NO FREE LAUNCH:

The Toxic Impact of America's Space Programs

[DRAFT: NOT FOR CITATION]

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Edward Teller, the "Father of the H-Bomb" and the man who inspired Ronald Reagan's Star Wars proposal, has found a new mission. Using technology being developed for strategic missile defense, he want 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—indeed, the average American—fails to recognize is that the environmental costs of launching such spacecraft would easily 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 major industrial polluters. Hughes Aircraft in Tucson, Arizona and Aerojet-General in Sacramento, California, for example, 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, in Denver, Colorado is the Air Force's now inactive Hydrazine Blending and Treatment facility, used for the production of hydrazine-based fuel for Titan missiles and other liquid-fueled rockets built nearby at Martin Marietta. Hydrazines are highly toxic and probably carcinogenic. For thirty years Martin Marietta flushed rinsewater from its rocket test stands into Brush Creek, a tributary of Denver's drinking water system. It "treated" a large portion of the rinsewater with copper sulfate, forming nitrosodimethylamine, which 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 other serious illnesses. They are now awaiting a Federal judge's decision whether or not to send the case to 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." Contact the Military Toxics Network for more information.)

Avtex Fibers, the largest polluter in the state of Virginia, shuttered its Front Royal plant in late 1989. Avtex had remained open despite high levels of toxic releases because it was the sole "free world" source 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 its reported 51 million pounds of air pollutants was carbon disulfide, but it released nearly 2 million pounds of chlorine as well. It reported the on-site land disposal of nearly 3 million pounds of zinc. But it did not admit 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]

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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.

[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.

Many rocket-fuel components are, as one might expect, 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 8 million pounds of the compound, 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] Since 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.)

According to the National Aeronautics and Space Administration (NASA), each shuttle booster delivers exhaust containing about 68,000 kilograms (150,000 pounds) of hydrogen chloride gas (HCl) to the stratosphere.[4] Like chlorofluorocarbons (CFC's), 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. Five other factories reported CFC-113 emissions comparable to two shuttle launches.[6]

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

> 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 in uneven over the Earth's surface, and genetic factors cause varying health effects among different populations. But there is a global consensus:

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

[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.

the detrimental impact of increased ozone depletion is enormous. Environmental Protection Agency data suggests, for Americans alone, that each 1 percent of ozone depletion allows on average a 2 percent increase in ultraviolet incidence. Each 2 percent increase in ultraviolet exposure brings a 4 to 6 % rise in basal and squamous cell carcinomas, projected to cause 3 to 15 million additional cases of skin cancer among Americans born before the year 2075. This translates, for that period, into 50,000 to 200,000 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 .25% 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 their 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 that proved 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 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]

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

[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.

elevated acidity showed increased abnormality and mortality.[10]

NASA and the Air Force file environmental assessments and impact statements evaluating—often whitewashing—their various launch programs, but launches are not regulated by air quality authorities. To protect public health and the environment, they should be subject the 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 reasons, 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 health risks as well as damage to the Gulf Coast wetlands. NASA initially plans four 2.25-minute tests of the new motors each year, expected to release about 1.7 million pounds of aluminum oxide, 123,000 pounds tons of chlorine, and more than a million pounds 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 3.2 million pounds 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 and test under optimum weather conditions.

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, 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 signing 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

[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.

[12]Shailagh Murray, "Clean Air Plan Could Scrub Test," *The SunHerald,* January 29, 1990, p. B-1.

> 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, comes directly from production runs. The proposed Advanced Solid Rocket Motor plant in Iuka, northern Mississippi, is expected to dispose of a million pounds 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 *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. And United Technologies Corp. [UTC] burns fuel from Minuteman missiles that it reconditioned for the Air Force—though opposition in San Jose, California forced UTC to move that part of its open-burning to the Sierra Army Depot, in Herlong, California, north of Lake Tahoe.

A UTC official explained the program to regulators:

> UTC bid on and was awarded a contract in 1984 from the Air Force to received fully operational third stage Minuteman systems from the Air Force for complete refurbishment. This involved stripping the accessory hardware from the system including the nozzle system, steering mechanism, ignition system, wiring harnesses, etc., for re-use. This resulted in a filament wound rocket motor case which contained propellant that was disposed of at our burn pits.[14]

UTC's ten burn pits are about 20 feet by 30 feet, each surrounded by a horseshoe shaped mound of dirt about four feet high, at the edge of UTC's property in the hills south of San Jose. There is no high-tech ignition system or monitoring equipment. 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. Critics say that UTC's emissions usually waft over Morgan Hill, a growing community south of San Jose. In 1989, UTC burned 281,000 pounds of waste propellant, but the previous year, when it was disposing of old Minuteman fuel, the total reached 789,000 pounds.

The Bay Area air board has forced UTC to limit its disposal operations to waste fuel from its mixing and machining operations, even though the company claimed that waste stripped from imported old rockets was "generated" on site, and it has ordered four pits closed. 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

[13]"Fueling a Controversy," *San Jose Mercury News* Editorial, April 6, 1990, p. 6B.

[14]Letter from J.L. Bohan, Vice President-Counsel, United Technologies Corporation Chemical Systems Division, to Lucas S. Stamous, Zoning Administrator, County of Santa Clara (California), January 31, 1990, p. 2.

burning because it is unaware of any alternate means of disposal.

Meanwhile the state 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.[15]

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 and it could provide the means for collecting and testing emissions for dioxins, extremely hazardous combustion products found when synthetic rubber is burned with chlorine. If the Aerojet incinerator does the job, UTC might follow suit, but incineration merely controls and collects toxic emissions. It reduces the threat of explosions, but the toxic hazards remain.

There is a third, superior alternative. Scientists at the Army's Redstone Arsenal have developed a technique, called Critical Fluid Demilitarization, that uses 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."[16]

Unfortunately, this project must fight for funds from already tight budgets. Until rocket manufacturers, NASA, and the military are forced 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, there is a critical need for the Army to develop large-scale, on-site propellant recycling programs.

No Free Launch

While applauding NASA's research on ozone depletion and other efforts to monitor environmental degradation, we must still work to halt the environmental destruction wrought by the American space business. All too often, the NASA, the military space program, and their contractors are exempt from environmental rules because their work is considered critical. But the price of national security should never be environmental insecurity, be it local, national, or global.

If the Advanced Solid Rocket Motor cannot be tested without abandoning toxic air contamination standards, then 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, 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 with oxygen propulsion systems. The National Research Council has recommended the replacement of solids with

[15]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.

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

all-liquid propellants, in part because solid fuel pollutes the atmosphere with chlorides.[17]

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."[18]

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.[19]

Of course, even if NASA and the Air Force move expeditiously to supplant solid rocket propulsion systems with less polluting ones, there will still be a need to dispose of solid rocket fuel. 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.

Open-pit burning, the standard method of disposing of solid rocket fuel, must be halted wherever it occurs. Incineration, one of the alternatives, is a stopgap remedy and it should be considered only until other methods, such as chemical separation, are fully developed and tested. The Army should be commended for its research on propellant disposal. 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.

Individuals and groups from all wavelengths in the American political spectrum 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, but environmental considerations never play an important part in the decision to proceed. Furthermore, 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."[20] **Before the U.S. considers of 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**

[17]"NRC Calls for Development of New Liquid Rocket Propellants," *Defense Daily,* March 6, 1990, p. 347.

[18]Eliot Marshall, "Shuttle Rocket Plan Under Fire," *Science,* April 14, 1989, p. 136.

[19]V. Filin and V. Burdakov, "Global Ecological Threat," p. 27.

[20]Letter from Heinz J. Mueller.

rockets, their components, and their propellants, from cradle to grave.

For more information, or additional copies of this report, contact the Military Toxics Network at 2802 East Madison, Suite 177, Seattle, WA, 98112 or call 206/328-5257. Fax: 206/328-5267)