Sandia National Laboratories Mobile Laser Tracking System Operations and Safety

4th Annual Laser Safety Officer Advanced Training Workshop

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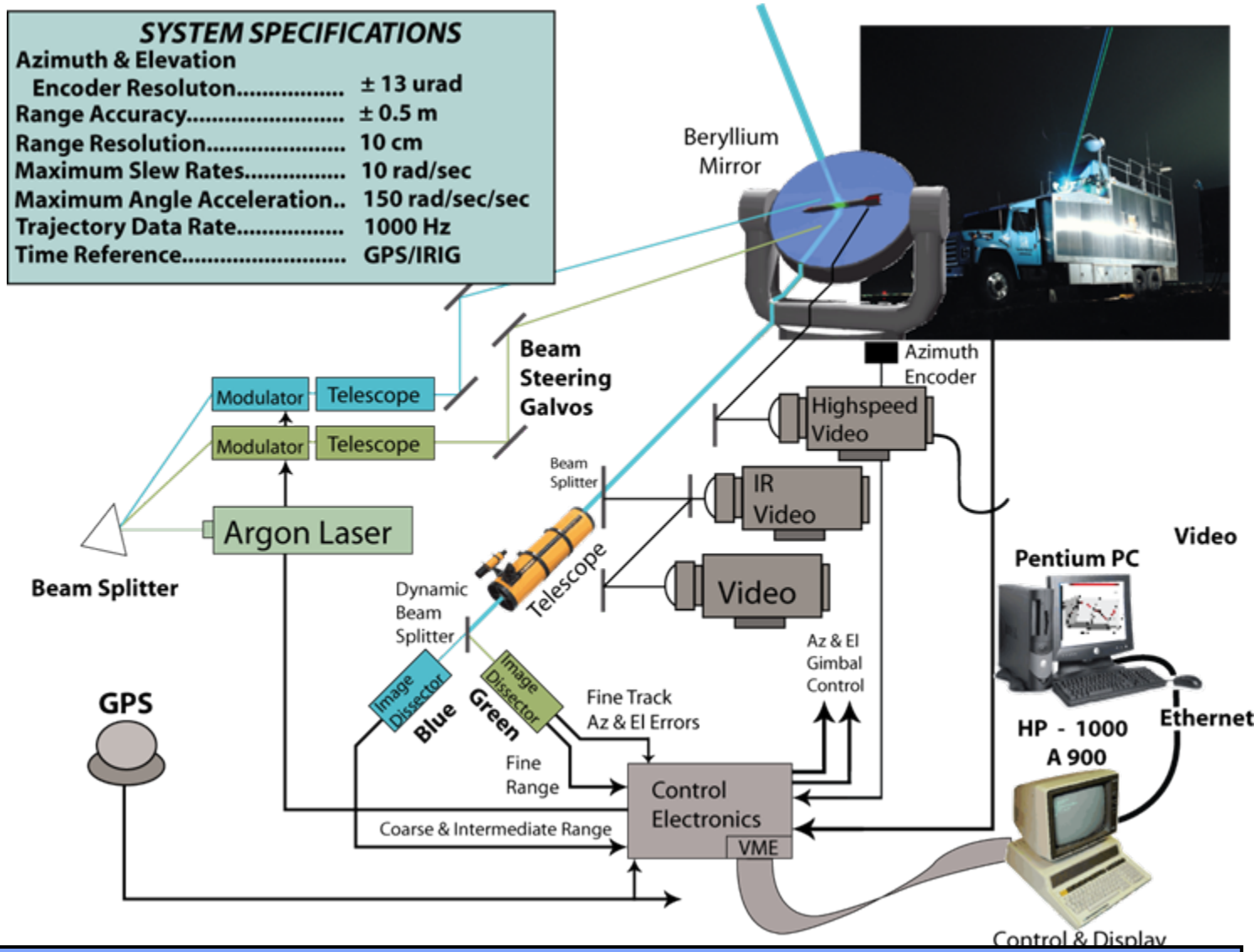
Diagnostic Applications
Engineering Sciences Center

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Outline

- System Overview
- Tracking Applications
- Tracking Operations
  - SNL Operations
  - Off-site Operations
- Safety Issues
  - Hazards
  - Hazard Controls
- Where do we go from here?

Sandia Laser Tracker



Blue beam doubly modulated (312 kHz & 39 kHz - coarse & medium ranging)

Green beam modulated at 5 MHz (fine ranging & tracking)

System Specifications

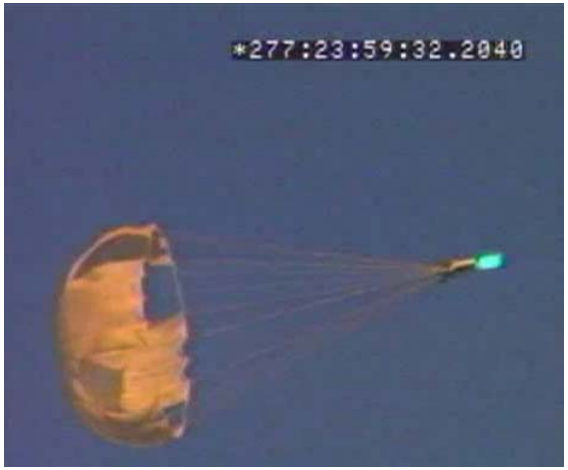
- Laser: Coherent INNOVA I-310 Argon Ion, Class IV, >4 Watts
- Laser Power (at mirror): 0.5 Watts total, 0.3 Watts in Green and 0.2 Watts in Blue
- Modulators:
  - Blue - 39 kHz (coarse ranging),
    312.5 kHz (intermediate ranging)
  - Green - 5 MHz (fine ranging, tracking)
- Gimbaled Mirror: Nickel coated Berylium substrate
- Gimbal Encoders: 18 bit
- IDT's: Photomultiplier tubes, 25kHz scan frequency
- Data Rate: 1 kHz
- Tracking Range: 50,000 ft (theoretical)
- Accuracy: 1-2 ft (practical)
- Divergence Control: 1 mrad to 25 mrad

Tracking Applications

- Missile Tracking / Countermeasure Evaluation
- Rocket Sleds
- Ejector Sleds
- Air-dropped munitions
- Artillery rounds
- Parachute evaluations
- Stereo Tracking Applications (save until the end)

SNL Tracking Operations

- Rocket Sled Tracks
- Aerial Cable Facility
- Field Test



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Off-Site Tracking Operations

- Tonopah Test Range
- WSMR
- Eglin AFB
- Holloman AFB
- Hurricane Mesa
- Others

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Laser Tracker Hazards

- Optical Hazards
  - Lasers (Class IV)
    - Beam Divergence
      - Gain control feature for laser beam
      - Automatic and manual capabilities
- Electrical Hazards
  - High and low voltage
  - RF communication hazards (antennas)
- Mechanical Hazards
  - Gimbal movements, etc.
  - Motorized optics

Hazard Controls

- NOHD Calculations
  - LAZAN – NOHD on the order of a few hundred feet
  - Worst case beam divergence considered
  - Startle hazard a consideration for controlled airspace operations
- Engineering Controls
  - Laser Shields
  - PPE (laser safety eyewear for alignment, etc)
- Administrative Control
  - Standard Operating Procedures
  - Training
  - Exclusion Zones
  - Horizontal Beam Path Operations (most of SNL operations)
  - Controlled Airspace Operations (Military, FAA)
  - Notifications (Onsite-FAA, KAFB; Offsite-Range Owners)

Where Do We Go From Here?

- Stereo Tracking Applications
- Atmospheric Mitigation
- Eye-Safe Ranging Systems
- Extreme Long-Range Tracking
- Uncooperative Tracking

Stereo Tracking Applications
Measuring Missile Motion

Moving FOV DIC

Uncertainty Analysis

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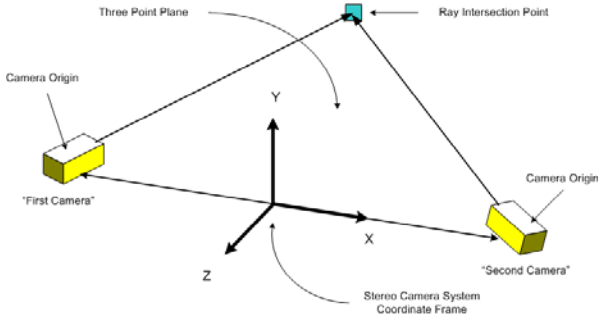
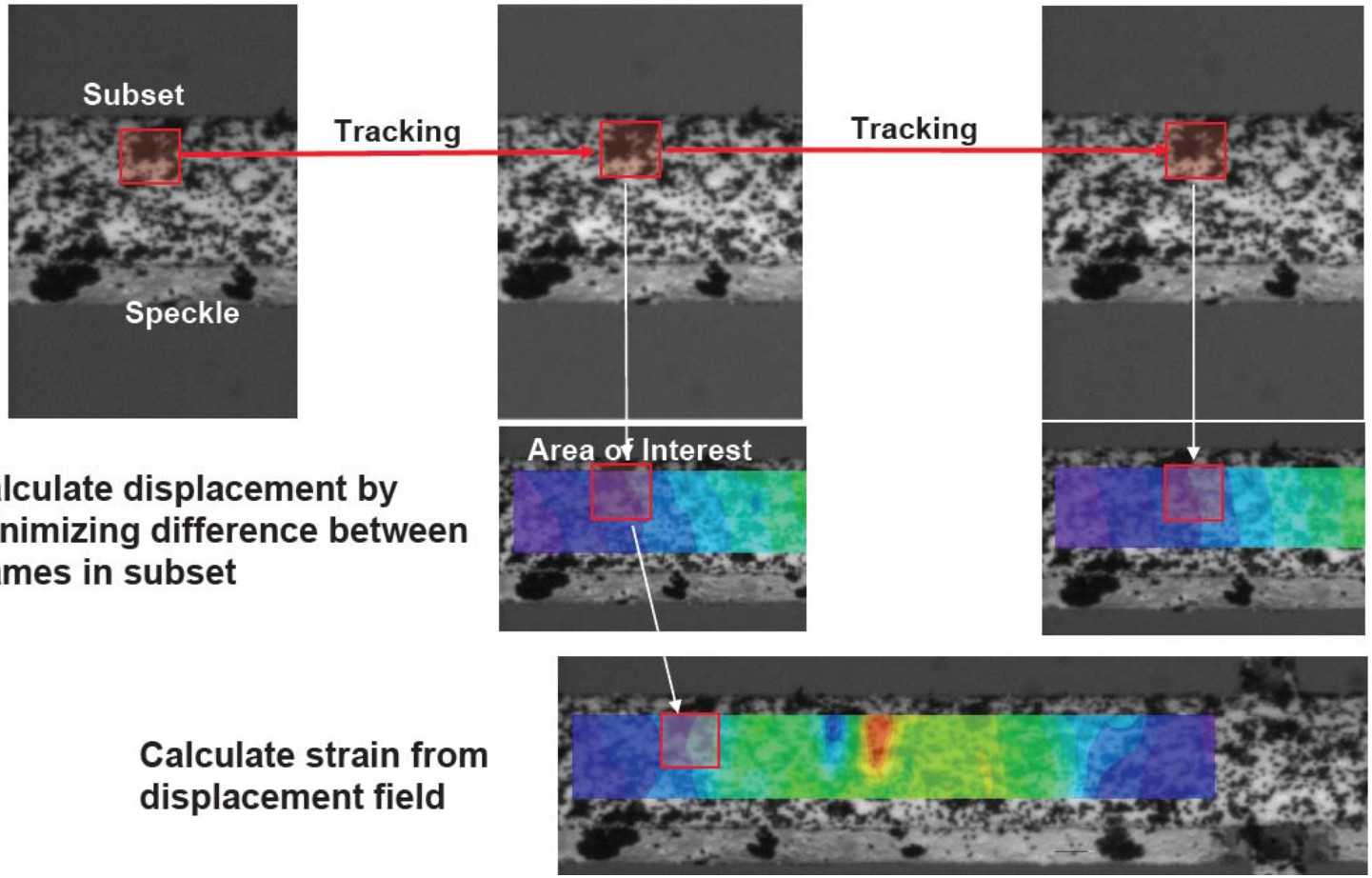
What is DIC?





Calculate displacement by minimizing difference between frames in subset

Calculate strain from displacement field

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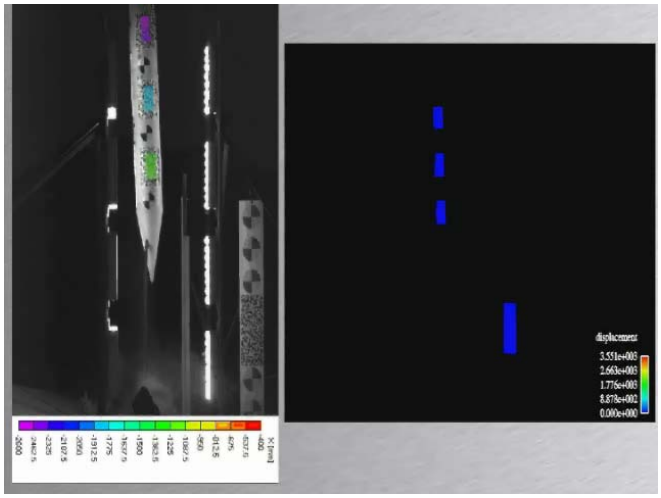
Medium Speed DIC Example



- **Typical Correlation Accuracy**
- **Out-of-plane resolution**
  1/100th to 1/50th of a pixel
- **In-plane resolution**
- **1/200th to 1/100th of a pixel**

Speckle Measured Velocity: 724.96 ft/s

95% Confidence Interval: 0.87 ft/s

- Typical TrackEye measurement accuracies (95% confidence interval):
  - Angle of impact and angle of attack uncertainty of 0.1-0.25 degrees.
  - Rotation rates uncertainty from 0.05-0.3 degrees/second.
  - Velocity uncertainties on order of 1.0% of the measured velocity.

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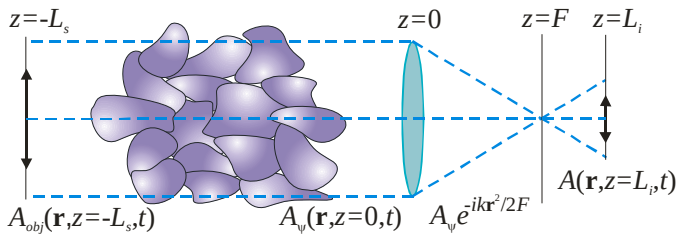
Discovery at the Interface of Science and Engineering: **Science Matters!**

Atmospheric Simulation: Laser Propagation and Imaging Through Turbulence and Aerosols

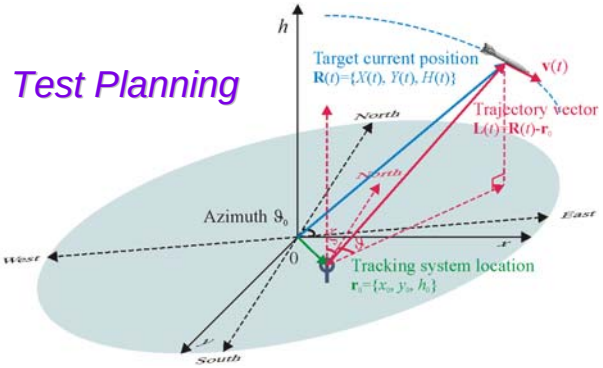
High fidelity software simulates high-speed target tracking through the atmosphere.

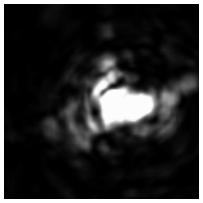
- ***Simulation for test planning, analysis algorithm development, and mitigation system & laser tracking system design.***
- ***Incorporates atmospheric effects that impact system performance, including molecular and aerosol absorption & scattering, enhanced backscatter, turbulence beam spread, and atmospheric refraction.***
- ***Models laser-target interaction for retro-reflective tape, rough surfaces, or single retro-reflector.***
- ***Generates performance values and simulated laser beam & scene imagery (images and movies).***
- ***Models source to target, interaction (scattering & reflection), and back propagation to detector.***
- ***Runs on personal computer (graphical user interface).***



Physics-Based Algorithms

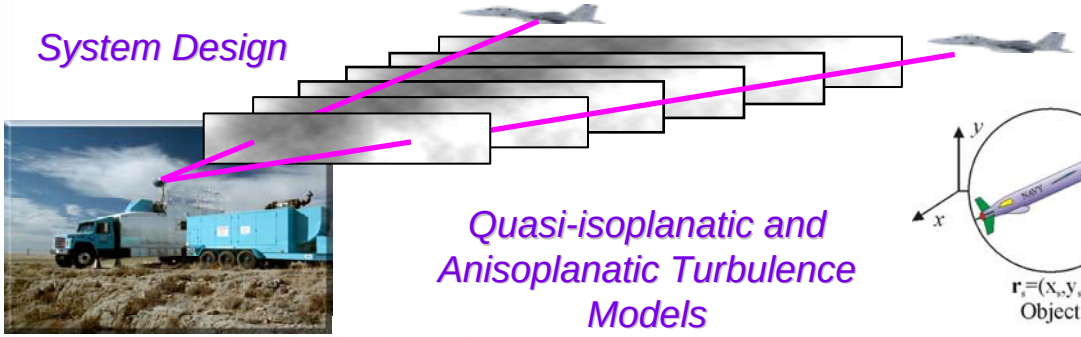
Test Planning





Laser Simulation

System Design



Quasi-isoplanatic and Anisoplanatic Turbulence Models

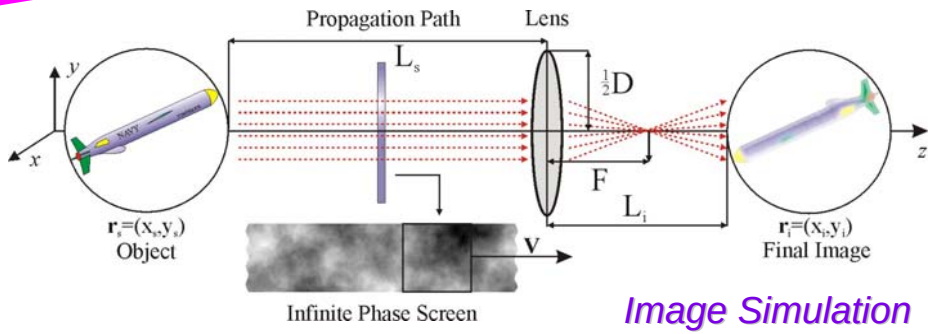


Image Simulation

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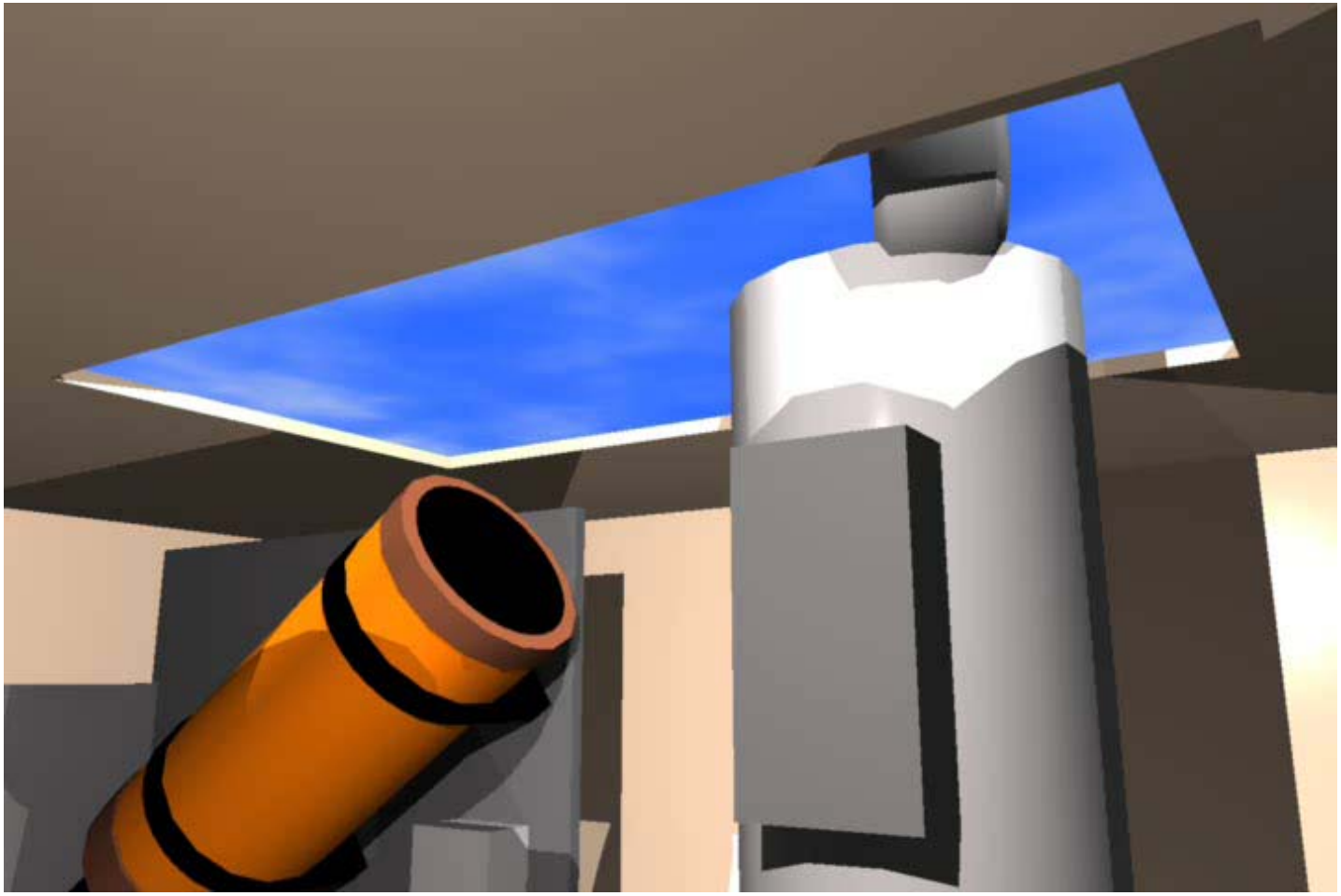
Advanced Ranging

- Developing an advanced pulsed laser ranging systems that is eye safe.



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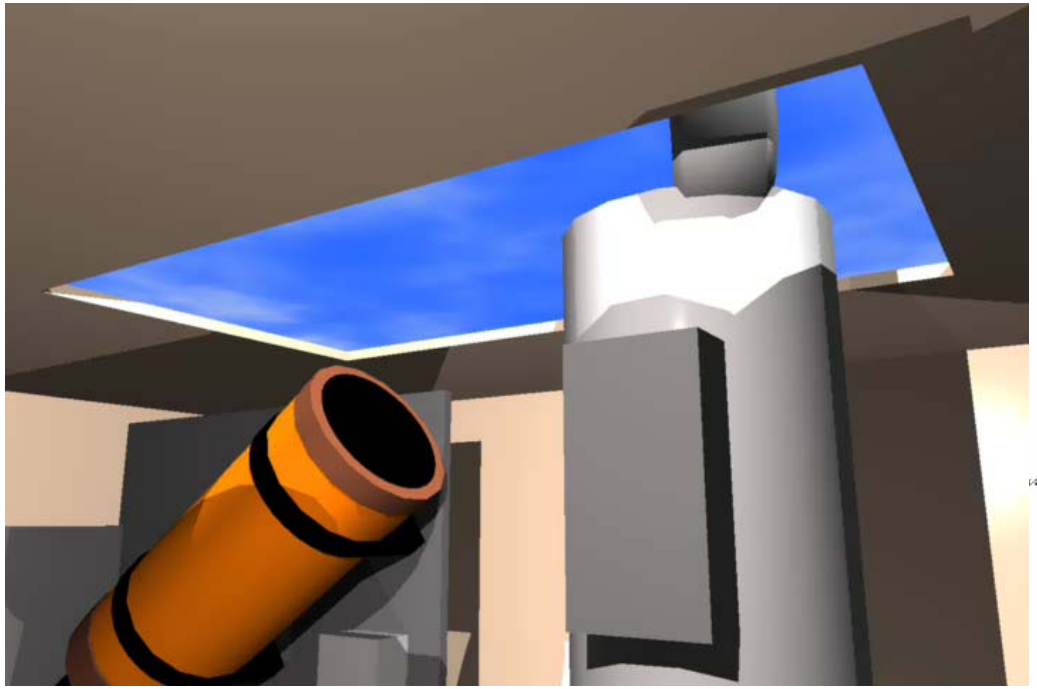
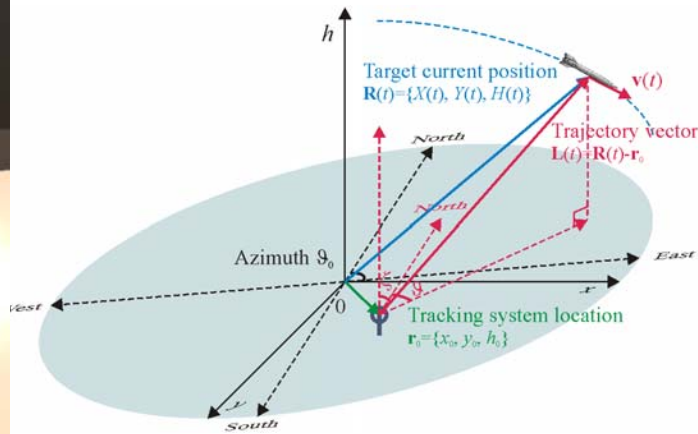
Advanced Tracking – Uncooperative Targets

- Current customers do not like us adding retro-reflectors or retro-tape to their test articles.
- Missile jamming tests are problematic because of retro acceptance angles.
- Need uncooperative tracking methods other than radar.





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