



U.S. Army Research, Development and Engineering Command

## Preliminary Testing of a 2-Fin Flechette



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

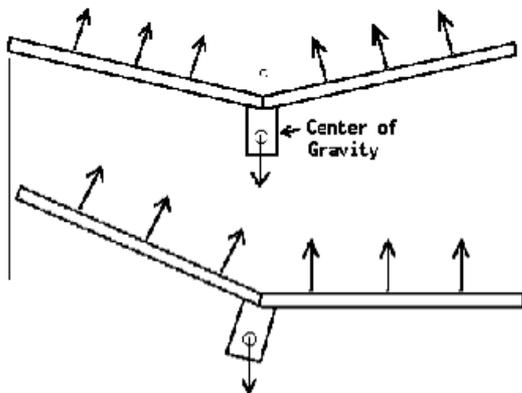
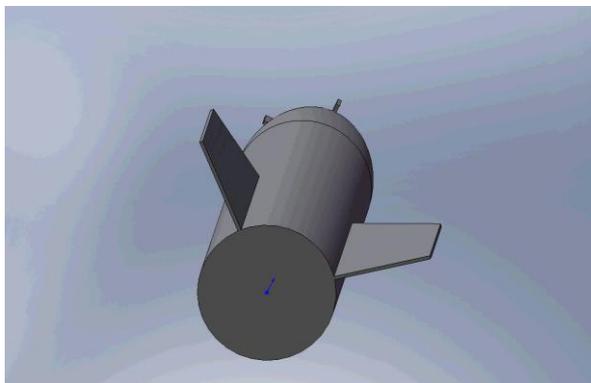
**Ilmars Celmins & Greg Oberlin**

**U.S. Army Research Laboratory, Flight Sciences Branch**

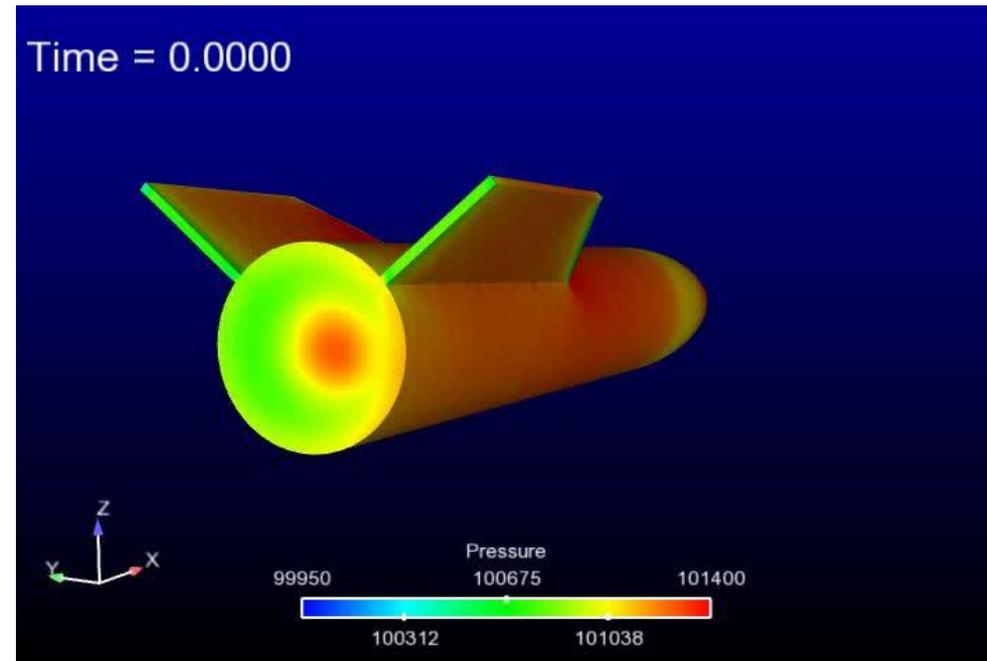
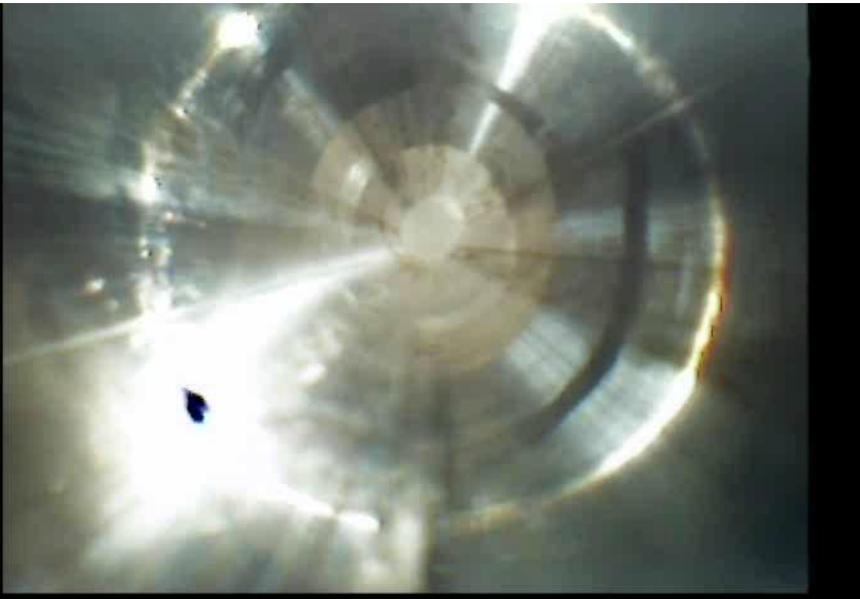
**26<sup>th</sup> International Symposium on Ballistics – September 2011**

- Background
  - V-Tail Flight Dynamics
  - Flechettes
  
- Testing
  - Spark Range Tests
  - Radar Tests
  
- Summary/Conclusions

- 2-Fin V-Tail projectiles are being investigated for guided munition applications
- Exploring feasibility of a roll-stable flight configuration (paper airplane concept)



- Preliminary research showed a tendency to settle into a stable coning motion
- Did not meet program objectives but potentially useful for other applications



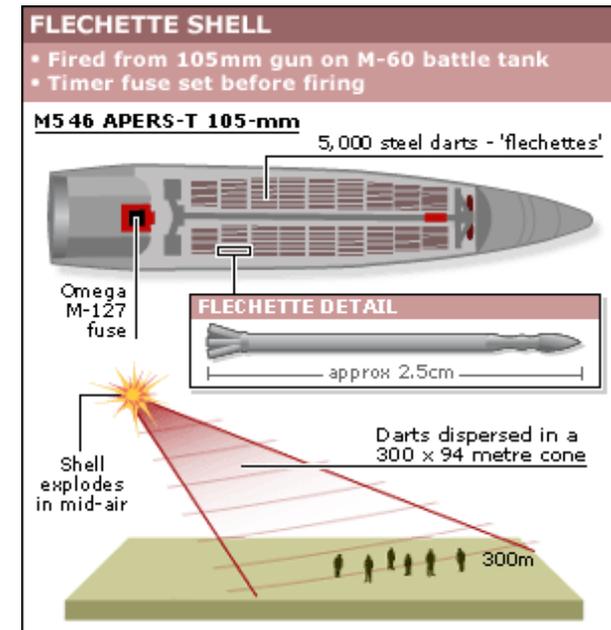
- Typically dispensed in large quantities from a cargo round
- Cloud of flechettes expected to disperse over target area
- Each flechette is a fin-stabilized long rod penetrator capable of penetrating light armor



<http://twistedscottishbastard.blogspot.com>

## Flechette requirements

- Aeroballistic requirements:
  - Fly in a nose first orientation
  - Minimal drag
  - Relatively low yaw at impact
  - No accuracy requirement for individual flechettes
- Other requirements:
  - Producibility
  - Dense packing



<http://news.bbc.co.uk>

- Producibility is very important
- Typically fabricated on automatic nail making machine modified to form fins instead of the nail head
- Produced in large quantities with loose tolerances



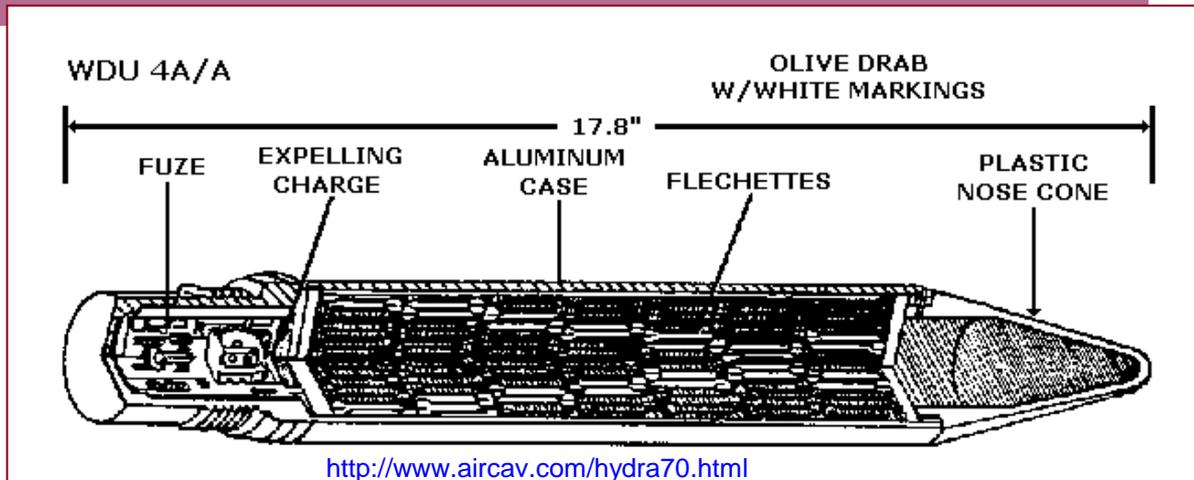
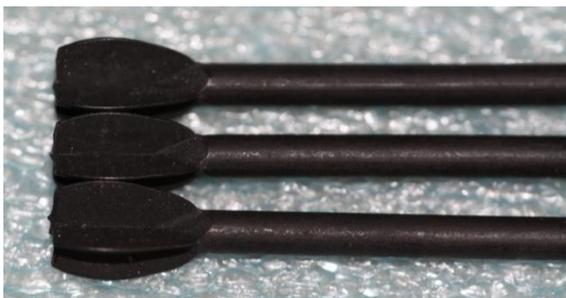
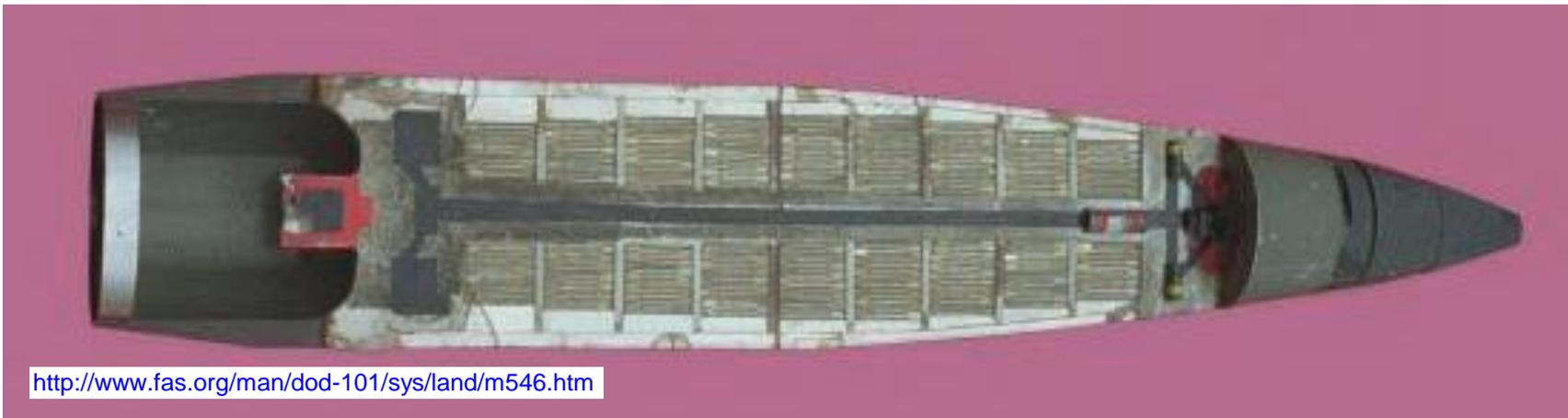
[http://www.wvguns.com/products\\_surplus.htm](http://www.wvguns.com/products_surplus.htm)



<http://www.auctionarms.com>



- Standard 4-Fin flechette configuration is a hindrance to dense packing due to fin interference



## Flechette requirements

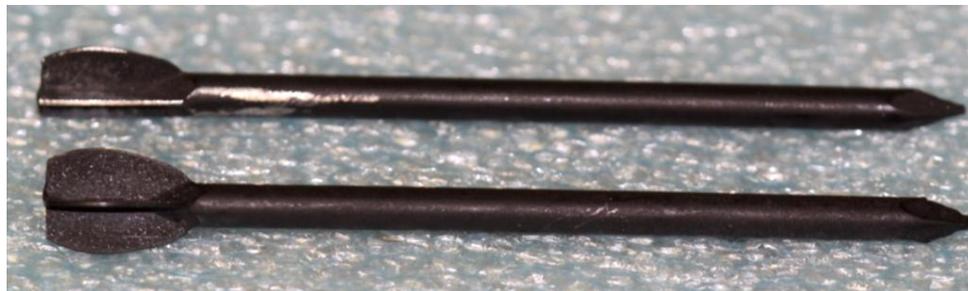
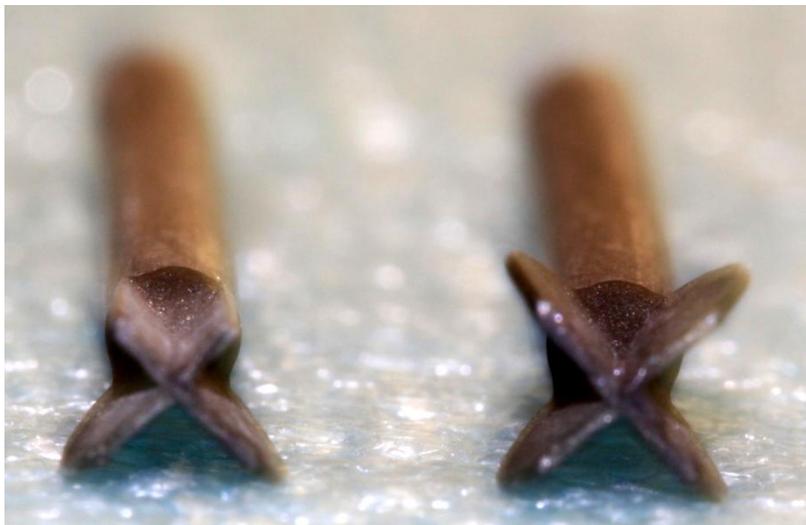
- Aeroballistic requirements:
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## 2-Fin V-Tail flechette configuration

- Improved packing (can stack projectiles without fin interference)
- Producibility similar to 4-Fin
- Aeroballistic performance unknown

- Preliminary testing of 2-fin flechette was conducted in the ARL Aerodynamics Experimental Facility (AEF)
- Shots were added to a 4-Fin flechette test program
- 2-Fin flechettes were made by grinding off two adjacent fins from the baseline 4-Fin flechette, leaving a V-tail configuration
- Goal was to have a direct aeroballistic comparison of 2-Fin vs. 4-Fin



39 direct image orthogonal shadowgraph stations in 5 groups

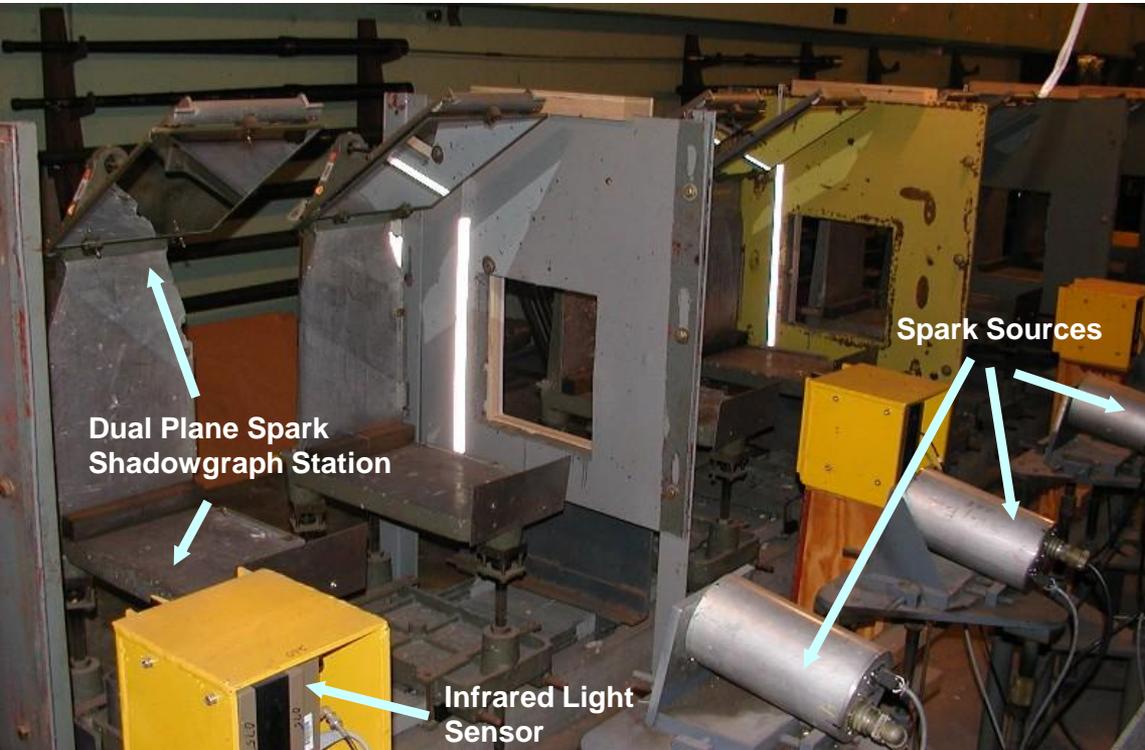
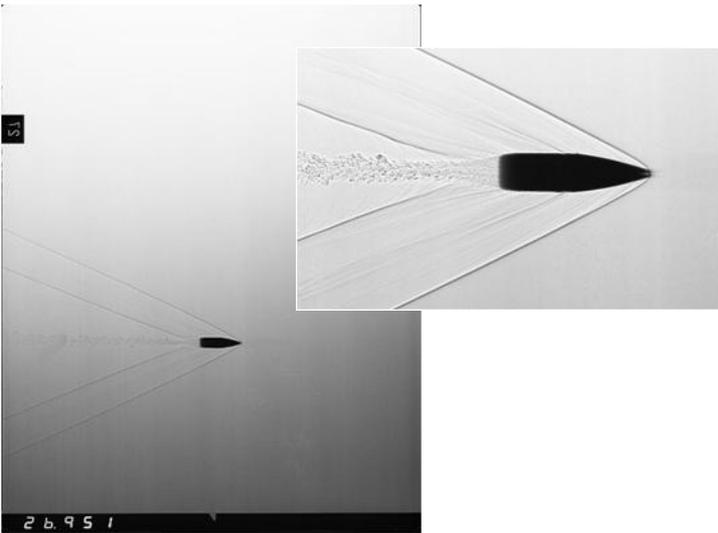


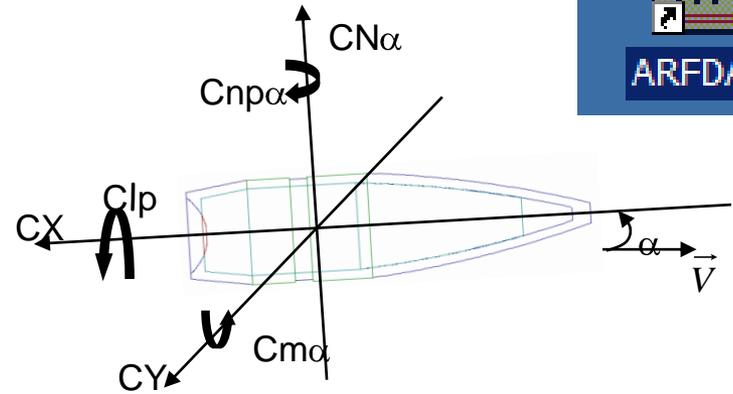
Image window is less than 14 inches across

Spark source triggered at a recorded time after infrared sensor detects passing projectile

Each station surveyed into a fiducial system that is simultaneously imaged on the film with the projectile



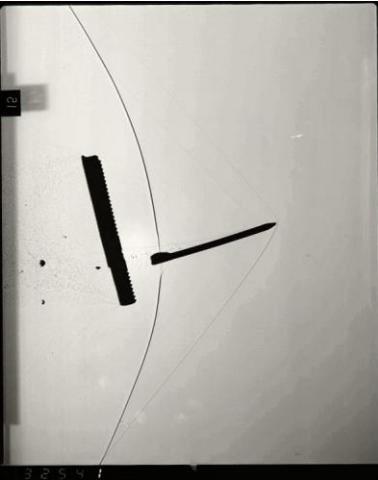
Aero Range Facility Data Analysis Software – ArrowTech Associates



Film is read using a precision light table to determine spatial coordinates and angular orientation of the projectile



Data is reduced for a 6-DOF fit in order to obtain an aerodynamic model and motion fit



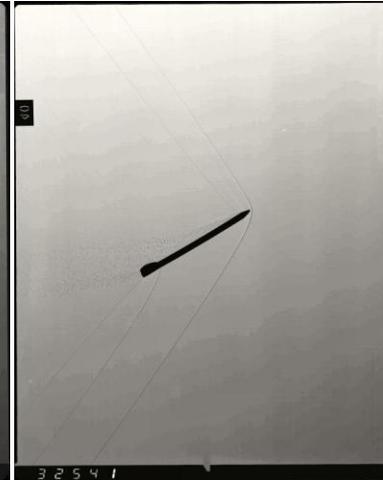
15V



20V



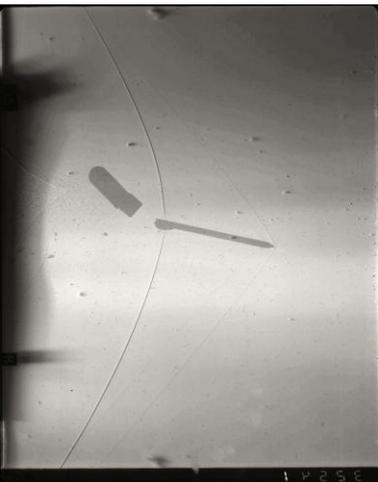
25V



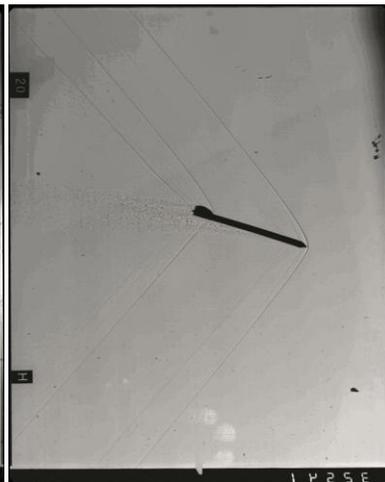
40V



45V



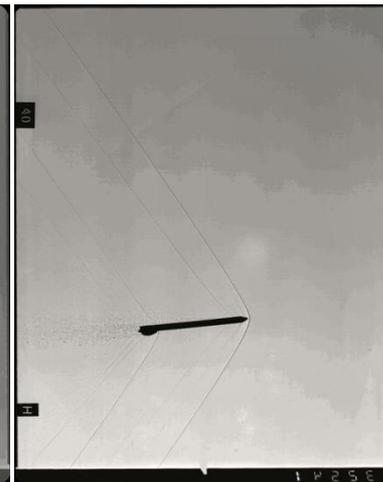
15H



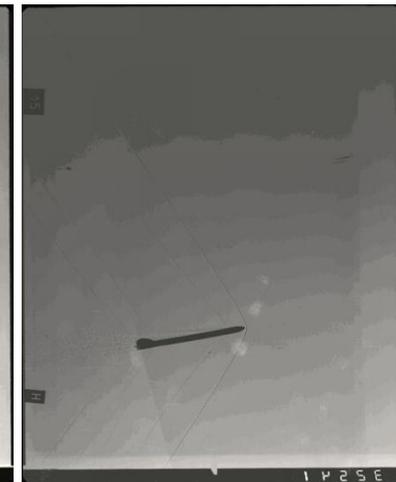
20H



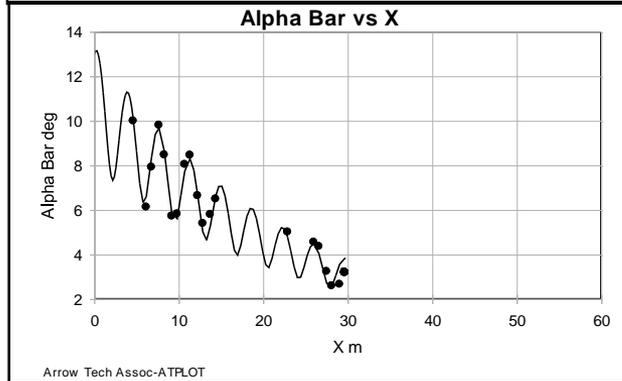
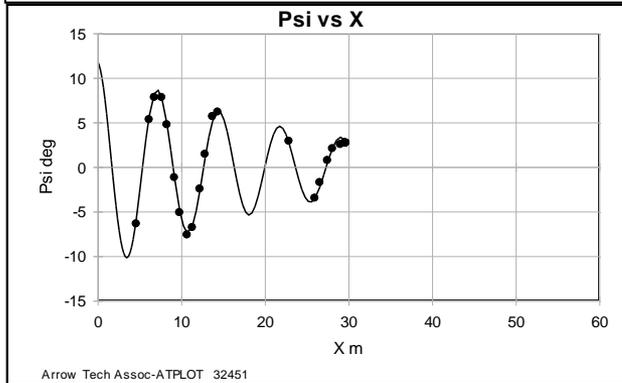
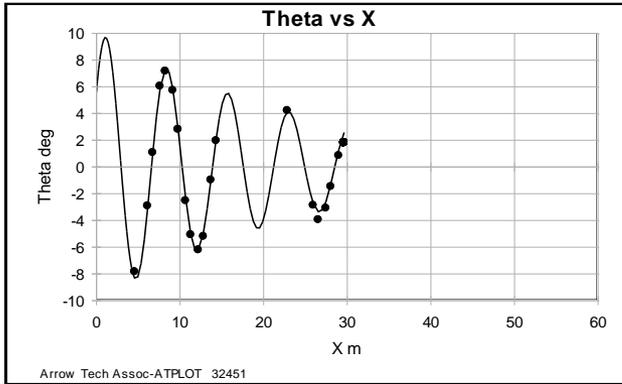
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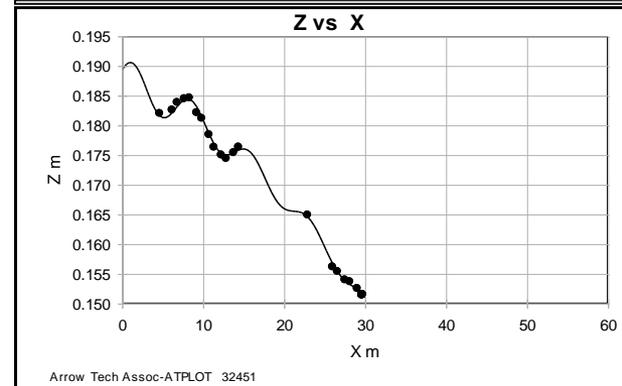
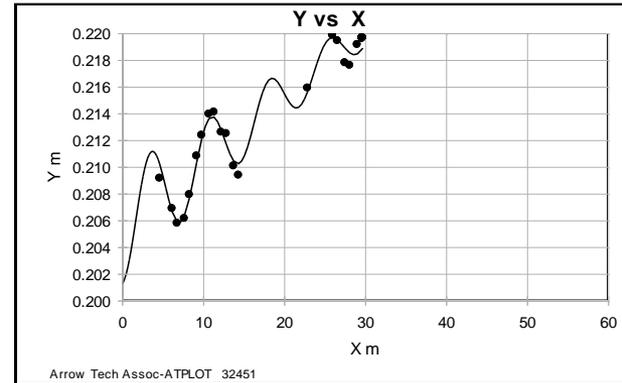
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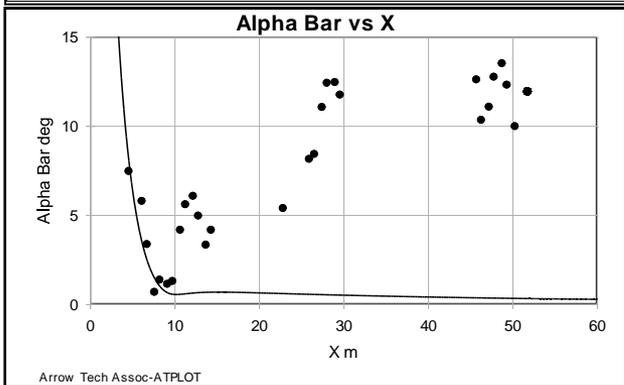
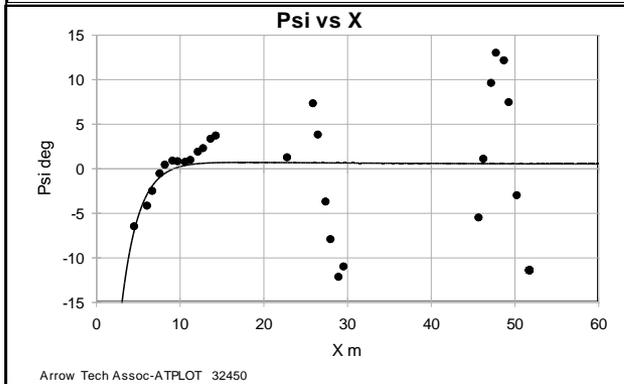
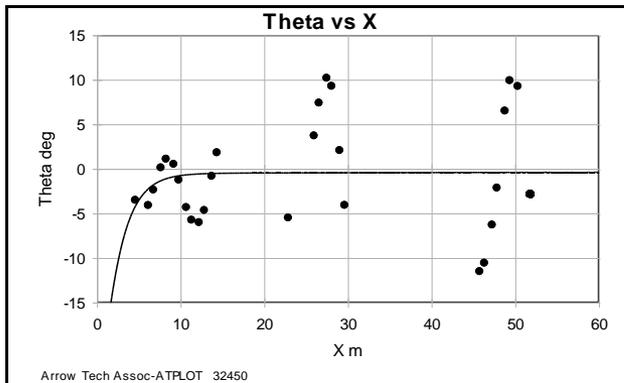


45H

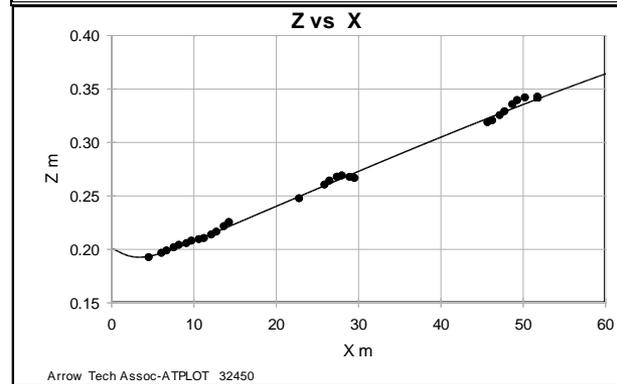
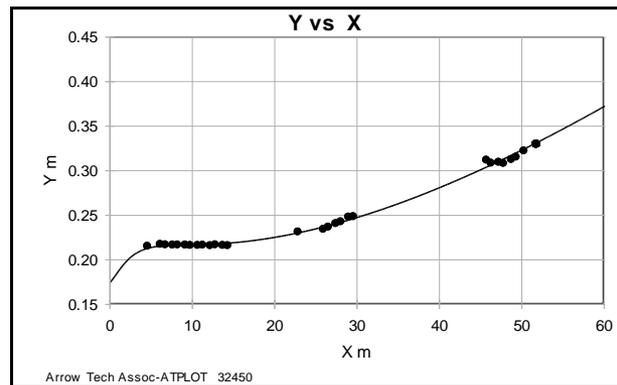


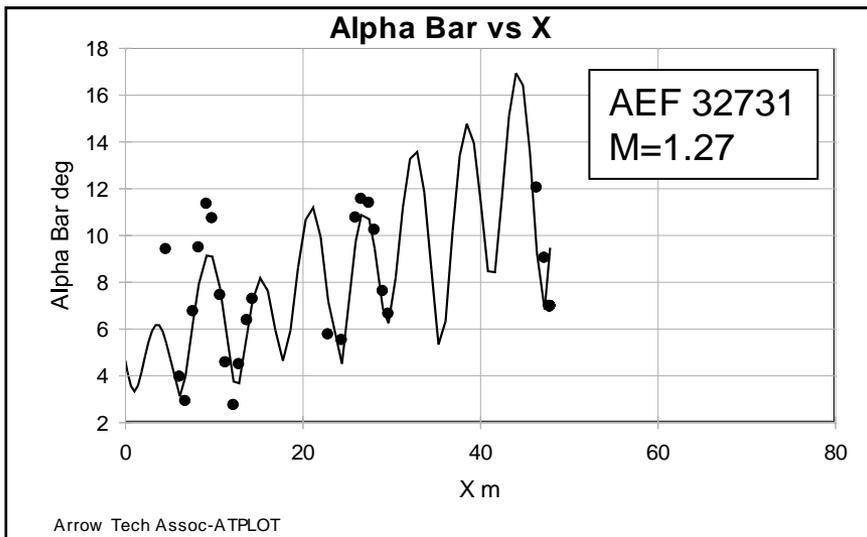
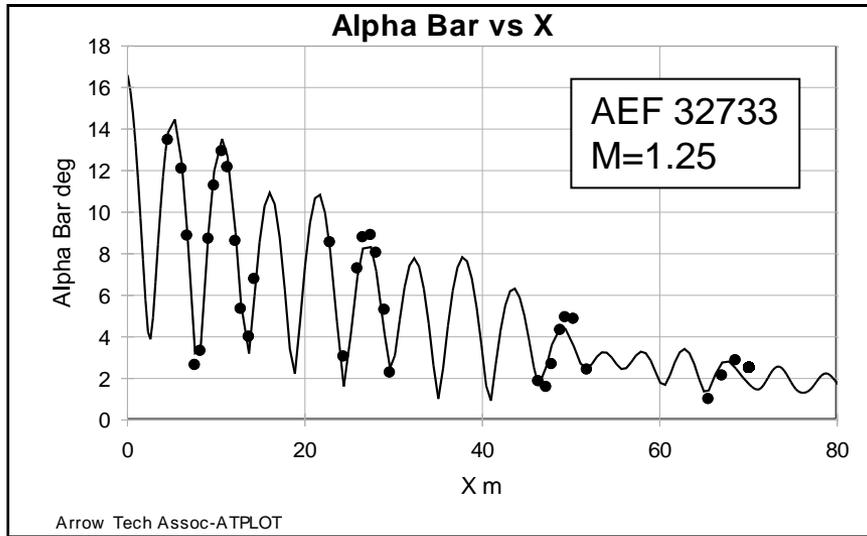
Some rounds were well behaved





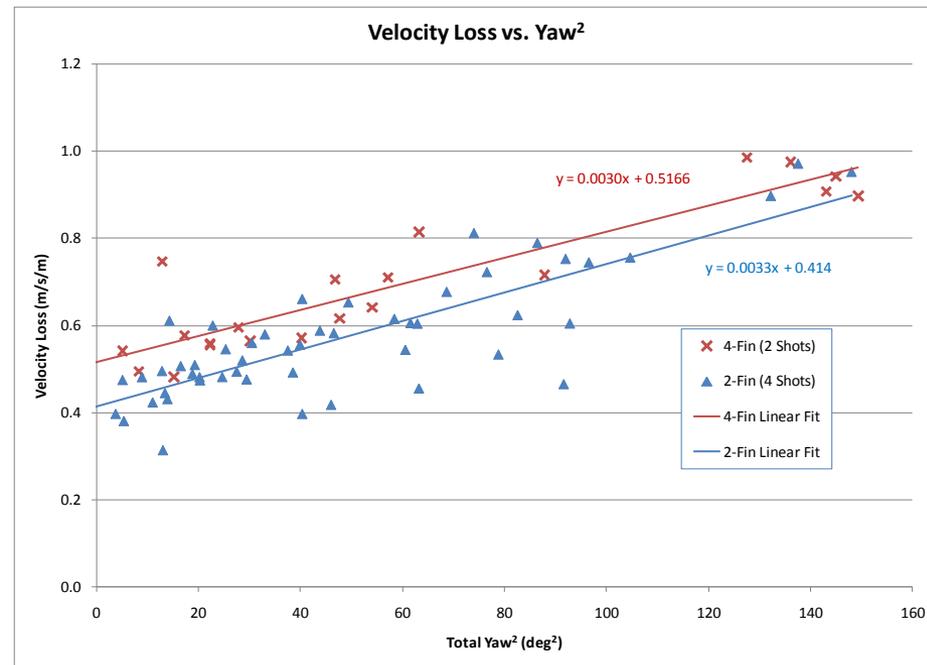
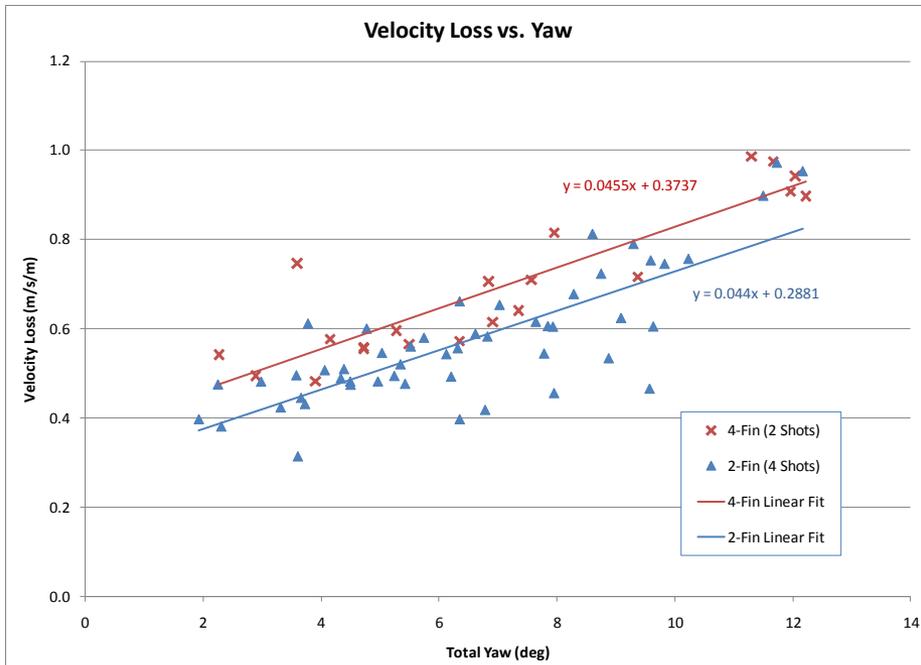
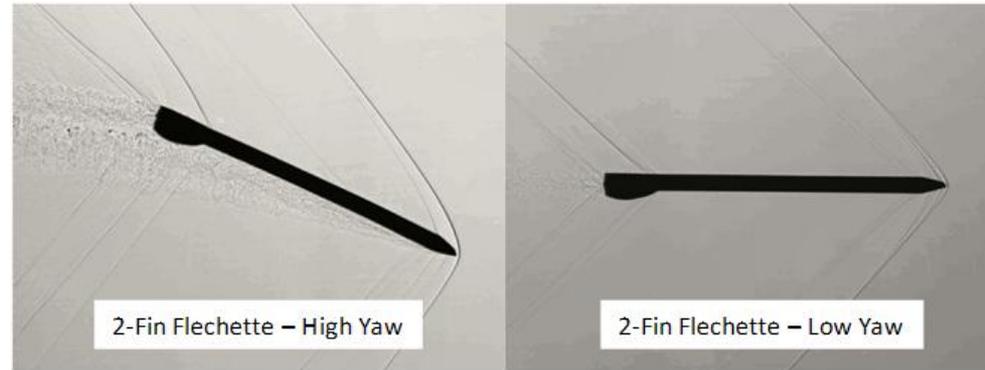
Some rounds behaved strangely



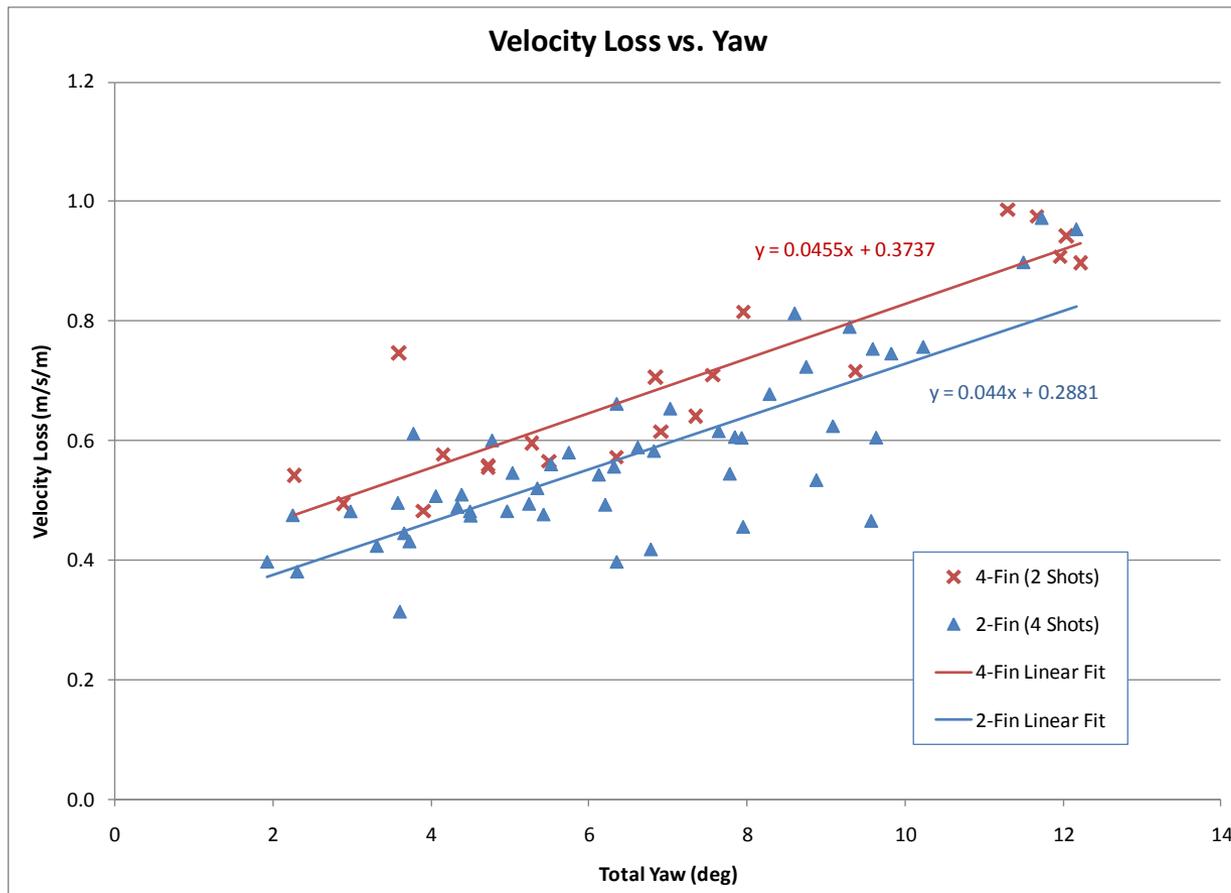


- 2-Fin V-Tail flechettes exhibited similarly inconsistent behavior
- Did not have enough “good” shots to perform standard data analysis
- Desire was to obtain drag comparison
- Difficult due to large yaw variation along trajectory
- A non-traditional approach was used to compare performance

- Evaluated correlation of velocity loss with total yaw
- Velocity loss is fairly independent of velocity

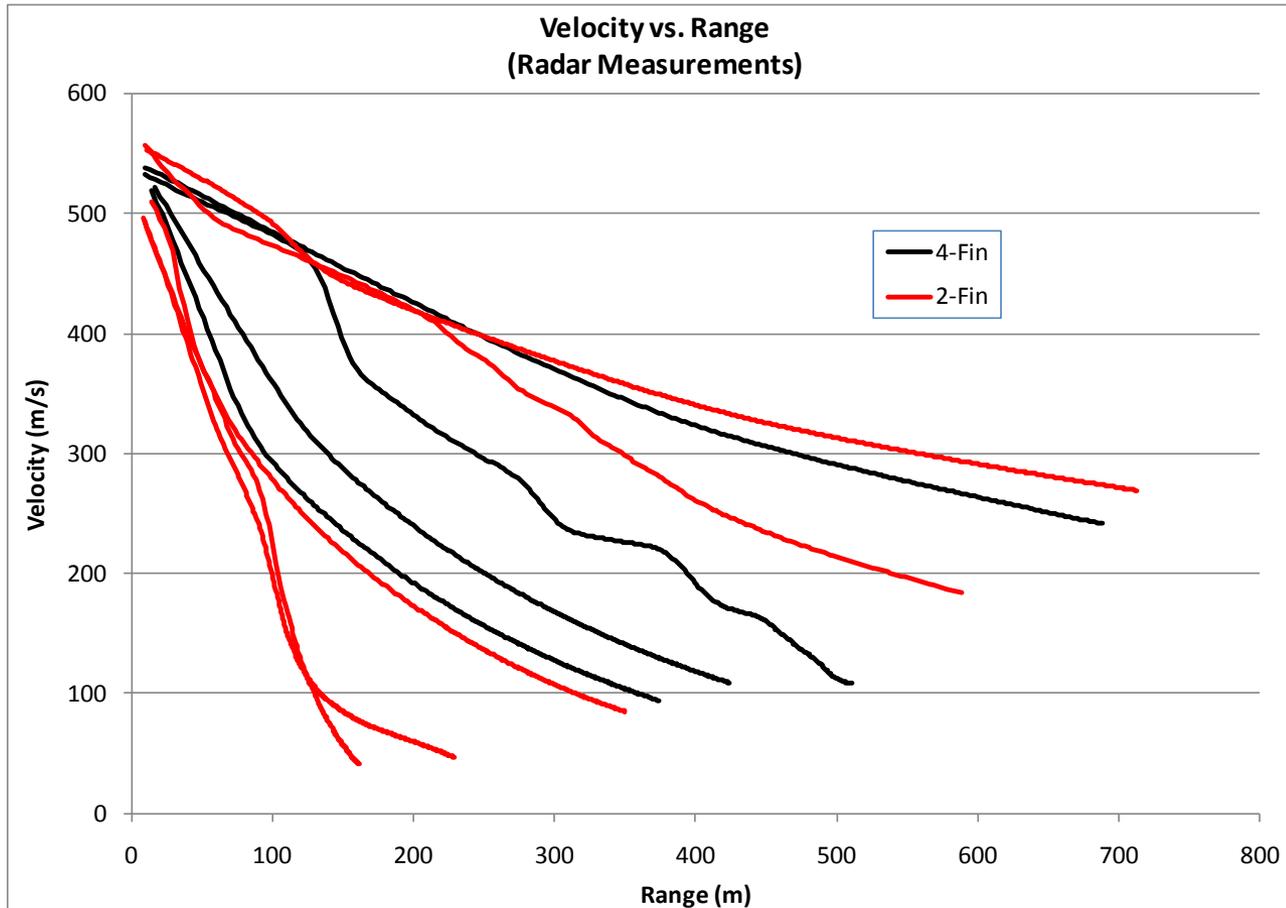


- Data quality leaves much to be desired, but does show trends
- Still need to know downrange yaw levels
- 2-Fin has lower drag if yaw not more than 2 deg. larger than 4-Fin yaw

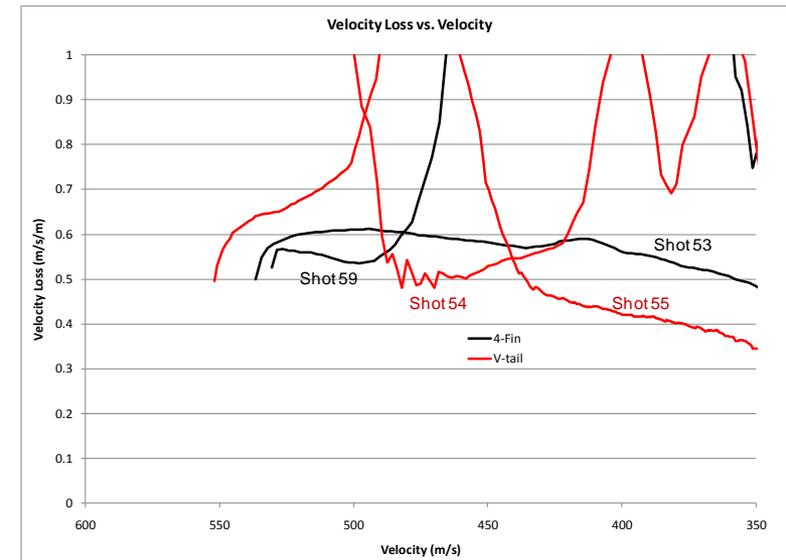
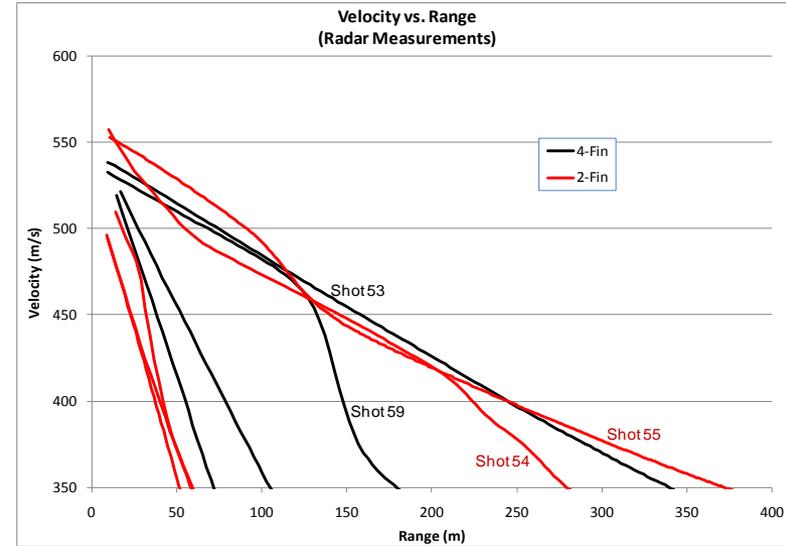
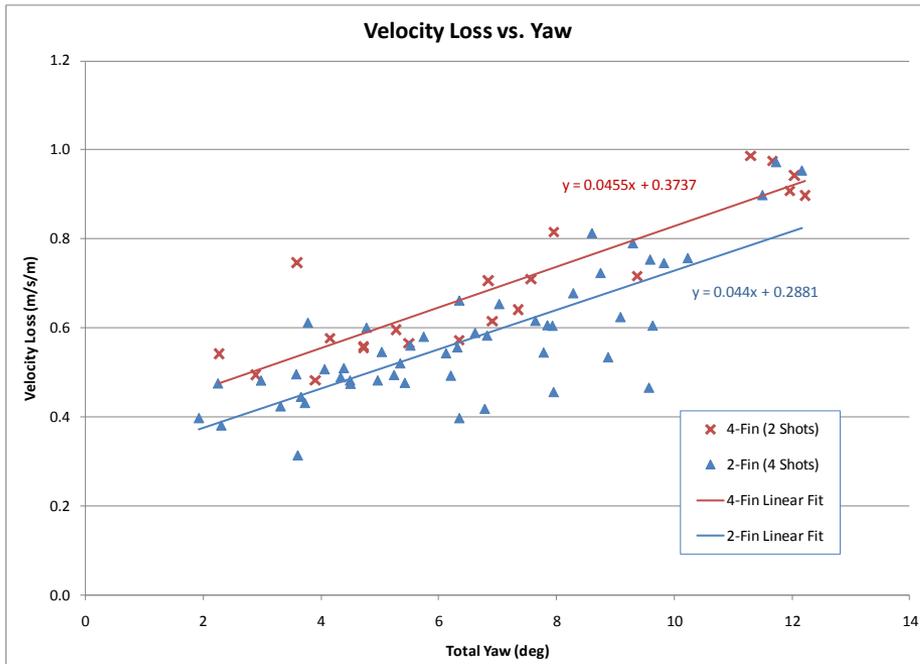


- Radar testing was conducted of both configurations
  - (4) 4-Fin baseline
  - (5) 2-Fin V-Tail
- Gun elevation = 10 degrees
- Muzzle velocity = ~550 m/s
- Sabot launched from .50 caliber smoothbore test barrel
  
- Goal was to determine performance after rounds had “settled down”

- Radar test results showed very inconsistent velocity loss for both configurations
- Rounds did not “settle down” as expected
- Spin-yaw resonance is one potential explanation



- Velocity above 350 m/s
- 4 “well behaved” rounds
  - 2 of each configuration
- Comparison of velocity loss indicates both configurations have nominal yaw of ~5 degrees



- There are flight stability issues with the baseline 4-Fin configuration
- Ballistic performance of 2-Fin V-tail is similar to 4-Fin baseline
- Comparison of “well behaved” rounds shows lower drag for 2-fin design
- 2-Fin V-tail appears to be a viable alternative for flechettes
- Further research is needed
  - Must address stability issues
  - Evaluate 2-Fin performance for stable baseline



## Contact Info



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