Boost-phase Missile Defense: the Airborne Laser

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Institute for Peace Research and Security Policy
at the University of Hamburg (IFSH)

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The Institute for Peace Research and Security Policy is an independent research institute at Hamburg University

Groups:

-Centre for OSCE Research

-Centre for European Peace and Security Studies

-Interdisciplinary Research Group on Disarmament, Arms Control and Risk Technologies

Introduction

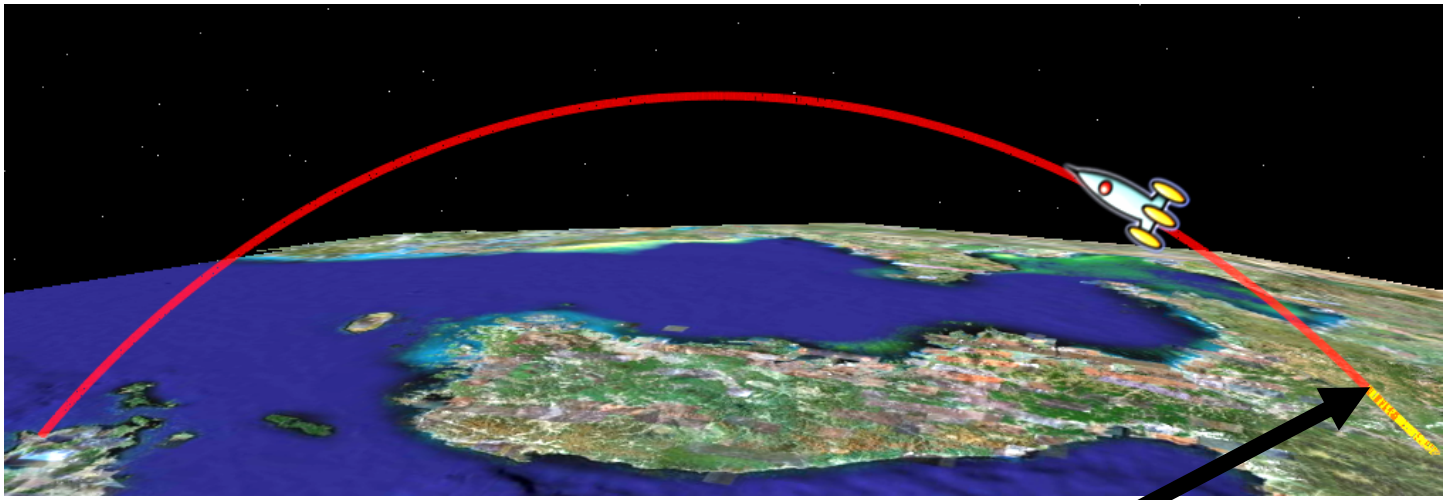
Assessment of the ABL‘s capabilities

Example of an ABL engagement

Summary

Introduction

Boost-phase missile defense takes place in the first few minutes of a missile's flight



Trajectory calculated by Geoffrey Forden's GUI_Missile_Flyout, graphics by GoogleEarth

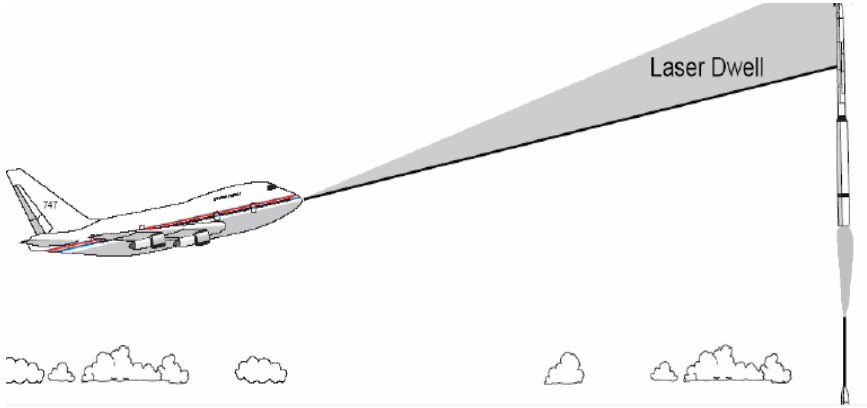
Source: Arianespace

end of boost-phase

Differences to missile defense during mid-course flight:

- simplified tracking
- shorter engagement time

The Airborne Laser (ABL) program is a US plan to use an airplane-based High-Energy Laser for missile defense



source: GAO NSIA-99-50

basic ABL facts

- task: boost-phase missile defense with high-energy laser

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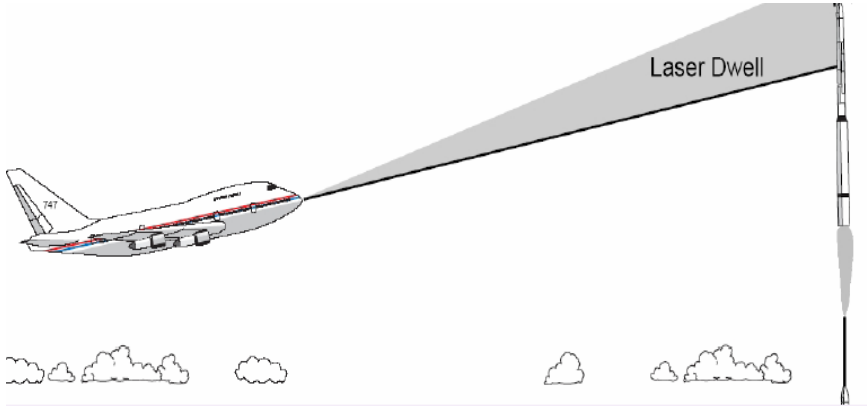

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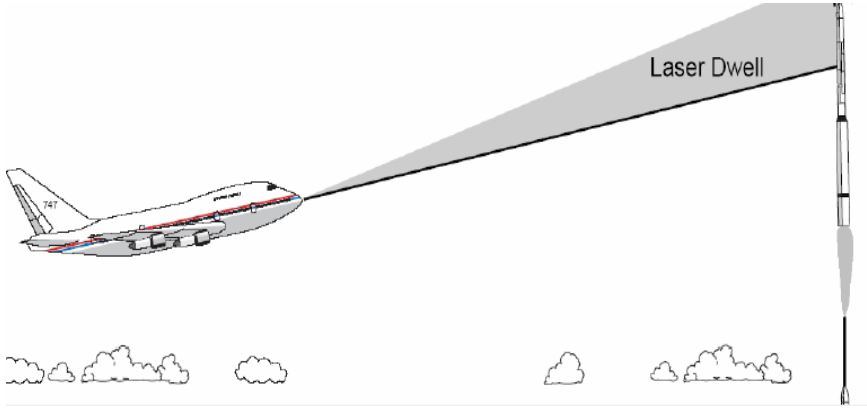

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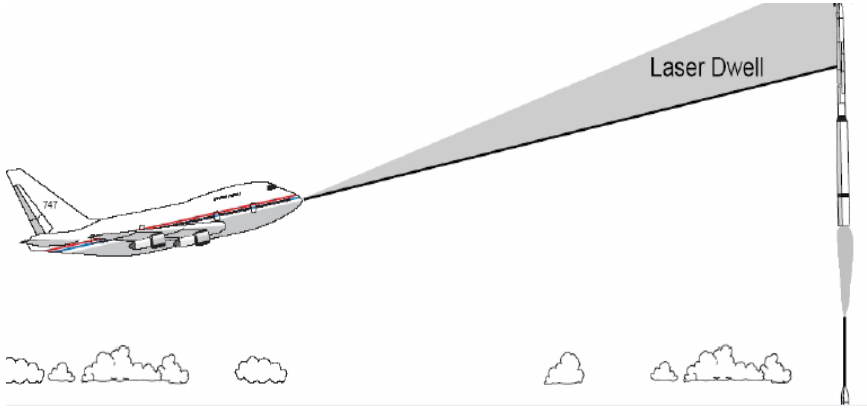

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basic ABL facts

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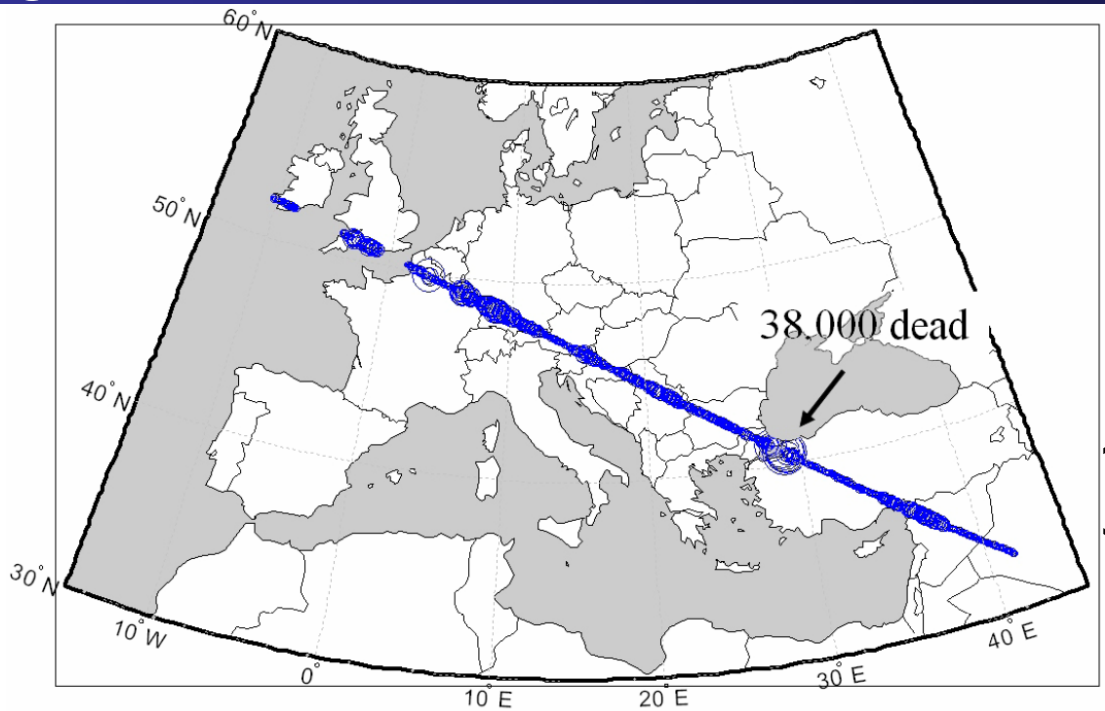
- since 1998 4.3 billion US$ have been spent
- schedule is seven years delayed
- status: integration of actual high-energy laser started, budget for 2008 in negotiation

This talk focuses on research looking into the problem of „short“-falling war heads



Source: G. Forden (MIT)

Short-fall problem

- Missile warhead will not be destroyed, only the booster

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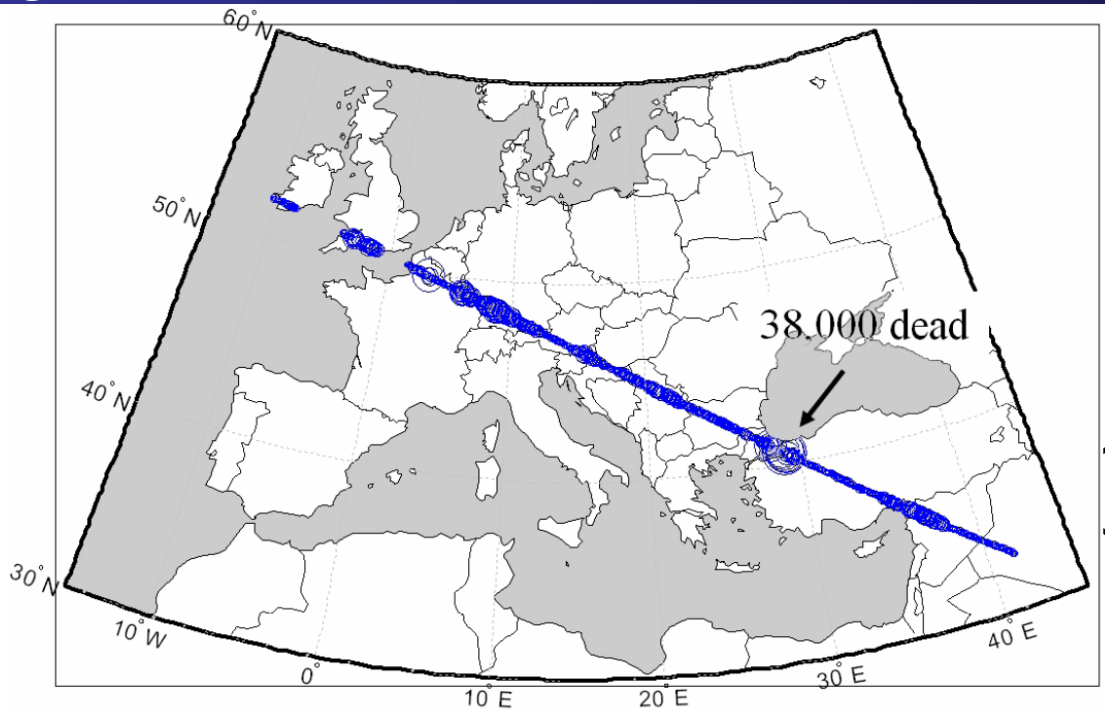

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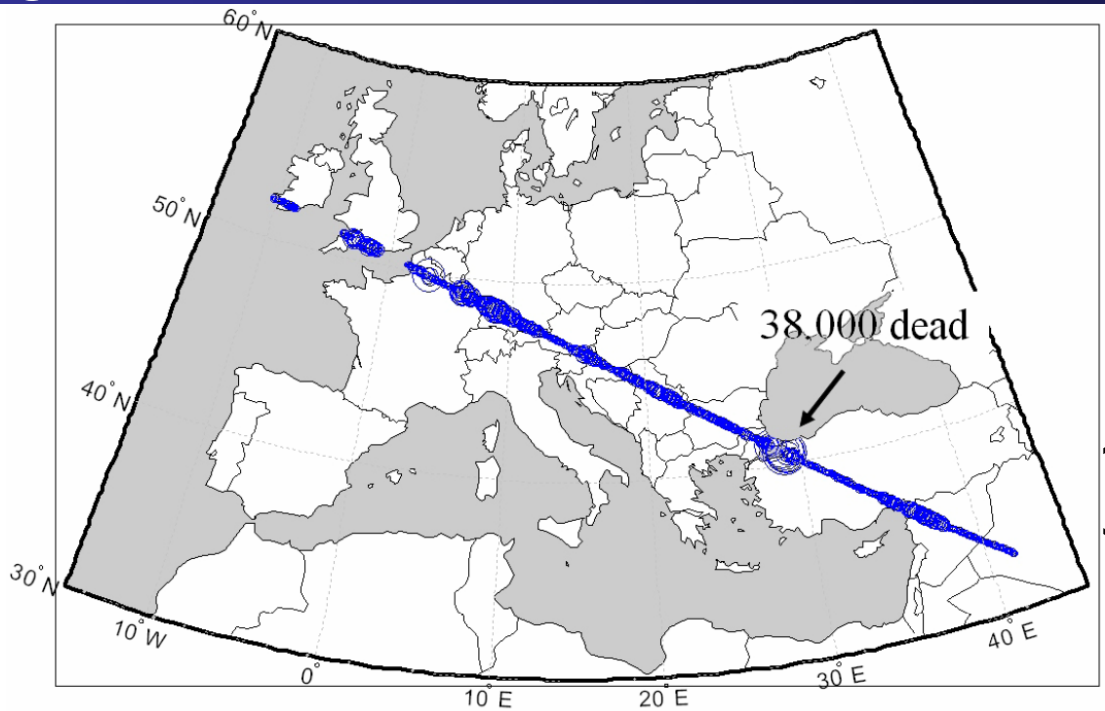

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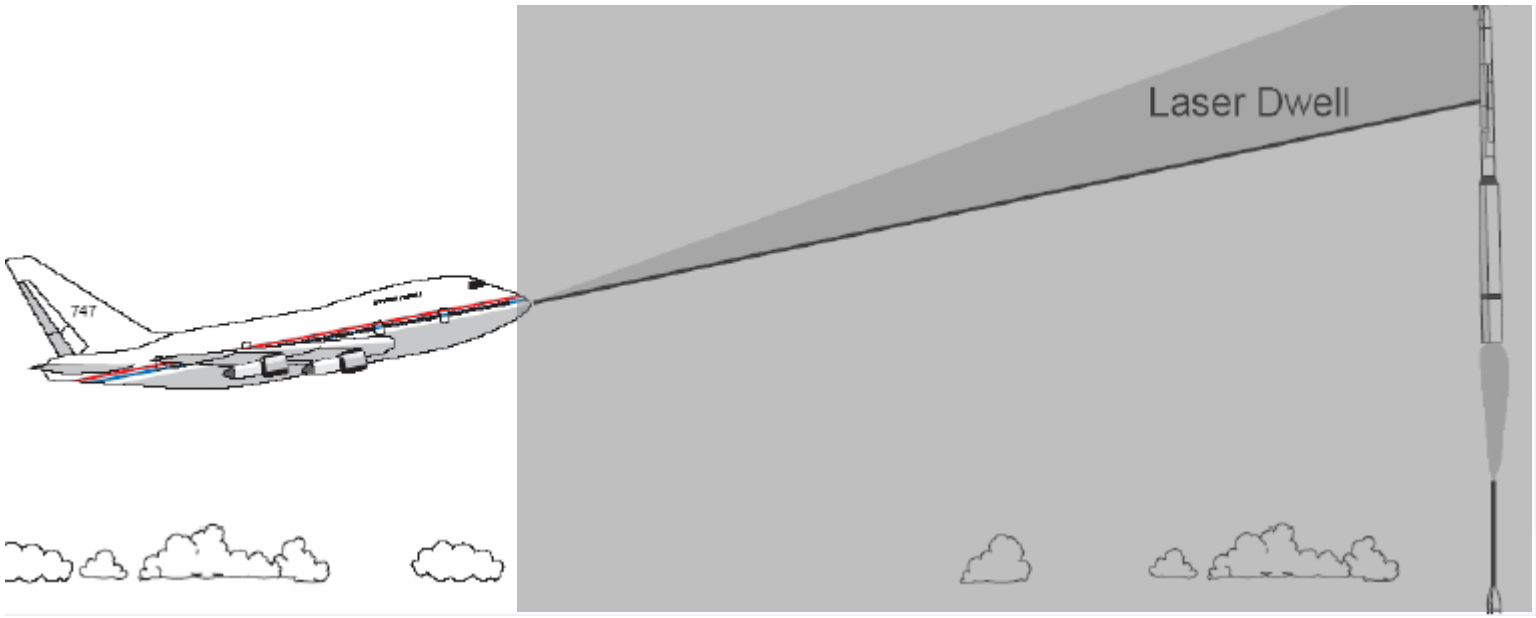
Short-fall problem

- Missile warhead will not be destroyed, only the booster
- Surviving warheads dangerous for third parties
- „successful engagement“: the warhead does not reach its intended target

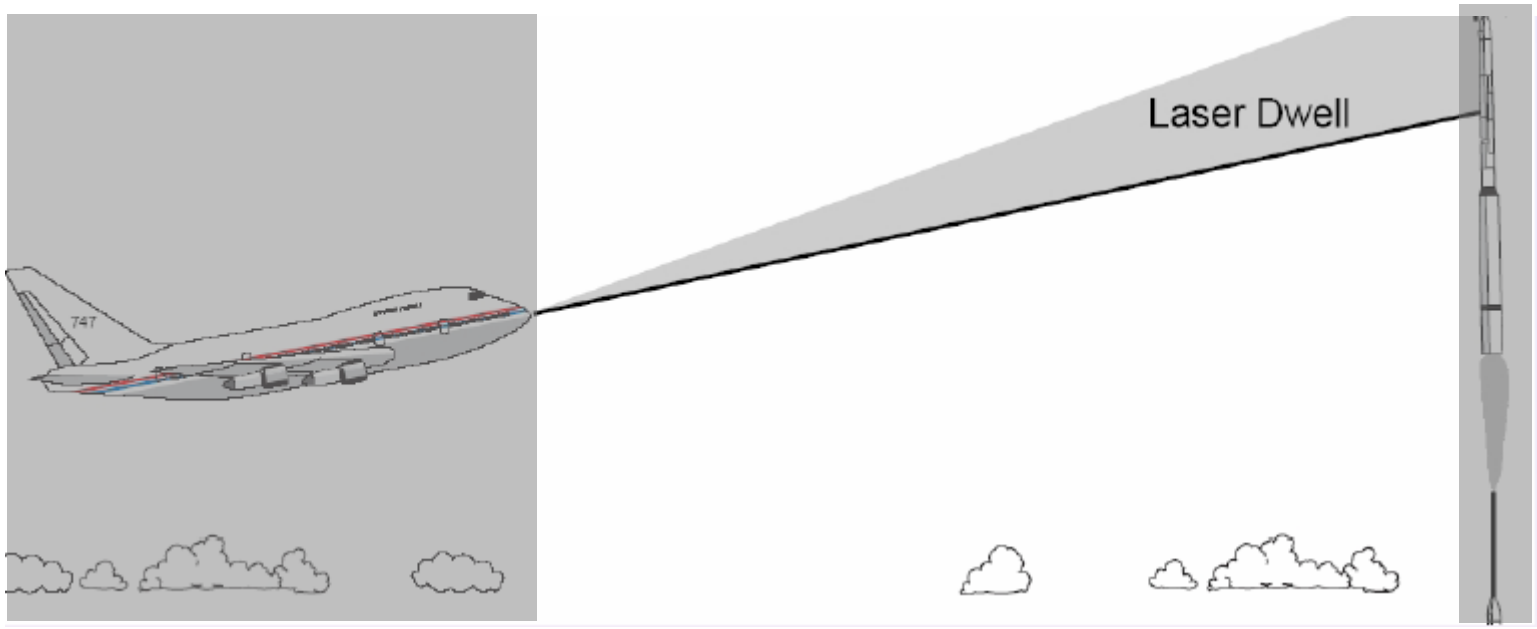
Assessment of the ABL‘s capabilities

Assessment follows the way of the beam



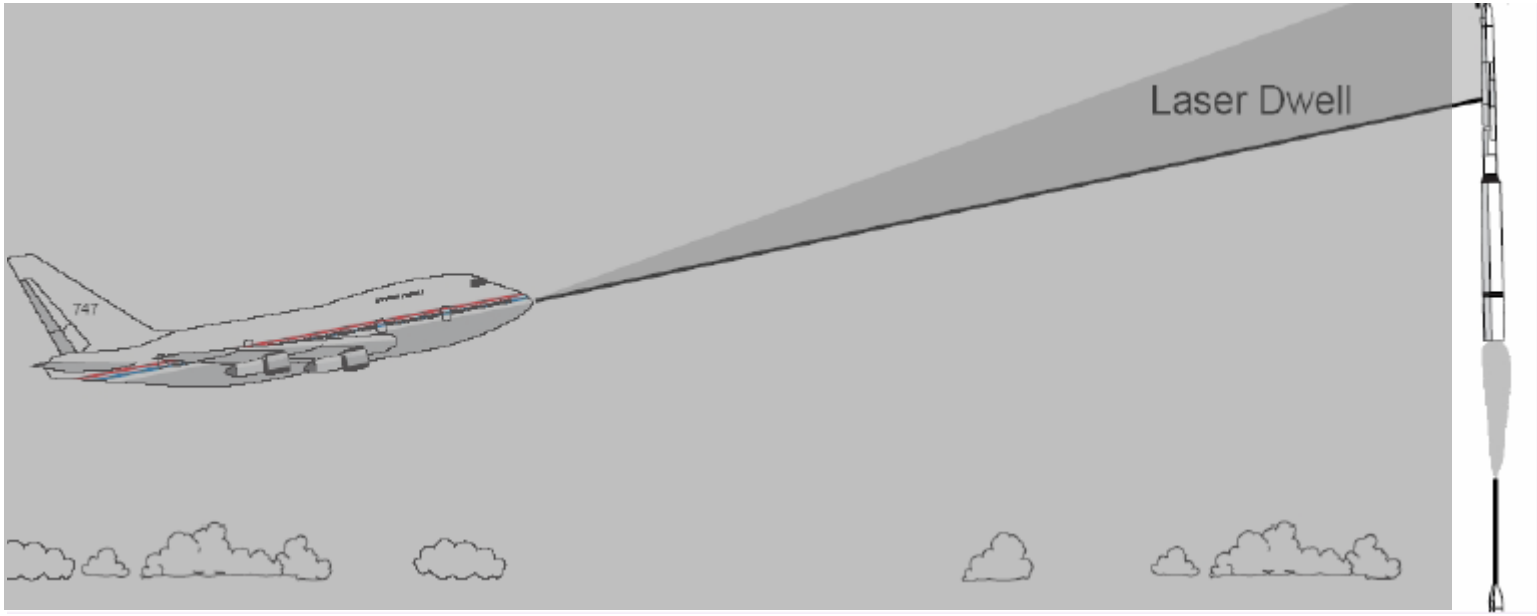
1. laser source

Assessment follows the way of the beam



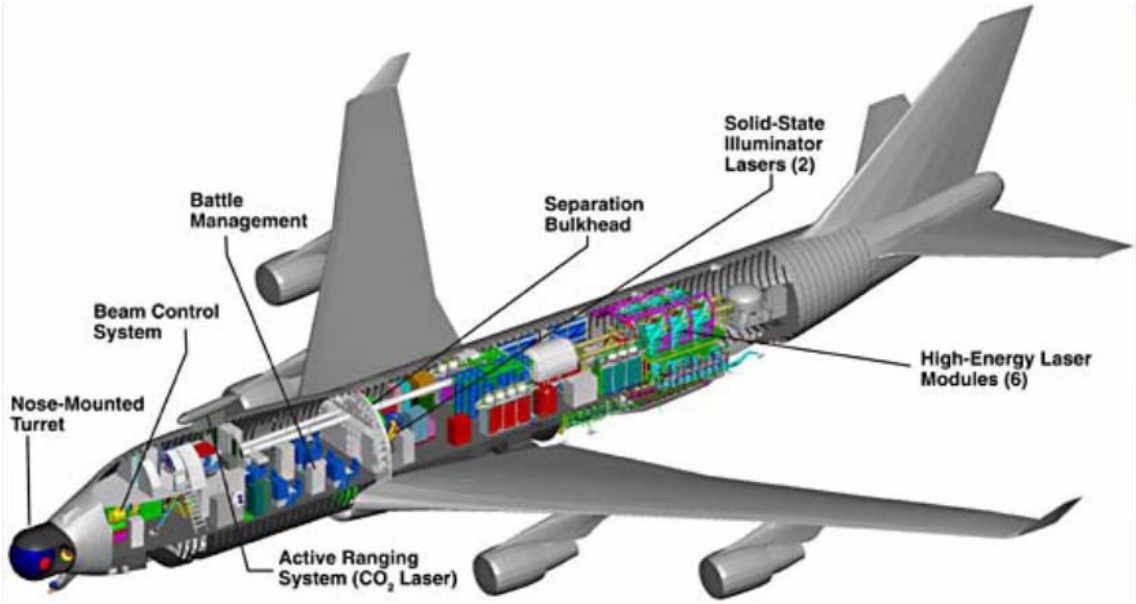
1. laser source
2. Incoming intensity: the path between source and target

Assessment follows the way of the beam



1. laser source
2. incoming intensity: the path between source and target
3. effects on the target

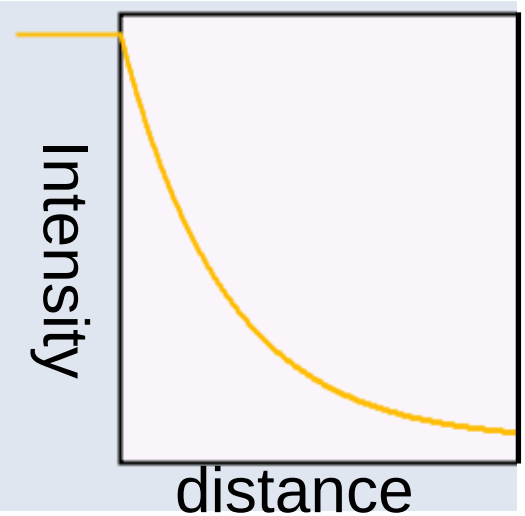
1. Source: This research assumes that the ABL is working within published specifications



ABL subsystems

- High Energy Laser (ca. 3 Megawatts continuous power)
- Nose-mounted turret (1.5m diameter mirror)
- Sensor and Adaptive Optics system

2. Intensity: Absorption reduces incoming total power



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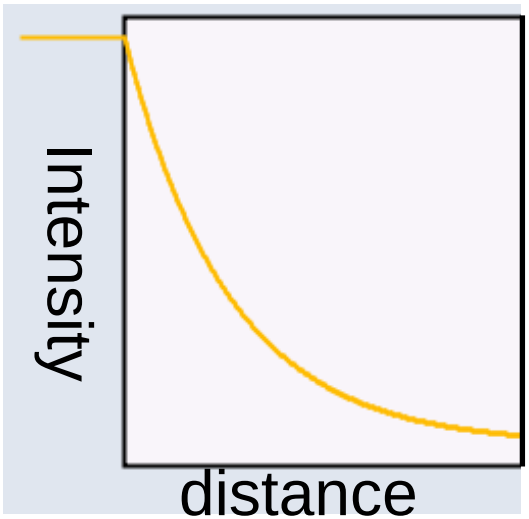
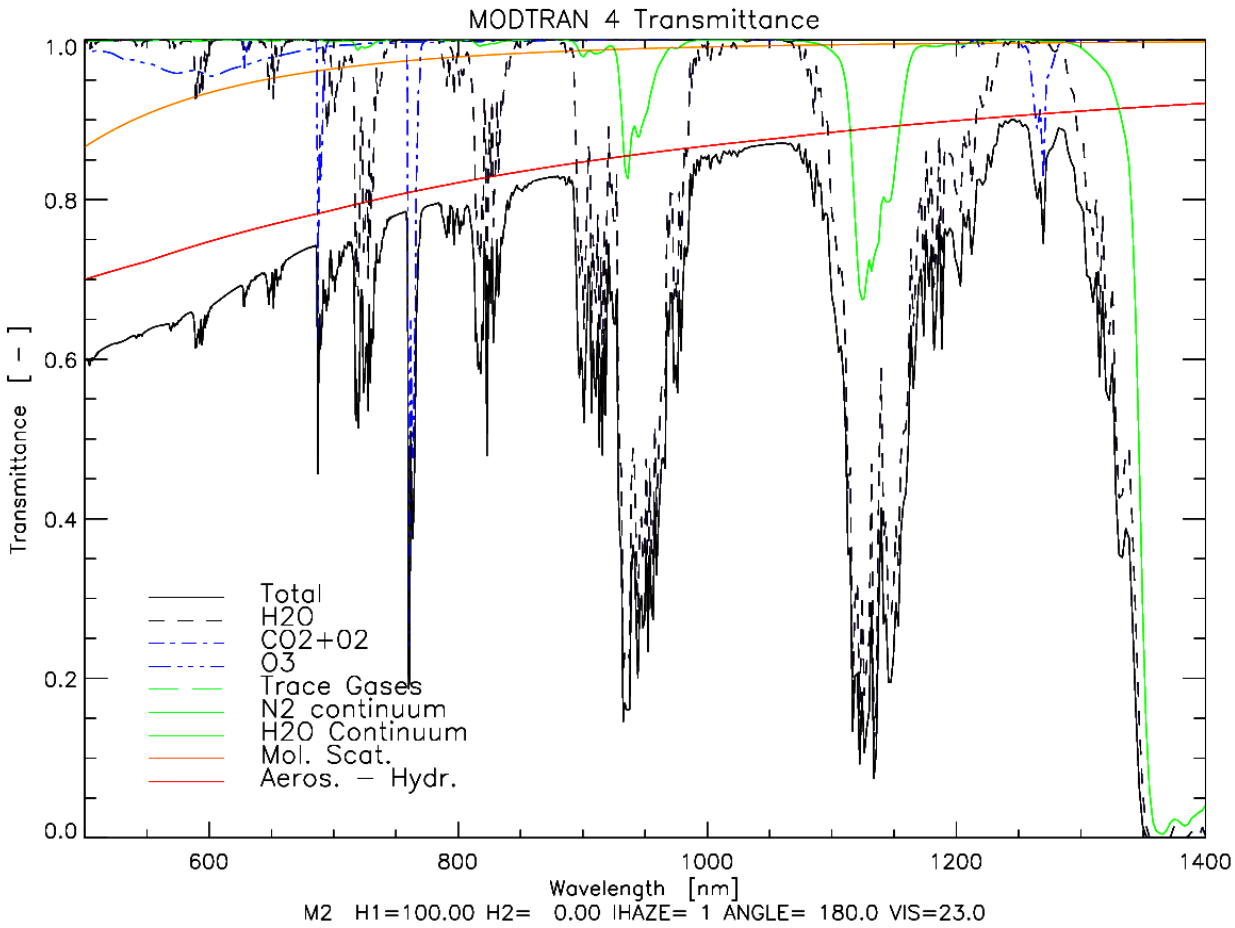
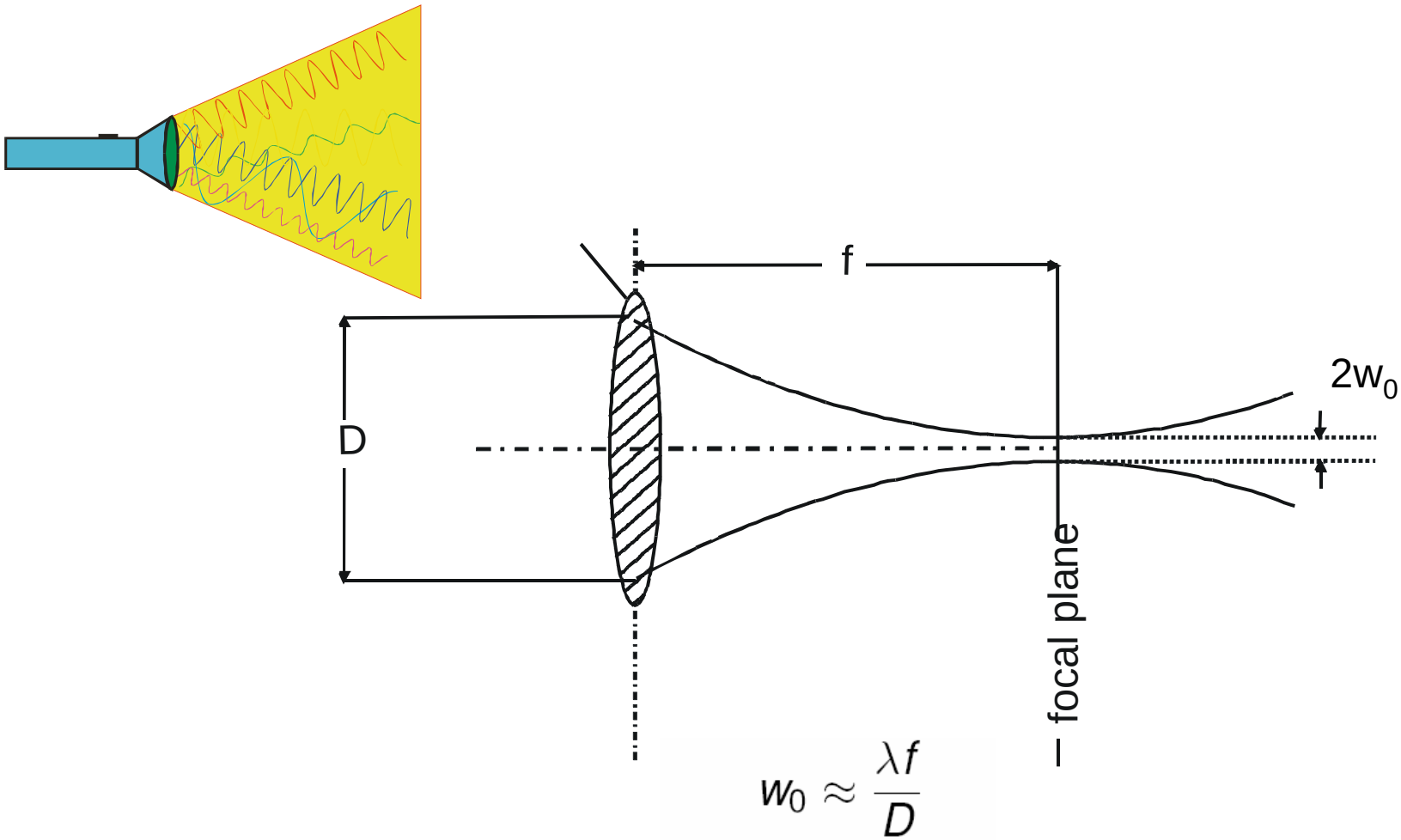




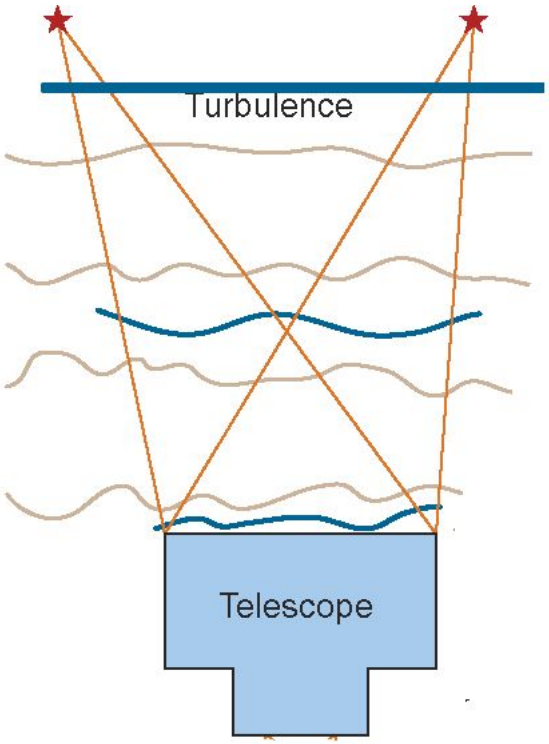
A standard computer code has been used to calculate absorption (MODTRANS).

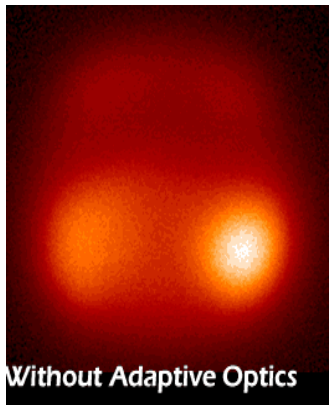
2. Intensity: Diffraction increases beam width



ABL mirror diameter D determines minimal beam diameter w_0

2. Intensity: Atmospheric Turbulence increases beam width





Source: http://www.ucolick.org/~max/289C/neptune.gif

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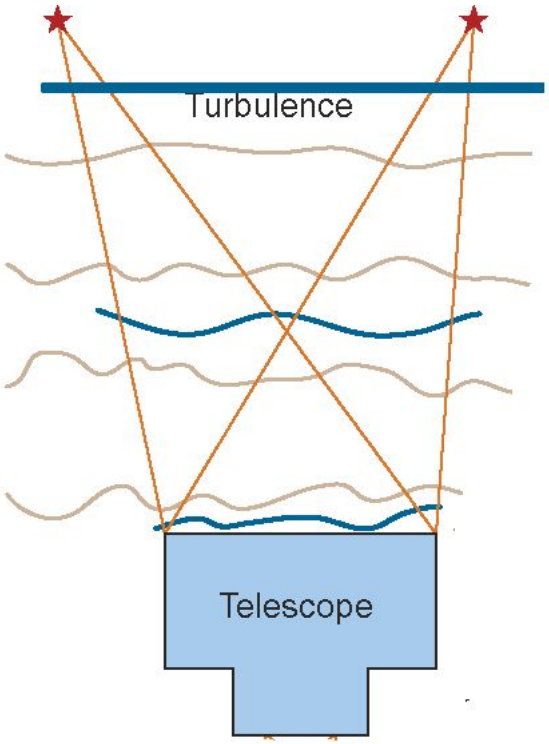

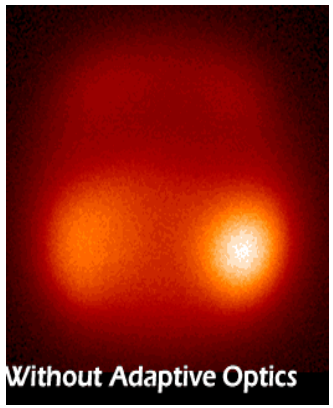

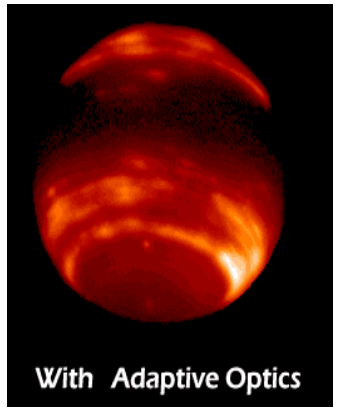

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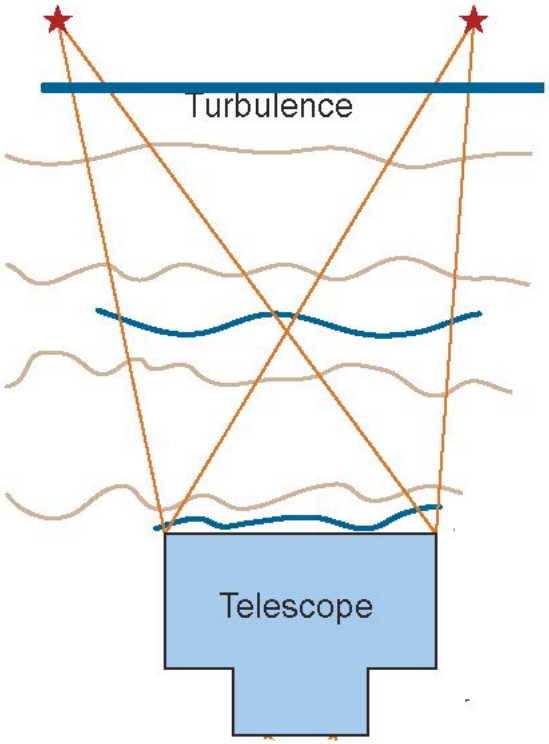

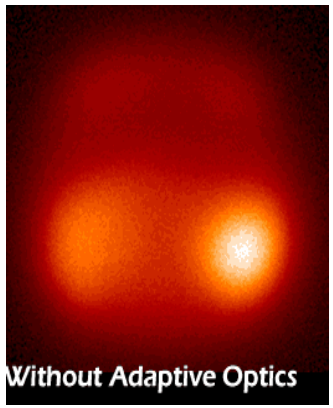

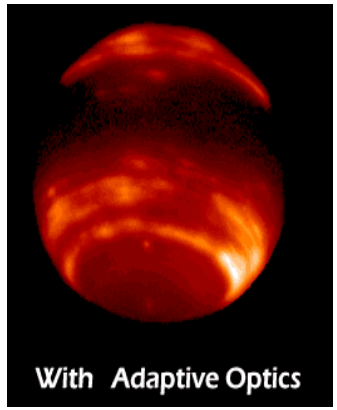

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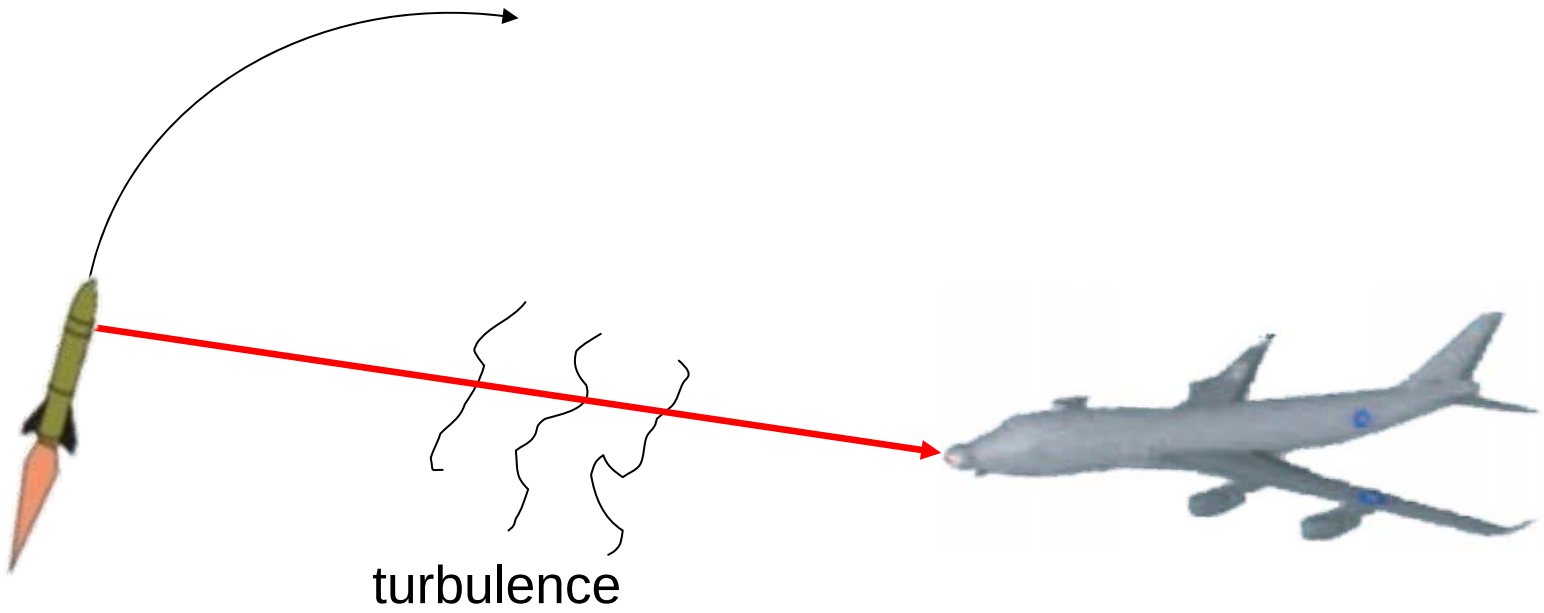
ABL‘s adaptive optics specifications have been used to calculate beam diameter

2. Intensity: Finite speed of light limits adaptive optics performance



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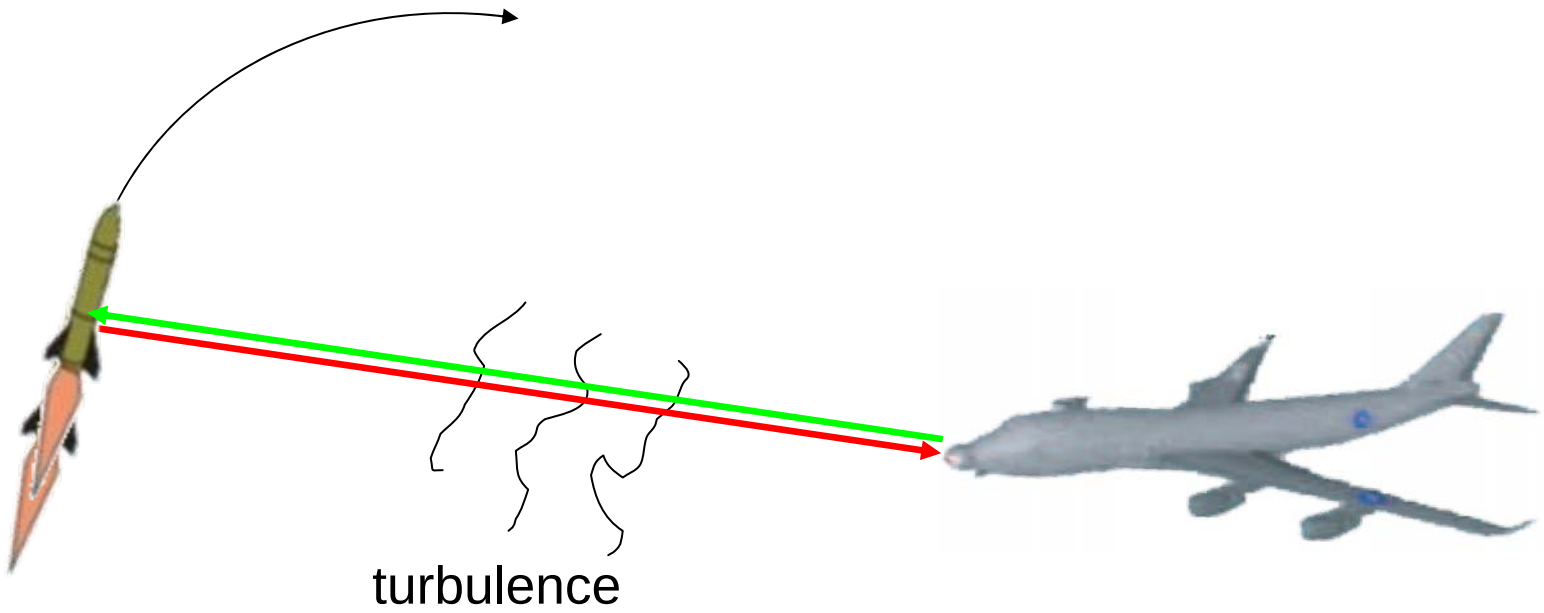

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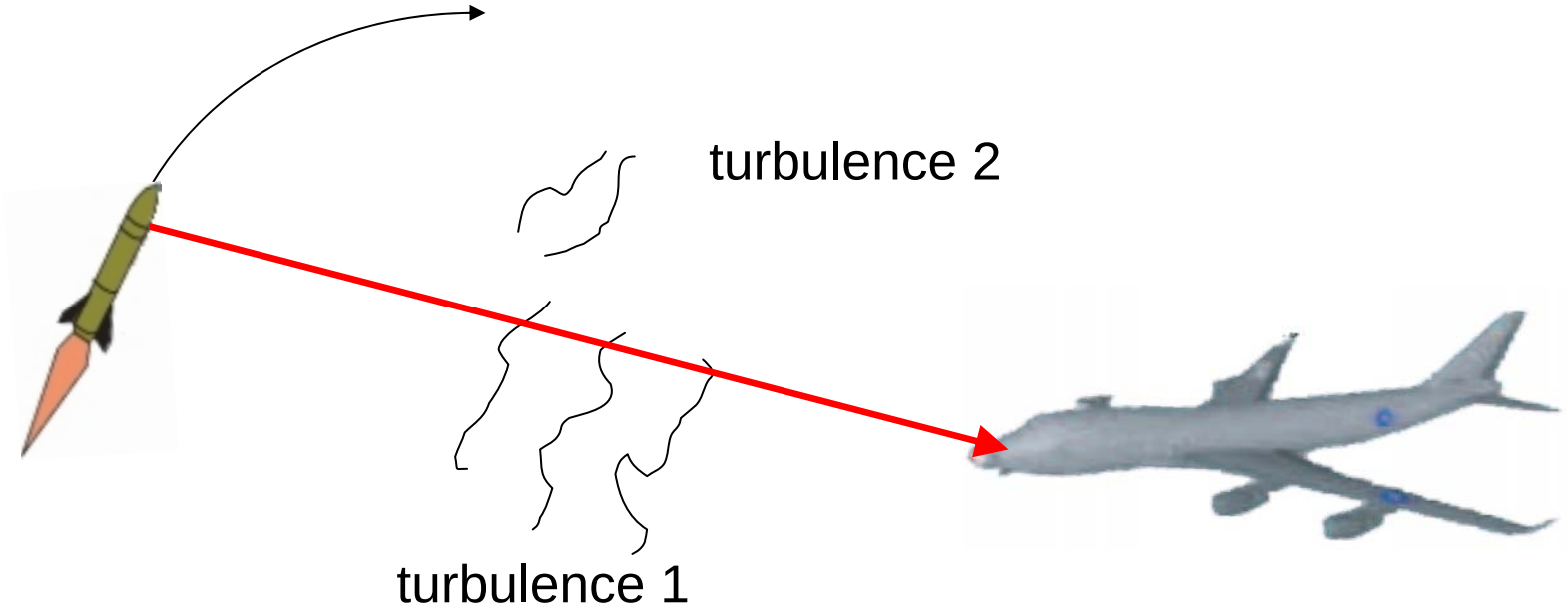

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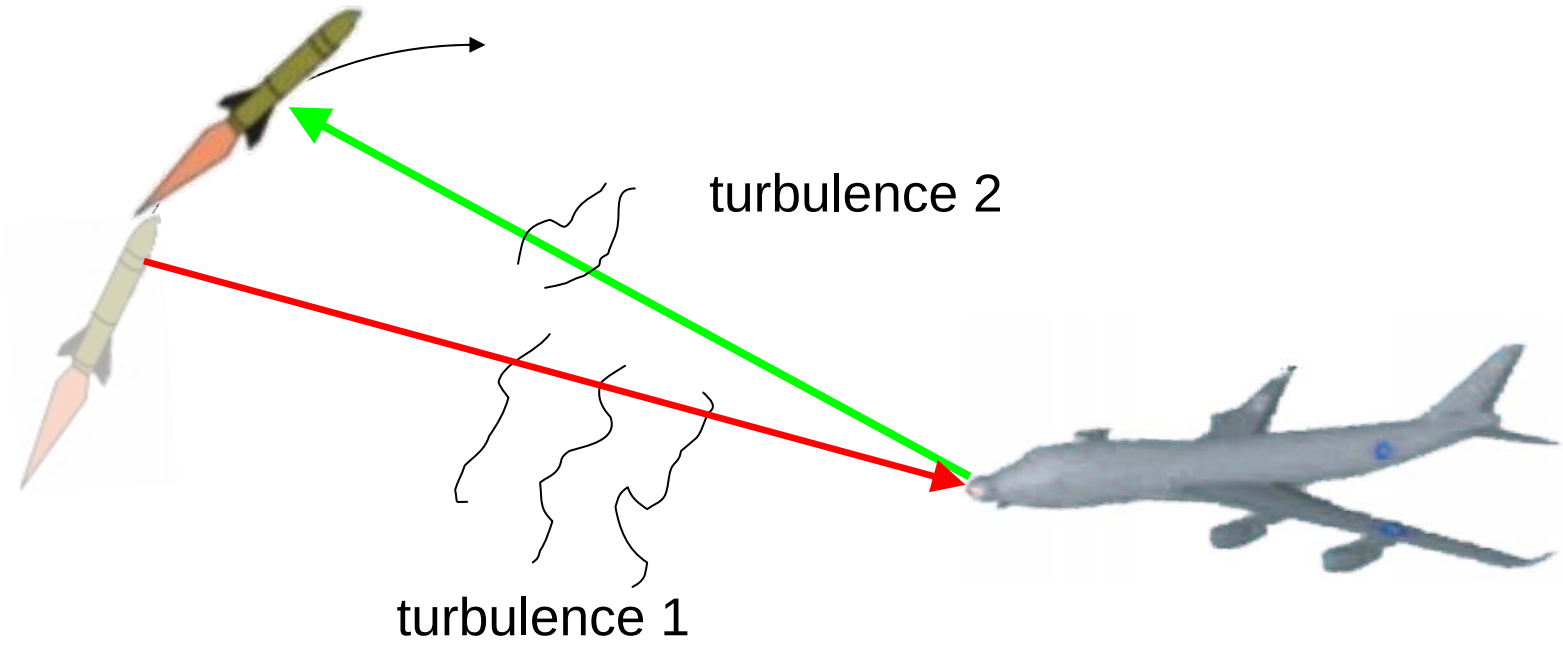

ABL‘s adaptive optics specifications have been used for calculations

3. Effects: reflectivity of the missile‘s surface is the key to countermeasures

Effects of incoming laser intensity might be negated through:

- Reflective coatings

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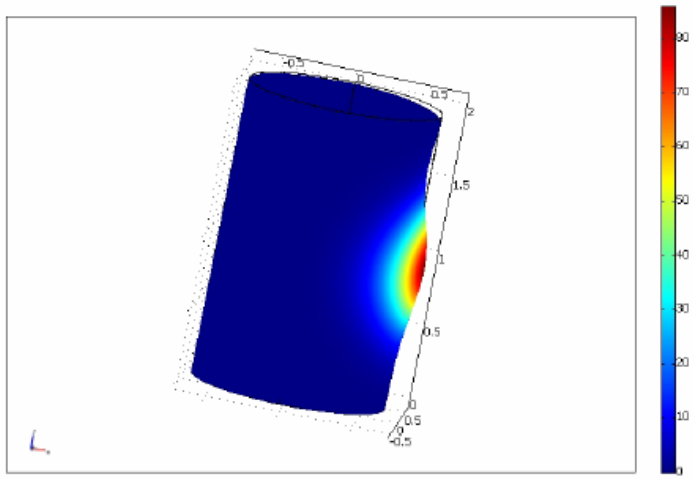
Effects of incoming laser intensity might be negated through:

- Reflective coatings
- Ablative coatings
- Rotating the missile around its axis

→For following example: no countermeasures, „best-case“ analysis!

3. Effects: Time is deciding factor for short-fall

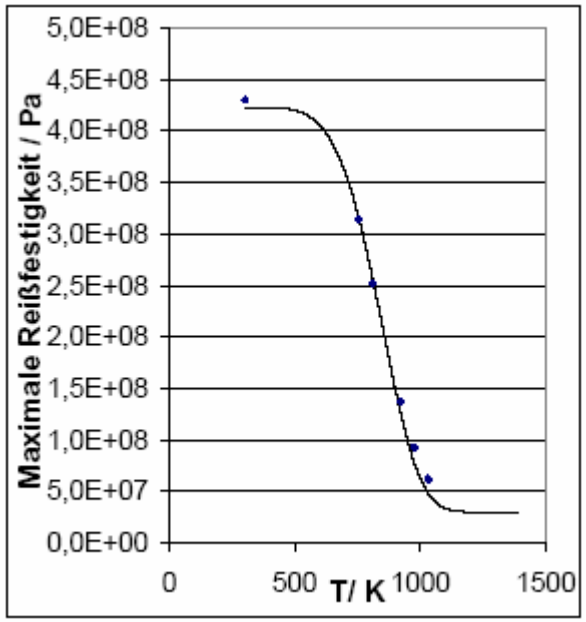
1. Structural failure will occur, after significant portions of the structure melt.
2. But: thermal stress and material softening might also result in earlier structural failure.



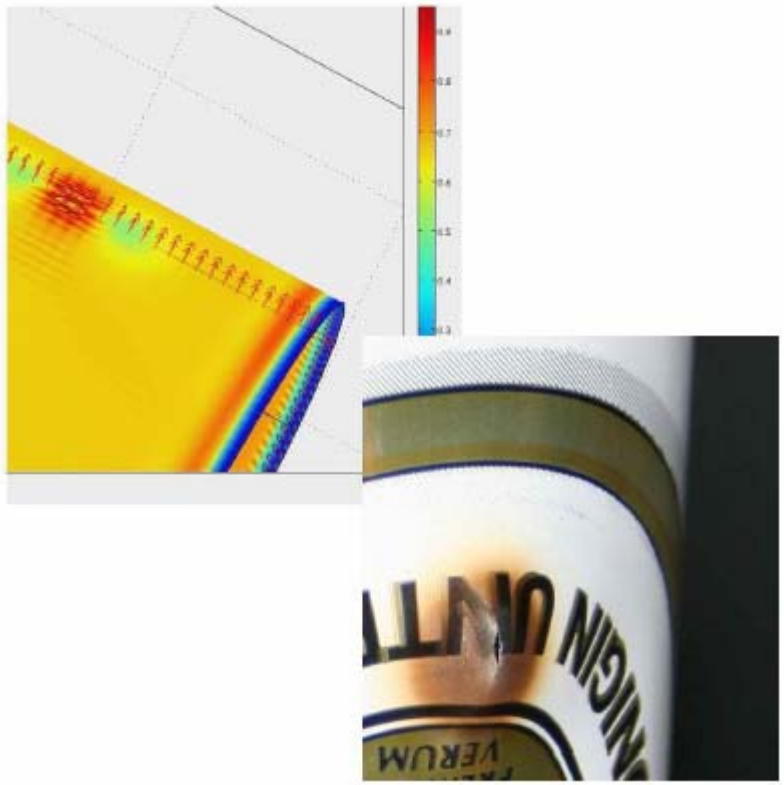
approach: computer simulations and experiments

3. Effects: Tensile strength rapidly decreases with temperature

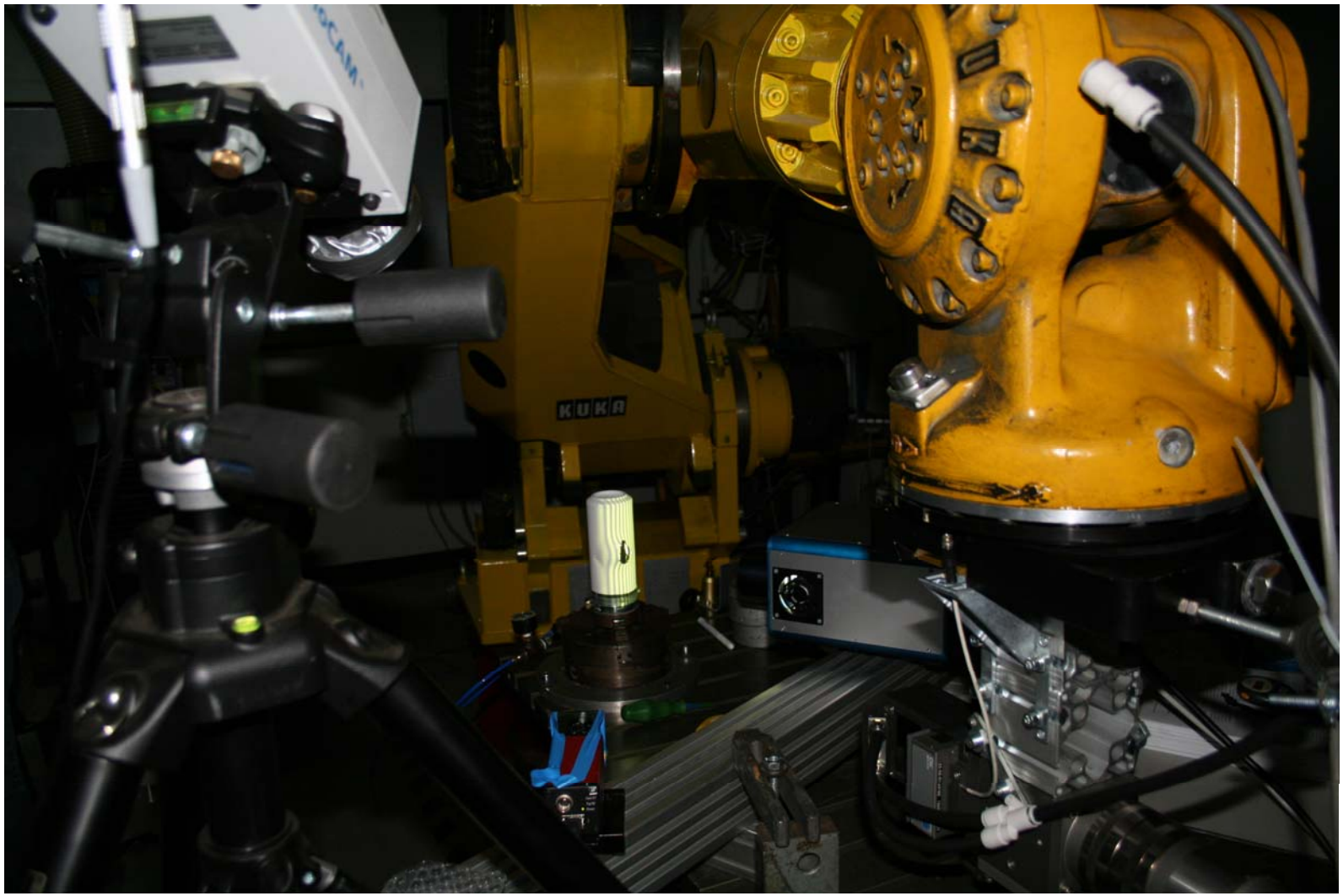
Ultimate tensile strength:



Nach: G.P. Sutton: Rocket Propulsion Elements; Fit: NIST: Invest. of WTC Disaster - Mech. Prop. of Str. Steels



3. Effects: Experimental setup combines thermal imaging and measurement of deformation



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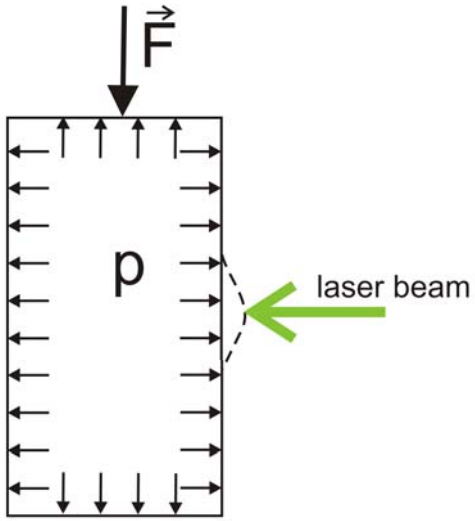
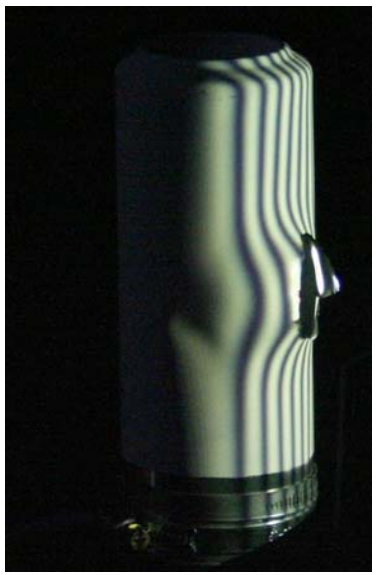
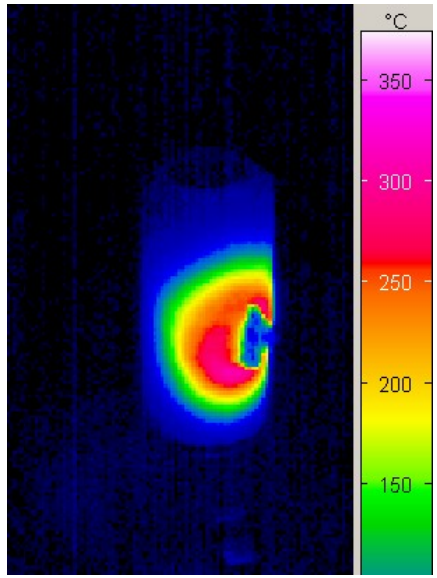
Setup:



Deformation:



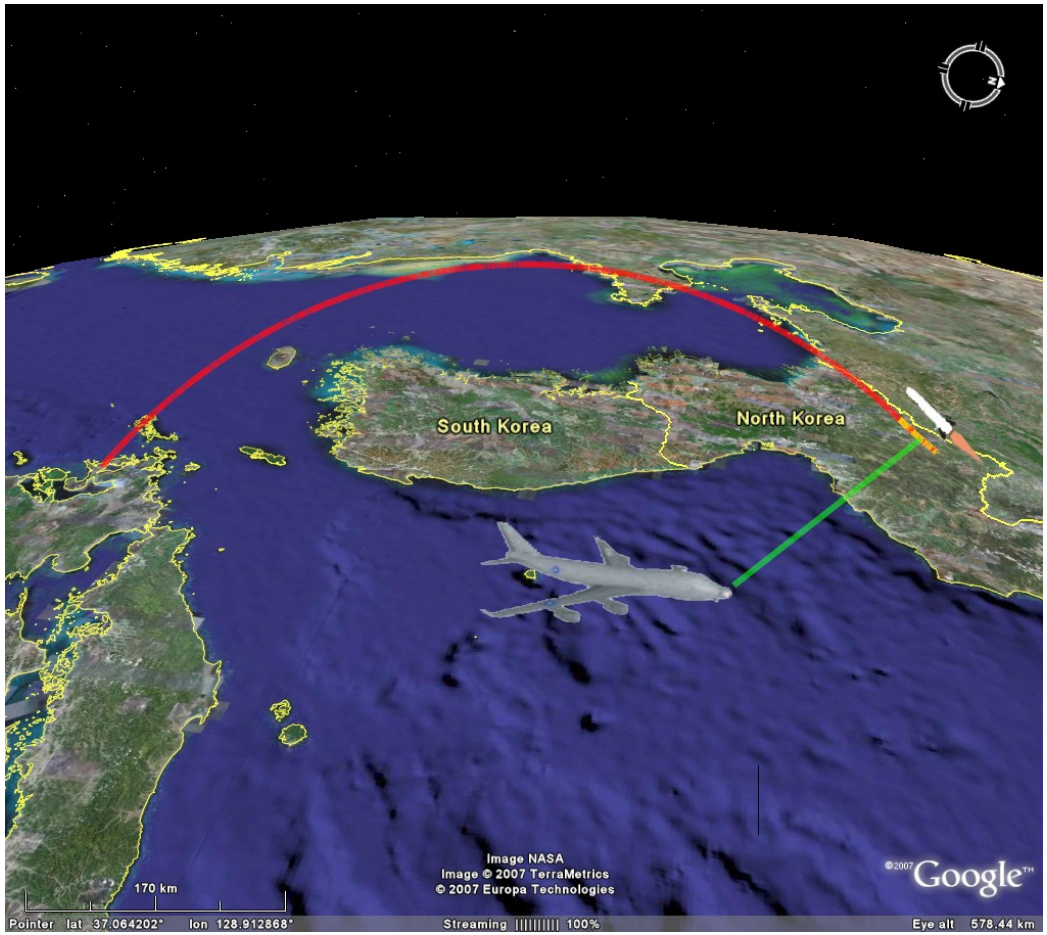
Temperature:



First results confirm computer simulations

Example of an ABL engagement

Distance decisive factor for success of engagement



Trajectory calculated by Geoffrey Forden's GUI_Missile_Flyout, graphics by GoogleEarth

missile:

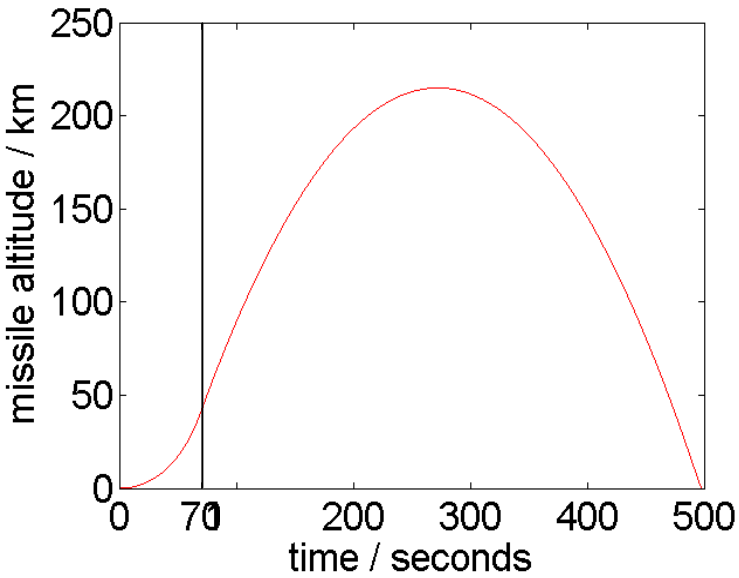
length: 12 m
thrust: ca. 500t
wall: 2mm AlMg4
pressure: 2 bar
surface: white,Refl.=90%

laser:

power: 3 MW
aperture dia.: 1.5 m
atmosphere: U.S. Stand.
turbulence: 2 x Clear-1N
Distance: 400…350 km

Missile altitude decisive for atmospheric absorption

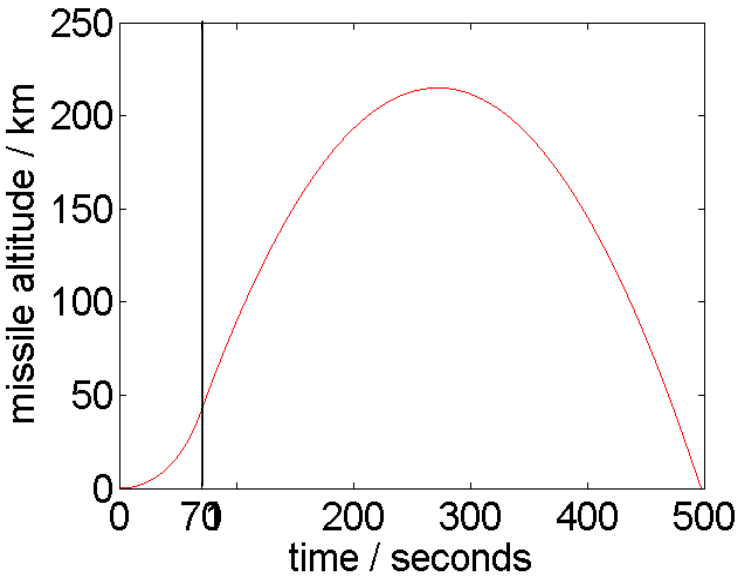
Missile altitude:



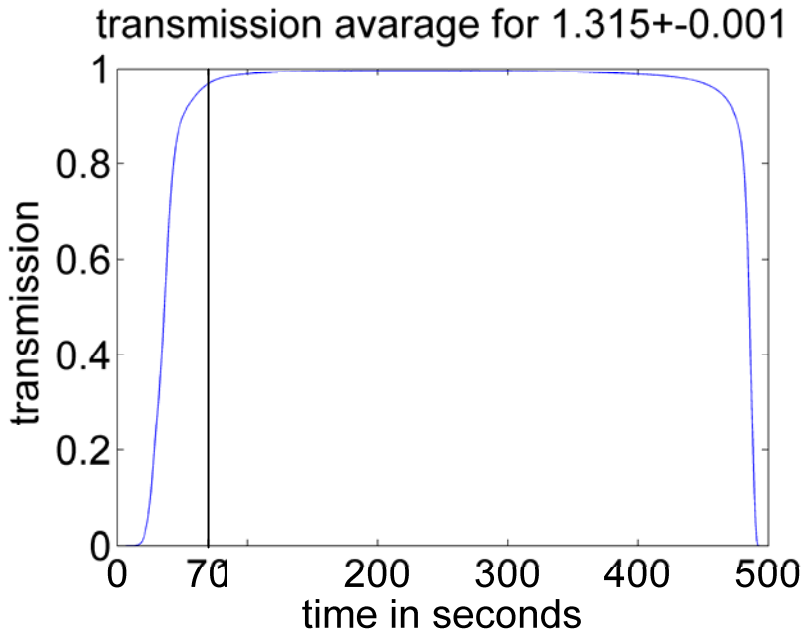
Trajectory calculated by Geoffrey Forden's GUI_Missile_Flyout program

Missile altitude decisive for atmospheric absorption

Missile altitude:



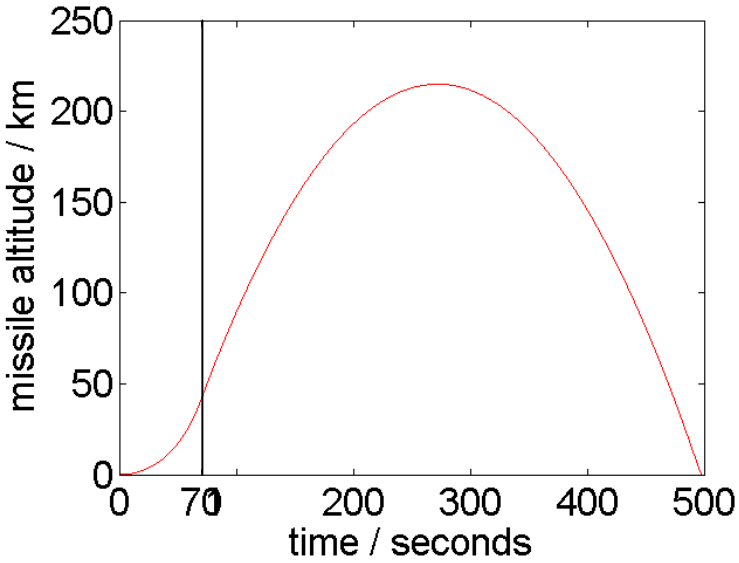
Transmission:



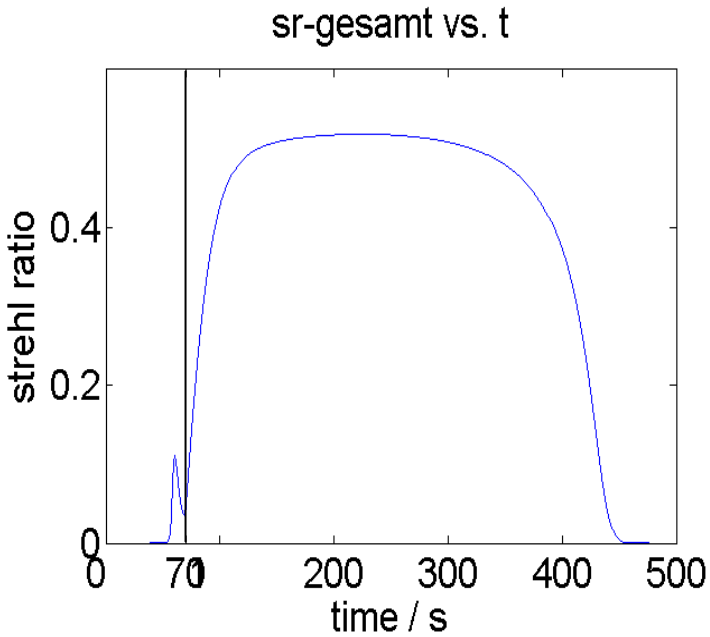
Trajectory calculated by Geoffrey Forden's GUI_Missile_Flyout program

Missile altitude decisive for degree of turbulence

Missile altitude:



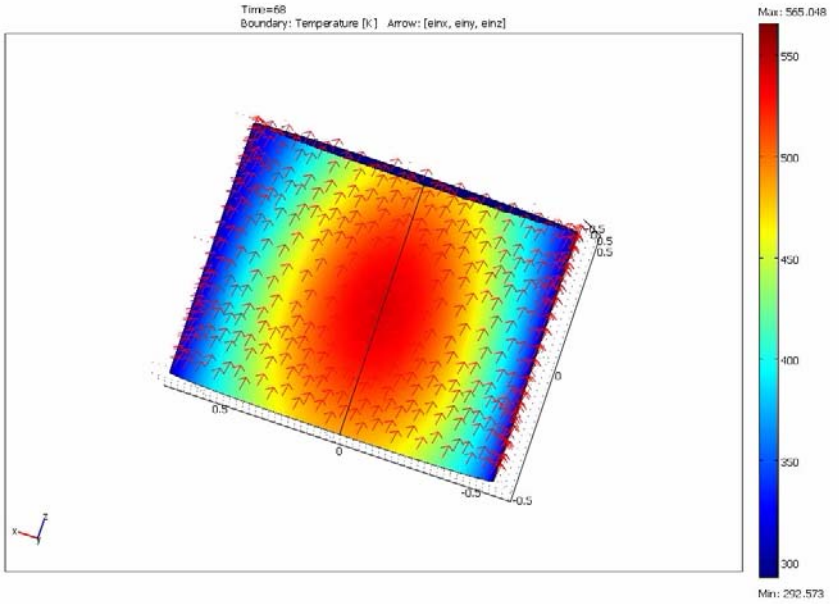
Combined Strehl ratios:



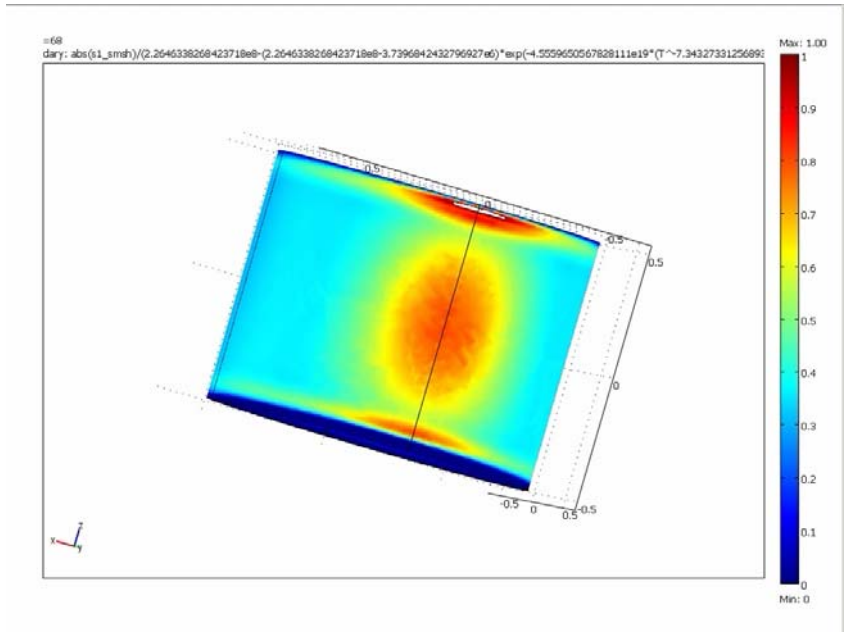
Trajectory calculated by Geoffrey Forden's GUI_Missile_Flyout program

Critical stress in missile wall is reached after 68s

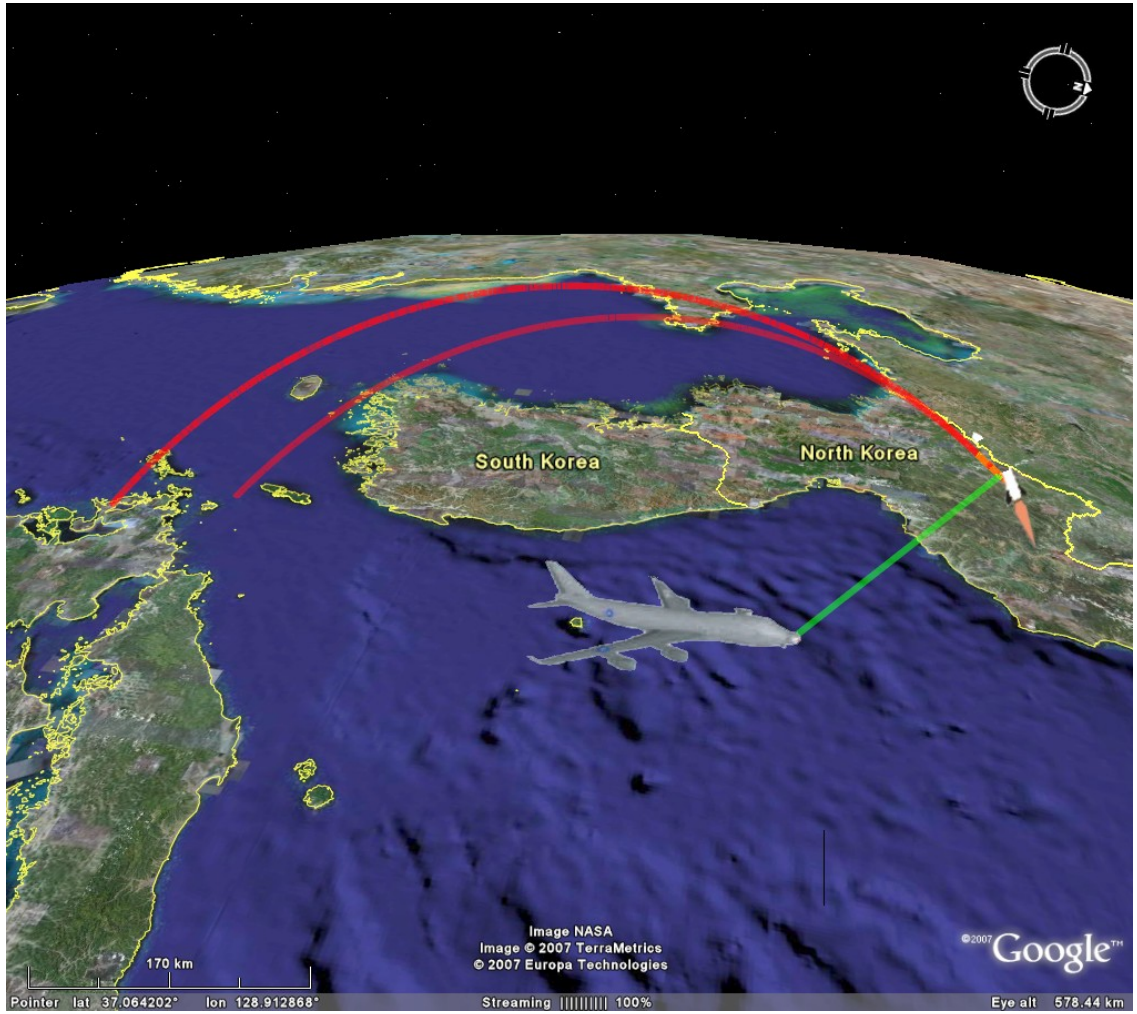
Temperature at 68s:



Relative stress at 68s:



Yield stress in missile wall is reached after 68s



Short fall will crash far away from missile launch area

Summary

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- ABL funding seems secured for 2008
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- Countermeasures
- Other ABL goals (ASAT) ?
- Political implications

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Thank You!

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