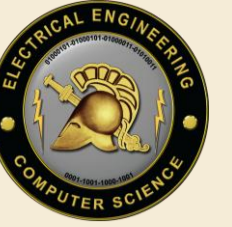




SPARK

Silent Panel Array Relay Kit

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Abstract

SPARK (Silent Panel Array Relay Kit) employs **passive optical communication** to enable encrypted, wireless data exchange with **zero RF and zero acoustic emissions**. Modern adversaries use Electronic Warfare systems to geolocate friendly forces from RF emissions within minutes — rendering conventional radios a liability in contested terrain. SPARK eliminates this vulnerability by encoding AES-256 encrypted messages as QR codes on e-ink displays, producing no detectable electromagnetic signal at any stage of operation. The system is rucksack-portable, drone-relay compatible, and fully operable by a single dismounted Soldier — restoring the ability to communicate inside the most contested slice of the electromagnetic spectrum.

PROJECT GOAL, IN NUMBERS

Throughput	≥ 20 kb/s
Link range	100 m
Relay range	10 km
System weight	< 5 lbs
Power draw	< 100 W
RF signature	0 dB

Background & Threat

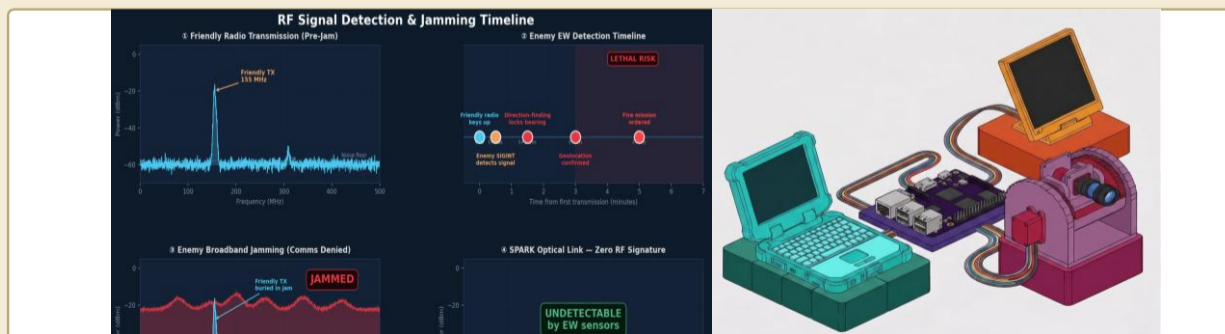
Background

Modern adversaries have deployed sophisticated Electronic Warfare (EW) systems capable of detecting, triangulating, and geolocating the source of any RF emission within minutes. Even a brief radio status update can reveal a sender's location with enough precision to trigger an immediate indirect-fire mission.

Recent conflicts have demonstrated that conventional radios are survivable only in uncontested terrain. When adversaries jam forward communications, Observation Posts lose the ability to report and coordinate — creating dangerous capability gaps precisely when reliable communication matters most. **A new class of silent, passive communication is required** to restore tactical initiative in the modern EW fight.



Image 1 - Russian communications jammer mounted on T-90.



Technical Architecture & Concept

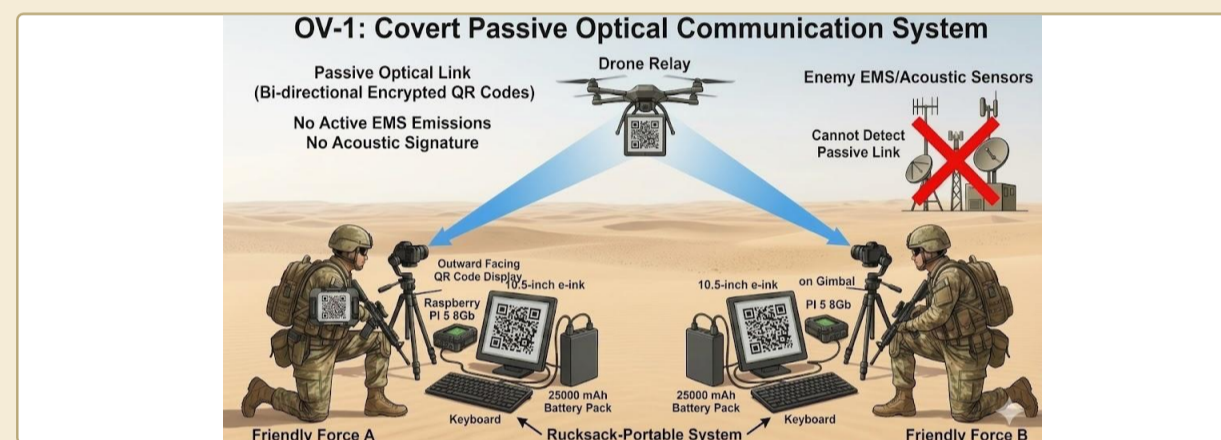


Image 2 - OV-1 - Covert Passive Optical Communication System.

Software

SPARK's software stack is built in Python using a modular pipeline: plaintext is compressed with Brotli, encrypted using X25519 + Fernet (HKDF-SHA256 key derivation), Base64-encoded, and rendered as a QR code on the e-ink display. The receive path reverses the process — the camera captures the QR, OpenCV decodes it, payload is decrypted and decompressed back to plaintext.

- Structured message templates: SITREP, TTL0DAC, Call for Fire
- Dedicated reply window displaying outgoing QR codes
- One-button re-key handshake for suspected compromise
- Arduino serial output for automated gimbal alignment

Hardware Architecture

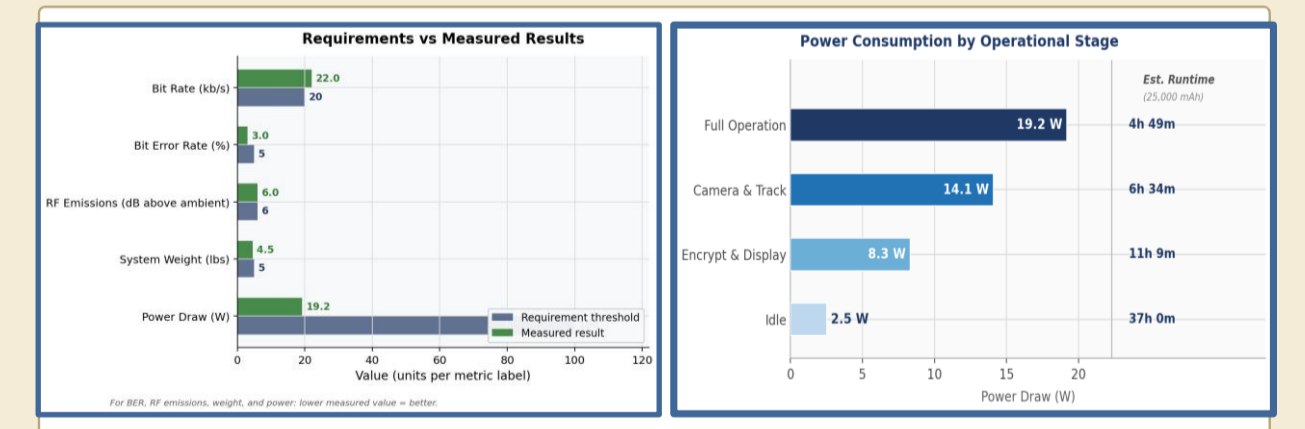
The SPARK payload integrates a Raspberry Pi 5 as the central compute unit, driving a 10.5" Waveshare e-ink display for passive QR output and an Arducam 12 MP camera mounted on a 2-axis motorized gimbal for autonomous target tracking. A 25,000 mAh battery powers the full system under 100 W, and an Arduino handles real-time gimbal alignment corrections via serial communication and a PID algorithm.

- Raspberry Pi 5 — encryption, QR render, camera decode
- Waveshare 10.5" e-ink panel — zero-emission message surface
- Arducam 12 MP + 2-axis gimbal — autonomous tracking

Results & Warfighter Impact

Measured Results

TASK / OBJECTIVE	STATUS
Bit rate ≥ 20 kb/s	Completed
RF emissions ≤ 6 dB above ambient (0–6 GHz)	Completed
AES-256 end-to-end encryption verified	Completed
Autonomous gimbal QR tracking operational	Completed
System weight < 5 lbs confirmed	Completed
Power draw < 100 W at full operation	Completed
Survived drop & shake — nominal function	Completed
10 km relay range — drone field trial	Future Work
Night operation (IR camera integration)	Future Work
Autonomous navigation to source	Future Work

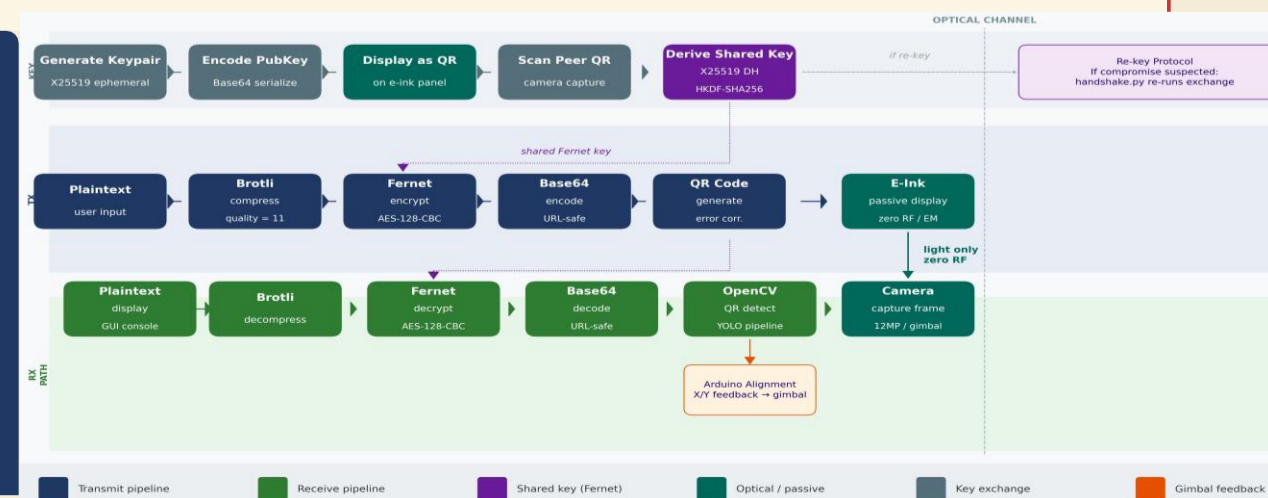


Requirements vs. measured results — all five primary metrics met or exceeded threshold.

Conclusion

SPARK proves that effective tactical communication does not require a radio. The team successfully designed, built, and validated a fully encrypted, rucksack-portable optical communication system that meets all seven primary performance requirements — transmitting AES-256 encrypted data at **22 kb/s** with zero detectable RF emissions.

For forces where a single radio transmission can betray position and trigger a fire mission, SPARK provides the ability to communicate, coordinate, and report in complete silence — restoring tactical initiative in the modern EW fight.



Warfighter Impact

Eliminates RF Signature

No active emissions at any stage. EW geolocation finds nothing to track; SPARK users are invisible to RF direction-finding equipment.

Survives Denied Environments

No Wi-Fi, cellular, or radio infrastructure required. SPARK survives jamming that defeats conventional communications.

Force Multiplication via UAS Relay

A single drone relay extends range to 10 km, creating a silent network. Relay nodes require no active processing.