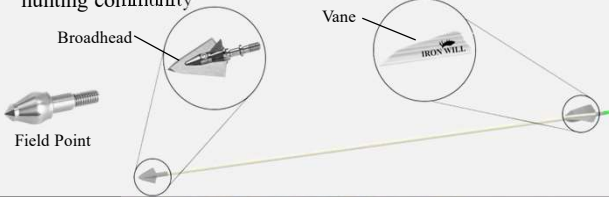


Background and Objective

- An arrow's vanes cause a moment during flight, creating lift when the arrow is at an angle to the airflow, rotating it back on track
- A broadhead is an arrow tip attachment used in hunting, it includes large and sharpened blades to increase target penetration
- These broadheads significantly alter airflow and an arrow's flight when compared to target field points
- Design, iterate, and test a new vane design to improve flight characteristics of broadhead-tipped arrows, marketed towards the hunting community



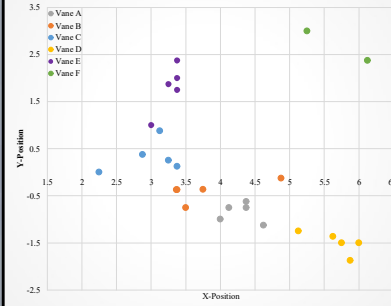
Requirements and Constraints

- Improve flight characteristics including accuracy, stability, drag, spin-up, and resistance to cross winds in that order over industry competitors
- Be validated at a range of 40 yards or more
- Meet the geometric and material dimensions that are industry standard
- Ensure large scale manufacturability

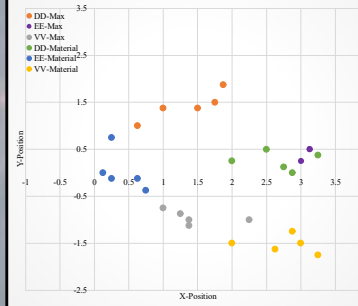
Results

VANE	SPREAD FP (in)	SPREAD BH (in)	FP TO BH DISTANCE (in)	VELOCITY (fps)	SOUND (dB) (over background)
EE-O M	0.901	2.30	1.40	269.9	42.4
EE MAX M	1.42	1.64	0.218	268.5	43.2
VANE A	1.07	1.67	0.600	269.6	46.0

Industry Vane Broadhead Benchmarking



Prototype Vane Broadhead Testing

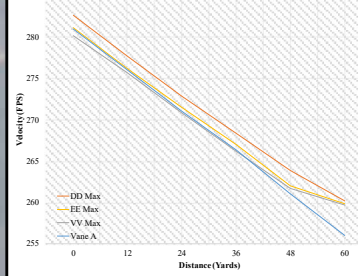


True to Size Broadhead Spreads



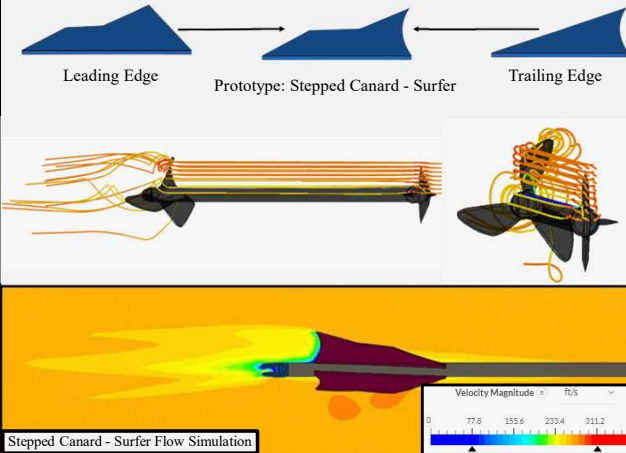
VV-Material
.38" x 1.25"
EE-Material
.63" x .88"
DD-Material
.5" x 1.25"

Prototype and Industry Vane Velocity



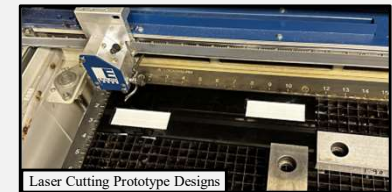
Utilizing Computer Simulation (CFD)

- Utilized SimScale software to refine vane design, integrated findings with experimental data for optimal vane selection
- Confirmed which design attributes have discernible impacts on diverse client specifications
- Optimized the simulation setup and analyzed CFD data for Velocity, Drag, Restoring Torque, and Spin-Up



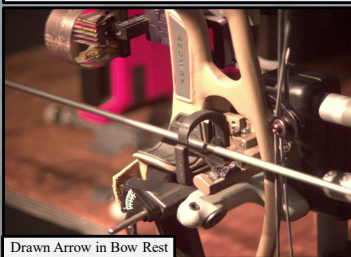
Manufacturing

- All vanes were exported from their CAD models used for CFD simulations and laser cut to their exact dimensions
- A Bitzenburger jig was used to attach the vanes onto the bare shafts, ensuring a constant fletching angle and spacing between the vanes



Testing Methodology

- Creation of Safety and Test Procedure
- Verify and validate the consistency of the shooting machine
- Benchmark leading industry vane designs
- Used 10 leading profiles and 21 trailing edge designs in a matrix to assess the performance of each alone and combined
- Create initial prototypes and narrow down designs through iterative empirical testing and CFD
- Final Optimization stage to incorporate small design iterations



Drawn Arrow in Bow Rest

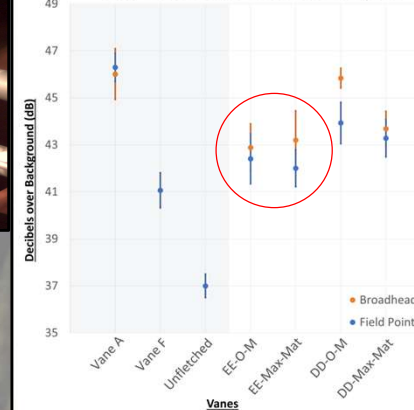


3 Prototype Vanes



Chronos 1.4 High Speed Camera

Arrow Vane Sound Levels- Difference From Background



Lessons Learned and Challenges

- Logistical challenges to satisfy testing requirements can often be as difficult as technical challenges
- Borrowed equipment may be broken or unavailable, including the highspeed camera we planned on using and the bow itself
- Ensuring the repeatability of your equipment and setup for accurate testing can take multiple testing sessions to properly validate