EMP Myths

by Jerry Emanuelson, B.S.E.E.

Futurescience, LLC

This is a page about common EMP myths.
I will begin by copying the Appendix on EMP Myths that was included in a report for Oak Ridge National Laboratories by Metatech.
Afterward, I will add my own comments about additional common EMP myths.

Note: **HEMP** is an acronym for *high-altitude nuclear electromagnetic pulse*.

Appendix From Oak Ridge National Laboratories/Metatech EMP Report

E1 HEMP Myths

Much of the literature on HEMP is either classified or not easily accessible. Probably because of this, some of what is openly available tends to vary in accuracy -- some, especially from the Internet, has major inaccuracies. Some discussions of HEMP have the right words and concepts, but do not quite have them put together right, or have inaccurate interpretations. Here we will discuss some common misunderstandings.

HEMP has also appeared in some movies, and there are on-line discussions about possible errors in their depiction of HEMP. Here we will be concerned with E1 HEMP, and ignore misunderstandings about other types of EMP.

Extremists: Some general emphasis of comments fall into either "the world as we know it will come to an end" if there is a high altitude nuclear burst, or the other extreme: "it's not a big deal, nothing much will happen". Since we really have never had a nuclear burst over anything like our current modern infrastructure, no one really knows for sure what would happen, but both extremes are not very believable.

Yield: There appears to be an assumption that yield is important -- it is not for E1. The assumption that E1 is an issue only for cold war type situations, but not for terrorists or rogue nations, is false. Very big bombs might have better area coverage of high fields by going to higher burst heights, but for peak fields the burst yield is only a very minor consideration.

1962 experience: Some point to the Starfish event, and the rather minor HEMP effects produced at Hawaii by it. However, there are many problems with extrapolating that experience:

1. That was about half a century ago. Since then the use of electronics has increased greatly, and the type of sensitive electronics we currently use did not really exist back then.

2. The burst was fairly far away from Hawaii, and the incident E1 HEMP was much less than worse case.

3. The island is small -- if over the continental U.S., long transmission lines would be exposed (especially an issue for late-time HEMP). In addition, widely separated substations would have been exposed, although with electromechanical relays (not solid state).

Also the yield argument has been used -- Starfish was a very big weapon, yet it did very little -- see the previous item, yield is not really very significant.

Cars dying: Some say that all vehicles traveling will come to a halt, with all modern vehicles damaged because of their use of modern electronics (and one movie even had a bulk, non-electronic part dying). Most likely there will be some vehicles affected, but probably just a small fraction of them (although this could create traffic jams in large cities). A car does not have very long cabling to act as antennas, and there is some protection from metallic construction. As non-metallic materials are used more and more in the future to decrease weight and increase fuel efficiency, this advantage may disappear.

Wristwatch dying: One movie critic pointed out that electronics in a helicopter were affected, but not the star's electronic watch. A watch is much too small for HEMP to affect it.

Electrons present: One critic, with some awareness of the generation process, said that HEMP could not be present unless there were also energetic electrons present. This is true when one is within the source region, which exists for all types of EMP -- there are energetic electrons present. However for the HEMP, the radiation and energetic electrons are present at altitudes of 20 to 40 km, not at the ground.

Turn equipment off: There is truth to this recommendation (if there were a way to know that a burst was about to happen). Equipment is more vulnerable if it is operating, because some failure modes involving E1 HEMP trigger the system's energy to damage itself. However, damage can also happen, but not as easily, to systems that are turned off.

Maximum conductor length: There is a suggestion that equipment will be OK if all connected conductors are less than a specific length. Certainly shorter lengths are generally better, but there is no magic length value, with shorter always being better and longer not. Coupling is much too complex for such a blanket statement -- instead it should be "the shorter the better, in general". (There can be exceptions, such as resonance effects, which depend on line lengths.)

Stay away from metal: There is a recommendation to be some distance away from any metal when a HEMP event occurs (assuming there was warning), because very high voltages could be generated. Metal can collect E1 HEMP energy, and easily generate high voltages. However, the "skin effect" (a term not really derived from the skin of humans or any other animal) means that if a human were touching a large "antenna" during an E1 HEMP event, any current flow would not penetrate into the body. Generally E1 HEMP is considered harmless for human bodies.

The above is what the Metatech report for Oak Ridge National Laboratories had to say about EMP myths.

Now, here is an expansion on those comments by electronics engineer Jerry Emanuelson of Futurescience, LLC.

First, though, allow me to make a brief comment about the awful EMP myths generated by movies and television. That situation is so bad that the United States Air Force Space Command commissioned ***Bill Nye, The Science Guy*** to make a video for the Air Force called "**Hollywood vs. EMP**." Apparently, the Air Force wanted to make sure they had a way to concisely remove popular EMP myths from the minds of those people that we must depend upon to be prepared to deal with ***the real thing***. That video is not available to the public. I'll have more to say about popular culture EMP myths toward the bottom of this page.

Now, more on these and additional common myths:

Nuclear Weapon Yield: The E3 component of nuclear EMP, which induces geomagnetic currents in much the same way as a severe solar storm (by causing short-term movements or changes in intensity of the earth's magnetic field), is very roughly proportional to the total energy yield of the weapon. The E1 component of high-altitude nuclear EMP is dependent upon the gamma ray output of the weapon. E1 is dependent upon several aspects of the gamma ray output. The gamma ray output of the bomb can often be increased by sacrificing some of the total energy yield. For example, making the casing of the bomb much thinner can greatly increase the gamma ray output, but can cause the weapon to blow itself apart before the nuclear reaction is complete, reducing the total energy yield. Nuclear weapons are complex weapons, and there are several techniques for optimizing different components of EMP.

It is important to note that, during United States high-altitude nuclear testing, the first indication of the dramatic effects of high-altitude EMP was obtained by a weapon of only **1.7 kilotons** launched by a primitive helium balloon in 1958. (See the descriptions of the Hardtack-Yucca test elsewhere on this web site, including the EMP History page.) That 1.7 kiloton nuclear test produced an EMP that was so large that it was off the scale that the instrumentation was set to measure.

E1, E2 and E3: Most EMP myths originate because people do not understand about the three components of nuclear EMP. The difference between E1 and E3 is especially important. I have a separate page explaining E1, E2 and E3. To a certain extent, all nuclear weapons will generate all of these components of EMP, especially when detonated at high altitude. It is especially important to note that solar storms are only known to produce an E3 component at ground level. (Solar storms can damage electronics in space, but the mechanism is different from the nuclear weapon mechanism for generating E1.) **A severe solar storm could knock the large sections of the electrical power grid out for years, but solar storms would not damage electronics equipment at ground level that is not connected to the electrical power grid or other very long lines.**

Much of the confusion about solar storms comes from people who refer to the effects of a geomagnetic storm as an electromagnetic pulse. **The effects of a geomagnetic storm *do* meet the scientific definition of an electromagnetic pulse, but the "pulse" is much slower that what the average person thinks of as a pulse.** The phrase ***solar EMP*** has caused an enormous amount of confusion.

Myth: EMP must obey the **inverse square law**, and therefore has only limited range.

Fact: There is some truth to the belief that the law of physics known as the *inverse square law* applies to nuclear detonations, but it is **not** relevant to most cases of nuclear EMP. There are several reasons for this. One reason is that, although the nuclear weapon may be detonated far away, the E1 EMP is generated in the atmosphere overhead. Most of this E1 generation is in a region of the stratosphere between 20 and 40 kilometers overhead. (That is about 12 to 24 miles overhead.) This region is commonly called the *source region* in scientific articles about EMP, since it is the source of most of the E1 EMP.

A second thing that makes the inverse square law less relevant is that there are saturation effects that limit high-altitude EMP to about 50,000 volts per meter (with known types of nuclear weapons). These saturation effects mean that the intensity of the E1 EMP is fairly uniform over an extremely large area, regardless of the intensity of the gamma radiation hitting the source region (unless the weapon has an unusually low gamma ray output).

A third thing that makes the inverse square law less relevant is that the inverse square law applies to the total energy density expanding outward from a single point. The damage generated by the E1 EMP is dependent upon the electric field intensity in volts per meter (or the magnetic field intensity in amperes per meter). These destructive components are **linearly** proportional to distance. **If the inverse square law applied to EMP in the way that many people argue, then radio and television broadcasting would only be effective very close to the transmitting site.**

(To be technically correct, though, in a symmetrical nuclear detonation at ***extremely*** high altitudes, the inverse square law does begin having an effect because of gamma ray dissipation. Even for extremely high altitude bursts, though, the gamma ray dissipation may not obey the inverse square law if the weapon is designed to emit most of the gamma radiation in a highly-directional manner.)

Myth: **Multiple EMP detonations can be used in a single attack to enhance E1.**

Fact: Multiple nuclear EMP detonations can add to the effectiveness of the geomagnetic disturbance due to the E3 component. Multiple nuclear EMP detonations can also help to insure coverage of a continent-sized area when one detonation wouldn't work, or wouldn't be high enough in altitude for the intended area of coverage. There is one very significant problem with multiple nuclear detonations, though. The first nuclear detonation will ionize the source region in the stratosphere over the line-of-sight area, making this part of the mid-stratosphere conductive. This turns this critical part of the atmosphere into somewhat of an electromagnetic shield, and renders it incapable of generating further E1 EMP for a period of time. This period of time will range from a few minutes to an hour or more, depending upon a number of factors.

The important thing to remember is that for multiple high-altitude detonations, even if they are carefully timed to be simultaneous, the E1 components will not add. The E1 as a result of second and subsequent detonations may even be negligible, depending upon a number of factors. These factors include the gamma ray output of the weapons and the altitude of the detonations.

Myth: During the 1960s, the **AT&T Long Lines Division was partially hardened against EMP**, therefore the 21st century telephone system is completely resistant to EMP.

Fact: This myth, like many others, is quite bizarre, since it involves a company that has not existed in a very long time; and most of the technology that they used has not been used in a long time. I only mention this myth here because I have heard it so many times. There are many other versions of this myth which assert that since some 30-year-old (or older) technology was EMP-resistant that current technology is also EMP resistant. **These myths get things exactly backward.** The actual facts are that **the main reason that the EMP threat is increasing is the fact that electronic devices are becoming more sensitive to EMP every year**.

Myth: Small transistorized radio receivers would survive a nuclear EMP attack.

Fact: In many areas affected by an EMP attack, **many** very small solid-state radio receivers probably **would** survive if their antennas were not extended and they were not connected to any external wires. **Many** other unprotected radio receivers probably would **not** survive, though. Where most people go wrong is the source of the information for their belief that radio receivers would survive. One source for the belief is the testing of small transistorized radios that was done during the 1970s. That testing **cannot** be extrapolated to today's solid-state receivers, which usually use integrated circuits that are much more sensitive to EMP than the receivers of the 1970s that used much more rugged discrete transistors.

More recent testing of ***portable professional two-way radios*** has shown that they were resistant to EMP up to quite high levels. ***Two-way radios*** must have fairly rugged inputs on the receive circuits since they have a transmitter in the same case as the receiver, often on the same circuit board. If two-way radios did not have fairly rugged receive circuits, the receive circuits could be blown as soon as the transmit button is pressed. One cannot extrapolate the EMP resistance of expensive professional two-way radios to all other solid-state radio receivers, especially inexpensive consumer radios.

Myth: **EMP is not a problem since there are many ways to protect against it.**

Fact: There **are** many ways to protect against EMP, but **they are very rarely being used**, especially in the civilian infrastructure. In an effort to save money in the short term, most companies do not even have any effective protection against lightning. A major television station spent several days off the air due to lightning damage in 2010. Two years earlier, I had been in the station manager's office and had told the station manager and the acting chief engineer that the station was very deficient in lightning protection, and I told them exactly what to do about it. My advice was completely ignored.

The myth that EMP is not a problem since there are many ways to protect against it is similar to the problem that many people have with preventive medicine. I have known many people with a "silent" medical condition such as high blood pressure. These people have been prescribed a blood pressure medication, and they have purchased the medicine, but they do not use it. They seem to think that a bottle of blood pressure medication setting in their cabinet will help their condition; **but it won't help if they don't use it**. The fact that critical infrastructure **could be protected** is irrelevant if that protection is not used.

Myth: EMP is a new kind of weapon.

Fact: EMP is seen as a secondary effect of all types of nuclear weapons, and was a problem in the very first nuclear weapons test in July, 1945. The official technical history for that first nuclear test in 1945 states, "We can understand the difficulty of transmitting signals during the explosion when we consider that the gamma rays from the reaction will ionize the air and other material within hundreds of yards. Fermi has calculated that the ensuing removal of the natural electrical potential gradient in the atmosphere will be equivalent to a large bolt of lightning striking that vicinity. . . . All signal lines were completely shielded, in many cases doubly shielded. In spite of this many records were lost because of spurious pickup at the time of the explosion that paralyzed the recording equipment."

As I stated on another page on this site, consider this Cold War era quotation from a widely-read and highly-respected publication: "The United States is frequently crossed by picture-taking Cosmos series satellites that orbit at a height of 200 to 450 kilometers above the earth. Just one of these satellites, carrying a few pounds of enriched plutonium instead of a camera, might touch off instant coast-to-coast pandemonium: the U.S. power grid going out, all electrical appliances without a separate power supply (televisions, radios, computers, traffic lights) shutting down, commercial telephone lines going dead, special military channels barely working or quickly going silent." -- from "Nuclear Pulse (III): Playing a Wild Card" by William J. Broad in *Science* magazine, pages 1248-1251, **June 12, 1981**.

The reason that EMP is getting more attention now is that the critical infrastructure that sustains our lives is becoming increasingly sensitive to the effects of EMP. This is happening because electronics equipment is becoming more sensitive to EMP all the time, and critical infrastructures are becoming increasingly dependent upon electronics.

The **next myth** is what I call the ***either-or*** myth with regard to electromagnetic shielding. The **myth** is the belief that ***either*** an electronic device is resistant to EMP ***or*** that it must be enclosed in a military-grade faraday cage. This myth is so bizarre that I heard it for years before I realized that many people actually believe it. Unfortunately, many of the "professionals" working in the EMP field seem to be responsible for spreading this myth through careless comments.

Of course, it is always better to have as much shielding protection as possible, and the means to obtain a high level of electromagnetic shielding are well known. The problem is that a maximally effective shield is often simply neither affordable nor practical.

If a device has a damage threshold of an EMP field of 20,000 volts per meter, then reducing the electromagnetic field by a factor of 3 or 4 will be enough to protect it from known weapons, and shielding it by a factor of 10 will protect it from the super-EMP weapons that are believed by many to exist. A very efficient 80 db. faraday cage would reduce the EMP by a factor of 10,000. In other words, it would reduce a 20,000 volts per meter EMP field to 2 volts per meter. This high level of shielding is necessary for some applications, but not for the average consumer (except for the most critical electronics such as an emergency radio receiver). For many applications, an imperfect shield is quite helpful and may be all that is necessary. (In some cases, though, such as an expensive solar panel system, it makes sense to try to get as close as possible to military grade protection since a functioning solar power system may determine whether you have electricity or not.)

The ***either-or*** myth is analogous to saying that if a coat doesn't keep you from being cold during a winter blizzard that you might as well just rip your coat off and go shirtless while out in the snowstorm. **Asking how much shielding that you will need is like asking how much of a coat you will need in the winter. (It depends upon how cold it will get, and upon how sensitive you are to the cold.)**

Myth: Solar storms only affect the side of the Earth that is facing the sun at the time that the storm arrives.

Fact: Solar storms, especially the most severe solar storms, tend to disturb the entire magnetic field of the Earth. The effect of the solar storm tends to be much greater near the geomagnetic poles, but it matters little whether it is night or day. When the electrical power grid of Quebec was shut down by a solar storm on March 13, 1989, the power grid was operating normally at 2:44 a.m., but the entire Quebec grid was off by 2:46 a.m. It went from normal operation to complete shutdown in the middle of the night over a span of only 92 seconds.

Myth: There are scientists who can predict the probability of a severe solar storm or nuclear EMP over a 5 or 10 year time frame.

Fact: Most of the attempts by the world's best solar scientists to predict solar activity over a 2 to 10 year time frame have proven to be quite embarrassingly wrong. The prevalence of severe solar storms on time scales of centuries is much better known. In the spring of 2011, several noted solar scientists predicted that the current solar maximum would likely fizzle, and that we may be heading for something like the Maunder Minimum of a few centuries ago or the more recent Dalton Minimum. Shortly after these predictions were reported in the news media, the sun began emitting a number of M and X class solar flares. Fortunately, none of the stronger solar flares were aimed directly at the Earth, but this increased solar activity did demonstrate the considerable difficulty in relatively short term predictions. It is important to say, however, that the way that solar scientist measure the activity of any particular solar cycle is usually not relevant to the occurrence of a few very large events.

The current solar maximum seems to actually be a double-peaked event. In 2011 and 2012, most of the sunspots were in the sun's northern hemisphere. Starting in early 2013, most of the solar activity is originating from the sun's southern hemisphere. The flipping of the sun's magnetic field, which is one indication of the peak of the solar cycle, happened in December 2013. After that most sunspots have been near the sun's equator.

There is a similar difficulty behind predicting the probability of nuclear EMP attacks. Such an attack would be a surprise attack. The most reliable characteristic of surprise attacks are that they are a ***surprise***!

I've seen a remarkable number of writings and videos about what to do if a nuclear EMP attack is imminent. If you are the average civilian, though, I do not think that you are likely to be receiving a courtesy telephone call from an attacking nation.

It is fairly easy to predict that the ability to produce both nuclear weapons, and the ability to send them to the necessary altitude, will be greatly increasing over the coming years. It is **not** so easy to predict whether any entity will actually make use of that capability to carry out an EMP attack.

Myth: Severe solar storms can damage automobiles and trucks.

Fact: Solar storms, no matter how severe, will not damage vehicles. This is a myth that has arisen in the past few years, and that just will not go away. (If you have an electric car, and it is plugged in to the electrical grid for charging, it is conceivable, though very unlikely, that it could be damaged.) A nuclear EMP can damage automobiles through the E1 component, **which is not present on the surface of the Earth during a solar storm**.

The voltages induced in automobile wiring by a severe solar storm would be less than 0.1 volt, and would be slowly increasing DC-like voltages. A typical automobile experiences voltage changes that are much greater, and that change much more rapidly, every time that the engine is started.

Severe solar storms have been experienced in relatively small areas of our planet at high latitudes during the years since automobiles have relied heavily on microelectronics. There were billions of dollars in damage to high-latitude electrical grids in the solar storms of 1989. That damage was mainly in Quebec, in northern Europe and to one very large transformer in New Jersey. In 2003, a solar storm in South Africa damaged at least 14 major transformers in the South African power grid. That solar storm left large parts of the South African power grid crippled for months. None of these solar storms resulted in reports of damage to automobiles.

Myth: A Faraday cage will protect against a solar storm.

Fact: There is some truth to this if you are designing a satellite or if you are located on the Moon or on Mars. If you are located on the surface of the Earth, a Faraday cage will protect only against the E1 and E2 components of nuclear EMP, and will do no good at all against a severe solar storm.

Myth: Severe solar storms always occur at the peak of the solar cycle and never occur near the solar cycle minimum.

Fact: Severe solar storms can, and do, occur at any point in the solar cycle. Severe solar storms are more probable during the peak half of the (approximately 11-year) solar cycle, but they can occur at any time. One of the strongest solar storms in the last thirty years occurred in 1986, at the lowest point of the solar cycle.

Myth: When an EMP hits the ground, the induced electric currents either head directly toward the center of the earth or they just vanish from existence.

Fact: When EMP (or lightning) hits the ground, the currents tend to spread out horizontally. These ground currents can do great damage, especially to underground cables of all kinds. Metal conduits are of little help, and may actually make the situation worse by providing a path for underground currents which can, in turn, induce large voltage spikes on the underground lines inside of the conduits. A large amount of damage has actually occurred due to these underground currents, due to both lightning strikes and nuclear EMP. This is one reason that so much of the information on the internet on grounding and on underground cabling is pure nonsense. Large variations in soil conductivity makes the ground current situation even more complex.

Myth: If the electrical grid failed, natural gas would continue to flow since natural gas is naturally pressurized.

Fact: We keep natural gas under pressure, often with electrical pumps, to facilitate the movement of natural gas. If natural gas had some mystical property that caused it to be naturally always pressurized, then it could easily be used to make a perpetual motion machine and we all could have our personal endless source of energy. That is just not the case. Like any other gas, natural gas must obey Boyle's Law and the other basic gas laws of physics. In order to maintain the pressure of natural gas as it is pumped over long distances, or consumed for fuel, pumps are required. After the failure of the electrical grid, natural gas stored in closed tanks would continue to maintain pressure until it was transported through pipes or consumed for energy. Then the natural gas pressure would gradually drop toward atmospheric pressure.

There has been a proposal to use only natural gas powered pumps in the natural gas pipeline system. That way, if the electrical grid fails, natural gas would continue to be available. This is an excellent idea, and quite logical. Unfortunately, excellent and logical proposals are quite often not acted upon. About 95 percent of the large natural gas compressor stations in the United States are natural gas powered. The huge vulnerability comes from the other 5 percent of the large compressor stations that are electrically powered, as well as from many smaller electrical pumps and electrical control systems in the natural gas pipelines.

Myth: A gamma-ray burst from outer space would cause an electromagnetic pulse over an entire hemisphere of the Earth that was facing the gamma-ray burst.

Fact: This actually could be true, but only over an extremely narrow range of circumstances. Gamma-ray bursts occur frequently in distant galaxies, and gamma radiation is constantly causing very minor electromagnetic disturbances. A really large interstellar gamma-ray burst aimed directly at the Earth from within our galaxy would severely damage the atmosphere, and could be a mass extinction event, possibly including the extinction of the human species. Such a mass extinction gamma-ray burst is very unlikely to hit the Earth before the Sun starts to become a red giant (and, in the unlikely event that humans are still around at such a very distant time, we will be having much more serious problems caused by the Sun running out of fuel). An extra-terrestrial gamma-ray burst could cause a massive electromagnetic pulse if it caused a gamma-ray impact on the upper atmosphere that was similar to that emitted by a nuclear warhead, or even one that is one or two orders of magnitude larger. The gamma-ray burst would also have to have a very fast rise time to create an EMP. An extraterrestrial gamma-ray burst that was just right could cause an EMP that is even more powerful and covering a much larger area than the EMP from a nuclear explosion. Such an event is just extremely unlikely, even over billion-year time spans.

All that is really known about an electromagnetic pulse that could be caused by an astronomical gamma-ray burst is that the upper atmosphere doesn't care whether a gamma-ray pulse comes from a nuclear weapon or an astronomical phenomenon. Nearly all observed interstellar gamma-ray bursts have too slow of a rise time to produce much of an electromagnetic pulse. (An astronomical gamma-ray burst is often hypothesized to have caused the Ordovician-Silurian mass extinction; but that was nearly 450 million years ago, so I don't worry much about astronomical gamma-ray bursts.)

Myth: A nuclear weapon detonated in an airplane at maximum cruising altitude would cause an EMP.

Fact: It would cause an EMP, but it wouldn't be very strong compared with nuclear weapons detonated at other altitudes unless it were a special military spy plane flying at an extremely high altitude. At normal jet aircraft maximum cruising altitudes, a nuclear weapon would do much less damage, from **any** effects, than a weapon detonated either near the ground or in space. (The EMP would be minimal because electron currents would radiate pretty much equally in all directions, each direction tending to cancel another out. At much higher altitudes, in the near-space region, the currents would radiate mostly downward due to the relative lack of air in the upward direction. Only gamma radiation would travel upward, but it would not collide with electron-containing atoms, and so would just disperse.)

Myth: Movies and television shows demonstrate a reasonably accurate portrayal of EMP.

Fact: This topic was mentioned briefly earlier, but it is such a large problem that some expanded explanations are warranted. In general, the Hollywood movie portrayal of EMP is beyond being a myth; and movies usually get it so badly wrong that it is just ridiculous and unworthy of any further comment.

Television usually does a better job. In the 1983 television movie *The Day After*, they did a pretty good job in getting the EMP right as far as how it would have been used during the Cold War era as a prelude to an all-out nuclear war.

In the 2000-2002 Fox series *Dark Angel*, they generally got EMP right except for the statement in the first episode that implied that a nuclear weapon detonated 80 miles up would directly affect the entire United States. At this altitude, the EMP would affect a very large area, but not directly damage the infrastructure of the entire country. At this altitude in the right location, though, the economic damage could certainly quickly expand throughout the entire country.

Finally in the 2006 CBS series *Jericho*, there is an EMP attack launched from within the United States in episode 6. Jericho also generally gets EMP right, with the only significant error being the early part of the episode where the residents of Jericho are outside at night watching as the missiles go up. Those people should have at least gotten a very severe case of temporary flash blindness, if not permanent retinal damage, when the nuclear detonation occurred. **High-altitude nuclear explosions are unbelievably bright**, although the flash last only about 100-200 milliseconds. This is faster than the human blink reaction time. Two U.S. military personnel suffered permanent, but partial, retinal damage during one high-altitude test in October of 1962, although they were not looking directly at the detonation at all. The reason that the United States chose Johnston Island to launch its nighttime high-altitude nuclear tests is specifically that they were afraid of blinding Pacific Islanders if the tests were done from any other Pacific location.

Myth: The Carrington Event of 1859 is the largest possible solar storm, and these storms happen at approximately 150 year intervals.

Fact: There is no known cycle or timetable for very large solar storms of the size of the 1859 or 1921 events. We are not "overdue." These very large solar events can happen at any time. A solar storm of about 20 times the size of the Carrington Event of 1859 may have occurred in the year **774 or 775** during what is known as the "774-775 carbon-14 anomaly." Another large cosmic event, which may have been a larger-than-1859 solar storm, occurred in approximately the year 993.

Also, **recent astronomical studies of other (G-type main sequence) stars very similar in size and composition to the Sun** have found solar flares that exceeded 100 times the energy of the Carrington event. (Some appeared to be more than 1000 times the energy of the Carrington event.) We do not know what may be going on inside of these other stars, so it is impossible to say if storms of this size are possible on our Sun, but these studies provide strong evidence of the possibility.

Myth: The "X-number" of a solar flare determines the effect that it will have on the electric power grids on the Earth.

Fact: Solar flares, coronal mass ejections and geomagnetic storms are all different things, although they are usually related.

A solar flare is an explosion on the Sun that releases the energy stored in unstable magnetic fields. These explosions release radiation, which usually arrives at the Earth in about eight and a half minutes. Solar flares often interrupt radio communications, but they rarely cause any direct damage to man-made assets, except to satellites. Solar flares are often, but not always, associated with a coronal mass ejection (CME).

A coronal mass ejection (CME) is an ejection of mass from the Sun. It is usually ejected upward from a particular solar flare location on the surface of the Sun, but does not generally travel in a straight line.

Whenever a CME impacts the Earth, it may result in a geomagnetic storm. The intensity of a geomagnetic storm is determined by many factors, especially the energy within the CME and the magnetic polarity of the CME when it hits the Earth. If the magnetic polarity of the CME is the same as the polarity of the magnetic field of the Earth, then the geomagnetic storm is not likely to have much of an effect. As anyone who has ever played with magnets knows, like magnetic poles repel and unlike magnetic poles attract. So if the magnetic polarity of a CME is opposite to the Earth, the geomagnetic effects will be much stronger.

It is difficult to predict the magnetic polarity of an approaching CME because the magnetic polarity of the CME is usually rotating before it impacts the Earth.

Also, in terms of the effects on the transformers in our electric power grids, duration is a very important factor. The most damaging solar storms are often those that release a number of coronal mass ejections within the space of a few days.

Myth: Popular Mechanics magazine says . . . "

Fact: Popular Mechanics is a fantasy magazine and a major source of EMP myths from incompetent science writers. They won't even publish a retraction after they are proven to be wrong. To make matters worse, their errors are copied all over the internet. Don't believe anything that you read in Popular Mechanics without checking the information in an independent source that is not merely copied from Popular Mechanics. Articles in other publications that use information sourced from Popular Mechanics should also be viewed with suspicion.

Related Issues and Uncertainties:

Myth?: The bright orange round glow in the Starfish Prime sky as shown on the Main EMP Page on this web site is actually fireball of the nuclear explosion. (That photo is also shown below.)

Fact: This one gets quite complicated, and filled with uncertainties, but I don't want to be guilty of promoting another myth myself, so I am addressing it here. This question is complicated because the Starfish Prime fireball was only spherical for a very brief instant, and it was quickly enlongated by the geomagnetic field and then very quickly dissipated as the sky began to glow with a bright aurora. In addition, the appearance in the sky of the brief Starfish Prime fireball was about the same size in the sky as the moon. From most places in Hawaii, it appeared to be fairly close in the sky to the location of the moon.

If you consult the NASA Moon Phases Table, you can see that the new moon before the Starfish Prime test occurred on July 1, 1962. On July 9 (UT), the first quarter moon occurred. A first quarter moon sets at midnight, local time (more precisely, midnight local solar time). The Starfish Prime test occurred about an hour before local midnight in Hawaii, so the first quarter moon at that time would be low above the western horizon (although not quite as low as a normal first quarter moon since Honolulu is west of the center of its time zone meridian). **The full moon did not occur until July 17**. (Hawaii does not observe Daylight Saving Time, and did not in 1962.)

If the fireball were actually a photographically-distorted first quarter moon, it would seem likely that the upper half of the "fireball" should have been noticeably darker than the lower half, even with photographic distortions caused by film speed or exposure times. The spherical glow in the photograph appears quite uniformly round (as a high-altitude nuclear explosion would appear an instant after the detonation), and nothing at all like a distortion of the normal "half-moon" appearance of a first quarter moon.

The Starfish Prime explosion also occurred fairly low in the western sky over Hawaii (not far in the sky from the moon). In some circumstances, a long photographic exposure time could have actually distorted the appearance of a half-moon into that of a full moon. In fact, this seems to be exactly what happened. The cloudy sky, however, complicates the issue further. I have seen motion picture film of the Starfish Prime explosion taken from other locations in the Hawaiian Island region where both the first quarter moon and the Starfish Prime explosion were visible in the same region of the cloudy sky, and those motion picture images do not help to resolve the matter. To resolve the question of whether the "fireball" is actually the moon, you would, at the very least, have to know whether the photo was taken one-tenth of a second after the detonation or two or more seconds after the detonation.

I have found two other images of the Starfish Sky, and they lead me to believe that the bright orange glow is the moon, and that the photo in question was taken a minute or so after the detonation. Those photos are shown below. From about 30 seconds after the detonation, and lasting for about 7 minutes, the sky over Hawaii glowed a bright orange due to the Starfish Prime aurora. I now believe that the Starfish Prime image on the main EMP page shows a long time exposure image of the Starfish Sky taken during the period from 30 seconds to a few minutes after the detonation, and shows the bright orange aurora over the Hawaiian Islands. The round glow in the sky is a probably a long time-exposure of the moon shining through the auroral display. The first quarter moon appears round because of the long time exposure of the photograph and the speed of the film being used.

In any case, based on the images of other high-altitude nuclear explosions, that image very much resembles what a high-altitude nuclear explosion looks a millisecond or so after detonation. I just wanted to set the record straight on what I believe that it really is.

The photo in question of the Starfish Sky from Honolulu

Starfish Prime from Maui Station. Time exposure from detonation to 15 seconds after the detonation. The sky appears blue at a hour before midnight for exactly the same reason that the sky appears blue during the daytime. The blue sky at night is characteristic of very high altitude detonations due to the extreme brightness of the nuclear explosion. The blue color is actually imprinted on the photograph during the first second after the detonation. The brightness of the sky was then much less until the appearance of the aurora across nearly the entire sky.

Photo courtesy of Los Alamos National Laboratories. ©Los Alamos National Security, LLC.

Starfish Prime from Maui Station. Time exposure from 45 seconds to 90 seconds after the detonation. This is a longer time exposure than the previous photograph because it does not have the benefit of the bright flash of the nuclear detonation. It is just the night sky and the Starfish aurora. The sky appears bright red-orange due to the aurora caused by the injection of large amounts of energetic charged particles into the Earth's magnetosphere by Starfish Prime. The aurora did not spread across the entire sky until several seconds after the nuclear explosion. The very bright aurora lasted for about 7 minutes over Hawaii. (Electrons following the magnetic field lines of the Earth cause the auroras to also appear within seconds of the detonation in the magnetic conjugate region near Fiji, in the southern hemisphere far from the Starfish Prime detonation.) That bright object behind the cloud is the moon.

Photo courtesy of Los Alamos National Laboratories. ©Los Alamos National Security, LLC.

With the changing colors in the photos above, taken only about a minute apart, you can see why these high-altitude nuclear explosions were sometimes called *rainbow bombs*.

Myth?: There is no use being prepared for a nuclear EMP attack since an EMP attack would immediately lead to an all-out nuclear war.

Fact: This is a surprisingly common belief, and it is a belief that is held by people that you would think would know better. Human actions are impossible to predict, and so it could be true. This is just my opinion, but it seems to me to be **extremely unlikely**.

Put yourself in the position of being the leader of a country that has just been hit with a nationwide EMP attack. Immediately after the EMP attack, the only citizens of the country who have been injured or killed have been people in hospital intensive care units and people in transportation accidents. Is your decision as leader of your country going to be to start an all-out nuclear holocaust? Although I have generally believed that most politicians are crazy, I don't think that they are **that** crazy. If the perpetrator can be identified, there would surely be a retaliation, but there is no reason to expect that the perpetrator would immediately launch a further major nuclear attack on cities. (That was the supposed Cold War scenario, but I didn't even believe it then. I could have easily seen either the Soviet Union or the United States launch an EMP attack during a severe crisis, then stop there to see what would happen next, trying to avoid an all-out nuclear war.)

No country has announced what their response would be to an EMP attack. (France, however, stated several years ago that they would not distinguish between a high-altitude EMP detonation and a single detonation near ground level.) Most nations have indicated a policy of "lesser retaliation" in order to prevent things from escalating into an even more dangerous situation. Exactly what that "lesser retaliation" would be is something that nations are not going to announce in advance. The idea that the response of an advanced nation (like the United States) would be to immediately take actions that are likely to lead to the immediate deaths of a large fraction of their own country's population is not very believable. A major country like the United States may very well use total destruction of a "rogue nation" that uses an EMP weapon, but only against a country with no "second strike" capability. The idea would be to use a form of retaliation that would shorten the conflict, and not escalate into further nuclear destruction.

An article that appeared online on July 11, 2016 from the magazine Popular Science stated: *" 'A single nuclear weapon detonated at high altitude over this country' would be the opening moment of a nuclear war that would almost certainly escalate and end all human life on earth."* That statement from Popular Science is ridiculously inaccurate on many levels. **That single statement is a Super-Myth** that contains so many inaccuracies that it would require a long article to discuss them all. The author of that Popular Science article seems to have been watching too many bad science fiction movies. Even if all of the nuclear weapons on Earth were converted to cobalt bombs, they wouldn't come close to being able to destroy all life on Earth (although it could certainly knock overall human civilization back a century or more, as well as extinguishing certain parts of human civilization).

I will admit that my favorite movie is the rarely-seen 2000 Australian-American version of *On The Beach*. But the major premise of *On The Beach* is simply wrong. Killing off all human life on Earth might be possible with biowarfare, but not with nuclear warfare (at least, using any sort of nuclear weapons systems that humans have so far deployed, or even considered). Even as bad as things were during the Cold War, the biological weapons of the Soviet Union posed more of an overall threat to the human species than all of the nuclear weapons on both sides. You can enjoy scientifically-inaccurate movies and books without getting your science education from them. Popular Science articles are too-often written by scientifically uneducated people.

Myth: The Cheyenne Mountain "nuclear bunker" Air Force Station closed in 2006, and re-opened in 2015 because of the EMP threat.

Fact: Internet stories about the Cheyenne Mountain facility that were widely published in April and May of 2015 were obviously mostly copied from each other because so many of them contain the same errors (such as the ridiculous claim that it is only a "half-acre" facility). The Cheyenne Mountain facility was never closed. It was placed on "warm standby" in 2006 and its staff was greatly reduced, but it was still operational 24 hours a day. Many of the headquarters operations were moved into EMP-hardened facilities in nearby Peterson Air Force base at that time. Many operations are being moved back into Cheyenne Mountain in 2015, so it may be back to a full staff by the end of 2015, although specific details are not being revealed.

The Cheyenne Mountain facility has always been EMP-hardened, and EMP-hardened communications from Cheyenne Mountain to other facilities has been an issue from the time that it was constructed. Because of the possibility of nuclear EMP weapons of greater intensity (along with the ever-increasing EMP sensitivity of the latest modern electronics), there has been frequent upgrading of the EMP-hardening of the Cheyenne Mountain facility, especially in recent years. Raytheon was awarded a $700 million contract in early 2015 to provide communications systems with increased EMP-hardening going from the Cheyenne Mountain facility to other military facilities. So some of the Raytheon work will actually be done at other facilities.

So most 2015 news stories about Cheyenne Mountain were somewhat close to the truth, but most just contained a significant number of major inaccuracies.

There are lots more EMP myths. (**They seem to be endless;** and most writings about EMP on the Internet, even from some widely-quoted news stories, are nonsense.)   I will have more later.

Back to the Main Futurescience EMP page.