Threat to U.S. Air Power: The Dust Factor

Dust clouds kicked up by a Soviet strike might shut down jet engines, disabling key warplanes the U.S. military relies on

The violent eruption last year of Mount St. Helens and the formation of its vast dust cloud have raised a question of critical importance to the U.S. military: whether huge dust clouds kicked up by exploding nuclear warheads would cripple the jet engines of key military aircraft. Dust from Mount St. Helens shut down several jet engines. On a four-engine military transport, two engines caught fire, which forced an emergency landing.

The implications of these failures are starting to worry military planners. One reason is the increasing U.S. reliance on aircraft. During the past two decades, a growing number of generals who plan on orchestrating the strategic U.S. nuclear forces in the event of a third World War have taken to the air, because flying command posts are considered more likely to survive strikes by increasingly large and accurate Soviet missiles than traditional U.S. command posts buried deep beneath the earth. Just for control of the Minuteman missile fields, the Strategic Air Command (SAC) has a fleet of two dozen Boeing 707's. The President too has an airborne command post.

The question is whether nuclear dust clouds would send the generals and the President into a tail spin, possibly compromising the U.S. ability to retaliate.

The dimensions of this potential and largely unforeseen flaw in the U.S. nuclear battle plan may extend even further. In addition to airborne command posts, the U.S. military counts on B-52 strategic bombers to fly through nuclear battle zones, as well as the soon-to-be-deployed cruise missiles, also powered by jet engines.

Unfortunately, although the blast from Mount St. Helens is often compared to a 10- to 50-megaton nuclear warhead, no one in the military seems quite sure how the volcanic dust cloud measures up in terms of a nuclear analogy. The problem is now being studied intensively by several Washington, D.C., defense contractors, by the Air Force, and by the Defense Nuclear Agency (DNA), which specializes in understanding the effects of nuclear weapons. Currently under examination are data on the density of the Mount St. Helens dust cloud, the failed engines, and the spread of nuclear dust clouds in general. Later, tests may be initiated on a variety of jet engines currently used by the U.S. military.

Aware of the potential implications for national defense, those publicly commenting on the work tend to choose their words carefully. "In most cases we don't think it is a serious problem," says Cyrus P. Knowles, assistant for testing to the DNA deputy director. "Whether or not dust makes a difference depends on the scenarios. Before it becomes a problem for aircraft there has to be dense attack. What Mount St. Helens has done is to make us relook at some of the testing of engines."

Depending on the outcome of the studies, solutions to the dust dilemma might be simple or might run to billions of dollars. Work on the development of a presidential command post that would circumvent the problem altogether by staying on the ground has already been speeded up for a variety of reasons, including dust. When delivered around 1984, the ground-mobile command post will allow the Commander in Chief to roam the interstate highway system in a tractor-trailer packed with sophisticated communications gear. It will be disguised as a commercial vehicle, such as a moving van.

An irony of the dust story is that questions about the vulnerability of airplanes are anything but new. Aircraft were repeatedly flown through dust clouds nearly two decades ago when tests of nuclear weapons still took place in the atmosphere. They were gasoline-fueled prop-planes, however, whereas aircraft today use sophisticated and sometimes fragile jet engines. The story is thus a case study in how vulnerabilities can quietly creep up on the military through the evolution of technology. It also illustrates how unforeseen impediments can complicate idealized war scenarios.

One reason the military has been slow to study the vulnerability of aircraft to atmospheric dust is the difficulty of simulating nuclear blasts. The partial test-ban treaty of 1963 limited testing of nuclear weapons to underground sites, and, since then, the military has used conventional explosives to mimic atomic blasts on the surface of the earth. Today the largest of these tests are generated by a 25-foot-high pile of TNT, which weighs about 500 tons. The resulting blast is roughly equal to a 1-kiloton nuclear burst, although, depending on the effect being studied (heat, blast, dust), the closeness of the analogy can be off by a factor of 2 or 3. The blast is not only quite small compared to the yield of a thermonuclear weapon but is also a single event, whereas a real nuclear war could involve multiple bursts.

The search for nuclear analogies leads the military to closely examine natural disasters, such as the eruption of Mount St. Helens. In fact, 1 day after the volcano started to vent its fury, the military was on the scene, getting ready to study the propagation of radar and radio signals through the dust cloud. It is ironic that what in retrospect has become an important issue—the vulnerability of jet engines—was not addressed at the time. What was studied is important, however, because some of the data collected in the propagation experiments are now being used to help determine the density of the dust cloud.

On 19 May 1980, the day after the first violent eruption, DNA initiated project DIMSKY. By 2 June an Army air defense radar station was set up and by 9 June the system was in operation. On 12 June the mountain erupted for the third time and DNA and its contractors started collecting data. Ideally, the results of such work would not only help predict how effective radar can be in a nuclear environment (an important consideration for determining the feasibility of an antiballistic missile system) but would also help determine the strength of the nuclear analogy by estimating cloud density. Unfortunately, the other experiments needed to collaborate and clarify the radar data never got off the ground. A radio receiving station for communication experiments had been set up by a defense contractor, SRI International, about 25 miles northwest of the volcano. It was planned that during an eruption a plane with special radio transmitters would attempt to broadcast through the dust cloud; the receiving station would also attempt to pick up signals from a military communications satellite. This experiment would reveal the ability of

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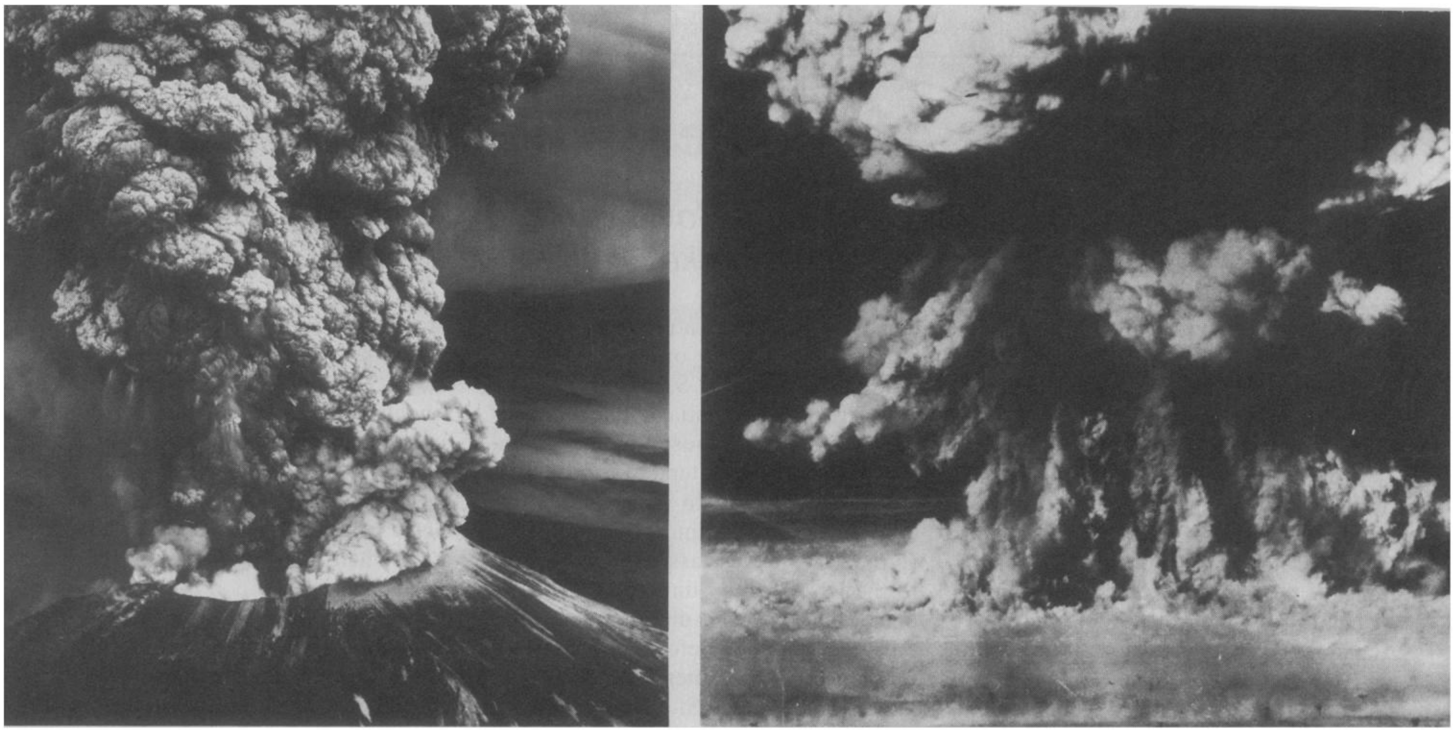


The fury of Mount St. Helens and the violence of a nuclear blast

The eruption of the volcano on 18 May 1980 resulted in a plume that shot to 60,000 feet. A 1-megaton surface blast would send dust slightly higher. After 24 hours, the leading edge of the Mount St. Helens cloud was over Wyoming, some 1000 miles to the east.

the signals to penetrate the cloud, and would, through measured attenuation of the signals, help determine its density. Unfortunately, during the 12 June eruption, the plane had unspecified "operational difficulties" (*1*) and was grounded. Moreover, the satellite, as fate would have it, was not in the correct position. Eventually, because the volcano was starting to spew steam instead of dust-generating debris, operation DIMSKY was ended.

While all this was taking place, aircraft were having problems with the dust cloud (*2*), and the Federal Aviation Administration was doing its best to keep pilots out of what was clearly revealed to be a dangerous situation. About 3 hours after the initial eruption on 18 May, a commercial DC-9 accidently flew into and quickly out of a plume at 35,000 feet. Engines continued to work, but analysis back on the ground showed that compressor blades in the jet engines had been damaged. The total time of exposure to the dust had been about 4 minutes.

On 25 May, during the second eruption, a commercial Lockheed L-100 transport was doing a run for the Navy when it encountered a plume over Portland, Oregon, and had to make an emergency landing after two of its four engines caught fire. Inspection showed that all four engines were damaged, and all were replaced. On 26 May, two Boeing 727 triengine transports were damaged, and analysis by Boeing engineers showed that midspan shrouds in the engines had seized.

Amid the pandemonium of the Mount St. Helens rescue operations, which eventually revealed that 61 people had lost their lives or were missing and presumed dead as a result of the eruptions, news of the difficulties with aircraft traveled slowly or not at all. Magazines such as *Aviation Week & Space Technology* eventually carried reports that were read in the Pentagon, but even then the details of the problems with jet engines were often buried in roundup stories about how Mount St. Helens affected air traffic.

A ripple of concern over the damage that a nuclear dust cloud might cause military aircraft started to travel back and forth among a few defense contractors and various arms of the Pentagon in June 1980, amid the eruptions. Briefings were held and reports outlining possible problems were submitted. By the time the Pentagon decided that the question warranted further study, Mount St. Helens was relatively quiet.

Today, study of the dust problem continues with the information available—the radar readings taken at Mount St. Helens, some of the failed engines, and nuclear test data. "There's a lot of uncertainty about the numbers, but we're making progress," says Herbert J. Mitchell of R & D Associates, a defense contractor in Arlington, Virginia. Mitchell wrote a report (*3*) in late 1980 that was pivotal in generating concern about the dust problem, both within the Pentagon and on Capitol Hill.

The dimensions of the nuclear analogy can be sketched, although the emerging details are classified and not available to reporters or the public. The dust cloud generated by Mount St. Helens is clearly larger than one produced by a *single* nuclear explosion. The volcano belched for hours, after all, whereas a thermonuclear blast vacates the ground after a few minutes. In each case, heat lifts the debris to similar altitudes—too high for most aircraft to fly above—and the atmospheric currents that disperse the dust are the same in each case. A classified detail concerns the size and composition of various particles kicked up by nuclear blasts, a variable that would determine sedimentation rates and the effect dust particles might have on machinery. Much scientific information has been published on the composition of particles lofted by Mount St. Helens, though little on cloud density (*4*).

"There is uncertainty about how much dust gets lofted by a single nuclear blast," says Knowles, who is recognized in the weapons community as an expert on the effects of dust. "With multiple detonations, the unknowns become bigger. Then add the uncertainty of the response of jet engines. Given all the ambiguity, we would say that even a large attack would not produce dangerous levels of dust. But in light of Mount St. Helens, we are looking to see if that is really the case."

Solutions to the dust problem, depending on the outcome of the studies, could be simple or formidable. Easiest would be minor changes in military specifications for jet engines. More difficult would be the fabrication of special electronic devices to warn flight crews of dangerous dust environments. Conceivably, command and control aircraft for the Minuteman missile fields scattered across the American heartland might, for a while, be able to fly upwind of dust clouds produced by a Soviet strike. The most expensive solution would be the retrofitting of current aircraft with more robust jet engines.

The most complicated (and perhaps fragile) of the jet engines are the turbofans and turboprops. More reliable are the older turbojets. Most robust of all are the ramjets.

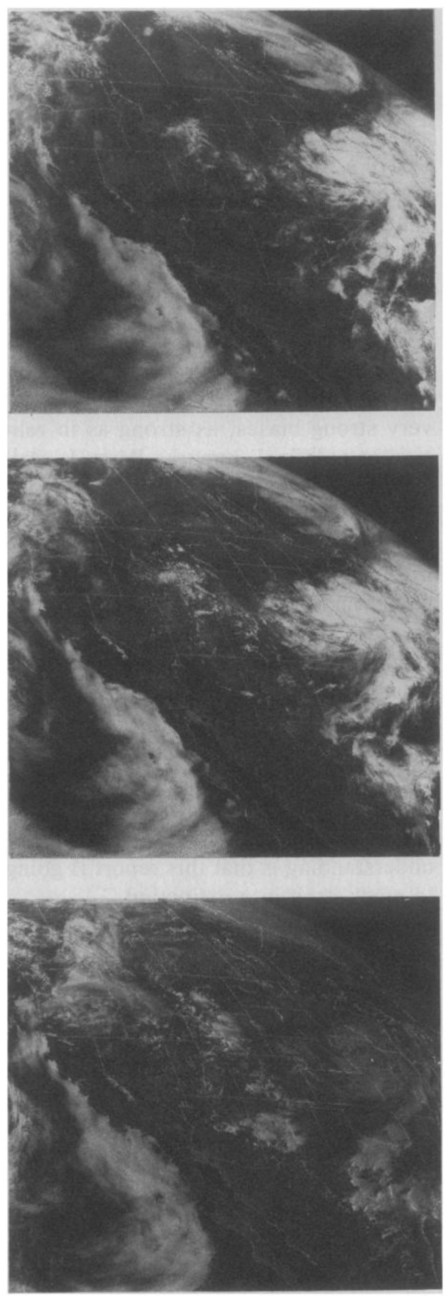
There is already talk of replacing the complicated turbofan engines in air-launched cruise missiles, which are being produced by Boeing, with more robust ramjet engines. Though difficult to start, a ramjet engine has no moving parts. The Lockheed L-100 in which two engines caught fire in the Mount St. Helens dust cloud uses turboprop engines. This plane is the civilian version of the ubiquitous C-130 military transport.

The most recent engine used in the evolution of the jet aircraft is the turbofan, an example of which can be seen under the wing of any Boeing 747. These engines run hotter than the turboprop and turbojet engines, and may melt particles picked up in the air more readily. It is believed that the deposition of melted particles on the stationary turbine blades in the engines of the Lockheed L-100 clogged the air flow and caused the engines to fail. "What we think happened," says Daniel S. Rubera, a DNA aerospace systems specialist, "was that the engine went to surge and the combustors just sort of sent flames directly into the turbine area, pure flame which just ate away at the metal."

The biggest airborne command posts are those used by top-ranking SAC generals and the President, converted Boeing 747's. Because of the many vulnerabilities of these planes and the change in U.S. war philosophy that emphasizes an ability to fight a prolonged (and supposedly "limited") nuclear war, the development of a ground-based mobile command post is being speeded up. In May 1980, the top Pentagon communications expert, Gerald P. Dinneen, testified on Capitol Hill that these ground-mobile command posts "would not come into the inventory perhaps until somewhere in the nineties" (*5*). Today, Pentagon officials say they are pushing for 1984.

It is clear that much uncertainty surrounds the whole issue of what the effects of dust kicked up by a nuclear salvo might be on military aircraft in a war. Further study might prove that the problem, even in a worst-case scenario, is minor. Then again, even minor problems have a way of becoming major. This was clearly the case with the ill-fated attempt to rescue the U.S. hostages held in Iran, an expedition aborted after helicopters failed in an unexpected Iranian dust storm.

At least one cynic on Capitol Hill who is aware of the on-going dust study fears that even if sizable problems are uncovered, little will be done. "MX makes this a relevant issue," says the budget office analyst, who is intimately familiar with defense procurement issues and who asked not to be named. "If deployed in the Southwest [and hit by Soviet missiles] it will kick up huge amounts of dirt. There are probably fixes, but the problem is that the issue takes such a low priority compared to such issues as getting a new bomber that nobody is going to spend the attention and effort it deserves."



Dispersal of volcanic dust on 18 May. Upper photo is at 8:45 a.m., middle is 10:15 a.m., and lower is 4:45 p.m.

This is probably an overly pessimistic appraisal of the problem. After all, the dust dilemma is being vigorously studied, and there are indications that military awareness of the potentially damaging effects of dust on jet engines is increasing far beyond the conference rooms of Washington, D.C. This past April, for instance, a volcano off the Kamchatka peninsula in the Soviet Union started belching dust and ash, forming clouds that started to drift over the Aleutian Islands. According to defense contractor Mitchell, the Alaskan airlines that serve a tiny island at the tip of the Aleutians, named Shemya, closed down operations as a precaution. "Also," says Mitchell, "a Coast Guard C-130 was totally directed out of the area, so people have apparently become somewhat more aware of the problem."

Perhaps the dust problem will prove to be major, the evolution of aeronautical technology having exposed the U.S. military to an unforeseen danger. It seems inconceivable that something as mundane as dust could wreak havoc among the many cogs of the military machine. This nevertheless seems to be a very real possibility. Considering the ease with which the dust factor was overlooked, one wonders whether there are other unforeseen impediments that might considerably complicate the idealized war scenarios the military has in mind.

—WILLIAM J. BROAD

References and Notes

1. For a summary of operation DIMSKY see *Proceedings of Mount St. Helens Scientific Workshop November 13–14, 1980* (Federal Emergency Management Agency, Washington, D.C., 1981), pp. 27–30.
2. See *Aviation Week & Space Technology*, 26 May 1980, p. 18; 2 June 1980, p. 18; 23 June 1980, p. 31.
3. Classified, *Late-Time Nuclear Dust Cloud Environment: An Emerging Issue for Air-Breathing Vehicles* (R & D Associates, Inc., Arlington, Va., 1980).
4. The 20 February 1981 issue of *Science* contains 12 reports on the analysis of the eruption. Some cloud density measurements were made with the SAGE satellite operated by NASA, but these were optical measurements, and contractors say they do not help in analysis of the inner dynamics of the cloud.
5. Hearings before a subcommittee of the committee on appropriations, Department of Defense Appropriations for Fiscal 1981 [U.S. House of Representatives, 96th Congress, 2nd session, (part 7, p. 459)].