Improved Lethality Test Capabilities of the Arnold Engineering Development Center

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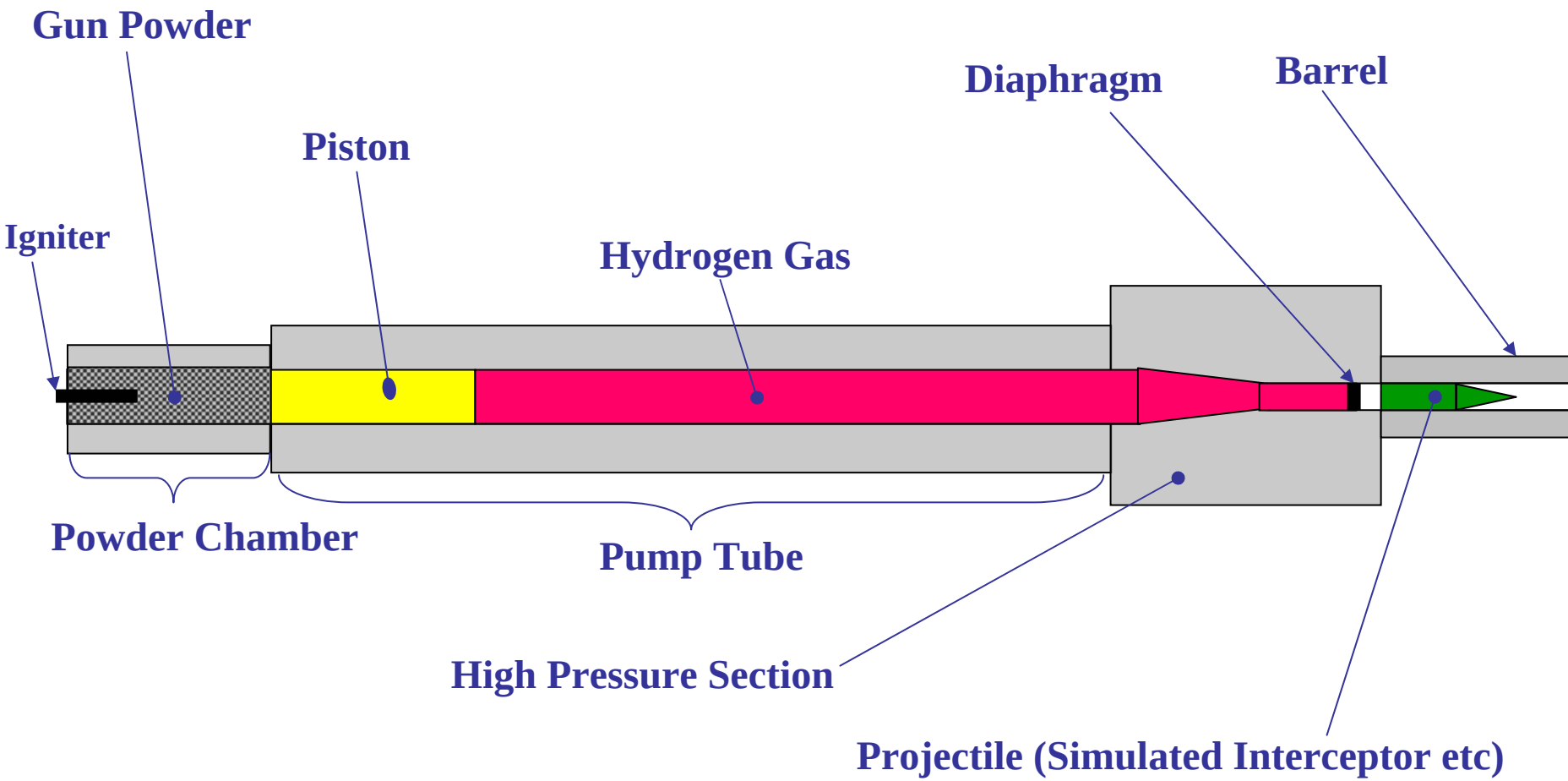
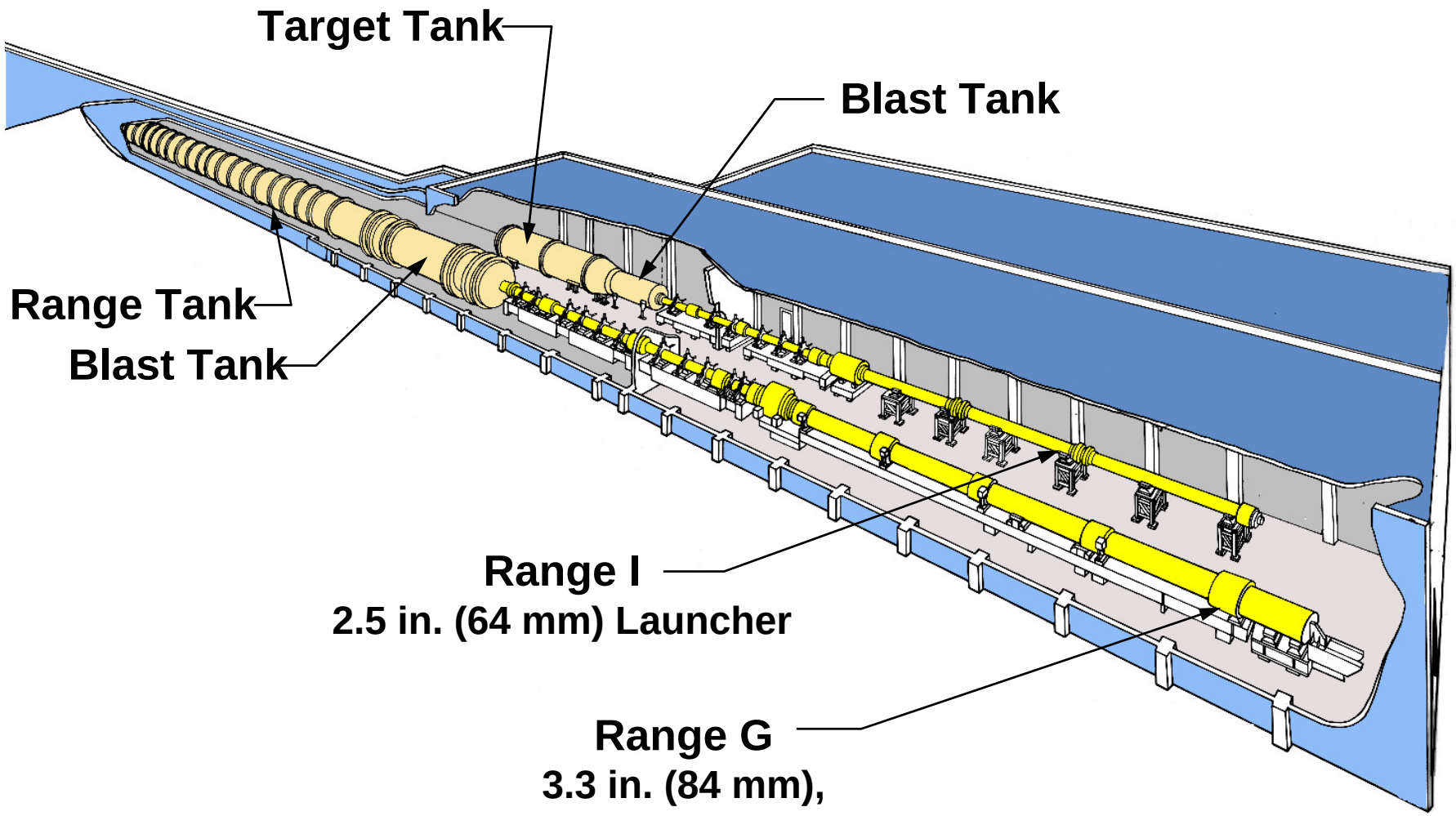
This presentation is an overview of continuously improving impact lethality ground testing methods using the Range G two stage light gas gun facility and it's evolution into one of the premier ground test facilities for the Missile Defense Agency **(MDA)**

TYPICAL TWO STAGE LIGHT GAS GUN OPERATION

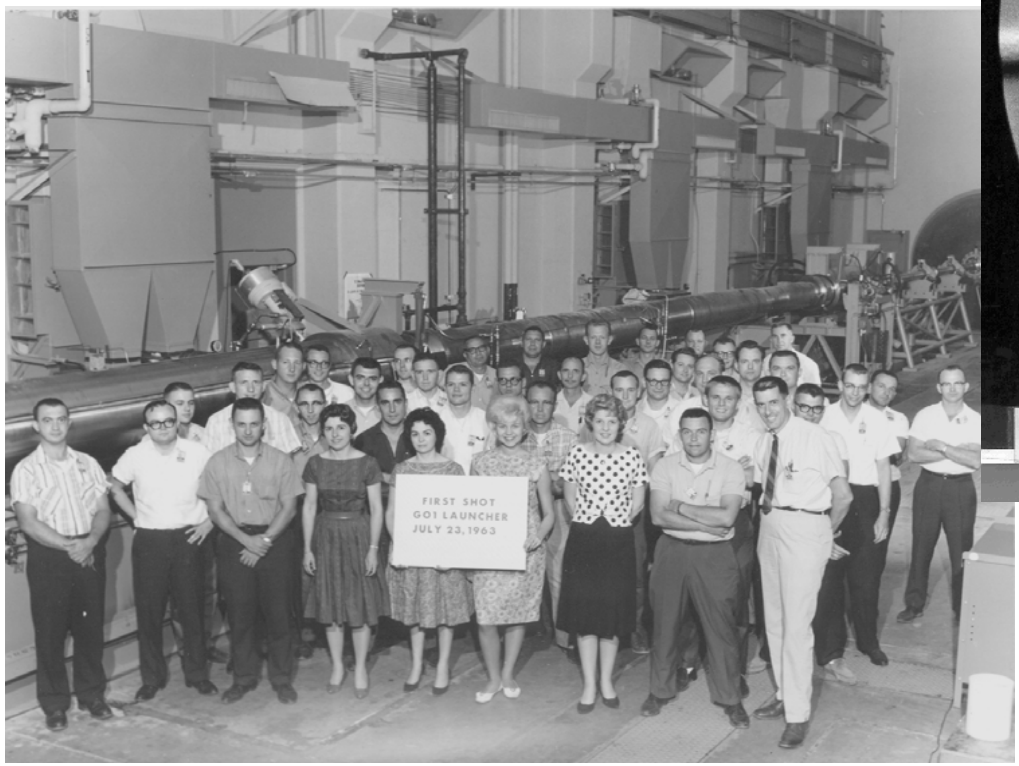


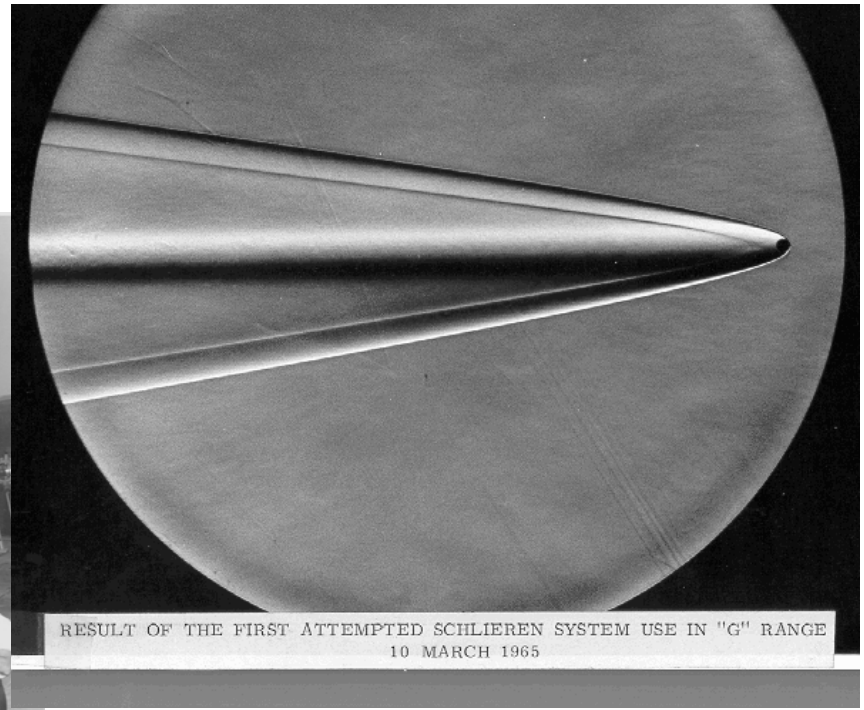
RANGE COMPLEX INCLUDING RANGE G AND RANGE I



A BRIEF HISTORY OF AEDC RANGE TEST TECHNIQUES – “The 60’s”

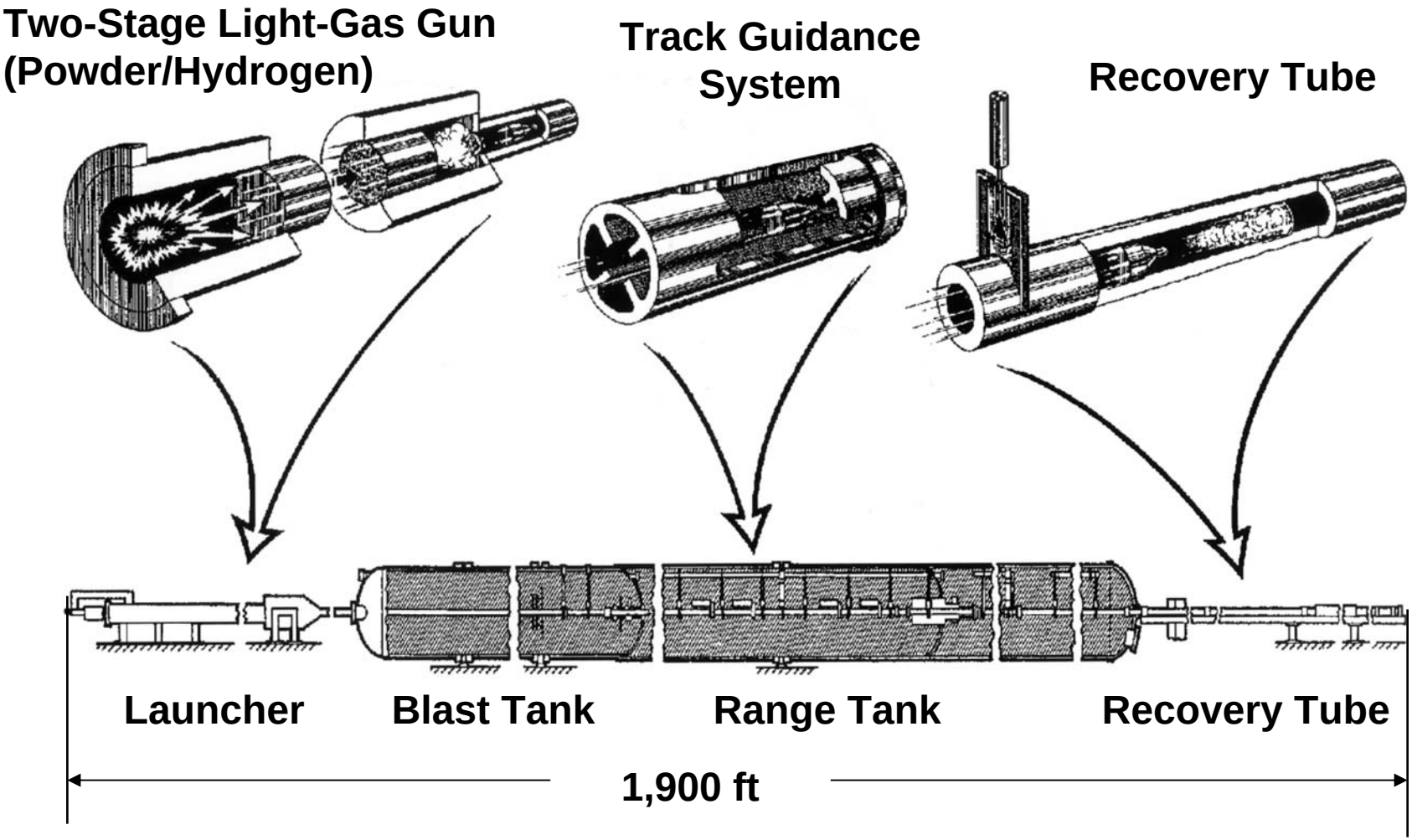
The original Range G 2.5 inch launcher and tank system was developed for high velocity Aeroballistic testing in the 1960s.



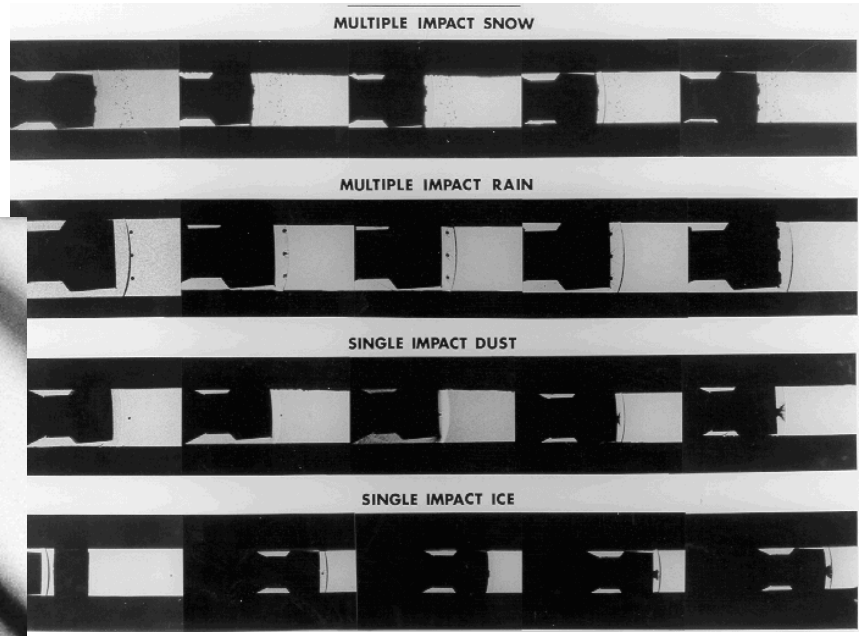


Free Flight Projectile Schlieren Image

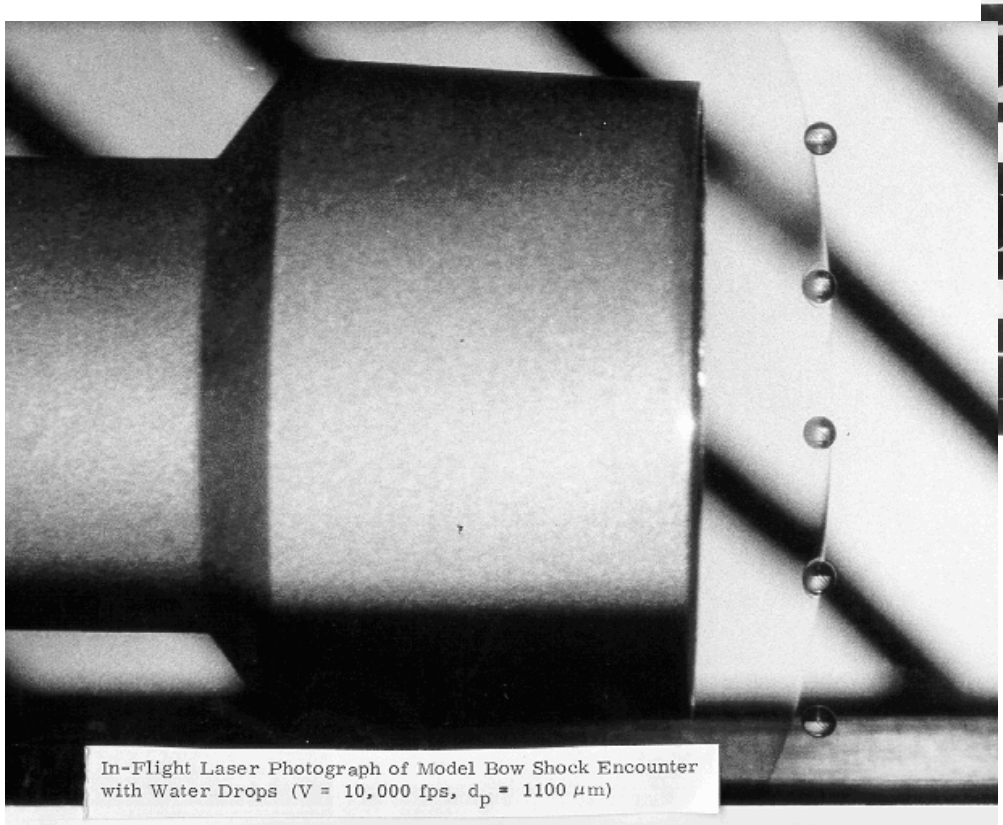
UPGRADE RANGE G TRACK AND RECOVERY TUBE SYSTEM – “The 70’s”



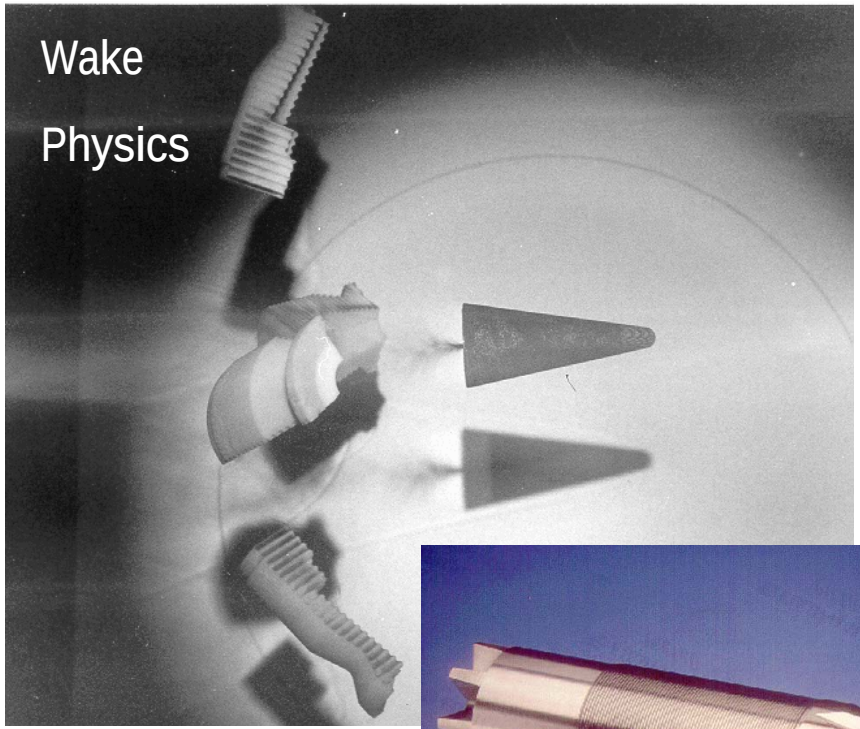
EROSIVE FIELD TRACK GUIDED RANGE TEST TECHNIQUE – “The 80’s”

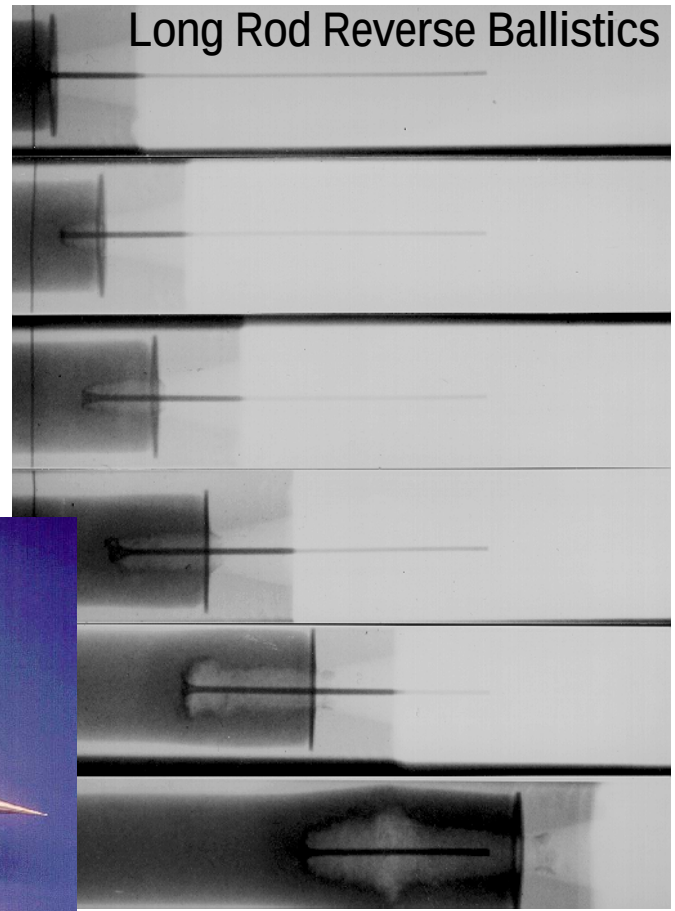


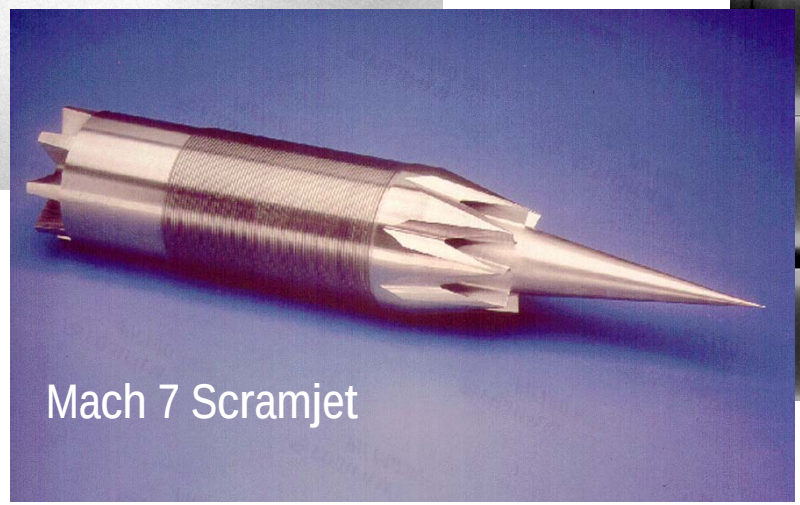
Erosive Fields
(snow, rain, dust, and ice)
testing via track


In-Flight Laser Photograph of Model Bow Shock Encounter with Water Drops (V = 10,000 fps, d_p = 1100 μm)

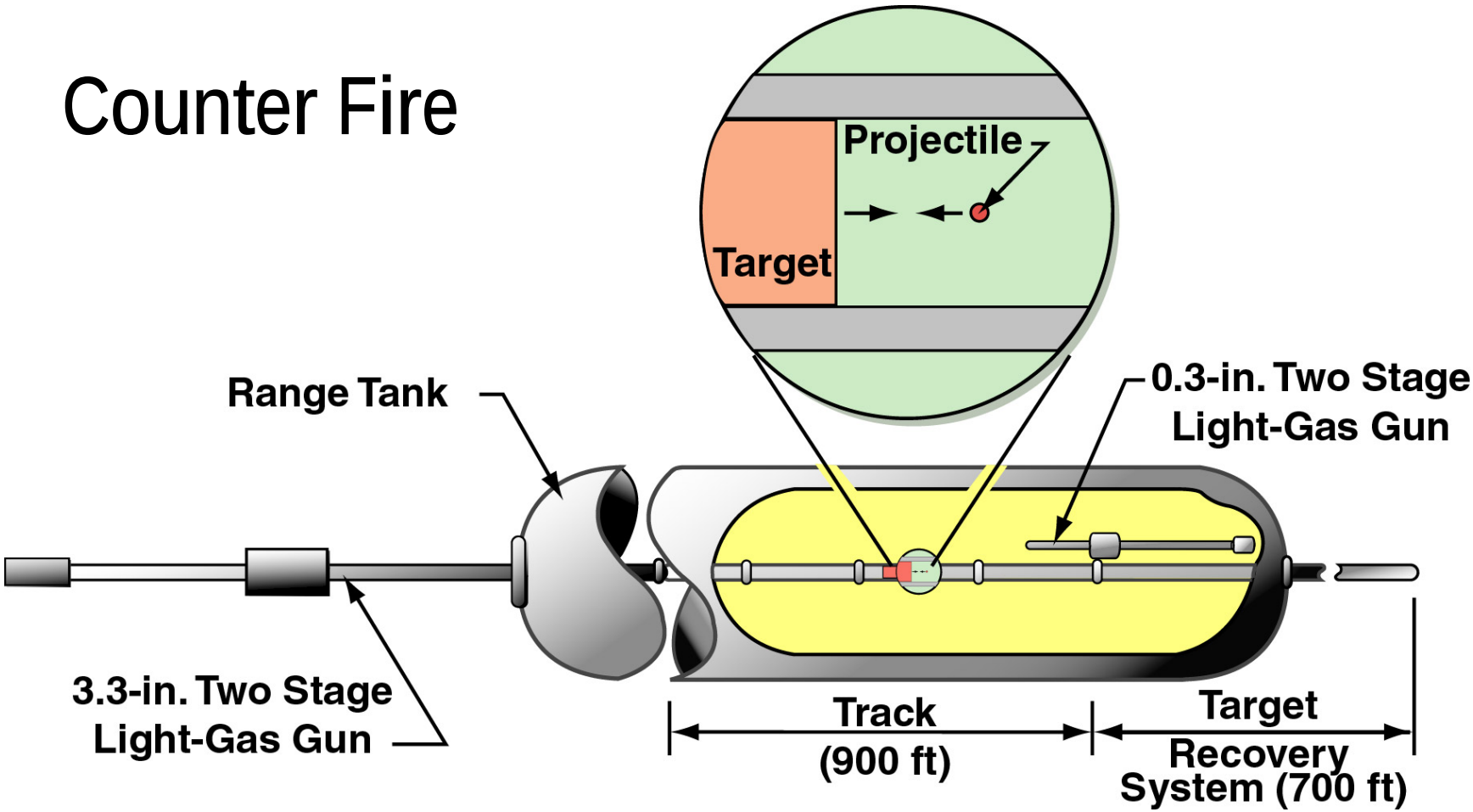
TRANSITIONAL AEDC RANGE TEST TECHNIQUES – “The 90’s”



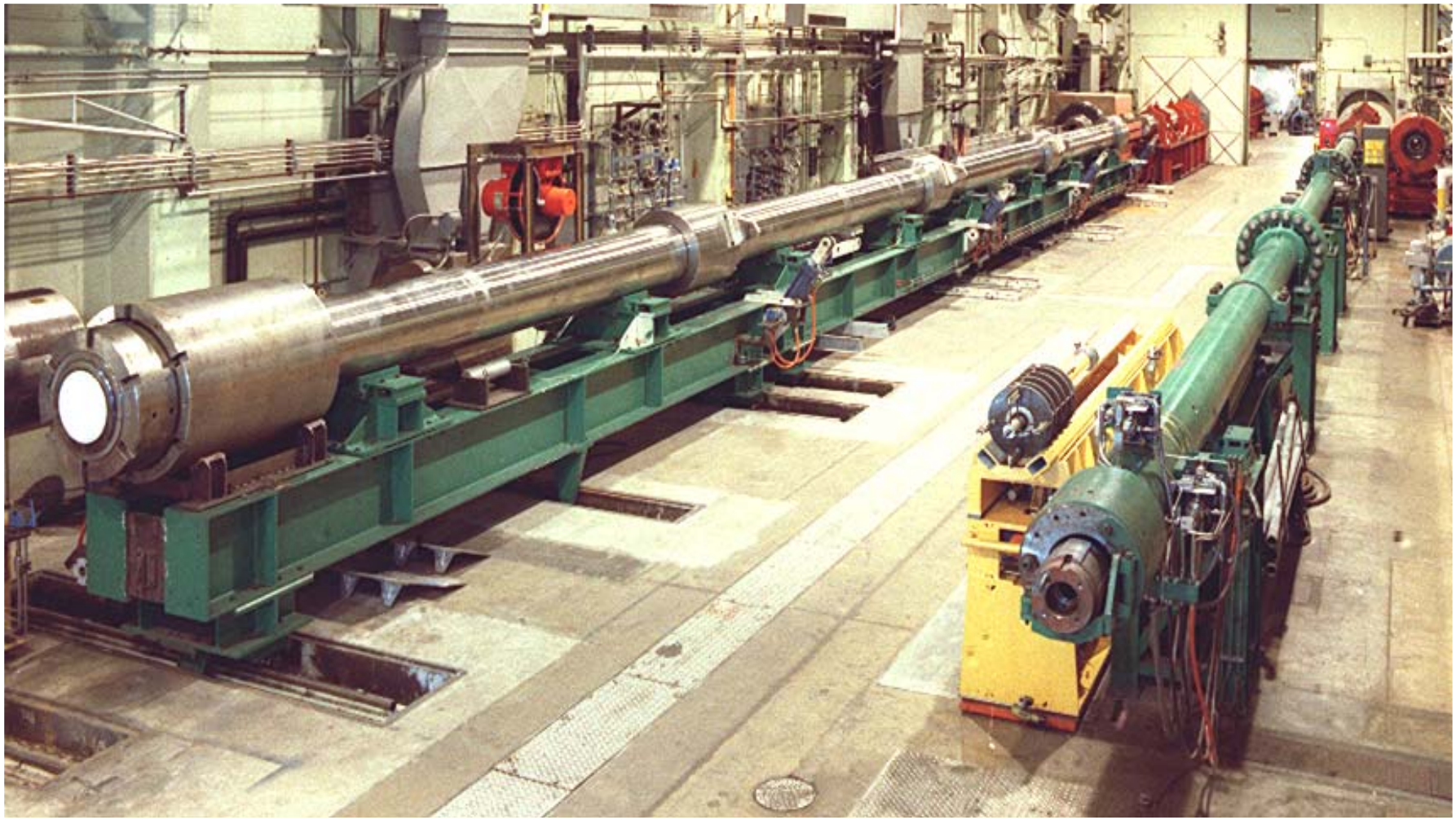




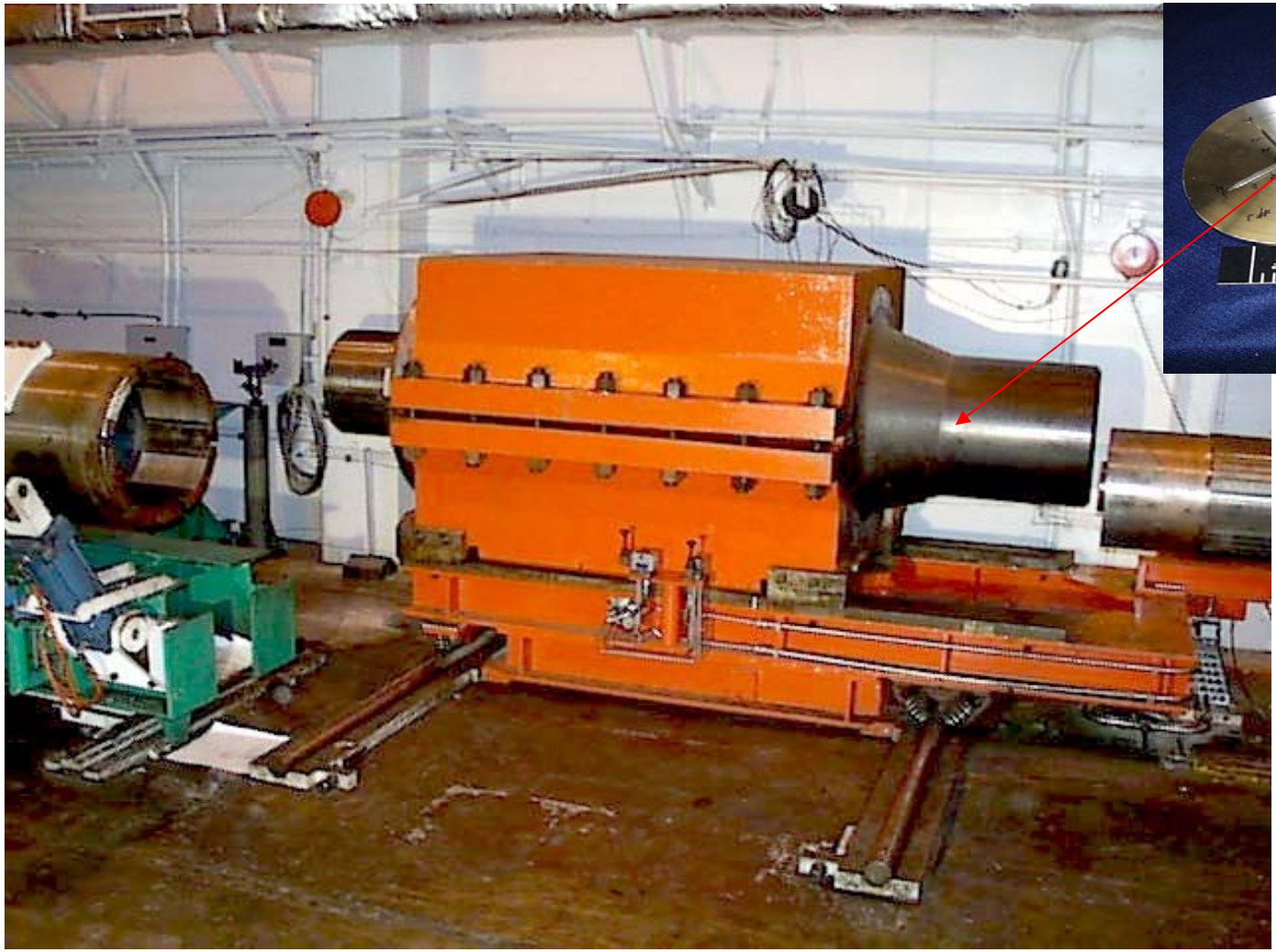
NEW RANGE TEST TECHNIQUES POSSIBLE WITH 3.3 INCH LAUNCHER



RANGE G HYPERVELOCITY
3.3 INCH LAUNCHER UPGRADE



3.3 INCH LAUNCHER COMPONENTS: 60 TON HIGH PRESSURE SECTION



3.3 INCH LAUNCHER COMPONENTS: LAUNCH TUBE (3.3, 4.0, and 8.0-IN)

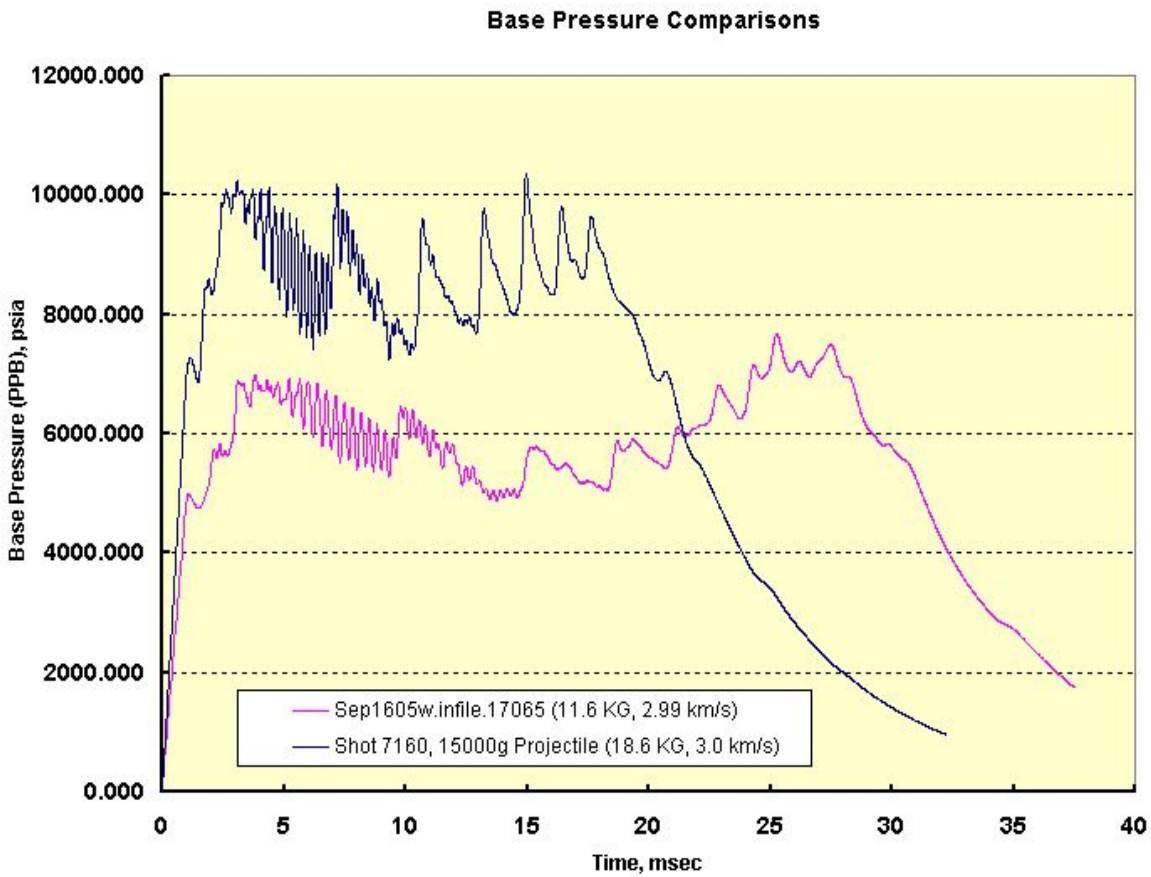
IMPROVED LETHALITY TEST CAPABILITY REQUIREMENTS

MDA funded an extended High Fidelity Development Program to enhance Range G testing capabilities for future test program support.

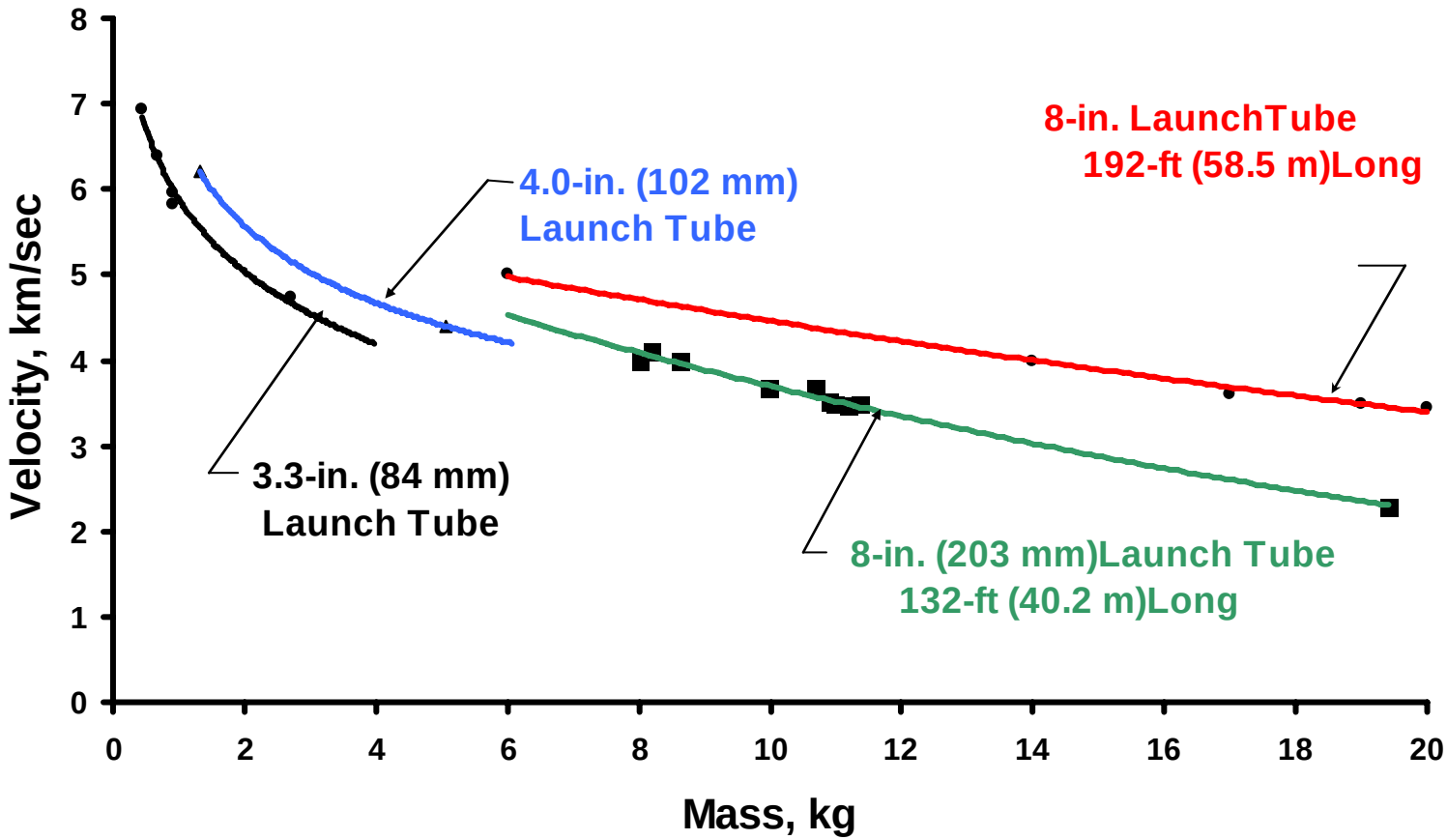
- Large Scale Hi Fidelity Projectile
- Velocities up to 5 Km/sec with 8” bore launch tube
- Improved gun cycle with lower launch accelerations
- Projectile Pitch capability
- Soft Catch of Target Debris Field
- Updated and Improved Instrumentation
- Improved Optical and X-ray recording equipment

PARAMETRIC STUDY YIELDS IMPROVEMENTS TO GUN CYCLE

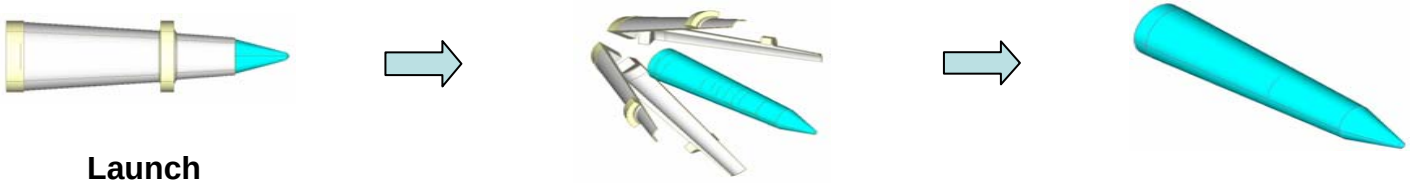
- An improved gun cycle was developed based on testing requirements
- Use of a heavier piston theoretically results in a 38% reduction in peak g-loading when combined with additional hydrogen mass
- Peak acceleration and base pressure occur much further into the cycle
- Longer barrel further softens launch loads



MAXIMUM VELOCITY VS PROJECTILE MASS FOR RANGE G CONFIGURATIONS



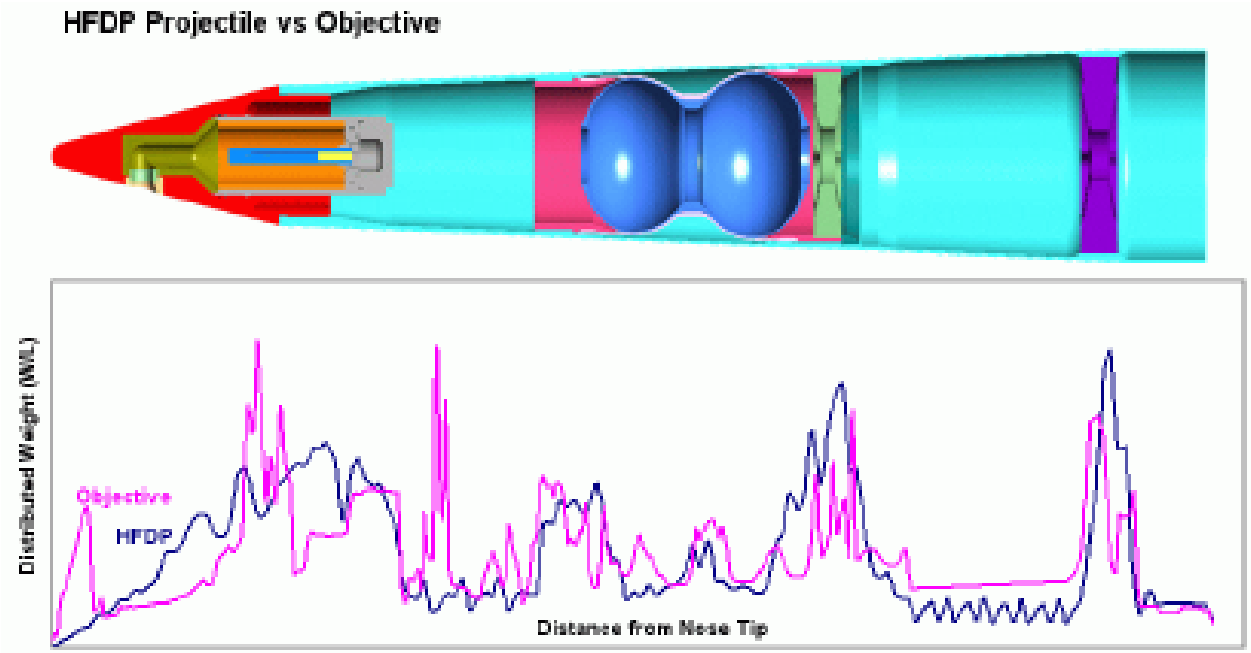
OUR GOAL: A 40%-SCALE INTERCEPTOR HIGH FIDELITY PROJECTILE



Launch Package

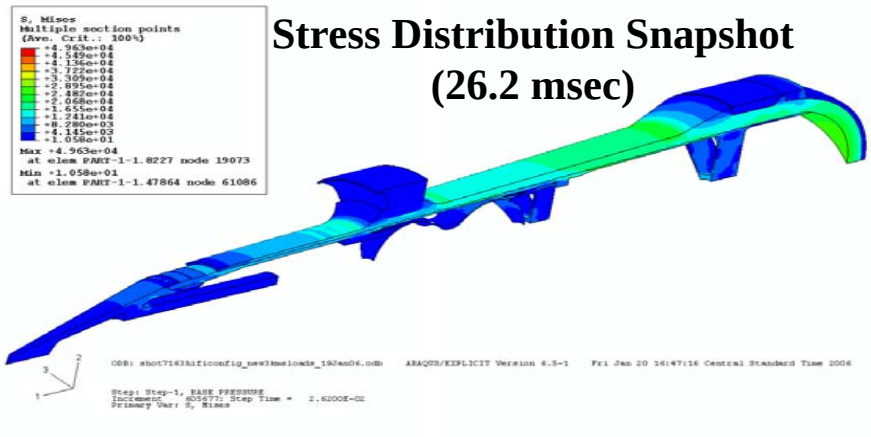
Sabot Separation

Impact Projectile

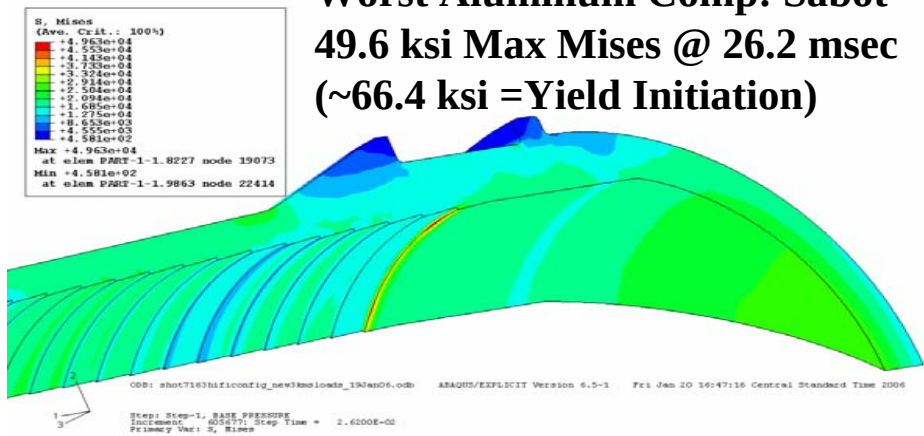


Abaqus Explicit ™ STRESS ANALYSIS FOR CANDIDATE PROJECTILE DESIGNS

Full Model
Stress Distribution Snapshot
(26.2 msec)

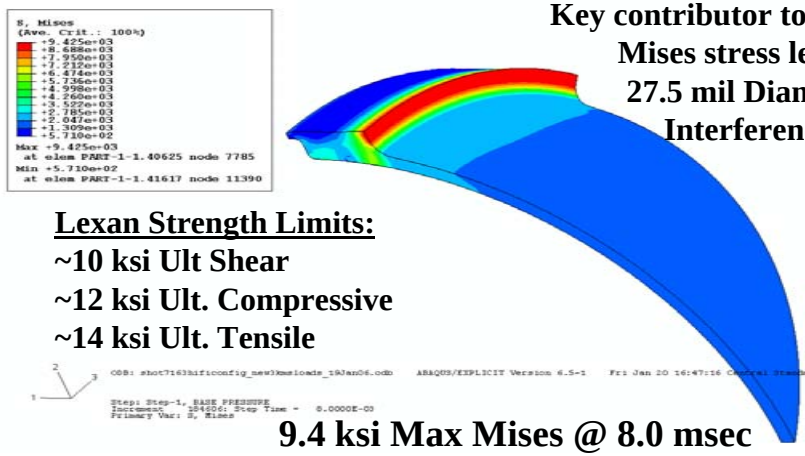


Worst Aluminum Comp: Sabot
49.6 ksi Max Mises @ 26.2 msec
(~66.4 ksi =Yield Initiation)



3.3 ksi Max Mises @ 8.1 msec
(~7 ksi Nylon Tensile Strength, Yield)

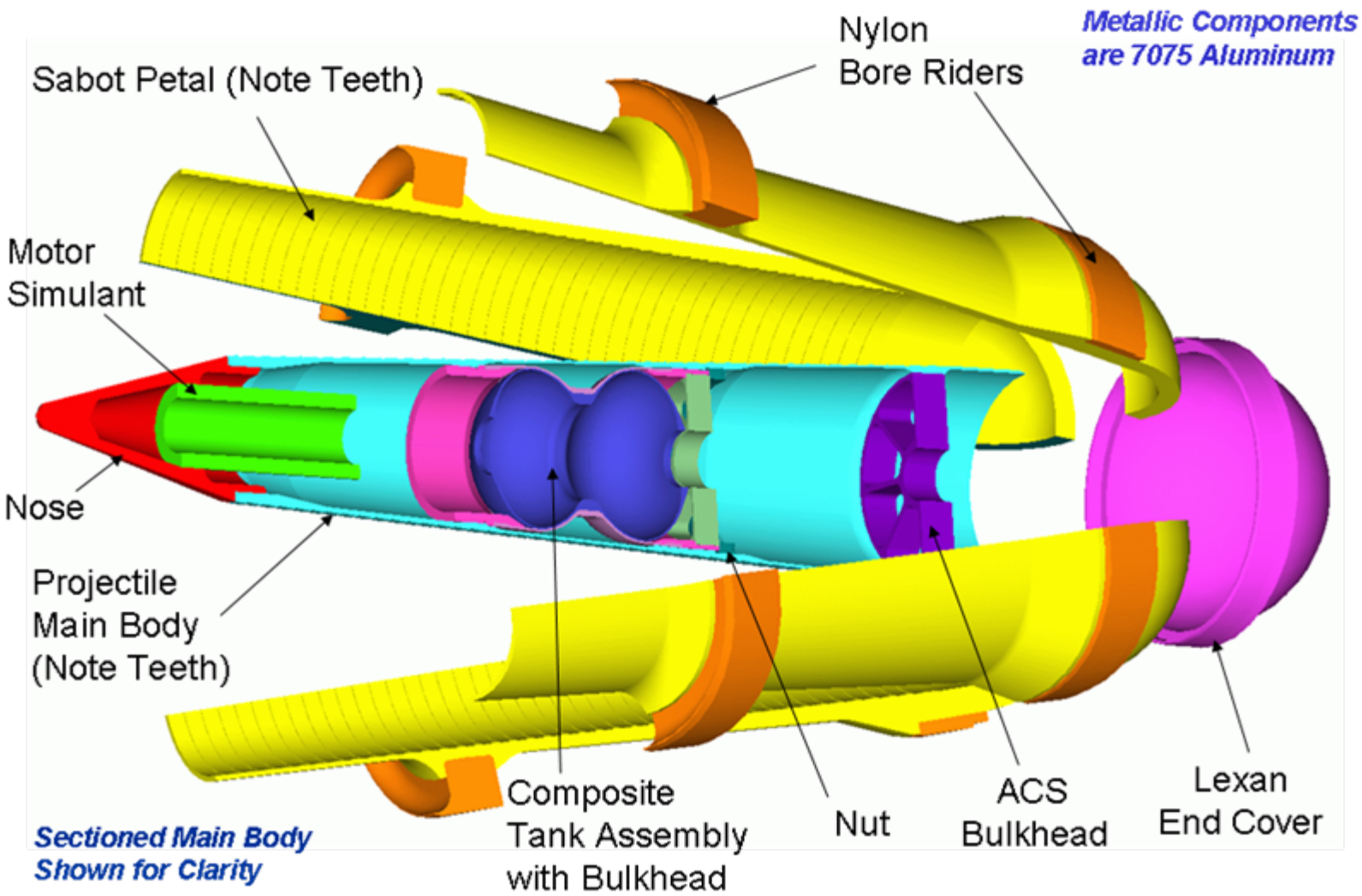
Key contributor to peak Mises stress level is 27.5 mil Diametric Interference Fit



Lexan Strength Limits:
~10 ksi Ult Shear
~12 ksi Ult. Compressive
~14 ksi Ult. Tensile

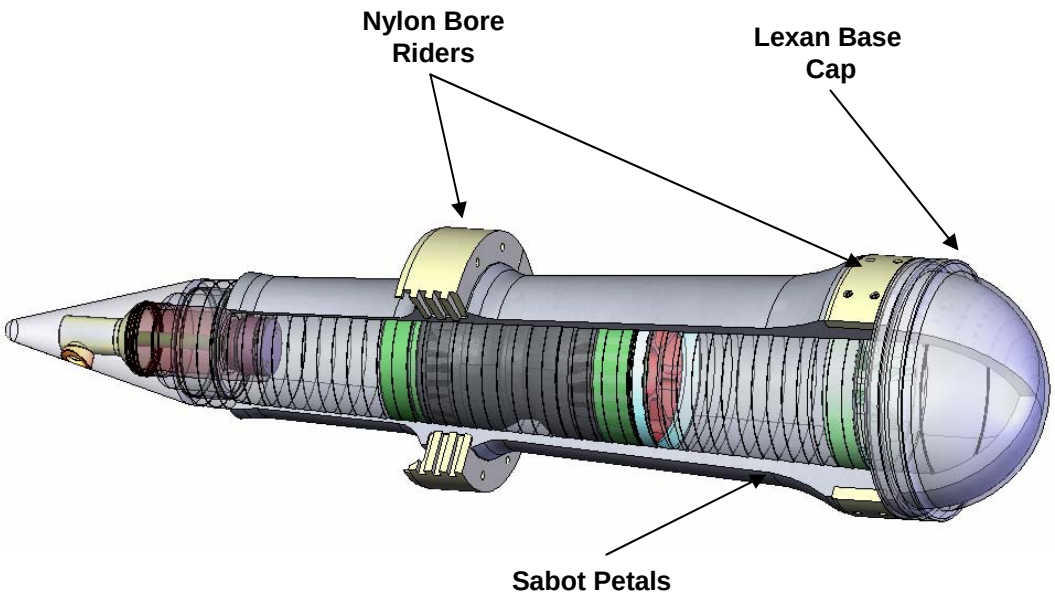
9.4 ksi Max Mises @ 8.0 msec

HIGH FIDELITY PROJECTILE FINAL DESIGN



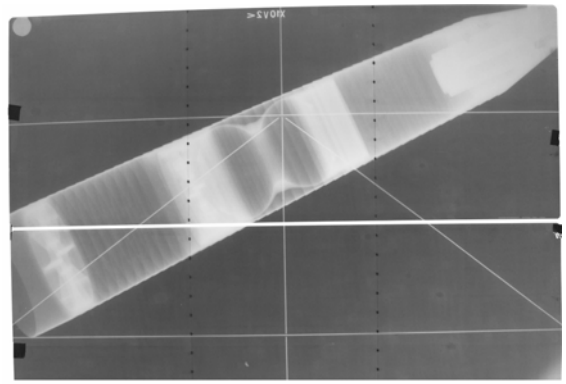
BASIC PROJECTILE DETAILS

- Launch package is 4-petal sabot design
- Lexan base cap
- Separation event achieved in 75’ of flight in blast tank



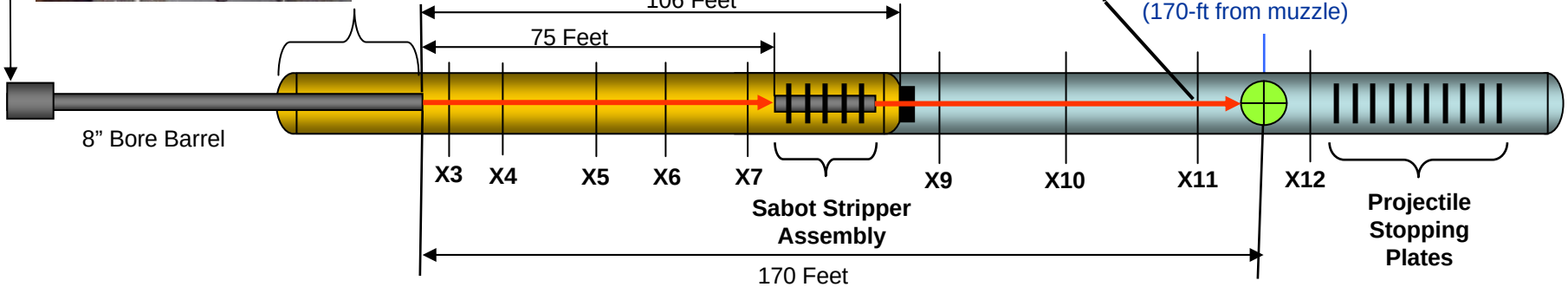
AMRDEC DESIGNED PITCH MOTOR ASSEMBLY

PITCHING PROJECTILE TEST TECHNIQUE



X-ray of projectile prior to impact

X-ray of sabot separation

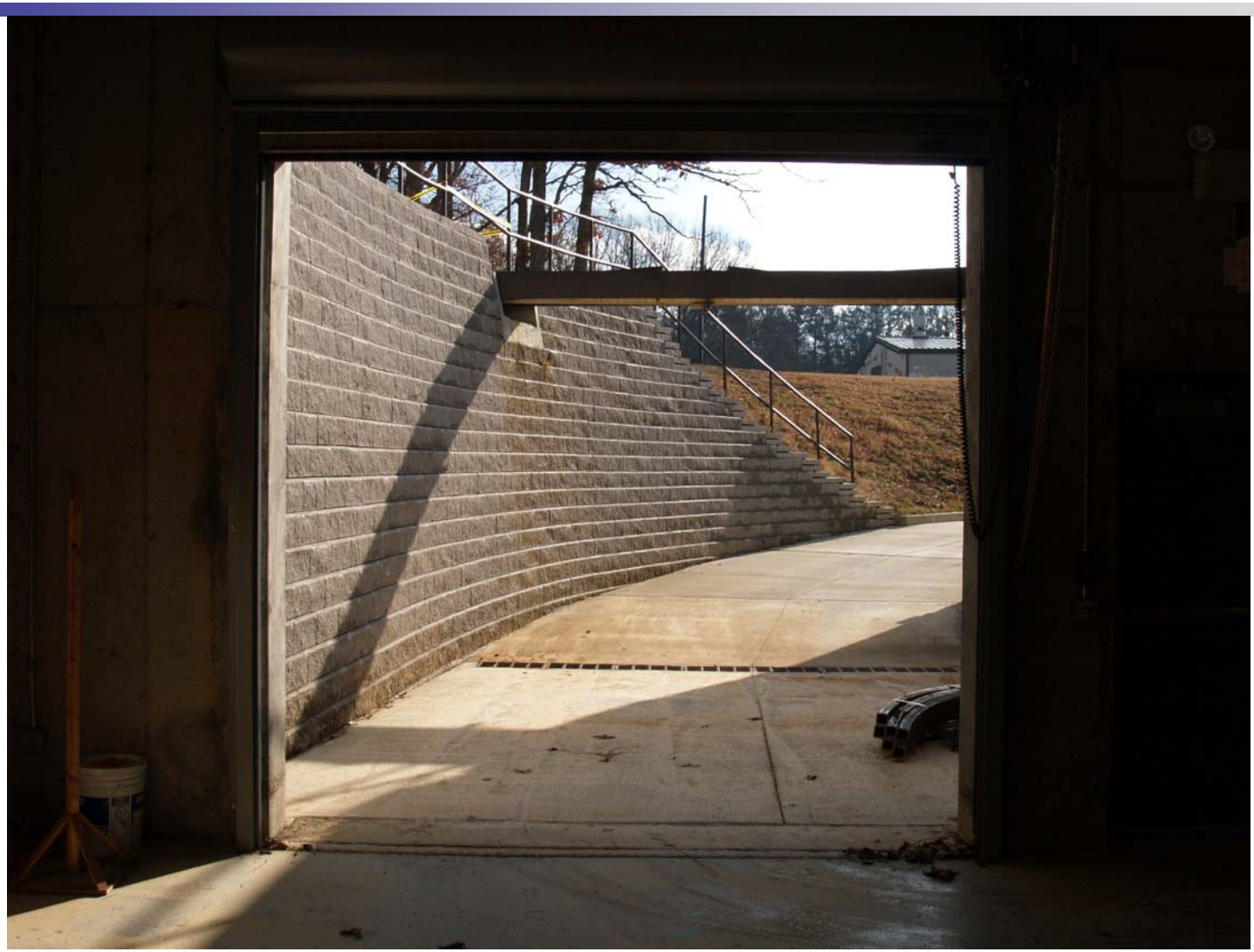


ROOM FOR TARGET AREA ACCESS – SERVICE TUNNEL ADDITION

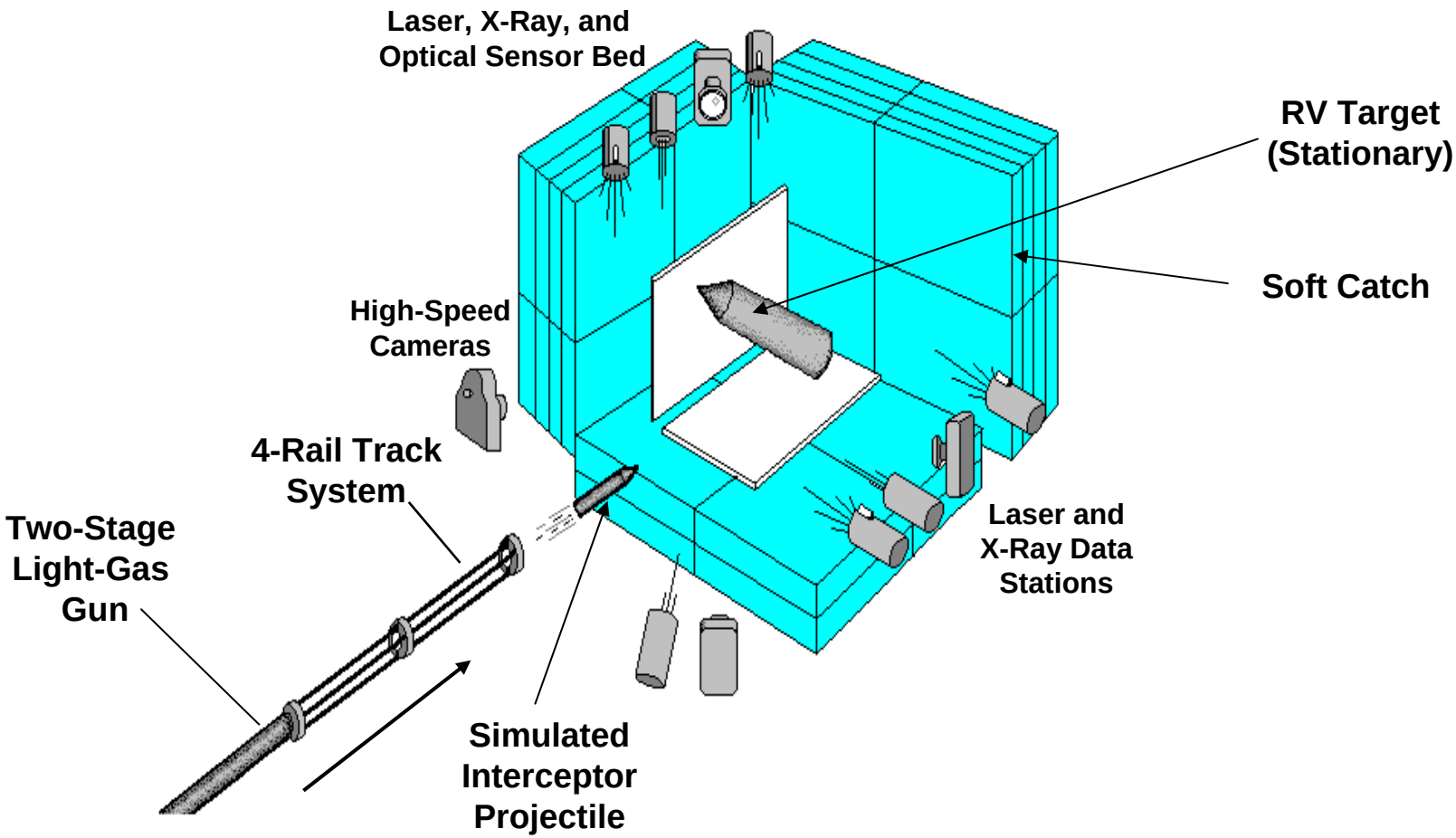
TARGET AREA ACCESS DOOR INSTALLATION

COMPLETED SERVICE TUNNEL UPGRADE

SERVICE TUNNEL UPGRADE
RAMP ADDITION

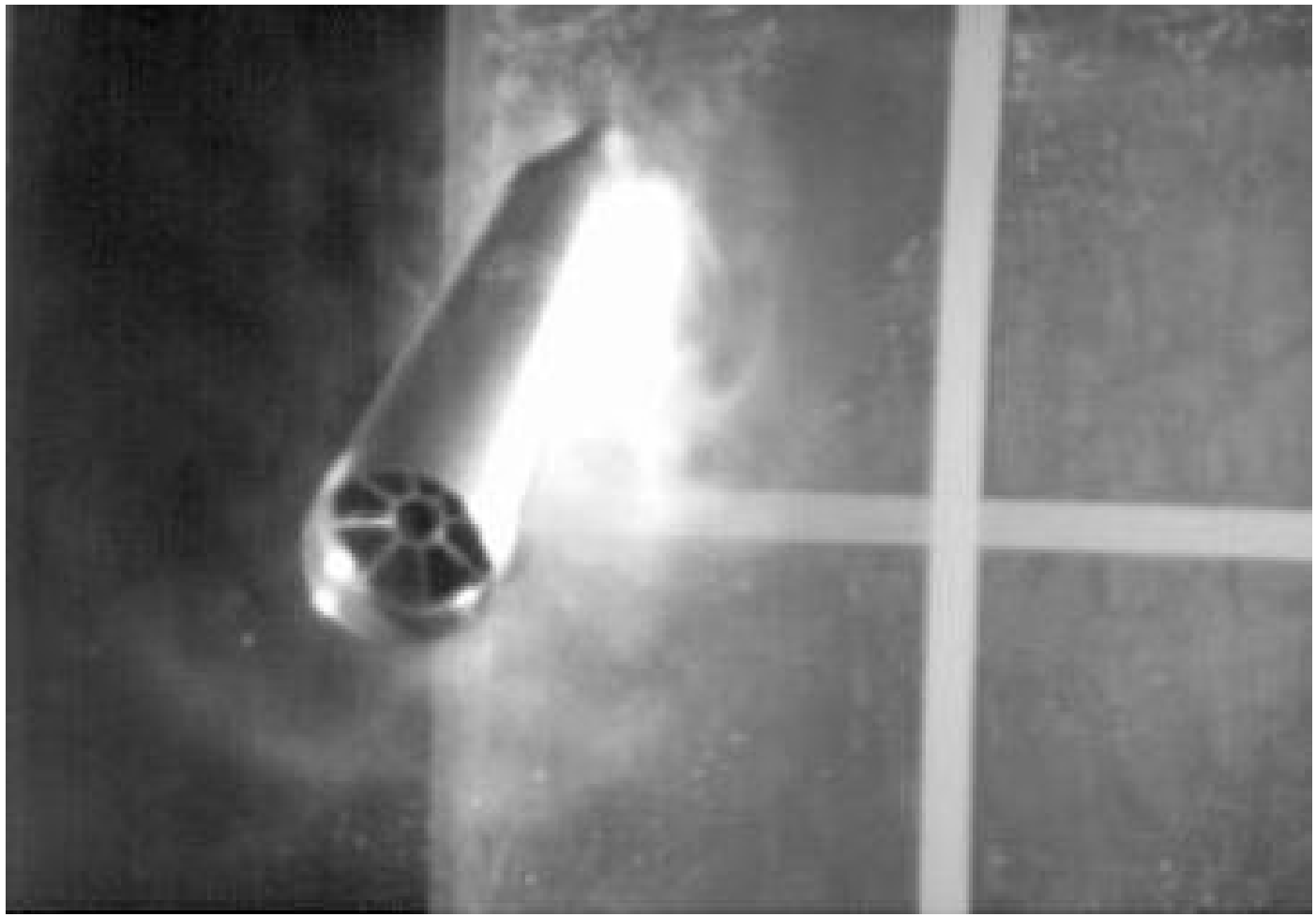


TYPICAL LETHALITY TARGET ARENA



TARGET IMPACT ARENA

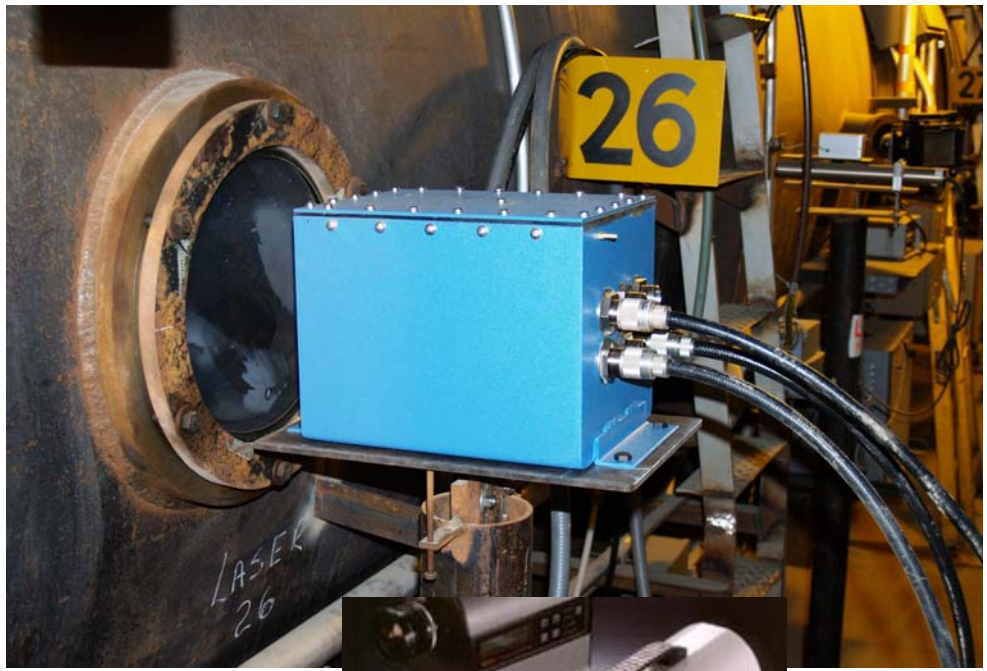
FREE FLIGHT PROJECTILE WITH PITCH MOTOR PRIOR TO IMPACT



IMPROVEMENTS TO RANGE INSTRUMENTATION

- Replacement of film cameras with high speed digital cameras such as Quik-E® single frame and Phantom 7® and Phantom 9® video cameras.
- Replacement of old PDP based computers with modern PC's used to control timing, sequencing, and firing the launcher.
- Obtained commercial VIES systems with three 10 channel pulse generators and 20 four channel delay generators.
- Replacement of old laser detectors along the range with modern systems.
- Inclusion of new X-Ray cinematography system.

X-RAY CINEMATOGRAPHY SYSTEM



SUMMARY

- AEDC has leveraged 44 years of hypervelocity range testing experience and continuous upgrades to build unprecedented capability for evolving test requirements.
- Improvements to range facilities, instrumentation, and operational parameters contributed greatly to enhance the overall testing capabilities.
- In house projectile design and systems operation expertise while partnering with other DOD contractors has achieved the required improvements in lethality testing capabilities for MDA.

CONTACT INFORMATION

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