The

Broadcasters' Desktop Resource

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The Maintenance Shift

Long Term System Survival From EMP

By Glen Clark

[January 2018] This is the final, fifth part of Glen Clark's look at what EMPs (Electromagnetic Pulses) are, what dangers they present to broadcasters, and what, if anything can be done to minimize damage from an EMP.

It is important for us to stop and rethink the length of time that we need to be able to provide for ourselves should commercial power fail.

In these turbulent times, it seems as if every day another vendor is preaching an imminent Armageddon about something. Many are hawking food packets with long shelf lives. Others have various survivalist items ready for mail order delivery.

Of course, some Armageddon scenarios are credible. Some are not. In fact, if we believed every Armageddon scenario that we find on the web, we would never come out of our basements. Yet, the danger of a Cassandra regret is very real when discussing EMPs.

HOW LONG DO WE NEED?

The present conventional wisdom for broadcast plant diesel generators is that the genset should be able to cover an hour-long outage caused by a car clipping a power pole.

The genset also should be able to cover a 3-day outage for a hurricane between Long Island and Brownsville, Texas, or a 6-day outage for an ice storm that put an inch of radial ice on transmission lines.

Unfortunately, few transmitter and studio plants today are configured with the intention of being able to maintain operations for more than a week.

To prepare for the possibility of an EMP, that number needs to be extended to six months. That does not mean that stations need to have six months of fuel on-premises. But they should have enough oil filters, oil and other consumables on-site to last that long.

DANGER FROM HIGHWAYMEN

There is a credible story from the Gulf Coast of a fuel delivery truck which was on the way to deliver fuel to a large, major-market station when the truck was commandeered by local authorities during a weather emergency.

The station was told that the authorities had a greater need somewhere else, which justified the ad hoc appropriation. Yet, it is hard to imagine any need for AC power which exceeds the need for a full-market signal which can reach every person inside the weather emergency.

If there was a reason to do so, this story could be chased down. But the take-away would not change: to run the generator for six months will require regular resupply at a time when many people will be desperate for fuel. The bright Y-106 logo on the side of the station van that makes friends when you go to the remote with the T-shirt cannon will not slow bad guys down for a second.

ATMS WITH DUSTY SPIDER WEBS

Many people live an ATM-centric life. They buy groceries, gasoline, and almost everything by swiping the magnetic strip in a Point Of Sale (POS) device.

The POS device needs two pieces of functional infrastructure underneath it to dispense money. The POS needs AC power and it needs a functional Internet connection. As many electronics systems will fail after an EMP and as the most vulnerable systems are those attached to long wires, you have two chances to lose.

The TV ad for a popular state lottery "scratch and win" ticket boasts "Two chances to win!!" The ATM has "two chances to lose." One cannot say with certainty that every ATM inside the EMP zone will cease operation. But the facts support an expectation that a lot of people will go back to cash-based transactions.

WHERE WE STAND

Because of the length of this series, a summary of the main theme may be helpful.

We have reason to expect that continued broadcasting (or intermittent scheduled broadcasting) will rely on the continued operation of two physical plants:

1) the electric utility that furnishes commercial power, or a suitable substitute.
2) the broadcast transmission plant.

While cellular phones are not directly part of broadcasting itself, they are a part of broadcast staff security. In a post-EMP world, many things we now take for granted will no longer be true. A British politician said *"Most of us are just nine missed meals from doing things that we never imagined that we would do."*

Combine that with the fact that moving generator fuel to the transmitter and/or the studio will be a never-ending resupply process – and staff security concerns become greatly elevated. So, a third physical plant, the cellular infrastructure, also deserves attention.

Of course, there is not much you can do to help the utility to stockpile or replace step-down transformers. And there is not much that you can do to help the utility to stockpile or replace insulator bushings.

The rather considerable pre-ceding text about rewinding transformer cores and carbon-tracking of power line insulator bushings was simply to drive home the fact that a wide-area EMP event would exceed the resources presently stockpiled.

WAVES VERSUS PARTICLES

It has been the purpose of this series of articles - to address the question of how to prepare for and how to recover from an EMP.

We intended specifically to avoid almost all discussion of the nuclear physics involved and how EMPs are created. This section is the exception to that focus. Three kinds of energy are released by a nuclear detonation:

1) a Newtonian, kinetic shock wave.
2) high-speed particles (ionizing radiation).
3) electromagnetic waves (non-ionizing radiation).

The shock wave is the simplest. It is just a thunderclap. It might be a thunderclap of incredible size but it is just air molecules banging into other air molecules which bang into other air molecules. It is mentioned only in the interest of completeness. The Newtonian wave is not involved in an EMP and will be not mentioned again.

IONIZING RADIATION

Ionizing radiation is sometimes called "fast neutrons" more because it conveys an idea than because it is scientifically accurate.

In the same way that a terrorist bomb is packed with carpet tacks and other projectiles, when a nuclear detonation takes place, all manner of junk comes flying out of the nuclear core. That junk is composed of protons, neutrons and electrons, subatomic particles which have mass.

Think of them as jagged fragments of what used to be an atom. Place a clear glass sphere that is the size of a cue ball on a concrete floor. Now hit it as hard as you can with a sledge hammer. Small fragments will fly in all directions.

Most people have seen a picture illustration of how a Uranium chain reaction works. One Uranium atom ejects two neutrons, which cause two other atoms to eject four neutrons, which cause four new atoms to eject eight neutrons. But the sphere of uranium is not infinite. At some point the chain reaction reaches the outer shell of the Uranium. And then there is nothing to obstruct the ejected neutrons and other fragments. And for a surface-of-the-earth detonation of a Uranium device, it is these nuclear fragments ("fast neutrons") which cause the greatest damage.

DOUBLY DAMAGING PARTICLES

A sandblaster can be used to remove the paint from a metal panel. Millions of grains of sand, traveling at high speed, deliver kinetic energy which dislodges the paint, one fleck at a time.

Fast neutrons are smaller and faster than the grains of sand. And there are more neutrons than there are grains of sand. But the comparison is useful. These neutrons are a sandblaster at a subatomic level.

One of the better-known, declassified government films of the damage caused by an atomic blast shows a white, two-story frame house where the paint begins to smoke and, a few seconds later, the house is laid flat.

There is a wealth of information in that 5-second film clip.

The Newtonian kinetic shock wave travels at the speed of sound. The fast neutrons travel at nearly the speed of light. So the shock wave and the neutrons do not arrive at the same time. That explains the delay between the paint smoking and the building being knocked to the ground.

SMOKING HOT PAINT

Why does the paint smoke?

Fast neutrons impacting the molecules in the paint deliver energy to the paint which raises the temperature of the paint. When the temperature of the paint rises to a high enough level, it begins to react with the oxygen in the air.

Remove the painted house and put a person in the path of the neutrons. What happens? The explanation is unpleasant and it would normally be left out of a scientific article if it was not an essential link in the understanding of the physiccal processes. If the neutron density is high enough, death will be instantaneous because the body is turned to ash.

The same neutrons that made the paint smoke are heating the cells of the body and boiling away all of the water in the cells. With a high enough neutron flux, the flesh burns just as if had been hit with napalm, leaving nothing but ash.

NOT GOOD EFFECTS

Even with a much lower neutron flux, lethal effects still materialize. They just take longer.

The reason is that fast neutrons do not destroy existing cells. They just shatter DNA strings and make new cell generation defective. The resulting cancer could kill you the following day or 20 years later.

The brave firemen and helicopter pilots who put tons of sand and borax on the glowing, exposed reactor core at Chernoble died from this kind of effect. All of them died within a week of their exposure.

Lead is the normal shield against fast neutrons. Before your dentist will take an X-ray of your teeth, (s)he will temporarily cover your torso with a lead apron. Steel, because the atoms are not as dense, do not shield as well as lead does, on an attenuation per unit mass basis.

And this is the mental paradigm that the public has lived in for the last half-century. Nuclear detonations generate gobs and gobs of tiny atomic fragments which:

1) have mass.
2) travel in straight lines.
3) come hurtling at you at incredible speed.
4) will instantly turn you to a cinder at a high neutron flux density.
5) might kill you from cancer at some future date with a lower flux density.

But the EMP is not particles. It is a wave.

(Note: The hot-shot physicist reader will object that this ignores the partical/wave duality. And that is an accurate observation. But ignoring the duality here is justified because doing so removes unnecessary complexity from the explanation without decreasing the understanding.

I salute those of you who were about to object for really knowing your stuff.)

FORGET WHAT I JUST SAID

Ground level nuclear blasts and those within a mile of the earth's surface deliver fast neutrons to the target.

However, a detonation at 100 miles above the earth's surface delivers neutrons to the upper layers of the atmosphere, where a conversion takes place: the particles are converted to waves. But waves have no mass. And, unlike particles, waves do not travel in straight lines.

So, it is good to keep these three points in mind:

1) protecting against a wave is not the same as protecting against particles.
2) protection against an EMP, often a Faraday cage, should be made from materials which are good conductors, like copper or aluminum, not from materials with high atomic numbers, like lead.
3) when protecting against a wave, think more about how the pulse will get inside the Faraday cage at a seam than about the pulse going through the side of the cage because the cage wall was too thin.

UNDERSTANDING THE WAVE

Many engineers seem to understand points 1 and 2.

But our past understanding about protection from ground level detonations leaves us with an intuitive feeling that contradicts point 3.

We still seem to think that thick walls on the Faraday cage are the guarantee of protection.

For example, some people think that, if their car is "bricked" by the EMP, the "ingress route" will be through the automobile's steel hood, the steel firewall, and the aluminum extrusion bolted to the firewall – which holds a gob of electronics in a straight line the whole way from the detonation at 100 miles above the earth to the IC behind the firewall.

A MORE CONSIDERED ROUTE

A more likely scenario is that the EMP will be brought to the car's electronics by either the in-the-windshield radio antenna or the in-the-window defroster heater. From there, the pulse follows the wiring back to the radio and backfeeds the wiring harness where it can then flow anywhere in the vehicle.

Another ingress route in an automobile is for the pulse to enter the passenger compartment via the glass windshield or a side window, and then enter the "aperture" in the dashboard where the speedometer and other gauges are located. Some instrument clusters are alleged to have a fine wire mesh embedded in the clear plastic which sits in front of the gauges. Such a mesh might make the plastic "RF opaque."

But how many dB of attenuation it would provide would depend on the frequency of the pulse and the orientation of the car at the instant of detonation.

YES, WE KNOW YOU WANT ANSWERS

Accountants, planners and politicians want – in fact, they demand – exact answers.

Exactness makes their jobs easier. But there are no exact answers and there will be no exact answers to the question of what will survive an EMP, not in this decade. And this will cause much friction between the scientists and the suits.

In the beginning, the accountants, planners and politicians will go "venue shopping." "If the first group of scientists will not give us an exact answer, we will go find scientists who will." Eventually, they will find the scientists who will give them an exact answer.

But the bound report will have so many footnotes, qualifications and asterisks at the bottom that the report is totally meaningless.

THE CARD TRICK

Seldom is it good to take a side-trip and interrupt the momentum of the main theme. But an exception seems warranted here due to a universal and powerful truth made in the following side point.

If someone writes a lengthy and detailed report with the specific goal of hiding a steamer, the “card trick” will not be in the 30 pages of words like "forward-looking," "increasing cost of capital," and "poly-parametric optimization."

The card trick will not be in the dozen pages of tabular data. The card trick will not be in publication-quality multi-color pie charts and histograms.

The card trick will be in the footnotes.

If one of the footnotes says "The above conclusions are based on management's considered belief that a gerbil will be elected president within the decade," it kind of negates the accompanying conclusions, does it not?

RESISTING ABSURDITY

Of course, this example tests the limits of absurdity and adult debate.

But this absurd example was done intentionally to make a specific point. Many of the footnotes in expensive consultant's reports are almost as bizarre and almost as totally debilitating.

This is a universal truth about business, government, and finance. It is not just a statement about the inevitable friction between technologists and suits when developing strategies to deal with EMPs.

If a consultant has to hide a dead body in a report, it will not be hidden in the middle of a page. It will be buried in one or more harmless-looking footnotes.

At some point, the accountants, planners, and politicians will resign themselves to the fact that exact answers are not possible and will not be possible within the foreseeable future.

MORE SHIELDING IS BETTER

While we cannot come up with exact answers for EMP predictions, we are not entirely helpless.

For instance, we may not be able to say that exactly three wraps of aluminum foil will protect a spare PC board from a certain strength of arriving pulse. But we can say that three wraps of foil is better than two wraps and that four wraps is better than three.

Similarly one can make a poor man's Faraday Cage from a clean, empty, one-gallon paint can. But, whatever level of protection would be provided by a one-gallon Faraday can, greater protection would be provided by putting that can inside the clothes drum of a decommissioned clothes dryer.

Yet, how much shielding is enough?

First, please, tell me where the detonation is and tell me how much energy is released.

Will the one gallon can be sufficient? Would putting the can inside the clothes dryer be overkill? It is hard to tell. But, if additional shielding can be added inexpensively, what is the harm in erring on the high side?

In other words, as most engineers know, it is better to have too much shielding than not enough shielding.

WHAT TO DO

As you analyze your operations, you should develop a checklist of things that you can control – and plans to cope when one part or another fails.

The checklist should contain the systems critical to staying on the air. It should also contain an inventory list of things that should be bought and stocked.

For example, each facility should have:

A clamp-on Ammeter.
vacuum food storage.
Solar panels to charge cell phones (Harbor Freight).
Secondary generator (Harbor Freight).
Footwear.

Additionally, consider the key systems which might be called to service.

- **The Generator**
  Arrange for a generator with a mechanical injector pump rather than a high-pressure rail if you can.

  Stockpile oil and oil filters.

  If your genset has a day tank, understand it inside out. Know how it works. Test it frequently.

  Many $200,000 generators have coughed to a stop during a commercial power failure because someone ran the fuel transfer pump from the commercial mains. When the day tank ran dry, the generator just … stopped.

  A caution: There is a strong temptation to hang all kinds of telemetry on the generator so that you can monitor it from your smart phone. Resist that temptation. The genset is critical times two. Creating multiple ingress vectors for an EMP into the genset through the telemetry sensor wiring is not wise.

- **Security**Physical safety will be a real concern when doing fuel resupply. Plan this out thoroughly in advance.

The cellular companies have very specific plans for how to shuttle fuel to their sites while keeping a low profile. You should also.

- **Communications**
  Cellular handsets may survive an EMP. Base site failures and "backhaul" failure are more likely. Some sites have batteries; some have generators. Learning which cells might be more likely to stay up might save the day in an emergency.

WHAT TO EXPECT

It is only natural to investigate what electronic hardware will continue to function after an EMP and what will not.

As a reader of this series, you probably have already guessed that an exact answer will never be possible

As noted above, it is human nature to want exact answers. Knowing that your flight from Boston will pull up to the arrival gate in Denver at exactly 3:07 PM allows you to tell your relative what time to pick you up at curbside. Knowing the exact per-ton cost of concrete allows a contractor to submit an accurate bid for a construction project.

Everyone wants an answer that nails down exactly what is going to happen.

Still, an exact answer to the question of what hardware will survive an EMP and what hardware will not survive is impossible and always will be. The best that we can do is "more likely" and "less likely."

SCARCITY OF DATA

The reason why we cannot provide an exact answer is the scarcity of field data. We just do not know for sure what will happen.

We have accurate models of how surface weather works because we have had decades of data collected from ground stations and from weather satellites. And that mountain of data has allowed us to tweak and refine our surface weather models to their present state of near-perfection.

We have no such mountain of data to perfect our computer models of EMPs.

A SHORT SEASON

The first EMP test was performed in 1962 under the government codename "Starfish Prime." A Google search on Starfish Prime reveals a wealth of information including several YouTube videos.

AM radio was still the dominant music delivery system then. Cars had carburetors rather than fuel injection. Most families still had black & white televisions that used vacuum tubes in the living room. Data was entered into computers on cardboard "punch cards." Transistors were rare. Integrated circuits were almost unheard of.

A year later, in 1963, the atmospheric test ban treaty was signed. While compliance was imperfect in the early years, tests on EMPs soon came to a halt. Real-world data collected on EMPs began in 1962 and ended just a few years later. The total data collected from atmospheric tests was miniscule. Governments have some models of how we think EMPs work in a quantitative sense. But the models are largely unproven.

What we are saying is that the middle of World War III is not a good time to discover the shortcomings of your computer models.

LACK OF DATA ON EMP CAUSES

Our computer models for EMPs are imperfect because:

1) We do not know the payload yield, the total energy emitted, by the incoming weapon.

2) We do not know the spectral distribution of the EMP generated and any potential aggressor is unlikely to tell us.
3) Few warheads generate a perfectly spherecal wave. We do not know the exact orientation of the weapon at the instant of detonation. So the energy directed toward a particular electronics device could vary by 6 dB, or more, depending on where in the tumble it is at the moment of detonation.
4) We do not know beforehand the latitude, longitude, or altitude of the warhead at the instant of detonation.

In this context, we have an "intractable problem" in that you can write the source code for a solving algorithm, but you would need all of the energy generated by our sun plus the ten nearest stars, running for one million years, to get an answer. Predicting exactly what devices will and will not survive an EMP is an intractable problem.

Even if the two issues above could be overcome, the required computation is unachievable without infinite computing power.

Deep-penetration espionage might tell us more about the incoming weapon – but this will remain an intractable problem unless and until a working quantum computer is developed. The quantum solution is unlikely to be available within the lifetime of anyone now alive.

SOME BEST GUESSES

Some of the things which we should think about prior to any EMP are obvious. Some are not so obvious.

As we address the list, remember that the best answers available are "more likely" and "less likely."

Some answers may appear to be apparent. In particular, older equipment is more likely to continue functioning. A car or truck manufactured before 1975, before solid-state accessories became common, has a much better chance of surviving an EMP than does a post-1975 car with a fully-electronic dash and multiple engine computers.

Some surprises:
1) small single-engine airplanes are very likely to work, even if some of the electronics may not work.
2) if you can find oil and gasoline, simple motorcycles may be one of the most reliable post-pulse conveyances .

AN ATTEMPT AT ANSWERS

There are obvious questions to ask:
- Will my car run after an EMP and the utility electric dies for an extended period (six months or more)?

  The estimated number of functional cars:

  pre-1970s cars or light trucks will function: 80% if gasoline, 90% if diesel.

  1970-1990 cars or light trucks will function: 50% if gasoline, 60% if diesel.

  post-1990 cars or light trucks will function: 15% if gasoline, 15% if diesel.

- Will my cellphone work?
- There is an 80% chance your charged cellphone will connect 1 hour after an EMP.

  There is a 40% chance your charged cellphone will connect 1 week after an EMP.

- Will my furnace work?

  The estimated likelihood that a carbon-fueled furnace with an old-style thermostat will work:

  80% The estimated likelihood that a carbon-fueled furnace with a new-style thermostat will work: 50%

As you can see, almost every question will lead us to a discussion about probabilities – probabilities based on the level of solid-state based circuits in the product. As we have seen, these probabilities are not always easy to resolve.
We can go on with a long list of "will xxx work after an EMP?" What would you like to know?

- will my 15 kW diesel generator from Onan or Koehler or Generac still work?
- will my 3 kW gasoline generator from Harbor Freight or Tractor Supply still work?
- will my well pump work?
- will my sump pump work?
- will my electric garage door opener work?
- will my air conditioner work?
- will the gasoline pump at the convenience store still work?
- will my microwave oven work?
- will my desktop computer and display work?
- will my handheld "pad" computer work?
- will my flatscreen TV screen work?
- will my satellite receiver work?
- will my Comcast/Xfinity/Verizon-FiOS/Charter/Cox "cable box" work?
- Will my **_________**work after an EMP?

KEEP LEARNING AND PLANNING

In many ways we have to leave you not far from where we started. Yes, you have a lot more information than when we started, but in many ways the discussion has only started.

We hope you have found the explanations useful, especially in discussing options with bosses and colleagues, as they also are led to grasp and understand the danger from an EMP, not as an abstract idea from the movies, but as a real possibility – and why planning now is worthwhile.

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For those of you who would like to delve even deeper into the topic surrounding EMPs, Glen currently is working on a web site with a deeper look at the mechanics of EMPs, what knowledge and data are available, more "will my xxx work?" and helpful advice on the best ways to plan on how to survive the effects of EMPs.

We invite you to subscribe to the BDR Newsletter for notice when the website goes live.

Just click here – it only takes 30 seconds – and we will announce when the site is ready.

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Glen Clark was, in a previous life, the founder of TEXAR and the designer of the AUDIO PRISM. Today, he is the chief scientist for kiprosys.com.

He can be reached at: glen@kiprosys.com

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