# computers are bad



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## 2022-09-13 the nevada national security site pt 2

This is a continuation of part 1, and I would recommend that you start there for context. Or dont and figure it out as you go.

After our time milling around the Mercury cafeteria, it was back aboard the coach to enter the test site proper. As our guide explained, the NNSS can be divided into work areas such as Mercury and the range itself. On the days that tests were scheduled, everyone other than personnel for that specific test was prohibited from entering the range area for safety reasons. Considering weather delays and technical issues, this sometimes meant a full day of lost work as the entire staff huddled in Mercury awaiting news that they could once again head out to test sites.

The first point on the tour after Mercury, then, and perhaps the first truly related to nuclear testing, was Checkpoint Pass. Here, where the road passes over a low ridge, there is still a wide part of the road with a row of floodlights where guards would check if each person was on the staff list for the test of the day. This is one of many places where the history of nuclear testing seems remarkably well preserved, even ready to be returned to use. There are reasons for this, as we will discuss later.

Shortly after Checkpoint Pass our guide points towards Control Point. This is the building from which underground tests were actually performed. Like the operations control center, it is a largely unremarkable low concrete building. What stands out is the rack of microwave antennas spanning the side of the building facing the valley. Presumably a great deal of microwave communications were used for control and monitoring, probably in the later era of testing based on the use of delay-lens antennas. Microwave communications were widely deployed by telcos in the 1950s but the equipment and antennas were exceptionally large and heavy. I am not sure if this early microwave equipment would have been used in the frequently-reconfigured testing environment. By the 80s microwave would have become an inexpensive and fast to deploy network medium.

The microwave infrastructure here was clearly substantial. Looking down the ridge into the valley several passive repeaters (billboard-like structures that act as mirrors for directional microwave links) can be seen, their aim suggesting that they allowed antennas at Control Point to reach sites on the other side of a hill to the buildings west. Passive microwave repeaters have always been a minor fascination of mine. They are only really practical for the very short wavelengths of GHz microwave systems, and the high attenuation of a passive reflector combined with the ever lower cost and maintenance burden of active repeaters makes them rare today. Passive repeaters can sometimes still be found in use by rural telcos to reach AT&T or MCI sites outside of direct view of their exchange facilities, but perhaps the best places to hunt for them are dams. Likely a majority of the hydroelectric dams of the southwest, often being in deep canyons, used passive repeaters set on the canyon rim to get telephone and industrial control signals to the powerhouse.

I should avoid dallying too long on the details of the telecom equipment, but this will not be the only example I find interesting. The communications infrastructure at these types of national security sites is a revealing example of the very close relationship between national defense and the telecommunications industryespecially AT&T, which at the NNSS as in other places is practically an arm of the government.

Just past control point, our guide calls out two sets of wooden benches, one at each side of the road. These were the spectator stands for atmospheric tests, set far enough away for safety but with a clear view. Anyone not wearing safety goggles was required to face away for one minute around detonation, protecting them from vision damage due to the intensely bright light. One set of benches, closer to the road, was for government officials and other VIPs. The other, somewhat further away, was for the scientists and engineers who had planned the test. And just a bit ahead of the benches, a rocky outcropping is known as News Nob due to its use by media crews invited to report on nuclear tests.

Despite the commonplace nature of worn wooden benches and a rock face, this is one of the more emotionally impactful sites on the tour. From 1951 to 1963, the NNSS detonated nuclear devices above ground, typically on short metal towers. These tests were not just sources of data but spectator events. On this topic, our tour guide, who had seen underground tests but started decades too late to see any above ground, seemed practically wistful. Imagine what it would be like to see that, he said. I cannot be sure if this is reality or an embellishment by my own memory, but I could swear that he then echoed the words of Oppenheimer and the Bhagavad Gita: to see the radiance.

This is one of those things about nuclear weapons that is difficult to capture in language without resorting to poetry. As much as we might hope for disarmament, and as much as we might celebrate the end of atmospheric testing and the end of all testing some decades later, I am quite sure that we all want to see it, just once. Lots wife, as we usually understand it, turned back to see the cities. I have always thought, though, that it is a better explanation that she turned back to see the *destruction.* Who wouldnt be curious about the physical manifestation of Gods power? A surprising number of people, sitting on those benches and equipped with protective eyewear, saw just that. They looked down on Frenchman Flat, toward all the land of the plain, and saw dense smoke rising from the land, like smoke from a furnace (Gen. 19:28 NIV). Lucky that Oppenheimer had developed a fascination with Hinduism; had he been a Christian, he, too, might have been turned to salt. Then again, he might not have been labeled a Communist and stripped of his clearance. Oppenheimer had a difficult time with more than one higher power.

As our coach carried on towards Sodom and Gomorrah, the guide pointed out the two matching sets of utility poles, one on each side of the road. During testing, utility crews would relocated the electrical lines to whichever side of the road was opposite the current test site. This way, cranes and other tall vehicles could be moved more easily and safely. Likely from later testing, there is also a tremendous amount of buried conduit throughout the valley. At seemingly random locations, but probably corresponding to various tests, rusting electrical panels popped up by the side of the road with disconnects and pin-sleeve connectors. Small signs marked the route of high voltage raceways, and numbers on the panels hinted at a probably rather hairy stack of maps and diagrams.

For quite some distance along this road a hefty bundle of telephone cables runs along its own poles. One branch of it heads uphill to a microwave site atop a small peak, south of control point. It continues some way into the valley but likely drops into underground conduit before too far.

I wondered, of course, who installed and maintained the telephone infrastructure. While I cannot provide an in-depth discussion of this topic (at least not yet), the existence of an AT&T special toll area tariff for the Nevada Test Site suggests that AT&T provides the service, and the tariff includes detailed rates for certain services which were or are presumably in use. This includes a Dimension 2000 PBX (nearly $10,000 per month after a $75,000 installation charge), a 225 kW diesel generator, and dedicated emergency lines. The Dimension 2000 is capable of up to 2000 lines and 14 attendant consoles. This equipment was probably installed somewhere in Mercury in an NNSS-provided building, and maintained by appropriately cleared AT&T personnel.

The microwave site near Checkpoint Pass has been licensed, at various recent times, to WCS Microwave Services and Verizon Select Services. Neither company is easy to find much information about, but both seem to bid on various government contracts for connectivity. WCS is a subsidiary of Williams Communications and VSS is, of course, a subsidiary of Verizon Communications. I would hazard to speculate that the NNSS turned to these vendors to provide their backhaul (and based on license locations some internal connectivity) after the breakup of AT&T introduced a great deal more competition in that market. Its interesting that Williams Communications specializes in cable television systems, inviting one to wonder if they specifically provided services related to the many video cameras that were used to observe and record tests.

As we drove further into the valley, several towers started to loom on the horizon. One of them was our next destination: the Icecap site. Icecap was an underground nuclear test planned to be 20-150 KT and buried 1,550 feet underground. It was scheduled for Spring 1993, just months after the official issuance of a moratorium on all nuclear testing. As a result the site, nearly ready for the test, was abandoned in place. It now serves as an excellent historical example of the preparations for an underground test.

There are several prominent features at the site, but at the core is a 157 foot tall modular metal tower. After drilling of the test shaft was completed (at 3-5 feet across with very tight linearity tolerances this was no small feat), a metal cover was installed over the shaft for safety and a set of sea container-like modules stacked above it to form a temporary tower. Inside of that tower, the tall cylindrical canister or rack was assembled. The canister is suspended from the top of the tower by cables. Round walkways throughout the height of the tower, reached by stairs and a small lift on the side, provided technicians with relatively easy access to different points throughout the canister.

The size and mass (300,000 pounds) of the canister are surprising, while the fact that large portions of it seem to have been sealed up with duct tape is a reassuring bit of normalcy. Nuclear testing is just about as complicated as the design of the weapons themselves. While the canister contained the nuclear device (not called a weapon because it is not equipped with delivery or fuzing equipment), most of it is taken up by a dizzying number of instruments that measure physical force, radiation, and other properties of the detonation. These measurements are the actual outcome of the test, and can be compared against calculations to determine the performance of the device.

There is a problem: nuclear detonations are a hostile environment for precision instruments. This is the central challenge of underground testing. In atmospheric testing, instruments can be located far enough away from ground zero to survive the detonation (we will see an example of this later). For underground tests, the radius of destruction is relatively small, but it contains far too much soil and rock for remote instruments to be useful. Instead, most of the measurements must be taken from the same shaft as the device.

To resolve this conundrum, engineers had to dance very closely with the destruction. It is simply the nature of underground nuclear testing that the measurement instruments will be destroyed almost instantly. They must collect their data and report it before the blast reaches them. Every underground test was a remarkable race: as the blast propagated through the canister, each instrument produced a signal which traveled through cables to safety just ahead of the advancing shockwave. Cables were turned to vapor just behind the messages they carried.

The canister, then, looks something like a diving bell. From the top, dozens of coaxial cables and just a few fiber optic bundles (92 was still an early era for small-scale fiber optic systems) hang back down the tower and then out a small hatch at ground level, where they are lined up on a series of zigzagging wheeled racks that allow them to be unfolded as the canister is lowered.

The primary motivation for underground testing is containment of contamination. In a properly performed underground test, almost no radioactive particles escape to the surface. This is achieved simply through the tremendous mass of a thousand feet of earth. There is a problem, though: the shaft itself.

Once preparation of the canister is completed, the tower is disassembled and the canister is transferred to a crane. Due to the limited length of the cranes hoist cables, the canister is lowered into the shaft in a series of steps. After each step, it is transferred to hang off of anchors around the shaft while long rods are added on so that the crane can retract its cables, attach to the top of the rods, and then lower the canister another step. Once this slow descent is completed, the shaft is backfilled with materials carefully chosen to prevent the blast pushing them out. A certain amount of the backfill and suspension rods will be vaporized in the detonation, as will the cables.

The greater challenge is small leaks: because the cables have multiple layers of jacketing that are easily destroyed, they can provide narrow paths to the surface through which the immense pressure in the blast cavity will force fallout. To prevent this, the cables are periodically interrupted by packings where various mineral and artificial materials are sealed around the cable. These materials are designed to flow and fuse under heat and pressure, sealing off the cable path.

About ten meters from the top of the shaft, our guide points out a metal pipe sticking out of the ground. This is the casing of a second shaft, drilled to comply with mutual verification provisions in treaties with Russia. The Russian government has the option of installing their own instruments in this small second shaft, if they so choose, allowing them to independently measure the yield of the device. Our guide explains that this was rarely done in the late years of testing, as remote sensing and seismic methods had improved to the degree that Russia could collect the same information without the need to arrange a site visit. Nonetheless, the option was always made available.

A surprisingly short distance away from ground zero are the trailers. These are the endpoint of the cables suicide mission, and contain a variety of recorders and control equipment that are used to both prepare the canister for the test and collect the resulting data. Even at their close range (around 200 meters) they are safe from any immediate effects of the blast, but within the blink of an eye after detonation the ground under them will be lifted slightly upwards before falling back down. At their position this movement is small but still extremely fast, creating enough G-force to damage equipment. To protect the recorders (some of which were likely still electromechanical even in these late tests), the trailers were installed on frames that sat on piers supported by stacks of honeycomb-like blocks of corrugated aluminum. These collapsed under the force of the shockwave and cushioned the trailers.

There are not just a few trailers. Some have been removed from the Icecap site but there are still almost 20 left, each one numbered to keep track of them as they were moved from test to test. Some are just enclosures for racks of equipment, others are frames with electrical switchgear and communications equipment. One wonders if any of the engineers who designed these trailers went on to contribute to todays modular data center systems. Sandias involvement in mobile data terminals and control systems for the military suggests so.

As we drove away from the Icecap site (and passed a couple of other towers remaining from planned tests that were canceled at earlier stages of development), our guide explained the problem of the craters.

The whole underground testing area of the NNSS is littered with small craters, often packed in a surprisingly tight grid. These craters are not the result of soil thrown away by the detonation, which occurred far below them. Rather, they are subsidence craters. The heat of the detonation compacted, melted, and fused the materials near the device, leaving an underground cavern lined with a glass-like material. At some point after the detonation, the walls of this cavern would fail, causing a column of soil above the cavity to fall downwards. The resulting crater is not very big or deep and the test planners became adept at predicting the size of the craters, allowing them to place the trailers just outside. What proved far more difficult was predicting *when* this collapse would occur.

As we drove onwards, our tour guide took advantage of the coachs entertainment system and played a short film which he called zero time to collapse. This video consisted of footage of a series of different tests, cut together so quickly that the effect was somewhat dizzying. Over and over, we saw footage from a helicopter circling a bit of desert as a voice counts down. At zero a chirping alarm sounds as a shockwave whips through the scrubcuriously, the wrong direction. Our guide explained this perceptual oddity: the lifting of the surface by the shockwave occurs too quickly to be caught on video or even really to be perceived by the eye. What you see instead is the soil falling back down to its original position with the acceleration of gravity, which of course settles to a stop first further away from ground zero where it was displaced by less.

Then, there is a cut, which skips over a period of minutes to hours (in some cases, we were told, as long as 48 hours). A voice, working off of seismic instruments that monitor for the failure of the cavern walls, says collapse imminent and within seconds the ground simply falls away, leaving a crater.

And then it repeats. Over, and over, and over, showing perhaps 20 tests. By the end it almost becomes boring, a highly accelerated introduction to the mundanity of evil. Not even the wonder of tens of kilotons equivalent creating an impossible cavern endures the about 900 underground detonations performed at NNSS.

Some of the tests are slightly different from others. In one, the video of the collapse is from a low angle and not very clear. Our guide explains that the helicopter had had to land for fuel while waiting for the collapse and so missed filming it. In another, the collapse is less a crater than a sinkhole, with neatly vertical walls. Our guide says that this result is an oddity and something of a mystery; it only happened in one test and presumably results from some detail of the geology that still hasnt been determined. In just one test, the voice counting down is a womans, reminding you of the gender disparity that remains to this day in the defense industry. The nuclear weapons complex has its own deep history of sexism, homophobia, hysterical anti-communism, etc., but that is a topic for another time.

We are by this point many miles deep in the NNSS and have more miles to cover to reach our next stop. On the way, our guide points out some support facilities. The Big Explosives Experimental Facility or BEEF is a range equipped to test huge quantities of high explosives. As a whimsical anecdote, our guide explains that BEEFs cow-shaped steel sign had been stolen some time earlier, perhaps as a prank by military personnel. NNSS craft workers made a new, larger sign and then buried its base under a ton of gravel. That ought to discourage any future larceny.

Driving along the main road, we passed the U1a complex, or as our guide allows himself to joke once, the A-hole. This deep shaft complete with mine-type hoist headworks, along with a neighbor, connects to a complex of underground tunnels where subcritical experiments are conducted. In these tests, weapon pits a little shy of heavy enough to achieve criticality are subjected to the high-explosive implosion mechanism used inside weapons. After the test the deformed pit can be measured to calculate the implosion forces. An addition to the U1a complex currently underway is a linear accelerator that will be used to image the internal density of the pits, giving more data about the accuracy of the implosion. In a moment my husband found especially amusing, our guide said that office space in the underground complex has become very limited but, due to the time involved in taking the hoist up and down, the scientists were reticent to regularly come to the surface. The office trailers at the top of the shafts are being renovated in an effort to lure the staff above ground and free up space. The scientists have dug in, my husband quips, and are refusing to come up. They say they want more plutonium.

This, too far into the series to explicitly touch on this important topic, is a good time to finally say something about stockpile stewardship. This is the greatest challenge of the nuclear weapons complex today and, by budget, the main activity of the Department of Energy.

The United States has not detonated a nuclear weapon in thirty years.

This raises a troubling question: do they still work?

Every year, the National Nuclear Security Administration (the component of the Department of Energy that oversees the weapons program) and directors of the three nuclear weapons laboratories (Los Alamos, Lawrence Livermore, and Sandia) prepare a report to the President of the United States. This report says that the Department of Energy is confident that the United States nuclear arsenal is not only safe, but also functional. Some years ago I heard Dr. Jill Hruby, at the time the director of Sandia National Laboratories and now the Undersecretary of Energy over the NNSA, say that she considers developing the confidence to sign this report to be the most important function of the weapons program.

Because the only designs that have been subject to real quality control testing (by detonation of sample units) are more than 30 years old and thus have undergone radioactive decay, mechanical wear, maintenance and refurbishment activities, etc., and an increasing portion of the stockpile consists of designs that have never been tested, this assurance must make the directors a bit nervous. Our confidence in the nuclear stockpile today rests on subcritical testing, testing of individual components, and increasingly, computational modeling. It is exactly because of the challenge of stockpile assurance that a surprising portion of the worlds most powerful computers are owned and operated by the Department of Energy.

A tremendous amount of effort has been put just into understanding how weapons-grade plutonium and uranium change (or dont) when left in storage for decades, and how to refurbish weapon pits. The same problems exist for the high explosives, neutron generators used to force prompt criticality, specialized thermal batteries that power electrical systems in nuclear weapons, and even simple mechanical components.

An enormous staff of people (probably 30,000 across the complex) and billions of dollars in budget go, essentially, to doing everything anyone can think of other than actual testing to determine whether or not nuclear weapons even work. Every year the degree of separation between tested designs and the current stockpile increases, and so this confidence becomes based on greater levels of abstraction. In a way, it adds a fascinating new aspect to the fear of nuclear apocalypse: the outcome of a nuclear war has perhaps become even harder to predict as the possibility increases that some portion of our nuclear arsenal (and, for the same reasons, that of other major nuclear powers) will just not work.

It is because of nervousness about this possibility that there have been some calls to resume nuclear testing in the United States. I will not go into analysis of this decision, although I personally am strongly opposed. It is a closer possibility, though, than you might imagine. At several points our tour guide gave the context that the NNSS remains under standing orders to be ready to pick up where it left off. While testing has not been performed for so long that mastery of all the steps involved is now somewhat questionable, the NNSS retains an inventory of ready-to-go boreholes, drilling equipment, tower modules and components. In theory, should the order come, the NNSS could perform an underground nuclear test within 24 to 36 months.

Subjectively, the NNSS does not feel abandoned so much as it feels like it is in waiting. And administratively, it is.

We are, at this point, probably only a few hours into the 8 or so hours of the tour. I will return with Part 3, once again probably quite soon.