Clear Skies

A Reference Architecture for Resilient Alaskan Microgrid Cyberinfrastructure

John Haverlack

Author: John Haverlack

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Introduction

2.0.1 Vision Statement

Clear Skies is a locally grown initiative to build **community-owned, cloud-free digital infrastructure** across rural Alaskan microgrid communities. It empowers villages, tribes, and regional utilities to host and secure their own data, communications, and operational systems — right where they live and work without reliance on distant cloud services.

By bringing computing power, cybersecurity, and communications back under local control, **Clear Skies** advances *digital sovereignty* as as a modern expression of community and tribal self-determination.
It strengthens self-reliance, ensures continuity during network outages, and creates a foundation for innovation that reflects Alaska's values of **independence, stewardship**, and **cooperation**.

The following reference architecture outlines how Clear Skies can be implemented in scalable layers, from physical infrastructure to regional collaboration.

2.1 Problem Statement

Chapter 3

Strategic Architecture

Clear Skies is built on a simple principle: **local-first by design.**
Every system — from the smallest sensor to the community data center — operates independently of the cloud services, ensuring that essential services remain available, secure, and under local control even when Internet connectivity is lost.

Clear Skies adopts a layered approach to build increasingly complex modular capabilities on top of a resilient cyberinfrastructure foundation.

[[ClearSkies-Overview-notitle.excalidraw.png]] ## Layer 0 - Hardware (HW)

The hardware selection can be based on 3 tiers to accommodate different cost, scalability, and resiliency needs.

3.0.1 Tier 1 - Camp Site

Purpose: Portable or training-scale deployments for small teams and pilot projects.

- Commodity Grade Hardware
- Low Cost of Entry and Maintenance
- Portability
- Limited Capacity
- Basic Services
- Limited Resiliency
- Scales to 10's of People

3.0.2 Tier 2 - Village Site

Purpose: Fully featured, community-level cyberinfrastructure supporting daily operations.

- Commodity Grade Hardware
- Low Cost of Entry and Maintenance
- Full Stack Service Capabilities
- Full Resiliency - Zero Single Points of Failure

- Scales to 100's of People

3.0.3 Tier 3 - Regional Site

Purpose: High-capacity, multi-community or research hub supporting advanced services and federation.

- Enterprise Grade Hardware
- Moderate Cost of Entry and Maintenance
- Full Resiliency - Zero Single Points of Failure
- Scales to 1000's of People

#
Layer
1 -
Cy-
berin-
fras-
truc-
ture
(CI)

#
Layer
2 -
Local
Ser-
vices
(LOC)

#
Layer 1 - Cyberinfrastructure (CI)
ayer 2 builds upon the Cyberinfrastructure (CI) foundation to deliver the mission-specific functions that keep a community operating, informed, and connected. These following modular service areas

#	Layer 1 - Cyberinfrastructure (CI)
	ach category reflects a practical application of the local-first philosophy: keeping critical data, control, and communication inside the community while remaining interoperable with re-

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Layer 1 - Cyberinfrastructure (CI)

Operational Technology (OT) / SCADA / ICS

*Purpose:** maintain safe, efficient, and observable microgrid operations under all conditions.

#	Layer 1 - Cyberinfrastructure (CI)	Supervisory control and monitoring for generation, distribution, and storage systems. Secure, segmented access for operators, engineers, and vendors. Local data historians for real-time visibility even

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Layer 1 - Cyberinfrastructure (CI)

Industrial Internet of Things (IIoT) Networks

*Purpose:** gather and use data from across the community—power, heat, water, environment—to inform decisions locally.

#	Layer 1 - Cyberinfrastructure (CI)	LoRaWAN, Modbus TCP, and MQTT telemetry from sensors across the community. Local brokers and dashboards (Node-RED, Grafana) for low-bandwidth visualization. Edge analytics and rule-based automation

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Layer 1 - Cyberinfrastructure (CI)

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*Purpose:** ensure situational awareness and coordination during disasters or outages.

#	Layer 1 - Cyberinfrastructure (CI)
	Local voice, text, and alerting systems that function when commercial networks fail. Interoperable with radios, satellite links, or FirstNet gateways when available. Capable of community-wide paging,

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Layer 1 - Cyberinfrastructure (CI)

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*Purpose:** strengthen community cohesion and digital inclusion through local, private communication spaces.

#	Layer 1 - Cyberinfrastructure (CI)
	Locally hosted chat, video, and bulletin-board tools (Matrix, Jitsi, etc). Intranet portals for schools, clinics, and tribal councils. Content caching and offline web access for education and information sharing.

Layer 1 - Cyberinfrastructure (CI)

Additional Service Categories (Expandable)

Cybersecurity Operations: IDS/IPS, log correlation, vulnerability scanning, and SOC visualization.

Education & Research Sandboxes:

Layer 1 - Cyberinfrastructure (CI)

Outcome

Layer 1 - Cyberinfrastructure (CI)

ayer 2 turns Clear Skies from infrastructure into impact — providing the tools that make a self-reliant community not only operationally resilient but also informed, connected, and empowered.

Layer 1 - Cyberinfrastructure (CI)

3.1 Layer 3 - Community Connections (COMM)

Layer 3 extends Clear Skies beyond individual communities.
It enables **secure collaboration, knowledge sharing, and regional coordination** between sites — while preserving each community's digital sovereignty.
These connections are intentional, encrypted, and always under local control. ### Secure Networking and Federation - **Tailscale / Headscale Zero-Trust Network Access (ZTNA) Bridges:** lightweight, encrypted overlays that connect Camp, Village, and Regional sites into a trusted mesh without public exposure. - **Cross-Site Data Sharing:** optional, policy-driven replication of telemetry, research, and analytics data between communities or partner institutions. - **Federated Identity and Trust:** local identity systems (Keycloak / Smallstep CA) exchange only the credentials necessary for inter-site collaboration. - **Bandwidth-Aware Synchronization:** asynchronous, store-and-forward file and database replication designed for limited or intermittent connectivity.

3.1.1 Collaborative Applications

- Shared monitoring dashboards and situational-awareness maps.
- Federated educational resources and research datasets.
- Inter-community communication tools for regional operations centers or cooperative utilities.

Purpose: build a network of sovereign digital islands — each self-reliant, yet capable of cooperating across Alaska's vast geography through secure, transparent, and low-bandwidth bridges.

3.1.2 Outcome

Layer 3 transforms Clear Skies from isolated local systems into a **distributed ecosystem of collaboration**.
Communities retain full control of their data and infrastructure while participating in a resilient, Alaska-wide digital commons built on trust, openness, and shared stewardship.

Chapter 4

Terminology

Chapter 5

Citations