cial nuclear plants would fit into one 1.5 mile underground repository.

There is no mystery to the permanent burial of nuclear waste. The basic method used today in France was actually developed in the 1950s in the United States, by Brookhaven National Laboratory, and there have been continuous improvements in the technology to make the waste more stable.

The liquid waste is mixed with glass frit, and then poured into a 1-inch thick stainless steel canister that is 10 feet high and ½ to 2 feet in diameter. The canister is heated until the glass melts and then it is cooled, which fixes each atom of the waste solidly in the borosilicate glass. The canister is then packed in a another barrier of molded steel, and the entire assembly is surrounded with a metal or ceramic corrosion barrier. Finally, the assembly is buried in a specially designed vault in a geological formation in salt, volcanic rock, or granite, which forms an additional barrier. The United States has been testing various geological formations to see which are the most stable for long term storage.

The general principle is to set up a system of multiple barriers, to ensure that no radioactivity is released.

The tests that the French have done on this vitrified waste indicate that after 900 years of storage, the glass will still be a satisfactory storage medium. According to the International Atomic Energy Agency, such glass is so stable that even if placed in flowing warm water, "it would take 100 years to dissolve away about 1 millimeter of the surface of such a glass."

There have also been advances in the preparation and transportation of fuel. For example, the casks for transporting waste are probably the best designed containers ever made. They became famous in films made by the Sandia National Laboratories, showing trucks with waste casks colliding full speed with a locomotive or crashing into a wooden structure. In all these dramatic tests, the cask emerged unscathed.

Alternative methods of waste disposal have been developed that are also ready now. For example, fluidized bed calcining, developed at the Idaho Chemical Processing Plant near Idaho Falls, solidifies the waste and stores it dry. The defense waste at the Idaho facility has been stored in this manner.

The future

The pioneers of the atomic age saw the Atoms for Peace program as a way to lift mankind out of poverty worldwide and into an age of plenty. Their technological optimism is as well-founded today as it was in the 1950s. We should be mass-producing nuclear plants for domestic use and export, and we should overturn the present "throwaway" nuclear fuel cycle and implement a reprocessing program. If we immediately gear up to reprocess nuclear waste and turn 96% of it—and probably all of it—into new resources, there will be no problem of nuclear waste burial.

Fighting lasers with

by Charles B. Stevens

In an apparent turnabout, Dr. Thomas Karas, project director of the Congressional Office of Technology Assessment, has called on the U.S. government to respond immediately to the imminent threat of a Soviet breakout from the ABM Treaty. The OTA has been a bastion of opposition to President Reagan's Strategic Defense Initiative (SDI).

Testifing before the Research and Development Subcommittee of the House Armed Services Committee on March 11, Dr. Karas sounded the alarm that, "at least in the near term, the Soviet Union is better prepared than the U.S. to deploy a nationwide, if only modestly effective, BMD [ballistic missile defense] system."

Karas's warning is opportune, but the solution he offers is a disaster. The OTA is demanding that the SDI missile defense program be focused on *near-term deployment systems,* like the obsolete anti-missile missile defenses ("High Frontier") championed by Lt.-Gen. (ret.) Danny Graham, to the detriment of research and development on the more advanced directed energy laser and particle beam systems, such as the x-ray laser, which actually hold the key to the future of antiballistic missile defense.

Already, under pressures of the Gramm-Rudman budget-cutters and the OTA, over 50% of the SDI budget is being diverted to High Frontier-type kinetic energy weapon and anti-missile missile defenses, and away from more advanced beam-weapon approaches.

Soviet force improvements

The Air Force has presented Congress with updated reports on the "determined, steady increase" in Soviet strategic nuclear weapons programs, emphasizing that the "momentum of these improvements is a clear and growing sign of Soviet intentions; they serve as a danger signal to Western security." The latest developments summarized by the Air Force include:

- **ICBMs:** The Soviets currently have 1,373 intercontinental ballistic missile launchers carrying nearly 6,500 warheads, with a payload (throwweight) about three times that of the U.S. ICBM force. The 300 SS-18s, alone, have a hard-target throwweight capability in excess of that of the entire U.S. strategic missile force—both submarine and ICBM. In violation of the SALT II Treaty, the Soviets are deploying,

sticks and stones

according to the most recent National Intelligence Estimate, 12 to 14 warheads each on these SS-18s, instead of the 10 warhead limit allowed by the Treaty. The new road-mobile SS-25 and the rail-mobile SS-X-24 are "expected to be operational in 1987." In addition, three new Soviet ICBMs are expected to enter flight testing "in the next four years."

- **SLBMs:** Currently the Soviet submarine-launched ballistic missile force includes 950 missiles with 2,600 warheads. Two-thirds of this force can be fired at the United States from Soviet home waters. New MIRVed missiles, with many more warheads, continue to be deployed on old and new submarines, such as the giant Typhoon.
- **Strategic defense:** The Soviets have nearly 14,000 surface-to-air missile launchers and are continuing deployment of the SA-10 air defense missile. They are developing a newer mobile air defense missile system, the SA-X-12, "which may have the potential to intercept U.S. strategic ballistic missiles, as well." To control ballistic missile intercepts, the Soviets are completing construction of a massive phased-array radar at Pushkino. "This ABM system will reach full operational status in the late 1980s." The Soviets are also building a new phased array radar at Krasnoyarsk, which "could provide a basis for a territorial ABM defense capability," and which is a violation of the 1972 ABM Treaty. If the Soviets continue to develop engagement and guidance radars as well as above-ground launchers for high-acceleration interceptors, they "could use them for a rapidly-deployable ABM network in violation of the ABM Treaty."

The U.S. cutbacks

In his testimony to Congress March 4 and 5, Lt.-Gen. James A. Abrahamson, director of the Strategic Defense Initiative Organization (SDIO), detailed how already implemented congressional cuts were undermining the U.S. missile defense program. For example, Abrahamson noted that last year's $1 billion cut in SDI funds led to an unwanted change in the "fundamental philosophy" of the SDIO. Orginally, the SDIO expected to develop a large number of promising laser candidates, but the budget cuts forced the program to narrow down to a few possibilities, such as ground-based lasers, while cutting back, for example, on space-based lasers.

Meanwhile, according to Abrahamson, the Soviets are "improving all elements" of their existing ABM system, and "are also developing components of a new ABM system that apparently are designed to allow them to construct individual ABM sites in a matter of months, rather than the years required for more traditional ABM systems."

The folly of the approach of the born-again "pro-defense" liberals, is most sharply seen in the case of the x-ray laser, which is now getting short shrift in the SDI budget. According to leading defense scientists, such as Dr. Edward Teller, the Soviets have probably already deployed nuclear bomb-pumped x-ray lasers. This is by no means unexpected. U.S. x-ray laser experts have consistently reported that the Soviets have maintained a 10-fold larger R&D effort in this field, and that successful U.S. research has generally been based on concepts first developed by the Soviets.

The potential of the x-ray laser

In 1982, the Lawrence Livermore National Laboratory and Martin Marietta, Inc. completed a study showing that primitive forms of x-ray lasers could be developed and deployed against some types of missiles, such as the slower-moving submarine and sea-launched varieties, within five years. And despite their recent pleas for a total nuclear test ban, the Soviets have carried out almost double the number of underground explosions within recent years that the United States has. It would not be surprising to discover that the Soviets have already deployed x-ray lasers.

Given sufficient resources, the U.S. x-ray laser could now be developed within two years.

The tremendous potential firepower of the nuclear bomb-energized x-ray laser, underscores the insanity of focusing U.S. missile defense efforts on obsolete systems. As Dr. Lowell Wood of Lawrence Livermore stated in testimony to Congress in early 1985, "One contemplates the functional (and perhaps physical) destruction of entire fleets of ICBMs, with a single weapon module lofted by a single defensive missile. Each of these primary prospects has significant, albeit early, experimental results behind them at the present time. They are not dreams, nor are the corresponding applications studies naive."

With the plasma lens utilzed to focus x-ray laser beams, a single x-ray laser bomb, in the megaton total output range, popped into space on a single missile, could generate enough beams to destroy 10,000-100,000 hardened warheads over ranges of several thousand kilometers. In other words, one x-ray laser bomb could destroy all of the Soviet ICBM warhead and decoy capability, and do it during the 20 minutes of flight through space which the re-entry vehicles, carrying the warheads, traverse on their way to the United States.

Alternatively, Soviet x-ray lasers could easily destroy High Frontier's kinetic energy weapons and anti-missile missiles.