FeToolKit.com

GOLF ANALYSIS TOOLS

User Handbook

Version 2.0 (Revision B) · September 2026

Covers: Golf Club Dynamics · Golf Club Face and Ball Impact ·
Golf Club Face Fracture Review · Parameter Review · Probabilistic Fracture Life
Test Data Input (Material Properties & Statistical Scatter)

This handbook explains how to access and use the seven golf analysis tools, how they connect to each other, and how to read and print their results. It is not an engineering reference — the detailed physics, formulas, material property data, and equation derivations behind each tool's results are documented in the ***FeToolKit Technical Reference Manual (FTRM)****, an internal document with restricted circulation. Wherever this handbook touches something technical, look to the FTRM for the full explanation.*

A special notice. The tools built in this handbook apply aerospace methods of structural analysis to golf club engineering. Some of these methods have been developed and refined by the author over more than 30 years of practice. As with any tradition of engineering development, we owe a debt of gratitude to those whose shoulders we stand on — and whose innovation, effort, and contribution to the science is not always fully credited. That debt is acknowledged here, with thanks.

The Tool Chain, at a Glance

Before the details: these seven tools aren't independent calculators. Impact Mechanics computes a real COR and feeds it both back to Golf Club Dynamics and forward to Fracture Review as a peak stress. Parameter Review and Probabilistic Fracture Life both reuse the same underlying physics but don't exchange live data with the others — unless you feed them your own tested material data via the two Test Data Input tools, which replace illustrative material values with real, measured ones.

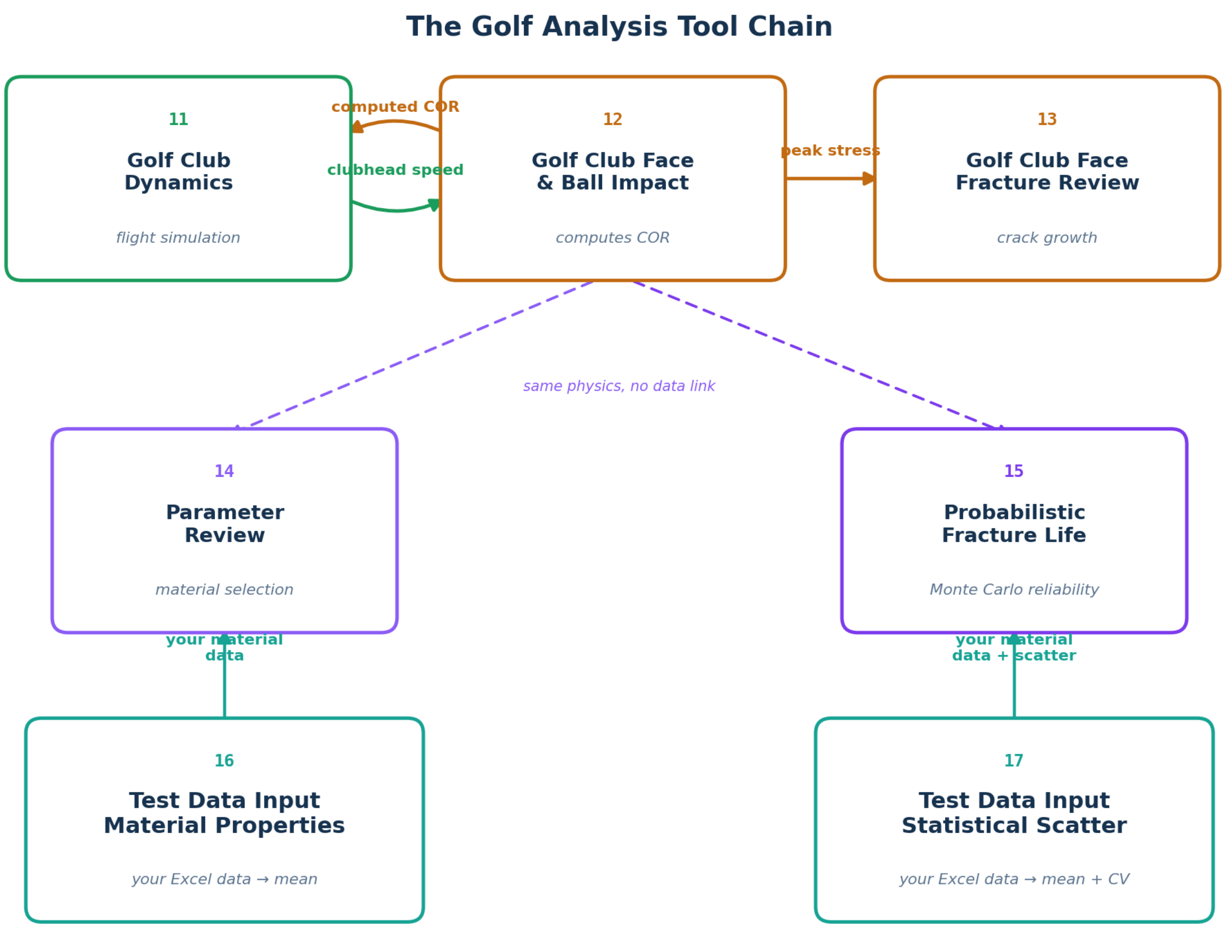

Figure 1. The golf analysis tool chain — how data flows between all seven tools.

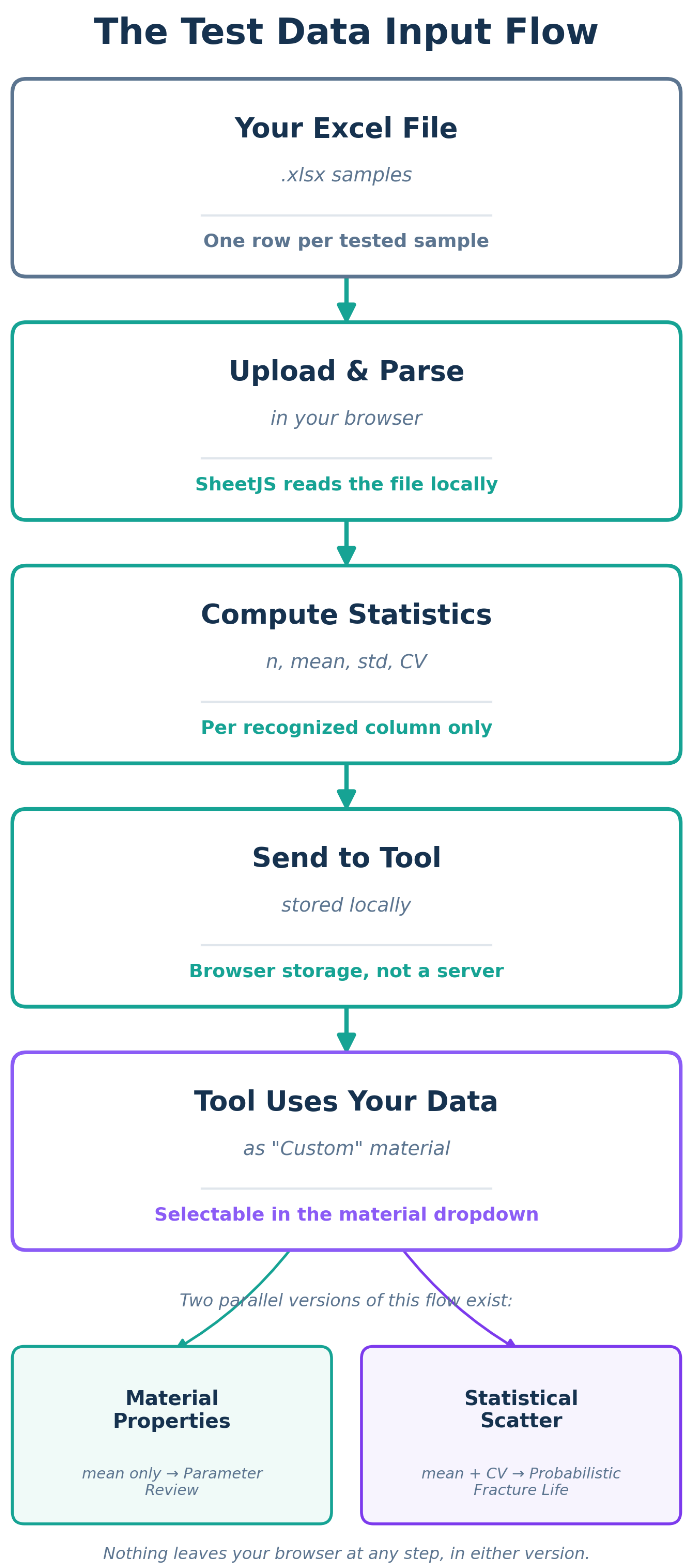

Figure 2. The Test Data Input flow — how your own tested samples become a usable material or scatter estimate.

Figure 3. How the seven tools map to the FeToolKit Technical Reference Manual (FTRM) — each box's Reference ID (Section N) is the section of the FTRM covering that tool's underlying physics and equations.

Reference Equipment

The clubs photographed below are the author's own, provided as a grounding reference for the tools in this handbook, not measurements, certified data, or a claim that any specific numeric value in these tools was derived from them. Where a photo shows something directly relevant to a specific tool, that's noted.

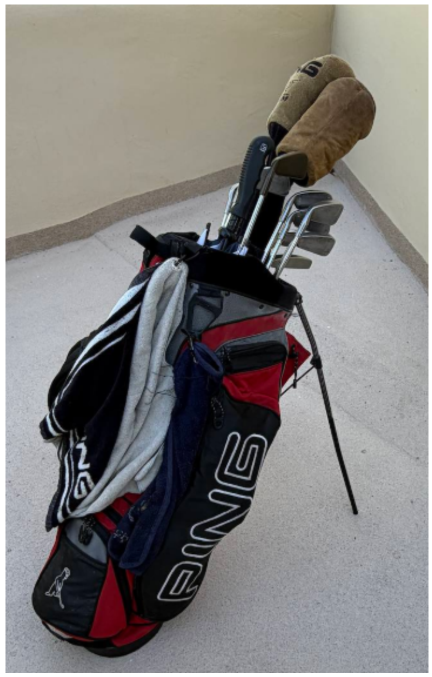

Figure 4. A PING bag and full set, shown as a general reference for the kind of equipment these tools model.

Figure 5. A PING driver head marked “Ti… TITANIUM, KARSTEN 8.5°” (left) — the T9S+ alloy referenced throughout Impact Mechanics, Fracture Review, Parameter Review, and Probabilistic Fracture Life is this same PING driver-face material family — and a different, modern grooved driver face (right). Real groove geometry like this is what the grooved-face option in Golf Club Face Fracture Review models — see Section 5, “Groove stress concentration.” For a closer look at this groove pattern, with estimated dimensions and material discussion, see the FTRM, Section 123, Figure 123.1.

Figure 6. A PING Eye2 iron, marked “KARSTEN PHOENIX AZ 85066 USA” — an older, cavity-back design (left), and the same iron's grooved face (right). Iron faces like this are substantially thicker than a driver face, which is why the USGA/R&A groove regulations discussed in Section 5 can be used closer to their limit on an iron than on the thin driver face modeled throughout this handbook.

Contents

SECTION 1

Getting Started

The golf tools are hosted at **fetoolkit.com**, in an area separate from the site's aerospace/structural tools. Getting there:

1. Go to **fetoolkit.com** and click **Beyond Aerospace** in the main menu.
2. Click the **Golf Analysis Tools** card.
3. Enter the username and password when prompted by your browser:

Username:	`golf`
Password:	`PING2026`

Once signed in, you'll land on the golf tools listing page, showing all seven tools as cards. This same login covers all seven — you only need to sign in once per browser session.

Note on browsers: *the sign-in prompt is your browser's own login dialog, not a page on the site. If you're switching computers or using a private/incognito window, you'll be asked to sign in again.*

Before you use these tools: they are provided free of charge, "as is," without warranty of any kind, express or implied. No warranty or responsibility is accepted for their use, or for any decisions made based on their output. In no event shall FeToolKit or its author be liable for any direct, indirect, incidental, or consequential damages arising from use of these tools. These tools do not constitute professional engineering advice and must not be relied upon for actual part design, certification, or safety-critical decisions. All material and process data used has been sourced from public information, not provided by or verified with any manufacturer, and is presented solely to support the illustrative engineering calculations described in this handbook — see Section 13, Engineering Caveats, for the full data-sourcing statement. These tools and this site may change or be discontinued at any time, without notice. Questions or concerns should be addressed in the first instance to **steve@fetoolkit.com**.

SECTION 2

How the Seven Tools Fit Together

All seven tools share the same underlying physics engine, applied to different questions. Understanding this chain makes the whole suite easier to use:

Tool	Question it answers	Feeds into
Golf Club Dynamics	Given a COR, how far does the ball fly and how does it curve?	Uses COR from Impact Mechanics
Golf Club Face and Ball Impact	Given a face material and thickness, what COR and fatigue life result?	Feeds COR to Golf Club Dynamics; feeds stress to Fracture Review
Golf Club Face Fracture Review	Given a peening treatment, how long does a face survive once a crack starts?	Reads stress from Impact Mechanics
Parameter Review	Given a surface finish (or an assumed initial flaw), how long until failure?	Independent — reuses the same physics, different question
Probabilistic Fracture Life	Given scatter in flaw size, stress, and material, what's the reliability curve?	Independent — reuses the same physics as a Monte Carlo simulation
Test Data Input — Material Properties	Given your own tested samples (Excel), what's the mean material property?	Feeds a real, test-derived material into Parameter Review
Test Data Input — Statistical Scatter	Given your own tested samples (Excel), what's the mean and measured scatter?	Feeds mean and scatter (CV) into Probabilistic Fracture Life

Table 1. How the seven tools relate — what each answers and feeds into.

The key thing to know: Golf Club Face and Ball Impact *computes* a real COR from contact physics. Golf Club Dynamics normally just *assumes* a fixed COR per material. Visit Impact Mechanics first, and its computed COR automatically carries over — both to Golf Club Dynamics' flight simulation and to the live COR readout shown on Fracture Review and Parameter Review. This happens automatically in the background once you've opened Impact Mechanics in that browser — there's no button to press.

SECTION 3

Golf Club Dynamics

Simulates a full golf shot: club-to-ball impact (momentum and coefficient of restitution) feeding a real drag-and-lift flight model, with spin-axis tilt driving hook, draw, fade, or slice curvature.

Key inputs

Club brand and head material, ball construction, swing speed, loft, and face-to-path angle (the source of shot shape).

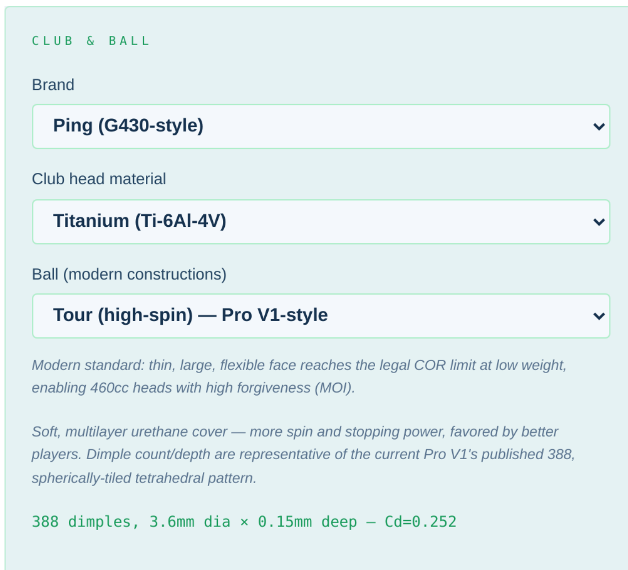

Figure 7. The Club & Ball panel, showing the material dropdown (now 15 head materials plus wood, grouped by family) and live property readouts below each selection.

Club brand selection

Brand	Model	Loft	Character
Ping	G430-style	10.5°	Large, high-MOI 460cc head, tuned for forgiveness
TaylorMade	Qi10-style	9.0°	Low-spin, carbon crown, favored by faster swingers
Honma	Beres-style	10.5°	Premium Japanese build, often lighter for higher swing speed
Tour Pro-Level Custom	Custom fit	9.5°	Representative top-tier custom-fit tour driver at the legal COR limit

Table 2. The four driver brands and their native loft/character.

Brand selection sets loft and a representative head character; club head material is chosen separately from the same 15-material list used throughout the other tools (plus a wood option, unique to this tool).

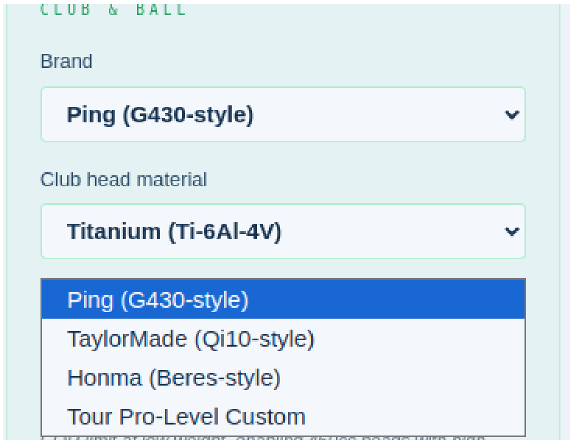

Figure 8. The Brand dropdown, open, showing all four options.

Ball construction

Ball	Character
Tour (high-spin)	Pro V1-style — 3-piece tour, highest spin
Tour (mid-spin)	Chrome Soft-style — softer feel, slightly lower spin
Distance (low-spin)	TP5-style — low-spin tour-distance construction
2-piece distance	Tour B-style — lowest spin, distance-focused

Table 3. The four ball constructions available in Golf Club Dynamics.

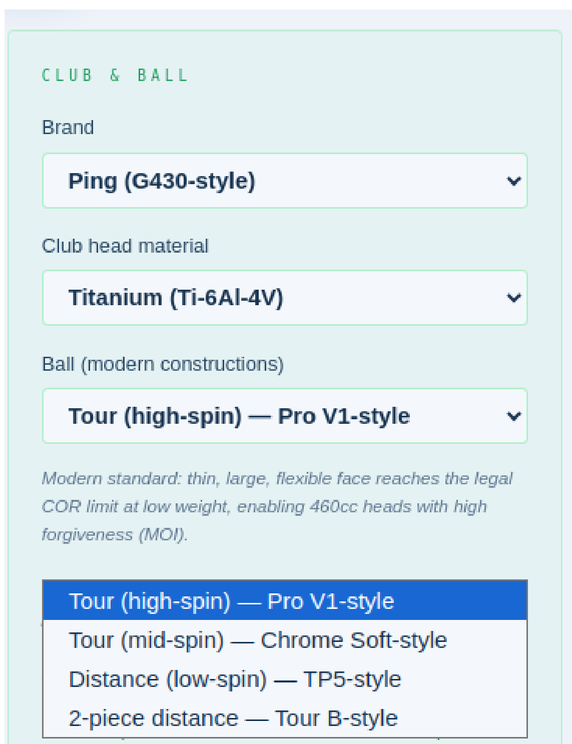

Figure 9. The Ball dropdown, open, showing all four options.

Key outputs

Ball speed, smash factor, launch angle, spin, carry and total distance, lateral curve, and a visual flight path over a rendered hole.

Compare All Drivers

A dedicated panel compares all 4 driver brands — each at its own native loft — side by side on carry distance, total distance, and launch angle, at your current swing speed, material, ball, and face-to-path settings. The currently selected brand is highlighted. Fairway woods and irons aren't included: irons in particular have much thicker, more complex face geometry that this tool's clamped-plate model doesn't represent well — planned as a separate treatment later, not squeezed into this comparison as-is.

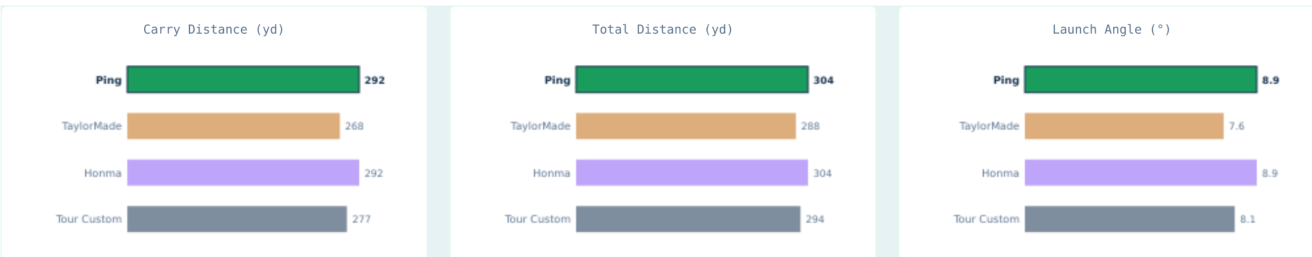

Figure 10. The Compare All Drivers panel — Ping selected, so Ping's bar is bold across all three metrics.

Things worth knowing

- Press **Swing!** to animate the shot. Dragging any slider updates the numbers instantly without needing to press Swing again.
- If you've visited Golf Club Face and Ball Impact in this browser, its computed COR replaces this tool's fixed per-material assumption automatically, with a banner confirming it and a link to clear the override if you want the fixed value back.

Key variables: Pro vs. Amateur

Ping brand, titanium head, Tour (high-spin) ball, straight face-to-path — only player type changes.

Variable	Pro / Tour	Amateur
Swing speed	113 mph	90 mph
Ball speed	167.9 mph	133.7 mph
Smash factor	1.49	1.49
Carry distance	292 yd	197 yd
Total distance	304 yd	219 yd

Table 4. Golf Club Dynamics — Pro vs. Amateur, same club and ball.

SECTION 4

Golf Club Face and Ball Impact

Models the ball and clubface as two springs in series — the ball compressing per Hertzian contact theory, the face flexing per clamped circular plate theory — to compute the real COR, peak force, and fatigue life this specific configuration produces.

Key inputs

Face material — 14 options across titanium, steel/superalloy, and aluminum families (see Section 6 for the full list), or a custom modulus override — face thickness, ball construction, impact speed, playing temperature, and a surface treatment configuration.

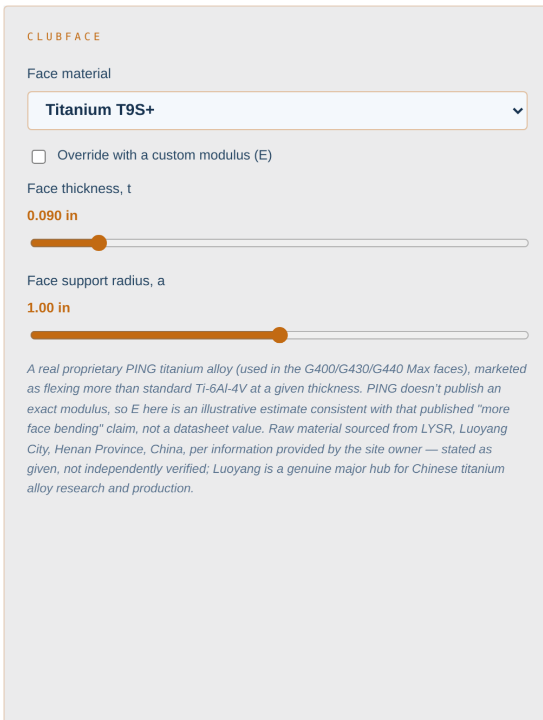

Figure 11. The Clubface panel: material dropdown, the custom-modulus override checkbox and slider, and face thickness/support radius controls, with the live material description below.

Key outputs

COR (with its legal-limit margin of safety), peak force, ball/face compliance split, contact time, and fatigue life at both the impact center and the clamped edge, with and without surface treatment.

Things worth knowing

- This is the tool that *computes* COR — every other tool's COR readout traces back to a visit here.

- The “Modulus Sensitivity” chart shows how every key result moves as face modulus alone varies ±30% around the Ti-6Al-4V baseline — useful for seeing which results are modulus-driven and which are capped by yield strength regardless of modulus.
- Use **Send Edge/Center Stress to Fracture Review** to carry this configuration's stress directly into that tool.

Key variables reference

This tool has no Pro/Amateur selector — impact speed is a direct slider. Typical range shown for the default T9S+ material.

Variable	Typical Range	Default
Face material	14 options	Titanium T9S+
Face thickness	0.060 – 0.300 in	0.090 in
Support radius, a	0.5 – 1.5 in	1.00 in
Impact speed	70 – 130 mph	113 mph
Resulting COR	varies with inputs	0.836 @ default

Table 5. Golf Club Face and Ball Impact — key variables and their ranges.

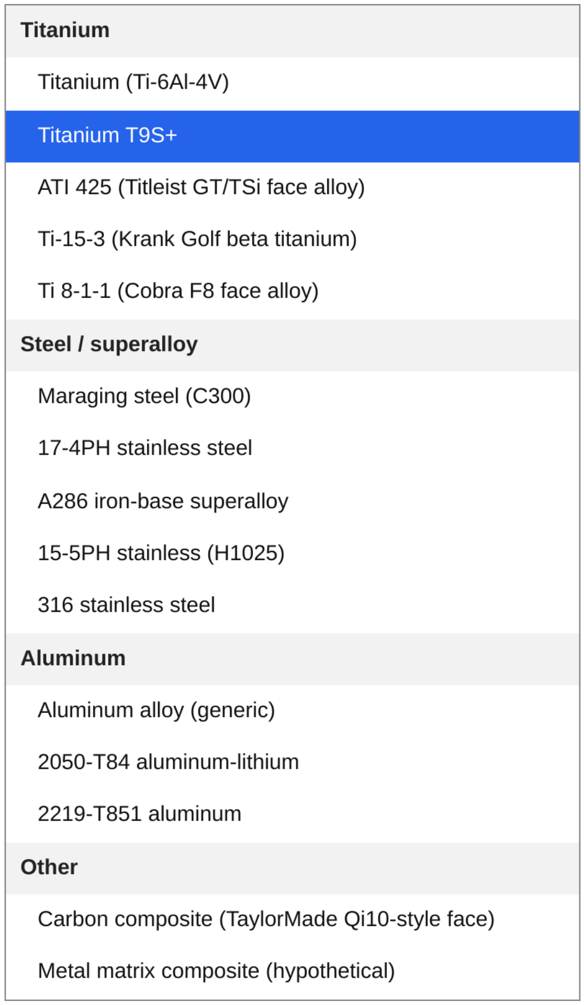

Figure 12. The Face material dropdown, open, showing all 15 options grouped by family. The same list appears in Fracture Review, Parameter Review, and Probabilistic Fracture Life.

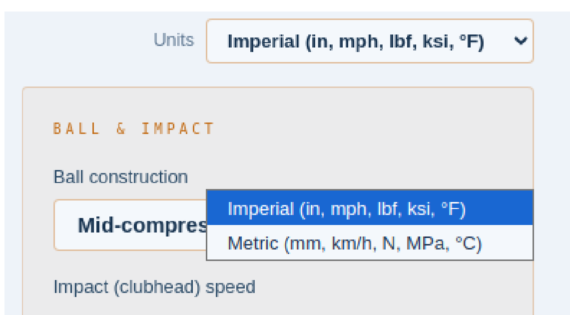

Figure 13. The Units dropdown, open, showing both options.

Ball	Character
2-piece distance	Tour B-style — lowest spin
Low-compression (soft)	Softest feel, lower compression

Mid-compression / 3-piece tour	Pro V1-style — the default
4-piece tour	Pro V1x-style — higher-spin 4-piece
High-compression (firm)	Firmest, highest compression

Table 6. The five ball constructions available in Golf Club Face and Ball Impact.

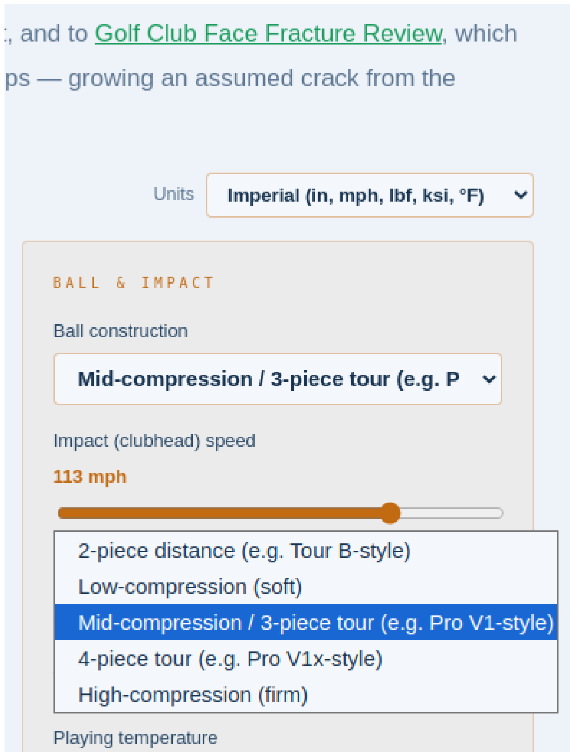

Figure 14. The Ball construction dropdown, open, showing all five options.

Peening method and surface treatment mode

Method	Character
Laser Shock Peening (LSP, full)	Deepest residual-stress layer, the default
Aerospace 2	Specific named aerospace finish method — proprietary definition, see FTRM
Aerospace 1	Specific named aerospace finish method — proprietary definition, see FTRM
Conventional shot peening	Shallowest, lower-magnitude residual stress

Table 7. The four peening methods — same set used in Golf Club Face Fracture Review.

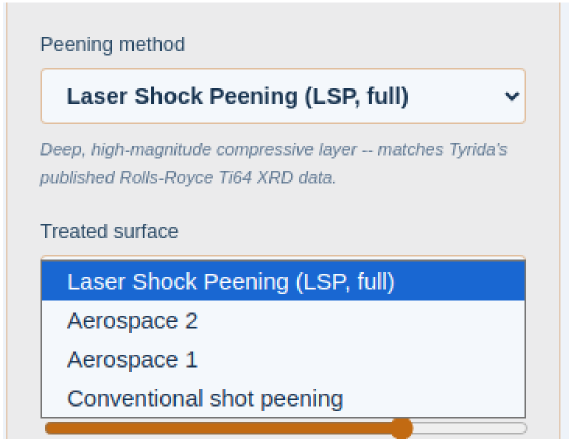

Figure 15. The Peening method dropdown, open, showing all four options.

Surface treatment mode (which face gets treated) is a separate control: None (baseline), Front (striking) surface only, Back (inside) surface only, or Both surfaces.

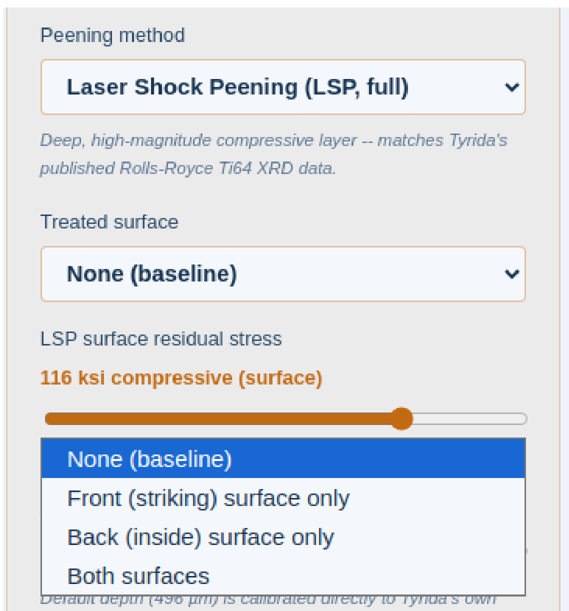

Figure 16. The Treated surface dropdown, open, showing all four options.

Manufacturing thickness tolerance can matter more than it looks: this tool's own live output, swept across a ±0.01 in tolerance band around the driver-face thickness used in the PING-vs-Cobra worked example (Section 14), shows the softer material actually crossing the legal COR limit within that band.

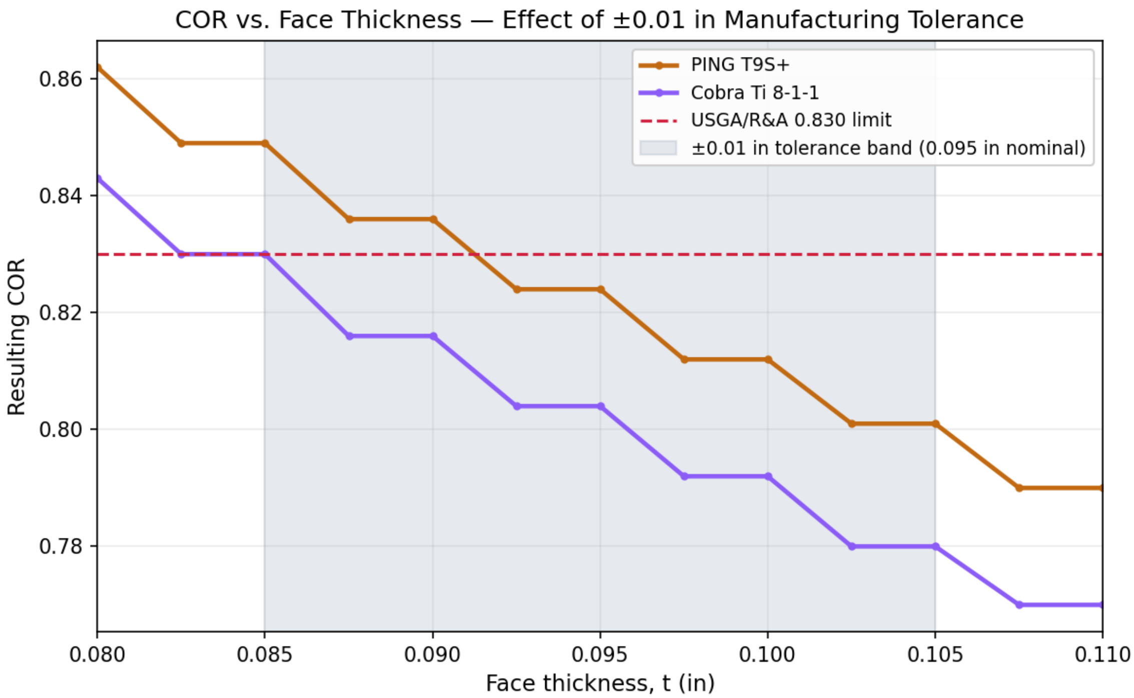

Figure 17. COR vs. face thickness for both materials, ±0.01 in tolerance band shaded. PING T9S+ (lower modulus) crosses the 0.830 legal limit within the band; Cobra Ti 8-1-1 stays legal across the same band, though with shrinking margin. **For the full derivation, the measured-value table, and why this matters more for a softer face, see the FTRM, Section 122.**

SECTION 5

Golf Club Face Fracture Review

Picks up where Impact Mechanics' fatigue estimate stops: assumes a crack has already formed at the peened depth, and grows it toward failure using Paris' Law fatigue crack propagation.

Key inputs

Material (14 options), peening method (LSP, two Aerospace variants, or shot peening), applied peak stress, face thickness, and the peening depth/surface stress/counter-stress.

Figure 18. The Peening & Material panel, showing the peening-method and material dropdowns together with the depth/stress sliders they feed.

Key outputs

Initial and critical crack length, governing failure mode, and cycles to failure — plus a live COR readout carried over from Impact Mechanics.

Things worth knowing

- This tool doesn't compute stress itself — it needs a peak stress, either typed in directly or sent from Impact Mechanics.
- The **Print Complete 11-13 Report** button (available on all three of these tools) generates a combined report covering Golf Club Dynamics, Impact Mechanics, and this tool together — see Section 8.

Key variables reference

This tool has no Pro/Amateur selector — peak stress arrives either typed in directly or sent from Impact Mechanics.

Variable	Typical Range	Default
Material	14 options	Titanium (Ti-6Al-4V)
Peening method	4 options	Laser Shock Peening (full)
Applied peak stress	depends on source	typed or sent value
Face thickness	0.060 – 0.300 in	0.090 in
Peening depth	0 – 800 microns	496 microns (LSP)

Table 8. Golf Club Face Fracture Review — key variables and their ranges.

Peening method options are the same four listed in Table 7 (Section 4).

Groove stress concentration

When a grooved face is selected, this tool now shows the stress concentration itself, not just the groove's geometry — a color-gradient field at each groove root, scaled by the computed local K_t, switching to a flat "yield-capped" reading once the raw elastic stress exceeds the material's yield strength.

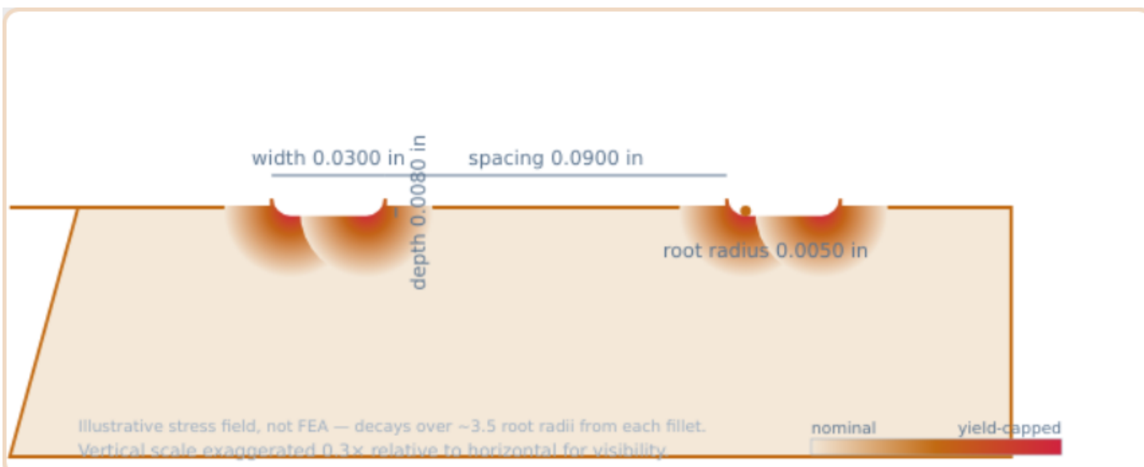

Figure 19. The groove cross-section diagram with the stress field overlay, as it renders in the tool — default settings shown, yield-capped. **For the full K_t derivation, the net-section factor, and the yield-capping limitation this diagram illustrates, see the FTRM, Section 123.**

SECTION 6

Parameter Review

Ties the whole chain together into one review, with the **initial flaw size** itself as the variable under study: derived from surface finish, set to a representative aerospace flaw size, or entered directly.

Key inputs

Golf club (driver, fairway wood, or iron), face material (all 14 options), thickness, player type (Pro/Tour or Amateur), and an initial flaw size source.

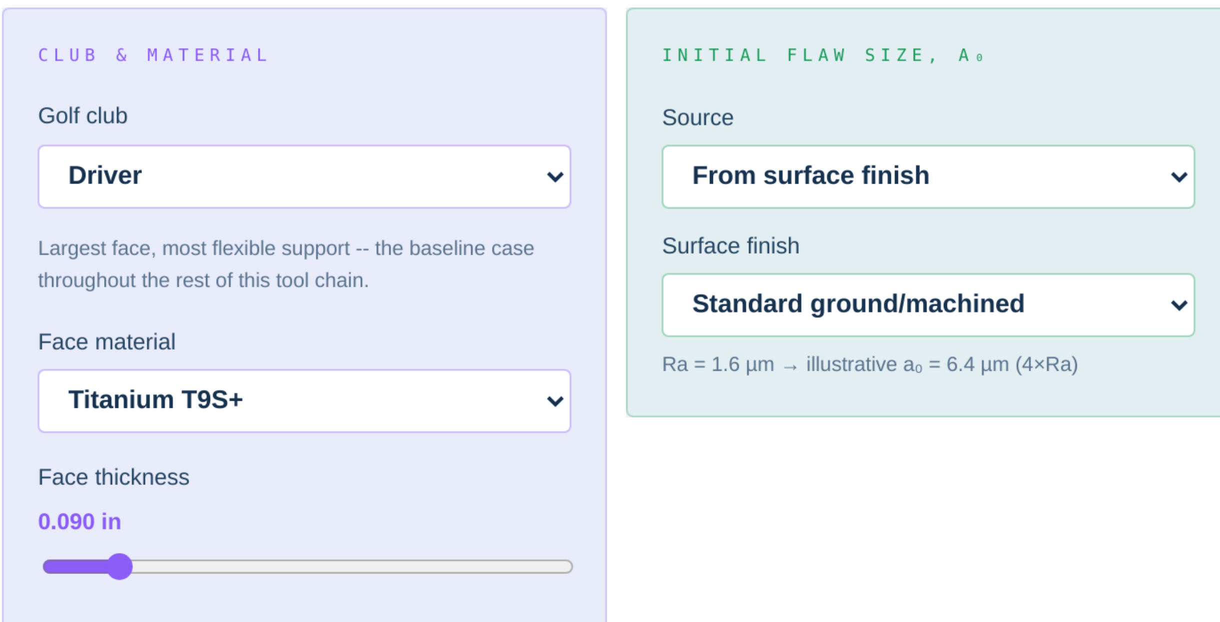

Figure 20. Left: club, material, and thickness controls. Right: the initial flaw size source selector.

Club type selection

Club	Support Radius	Character
Driver	1.00 in	Largest face, most flexible support — the baseline case throughout this tool chain
Fairway wood	0.85 in	Smaller, stiffer-supported face than a driver
Iron	0.65 in	Smallest, stiffest support of the three — irons are essentially never face-fatigue-critical in practice, included for comparison

Table 9. The three club types and their modeled support radius.

Club type sets the effective clamped-plate support radius that drives contact stiffness — a simplification stated on the page itself, not the club's actual geometry.

Figure 21. The Golf club dropdown, open, showing all three options.

Key outputs

Peak force, applied stress, initial and critical flaw size, failure mode, and crack life — plus a single chart that sweeps whichever variable you choose from a dropdown (thickness, surface finish, clubhead speed, or club support radius) against crack life.

The three flaw-size sources

- **From surface finish** — the initial flaw is estimated from the selected surface roughness (polished, standard, or rough).
- **Aerospace flaw size** — a representative flaw size in the class commonly used in aerospace fracture-control practice, adjustable by slider.
- **Custom value** — enter your own initial flaw size directly.

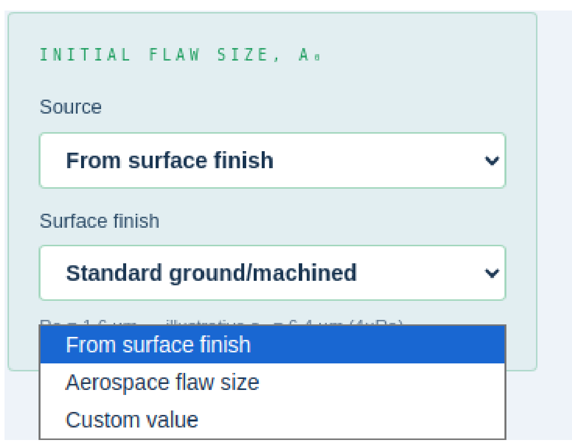

Figure 22. The Source (flaw size) dropdown, open, showing all three options.

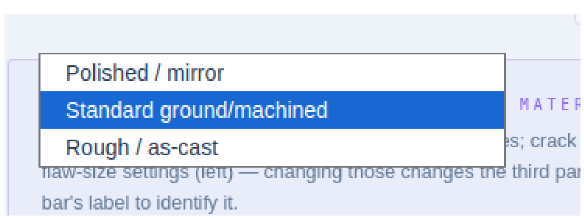

Figure 23. The Surface finish dropdown, open, showing all three options.

Comparing materials

Two features help with material selection specifically, both new in this version:

- **Compare all materials** — a checkbox above the chart overlays all 15 materials as colored lines on the same sweep chart, with the currently selected material drawn bold on top and a legend below the chart.
- **Material Selection Helper** — a dedicated section below the main chart with three side-by-side panels comparing all 15 materials at a glance: modulus, yield strength, and crack life at your current settings. The selected material is highlighted in each panel.

The 15 materials, by family

Titanium	Steel / superalloy	Aluminum	Other
Ti-6Al-4V, T9S+, ATI 425, Ti-15-3, Ti 8-1-1	Maraging (C300), 17-4PH, A286, 15-5PH, 316 stainless	Generic, 2050-T84, 2219-T851	Carbon composite, Metal matrix composite (hyp.)

Table 10. All 15 materials, grouped by family.

Ti 8-1-1 is the real, publicly confirmed Cobra F8 driver face alloy — the stiffest titanium in the list. ATI 425 and Ti-15-3 are genuinely lower-modulus titaniums by comparison, per their own published data sheets. See Section 13 for sourcing detail.

Key variables: Pro vs. Amateur

Driver, Titanium T9S+, 0.090 in, standard ground/machined finish — only player type changes.

Variable	Pro / Tour	Amateur
Peak force	5,276 lbf	4,117 lbf
Applied stress	116.0 ksi (yield-capped)	116.0 ksi (yield-capped)
Crack life (N)	2.84×10^{3} cycles	2.84×10^{3} cycles

Table 11. Parameter Review — Pro vs. Amateur. Peak force differs, but crack life doesn't: both speeds already yield-cap the stress at this thickness, so the fatigue-relevant number is identical — a real finding, not a rounding coincidence.

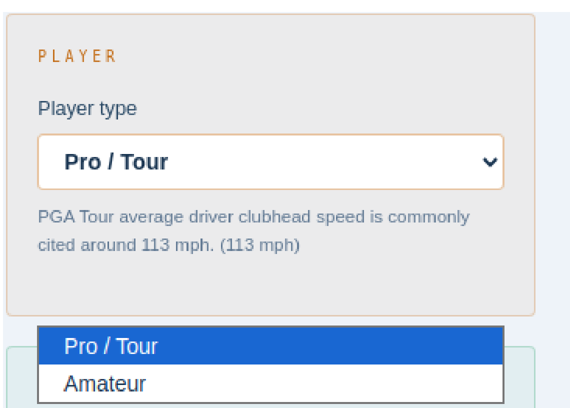

Figure 24. The Player type dropdown, open, showing both options.

SECTION 7

Probabilistic Fracture Life Analysis

Every other fracture tool in this suite gives a single number from a single set of fixed inputs. This tool runs a 3,000-trial **Monte Carlo simulation** instead, treating initial flaw size, applied stress, and material properties as distributions — producing a full reliability curve rather than one answer.

Key inputs

The same club, material (14 options), thickness, player type, and initial flaw size source as Parameter Review, plus three new **scatter** controls: coefficient of variation (CV) sliders for flaw size, applied stress, and material properties, and a target service life slider.

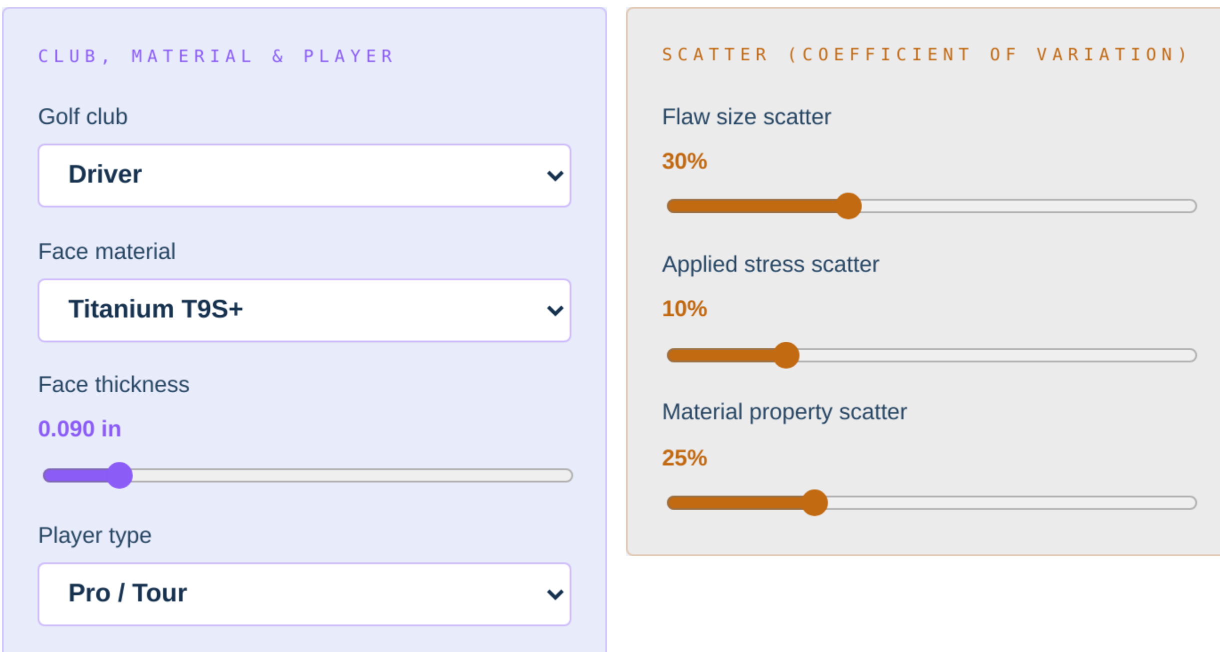

Figure 25. Left: the same club, material, and thickness controls as Parameter Review. Right: the three scatter (CV) sliders unique to this tool.

Key outputs

A full reliability curve (cumulative probability of failure vs. cycles), B10 life, B50 life (median), mean life, and the probability of failure by your chosen target service life.

What's sampled, and how

- **Initial flaw size** and the **Paris' Law coefficient C** are sampled from lognormal distributions — always positive, right-skewed, the standard choice for both.
- **Applied stress** and **fracture toughness** are sampled from normal distributions, clamped to stay physically positive.

- Each distribution's spread is set by its CV slider (CV = standard deviation ÷ mean). The defaults (30% flaw size, 10% stress, 25% material) are illustrative starting points, not measured scatter for any specific material or process.

Reading the results

B10 life is the cycle count by which 10% of a population would be expected to have failed — the standard reliability metric used for design-life decisions, more conservative than the median (B50) and much more conservative than the mean. Move the target service life slider to see the probability of failure at any specific cycle count directly from the same simulated population.

Manufacturing thickness tolerance

A fourth scatter slider, **Manufacturing thickness tolerance**, is unique to this tool — it's the only one of the four that's genuinely propagated through the underlying contact-stiffness physics each trial (recomputing peak force and stress from that trial's sampled thickness) rather than applied as a flat multiplier. The 2.0% default represents a common shop tolerance band around ±0.005 in on a 0.090–0.095 in face. It has little effect at configurations already yield-capped (which most default settings on this site are), but becomes meaningful at thicker, non-yield-capped configurations, where stress scales roughly as $1/t^2$ with thickness. None of the deterministic tools (Impact Mechanics, Fracture Review, Parameter Review) model this — doing so properly would mean turning them into probabilistic tools too, which is exactly what this tool already is.

Key variables: Pro vs. Amateur

Driver, Titanium T9S+, 0.090 in, standard finish, default scatter settings — only player type changes.

Variable	Pro / Tour	Amateur
Mean applied stress	116.0 ksi (yield-capped)	116.0 ksi (yield-capped)
B10 life	1.30×10^3 cycles	1.34×10^3 cycles
B50 life (median)	2.65×10^3 cycles	2.67×10^3 cycles
P(failure) by 2,000 cycles	30.5%	29.8%

Table 12. Probabilistic Fracture Life — Pro vs. Amateur. Nearly identical results for the same reason as Table 11: yield-capping erases most of the speed difference at this thickness.

Test Data Input — Material Properties

Every material on this site is illustrative by design — representative values, not certified test data, as every tool's methodology section says plainly. This tool replaces that with **your own** numbers: upload an Excel file of multiple tested samples, and it computes the mean of each property and sends it to Parameter Review as a real, test-derived material.

How it works

- Upload an .xlsx file, one row per sample, with any of: Sample ID, E (Msi), Su (ksi), Fcy (ksi), Paris C, Paris m, KIC (ksi√in). Column names are matched flexibly — only the columns you actually tested are needed.
- The tool computes n, mean, standard deviation, CV, and range for each recognized property.
- Pressing “Send Mean Values to Parameter Review” stores the means in this browser; Parameter Review then offers “Custom (from your test data)” as a material option.

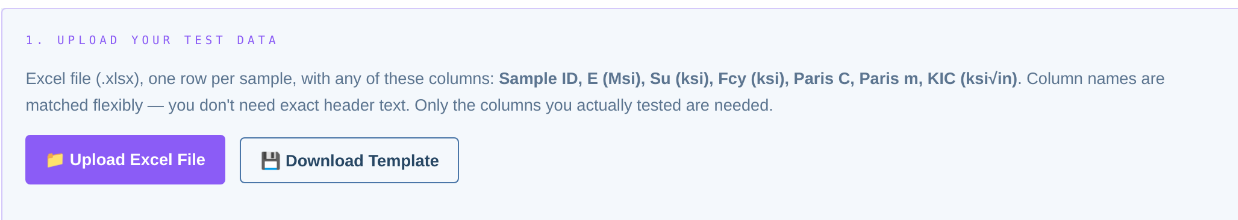

Figure 26. The upload panel — accepts .xlsx/.xls, with a downloadable template showing the expected column layout.

Property	n	Mean	Std Dev	CV	Range
E (Msi)	5	**15.080**	0.286	1.9%	14.700 – 15.400
Su (ksi)	5	**139.600**	2.408	1.7%	137.000 – 143.000
Fcy (ksi)	5	**117.400**	2.702	2.3%	114.000 – 121.000

Figure 27. Computed statistics from an uploaded file — the bold mean values are what get sent to Parameter Review.

Sample size matters

A mean computed from very few samples isn't a reliable estimate. Properties with fewer than 5 samples are flagged as low confidence — the tool still sends a value, but treat it accordingly. Everything happens in your browser; the uploaded file is never sent to any server.

SECTION 9

Test Data Input — Statistical Scatter

Probabilistic Fracture Life defaults its scatter sliders to illustrative coefficient-of-variation values (30% flaw size, 10% stress, 25% material) — explicitly not measured scatter for any real material. This tool replaces that with **your own measured scatter**: the same Excel upload as the tool above, but it computes and sends both the mean *and* the coefficient of variation for each property.

How it works

- Same file format as Test Data Input — Material Properties. At least 2 samples per property are required to compute scatter at all; 5+ gives a meaningfully more trustworthy estimate.
- Pressing “Send Mean & Scatter” stores both in this browser. Probabilistic Fracture Life's “Custom (from your test data)” option then uses your measured mean for the material and automatically sets the Material property scatter slider to your measured average CV, with a note confirming the value it used.

Property	n	Mean	Std Dev	CV (scatter)
E (Msi)	5	**15.080**	0.286	**1.9%**
Su (ksi)	5	**139.600**	2.408	**1.7%**
Fcy (ksi)	5	**117.400**	2.702	**2.3%**

Figure 28. Computed statistics including CV (scatter) — this is what gets sent to Probabilistic Fracture Life alongside the mean.

Why scatter needs more samples than a mean

A mean can be estimated, poorly, from just 2–3 samples. A standard deviation — and therefore a CV — is far more sensitive to sample size; with very few samples, the computed scatter can differ wildly from the true population scatter by chance alone. Treat any CV from a small sample count as a rough starting point, not a validated measurement.

Coefficient of Restitution (COR) and Margin of Safety

COR is shown, bold, on all five golf pages, because it's the single number that ties club performance to legality. The USGA/R&A legal limit for driver COR is **0.830**.

Where each page gets its COR from

- **Golf Club Face and Ball Impact** computes it directly from contact physics.
- **Golf Club Dynamics** uses a fixed per-material value, unless it's been overridden by a visit to Impact Mechanics in the same browser.
- **Fracture Review**, **Parameter Review**, and **Probabilistic Fracture Life** all show the COR last computed by Impact Mechanics in that browser, with the date/time it was computed.

Reading the margin of safety

Next to every COR figure is a margin of safety, using the same convention as this site's other engineering tools: **MS = (0.830 ÷ COR)** – **1**. A positive margin (shown in green) means the current configuration is legal; a negative margin (shown in red) means COR exceeds the legal limit.

Example	COR	MS	Reading
Comfortably legal	0.780	+0.064	6.4% of headroom below the limit
At the edge	0.830	0.000	Exactly at the legal limit
Over the limit	0.836	–0.007	Exceeds the legal limit by 0.7%

Table 13. Reading COR margin of safety — three worked examples.

SECTION 11

Saving, Loading, and Printing

Every tool

The **Print / Save as PDF** button (top right of each tool) opens your browser's print dialog with a clean, branded report layout — sliders and buttons are hidden, results and charts are kept, and a header shows the FeToolKit logo, tool name, and the exact date and time the report was generated.

Golf Club Dynamics and Golf Club Face and Ball Impact only

Save Data downloads the current configuration as a small JSON file; **Load Data** reads one back in, restoring the settings it recognizes. Useful for keeping a record of a specific configuration or sharing one with someone else who has access to the same tool.

The Complete 11-13 Report

Available from any of Golf Club Dynamics, Golf Club Face and Ball Impact, or Golf Club Face Fracture Review, the **Print Complete 11-13 Report** button generates one combined report covering all three tools at once. It works automatically: simply having visited each tool once in the same browser is enough for its latest results to be included, with a timestamp showing when each was last computed. A tool you haven't visited yet shows plainly as unavailable in the report, rather than silently leaving a blank.

Glossary

COR — Coefficient of Restitution — how efficiently energy is returned in a collision. 1.0 would be a perfectly elastic impact; real drivers sit around 0.78–0.84.

Monte Carlo simulation — Running a calculation many times (3,000, in Probabilistic Fracture Life) with randomly sampled inputs each time, to see the full range of possible results instead of just one.

Coefficient of Variation (CV) — A distribution's spread relative to its mean (CV = standard deviation ÷ mean). A CV of 30% means the typical scatter is about 30% of the average value.

B10 life — The cycle count by which 10% of a population would be expected to have failed — a standard reliability metric, more conservative than the median and used for real design-life decisions.

Margin of Safety (MS) — How much headroom exists before a limit is reached. Positive is safe, negative means the limit has been exceeded.

Face modulus (E) — Stiffness of the clubface material. Lower modulus flexes more at impact, which generally raises COR but also raises bending stress.

Peening / surface treatment — A process (laser shock peening or shot peening) that leaves a layer of compressive residual stress at the surface, extending fatigue life.

Fatigue life (N) — The number of impact cycles a component is predicted to survive before cracking initiates, shown in cycles (often as a power of ten, e.g. 2.6×10^4).

Initial flaw size (a_0) — The size of the crack-like flaw assumed to exist before crack growth begins — the starting point for Paris' Law calculations.

Critical flaw size (a_C) — The flaw size at which the material fractures — either because fracture toughness is exceeded or the crack has grown through the material.

Paris' Law — The standard equation relating crack growth rate to the stress intensity range at the crack tip, used to predict how many cycles it takes a crack to grow from a_0 to a_C.

Yield-capped stress — When the raw calculated stress exceeds the material's yield strength, the value used for fatigue calculations is capped at yield — a standard simplifying assumption.

These are plain-language definitions for using the tools. For the full equation behind each term — Paris' Law, the Goodman mean-stress correction, Hertzian contact, clamped-plate bending, and the rest — see the FeToolKit Technical Reference Manual (FTRM), Sections 1–6.

SECTION 13

Engineering Caveats

Data sourcing statement: every material property used in these tools — modulus, yield/ultimate strength, and fatigue/fracture constants — was obtained from public sources: manufacturer technical data sheets, published aerospace materials literature, and (for T9S+ and Ti 8-1-1) manufacturers' own public statements about their driver face alloys. No proprietary, confidential, or internal manufacturer data was used anywhere in this tool chain.

Trademark notice: all product and brand names mentioned in this handbook and in the tools it documents — including PING, T9S+, TaylorMade, Titleist, Cobra, NASA, ATI, and others — are trademarks of their respective owners. FeToolKit.com is an independent analysis tool and is not affiliated with, sponsored by, or endorsed by any of these companies.

These tools are preliminary, illustrative engineering models for exploring trends and trade-offs — not a substitute for certified fracture-mechanics analysis, measured material data, or real inspection program results. A few specific points worth knowing:

- **T9S+ material.** The alloy name and its use in PING driver faces are public information. The specific numeric values used in these tools (modulus, strength, fatigue constants) are illustrative estimates consistent with PING's own public qualitative description, not published datasheet values. Every tool also treats T9S+ as isotropic — one modulus and strength value in every direction. Real forged parts are commonly anisotropic (properties vary with grain flow direction), driven by the forging direction and die draft angles used to shape the part, but neither is published for the actual PING process, so that anisotropy and any through-thickness property variation from forging aren't captured here.
- **Aerospace flaw size.** The default value in Parameter Review is a representative figure in the size class commonly used in aerospace fracture-control practice, not a certified or tabulated value for any specific inspection method.
- **Surface-finish-to-flaw-size relationship.** The 4×Ra multiplier used in Parameter Review is an illustrative engineering approximation, not a measured relationship for any specific material or process.
- **Fatigue and fracture constants** (Paris' Law C and m, fracture toughness, S-N coefficients) are representative values for each material family drawn from general literature, not certified test reports for a specific heat, condition, or supplier.

- **Manufacturing thickness tolerance** (a real effect, around ±0.005 in on a 0.090–0.095 in face) is only modeled in Probabilistic Fracture Life, as a fourth scatter input propagated through the actual contact-stiffness physics. It's not in the three deterministic tools — Impact Mechanics, Fracture Review, Parameter Review — because properly modeling a tolerance band there would mean making them probabilistic too, which changes what kind of tool they are rather than just adding an input.
- **The 9 new materials added in this version** (ATI 425, Ti-15-3, Ti 8-1-1, A286, 15-5PH, 316 stainless, 2050-T84, 2219-T851, plus the aluminum-family Paris-law constants) all use modulus and yield/ultimate strength from published manufacturer data sheets. Where no published fatigue-crack-growth data exists for a specific alloy — true for all nine — Paris-law constants are borrowed from the closest modeled family (e.g. standard titanium, 17-4PH stainless, or a general aluminum-family estimate) and stated as such on each material's own description. Ti 8-1-1 and T9S+ are both real, publicly confirmed driver face alloys (Cobra and PING respectively); the others are realistic aerospace materials included for comparison, not materials actually used in golf club faces.

*The equations, derivations, and detailed sourcing behind these values are documented in the **FeToolKit Technical Reference Manual (FTRM)**, Sections 1–6, rather than reproduced in full here or on the tool pages themselves.*

Worked Examples: PING vs. Cobra

Two real, publicly-confirmed driver face alloys, run through the same tools with identical inputs, to show how the site's physics chain actually differentiates real materials. **PING's T9S+** and **Cobra's Ti 8-1-1** sit at opposite ends of this site's titanium family: T9S+ is one of the softer (lower-modulus) options, Ti 8-1-1 is the stiffest of any titanium modeled here.

Both examples use the same inputs throughout: ***Driver, 0.095 in face thickness, Pro/Tour player, standard ground/machined surface finish*** *— only the material changes.*

Example 1: Golf Club Face and Ball Impact — COR and legality

Material	COR	Margin of Safety	Reading
PING T9S+	0.824	+0.007	Legal, with a slim 0.7% headroom below the limit
Cobra Ti 8-1-1	0.804	+0.033	Legal, with a comfortable 3.3% headroom below the limit

Table 14. Example 1 — COR and margin of safety, PING T9S+ vs. Cobra Ti 8-1-1.

T9S+'s lower modulus lets the face flex more at impact, which is exactly why it produces a higher COR than Ti 8-1-1 — both are legal at this thickness, but T9S+ sits much closer to the 0.830 limit, with roughly a fifth of Ti 8-1-1's margin. (At the thinner 0.090 in used in Section 4's screenshot, T9S+ actually crosses the limit — this example uses 0.095 in specifically so both stay legal for a cleaner side-by-side comparison.)

Figure 29. The actual results panels, PING T9S+ (top) and Cobra Ti 8-1-1 (bottom), same inputs:

CONTACT MECHANICS RESULTS

EFFECTIVE MODULUS E*	FACE STIFFNESS K_{FACE}	PEAK CONTACT FORCE	PEAK BALL COMPRESSION	PEAK FACE DEFLECTION
0.10592 Msi	60911 lbf/in	5514 lbf	0.122 in	0.0905 in

BALL SHARE OF COMPLIANCE	FACE SHARE OF COMPLIANCE	CONTACT TIME	ENERGY LOST IN BALL	ENERGY LOST IN FACE
52%	48%	0.316 ms	13.23 ft·lbf	0.64 ft·lbf

RESULTING COR

0.824 MS +0.007 vs 0.830 legal limit

Within USGA/R&A 0.830 limit

CONTACT MECHANICS RESULTS

EFFECTIVE MODULUS E*
0.10607 Msi

FACE STIFFNESS K_{FACE}
79184 lbf/in

PEAK CONTACT FORCE
5888 lbf

PEAK BALL COMPRESSION
0.127 in

PEAK FACE DEFLECTION
0.0744 in

BALL SHARE OF COMPLIANCE
58%

FACE SHARE OF COMPLIANCE
42%

CONTACT TIME
0.298 ms

ENERGY LOST IN BALL
14.74 ft·lbf

ENERGY LOST IN FACE
0.57 ft·lbf

RESULTING COR
0.804 MS +0.033 vs 0.830 legal limit

Within USGA/R&A 0.830 limit

Example 2: Parameter Review — stress and crack life

Material	Peak Force	Applied Stress	Crack Life (N)
PING T9S+	5,514 lbf	116.0 ksi (yield-capped)	2.84×10^3 cycles
Cobra Ti 8-1-1	5,888 lbf	134.0 ksi (yield-capped)	1.60×10^3 cycles

Table 15. Example 2 — applied stress and crack life, PING T9S+ vs. Cobra Ti 8-1-1.

This is the counterintuitive result worth sitting with: Ti 8-1-1 is both stiffer *and* higher-yield-strength than T9S+, yet it comes out with the *shorter* crack life here — about 56% of T9S+'s. Its higher stiffness transmits more of the impact into face-bending force rather than absorbing it as ball compression (5,888 lbf vs 5,514 lbf peak force), and that higher force drives a higher stress even against Ti 8-1-1's higher yield cap (134.0 ksi vs 116.0 ksi). More stress applied against a bigger fatigue-relevant baseline outweighs the higher static strength. Neither material is simply “better” — the trade-off between COR, legality, and fatigue life is exactly what these tools are for exploring.

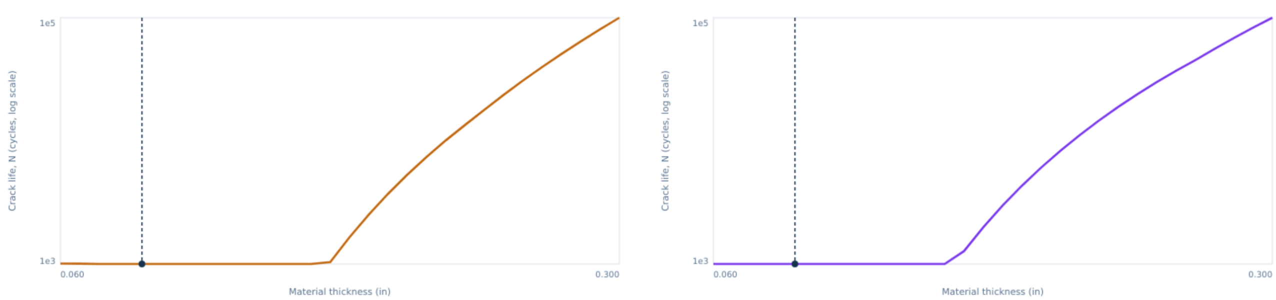

Figure 30. Crack life vs. thickness for each material, current point marked — PING T9S+ (left), Cobra Ti 8-1-1 (right). Same physics, same sweep, different material.

Try it yourself: open Golf Club Face and Ball Impact or Parameter Review, set Driver / 0.095 in / Pro / standard finish, and switch between Titanium T9S+ and Ti 8-1-1 (Cobra F8 face alloy) in the material dropdown to reproduce these results directly.

SECTION 15

A Typical Excel Test Data File

Both Test Data Input tools expect the same file shape. Here's the actual downloadable template (Sample ID plus whichever of E, Su, Fcy, Paris C, Paris m, and KIC you tested), filled in with five representative tensile-test samples, exactly as a real spreadsheet might arrive from a materials lab.

Sample ID	E (Msi)	Su (ksi)	Fcy (ksi)	Paris C	Paris m	KIC (ksi√in)
Sample 1	14.7	137	116	—	—	—
Sample 2	15.3	141	119	—	—	—
Sample 3	14.9	138	114	—	—	—
Sample 4	15.1	143	121	—	—	—
Sample 5	15.4	139	117	—	—	—

Table 16. A typical filled-in test data file — five tensile-test samples, E/Su/Fcy only (Paris law and KIC left blank, since those need separate fatigue/fracture testing).

This is a realistic case: the lab ran tensile tests (giving E, Su, Fcy for all 5 samples) but not fatigue-crack-growth or fracture-toughness testing, so those three columns are blank. That's fine — both tools only compute statistics for columns that actually have data, and leave the rest to fall back on the closest modeled material family.

What this file computes to

Property	n	Mean	Std Dev	CV
E (Msi)	5	15.080	0.286	1.9%
Su (ksi)	5	139.600	2.408	1.7%
Fcy (ksi)	5	117.400	2.702	2.3%

Table 17. The statistics both Test Data Input tools compute from Table 16 — verified by hand calculation, not just by the tool's own output.

Test Data Input — Material Properties would send the three means (15.080 Msi, 139.600 ksi, 117.400 ksi) to Parameter Review as a new “Custom (from your test data)” material. Test Data Input — Statistical Scatter would send those same means *plus* the CV column (1.9%, 1.7%, 2.3%, averaging to about 2.0%) to Probabilistic Fracture Life, which would set its Material property scatter slider to that measured 2.0% automatically.

There is no limit on the number of samples you can upload. The five-sample example above is just for illustration — both tools compute their statistics from however many rows your file contains. Aerospace test datasets in excess of 2,000 samples have been successfully run through the underlying statistics and Monte

Carlo algorithms behind these tools without issue.

This exact file is the live template — download it from either Test Data Input tool's “Download Template” button to see it yourself, or replace the numbers with your own tested values.

SECTION 16

Material Data

The 15 face materials used across every analysis tool in this handbook, listed here by name only. Every numeric property — modulus, density, strength, Paris' Law constants, fracture toughness — along with how each value is sourced and the equations that use it, is documented in the **FeToolKit Technical Reference Manual (FTRM)**: the full data set is FTRM Table 6.1, and each material also has its own descriptive paragraph, referenced below.

Material	FTRM Table	FTRM Paragraph
Titanium (Ti-6Al-4V) — also Callaway's confirmed internal support alloy*	Table 6.1	¶6.1
Titanium T9S+ (real PING driver-face alloy)	Table 6.1	¶6.2
ATI 425 (Titleist GT/TSi face alloy)	Table 6.1	¶6.3
Ti-15-3 (Krank Golf beta titanium)	Table 6.1	¶6.4
Ti 8-1-1 (Cobra F8 face alloy)	Table 6.1	¶6.5
Maraging steel (C300)	Table 6.1	¶6.6
17-4PH stainless steel	Table 6.1	¶6.7
A286 iron-base superalloy	Table 6.1	¶6.8
15-5PH stainless (H1025)	Table 6.1	¶6.9
316 stainless steel	Table 6.1	¶6.10
Aluminum alloy (generic)	Table 6.1	¶6.11
2050-T84 aluminum-lithium	Table 6.1	¶6.12
2219-T851 aluminum	Table 6.1	¶6.13
Carbon composite (TaylorMade Qi10-style face)	Table 6.1	¶6.14
Metal matrix composite (hypothetical — no commercial driver uses one)	Table 6.1	¶6.15

Table 18. All 15 face materials by name, with their reference in the FTRM.

**Callaway's Paradym Ai Smoke drivers are publicly confirmed to use “Ti 6-4” for an internal chassis support structure, not a confirmed statement about the striking face's own alloy — see FTRM ¶6.1 for the full caveat.*

A note on the two named aerospace peening finishes. “Aerospace 1” and “Aerospace 2,” offered alongside LSP and conventional shot peening in Golf Club Face and Ball Impact and Golf Club Face Fracture Review, are specific finish methods used in the aerospace industry, proprietary to FeToolKit. Their full technical definition is documented in the FeToolKit Technical Reference Manual (FTRM), Section 126, and is not reproduced here.

