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# ARKHE VEI v0.2 “CASULO”

Near-Orbit Vacuum Engineering Interface

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Technical Operations & Fabrication Manual

Revision 2.0 — Post-Validation (Kubo/FDTD/Thermal)

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**WARNING — LEVEL 5 RESTRICTED**

This document contains specifications for a vehicle capable of generating localized vacuum gradients. Misuse of the Phase Protocols herein may result in topological annihilation, molecular disintegration, or irreversible damage to the local space-time metric.

*Read the Safety Axioms before proceeding.*

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# Chapter 1

## Fundamentals

### 1.1 Scope and Philosophy

The VEI v0.2 is not an aerodynamic-lift aircraft, nor is it a Newtonian-thrust rocket. It is a **Phase-Impedance Isolator**. The vehicle neutralizes gravitational interaction between its mass and Earth by creating a locally modified vacuum bubble. Gravity is not cancelled by brute force; the scalar contraction-rate gradient ( $\nabla\delta C$ ) between the hull and the ground is driven to zero via extreme photonic coherence on the shell surface.

### 1.2 Rupture from the OrbVM Legacy

The OrbVM project (Patent CN109878712B, 20th century) failed because it operated in the **Fermion** domain:

- **Eddy currents:** Ohmic heating and coherence loss in polished aluminium.
- **Copper inertia:** Limited  $di/dt$  for angular-momentum generation.
- **Dirty plasma:** Reliance on atmospheric ionization (collisions, thermal noise).

The VEI v0.2 operates in the **Boson** domain. The hull is an AlN/graphene stack. Copper is replaced by **Coherent Light Rings**. Dirty plasma is replaced by **Vacuum-Refractive-Index Modulation** via Dynamical Casimir Effect assisted by solid-state plasmonics.

### 1.3 Theoretical Basis: Nottale Scale Contraction

Propulsion is not based on Newton's 3rd Law. It rests on the **Local Contraction Gradient** ( $\nabla\delta C$ ). The local space-time metric is modulated by injecting extreme **Phase Coherence** ( $\Lambda$ ). By creating a region of high coherence ( $\Lambda \rightarrow 1$ ,  $C \rightarrow 0$ ) ahead of the craft, the natural flow of space-time ( $C_{\text{cosmic}}$ ) drags the vessel forward. The craft does not accelerate; it *falls* into the modified vacuum.

The scale contraction rate is taken as a cosmological constant:

$$C = 2.27 \times 10^{-18} \text{ s}^{-1}. \quad (1.1)$$

### 1.4 The Golden Table of Operational Frequencies

Diagonalisation of the Scale Hamiltonian for a 3.0m radius Casulo yields three sacred frequencies. **These frequencies are immutable; they are the identity of the VEI.**

*Engineering note:* The propulsive mode is generated by **parametric mixing** (frequency difference between modes 10 and 11), not by frequency chirp.

Table 1.1: Immutable operational frequencies of the VEI v0.2.

<b>Mode Name</b>	<b>Frequency (THz)</b>	<b>Wavelength (<math>\mu\text{m}</math>)</b>	<b>Primary Function</b>
Heartbeat	43.9597	6.82	Hull stabilization and background
Cut-off (Gravity Decoupling)	58.5873	5.12	Vacuum-pump ignition (Schwingen)
Phase Gyro (OAM)	89.7718	3.34	Directional propulsion ( $l = 1$ vortices)

# Chapter 2

## Physical Architecture

### 2.1 Overall Geometry

- **Shape:** Spherical (vortex-containment geometry).
- **External radius:** 3.0 m.
- **Cabin volume:**  $\approx 113 \text{ m}^3$ .
- **Dry structural mass:** 1200 kg (excluding payload and coolant).
- **Primary material:** AlN ceramic composite.

### 2.2 Primary Structure: AlN Substrate and Cooling

The structure consists of an AlN shell 5.0 mm thick.

- **Thermal conductivity:**  $\kappa = 285 \text{ W}/(\text{m K})$ .
- **Function:** Rigid skeleton and primary heat sink for the Plasmonic Drain. The inner face is micro-textured to maximize heat exchange with the supercritical-Helium cooling system.

### 2.3 The Skin (AHG/PET Stack)

This is the critical interface with the vacuum. The validated canonical stack (outside  $\rightarrow$  inside) must be followed without deviation. The SiC:N/PET Maxwell-Garnett model was formally rejected (dielectric breakdown under WGM loading).

Table 2.1: Canonical layer stack of the VEI v0.2 hull.

Layer	Material	Thickness	Critical Parameter	Function
1	Bragg mirror ( $\text{Ta}_2\text{O}_5/\text{SiO}_2$ )	2.0 $\mu\text{m}$	5 pairs, $R > 99.999\%$	Primary laser reflector
2	CVD Graphene	0.335 nm	$\mu_c = 0.28 \text{ eV}$ (mandatory)	SPP drain (WGM assassinator)
3	HfO <sub>2</sub> gate dielectric	10 nm	Breakdown $> 3 \text{ V}$	Electrical isolation
4	AlN substrate	5.0 mm	$\kappa = 285 \text{ W}/(\text{m K})$	Structure + heat sink
5	Pure PET (inner face)	100 nm	$n = 1.57$ , no dopants	OAM transmission window

## 2.4 Propulsion System: 128-Element RPA Array

- **Location:** Equatorial ring on the inner face (radius 2.5 m).
- **Emitters:** 128 Radiation-Pressure Actuators (RPA).
- **Modulators:** LiNbO<sub>3</sub>, 12-bit. Phase resolution 0.0879°.
- **Standard angular shift:** 2.8125° per emitter to generate a pure OAM  $l = 1$  vortex.

## Chapter 3

# The Nervous System: WFP and Quantum Control

### 3.1 Wave-Function Processor (WFP) Architecture

The WFP is the craft's brain, maintaining vortex phase coherence against quantum and thermal noise.

- **Hardware:** Xilinx Versal FPGA with AI accelerators.
- **Function:** Real-time computation of the coherence matrix for the RPA mesh and adjustment of  $\text{LiNbO}_3$  signals.
- **Feedback latency:** 100  $\mu\text{s}$  loop.

### 3.2 Quantum-Noise Correction Pipeline (IBMQ v1.1)

The system incorporates a quantum-noise map derived from the IBMQ Heavy-Hex backend to pre-compensate fabrication asymmetries.

- **Method:** Fiedler-vector ( $\lambda_2$ ) analysis of the quantum chip to generate a contraction potential  $\Phi(i)$ .
- **Correction:** A  $0^\circ$  to  $11.5^\circ$  phase-correction map is loaded into the FPGA lookup table to neutralize substrate distortion.

### 3.3 12-Bit DAC Quantisation

The DAC step size is

$$\Delta\phi_{\min} = \frac{360^\circ}{4096} = 0.0879^\circ. \quad (3.1)$$

This results in spurious-mode- $l = 2$  contamination of only 0.0148%, safe for indefinite operation. A 16-bit DAC was formally rejected; 12-bit offers a **safety margin of 237 $\times$**  against  $l = 0$  leakage.

## Chapter 4

# Optical and Thermal Subsystems

### 4.1 Main Ignition Laser

- **Technology:** Optical Parametric Amplifier (OPA) pumped by Yb:YAG.
- **Wavelength:** 5.12  $\mu\text{m}$  (58.59 THz).
- **Peak power:** 10 TW.
- **Pulse duration:** 100 fs.
- **Repetition rate:** 1 kHz.

### 4.2 Emission Optics: DOE for 2.0 mm Spot

To prevent PET vaporization (autopsy of the 0.5 mm spot showed catastrophic failure), the beam is expanded and shaped by a Diffractive Optical Element (DOE) generated via the IFTA algorithm.

- **Spot diameter at PET:** 2.0 mm.
- **Result:** Power-density reduction by factor of 16. Adiabatic PET heating limited to  $\Delta T < 10\text{ K}$ .

### 4.3 The Plasmonic Drain: Physics and Validation

#### 4.3.1 Problem Statement

Whispering-Gallery Modes (WGMs) travelling tangentially along the hull represent a stored-energy hazard ( $Q_0 \sim 10^{10}$ ). Without a drain, the WGM accumulates energy until structural failure (*Inphinity* event).

#### 4.3.2 SiC:N Rejection

Initial modelling used Maxwell-Garnett effective-medium theory for SiC:N nanoparticles ( $n = 2.6 + 0.05j$ ) in PET. Analysis showed:

- $\tan \delta_{\text{max}} \approx 0.015$  at  $f_v = 30\%$  — insufficient.
- $\delta_{\text{pen}} > 29\ \mu\text{m}$  — WGM survives.
- No valid operating window exists for the required absorption.

**SiC:N/PET was formally rejected.**

### 4.3.3 Graphene SPP Coupler (Selected Solution)

A monolayer graphene sheet, electrostatically gated to  $\mu_c = 0.283$  eV, is patterned with a radial grating of period  $\Lambda = 50$  nm (50% duty cycle).

**Mechanism:**

1. The WGM ( $k_{\parallel} = n_{\text{eff}}k_0 \approx 1.8k_0$ ) strikes the grating.
2. The grating supplies the momentum kick  $\Delta k = 2\pi/\Lambda$  to phase-match the photon into a Surface Plasmon Polariton (SPP).
3. The SPP propagates only  $L_{\text{spp}} \approx 110$  nm before decaying.
4. SPP energy converts to phonons (heat) in the graphene lattice.

**Kubo conductivity at 58.59 THz:**

$$\sigma(\omega) = \sigma_{\text{intra}}(\omega) + \sigma_{\text{inter}}(\omega), \quad (4.1)$$

where the intra-band (Drude-like) term requires  $\mu_c > \hbar\omega/2 \approx 0.12$  eV for SPP existence. At  $\mu_c = 0.283$  eV:

$$\beta_{\text{SPP}}/k_0 \approx 26.8, \quad (4.2)$$

$$\lambda_{\text{SPP}} \approx 190 \text{ nm}, \quad (4.3)$$

$$Q_{\text{loaded}} \approx 15. \quad (4.4)$$

The loaded  $Q$  drops from  $10^{10}$  to  $\sim 15$ , corresponding to an attenuation of  $\exp(-2\pi/15) \approx 66\%$  per orbit. The WGM is assassinated in fewer than 10 orbits ( $\sim 1$   $\mu\text{s}$ ).

## 4.4 Thermal Dissipation

The heat generated in the graphene ( $\sim 1$ – $10$  W localized) is drained by the 5 mm AlN substrate ( $\kappa = 285$  W/(mK)). Supercritical Helium removes heat from the AlN to external radiators, keeping the hull temperature below 310 K.

**Steady-state temperature rise:**

$$\Delta T_{\text{AlN}} = P_{\text{total}} \cdot R_{\text{th}} \approx 1.28 \text{ W} \times 1.396 \text{ K/W} \approx 1.8 \text{ K}. \quad (4.5)$$

**Transient (single pulse):** Two-temperature modelling shows the graphene lattice temperature remains below 310 K for realistic WGM coupling energies ( $< 0.1$   $\mu\text{J}$ ). The electron subsystem may transiently reach  $\sim 3000$  K, but electron-phonon coupling ( $G_{\text{ep}} \sim 10^{14}$  W/m<sup>3</sup>) clamps the lattice to the substrate on a 10 ps timescale.

# Chapter 5

## Operational Procedures

### 5.1 Pre-Ignition Sequence (T+00:00 to T+00:05)

1. Power-on self-test (POST): verify FPGA integrity and MZI sensors.
2. Load lookup table: inject IBMQ v1.1 phase-correction map.
3. **Activate graphene gate:** apply bias to reach  $\mu_c = 0.283$  eV.  
*WARNING: If  $\mu_c < 0.12$  eV, the plasmonic drain FAILS. Ignition will cause catastrophic hull damage.*
4. Initiate supercritical-He flow to stabilize substrate temperature.

### 5.2 The Cut (Gravity Decoupling)

1. Fire cut-off laser (58.5873 THz).
2. Conditions: 1 mJ per pulse, 50 fs, 100 kHz.
3. The evanescent field creates the “Light Bed” between craft and ground.
4. **Success indicator:** Local gravitational field measured by external sensors drops to  $< 0.01$  m/s<sup>2</sup>.

### 5.3 Directional Flight (Cruise)

1. Activate Phase Gyro (89.7718 THz) and Heartbeat (43.9597 THz).
2. WFP applies angular phase shift across the 128 RPAs to tilt the OAM vortex.
3. The craft moves opposite to the phase tilt. Maneuvering is limited only by FPGA latency ( $< 100$   $\mu$ s).

### 5.4 Touchdown

1. Ramp-down cut-laser power.
2. Re-establish gravitational coupling gradually (controlled  $C$  rate).
3. Disable graphene gate **only after** mechanical rest on the ground is confirmed.

## Chapter 6

# Safety and Emergency Protocols

**Axiom 6.1** (Axiom of the Gate). The graphene gate voltage is a single-point failure for the entire hull. Redundancy is N+3. Any drop below  $\mu_c = 0.12$  eV triggers immediate laser shutdown.

### 6.1 Gate Failure (Critical)

- **Cause:** Auxiliary power-supply fluctuation.
- **Symptom:** Hull  $Q$ -factor rises above 100. Layer-2 temperature rises rapidly.
- **Action:** WFP executes immediate shutdown of all lasers. The craft enters standard Newtonian free-fall. Do **not** attempt re-ignition until the gate is repaired.

### 6.2 $l = 0$ Leakage (Coherence Loss)

- **Cause:** FPGA fault or LiNbO<sub>3</sub> modulator damage.
- **Symptom:**  $l = 0$  leakage  $> 1\%$ . Vortex centre fills with energy, focusing onto the hull.
- **Action:** Isolate faulty RPA via software (phase it to 0°). The craft loses 1/128 of thrust, but hull integrity is preserved.

### 6.3 Spot Aberration (Design Prohibited)

The collimation optical system is fixed at  $w_0 = 2.0$  mm. **Never** attempt manual focusing to increase thrust. A spot smaller than 1.5 mm causes instantaneous vaporization of Layer 5 (PET) and subsequent Bragg delamination.

## Chapter 7

# Maintenance and Inspection

### 7.1 In-Situ Skin Regeneration

**System:** Atomic-Layer Deposition (ALD) aboard the craft.

- **Precursors:** Trimethylaluminium (TMA) and  $\text{H}_2\text{O}$  for  $\text{Al}_2\text{O}_3$  repair.
- **Monitoring:** Laser ellipsometry measures Bragg thickness in real time.

### 7.2 Ghost-Mode Diagnostics

- **Symptom:** AlN temperature rises without laser power increase.
- **Probable cause:** Grating degradation ( $\Lambda$  deviates from 50 nm).
- **Corrective action:** Run WFP spectral sweep to detect  $l = 2$  peak (ghost signature 0.0148%). If detected, inspect hull coating.

### 7.3 Gate Integrity Verification

- **Frequency:** Every 100 flight hours.
- **Procedure:** Measure hull reflectivity versus angle. The coupling dip must be exactly at 58.59 THz at the predicted angle. If deviation is observed, recalibrate gate bias voltage.

### 7.4 Tile Replacement Logistics

The final 3 m hull is not continuous. It is tiled with hexagonal patches ( $\sim 10\text{ cm}^2$  each). If a graphene sector fails, the tile is mechanically removed and replaced with a pre-fabricated unit (Layers 1–5 deposited in a cleanroom and bonded to the AlN substrate).

# Appendix A

## Mathematical Appendix

### A.1 Kubo Conductivity of Gated Graphene

The optical conductivity of graphene at  $T = 300$  K is given by the Kubo formula:

$$\sigma(\omega) = \sigma_{\text{intra}}(\omega) + \sigma_{\text{inter}}(\omega), \quad (\text{A.1})$$

with

$$\sigma_{\text{intra}} = \frac{e^2 k_B T}{\pi \hbar^2} \frac{i}{\omega + i\gamma} \ln \left[ 2 \cosh \left( \frac{\mu_c}{2k_B T} \right) \right], \quad (\text{A.2})$$

$$\sigma_{\text{inter}} = \frac{e^2}{4\hbar} \left[ \theta(\hbar\omega - 2\mu_c) + \frac{i}{\pi} \ln \left| \frac{\hbar\omega + 2\mu_c}{\hbar\omega - 2\mu_c} \right| \right]. \quad (\text{A.3})$$

For SPP existence at  $\hbar\omega = 0.242$  eV, the intra-band term must dominate, requiring  $\mu_c > \hbar\omega/2$ .

### A.2 SPP Dispersion Relation

For a 2D graphene sheet between dielectrics  $\varepsilon_1$  (Bragg,  $\approx 3.24$ ) and  $\varepsilon_2$  (air, 1.0):

$$\frac{\varepsilon_1}{\sqrt{\beta^2 - \varepsilon_1 k_0^2}} + \frac{\varepsilon_2}{\sqrt{\beta^2 - \varepsilon_2 k_0^2}} = -\frac{i\sigma}{\omega\varepsilon_0}. \quad (\text{A.4})$$

At  $\mu_c = 0.283$  eV and  $\lambda_0 = 5.12$   $\mu\text{m}$ , the solution yields  $\beta/k_0 \approx 26.8$ .

### A.3 Grating Phase-Matching Condition

First-order coupling requires:

$$\beta_{\text{SPP}} = k_{\text{WGM}} + \frac{2\pi}{\Lambda}, \quad (\text{A.5})$$

where  $k_{\text{WGM}} = n_{\text{eff}} k_0 \approx 1.8k_0$ . Solving for  $\Lambda$  with the SPP dispersion gives the optimal grating period  $\Lambda = 50$  nm at  $\mu_c = 0.283$  eV.

### A.4 Loaded Quality Factor

For a spherical WGM of radius  $R = 3$   $\mu\text{m}$  and  $n_{\text{eff}} = 1.8$ :

$$Q_{\text{loaded}} = \left( \frac{1}{Q_0} + \frac{1}{Q_{\text{SPP}}} \right)^{-1}, \quad (\text{A.6})$$

with  $Q_{\text{SPP}} \approx \beta_{\text{SPP}} / (2 \text{Im} \beta_{\text{SPP}}) \approx 15$  and  $Q_0 \sim 10^{10}$ . Thus  $Q_{\text{loaded}} \approx 15$ .

## Appendix B

# IBMQ Phase-Correction Lookup (Excerpt)

Table B.1: Excerpt from the IBMQ-derived phase-correction LUT loaded into the Versal FPGA.

<b>RPA ID</b>	<b>Angular Position (<math>^{\circ}</math>)</b>	<b><math>\Delta\phi</math> (rad)</b>	<b>DAC Code</b>
RPA-000	0.00	0.1003	233
RPA-001	2.81	0.1445	336
RPA-002	5.63	0.0891	207
...	...	...	...
RPA-127	357.19	0.0904	210

# Appendix C

## Material Data Sheet

Table C.1: Thermo-optical properties of the canonical stack at 300 K.

<b>Material</b>	$n$ @ 5.12 $\mu\text{m}$	$\kappa$ (W/mK)	$T_{\text{max}}$ (K)	<b>Function</b>
Ta <sub>2</sub> O <sub>5</sub>	2.1	0.3	2200	Bragg high-index
SiO <sub>2</sub>	1.45	1.4	2000	Bragg low-index
Graphene (gated)	—	$\sim 5000$ (2D)	4500	SPP drain
HfO <sub>2</sub>	1.9	1.5	700	Gate dielectric
AlN	2.1	285	2200	Structure/heat sink
PET	1.57	0.15	523	OAM window

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*“The anvil is cold, but the steel is true.”*

ARKHE CORP. — Division of Vacuum Engineering

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