Rewarding the Pull: Plotting Ultimate Frisbee Pull Outcomes in Phase Space

TRINITY UNIVERSITY

Hugh Coleman, James Crosnoe

Rationale

In its young history as a sport, Ultimate Frisbee has grown in popularity in the past two decades. Participation in sanctioned club ultimate bounced from ~20,000 registered members in 2003 to ~61,000 registered members in 2019 (USAU, 2024). This burst in popularity has emerged in tandem with a competitive surge in the sport. What began as a high school passion project in the late 1960s has converted into a sport that barely missed an olympic berth for Paris 2024 (Eisenhood, 2019). Ultimate Frisbee is also a physically intensive sport with “high cardiovascular loading, and clear indications of fatigue” at the end of each game (Krustrup & Mohr 2015). In this fast-growing competitive sport, High School, College, Club, Professional, and National teams are looking for any edge they can get over their opponents.

To obtain this advantage, high-level defenses exploit ‘the pull’ or the kickoff that starts each point. The pull is perhaps the “most strategically important” plays in a game of Ultimate, and can provide a defensive advantage by trapping an opposing team in their endzone (Westerfield, 2018). One unique method for experimenting with pull outcomes involves the use of Phase Space. The Phase Space of a system offers a neat visualization of “all possible physical outcomes” as influenced by a set of specific parameters (2001). Phase Spaces have already been put to use in visualizing outcomes for changing trajectories in the release of a disc. According to Crowther & Potts’ simulation plotting flight distance against angle of release predicts that launch angles of 10° and 20° maximize flight range and duration respectively, while an initial roll angle of 6° returns the tightest flight path (2007). These results offer a helpful baseline for players looking to increase distance. However, the pull parameters involved could be manipulated further, with respect to a specific defensive point-of-attack in the opponent’s end zone.

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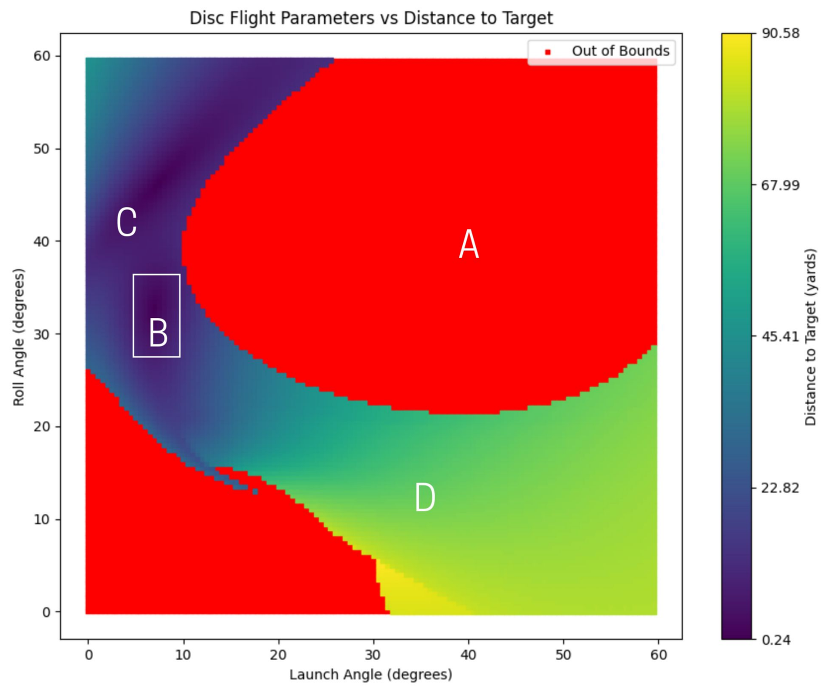
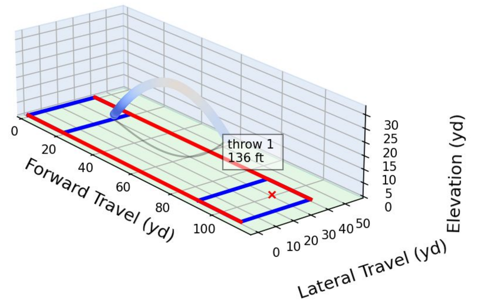
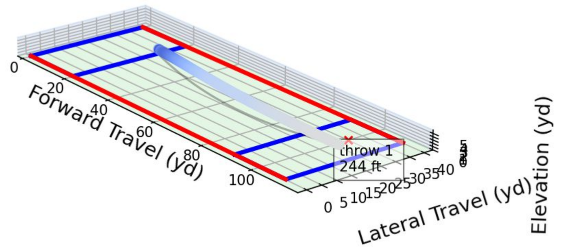
Findings

From these results we generated a phase space diagram. A red mark represents that the disc was out of bounds, resulting in a brick. The rest are a gradient, from 90 yards away from the target to 0.24 yards away.

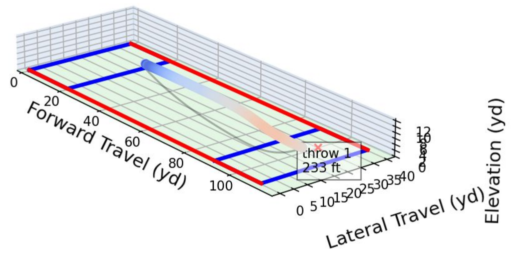




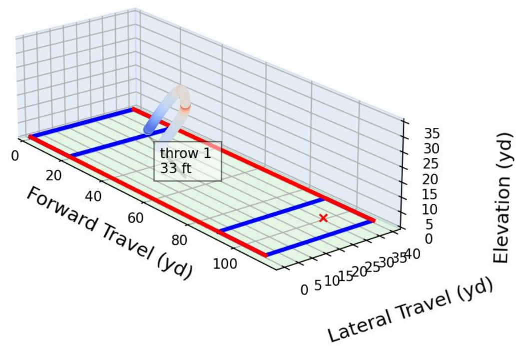
(A) 40° launch, 40° roll



(B) 7° launch, 30° roll



(C) 4° launch, 42.5° roll



(D) 35.5° launch, 14.5° roll

Our phase space graph has several markings. The box represents the optimal throwing parameters for a pull landing closest to the target location. The box is bounded by launch angle between 4.5° and 9.5°, and roll angles between 27.5° and 36.5°. If the thrower can throw within these bounds, their pull will land within approximately 10 yards of the target.

Figure A depicts a pull that goes out of bounds. Figure B denotes a successful pull, landing ~1 yard from the target. Figure C also depicts a successful pull, landing ~3 yards from the target. Figure D is a pull that while inbounds, lands ~68 yards from the target.

Limitations

An inherent limitation of simulating roll angle and launch angle is the ability for a human being to accurately replicate these parameters. Although the program can accurately produce these parameters to a hundred-trillionth of a degree, this accuracy is by no means actionable for a player. By creating broader targets of interest in our phase space diagrams, we’ve been able to acknowledge and work around this limitation.

A second set of limitations attached to this methodology is that the simulation assumes perfect flight physics on every iteration. Firstly, the simulation does not account for any amount of wobble throughout the disc’s flight. Every human-made throw contains some level of wobble, as human throwers cannot perfectly align the the spin force they apply with the orientation of the disc (Heywood, 2014). Wobble increases drag, which goes unaccounted for in simulated throws. Secondly, the simulation does not include any spin degradation over the duration of the pull. In a non-simulated throw, wind resistance applies friction to the disc, which slows the disc’s spin rate as it travels. The absence of wobble and spin degradation in simulated throws oversimplifies the pull process, and could generate overconfident results against constant flight parameters.

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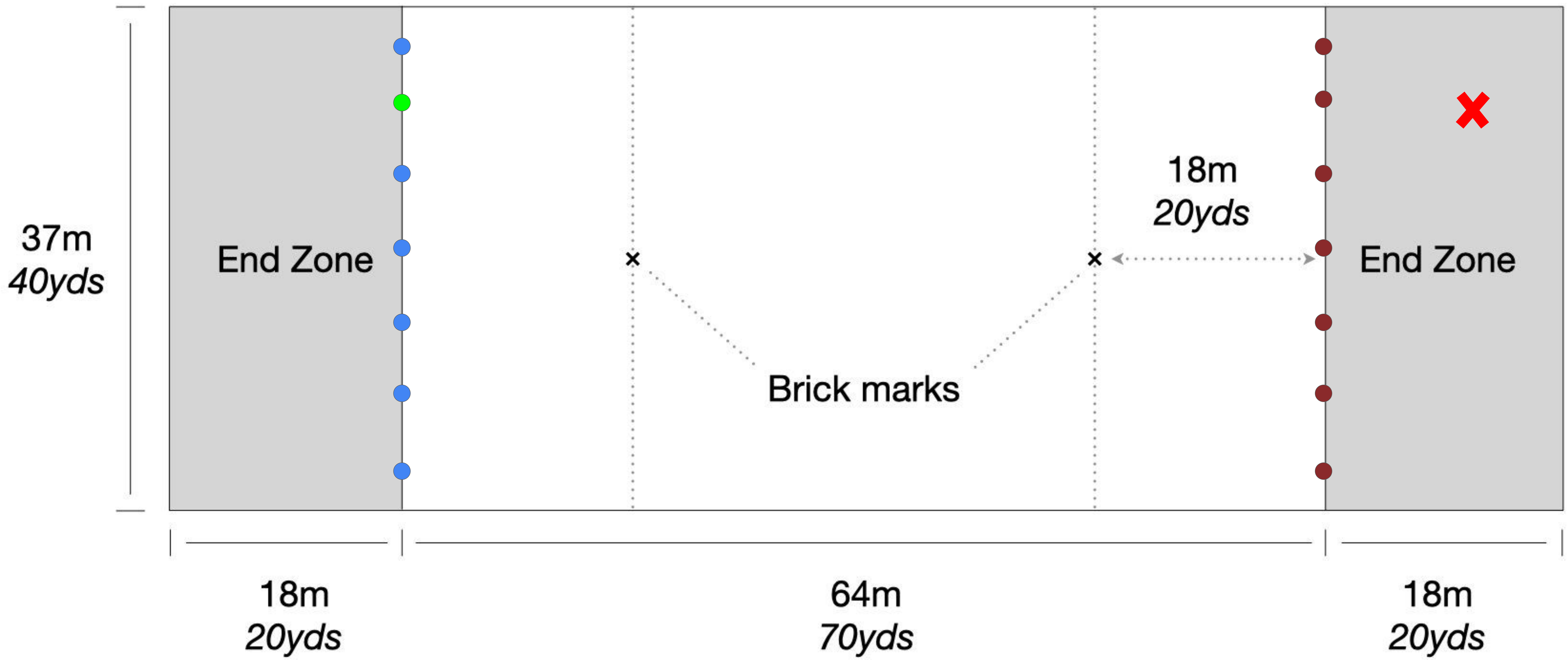
Ultimate Frisbee Field Dimensions



THE SPORTS EDU.

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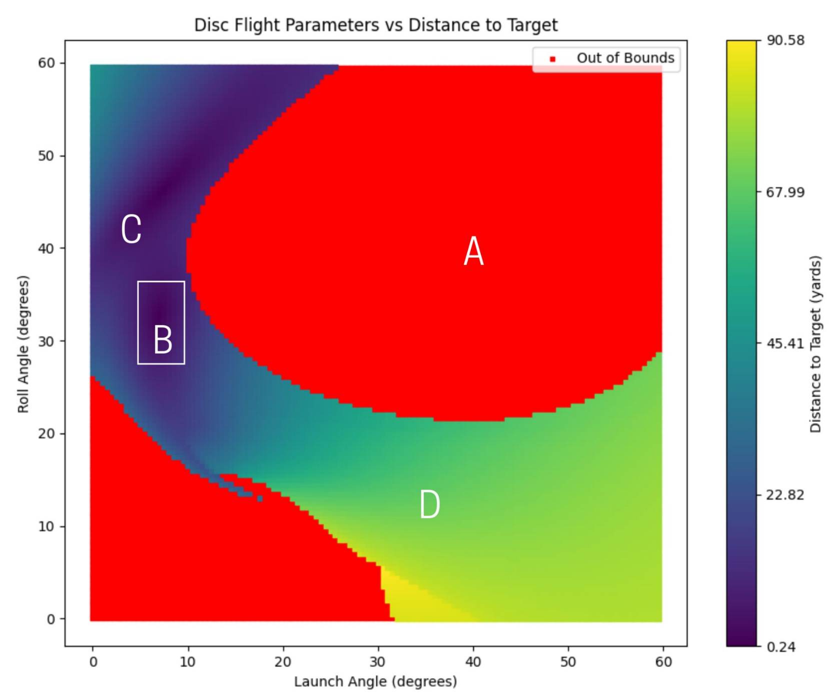

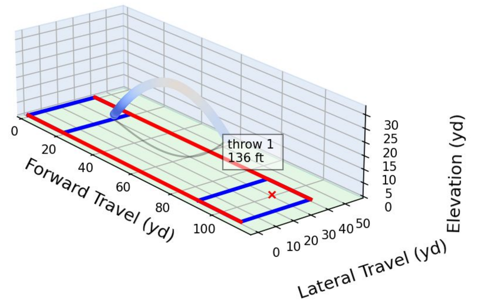

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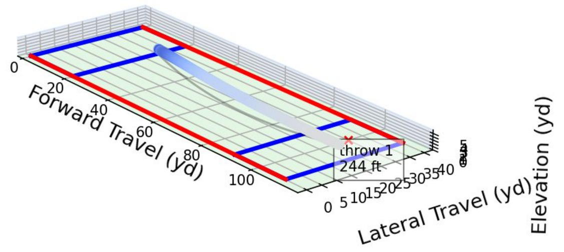

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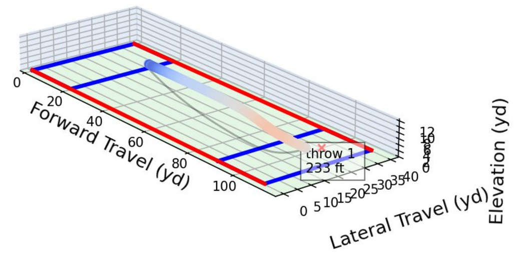

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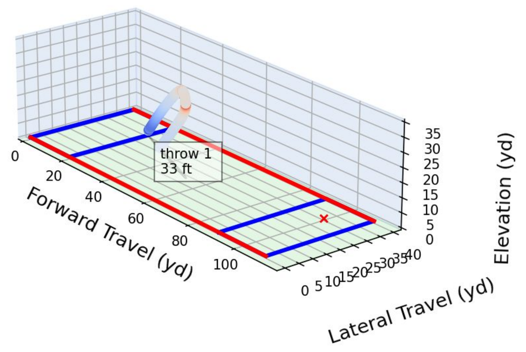

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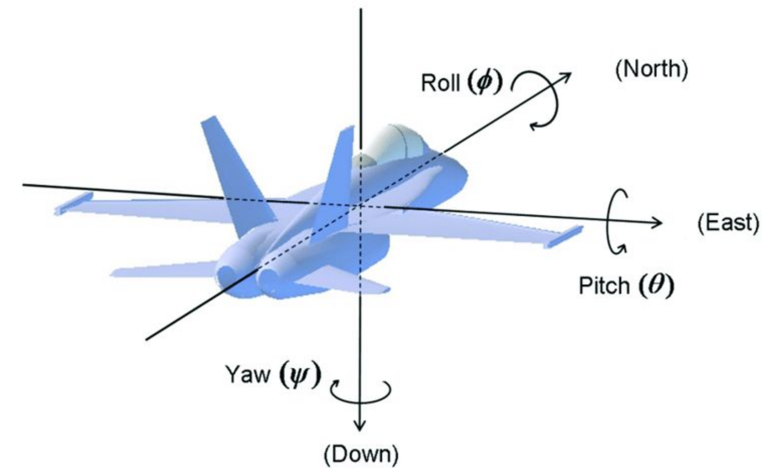
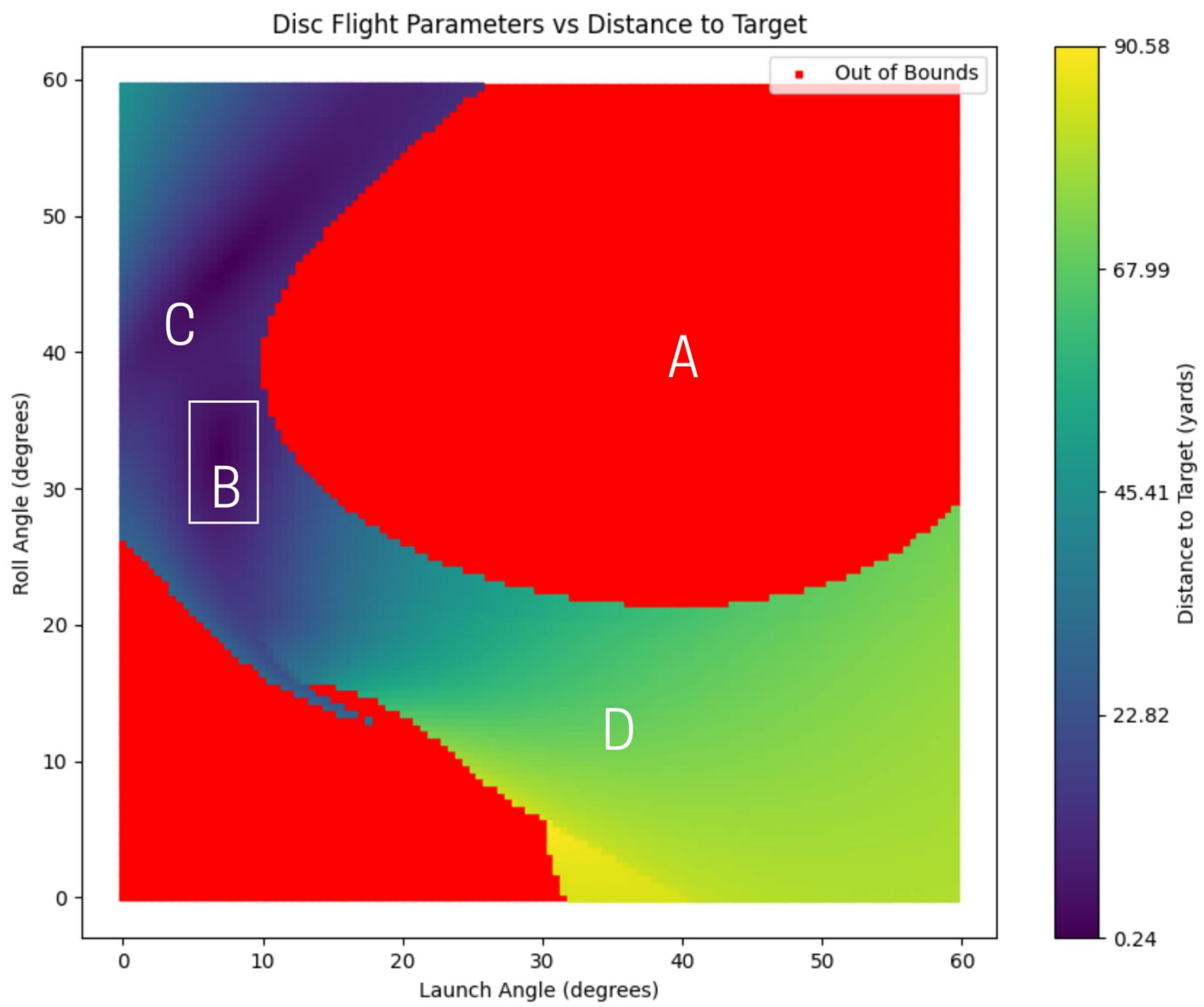
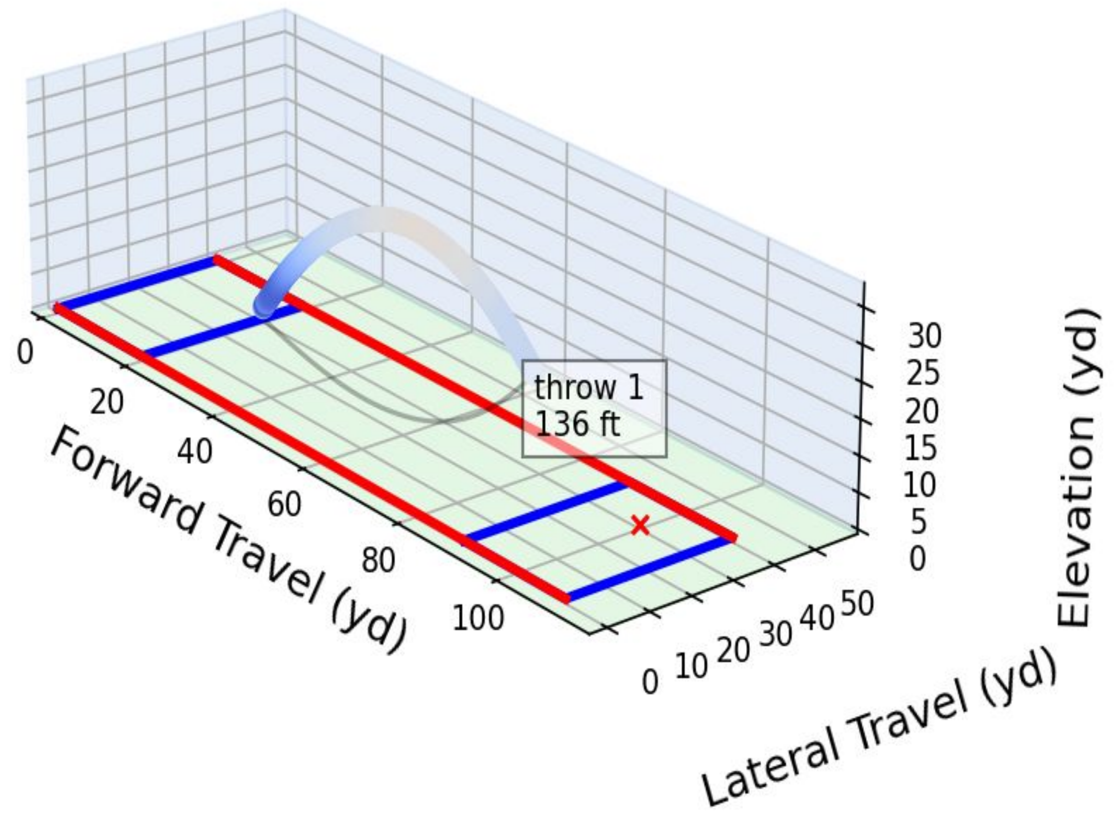
Supplemental Images







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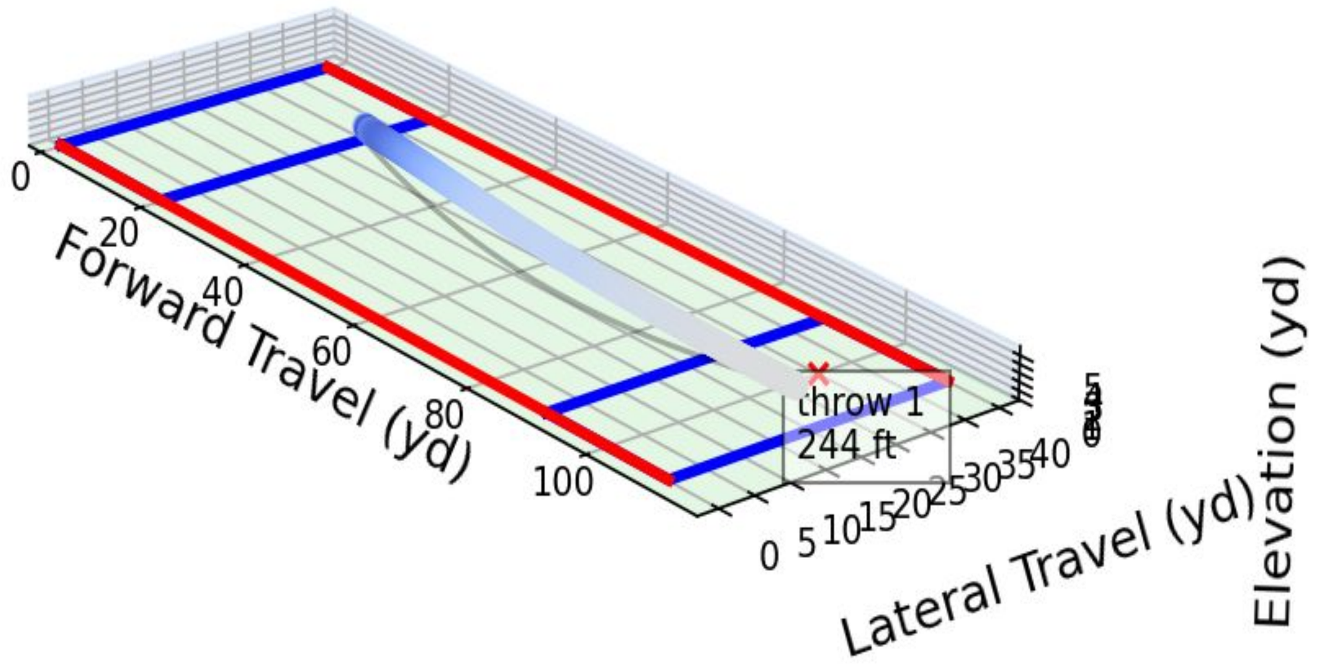

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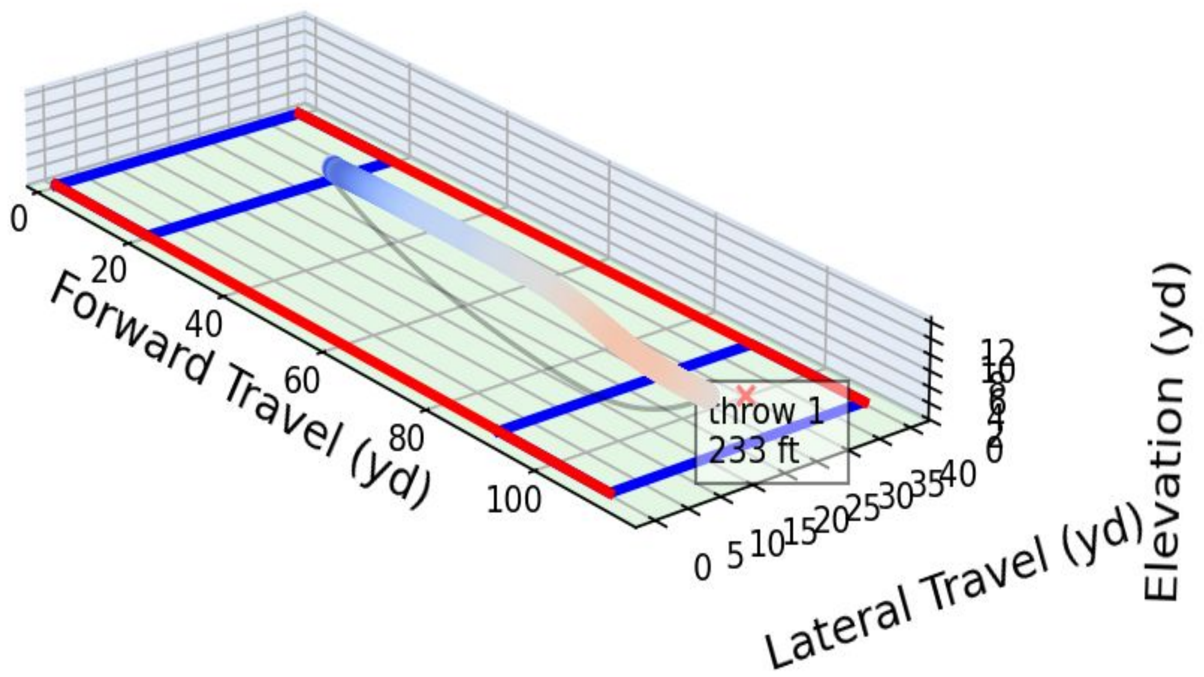

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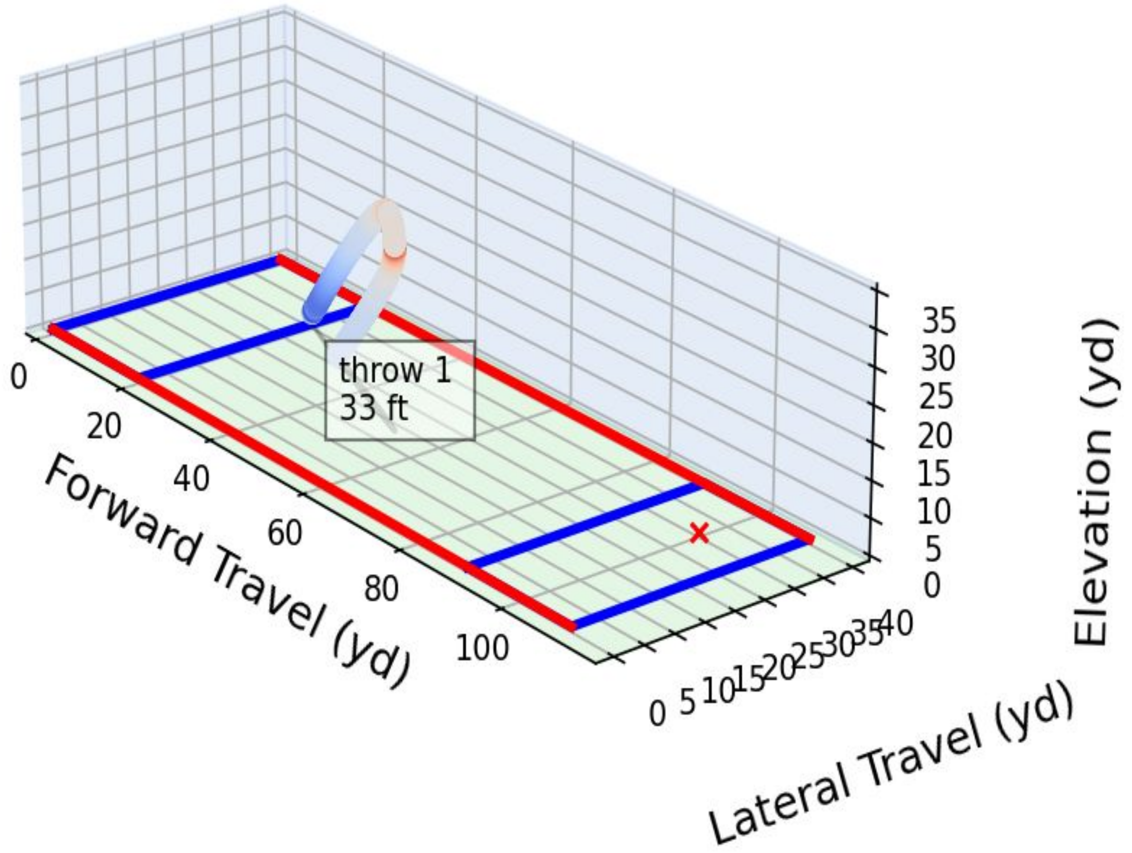

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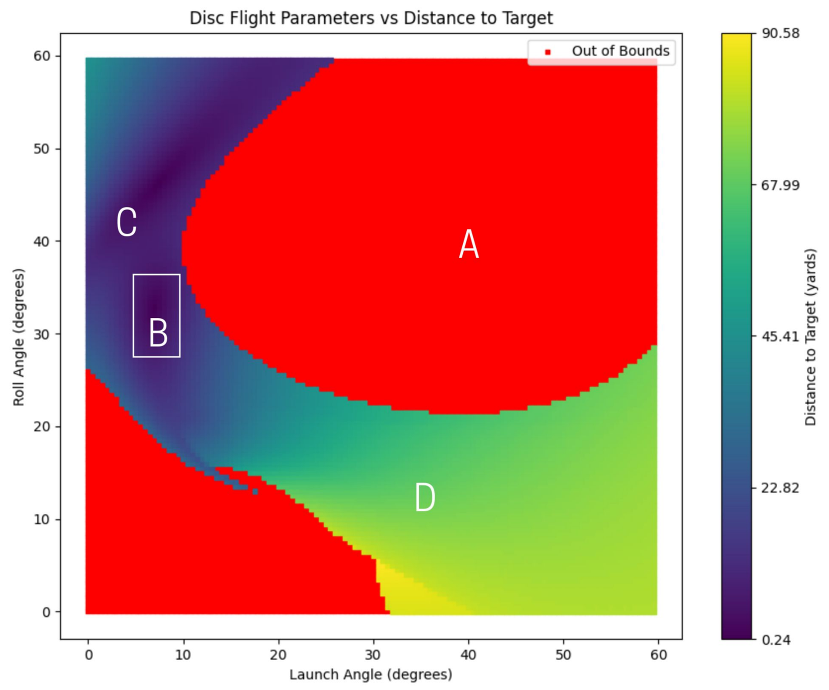

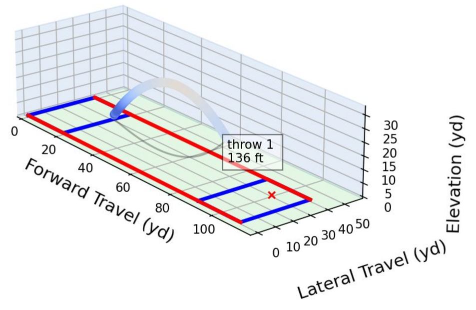

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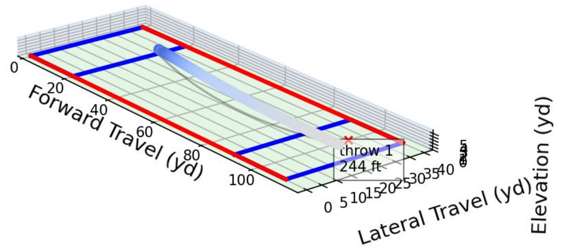

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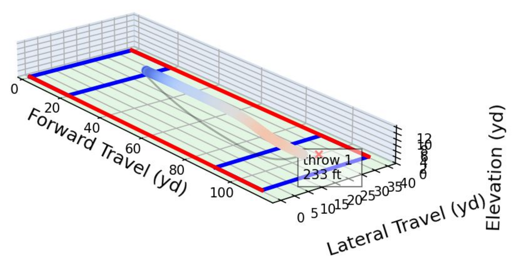

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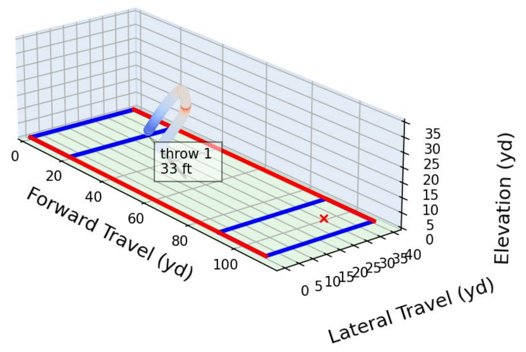

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Hugh's Images (OLD)

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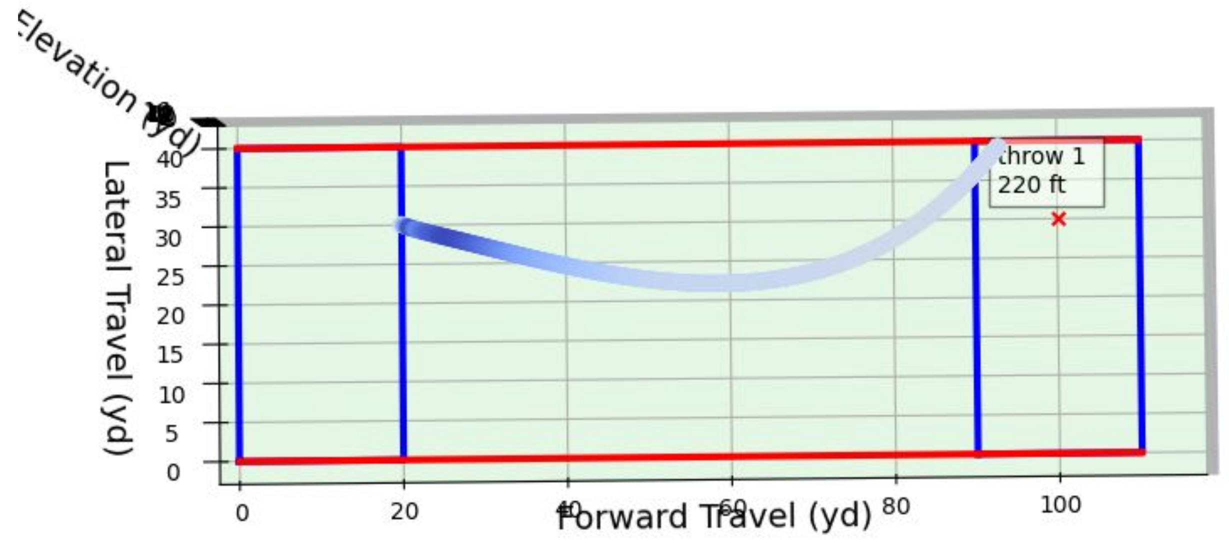

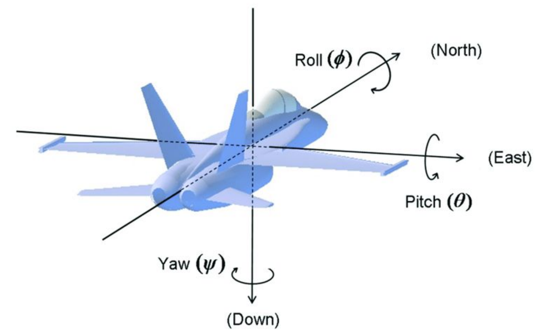

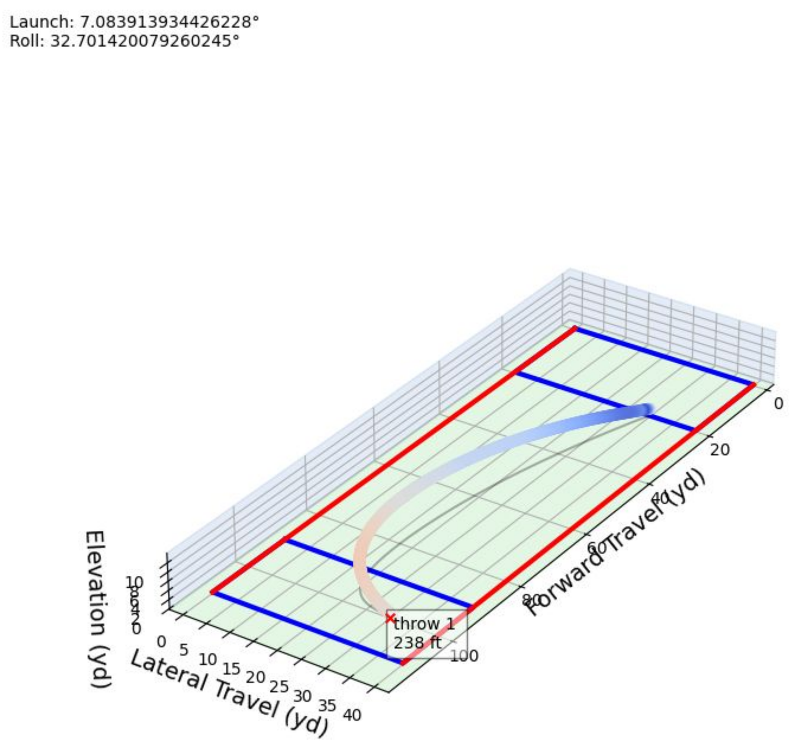

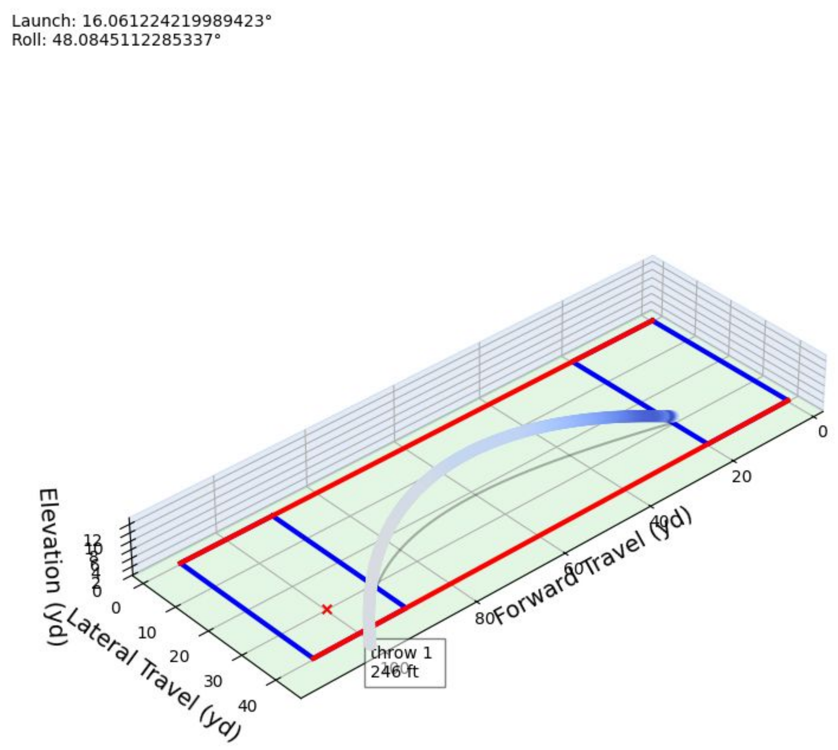

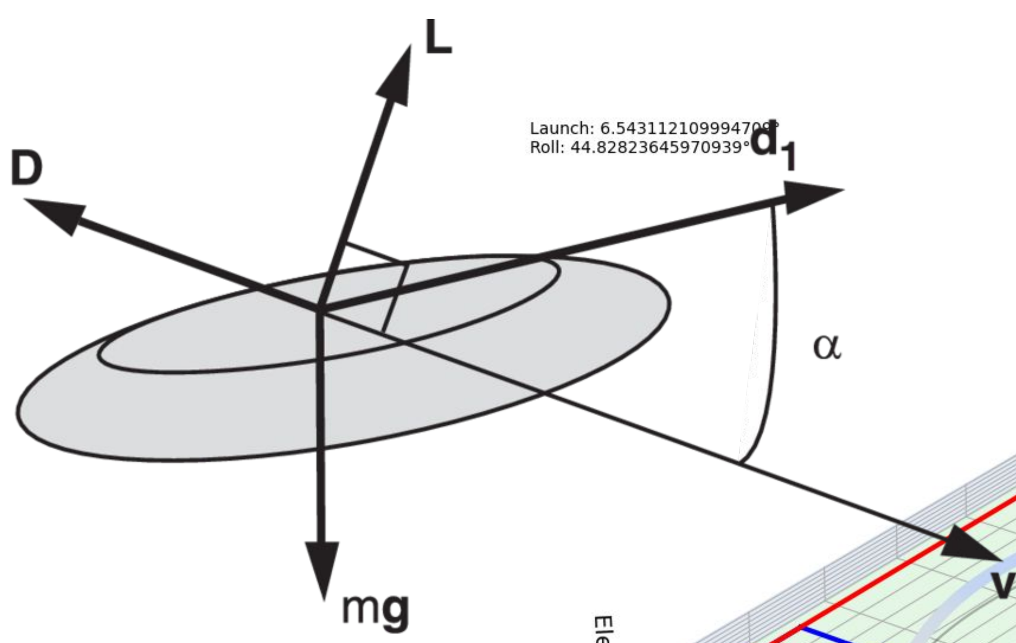

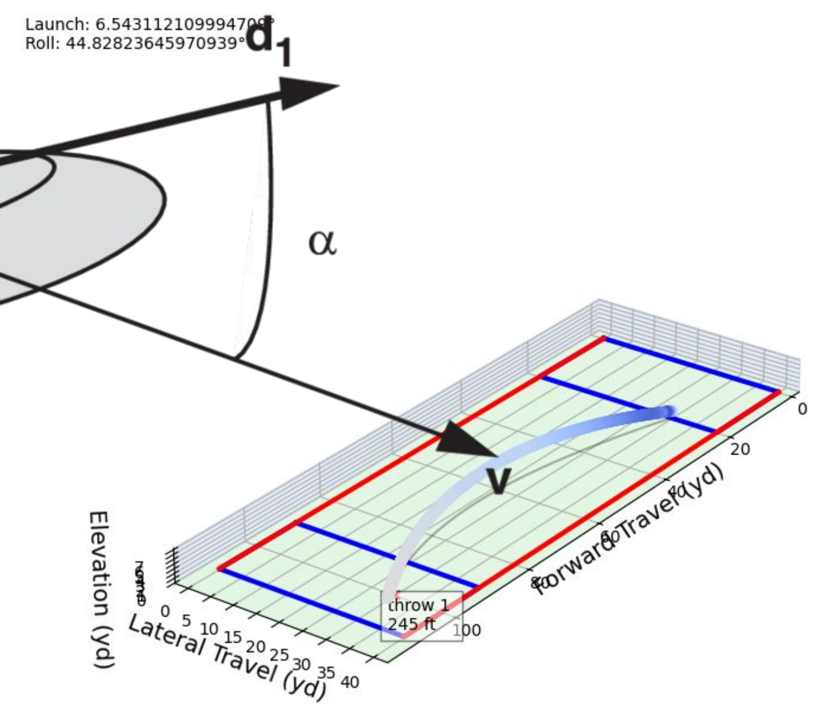

Analysis/Findings

have chart w/ box

have row of sub images of pulls

under all of the images

talk about the best ranges

drew box

dot in red means out of bounds

"target"