## A Timeline of Meteoric Descent

What excited Marshall astronomer Bill Cooke most about publication of the papers related to the Chelyabinsk fireball is how they "present a complete picture of the [event]," he said. He shared the following breakdown of the meteoroid's brief, startling voyage:

1. The approximately 62-foot-wide asteroid, weighing roughly 12,000 tons, enters the atmosphere over Russia, moving slightly north of due east at 42,600 mph. It is first detected on video at an altitude of 59 miles. In Chelyabinsk, on the slopes of the southern Ural Mountains, it is 9:20:21 a.m.
2. Approximately 9.5 seconds later, the fireball begins to break apart. Its speed is still nearly 42,600 mph, but it has quickly dropped in altitude; it is now 28 miles up.
3. The burning meteor continues to drop, and severe fragmentation occurs. As its altitude dips from 25 miles to 16 miles, approximately 500 kilotons of energy -- or about 40 times the explosive energy of the atomic bomb dropped on Hiroshima in 1945 -- are dumped into the atmosphere in just 2.7 seconds.
4. The peak of this event happens at about 19 miles in altitude, where more than 100 kilotons of energy erupt as the meteor travels just one mile. Also at this height, the meteor breaks into 20 boulder-sized fragments, each weighing more than 10 tons and each still moving at approximately 40,000 mph (On the ground directly below the fireball, it shines more than 30 times as bright as Earth's sun, and a cylindrical blast wave is generated, which shortly will affect the Chelyabinsk area -- breaking windows, damaging buildings and causing approximately 1,600 injuries).
5. At an altitude of 14 miles, just 13.5 seconds from first sighting, the boulders shatter into numerous smaller pieces, producing sonic booms. The biggest of the pieces, dubbed "F1," weighs approximately 1,100 pounds. Its trajectory will take it slightly farther north than most of the other pieces. The fragments have now slowed to 31,000 mph.
6. A little more than 1.5 seconds later, at an altitude of 10.5 miles, the larger fragments have rapidly decelerated to just 13,400 mph. The pieces continue to slow very quickly as they fall. Each piece stops emitting light when its speed drops below 9,000 mph.
7. The largest fragment, F1, is the last piece visible to tracking. It drops to an altitude of 7.8 miles, traveling at 7,100 mph, and disappears from view. Moments later, it

punches a 25-foot-diameter hole in the ice over Lake Chebarkul, where it will lay at the bottom of the lake until it's raised by researchers on Oct. 13.

Total elapsed event time (from first appearance on video to final sighting of F1 fragment): 16.7 seconds

Distance traveled in that time: 169 miles