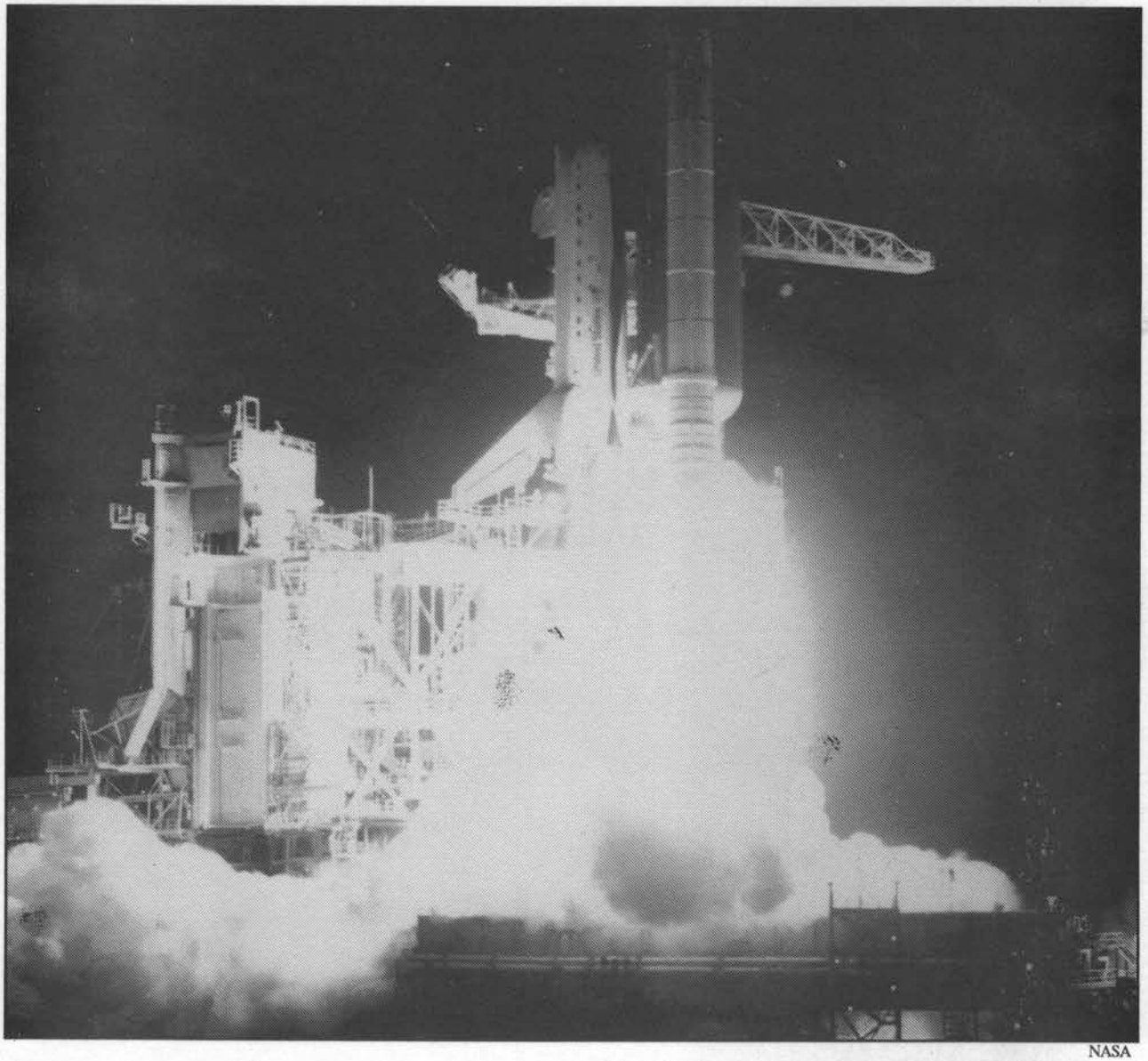
NO FREE LAUNCH:

The Toxic Impact of America's Space Programs



NASA

Military Toxics Network
of the National Toxics Campaign Fund

prepared by
Lenny Siegel

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SUMMARY

The manufacture, testing, launching, and dismantling of rockets, whether built for space science, commercial functions, or warfare, damages the environment in many ways. For example, the launching of solid rockets—including Space Shuttle boosters and Titan IV's—contributes to the depletion of the Earth's stratospheric ozone shield. In fact, every launch does more to deplete this vital shield—which protects life on the Earth's surface from overexposure to the Sun's ultraviolet radiation—than does the *annual* ground-level emissions of chlorofluorocarbons (CFC's) from most individual industrial plants.

Another example is the stationary testing of solid rocket motors and the burning of production wastes and old solid fuel, which release toxic contaminants into the lower atmosphere and surface environment. These wastes include chlorine, hydrogen chloride, which becomes acid rain or fog, and aluminum oxide, which is toxic when released into an acidic environment.

NASA is unable to bring its solid rocket testing into compliance with the toxic air contaminant restrictions of the new Clean Air Act. However, the President can invoke "national security" to exempt such pollution sources.

Federal agencies and their contractors presently burn waste solid fuel in open pits. The Army has developed a method of dissolving solid rocket fuel for reuse, but that technology is not yet being used because further funding is needed and because local, state, and Federal regulators have not cracked down on open burning.

Recommendations

1. If the Advanced Solid Rocket Motor cannot be tested without abandoning toxic air contamination standards, the program should be scrapped.
2. Open-pit burning, the standard method of disposing of solid rocket fuel, must be halted immediately.
3. Before the U.S. considers any new space ventures, our government must carry out an objective, comprehensive evaluation of the environmental impact of the entire space business, reviewing the pollution caused by rockets, their components, and their propellants, from cradle to grave.

NO FREE LAUNCH: The Toxic Impact of America's Space Programs

Edward Teller, the "Father of the H-Bomb" and the man who inspired Ronald Reagan's Star Wars proposal, has a new mission. Using technology being developed for strategic missile defense, he wants to focus a thousand "Brilliant Eye" spacecraft on the Earth to monitor climatic change, air pollution, and other forms of environmental degradation.[1] What Teller—like most Americans—fails to recognize is that the environmental costs of launching such spacecraft would far outweigh the benefits.

The manufacture, testing, launching, and dismantling of rockets, whether built for space science, commercial functions, or warfare, is a toxic business. The manufacturers of rockets and missiles are among the nation's worst polluters. For example, Hughes Aircraft's plant in Tucson, Arizona and Aerojet-General's plant in Sacramento, California are on the Superfund National Priorities List (NPL) because they have released toxic, carcinogenic trichloroethylene (TCE) into local groundwater. United Technologies' rocket plant, near San Jose, California threatens a nearby public reservoir with its TCE leaks.

One of the major hot spots at the Army's Rocky Mountain Arsenal, northeast of Denver, Colorado is the Air Force's now inactive Hydrazine Blending, Storage, and Treatment facility, used for the production of hydrazine-based fuel for Titan missiles and other liquid-fueled rockets built across town at Martin Marietta, southwest of Denver. Both the Arsenal and the Air Force-owned portion of Martin Marietta's complex are also on the Superfund NPL.

Hydrazines are highly toxic and carcinogenic. For thirty years Martin Marietta flushed rinsewater from its rocket test stands into Brush Creek, a tributary for a portion of Denver's drinking water system until December 1984, when closed due to contamination (following a campaign of local citizens and the National Toxics Campaign to determine the cause of a childhood cancer cluster down the line). It "treated" a large portion of the rinsewater with copper sulfate, forming nitrosodimethylamine, which is even more deadly and is known to cause numerous forms of cancer. Eleven families from the Denver-area Friendly Hills subdivision have charged that Martin Marietta's release of hydrazines and other compounds either killed their children or caused birth defects and serious illnesses. They are now awaiting a Federal judge's decision whether to send the case to a jury. (The Martin Marietta case will be documented in detail this fall in "Dirty Denver," a report by the National Toxics Campaign's Western Office.")

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[1] "Teller Proposes Environmental Satellite Program as Spin-Off of SDI Technology," *Aviation Week & Space Technology*, April 23, 1990, p. 63.

Another example of rocket-related toxic contamination is Avtex Fibers' Front Royal, Virginia plant, which was finally shuttered in late 1989. Avtex had remained open despite high levels of toxic releases because it was the sole source in the "free world" of carbonized rayon, a critical component of rocket nozzles. Avtex is a Superfund NPL site. In 1987, it was the second largest emitter of toxic air contaminants in the country. The bulk of the reported 25 thousand tons of air pollutants it released was carbon disulfide, but it released nearly a thousand tons of chlorine as well. Although Avtex reported the on-site land disposal of nearly 1.5 thousand tons of zinc, it did not acknowledge the problem that led to its closure: "The Virginia State Water Board revoked the company's license to discharge treated water into the Shenandoah River" because it "found conclusive evidence of extremely hazardous polychlorinated biphenyls (PCB's) that exceed federal limits in the effluent for Avtex's water-treatment and storm water discharge pipes."[2]

Some rocket-fuel components are, as might be expected, extremely explosive. In May, 1988 a series of blasts at Pacific Engineering's ammonium perchlorate plant in Henderson, Nevada, killed two company executives and injured 350 people. The explosions destroyed 4 thousand tons of the compound, which is used as an oxidizer in nearly forty solid-fuel U.S. missile and rocket systems, as well as half the American ammonium perchlorate manufacturing capacity.[3] Because rocket fuel is highly volatile, it has frequently been exempted from rules designed to minimize toxic emissions.

Ozone Depletion

The release of ozone-depleting hydrogen chloride (HCl) into the upper atmosphere by solid-fueled launch vehicles is the broadest environmental threat posed by the U.S. space program. Each launch of the Space Shuttle or the Air Force's Titan IV does more to deplete the fragile ozone layer, which protects denizens of the Earth's surface from overexposure to the Sun's ultraviolet radiation, than the *annual* ground-level emissions of chlorofluorocarbons (CFC's) from most individual industrial plants. (CFC-113, a solvent used in electronics and other industrial production, is considered one of the major culprits in the deterioration of the ozone layer, and its use is being phased out.)

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[2]"Avtex Fibers Abruptly Shutters Virginia Plant," *Chemical and Engineering News*, November 20, 1989, p. 5; "Avtex: The Polluted Price of Defense," *Nightline* Show #2142, ABC News, August 8, 1989; Norman Dean *et al*, *The Toxic 500*, National Wildlife Federation, August, 1989, pp. 2-278, 5-1.

[3]Richard Seltzer, "Impact Widening from Explosion of Nevada Rocket Oxidizer Plant," *Chemical and Engineering News*, August 8, 1988.

According to the National Aeronautics and Space Administration (NASA), each shuttle booster delivers exhaust containing about 68,000 kilograms (75 tons) of hydrogen chloride gas (HCl) to the stratosphere.[4] Like chlorofluorocarbons, HCl is broken down by ultraviolet light. The chlorine acts as a catalyst, triggering a series of chemical reactions which deplete many times its weight in ozone (O_3). In 1978, NASA's own Space Shuttle environmental impact statement estimated that 40 annual shuttle launches would cause "a .25 percent ozone reduction resulting in a .5 percent increase in ultraviolet radiation to the surface of the earth."[5]

In 1988, only two U.S. factories —GM-Harrison Radiator in Lockport, New York and IBM in Endicott, New York—reported releasing into the atmosphere enough CFC-113 to equal or exceed the ozone-depletion effect of the HCl directly deposited at the ozone layer by four shuttle launches. Only five other factories reported CFC-113 emissions even comparable to two shuttle launches.[6] Over the entire year 1989, CFC-113 releases from IBM's San Jose, California plant—recently the target of environmental protests because of its ozone-depleting emissions—actually did less to deplete the ozone layer than a single Space Shuttle or Titan IV launch!

Scientists in the Soviet Union, where large launch vehicles do not release chlorine compounds, consider solid-fuel rockets to be a major environmental threat. They contend:

> If no action is taken, the contribution of booster rockets toward destroying the ozone layer will amount to at least 10 percent of the total projected man-caused effect on the stratosphere by the year 2005.[7]

The impact of ozone-depletion is uneven over the Earth's surface, and genetic factors cause varying health effects among different populations. But a global consensus exists: increased ozone depletion is destroying the environment in which we live. Environmental Protection Agency data suggests, for Americans alone, that each .25% of ozone depletion leads on average to a .5% increase in ultraviolet exposure. Each .5% of that increase causes a 1 to 1.5 % rise in basal

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[4]R.J. Ciernone et al, "Assessment of Possible Environmental Effects of Space Shuttle Operations," University of Michigan Space Physics Research Laboratory, June, 1973, p. 57.

[5]"Environmental Impact Statement, Space Shuttle Program, Final," National Aeronautics and Space Administration, 1978, cited in "Environmental Impact Statement, Space Shuttle Advanced Solid Rocket Motor Program, Final," National Aeronautics and Space Administration, March, 1989. Most estimates for ozone reduction and ultraviolet reception are global averages.

[6]In general, the ozone-depletion potential is determined by the weight of the chlorine atoms in each compound. Other factors, such as altitude and diffusion rate, also affect the extent to which ozone molecules are destroyed.

[7]V. Filin and V. Burdakov, "Global Ecological Threat," *Aviatskiya Kosmonavtika*, July, 1989, translated in JPRS-UAC-89-1013, December 6, 1989, p. 27.

and squamous cell carcinomas, projected to cause .from 1 to 4 million additional cases of skin cancer among Americans born before the year 2075. This translates, for that period, into 13,000 to 50,000 additional cancer fatalities in the U.S. alone.[8] Ozone depletion, a process that affects the Earth's environment for decades, also hampers the human immune system, triggers cataracts, and damages plant life both on land and in the ocean.

NASA scientists, who have played a key role in documenting the degradation of the ozone shield, downplay the impact of solid rockets, asserting that ozone-depletion from the worldwide industrial emission of CFC's and other industrial chemicals is roughly four hundred times as great. NASA's Goddard Institute reports that a launch schedule of nine Space Shuttles and four Titan IV's would add only one quarter of one percent to the stratospheric load of chlorine, with most of the remainder coming from industrial halocarbons, including CFC's. They argue, correctly, that cutting those industrial releases is the highest priority.

However, even if one accepts NASA's data, there is still cause for alarm. Every action that diminishes the ozone layer threatens life on earth. Every response that eliminates unnecessary threats to that shield benefits public health and the environment. If consumers are to reject foam cups, if air conditioning shops are to install equipment for collecting coolant, if factories are to invest in new cleaning equipment, then NASA, the agency which, ironically, first demonstrated the existence of the "ozone hole" over Antarctica, must find alternate ways of launching rockets.

Launch Exhaust

The terrestrial release of toxic chemicals from solid rocket exhaust represents a more immediate, concentrated threat to the environment than ozone depletion. In fact, the reaction of hydrogen chloride with water in the lower atmosphere keeps chlorine from rising to the stratosphere, but the result is acid fog and acid rain.

> More than 85,000 pounds of toxic chemicals spew from a space shuttle [near the surface] every time one is launched from Kennedy Space Center. The toxic exhaust from the solid-fuel rocket boosters forms a huge, acidic cloud that kills thousands of small fish and burns plants and shrubs as it sweeps across the ground and nearby waterways. Occasionally, small birds cannot escape and are killed by the cloud as well.[9]

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[8]William Hively, "Science Observer," *American Scientist*, May-June, 1989.

[9]Cory Jo Lancaster, "Wildlife Pays Every Time Shuttle Flies," *Orlando Sentinel*, February 27, 1990.

Solid rocket exhaust contains chlorine, HCl, aluminum oxide powder, nitrogen oxides, and iron chloride. Yet, according to the Environmental Protection Agency (EPA), "To date there has been relatively little research into the secondary effects of rocket emissions on the environment." The EPA recently criticized the Air Force's environmental assessment of its Titan IV Upgrade Program, stating "For example, the aluminum oxide, a major by-product of motor combustion, is noted to be insoluble; hence not available to the environment. This is correct at or above neutral pH, but at lower pHs [read: in the presence of acids] the solubility/availability increases." The EPA points out that studies of fish exposed to aluminum in water with elevated acidity showed increased abnormality and mortality.[10]

NASA and the Air Force file environmental assessments and impact statements evaluating—and often whitewashing—their various launch programs, but launches are not regulated by air quality authorities. For the sake of public health and the environment, they should be subject to the same state and Federal clean air legislation as stationary sources.

Testing

While rocket launches lift pollutants away from the Earth's surface, stationary rocket-testing concentrates them in small areas. For this reason, residents in southern Mississippi are questioning NASA's plans to test the new Advanced Solid Rocket Motor (ASRM) at its Stennis Space Center. Stennis has conducted tests of liquid-fuel rockets since the mid-1960's, but the higher levels of pollution from solid rockets has people worried about the rockets' health risks as well as consequential damage to the Gulf Coast wetlands. NASA initially plans four 2.25-minute tests of the new motors a year, expected to release nearly 900 tons of aluminum oxide, 61 tons of chlorine, and more than 500 tons of hydrogen chloride at the site annually. When hydrogen chloride mixes with water, it forms hydrochloric acid, so the testing is likely to produce up to 1,600 tons of hydrochloric acid each year.[11]

NASA rejects claims that testing will threaten the environment or public, and its only proposed pollution controls are to deflect the exhaust plume upward

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[10]Letter from Heinz J. Mueller, Chief, Environmental Policy Section, Federal Activities Branch, EPA Region IV, to Captain Anthony E. Fontana, II, Environmental Planning Division, Department of the Air Force, March 28, 1990.

[11]Sharon Ebner, "NASA Studies Ways of Reducing Pollution from Test," *The SunHerald* (Mississippi Gulf Coast), February 11, 1990.

and test under optimum weather conditions. However, along the humid Gulf coast, the weather is never optimum for the release of acid gases.

Unlike actual launches, stationary rocket tests are subject to air quality legislation. However, when limitations on toxic air emissions in the new Clean Air Act started winding their way through Congress, NASA warned that it did not possess the technology to meet the standards for chlorine and hydrogen chloride emissions:

> Rebecca McCaleb, NASA's environmental officer [at the Stennis center], said agency officials are following the Congressional debate and that, whatever the outcome of the legislation, NASA has "full intentions of complying." But McCaleb acknowledged that, to date, NASA has not found a technology that would reduce emissions by the amount required by current clean air legislation. If the bill becomes law, NASA will likely assign a team of engineers to research possibilities, she said.[12]

It is likely, however, that the President will be forced to exempt solid-rocket testing from the Clean Air Act's rules, something he can do simply by authorizing a finding that "the technology to implement such standards is not available and the operation of such source is required for reasons of national security."

Adding Too Much Fuel to the Fire

> Burning trash in an open pit is against the law; burning rocket fuel isn't. United Technologies Corp.has permission from the Bay Area Air Quality Management District to burn rocket fuel at its San Jose plant on Metcalf Road on the grounds that the fuel is too explosive to transport and dispose of any other way. Some air district board members are skeptical of that now. They ought to be perpetually skeptical.[13]

Most, if not all, manufacturers of rocket motors burn waste fuel in open pits. Some of the waste propellant, liquid as well as solid, results directly from production runs. The proposed Advanced Solid Rocket Motor plant in Iuka, northern Mississippi, is expected to dispose of 500 thousand tons of waste propellant each year.

In other cases manufacturers contract with Federal agencies to destroy fuel that has been sitting in rockets for years. Solid rocket fuel consists primarily of aluminum powder and the oxidizer ammonium perchlorate meshed into a rubber-like material, so it cannot be drained like gasoline. In Utah, Morton-Thiokol has reportedly been torching fuel from shuttle rockets unwanted by NASA after the

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[12]Shailagh Murray, "Clean Air Plan Could Scrub Test," *The SunHerald*, January 29, 1990, p. B-1.
[13]"Fueling a Controversy," *San Jose Mercury News* Editorial, April 6, 1990, p. 6B.

Challenger disaster. And the Army, following the dictates of the Intermediate-Range Nuclear Forces (INF) Treaty, openly burns the fuel from decommissioned Pershing II Missiles at Colorado's Pueblo Army Depot and the Longhorn Army Ammunition Plant in east Texas. Finally, United Technologies Corp. [UTC] burns fuel from Minuteman missiles that it reconditions for the Air Force—though opposition in San Jose, California forced the company to move that part of its open-burning to the Sierra Army Depot, in Herlong, California, north of Lake Tahoe.

At the edge of its property in the hills south of San Jose, UTC has ten burn pits, each about 20 feet by 30 feet each, each surrounded by a horseshoe-shaped mound of dirt about four feet high. No high-tech ignition system or monitoring equipment is present. Former workers report that the company has disposed of a variety of known and unknown chemicals there over the last 27 years, but the primary fuel now appears to be solid rocket propellant.

When burned, waste solid rocket fuel emits the same pollutants as solid rockets being launched or tested: aluminum oxide, chlorine, hydrogen chloride, nitrogen oxides—a component of smog—and probably even dioxins. UTC emissions usually waft over Morgan Hill, a growing community south of San Jose. In 1989, UTC burned over 140 tons of waste propellant; the previous year, when the company was disposing of old Minuteman fuel, the total approached 400 tons.

Even though the company claimed that waste stripped from imported old rockets was "generated" on site, the Bay Area air board has forced UTC to limit its disposal operations to waste fuel from its mixing and machining operations, and it has ordered four pits closed. As required by state law, UTC and the Board are belatedly evaluating the health risks of UTC's open burning. But the Air Quality District is reluctant to ban open burning because it is unaware of any alternate means of disposal.

Meanwhile the California Department of Health Services, which regulates the burn pits as a Hazardous Waste Treatment Facility, has raised questions about soil, groundwater, and surface water contamination at UTC, which lies about 100 feet from a tributary of San Jose's Anderson reservoir and within 300 feet of the active Calaveras earthquake fault. It also is insisting that UTC submit a plan for the reduction of waste generation as well as an evaluation of recycling

approaches. If the company's answers do not satisfy the agency, the treatment-facility permit could be revoked.[14]

Another California rocket-maker, Aerojet-General, is testing an alternate form of "disposal," incineration, at its plant near Sacramento. Aerojet, like UTC, burns solid rocket motor waste in open pits. Regulators generally support the Aerojet project because it dramatically reduces emissions and it may provide a method of collecting and testing emissions for dioxins, which are extremely hazardous combustion products found when synthetic rubber is burned with chlorine. If the Aerojet incinerator does the job, UTC might follow suit. However, incineration still releases dangerous chemicals into the air and concentrates toxics in the form of ash. It reduces the threat of explosions, but the toxic hazards remain.

A third, superior alternative exists. Scientists at the Army's Redstone Arsenal have developed a technique, called Critical Fluid Demilitarization, that utilizes pressurized liquid ammonia to dissolve solid fuel, even when still held in rocket cannisters. The method safely separates the fuel, and it "allows the re-use of waste propellants in their production process, recovers the value of the raw materials and greatly reduces the volumes of waste to be disposed."[15]

Unfortunately, this project must compete for funds from already tight budgets. Until rocket manufacturers, NASA, and the military are compelled to take responsibility for the environmental costs of waste burning, fuel recycling may remain an experimental novelty. As the U.S. and the Soviet Union move toward arms agreements mandating the elimination of intercontinental ballistic missiles, a critical need exists for the Army to develop large-scale, on-site propellant recycling programs.

No Free Launch

While acknowledging NASA's research on ozone depletion and other efforts to monitor environmental degradation, we must continue to work to halt the environmental destruction wrought by the American space program. Too often, NASA, the military space program, and their contractors have been exempted from environmental rules because their work is considered critical. But

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[14]Letter from Michael R. James, Chief, Facility Permitting Unit, Region 2, Toxic Substances Control Program, California Department of Health Services to Dale Thrasher, United Technologies Corporation, June 21, 1990.

[15]*Defense Environmental Restoration Program*, Annual Report to Congress for Fiscal Year 1989, February, 1990, p. 24.

the price of national security should never be environmental insecurity and catastrophe, whether local, national, or global.

If the Advanced Solid Rocket Motor cannot be tested without abandoning toxic air contamination standards, the program should be scrapped. In fact, the anticipated switchover from the current shuttle engines to the ASRM provides the opportunity for a more responsible change, one from solid rocket fuel to advanced liquid—that is hydrogen/oxygen—fuels. This seemingly dramatic demand actually has support from official circles and portions of the aerospace industry, including industry giant General Dynamics. Even UTC and Aerojet are developing hydrogen-oxygen propulsion systems. The National Research Council has recommended the replacement of solids with all-liquid propellants, in part because solid fuel pollutes the atmosphere with chlorides.[16]

Jerry Gray of the American Institute of Aeronautics and Astronautics told Congress this year that the ASRM project is a "dead-end development," saying that "he believes the next generation of transport systems will rely mainly on liquid-fueled engines, such as the European Ariane rocket and the Soviet heavy lifter Energia do." Lawrence Matson, representing an American Society of Mechanical Engineers task force, echoed, "We think NASA should take another look at the liquid rocket booster before they run off on full-scale development of the ASRM."[17]

Soviet space scientists, aware that they—perhaps by chance—have a space-launching system that is friendlier to the global environment, are calling for the elimination of solid rocket boosters in launchers and missile systems. They suggest an international agreement in the spirit of the Montreal Protocol on ozone depletion.

> Is it not high time to adopt in the area of space exploration strict procedures to monitor the use of hardware, to establish an international system for approving and certifying launch vehicles, and to establish parity between countries pertaining to number of launches, and not only from the standpoint of preserving the ozone layer but also in order to reduce other harmful effects on the environment? In this period of international détente, resolution of these problems is becoming not only a good idea but also a real possibility.[18]

Of course, even if NASA and the Air Force move expeditiously to banish solid rocket propulsion systems and replace them with less harmful systems, the

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[16]"NRC Calls for Development of New Liquid Rocket Propellants," *Defense Daily*, March 6, 1990, p. 347.
[17]Eliot Marshall, "Shuttle Rocket Plan Under Fire," *Science*, April 14, 1989, p. 136.
[18]V. Filin and V. Burdakov, "Global Ecological Threat," p. 27.

question of solid rocket fuel disposal will remain. In fact, if existing rocket motors are destroyed to protect the environment, or if additional arms control agreements specify the decommissioning of missiles, then the requirement for fuel disposal could skyrocket, so to speak.

Open-pit burning, the standard method of disposing of solid rocket fuel, must be halted immediately. Incineration, one of the alternatives, is a stopgap remedy and it should be considered only after other methods, including chemical separation, are fully developed and tested. Now is the time for air quality regulators, as well as the agencies that require fuel disposal, to force the adoption of the new technology.

Today in America many individuals and groups are proposing space programs, from the "Brilliant Pebbles" strategic defense system to interplanetary travel, that would require a massive increase in space-launching. As each new venture is considered, NASA or the Air Force commissions an environmental impact study; however, environmental considerations never play an important role in the actual decision whether to proceed. Moreover, as the EPA points out, "each of the programs is examining impacts in their NEPA [National Environmental Policy Act] documents without fully considering the cumulative/synergistic consequences of the others."[19] **Before the U.S. considers any new space ventures, the government must carry out an objective, comprehensive evaluation of the environmental impact of the entire space business, reviewing the pollution caused by rockets, their components, and their propellants, from cradle to grave.**

Lenny Siegel is the chief researcher of the National Toxics Campaign Fund's Military Toxics Network (MTN) and Director of the Pacific Studies Center in Mountain View, California.

For more information about rocket toxics, additional copies of this report, or information about MTN's October, 1990 report on military toxics ("Our Own Worst Environmental Enemy"), contact MTN at 2802 East Madison, Suite 177, Seattle, WA, 98112 or call 206/328-5257. Fax: 206/328-5267). In October. For more on the "Dirty Denver" report, contact Adrienne Anderson at the National Toxics Campaign's Western Office in Denver at 303/333-9714.

[19]Letter from Heinz J. Mueller.