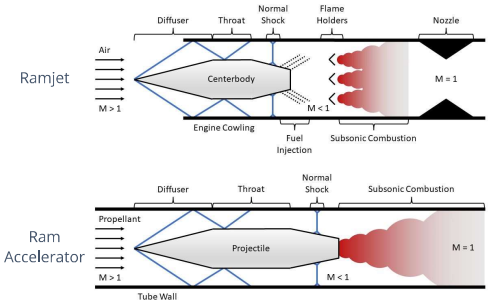
ADVANCES IN BAFFLED AND RAILED TUBE RAM ACCELERATOR OPERATION

STUDENTS: BRIAN LEEGE

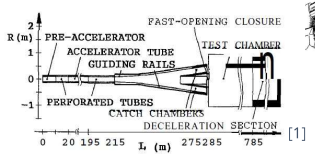
What is a Ram Accelerator?

- Hypervelocity mass driver system
- Developed at UW in the 1980s
- Chemical propulsion with ramjet-like propulsive cycle

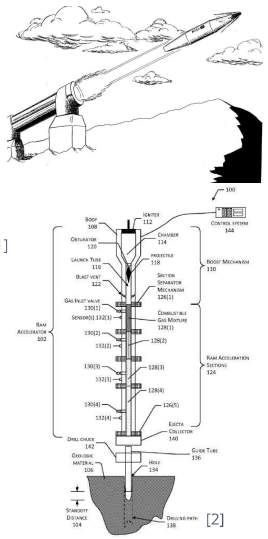


Applications

- Orbital launches
- Aeroballistic testing
- Drilling and boring
- Military
- Anything else requiring hypervelocity



[1]


[2]

Research Objectives

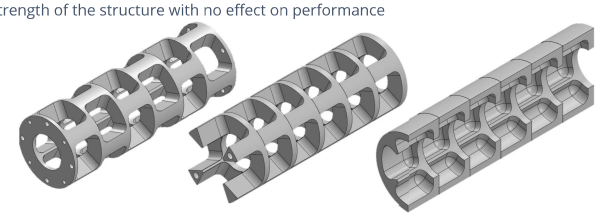
Develop a few key technological advances to bring the ram accelerator to commercial industry in the next few years:

- Characterize baffled and railed tube ram accelerator (BTRA & RTRA) operation with axisymmetric projectiles
- Eliminate the need for an obturator (a sabot-like device) in the ram accelerator system

New BTRA and RTRA Designs

Developed and tested two new BTRA designs: the BTRA 500 and BTRA 110

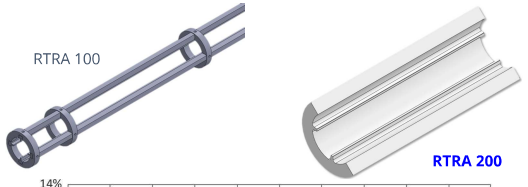
- The BTRA 500 decreased the baffle chamber diameter from the original BTRA 100 design and doubled its ballistic efficiency
- The BTRA 110 eliminated the 'clocked' baffle feature of the BTRA 100 to increase the strength of the structure with no effect on performance

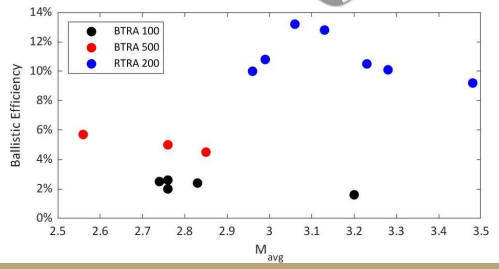


BTRA 100 BTRA 110 **BTRA 500**

Developed and tested first ever RTRAs at UW: the RTRA 100 and RTRA 200

- The RTRA 100 achieved successful operation but was destroyed after a few tests
- The RTRA 200 was designed to be much stronger and has undergone successful testing, achieving operating ballistic efficiencies more than double that of any BTRA

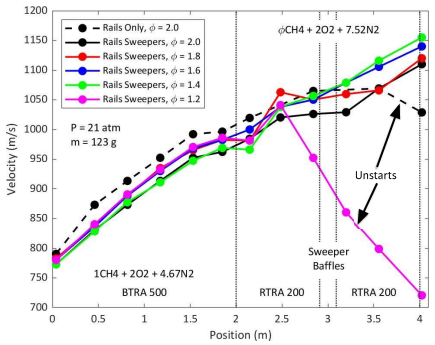




RTRA with Baffle Sweeper Configuration

New ram configuration

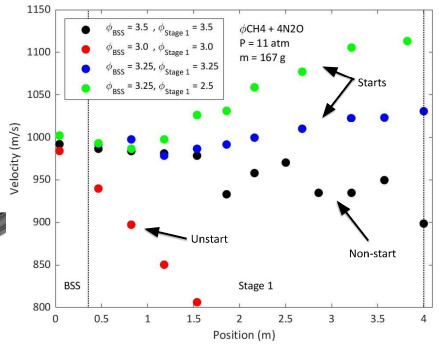
- RTRA with baffles interspersed throughout
- Baffles hinder combustion wave, delaying or preventing unstarts
- Allows use of more energetic and efficient propellants in the RTRA



Obturator-less Starting

Developed the Baffled Start Stage (BSS)

- Short section of baffles at ram entrance
- Propellant tuned to allow ignition but prevent unstarts
- Baffles are critical in preventing unstarts
- Nominal operation after the BSS



Acknowledgments and References

- The author would like to thank all the graduate students who aided in the work: Finn van Donkelaar, Chase Smith, John Correy, Desiree Bernhard, and Jason Ginos.
- The author would also like to thank all the undergraduate students who helped with the experiments who are too numerous to list here.
- The author declares a financial interest in HyperSciences, Inc., which has licensed the described technology from the University of Washington in concert with EnergeticX, LLC.

References

[1] Naumann, K. W., and Bruckner, A. P., "Ram Accelerator Ballistic Range Concept for Softly Accelerating Hypersonic Free-Flying Models," *Journal of Aircraft*, 1994, pp. 1310–1316. https://doi.org/10.2514/3.46652.

[2] Russel, M. C., "Ram Accelerator System," U.S. Patent 9,500,419 B2, issued 22 Nov. 2016.

WILLIAM E. BOEING
DEPARTMENT OF AERONAUTICS & ASTRONAUTICS

ADVISERS: DR. CARL KNOWLEN

SPONSORS: HYPERSCIENCES, INC.