TACOM
Lethality, Survivability, Mobility and Sustainment for America's Army

National Defense Industrial Association
Small Arms Symposium

Light Fighter Lethality Seeker Projectile

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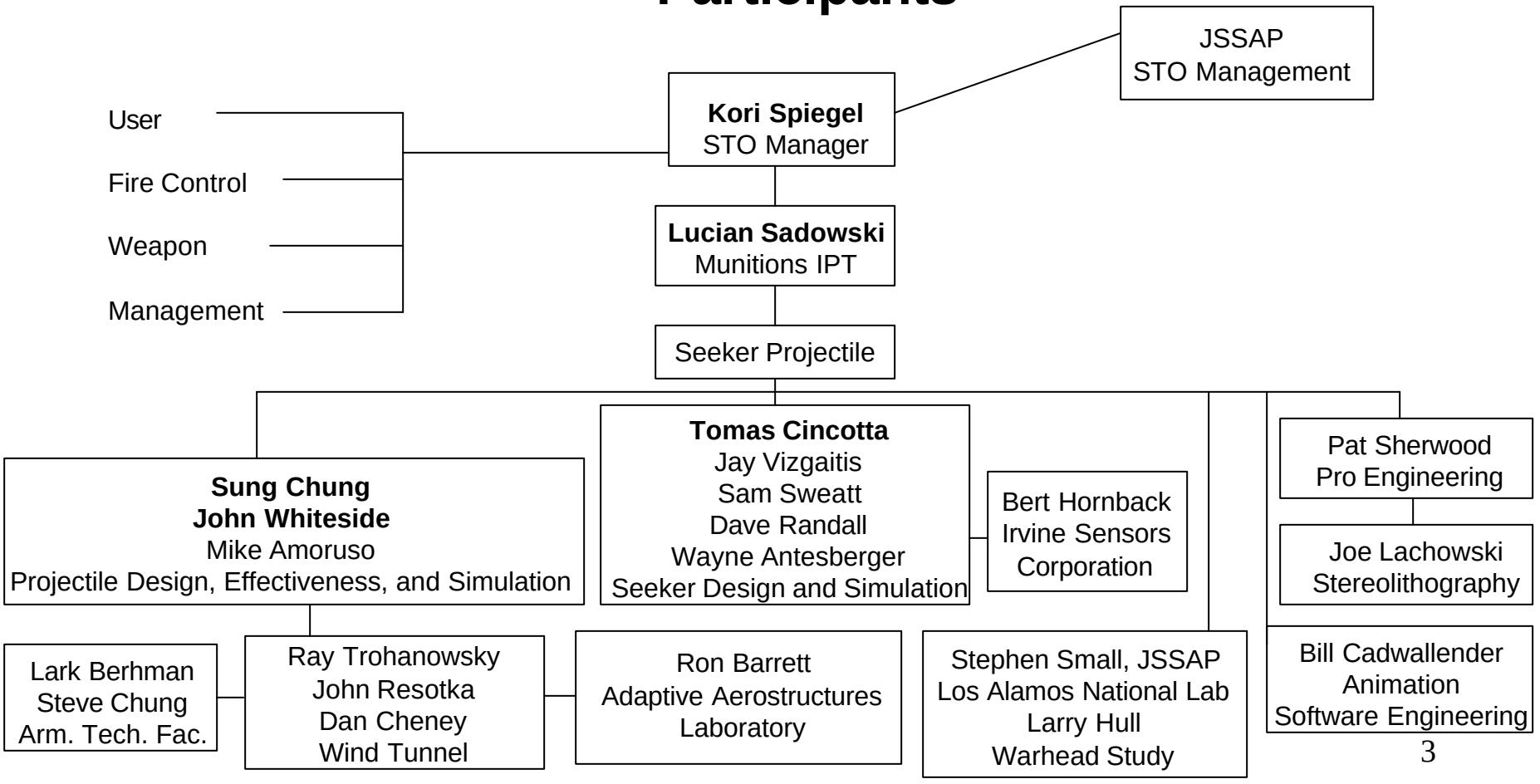
Light Fighter Lethality Participants



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Light Fighter Lethality

Program Objective: Define, Develop, and Demonstrate an Ultra-Lightweight Lethality System that:

- **Dramatically Reduces Warfighter Weight**
- **Increased Lethality for the Individual Soldier**
- **Maximizes Operational Utility and Survivability**
- **Operates In All Environments**
- **Tailorable To Mission Specific Roles**

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PERFORMANCE METRICS:

	Threshold	Goal
Individual System Weight		
- Less Than	10 lbs	5 lbs
Probability of Incapacitation		
- Greater Than 0.5 @	300 M	500 M
Ammunition Weight		
- Less Than	0.5 lbs	0.25 lbs

Seeker Projectile System Concept Description

- Concept Based on Projectile knowing Target Location at Launch
- Projectile knows how far it is off its initial trajectory during flight
- In Flight, the Seeker can detect/recognize the Target, Stationary or Moving

Operation

- Target Image, Range, and Azimuth Given To Projectile At Launch
- Projectile Flies Autonomously to Target Coordinates
- Initial Stages of Projectile Flight:
  - Projectile Determines Orientation, Position, and Course Corrections Required Using On-Board Inertial Reference Measuring Device
  - Activates Maneuver Mechanism as Required
- Projectile Approaching Target Coordinates:
  - Activates On-Board Seeker
  - Seeker Locates Target Signature
  - Projectile Maneuvers and Engages Target

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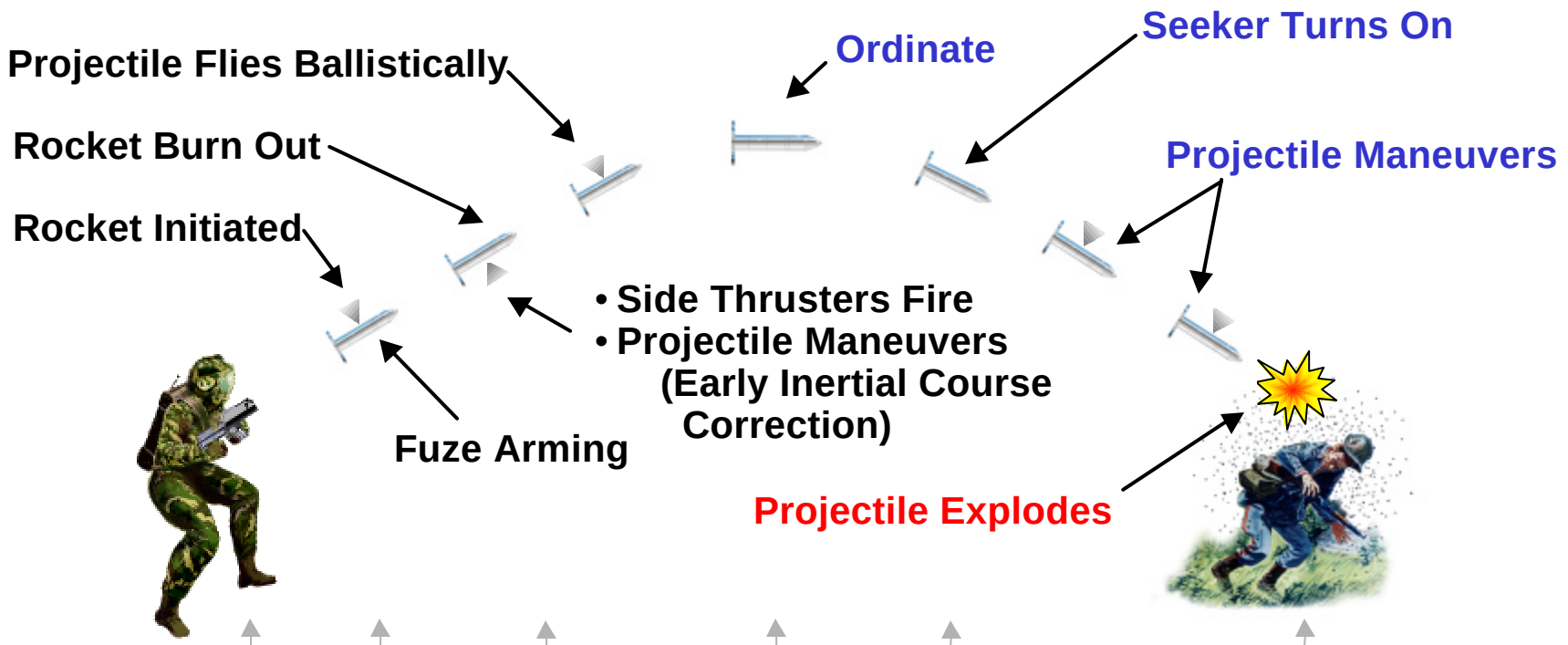
Close Combat Armaments Center

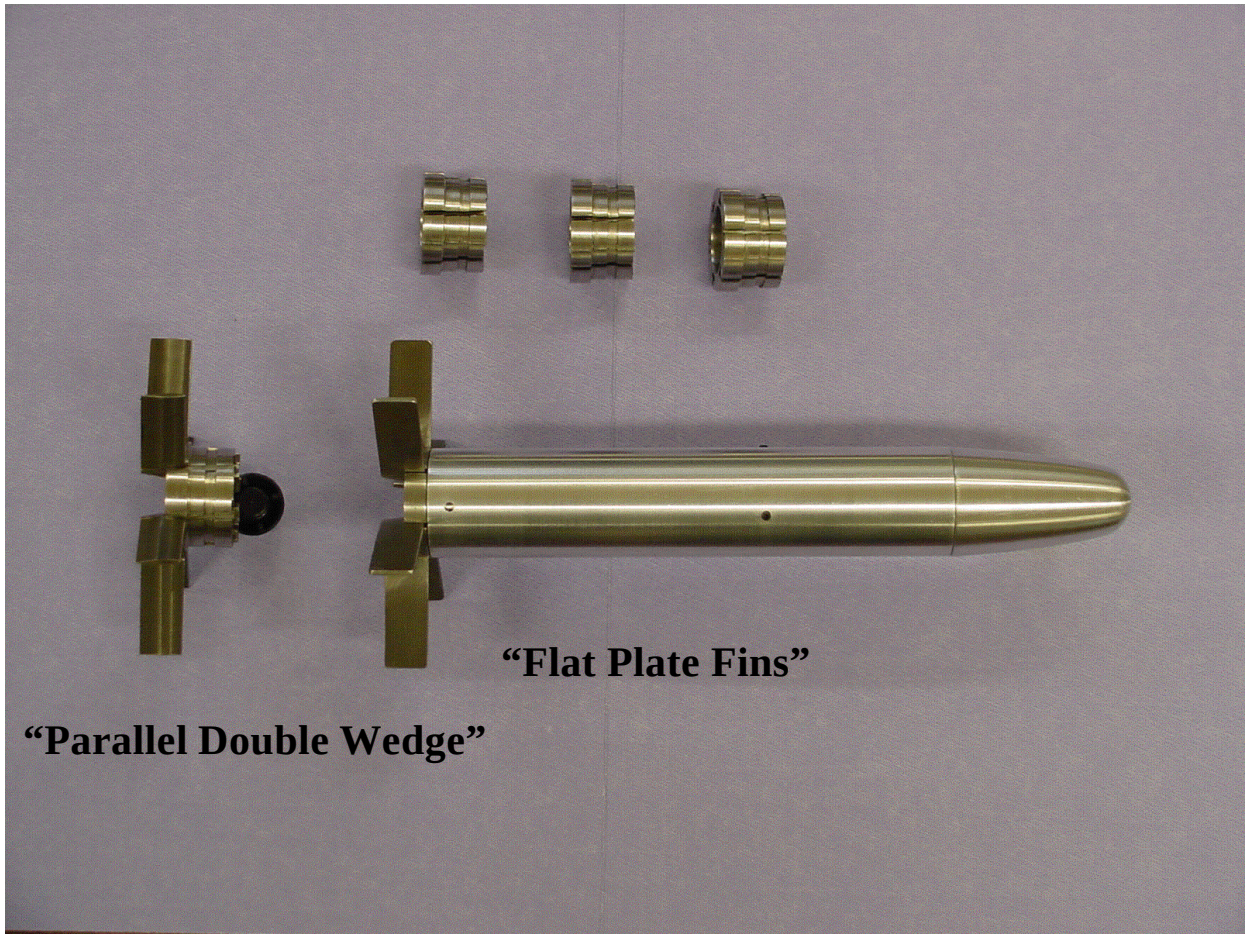
J·S·S·A·P JOINT SERVICE SMALL ARMS PROGRAM

500m Trajectory Example

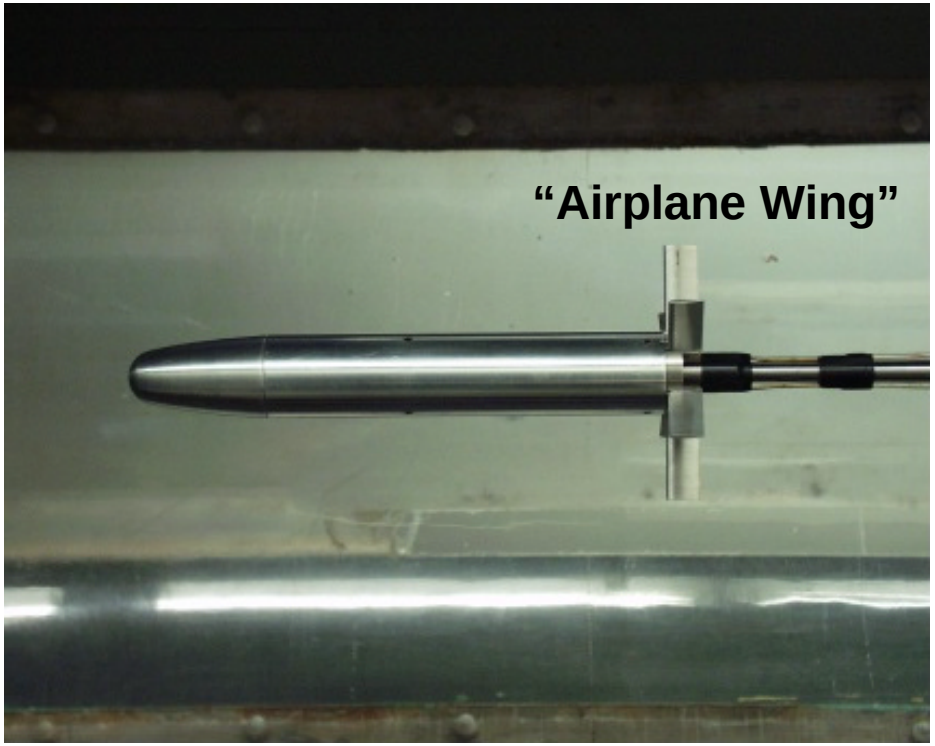


Range (meters)	0	29	148	250	296	500
Velocity (m/s)	60	58	180	159	150	117
Time of Flight (sec)	0	0.5	1.5	2.1	2.4	4
Altitude (meters)	0	5	13	15	14	0

In-House LFL Seeker Projectile Wind Tunnel Model



In-House LFL Seeker Projectile
Wind Tunnel Model in the Chamber



Wind Tunnel Test Plan

The Light Fighter Seeker Projectile is Fin Stabilized - Six Fins
Length is 155 mm (6.1 inches), 25mm in diameter, weight is 240 grams (.53 lbs.)
Model is 25% larger than the current LFL Seeker Projectile Design
Testing was conducted in the TACOM-ARDEC Picatinny Wind Tunnel Facility
One Ogive (nose), One Body and
Three Different Fin Designs
- "Flat Plate", "Parallel Double Wedge", and "Airplane Wing" Fin Designs

Three different Fin Cant Angles
- 0 Degrees, 2 Degrees, and 4 Degrees

Angles of Attack
- 0 Degrees up to 20 Degrees.

Mach Numbers
- .1, .2, .3, .4, and .56

Fin Roll Angles
- 0, 7, 15, 25 Degrees

Preliminary Wind Tunnel Results
In-House Design

	Drag (alpha = 0 Degrees)	Static Stability (calibers / %)
"Flat Plate" Fin Mach Number 0.56	0.54	1.77 / 28
"Parallel Double Wedge" Fin Mach Number 0.56	0.28	1.46 / 23
"Airplane Wing" Fin Mach Number 0.56	0.27	1.80 / 29

Static Stability is in % of body length which is 6 .228 calibers
Center of Gravity location is 3.6 calibers from the nose

What is an Adaptive Material ?

A material which undergoes a change in mechanical, thermal, optical, chemical, electrical, or magnetic properties as a function of a given stimulus*

Why use Adaptive Material ?

- Adaptive materials can be used as Flight Control Actuators
- Adaptive materials can be configured into Canards or Fins
- Adaptive Materials only require electrical energy
- No more motors and gears, saving weight and space

* Fundamentals of Adaptive/Smart Aerostructures Short Course by Dr. Ron Barrett, Auburn University, AL

Which Adaptive Material is used in the Model?

The actuators were made from tape-cast PZT-5A Piezoceramic Sheets
Nomenclature - Lead-Zirconate Titanate Micro-Flex Actuator*

How is Auburn University Involved?

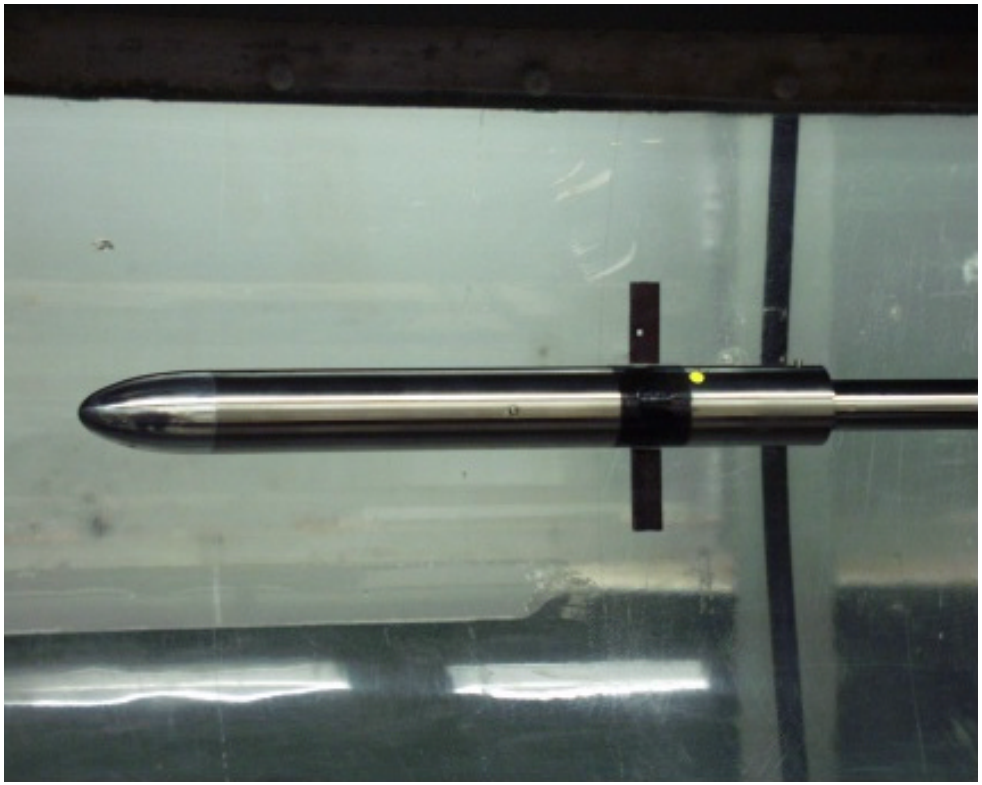
Leaders in the field of Adaptive Materials and applications to Aerostructures
Successful Phase 1 SBIR with Lutronix, Auburn Univ. was the sub-contractor
Title of the FY 2000 SBIR - Cal. 50 Smart Bullet
Application of this technology as a maneuver mechanism
Purchase Order with Barrett Aerospace Technologies in FY 2001
Fabricate an Adaptive Material Wind Tunnel Model
Configuration of a version of the LFL Seeker Projectile

* Fundamentals of Adaptive/Smart Aerostructures Short Course by Dr. Ron Barrett, Auburn University, AL

Adaptive Material Wind Tunnel Model Properties

Length of the model - 227 mm - 9 inches
Diameter of the model - 25 mm - 1 inch
Location of fins from ogive - 169 mm- 6.6 inches
Fin Semi-Span - 25 mm - 1 inches
Fin Chord - 10 mm - .4 inches
Thickness of Fin - 1 mm - 0.04 inches
Two fixed fins - carbon fiber
Two fins - Adaptive Material - steel spar
Maximum Fin Deflection - 2.6 Degrees at 140 Volts
Actuation Frequencies - 0 to 260 Hz, resonance at 160 Hz

Adaptive Material Wind Tunnel Model

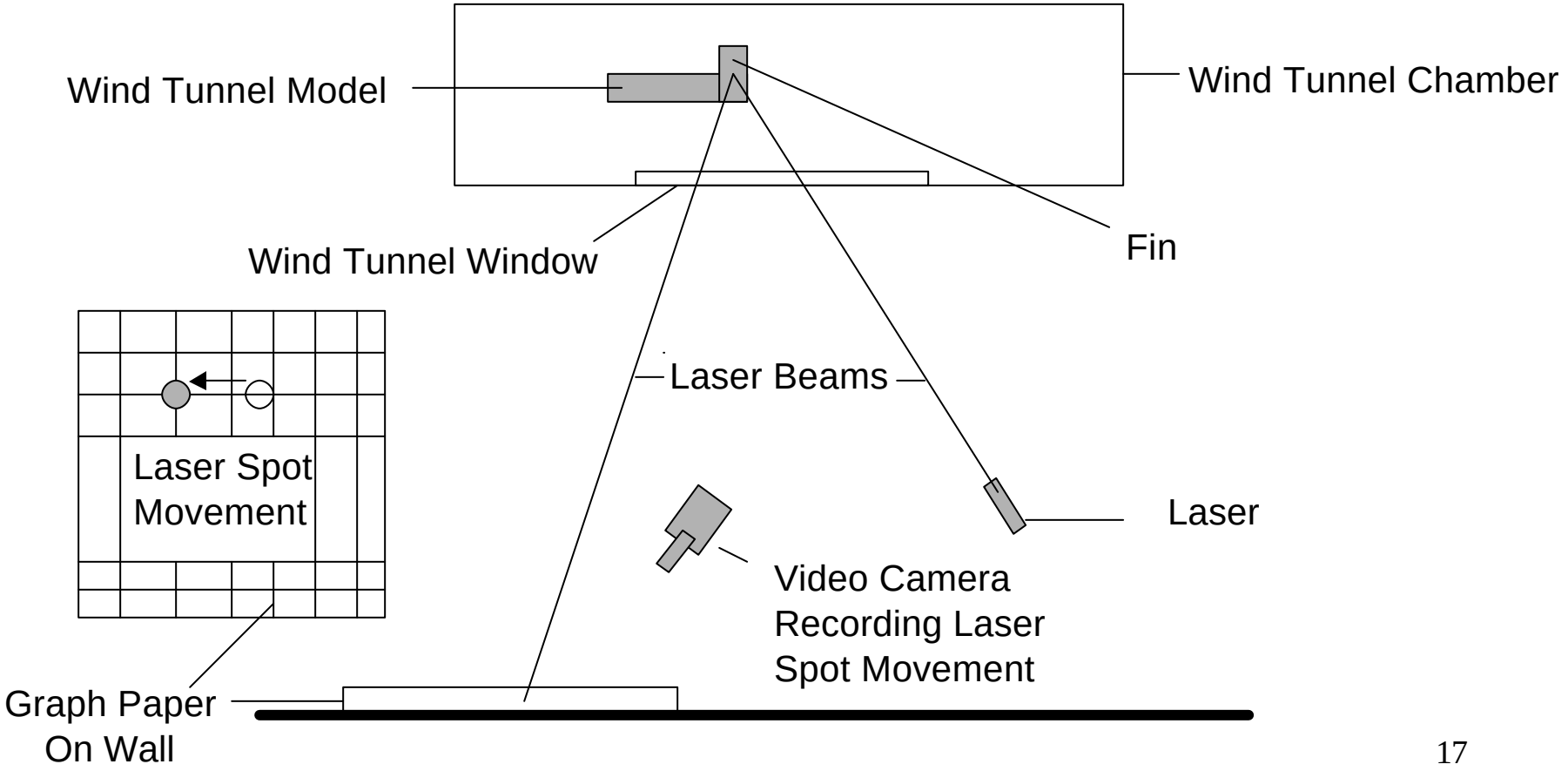


Adaptive Material Wind Tunnel Model

First Wind Tunnel Test of Adaptive Material for Small Arms Ammunition

Place Model in the Wind Tunnel
Observe the Angular Fin Movement
Wind Off and Wind On
Documented Motion of the Fin
- Laser Light Deflection Experiment
- High Speed Video Experiment

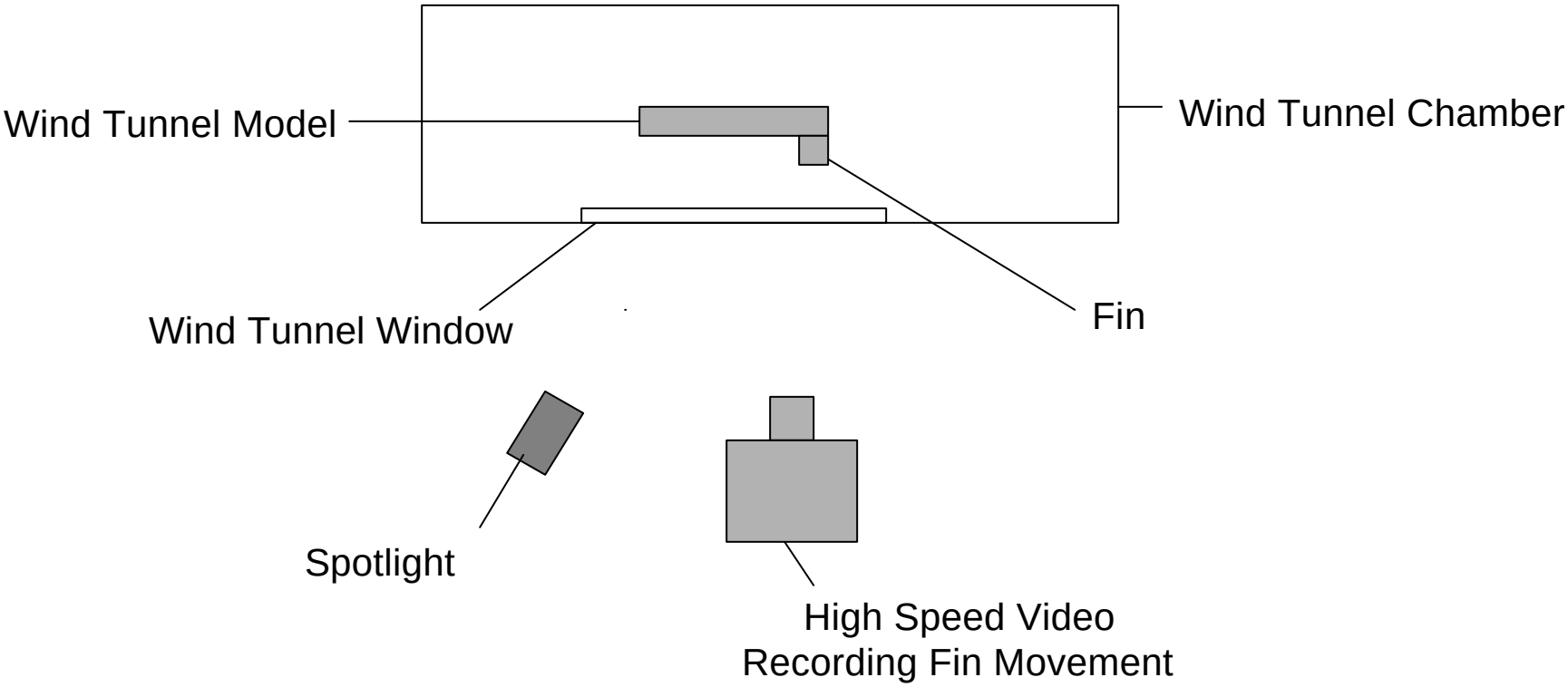
Adaptive Material Wind Tunnel Model Laser Light Deflection Experiment



Adaptive Material Wind Tunnel Model Preliminary Test Results

Mach Numbers 0.0, 0.1, 0.2, 0.3, 0.4, and 0.49
Angle of Attack - 0 Degrees
Laser Light Deflection Experiment
- Dynamic Mode - 1 Hz
  - Total angular deflection approximately 1.9 degrees
    - No difference between Wind Off or Wind On
- Static Mode - 0 degrees, 0.8 Degrees, 2.0 Degrees
  - Total angular deflection
    - No difference between Wind On or Off
  - Mid position - Mach 0.4
    - Difference of 0.5 degrees between Wind On or Off

Adaptive Material Wind Tunnel Model High Speed Video Experiment



Adaptive Material Wind Tunnel Model Preliminary Test Results

High Speed Video Experiment - Initial Observations

- Rotated Model 90 degrees to view moving fin edge on.
  - Dynamic Mode - Total Angular Deflection - 3.6 Degrees
    - Mach Numbers - 0.0, 0.3, 0.4 - 1 Hz
      - No difference between Wind Off and Wind On
    - Mach Number - 0.5
      - Dynamic Mode - 20, 30, 40, 60, 100, and 125 Hz
        - No difference in fin deflection, Wind Off and Wind On
    - Noticed Fin did move downward with Wind On

Adaptive Material Wind Tunnel Model Summary

Adaptive Material Fin Function:

- -Reliable, Repeatable, Predictable
- -Capable of Fast Response times approaching Explosive Squibs
- -Considering Adaptive Material Fins as a Complimentary Maneuver Mechanism for the LFL Seeker Projectile

Adaptive Materials have application to Small Arms Ammunition

Conclusions

- Wind Tunnel Model testing was a success!
- The In-House Projectile Design is Stable!
- Adaptive Material Wind Tunnel Model testing was a success!
- Adaptive Materials are Capable of Very Fast Response times Approaching Explosive Squibs
- Considering Adaptive Material Fins as a Complimentary Maneuver Mechanism for the LFL Seeker Projectile

A Light Fighter Lethality Projectile is Feasible!

Future Plans

Broad Agency Announcement:

Two contracts were awarded on May 3, 2002 !

- General Dynamics Ordnance and Tactical Systems (Aerospace)
  - Redmond, WA
- Schafer Corporation
  - Huntsville, AL

Goals:

1. To Conceive, Design, and Fabricate a LFL Seeker Projectile
2. To Demonstrate in Two Years:
   a. Working Breadboard of the Projectile
   b. Fabricate and Fire Inert Projectiles
   c. Perform Course Corrections in Flight