coordination capacity available under disruption, the paper-vs-real distinction this research applies throughout. Tribal authority within that gap is examined under the sovereignty, consent, and reciprocity framework established in the Research Foundation.

Key Insight: No single agency controls all infrastructure or response capabilities, and pre-established agreements with private-sector organizations critical for effective early-phase response, are rarely in place with the specificity those conditions require.

Seasonal Asymmetry and the Berlin Airlift Anchor

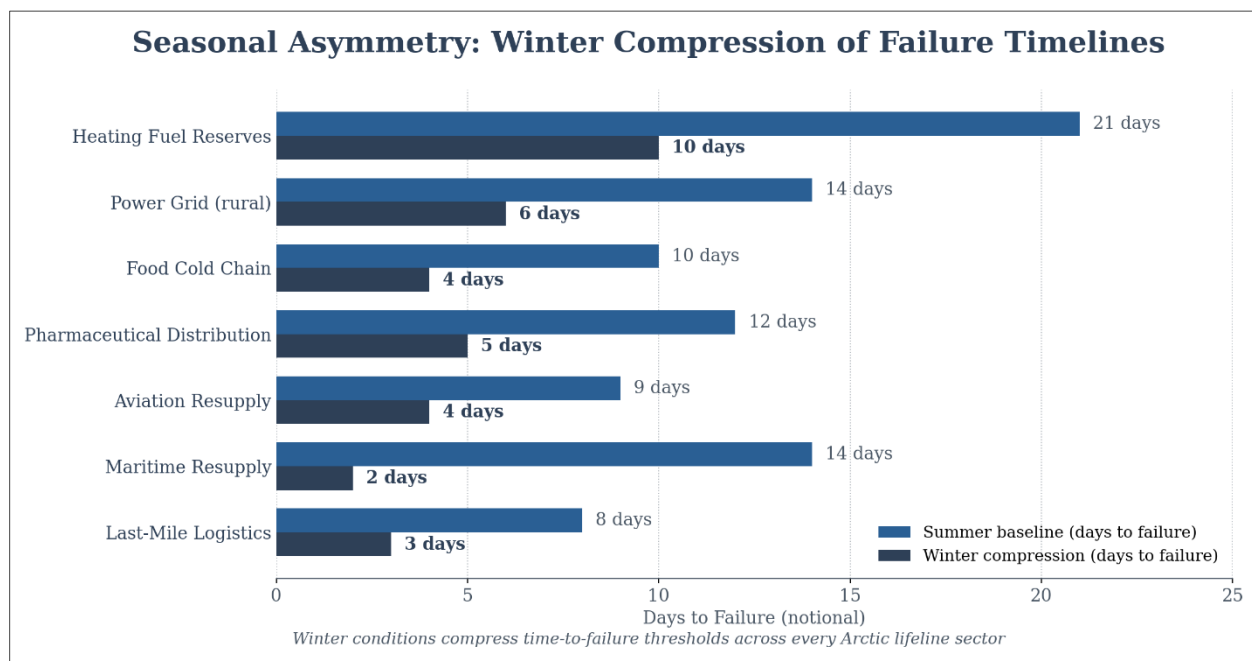
Seasonal asymmetry between summer and winter disruption scenarios is one of the scenario's most consequential and most consistently misunderstood conditions. Bulk fuel delivery to rural Alaska occurs by barge in late fall, before sea ice and river ice set in; any additional fuel required between ice-in and spring breakup must be delivered by bush plane at substantially higher cost and substantially lower volume. A West Coast port disruption occurring during or after the fall barge season therefore operates against communities that cannot receive bulk fuel resupply by the primary delivery mode until spring. Aviation-based fuel resupply under those conditions is not a functional substitute; it is a constrained emergency mechanism operating against depleted reserves with no resupply window. This seasonal asymmetry compresses winter failure timelines from weeks to days because depleted reserves eliminate the barge resupply option.

The rapid-degradation timeline assumed in this scenario is anchored by the historical record. *Operation Vittles*, the Berlin Airlift (1948–1949), is the empirical benchmark for what continuous, highly optimized airlift operations can and cannot deliver under conditions of primary-infrastructure denial. The operation required 321 days of continuous airlift to sustain a defined urban population of approximately two million people, fell short of the approximately 13,500 tons per day requirement during its initial phase, and identified coal (energy) as the dominant sustainment commodity by mass at approximately 2,000 tons per day minimum [66].

The Berlin record is frequently invoked in contingency planning to suggest that aviation can substitute for maritime supply under crisis conditions; on examination it establishes the opposite. The airlift succeeded only because of conditions that do not apply to the Arctic dual-theater scenario: total Allied political commitment sustained over eleven months, a defined and limited urban population, mature undamaged airfield infrastructure, multiple receiving airfields in close proximity, predictable European weather windows, significant international support, and a specific geographic advantage that compressed flight distances. Each of these conditions is favorable rather than

adversarial to airlift feasibility, and yet the operation still fell short of its tonnage requirement during the initial phase. The Berlin record is therefore conservative rather than aspirational when applied to Arctic conditions, and the analytical conclusion the case supports is that airlift is a constrained supplemental mode rather than a substitute for bulk maritime capacity.

Two governing constraints emerge from the Berlin record that this research applies throughout. First, throughput at the receiving airfield, not supply availability at origin, is the governing constraint on aviation-based sustainment: the operation succeeded or failed at the airfield, not at the staging base. Second, the substitution argument fails categorically rather than at the margins: there is no scaling factor at which airlift becomes a feasible substitute for bulk maritime capacity, only thresholds at which it can serve as a constrained supplemental mode for high-value, low-volume cargo. The framework implications of these constraints are developed in the Sustainment Modes Aviation subsection that follows; the case confirms that rapid-degradation timelines of the type modeled in this scenario are a documented historical pattern under infrastructure denial, not a projection.



Winter conditions sharply compress time-to-failure across sectors; heating becomes a binding survival constraint that is not present in summer.

Workforce Digital Dependency

A dimension of workforce disruption that current planning frameworks do not adequately address is the vulnerability concentrated in the youngest segment of the civilian and contractor workforce, teenagers, college students, and young adults roughly ages 13 through 30. This population is disproportionately represented in the entry-level and gig-economy roles that are most immediately stressed under supply disruption: food service, logistics, ride-share and delivery services, retail, childcare, and construction. Their

operational reliability under disruption conditions is constrained by a specific and well-documented vulnerability: near-total dependence on mobile devices and digital connectivity as their primary tools for communication, navigation, information access, and coordination.

In emergency scenarios characterized by power outages, telecommunications failures, and infrastructure degradation, precisely the conditions the dual-theater scenario produces, this digital dependency becomes a concentrated liability. Without reliable cellular networks or internet access, this population loses situational awareness, cannot navigate without GPS, cannot coordinate with employers or community resources, and cannot comply with emergency directives that reach them only through digital channels.

They are simultaneously the workforce segment most needed for surge capacity and the segment least equipped to function when the infrastructure they depend on fails. In rural and tribal communities where this dynamic is compounded by greater distances between services and more pronounced infrastructure fragility, the gap between their potential contribution and their actual availability under disruption conditions is most acute. This generational workforce vulnerability is examined further in the workforce dependency analysis later in this report; the operative point for the scenario architecture is that the labor segment most needed for surge capacity is structurally the segment least equipped to function under the infrastructure conditions the dual-theater scenario produces.

Key Insight: The youngest segment of the civilian workforce, heavily digitally dependent and without analog backup skills, represents a latent vulnerability that emerges rapidly when communications infrastructure degrades, precisely when their labor capacity is most needed.

Scenario Stressors to Be Modeled

The scenario introduces four categories of stressors that shape all downstream analysis across the dependency mapping and risk and vulnerability assessment.

Logistics and supply stressors include reduced and unpredictable flow of Alaska-bound cargo; disrupted last-mile delivery to rural, remote, and tribal communities; delays in fuel, food, pharmaceuticals, and essential materiel; and increased reliance on aviation resupply for high-priority goods despite the limited capacity that RAND Plan Blue 21 confirms cannot substitute for maritime cargo volumes at scale [46].

Infrastructure and utility stressors include fuel shortages affecting heating, power generation, transportation, and aviation; power and communications system strain under peak demand; telecommunications outages affecting commercial operators, logistics coordination, and installation support; and the reduced resilience of commercial utility systems under prolonged stress that the DOE Arctic Strategy documents as the foundational vulnerability across all downstream lifeline systems [26].

Workforce and operational stressors include workforce attrition affecting installation support functions, competition between operational and logistics aviation for constrained

airfield capacity, reduced availability of maintenance and support personnel, and degraded operational capacity over time as compounding effects accumulate (the workforce dependency dynamic is examined in detail in Vulnerability Assessment).

Governance and prioritization stressors include competing civilian and military claims on scarce fuel, food, transportation, and medical capacity; the absence of predefined adjudication mechanisms for those competing claims; the friction created by overlapping jurisdictions without coordinated decision authority; and the commercial cargo prioritization decisions made by private operators with no obligation to account for defense sustainment requirements [34; 78].

TARGETED DEPENDENCY MAPPING

If the Scenario Framework establishes the conditions under which Arctic lifeline systems will be stressed, the Targeted Dependency Mapping answers the question of what, exactly, is connected to what, and what breaks when those connections are disrupted. This section moves from operational context to structural analysis, building a systematic picture of how commercial infrastructure sustains Arctic defense operations and where the failure points are concentrated.

Operative phase for this section: Days 0–14, the early-disruption window when the gap between what planning assumes and what the system can actually deliver is widest and most consequential. Full scenario architecture is developed in the Scenario Framework section. The dependency mapping builds directly on that framework and produces the analytical foundation for the risk and vulnerability assessment that follows.

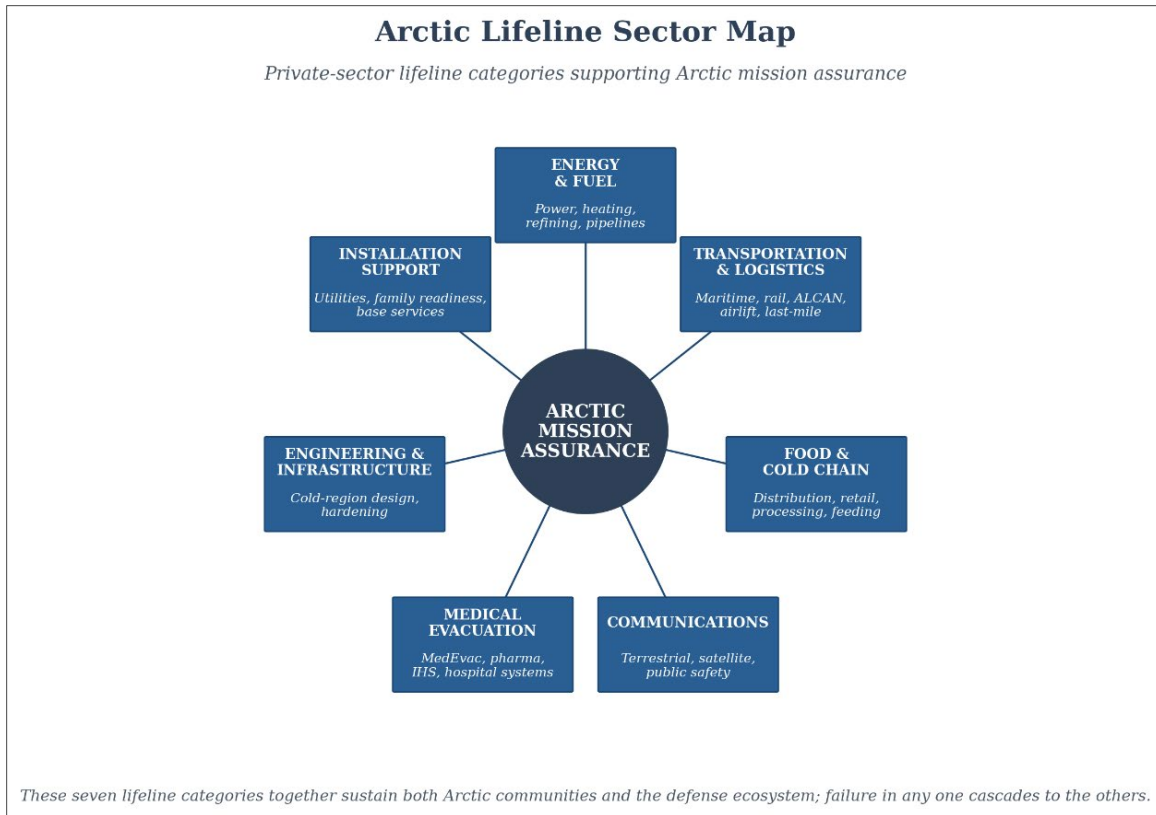
Framework: Five Layers of Arctic Dependency

Dependencies are assessed across five interconnected layers, each representing a different distance from the point of disruption and a different relationship to defense operations. Together, they describe how a port throughput degradation on the West Coast translates, within days, into mission constraints at Arctic installations. The first three layers identify spatial dependency; the fourth and fifth identify cross-cutting dependencies, workforce, and communications, which propagate across all spatial layers simultaneously.

Each dependency is mapped to identify upstream suppliers and supply pathways; downstream users, defense, contractors, civilian populations; chokepoints and time-sensitive failure modes; storage capacity and inventory duration; and redundancy, substitutability, and recoverability under Arctic conditions.

Critical System Integration: The Master Dependency Chain.

Across these systems, a core dependency pathway is consistently observed: *Fuel → Power Generation → Heat → Water Systems → Communications → Operational Coordination.*



*Energy and communications operate as master dependencies;
their failure modes propagate across all other lifeline sectors.*

Layer 1: National Supply Pathways Feeding the Arctic

The just-in-time architecture (Glossary) that DoD contractors and commercial suppliers rely on begins to erode almost immediately under dual-theater disruption: container throughput drops, congestion drives cargo toward Gulf and East Coast ports, and stressing rail and trucking capacity in ways that compound the original disruption. Food, fuel, and medical inventories intended for northern movement begin drawing down.

The first layer captures the upstream commercial systems whose degradation rapidly invalidates sustainment assumptions during the first fourteen days. This is where the disruption begins: the maritime, rail, and intermodal networks supplying Alaska and northern Canada; the CONUS-origin logistics flows tied to Pacific Northwest ports at Seattle/Tacoma and Los Angeles/Long Beach; the national fuel, pharmaceutical, telecommunications, and equipment supply chains; and the warehouse, cold-chain, and trucking nodes that support northbound movement. Mapping emphasis falls on early loss of throughput and schedule predictability, backlog formation across ports and intermodal systems, limited visibility into cargo prioritization and allocation decisions, and dependency on a small number of maritime gateways with limited surge alternatives. [26; 49]

This layer's maritime chokepoint structure is a specific instance of the exterior-lines vulnerability characterized in the contested-logistics doctrinal frame (developed in the

Institutional Coordination section), in which the same maritime gateway nodes and transit infrastructure that sustain Pacific operations also sustain northern resupply. [30; 50; 58]

The petroleum volumes the Port of Alaska processes annually, exceeding 1.47 million tons, establish why the fourteen-day window is the critical planning frame. That volume cannot be rerouted, replaced, or approximated by any alternative mode or pathway within the period when sustainment decisions are most consequential. Alaska has no continental rail connection, barge and air cargo serve as last-mile delivery for the majority of western and northern communities, and the entire system was designed for cost efficiency under normal conditions, not for resilience under disruption.

Key Condition: *Disruptions at major maritime gateways rapidly constrain the flow of essential goods, including food, fuel components, pharmaceuticals, and equipment, before alternative routing can meaningfully compensate.*

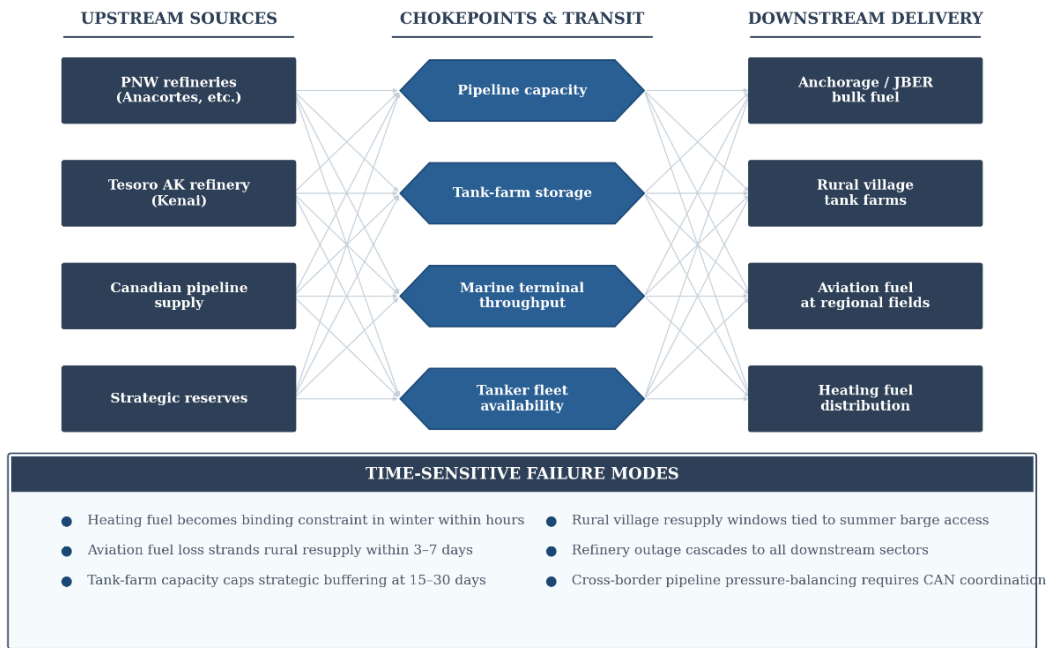
The downstream concentration risk this layer reveals is documented in the Key Findings: a single Anchorage intermodal hub handles the majority of all inbound state freight and fuel. Disruptions at West Coast gateways do not produce distributed degradation; they concentrate failure at that node with immediate statewide effect and no equivalent alternative within the fourteen-day window.

Port disruptions produce nonlinear, cascading impacts across supply chains and regional economies that are not captured by single-event planning models. The key condition this layer reveals is that the United States depends on a small number of maritime gateways for the flow of essential goods into the Arctic, and those gateways have no meaningful surge alternatives available within a fourteen-day window. Disruptions at West Coast gateways do not produce distributed degradation across the state, they concentrate failure at a single node with no equivalent substitute.

The four pathway diagrams that follow trace the structural geography of how food, fuel, warehousing, and cold-chain goods move from upstream sources, through critical chokepoints, and into Arctic distribution. Each pathway shares the same three-column architecture, upstream sources on the left, the chokepoints and transit infrastructure that actually govern flow in the middle, and the downstream delivery points that depend on them on the right. Read together, the figures expose a recurring pattern: redundancy on paper collapses into a small number of shared chokepoints in practice, and the failure modes that emerge under Arctic stress are tightly coupled across all four sustainment systems. Time-sensitive failure modes are noted at the base of each diagram to indicate where degradation begins, how quickly it propagates, and which downstream populations are exposed first.

National Supply Pathway — Fuel

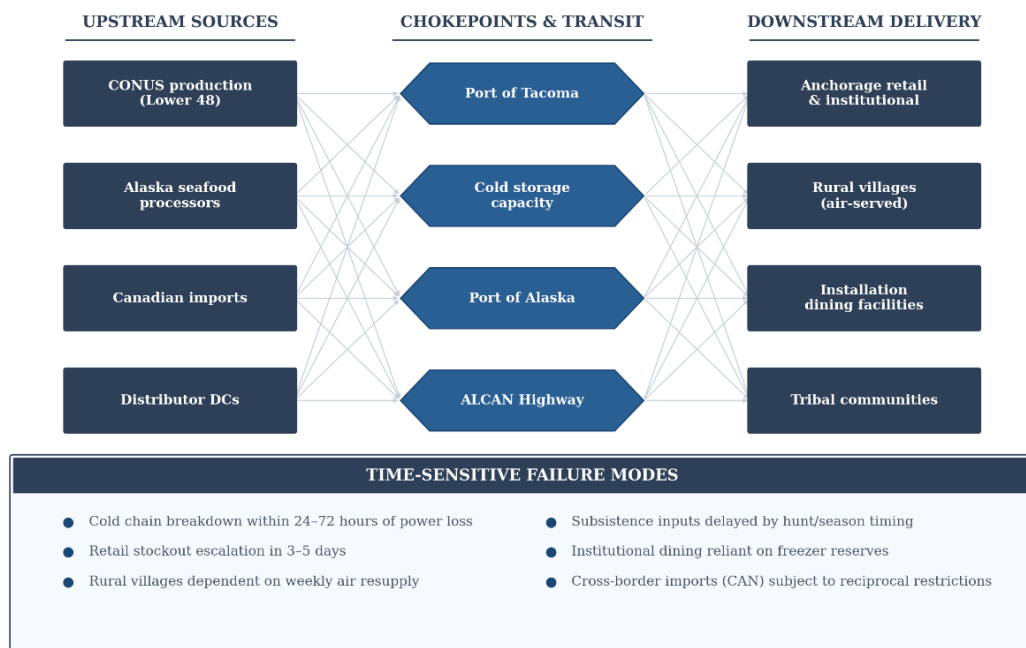
Refined product flow from refineries to Arctic delivery points



Fuel pathways exhibit limited redundancy; rural distribution depends on seasonal access windows that cannot be expanded under crisis.

National Supply Pathway — Food

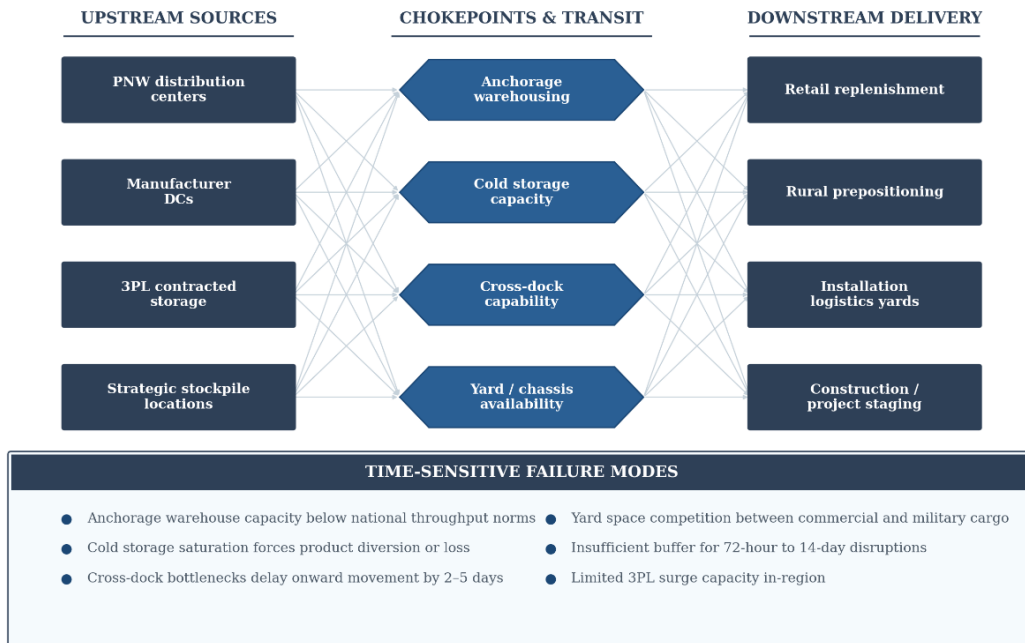
Upstream production through chokepoints to Arctic distribution



Food supply concentration through Tacoma-Anchorage corridor creates single-pathway exposure for the bulk of Arctic provisions.

National Supply Pathway — Warehouse Capacity

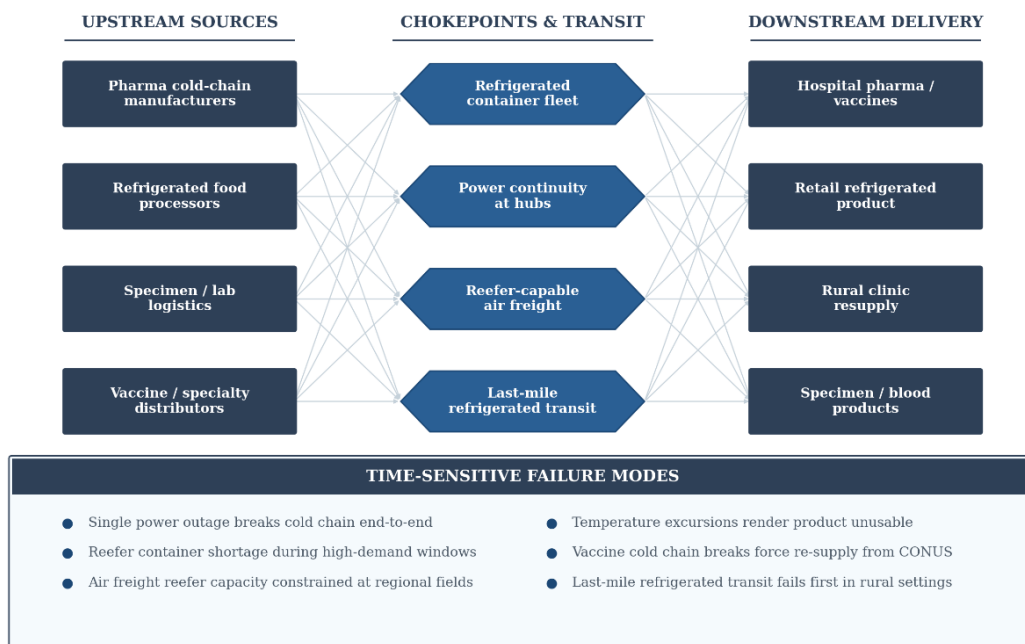
Storage and staging capacity feeding Arctic distribution



Arctic warehousing operates near steady-state ceilings; surge events expose insufficient buffer relative to throughput needs.

National Supply Pathway — Cold Chain

Temperature-controlled flow for food, pharma, and medical supplies



Cold-chain failure is binary not gradual; a single break can require re-shipment from CONUS at multi-day cost.

Layer 2: In-Theater Arctic Lifeline Systems

This layer captures the regional systems that immediately experience upstream disruption and directly sustain installations, missions, and civilian populations. In-theater Arctic lifeline systems span six interdependent sectors: energy and fuel systems including bulk fuel imports, storage terminals, aviation fuel distribution, local power generation, and heating fuel systems; food supply chains relying on barge lines, air cargo resupply, grocery distribution centers, cold storage, and limited warehouse capacity; medical logistics encompassing pharmaceutical cold-chain systems, medevac capacity, regional hospitals, and limited specialty care; communications and data infrastructure including satellite systems, fiber, microwave, and public-safety communications; transportation networks relying on the ALCAN Highway, regional and remote airfields, limited deep-water ports, and seasonal routes; and water and wastewater systems comprising community water utilities and washeteria-based distribution.

Transportation networks rely on the ALCAN Highway, regional and remote airfields, limited deep-water ports, and seasonal routes. Water and wastewater systems operate under baseline conditions with no parallel in the contiguous United States: twenty-two percent of Alaska households, roughly one in five, are unserved by water utilities, and energy costs for water systems in rural Alaska are up to 260 times higher than in the Lower 48, producing chronic fiscal stress that limits community capacity to maintain resilience reserves [26].

Fuel enables power generation. Power systems support heating, water treatment, and communications infrastructure. Heating systems are critical to preventing infrastructure failure in Arctic conditions. Water and wastewater systems depend on both power and heat. Communications systems depend on stable power and environmental conditions.

Fuel is simultaneously a cross-sector enabler for the emergency response infrastructure that would be activated to address a disruption: Alaska's feeding support operations, emergency response vehicles, and generator-powered fixed sites all depend on the same fuel supply chain whose degradation would trigger plan activation [6; 7]. Fuel disruption does not remain contained within the energy sector; it simultaneously disables the response capacity that would otherwise compensate for the initiating disruption.

The dependency chain is empirically confirmed by the Alaska energy resilience case literature, which documents an energy architecture characterized as fragmented and non-redundant. The centralized Railbelt grid carries approximately 79 percent of Alaska's electricity through a single interconnected corridor concentrated in the urban Southcentral and Interior regions. Outside that corridor, more than 150 isolated microgrids serve communities scattered across geographically remote locations [26]. This bimodal architecture concentrates failure risk in urban corridors served by the Railbelt while limiting recovery options in rural communities served by standalone microgrids; the two populations face structurally distinct vulnerabilities under the same disruption scenario.

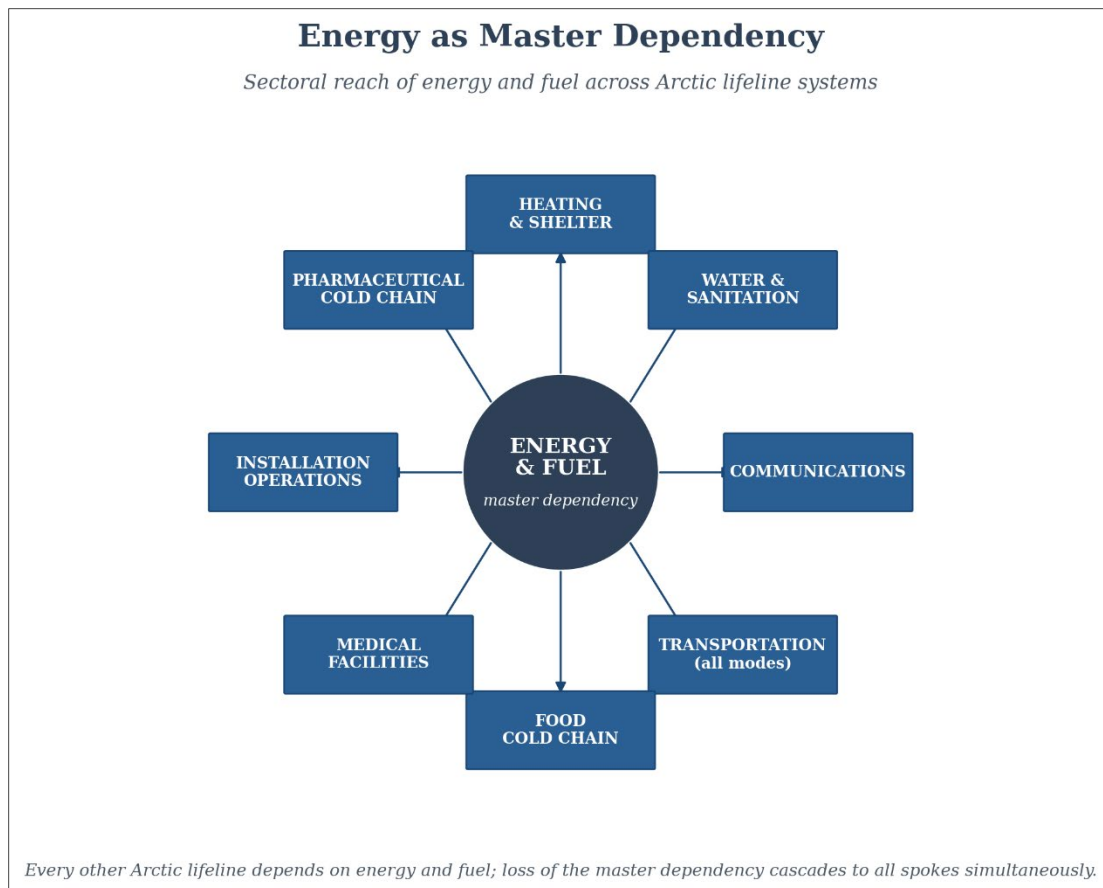
The 150 standalone microgrids are the analytically operative figure for repair logistics, workforce dependencies, and recovery options under disruption. These systems rely

primarily on diesel generation, with renewable penetration typically capped at 10–20 percent before integration complexity yields diminishing returns and at approximately 80 percent before storage requirements become binding [7; 26]. Diesel generators in these communities supply both electricity and recovered heat; renewable substitution reduces fuel consumption but simultaneously reduces heat output, creating secondary failure modes, facility freezing, water system damage, delayed generator startup, that pure-energy substitution models do not capture.

Standalone microgrids do not have access to the mutual aid agreements and shared lineman crews that Railbelt-interconnected utilities can mobilize. When a standalone microgrid fails in a remote community, repair is contingent on a workforce that must be flown in, using fuel that is itself constrained, to address equipment that may be unavailable due to the documented worldwide transformer shortage and the broader workforce constraints affecting Alaska’s electric utilities [26]. Documented wind-system failures at Nikolski and St. George illustrate that renewable integration introduces operational complexity that can reduce, rather than increase, reliability in the absence of sustained workforce and maintenance capacity.

Microgrids and distributed energy resources are nonetheless already operational across Alaska and represent realistic resilience strategies to reduce single-point-of-failure exposure and improve local energy security [26]. The mitigation pathway is therefore not theoretical; the analytical question is whether expansion is paired with the workforce capacity, spare-parts logistics, and Arctic-conditioned operational support that determine whether installed capacity translates into operational reliability under disruption.

Key Condition: Failure in upstream fuel or energy systems propagates rapidly across all dependent lifelines, creating multi-system degradation rather than isolated outages. Many Arctic systems operate with minimal buffer capacity, meaning disruptions in upstream supply chains translate into localized shortages within days, particularly food, fuel, and medical supplies.



Energy underpins virtually every other lifeline; loss propagates across heating, water, food, transport, medical, communications, workforce, and warehousing.

Layer 3: Mission-Dependent Community Infrastructure

The third layer reflects civilian systems whose degradation directly affects defense readiness, workforce availability, and operational continuity, and which are often absent from defense infrastructure planning because they are neither military-owned nor formally classified as critical infrastructure.

This layer includes local utilities supporting both installations and communities, workforce populations whose access to food, fuel, healthcare, and housing determines their availability for defense-enabling roles, commercial services supporting dependents and contractors, tribal governance systems that shape prioritization and coordination decisions in ways no federal framework fully anticipates, and community-level distribution systems with no meaningful surge capacity.

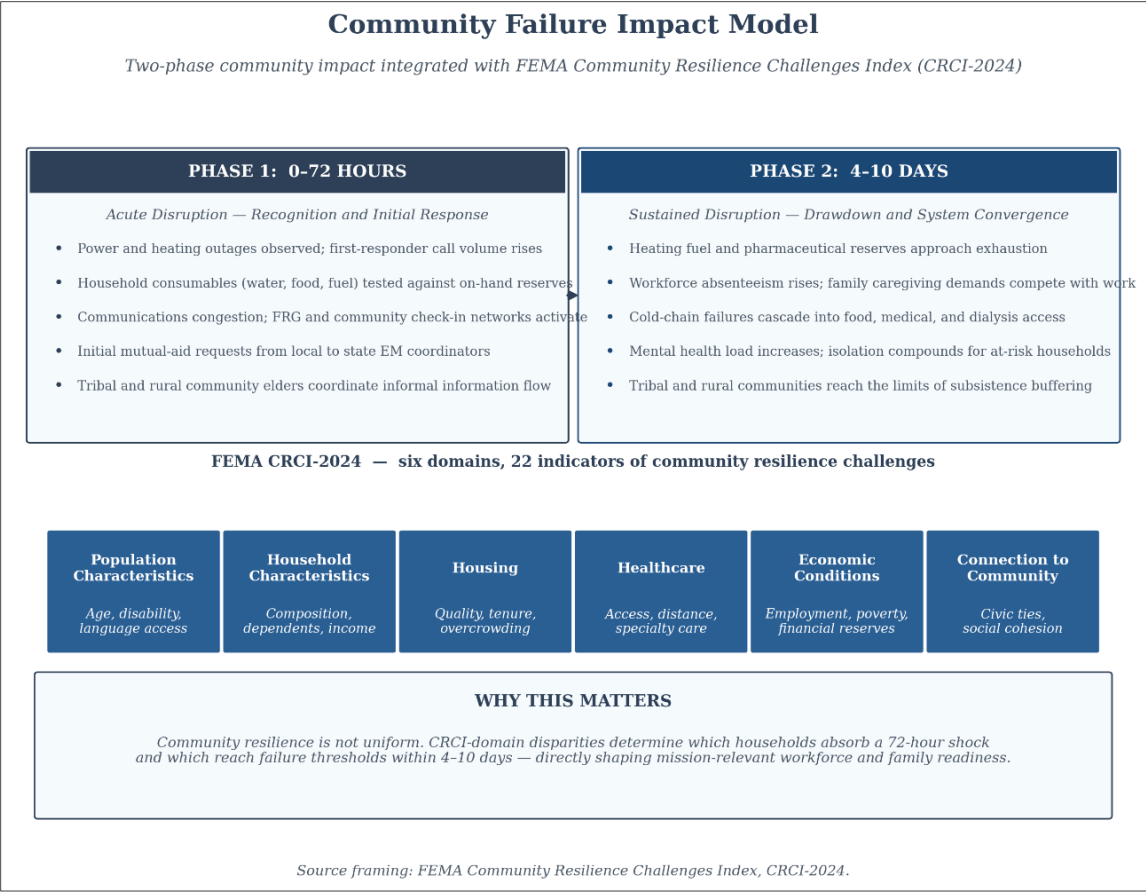
Mapping emphasis falls on workforce fragility driven by supply shortages and service disruption; household-level access constraints that determine whether workforce members can reach installations or receive emergency information during disruption; economic reserve depth that determines how quickly households begin making tradeoffs between work attendance and household survival when food and fuel access becomes unreliable; civil–military competition for scarce resources; governance complexity

affecting prioritization and allocation decisions; and community-level instability as a multiplier of operational risk.

Community-level vulnerability is not uniformly distributed across Alaska, and the pre-existing resilience challenges that shape cascade trajectory can be characterized systematically. The FEMA Community Resilience Challenges Index identifies 22 peer-reviewed indicators across six domains, population characteristics, household characteristics, housing, healthcare, economic conditions, and connection-to-community, which predict where the Days 0–14 failure cascade will move fastest because reserve capacity is thinnest [22 ; 65]. Communities with compounding challenges across multiple domains, high unemployment combined with limited vehicle access; thin healthcare capacity combined with low civic organization density, are the communities where each link in the failure cascade accelerates most quickly.

Peer-reviewed disaster-resilience research from the University of Washington's Disaster Resilience Research Network corroborates that pre-incident community resilience, measured through validated indicators of household composition, civic infrastructure, healthcare access, and economic reserve depth, is a stronger predictor of post-disruption cascade trajectory than disaster magnitude alone [65]. The risk-amplifier framing this section applies to community vulnerability is consistent with that research tradition.

Key Condition: Operational readiness directly tied to community sustainment. When workforce availability, family stability, and local services degrade under prolonged disruption, the effects are not confined to the civilian population; they propagate directly into mission capability. This is the layer of the dependency picture most systematically absent from current planning.



*CRCI domains shape acute-phase impacts and amplify cumulative stress;
Arctic-specific factors compress resilience reserves further.*

Layer 4: Workforce as a Cross-Cutting Dependency

Across all three layers, workforce functions as a critical enabling condition, not a standalone sector. Workforce availability directly affects fuel distribution and handling, power generation and system maintenance, transportation and logistics operations, medical care and emergency response, and communications system operation and repair. Under the dual-theater scenario, this dependency becomes more acute rather than more elastic. Deploying additional personnel or materiel into the region to compensate for shortfalls would itself be compromised by Arctic weather conditions, runway closures, ceiling and visibility limits, sea-state and icing constraints on maritime resupply, and ground transportation degradation along the ALCAN corridor all narrow the deployment window precisely when demand is highest. To the extent that resources could be moved by alternate methods, barge timing windows, overland convoy, rotary-wing shuttle, or ad hoc commercial charter, each alternate pathway introduces its own workforce requirement to receive, stage, handle, distribute, and sustain those resources at the point of need. Deployable equipment without deployable people to operate it is not a substitute for in-region workforce capacity; it is a deferred dependency. This compounding effect, that the very act of surging into the region creates new workforce demand at the receiving end, is not consistently captured in current Arctic mission assurance planning, which tends to treat deployment as a workforce solution rather than a workforce multiplier.

Workforce fragility is driven by food availability, fuel and heating access, healthcare capacity, housing and community stability, and pre-existing community resilience challenges measured by validated peer-reviewed indicators, including single-parent household prevalence, households without smartphones, and civic organization density, each of which correlates with workforce disruption risk under stress conditions [22; 65]. Availability also depends on specialized technical personnel, rotational or non-local labor, and the absence of surge capacity under extreme conditions.

Workforce concentration risk is illustrated by the seafood processing sector, which is both a significant Alaska employer and an input to the sustenance supply chain. Approximately 27,000 shoreside seafood processing workers in Alaska are seasonal, including substantial migrant workforce under H-2B visa arrangements [5; 17]. Travel restrictions, immigration policy changes, or transportation disruptions that prevent seasonal workforce arrival would degrade processing capacity, affect fisheries buyers and distribution, and reduce local food supply simultaneously. This is a worked example of workforce fragility acting as a force degrader across multiple lifeline categories from a single disruption pathway.

Layer 5: Communications as the Coordination Spine

Communications systems function as the coordination and decision-making backbone across all lifelines, depending on power and backup power systems, physical infrastructure (fiber, satellite, microwave), and environmental stability. Communications degradation reduces situational awareness during disruption, limits visibility into logistics, infrastructure status, and resource availability, degrades coordination across sectors and agencies, and increases the time required for prioritization and allocation decisions. The dependency picture is defined by two compounding realities: a fragile baseline that exists before any disruption begins, and a degradation surface that converts that baseline into an actively exploitable vulnerability under contested conditions.

[10; 14; 28]

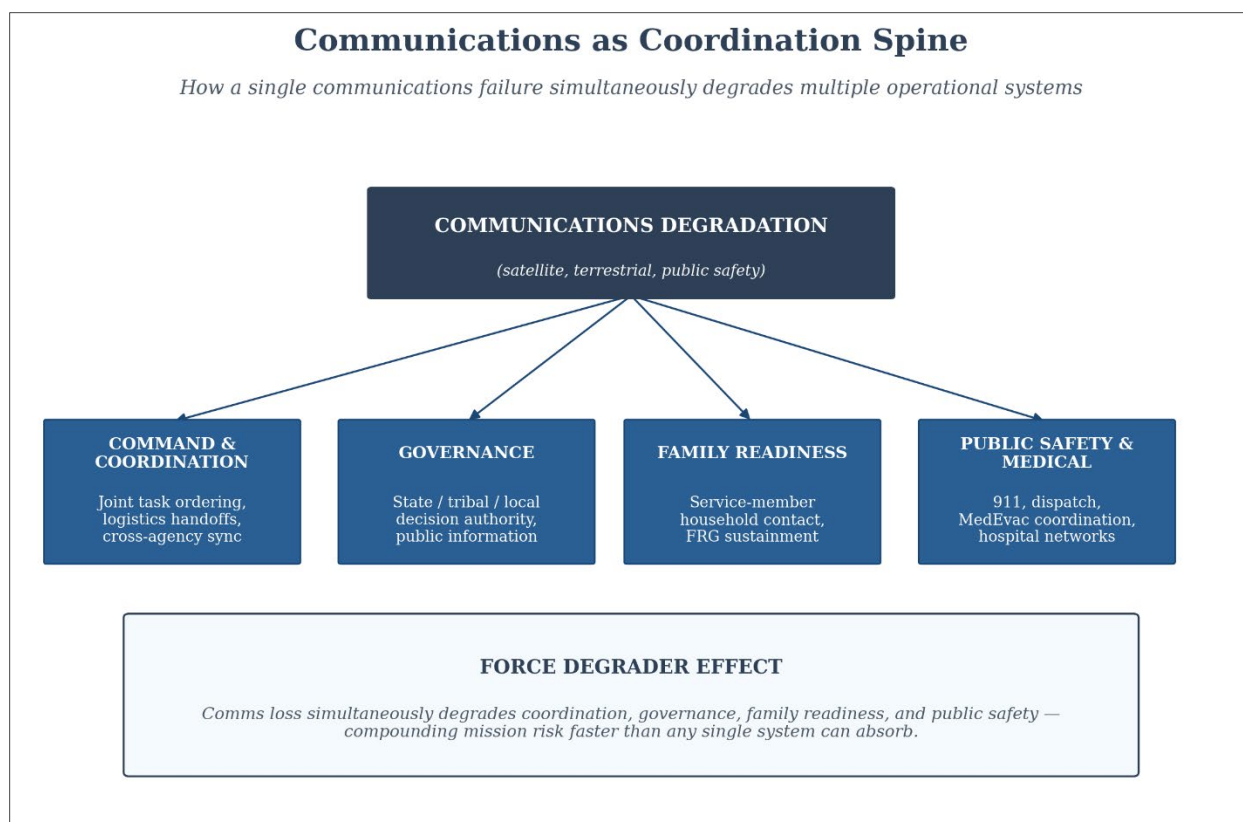
The fragile baseline is structural. Arctic communications operate against fragmented systems, bandwidth limitations, single-point failure exposure, and insufficient remote infrastructure as baseline conditions, not disruption consequences [10; 28; 56]. High-latitude geometry adds a binding technical constraint: geostationary satellites lose effective coverage above approximately seventy degrees north, making low Earth orbit and highly elliptical orbit constellations the primary space-based options for sustained Arctic connectivity. No single satellite architecture provides full Arctic coverage. Terrestrial backup is similarly exposed: the Denali Commission documents ice scour severing subsea fiber cables and producing months-long outages, confirming that the terrestrial layer cannot be assumed to remain available when the space-based layer degrades [25].

The degradation surface compounds that baseline through four overlapping vectors. First, weather, and environmental degradation, including ice scour, geomagnetic events, and Arctic-specific climate stressors, produce baseline reliability degradation that planning frameworks built for temperate-latitude operations consistently underweight. Second, adversarial degradation operates as ongoing capability rather than hypothetical risk:

Russian GPS jamming and potential undersea cable interference are documented gray-zone tactics in the Arctic theater [13; 14; 25; 45]. Third, cyber degradation extends the adversarial vector into the digital layer, with Arctic ground stations, including Svalbard-based facilities supporting commercial, scientific, and U.S. government missions, attractive targets due to remote locations, limited staffing, and internet-dependent operations, susceptible to cyberattack alongside jamming and physical disruption. Fourth, commercial provider autonomy introduces a degradation vector that no other lifeline category exhibits at this magnitude: over half of U.S. satellites are commercially owned and operated, and Arctic operations depend on commercial providers for positioning, navigation, timing, communications, and Earth observation [15; 16]. Commercial operators may alter service availability during conflicts based on financial or political considerations, with no governance framework currently requiring service continuity or military traffic prioritization. The United States has not formally designated space as a critical infrastructure sector, meaning the coordination, information-sharing, liability, and incident response frameworks developed for the sixteen designated sectors do not cleanly apply to the satellite systems those sectors depend on [12].

Cybersecurity within this dependency picture is therefore not a parallel analytical domain but one degradation vector among four operating against the fragile communications baseline. The cyber vector compounds the weather, adversarial-jamming, and commercial-autonomy vectors rather than substituting for them. A communications mitigation portfolio that addresses cybersecurity without addressing the other three operates against an unmitigated dependency on the systems whose failure it is designed to absorb.

Key Condition: Communications degradation does not create isolated failure but instead amplifies and accelerates cascading impacts across all other lifelines. Communications degradation operates as a force degrader, and commercial provider autonomy introduces a paper-redundancy pattern analogous to the one documented in maritime and aviation substitution: contractually available capacity is not necessarily operationally available under stress.



A single communications failure simultaneously degrades command, governance, family readiness, and public safety, illustrating how comms loss functions as a force degrader across multiple operational systems rather than a single isolated outage.

Critical Dependencies Being Mapped

Fuel and Energy Systems

Arctic fuel dependency is singular in its operational significance. The entire system, aviation, transportation, heating, power generation, runs on imported fuel products with limited regional refining capacity and constrained storage [26]. Rural Alaska is heavily dependent on diesel-based microgrids with limited redundancy, fuel supply chains dependent on seasonal maritime delivery creating narrow resupply windows, and no grid interconnection that would permit load sharing or rapid recovery across regions. During the first fourteen days of disruption, rapid drawdown of stored fuel inventories competes directly with civilian heating demand and military and aviation requirements. Fuel disruption produces cascading cross-sector impacts affecting transportation, power, heating, and aviation simultaneously, not sequentially.

Two single-source fuel dependencies sit at the heart of the cascade structure. First, Crowley is the sole importer of aviation gasoline in Alaska, and all of it flows through the Port of Alaska [26]. AV Gas powers the small bush aircraft that deliver food and supplies to isolated communities through the Bypass Mail program, meaning that Port of Alaska disruption does not merely affect jet fuel for military and commercial aviation; it severs

the last-mile air delivery system that remote communities depend on for basic sustenance.

A disruption at the Port of Alaska therefore simultaneously disables the bush plane network that delivers food, fuel, and medical supplies to off-road communities, the same air cargo infrastructure on which last-mile distribution depends when maritime alternatives are constrained. This is a convergence failure in which a single upstream node disables both the primary maritime lifeline and its principal substitution pathway simultaneously.

Second, the upstream refining dependency compounds the single-node aviation fuel risk. Approximately eighty percent of crude oil produced in Alaska is refined in Washington and California rather than in-state; the remaining twenty percent is processed across five in-state facilities with a combined capacity of approximately 164,200 barrels per calendar day. Under the scenario, degradation of West Coast port operations simultaneously constrains the delivery of refined petroleum products flowing back into Alaska from CONUS refineries, while in-state refining capacity is insufficient to compensate for the loss. Alaska is therefore in the structurally anomalous position of being a major crude producer that depends on CONUS refining and maritime resupply to receive its own petroleum products in usable form, a dependency chain that collapses at the same maritime chokepoint that governs food and medical supply.

Cook Inlet 2030 depletion creates a structural convergence between the electric power system and the maritime fuel-import chokepoint (full treatment in the Cross-Sector Chokepoints subsection on the next page). The Fuel and Energy Systems implication is that the same disruption that interrupts maritime delivery of refined petroleum simultaneously stresses the gas-fired generation capacity that depends on imported fuel as Cook Inlet declines. [26]

Seasonal fuel delivery structure for rural communities defines a hard constraint on substitution timelines that is distinct from the urban distribution system. Bulk fuel delivery to rural Alaska occurs in late fall by barge, before sea ice and river ice set in; any additional fuel required before spring breakup must be delivered by bush plane at substantially higher cost. The seasonal lock-in dynamic (developed in the Scenario Development's, Seasonal Asymmetry) is the binding scenario constraint: a winter disruption forecloses bulk delivery to rural communities until spring.

Key Condition: Aviation-based fuel resupply under those conditions is not a functional substitute for barge delivery; it is a constrained emergency mechanism operating against depleted reserves with no resupply window. This seasonal asymmetry compresses failure timelines from weeks to days in winter disruption scenarios relative to summer.

Food and Essential Commodities

Alaska's food system is structurally bimodal. The commercial food distribution system supplies approximately 95 percent of Alaska's food through a just-in-time architecture optimized for cost rather than resilience, while the subsistence harvest system supplies the parallel pathway through which rural communities sustain themselves outside commercial channels [1; 26; 38]. Both systems are currently under independent stress, and the risk-amplifier condition for the dual-theater scenario is that disruption affecting both pathways simultaneously produces food security outcomes more severe than either system's fragility alone would indicate.

The commercial pathway operates on maritime resupply cycles that underpin the entire system. Food departing the Port of Tacoma arrives at the Port of Alaska in three days and reaches retail shelves on the fourth day; ships arrive on Sundays and Thursdays; the state has no meaningful warehousing capacity; and inventory buffers are commonly estimated at 6–10 days under normal operating conditions. [38] When those cycles are disrupted, the limited commercial inventory begin drawing down immediately. Cold-chain fragility compounds the problem: the perishable goods and medical commodities that require temperature-controlled logistics are among the first to be affected when the systems supporting them are stressed.

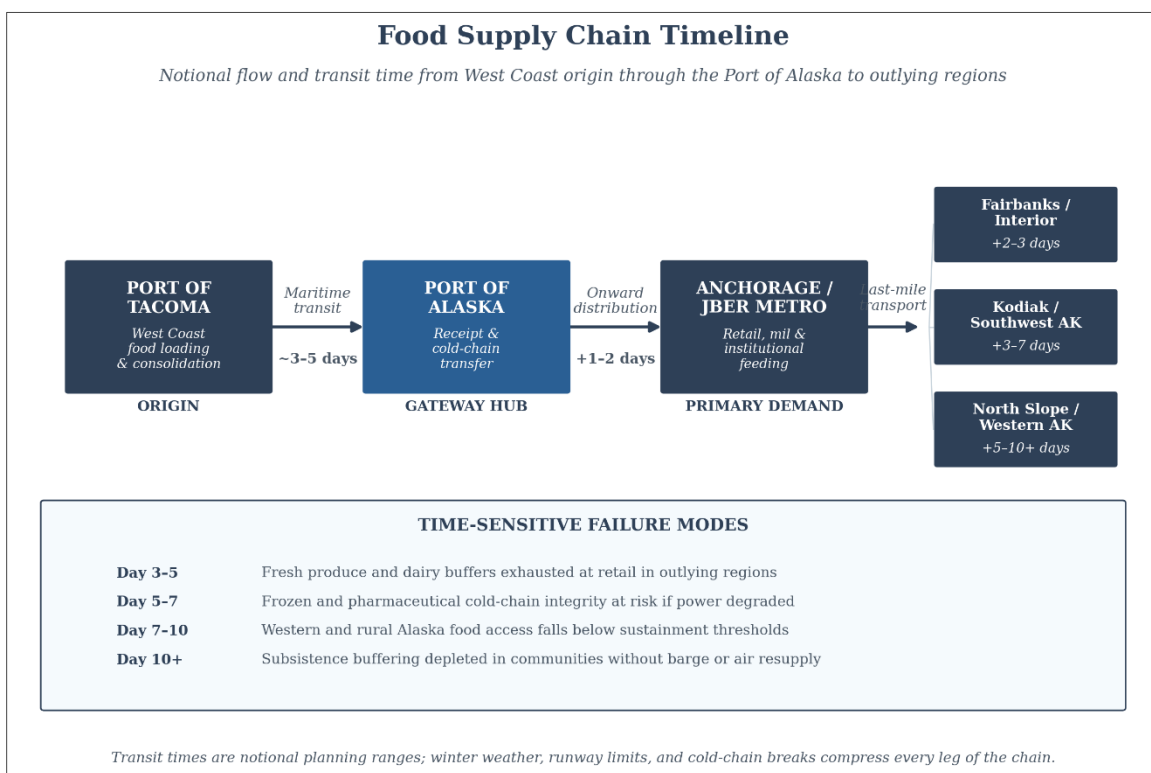
The structural thinness of Alaska's commercial food architecture is characterized by single-source concentration at both the wholesale and retail tiers. At the wholesale tier, a single produce distributor (Charlie's Produce) operates from one Anchorage location; beverage distribution is concentrated across three to seven locations per carrier; and general-line distribution is similarly limited to single locations outside Anchorage. At the retail tier, major chains include Alaska Commercial Company locations, Carrs/Safeway, Fred Meyer, and Walmart. The geographic concentration means that disruption at or upstream of the Port of Alaska simultaneously affects all downstream retail channels, with no independent distribution tier capable of absorbing the disruption. State feeding operations depend on the same commercial supply chain whose disruption would trigger plan activation, including Sysco, Carrs/Safeway, Fred Meyer, Walmart, and Costco, reinforcing that the named commercial partners in Alaska's emergency feeding doctrine are not redundant to the disrupted system but embedded within it [6; 7]. This is a clear instance of paper redundancy without operational redundancy: the backup feeding architecture and the primary commercial food system depend on the same upstream nodes.

In-state processing capacity is similarly thin. Alaska has three USDA-certified meat processing facilities and two mobile units statewide, and two FDA-certified dairies, a structural condition that eliminates local production as a meaningful substitute for imported food within the Days 0–14 window even where raw agricultural output exists. [1; 6]

The subsistence harvest pathway carries the parallel-system load. Wild food harvest of approximately 18,000 tons annually, with replacement value approaching one billion dollars and supporting up to 98 percent participation in some rural communities, is sustained by fish and wildlife populations that are currently in decline, including the

Western Arctic Caribou Herd down 23 percent over two years and 50 percent over ten years, and fishery closures driven by fish population collapse [7]. Subsistence harvest activities, where seasonally available, depend on fuel for boats, snowmachines, and aircraft, meaning that subsistence resilience is itself coupled to the commercial fuel supply chain whose disruption is the initiating condition of the scenario. The bimodal architecture does not provide independent redundancy under disruption; both pathways degrade through partially shared dependencies on fuel, transportation, and workforce.

Key Condition: Alaska has no major warehousing capacity. When maritime supply is disrupted, there is no buffer to draw down. Shortages appear at the retail and community level within days not weeks, because the system was designed to function with no slack.



End-to-end food path is sequential: a chokepoint failure at any stage propagates downstream within days.

Medical and Pharmaceutical Supply Chains

Medical system fragility in the Arctic is a function of distance, weather, and supply chain structure simultaneously. Limited regional healthcare capacity and specialty care availability mean that any degradation in the ability to evacuate personnel or resupply pharmaceuticals and medical consumables has immediate operational consequences. [4; 18] Pharmaceutical cold-chain systems are among the most vulnerable elements of the entire supply network. They require temperature control throughout transit, have no meaningful substitution options when disrupted, and operate on resupply cycles that

cannot be easily compressed [74; 76]. Medevac constraints driven by weather and airfield limitations compound the pharmaceutical supply picture.

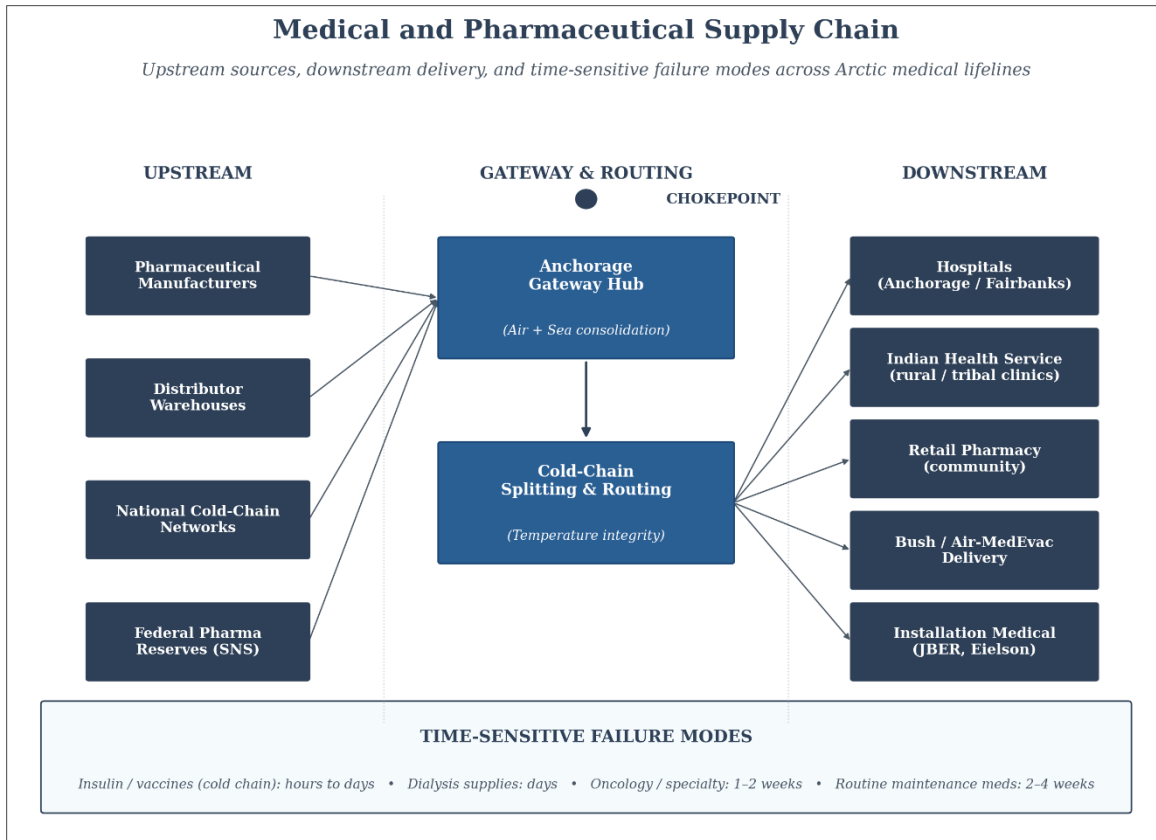
National pharmaceutical distribution operates on just-in-time inventory principles, with retail and hospital pharmacy inventories typically maintained at seven to thirty days of supply [9]. Alaska's position at the end of that pipeline compresses national depletion timelines further, and a disruption that simultaneously affects power, fuel, and communications produces parallel cold-chain failure across distribution centers, pharmacies, and clinics rather than at a single point. Products affected by cold-chain failure are not delayed but destroyed, converting a resupply problem into an inventory-destruction problem that must be resolved through the same disrupted supply chain that produced the failure [27].

Regional healthcare capacity imposes a hard ceiling on surge absorption. Alaska's hospital infrastructure is sized for baseline demand with limited margin, consistent with the broader pattern in which rural and frontier healthcare systems operate near effective capacity under normal conditions [4; 9]. When civilian, military dependent, and contractor populations draw on the same civilian system, the binding constraint is specialty staff rather than beds, and specialty staff cannot be flown in under the fuel and aviation constraints the scenario imposes.

Indian Health Service and tribal health system facilities, operated under tribal compact and co-management arrangements with the Alaska Native Tribal Health Consortium, regional tribal health organizations, and village-level Community Health Aide Programs, extend healthcare access into communities that commercial and state healthcare infrastructure does not reach [40]. This system depends on the same pharmaceutical supply chain, cold-chain infrastructure, medevac network, and fuel availability as the rest of the Alaska healthcare system. It is not redundancy against the disruption scenario; it is an additional set of dependent nodes whose degradation compounds the capacity gap.

Medevac operations represent the convergence pathway in compressed form: Guardian Flight, LifeMed Alaska, and tribal and commercial air ambulance operators depend on aviation fuel, weather windows, thin crew availability, and communications for flight following and receiving-facility coordination, placing medevac capacity in direct competition with cargo airlift, installation sustainment, and defense operational requirements for the same constrained fuel pool [7; 36].

Key Condition: Aviation-based fuel resupply under those conditions is not a functional substitute for barge delivery; it is a constrained emergency mechanism operating against depleted reserves with no resupply window. This seasonal asymmetry compresses failure timelines from weeks to days in winter disruption scenarios relative to summer.



Pharmaceutical pathways are heavily concentrated; cold-chain integrity is the binary constraint that converts delay into total product loss.

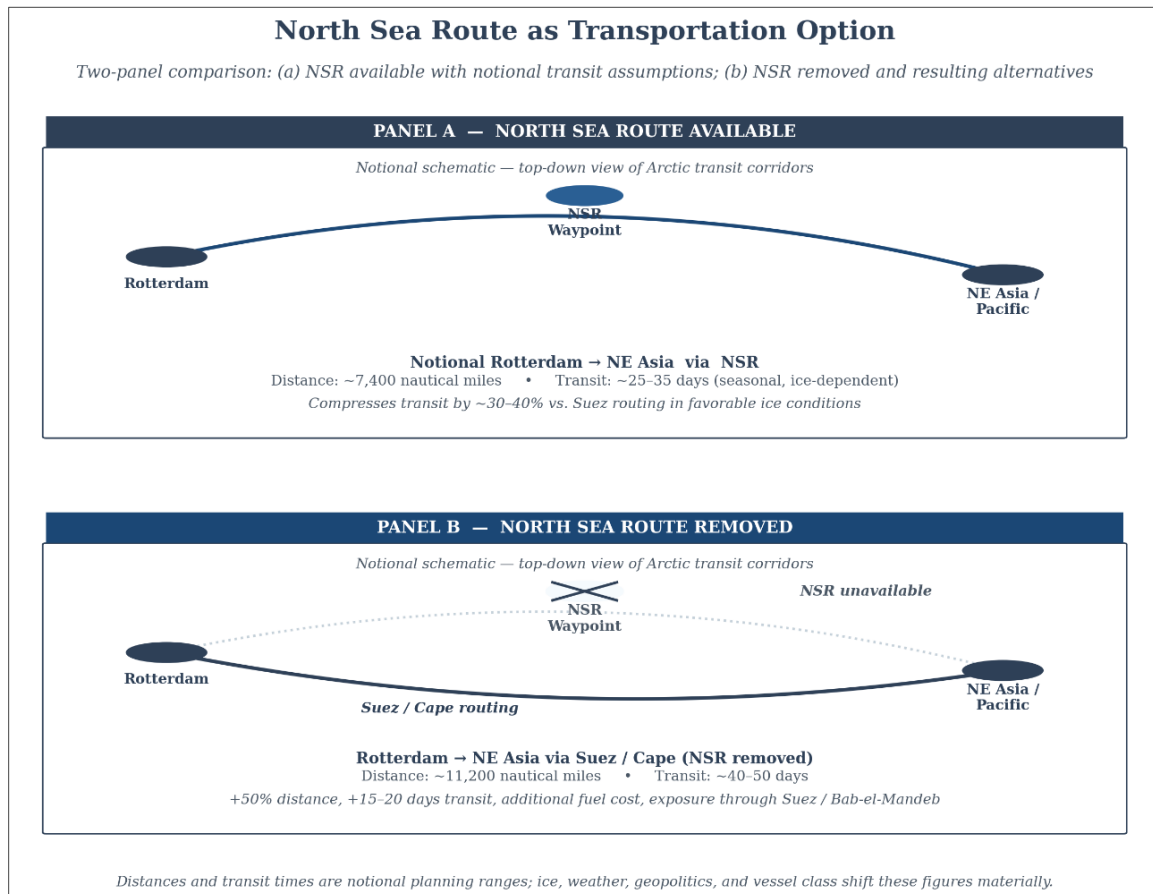
Transportation and Logistics Nodes

The transportation picture in the Arctic is defined by constraint at every level, and the literature is unusually specific about those constraints. There is no continental rail connection to Alaska. The Coast Guard search-and-rescue station nearest to the Arctic is in Kodiak, approximately 820 nautical miles south of Utqiagvik. The Nome port deepening project, the only active effort to create a northern deep-draft capability, remains in design phase with no permanent facility yet constructed [19; 34; 37].

The Port of Alaska handles five times more inbound marine cargo than all other Southcentral Alaska ports combined, with 1.66 million tons inbound and 1.47 million tons of refined petroleum products received in 2019. Its infrastructure includes 3,500 feet of dock frontage, gantry crane capacity, and 3.1 million barrels of liquid fuel storage capacity. No alternative port in Southcentral Alaska replicates this combination of throughput capacity, fuel storage, and land connectivity. The six identified contingency alternatives, Seward, Valdez, Kodiak, Homer, Whittier, and MacKenzie, each require capital investment before they could function as container cargo substitutes [26; 44].

Rerouting feasibility analysis must also account for Northern Sea Route availability under disruption conditions. The NSR represents a potential maritime rerouting option in benign planning models but could be closed or degraded by adversarial action under

UNCLOS Article 234 claims at the moment of greatest need. Russian infrastructure in the Arctic is characterized by a dual-use structure, facilities capable of both civilian search-and-rescue and military use, meaning escalation can convert cooperative infrastructure into contested access points with little warning [14]. This eliminates a rerouting pathway that otherwise appears as an alternative in substitution-limit analyses.



NSR availability is a conditional asset; loss of access materially extends transit times and exposes alternate routes to congestion.

Cross-Sector Chokepoints Identified

The dependency mapping identifies nodes where multiple lifeline systems converge, creating disproportionate mission risk when those nodes are degraded. These are not simply vulnerable points; they are the locations where disruption in one system immediately propagates into multiple others. The literature is unusually consistent in identifying the same nodes across independent sources.

Communications Systems: SATCOM and Commercial Telecom with Limited Redundancy

Communications is treated as a cross-sector chokepoint at the Layer 5 dependency treatment, where the fragile baseline, the four overlapping degradation vectors (weather,

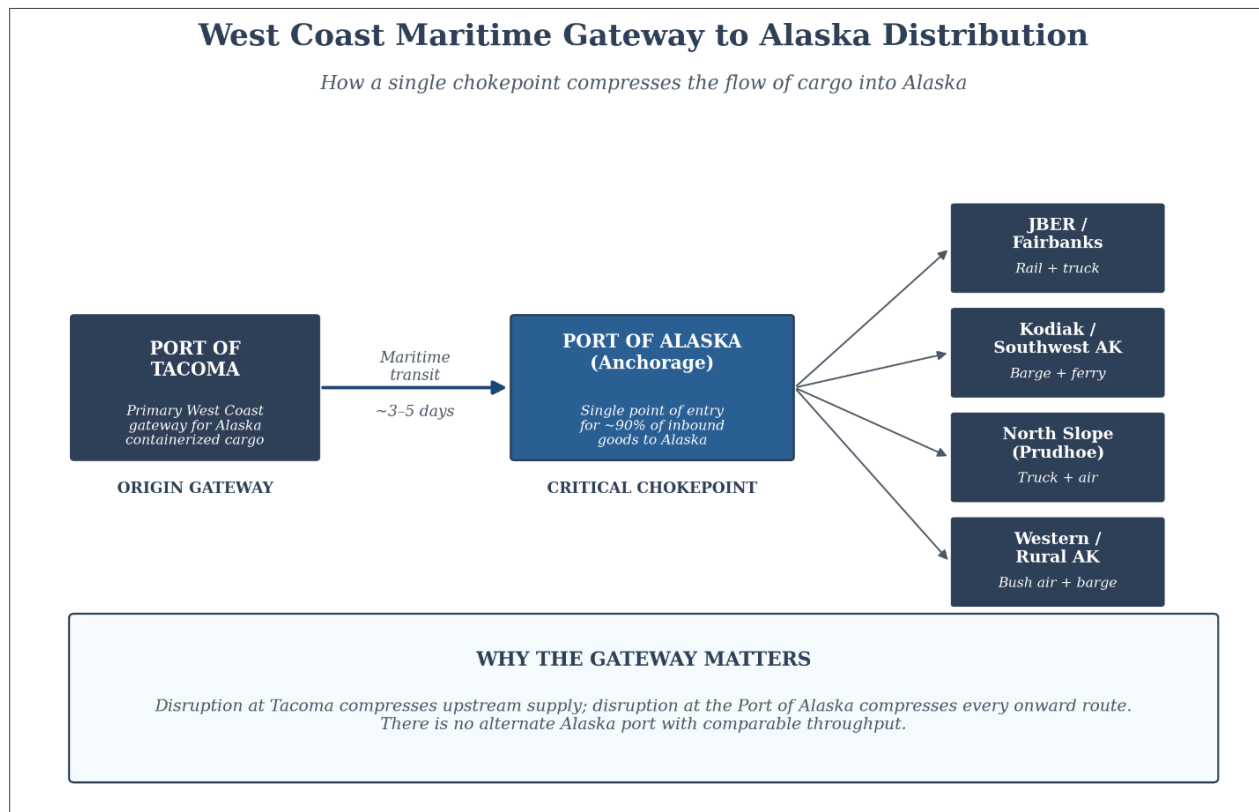
adversarial jamming, cyber, commercial provider autonomy), and the space-as-uncategorized-critical-infrastructure governance gap are developed in full.

Maritime Gateways: West Coast Ports as Primary Entry Point

Documented loss thresholds: peer-reviewed computable general equilibrium modeling of a compound disruption at the Los Angeles–Long Beach port complex finds GDP losses propagating well beyond the port region through commercial supply-chain transmission, with food and agricultural supply chains disrupted immediately and no rerouting alternative available at sufficient scale [49; 73]. That documented impact is not an abstraction for Arctic planning; it is the economic expression of a supply architecture whose failure propagates directly into Alaska sustainment within the first seventy-two hours.

Port of Alaska / Anchorage Hub: Central Consolidation Node

Single facility handling approximately 50 percent of all inbound freight and fuel into Alaska, supplying approximately 90 percent of the state's population through downstream distribution, and functioning as a DoD-designated commercial strategic seaport projecting power across Alaska, the Pacific Rim, and the Arctic [26; 44]. Its 1.47 million tons of annual refined petroleum throughput makes it the primary fuel entry point for a state with no regional refining capacity. Disruption here does not slow one mode; it degrades the entire downstream distribution architecture simultaneously.



Two-port concentration creates single-pathway exposure for Arctic sustainment; redundancy options are limited and seasonal.

ALCAN Highway: Key Overland Redundancy with Limited Surge Capacity

The Alaska–Canada Highway is the category of redundancy this research identifies as most consequential to examine: one that exists in planning documents, moves real cargo under normal conditions, and consistently fails to perform at the scale disruption response requires when conditions are most demanding [19; 26; 46].

Current average daily traffic on the highway is approximately 350 vehicles per day, of which commercial trucks constitute approximately six percent, or 20–25 trucks per day. Road classification can theoretically accommodate 12,000–15,000 vehicles per day under good conditions, suggesting that up to thirty times current traffic volume may be feasible at nominal capacity [55; 62]. The gap between the 350-per-day operating reality and the 12,000–15,000-per-day theoretical ceiling is the empirical expression of the paper-redundancy condition applied to the transportation layer.

Three structural conditions govern whether the gap can be closed under disruption. First, the 1,387-mile route requires pre-staged rest stops, fueling resources, and logistics support infrastructure that does not currently exist; the longest stretch without services is 100 miles, and not all available services operate year-round or on a 24-hour basis. [55; 62] Second, weather exposure across significant route segments produces winter closures and dangerous driving conditions, with closure cadence concentrated precisely in the months when demand for heating fuel and essential goods peaks; this seasonal compression converts the corridor from a marginal redundancy in summer to an unreliable one in winter. Third, the corridor requires transiting approximately 1,200 miles of Canadian sovereign territory, introducing customs, weight-restriction waiver, hours-of-service waiver, and provincial permitting decision points that U.S. planning cannot resolve unilaterally [45].

ALCAN optimization therefore divides analytically into two distinct investment categories with different time horizons. The first, pre-scripted regulatory pathway activation, including weight-restriction waivers, hours-of-service waivers, CDL endorsement coordination, and Canadian provincial permitting, can be achieved within the Days 0–14 window because its cost is administrative rather than capital. The second, physical pre-staging of driver support, lodging, and fuel infrastructure along the route, is a pre-event investment that determines whether the theoretical surge capacity is operationally accessible at all. The corridor is a real redundancy that moves real cargo, but absent both investment categories it cannot deliver the volume, speed, or reliability that maritime disruption response requires within the analytical window.

Airfields: Critical but Constrained for High-Priority Sustainment

The wargame and live-exercise literature converge on this chokepoint. Arctic Edge 2025 documents that multi-domain integration requirements, HIMARS rapid insertion, missile defense, maritime security operations, and expeditionary aviation, compete simultaneously for the same constrained airfield capacity under exercise conditions [67]; the RAND Plan Blue 21 wargame establishes that airlift cannot substitute for maritime supply at the scale Arctic operations require under contested conditions [46].

When the dual-theater scenario introduces fuel constraints simultaneously, the competition between operational aviation requirements and logistics and medevac needs becomes acute in ways that no aviation surge assumption can adequately buffer. Aviation does not substitute for the Port of Alaska's throughput volume under disruption; the operational arithmetic is documented in the Substitution Inventory. The aviation substitution argument does not fail at the margins. It fails categorically.

Electric Power: The Cook Inlet Depletion Trajectory

The electric power system introduces an additional cross-sector chokepoint with a documented long-horizon trajectory. The majority of Alaska's electricity is generated by natural gas, and the principal natural gas source for the Railbelt, the Cook Inlet basin, faces near-term supply decline. The Railbelt grid, which runs from Fairbanks through Anchorage to the Kenai Peninsula, produces most of Alaska's electricity and serves Joint Base Elmendorf-Richardson, Elmendorf's power load, and the majority of the state's population. [26]

As Cook Inlet gas reserves decline, the Railbelt becomes increasingly dependent on fuel imports to sustain generation, an energy dependency that converges directly with the fuel import chokepoint already identified as the primary cross-sector cascade trigger. Infrastructure stakeholder interviews additionally documented a worldwide transformer shortage, aging infrastructure with no rehabilitation plans, and a shortage of trained linemen as compounding conditions that reduce the Railbelt's operational buffer.

Coordination Architecture as a Cross-Sector Chokepoint

Where Business Emergency Operations Centers (BEOCs) and formalized private-public partnership charters exist and have been exercised, coordination moves at the pace disruption requires [33]. The Nebraska Preparedness Partnership's twelve-hour logistics coordination during 2019 flooding and the Houston Supply Chain Group's COVID-19 response pivot illustrate the model. Where these mechanisms do not exist, coordination must be improvised under time pressure. Alaska's Partnership for Infrastructure Protection provides a state-level precedent for formalized cross-sector coordination, though its scope and activation parameters under dual-theater disruption conditions remain a subject for follow-on analysis.

Cross-Border Interdependencies and Sovereignty Constraints

The cross-border sovereignty constraints documented here represent the governance dimension of the paper-redundancy problem identified in the Key Findings. ALCAN, the Northern Sea Route, and Canadian corridor access each appear in planning documents as available alternatives. Each is subject to conditions, sovereign decision-making, adversarial control, pre-defined coordination mechanisms that do not currently exist, that can make them unavailable at the moment they are most needed [13; 14; 19; 45]. The gap between planned redundancy and operational redundancy is widest precisely at the cross-border nodes where U.S. planning authority ends.

The RAND governance gaps analysis provides the most analytically precise framing of why this matters: the risk is not adversarial Canadian action but the absence of pre-

defined coordination mechanisms adequate to resolve competing priorities between two allied nations under simultaneous stress [45]. Existing cooperative frameworks, including Arctic Council mechanisms and bilateral agreements, are not designed for the pace and nature of change now underway, and security dialogue mechanisms have atrophied since 2014. Cross-border dependencies introduce delay and uncertainty precisely when decision timelines are most compressed, converting the ALCAN redundancy from a planning given into an unresolved coordination problem under the scenario conditions this assessment models.

UNCLOS Article 234 and the Conversion of Cooperative Redundancy into Contested Access

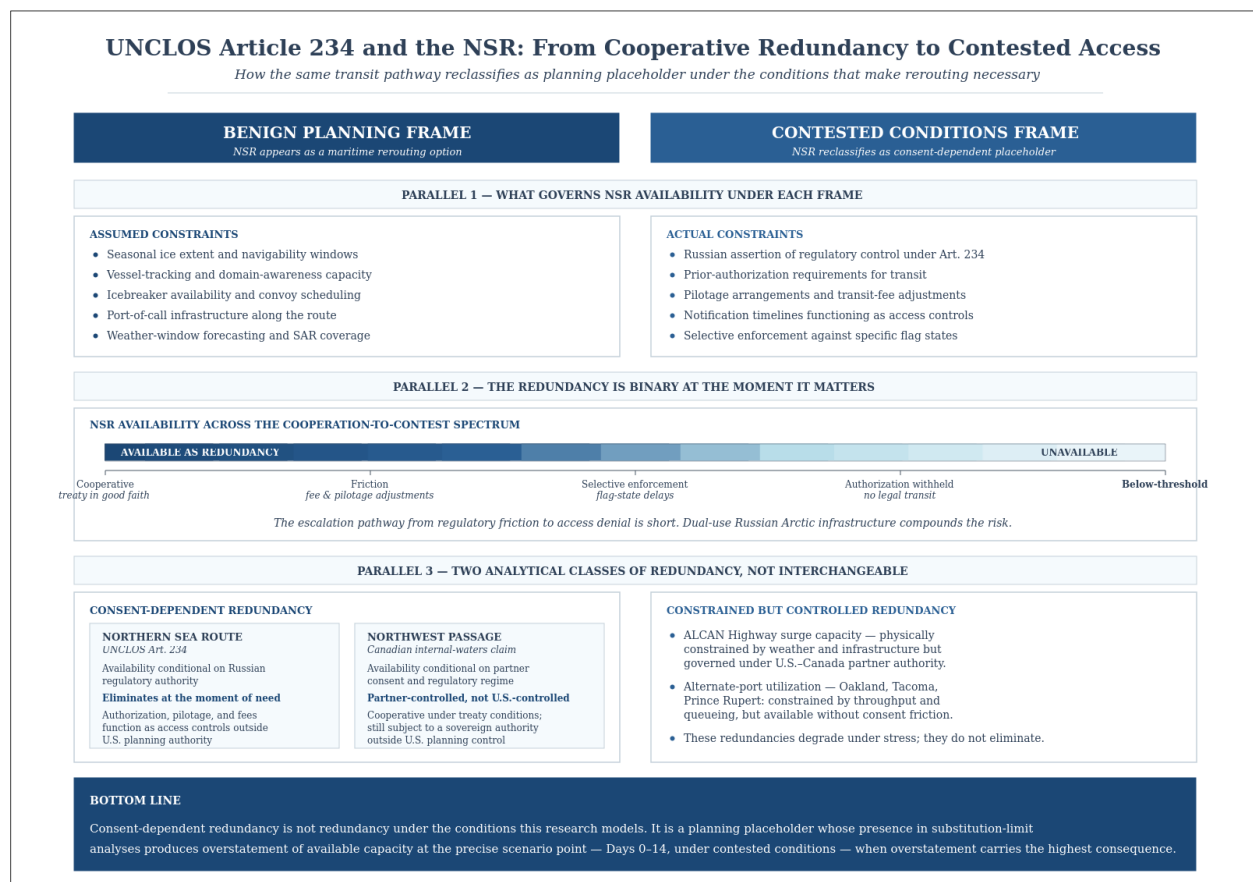
The Northern Sea Route is treated in most contingency planning literature as a maritime rerouting option that becomes available when Pacific gateway access is degraded. Under benign assumptions, the NSR appears as a redundancy whose seasonality is the principal constraint on use. Under the dual-theater scenario, that framing is incomplete in a way that matters analytically. The NSR is not a redundancy whose availability is determined by ice conditions and vessel-tracking capacity. It is a transit pathway whose availability is determined by Russian assertion of regulatory control under UNCLOS Article 234, a provision that authorizes coastal states to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction, and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone [14; 63].

Article 234 was drafted with environmental protection in view. Russian practice has extended its operational interpretation to require prior authorization for transit, pilotage arrangements, fee payments, and notification timelines that function in effect as access controls [13; 14; 49]. The risk-assessment implication for Arctic mission assurance is straightforward and severe. The NSR is a redundancy whose availability is conditional on conditions outside U.S. planning authority and outside the conditions that would make rerouting most necessary. Under adversarial action below the threshold of overt armed conflict, pollution-prevention enforcement asserted against specific flag states, transit-fee adjustments, pilotage suspensions, or the application of Article 234 standards in ways that selectively delay non-Russian shipping, the NSR becomes operationally inaccessible at exactly the moment West Coast gateway disruption makes it most operationally necessary. The redundancy does not fail because of weather or ice. It fails because the regulatory authority that governs it can be exercised as a disruption tool.

This pattern is consistent with the paper-redundancy condition documented throughout the lifeline architecture of this research. The NSR appears in benign planning models as a maritime option. The same NSR, examined against the conditions under which rerouting would actually be required, eliminates as a redundancy at the moment of greatest need. The dual-use character of Russian Arctic infrastructure, facilities capable of both civilian search-and-rescue and military application, compounds the risk by ensuring that an escalation pathway from regulatory friction to access denial exists and is short [13; 14]. There is no analytical equivalent of soft Article 234 enforcement against a vessel that cannot legally proceed once authorization is withheld; the redundancy is binary at the moment it matters.

The framework consequence is that Arctic rerouting alternatives must be evaluated against a feasibility test that accounts for the sovereign authority that governs them, not only the physical and seasonal conditions under which they would be exercised. The Northern Sea Route, the Northwest Passage, and any other transit pathway whose availability depends on third-state regulatory consent should be classified analytically as consent-dependent redundancy, distinct from constrained but U.S.- or partner-controlled redundancy such as ALCAN surge capacity or alternate-port utilization. Consent-dependent redundancy is not redundancy under the conditions this research models; it is a planning placeholder whose presence in substitution-limit analyses produces overstatement of available capacity at the precise scenario point, Days 0–14, under contested conditions, when overstatement carries the highest consequence.

The same logic applies, with different actors and different legal instruments, to any maritime chokepoint where transit is governed by a coastal state whose interests under disruption do not align with U.S. sustainment requirements. The Strait of Hormuz example documented in the Scenario Development section below illustrates the broader pattern: when a single coastal state asserts regulatory authority over a transit corridor and the conditions under which that authority is asserted shift from cooperative to contested, the operational availability of the corridor collapses faster than substitution-limit modeling typically anticipates. The lesson for Arctic planning is to treat consent-dependent redundancy as a planning placeholder rather than as available capacity, regardless of the specific legal instrument under which the consent operates [20; 49].



Alaska Native and Tribal Community Considerations as Risk Amplifier

Alaska Native communities occupy a distinct position in the Arctic vulnerability picture that this research treats as a risk-amplifier dimension. The CRS Arctic report documents that 144 Alaska Native communities face infrastructure damage from erosion, flooding, and permafrost degradation, that more than one-third face compounding threats, and that more than one-third of highly threatened villages received no relevant federal assistance during the five years reviewed. Twenty federal programs each have at least one characteristic that could obstruct access for small remote communities, including competitive grants, cost-share requirements, cost-benefit analysis rules, and national competition that disadvantages communities with limited administrative capacity.

[19; 24]

The Alaska Native governance and economic ecosystem, 12 regional corporations, more than 200 village corporations, tribal governments, regional nonprofits, and statewide Native organizations, collectively controls land, workforce, and local infrastructure that defense operations depend on. [7] Barge routes, airstrip operations, fuel distribution, and local logistics functions that defense supply chains rely on run through or are managed by entities within this ecosystem. Where these infrastructure systems are degraded simultaneously with the broader supply chain, the cascade accelerates rather than stabilizes, because the entities that operate critical last-mile functions are absorbing the same disruption the larger system is experiencing. This is the risk-amplifier framing: tribal community vulnerability does not sit adjacent to the lifeline cascade; it sits inside it.

Functional coordination capacity between non-tribal institutions and tribal governments depends on pre-existing relationships that cannot be improvised under disruption conditions [21; 61]. Statutory consultation mechanisms do not substitute for substantive operational engagement built over time. The risk-amplifier finding does not assign causation to tribal communities; it identifies the structural conditions under which disruption impacts will be most severe and where pre-incident coordination investment yields the highest resilience return.

FOCUSED RISK AND VULNERABILITY ASSESSMENT

The Focused Risk and Vulnerability Assessment is where the scenario conditions and the dependency map converge into operational consequence. Operative phase for this section: Days 0–14, with extension into Days 10–45 where mitigation timelines require it. Full scenario architecture is developed in the Scenario Framework section. The risk and vulnerability assessment below evaluates how disruptions propagate under the scenario conditions documented in the Scenario Framework section.

The central insight this assessment is designed to surface is one that does not emerge from single-system analysis: Arctic mission assurance does not fail because one system breaks. It fails because multiple systems degrade simultaneously, their failure modes interact, and the cumulative effect arrives faster, and cuts deeper, than any individual system failure would predict. The value of this assessment is in mapping those interaction effects with enough specificity that decision-makers can see where the critical thresholds are, and where investment and coordination attention will have the greatest return.

Analytical Approach

The assessment evaluates how disruption propagates across interconnected lifeline systems under realistic Arctic conditions, with emphasis on threshold-driven system degradation rather than steady-state vulnerability. For each lifeline system, fuel, energy, food, communications, medical, transportation, the analysis identifies the initial point of disruption; immediate operational impacts; secondary and tertiary cascading effects across systems; trigger thresholds that shift systems from degraded to failed; and time-to-degradation and time-to-failure under constrained resupply conditions.

Representative Cascade: Port Throughput Degradation

For each lifeline system, fuel and energy, food distribution, communications, medical supply, and transportation, the assessment identifies the initial point of disruption, the immediate operational impacts, the secondary and tertiary cascading effects that propagate across interdependent systems, and the time-to-degradation and time-to-failure under constrained resupply conditions.

Ports and interconnected logistics networks produce nonlinear, compounding effects in which small disruptions generate large consequences [41; 49]. Fuel disruption simultaneously affects transportation, power, heating, and aviation operations, not as sequential effects but as concurrent system failures that share common infrastructure dependencies. In Arctic scenarios, logistics capacity falls below operational demand, coordination speed falls below disruption speed, and civilian system resilience falls below military dependency, creating conditions where the cumulative failure arrives faster and cuts deeper than any individual system failure would predict.

This cascade structure is consistent with FEMA's community lifelines framework and its explicit finding that failure in one lifeline propagates into others through shared

infrastructure dependencies, generating secondary supply chain problems not visible in single-system analysis [32; 41; 45]. Analytical emphasis falls on the throughput-versus-capacity distinction: systems may remain operational, capacity exists, but fail due to insufficient throughput, as in ports that are open, but whose cargo velocity is too low to sustain demand. Threshold-based degradation produces non-linear collapse once inventory falls below minimum operating levels, fuel allocation decisions begin, or workforce availability drops below sustainment requirements.

Risk is not driven by a single failure, but by the convergence of fuel limitations, logistics delays, communications degradation, and workforce instability that together create system-wide degradation. This convergence pattern is the operational expression of the tight-coupling/loose-coupling condition characterized in the contested-logistics doctrinal frame (Institutional Coordination section): tight coupling at the Pacific Northwest maritime gateway concentrates risk at a single node; loose coupling across in-state distribution prevents that risk from being absorbed within the Days 0–14 window. [30; 51]

Key Condition: Port throughput degradation delays northbound cargo, which reduces warehouse replenishment rates, which triggers rapid inventory drawdown, which increases reliance on aviation resupply, which drives a surge in fuel consumption, which introduces aviation fuel constraints, which limits medevac

Time-Phased Degradation: Days 0-14

The cascade evolves across three sub-windows in the Days 0–14 frame, each describing both the immediate operational impacts and the threshold indicators that signal transition into the next phase.

Days 0–3: Disruption Recognition and System Strain

The dominant conditions in this window are disruption recognition, backlog formation, and limited situational awareness. Even a single Arctic maritime incident triggers simultaneous demands that exceed local capacity, with notification-system delays and inconsistencies, no common operating picture, and authority-transition friction operating as persistent early-phase constraints. The structural reason is governance: existing coordination mechanisms were not designed for the pace and nature of Arctic change now underway, and post-2014 security-dialogue gaps mean that early-phase uncertainty cannot be resolved through established deconfliction channels.

Days 3–7: Inventory Drawdown and Early Allocation

Warehouse replenishment falls below demand, food and medical inventories begin measurable decline, and fuel consumption increases due to operational adjustments. Threshold indicators include inventory levels falling below reorder thresholds, fuel resupply uncertainty triggering allocation planning, and early prioritization decisions between civilian and defense demand [7; 26]. This is the window in which the Days 0–14 analytical frame transitions from a planning concern to an operational reality, and in

which the absence of pre-defined adjudication mechanisms for civilian–military resource competition begins to produce friction that compounds across systems.

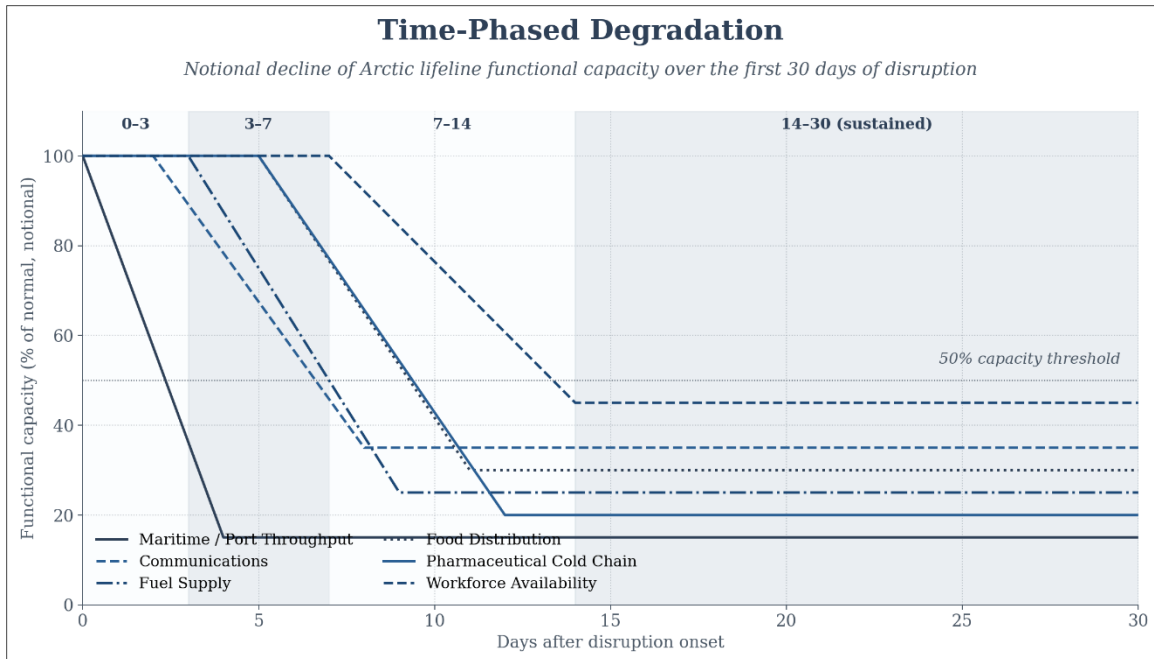
Days 7–14: Resource Scarcity and System Convergence

Sustained lack of resupply creates structural shortages, fuel availability becomes a limiting factor across sectors, and workforce degradation begins affecting operations. Threshold indicators include fuel allocation or rationing initiated, aviation fuel constraints limiting airlift and medevac, food availability impacting workforce stability, and communications degradation reducing coordination effectiveness. The Arctic Climate Change and Homeland Security 2024 report establishes that the environmental conditions of this period are not neutral: the Arctic is warming at approximately four times the global average, wave heights are projected to increase two to three meters, and more frequent and intense cyclones and polar lows are creating compound maritime risk environments [57; 72].

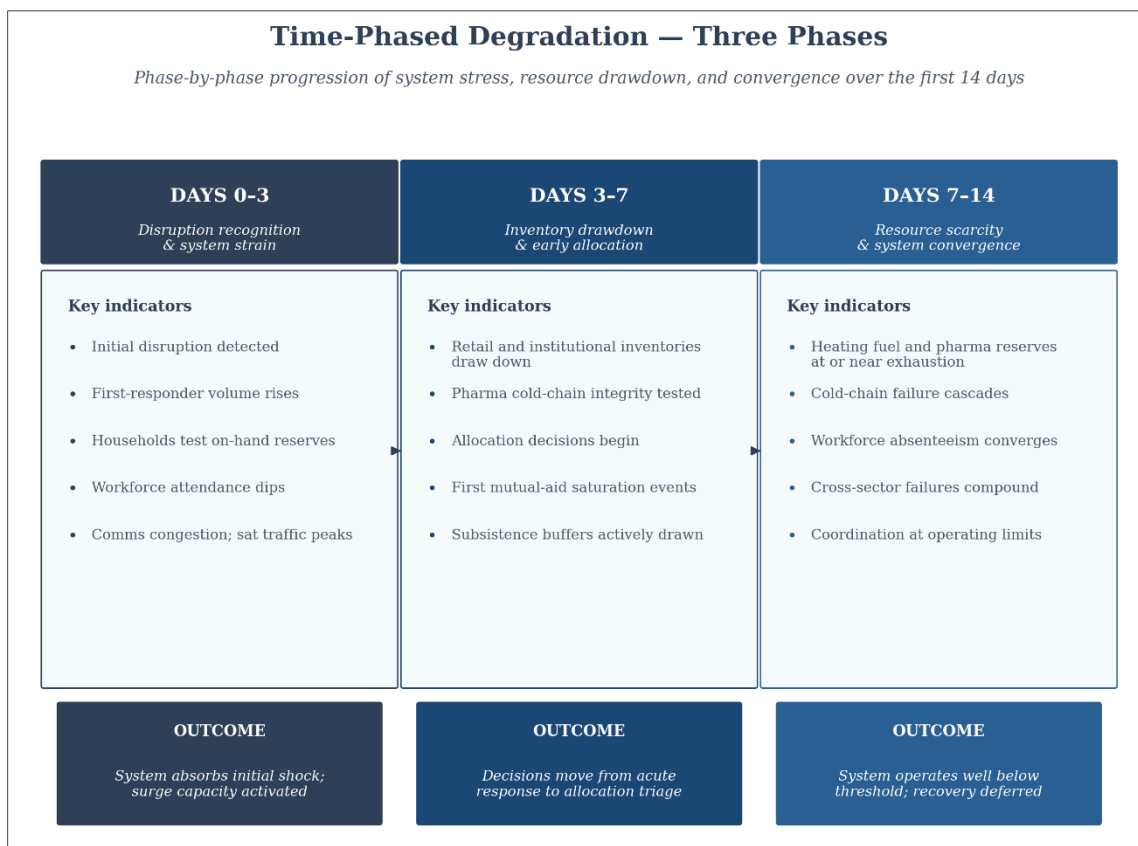
Workforce degradation begins affecting operations as household-level access constraints translate into absenteeism, particularly in workforce categories that lack remote-work options. Threshold indicators include fuel allocation or rationing initiated, aviation fuel constraints limiting airlift and medevac, food availability impacting workforce stability, and communications degradation reducing coordination effectiveness. By Day 14, the system has either stabilized through external intervention or entered a non-linear degradation trajectory that the post-disruption period cannot easily reverse.

Time-to-Failure Thresholds by Sector, Days 0–14

Sector	Initial Impact	Degraded Operations	Failure Threshold	Winter Compression
Heating	Day 0 (winter)	Days 0–1	Within hours	Binding constraint absent in summer
Fuel	Day 2	Days 2–7	Day 12 (summer); Day 3.5 (winter)	–71% time-to-failure
Food	Day 3	Days 3–8	Day 10 (summer); Day 4 (winter)	–60% time-to-failure
Medical	Day 4	Days 4–10	Day 8 (summer); Day 3 (winter)	–62% time-to-failure
Transport	Day 1	Days 1–11	Day 11 (summer); Day 4.5 (winter)	–59% time-to-failure
Workforce	Day 5	Days 5–11	Day 14	Stress compounds in winter
Communications	Day 6	Days 6–12	Day 9 (summer); Day 5.5 (winter)	–39% time-to-failure



*Composite curve illustrates aggregated lifeline degradation;
component sectors degrade on differing timelines.*



*Each phase represents a distinct operational regime; transitions reflect
cumulative system stress, not discrete events.*

Cascading Failure Analysis: From Trigger to Convergence

The assessment identifies six categories of Arctic-specific vulnerabilities driven by geography, infrastructure constraints, and supply chain structure. Each category is presented in operational terms, what fails, on what timeline, with what cascading effect, rather than as a generic vulnerability inventory.

Transportation and Logistics Vulnerabilities

As established in the Dependency Mapping section and the Substitution and Redundancy Reality Check, Arctic transportation alternatives exist in planning documents but cannot deliver required throughput within Days 0–14, leaving the cascading risk pathway without an effective substitution release valve [19; 34; 37].

The scale of the maritime substitution problem can be stated quantitatively. Replacing Port of Alaska cargo volume through aviation alone would require approximately seven hundred wide-body cargo jet landings per week, a throughput requirement that no Arctic airfield network, fuel supply chain, crew pool, or scheduling system can meet within the Days 0–14 window. The 2023 Baseline Assessment evaluated six candidate alternatives for containerized cargo (Seward, Valdez, Kodiak, Homer, Whittier, MacKenzie) and concluded that no viable alternative to the Port of Alaska currently exists; specific infrastructure investments required at each candidate are developed in the Port and Maritime Throughput Resilience mitigation category [26].

Key Risk Condition: Alternative routing options exist but are insufficient to replace disrupted maritime throughput within the first 14 days, creating a sustainment gap. This is a paper-redundancy condition applied to the transportation layer.

The substitution alternatives identified in practitioner-level coordination forums underscore the fragility rather than the robustness of these pathways. Alaska's Value Chain Coordination Council, convened in December 2025, examined USPS Bypass Mail and in-state backhaul opportunities for rural supply, confirming that even the alternatives actively under examination depend on federal postal infrastructure and ad hoc logistics arrangements rather than purpose-built redundant systems.

Fuel and Energy Vulnerabilities

Fuel disruption follows a clear cascade sequence: declining bulk delivery, storage drawdown below operational thresholds, allocation decisions, and simultaneous propagation into power generation, heating, water and wastewater, transportation and aviation, and communications. The cascade is amplified by an upstream refining dependency: approximately 80 percent of crude oil produced in Alaska is refined in Washington and California, and in-state refining capacity is structurally insufficient to compensate for disrupted maritime delivery (the operational figures are documented in the Dependency Mapping, Fuel and Energy Systems). West Coast port degradation therefore simultaneously constrains both the maritime delivery of refined product and the in-state refining of locally produced crude, a two-sided constraint that the

vulnerability assessment treats as compound rather than alternative. West Coast port degradation therefore simultaneously constrains refined-fuel delivery into Alaska and the in-state processing capacity that depends on imported additives and blending components [26]. Seasonal asymmetry compounds the cascade: a winter disruption depletes reserves against communities that cannot receive bulk resupply until spring breakup, collapsing the substitution window.

Within the contested-logistics doctrinal frame (Institutional Coordination section), fuel is identified as a non-substitutable foundation whose disruption cascades immediately into transportation, power generation, heating, and operational tempo, and as the ultimate last-mile challenge in contested environments [30; 51]. In the Arctic, fuel is simultaneously the foundation of commercial lifeline continuity and of household survival, where loss of heat becomes dangerous within hours.

| **Key Risk Condition:** Fuel system disruption acts as a primary cross-sector trigger initiating cascading failure across all lifelines.

Food and Essential Commodity Vulnerabilities

Urban Alaska operates on approximately seven to ten days of commercial inventory under normal conditions as a just-in-time retail system with no meaningful warehousing buffer [26]. Rural systems are shorter and more variable, with most communities served by a single retail food source and no local fallback. Alaska state emergency doctrine formally divides disaster feeding response into three operational phases, with the first phase defined by the absence of outside assistance and the structural constraint that assistance may require twenty-four hours or more to arrive in affected communities. Survivors will not typically arrive at shelters with a 72-hour household food and water supply, directly contradicting a planning assumption embedded in national-average emergency frameworks [6; 7].

As established in the Dependency Mapping section, Alaska's bimodal food system places the highest concentrated risk on rural and Western Alaska communities under the dual-theater scenario, with parallel degradation likely across both the commercial and subsistence pathways. The 2025 termination of the USDA Islands and Remote Areas Regional Food Business Center, which had been standing up technical assistance and coordination infrastructure for Alaska food businesses, demonstrates that the programmatic infrastructure supporting food system resilience is itself subject to cascade dynamics: when federal funding was withdrawn, the relationship capacity required to operationalize supply chain improvements was lost before it could be established [3]. Food system resilience depends on institutional continuity as well as physical inventory, and both are currently thin.

| **Key Risk Condition:** Food system disruption rapidly translates into community instability and workforce degradation, amplifying operational risk.

Communications Vulnerabilities

As established in the Layer 5 Communications dependency treatment, the Arctic communications baseline is structurally fragile (high-latitude geometry, bandwidth limitations, single-point failure exposure, insufficient remote infrastructure) and is acted on by four overlapping degradation vectors: weather and environmental, adversarial jamming and physical interference, cyber, and commercial provider autonomy. The risk-assessment implication is that communications failure does not arrive through a single failure pathway but through compounding effects across these vectors operating concurrently. GPS jamming and potential or actual interference with submarine telecommunications cables are active adversarial tactics in the Arctic theater rather than hypothetical failure modes [14; 25]. Russia's 2022 Viasat cyberattack degraded European civilian services as collateral to its military targeting, illustrating the cascade pathway in which the cyber vector compounds the adversarial-jamming and commercial-autonomy vectors and produces simultaneous defense and civilian impacts [28]. The risk this assessment surfaces is not the failure of any single vector but the convergence of all four against a baseline that has no functional redundancy at the Arctic latitude where defense operations depend on the system most heavily.

Key Risk Condition: Communications degradation functions as a force degrader, accelerating cascading impacts by delaying coordination and response.

Medical and Pharmaceutical Vulnerabilities

Urban Alaska operates on approximately seven to ten days of commercial inventory under normal conditions as a just-in-time retail system with no meaningful warehousing buffer [26]. Rural systems are shorter and more variable, with most communities served by a single retail food source and no local fallback. Alaska state emergency doctrine formally divides disaster feeding response into three operational phases, with the first phase defined by the absence of outside assistance and the structural constraint that assistance may require twenty-four hours or more to arrive in affected communities.

Survivors will Arctic medical and pharmaceutical sustainment depends on systems that share the same fragile-baseline-plus-degradation-surface architecture documented across the other lifelines, with two domain-specific intensifiers: cold-chain pharmaceutical integrity is non-recoverable once broken within the Days 0–14 window, and medevac access is governed by weather and infrastructure constraints that cannot be substituted by airlift surge in the way bulk cargo theoretically can. Pharmaceutical distribution into Alaska depends on a small number of national wholesalers operating temperature-controlled supply chains across the same maritime and aviation pathways constrained by the dual-theater scenario; once the cold chain is broken, affected inventory is lost, not delayed.

NASEM observations from Hurricanes Harvey, Irma, and Maria document the same cold-chain and pharmaceutical-distribution cascade pattern across U.S. disaster experience: maritime-import-dependent populations experience non-recoverable pharmaceutical loss within compressed timelines when port and aviation logistics degrade concurrently with power and fuel disruption [41]. The Arctic case examined here is structurally

analogous to the Puerto Rico under Maria case but operates under more severe geographic isolation and seasonal compression constraints.

As established in the Dependency Mapping section, the Alaska Native Medical Center hub-and-spoke care model concentrates specialty care, surgical capacity, and pharmaceutical distribution at a small number of urban nodes, with weather-limited evacuation as the connection between those nodes and the rural and Western Alaska communities they serve. The risk-assessment implication is that medevac delay is not a logistics inconvenience but the failure mode that converts a survivable medical event into a non-survivable one, and that medevac and pharmaceutical-shortage degradation are not parallel failures but a convergent failure: when both occur concurrently, the affected population loses access to acute intervention and to the maintenance medications (insulin, anticoagulants, antiepileptics, antibiotics) whose interruption produces clinical deterioration on the same Days 0–14 timeline as the disruption itself.

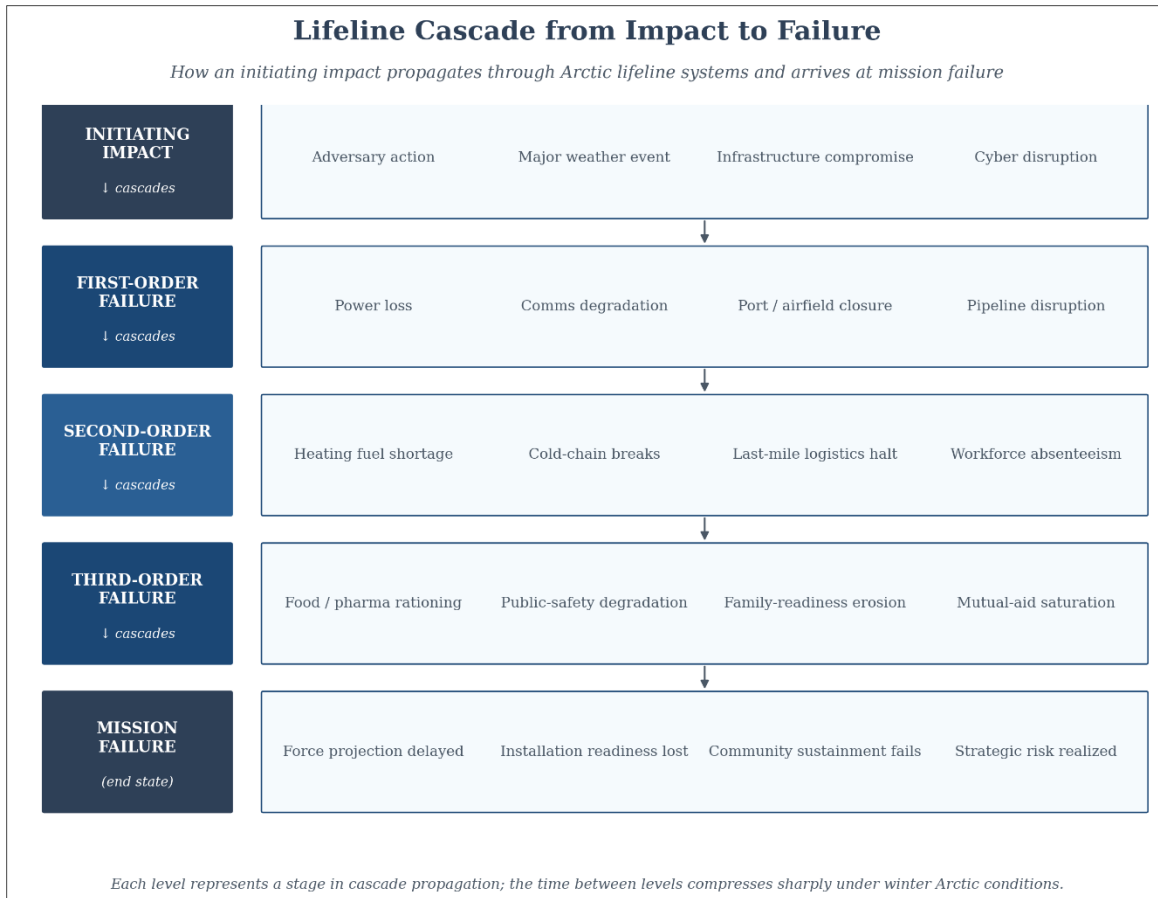
Key Condition: Pharmaceutical cold-chain failure is non-recoverable within the Days 0-14 window. Medical system strain becomes mission-limiting when medevac delays and pharmaceutical shortages converge

Workforce and Community Dependency Vulnerabilities

The workforce dimension is the most systematically underweighted element of current Arctic defense planning, and the literature supports treating it as an operational dependency rather than a quality-of-life consideration. RAND Plan Blue 21 confirms that workforce and institutional capacity become limiting factors as systems degrade, reducing the functionality of otherwise intact infrastructure [22; 45]. Key logistics, aviation, and processing sectors in Alaska depend on transient, seasonal, and external workforce populations whose availability is directly affected by the same supply disruptions the research is examining. The electric power sector illustrates the failure mechanism in concrete terms: a documented shortage of trained linemen, a worldwide transformer shortage affecting repair lead times, and aging infrastructure with no rehabilitation plans [26]. As established in the Dependency Mapping section, this fragility concentrates at the standalone microgrid layer, where repair under scenario conditions requires airlifting personnel and components using fuel that is itself constrained.

Workforce fragility is not evenly distributed across the communities from which Alaska's civilian and contractor workforce is drawn. Communities with compounding pre-existing resilience challenges (economic sector concentration, limited healthcare access, constrained transportation and communications, thin civic organization density) experience workforce degradation on accelerated timelines because they have the least reserve capacity to absorb early shocks. The FEMA Community Resilience Challenges Index provides a federally validated, annually updated empirical framework for identifying these communities before disruption, enabling workforce vulnerability assessment grounded in peer-reviewed indicators rather than general inference [29; 65].

Key Risk Condition: Workforce degradation is not a secondary effect; it is a primary failure pathway, rendering otherwise intact infrastructure non-functional.



Cascade is rarely linear in time; later stages often compress as compounding failures reinforce one another.

Cross-Border Interdependencies as Risk Amplifiers

Cross-border dependencies implicate legal and regulatory chokepoints that informal coordination does not address. The Jones Act can be waived only by the Secretary of Homeland Security upon a finding that the transportation is necessary in the interest of national defense and that no coastwise-qualified vessels are available, a high evidentiary bar requiring advance planning and documentation. The waiver mechanism is recognized in federal supply-chain guidance as a key enabler and chokepoint for OCONUS supply-chain flows.

As established in the Cross-Border Interdependencies and Sovereignty Constraints subsection of the Dependency Mapping section, the Northern Sea Route, UNCLOS Article 234 claims, and the suspension of military security dialogue with Russia since 2014 collectively define a cross-border risk surface beyond Canada. The risk-assessment implication for the dual-theater scenario is that the absence of functional deconfliction mechanisms compresses the time available before military and civilian systems must adapt to a degraded or contested environment, eliminating the rerouting redundancies that benign planning models treat as available at the precise moment they are needed.

Key Condition: Coordination architectures that exist on paper but have not been exercised, formalized through charter, or integrated into lifeline operator business processes do not meaningfully reduce risk during Days 0–14. This is the paper-redundancy condition applied at the governance layer.

Cross-Border Dependency Summary (US–Canada)

Domain	Bilateral Dependency	Failure Implication
Maritime corridor	Seasonal Arctic shipping windows shared between US and Canadian operators	Loss of access constrains both nations' Arctic resupply timing
Energy / pipeline	Canadian pipeline supply contributes to PNW refined product flow	Pressure-balancing requires bilateral coordination during disruption
Communications	Cross-border coordination protocols rely on integrated networks	Force-degrader effects extend across both forces simultaneously
ALCAN Highway	Single road link between Lower 48 and Alaska, traverses Canadian territory	Closure or restriction halves operational mobility options
Search & rescue	Joint US–CAN agreements for Arctic SAR coverage	Capacity gaps emerge if either national capability is reduced
Workforce	Specialty labor and contractors cross border for rotational work	Cross-border restrictions compound workforce attrition

Alaska Native and Tribal Community Dependency as a Risk Amplifier

The tribal-community vulnerability picture identified in the Dependency Mapping section becomes a specific risk-amplifier condition in this assessment. As that section establishes, the Alaska Native governance and economic ecosystem operates barge routes, airstrip operations, and fuel distribution channels that defense supply chains depend on, and the 144 communities documented to face baseline infrastructure stress represent fragility that disruption accelerates rather than creates. The risk-assessment implication for the dual-theater scenario is that workforce availability, last-mile logistics, and local coordination capacity in the regions surrounding installations can degrade faster than the dependency mapping alone would suggest, because the entities that operate those functions are simultaneously absorbing the same supply disruption the assessment is modeling. The amplifier effect is concentrated at the same communities whose pre-existing federal-assistance gaps and limited administrative capacity reduce reserve absorption, producing a cascade timeline that compresses for the populations least able to respond.

Mission Impact Assessment

Mission impact in this assessment is evaluated across five operational categories: force mobilization through constrained northern corridors, sustainment of Arctic and sub-Arctic installations, aviation operations dependent on fuel and maintenance, medical support to personnel and dependents, and operational coordination dependent on communications systems. Each category is evaluated against severity (degraded, constrained, or failed capability), likelihood under scenario conditions, time-to-impact during Days 0–14, and dependency convergence at the time of impact. The convergence dynamic established across the Arctic-Specific Vulnerabilities subsections is the operative analytical input; the cascade narrative that follows develops the operational and community-level consequences that convergence produces.

Cascading Impact Narratives

The cascading failure pathway documented in the Focused Risk and Vulnerability Assessment is not abstract. Under the operative phase conditions of Days 0–14, with cascade propagation extending into Days 10–45 as compounding effects materialize, the cascade produces operational and community-level consequences that arrive on a compressed timeline, in coordinated rather than independent fashion, with reinforcement effects that make each subsequent failure mode harder to address than the one before it.

The narrative that follows is organized by time window rather than by sector because the defense and civilian cascades are not parallel processes operating through separate pathways: they are the same process producing simultaneous, mutually reinforcing degradation across military mission assurance and the communities on which mission assurance depends. Within each window, the defense and civilian lanes describe how the same upstream disruption produces concurrent effects on installations and communities that cannot be analytically separated because the underlying systems are not operationally separable.

Days 0–3: Throughput Degradation and First-Cycle Retail Signal

West Coast port throughput drops below normal operating levels through cyber intrusions, navigation interference, and labor stand-downs that produce compound rather than catastrophic disruption. Container backlogs form at terminals and intermodal transfer points, and maritime carrier scheduling reliability collapses for Alaska routes.

Defense lane. DoD and defense-contractor supply flows routed through the Seattle/Tacoma gateway lose schedule predictability. Defense logistics operators have limited visibility into commercial cargo prioritization decisions, and the absence of pre-defined arrangements with private-sector lifeline providers means that DoD cannot exercise meaningful influence over allocation outcomes during the window when those decisions are being made. Planning assumptions embedded in standing logistics frameworks are invalidated before alternative arrangements are operationally viable. The Days 0–3 window is the period during which the disruption is happening but is not yet

visible to most decision-makers, because supply chain effects propagate ahead of the infrastructure-level signals on which planning frameworks typically rely [26; 49].

Civilian lane. The earliest civilian-visible signal is at the retail and healthcare layer. The four-day Tacoma-to-shelf cycle established in the Dependency Mapping (Layer 1 dependency mapping) means that when West Coast throughput degrades, the retail effect appears within the first cycle [26]. Hospital pharmacy inventories, typically maintained at seven to thirty days of supply, begin showing reorder pressure for high-velocity products including insulin, antibiotics, and oxygen [9]. Most rural communities operate with a single retail food source, meaning that disruption upstream of the Port of Alaska eliminates local fallback capacity entirely rather than shifting demand to secondary providers [6; 38]. Communities served by Bypass Mail and the bush plane network see disruption immediately because the distribution architecture has no buffer; communities served by the Anchorage retail and pharmaceutical pipeline see it within days for the same reason.

Days 3–7: Inventory Drawdown, Allocation Friction, and Household Decisions

Warehouse replenishment falls below demand. Food, fuel, and pharmaceutical inventories intended for northern movement begin drawing down against reserves that were never designed to absorb sustained throughput loss. Multiple lifeline systems begin degrading concurrently rather than in sequence.

Defense lane. Defense-relevant cargo competes with commercial cargo for the same constrained transportation capacity, and the absence of a predefined cargo prioritization mechanism means that allocation outcomes are produced by commercial operators making decisions on commercial logic that does not formally account for defense sustainment requirements. Workforce absenteeism begins climbing as household sustainment needs draw workforce toward home rather than installation. Aviation fuel allocation conversations begin between commercial operators, airfield managers, and DoD logistics staff, and the throughput-versus-capacity distinction becomes operationally salient: airfield capacity exists, but aviation fuel availability and competing medevac and cargo demand begin compressing usable throughput [46]. The institutional gap visible in this window is the absence of pre-established adjudication mechanisms for civilian–military resource competition: installation commanders hold Title 10 authority over on-base resource allocation but have no control over commercial cargo prioritization or civilian workforce availability; state authority can reallocate scarcity across competing populations but cannot create supply; commercial operators make prioritization decisions based on commercial logic. The result is coordination friction that is not a failure of any individual actor but a structural absence of agreed authority and prioritization criteria for decisions being made under time pressure.

By the end of this window, the substitution mechanism most often invoked when maritime supply degrades, aviation surge, fails categorically rather than at the margins. Arctic airfields are simultaneously constrained by weather, fuel, maintenance capacity, and crew availability in ways that compound under scenario stress; space weather adds a non-terrestrial constraint as geomagnetic events disrupt navigation systems and force

rerouting or cancellation of polar flights during the conditions Arctic escalation is most likely to produce. As established in the Berlin Airlift Anchor, air-only sustainment requires conditions that do not apply to the Arctic dual-theater scenario; the cascade in this window runs forward without aviation as an effective substitution release valve.

Civilian lane. As inventory drawdown becomes visible, household-level decision-making about food, fuel, and healthcare access begins. Communities with compounding pre-existing resilience challenges, high unemployment combined with limited vehicle access; thin healthcare capacity combined with low civic organization density, experience these decisions earlier and with less reserve capacity to absorb the consequences. Rural and Western Alaska communities, where dependency on a single retail source is highest, experience the first acute shortages. Households with limited economic reserves face tradeoffs between work attendance and household sustainment. Subsistence harvest activities, where seasonally available, become more critical, but those activities themselves depend on fuel for boats, snowmachines, and aircraft, and the fuel supply chain is itself disrupted. Healthcare clinics and the Community Health Aide Program serving villages with no other clinical presence experience pharmaceutical resupply delays for chronic-disease management; insulin, antibiotics, oxygen, and dialysis supplies are the categories where depletion produces life-threatening outcomes within days [76].

State emergency management planning recognizes this dynamic explicitly: outside assistance to affected communities may require twenty-four hours or more to arrive, establishing an early-phase response gap that local and tribal resources alone must absorb. Survivors will not typically arrive at shelters with a 72-hour household food and water supply, directly contradicting a common planning assumption embedded in national-average emergency frameworks.

In this same window, the pre-existing fragility documented in the Dependency Mapping section converts into the early collapse of last-mile logistics functions managed within the Alaska Native governance and economic ecosystem, producing supply shortfalls in precisely the communities whose institutional resilience options are fewest. Barge routes, airstrip operations, fuel distribution, and local logistics functions that defense supply chains rely on run through or are managed by entities within the Alaska Native governance and economic ecosystem; when maritime logistics degrade, these are among the first systems to experience supply shortfalls and among the last to receive resupply prioritization in frameworks that do not formally account for them. Functional tribal coordination capacity depends on pre-existing relationships between non-tribal institutions and tribal governments that cannot be improvised under disruption conditions [21; 61]. Statutory consultation mechanisms do not substitute for substantive operational engagement.

Days 7–14: Convergence, Workforce Degradation, and Mission Impact

Fuel availability becomes a limiting factor across multiple sectors simultaneously, the medical pathway emerges as the fastest-cascading lifeline failure in the scenario, and the workforce dependency that was forming across the prior windows is now operationally realized.

Defense lane. Aviation fuel allocation decisions force tradeoffs between defense operational aviation, cargo airlift, and medical evacuation. Aviation gasoline for the small bush aircraft network that delivers food and supplies to off-road communities, supplied by a single importer through the Port of Alaska, is constrained at the same time and through the same upstream node that constrains defense fuel availability [26]. Medevac operations face simultaneous fuel, weather, and crew constraints, competing for the same fuel pool as cargo airlift and operational aviation. Cold-chain failure across distribution centers, pharmacies, and clinics produces parallel pharmaceutical loss rather than at a single point. Outside transfer to Seattle for definitive care, the relief valve on which the Alaska healthcare system depends, is closed by the same maritime and aviation disruption affecting all other lifelines.

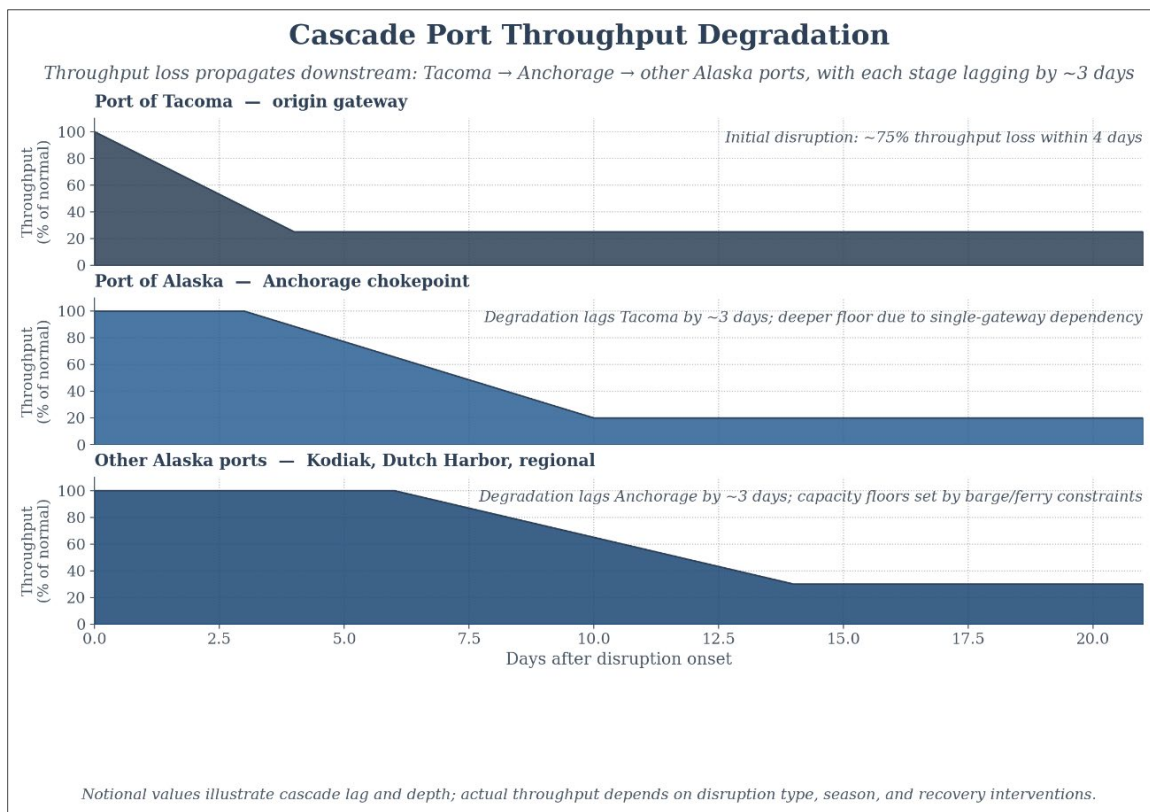
Installation sustainment now depends on a workforce drawn from the same communities the civilian cascade is degrading, and the household decisions of the prior window have now reached the threshold that drives workforce availability. Specialty roles, utility maintenance, medical care, communications operations, fuel handling, are the most consequential because they have the thinnest depth of qualified replacement. The seasonal-workforce concentration risk in the seafood processing sector (the 27,000 H-2B and seasonal-workforce population developed in Vulnerability Assessment, Workforce / Community Dependency Vulnerabilities) is the worked example of workforce fragility acting as a force degrader across multiple lifeline categories from a single disruption pathway.

By Day 14, converging constraints produce mission impacts that are not attributable to any single failure mode. Force projection through northern corridors is constrained by fuel availability, ALCAN throughput limits, and aviation capacity absorbed by competing logistics, operational, and medical evacuation demands. Sustainment of Arctic and sub-Arctic installations is constrained by workforce degradation, fuel allocation tradeoffs, and food and pharmaceutical supply that has not been replenished against initial drawdown. Operational coordination is degraded by communications failures that reduce visibility into logistics status, infrastructure performance, and resource availability. Mission degradation does not arrive as a single recognizable event; it arrives as the accumulation of constraints across systems that were each near baseline before the disruption began.

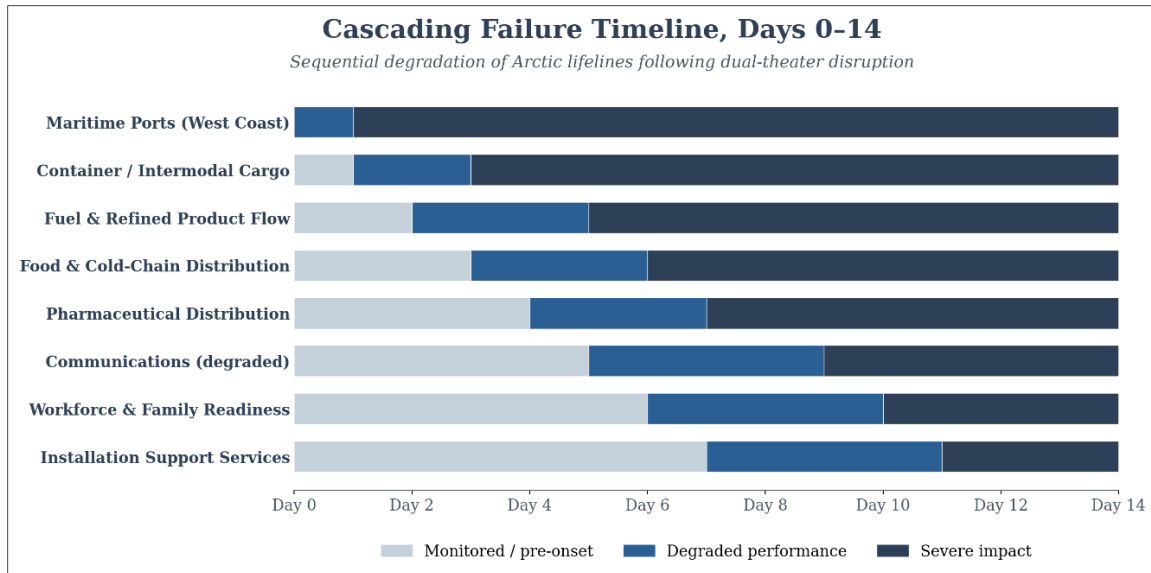
Civilian lane. Civilian healthcare systems experience demand surge from disruption-related injuries, exacerbated chronic conditions, and pharmaceutical access failures. When military dependent and contractor populations draw on the same civilian system because installation medical capacity is exceeded, the binding constraint is specialty staff rather than beds, and specialty staff cannot be flown in under the fuel and aviation constraints the scenario imposes [4]. The Indian Health Service, the Alaska Native Tribal Health Consortium, regional tribal health organizations, and village-level community health aide programs serve communities that commercial and state healthcare infrastructure does not reach; they depend on the same pharmaceutical supply chain, cold-chain infrastructure, medevac network, and fuel availability as the rest of the Alaska healthcare system. Multiple parallel pathways converge on the same constrained upstream resources, with no independent redundancy across them [7; 36].

Heating fuel reserves in rural communities, structured around the fall barge season, are insufficient to bridge to spring resupply. Water and wastewater systems in the 22 percent of Alaska households unserved by utilities face direct degradation as the fuel and power they depend on becomes constrained [26]. The Alaska Mass Care Group and Feeding Task Force [7], which depends on the same commercial supply chain whose disruption triggered the cascade, experiences the paper-redundancy condition directly: the named commercial partners in state feeding doctrine, Sysco, Carrs/Safeway, Fred Meyer, Walmart, Costco, are not redundant to the disrupted system but embedded within it [6].

By the end of the second week, the household-level decisions that began in the prior window produce visible workforce effects across logistics, utilities, healthcare, transportation, retail, and emergency response. The civilian and contractor workforce supporting installation operations experiences absenteeism that intersects with the supply chain degradation that drove household decisions in the first place, a feedback loop in which workforce withdrawal accelerates the supply chain failures that were producing workforce withdrawal.



Throughput losses propagate downstream with damping, but compound at chokepoints; combined effects exceed any single-port loss.



Cross-sector failure propagation across the port degradation window. Cascade timing reflects scenario stress test; actual sector-specific thresholds vary by season and inventory state.

Civilian–Military Convergence

The Days 7–14 window is the point at which the civilian and defense lanes become operationally indistinguishable. Workforce degradation reduces both civilian system functionality and installation sustainment functionality through the same mechanism. Pharmaceutical cold-chain failure destroys both civilian and military-dependent medication supply through the same upstream failure. Aviation fuel allocation forces tradeoffs that simultaneously degrade civilian medical evacuation and defense operational aviation.

The communities, families, and workforce that the civilian lane describes are the same populations on which mission assurance depends. The civilian lane is not a downstream effect of the defense lane; it is a concurrent process operating through the same systems, on the same timeline, with the same driving constraints. Protecting it is not adjacent to mission assurance; it is mission assurance.

The Reinforcement Mechanism

Three specific mechanisms drive the mutual reinforcement that makes the cascade non-linear. First, shared infrastructure means that degradation in any single system simultaneously affects both lanes. Fuel constraints affect both civilian heating and defense operational aviation. Communications degradation affects both retail logistics coordination, command, and control. Pharmaceutical cold-chain failure affects both civilian patients and military dependent populations. The lanes are not analytically separable because the underlying systems are not operationally separable.

Second, workforce dependency means that civilian household-level decisions directly produce defense-side capability degradation: the workforce that installation operations depend on lives in the communities experiencing the civilian cascade, and there is no organizational firewall that separates the two.

Third, governance friction amplifies both lanes. The absence of pre-defined adjudication mechanisms for civilian–military resource competition means that allocation decisions are made under time pressure, with incomplete information, across authorities that have no established shared framework. This friction adds delay to every decision and reduces the effectiveness of any individual mitigation action. The institutional coordination gap is itself a force degrader operating across both lanes simultaneously, and its treatment in the next major section of this report develops the implications for mission assurance planning.

ARCTIC SUSTAINMENT MODES AND REDUNDANCY REALITY CHECK

The most analytically significant finding of this research is the gap between the redundancies embedded in planning documents and the redundancies that actually function under Arctic disruption conditions. Closing that gap is the organizing challenge that the recommendations and the PSEMA network framing address.

This section consolidates the substitution and redundancy analysis distributed across the prior deliverables into a single reality check, organized to make the gap visible at the level of detail that mitigation prioritization requires.

The framework is straightforward. For each redundancy commonly cited in Arctic sustainment planning, the analysis identifies what the redundancy claims to provide on paper, what the redundancy actually delivers under disruption conditions, and what the gap between the two means for the Days 0–14 window. The intent is not to discredit the redundancies, most of them perform real functions under normal conditions, but to clarify the conditions under which they cease to perform the function planning frameworks assume they perform.

The Substitution Inventory: Paper Versus Operational

This section operationalizes the paper-redundancy / operational-redundancy distinction (Glossary) at the level of detail that mitigation prioritization requires. The distinction is not rhetorical; it is the gap between what planning documents assume and what systems actually deliver under Arctic stress, and it is where the highest-consequence planning failures concentrate.

The substitution inventory below evaluates each redundancy commonly cited in Arctic sustainment planning, the modal substitutions (alternate ports, aviation surge, ALCAN overland surge) and the cross-cutting substitutions (backup fuel storage, satellite communications backup, pharmaceutical distribution diversification, state emergency feeding architecture, public-private coordination charters), against the same three-field structure: paper redundancy, operational reality, and Days 0–14 implication. None of the inventoried substitutions function as real redundancies under the conditions this research models.

Maritime Substitution: Alternate West Coast and Southcentral Port

Paper redundancy. Alternate ports appear in planning documents as substitutes for the Port of Alaska under disruption conditions. The 2023 Baseline Assessment identifies six candidates: Seward, Valdez, Kodiak, Homer, Whittier, and MacKenzie [26].

Operational reality. Each candidate requires specific capital investment before functioning as a substitute. Seward requires 200 reefer plug-ins, RO/RO ramp acquisition, and a pre-scripted emergency rail-activation pathway. Valdez requires

ruggedized paired-chassis dollies, weight-restriction exemptions, and crane improvements. Whittier requires construction of a deep-draft cargo port with cranes, ramps, and rail integration. MacKenzie requires conveyor infrastructure, a barge landing, crane pad, fencing, and road improvements. Kodiak and Homer require comparable category-specific investment. Arctic Edge 2025 tested an unimproved Port Mackenzie opening for force-flow reestablishment under exercise conditions, demonstrating that the substitute-port pathway is operationally addressable at the exercise scale but reinforcing the Baseline Assessment finding that container cargo throughput at the scale required by a Port of Alaska disruption is not achievable without the specific infrastructure investments documented above [67]. The documented conclusion of the assessment is explicit: currently, no viable alternative to the Port of Alaska exists, and all options require funding for improvements before they could function as operational redundancy [26].

Days 0–14 implication. Maritime is the primary and dominant sustainment mode on which all other modes depend for their effective volume. Disruption at the West Coast gateways produces immediate, statewide, cross-sector effects. No realistic alternative mode provides equivalent capacity within the analytical window; the alternate-port pathway is a long-horizon investment whose mitigation value lies beyond the scenario window.

Aviation Substitution for Maritime Cargo

Paper redundancy. Airlift is consistently cited in contingency planning as the alternative when maritime routes are disrupted. The wargame literature treats aviation surge as a sustainment option for Arctic operations.

Operational reality. The aviation substitution arithmetic, approximately 700 wide-body cargo sorties to replace one week of Port of Alaska throughput, does not account for fuel, de-icing, crew, runway capacity, turnaround time, or the cold-weather operating constraints that further reduce effective payload per sortie. Arctic airfields are simultaneously constrained by weather, fuel availability, maintenance capacity, and crew availability [26]. Space weather adds a non-terrestrial constraint as geomagnetic events disrupt navigation and force rerouting or cancellation of polar flights [3]. Each sortie also generates a workforce demand at the receiving end that the arithmetic does not capture: ramp crews to marshal and offload aircraft, fuel handlers working in cold-weather PPE at reduced throughput, ground transportation operators to move cargo onward, warehouse and cold-chain personnel to receive and stage materiel, and maintenance technicians to sustain accelerated turn cycles. Surge sortie rates assume surge ground workforce, which Arctic airfields do not have on standby and cannot rapidly import without consuming the same airlift capacity the sorties are meant to deliver. The Berlin Airlift Anchor (Scenario Conditions) establishes the empirical upper bound on aviation-only sustainment under conditions favorable to airlift feasibility and confirms that airlift is a constrained supplemental mode rather than a substitute for bulk maritime capacity; those conditions do not apply to the Arctic dual-theater scenario.

Days 0–14 implication. Aviation is operationally indispensable for high-priority cargo, medical evacuation, personnel movement, and operational lift, but cannot substitute for maritime cargo at the volume sustainment requires. The substitution argument fails

categorically rather than at the margins [46]. Competition between operational aviation, medical evacuation, and logistics use of limited airfield capacity is immediate and zero-sum; every military cargo flight displaces medevac capacity that directly affects civilian and family survivability. Surging additional aircraft into the theater compounds rather than resolves this competition, added sorties draw against the same finite ramp space, fuel stocks, ground crew capacity, and air traffic management bandwidth that medevac and operational lift already depend on, and any deployment of supplemental ground workforce to expand throughput must itself arrive by the same constrained aviation pipeline. The deployment-to-receive workforce dependency identified in Layer 4 applies with particular force here: aviation substitution is not bottlenecked by aircraft availability but by the ground-side human and infrastructure capacity to absorb what the aircraft deliver.

Overland (ALCAN) Substitution: Cross-Border Surge Capacity

Paper redundancy. The Alaska-Canada Highway is cited in planning frameworks as overland surge capacity to substitute for degraded maritime delivery, with theoretical lane capacity of 12,000 to 15,000 vehicles per day across the 1,387-mile corridor.

Operational reality. Operating throughput is approximately 350 vehicles per day, an order-of-magnitude gap below the theoretical ceiling. The corridor crosses approximately 1,200 miles of Canadian sovereign territory, where transit decisions cannot be resolved by U.S. planning authority unilaterally. Optimization requires two distinct investment categories: pre-scripted regulatory pathway activation (weight-restriction waivers, hours-of-service waivers, CDL endorsement coordination, Canadian provincial permitting) achievable within the Days 0–14 window through administrative pre-staging; and physical pre-staging of driver support, lodging, and fuel infrastructure along the route, which is a pre-event capital investment that determines whether theoretical surge capacity is operationally accessible at all [31].

Days 0–14 implication. ALCAN is a constrained-redundancy mode, not a surge alternative. It provides genuine but volume-limited overland capacity subject to Canadian sovereignty, weather closure cadence, and the seasonal-corridor conditions documented in the Dependency Mapping section. The corridor moves real cargo, but absent both investment categories it cannot deliver the volume, speed, or reliability that maritime disruption response requires within the analytical window.

Northern Sea Route: Adversarial-Subject Pathway

Russia's assertion of control over the Northern Sea Route under UNCLOS Article 234 creates a potential rerouting option that could be denied by adversarial action at exactly the moment West Coast disruption makes Arctic routing most necessary [13; 14; 19; 49; 73]. The dual-use nature of Russian Arctic infrastructure means that escalation can convert nominally cooperative transit routes into contested access points with little warning. NSR represents a redundancy whose availability is entirely dependent on conditions outside U.S. planning authority. For the dual-theater scenario, this matters because the NSR could be denied at exactly the moment when West Coast port disruption makes Arctic routing most operationally necessary, eliminating a redundancy at the precise moment it is most needed.

Backup Fuel Supplies and Storage

Paper redundancy. Bulk fuel storage at the Port of Alaska, 3.1 million barrels of liquid fuel storage capacity, and at distribution terminals across the state appears in planning frameworks as a buffer against supply disruption. [26; 44]

Operational reality. Storage levels reflect just-in-time delivery cycles, not strategic reserves. The Days 0-14 implication is that backup fuel storage is a paper redundancy unless pre-positioned product is in place before disruption begins. The Days 0-14 implication is that the substitution argument for backup fuel storage rests not on the existence of in-state refining capacity but on whether pre-positioned product is in place before disruption begins. Aviation gasoline for the bush plane network that delivers food and supplies to off-road communities is supplied by a single importer, with all aviation gasoline flowing through the Port of Alaska, a single-supplier, single-node dependency that makes aviation fuel availability immediately vulnerable to any disruption at the port. Rural communities receive bulk fuel by barge in late fall before ice closes waterways; any additional fuel needed before spring breakup must arrive by bush plane at higher cost and limited volume.

Days 0-14 implication. Storage capacity is not the same as reserve capacity. The fuel architecture is operationally fragile because the storage system functions as a buffer for normal-operations flow rather than as a strategic reserve. Seasonal asymmetry compounds the vulnerability: winter disruption against communities that cannot receive resupply by the primary delivery mode until spring compresses failure timelines from weeks to days.

Satellite Communications as Backup to Terrestrial Infrastructure

Paper redundancy. Multiple commercial satellite systems, Iridium, Starlink, OneWeb, Inmarsat, and traditional GEO providers, are cited in Arctic planning frameworks as redundant communications pathways when terrestrial infrastructure is degraded.

Operational reality. No single satellite architecture provides full Arctic coverage. Bandwidth and latency constraints limit the operational uses each system can support. Commercial provider autonomy means that operators may alter service availability during conflicts based on financial or political considerations, with no governance framework currently requiring them to maintain service or prioritize military traffic. The adversarial-exploitability of communications is documented in the Dependency Mapping. The United States has not formally designated space as a critical infrastructure sector meaning the coordination, liability, and resilience frameworks that apply to other lifeline sectors do not cleanly cover the satellite systems those sectors depend on [12].

Days 0-14 implication. Satellite communications redundancy is a paper redundancy in two distinct senses. First, the technical redundancy assumes that backup systems will function under the conditions that necessitate their use, an assumption directly contradicted by adversarial capability and commercial provider autonomy. Second, the governance redundancy assumes that contractual relationships will produce operational continuity under stress, an assumption directly contradicted by the absence of formal

critical infrastructure designation for the space sector. The Days 0–14 window cannot wait for governance gaps to be closed.

Pharmaceutical Resupply Through Alternative Distribution

Paper redundancy. Pharmaceutical distribution networks include multiple wholesale distributors, mail-order pharmacy services, hospital pharmacy networks, and tribal health system distribution channels, suggesting redundancy through diversified pathways.

Operational reality. The 7-30 day pharmacy inventory threshold (Dependency Mapping) compresses against Arctic delivery cycles, so the operational substitution window for pharmaceutical resupply is shorter than the headline inventory figure suggests. Alaska's position at the end of that pipeline compresses national depletion timelines further. The diverse distribution channels in Alaska, commercial wholesalers, hospital pharmacy networks, the Indian Health Service, the Alaska Native Tribal Health Consortium, regional tribal health organizations, the Community Health Aide Program, depend on the same upstream pharmaceutical supply chain, the same cold-chain infrastructure, the same medevac network, and the same fuel availability. Cold-chain failure across multiple parallel nodes accelerates pharmaceutical loss beyond what single-pathway failure modeling would predict, and products affected by cold-chain failure are not delayed but destroyed.

Days 0–14 implication. The pharmaceutical distribution architecture in Alaska looks redundant in its endpoints but is single-pipeline at the upstream level that disruption affects first. The diverse distribution channels are dependent nodes whose degradation compounds rather than mitigates the capacity gap.

State Emergency Feeding Operations

Paper redundancy. Alaska's Mass Care Group Feeding Support Operations Guide identifies SYSCO, Carrs/Safeway, Fred Meyer, Walmart, and Costco as named commercial partners for emergency feeding response.

Operational reality. The named commercial partners in Alaska's emergency feeding doctrine are not redundant to the disrupted commercial food system; they are embedded within it, drawing from the same upstream supply pathway and reaching the same downstream distribution tier.

Days 0–14 implication. The state feeding system is a paper redundancy in the strict sense: the framework exists, the relationships are documented, the contracts are in place, but the operational capacity the framework describes does not exist independently of the system the framework is supposed to back up. The backup feeding architecture and the primary commercial food system depend on the same upstream nodes. This is a clear instance of paper redundancy without real redundancy at the institutional layer.

Public-Private Coordination Architecture

Paper redundancy. Federal guidance documents formalized private-public partnership frameworks, Business Emergency Operations Centers, executive committees, co-chair structures, formal terms of engagement, as the institutional scaffolding that converts aspirational private-sector cooperation into operationally reliable capacity. Alaska's Partnership for Infrastructure Protection provides a state-level precedent for formalized cross-sector coordination.

Operational reality. Where these mechanisms exist and have been exercised, as documented in the Nebraska Preparedness Partnership's twelve-hour logistics coordination during 2019 flooding and the Houston Supply Chain Group's COVID-19 response pivot, coordination moves at the pace disruption requires. Where they do not exist, coordination must be improvised under time pressure. The presence or absence of pre-established cross-sector coordination architecture directly shapes whether disruptions stabilize or cascade, the paper-redundancy pattern applied at the governance layer. Closing this gap is a pre-incident institutional investment, not a capability that can be improvised during disruption.

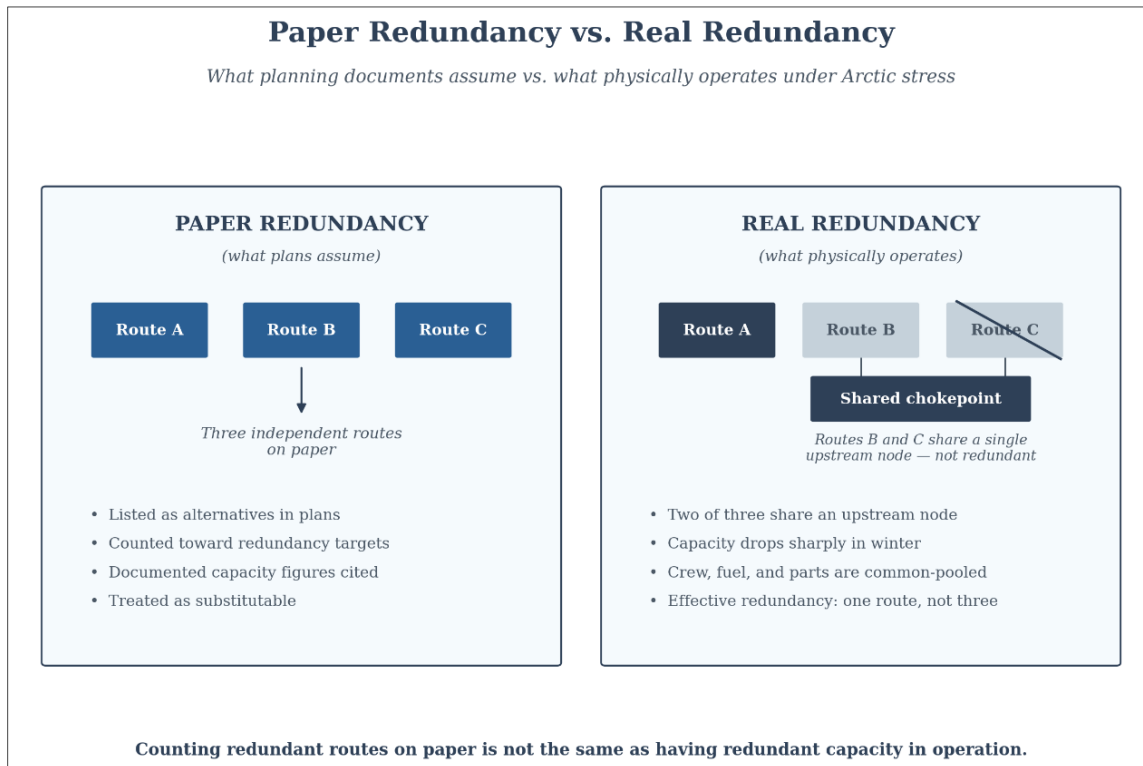
Coordination architectures that exist on paper but have not been exercised, formalized through charter, or integrated into lifeline operator business processes do not meaningfully reduce risk during the disruption window. This is the paper-redundancy condition applied at the governance layer; closing the gap is a pre-incident institutional investment, not a capability that can be improvised during disruption.

Civilian-Versus-Military Competition Across All Modes

The multi-modal picture is further complicated by competition between civilian and military users for the same constrained assets across every mode simultaneously. There is no predefined governance framework for adjudicating this competition. Installation commanders hold Title 10 authority over on-base resource allocation but have no control over commercial cargo prioritization or civilian workforce availability. State authority can reallocate scarcity across competing populations but cannot create supply. Commercial operators make prioritization decisions based on commercial logic that does not account for defense sustainment requirements.

The governance gap this creates is not a coordination problem that better communication solves. It is a structural absence of predefined authority and agreed prioritization criteria for decisions that will be made under time pressure, with incomplete information, across authorities that have no established shared framework. Pre-established governance frameworks and private-sector cargo prioritization agreements are the two highest-return, lowest-capital investments for closing this gap before the next disruption requires those frameworks to exist.

Bottom Line: Arctic lifeline sustainment is not a redundancy architecture that provides equivalent alternatives. It is a hierarchy in which maritime is primary and all other modes provide partial, constrained, and competitive supplementary capacity. Planning that treats aviation or ALCAN as viable substitutes for maritime disruption is planning that accepts statewide shortages as the operational baseline.



Paper redundancy is not real redundancy; alternates that share underlying constraints fail concurrently, not independently.

The Pattern: Paper Redundancy as Systemic, Not Incidental

Reading the substitution inventory in aggregate reveals that the paper redundancy problem is not an isolated planning oversight in any single sector. It is a systemic feature of the Arctic sustainment architecture, present at the maritime, aviation, fuel, communications, pharmaceutical, feeding, and governance layers simultaneously. Three structural conditions explain why.

First, planning frameworks consistently substitute capacity figures for throughput figures. A port that remains physically open but processes cargo at a fraction of required velocity, a highway classified to accommodate thousands of vehicles daily but unsupported by fueling and rest infrastructure at emergency volume, an aviation network with airfield capacity but insufficient fuel, crew, and scheduling throughput to substitute for maritime freight, each of these is a system whose capacity remains nominally intact while its throughput collapses below sustainment requirements. The capacity-versus-throughput distinction is the most operationally significant analytical commitment of this

research, and the paper redundancy pattern is what happens when planning frameworks do not maintain it.

Second, redundancies that share upstream dependencies are not actually redundant against disruptions affecting those dependencies. The pharmaceutical distribution architecture in Alaska looks redundant in its endpoints but is single-pipeline at the upstream level. The state feeding architecture is embedded in the commercial food system it is supposed to back up. The diverse satellite communications providers depend on the same regulatory regime that provides no operational guarantees under stress. Architectural redundancy at the visible layer is not the same as substitution capacity at the layer where disruption actually occurs.

Third, the institutional and governance redundancies that should make physical redundancies operationally executable have themselves not been built to the maturity level that disruption response requires. Coordination frameworks exist on paper at maturity levels that have not been exercised. Pre-incident relationship infrastructure between federal, state, tribal, military, and private-sector actors is episodic rather than formalized. The contractual arrangements that should produce private-sector cooperation under stress do not include the prioritization criteria that would convert cooperation into operationally reliable capacity. The paper redundancy pattern at the infrastructure layer is mirrored by paper redundancy at the governance layer, and the two reinforce each other.

Bottom Line: Paper redundancy is not a problem of planning quality; it is a structural condition of the Arctic sustainment architecture in which the redundancies that exist on paper consistently do not perform under the specific stress conditions the dual-theater scenario imposes. Risk reduction requires closing both the infrastructure-layer gap and the governance-layer gap simultaneously, and neither can be substituted for the other.

Institutional Coordination as a Risk Amplifier

The paper-redundancy principle does not stop at the infrastructure layer. It applies with equal force, and in some cases with greater consequence, to the institutional and governance architectures on which civil-military coordination depends during disruption. This section examines two specific governance instruments whose operational status determines whether coordination architecture functions as operational redundancy or as paper redundancy: the Jones Act waiver framework for emergency maritime capacity expansion, and the FEMA Private-Public Partnership maturity model for cross-sector coordination.

The Jones Act Waiver Framework: Pre-Staging as the Determining Variable

The Jones Act, Section 27 of the Merchant Marine Act of 1920, restricts coastwise transportation of merchandise to vessels that are U.S.-built, U.S.-flagged, U.S.-owned, and U.S.-crewed. The Secretary of Homeland Security may waive these requirements upon a finding that the transportation is necessary in the interest of national defense and that no coastwise-qualified vessels are available to meet the requirement [31; 22]. The evidentiary bar for the second element is high: documentation of non-availability must be specific, current, and capable of supporting a defensible waiver determination.

The FEMA Restoring Flow guide is explicit about the implication for emergency planners. Jones Act waiver capacity expansion is not an emergency tool that can be activated reactively under disruption conditions; it is a pre-incident planning capability that depends on relationships, documentation, and procedural readiness established before the disruption begins. The FEMA Distribution Management Plan Guide identifies the Jones Act as a key enabler and chokepoint for OCONUS supply chain flows, recognizing that rapid maritime capacity expansion requires regulatory mechanisms that are not pre-positioned for Arctic disruption scenarios [31].

Whether the existing pre-incident relationship infrastructure between FEMA, DHS, and Alaska's maritime stakeholders is sufficient to support a Jones Act waiver request within the Days 0–14 window remains an unresolved question. The research treats this as a paper-redundancy condition at the regulatory layer: the waiver mechanism exists, but its operational accessibility under the scenario's compressed timeline depends on pre-staging that, to the best of this research's ability to determine, has not been completed. Waiver pre-staging is therefore identified as a high-return, low-capital near-term recommendation in the Recommendations section that follows.

The FEMA Public-Private Partnership Maturity Model: Where Arctic Jurisdictions Currently Sit

The federal Building Private-Public Partnerships framework, issued in May 2025 in coordination with the U.S. Chamber of Commerce Foundation, the National Emergency Management Association, the National Association of Counties, Big City Emergency Managers, and the International Association of Emergency Managers, formalizes the institutional scaffolding through which commercial lifeline operators and government entities coordinate under disruption conditions [33]. The framework characterizes P3 capacity along a Basic, Intermediate, Advanced continuum.

Basic-tier P3 programs operate through episodic engagement, ad hoc relationships, and resource commitments not formalized through charter or tested through exercises. Intermediate programs operate through formalized relationships with documented terms of engagement, established Business Emergency Operations Center structures, and exercise-based validation of coordination capacity at moderate intensity. Advanced programs operate through institutionalized cross-sector partnerships with co-chair

executive committees, defined membership, exercised procedures, and integration of P3 stabilization targets into joint scenario planning.

Most Arctic jurisdictions relevant to this assessment currently operate at the Basic or low-Intermediate tier. Episodic engagement during named events. Resource commitments not formalized through charter. Coordination procedures not tested through exercise against the dual-theater scenario or its analogs. Where formalized P3 architecture has been built and exercised, the Nebraska Preparedness Partnership's twelve-hour logistics coordination during 2019 flooding, the Houston Supply Chain Group's COVID-19 response pivot, coordination moves at the pace disruption requires [33; 41]. Where it has not, coordination must be improvised under time pressure with predictably degraded results.

Alaska's Partnership for Infrastructure Protection provides a state-level precedent for formalized cross-sector coordination, though its scope and activation parameters under dual-theater disruption conditions remain a subject for follow-on analysis. The Alaska Mass Care Group and Feeding Task Force, led by the Salvation Army under the Alaska Division of Homeland Security and Emergency Management, already operates a functioning multi-agency coordination mechanism integrating state agencies, nongovernmental organizations, tribal contacts, and private-sector food vendors [55]. The Alaska Food Value Chain Coordination Council, convened in October 2025 under the USDA Regional Food Systems Partnership framework, demonstrates that cross-sector coordination infrastructure can be built when given institutional structure [3].

The Permanent Coordinating-Entity Gap

Open-source analysis identifies a structural gap at the federal level: the federal enterprise currently lacks a permanent coordinating entity for anticipating and responding to cross-sector supply chain disruption; existing responses rely on temporary, ad hoc task forces assembled after crises are underway [12]. A pivot-model Supply Chain Intelligence Center housed at DHS Headquarters that would leverage FEMA's Defense Production Act authorities, CISA's Critical Infrastructure Partnership frameworks, and peer-level coordination with DOT, DOC, and ODNI is one proposed remedy [12]. The proposal is significant because it precisely identifies the analytical architecture whose absence concentrates risk in Arctic early-phase disruption.

FEMA's own Supply Chain Resilience Guide establishes a five-phase methodology, Research and Mapping, Analysis, Outreach, Action, Assess and Refine, that operationalizes pre-disaster coordination through structured private-sector engagement, geospatial flow mapping, and public-private exercise stress testing [32]. CNA's Supply Chain Operational Engagement methodology provides an analytically validated framework for conducting that characterization and has already been applied in partial form to Alaska through the SCAN baseline assessment [15; 26]. The methodological scaffolding to close the coordination gap exists. What is missing is the deliberate, sustained application of that scaffolding to Arctic conditions.

Bottom Line: The presence or absence of pre-established cross-sector coordination architecture directly shapes whether disruptions stabilize or cascade. Coordination architectures that exist on paper but have not been exercised, formalized through charter, or integrated into lifeline operator business processes do not meaningfully reduce risk during Days 0–14. This is a direct application of the paper-redundancy principle to the governance layer: the existence of a framework is not equivalent to the operational capacity the framework describes. Closing this gap is an institutional investment with a pre-incident horizon, not a capability that can be improvised during disruption.

Contested Logistics: The Doctrinal Frame

The contested-logistics literature developed since 2022 provides the doctrinal frame within which institutional coordination becomes operationally significant. The literature is unusually convergent across independent sources on three claims that bear directly on Arctic mission assurance. Senior Army leadership articulated the contested-logistics priority at AUSA 2023, characterizing sustainment under contested conditions as a defining institutional challenge for the service over the coming decade and not a residual logistics concern [79].

First, sustainment is the pacing function in modern conflict. The 2025 National Defense Strategy and the contested-logistics modernization writing developed within the Department of Defense, Army Materiel Command's five sustainment imperatives, the Unified Pacific Wargame Series, the Naval Postgraduate School theses on supply chain resilience and crisis-standards prioritization, converge on the conclusion that the operational tempo of modern conflict is set by the rate at which sustainment can flow through pipelines that adversaries actively contest, not by the rate at which forces can maneuver. The Army's establishment of the Contested Logistics Cross-Functional Team in 2023 and the institutional priority articulated in the five sustainment imperatives, predictive logistics, autonomous reach, reduced logistics tail, alternative fuels, and Army watercraft strategy, establish that the analytical framing employed in this research reflects a recognized category of strategic vulnerability rather than a theoretical construct [34; 48; 64; 70].

Second, the homeland is no longer a sanctuary. Adversary actions can obstruct and disrupt power projection and sustainment operations within the United States, including through cyber intrusion, infrastructure interference, gray-zone tactics, and adversarial influence operations. The 2025 National Defense Strategy explicitly names the simultaneity problem, the possibility that adversaries could act in a coordinated or opportunistic fashion across multiple theaters and identifies adversary influence extending across the Arctic [42]. The dual-theater disruption scenario this research employs is structurally consistent with the simultaneity problem the current governing strategy identifies as a primary planning challenge.

Third, the commercial supply architecture optimized for cost efficiency under normal conditions is structurally vulnerable under contested conditions. Tight coupling produces

operational tempo but concentrates exploitable vulnerability at pipeline nodes; loose coupling creates the gaps between supply nodes where cascading failure most readily takes hold. The Arctic commercial lifeline architecture exhibits both conditions simultaneously, as the dependency mapping section of this research documents in detail. The contested-logistics literature converges on a conclusion that bears directly on the institutional coordination question: the response to contested logistics requires commercial and international partnership solutions that the current architecture does not adequately provide. Fuel delivery, identified as the ultimate last-mile challenge in contested environments, illustrates the convergence: the fuel supply chain depends on commercial operators, commercial vessels, commercial refining capacity, and commercial distribution infrastructure, none of which is under direct DoD control, all of which require coordination architecture that does not yet exist at the maturity level the scenario requires.

Doctrinal Implication: The contested-logistics literature establishes that institutional coordination between defense and commercial actors is not adjacent to mission assurance, it is mission assurance. The connective infrastructure that enables coordination at the pace and depth modern conflict requires is the high-priority preparatory investment whose return is realized before disruption rather than during it.

Convergent Conclusion: Why Coordination Is the Risk Amplifier

The three treatments above, the P3 maturity model, the Jones Act waiver framework, and the contested-logistics literature, converge on the same operational conclusion. The capacity to adjudicate civilian–military resource competition, route emergency authorities through interagency review, and translate between defense mission requirements and commercial operating logic does not exist at the maturity level the dual-theater scenario requires. Each instance of paper redundancy at the infrastructure layer is mirrored by a corresponding paper redundancy at the institutional layer.

Three specific institutional gaps deserve explicit identification. First, the absence of pre-defined adjudication mechanisms for civilian–military resource competition means that allocation decisions are made under time pressure, with incomplete information, across authorities that have no established shared framework. Installation commanders hold Title 10 authority over on-base resource allocation but have no control over commercial cargo prioritization or civilian workforce availability. State authority can reallocate scarcity across competing populations but cannot create supply. Commercial operators make prioritization decisions based on commercial logic that does not formally account for defense sustainment requirements.

Second, cross-border coordination architecture is structurally underdeveloped. The RAND governance gaps analysis finds existing mechanisms inadequate for the pace of change now underway. Security dialogue mechanisms have atrophied since 2014. The ALCAN corridor, the Northern Sea Route, and the bilateral agreements with Canada that the dual-theater scenario implicates each operate within a coordination architecture that was not designed for simultaneous, multi-theater disruption.

Third, the connective infrastructure between defense, commercial, nongovernmental, tribal, and academic actors that contested-logistics doctrine identifies as essential does not currently exist at the maturity level Arctic mission assurance requires. Episodic engagement, transactional contracting, and incident-response-only coordination are different from a sustained, trust-based, operationally tested intermediary architecture that can translate between defense mission requirements and the privately operated systems that sustain them. This is the institutional gap that frames the recommendations and the PSEMA network section of this report.

Bottom Line: Institutional coordination is not a passive backdrop to the cascading failure pathways this research documents. It is itself a primary cascade trigger, and its absence operates as a risk amplifier on every other failure mode.

PRELIMINARY MITIGATION AND COST-BENEFIT PRIORITIZATION

The Preliminary Mitigation and Cost–Benefit Prioritization deliverable moves from vulnerability identification to actionable response. It evaluates high-impact resilience options against five operational criteria, Mission Impact, Cascade Risk, Time Sensitivity, Feasibility, and Dual-Use Value, and identifies the limited set of preparatory investments whose return is realized before disruption rather than during it. The framework is intentionally structured to surface the gap between paper redundancies and operational redundancies, and to distinguish investments that close that gap from those that simply formalize a redundancy that does not function under stress.

The mitigation framework below addresses the failure pathways that emerge under the scenario conditions documented in the Scenario Framework section. The framework is operational in posture, not doctrinal: each mitigation category identifies what the investment is, why it ranks where it does, what its limits are, and how it interacts with the other categories. The objective is not a comprehensive Arctic resilience inventory; it is the limited set of investments that the analytical record identifies as most consequential for closing the gap between current capacity and what the dual-theater scenario requires.

Implication for Mitigation Strategy

Operative phase for this section: Days 0–14 as the decision window, with mitigation timelines evaluated against extension into Days 10–45. Full scenario architecture is developed in the Scenario Framework section.

The operating environment laid out in the research reorders mitigation priorities. Mitigation must prioritize early-phase survivability, throughput preservation rather than infrastructure protection alone, and cross-sector cascade prevention, not as separate workstreams but as integrated design criteria applied to each candidate intervention.

Four implications follow directly from the dependency map and scenario architecture:

Days 0–14 is the decision window, not the response window. Sustainment decisions are made under uncertainty, before federal augmentation arrives, and before the cascade has fully propagated. Mitigation investments that come online after Day 14 address conditions that are already established. Survivability investments must be pre-positioned, pre-coordinated, and pre-authorized to take effect inside this window.

Throughput, not capacity, is the operative metric. The dependency mapping establishes that infrastructure can remain nominally intact while throughput collapses below the level required to sustain the mission. Mitigation strategy must therefore evaluate candidate investments on their contribution to sustained operational throughput under degraded conditions, not on their nameplate capacity or theoretical redundancy. Paper redundancy is not redundancy.

Cascade prevention requires upstream intervention. Because fuel and communications sit at the head of the dependency chain, mitigation directed at downstream symptoms, food shortages, workforce attrition, household instability, addresses outputs of a cascade already in motion. Early-phase mitigation must be directed at the cascade triggers (maritime chokepoints, fuel storage and delivery, communications continuity, and the coordination architecture that links them) to prevent the propagation that drives downstream failure.

Private-sector lifelines must bear more of the early-phase sustainment burden. The dependency map confirms that the systems that fail first are commercially operated: ports, fuel distribution, food wholesale, communications carriers, and pharmaceutical distribution. These are the substrate on which mission assurance depends during the operative phase before federal sustainment can arrive. Mitigation strategy must therefore engage commercial operators as mission partners, not as regulated entities or contracted vendors.

The executive framing localizes to the Arctic theater and to its privately operated lifeline systems the simultaneity problem the 2025 National Defense Strategy identifies as a primary planning challenge across the Western Hemisphere (developed in the Institutional Coordination section) [70].

The remainder of this report develops the calibration that follows from this reordering: a prioritization framework, candidate mitigations evaluated against mission impact, cascade risk, time sensitivity, and cost-benefit, and the early-phase investments most likely to preserve throughput across the window in which the cascade is decided.

Prioritization Framework

Five criteria structure the evaluation of candidate mitigations. Mission Impact captures the degree of degradation to NORAD and USNORTHCOM operations when the candidate system fails or, conversely, the degree of mission preservation when the candidate mitigation operates as designed. Cascade Risk captures the cross-sector failure propagation potential of the system the mitigation addresses; ports, energy, and communications carry the highest cascade risk because their degradation initiates failures across multiple downstream lifelines simultaneously.

Time Sensitivity captures the failure timeline in hours and days under disruption conditions; food, fuel, and communications degrade most rapidly. Feasibility captures the implementation complexity in Arctic conditions, where infrastructure and workforce constraints raise the cost and lengthen the timeline of nominally straightforward investments. Dual-Use Value captures the civil and military benefit of the candidate, with the highest-return investments reinforcing whole-of-society resilience rather than serving narrow operational segments.

Extreme concentration risk.

The Port of Alaska handles five times more inbound marine cargo than any other Alaska port and is non-substitutable within the Days 0–14 window. The Seattle/Tacoma–Port of Alaska corridor is the dominant maritime resupply pathway for Southcentral Alaska. The same West Coast gateways are simultaneously the staging arteries for Pacific–Arctic defense logistics, meaning a single chokepoint sits at the convergence of civilian and defense supply chains.

Minimal redundancy and limited substitution capacity

Alternative pathways such as ALCAN, aviation, and Southcentral port substitution exist on paper but cannot deliver required throughput within the Days 0–14 window. This is the operational meaning of the paper-redundancy condition: capacity exists nominally, but throughput collapses below the level needed to sustain the mission.

Energy as the master dependency across all systems

The dependency chain Fuel → Power Generation → Heat → Water Systems → Communications → Operational Coordination governs all downstream lifeline behavior. As established in the Dependency Mapping section, the Alaska energy architecture is bimodal: the centralized Railbelt grid carries the majority of state electricity through a single interconnected corridor, while approximately 150 standalone microgrids serve geographically isolated communities outside that corridor without mutual-aid substitution. Fuel disruption simultaneously disables the response capacity that would otherwise compensate for the initiating event, and the bimodal architecture concentrates that compounding effect at the standalone-microgrid population, which has the fewest substitution options under the dual-theater scenario.

Communications as the coordination spine and failure amplifier

Communications systems depend on stable power and environmental conditions and degrade as a function of upstream energy failure. In contested or degraded conditions, communications failure operates as a force degrader, propagating across multiple lifeline categories from a single point of failure and disabling the coordination architecture on which civil–military response depends.

Rapid degradation timelines driven by just-in-time supply chains

Many Arctic systems operate with minimal buffer capacity, meaning upstream supply chain disruptions translate into localized shortages within days, particularly for food, fuel, and medical supplies. Seasonal asymmetry compresses these timelines further: winter disruptions eliminate the barge resupply window entirely, collapsing failure intervals from weeks to days because depleted reserves cannot be replenished until thaw.

These characteristics are not independent. They compound through a common cascade pathway in which a single chokepoint degradation propagates across energy, communications, food, medical supply, and workforce systems within the same compressed window in which sustainment decisions must be made under uncertainty.

Mitigation Prioritization Criteria

The five criteria are not weighted equally. Mission Impact and Cascade Risk are the primary criteria for ranking categories against one another. Time Sensitivity refines the prioritization within high-Mission-Impact categories by distinguishing investments that produce Days 0–14 benefit from those whose return is realized only over longer horizons. Feasibility shapes the recommendation pathway for each category, what can be done now, what requires capital investment with multi-year horizons, and what depends on regulatory or coordination architecture that must be built before it can operate. Dual-Use Value strengthens the case for any category that produces benefit beyond the defense mission, particularly in jurisdictions where investment decisions are shaped by civilian and tribal stakeholder priorities.

Mitigation Prioritization Matrix					
Five-criteria framework for evaluating Arctic resilience investments					
	Mission Impact	Feasibility	Time to Deploy	Cost Efficiency	Cross-Sector Reach
Energy Resilience (microgrids, fuel buffers)	5	4	3	4	5
Port & Maritime Throughput Hardening	5	3	2	3	5
Communications Redundancy (sat / deployable)	5	4	4	4	5
Multi-Modal Logistics Redundancy	4	3	3	3	4
Workforce & Maintenance Sustainment	4	4	3	4	3
Food & Critical Supply Buffering	3	5	4	4	3
Coordination Architecture & P3 Development	4	5	5	5	4
Score:	1	2	3	4	5
1 = low / low-impact 5 = high / high-impact					

Each mitigation option is scored against all five criteria; the composite score informs tier placement in the recommendations roll-up.

The prioritization shown in the above image reflects the interaction of five evaluation criteria, applied consistently across all categories analyzed. Together, these criteria produce the relative ordering displayed in the matrix and form the basis for the tiered recommendations that follow. The criteria are defined below; with the relative weight each carries in the overall prioritization.

Mitigation Prioritization Criteria and Definitions

Criterion	Definition	Scoring Range
Impact magnitude	How much risk does the option reduce, and how broadly?	0–3 points
Time-to-effect	How quickly can the option be in place and operationally effective?	0–3 points
Cost efficiency	Risk reduction achieved per dollar of investment	0–3 points
Implementability	Authority, feasibility, contracting, and partnership requirements	0–3 points
Sustainability	Whether the option creates durable, not one-time, capability	0–3 points
Composite	Sum across all five criteria; informs tier placement	0–15 points

Priority Mitigation Categories

The risk and vulnerability assessment conducted under this research identifies seven mitigation categories that, applied in integrated fashion, materially reduce cascade risk during the Days 0–14 disruption window and beyond. The categories are structurally interdependent; failure in one accelerates degradation across the others. The integrated prioritization that closes this section reflects the strategic value each category contributes to the system as a whole, not a substitution hierarchy in which higher-ranked investments displace lower-ranked ones.

Each category targets a distinct point in the cascade chain, energy at the master-dependency layer, port and maritime throughput at the system's primary intake, communications across the coordination spine, multi-modal logistics in the distribution layer, workforce and maintenance in the operational layer, food and critical supply at the consumption layer, and coordination architecture spanning the entire chain. Together they constitute a layered mitigation architecture in which the value of each category compounds as adjacent categories are addressed in parallel. Investments made in only one or two categories produce limited returns; the resilience benefit emerges from coordinated investment across the set. The categories that follow are presented in order of priority for the Arctic mission-assurance context, but their integrated character means each remains essential regardless of where it falls in the ranking.

Fuel and Energy Resilience

The Dependency Mapping and Risk Assessment sections establish fuel as the master dependency in the Arctic operating environment. Energy resilience therefore ranks first in this prioritization: every other mitigation operates at degraded effectiveness, or fails outright, when the fuel and energy layer is not addressed.

Cost-Benefit Snapshot: Distributed Microgrids (Hybrid Systems)

Cost driver: Capital cost of hybrid generation, storage, and renewable inputs; sustained workforce and maintenance investment is the binding cost factor, not equipment.

Benefit driver: Reduces fuel-import exposure at the standalone microgrid layer where mutual aid is unavailable; reliability-over-penetration design hedges against the workforce-airlift-fuel cascade.

Feasibility: Moderate. Limited by trained-lineman shortage, transformer lead times, and the absence of mutual aid agreements at the standalone-microgrid population.

Time horizon: Medium to long. Hardware deploys on a multi-year horizon; operational benefit requires sustained workforce investment in parallel.

Cost-Benefit Snapshot: Increased Fuel Storage and Pre-Positioning

Cost driver: Capital cost of refined-product storage capacity, distributed across regional and installation locations; calendar timing constraint dominates capital cost as a planning variable.

Benefit driver: Extends the sustainment window beyond the documented 7–10 day commercial inventory threshold; the only mitigation in this category that delivers Days 0–14 benefit reliably.

Feasibility: High when executed before fall barge season closure; categorically infeasible after ice-in until spring breakup if reserves were not pre-positioned.

Time horizon: Short. Pre-positioning effectiveness is determined by calendar timing rather than capital investment and supports Days 0–14 sustainment if executed pre-event.

Cost-Benefit Snapshot: Regional Energy Hubs

Cost driver: High capital cost for shared infrastructure (distributed storage, hybrid generation, interoperable grid capacity) serving communities, installations, and other critical nodes.

Benefit driver: Hedges against two converging risks: scenario disruption and the projected 2030 Cook Inlet natural gas depletion. Dual-use civilian and installation benefit aligns with NSM-22 and DoDD 3020.40 [26; 69;80].

Feasibility: Moderate. Multi-stakeholder coordination across communities, installations, and utilities is the binding feasibility factor; technical engineering is well-established.

Time horizon: Long. Hub investment is a multi-year commitment whose value materializes regardless of whether the scenario occurs.

Cost-Benefit Snapshot: Pre-Scripted Regulatory Waiver Protocols

Cost driver: Administrative effort only; no capital investment, no construction timeline, no workforce expansion. Cost is in pre-event documentation and interagency coordination.

Benefit driver: Compresses Jones Act, weight-limit, hours-of-service, CDL endorsement, and Canadian provincial waiver activation timelines from real-time crisis adjudication to pre-staged activation; return is measured in days saved when days are most expensive.

Feasibility: High. Waiver mechanisms exist in current federal and state frameworks; pre-staging is achievable within current authorities without legislative change.

Time horizon: Short. Activation occurs within the Days 0–14 window if pre-staging is complete; the highest-return-per-dollar option in this category.

Coordination Architecture & Private-Public Partnership Development

The Risk Assessment section and the Substitution and Redundancy Reality Check establish coordination architecture as a risk amplifier in its own right. The four options developed below address that coordination gap and the tempo mismatch stakeholder engagement specifically surfaces: commercial supply chains operate on hours timelines while government activation operates on days' timelines, and pre-staged architecture must include commercial-pace activation triggers.

The disaster-diplomat framing developed in the homeland security practitioner literature characterizes the emergency management function not as a technical or logistical role but as a sustained cross-sector intermediation function whose effectiveness depends on pre-incident relationship investment rather than incident-response activation [53]. The framing is directly applicable to the Arctic civil–military adjudication gap this section addresses.

Cost-Benefit Snapshot: Formalize Cross-Sector Coordination Charters

Cost driver: Relational and institutional investment; modest documentation and convening costs. Building from established precedent (Alaska Partnership for Infrastructure Protection) reduces baseline cost.

Benefit driver: Converts episodic coordination relationships into documented capability that survives personnel transitions, jurisdictional changes, and the operational pace of disruption. Business Emergency Operations Center architecture pre-establishes authority, information flow, and decision sequencing.

Feasibility: High. Builds on existing federal and state frameworks; charter expansion or parallel charter development to cover civil-military adjudication is the principal feasibility step.

Time horizon: Short to medium. Charter formalization is achievable within months; exercised operational capability requires a multi-year exercise cadence.

Cost-Benefit Snapshot: Advance Program Maturity

Cost driver: Sustained relationship and exercise investment over multi-year horizon; funding for personnel continuity, exercise programs, and stabilization-target framework integration.

Benefit driver: Movement from Basic toward Advanced P3 tier produces compounding capability across successive disruption cycles; converts coordination from a personal-relationship dependency into a documented, exercised capability.

Feasibility: Moderate. Capability does not exist at scenario-required level today; advancement requires sustained pre-event investment that current funding cycles do not consistently support.

Time horizon: Long. Multi-year horizon; Days 0–14 benefit depends entirely on pre-event maturation and cannot be reconstituted at pace once disruption is underway.

Cost-Benefit Snapshot: Resource the Disaster Diplomat Function

Cost driver: Personnel cost: emergency management staffing positions and defined authority at state and local levels matched to scenario-conditioned coordination demand rather than to historical disaster experience.

Benefit driver: Operates as the workforce precondition for charter formalization and program maturity; absent staffing, the preceding two options produce documented architecture without personnel capacity to operate it [53].

Feasibility: High administratively (staffing positions and authority definition); moderate politically and fiscally because emergency management capacity is typically resourced against historical disaster experience.

Time horizon: Short to medium. Personnel hiring and authority definition is achievable within current cycles once funding is committed; full coordination capability requires sustained tenure.

Cost-Benefit Snapshot: Leverage Existing Federal Methodology and Data Infrastructure

Cost driver: Application cost rather than development cost; FEMA Supply Chain Resilience Guide five-phase methodology and CNA SCOPE framework are validated outside Arctic context and partially applied within it [33].

Benefit driver: Highest analytical return per dollar in this category because foundational methodology development is complete; requirement is application and adaptation, not invention. Aligned NSM-22 and 2025 NDS policy substrate further reduces speculative risk [70].

Feasibility: High. Federal methodology, partial Arctic application, proposed Supply Chain Intelligence Center architecture, and aligned policy substrate position this option as materially less speculative than equivalent investments in less-developed analytical domains.

Time horizon: Short to medium. Methodology application begins immediately; integrated federal coordinating architecture is a multi-year build operating against established precedent.

Port and Maritime Throughput Resilience

The Dependency Mapping and Risk Assessment sections establish the Port of Alaska as a no-fail node with no rapid substitute. The three options developed below operate against a substitution baseline of zero: redundant port capacity addresses the long-horizon investment gap, pre-positioned stockpiles address the Days 0–14 window where substitution is unavailable, and surge offload capability addresses the intermediate gap between the two.

Cost-Benefit Snapshot: Redundant Port Capacity

Cost driver: Very high capital cost across the six 2023 Baseline Assessment alternatives (Seward, Valdez, Kodiak, Homer, Whittier, MacKenzie); each requires specific infrastructure investment before functioning as substitute.

Benefit driver: Long-horizon strategic resilience against the Port of Alaska single-point-of-failure condition; addresses the vulnerability the Baseline Assessment confirms has no current viable alternative.

Feasibility: Low to moderate. Every identified option requires capital investment before functioning as real redundancy; financing pathway, environmental permitting, and rail/road integration are binding constraints.

Time horizon: Long. Multi-year construction horizon places mitigation value beyond the scenario window; near-term burden falls to pre-positioned stockpiles and surge offload.

Cost-Benefit Snapshot: Pre-Positioned Strategic Stockpiles

Cost driver: Moderate capital cost for stockpile depth across fuel, food, and repair materials; geographic distribution across Seward, Valdez, Fairbanks, and JBER drives deployment cost more than per-unit inventory cost.

Benefit driver: The only option in this category capable of producing operationally meaningful effect within the Days 0–14 window; bridges the gap between disruption onset and substitution availability.

Feasibility: High. Storage infrastructure, inventory rotation, and geographic distribution are well-understood operational requirements; binding constraint is sustained funding for inventory rotation rather than initial deployment.

Time horizon: Short. Pre-positioning delivers Days 0–14 benefit if stocks are in place before disruption occurs; the lowest-capital, shortest-horizon option in this category.

Cost-Benefit Snapshot: Surge Offload Capability

Cost driver: Very high capital cost for polar icebreaker fleet expansion (current operational fleet of two against documented 8–9 vessel requirement) and shore infrastructure investment (more than seven billion dollars in backlog) [68; 21].

Benefit driver: Theoretical intermediate pathway between near-term stockpile reliance and long-horizon port construction; retains marginal value for targeted resupply of installations and high-priority community nodes.

Feasibility: Low to moderate. Polar Security Cutter program cost growth and schedule delay defer fleet capacity; no deep-draft port exists within 800-plus miles of the Bering Strait.

Time horizon: Long. Cannot be assumed available at scenario-required scale and location within the operational window; not a reliable category substitute for Port of Alaska throughput.

Communications and Data Resilience

The Dependency Mapping and Risk Assessment sections establish communications failure as the force degrader operating across every other lifeline category. The three options developed below therefore address a vulnerability whose effects compound across all six other mitigation categories in this section.

Cost-Benefit Snapshot: Multi-Layer Communications Architecture

Cost driver: Moderate to high capital cost for LEO/HEO satellite capacity, HF radio backup, and terrestrial redundancy; contractual and policy reinforcements (liability, segmentation, cybersecurity standards) add policy-development cost.

Benefit driver: Foundational mitigation pathway for Arctic communications resilience; produces real redundancy when each layer carries essential traffic independently of the others rather than sharing upstream nodes.

Feasibility: High technically; moderate at the governance layer. Space is not formally designated critical infrastructure, so coordination, liability, and resilience frameworks do not cleanly apply to the commercial satellite systems Arctic operations depend on.

Time horizon: Medium. Satellite capacity contracting and HF backup deployment achievable within months; correlated-failure architectural review is the analytically time-consuming step.

Cost-Benefit Snapshot: Protected & Resilient Networks

Cost driver: Capital cost for anti-jam capability, redundant pathway design, and subsea cable risk mitigation; correlated-failure analysis adds analytical cost as the most underweighted element of current Arctic communications planning.

Benefit driver: Addresses threat-side and physical-infrastructure-side vulnerabilities multi-layer architecture alone does not resolve; cable repair under Arctic winter conditions cannot be assumed within the Days 10–45 escalation window.

Feasibility: Moderate. Anti-jam capability and pathway redundancy are established technical disciplines; subsea cable risk mitigation is constrained by vessel availability, ice conditions, and seasonal repair envelopes.

Time horizon: Medium to long. Anti-jam capability deployable on shorter horizons; subsea cable redundancy and landing-point diversification are multi-year infrastructure investments.

Cost-Benefit Snapshot: Data & Monitoring Expansion

Cost driver: Moderate capital cost for SCADA expansion across fuel storage, electric generation, water and sanitation, and transportation nodes; real-time logistics visibility platform integration is the principal cost driver.

Benefit driver: Converts the other communications capabilities into decision capabilities; in the Days 0–14 window, materially shortens the interval between failure onset and decision-maker awareness when substitution options are closing fastest.

Feasibility: High. SCADA, remote diagnostics, and logistics-visibility technologies are mature; binding constraint is operator integration and pre-event sensor placement.

Time horizon: Short to medium. Sensor deployment and platform integration achievable within months to a year; full multi-modal logistics visibility requires sustained operator coordination.

Workforce & Maintenance Capacity (Hidden Dependency)

The Dependency Mapping section and the Stakeholder Engagement findings establish workforce degradation as a force degrader and the most binding operational constraint across sectors. Hardware redundancy alone cannot resolve this constraint; an idle pre-positioned generator, a grounded reefer container, or a parked tanker delivers no operational value when the certified operators, mechanics, and dispatchers required to run them are absent or unreachable. The Arctic compounds this dependency through small population centers, narrow specialty pipelines, and seasonal contraction in the available workforce, conditions that mean a localized illness cluster, a single retirement, or a cross-border travel restriction can disable capability that no amount of capital investment can replace on the same timeline. The three options developed below address the operator-and-maintainer dependency that hardware availability cannot resolve on its own, with each option targeting a different layer of the workforce-resilience problem: building local capacity, sustaining the technicians who maintain installed systems, and broadening the skill pool so single-point-of-failure roles do not bring entire sectors to a halt.

Cost-Benefit Snapshot: Local Workforce Development

Cost driver: Sustained multi-year investment in technical trades training across energy, infrastructure maintenance, and logistics; training infrastructure, instructor capacity, and apprenticeship programming.

Benefit driver: Mitigates the binding workforce constraint identified throughout the research; reduces sustained dependence on personnel deployment under exactly the conditions that make personnel deployment most difficult.

Feasibility: Moderate. Training infrastructure exists in partial form; binding constraint is multi-year horizon between investment and operational workforce delivery.

Time horizon: Long. Trade-skilled workforce development operates on multi-year horizons that do not deliver Days 0–14 benefit but determine whether Days 0–14 response continues to depend on flown-in personnel.

Cost-Benefit Snapshot: Regional Maintenance Hubs

Cost driver: Capital cost for pre-positioned equipment, tools, and spare parts at hub locations plus sustained operator presence; geographic catchment design and transportation pathway investment.

Benefit driver: Reduces maintenance response distance and time at the standalone microgrid layer; addresses the geography problem that workforce development alone cannot resolve.

Feasibility: Moderate. Three-component (parts, personnel, transportation) integration is the binding feasibility factor; hubs designed without all three reproduce paper-redundancy condition.

Time horizon: Medium. Hub establishment achievable within a year to two; sustained operator capacity at hub locations requires ongoing workforce investment.

Cost-Benefit Snapshot: Cross-Training Across Lifelines

Cost driver: Moderate cost for multi-lifeline training curriculum development and instructor capacity across power, water, communications, and fuel systems; cost concentrated in remote-community training delivery.

Benefit driver: Expands the available trained-personnel pool in remote communities where the population base does not support specialized full-time positions; produces redundancy against operator unavailability that single-discipline staffing cannot absorb.

Feasibility: High. Multi-skilled-operator training is established practice in remote-community contexts; binding constraint is sustained training delivery to the rural communities where the option produces most benefit.

Time horizon: Short to medium. Initial cross-training certifications achievable within months; full multi-lifeline operator pool requires sustained training cadence.

Multi-Modal Logistics Redundancy

The Dependency Mapping section, the Risk Assessment section, and the Berlin Airlift Anchor establish the Arctic modal hierarchy as maritime-primary with aviation and overland routes in critical-but-capacity-limited and constrained-redundancy tiers. The three options developed below must therefore be evaluated against airfield throughput ceilings, ALCAN seasonal and sovereignty constraints, and the integration vulnerability at handoff points. Multi-modal redundancy is real-redundancy only when the integration mechanism that synchronizes modes is itself pre-staged.

Cost-Benefit Snapshot: Pre-Identified Rerouting Plans

Cost driver: Two distinct cost categories: pre-scripted regulatory pathway activation (administrative effort, low capital) and physical pre-staging of driver support, lodging, and fuel infrastructure along the corridor (high capital, multi-year horizon).

Benefit driver: Activates the constrained-redundancy ALCAN tier as an operationally accessible substitution mechanism; community last-mile delivery (sled teams, snowmobile networks, small-boat distribution, airdrop reception) provides delivery capacity that does not depend on commercial logistics workforce.

Feasibility: High for regulatory pathway activation; low to moderate for physical pre-staging absent multi-year capital commitment to corridor support infrastructure.

Time horizon: Mixed. Regulatory pathway activation deliverable within Days 0–14 window if pre-scripted; physical pre-staging is a long-horizon investment that determines whether theoretical surge capacity is operationally accessible at all.

Cost-Benefit Snapshot: Airlift Prioritization Framework

Cost driver: Administrative cost only; framework development, pre-scripted prioritization protocols, and exercised activation procedures. No capital investment required.

Benefit driver: Triage high-value, low-volume sustainment (pharmaceuticals, repair parts, critical personnel, time-sensitive components); prevents allocation of scarce lift to commodities the mode cannot meaningfully sustain. Berlin Airlift Anchor establishes the empirical benchmark.

Feasibility: High. Framework development is achievable within current authorities; binding constraint is interagency agreement on prioritization criteria across DoD, FEMA, and state authorities.

Time horizon: Short. Framework activatable within Days 0–14 window if pre-scripted; the most analytically constrained but operationally honest option in this category.

Cost-Benefit Snapshot: Intermodal Coordination Systems

Cost driver: Moderate cost for synchronization infrastructure across maritime, rail, road, and air movement; coordination authority, communications infrastructure, and pre-scripted prioritization protocols.

Benefit driver: Converts the multi-modal mode portfolio from a collection of theoretical alternatives into an operational sustainment system; addresses the integration vulnerability that the preceding two options cannot resolve on their own.

Feasibility: Moderate. Analytically dependent on data and monitoring infrastructure addressed in the Communications and Data category; without real-time visibility, intermodal coordination defaults to scheduled handoffs that cannot adapt to ongoing degradation.

Time horizon: Medium. Coordination authority establishment achievable within months; full real-time multi-modal synchronization requires the Communications and Data category investments to be in place.

Food & Critical Supply Buffering (Early-Phase Stability)

The Dependency Mapping and Risk Assessment sections establish Alaska's food system as structurally bimodal across commercial and subsistence pathways, operating against a wholesale chokepoint that emergency feeding doctrine itself depends on. The five options developed below must therefore operate downstream of that chokepoint, address both pathways rather than only the commercial one, and distinguish near-term mitigation horizons (caches, cold chain, prioritization, coordination leverage) from long-horizon investments (processing infrastructure) whose value lies beyond the scenario window.

Cost-Benefit Snapshot: Distributed Food Caches

Cost driver: Capital cost for cache inventory across urban and rural staging locations; geographic distribution downstream of the wholesale chokepoint is the design-driving cost factor.

Benefit driver: The only mitigation in this category capable of inserting real redundancy downstream of the supply chain chokepoint within the Days 0–14 window; rural cache pre-positioning addresses the documented first-phase gap before outside assistance can arrive.

Feasibility: High when caches are positioned downstream of the wholesale chokepoint and use shelf-stable, cold-chain-independent inventory; positioning upstream reproduces the chokepoint condition the mitigation is intended to address.

Time horizon: Short. Pre-positioning delivers Days 0–14 benefit if caches are in place before disruption; the operative condition is downstream geographic positioning rather than capital scale.

Cost-Benefit Snapshot: Cold Chain Resilience

Cost driver: Capital cost for backup power and storage infrastructure protecting perishable inventories; backup generation independence from disrupted fuel and grid restoration is the binding cost factor.

Benefit driver: Addresses the failure mode that converts distributed food caches and existing commercial inventory from real to paper redundancy under scenario conditions; cold chain failure converts inventory into loss faster than any other failure mode.

Feasibility: Moderate. Backup generation that depends on the same fuel supply chain or grid restoration produces paper redundancy at the moment of greatest stress; correlated-failure mitigation is the binding design factor.

Time horizon: Short to medium. Backup power deployment achievable within months; sustained correlated-failure independence requires multi-year fuel-source diversification.

Cost-Benefit Snapshot: Prioritization Protocols

Cost driver: Administrative cost only; protocol development, civilian-military alignment framework, and pre-event interagency agreement. No capital investment required.

Benefit driver: Converts ad-hoc adjudication under crisis conditions into pre-staged decision frameworks activatable within scenario decision cycles; addresses the workforce overlap that makes civilian-military protocols inseparable.

Feasibility: Moderate. Pre-event protocol development is achievable within current authorities; binding constraint is reaching civilian-military and interagency agreement on the workforce-overlap framing.

Time horizon: Short. Protocols activatable within Days 0–14 window if pre-staged; the more time-sensitive of prioritization and rationing because it governs sequence of sustained support.

Cost-Benefit Snapshot: Coordination Architecture as a Leverage Point

Cost driver: Administrative cost only; integration of defense installation feeding dependencies and contractor workforce continuity into the Mass Care Group, Feeding Task Force, and Alaska Food Value Chain Coordination Council. No new institution-building required.

Benefit driver: Low-capital, high-return resilience investment; the underlying coordination mechanisms are already operational and surface transportation, cold storage, and communications gaps in their inaugural sessions.

Feasibility: High. The leverage point is formal integration rather than new institution construction; integration delivers Days 0–14 benefit because the underlying mechanisms are already operational.

Time horizon: Short. Formal integration achievable within months; ongoing benefit accrues across each subsequent disruption cycle.

Cost-Benefit Snapshot: Processing Infrastructure as a Long-Horizon Resilience Investment

Cost driver: Very high capital cost for USDA-certified processing facilities and FDA-certified dairy capacity; long-horizon construction and certification timelines.

Benefit driver: Changes the starting position from which future disruptions are absorbed by reducing the baseline import-dependency ratio; not a near-term scenario mitigation.

Feasibility: Low to moderate. Cannot substitute for imported food at meaningful scale within the Days 0–14 window or the Days 10–45 escalation window; categorized as recommendation for follow-on funding rather than current-cycle deliverable.

Time horizon: Long. Multi-year horizon; mitigation value is realized over decades by changing baseline conditions rather than by responding to the modeled scenario.

Integrated Prioritization (Final Ranking)

Rank	Mitigation Area	Strategic Value
1	Fuel and Energy Resilience	Foundational (enables all systems)
2	Coordination Architecture and P3 Development	Foundational (enables all other mitigation)
3	Port and Maritime Throughput Resilience	Throughput critical
4	Communications and Data Resilience	Coordination backbone
5	Workforce and Maintenance Capacity	Sustains all mitigation
6	Cross-Modal Logistics Redundancy	Enables adaptation
7	Food and Critical Supply Buffering	Stabilizes population

Strategic Takeaways

The priority mitigation categories identified in this research reflect a set of consistent analytical conclusions that extend beyond any single category or investment. Taken together, these conclusions reframe how Arctic resilience must be understood, not as an infrastructure procurement problem, but as a systems design and institutional coordination challenge operating under compressed timelines and extreme operating conditions.

There Is No Single-Point Solution

No individual investment, policy change, or infrastructure upgrade resolves the vulnerabilities identified in this research. Alaska's lifeline architecture fails under dual-

theater disruption because it is structurally concentrated, operationally thin, and institutionally fragmented across multiple sectors and jurisdictions. Resilience sufficient to sustain Arctic mission assurance requires layered mitigation across energy, maritime throughput, communications, coordination architecture, workforce, logistics, and food systems simultaneously. Sequencing matters, energy, and coordination architecture are the foundational categories on which others depend, but the overall architecture is layered, not linear.

Early-Phase (Days 0–14) Is Decisive

The analytical record consistently establishes that mission impact accumulates within the first two weeks of disruption, that the window for intervention closes faster than linear degradation models suggest, and that the convergence of fuel, logistics, communications, and workforce stressors produces non-linear escalation once thresholds are reached. Investment prioritization must therefore reflect Days 0–14 benefit as a primary criterion, not a secondary one. Long-horizon investments, secondary port construction, processing infrastructure expansion, structural workforce capacity-building, are necessary but cannot substitute for near-term investments that close the early-phase gap.

Infrastructure Alone Is Insufficient

The paper redundancy pattern documented throughout this research means that physical investment without complementary institutional investment produces nominal capacity that does not perform under stress. The maturity progression of public-private partnership architecture, the pre-staging of regulatory waiver pathways, and the integration of defense requirements into civilian coordination mechanisms are not adjacent to the infrastructure investments, they are conditions under which the infrastructure investments produce operational benefit. Closing both gaps simultaneously is required; closing either alone leaves the architecture vulnerable to the same failure modes the investments were intended to prevent.

The Highest Return-on-Investment Mitigation Options Are Not Always the Most Capital-Intensive

Coordination architecture and Public-Private Partnership development rank second in cascade reduction value, behind fuel and energy resilience, despite the lowest capital cost in the prioritized framework. Pre-scripted regulatory waiver protocols, pre-positioned strategic stockpiles, and exercised cross-sector coordination charters yield Days 0–14 benefit at orders-of-magnitude lower cost than the secondary port construction or the polar icebreaker fleet expansion that would yield comparable physical resilience benefit only over multi-year horizons. The investment portfolio that produces the greatest near-term cascade reduction is not the most capital-intensive; it is the portfolio that closes the institutional and coordination gaps that paper redundancy has masked.

Arctic Resilience Is a Specific Application of Institutional Coordination Doctrine

The contested-logistics literature, the FEMA Public-Private Partnership maturity model, the Jones Act waiver framework, and the National Security Memorandum 22 framing of defense critical infrastructure converge on the same conclusion: institutional coordination between defense and commercial actors is mission assurance, not adjacent to it. Arctic mission assurance is therefore not a unique problem requiring novel coordination doctrine; it is a specific application of doctrine that the broader institutional record has been developing for years. The Arctic case is distinguished by the geographic concentration, seasonal asymmetry, and cross-border complexity that make the doctrinal failures more consequential, not by requiring different doctrine to fail.

The Paper-Redundancy Gap Is a Planning-Compliance Failure, Not an Engineering Problem

Throughout the research, the gap between documented redundancy and operationally available redundancy is consistently traced to planning frameworks that substitute capacity figures for throughput figures, which treat contractual relationships as operational guarantees, and that assume coordination architectures perform at the maturity level the documents describe rather than the maturity level that has actually been built. Closing the gap requires planning frameworks that maintain the capacity-versus-throughput distinction, integrate stress-condition assumptions into redundancy calculations, and treat institutional coordination maturity as a measurable variable rather than a documented commitment. This is a planning-compliance discipline, not an engineering challenge.

Across every sector represented in stakeholder engagement, practitioners identified workforce availability as the most binding constraint determining whether operations curtail, ration, or stop, a cross-sector convergence that does not alter the master-dependency role of fuel in the integrated prioritization but that elevates workforce and maintenance capacity from a planning consideration to a mission-assurance variable warranting commensurate investment attention.

Integrated Prioritization

Taken in integrated form, the seven mitigation categories reflect a strategic ranking that organizes investment sequencing rather than substitution. Fuel and energy resilience is foundational because it enables all other systems. Coordination architecture and private-public partnership development is foundational because it enables all other mitigation. Port and maritime resilience is throughput-critical. Communications and data is the coordination backbone. Workforce capacity sustains all mitigation. Cross-modal logistics redundancy enables adaptation. Food and supply buffers stabilize the population. The ranking is structural, not exclusive: an investment program that addresses only the top categories without reinforcing the lower-ranked ones produces point improvements that cascade pathways shift around rather than eliminate.

STAKEHOLDER ENGAGEMENT

Stakeholder engagement methodology, instrument design, and the three engagement principles are documented in the Methodology section. Question architecture and the core question set are documented in Appendix E. The substantive engagement findings are presented below, organized first by sector, then synthesized across sectors to identify cross-sector convergences and divergences carried forward into the Mitigation and Recommendations sections.

Sectors Engaged

Engagement across the lifeline sectors examined in this research drew on three complementary inputs: a structured survey instrument distributed across sector contacts, informal conversations with operators and subject-matter experts conducted under the three-month performance window, and a literature review of authoritative public sources, sector reporting, federal and state planning documents, and prior PSEMA engagement records. Findings in this section reflect the convergence of these inputs rather than a structured interview program; where a finding rests primarily on one input, the attribution is identified.

Energy and Fuel

The analysis examined power generation, bulk fuel, aviation fuel, heating fuel, and the single-source aviation gasoline dependency at the Port of Alaska. The analytical scope included the in-state refinery operators representing the approximately twenty percent of Alaska oil refined in-state; the primary Railbelt utility serving Joint Base Elmendorf-Richardson and the Anchorage area, including the Cook Inlet natural gas dependency and its projected 2030 depletion trajectory; and Western Alaska diesel distribution operators representing upstream dependency nodes distinct from the Port of Alaska corridor.

The literature and operator reporting consistently indicate that stated reserve windows do not reliably distinguish between summer and winter operating conditions; reserve figures presented in days-of-supply terms frequently reflect summer or normal-season inventory cadences and do not account for the full winter window between fall barge delivery and spring breakup. The single-source dependency at the Port of Alaska for aviation gasoline is a structural condition documented across operator filings and state planning records, with no immediate mitigation identified. The Cook Inlet natural gas depletion trajectory is a pre-existing concern that compounds maritime fuel-import dependency under any disruption scenario [26]. Informal conversations with sector contacts reinforced the workforce constraint: trained linemen are scarce, transformer lead times have lengthened due to global supply chain conditions, and remote microgrid repair depends on a workforce that must be flown in using the same fuel that is constrained.

Transportation and Logistics

The analysis examined ports, including the Port of Alaska and the Tacoma-to-Alaska maritime corridor, maritime carriers, trucking, and aviation cargo. Analytical scope specifically included the six identified contingency alternatives to the Port of Alaska, Seward, Valdez, Kodiak, Homer, Whittier, and MacKenzie, to surface the specific infrastructure gaps and investment requirements that determine whether each could function as a substitute under disruption conditions. Alaska Railroad analysis focused on the emergency freight activation pathway, including winter-operations constraints, fuel transport capacity, and the rail-to-port integration that would be required for any container cargo rerouting scenario. ALCAN Highway analysis drew on Alaska DOT&PF and Canadian provincial transportation authority documentation to examine the prescribed waiver pathways, service-interval conditions, and pre-staging requirements that determine whether the highway's theoretical surge capacity is operationally accessible.

The throughput-versus-capacity distinction was reinforced across both the literature and informal conversations with sector contacts. Port operations reporting consistently establishes that nameplate capacity figures do not reflect operational throughput under crew, equipment, or weather constraints. ALCAN reporting and informal conversations distinguished between theoretical road capacity and operational truck throughput under emergency winter conditions absent pre-staged fueling and rest infrastructure. Aviation sector reporting characterizes airlift as a constrained supplemental mode, not a substitute for maritime cargo at sustainment volumes. The workforce-mobility waiver issue surfaced consistently across the literature: cross-border trucking surge along the ALCAN depends on Canadian provincial permitting, hours-of-service waiver activation, and CDL endorsement coordination that is not pre-positioned [22].

Food and Retail Distribution

The analysis examined wholesale distribution, grocery, cold chain, warehouse operations, and the four-day Tacoma-to-shelf transit cycle. Analytical scope included the primary food service distributors operating from limited Alaska locations; the sole produce distributor operating from a single Anchorage location; and the dominant retail tier whose geographic and organizational concentration creates the single-pipeline architecture identified in the dependency mapping.

Sector engagement and the literature converge on the structural conditions established in Dependency Mapping: the four-day Tacoma-to-shelf cycle and the absence of major in-state warehousing mean that stated reserve figures reflect inventory in transit and on shelves, not warehouse storage, and disruption of the replenishment cycle produces shortfall faster than stated reserve windows suggest. The single-source concentration at the wholesale tier (Charlie's Produce as the primary produce node) is documented in state distribution analyses. [38] The three-figure buffer reconciliation developed in Food Security and Access (seven-to-ten-day commercial pipeline, three-to-seven-day retail warehousing, two-to-three-day effective availability under demand surge) is operationally consistent with what practitioners describe. The single-source concentration at the wholesale tier is documented in state distribution analyses. The continued dependency of state feeding operations on the same commercial pipeline

whose disruption would trigger plan activation is a paper-redundancy condition documented across state planning records [3; 24; 55].

Communications and Data Systems

The analysis examined satellite operators, fiber networks, commercial carriers, and Arctic ground station operators. Analytical focus addressed contractual resilience commitments, network segmentation practices, cyber incident response capacity, and private-sector decision pathways for service continuity during conflict, the conditions under which the paper redundancy pattern documented in the analytical sections is most directly produced.

The literature and operator reporting establish that no single satellite architecture provides full Arctic coverage and that commercial provider service availability during conflict is a discretionary commercial decision, not a contractual guarantee [15; 28]. Cyber incident response capacity for Arctic ground stations is documented as adequate for routine threat profiles but has not been exercised against the integrated cyber-and-jamming scenario the research models. Multi-orbit satellite redundancy is identified across the literature as the most achievable near-term communications resilience investment, with terrestrial backup systems requiring longer pre-incident investment cycles [10].

Medical Supply, Cold Chain, and Medical Evacuation

The analysis examined pharmaceutical distributors, cold-chain logistics, hospital systems, medevac operators, Indian Health Service facilities, and Alaska Native tribal health organizations. The analytical structure treated these as lifeline dependency nodes whose failure produces nonlinear workforce and community destabilization, rather than as healthcare providers secondary to physical infrastructure.

Pharmaceutical cold-chain failure under simultaneous power, fuel, and communications disruption is documented across the literature as a non-recoverable outcome within the Days 0–14 window [74; 76]. Insulin, antibiotics, oxygen, and dialysis supplies are consistently identified across pharmaceutical distribution reporting as the categories where depletion produces life-threatening outcomes within days [76]. Medevac sector reporting establishes that aviation fuel allocation directly constrains medevac capacity and that no pre-established prioritization framework governs fuel allocation between medevac, cargo airlift, installation sustainment, and defense operational requirements. Indian Health Service and tribal health system facilities are additional dependent nodes whose failure would compound rather than mitigate the civilian healthcare capacity gap.

Warehousing and Distribution Nodes

The analysis examined regional hubs, intermodal staging, and pre-positioning operations. Analytical focus addressed capacity for emergency cargo prioritization, surge handling under degraded scheduling, and the relationships between commercial warehousing and the state and federal emergency response architecture that would activate under disruption conditions.

Workforce and Maintenance Operators

The analysis gave specific attention to the transient, seasonal, and locally rooted labor pools on which critical systems depend, and whose availability is itself dependent on community conditions including household-level access constraints and economic reserve depth that determine whether workforce members can sustain work attendance under disruption.

Emergency Management and Coordination Entities

The analysis examined state, federal, and interagency coordination architectures, structured to engage with rather than duplicate existing convening bodies, the Alaska Mass Care Group and Feeding Task Force, the Alaska Food Value Chain Coordination Council stood up in 2025 under the USDA Regional Food Systems Partnership framework, and the partnership architecture that operates under Alaska's Partnership for Infrastructure Protection [3; 55].

The federal P3 maturity finding, Arctic jurisdictions operating predominantly at the Basic or low-Intermediate tier, is documented in the literature and reinforced in informal conversations with state and local emergency management contacts [33]. The absence of pre-established civil-military adjudication frameworks for fuel, airlift, medevac, and communications prioritization is a structural condition documented across federal planning reviews; closure of this gap requires policy and exercise investment, not capital infrastructure. The Mass Care Group, Feeding Task Force, and Alaska Food Value Chain Coordination Council are functioning state-level coordination architectures whose integration with installation and contractor sustainment requirements is incomplete but achievable through deliberate engagement [3; 55].

Findings in this section reflect the three-month performance window and the engagement modalities available within it. Validation through structured stakeholder engagement, including direct interviews with operators across the sectors examined, is identified in the recommendations as a near-term follow-on requirement.

Stakeholder Engagement Sectors and Inputs

Stakeholder Category	Input Domains	Engagement Intensity
Maritime & port operators	Cascade dynamics, sector interdependency, risk mitigation, recommendations	Substantial
Logistics & 3PL providers	Cascade dynamics, sector interdependency, risk mitigation	Substantial
Energy & fuel distributors	Sector interdependency, risk mitigation, recommendations	Substantial
Telecom & satellite providers	Cascade dynamics, risk mitigation	Substantial
Healthcare & EM organizations	Risk mitigation, recommendations shaping	Substantial
Tribal & Alaska Native organizations	Recommendations shaping (risk amplifier framing)	Moderate to substantial
DoD installation liaisons	Sector interdependency, workforce & operations	Substantial
Cross-border (US–CAN) entities	Cascade dynamics, sector interdependency	Moderate

Stakeholder Engagement Traceability Matrix

Stakeholder categories mapped to the analytical domains and lines of effort their input shaped. Aggregated, non-attributed.

	Scenario framing	Governance & authority	Tribal & Alaska Native	Family readiness	Workforce & workforce-family loop	Comms cascade	Framework & mitigation
Infrastructure & access systems	Primary input	Supporting input			Supporting input	Supporting input	Primary input
Energy, utilities & fuel	Primary input	Supporting input	Supporting input		Supporting input	Supporting input	Primary input
Supply chain, logistics & distribution	Primary input	Supporting input		Supporting input	Primary input	Supporting input	Primary input
Communications & technology	Supporting input	Primary input	Supporting input	Primary input	Primary input	Primary input	Primary input
Community organizations & nonprofit		Supporting input	Supporting input	Primary input	Primary input	Supporting input	Primary input
Tribal governments & ANCs	Supporting input	Primary input	Primary input	Primary input	Supporting input	Primary input	Primary input
State, local & territorial agencies	Supporting input	Primary input	Supporting input	Supporting input	Supporting input	Supporting input	Primary input
Family readiness practitioners		Supporting input	Supporting input	Primary input	Primary input	Primary input	Primary input
Academic institutions	Primary input	Primary input	Primary input	Primary input	Primary input	Primary input	Primary input

Primary input
Supporting input
(blank) Not engaged in this domain

Engagement was distributed across all five analytical domains.

Cross-Sector Assumption Misalignments

The most analytically valuable findings from the engagement were the cross-sector assumption misalignments, the seams at which operators from adjacent sectors held incompatible beliefs about each other's behavior under disruption. These misalignments are operator-level expressions of the paper-vs-real condition this research applies throughout: assumptions documented on paper across sectors fail to align with operational capacity those sectors describe under disruption. Three categories of misalignment recurred consistently across the engagement.

First, downstream operators consistently overestimated the resilience of upstream supply chains. Fuel distributors assumed that maritime delivery cycles would adjust to disruption faster than maritime operators believed they could. Healthcare operators assumed pharmaceutical distribution networks would prioritize Alaska medical supply over other regions; pharmaceutical distributors did not confirm that prioritization would occur absent specific pre-incident agreement. Installation logistics personnel assumed commercial cargo prioritization would account for defense sustainment requirements; commercial carriers confirmed that defense priority is not built into their routine cargo allocation logic.

Second, regulatory and waiver pathway assumptions were inconsistent across operators. Some assumed Jones Act waivers would be available reactively under disruption conditions; the FEMA Restoring Flow guide and the operators with direct waiver experience confirmed that waiver readiness is a pre-incident planning capability. Some assumed Canadian provincial waivers for ALCAN trucking surge would be expedited under emergency conditions; ALCAN operators identified specific procedural and documentation requirements that have not been pre-positioned [32].

Third, communications continuity assumptions diverged significantly across sectors. Operators dependent on commercial satellite communications generally assumed service availability under disruption conditions; satellite operators acknowledged the discretionary character of service continuity decisions during conflicts and the structural absence of governance frameworks requiring service preservation. This misalignment is particularly consequential because it produces a coordination failure mode in which downstream operators continue to operate under invalidated communications continuity assumptions while the system they depend on has already begun degrading service. Communications failure operates as a force degrader across every other lifeline category, and the misalignment between downstream operator assumptions and upstream operator behavior is the mechanism through which that force-degrader effect compounds at the cross-sector level.

Engagement Findings Carried Forward

Three engagement findings are carried forward into the Mitigation and Recommendations sections that follow. First, the paper-redundancy condition is confirmed at the operator level across multiple sectors, validating the substitution-reality-check finding as an operationally grounded conclusion rather than a documentary

inference. Second, the master-dependency role of energy is confirmed by operators across sectors, reinforcing the prioritization of fuel and energy resilience as the highest-return Tier 1 investment category developed in the Cost-Benefit Posture. Third, the absence of pre-established civil–military coordination frameworks is identified by emergency management and lifeline operators as the single most consequential governance gap, validating coordination architecture and P3 development as the highest-return, lowest-capital-cost mitigation category available within the current planning window, the framework finding that operates as a force degrader on mission outcomes when adjudication fails.

Question Architecture

The structured question framework was organized around six analytical emphasis areas, Failure Pathways, Throughput and Capacity Constraints, Resource Competition and Prioritization, Time Sensitivity, Substitution and Operational Reality, and Governance and Authority Gaps, each calibrated to the dual-theater scenario and tied to a canonical home subsection in the body of this report. The full question framework, including the six-area probe lines and the core question set, is in Appendix E.

Synthesized Findings

The synthesis below presents the engagement findings organized by analytical emphasis area. The April 30, 2026, extended response deadline closed the engagement window for the analysis carried into this report; where stakeholder input materially extends, qualifies, or contradicts literature-derived findings, that integration is reflected in the relevant analytical section rather than as a standalone block of practitioner data.

Failure Pathway Findings

This subsection consolidates practitioner perspectives on what fails first under disruption conditions, how impacts propagate across systems, and where cascading effects accelerate. Findings are organized by sector, then synthesized across sectors to identify the convergent failure pathways and the points at which sector-specific practitioner models diverge from the cross-sector analytical model.

The aggregated practitioner record converges with unusual consistency on the cascade pathway the dependency mapping identifies. Across sectors, transportation and logistics interruption is the most-cited early warning sign of Arctic disruption, identified by more than three-quarters of respondents as the first signal that the systems their operations depend on are beginning to degrade. Workforce shortages and employees unable to report to work are the second-most-cited early warning, reported by two-thirds of respondents and confirmed in open-ended responses as the binding constraint that determines whether operations continue, scale down, or stop. Communications and IT system disruptions are third, reported by more than half.

This sequencing matters analytically because it walks the cascade entry from the outside in: external transportation degrades first, internal workforce availability follows, and the coordination layer that would normally compensate for both is itself degraded by

communications loss. The pattern is visible across sectors, defense logistics, healthcare and pharmaceutical, supply chain distribution, engineering, and humanitarian response, with no sector treating its own internal capacity as the cascade entry point. The cascade is overwhelmingly perceived as exogenous to the respondent's operation, originating in shared infrastructure and propagating inward.

The thematic pattern across open-ended cascade descriptions reinforces a finding the analytical record has carried throughout this research: failure is convergent rather than sequential. Practitioners describe fuel, power, and communications as failing together because they share underlying infrastructure, not as a clean sequence in which one system fails before the next. The most operationally distinctive characterization of this convergence comes from the consulting and emergency management sector, which frames communications loss as the cascade amplifier that “force[s] organizations to make choices with bad information,” directly validating the analytical position that communications failure operates as a force degrader across every other lifeline category.

A long-horizon cascade dimension surfaced from the engineering / hazard mitigation sector is worth flagging as an extension to the cascade analysis developed elsewhere in this report. Practitioners describe post-event population displacement as a cascading consequence that does not reverse, communities depopulated under prolonged disruption may not return, converting an acute incident into permanent demographic loss. This dimension is not currently developed in the Risk and Vulnerability Assessment, but it is consistent with the analytical posture the research has carried throughout: cascading failure compresses timelines and changes the character of recovery.

Throughput and Capacity Findings

This subsection consolidates practitioner perspectives on maximum operational capacity under degraded conditions, volume limitations, and the gap between theoretical capacity and operational throughput under the specific stress conditions of the dual-theater scenario. Particular attention is given to the substitution-limit findings developed in the Substitution and Redundancy Reality Check section, where practitioner input is most directly evidentiary.

Practitioner input on throughput and capacity converges most strongly on a single proposition: the alternatives most often invoked in contingency planning, particularly aviation surge and alternate-route rerouting, are the alternatives most consistently identified as unrealistic under Arctic conditions. The pattern is visible across sectors. Healthcare and pharmaceutical respondents identify air transportation as structurally unable to absorb ground-mode disruptions at the volume sustained pharmaceutical distribution requires. Defense logistics respondents identify the assumption of single-mode supply continuity as unrealistic, with explicit recognition that maritime supply works in summer and ground transportation works in winter, but neither delivers the full-year throughput planning frameworks assume. Humanitarian response respondents identify air assets as routinely depended on and routinely insufficient when secure stockpile depth is the actual binding constraint.

The throughput-versus-capacity distinction emerges particularly clearly in two operationally specific framings. First, multiple respondents independently identify that alternate routes, alternate airports, and multiple distribution locations are assumed in planning to remain available during disruption, when in practice Arctic events affect wide geographic areas simultaneously and degrade redundant pathways concurrently. The assumption that if Route A fails, Route B is available is itself a paper redundancy when the conditions that fail Route A also fail Route B. Second, the pharmaceutical distribution sector framing characterizes Arctic disruption as a transportation-driven external risk rather than a loss of internal capacity, with operational impact escalating as domestic mobility degrades rather than from internal capacity shortfalls.

A distinctive throughput finding from the commercial pharmaceutical sector concerns the tempo at which commercial supply chains operate. Practitioners describe healthcare distribution as operating on hours-not-days' timelines, with even short transportation, power, or logistics disruptions cascading rapidly into reduced service levels and patient impact. This tempo-mismatch finding is operationally consequential: planning frameworks calibrated to government response timelines, measured in days, do not match the pace at which commercial supply chains absorb disruption or fail.

Resource Competition and Prioritization Findings

This subsection consolidates practitioner perspectives on allocation decisions under constrained supply, interactions between civilian and defense demand, and the internal prioritization criteria that operators apply when external prioritization frameworks have not been pre-defined. Findings here directly inform the institutional coordination analysis and the recommendations for pre-incident adjudication architecture.

Practitioner input on resource competition and prioritization is the single most directionally consistent finding in the engagement record. Roughly nine of ten respondents identify joint coordination between government and industry as the action most likely to strengthen resilience in their sector, the highest-consensus finding across the entire engagement. No single actor, government, industry, military, or nonprofit, is identified by a majority of respondents as the appropriate sole owner of the resilience improvement that matters most. The directional message is unambiguous: the action that practitioners believe is most needed is precisely the action that requires pre-defined cross-sector coordination architecture rather than unilateral capital investment by any single party.

The pattern is reinforced by open-ended responses describing the misunderstanding that decision-makers most often hold about Arctic infrastructure disruption. Practitioners across sectors converge on a small number of recurrent misconceptions: that restoration timelines can be compressed to lower-latitude norms; that civilian commercial operations can absorb delays in the way government systems can; that workforce stability is a secondary concern rather than the binding mission-assurance constraint; that civilian populations and defense installations rely on different lifelines when in fact they share the same energy, transportation, medical, and sustenance pathways. The most concise practitioner statement of this convergence comes from the defense logistics sector: *workforce stability is mission assurance*.

Practitioners also describe the absence of pre-event coordination as the failure mode that converts a disruption into a crisis. An emergency management consulting respondent identifies the assumption that external partners, federal, military, or nonprofit, will arrive with resources ready to deploy as the most consistently unrealistic backup solution in Arctic planning. The pharmaceutical distribution respondent identifies the absence of state-level Emergency Operations Center capacity as a baseline gap that complicates downstream coordination architecture, an observation that warrants verification against the canonical inventory of state EOC postures before further integration but is operationally consistent with the maturity-of-coordination findings developed in the FEMA Public-Private Partnership maturity model.

Substitution and Operational Reality Findings

This subsection consolidates practitioner perspectives on feasible alternatives versus theoretical options, the specific conditions under which a documented redundancy ceases to perform, and constraints driven by weather, workforce, infrastructure, and scale. Findings here directly inform the paper redundancy versus operational redundancy analysis that is central to the report's analytical contribution.

Practitioner input on substitution feasibility is the single most directly evidentiary engagement finding for the analytical position the research has carried throughout: paper redundancy is not redundancy. Across sectors, the alternatives most consistently identified as unrealistic under Arctic conditions are precisely the alternatives the substitution catalog elsewhere in this report identifies as paper redundancies. Aviation surge as a substitute for maritime sustainment is named directly by multiple respondents as an unrealistic backup. Disruptions clearing within days is named as an unrealistic baseline assumption in commercial supply chain planning. External federal partners arriving with resources ready to deploy is named as an unrealistic dependency in the consulting and humanitarian sectors. Alternate airports and multiple distribution locations remaining available during wide-area Arctic events is named as an unrealistic assumption in the pharmaceutical distribution sector. Adequate generator and fuel-storage capacity at the community level is named as an assumed baseline that frequently does not exist in remote Arctic communities.

Two operationally distinctive findings warrant integration into the substitution analysis developed in the Substitution and Redundancy Reality Check section of this report. First, the seasonal lock-in dimension surfaces from defense logistics framing as a binding constraint that the Days 0–14 frame may understate: when fall barge season closes before disruption arrives, the only operational alternative in some communities is to wait for spring breakup, extending the no-substitution window from days into months. This dimension is consistent with the seasonal asymmetry analysis developed elsewhere in this report and reinforces it from the practitioner side. Second, the hub-and-spoke last-mile community delivery pattern surfaces from the humanitarian response sector as a substitution pathway distinct from commercial logistics: where central hubs can receive bulk goods, locally-retrieved last-mile delivery using traditional transport, including sled teams and airdrop reception by community members, provides a delivery mechanism that does not depend on commercial logistics or aviation substitution. This is operationally significant as a community-resilience dimension that the analytical record has not

previously developed and that may warrant inclusion in the cross-modal logistics redundancy mitigation pathway.

The differential between practitioner identification of inputs as essential and identification of those same inputs as hardest to replace is itself an empirical signal of where paper redundancies are most prevalent. Workforce availability and transportation access show no substitution-belief differential, practitioners do not believe these can be replaced. Communications shows the largest substitution-belief differential, suggesting that practitioners may underestimate communications irreplaceability relative to the analytical position developed elsewhere in this report that communications loss is a force degrader across every other lifeline category. This signal is worth flagging because it identifies a practitioner-vs-analytical-record divergence rather than a convergence: the analytical record treats communications as the cascade amplifier; the practitioner record treats it as the most-substitutable of the top-tier essential inputs. Both positions cannot be correct; the divergence is itself a finding worth carrying forward into the Communications and Data Resilience mitigation pathway.

Governance and Authority Gap Findings

This subsection consolidates practitioner perspectives on how scarce resources are allocated in practice, where that authority diverges from formal coordination frameworks, and where civilian, military, tribal, and commercial authority structures operate in parallel without coordination. Findings here directly inform the Institutional Coordination as a Risk Amplifier section and the near-term recommendations for pre-incident coordination architecture.

Practitioner input on governance and authority gaps converges directly with the analytical position developed in the Institutional Coordination as a Risk Amplifier section of this report. Respondents identify the absence of pre-established cross-sector coordination as the failure mode that converts a disruption into a crisis. Practitioners across sectors, defense logistics, supply chain distribution, healthcare, humanitarian response, engineering, identify joint government-industry coordination as the highest-priority resilience action by a margin that is unusually consistent for a multi-sector engagement record.

The practitioner record identifies three specific governance gaps that align with the institutional-coordination analytical work developed elsewhere in this report. First, the gap between commercial supply chain tempo and government response tempo is identified as a coordination failure mode in its own right: pharmaceutical and food distribution operate on hours timelines, while government activation operates on days' timelines, producing a misalignment in which downstream impact develops faster than upstream coordination can adjudicate. Second, the assumption that external partners, federal, military, or nonprofit, will arrive with resources ready to deploy is identified as the most consistently unrealistic baseline assumption in Arctic planning. Third, baseline coordination capacity at the state-EOC level is identified as variable, with some jurisdictions lacking the activation infrastructure that downstream coordination architecture assumes is in place.

These gaps validate the analytical position that pre-established cross-sector coordination architecture is the highest-return, lowest-capital-cost mitigation category available in the current planning window. Coordination capacity that depends on improvisation under time pressure cannot match the pace at which Arctic disruption develops; coordination capacity that has been pre-staged through charters, exercises, and pre-scripted authority transitions can. Practitioner input does not contest this analytical claim; it strengthens it by identifying with specificity which coordination assumptions in current Arctic planning are most consistently invalidated under stress.

Cross-Sector Patterns and Integration with Analytical Findings

Beyond the sector-specific findings consolidated above, the engagement was designed to surface cross-sector patterns, the points at which practitioner observations across multiple sectors converged on the same finding, and the points at which they revealed misalignments in sector-level assumptions about adjacent systems.

Three cross-sector convergences and one cross-sector divergence emerged from the engagement record and warrant integration with the analytical findings developed elsewhere in this report.

The first convergence is the systematic identification of workforce availability as the binding constraint across every sector represented in the engagement. Defense logistics, healthcare and pharmaceutical, supply chain distribution, engineering, and humanitarian response respondents all identify workforce shortages as the curtailment, rationing, or stop-operations trigger under Arctic conditions. Workforce ranks among the top two essential inputs and the top two hardest-to-replace inputs across the dataset, with no substitution-belief differential. This convergence directly validates the analytical position that the civilian and contractor workforce is a critical but under modeled dependency in current planning, and it strengthens the case for the workforce and maintenance capacity mitigation category developed elsewhere in this report.

The second convergence is the systematic identification of paper-redundancy conditions across sectors. The alternatives most consistently named as unrealistic, aviation surge for maritime, short-duration restoration assumptions, alternate airport availability, generator-fuel-volume baselines, external partner arrival on schedule, align directly with the substitution catalog developed in the Substitution and Redundancy Reality Check section. No respondent describes a paper redundancy that the analytical record has not also identified; the cross-sector convergence is in identifying the same paper-redundancy conditions from independent operational vantage points.

The third convergence is the systematic identification of joint government-industry coordination as the highest-priority resilience action. This convergence directly validates the analytical position that pre-established coordination architecture is the highest-return, lowest-capital-cost mitigation category available in the current planning window.

The single cross-sector divergence worth flagging concerns communications. The analytical record treats communications loss as a force degrader across every other lifeline category, the cascade amplifier whose degradation propagates simultaneously into

logistics visibility, coordination capacity, and command awareness. The practitioner record treats communications as the most-substitutable of the top-tier essential inputs, with the largest gap between identification as essential and identification as hardest to replace. This divergence is itself a finding: practitioners may be operating with substitution assumptions about communications that the analytical record does not support. The implication is that the Communications and Data Resilience mitigation category should explicitly address not only the technical substitution gap but also the practitioner-perception gap that converts technical substitutability into operational over-reliance.

Where stakeholder input materially extends, qualifies, or contradicts literature-derived findings in the body of this report, that integration is reflected in the relevant analytical section. Specifically, practitioner input on Days 0–14 inventory thresholds, fuel allocation decision criteria, communications resilience under commercial provider autonomy, and the operational adequacy of existing coordination architecture refines the findings developed in the Targeted Dependency Mapping, Focused Risk and Vulnerability Assessment, Substitution and Redundancy Reality Check, and Institutional Coordination sections, respectively.

The mitigation prioritization framework developed in the next section incorporates stakeholder input directly as a weighting input on the Feasibility criterion. Where practitioner consensus indicated that a proposed mitigation is more or less operationally feasible than literature-derived analysis suggested, the Feasibility scoring is adjusted accordingly, with the basis for adjustment documented in the relevant entry.

Engagement limits are documented in the Methodology section Limits subsection. Follow-on engagement and exercise-based validation are identified in the Recommendations section as near-term priorities, on the basis that the foundation established here is the starting point for the sustained engagement architecture Arctic mission assurance requires.

RECOMMENDATIONS

The recommendations below address the gap between current Arctic mission assurance capacity and the demands the scenario documented in the Scenario Framework section imposes. Each recommendation is tagged against five criteria, Mission Impact, Cascade Risk, Time Sensitivity, Feasibility, and Dual-Use Value, that together identify both the strategic value of the investment and the conditions under which it produces return. Tagging is not a substitute for the integrated analysis that precedes it; it is a planning aid for sequencing investments under resource constraints. The tiering reflects implementation horizon rather than priority: near-term investments are not more important than long-term ones, but they are the investments that close the Days 0–14 gap before the next disruption requires those frameworks to exist.

The recommendations developed in this section translate the analytical findings of the prior sections into specific, actionable lines of effort organized across three time horizons. Each recommendation is tagged by the five-criteria framework introduced in the Mitigation and Cost–Benefit Prioritization section, Mission Impact, Cascade Risk, Time Sensitivity, Feasibility, and Dual-Use Value, and identifies the external partners responsible for the line of effort. The intent is that each recommendation can be read as an executable assignment, not a directional statement of need.

The three-tier structure reflects the analytical conclusion that Arctic mission assurance requires layered investment across overlapping time horizons rather than sequential prioritization. Near-term recommendations close gaps that the Days 0–14 window would expose immediately if disruption occurred today. Mid-term recommendations build the institutional and infrastructure capacity that converts near-term mitigations from improvisation into sustained operational architecture. Long-term recommendations identify the research, infrastructure, and coordination investments whose return is realized over multi-year horizons, but whose initiation cannot wait for those horizons to begin.

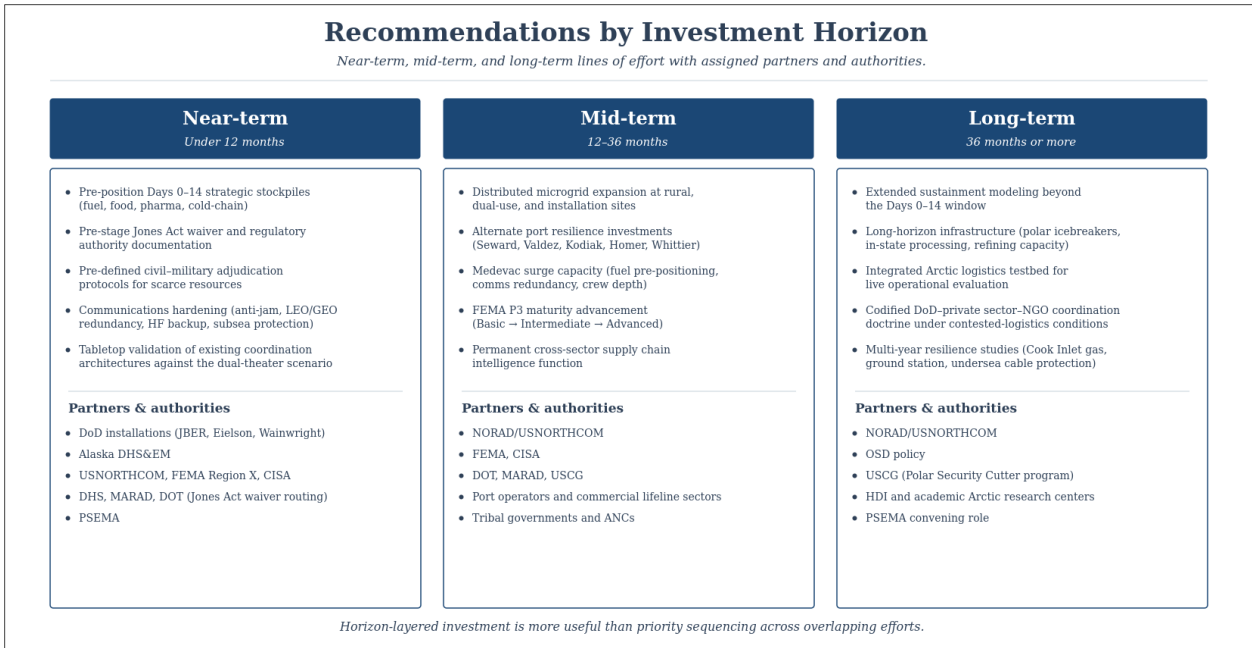
External partner identifiers used throughout this section refer to the following entities. The Homeland Defense Institute is the primary contracting and convening institution for Arctic homeland defense research priorities. NORAD and USNORTHCOM are the operational mission assurance authorities. Alaska DHS&EM is the state-level emergency management authority. FEMA holds federal authority for emergency response coordination, supply chain resilience programs, and the Public-Private Partnership maturity framework. CISA holds federal authority for critical infrastructure protection and cybersecurity coordination. Tribal governments and Alaska Native organizations hold sovereign authority over tribal lands, communities, and citizens, and operate under sovereignty, consent, and reciprocity protocols. [23] Academic institutions, including the Ted Stevens Center for Arctic Security Studies, RAND Corporation, the Naval Postgraduate School, and university research centers with Arctic specialization, provide the analytical capacity for follow-on research and validation. PSEMA functions across these recommendations as the connective infrastructure described in the next section of this report.

Recommendations Roll-Up by Investment Horizon and Decision Authority

*Near-term (under 12 months), mid-term (12–36 months), and long-term (36 months or more)
lines of effort with assigned partners and authorities.*

Horizon	Recommendation Line of Effort	Decision Authority / Partners
Near-term (Under 12 months)	• Pre-position Days 0–14 strategic stockpiles (fuel, food, pharma, cold-chain). • Pre-stage Jones Act waiver and regulatory authority documentation. • Pre-defined civil–military adjudication protocols for scarce resources. • Communications hardening (anti-jam, LEO/GEO redundancy, HF backup, subsea protection). • Tabletop validation of existing coordination architectures against the dual-theater scenario. • Pharmaceutical cold-chain pre-positioning at regional, IHS, and ANTHC nodes. • Sustained stakeholder engagement architecture across DoD, federal, state, tribal, and private-sector lifeline partners.	DoD installations (JBER, Eielson, Wainwright) Alaska DHS&EM USNORTHCOM FEMA Region X CISA DHS MARAD, DOT(Jones Act waiver routing) PSEMA
Mid-term (12–36 months)	• Distributed microgrid expansion at rural, dual-use, and installation sites. • Alternate port resilience investments (Seward, Valdez, Kodiak, Homer, Whittier, MacKenzie). • Medevac surge capacity build (aviation fuel pre-positioning, comms redundancy, crew depth). • FEMA P3 maturity advancement (Basic → Intermediate → Advanced). • Permanent cross-sector supply chain intelligence function. • Tribal partner protocols for sustained engagement under sovereignty, consent, and reciprocity framing. • Cold-chain and pre-positioning infrastructure at tribal and community health nodes.	NORAD/USNORTHCOM FEMA CISA DOT MARAD USCG Port operators and commercial lifeline sectors Tribal governments and Alaska Native Corporations Academic institutions

Long-term (36 months or more)	- Extended sustainment modeling beyond the Days 0–14 window. - Long-horizon infrastructure investments (polar icebreakers, in-state processing, refining capacity). - Integrated Arctic logistics testbed for live operational evaluation. - Codified DoD–private sector–NGO coordination doctrine under contested-logistics conditions. - Multi-year resilience studies (Cook Inlet gas depletion, ground station, undersea cable protection). - Operational piloting of recommended coordination architectures under live operational conditions.	NORAD/USNORTHCOM OSD policy USCG (Polar Security Cutter program) HDI and academic Arctic research centers PSEMA convening role
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Tiered visual organizing near-term (under 12 months), mid-term (12–36 months), and long-term (36 months or more) recommendations with assigned partners and authorities.

Near-Term Recommendations (0–12 Months)

Near-term recommendations are investments that can be activated within the current planning and budget cycle and that materially compress the activation timeline of early-phase response. They share a common characteristic: their return is realized before disruption occurs, in the form of pre-positioned stocks, pre-coordinated authorities, exercised relationships, and tested protocols. None of them require new construction; all of them require deliberate institutional commitment and resource allocation.

Pre-Position Strategic Stockpiles for the Days 0–14 Window

Establish pre-positioned reserves of fuel, food, pharmaceuticals, cold-chain capacity, and critical materiel sufficient to bridge the Days 0–14 disruption window at the most consequential nodes, Anchorage, Fairbanks, the Joint Base Elmendorf-Richardson area, and the rural community hubs whose seasonal resupply windows close with the fall barge season. Stockpiles must be sized for both routine demand and disruption-period demand surge, with rotation protocols that preserve operational readiness without producing inventory destruction. The investment is the only mechanism that closes the inventory-buffer gap within the analytical window the dual-theater scenario imposes.

Pre-Stage Jones Act Waiver and Regulatory Authority Documentation

Develop and maintain pre-staged documentation packages supporting Jones Act waiver requests, transportation weight-limit waivers, hours-of-service waivers, CDL endorsement waivers, and Canadian provincial permitting for ALCAN trucking surge. Pre-staged documentation includes vessel availability surveys, shipper demand data, alternative routing analysis, and defense necessity findings updated against current conditions on a rolling basis. Pre-staged interagency coordination architecture exercises waiver routing through DHS, MARAD, the Department of Transportation, and the Department of Defense before disruption requires it. The investment converts the Jones Act waiver process from a capability that may exceed the operational window during a disruption into a regulatory mechanism activatable within hours.

Establish Pre-Defined Civil–Military Adjudication Protocols

Develop pre-defined protocols for adjudicating civilian and military claims on scarce fuel, food, transportation, and medical capacity under the dual-theater scenario. Protocols must address allocation across Title 10 authority, state emergency management authority, tribal sovereignty, and commercial cargo prioritization, with clearly identified decision authorities, documented prioritization criteria, and pre-established communication pathways. Protocols are exercised under the Tabletop Exercise recommendation that follows and integrated into the standing operations of the participating authorities.

The case for elevating this recommendation to near-term priority is the time-compression characteristic of the Days 0–14 window. Adjudication that has not been hammered out before disruption begins will consume the first portion of the operational window in political contestation. Federal, state, and tribal authorities, military commanders, and commercial operators will be making allocation claims against the same constrained pool of fuel, transportation capacity, medical resources, and pharmaceuticals. In the absence of pre-defined criteria and decision authority, those claims will be litigated in real time through media channels, intergovernmental correspondence, and emergency declarations whose legal effect is contested as it is being asserted. The operational consequence is that the degradation pathway the research documents accelerates while the institutional architecture that would slow it is still being constructed. The lost time is not recoverable. Lifeline degradation in the Arctic operates on inventory clocks that do not pause for governance to catch up.

The historical record establishes that the United States has constructed civilian–military resource adjudication architectures under wartime and crisis conditions before, that the architectures have functioned when pre-established and have failed when improvised, and that pre-establishment is feasible within existing authorities without legislative change. Three precedents inform the design.

First, the War Industries Board, established by Executive Order in July 1917 under the Council of National Defense to coordinate U.S. industrial mobilization for World War I, demonstrated both the value of centralized priorities adjudication and the cost of constructing it after the conflict had begun. The WIB operated for sixteen months before achieving substantive operational effectiveness under Bernard Baruch’s chairmanship in March 1918, and the period before that operational maturity was characterized by competing military procurement authorities, voluntary compliance regimes that produced inconsistent results, and the inefficiencies that delayed authority-construction always produces. The WIB record is the foundational U.S. case for the proposition that resource-adjudication architecture should be pre-established rather than constructed under stress.

Second, the World War II succession from the Office of Production Management (January 1941) to the Supply Priorities and Allocations Board (August 1941) to the War Production Board (January 1942), all of which adjudicated competing civilian, military, and Allied claims on industrial output and raw materials, demonstrates the same lesson at greater scale. The WPB allocated steel, aluminum, rubber, fuel, and consumer goods across military and civilian demand throughout the war, operating under Executive Order 9024 with priorities and rationing authority over the U.S. industrial base. The WPB’s effectiveness rested on the pre-1941 foundation laid by the OPM and SPAB; it did not begin from a standing start in 1942. The lesson is that adjudication architecture builds on prior architecture rather than emerging from improvisation, and that the institutional learning required is not compressible to crisis timelines.

Third, the COVID-19 allocation framework—operating through Defense Production Act authorities, the FEMA temporary final rule on prioritization and allocation of scarce health and medical resources, the CDC Advisory Committee on Immunization Practices guidance on vaccine prioritization, and the National Academies’ Framework for Equitable Allocation of COVID-19 Vaccine—provides the closest contemporary analog to the architecture this recommendation calls for. The COVID framework operated under acute time compression to allocate ventilators, personal protective equipment, vaccines, and pharmaceuticals across states with significant inter-state variability, federal-state friction, and contested public health authority claims. The framework worked in important respects and failed in others, and both the successes and failures are operationally instructive. Where pre-existing pandemic planning infrastructure existed, allocation decisions were made faster and with greater institutional defensibility. Where the architecture was constructed during the crisis, allocation decisions were inconsistent across states, litigated in courts and media simultaneously, and produced inequities whose corrective addresses arrived after the most consequential allocation decisions had been made. The Arctic Days 0–14 window will operate under the same time-compression

characteristics with less margin for state-level variability and a smaller pool of authority that can be activated late.

The design parameters for the Arctic adjudication architecture follow from these precedents and from the analytical findings developed throughout this report. Pre-defined criteria for life-safety, mission-critical, and economic-essential categorization, applied consistently across requesting authorities, are required to avoid case-by-case adjudication during the operational window. Pre-identified decision authorities, distinct from the requesting authorities, are required to avoid the conflict of interest that real-time allocation under stress otherwise produces. Pre-established communication pathways between federal coordination (USNORTHCOM, FEMA Region X, CISA), state authority (Alaska Department of Homeland Security and Emergency Management, Alaska Governor's Office), tribal sovereign authorities, and commercial operators are required so that allocation decisions arrive at the operators who execute them within hours rather than days. The PSEMA network is the institutional architecture through which the commercial-operator end of this pathway is operationally addressable; the FEMA Public-Private Partnership maturity framework provides the institutional doctrine; the Jones Act waiver pre-staging recommendation that precedes this item provides the regulatory mechanism through which the adjudicated allocations are implemented at the maritime supply layer [30; 80].

Conduct Tabletop Exercise–Based Validation of Existing Coordination Architectures

Convene structured tabletop exercises that test Alaska's Partnership for Infrastructure Protection, the Mass Care Group and Feeding Task Force, the Alaska Food Value Chain Coordination Council, and the relevant federal-state-tribal-military coordination architecture against the dual-theater disruption scenario this research documents. Exercises must test civilian–military resource adjudication, cross-border coordination with Canadian counterparts, and time-compressed prioritization decisions under the Days 0–14 window. After-action findings convert paper-redundancy coordination architectures into operationally validated capacity.

Establish Communications Hardening Priorities for Multi-Layer Architecture

Identify the specific communications hardening investments, anti-jam capability for primary defense and emergency management nodes, redundant satellite pathways across LEO and GEO providers, high-frequency radio backup for installation-to-installation coordination, and subsea cable protection for Arctic maritime corridors, whose deployment within twelve months produces material reduction in the communications cascade pathway documented in this research. Establish liability and resilience agreements with commercial satellite providers that include service continuity commitments under stress conditions.

Establish Pharmaceutical Cold-Chain Pre-Positioning at Key Nodes

Pre-position the pharmaceutical categories, insulin, antibiotics, oxygen, dialysis supplies, and other categories where inventory depletion produces life-threatening outcomes

within days, at the regional hospital, Indian Health Service facility, and Alaska Native Tribal Health Consortium nodes whose service populations cannot be reached by external resupply within the Days 0–14 window. Investment includes backup power for cold-chain refrigeration, redundant temperature monitoring, and pre-staged distribution agreements with the commercial pharmaceutical distributors operating in Alaska. Cold-chain failure is non-recoverable within the disruption window; pre-positioning is the only mechanism that closes the medical pathway gap.

Initiate Sustained Stakeholder Engagement Architecture

Convert the engagement architecture established for this research into a sustained, recurring engagement mechanism connecting DoD mission assurance planners, NORAD and USNORTHCOM J-staff equivalents, Alaska DHS&EM, FEMA, CISA, tribal governments under sovereignty protocols, and the private-sector lifeline operators across the seven sectors examined in this research. Engagement is structured around the analytical findings of this report, with a recurring cadence that converts episodic stakeholder input into a continuous data architecture supporting future research and operational coordination.

Mid-Term Recommendations (12-36 Months)

Mid-term recommendations require sustained investment beyond a single budget cycle but can be substantially completed within a three-year horizon. They include the institutional and infrastructure investments that build resilience above the early-phase floor that near-term recommendations establish.

Distribute Microgrid Capacity to Reduce Single-Point Energy Dependency

Expand distributed microgrid capacity at the rural Alaska communities, regional installations, and dual-use civilian-military sites where energy concentration risk is highest. Investment focuses on reliability rather than maximum renewable penetration, with diesel-plus-renewable-plus-storage configurations sized for community and installation demand under disruption conditions. Investment includes the workforce capacity and spare-parts logistics required to sustain microgrid operations under Arctic conditions, addressing the workforce-infrastructure-logistics dependency documented in this research.

Begin Alternate Port Resilience Investments

Initiate the capital investment programs required to convert the six identified contingency alternatives to the Port of Alaska, Seward, Valdez, Kodiak, Homer, Whittier, and MacKenzie, into functional substitutes for containerized cargo handling. Specific investments include reefer plug-in installation at Seward, Valdez, and Homer; roll-on/roll-off ramp acquisition; weight-restriction exemption infrastructure; deep-draft cargo port construction at Whittier; conveyor and crane infrastructure at MacKenzie; and the rail and road improvements required to connect alternate ports to Alaska's downstream distribution architecture. Investment yields strategic resilience over multi-year horizons rather than Days 0–14 benefit but is necessary for the long-term reduction of single-point-of-failure exposure.

Build Medical Evacuation Surge Capacity

Expand medical evacuation surge capacity through pre-positioned aviation fuel reserves at key medevac airfields, redundant flight-following and medical consultation communications, pre-defined receiving-facility coordination protocols at Anchorage and Seattle tertiary care centers, and crew availability programs that build depth in the thin specialty workforce that medevac depends on. Investment addresses the convergence pathway in which medevac competition with cargo airlift, operational aviation, and other defense aviation requirements produces the fastest-cascading lifeline failure documented in this research.

Establish Tribal Partner Protocols for Sustained Engagement

Build a standing protocol for tribal and Alaska Native organization participation in Arctic mission assurance research, planning, and operational coordination. Protocols address the absence of pre-existing relationships between non-tribal institutions and tribal governments that the Dependency Mapping section identifies as a structural coordination gap and that the Risk and Vulnerability Assessment establishes as a primary risk-amplifier condition. Implementation parameters appropriate to specific engagement contexts are addressed in the companion study under continuity-of-society framing; this recommendation specifies the institutional investment in coordination architecture required to close the risk-amplifier gap.

Advance FEMA P3 Maturity Beyond Basic and Low-Intermediate Tier

Build the institutional architecture that progresses Alaska's Partnership for Infrastructure Protection, the federal-state-tribal-military coordination mechanisms relevant to Arctic mission assurance, and the cross-sector private-public partnership architecture from current Basic and low-Intermediate maturity toward Advanced tier. Investment includes formalized charters, sustained pre-incident engagement, regular exercise activity, and integration into commercial lifeline operator business processes. Advancement is the institutional analog to the infrastructure investments identified elsewhere in this report.

Establish a Permanent Cross-Sector Supply Chain Intelligence Function

Build, in coordination with the open-source Supply Chain Intelligence Center proposal, a permanent coordinating capability for anticipating and responding to cross-sector supply chain disruption [12]. The capability leverages FEMA's Defense Production Act authorities, CISA's Critical Infrastructure Partnership frameworks, and peer-level coordination with the Department of Transportation, Department of Commerce, and the Office of the Director of National Intelligence. Application of CNA's Supply Chain Operational Engagement methodology and FEMA's Supply Chain Analysis Network framework to Arctic-specific conditions provides the analytical foundation [16; 33].

Build Cold-Chain and Pre-Positioning Infrastructure at Tribal and Community Health Nodes

Expand cold-chain capacity, backup power, and pre-positioned medical supply at the Indian Health Service facilities, Alaska Native Tribal Health Consortium nodes, regional tribal health organizations, and the Community Health Aide Program village sites that

constitute the only line of healthcare access for many Alaska Native communities. Investment is sized to address the parallel cold-chain failure pathway documented in the Risk and Vulnerability Assessment. Implementation parameters appropriate to tribal-health-system context are addressed in the companion study; this recommendation specifies the infrastructure investment required to close the risk-amplifier gap identified in this report.

Long-Term Recommendations (36 Months or More)

Long-term recommendations require multi-year construction, sustained policy commitment, or sustained research engagement beyond the current grant window. They address the structural conditions of the Arctic operating environment that no near- or mid-term investment alone can resolve, and they establish the baseline against which future disruption response will operate.

Extended Sustainment Modeling Beyond the Days 0–14 Window

Conduct extended sustainment modeling for the recovery dynamics, structural reconstitution, and multi-month sustainment trajectories that lie beyond the Days 0–14 analytical window of this research. Extended modeling supports investment prioritization decisions whose horizons exceed the early-phase window and provides the time-to-failure parameter precision that command-level decisions ultimately require. Extended modeling is identified in this research's methodology section as the most consequential follow-on research priority.

Multi-Year Resilience Studies Across Lifeline Sectors

Conduct multi-year resilience studies that build on the dependency mapping and risk assessment foundation of this research. Studies extend the analytical scope to include longer-horizon vulnerabilities, Cook Inlet natural gas depletion, polar icebreaker fleet recapitalization, Arctic ground station resilience, undersea cable protection, which exceed the engagement window of this research but are operationally consequential for Arctic mission assurance over a five-year horizon.

Operational Piloting of Recommended Coordination Architectures

Pilot the coordination architectures identified in the near-term and mid-term recommendations under live operational conditions, including federally declared emergencies, large-scale exercises, and Arctic-specific TTX programs. Operational piloting converts coordination architectures from validated-on-paper to validated-in-operations, addressing the specific concern that paper-redundancy coordination does not perform under the time pressure that disruption response imposes.

Integrated Arctic Logistics Testbed

Establish, in partnership with the Department of Defense, the Department of Transportation, the Maritime Administration, FEMA, the State of Alaska, tribal governments, and the private-sector lifeline operators, an integrated Arctic logistics testbed that supports operational evaluation of mitigation investments, coordination architectures, and emerging logistics technologies under realistic Arctic conditions. The

testbed is the institutional vehicle through which research, operational capability, and private-sector partnership converge for the long-term resilience investment that single-program lines of effort cannot deliver.

Codified DoD–Private Sector–Nongovernmental Coordination Doctrine

Develop, in coordination with NORAD, USNORTHCOM, the Office of the Secretary of Defense, FEMA, and the broader emergency management and private-sector partnership community, codified doctrine for DoD–private sector–nongovernmental coordination under contested-logistics conditions. Doctrine builds on NSM-22's defense critical infrastructure framework, the FEMA Public-Private Partnership maturity model, the Jones Act waiver framework, and the contested-logistics literature, and produces the doctrinal foundation under which the recommendations of this report and the connective infrastructure of the PSEMA network operate [30; 34; 80].

Long-Horizon Infrastructure Investments, Polar Icebreakers, Processing Capacity, Refining

Sustain the long-horizon infrastructure investments identified across this research as necessary for structural Arctic resilience but exceeding the analytical window of this engagement. These include polar icebreaker fleet recapitalization through the Polar Security Cutter program and the April 2025 Request for Information for Arctic Security Cutters [21; 68]; in-state food processing capacity expansion to address the structural processing-capacity ceiling [3]; and in-state refining capacity assessment to address the upstream refining dependency that compounds Alaska's fuel vulnerability. None of these is a Days 0–14 mitigation; all are necessary for the resilience baseline against which future disruption will be measured.

FROM RECOMMENDATIONS TO IMPLEMENTATION

The Coordination Gap This Research Has Identified

The recommendations developed in this report identify multiple external partners across every line of effort: the Homeland Defense Institute, NORAD and USNORTHCOM, Alaska DHS&EM, FEMA, CISA, tribal governments and Alaska Native organizations, academic institutions, and the private-sector operators across the seven lifeline sectors examined in this research. The recommendations themselves are operationally executable. What this section names directly is the connective infrastructure under which they become operationally executable, and the institutional gap that infrastructure exists to fill.

The most analytically significant institutional finding of this research is direct. There is no sustained, trust-based, operationally tested intermediary connecting Department of Defense components to the family readiness organizations, civilian and contractor workforce networks, tribal and Alaska Native governance structures, behavioral health systems, faith-based networks, and community organizations that together sustain Arctic mission assurance at the human-systems layer. Every population in that list is operationally consequential during Days 0–14 disruption. None is currently connected to DoD through a sustained intermediary that combines non-attribution, sector neutrality, and operational credibility. The protocols on paper assume a connector that does not exist with the reach, trust, and operational credibility the Days 0–14 window requires.

The consequence under the dual-theater scenario is direct. Commercial operators, port authorities, maritime carriers, rail operators, trucking companies, telecommunications providers, and pharmaceutical distributors, make cargo prioritization and service-availability decisions based on commercial logic that does not account for defense sustainment requirements. Installation commanders hold authority over on-base resource allocation but have no control over the commercial cargo prioritization or civilian workforce availability on which sustainment depends. State authority can reallocate scarcity across competing populations but cannot create supply. Tribal governments hold sovereign authority over land, workforce, and local infrastructure that defense operations depend on but operate outside formal defense coordination architectures. The result is a structural fragmentation that no individual entity can resolve unilaterally, and that no after-event coordination mechanism can match for speed.

Three structural facts beneath this fragmentation make the gap analytically primary rather than peripheral. First, the privately operated lifelines and human-systems partners that sustain Arctic operations are owned, operated, and led outside DoD authority; mission assurance therefore depends on cross-sector coordination that no single contract, command, or agency is positioned to deliver. Second, the federal partnership architecture has known gaps for the function this research identifies, FEMA's P3 model is calibrated to civilian disaster response, CISA holds critical infrastructure protection authority without functioning as an operational intermediary for Arctic contested-logistics, and DoD itself cannot be sector-neutral by definition because it is one of the parties whose

interests must be coordinated. Third, trust-based intermediation is not a function that contracts can produce. The relationships across commercial operators, federal agencies, state authorities, tribal governments, and academic institutions that the recommendations require depend on sustained engagement under non-attribution protocols, cross-sector translation that respects sectoral confidentiality, and operational credibility built through consistent presence in the spaces where lifeline systems and defense requirements actually intersect. None of those conditions can be created transactionally during a disruption.

The PSEMA Network as Connective Infrastructure

The recommendations developed in the previous section identify what must happen across near-term, mid-term, and long-term horizons to close the gap between current Arctic mission assurance capacity and the demands the dual-theater scenario imposes. Every recommendation identifies multiple external partners: the Homeland Defense Institute, NORAD and USNORTHCOM, Alaska DHS&EM, FEMA, CISA, tribal governments and Alaska Native organizations, academic institutions, and the private-sector operators across the seven lifeline sectors examined in this research. The recommendations are operationally executable. What requires explicit articulation is the connective infrastructure under which they become operationally executable.

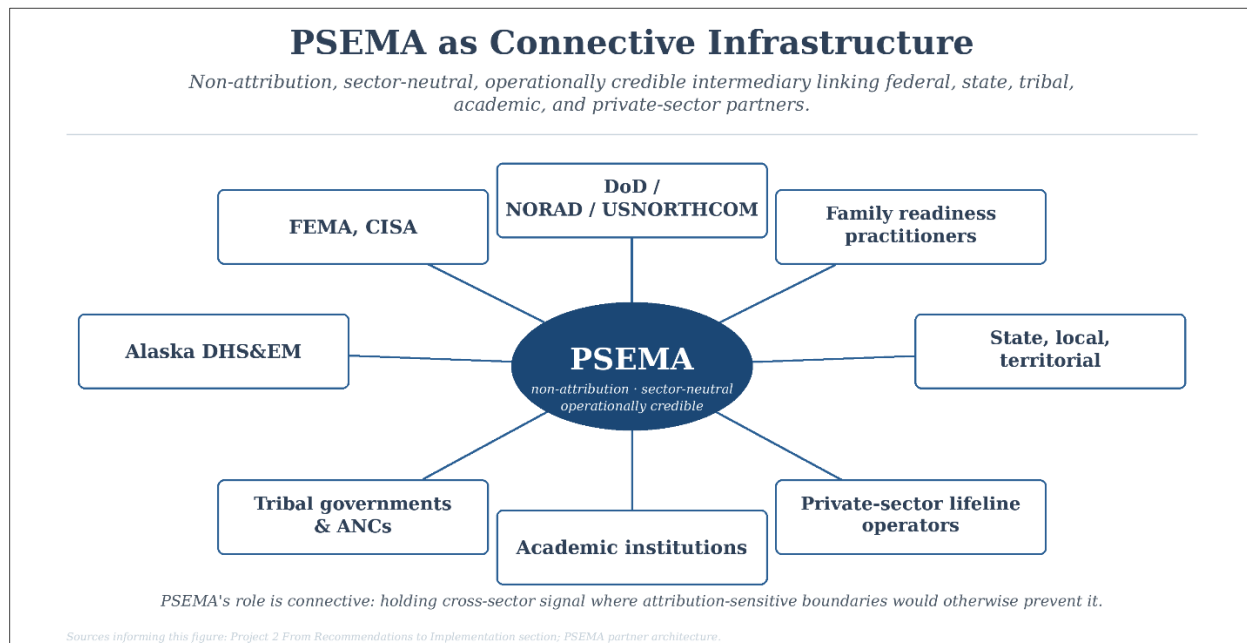
This section names that requirement directly and develops the partnership case that follows from it. The most analytically significant institutional finding of this research is that the architecture necessary to translate between defense mission requirements and the privately operated systems that sustain them, the connective infrastructure that the recommendations and the contested-logistics literature both identify as essential, does not currently exist within the federal architecture at the maturity Arctic mission assurance requires. The Private Sector Emergency Management Association, whose institutional identity, mission, membership composition, and operational posture are described in the Research Sponsor and Institutional Context section earlier in this report, is positioned to fill that gap. This section explains what the gap is, why a sector-neutral, non-attribution intermediary is the architecture required to close it, how PSEMA is structured to operate as that intermediary across the lifeline sectors examined in this research, the specific connection points through which the network engages the external partners the recommendations name, and the continuation availability PSEMA offers to extend this research into the multi-year horizon the analytical record establishes as necessary.

Multi-stakeholder convenings, such as the Ted Stevens Center's High North Security Dialogue, demonstrate that structured cross-sector dialogue is increasingly recognized as a primary mechanism for surfacing operational realities that single-author analysis cannot capture [60].

This research has documented the human-systems coordination weakness that determines whether Arctic continuity of society holds under disruption. The weakness is specific and operationally consequential: there is no sustained, trust-based, operationally tested intermediary connecting DoD and military components to the family readiness organizations, civilian and contractor workforce networks, tribal and Alaska Native

governance structures, behavioral health systems, faith-based networks, and community organizations that together sustain Arctic mission assurance at the human-systems layer. The protocols on paper assume an intermediary that does not exist with the reach, trust, and operational credibility the Days 0–14 window requires.

The Private Sector Emergency Management Association is positioned to fill that role, and this section articulates why and how. The framing is integrated with the companion study's PSEMA Network section to present a unified connective architecture across both research lines: where the companion study positions PSEMA as the intermediary connecting DoD to the privately operated lifeline systems on which Arctic operations depend, this research positions PSEMA as the intermediary connecting DoD to the human-systems partners through whom continuity of society is sustained.



Visual depicting PSEMA's sector-neutral intermediary role linking business, industry, , associations, government, nonprofit, and academic.

Why a Sector-Neutral Intermediary Is The Architecture Required, and Why PSEMA Fits It

The Private Sector Emergency Management Association occupies an institutional position uniquely suited to closing this gap. PSEMA operates as a non-attribution, sector-neutral, operationally credible intermediary across the categories of private-sector lifeline operators that Arctic mission assurance depends on: energy and fuel providers, transportation and logistics firms, telecommunications and technology companies, food distribution and supply chain partners, medical and pharmaceutical providers, warehousing and cold-chain operators, and humanitarian and disaster-relief organizations. The non-attribution posture is operationally consequential: it enables candid practitioner engagement with the operators who would otherwise be constrained

from discussing system vulnerabilities and operational limits in attributed forums, generating the kind of operational data this research has documented as essential to validated mitigation planning.

The sector-neutrality is structurally important because the dependencies this research has mapped are cross-sector. A coordination architecture anchored in any single lifeline category, energy, transportation, communications, food, medical, would replicate the fragmentation that the dependency mapping identifies as the underlying vulnerability. PSEMA's design is the inverse: it is anchored in the cross-sector logic that the cascade pathways require, with sustained relationships across the operator categories whose interactions determine system performance under disruption.

The connective infrastructure Arctic mission assurance requires has a specific institutional shape. It must be non-attribution, because the operational realities that determine system performance under disruption cannot be surfaced in attributed forums. It must be sector-neutral, because the dependencies this research has mapped are cross-sector and a coordination architecture anchored in any single lifeline category would replicate the fragmentation the dependency mapping identifies as the underlying vulnerability. And it must be sustained across pre-incident, incident, and post-incident periods, because the trust and relational continuity that operational coordination depends on cannot be built transactionally once a disruption is underway.

These three characteristics are the operational posture established as PSEMA's institutional foundation in the Research Sponsor and Institutional Context section. This subsection makes the operational case for why they are the right architecture for the gap this research has identified and translates them into three concrete mechanisms through which the PSEMA network closes the paper-redundancy gap at the coordination layer where it originates.

PSEMA's institutional position addresses the paper-redundancy gap at the layer where it originates: the coordination and governance architecture that determines whether documented redundancies translate into operational throughput. PSEMA operates as a sustained intermediary across the categories of private-sector lifeline operators and human-systems partners that Arctic mission assurance depends on, energy and fuel providers; transportation and logistics firms; telecommunications and technology companies; food distribution, supply chain, and humanitarian feeding organizations; medical and pharmaceutical providers; engineering and infrastructure resilience consultancies; tribal and Alaska Native organizations; family readiness and behavioral health networks; and the federal, state, and academic partners whose engagement the recommendations require. The cross-sector reach is not incidental; it is the structural condition that makes the three mechanisms below operationally feasible.

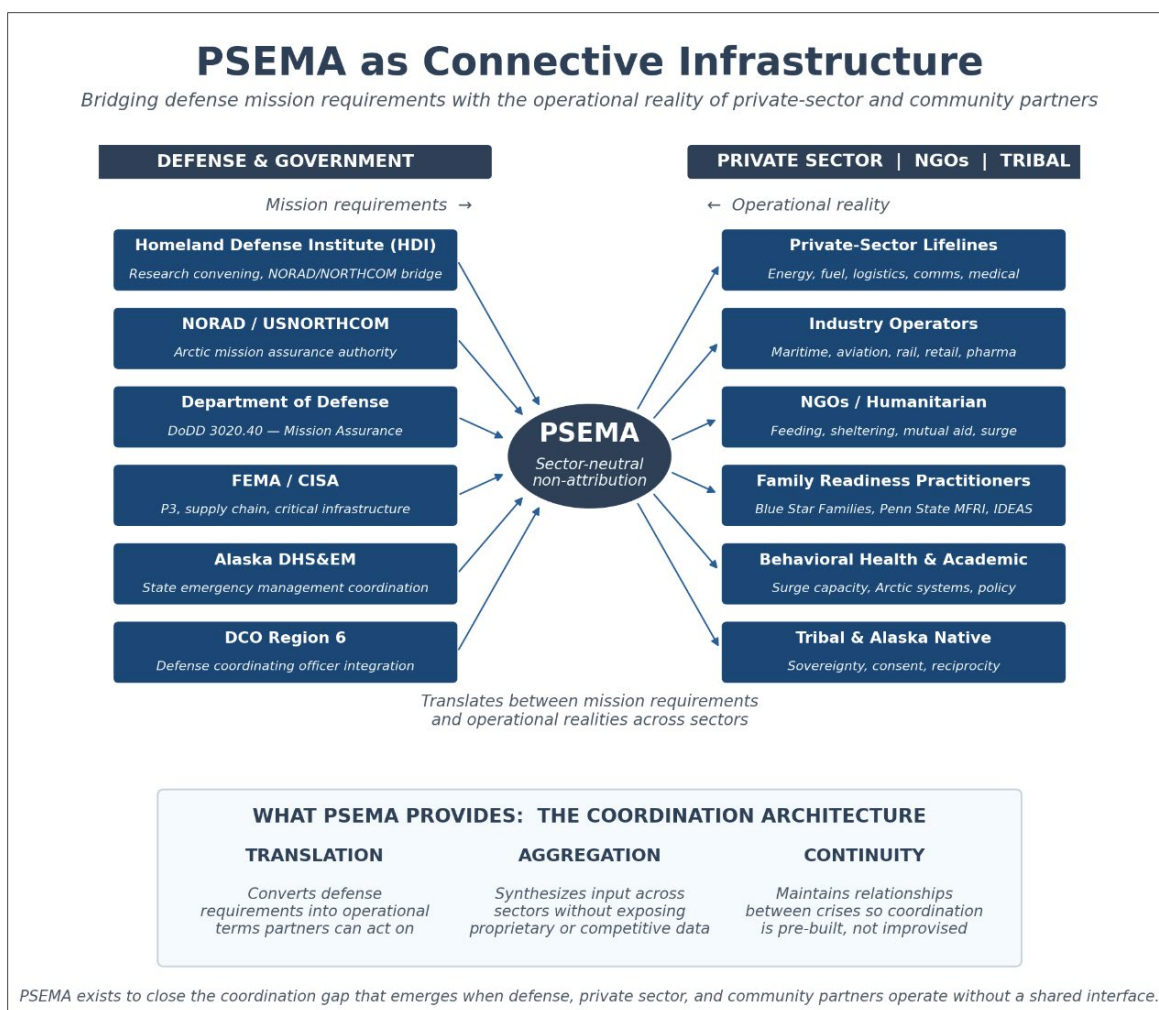
First, PSEMA converts episodic engagement into sustained engagement architecture. The federal Public-Private Partnership maturity model identifies sustained engagement as the precondition for the operational coordination that disruption response requires [28]. Episodic engagement, incident-only, transaction-only, contract-only, produces the paper-redundancy condition that disruption response

exposes. Sustained engagement, pre-incident, through-incident, post-incident, with consistent participants and consistent analytical posture, converts paper relationships into operational architecture. Business Emergency Operations Center architectures connecting commercial lifeline operators, installation commanders, state emergency management, and tribal governments produce the institutional infrastructure through which civil-military resource adjudication can occur under time pressure. PSEMA is structured for the sustained mode rather than the episodic one.

Second, PSEMA functions as the cross-sector translation layer that no single agency or sector is positioned to provide. Defense components understand defense mission requirements; commercial operators understand commercial operating realities; tribal governments understand tribal sovereignty; federal civilian agencies understand federal civilian authority. The translation across these vocabularies, frameworks, and decision-making paradigms is itself the function the contested-logistics literature identifies as missing [44]. Without a sector-neutral translator, each party operates from a partial mental model of how the others will behave under stress, and the assumption misalignments that result are themselves a primary cascade trigger. PSEMA's sector-neutral positioning makes the translation function structurally feasible because PSEMA is not a party to the operational decisions whose coordination it facilitates.

Third, PSEMA produces and disseminates the integrated analytical products that close the information-asymmetry condition that paper redundancy depends on. When defense planners assume that contractual relationships produce operational continuity under stress, when commercial operators assume that defense requirements will be coordinated through standing channels that do not exist at the maturity assumed, and when state and tribal authorities assume that federal-level coordination architecture will deploy at the pace disruption requires, the asymmetry of expectations among the parties is what produces the paper-redundancy outcome. Integrated analytical products, like this research and its companion study, convert asymmetric expectations into shared analytical foundation, against which expectations can be calibrated and operational coordination architecture can be built. The non-attribution posture is what makes the underlying operational data accessible to the analytical record at all; the sector-neutral positioning is what makes the cross-sector synthesis possible; and the sustained engagement is what allows the analytical products to track evolving conditions across the multi-year horizon Arctic mission assurance requires.

Operational Implication: Paper redundancy at the governance and coordination layer cannot be closed by infrastructure investment, by additional contracts, or by federal directive alone. It can be closed only by sustained, sector-neutral, operationally credible intermediation that converts episodic engagement into continuous architecture. PSEMA is the connective infrastructure positioned to fill that role across the lifeline sectors examined in this research.



Connection Points: How PSEMA Connects to the External Partners

The recommendations developed in this report identify specific external partners across every line of effort, the full mapping of recommendations to lead actors and supporting partners is consolidated in the Appendix H. The PSEMA network connects to those partners through specific institutional pathways developed over years of sustained engagement. Six connection point categories warrant explicit identification.

HDI and the Homeland Defense Research Architecture

PSEMA's research engagement with the Homeland Defense Institute, including this research effort and its companion study, establishes a direct working relationship with the institutional convening function for Arctic homeland defense research priorities. HDI's partner architecture provides connection to NORAD and USNORTHCOM operational requirements, to interagency research priorities, and to the academic institutions whose analytical capacity supports follow-on research. The connection point is direct, current, and operationally productive; this report itself is a worked example of the architecture in operation.

NORAD/USNORTHCOM Mission Partners

PSEMA's strategic conversations with current and former NORAD and USNORTHCOM leadership establish the operational requirements that the analytical record of this research be designed to support. The connection point provides direct access to the mission assurance authorities that hold Arctic homeland defense responsibility, and to the J-staff equivalents whose operational planning incorporates the findings the research delivers. Sustained engagement converts episodic strategic dialogue into a continuous information architecture supporting both research and operational coordination.

Alaska DHS&EM, FEMA, CISA, and the Federal Emergency Management Architecture

PSEMA's institutional standing within the emergency management community connects directly to Alaska DHS&EM at the state level, FEMA at the federal level, and CISA for critical infrastructure coordination. These connections are particularly consequential because the recommendations developed in this report depend on the public-private partnership maturity progression, the federal supply chain resilience programs, and the critical infrastructure protection coordination that these agencies hold. PSEMA's positioning within the emergency management community, rather than adjacent to it, makes the connection operationally substantive rather than nominal.

Tribal Governments and Alaska Native Organizations

PSEMA's tribal partnerships operate under sovereignty, consent, and reciprocity throughout. Tribal governments are sovereign entities whose engagement with PSEMA proceeds on terms agreed by tribal participants. Reciprocity ensures that PSEMA-mediated coordination returns usable findings to tribal participants rather than extracting data. The connective role is structurally limited: PSEMA does not represent tribal governments or speak for them; it provides the coordination infrastructure through which tribal-DoD-state-federal coordination can occur on tribal terms.

Family Readiness Practitioners and Behavioral Engagement Partners

PSEMA's connection to the family readiness ecosystem combines two complementary capacities. The first is family-research and household-support reach: Blue Star Families, the Penn State Military Families Research Institute, the National Military Family Association, and the broader military family research and support community provide the family readiness coordination capacity that the FRG decline has left open, with bidirectional flow that surfaces practitioner reality from family readiness organizations to DoD planning and surfaces DoD operational requirements to family readiness organizations in operationally usable form.

The second capacity is behavioral engagement and preparedness campaign design, anchored by IDEAS. IDEAS is the creative and engagement firm that designed the original *Kids Get a Plan* preparedness platform in partnership with the Florida Division of Emergency Management, one of the most behaviorally effective youth preparedness platforms in the United States. The platform's assets are now owned by the PSEMA Foundation under an agreement with the Florida Division of Emergency Management that authorizes extension, adaptation, and expansion into new audiences and operational environments. The platform has already been adapted to an Alaskan context through the

Turn Around, Don't Drown expansion developed with the Alaska Division of Homeland Security and Emergency Management. For this research, the IDEAS connection point is operationally consequential: it is the partner through which the *Household-Level Preparedness Extension to Underserved Populations* recommendation and the Arctic Rising Generation Preparedness Initiative move from analytical proposal to deployed campaign capability, without reconstructing methodology, asset library, legal vehicle, or state-agency relationship from the ground up. The combined connection point, family research and support networks paired with a twenty-year behavioral engagement and campaign-design capability, is the architecture through which the household-level and family-readiness recommendations of this report become operationally executable.

Behavioral Health Systems and Academic Institutions

PSEMA's connections to behavioral health systems operationalize the surge capacity gap this research identifies as the workforce-sustainment ceiling, including the trained provider pool, tele-behavioral health infrastructure capable of operating under degraded communications, and tribal-led behavioral health programming under sovereignty protocols. PSEMA's research collaboration with the Ted Stevens Center for Arctic Security Studies, with university research centers specializing in Arctic homeland security, and with research institutions including RAND, the Naval Postgraduate School, and the broader contested-logistics research community provides connection to the analytical capacity required for follow-on research. The connection is operationally productive because academic partners contribute the methodological depth and the multi-year research horizons that single-program engagements cannot sustain, including the longitudinal family readiness studies and multi-year continuity-of-society modeling identified in the long-term recommendations.

Private-Sector Lifeline Operators Across the Seven Sectors

PSEMA's standing engagement spans the seven lifeline sectors examined in this research, and the cross-sectoral reach is the architecture that converts research findings into operationally executable coordination across the recommendations of this report.

Continuation Availability

The recommendations developed in this report exceed the engagement window of this research. Near-term lines of effort begin within twelve months of report submission; mid-term lines require sustained execution across one to three years; long-term and follow-on research lines identify investments whose multi-year horizons begin now but extend well beyond the current research engagement. Each tier requires the connective infrastructure described in this section to operate effectively, and that infrastructure cannot be reconstructed at each transition between research phases.

PSEMA views this research as a foundational exploration of Arctic continuity of society and is positioned to continue the connective infrastructure function across the recommendations identified in this report and across the follow-on research priorities the analytical record supports. Continuation availability is offered to HDI, NORAD/USNORTHCOM, and the broader interagency partnership architecture as a structural commitment, not as a transactional offer.

Specifically, PSEMA is positioned to support the following continuation lines of effort: convening and facilitation of the tabletop exercises identified in the near-term recommendations; engagement architecture development for the sustained stakeholder engagement and the public-private partnership maturity progression identified in the mid-term recommendations; cross-sector facilitation of the operational piloting cross-sector facilitation of the operational piloting and Arctic societal sustainment testbed concepts (paired with the companion study's infrastructure testbed) identified in the long-term recommendations, ongoing coordination with academic partners on the extended sustainment modeling and multi-year resilience studies that exceed the engagement window of this research; and continuing analytical work as new data, new operational conditions, or new research priorities emerge from the integrated picture this report and its companion study deliver.

The closing analytical proposition is straightforward. Arctic homeland defense cannot be sustained against the dual-theater disruption scenario this research models without the layered investment, the institutional coordination, and the connective infrastructure that the recommendations and this section together identify. Closing the gap between current capacity and what the threat environment requires is not a single-program effort; it is a sustained, multi-partner, multi-year line of work whose return is realized over horizons that no single research engagement can encompass. PSEMA is structured for that horizon, positioned within the network the recommendations require, and committed to the continuation availability the analytical record establishes as essential.

CONCLUSION

Arctic mission assurance is a systems problem, not a capital investment problem. The lifeline systems on which Arctic homeland defense depends were not designed for the disruption scenario this research models; they were designed for normal operating conditions, and they are thin at every margin, in storage capacity, in redundancy, in workforce, in coordination architecture, and in the time available before failures cascade across sectors. Under dual-theater disruption, those margins compress from weeks to days, and in some cases to hours.

The five-deliverable architecture this report develops establishes the analytical foundation operational planning requires. The scenario framework defines the Days 0–14 decision window in which sustainment assumptions fail and consequential decisions must be made under uncertainty. The dependency mapping identifies what is connected to what across national supply pathways, in-theater lifeline systems, and mission-dependent community infrastructure. The risk and vulnerability assessment establishes where and when those connections break, how failure cascades non-linearly, and which vulnerabilities become mission-limiting within the first fourteen days. The substitution and redundancy reality check documents the gap between paper redundancy and operational redundancy. The institutional coordination review identifies governance architecture as a risk amplifier in its own right. The mitigation prioritization translates these findings into seven integrated investment categories, and the recommendations organize that pathway across near-term, mid-term, and long-term horizons. The PSEMA Network section identifies the connective infrastructure under which the recommendations become operationally executable.

Five integrating observations close the analytical record.

First, the dual-theater disruption scenario is structurally consistent with the simultaneity problem the 2025 National Defense Strategy identifies as a primary planning challenge, calibrated to Arctic geographic and seasonal realities and grounded in the commercial supply architecture that NSM-22 explicitly recognizes as defense critical infrastructure [70; 80].

Second, failure pathways are non-linear, fast-cascading, and self-reinforcing. The window for effective intervention closes faster than linear degradation models suggest. Inventory buffers measured in days eliminate the multi-week adjustment period that planning frameworks implicitly assume; communications failure operates as a force degrader on every other failure pathway; pharmaceutical cold-chain failure is non-recoverable within the analytical window.

Third, paper redundancy is the systemic condition that makes the failure pathways consequential. Alternate ports, aviation substitution, satellite communications backup, pharmaceutical distribution diversification, state emergency feeding architecture, and public-private coordination frameworks all exist on paper at maturity levels that do not

perform under the stress conditions the dual-theater scenario imposes. The capacity-versus-throughput distinction is the analytical commitment that surfaces the gap.

Fourth, institutional coordination is a primary cascade trigger, not a passive backdrop. The absence of pre-defined civilian–military adjudication mechanisms, underdeveloped cross-border coordination architecture, and the absence of a sustained, trust-based intermediary across defense, commercial, nongovernmental, tribal, and academic actors are structural risk amplifiers. Building the coordination architecture before the crisis is a high-return, low-capital priority that no infrastructure investment can substitute for.

Fifth, the path forward is layered, multi-partner, and multi-year. Near-, mid-, and long-term recommendations operate concurrently rather than sequentially. Energy and coordination architecture are foundational, but the layered architecture across maritime throughput, communications, workforce, logistics, food, and the cross-sector connective infrastructure that holds them together is what produces the resilience baseline Arctic mission assurance requires.

End state. The end state this research is constructed to support is straightforward: an Arctic homeland defense architecture in which privately operated lifeline systems are recognized as defense critical infrastructure under NSM-22 [80]; in which the dual-theater disruption scenario is integrated into mission assurance planning at the operational specificity command-level decisions require; in which preparatory investments, pre-positioned reserves, pre-staged regulatory authority, pre-defined civilian–military adjudication, multi-layer communications redundancy, and exercised coordination architectures, are in place before disruption requires them; and in which the cross-sector connective infrastructure that translates between defense mission requirements and the privately operated systems that sustain them operates at the maturity the threat environment requires. This end state is achievable. The recommendations are operationally specific, the partner architecture is identified, the time horizons are realistic. What remains is the institutional commitment to fund, exercise, and sustain the layered investment the analytical record establishes as required.

Forward linkage. The findings, recommendations, and connective infrastructure framing carry forward to the June 2026 Homeland Defense Awareness Symposium briefing, where they will be positioned against the operational planning cycles of the audience institutions and the cross-cutting institutional coordination question, the connective infrastructure gap and the PSEMA network framing, surfaced for direct discussion. Beyond the symposium, the long-term recommendations identify the follow-on research agenda the analytical foundation supports: extended sustainment modeling, multi-year resilience studies, operational piloting, the integrated Arctic logistics testbed, codified DoD–private-sector–nongovernmental coordination doctrine, and the long-horizon infrastructure investments. The companion study, *Continuity of Society in the North: Multi-Modal Resiliency in Arctic Defense*, addresses the human-systems dimensions of the same disruption environment, and the integrated picture across the two studies positions the homeland defense research community to engage Arctic resilience as the systems-design and institutional-coordination challenge the analytical record establishes it to be.

PSEMA is committed to that work and welcomes the opportunity to discuss with the Homeland Defense Institute, NORAD/USNORTHCOM, and mission partners how this research can be extended and deepened in support of Arctic homeland defense and the commercial and community systems that make it possible.