COMMERCIAL / TECHNICAL OVERVIEW

A Ballistics Engine Built for Arrows

How BowPro+ turns the actual arrow, atmosphere and sight geometry into one coherent external-ballistics solution.

BowPro+ is not a generic projectile calculator with archery labels added afterward. It begins with a completed arrow, an explicit launch velocity, the real atmosphere and the measured sight relationship, then integrates the flight continuously to the requested distance.

01

Continuous flight simulation

Fourth-order Runge-Kutta integration with a default 0.00075-second step: approximately 1,333 state updates per second of flight.

02

Arrow-specific response

Shaft diameter, mass, length, component build and vane geometry describe the projectile that is actually being launched.

03

True sight geometry

The engine solves the launch angle that makes the arrow intersect the real line of sight instead of applying a simple drop correction.

04

Measurement-backed calibration

Launch speed, downrange speed and shooting references can refine the model while preserving the underlying physics.

05

One internally consistent state

Trajectory, time, velocity, path angle, energy and momentum all come from the same numerical solution.

06

Local and reproducible

The calculation can run fully on-device from an immutable equipment-and-environment snapshot, independent of an account or server.

The technical bar has moved

By 2026, offline calculation, air-density correction and downrange calibration are no longer sufficient on their own to distinguish an advanced archery application. BowPro+ should therefore be positioned on the depth and coherence of the architecture: an explicit finished-arrow model, inspectable assumptions, true sight geometry, multiple measurement paths and one engine reused across practical tools.

The strongest defensible claim

Without a controlled benchmark against every current application, “best in the world” cannot be proven. What can be defended is that BowPro+ has a class-leading technical foundation and combines capabilities that are still rarely integrated in one local-first archery system.

The bow defines launch; the arrow defines flight

BowPro+ accepts a measured, discovered or separately estimated launch velocity. It does not continue to infer external ballistics from IBO speed or a generic bow category after release. Once the arrow leaves the string, its motion is governed by initial conditions, gravity, aerodynamic loading and the atmosphere.

BOWPRO+ NUMERICAL CORE

Solve the Flight, Not a Shortcut

A continuous state model preserves the changing relationship between speed, drag, gravity and trajectory.

The flight state is updated continuously

The core engine is a two-dimensional external-ballistics simulation. Its state contains horizontal and vertical position, horizontal and vertical velocity, elapsed time and derived flight angle. At each step, position advances from velocity and velocity advances from gravity plus aerodynamic deceleration.

Simplified physical form

Conceptually, the solver follows dr/dt = v and dv/dt = g - (rho CdA / 2m)|v|v. The production engine uses its own effective arrow model and calibration factors, but the essential point remains: drag acts continuously, opposite the instantaneous velocity vector, and changes as the arrow slows.

Why RK4 is appropriate

Fourth-order Runge-Kutta integration is a strong practical choice for this problem. It is deterministic, fast enough for repeated launch-angle searches on a phone, and substantially more accurate than a simple forward-Euler step at the same interval. With the default 0.00075-second step, a one-second flight receives roughly 1,333 state updates.

Numerical element	What BowPro+ does	Why it matters
State integration	Recalculates position and velocity through the complete flight.	Retains the nonlinear relationship between speed loss and drop.
Event interpolation	Interpolates the exact state when the arrow crosses a requested distance.	Avoids limiting outputs to the nearest time step.
Launch-angle search	Repeats the simulation until the trajectory intersects the line of sight at the selected distance.	Makes every sight mark a solved geometry problem.
Bounded convergence	Uses finite iteration and residual limits rather than assuming a result exists.	Supports diagnostics when geometry or input data are inconsistent.
Deterministic snapshot	Runs from a fixed set of equipment, atmosphere and model parameters.	Makes results repeatable and auditable.

True sight geometry is inside the solution

The arrow begins below the eye-to-sight line by the measured shaft-to-eye or peep geometry. BowPro+ then solves the launch angle that places the arrow on that line at the chosen zero or sight-mark distance. Angular change is converted through the actual sight radius or native sight mechanics only after the trajectory has been solved.

- Near-field behavior is preserved: the arrow can begin below the line of sight, cross it, rise relative to it and cross again depending on the selected zero.
- A mark is not merely “drop at distance.” It is the change in launch direction required by the complete sight-and-arrow geometry.
- The same approach supports pin positions, millimetre tape coordinates, click values and geared sight ratios without changing the underlying physics.

Why a parabola is not enough

A no-drag parabola can be useful for explanation, but it is not a sight-tape engine. It cannot preserve velocity-dependent deceleration, changing time of flight, retained speed or the actual relation between the shaft and the line of sight.

BOWPRO+ ARROW AND ATMOSPHERE MODEL

Model the Finished Arrow That Flies

Geometry creates aerodynamic loading; mass converts that loading into deceleration; the complete build defines the result.

Equal weight does not mean equal flight

Two arrows can share the same total mass and still decelerate differently. Shaft diameter changes frontal and wetted area. Vane height, length, count, offset and helical alter stabilizing surface and drag. A broadhead, surface finish or unusual vane profile can add effects that catalogue dimensions do not fully describe.

Input group	Role in the model	Practical consequence
Shaft geometry	Outside diameter, length and GPI establish the main body of the arrow and its mass.	Diameter can materially change aerodynamic loading, especially at long range.
Completed mass	Point, insert/outsert, nock, wrap, vanes and shaft determine total mass.	The same aerodynamic force produces less deceleration on a heavier arrow.
Mass distribution	Front and rear components determine balance point and FOC.	Supports the complete arrow description and stability or fit-related modeling; it is not treated as decorative metadata.
Vane package	Height, length, count, offset and helical define an explicit geometric proxy.	Avoids reducing every fletching system to a generic low/medium/high choice.
Non-standard aerodynamics	Broadhead, surface finish, turbulence and manufacturing variation are not perfectly known from dimensions.	Measured downrange speed can absorb the remaining effective drag difference.

Keep the physics roles clear

A technically credible model does not let every input act as an unexplained multiplier. BowPro+ constructs the finished arrow from all component data, but the roles remain conceptually distinct: geometry drives aerodynamic area and vane contribution; total mass converts force to acceleration; mass distribution supports balance, stability and dynamic-fit relationships. This separation makes the model easier to inspect and improve.

Drag is the honest uncertainty

The largest unknown is rarely gravity. It is the effective aerodynamic behavior of the real arrow: boundary-layer effects, vane deformation, yaw, broadheads, surface texture and small build differences. BowPro+ therefore combines a detailed prior model with measurement calibration instead of pretending dimensions alone are perfect.

Real atmosphere, not a fixed standard day

Air density is derived from temperature, pressure, altitude and humidity. BowPro+ can use measured station pressure directly or estimate local pressure from sea-level pressure and elevation. Humidity normally has a smaller effect than pressure or temperature, but keeping it in the density calculation makes the environmental state complete and avoids hidden assumptions.

- At short hunting ranges, atmospheric differences are often smaller than shooting variation.
- At longer target distances, in steep-angle work and when comparing tapes made in different conditions, the effect becomes increasingly visible.
- The atmosphere is applied to the same continuous simulation used for every other output, not as an after-the-fact percentage correction.

BOWPRO+ MEASUREMENT AND VALIDATION

Prediction First, Calibration When Available

The engine can operate from specifications alone, then become setup-specific as real measurements are added.

A hierarchy of useful evidence

BowPro+ supports several ways to establish or refine the initial and downrange state. These methods are complementary rather than interchangeable: each constrains a different part of the problem, and no single measurement can repair every incorrect input.

Evidence	Primarily constrains	Strength and limitation
Measured launch velocity	Initial speed at release.	Best direct starting point; still requires correct drag and geometry.
Phrono audio measurement	Flight timing over a known distance.	Field-friendly and local; depends on clean shot/impact detection and correct microphone geometry.
Physics-based launch estimate	Expected launch speed from bow and arrow energy relationships.	Useful before measurement; should be treated as an informed prior, not ground truth.
Downrange velocity	Effective deceleration over a long baseline.	Excellent for drag calibration; does not by itself validate sight height or print scale.
Two or more sight references	Observed sight position versus distance.	Anchors the complete tape to the shooter and sight; includes form, geometry and printing effects.
Known-distance trajectory difference	Launch speed consistent with measured vertical separation under fixed geometry.	Powerful refinement method when bounded around a credible estimate and accompanied by residual diagnostics.

Downrange velocity calibrates effective drag

Given launch speed and a reliable speed measurement at approximately 50 metres / 55 yards or farther, BowPro+ iteratively adjusts an effective drag multiplier until the simulated deceleration reproduces the measurement. The long baseline is important: a short interval contains too little velocity loss to distinguish measurement noise from true aerodynamic behavior.

Two operating levels

Specification mode predicts from the completed arrow and atmosphere. Measurement-calibrated mode retains the same physics but tunes the effective drag to the individual setup. The second level is especially valuable for unusual vanes, broadheads and long-range tapes.

Sight validation is a fitted layer above the pure engine

The pure ballistics engine remains responsible for physics. A shared validation layer can then normalize calculated tape positions to measured references, reproduce exact measured marks, interpolate residual correction inside the validated range and use fitted ballistic extrapolation beyond it. This separation prevents user correction from contaminating the reusable physical core.

Launch-speed discovery remains bounded

Where speed is inferred from measured trajectory, BowPro+ searches within a hard window around its physics-based estimate, uses the fixed known shaft-to-eye geometry, solves the reference zero and compares the simulated and measured separation. A boundary result or unresolved residual is reported as low confidence rather than accepted as a convenient answer.

BOWPRO+ APPLIED BALLISTICS

One Engine, Many Practical Tools

Every workflow uses the same arrow state instead of assembling unrelated formulas for each screen.

The engine returns a complete flight state

At any requested distance, BowPro+ can report trajectory height relative to the line of sight, elapsed time, horizontal and vertical velocity, total speed, flight-path angle, kinetic energy and momentum. Apex height, retained speed and impact state are therefore consequences of one solution, not values calculated by separate approximations.

01

Sight tapes and sight marks

Solve the launch angle for every distance, convert angular change through sight geometry, then apply measured validation when available.

02

Near-field markers

Preserve the real line-of-sight crossings and short-range offset instead of assuming the first metres follow a scaled long-range curve.

03

Cut charts and angle shots

Solve the selected uphill or downhill geometry with the setup's actual time of flight, retained velocity and sight relationship—not cosine distance alone.

04

Magic Marks and shot tools

Reuse the same validated trajectory for fast "shoot-for" references, shot windows and field decisions.

05

Arrow Flight exploration

Expose path, apex, speed loss, angle, energy and momentum so equipment changes can be understood rather than merely accepted.

06

Speed discovery and diagnostics

Use the engine in reverse to search for launch speed or drag that best explains measured data, with residuals and confidence reporting.

Why internal consistency matters

A sight tape, cut chart, energy table and trajectory display should not disagree because each feature used a different approximation. BowPro+ treats the trajectory as a shared source of truth. A change to launch speed, atmosphere, arrow build, drag calibration or sight geometry propagates through every dependent output.

A calculation is a reproducible object

The strongest implementation records the equipment snapshot, environment, units, model version, catalog version and fingerprints used for the result. That makes a saved tape or shared setup explainable later, even after catalogs or algorithms evolve.

Angle solving: more than cosine

Cosine distance is a useful first-order rule because gravity acts vertically while the line of sight may be inclined. It is not a complete arrow solution. Drag changes time of flight, the arrow begins below the sight line, the launch direction must be solved, and steep uphill and downhill trajectories are not perfectly symmetric once the complete geometry is included.

- At moderate ranges and angles, cosine and full simulation may agree closely.
- At long ranges, large angles or low-speed/heavy-arrow setups, the remaining difference can become relevant to scoring or clearance.
- BowPro+ can show the actual calculated cut rather than hiding the approximation behind one equivalent distance.

BOWPRO+ ACCURACY AND POSITIONING

Accuracy Is an Input-and-Validation System

A sophisticated solver reduces model error; it cannot remove measurement error, print scaling or inconsistent shooting.

The practical error budget

Source	Typical effect	BowPro+ response
Launch speed	Shifts the complete curve and time of flight.	Use measured V0, Phrono, an estimate or bounded trajectory refinement; record confidence.
Effective drag	Creates increasing long-range error.	Model arrow and vanes, then calibrate from downrange speed or spaced references.
Sight geometry	Changes angle-to-tape or click conversion.	Use measured shaft-to-eye/peep offset, sight radius and sight mechanics.
Atmosphere	Changes density and velocity retention.	Use pressure, temperature, elevation and humidity.
Reference marks	Contain aiming and measurement variation.	Use spaced references, residual diagnostics and interpolation.
Printing and installation	Scale error accumulates over tape length.	Print at exact size and verify a physical dimension.
Shooter repeatability	Can exceed remaining model error.	Verify the final reference by shooting safely.

What the core engine does not pretend to be

The current core is a two-dimensional external-ballistics engine. It is not a full six-degree-of-freedom arrow simulation of yaw, pitch, roll, spin, flex and aerodynamic moments. Some unresolved effects can be absorbed through calibrated effective drag, but the boundary should be stated honestly.

- It predicts the center-of-mass flight path; it does not claim to simulate every flexing and rotational mode of the arrow.
- Calibrated broadhead or vane behavior can be modeled in translation without claiming every mechanism has been identified.
- Real-world verification remains mandatory for competition, hunting and any high-consequence use.

Our position

Lead with integration, transparency and measurement discipline. “One of the most advanced and comprehensive archery external-ballistics engines” is defensible; an absolute accuracy claim requires a controlled benchmark.

Why the architecture is class-leading

- Continuous RK4 integration rather than a parabolic or lookup-table-only trajectory.
- A finished-arrow model with explicit shaft, component and vane detail.
- Real atmospheric density and true shaft-to-sight geometry inside the solve.
- Separate calibration paths for launch speed, downrange deceleration and measured sight references.
- One internally consistent solution reused across tapes, cuts, near-field marks, flight exploration and diagnostics.
- Local-first operation, reproducible snapshots and no critical server dependency.

In a nutshell

BowPro+ describes the arrow that actually exists, solves the flight that follows, and gives the archer independent ways to test whether the model agrees with reality.