Artificial Meteor Fireworks

D. Caulkins
Millennium Meteor Fireworks Project, 437 Mundel Way, Los Altos, CA 94022-1118, USA
e-mail: dcaulkins@igc.org

ABSTRACT

The use of ballistic-missile-delivered artificial meteors is discussed as a means of generating large scale pyrotechnic displays. Possible delivery vehicles are suggested, and designs are presented for the artificial meteors, payloads, and deployment missions. Safety and cost issues are discussed.

Keywords: artificial meteor, ballistic missile, ICBM

Introduction

This paper discusses the use of now-obsolete ballistic missiles to generate very large and spectacular displays of Artificial Meteors, at a cost not much more than that that now spent on ordinary fireworks displays. Television pictures of Scud missile re-entries during the Gulf War are an existence proof of the fact that even short-range low-throw-weight ballistic missiles can produce “artificial meteor” effects.

Artificial Meteor displays over a number of the world’s cities could provide a suitably large scale commemoration of humanity’s entry into the next millennium.

Artificial Meteor Fireworks

Artificial Meteor (AM) firework displays can be much brighter, more numerous, and more spectacular than natural meteors (see Appendix A for details on natural meteors). An AM is an object whose mass is in the range of 1 to 100 grams; a group of AMs is launched into space by an obsolete ballistic missile. Ballistic missiles have throw weights ranging from hundreds of pounds for smaller missiles up to many thousands of pounds for ICBMs like the Russian SS-18 and the American MX. The expensive parts of the missiles—rocket engines, guidance computers, and control systems—are already paid for. All that is needed is to replace the warheads with packages of inexpensive AMs. Each AM would have a mass in the range of 10 to 100 grams, one or two orders of magnitude greater than most natural meteors. Thus each missile could carry tens of thousands of AMs.

Large conventional pyrotechnic shells can produce spherical displays of stars approximately 450 meters in diameter. AM displays can produce spherical arrays of AMs that are 50,000 meters in diameter, more than 100 times bigger.

Design of Individual AMs

Natural meteors are composed of a variety of elements, and typically leave white or yellowish trails lasting for less than a second. AMs can and should produce colored trails, and these trails can last much longer than those of typical natural meteors. The usual pyrotechnic coloring agents could be used to produce colored trails: yellow (sodium), red (strontium), green (barium), blue (copper), etc. It may be desirable to include chlorine donor materials to deepen the colors.[3] Since there is no fuel required, no allowance need be made for fuel spectra in the design of the coloring agents.

Some AMs could be made with concentric layers of different color-generating materials; they would produce trails which would change color as ablation exposed the various layers. AMs need none of the usual star composition fuels or oxidants to produce a colored trail; atmospheric friction provides all necessary energy. Any mass entering the atmosphere at a velocity of about 11 kilometers per second has potential energy 15 times greater than an equivalent mass of high explosive.

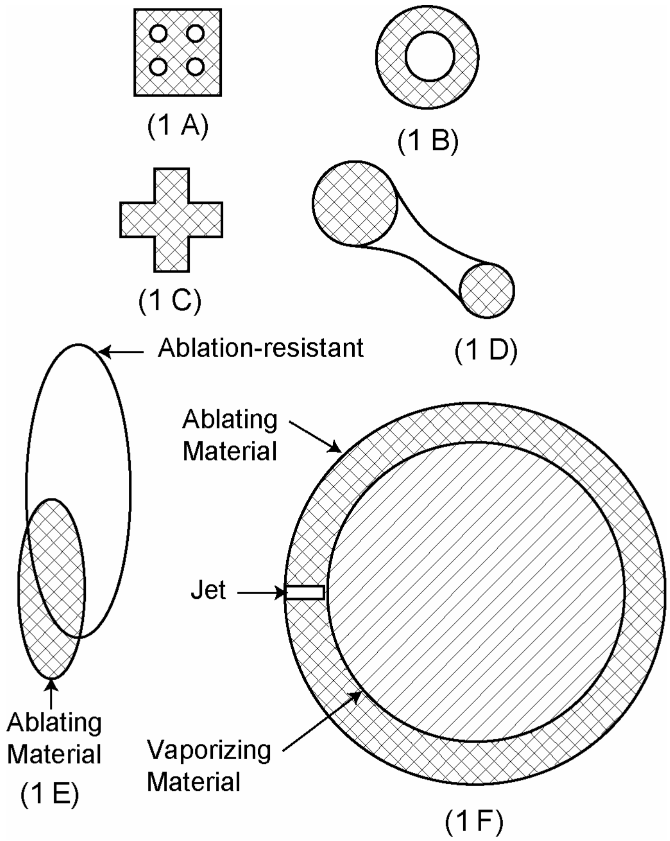

Figure 1. Artificial meteor designs. [1A – A cube with four cylindrical holes; 1B – A hollow cylinder; 1C – A six-armed rectangular cross; 1D – Two unequal spheres connected by a web; 1E – An ellipsoid of pyrotechnic ablating material formed on an ablation-resistant angled vane; and 1F – A sphere of pyrotechnic ablating material containing a material that will vaporize from the heat of ablation.]

The conditions producing incandescence in an AM involve higher temperatures and lower pressures than those encountered by typical stars from a conventional pyrotechnic shell. Some experiments would be desirable to be sure that the planned coloring agents function as intended. Even though the AMs are much further away than conventional pyrotechnic stars, the colors of their trails should still be visible. Astronomical objects subtending comparable angles but at much greater distances appear colored to the naked eye; the planet Mars is a good example.

AMs should have special shapes to insure that they are completely consumed while well above any man-made objects, like airplanes. A good design target would be reduction to zero mass at or before an altitude of 15 kilometers.

The ideal shape would be one that stayed brightly incandescent for as long as possible, but was guaranteed to have been reduced to a mass of a fraction of a gram at an altitude of 15 kilometers. A shape with holes or internal cavities would probably have the right performance.

There are at least two other interesting possibilities:

- Some of the AMs could be made with aerodynamic shapes that would cause them to perform various maneuvers as they fall, producing non-straight trails. For additional variety some AMs could be filled with substances that would produce gas jets when heated by ablation; the reaction force from these jets could cause additional changes in trajectory.

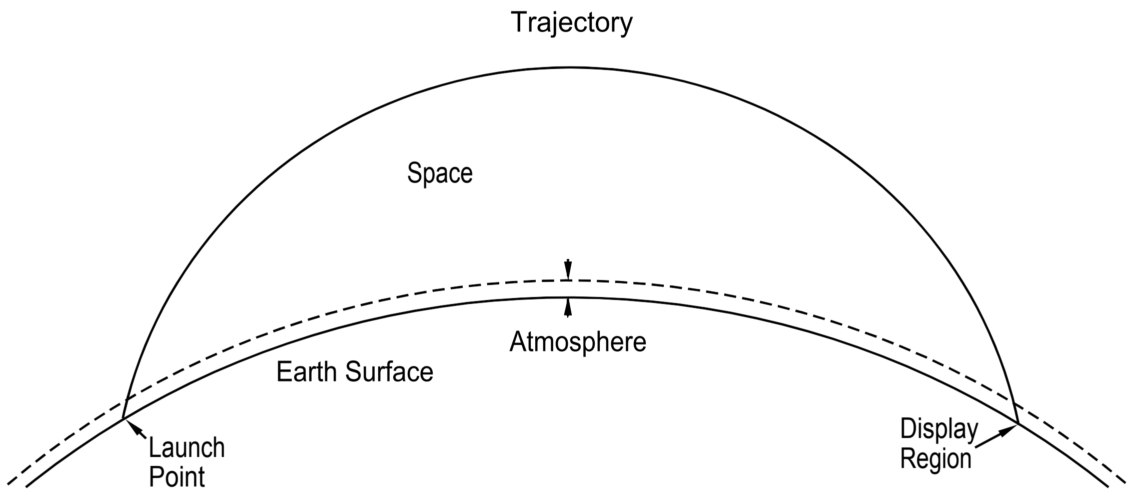

Figure 2. Artificial meteor missile trajectory.

- AMs travel at supersonic velocities; they could be designed to penetrate the atmosphere to a point where sonic booms would be produced.

Cross sections of some possible AM designs are shown in Figure 1. Figure 1-A is a cube with four cylindrical holes; Figure 1-B is a hollow cylinder, and Figure 1-C is a six-armed rectangular cross. The last three have aerodynamic properties; Figure 1-D is two unequal spheres connected by a web—the web will cause tumbling until it burns away, splitting into two AMs. The same design could be used with three or more web-connected AMs. Figure 1-E has an ellipsoid of pyrotechnic ablating material formed on an ablation-resistant angled vane. As the ellipsoid ablates away, the center of gravity will change and the rotation of Figure 1-E will also change. Figure 1-F is a sphere of pyrotechnic ablating material containing a material that will vaporize from the heat of ablation. Reaction force from the resulting vapor jet will cause the sphere to take an erratic path, producing an irregular trail. The AM trails would be observed by an audience 80 to 100 kilometers away; it is not clear that these irregularities in the AM trails would be visible.

System Design

Vehicles

There are many military vehicles available for deploying AMs. The best would be ICBMs similar to the American MX or the Russian SS-18—these have throw-weights of many thousands of kilograms (tens to hundreds of thousands of AMs) over ranges of 10,000 kilometers with an accuracy on target of less than a kilometer. Smaller ballistic missiles of the IRBM type could also be used.

Payload

Alteration of a ballistic missile for AM generation is not difficult—remove the warhead and replace it with one or more canisters containing the AMs and their bursting charges.

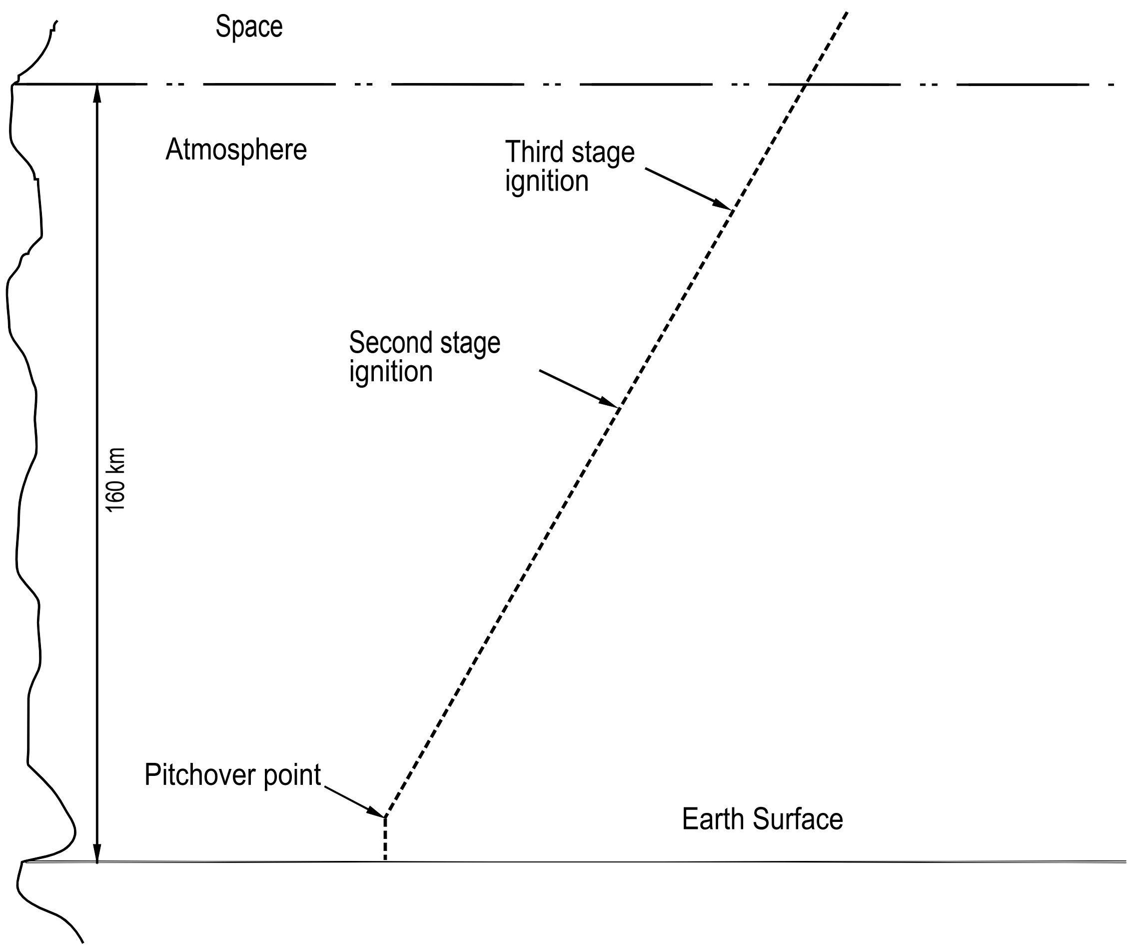

Figure 3. Artificial meteor missile launch.

The payload for an AM deployment mission would consist of spherical or cylindrical canisters containing AMs of the kind described above. Each canister would have redundant bursting charges at its center designed to deploy the AMs into a spherical cloud after the missile boost phase was finished and before reentry. The AM canister(s) would have radio transceivers which would permit the payload to be tracked, and to be destroyed if it failed to perform as designed.

Deployment

The AM carrier missile target coordinates are set to deliver the payload to the desired display point. Safety checks are made, and when the missile is ready for launch a phone call is made to the target area; if the weather there is suitable (small or no cloud cover) the missile is launched about 30 minutes before the desired display time.

A profile of a typical AM missile flight is shown in Figures 2, 3, and 4. The entire trajectory is shown in Figure 2. Figure 3 shows the launch trajectory; the AM missile behaves just as it was designed to in its military role in lifting the payload into space on the correct trajectory to the target.

Figure 4 shows the final part of the flight; first and second stage missile separations have occurred. When the payload is in the correct position, a bursting charge is fired, deploying the AMs into an expanding spherical cloud. If there is any remaining missile payload or third stage structure, this too will be fragmented with

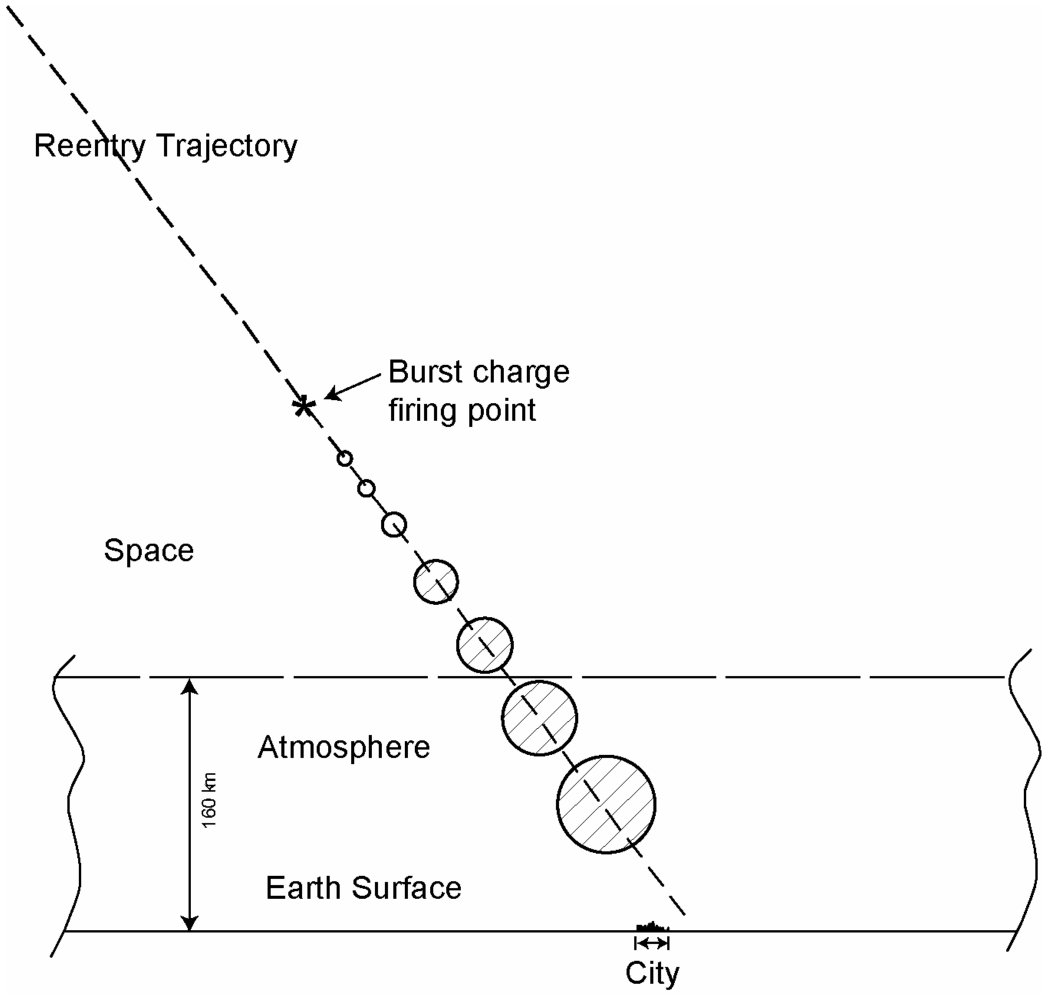

Figure 4. Artificial meteor reentry and display.

explosive charges, adding a few more AMs to the display.

During payload reentry the velocities imparted to the tens of thousands of AMs by the bursting charge cause them to form an expanding sphere from 5 to 20 kilometers in diameter, enough to fill most of the night sky over the target area.

As each AM in the cloud reaches an altitude of about 120 kilometers it will begin to produce a glowing trail.

Each canister could include several AMs designed to produce sonic booms in the leading edge of the cloud; the noise produced by these will alert viewers to look up and see the rest of the display, which will last for several seconds as determined by the size of the spherical AM cloud.

If a display lasting longer than a few seconds is desired and MIRV'd missiles are available, each RV in the MIRV could be used for a separate AM canister. Retro rockets on each RV could be used to cause the AM canisters to arrive sequentially, separated by as much time as desired.

Practice Launches

It would be desirable to do some practice launches to test the design of the AMs. For this purpose IRBMs or smaller unguided rockets could be used.

Safety

Some people may worry about use of missiles in this way; after all, the AM missiles were originally designed to destroy cities. Several techniques can be used to make creation of AM displays safe.

- The payload radio transceivers will be used to monitor performance and position during the boost and mid-course parts of the flight. If any malfunctions are detected, the missile and/or its payload can be reduced to fragments by explosive charges. Note that in many cases this will still produce AM displays at or near the target area.
- Most of the ballistic missiles suitable for AM have first and second stage motors; the casings of these motors will fall to earth along the track of the missile. To avoid any possible damage from first and second stage motor impacts, the AM missiles should be launched over an ocean. For this reason and because of the economy of using existing launch facilities, places like Vandenberg Air Force Base (near Lompoc in California) and Cape Canaveral (Florida) might be used. Islands would also make good launch sites. Submarine or surface ship launched missiles could also be used to solve this problem.
- For those who may be concerned with pollution from the materials deposited in the upper atmosphere by AM trails, it should be noted that natural meteors deposit much more material every day than would be caused by several AM displays every month for a year.

Cost

The great majority of the cost of an AM missile has already been paid during its service as a weapon. Construction of the payload should be comparable in cost to the construction of a large shell for an ordinary fireworks display. In some ways the payload is easier to make; the AMs (stars) require no dangerous energetic compositions. All necessary energy will be supplied by air friction during reentry.

Glossary

Ablation – Removal of material by melting or vaporization produced by the heat of friction as an object enters the earth's atmosphere from space.

ICBM – Intercontinental Ballistic Missile.

IRBM – Intermediate Range Ballistic Missile.

Meteor – A solid object entering the earth's atmosphere and producing a luminous trail.

Meteorite – A meteor of large enough mass not to be completely consumed during its transit of the atmosphere; it reaches the ground. Artificial meteors are designed never to become meteorites.

MIRV – Multiple Independently-targetable Reentry Vehicle.

Pitchover – The point in the launch trajectory of a ballistic missile where the missile is rotated around the pitch axis to acquire velocity in the direction of the target.

RV – Reentry Vehicle; each MIRV "bus" carries several.

Throw-weight – The weight of the payload that a ballistic missile can deliver to its target.

Appendix A

Natural Meteors

The active life of a natural meteor starts when it first encounters atmospheric density sufficient for friction to heat it to incandescence, leaving a visible trail in the night sky. This typically occurs at about 120 kilometers Usually a meteor is first seen at about 100 kilometers above the surface of the earth, and disappears at about 50 kilometers. Initial meteor velocities fall between 11 and 72 kilometers per second.[1]

One of two things can happen to a meteor:

1) For the typical small meteor weighing a few grams or less the trail remains visible until the mass of the meteor is completely consumed by ablation.

2) Larger objects can reach what is called "the point of retardation"; velocity drops to less than 100 meters per second, too small to heat what is left of the meteor to incandescence. The meteor, now called a meteorite, falls to earth at a constant velocity determined by its mass and drag.

Observations of 7 meteorites showed points of retardation varying from 4 to 42 kilometers in altitude, with a mean of 17 kilometers.[2]

References

1) S. J. Edberg and D. H. Levy, *Observing Comets, Asteroids, Meteors, and the Zodiacal Light*, Cambridge University Press, 1994.

2) F. Heide, *Meteorites*, 1891. Translated by Edward Anders, 1964.

3) T. Shimizu, *Fireworks, The Art, Science, and Technique*, Pyrotechnica Publications, 1981.