

# Missile defense interception and space debris: some technical issues

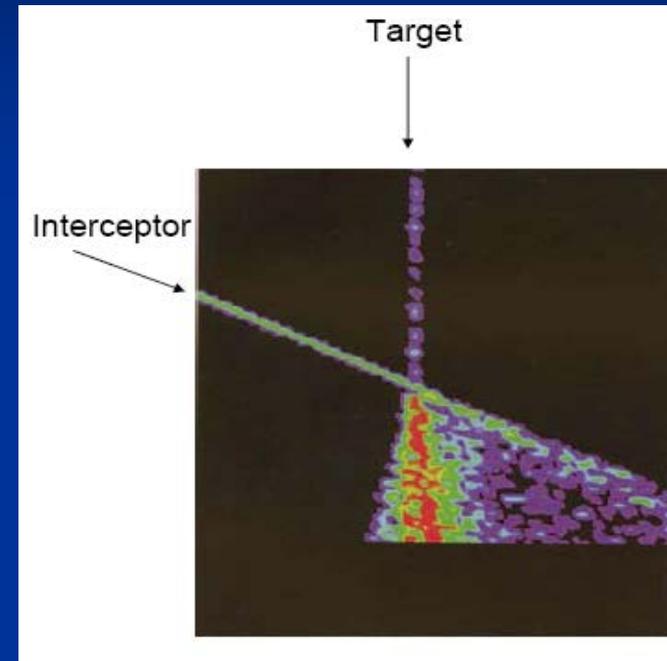
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# Background

- The US is developing its Missile Defense systems.
- The HTK based interception produces fragments
- Possibility of the fragments entering the low earth orbit has raised concerns.
  - Especially those from interception of long range missiles



Huge amount of fragments generated during the interceptions ( picture released after the IFT6 of GMD system)

# About this work

- Analyze the characteristics of the debris from the long range missile interceptions
  - Taking GMD as an example
- Discuss some issues relating to space debris

# Scenario assumptions

- The GMD is designed to intercept long range missiles from countries such as Iran, North Korea
- Assumptions
  - Attacking missile
    - North Korea to west coast of US
    - Iran to east coast minimum energy trajectory
  - Interceptor
    - Orbital Science Boost Vehicle, 3 stages(OBV3) +EKV
    - Launched from Fort Greely, Alaska

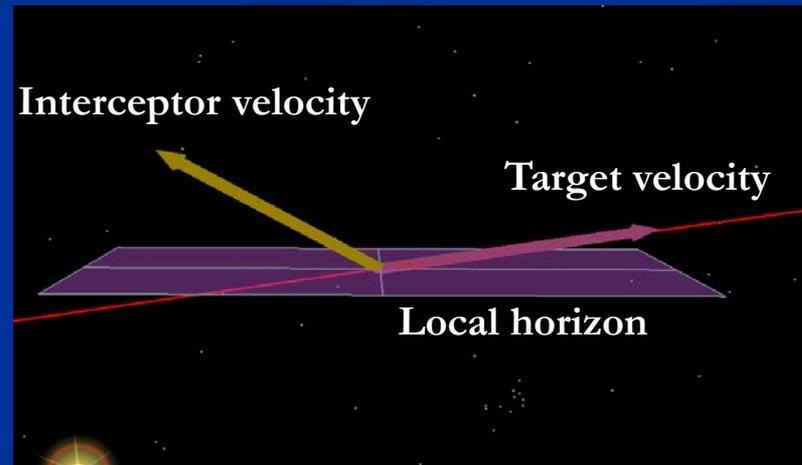
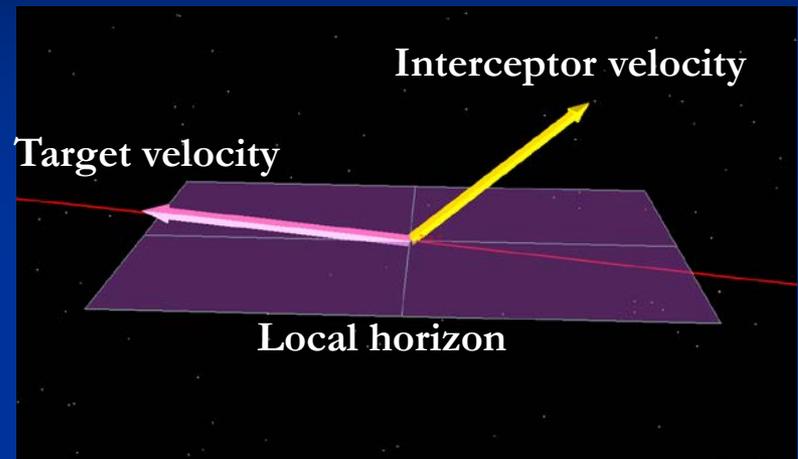
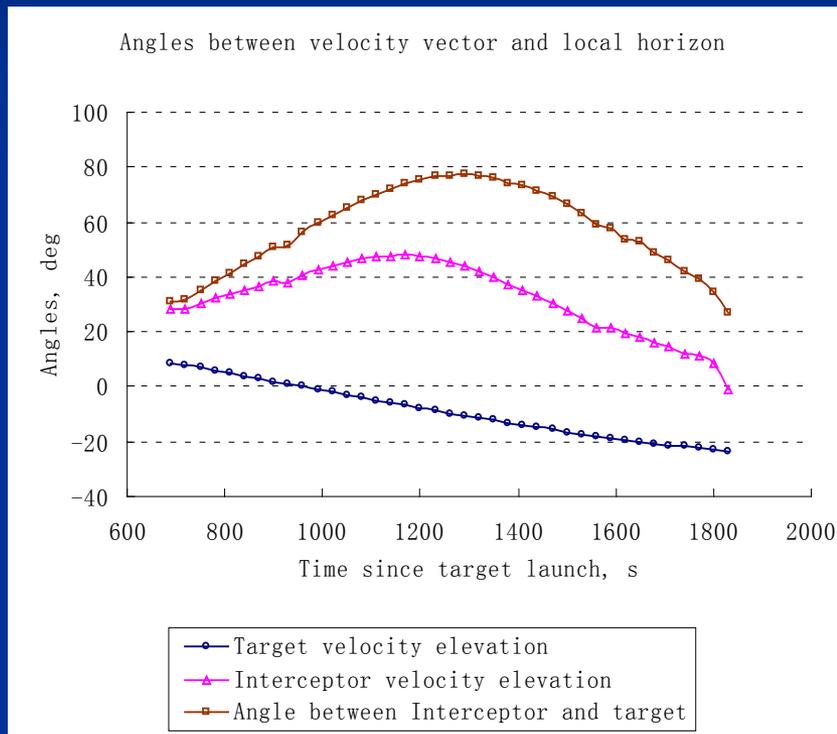


- The defense is able to launch interceptor 10s after the attacking missile burns out
- Lowest intercepting altitude : 100km

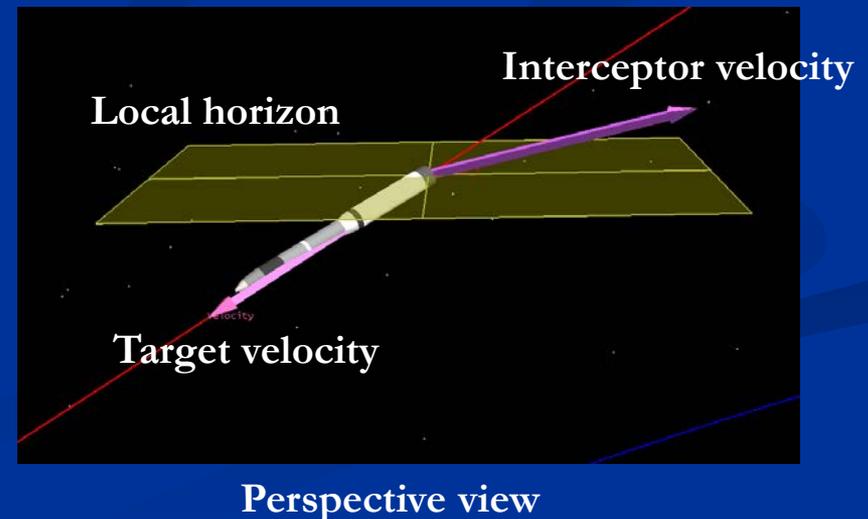
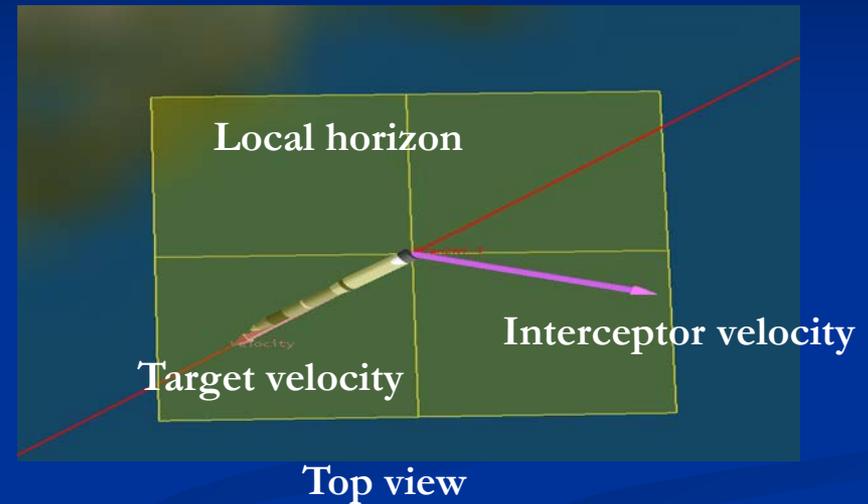
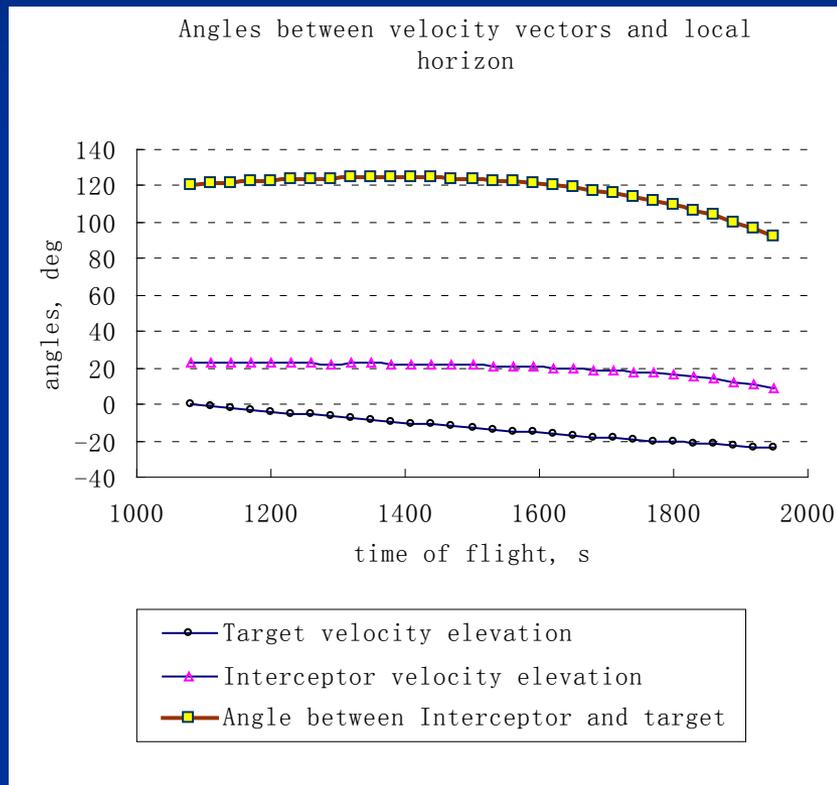
### Some parameters on assumed attacking missile and interceptor

Missile/ interceptor	Burnout time, s	Burnout speed, km/s	Apogee time, s	Apogee altitude, km	Intercepting window, s
NK to west coast	200	6.8	955	1371	690~1830
Iran to east coast	200	7.4	1075	1773	1080~1920
OBV 3	198	9.3	-	-	

# Geometries at impacting point (North Korea Case)

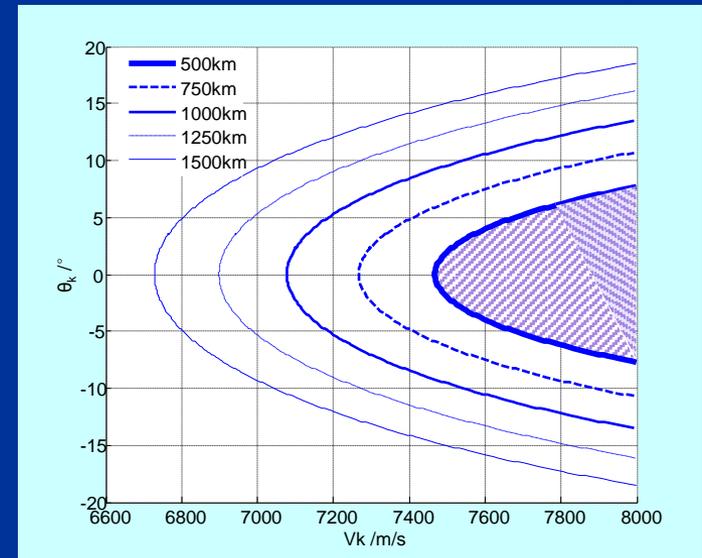
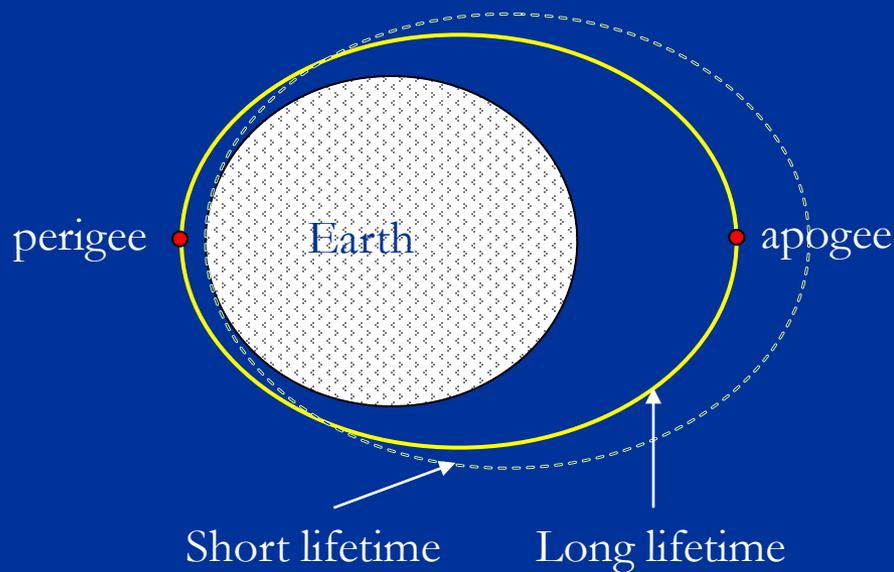


# Geometries at impacting point (Iran Case)



# Fragments and space debris

- With proper **velocity** and **altitude**, fragments could become space debris



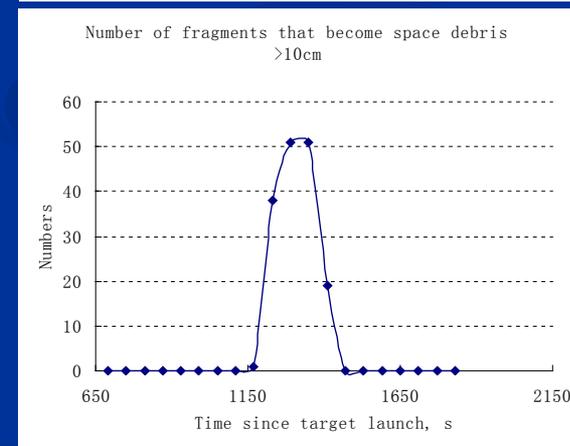
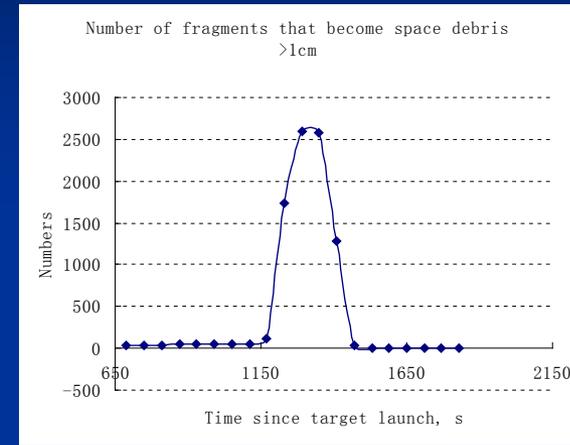
Fragments with proper velocity (e.g. points in shadowed area) could become space debris

# Debris estimation

- NASA breakup model of EVOLVE4.0
- Assumptions
  - EKV mass: 48kg
  - Warhead mass: 500kg
  - Parameters from assumed scenarios
  - A fragment becomes a space debris if its perigee > 300km

# Debris estimation (North Korea Case)

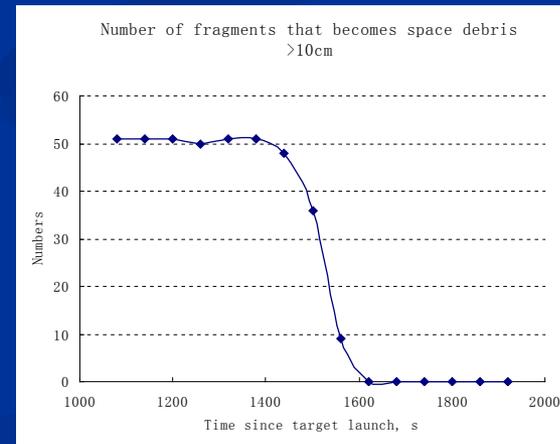
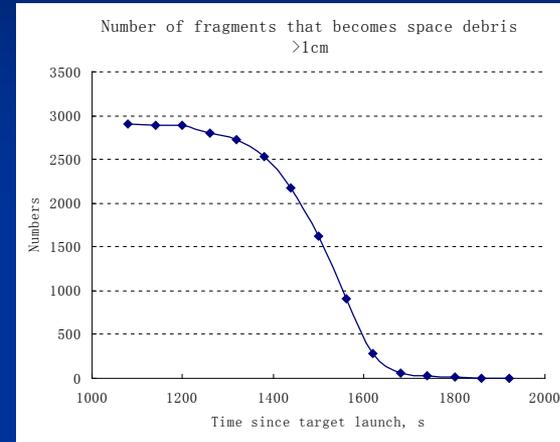
- Number of fragments
  - 29791, >1cm
  - 581, >10cm
- Number of fragments that become space debris
  - 0~2590, >1cm
  - 0~50, >10cm
- More space debris created near Apogee !



Number of fragments that become space debris if intercepted at different time

# Debris estimation (Iran Case)

- Number of fragments
  - 29791, >1cm
  - 581, >10cm
- Number of fragments that become space debris
  - 0~2909, >1cm
  - 0~51, >10cm
- More space created debris near Apogee !!



Number of fragments that become space debris if intercepted at different time

# Findings

- Space debris be generated during GMD interception
  - More space debris if intercepted near apogee of the target trajectory
- The higher the impacting velocities, higher interception altitude and the closer loft angles of the trajectories to local horizon, the more possibility fragments become space debris

# Findings

- Long range missile interception features higher velocity and higher altitude, which could lead to more space debris
- Missile defense systems against long range missile will be new sources of space debris

**Thank you!**