



## Debris from China's Kinetic Energy Anti-Satellite Test

May 2007

On January 11, 2007 (U.S. time), China tested an anti-satellite (ASAT) weapon against a defunct Chinese weather satellite. The test used a kinetic energy ASAT weapon, which apparently destroyed the satellite by homing on it and colliding with it at very high speed.

The satellite, called Feng Yun 1-C (FY-1C) had a mass of just under one ton and was orbiting at roughly 850 km altitude when the collision occurred. The collision took place at a speed greater than 8 km/s and would be expected to completely break the satellite into fragments, the vast majority of which would orbit the earth as space debris. Because this breakup took place at a high altitude where the atmospheric density is very low, a large fraction of this debris will remain in orbit for decades.

### Debris from the Chinese Test

Because of their high speed, even small pieces of orbiting debris can threaten satellites. Since high-altitude debris can stay in orbit for decades or longer the amount of debris grows with time, and there is no effective way to remove it. Controlling the production of debris is therefore essential for preserving the long-term use of space.

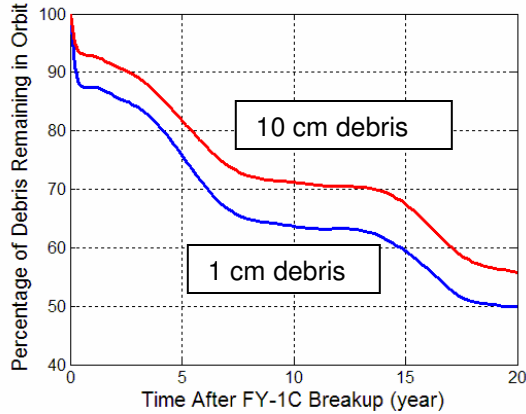
Using a NASA model developed to describe satellite breakups in high-speed collisions, one can estimate the number of debris fragments with size greater than 1 mm that resulted from the FY-1C breakup. By May, the U.S. Space Surveillance Network had already cataloged some 1,600 pieces of debris (presumably larger than 5 to 10 cm) from the Chinese test. This debris represents a significant increase in the total estimated amount of debris of these sizes throughout low earth orbit (LEO), *i.e.*, at all altitudes up to 2,000 km (see table below).

	Debris size		
	1 mm to 1 cm	1 cm to 10 cm	> 10 cm
<b>Total debris in LEO before Chinese test</b>	<b>140 million</b>	<b>180,000</b>	<b>9,700</b>
<b>Debris from the FY-1C breakup</b>	<b>2 million</b>	<b>40,000</b>	<b>1,500</b>

Since the debris from this test is concentrated at altitudes near 850 km, it would double the density of debris larger than 1 cm in that region for at least five years.

Satellites cannot be shielded effectively against collisions at this speed with debris larger than about 1 cm. Moreover, debris smaller than about 10 cm cannot be reliably tracked from the ground to give warning of a possible collision.

Figure 1.



Using the NASA model, debris and atmosphere data, and orbit calculations, one can estimate how long the debris from this test will stay in orbit. Our estimates (Figure 1) are that more than 50% of the debris with size greater than 1 cm will remain in orbit for more than 20 years, and perhaps considerably longer. The sections of the curves that show sharp declines in debris are due to the periodic maximums of solar activity, which cause the earth's atmosphere to expand slightly, increasing the atmospheric drag on the debris.

Most of the debris from such a breakup will orbit at altitudes near the altitude at which the collision took place. Over time the debris will spread out in a shell around the earth, so that it places at risk all satellites that pass through that altitude (Figures 2 to 5).

### Debris from Larger Satellites

The breakup of satellites larger than FY-1C will produce significantly more debris. Satellites that are considered likely targets of ASAT weapons, such as spy satellites, have masses ten times that of the FY-1C satellite. The breakup of a single large satellite with a mass of 10 tons would double the amount of debris in low earth orbit with size larger than 1 cm, and could increase the density of debris in altitudes near the breakup altitude by several hundred percent. The debris estimates for this case are shown in the table below.

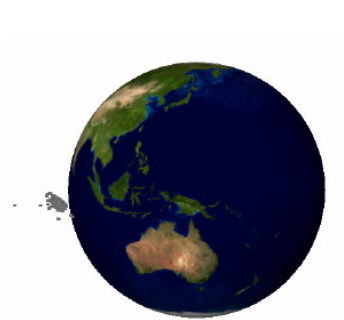


Figure 2. Cloud of debris greater than 10 cm in size after 10 minutes.

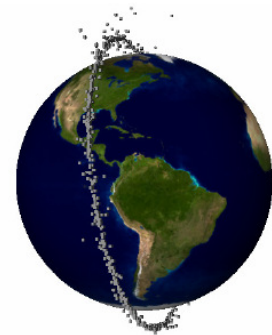


Figure 3. Debris cloud after 10 days.

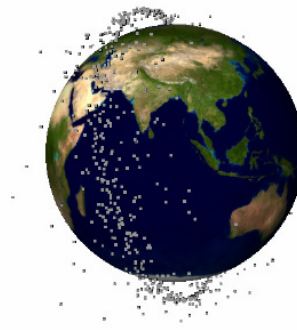


Figure 4. Debris cloud after 6 months.

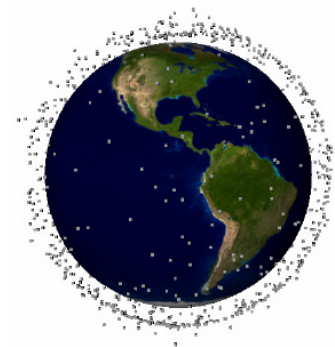


Figure 5. Debris cloud after 3 years.

	Debris size		
	1 mm to 1 cm	1 cm to 10 cm	> 10 cm
<b>Total debris in LEO before Chinese test</b>	<b>140 million</b>	<b>180,000</b>	<b>9,700</b>
<b>Debris from the breakup of a 10-ton satellite</b>	<b>14 million</b>	<b>250,000</b>	<b>5,000</b>

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