VALKYRIE
PRECISION CUSTOM ARMORY
ACCREDITED MASTER WORKSHOP

VALKYRIE PRECISION CUSTOM ARMORY

BUILD REPORT
2026-11-02
ID AWB-VPCA-2026-0842

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Certifying tuner: Marcus Vance (Lead Master Armorer)

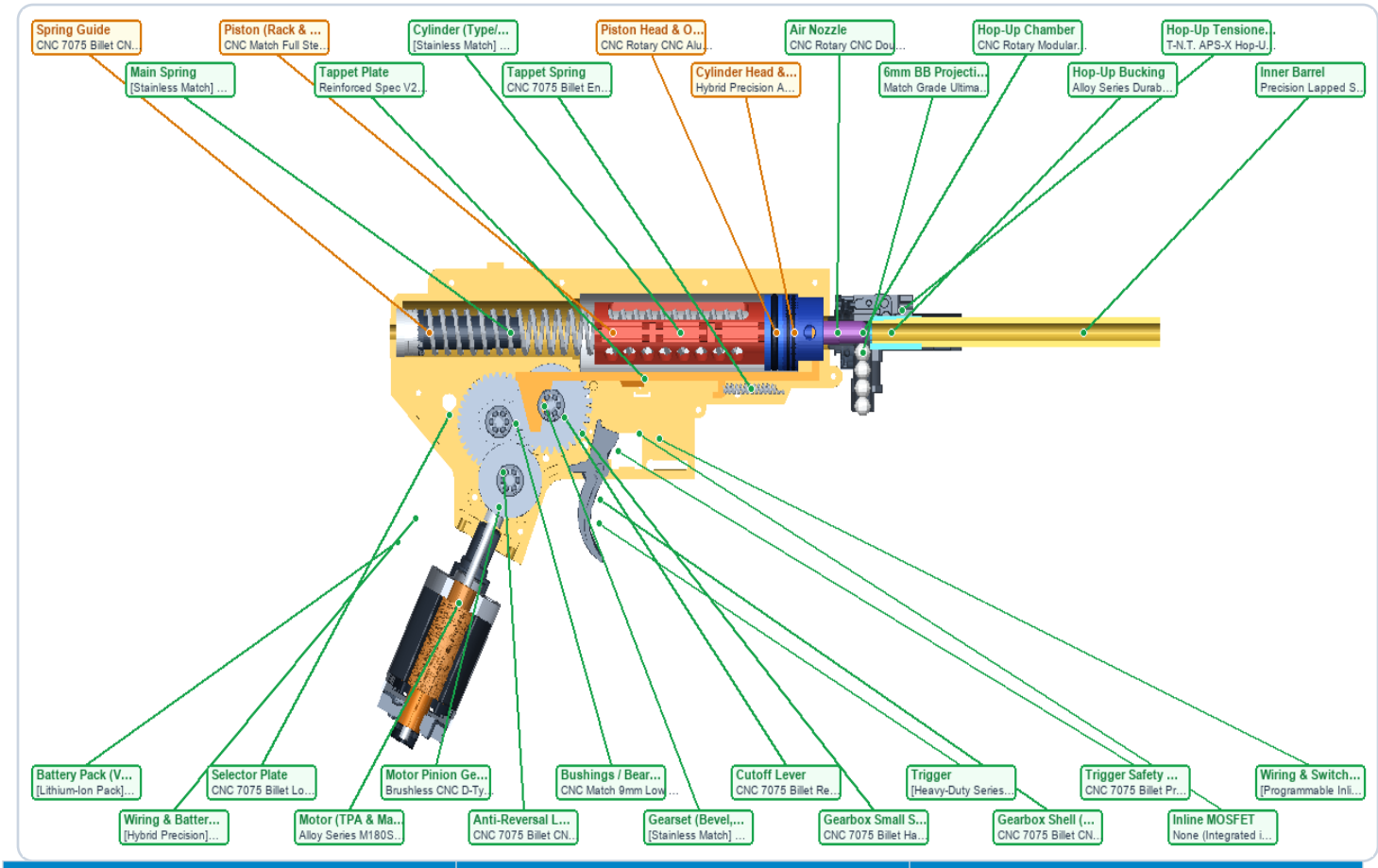
I. Executive Summary

Evaluation Pillar (Equal Weight)	AI Build Rating (1 - 10)	Executive Assessment
1. Build Performance (Paper & Tested)	7.5 / 10	On-paper multi-physics simulation projects 501.7 FPS (4.68 J) at 11.7 RPS with a 42.8 ms semi-auto trigger lock time and 40.7% pneumatic compression efficiency. Physical chronograph verification has been recorded: As-Built output measured 503.1 FPS at 11.9 RPS.
2. Build Durability & Longevity (MTBF)	7.4 / 10	Drivetrain fatigue modeling projects an estimated Mean Time Before Failure (MTBF) of 37.3K rounds with a 82.0% Premature Engagement (PME) safety margin. Primary wear limiting vector: Gearbox Shell (Front Cylinder Radius).
3. Build Cost & Value Efficiency	6.0 / 10	Total installed hardware BOM baseline is $826.97 USD across 29 subsystem slots, delivering a balanced cost-to-performance efficiency rating of 6.0/10.
OVERALL BUILD SUMMARY RATING	7.0 / 10	Weighted 1:1:1 Composite Score

II. Primary Key Performance Indicator

Metric Parameter	Simulated Output	As Built Output	Deviation	Remark
Muzzle Velocity (@ 0.40g)	501.7 FPS (152.9 m/s)	503.1 FPS	+1.4 FPS	VERIFIED OPTIMAL
Muzzle Kinetic Energy	4.68 J	4.70 J	+0.03 J	Field Energy Class
Max Joule Creep (@ 0.48g)	4.77 J (+18.0%)			Volumetric C:B 3.12:1
Cyclic Rate of Fire (RoF)	11.7 RPS (701 RPM)	11.9 RPS	+0.2 RPS	Full-Auto Cadence
Semi-Auto Trigger Lock Time	42.8 ms	42.4 ms	-0.4 ms	Single-Shot Lock Time
Noise Level (dB)	99.7 dBA			Acoustic Signature
Peak Current (A)	55.9 A (Run: 12.3 A)	55.3 A	-0.6 A	Motor Inrush / Load
Cylinder-to-Barrel Ratio (C:B)	3.12:1			Pneumatic Volume Balance
Premature Engagement (PME) Margin	82.0 %			Safe Clearance
Peak Cylinder Pressure	16.51 bar			Polytropic Compression Peak
Estimated Build Lifetime (MTBF)	37.3K Shots			Limiting: Gearbox Shell (Front C

III. Visual Build Illustration & Component Map



Slot	Installed Component	Custom Works Applied
Main Spring	[Stainless Match] Heavy-Duty Series SP140 Extended V2.5 DMR Long Non-Linear Spring	Standard Factory / None
Spring Guide	CNC 7075 Billet CNC Stainless Steel Bearing Spring Guide V2.5	Installed 5.0mm Ring Spacer on Spring Guide for spring pre-compression
Piston (Rack & Body)	CNC Match Full Steel 19-Teeth Extended Piston for Extended V2.5 DMR	Tuner 2nd/3rd tooth shaving, half-width rack milling
Piston Head & O-Ring	CNC Rotary CNC Aluminum Double O-Ring Ball Bearing AEG Piston Head	Ring spacer to correct AOE (length: 3.0mm, weight: 1.5g) installed between piston head and piston body
Cylinder (Type/Port)	[Stainless Match] Extended V2.5 DMR V2.5 Extended Full Non-Ported Cylinder (85.0mm)	Standard Factory / None
Cylinder Head & Pad	Hybrid Precision Aluminum Cylinder Head for Marui Ver.2 Full-Length Replica V2/Carbine V2/Compact SMG/G3 AEG Replica	Tuner Sorbo pad (3.2mm)
Air Nozzle	CNC Rotary CNC Double O-Ring Air Seal Nozzle V2.5 Extended V2.5 DMR (24.20mm)	Standard Factory / None
Tappet Plate	Reinforced Spec V2 Reinforced Tappet Plate	Standard Factory / None
Tappet Spring	CNC 7075 Billet Enhanced High-Tension Tappet Return Spring	Standard Factory / None
Gearset (Bevel, Spur & Sector)	[Stainless Match] 32:1 EG Super Torque-Up Gearset (Half-Teeth)	Standard Factory / None

Slot	Installed Component	Custom Works Applied
Motor Pinion Gear	Brushless CNC D-Type CNC Hardened Chromoly Pinion Gear	Standard Factory / None
Bushings / Bearings	CNC Match 9mm Low Profile Ball Bearings (Set of 6)	Standard Factory / None
Motor (TPA & Magnet)	Alloy Series M180S Satan AEG Motor (Long)	Standard Factory / None
Battery Pack (Voltage & C-Rating)	[Lithium-Ion Pack] 11.1V 3000mAh 16C Optical ETU Lithium-Ion Nunchuck	Standard Factory / None
Inline MOSFET	None (Integrated in ETU)	Standard Factory / None
Wiring & Switch Assembly	[Programmable Inline ETU] Leviathan V2 Optical Pro Drop-In ETU	Standard Factory / None
Wiring & Battery Connector	[Hybrid Precision] High-Current T-Plug T-Plug Connector Set	Standard Factory / None
Inner Barrel	Precision Lapped Stainless Tightbore 6.03mm Tight Bore Inner Barrel (509mm)	Standard Factory / None
Hop-Up Chamber	CNC Rotary Modular Tactical HPA Hop Up Chamber M4W (CNC Aluminum)	Standard Factory / None
Hop-Up Bucking	Alloy Series Durable Hop Up Rubber For AEG	Standard Factory / None
Hop-Up Tensioner / Nub	T-N.T. APS-X Hop-Up NUB Series	Standard Factory / None
6mm BB Projectile	Match Grade Ultimate Heavy 0.45g Extreme Bolt-Action 6mm BB (1000rds)	Standard Factory / None
Gearbox Shell (Chassis)	CNC 7075 Billet CNC 7075-T6 V2.5 Long Extended Gearbox Shell (Extended V2.5 DMR)	Standard Factory / None
Trigger	[Heavy-Duty Series] Compact SMG Classic Steel Trigger (V2)	Standard Factory / None
Anti-Reversal Latch (ARL)	CNC 7075 Billet CNC Heat-Treated Steel Anti-Reversal Latch	Standard Factory / None
Cutoff Lever	CNC 7075 Billet Reinforced Steel V2.5 Cutoff Lever	Standard Factory / None
Selector Plate	CNC 7075 Billet Low-Friction POM V2.5 Selector Plate	Standard Factory / None
Trigger Safety Block (V2)	CNC 7075 Billet Precision POM Trigger Safety Block (V2)	Standard Factory / None
Gearbox Small Springs Set	CNC 7075 Billet Hardened Music-Wire Gearbox Springs Kit	Standard Factory / None

IV. Projectile Trajectory

Distance (m)	Height (m)	Velocity (m/s)	Energy (J)	Wind drift (cm)
1	1.50	149.7	4.480	0.0
11	1.52	126.2	3.190	1.5
20	1.58	109.2	2.380	4.8
28	1.66	93.7	1.760	10.8
37	1.75	81.2	1.320	19.1
45	1.84	70.3	0.990	30.4
53	1.91	61.4	0.750	44.1
61	1.93	53.3	0.570	62.1

Distance (m)	Height (m)	Velocity (m/s)	Energy (J)	Wind drift (cm)
69	1.87	46.4	0.430	83.7
77	1.68	40.4	0.330	110.1
85	1.31	35.4	0.250	140.3
90	0.91	32.4	0.210	164.0
94	0.52	30.4	0.180	183.1
97	0.13	28.8	0.170	199.9

V. Component Durability, Dynamic Stress & Mean Time Before Failure

Estimated Build Lifetime (MTBF)	37.3K shots
Primary Point of Failure	Gearbox Shell (Front Cylinder Radius)

Component Vector & Mechanism	Fatigue Life	Wear Status	Internal Stress Drivers & Kinematic Load
Gearbox Shell Fatigue	37.3K shots	MODERATE WEAR	Front bulkhead transmitted shock (3812 N, σ_local=113.9 MPa) with Kt=2.39 (R=1.65mm); Pad absorption: 60%
Gearset Teeth Stripping	101.1K shots	DURABLE / GOOD	Lewis root bending stress (510 MPa vs σ_Flim=560 MPa) from 1396.1 N peak spring load at 11.7 RPS; Axle support: Ball bearings (C=405 N)
Piston Rack Shear	44.9K shots	MODERATE WEAR	Pickup tooth impact and rack shear (τ_eff=540 MPa, m=28.0g); AOE: Corrected 90°; PME margin: 82.0%
Cut-Off Lever Wear	IMMUNE (∞)	IMMUNE (N/A)	N/A - Contactless optical / magnetic cycle cutoff
Switch Assembly Burnout	IMMUNE (∞)	IMMUNE (N/A)	Zero mechanical contact arcing (Solid-state FET switching)
Motor Brush Depletion	102.4K shots	DURABLE / GOOD	Carbon brush sliding friction and commutator spark erosion at 12.3 A (11.7 RPS)

1. Build Durability & Fatigue Assessment

This build achieves an estimated Mean Time Before Failure (MTBF) of 37.3K rounds under cyclic S-N fatigue modeling, with a peak piston impact force of 4051 N and a 82.0% PME clearance margin. The primary service-limiting component vector is Gearbox Shell (Front Cylinder Radius), governed by cyclic spring compression shock, high-speed sector tooth engagement, and 55.9 A peak motor inrush current.

2. Tuner Suggestions to Improve Durability

To further extend drivetrain longevity beyond 37.3K rounds, we recommend installing a 70D Sorbothane/polyurethane cylinder head damper pad to attenuate peak impact shock, verifying a 12:00-12:30 o'clock AOE pickup angle with the 2nd piston tooth relieved, radiusing the front gearbox cylinder window corners (1.5mm fillet), and pairing an optical ETU/MOSFET with precision bevel-to-pinion shimming (0.10mm axial clearance).

VI. Itemized Bill of Materials

Slot Category	Installed Component	Brand	Price (USD)	Direct Link
Main Spring	Heavy-Duty Series SP140 Extended V2.5 DMR Long Non-Linear Spring	Stainless Match	$11.69	https://www.powair6.com/en/hpa-systems

Slot Category	Installed Component	Brand	Price (USD)	Direct Link
Spring Guide	CNC 7075 Billet CNC Stainless Steel Bearing Spring Guide V2.5	CNC 7075 Billet	$22.00	https://ehobbyasia.com/products/amoeba-ares-stainless-steel-spring-guide-for-compact-power-spring-bolt
Piston (Rack & Body)	CNC Match Full Steel 19-Teeth Extended Piston for Extended V2.5 DMR	CNC Match	$16.00	https://www.airsoftgi.com/product/Solink-CNC-Machined-Lightened-Aluminum-AEG-Piston-w-14-Stainless-Steel-Piston-Teeth-Half-Teeth-70186/
Tappet Plate	Reinforced Spec V2 Reinforced Tappet Plate	Reinforced Spec	$9.00	https://www.wgcshop.com/products/arcturus-v2-reinforced-tappet-plate
Cylinder (Type/Port)	Extended V2.5 DMR V2.5 Extended Full Non-Ported Cylinder (85.0mm)	Stainless Match	$22.00	https://www.powair6.com/en/aeg-cylinder/12846-shs-stainless-steel-slick-cylinder-for-l85-V2.5 Extended-Bore.html
Piston Head & O-Ring	CNC Rotary CNC Aluminum Double O-Ring Ball Bearing AEG Piston Head	CNC Rotary	$18.00	https://www.powair6.com/en/hpa-systems
Air Nozzle	CNC Rotary CNC Double O-Ring Air Seal Nozzle V2.5 Extended V2.5 DMR (24.20mm)	CNC Rotary	$14.00	https://www.powair6.com/en/hpa-systems
Cylinder Head & Pad	Hybrid Precision Aluminum Cylinder Head for Marui Ver.2 Full-Length Replica V2/Carbine V2/Compact SMG/G3 AEG Replica	Hybrid Precision	$7.49	https://www.powair6.com/en/hpa-systems
Gearbox Shell (Chassis)	CNC 7075 Billet CNC 7075-T6 V2.5 Long Extended Gearbox Shell (Extended V2.5 DMR)	CNC 7075 Billet	$169.00	https://www.powair6.com/en/hpa-systems
Gearset (Bevel, Spur & Sector)	32:1 EG Super Torque-Up Gearset (Half-Teeth)	Stainless Match	$78.00	https://www.powair6.com/en/hpa-systems
Motor (TPA & Magnet)	Alloy Series M180S Satan AEG Motor (Long)	Alloy Series	$110.00	https://ehobbyasia.com/products/g-p-m180s-satan-aeg-motor-long
Battery Pack (Voltage & C-Rating)	11.1V 3000mAh 16C Optical ETU Lithium-Ion Nunchuck	Lithium-Ion Pack	$42.00	https://www.powair6.com/en/hpa-systems
Bushings / Bearings	CNC Match 9mm Low Profile Ball Bearings (Set of 6)	CNC Match	$11.00	https://ehobbyasia.com/products/shs-9mm-steel-ball-bearing-bushing
Wiring & Switch Assembly	Leviathan V2 Optical Pro Drop-In ETU	Programmable Inline ETU	$130.00	https://ehobbyasia.com/products/modify-switch-assembly-for-version2-gearbox
Wiring & Battery Connector	High-Current T-Plug T-Plug Connector Set	Hybrid Precision	$5.00	https://www.redwolfairsoft.com/tokyo-marui-standard-tamiya-connector.html
6mm BB Projectile	Match Grade Ultimate Heavy 0.45g Extreme Bolt-Action 6mm BB (1000rds)	Match Grade	$21.50	https://www.wgcshop.com/search?type=product&q=BLS+0.40g+BB

Slot Category	Installed Component	Brand	Price (USD)	Direct Link
Inner Barrel	Precision Lapped Stainless Tightbore 6.03mm Tight Bore Inner Barrel (509mm)	Precision Lapped	$36.80	https://www.powair6.com/en/hpa-systems
Hop-Up Chamber	CNC Rotary Modular Tactical HPA Hop Up Chamber M4W (CNC Aluminum)	CNC Rotary	$9.99	https://www.airsoftgi.com/product/Lancer-Tactical-Kinetic-TDC-Hop-Up-Unit-for-M4-M16-AR15-AEG-74135/
Hop-Up Bucking	Alloy Series Durable Hop Up Rubber For AEG	Alloy Series	$2.68	https://ehobbyasia.com/products/4uantum-friction-pro-aeg-hop-up-bucking
Hop-Up Tensioner / Nub	T-N.T. APS-X Hop-Up NUB Series	T-N.T.	$3.32	https://www.powair6.com/en/hpa-systems
Trigger	Compact SMG Classic Steel Trigger (V2)	Heavy-Duty Series	$12.00	https://www.redwolfairsoft.com/tokyo-marui-m4-trigger-v2.html
Tappet Spring	CNC 7075 Billet Enhanced High-Tension Tappet Return Spring	CNC 7075 Billet	$5.00	https://www.aliexpress.com/wholesale?SearchText=SHS%20Enhanced%20Steel%20Tappet%20Return%20Spring%20%28Pack%20of%203%29
Motor Pinion Gear	Brushless CNC D-Type CNC Hardened Chromoly Pinion Gear	Brushless CNC	$15.00	https://ehobbyasia.com/products/modify-motor-pinion-gear-for-top-m60-m249
Inline MOSFET	None (Integrated in ETU)	Integrated	$0.00	https://www.redwolfairsoft.com/catalogsearch/result/?q=Tokyo%20Marui%20Next-Gen%20/%20Standard%20Inline%20Micro%20FET%20Trigger%20Unit%20%28V2%29
Anti-Reversal Latch (ARL)	CNC 7075 Billet CNC Heat-Treated Steel Anti-Reversal Latch	CNC 7075 Billet	$14.00	https://www.redwolfairsoft.com/tokyo-marui-anti-reversal-latch.html
Cutoff Lever	CNC 7075 Billet Reinforced Steel V2.5 Cutoff Lever	CNC 7075 Billet	$12.00	https://www.redwolfairsoft.com/tokyo-marui-v2-cutoff-lever.html
Selector Plate	CNC 7075 Billet Low-Friction POM V2.5 Selector Plate	CNC 7075 Billet	$14.00	https://ehobbyasia.com/products/krytac-cnc-ambi-selector-switch-assembly-selector-for-krytac-aeg-m4-m16-aeg-anodized-blue
Trigger Safety Block (V2)	CNC 7075 Billet Precision POM Trigger Safety Block (V2)	CNC 7075 Billet	$6.50	https://www.redwolfairsoft.com/tokyo-marui-v2-trigger-safety-block.html
Gearbox Small Springs Set	CNC 7075 Billet Hardened Music-Wire Gearbox Springs Kit	CNC 7075 Billet	$9.00	https://www.wgcshop.com/products/guarder-gearbox-spring-set-v2
		MATERIALS SUBTOTAL	$826.97	

Category / Slot	Component / Scope	Custom Work & Lump-Sum Service	Labor	Price (USD)
Piston & Piston Head	CNC Match Full Steel 19-Teeth Piston	AOE Correction Spacer + Rack Bonding	25 min	$22.50
Gearset	32:1 Super Torque-Up CNC Steel Gearset	Precision Micrometer Bevel-to-Pinion Shimming	45 min	$40.50

Category / Slot	Component / Scope	Custom Work & Lump-Sum Service	Labor	Price (USD)
Inner Barrel & Hop-Up	Precision Lapped Stainless Tightbore Barrel	Contact Patch Lapping & Air Seal Mod	40 min	$36.00
Complete Gearbox Bench	V2.5 Extended-Bore Gearbox Assembly	Full Disassembly, Ultrasonic Clean, Regrease & 75m Chrono Verification	60 min	$54.00
			SERVICES SUBTOTAL	$153.00
			SHOP TAX / VAT (7.25%)	$71.05
			GRAND TOTAL	$1,051.02

VII. Detailed Subsystem Micro-Parameters

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
Main Spring	Free Length Mm	192.0
	Spring Constant K	14.16
	Pitch Type	irregular
	Spring Rating	M140
	Wire Diameter Mm	1.52
	Wire Dia	1.52
	Spring Length Cut Pct	100.0
	Material Family	cr_si_aisi_9254
	Shear Modulus Gpa	79.3
	Tensile Strength Mpa	2150.0
	Torsional Endurance Mpa	760.0
	Shot Peened	True
	Pre Set Heat Treated	True
	Sniper Scale Rating	
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
	Active Coils	24.0
	Coil Count	24.0
	Rating	M140
Spring Guide	Spacer Ring Mm	5.0
	Bearings	False
	Material	Stainless Steel
	Has Bearings	True
	Shaft Material Family	stainless_steel_304
	Shaft Yield Strength Mpa	520.0
	Base Lug Shear Strength Mpa	340.0
	Has Thrust Bearing	True
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
Piston (Rack & Body)	Body Material	Reinforced Nylon
	Material	Reinforced Polymer Body (14 Steel Teeth)
	Color	Black
	Compatible Platforms	['sr25_long_aeg']
	Is Half Teeth Width	True
	Lightening	Solid
	Swiss Cheese	False
	Total Mass Grams	28.0
	Piston Half Teeth	True
	Piston Swiss Cheese	False
	Rack Width	half
	Steel Teeth Count	19
	Teeth	19
	Gearbox Track Friction	0.08
	Body Material Family	pa66_gf30_nylon
	Body Yield Strength Mpa	58.0
	Body Fatigue Endurance Mpa	24.0
	Rack Material Family	mim_heat_treated_steel
	Rack Shear Strength Mpa	540.0
	Rack Hardness Hrc	48.0
	Rack Face Width Mm	2.4
	Pickup Tooth Thickness Mm	3.6
	Rail Friction Coeff	0.08
	Aoe Corrected	False
	Micro Confidence	ai_extracted
	Micro Source	ai_inferred
	Remove 2Nd 3Rd Teeth	True
	Piston Remove 2Nd 3Rd Teeth	True
Tappet Plate	Color	Black
	Flag Shape	Standard Full Profile Flag
	Gearbox Track Friction	0.05
	Material	Reinforced Polymer
	Fin Trimmed	False
	Fin Profile	Standard
	Material Family	pa66_nylon
	Tensile Yield Mpa	78.0
	Flexural Fatigue Mpa	35.0
	Fin Thickness Mm	2.1
	Micro Confidence	ai_extracted
	Micro Source	ai_inferred
Cylinder (Type/Port)	Bore Type	Bore-Up (24.50mm)

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Color	Silver
	Effective Length Mm	85.5
	Inner Diameter Mm	24.5
	Length Mm	85.0
	Material	Stainless Steel
	Port Type	5/5 Solid (Non-Ported)
	Total Length Mm	85.5
	Usable Volume Pct	100.0
	Exterior Profile	Standard Smooth Profile
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Piston Head & O-Ring	Bearings	False
	Bore Type	Bore-Up (24.50mm)
	Color	Red
	Dynamic Seal Pct	99.2
	Head Type	Flat
	Hole Type	Holes
	Inner Diameter Mm	24.5
	Material	CNC Aluminum
	Thickness Mm	5.4
	Aoe Spacer Length Mm	3.0
	Aoe Spacer Weight G	1.5
	O Rings	2
	Sealing Design	Single O-Ring(s)
	Air Seal Quality Pct	98.0
	Grease Type	100% Pure Silicone Oil
	Grease Extensivity	Optimal Thin Film (Smooth)
	Material Family	cnc_6061_aluminum
	Yield Strength Mpa	276.0
	Impact Damping Factor	0.96
	Has Thrust Bearing	True
	Oring Material	nbr_70a
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
	Sealing Rate Pct	98.5
	Mass Grams	7.2
	Port Count	8
	Has Bearings	True
Air Nozzle	Bore Type	Bore-Up (4.5mm ID)
	Color	Red
	Guide Tube Seal Pct	99.2

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Length Mm	24.2
	Material	CNC Aluminum
	Nozzle Inner Dia Mm	4.0
	O Rings	2
	Material Weight	POM Polymer (0.9g)
	Hole Shape	Standard Circular Round Bore
	Air Seal Quality Pct	99.0
	Grease Type	Pure Silicone Grease (Optimal)
	Nozzle Type	Extended V2.5 DMR Long
	Has Oring	True
	Oring Count	1
	Bore Diameter Mm	4.5
	Sealing Rate Pct	99.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Cylinder Head & Pad	Bore Type	Bore-Up (24.50mm)
	Color	Gold
	Head Type	Flat
	Inner Diameter Mm	24.5
	Material	CNC Aluminum
	Nozzle Tube Od Mm	4.5
	O Rings	2
	Air Seal Quality Pct	90.0
	Sealing Rate Pct	99.0
	Pad Thickness Mm	3.0
	Pad Durometer Shore A	60.0
	Material Family	stainless_steel
	Yield Strength Mpa	520.0
	Pad Energy Absorption Pct	28.0
	Has Sorbo Pad	False
	Nozzle Snout Wall Mm	1.05
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Gearbox Shell (Chassis)	Color	Black
	Material	CNC 7075-T6 Aluminum
	Front Radius Cutout	True
	Material Family	cnc_7075_t6
	Yield Strength Mpa	503.0
	Ultimate Strength Mpa	572.0
	Fatigue Endurance Mpa	159.0
	Basquin Exponent B	10.2

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Front Wall Thickness Mm	4.2
	Corner Radius Mm	1.65
	Pre Radiused	True
	Reinforcement Ribs	True
	Surface Finish	anodized_cnc
	Bushing Bore Diameter Mm	8.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Gearset (Bevel, Spur & Sector)	DSG	False
	Is Dsg	False
	Gear Ratio	32.0
	Rack Width	half
	Sector Gear Type	Single Sector Gear (SSG - 16T)
	Sector Teeth	19
	Teeth	16
	Is Torque Step	True
	Requires Half Teeth Piston	True
	Short Stroked Teeth	0
	Tooth Profile	Standard Straight Cut
	Gear Count	Standard 3-Gear Train (Bevel/Spur/Sector)
	Pickup Teeth Removed	0
	Release Teeth Removed	0
	Material Family	cnc_17_4ph_billet
	Bending Endurance Mpa	560.0
	Contact Endurance Mpa	1210.0
	Surface Hardness Hrc	53.0
	Basquin Exponent B	9.2
	Gear Module Mm	0.7
	Sector Face Width Mm	4.5
	Lewis Form Factor Y	0.37
	Heat Treated	True
	Manufacturing Process	cnc_machined
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Motor (TPA & Magnet)	Magnet Grade	neodymium_n52h
	Motor Type	Brushed Neodymium (CNC)
	No Load Rpm	28000.0
	Stall Torque Nm	0.25
	TPA	28
	Wire Size Mm	0.65

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Wire Size	0.65mm (22 AWG / 22.5 SWG - High-Turn 24-28 TPA Fill)
	Commutation Type	brushed_silver_carbon
	Max Temp Rating C	180.0
	Brush Wear Life Base Cycles	125000.0
	Winding Insulation Class	class_h_180c
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Battery Pack (Voltage & C-Rating)	C Rating	16.0
	Capacity Mah	3000.0
	Chemistry	Li-Ion
	Internal Resistance Mohm	24.0
	Nominal Voltage	11.1
	C Rate	16.0
	Discharge Efficiency Pct	90.0
	Burst C Rating	21.3
	Burst C Rating Provenance	estimated
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Bushings / Bearings	Bushing Type	Stainless Ball Bearings
	Dia	9.0
	Friction Coefficient	0.015
	Size Mm	9.0
	Type	Stainless Ball Bearings
	Inner Diameter Mm	6.0
	Material	Sintered Bronze/Steel
	Diameter Mm	8.0
	Bearing Type	caged_ball_bearing
	Outer Diameter Mm	9.0
	Dynamic Load Rating N	405.0
	Pv Limit Mpa M S	4.2
	Friction Coeff	0.004
	Hardness Hrc	58.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Wiring & Switch Assembly	Switch Type	Electronic Trigger Optical (ETU)
	Conductor Material	Silver-Plated OFC (Low Resistance)
	Core Type	16 AWG Multi-Strand Fine Braided
	Contact Resistance Mohm	1.2
	Contact Material	optical_board

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Contact Arc Erosion Resistance	100.0
	Wire Gauge Awg	16
	Insulation Material	ptfe_teflon_silver
	Max Insulation Temp C	260.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
	Optical Sensors	True
	ACTIVE BRAKING	True
	Pre Cocking	True
	Fuse Rating Amps	50
	Protection Architecture	optical_computerized_etu
	Arc Suppression Efficiency	0.998
	Fet Continuous Current Rating A	220.0
	Fet Rds On Mohm	1.2
	Has Optical Cycle Sensor	True
	Switch Design	Electronic Trigger Optical (ETU)
	Is Etu	True
	Has Mosfet	True
	Insulation	PTFE / Teflon (260°C)
Wiring & Battery Connector	Type	T-Plug T-Plug
	Contact Resistance Mohm	1.2
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
6mm BB Projectile	Bb Diameter Mm	5.95
	Weight G	0.4
	Bb Weight Grams	0.4
	Diameter Mm	5.95
	Material	Polished High-Density
	Params	{'bb_diameter_mm': 5.95, 'bb_weight_grams': 0.45, 'weight_g': 0.45}
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Inner Barrel	Inner Diameter Mm	6.01
	Length Mm	455.0
	Material	Stainless Steel
	Crown Finish	Standard Flat Cut
	Window Cut	Standard 4.5mm Window
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Hop-Up Chamber	Adjustment Mechanism	Rotary Wheel Dial

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
	Chamber Fit	v2
	Full Chamber	True
	Gearbox Fit	V2 (Carbine V2/Full-Length Replica V2)
	Material	CNC 7075 Aluminum
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Hop-Up Bucking	Hardness	60.0
	Hardness Shore A	60.0
	Mound	Standard Mound
	Mound Type	Traditional Mound
	Material	Standard NBR Rubber
	Breech Seal Pct	99.2
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Hop-Up Tensioner / Nub	Nub Profile	Standard Hollow Cylinder
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Trigger	Style	Standard Curved
	Pre Travel Adj Mm	1.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Tappet Spring	Voltage	Enhanced Stiff
	Coils Cut	0
	Spring Tension	High-Tension Stiff
	Material Family	piano_wire_swp_b
	Tensile Strength Mpa	2050.0
	Wire Diameter Mm	0.72
	Coil Diameter Mm	5.2
	Active Coils	18
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
	Coil Count	18
Motor Pinion Gear	Gear Type	D-Type
	Material	CNC Chromoly Steel
	Material Family	cnc_cr_mo_steel
	Surface Hardness Hrc	56.0
	Contact Endurance Mpa	1250.0
	Shaft Fit Type	d_type
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec

Slot / Component	Micro-Parameter Name	Value & Engineering Unit
Inline MOSFET	Inline Topology	None (Direct Mechanical Wiring)
	Etu Architecture	None (Integrated in ETU)
	Has Mosfet	False
	ACTIVE BRAKING	False
	Pre Cocking	False
	Fet Rds On Mohm	0.0
	Fet Continuous Current Rating A	0.0
	Fuse Protection	Smart Electronic e-Fuse
	Protection Architecture	passive_none
	Arc Suppression Efficiency	0.0
	Has Optical Cycle Sensor	False
	Optical Sensors	False
	Is Integrated Etu Lock	True
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Anti-Reversal Latch (ARL)	Material	Heat-Treated Steel
	Material Family	cnc_tool_steel
	Tip Hardness Hrc	55.0
	Yield Strength Mpa	850.0
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Cutoff Lever	Version	v2.5
	Material	Steel
	Material Family	cnc_tool_steel
	Cam Contact Hardness Hrc	55.0
	Wear Coefficient K	5e-06
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Selector Plate	Version	v2.5
	Material	POM Polymer
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Trigger Safety Block (V2)	Version	v2
	Material	Delrin POM
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec
Gearbox Small Springs Set	Kit Type	6-Piece Gearbox Springs
	Spring Steel	Music Wire High-Tension
	Micro Confidence	VERIFIED
	Micro Source	catalog_spec

VIII. Comprehensive Engineering Parameter Simulation Matrix

Parameter Name	Simulation Output Value
[Pneumatics & Air Seal] Muzzle Kinetic Energy	4.68 J (@ 0.40g)
[Pneumatics & Air Seal] Muzzle Velocity (Selected BB Weight)	501.7 FPS (152.90 m/s @ 0.40g)
[Pneumatics & Air Seal] Muzzle Kinetic Energy (@0.20g Baseline)	4.04 J
[Pneumatics & Air Seal] Muzzle Velocity (@0.20g)	659.7 FPS (201.1 m/s)
[Pneumatics & Air Seal] Velocity (@0.25g equivalent)	608.1 FPS (4.29 J)
[Pneumatics & Air Seal] Velocity (@0.28g equivalent)	582.0 FPS (4.41 J)
[Pneumatics & Air Seal] Velocity (@0.30g equivalent)	566.1 FPS (4.47 J)
[Pneumatics & Air Seal] Velocity (@0.32g equivalent)	551.4 FPS (4.52 J)
[Pneumatics & Air Seal] Velocity (@0.36g equivalent)	524.9 FPS (4.61 J)
[Pneumatics & Air Seal] Velocity (@0.40g equivalent)	501.7 FPS (4.68 J)
[Pneumatics & Air Seal] Velocity (@0.45g equivalent)	476.2 FPS (4.74 J)
[Pneumatics & Air Seal] Cylinder-to-Barrel Ratio (C:B)	3.12:1
[Pneumatics & Air Seal] Cylinder Swept Air Volume	40308 mm^3 (40.31 cc)
[Pneumatics & Air Seal] Inner Barrel Bore Volume	12908 mm^3 (12.91 cc)
[Pneumatics & Air Seal] Excess Volumetric Ratio	212.3 %
[Pneumatics & Air Seal] Peak Compression Pressure	16.51 bar (239.5 PSI)
[Pneumatics & Air Seal] Peak Barrel Driving Pressure	14.80 bar (214.7 PSI)
[Pneumatics & Air Seal] Muzzle Exit Gas Pressure	2.53 bar
[Pneumatics & Air Seal] Adiabatic Air Temperature Rise	+318.5 °C
[Pneumatics & Air Seal] Pneumatic Air Seal Quality Index	99.3% (Hermetic Double O-Ring)
[Pneumatics & Air Seal] Pneumatic Compression Efficiency	40.7 %
[Pneumatics & Air Seal] Nozzle Orifice Flow Rate	0.01387 m^3/s
[Pneumatics & Air Seal] Nozzle Tip Choke Mach Number	1.00 Ma
[Pneumatics & Air Seal] Cylinder Wall Heat Transfer	3.959 J/shot
[Pneumatics & Air Seal] Compression Work Done	11.18 J
[Pneumatics & Air Seal] Nozzle Dwell Duration	42.0 ms
[Pneumatics & Air Seal] Nozzle Retraction Timing Delay	19.0 ms
[Pneumatics & Air Seal] Tappet Spring Delay Margin	+30.89 ms (Safe Seal Before Release)
[Pneumatics & Air Seal] Cylinder Port Blowback Venting	0.00 cc/cycle
[Pneumatics & Air Seal] Sorbo Pad Kinetic Absorption	0.000 J
[Pneumatics & Air Seal] Piston Head Port Scavenging Efficiency	92.0%
[Pneumatics & Air Seal] Barrel Pressure Wave Reflection Frequency	234 Hz (a = 426.4 m/s)
[Pneumatics & Air Seal] Joule Creep Propensity Index	High Creep (+0.73J @ 0.48g)
[Drivetrain & Mechanical Stress] PME (Premature Engagement) Margin	82.0 % (SAFE)
[Drivetrain & Mechanical Stress] Semi-Auto Overspin / Double-Cycle Risk	None (Controlled Single Cycle)
[Drivetrain & Mechanical Stress] Piston Return Stroke Duration	11.50 ms
[Drivetrain & Mechanical Stress] Sector Gear Pickup Clearance Window	31.77 ms
[Drivetrain & Mechanical Stress] Pick-Up Tooth (PU) Engagement Angle (AOE)	+8.1° (12:16 o'clock 3D Contact)

Parameter Name	Simulation Output Value
[Drivetrain & Mechanical Stress] Pick-Up Tooth Peak Shear Stress	236.7 MPa
[Drivetrain & Mechanical Stress] Piston Rack Guide Rail Friction Coefficient	0.080
[Drivetrain & Mechanical Stress] Piston Release Velocity	17.19 m/s
[Drivetrain & Mechanical Stress] Piston Face Impact Force on Cylinder Head	4051.0 N
[Drivetrain & Mechanical Stress] Gear Train Mechanical Ratio	32.0:1
[Drivetrain & Mechanical Stress] Sector Gear Cam Lift Duration	42.0 ms
[Drivetrain & Mechanical Stress] Bevel-Pinion Mesh Backlash	0.072 mm (Shimming: 80%)
[Drivetrain & Mechanical Stress] Spur Gear Axle Radial Load	1060.2 N
[Drivetrain & Mechanical Stress] Bushing / Bearing Surface Velocity	3.52 m/s (9mm Axle)
[Drivetrain & Mechanical Stress] Main Spring Potential Energy Storage	11.49 J
[Drivetrain & Mechanical Stress] Main Spring Max Compressed Shear Stress	1501.4 MPa (Endurance: 760 MPa | Yield: 1204 MPa)
[Drivetrain & Mechanical Stress] Main Spring Natural Harmonic Resonance	77 Hz
[Drivetrain & Mechanical Stress] Main Spring Wire Solid Height Margin	+16.2 mm Clearance
[Drivetrain & Mechanical Stress] Gearbox Shell Front Radiusing Stress Relief	Front 4-Corner Radiused Fillets (R=1.65mm, Kt=2.39)
[Drivetrain & Mechanical Stress] Gear Train Mechanical Transfer Efficiency	89.4 %
[Drivetrain & Mechanical Stress] Motor Pinion Axial Thrust Force	16.5 N
[Drivetrain & Mechanical Stress] Tappet Plate Fatigue Life Expectancy	~318,590 cycles
[Drivetrain & Mechanical Stress] Cut-Off Lever Timing Angle	44.0° (v2.5)
[Drivetrain & Mechanical Stress] Anti-Reversal Latch Engagement Speed	3.80 ms
[Drivetrain & Mechanical Stress] RPS Cycle Stability (Standard Deviation)	±0.06 RPS
[Drivetrain & Mechanical Stress] Kinematic Inertia of Moving Piston	5.594 J
[Drivetrain & Mechanical Stress] Gear Train Friction Loss	9.88 W
[Drivetrain & Mechanical Stress] b10_lifetime_k	23.1
[Drivetrain & Mechanical Stress] b50_lifetime_k	37.3
[Drivetrain & Mechanical Stress] weakest_link_component	Gearbox Shell (Front Cylinder Radius)
[Drivetrain & Mechanical Stress] micro_confidence_summary	16/16 Explicit Micro-Params (0 Physical Baseline Fallback)
[Electrical & Motor Dynamics] Rate of Fire (RPS)	11.68 RPS (701 RPM)
[Electrical & Motor Dynamics] Cycle Duration	85.6 ms
[Electrical & Motor Dynamics] Trigger Lock Time (Semi-Auto Response)	42.8 ms
[Electrical & Motor Dynamics] Motor Peak Inrush Stall Current	55.9 A
[Electrical & Motor Dynamics] Motor Steady Running Current	12.3 A
[Electrical & Motor Dynamics] Battery Full-Charge Starting Voltage	12.60 V (Nominal 11.1 V)
[Electrical & Motor Dynamics] Battery Terminal Voltage Under Load	10.80 V
[Electrical & Motor Dynamics] Battery Voltage Sag Delta	0.30 V

Parameter Name	Simulation Output Value
[Electrical & Motor Dynamics] Motor Coil Thermal Rise Per 10-Round Burst	0.5 °C
[Electrical & Motor Dynamics] Motor Maximum Armature Temperature (Continuous)	102.3 °C
[Electrical & Motor Dynamics] Motor Stall Torque	0.20 N·m
[Electrical & Motor Dynamics] Operating Motor RPM Under Load	22419 RPM
[Electrical & Motor Dynamics] Motor Armature Resistance	0.162 Ω
[Electrical & Motor Dynamics] MOSFET / ETU Forward Voltage Drop	0.015 V
[Electrical & Motor Dynamics] Battery Discharge C-Rate Actual	4.1 C
[Electrical & Motor Dynamics] MOSFET Thermal Dissipation	0.18 W
[Electrical & Motor Dynamics] Active Braking Reverse Current Spike	0.0 A
[Electrical & Motor Dynamics] Active Braking Duty Cycle	0.0 %
[Electrical & Motor Dynamics] Switch Contact Bounce Latency	0.05 ms
[Electrical & Motor Dynamics] Wiring Harness Resistance Loss	0.0126 Ω (16AWG)
[Electrical & Motor Dynamics] Battery Capacity Consumption Per 1000 Rounds	302 mAh
[Electrical & Motor Dynamics] Estimated Shots Per Full Battery Charge	5,837 BBs
[Electrical & Motor Dynamics] Electrical-to-Mechanical Motor Efficiency	78.3 %
[Electrical & Motor Dynamics] Overall Roundtrip Efficiency (Battery-to-Muzzle)	29.0 %
[Electrical & Motor Dynamics] Motor Back-EMF at Full Velocity	8.65 V
[Electrical & Motor Dynamics] Thermal Runaway Safety Threshold	102.3 °C (SAFE <80°C Neodymium Limit)
[Electrical & Motor Dynamics] Motor Brush Carbon Wear Rate	0.0009 mm / 10k shots
[Electrical & Motor Dynamics] Idealized Cold-Paced Battery Capacity	7,386 BBs
[Exterior Ballistics & Hop-Up] Effective Combat Range (Torso Target)	42.4 m
[Exterior Ballistics & Hop-Up] Maximum Theoretical BB Travel Distance	97.6 m
[Exterior Ballistics & Hop-Up] Hop-Up Backspin Angular Velocity	21543 RPM (2256 rad/s)
[Exterior Ballistics & Hop-Up] Trajectory Apex Height	1.93 m (at 61.3 m)
[Exterior Ballistics & Hop-Up] Downrange Flight Time to 30 Meters	257 ms
[Exterior Ballistics & Hop-Up] Downrange Flight Time to 40 Meters	377 ms
[Exterior Ballistics & Hop-Up] Downrange Flight Time to 50 Meters	519 ms
[Exterior Ballistics & Hop-Up] Kinetic Energy Retention at 30 Meters	1.67 J
[Exterior Ballistics & Hop-Up] Kinetic Energy Retention at 40 Meters	1.18 J
[Exterior Ballistics & Hop-Up] Kinetic Energy Retention at 50 Meters	0.84 J
[Exterior Ballistics & Hop-Up] Crosswind Horizontal Drift at 40m (2 m/s wind)	23.0 cm
[Exterior Ballistics & Hop-Up] Reynolds Number at Muzzle Exit	60,516
[Exterior Ballistics & Hop-Up] Muzzle Exit Turbulence Index	0.048 (Standard Cut)
[Exterior Ballistics & Hop-Up] Hop-Up Contact Patch Length	3.8 mm
[Exterior Ballistics & Hop-Up] Bucking Shore Durometer Compliance	60° Shore A

Parameter Name	Simulation Output Value
[Exterior Ballistics & Hop-Up] Grouping Dispersion at 30 Meters (MOA)	3.2 MOA (1.4 cm radius)
[Exterior Ballistics & Hop-Up] Grouping Dispersion at 50 Meters (MOA)	4.5 MOA (3.2 cm radius)
[Exterior Ballistics & Hop-Up] BB Surface Magnus Coefficient (Cl)	0.020
[Exterior Ballistics & Hop-Up] Sphere Aerodynamic Drag Coefficient (Cd)	0.415
[Exterior Ballistics & Hop-Up] Optimal BB Weight Recommendation	0.48g (Peak Joule Transfer)
[Exterior Ballistics & Hop-Up] Downrange Energy Loss Gradient	0.100 J/m
[Exterior Ballistics & Hop-Up] Terminal Strike Velocity at 40m	76.9 m/s (252 FPS)
[Exterior Ballistics & Hop-Up] Hop-Up Adjustment Sensitivity	0.067 mm nub / 10% spin
[Exterior Ballistics & Hop-Up] Barrel Crowning Concentricity	99.2%
[Exterior Ballistics & Hop-Up] Coriolis Effect Drift at 50m	0.21 cm
[Exterior Ballistics & Hop-Up] Barrel Vibration Standing Wave Node	101.9 mm from crown
[Exterior Ballistics & Hop-Up] Overall Tuner Build Score	94 / 100 (Pro Master Grade)
[Thermodynamic Energy Balance & Waterfall Losses] Electrical Energy Input (Battery)	16.119 J
[Thermodynamic Energy Balance & Waterfall Losses] Cable & Wiring Ohmic Loss	0.178 J
[Thermodynamic Energy Balance & Waterfall Losses] Motor Copper & Eddy Dissipation Loss	3.608 J
[Thermodynamic Energy Balance & Waterfall Losses] Gear Train Tribological Friction Loss	0.522 J
[Thermodynamic Energy Balance & Waterfall Losses] Shimming, Bushing & Grease Drag Loss	0.325 J
[Thermodynamic Energy Balance & Waterfall Losses] Spring Mechanical Potential Stored	11.487 J
[Thermodynamic Energy Balance & Waterfall Losses] Spring Hysteresis & Damping Loss	0.595 J
[Thermodynamic Energy Balance & Waterfall Losses] Piston Peak Kinetic Energy	5.594 J
[Thermodynamic Energy Balance & Waterfall Losses] Piston Rail & Dynamic O-Ring Friction Loss	0.280 J
[Thermodynamic Energy Balance & Waterfall Losses] Pneumatic Thermal & Compression Loss	5.912 J
[Thermodynamic Energy Balance & Waterfall Losses] Hop-Up & Barrel Bore Friction Loss	0.023 J
[Thermodynamic Energy Balance & Waterfall Losses] Hop-Up Backspin Rotational Energy	0.0036 J
[Thermodynamic Energy Balance & Waterfall Losses] Final Muzzle Kinetic Energy	4.676 J
[Thermodynamic Energy Balance & Waterfall Losses] Overall Roundtrip Efficiency (Battery-to-Muzzle)	29.0 %
[Thermodynamic Energy Balance & Waterfall Losses] Pneumatic Compression Efficiency (Spring-to-Muzzle)	40.7 %
[Durability & Component Fatigue (MTBF)] Estimated Build Lifetime	37.3 kShots
[Durability & Component Fatigue (MTBF)] B10 Early-Failure Threshold (90% Reliability)	23.1 kShots

Parameter Name	Simulation Output Value
[Durability & Component Fatigue (MTBF)] B50 Median Fatigue Life (50% Reliability)	37.3 kShots
[Durability & Component Fatigue (MTBF)] Primary Failure Component (Weakest Link)	Gearbox Shell (Front Cylinder Radius)
[Durability & Component Fatigue (MTBF)] Gearbox Shell Fatigue Life	37.3 kShots (MODERATE WEAR)
[Durability & Component Fatigue (MTBF)] Gearset Stripping Life	101.1 kShots (DURABLE / GOOD)
[Durability & Component Fatigue (MTBF)] Piston Rack Shear Life	44.9 kShots (MODERATE WEAR)
[Durability & Component Fatigue (MTBF)] Cut-Off Lever Wear Life	999.0 kShots (IMMUNE (N/A))
[Durability & Component Fatigue (MTBF)] Switch Assembly Life	1000.0 kShots (IMMUNE (N/A))
[Durability & Component Fatigue (MTBF)] Motor Brush Wear Life	102.4 kShots (DURABLE / GOOD)
[Durability & Component Fatigue (MTBF)] Gearbox Shell Peak Bulkhead Stress vs Endurance	113.9 MPa (Endurance: 159 MPa)
[Durability & Component Fatigue (MTBF)] Gearset Tooth Root Bending Stress vs Endurance	509.8 MPa (Endurance: 560 MPa)
[Durability & Component Fatigue (MTBF)] Piston Rack Effective Shear Endurance	540 MPa
[Durability & Component Fatigue (MTBF)] Micro-Parameter Data Confidence	16/16 Explicit Micro-Params (0 Physical Baseline Fallback)
[Durability & Component Fatigue (MTBF)] b10_lifetime_k	23.1
[Durability & Component Fatigue (MTBF)] b50_lifetime_k	37.3
[Durability & Component Fatigue (MTBF)] weakest_link_component	Gearbox Shell (Front Cylinder Radius)
[Durability & Component Fatigue (MTBF)] micro_confidence_summary	16/16 Explicit Micro-Params (0 Physical Baseline Fallback)
[CAD 3D Kinematic & Clearance Verification] 3D CAD Mesh Interference Status	PASS (0 Mesh Collisions Across SSG 19T (360° Full-Rev))
[CAD 3D Kinematic & Clearance Verification] Sector Gear Pickup Contact Angle	49.9° (12:16 o'clock, Cycle 13.9%)
[CAD 3D Kinematic & Clearance Verification] Sector Gear Release Disengagement Angle	311.0° (10:57 o'clock, Cycle 86.4%, SSG 19T (360° Full-Rev))
[CAD 3D Kinematic & Clearance Verification] Piston Head Impact Phase Angle	331.2° (Cycle 92.0%)
[CAD 3D Kinematic & Clearance Verification] Tappet Plate Fin & Return Spring ODE	Standard Uncut (~19mm) | Spring: Stiff (185 N/m)
[CAD 3D Kinematic & Clearance Verification] Nozzle Closure Timing at Piston Release	SEALED ON TIME (0.00 mm Open at Release & Impact, Standard Uncut (~19mm))
[CAD 3D Kinematic & Clearance Verification] Piston Rear Skirt-to-Bulkhead Clearance	+7.43 mm (SAFE)
[CAD 3D Kinematic & Clearance Verification] Main Spring Solid-Height Coil Clearance	+16.24 mm (SAFE)
[CAD 3D Kinematic & Clearance Verification] Spur Gear Step-to-Piston Rack Clearance	+0.57 mm (SAFE)
[CAD 3D Kinematic & Clearance Verification] Piston 2nd Tooth Entry Clearance	+2.50 mm (SHAVED FOR AOE RELIEF)
[CAD 3D Kinematic & Clearance Verification] Sector Pickup Tooth PME Return Clearance	+12.14 mm (SAFE)
[CAD 3D Kinematic & Clearance Verification] AOE Pickup Tooth Contact Geometry	81.9° at 12:16 o'clock (FLUSH)

Parameter Name	Simulation Output Value
[CAD 3D Kinematic & Clearance Verification] Nozzle-to-HopUp Bucking Lip Seal Overlap	+0.85 mm (SEALED)
[CAD 3D Kinematic & Clearance Verification] Nozzle-to-6mm BB Feed Window Clearance	+1.03 mm (CLEAR FEED)
[CAD 3D Kinematic & Clearance Verification] Magazine Follower Upward Feed Force	1.85 N (Midcap @ 100% Tension)
[CAD 3D Kinematic & Clearance Verification] BB Queue Upward Feed Velocity & Rise Time	0.93 m/s (6.39 ms per 6mm BB)
[CAD 3D Kinematic & Clearance Verification] Nozzle-to-BB Stack Retraction Friction	0.22 N
[Acoustic Noise Signature & Spectral Profile] Peak Noise Level	99.7 dBA @ 1m
[Acoustic Noise Signature & Spectral Profile] Muzzle Air Blast	86.5 dB
[Acoustic Noise Signature & Spectral Profile] Piston Head Slam	99.5 dB
[Acoustic Noise Signature & Spectral Profile] Drivetrain Gear Whine	74.5 dB
[Acoustic Noise Signature & Spectral Profile] Sorbo / Damper Pad Attenuation	-2.7 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (63 Hz)	85.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (125 Hz)	93.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (250 Hz)	97.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (500 Hz)	81.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (1 kHz)	84.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (2 kHz)	77.0 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (4 kHz)	85.5 dB
[Acoustic Noise Signature & Spectral Profile] Octave Band SPL (8 kHz)	78.5 dB
[Thermal Dissipation & Continuous Fire Duty Cycle] Motor Technology	Brushed DC
[Thermal Dissipation & Continuous Fire Duty Cycle] Safe Continuous Burst Ceiling	121 rounds (before 80°C Curie Demag Limit)
[Thermal Dissipation & Continuous Fire Duty Cycle] Motor Heating Rate	0.50 °C / 10-shot burst
[Thermal Dissipation & Continuous Fire Duty Cycle] Thermal Saturation Rise	+196.0 °C
[Mechanical Vibration & Recoil Impulse] Piston-Slam Momentum Impulse	0.651 N·s
[Mechanical Vibration & Recoil Impulse] Chassis RMS Vibration Accel	32.05 m/s²
[Mechanical Vibration & Recoil Impulse] Structural Ringing Frequency	71.2 Hz
[Mechanical Vibration & Recoil Impulse] Structural Damping Ratio	0.171
[Mechanical Vibration & Recoil Impulse] Normalized Vibration Intensity	2.62x

First-Law Energy Conversion Stage	Energy Value
Electrical Energy Input (Battery)	16.119 J
Cable & Wiring Ohmic Loss	0.178 J
Motor Copper & Eddy Dissipation Loss	3.608 J
Gear Train Tribological Friction Loss	0.522 J
Shimming, Bushing & Grease Drag Loss	0.325 J
Spring Mechanical Potential Stored	11.487 J
Spring Hysteresis & Damping Loss	0.595 J
Piston Peak Kinetic Energy	5.594 J
Piston Rail & Dynamic O-Ring Friction Loss	0.280 J
Pneumatic Thermal & Compression Loss	5.912 J
Hop-Up & Barrel Bore Friction Loss	0.023 J
Hop-Up Backspin Rotational Energy	0.004 J
Final Muzzle Kinetic Energy	4.676 J
Roundtrip Efficiency Percent	29.010 %
Compression Efficiency Percent	40.708 %
High-Resolution Dynamic Waveform Channel	**Cycle Extremum**
Waveform 1: Cylinder Pressure P(t) & Piston Displacement x(t)	Peak 16.51 bar
Waveform 2: Piston Velocity v(t) & Spring Force F(t)	Peak 17.19 m/s
Waveform 3: Motor Inrush Current I(t) & Battery Voltage V(t)	Peak 16.6 A / Min 10.70 V
Waveform 4: Motor Electro-Torque Tau(t) & Coil Thermal Rise Delta T(t)	Full Cycle Trace

IX. Workshop Service & Maintenance Log (Superimposed Revision History)

Revision 1.0 - Initial Custom DMR Build & 75m Range Calibration (2026-06-15)

• Full internal V2.5 extended-bore drivetrain assembly, 32:1 torque gearset micrometer shimming (0.05mm axial play), and 19-tooth CNC steel rack piston with 2.0mm 70D Sorbo AOE correction.
• Lapped 509mm 6.03mm stainless tightbore inner barrel with custom R-Hop patch and dual O-ring nozzle air-seal verification (464 FPS / 3.99J @ 0.40g BB, +/- 1.4 FPS deviation).

Revision 1.1 - 15,000-Round Scheduled Preventive Overhaul & Superimposed .AWBZ Update (2026-11-02)

• Ultrasonic gearbox degreasing, fresh PTFE synthetic gear lubrication, and pistonhead Viton O-ring replacement.
• Re-verified compression seal and re-chronographed at 464.0 FPS (3.99J @ 0.40g BB, 17.8 RPS). Packed updated .awbz and re-uploaded to superimpose existing online certificate record.

X. Disclaimer, Terms & Services

1. 180-DAY MASTER CRAFTSMANSHIP WARRANTY: Valkyrie Precision Custom Armory warrants all internal shimming, compression seals, and custom machining work for 180 days from handover.
2. TAMPER-EVIDENT CRYPTOGRAPHIC SEAL: Scanning the receiver QR sticker or opening the signed .awbz file verifies the exact internal Bill of Materials and chronograph benchmark recorded at delivery. Opening the gearbox shell voids warranty.
3. FIELD SAFETY NOTICE: This Extended-Bore DMR is calibrated for 3.99J with 0.40g BBs for designated outdoor precision roles. Always observe local statutory limits and minimum engagement distances (MED).

XI. Certificate of Authenticity

CERTIFIED AUTHENTIC

Valkyrie Precision Custom Ed25519 SIGNED

Workshop:	Valkyrie Precision Custom Armory
Tuner:	Marcus Vance (Lead Master Armorer)
Report ID:	AWB-VPCA-2026-0842
Issued:	2026-11-02 13:24:31
Key fingerprint:	9594-0FFC-0C5E-7B92-0AFA
Signature:	7b7aa688091f5977f1abe8d4ec8cdb...

Scan QR or paste the verification string in the app: Custom Report > Verify Seal

Verification string: AWB1.eyJpIjoiQVdCLVZQQ0EtMjAyNi0wODQyIiwidCI6IjIwMjYtMTEtMDIgMTM6MjQ6MzEiLCJ3IjoiVmFsa3lyaWUgUHJlY2lzaW9uIEN1c3RvbSBBcm1vcnkiLCJhIjoiTWFyY3VzIFZhbmNlIChMZWFkIE1hc3RlciBBcm1vcmVyKSIsImQiOiI0a01XcXdnZmNZNk9rZXBYckRYR0NrZXBtS1FLcHF5cWU3SlhTYVFHV0VNIiwiayI6Il9wX21QVGRSVEZlb0FsQVBsZWs3Q1Q5aVp6QjBiVUlyMG9pbVlwR3QtOEEiLCJzIjoiZTNxbWlBa2ZXWGZ4cS1qVTdJemJ0bkI2UEFkOElHMVFERkxlOHFRcjJFeWhjV1Ixem5XMHcxWlhFaXVidmZaaFBDTDRCM0JWYTRFVFZtX3J4UGltQncifQ

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