# Deep Borehole Disposal CP

## 1NC—Deep Borehole Disposal CP

### The United States federal government should amend all relevant federal laws to allow for deep borehole disposal of nuclear waste. The United States federal government should create 950 5-kilometer deep boreholes with off-the-shelf oilfield and geothermal drilling techniques that are at least 200 meters away from another borehole. The United States federal government should fill these holes 2 kilometers deep with nuclear waste materials.

## Solvency

### The CP solves disposal safely and cost effectively

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Preliminary evaluation of deep borehole disposal of high-level radioactive waste and spent nuclear fuel indicates the potential for excellent long-term safety performance at costs competitive with mined repositories. Significant fluid flow through basement rock is prevented, in part, by low permeabilities, poorly connected transport pathways, and overburden self-sealing. Deep fluids also resist vertical movement because they are density stratified. Thermal hydrologic calculations estimate the thermal pulse from emplaced waste to be small (less than 20 oC at 10 meters from the borehole, for less than a few hundred years), and to result in maximum total vertical fluid movement of ~100 m. Reducing conditions will sharply limit solubilities of most dose-critical radionuclides at depth, and high ionic strengths of deep fluids will prevent colloidal transport. For the bounding analysis of this report, waste is envisioned to be emplaced as fuel assemblies stacked inside drill casing that are lowered, and emplaced using off-the- shelf oilfield and geothermal drilling techniques, into the lower 1-2 km portion of a vertical borehole ~ 45 cm in diameter and 3-5 km deep, followed by borehole sealing. Deep borehole disposal of radioactive waste in the United States would require modifications to the Nuclear Waste Policy Act and to applicable regulatory standards for long-term performance set by the US Environmental Protection Agency (40 CFR part 191) and US Nuclear Regulatory Commission (10 CFR part 60). The performance analysis described here is based on the assumption that long-term standards for deep borehole disposal would be identical in the key regards to those prescribed for existing repositories (40 CFR part 197 and 10 CFR part 63).

### 950 boreholes solve the affirmative

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Petroleum drilling costs have decreased to the point where boreholes are now routinely drilled to multi-kilometer depths. Research boreholes in Russia and Germany have been drilled to 8-12 km. The drilling costs for 950 deep boreholes to dispose of the entire 109,300 MTHM inventory, assuming a cost of $20 million per borehole (see Section 3.1), would be ~ $19 billion. Very rough estimates of other costs are $10 billion for associated site characterization, performance assessment analysis, and license application, $20 billion for disposal operations, monitoring, and decommissioning, $12 billion for ancillary program activities, and $10 billion for transportation, resulting in a total life-cycle cost for a hypothetical deep borehole disposal program of $71 billion (in 2007 dollars). Although there are significant uncertainties in the cost estimates for deep borehole disposal presented here, the estimated total life-cycle cost may be significantly lower than the estimated total cost of Yucca Mountain. Note in particular the lower construction/operation and transportation outlays that borehole disposal would allow.

### The counterplan solves terrorism— materials are sealed away forever

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Third, requirements in both the NWPA and the EPA and NRC regulations specific to the retrievability of waste are assumed to be modified to reflect the more permanent disposal nature of a deep borehole disposal system. Although retrievability would be maintained during emplacement operations, waste may not be fully recoverable once the borehole has been sealed, and deep borehole systems may not be the best choice if permanent and irreversible disposal is not intended. Consistent with this observation, it should be noted that although the analysis presented in this report treats the direct disposal of SNF as a bounding performance case, deep borehole disposal systems may be particularly appropriate for other waste forms, including reprocessing wastes.

### Counterplan solves the first advantage while avoiding any risk of leaks due hazards

Gibb 99 [Fergus G. F. Department of Earth Sciences, University of Sheffield, “High-temperature, very deep, geological disposal: a safer alternative for high-level radioactive waste?, 1/22/99, http://www.sciencedirect.com/science/article/pii/S0956053X99000501]

One of the main arguments against any form of deep borehole disposal for radioactive waste is that it renders recovery difficult if not impossible. There is a fairly clear trade-off between safety and recoverability with increasing depth of disposal which must raise questions about the importance of recoverability. There appears to be little scientific or technical basis at present for this requirement and it is largely a political constraint in case a better solution to the problem emerges sometime in the future. Against this must be weighed the possibility that difficult or impossible recovery might be a good thing since it virtually eliminates the risk of deliberate intrusion for the purposes of theft, terrorism, sabotage, etc. and greatly reduces the risk of accidental intrusion. Two other advantages of the proposed scheme are (1) that the positions of the waste packages remain fixed, and known, permitting post-closure monitoring if required and (2) the greater depths improve the chances that the containment will survive seismic, tectonic and other hazards. In the event of some geological process, such as faulting, fracturing the waste package and all the near-field barriers it is improbable that the isolation of the fracture fluid layers in the host rock would break down.

## A2: Don’t Need Regulation

### Regulatory reform is needed— Current policy is only set up for Yucca

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

The current regulatory and legal framework for radioactive waste management is centered on mined geologic repositories, and was not intended to be applied to the long-term performance of deep borehole disposal systems. The Nuclear Waste Policy Act (NWPA) restricts consideration of geologic repositories in the United States to a single site, Yucca Mountain in Nevada, and EPA and NRC regulations (40 CFR part 197 and 10 CFR part 63, respectively) have been written specific for that site. Implementation of a deep borehole disposal system would, therefore, at a minimum, require amendment of the Nuclear Waste Policy Act. In principle, existing regulations from the 1980s that predate the selection of Yucca Mountain (i.e., 40 CFR part 191 and 10 CFR part 60) could be applied to borehole disposal systems without modification. However, these early regulations are inconsistent with recommendations provided to the EPA in 1995 by the National Research Council of the National Academies of Science and Engineering at the request of Congress, which called for system-level performance metrics based on annual risk, and may therefore be viewed as inadequate. In order to evaluate the system performance of a deep borehole disposal concept, it is necessary to adopt or develop a regulatory standard by which the performance can be measured. For the purposes of this preliminary analysis, the NWPA is assumed to be amended to allow consideration of sites other than Yucca Mountain and alternative disposal concepts, and new regulations are assumed to be promulgated that are similar in key regards to the current Yucca Mountain regulations, consistent with the EPA’s interpretation of the National Academies’ recommendations as promulgated in 40 CFR part 197. Thus, the primary overall performance measure of interest is mean annual dose to a hypothetical individual, with limits set at 0.15 mSv/yr for 10,000 years following disposal and for 1 mSv/yr for the period between 10,000 years and 1 million years. Other details of the regulatory framework, including screening criteria for potentially relevant features, events, and processes, as described in Section 4, are also assumed to be unchanged from those stated in 40 CFR part 197 and 10 CFR part 63, with the exception of human intrusion scenarios, for which new regulatory requirements would need to be developed. Four assumptions warrant further explanation.

## A2: The Counterplan is Bad for the Environment/Leaks

### The Counterplan is better for the environment than status quo storage system— Multiplicity of factors ensures no leaks

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In 1957 the US National Academy of Sciences Committee on Waste Disposal considered both deep borehole disposal of radioactive waste (in liquid form) and mined storage of radioactive waste in a positive light (National Academy of Sciences 1957). The intervening half-century has seen high-level waste (HLW) and spent nuclear fuel (SNF) disposal efforts in the US and other nations focus primarily on mined repositories, yet over the same time, the potential technical and cost advantages of deep borehole disposal have become more apparent. Radioactive waste emplaced in solid form (spent fuel or glass) at the bottom of deep (3-5 km) boreholes in crystalline basement rocks – typically granites (see schematic in Figure 1) - with off-the-shelf oilfield technology would be more effectively isolated from the biosphere than waste emplaced in shallower, mined repositories. The physical transport of radionuclides away from HLW and SNF at multi-kilometer depths would be limited by: low water content, low porosity and low permeability of crystalline basement rock, high overburden pressures that contribute to the sealing of transport pathways; and the presence of convectively stable saline fluids. Deep borehole disposal of radioactive waste has the added advantage of not producing as large a “thermal footprint” as a mined geologic repository, because boreholes placed more than ~200 m apart are unlikely to thermally affect one another.

### No leaks for a million years— five warrants

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Deep emplacement of HLW and SNF in crystalline basement rocks underlying sedimentary strata is expected to provide effective long-term (> 1 million years) isolation of radionuclides from the biosphere due to the following thermal, hydrologic, chemical, and mechanical characteristics of the borehole and the surrounding rock at depths of several kilometers: Long transport pathways - Potential transport pathways to the biosphere are long and would therefore involve extensive radioactive decay, dilution, formation of radionuclide- bearing phases, and retardation, given the impediments to vertical migration of radionuclides from several kilometers depth. Slow fluid movement - Fluid movement at > 4 km depth is inhibited by low porosities (< 1%), very low permeabilities (10-16 to 10-20 m2), and the presence of convectively-stable, high ionic strength brines ( 150 g/L) (See Table 1) in the rock. The permeabilities of deep crystalline rock are roughly 10 orders of magnitude less than those of gravel aquifers. The porosities of deep crystalline rock are 10 to 40 times less. Deep crystalline rocks typically have low water content. Minimal hydrologic flow is thought to occur, primarily through discontinuous fractures. Fluid movement up boreholes will likewise be limited by low permeabilities in the filled borehole and/or disturbed rock annulus which are expected to range from 10-13 m2 for fractured rock to 10-16 m2 for packed sediments, to 10-18 m2 for clay or bentonite (Freeze and Cherry, 1979; Table 2.2). Insufficient upward ambient driving pressure – Basement rocks do not typically contain pressurized aquifers or other flow features that would produce significant upward flow gradients under ambient conditions. Therefore, the most significant driving force for fluid flow and radionuclide migration away from a deep borehole is likely to be minor thermal pressurization from decay heat. Chemical conditions limit radionuclide release and transport – Reducing conditions are likely to prevail at depth which will maintain fuel and most radionuclides at very low solubilities. High ionic strength brines will limit the formation and movement of radionuclide-bearing colloids. Finally, sorption of many radionuclides onto the crystalline rock and/or borehole fill material will retard transport. Mechanical stability – Crystalline rocks such as granites are particularly attractive for borehole emplacement because of their large size, relatively homogeneous nature, low permeability and porosity, and high mechanical strength (to resist borehole deformation). In addition, high overburden pressures contribute to sealing of some of the fractures that provide transport pathways.

### These boreholes are like Fort Knox— The seals are durable and can be made with existing technology

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

The borehole seal system is designed to limit entry of water and migration of contaminants through the borehole after it is decommissioned. The key features of the seal system design are that it exhibits excellent durability and performance and is constructible using existing technology. The design approach applies redundancy to functional elements and specifies multiple, common, low-permeability materials to reduce uncertainty in performance. In the waste disposal zone itself, bentonite will be used as a buffer/seal material because of its low permeability, high sorption capacity, self-sealing characteristics, and durability. The canister strings will be surrounded by “deployment mud” comprised of bentonite-water slurry. Canister strings will be separated by an approximately 1 m interval of compacted bentonite. Compacted bentonite will also be used at the top of the waste disposal zone, above the canister strings. Mechanical barriers (bridge plug, packer, etc.) in the casing at the top of the waste disposal zone could be used to isolate the wellbore. However, the elastomeric materials typically used as part of their sealing element will degrade over time and there may be operational difficulties in running (or retrieving) the plugs. Therefore this option is not considered to be desirable or highly feasible. The upper 1,500 m (5,000 ft) of the emplacement borehole casing will be removed after canister placement and sealing. A borehole seal system extending from the top of the waste disposal zone to the surface will be deployed to further isolate the emplaced wastes from the accessible environment. This borehole seal system will use a combination of bentonite, asphalt and concrete. The main seal will consist of compacted bentonite packs placed in a bentonite-water slurry (deployment mud). If the intermediate 20” casing is left in the borehole, this casing can be milled out at appropriate intervals to allow free movement of the sealing medium from the hole to the annulus and surrounding rock. A top seal will consist of asphalt from 500 m to 250 m, with a concrete plug extending from 250 m to the surface. Seal materials are discussed below.

### Clay caps solve— They are proven impermeable and durable

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Compacted clays are commonly proposed as primary sealing materials for nuclear waste repositories and have been extensively investigated against rigorous performance requirements (e.g., Van Geet 2007). Advantages of clays for sealing purposes include: low permeability, demonstrated longevity in many types of natural environments, deformability, sorptive capacity, and demonstrated successful utilization in practice for a variety of sealing purposes. Compacted clay as a borehole sealing component functions as a barrier to water flow and radionuclide movement and possibly to gas flow.

### Even if there are leaks the timeframe is a million years in the future

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

The vertical concentration profile above the waste from this solution is plotted in Figure 12 at 1,000,000 years after waste emplacement, assuming an effective diffusion coefficient of 1 x 10-10 m2/s. Migration of radionuclide mass via diffusion has occurred to a vertical distance of about 200 m above the waste in this time. The concentrations shown in Figure 12 are overestimated with regard to the geometry of the system. Diffusion from the top of the waste disposal zone would have a radial component as well as a vertical component, reducing the migration rate in the vertical direction. Radionuclides that sorb on the rock matrix and borehole sealing material would be significantly retarded during diffusive migration. In addition, radioactive decay for radionuclides with half lives less than the time frame of the calculation would decrease concentrations. The value of the effective diffusion coefficient (1 x 10-10 m2/s) used in the analysis is relatively high for granite, but is approximately representative of the elevated temperature conditions in the deep borehole disposal system. Overall, diffusion in crystalline host rock and borehole seals is a slow process for the migration of radionuclide contamination, even on geologic time scales. Given the depth of deep borehole disposal system, diffusion can be excluded as a significant process from further consideration in performance assessment analyses.

### Prefer our evidence— It cites specific calculations and come up with concrete numbers— the impact would be below current standards

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Thermal, hydrologic, and geochemical calculations suggest that radionuclides in spent fuel emplaced in deep boreholes will experience little physical reason to leave the borehole/near borehole domain. The vast majority of radionuclides, and the fuel itself, will be thermodynamically stable and will therefore resist dissolution into borehole fluids, or movement into and through the adjacent rocks. Thermal-hydrologic calculations indicate that, except for an early window extending from the time of emplacement to ~ 150 years post-emplacement (in the borehole), and ~ 600 years (to the top of the basement), there will be no vertical fluid flow to transport radionuclides towards the surface. Vertical transport velocities in the early flow window will be between 0.1 (basement) and 0.7 (borehole) m/yr. This means that total vertical fluid movement in, and adjacent to, deep borehole disposal zones should not exceed roughly 100 meters. In the absence of advection, chemical diffusion cannot move radionuclides from boreholes through discontinuous, stagnant, and density-stratified waters over distances much greater than about 200 meters in the 1,000,000 years needed for the vast bulk of the radioactivity to decay away. Simplified and conservative performance assessment calculations indicate that radiological dose to a human receptor via the groundwater pathway would be limited to a single radionuclide (129I) and would be negligibly small, ~10 order of magnitude below current criteria.

### No effect on humans— releases are a billion time less that what is allowed

USNWTRB No Date Cited [United States Nuclear Waste Technical Review Board, “Deep Borehole Disposal of Spent Nuclear Fuel and High-Level Waste”, <http://www.nwtrb.gov/facts/factsheets.html>, TT]

Deep borehole disposal has the potential to provide very robust waste isolation. For example, calculations by Sandia National Laboratories estimate the peak dose from a hypothetical borehole containing 150 MT SNF to be approximately 1x10‐10 mrem/yr, more than a billion times below current regulatory limits for releases from geologic repositories (1). Actual isolation performance will depend strongly on the geology of the borehole environment, and extraordinary performance of engineered systems should not be required.

## A2: No Technology

### The counterplan is being done in the status quo for other industries— Oil, gas and geothermal

USNWTRB No Date Cited [United States Nuclear Waste Technical Review Board, “Deep Borehole Disposal of Spent Nuclear Fuel and High-Level Waste”, <http://www.nwtrb.gov/facts/factsheets.html>, TT]

Drilling deep boreholes for disposal of SNF and HLW is feasible using proven available technology. Numerous boreholes greater than 2‐Km deep have been drilled (2), including a 6‐Km deep petroleum exploration borehole in Nevada (6) and a 12‐Km deep borehole in Russia (7). Deep boreholes have also been used for geothermal energy production (4). For example, 17 production wells drilled in Japan’s Okuaizu geothermal field ranged from 1.6 to 2.4‐Km deep (8). Although not a technical issue, economic cost could factor into the feasibility of borehole disposal. The cost of drilling and constructing deep boreholes depends upon rock type, depth and diameter of the borehole, and well casing design, among other factors. Cost estimates for drilling deep boreholes, including some based on geothermal energy production wells, have ranged from $1‐$4M/Km (2, 4). In general, for similar diameter and lithology drilling costs for deep borehole disposal are likely to be comparable to those for other deep oil, gas and geothermal boreholes.

## **A2: Earthquakes/Volcanoes**

### Fiat solves— Boreholes would only be dug in locations with minimal risks— There are plenty

USNWTRB No Date Cited [United States Nuclear Waste Technical Review Board, “Deep Borehole Disposal of Spent Nuclear Fuel and High-Level Waste”, <http://www.nwtrb.gov/facts/factsheets.html>, TT]

Many locations throughout the U.S. are likely to have suitable geologic strata at depth, including sedimentary, igneous and metamorphic rock types (1, 2). Maximum isolation capability and reliability will be associated with geologic settings that have: low permeability; reducing geochemistry; a high capacity for retarding radionuclide migration; no natural resources (including geothermal resources); and negligible seismic and igneous activity.

## **A2: Requires Too Much transportation**

### The counterplan requires less transportation that the plan— Borehole fields would be regional to allow easy disposal

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Because crystalline basement rocks are relatively common at 2-5 km depth (See Figure 2; also see O’Brien et al. 1979; Heiken et al. 1996), the US waste disposal burden might be shared by shipping waste to regional borehole disposal facilities. If located near existing waste inventories and production, shipping would be minimized. A disposal length of ~2km, and holes spaced 0.2km apart suggests the total projected US inventory could be disposed in several borehole fields totaling ~30 square kilometers.

## A2: Criticality DA

### Strong regulation means no criticality

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

During transportation to the site and during repository operations when humans are present, stringent administrative and physical measures would be in place to prevent criticality. These standard operational aspects are not discussed here. Rather, this discussion focuses on the low probability of criticality after deep borehole disposal in two general locations: in the waste canister (Section 4.3.1.1); and outside the waste canister in the near or far field (Section 4.3.1.1). The focus here is on direct disposal of spent fuel assemblies rather than HLW which has most of the fissile mass removed.

### No criticality inside the waste container— multiplicity of factors needed and physical constraints

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Fissile material cannot become critical after disposal unless several conditions are met. Specifically, several features must be present, and events and especially geologic processes must act to alter the waste canister and its contents for a critical event to occur inside the canister. However, physical constraints limit the possibility of criticality inside the waste canister. To elaborate, because of the small diameter of a deep borehole, the number of CSNF assemblies that can be placed in a canister is limited. This criticality analysis assumes one PWR assembly is placed in a canister. One PWR assembly cannot become critical even when fully flooded. For low enriched uranium, the heterogeneous lumping of the uranium in an assembly is the most reactive configuration. Hence, any re-arrangement to a more homogeneous configuration lowers the reactivity. Based on 383 kg of uranium in a reference PWR (derived from Table 7), the amount of fissile 235U would vary between 3% (11.5 kg) for older fuel, 5% (19 kg) for fuel 38 currently in use, and perhaps a maximum of 10% (38 kg) for fuel sometime in the future. Yet, homogeneous mixtures of rock with high silica content (~75%wt silica), typically require >350 kg, >65 kg, or >30 kg of fissile 235U, respectively, ignoring the presence of any neutron absorbing elements such fission products, actinides, or purposely placed boron or gadolinium (Figure 9 from Rechard, Sanchez et al. 2003). Hence, only a homogeneous mixture of future fresh fuel at 10% enrichment could be critical in a single canister. In reality fission products and actinides would also be present in spent fuel, which would lower reactivity, hence, even future CSNF at an initial 10% enrichment would not be critical. More importantly, the diameter of the canister or borehole is not sufficient to prevent excess loss of neutrons within the fissile material as discussed in Section 4.3.1.2 for criticality outside the waste canister.

### No criticality in the field— physical constrains, size of borehole and needed concentration

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

Because of the physical constraint on the amount of fissile mass in a canister, criticality is not credible inside the canister. Criticality directly outside the canister also has physical constraints. Specifically, the minimum diameter of a homogeneous critical sphere is greater than the 0.445 m (17.5 in.) diameter borehole at depth (Figure 3). For example, the minimum diameter for a critical sphere at 10% enrichment and a 20 kg/m3 concentration at the minimum mass of 30 kg is 0.71 m; More realistic depositional concentrations of 5 kg/m3 (concentrations found in high grade ores ~2300 ppm) result in a minimum diameter of 1.1 m. Ideal planar configurations must also be at least 0.5 m thick, as corroborated by the natural reactors at Oklo that were about 1 m thick (Rechard et al. 2001; Section 3.5). Hence, criticality is not credible in the confines of the borehole at depths where disposal occurs. If a critical event is to occur outside the package, geologic processes must transport fissile material from several packages into the host rock or to depositional zones away from the disposal area and then assemble the fissile material into a critical configuration. These geologic processes are the same as must be invoked to remove fission products and actinides from the waste and transport them to the biosphere. As discussed in Section 3.3, the chemical environment in a deep borehole greatly limits the mobility of radionuclides, in general, and fissile material, in particular. There is no likely mechanism to oxidize the uranium to the more mobile species (i.e., U+6); hence, the solubility of uranium (U+4) in the anoxic environment of the borehole is 10-8 mole/L (2.38 10-6 kg/m3) (Table 4). As noted above, the concentration, either as a liquid or solid, must reach ~5 kg/m3 (~2300 ppm) to go critical (6 orders of magnitude higher concentration). More importantly, enough mass must be released from the borehole waste disposal zone. As noted below in Section 5, uranium is not transported out of the waste disposal zone. At the upward velocities from thermal effects that might occur in the initial 200 years after disposal, it would take 9 billion years to deplete the uranium in a single waste canister (383 kg). In one million years, about 0.04 kg would be depleted using the thermal upward velocity in the initial 200 years. If a disposal borehole had 450 canisters, the maximum release from the disposal zone would only be 39 about 19 kg, of which at most 10% would be fissile. A release of 1.9 kg of fissile 235U is much less than the 30 kg necessary to become critical. Hence, criticality in the far field is not credible.

## A2: Temperature DAs

### Reducing the concentration of waste in each borehole solve your DA

Brandy et. al. 2009 [Patrick V., Ph.D., Northwestern University, Senior Member at Sandia National Laboratories, “Deep Borehole Disposal of High-Level Radioactive Waste”, August 2009, [www.mkg.se/Bil\_2\_Deep\_Borehole\_Disposal\_High-Level\_Radioactive\_Waste](http://www.mkg.se/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste), TT]

The resulting temperature histories for varying distances from the centerline of the disposal borehole are shown in Figure 6. The simulated temperature increases are significantly higher for the disposal of HLW than those for disposal of spent fuel assemblies, with the temperature increasing by about 125 oC at the borehole wall at the time of peak temperature. Temperatures decline more rapidly for the disposal of HLW because the heat output from the reprocessing waste is dominated by the relatively short-lived fission products 90Sr and 137Cs. It should be noted that the thermal impacts of HLW disposal could easily be controlled by reducing the diameter of the waste canisters or by reducing the concentrations of fission products in the waste glass. Reducing the diameter of the waste canister by a factor of two would reduce the thermal output per meter of borehole and the peak increase in temperatures by about a factor of four.

# Operational Safety CP

## 1NC—Operational Safety CP

### The United States federal government should mandate that: all spent nuclear fuel be transferred from wet to dry storage within five years of discharge; all nuclear power plants minimize the movement of spent-fuel casks over spent-fuel pools and minimize occasions when the entire core is moved to the pool during refueling outages; all nuclear power plants switch to open-frame storage rooms for the storage of spent fuel, install emergency water sprays, and make emergency preparations for emergency repairs of holes.

### The counterplan solves safety and security concerns.

Alvarez Et Al 3(\*Robert, a Senior Scholar at IPS, where he is currently focused on nuclear disarmament, environmental, and energy policies, served as a Senior Policy Advisor to the Secretary and Deputy Assistant Secretary for National Security and the Environment. \*Jan Beyea, PhD, earth science and environmental studies \*Klaus Janberg, \*Jungmin Kang, \*Ed Lyman, \*Allison Macfarlane, \*Gordon Thompson, \*Frank N. von Hippel, PhD Princeton University. “Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States” Science and Global Security, 11:1–51, 2003 www.irss-usa.org/pages/documents/11\_1Alvarez.pdf) MFR

No such event has occurred thus far. However, the consequences would affect such a large area that alternatives to dense-pack storage must be examined—especially in the context of concerns that terrorists might ﬁnd nuclear facilities attractive targets. To reduce both the consequences and probability of a spent-fuel-pool ﬁre, it is proposed that all spent fuel be transferred from wet to dry storage within ﬁve years of discharge. The cost of on-site dry-cask storage for an additional 35,000 tons of older spent fuel is estimated at $3.5–7 billion dollars or 0.03–0.06 cents per kilowatt-hour generated from that fuel. Later cost savings could offset some of this cost when the fuel is shipped off site. The transfer to dry storage could be accomplished within a decade. The removal of the older fuel would reduce the average inventory of 137 Cs in the pools by about a factor of four, bringing it down to about twice that in a reactor core. It would also make possible a return to open-rack storage for the remaining more recently discharged fuel. If accompanied by the installation of large emergency doors or blowers to provide largescale airﬂow through the buildings housing the pools, natural convection air cooling of this spent fuel should be possible if airﬂow has not been blocked by collapse of the building or other cause. Other possible risk-reduction measures are also discussed.

### And the counterplan solves all of the reasons that fuel storage is dangerous.

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Minimize the Movement of Spent-Fuel Casks Over Spent-Fuel Pools The NRC staff study, Spent Fuel Accident Risk, concludes that “**spent fuel casks are heavy enough to catastrophically damage the pool if dropped**.” The study cites industry estimates that casks are typically moved “near or over the SFP (spent fuel pool) for between 5 and 25 percent of the total path.” It was concluded that this was not a serious concern, however, because industry compliance with NRC guidance would result in the probability of a drop being reduced to less than 10−5 per reactor-year.74 Nevertheless, we recommend consideration of whether the movements of spent-fuel casks over pools can be reduced. We also acknowledge that reducing a pool’s inventory of fuel, as recommended below, will increase the number of cask movements in the near term—although all the fuel will eventually have to be removed from the pools in any case. The resulting risk increase should be minimized as part of the implementation plan. Minimize Occasions When the Entire Core is Moved to the Pool During Refueling Outages Refueling outages occur every 12 to 18 months and typically last a month or so. Pool dry-out times decrease dramatically when full cores are placed into spent-fuel-storage pools only a few days after reactor shutdown. Only a third to a quarter of the fuel in the core is actually “spent.” The remainder is moved back into the core at new positions appropriate for its reduced ﬁssile content. It is not necessary to remove the entire core to the spent fuel pool to replace the fuel assemblies in their new locations.75 Even when it is necessary to inspect the interior of the pressure vessel or to test the fuel for leakage, removal of part of the fuel should be adequate in most cases. The only regulatory requirement for removal of the entire core is on those infrequent occasions when work is being done that has the potential for draining the reactor pressure vessel. This would be the case, for example, when work is being done on a pipe between the pressure vessel and the ﬁrst isolation valve on that pipe—or on the isolation valve itself.76

## Solvency

### Open frame storage rooms allow for ample ventilation to prevent cooling issues

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Go to Open-Frame Storage As already noted, the Sandia study found that, for pools with open-frame storage in well-ventilated storage buildings (see below), spent fuel in a drained storage pool will not overheat if it is cooled at least 5 days before being transferred to the pool. Furthermore, for partial drainage, which blocks air ﬂow from below, open-frame storage allows convective cooling of the fuel assemblies from the sides above the water surface. The simplest way to make room for open-frame storage at existing reactors is to transfer all spent fuel from wet to dry storage within ﬁve years of discharge from the reactor. Consequently, our proposal for open-frame storage is tied to proposals for dry storage, as discussed below. The open-frame storage considered in the Sandia study could store, however, only 20 percent as much fuel as a modern dense-pack conﬁguration. Thus, a pool that could hold 500 tons of dense-packed spent fuel from a 1000-MWe unit could accommodate in open racks the approximately 100 tons of spent fuel that would be discharged in ﬁve years from that reactor.77 However, about twice as large a pool would be required to provide enough space in addition to accommodate the full reactor core in open-frame storage. If this much space were not available, occasions in which a full-core discharge is required would remain dangerous—although less frequent, if the recommendation to minimize full-core ofﬂoads is adopted. Alternative approaches to a lack of sufﬁcient space for open-rack storage would be to move spent fuel out of the pool earlier than ﬁve years after discharge or to adopt racking densities intermediate between dense-pack and the Sandia open rack arrangement. Two interesting intermediate densities that should be analyzed are: 1) an arrangement where one ﬁfth of the fuel assemblies are removed in a pattern in which each of the remaining fuel assemblies has one side next to an empty space; 2) an arrangement where alternate rows of fuel assemblies are removed from the rack. These geometries would have to include perforations in the walls to allow air circulation in situations where enough water remained in the pool to block the openings at the bottoms of the boxes, or removal of some partitions entirely.

### Emergency water sprays and repairs of holes prevents coolant failure

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Install Emergency Water Sprays The Sandia report also proposed that a sprinkler system be installed.83 For 80 tons of spent fuel generating 100 kWt/MTU, the amount of water required if it were all evaporated would be about 3 liters per second. Such a ﬂow could easily be managed in a sprinkler system with modest-sized pipes.84 The sprinkler system should be designed with an assured supply of water and to be robust and protected from falling debris. It should also be remotely operated, since the radiation level from uncovered fuel would make access to and work in a spentfuel building difﬁcult to impossible—especially if the building were damaged. The hottest fuel should be stored in areas where spray would be the heaviest, even if the building collapses on top of the pool (e.g., along the sides of the pool). The spray would need to reach all of the spent fuel in the pool, however— especially in scenarios where the spray water accumulated at the bottom of the pool and blocked air ﬂow into the dense-pack racks. Another circumstance in which the spray could aggravate the situation would be if the spent-fuel racks were crushed or covered with debris, blocking the ﬂow of air. In such a case, steam generated from water dripping into the superheated fuel could react with the zirconium instead. The circumstances under which sprays should be used would require detailed scenario analysis. Make Preparations for Emergency Repairs of Holes A small hole, such as might be caused by the penetration of a turbine shaft or an armor-piercing warhead, might be patched. For a hole in the side, a ﬂexible sheet might be dropped down the inside of the pool.85 However, in the turbineshaft case, the space might be blocked if the projectile was protruding from the wall into the spent-fuel rack. Or the racks might be damaged enough to close the gap between them and the side of the pool. Also, if the top of the fuel were already exposed, the radiation levels in the pool area would be too high for anything other than pre-emplaced, remotely controlled operations. Patching from the outside would be working against the pressure of the water remaining in the pool (0.1 atmosphere or 1 kg/cm2 per meter of depth above the hole). However, there could be better access and the pool wall would provide shielding—especially if the hole were small. Techniques that have been developed to seal holes in underground tunnels might be useful.86 Armor Exposed Outside Walls and Bottoms Against Projectiles The water and fuel in the pool provide an effective shield against penetration of the pool wall and ﬂoor from the inside. It should be possible to prevent penetration by shaped charges from the outside with a stand-off wall about 3 meters away that would cause the jet of liquid metal formed by the shaped charge to expand and become much less penetrating before it struck the pool wall. In the case of the turbine shaft, Pennington’s analysis for dry casks suggests that it also might be possible to absorb the shaft’s energy with a thick sheet of steel that is supported in a way that allows it to stretch elastically and absorb the projectile’s kinetic energy (see below).

# Nuclear Accidents DA

## 1NC—Nuclear Accidents DA

### Accidents likely – launch and orbit failures, meteor strikes

CISAC ‘94[Committee on International Security and Arms Control, National Academy of Sciences, “Management and disposition of excess weapons plutonium”, 1994, <http://www.nap.edu/openbook.php?record_id=2345&page=268>]

The main risks in this case would result from potential launch accidents, reentry from failed orbits, and if launch had been successful, possible long-term risks of collision of the payload with meteors in space. For example, a 1980 study examined the risk if a payload carrying HLW in a "cermet" (metallic ceramic) waste form were to reenter the atmosphere from a failed orbit.29 The study predicted that with the package design envisioned, 11 percent of a S-metnc-ton waste package would burn up during reentry. The study estimated that the result, depending on circumstances, would range from "a few cancer deaths to as many as 100 or so" (for HLW rather than plutonium). Space disposal of plutonium would require designs that would reliably pre- vent criticality accidents (which are not a problem in disposal of HLW). On the other hand, however, the minimal gamma radiation from plutonium makes the design and conduct of the missions easier than for HLW. There is little doubt that large (multiton) or small (10-kilogram) payloads of weapons plutonium can be designed that would reliably survive plausible accidents, including launch explosions or fires, reentry into the atmosphere, and high-speed impact on the ground although demonstrating such safety to regulators and the pub- lic would be problematic. Yet, unlike HLW, the plutonium payload, if it re- tumed to earth intact, would be a matter of great concern because it could be used to fabricate nuclear weapons. Thus, the inevitable risk of launch accidents is a fundamental problem for the space disposal approach. Launching the plutonium into low-earth orbit (which requires a velocity of about 8 kilometers per second) would not be sufficient, because material in low- earth orbit falls back to earth on a time scale shorter than the decay time of plu- tonium. Therefore one would have to launch the material into an orbit around the sun unlikely to encounter the earth (which requires at least 11 kilometers per second (km/s)), to a path that will escape the solar system (16.8 km/s), or into the sun itself (more than 18 km/x).30 Because the rocket launch mass re- quired grows exponentially with the required velocity, options requiring high velocity would greatly increase the cost of the project. 29 For an exhaustive analysis of the issues involved, see Analysis of Nuclear Disposal in Space, Vol. I, Executive Summary, and Vol. II, Technical Report, Phase 3, Battelle Columbus Laboratories, March31, 1980.

### And—Launch and orbit failures could easily send waste packages back to Earth.

NRC, ’01 [National Research Council Board on Radioactive Waste Management, *Disposition of High-Level Waste and Spent Nuclear Fuel:The Continuing Societal and Technical Challenges*, 2001, <http://www.nap.edu/openbook.php?record_id=10119&page=114>]

Extraterrestrial disposal is conceptually straightforward—the waste material is simply given a one-way ride into outer space. Realistically, however, this option is not feasible due to scientific, technical, and economic factors. These include the energy required to boost payloads into space, the failure of launches and their consequences, and the tradeoffs between cost and safety (Rice and Priest, 1981). Extraterrestrial disposal of HLW would require transport via spacecraft, with extreme attention to safety to avoid release of radioactive materials in the event of malfunction. Placing the waste in space near earth would not be sufficient. Orbits either around earth or around the sun in the inner solar system change over time periods that are short compared to the lifetime of waste components, so that a waste package placed in such orbits conceivably could return to earth. Most discussion of extraterrestrial disposal has therefore involved sending the HLW into the sun, which requires considerably more energy per pound than placing a payload into orbit, that is, larger rockets, and consequently, extremely high cost per pound of waste disposed. Although a technological approach has been described (Taylor, 1995), the formidable energy requirements for solar disposal imply that only the most dangerous waste components might warrant such expensive disposal. Accordingly, reprocessing or separation would be required, as in the case for P&T.

## Internal Link Magnifier

### Orbits likely to intersect the Earth

Eder, ‘84 [Dani Eder, previously engineer for Boeing, “Nuclear waste disposal in space”, 6/13/84, <http://yarchive.net/space/science/nuke_waste.html>]

Presumably your goal is to reduce risk to earthlings.  If you have a fallible space transportation system, and you are trying to launch something into the Sun (or to Solar System escape) your transport may fail at the wrong time.  If it does, it may leave your nuclear  waste in an elliptical orbit that intersects the Earth.  This isn't so bad, as you probably designed your waste container to survive reasonable re-entry velocities (in case of launch failure).  But if the orbit intersects another planet, the waste may be perturbed into an orbit that intersects the Earth at high velocity, up to twice the Earth's velocity around the Sun.  This becomes a very difficult container design problem.

### Meteor collisions and launch failures increase risks of accidents and radiation

Hewitt, ‘85[Robin Hewitt, “Outer space: the easy way out?”, 1985, <http://www.robinhewitt.com/write/articles/space.html>]

And then there's the risk involved in space dumping. Putting radioactive waste into a heliocentric orbit would only reduce, not eliminate, the risks of putting it into a geocentric orbit. Even though the waste containers would be farther away, radioactive particles released from collisions with meteors could still make their way back to earth. Worse, a failure of the Orbital Transfer System could result in the entire waste package returning to earth, burning up on re-entry, and releasing its radioactive contents into the atmosphere. A launch failure would bring the waste plummeting back to earth, and, according to the Battelle study, even that 58,800 pounds of packaging might not withstand such a fall if the payload should happen to land on hard rock. It might also land in the ocean, where, if recovery attempts should fail, it would eventually corrode, releasing all its radioactive wastes. The Battelle report also lists several other possible accidents which could result in a release of radioactive waste. And, of course, the more waste disposed in space, the greater the risk of an accident with serious consequences. There are no science-fiction style rescue missions on the way to save the people of earth from their follies and indulgences. On the contrary, the fact that the U.S. government has turned to investigating space disposal schemes indicates how desperate the radioactive waste problem has become.

# Links to Generics

## Prizes CP Solvency

### Utilizing the free market is possible – it’s been done before in the context of laser propulsion

Ray 11/10/09 (Bill, staffwriter “NASA hands over $900K for Laser propulsion system” <http://www.theregister.co.uk/2009/11/10/space_elevator_prize/>) MFR

LaserMotive has scooped a $900,000 prize from NASA for demonstration of an elevator powered from a ground-based laser. LaserMotive's climber crawled up 1km of rope held in place by helicopter, achieving an average speed of four metres per second and powered by a laser focused onto solar panels on the back of the climber. That gained the company $900,000 from the Power Beaming Challenge being run by the Spacewards Foundation for NASA. Three teams entered the competition, with the Kansas City Space Pirates coming second having nearly gained the top of the vertical track. The Pirates were let down by their lightweight climber which lacked rigidity, but the official coverage at Space Elevator Games reports the design is sound, and could deliver more power than LaserMotive's if they can get it working. The third team, from the University of Saskatchewan, had technical problems and didn't get to compete on the day. No one managed the five metres per second necessary to win the remaining prize fund of $1.1m this time, but the games will continue. All this is intended to discover whether or not a space elevator is possible: not having to carry fuel would reduce the weight of such an elevator considerably, even if batteries had to be used for part of the journey, but practical applications are still a very long way off and for the moment it's just a matter of seeing what can be done. ®

## Spending DA Link

### Your own author concludes you cost 10 billion initially – the plan spends a lot

Coopersmith 8/22/05 (Jonathan, associate professor of history at Texas A&M University, specializes in the history of technology and the history of Russia. “Nuclear waste in space?” <http://www.thespacereview.com/article/437/1>) MFR

How can a system be both expensive and inexpensive? Judging by the costs of other high technology projects such as the Airbus 380 and Boston’s Big Dig, developing a laser launch system will require at least $5–10 billion. This is a lot of money, but historically space technologies are expensive: The Apollo program cost over $150 billion in contemporary dollars. Constructing the actual launch system will require a few billion dollars and operations will consume billions more. And even if the price of a pound to escape velocity is only $100, 5000 tons is $1 billion.

### The plan would cost 2.2 trillion dollars to solve— That triggers our link

Whipple, 2010 [Chris, PhD and MS, Engineering Science, California Institute of Technology, “Disposal of Spent Nuclear Fuel and High-level Radioactive Waste”, 9/10/10, [www.brc.gov/disposal\_of\_spent\_nuclear\_fuel\_and\_high\_level\_radioactive\_waste](http://www.brc.gov/disposal_of_spent_nuclear_fuel_and_high_level_radioactive_waste), TT]

Cost and the risk of an accident during launch has kept space disposal from being taken seriously. With the current cost of putting objects in orbit at around $10,000 per pound, and given that the U.S. inventory of spent fuel and high-level waste is of the order of 100,000 metric tons, not including the heavy shielding that would be required, the costs with present technology would be prohibitive, even if the risks of radioactive wastes crashing back to earth could be managed somehow. But if one wanted to dispose of only the very long-lived waste, e.g., technetium-99, cesium-135, iodine-129, and the long-lived actinides, then the amounts are much more manageable, of the order of a few million kilograms for all current U.S. wastes. This is still very expensive at $10,000 to put a pound in orbit, and does not include the costs to separate out these long lived wastes from the other components. Proposals to launch wastes into space using earth-based lifting devices23 (lasers, microwaves, and high speed rail guns) offer the advantage that not all that fuel needs to be lifted, but the capability of these technologies to put materials into space has not been demonstrated. It appears that in order to make space disposal feasible, significant advances are needed in the technologies for separating nuclear wastes and in the cost of moving materials into space.

### Maintaining the beam is highly expensive

Ang, 2k[Weng Ang et al, Space Tourism, 2000, <http://www.pddnet.com/uploadedFiles/PDD/News_And_Editorials/Editorials/2010-08/ssp2000_space-Tourism.pdf>]

Solar and laser sails have also been suggested for interplanetary travel. They use the pressure of solar radiation for thrust, but their drawback is that the sails must be large, light and very reflective. Using large lasers on Earth to push a spacecraft could enhance their effectiveness, but this also effectively limits the distance the spacecraft can travel because a laser beam diverges in proportion to the distance it travels. It is very expensive to maintain the intensity of the beam throughout its trip.

## Politics—Plan Unpopular

### Storing spend fuel is politicizing – GOP opposes due to spending and safety

Wald 5/12/11 (MATTHEW L., Staffwriter for the NYtimes “Panel on Nuclear Waste Disposal to Propose Above-Ground Storage” <http://www.nytimes.com/2011/05/13/science/earth/13waste.html>) MFR

WASHINGTON — A commission created to help resolve the impasse over the disposal of the nation’s nuclear waste will propose establishing one or more sites where used reactor fuel could be stored in steel and concrete structures on the earth’s surface for decades, members of the commission said this week. A draft recommendation for such sites is to be discussed on Friday at a meeting of the panel, which was set up last year by the Department of Energy after President Obama canceled a longstanding plan to bury waste at Yucca Mountain, a site in the Nevada desert. The commission will also recommend opening a new effort to find a burial site, members said, and suggest that it be led by an organization that is independent of the Department of Energy, which has been working on the waste disposal effort for decades. Commission members say they will suggest securing the assent of local and state governments before a burial site is chosen. With a selection process that is based more on science than politics and the promise of local economic benefit, a host site could potentially be found, some of them said. Yucca Mountain was chosen by Congress in 1987 after a battle driven by not-in-my-backyard politics. Friday’s meeting will be the first public discussion of draft recommendations by the panel, which is scheduled to issue a draft report this summer and a final report next year. The quest for a national repository for spent fuel has been a festering issue for decades but gained higher visibility after a March 11 earthquake and tsunami hit the Fukushima nuclear plant in Japan. The disaster not only damaged reactors but led to the loss of cooling water in at least one pool of spent radioactive fuel, raising the risk of the release of radioactive materials. At nuclear plants in the United States, pools of spent fuel are far more heavily loaded. The National Academy of Sciences warned in a study in 2005 that the presence of vast stores of radioactive fuel could make the plants an attractive target for terrorists. For now, members of the waste commission say, the panel is unlikely to make a recommendation for starting work on two controversial disposal methods: reprocessing the spent fuel to recover plutonium for reuse, as France and Japan do, or building a new class of reactors that would break up the most troublesome wastes into materials that are easier to handle. Instead, it will recommend more research, the members said. “Neither the technology nor the economics are ready to compel us to make a decision on that at this point,” said Phillip A. Sharp, an Indiana Democrat on the commission. The 2005 study by the National Academy of Sciences, ordered by Congress after the attacks of Sept. 11, 2001, made a variety of recommendations for nuclear waste disposal, some of which were kept secret. One obvious approach has been moving the fuel into dry casks, or steel and concrete structures in which the fuel is cooled by the natural circulation of air rather than any moving parts. Such casks are already in use at a variety of reactor sites. The commission will recommended that storage of such casks be centralized at a handful of sites, starting with “orphan” sites where the reactors have been retired and torn down. The number of orphaned nuclear sites will grow significantly before the United States can establish a permanent burial place, commission members predict. Some nuclear industry experts have been hoping for a stronger commitment to recycling, in which the fuel is chopped up and the plutonium that was created during reactor operations is scavenged and purified for use in new fuel. Leftover uranium is purified and could also be reused, but most of it is stockpiled. But recent studies argue that there is plenty of virgin uranium and thus no reason to recycle. And American utilities have been reluctant to use the plutonium fuel, even when asked by the Energy Department in an effort to help dispose of surplus plutonium from the weapons program. Areva, the French nuclear company, has been arguing that recycling cuts the cost of disposal and eliminates the need to mine uranium, which itself is environmentally damaging. If the fuel is moved to above-ground casks, said David C. Jones, a senior vice president of the company, “We’re essentially back to where we were 30 years ago,” when Congress first told the Energy Department to look for a burial site. The draft recommendations to also include a plan to provide steady financing for the site selection and development process from money collected by utility companies that generate nuclear waste. Congress has been intermittently stingy in appropriating money, prodded partly by one of the opponents of the Yucca project, Senator Harry Reid of Nevada, the Democratic majority leader. Citing Senator Reid’s stance, Republicans in Congress have in recent months stepped up their criticism of President Obama’s decision to cancel the Yucca project, saying that it was driven purely by politics.

### Anything that isn’t Yucca is incredibly unpopular in Congress— Future solutions have the perception of being costly and dangerous

Huffington Post 2011 [“Where Do We Store Nuclear Waste? Solution Could Cost Billions, Take 20 Years, 5/13/11, http://www.huffingtonpost.com/2011/05/13/watchdog\_n\_861547.html]

The controversy over President Obama's decision to pull the plug on the decades-long, multi-billion-dollar Yucca Mountain nuclear waste repository project keeps brewing. The latest Government Accountability Office report, "Commercial Nuclear Waste: Effects of a Termination of the Yucca Mountain Repository Program," should only fuel the fire. Though terminating the program has some benefits, the report finds it will cost the government billions and perhaps 20 years to restart the whole process of finding a safe place to store such waste. Located deep underground, the Yucca Mountain site in Nevada was intended for permanent storage of spent nuclear fuel from power plants and high-level radioactive waste from Pentagon facilities, and attracted intense opposition from some environmentalists and safety watchdogs. The administration's move frees up the Energy Department to explore more-popular alternatives to radioactive waste management. But since an affordable and effective option doesn't yet exist, the prognosis is grim. The decision will also prolong the need for interim storage of spent fuel on-site at nuclear plants -- a practice which helped intensify the recent nuclear crisis in Japan. By failing to take custody of the waste by 1998, as required by law, such on-site storage has cost the government more than $15.4 billion. Currently, about 65,000 metric tons of commercial spent nuclear fuel are stored at 75 sites in 33 states, and the amount is increasing by about 2,000 metric tons a year, GAO said. Here is the Nuclear Energy Institute's map of nuclear waste storage sites in 2009. Meanwhile, Rep. Darryl Issa (R-Calif.), frustrated with the lack of response to his request for documents about the project, is threatening the Nuclear Regulatory Commission with a subpoena. In the May 6 letter, Issa calls the delay "unacceptable." The agency has refused to make public whether it will allow the Energy Department to withdraw its license application for the repository, reports the Bureau of National Affairs.

### The link turns the affirmative— environmental lobbies hate the plan— The have the ability to influence policies like the plan

American Society of Mechanical Engineers 2011 [“Congress Needs to Wake Up to Nuclear Waste Disposal, Part 1”, 5/2/11, http://www.american-society-of-mechanical-engineers.bestsellers3dledtv.com/congress-needs-to-wake-up-to-nuclear-waste-disposal-part-1/]

The endless merry-go-round of choosing upon a final resting place for nuclear waste has been studied for more than two decades, has cost taxpayers more than billion and has assuredly been solved. Unless of course, you are talking about an ideal explication which is required to be as satisfactory for up to one million years from now as it might be some 10,000 years into the future. That appears to be the most modern verdict – let’s keep nuclear waste in temporary storehouse scattered over geologically challenged locations, some near major cities, for decades to come, because a minority of environmentalists are “uncomfortable” with a well-studied, scientifically satisfactory centralized disposal site in a remote location. Instead of spirited forward with a site, which will reportedly store the waste safely for 10,000 years (and probably up to 80,000 years), the environmental lobby would prefer a toxic risk for tens of millions of Americans from ‘overcrowded’ temporary storehouse sites. They would like to stall matters until scientists can prove a centralized storehouse site can survive all potential abuse for up to one million years.

## Politics—Plan Popular

### NIMBY outweighs all other concerns— Congressmen just want the waste gone

New York Times 2009 [John J. Fialka is a staff writer for the NYT, “The Screw Nevada Bill and How it Stymied U.S. Nuclear Policy”, 5/11/9, http://large.stanford.edu/publications/coal/references/fialka/]

In the House-Senate conference committee meeting that picked Yucca, Johnston, a conservative Democrat, said he wanted DOE to select the finalist. But the matter was settled by two of the most powerful Democrats then in Congress: Jim Wright Jr. (D-Texas), the speaker of the House, and Tom Foley (D-Wash.), the House majority leader. They vehemently wanted it out of their states. "The politics of the situation was that they had the power," recalled Johnston, who is currently a Washington lobbyist. "Unfortunately, some people still give me credit for the 'screw Nevada bill.'" In the face of the dogged opposition of Sen. Reid and the Obama administration's interest in looking for alternatives to Yucca, this process could begin again. In December, DOE issued a report predicting that there will be 34 new nuclear reactors seeking licensing approval by 2010. It suggests that Congress either increase the legal capacity for waste storage in Yucca Mountain or renew the hunt for a second site. The report notes that new research shows that "all states in the contiguous United States have a potential area that could be considered for the second repository."

### NIMBY even comes before party lines— Obama proves

New York Times 2009 [John J. Fialka is a staff writer for the NYT, “The Screw Nevada Bill and How it Stymied U.S. Nuclear Policy”, 5/11/9, http://large.stanford.edu/publications/coal/references/fialka/]

It may seem odd that a president who says the nation needs nuclear power pulls back from this project and that a Democrat-led Congress whose leaders want to mobilize against global warming bleeds Yucca Mountain's budget to the point of immobility. But Stewart thinks that much of this can be explained by the peculiar politics here. It doesn't follow party lines or liberal-conservative lines. The politics that governs the nation's nuclear waste repository is determined by state lines. As Stewart recently explained at a Washington symposium, the politics begins with what he calls "a deep and abiding sense of grievance on the part of Nevada" over the 1987 law. Technically, it was an amendment to the Nuclear Waste Policy Act that made Yucca Mountain the nation's only repository for nuclear waste. Some in Congress and many people in Nevada call it the "screw Nevada bill."

# Nuclear Accidents Advantage

## 1NC—Nuclear Accidents Frontline

### Defer to our impact, studies prove your impact is improbable

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The U.S. Nuclear Regulatory Commission (NRC) has estimated the probability of a loss of coolant from a spent-fuel storage pool to be so small (about 10−6 per pool-year) that design requirements to mitigate the consequences have not been required.1 As a result, the NRC continues to permit pools to move from open-rack conﬁgurations, for which natural-convection air cooling would have been effective, to “dense-pack” conﬁgurations that eventually ﬁll pools almost wall to wall. A 1979 study done for the NRC by the Sandia National Laboratory showed that, in case of a sudden loss of all the water in a pool, dense-packed spent fuel, even a year after discharge, would likely heat up to the point where its zircaloy cladding would burst and then catch ﬁre.2 This would result in the airborne release of massive quantities of ﬁssion products.

### All scenarios that would cause an accident are highly unlikely

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The cooling water in a spent-fuel pool could be lost in a number of ways, through accidents or malicious acts. Detailed discussions of sensitive information are not necessary for our purposes. Below,we providesomeperspective for the followinggeneric cases: boil-off; drainageinto other volumes through the opening of some combination of the valves, gates and pipes that hold the water in the pool;a ﬁre resulting from the crash of a large aircraft; and puncture by an aircraft turbineshaft or a shaped charge**.** Boil Off Keeping spent fuel cool is less demanding than keeping the core in an operating reactor cool. Five minutes after shutdown, nuclear fuel is still releasing 800 kilowatts of radioactive heat per metric ton of uranium (kWt/tU)30 . However, after several days, the decay heat is down to 100 kWt/tU and after 5 years the level is down to 2–3 kWt/tU (see Figure 5). In case of a loss of cooling, the time it would take for a spent-fuel pool to boil down to near the top of the spent fuel would be more than 10 days if the most recent spent-fuel discharge had been a year before. If the entire core of a reactor had been unloaded into the spent fuel pool only a few days after shutdown, the time could be as short as a day.31 Early transfer of spent fuel into storage pools has become common as reactor operators have reduced shutdown periods. Operators often transfer the entire core to the pool in order to expedite refueling or to facilitate inspection of the internals of the reactor pressure vessel and identiﬁcation and replacement of fuel rods leaking ﬁssion products.32 Even a day would allow considerable time to provide emergency cooling if operators were not prevented from doing so by a major accident or terrorist act such as an attack on the associated reactor that released a large quantity of radioactivity. In this article, we do not discuss scenarios in which spent-fuel ﬁres compound the consequences of radioactive releases from reactors. We therefore focus on the possibility of an accident or terrorist act that could rapidly drain a pool to a level below the top of the fuel. Drainage All spent-fuel pools are connected via fuel-transfer canals or tubes to the cavity holding the reactor pressure vessel. All can be partially drained through failure of interconnected piping systems, moveable gates, or seals designed to close the space between the pressure vessel and its surrounding reactor cavity.33 A 1997 NRC report described two incidents of accidental partial drainage as follows:34 Two loss of SFP [spent fuel pool] coolant inventory events occurred in which SFP level decrease exceeded 5 feet [1.5 m]. These events were terminated by operator action when approximately 20 feet [6 m] of coolant remained above the stored fuel. Without operator actions, the inventory loss could have continued until the SFP level had dropped to near the top of the stored fuel resulting in radiation ﬁelds that would have prevented access to the SFP area. Once the pool water level is below the top of the fuel, the gamma radiation level would climb to 10,000 rems/hr at the edge of the pool and 100’s of rems/hr in regions of the spent-fuel building out of direct sight of the fuel because of scattering of the gamma rays by air and the building structure (see Figure 6).35 At the lower radiation level, lethal doses would be incurred within about an hour.36 Given such dose rates, the NRC staff assumed that further ad hoc interventions would not be possible.37 Fire A crash into the spent fuel pool by a large aircraft raises concerns of both puncture (see below) and ﬁre. With regard to ﬁre, researchers at the Sandia National Laboratory, using water to simulate kerosene, crashed loaded airplane wings into runways. They concluded that at speeds above 60 m/s (135 mph), approximately 50% of the liquid is so ﬁnely atomized that it evaporates before reaching the ground. If this were fuel, a ﬁreball would certainly have been the result, and in the high-temperature environment of the ﬁreball a substantially larger fraction of the mass would have evaporated.39 The blast that would result from such a fuel-air explosion might not destroy the pool but could easily collapse the building above, making access difﬁcult and dropping debris into the pool. A potentially destructive fuel-air deﬂagration could also occur in spaces below some pools. Any remaining kerosene would be expected to pool and burn at a rate of about 0.6 cm/minute if there is a good air supply.40 The burning of 30 cubic meters of kerosene—about one third as much as can be carried by the type of aircraft which struck the World Trade Center on September 11, 200141 —would release about 1012 joules of heat—enough to evaporate 500 tons of water. However, under most circumstances, only a relatively small fraction of the heat would go into the pool. Puncture by an Airplane Engine Turbine Shaft, Dropped Cask or Shaped Charge As Figure 2 suggests, many spent-fuel pools are located above ground level or above empty cavities. Such pools could drain completely if their bottoms were punctured or partially if their sides were punctured. Concerns that the turbine shaft of a crashing high-speed ﬁghter jet or an act of war might penetrate the wall of a spent-fuel storage pool and cause a loss of coolant led Germany in the 1970s to require that such pools be sited with their associated reactors inside thick-walled containment buildings. When Germany decided to establish large away-from-reactor spent-fuel storage facilities, it rejected large spent-fuel storage pools and decided instead on dry storage in thick-walled cast-iron casks cooled on the outside by convectively circulating air. The casks are stored inside reinforced-concrete buildings that provide some protection from missiles.42 Today, the turbine shafts of larger, slower-moving passenger and freight aircraft are also of concern. After the September 11, 2001 attacks against the World Trade Center, the Swiss nuclear regulatory authority stated that From the construction engineering aspect, nuclear power plants (worldwide) are not protected against the effects of warlike acts or terrorist attacks from the air. . . . one cannot rule out the possibility that fuel elements in the fuel pool or the primary cooling system would be damaged and this would result in a release of radioactive substances [emphasis in original]43 The NRC staff has decided that it is prudent to assume that a turbine shaft of a large aircraft engine could penetrate and drain a spent-fuel-storage pool.44 Based on calculations using phenomenological formulae derived from experiments with projectiles incident on reinforced concrete, penetration cannot be ruled out for a high-speed crash but seems unlikely for a low-speed crash.45 This is consistent with the results of a highly-constrained analysis recently publicized by the Nuclear Energy Institute (NEI).46 The analysis itself has not been made available for independent peer review “because of security considerations.” According to the NEI press release, however, it concluded that the engine of an aircraft traveling at the low speed of the aircraft that struck the Pentagon on Sept. 11, 2001 (approximately 350 miles/hr or 156 m/s) would not penetrate the wall of a spent-fuel-storage pool. Crashes at higher speed such as that against the World Trade Center South Tower (590 miles/hr or 260 m/s), which had about three times greater kinetic energy, were ruled out because the “probability of the aircraft striking a speciﬁc point on a structure—particularly one of the small size of a nuclear plant—is signiﬁcantly less as speed increases.”

# Reprocessing Advantage

## 1NC—Reprocessing Leadership Frontline

### You’ve got the advantage all wrong – the only way to solve proliferation and nuclear leadership is to utilize reprocessing

Domenici 12/1/09 (Pete, J.D in education. U.S. Senator. “Has America's Nuclear Renaissance Stalled?” www.usea.org/Publications/Documents/Domenici\_12\_1.pdf) MFR

The global resurgence of nuclear power is a reality. We need to recognize that and provide leadership in the areas of non-proliferation and waste treatment. Sadly, much of our policy framework is frozen in time, accommodating domestic nuclear plants and waste already in existence, but offering nothing to meet the challenges ahead. The United States can acknowledge reality or we can continue to bury our head in the sand while nuclear waste, and nuclear proliferation dangers, build up throughout the world. We have an opportunity to pro-actively address this challenge. We can provide a safe and reliable global nuclear energy infrastructure that accommodates growth of nuclear power here and abroad. An important recent example is the Section 123 Agreement for peaceful nuclear cooperation between the United States and the United Arab Emirates. In short, UAE wants to actively develop a civilian nuclear energy program to produce secure and reliable electricity to support its developing economy. This U.S.-UAE agreement that recently went into effect contains the strongest non-proliferation conditions ever agreed to by a foreign nation. The UAE has accepted a legally binding obligation not to pursue its own uranium enrichment. Instead, they will receive guaranteed long-term fuel contracts with international suppliers. The UAE has also agreed to refrain from pursuing recycling. Instead, the spent fuel will be returned to the international parties, the United Kingdom and France in this instance. This is a model that, with modifications, may work in future agreements with other nations. However, this model requires adequate international infrastructure to responsibly manage used fuel through arrangements for take-back, treatment, recycling, and storage of spent fuel. America's present domestic policy is out of step with our demonstrated technology and scientific abilities.

### No solvency— High radiological risk and the plan still requires reprocessing to send waste to space

CEAA, ‘10 [Canadian Environmental Assessment Agency, “Various approaches to long-term management of nuclear fuel wastes”, 3/31/10, <http://www.ceaa.gc.ca/default.asp?lang=En&n=0B83BD43-1&xml=0B83BD43-93AA-4652-9929-3DD8DA4DE486&offset=20&toc=show>]

Disposing of used fuel by sending it into space has been considered since before the Hare Report. A number of people advocated this approach during the review. Of all disposal methods, it has the greatest potential to isolate the wastes permanently from the biosphere. Accordingly, it would not permit waste retrieval. Although we know that it is technically possible, we also recognize that its costs would be very high. Studies cited in the EIS indicate that, since the number of flights required to transport the existing volume of spent fuel would be impractical, space disposal could be feasible only for a smaller volume of reprocessed high-level wastes. This would entail all the advantages and disadvantages of reprocessing, including the need to manage intermediate- and low-level wastes in some other way. AECL reported that the risk of catastrophic accidents was about one per cent per flight, and thus that the radiological risk of disposal in space would be higher than that of geological disposal. Combined with the fact that Canada has neither the required facilities nor international approval to dispose of nuclear wastes in this manner, it does not appear to be a viable or acceptable solution at this time.

# Terrorism Advantage

## 1NC—Nuclear Terrorism Frontline

### No Nuclear terrorism in the U.S.

### A) Terrorist don’t have nuclear weapons and knowledge to build a bomb and carry out the near impossible attack

Bunn 2008 [Matt, Associate Professor of Public Policy at the Belfer Center, “THE RISK OF NUCLEAR TERRORISM – AND NEXT STEPS TO REDUCE THE DANGER”, 4/2/8, elfercenter.ksg.harvard.edu/files/bunn-nuclear-terror-risk-test-08.pdf, TT]

Fortunately, there is good news in this story as well. First, there is no convincing evidence that any terrorist group has yet gotten a nuclear weapon or the materials needed to make one – or that al Qaeda has yet put together the expertise that would be needed to make a bomb. Indeed, there is some evidence of confusion and lack of nuclear knowledge by some senior al Qaeda operatives.16 Second, making and delivering even a crude nuclear bomb would be the most technically challenging and complex operation any terrorist group has ever carried out. There would be many chances for the effort to fail, and the obstacles may seem daunting even to determined terrorists, leading them to focus more of their efforts on conventional tools of terror – as al Qaeda appears to have done.17 Both al Qaeda and Aum Shinrikyo appear to have encountered a variety of difficulties, demonstrating that getting a nuclear bomb is a difficult challenge, even for large and well-financed terrorist groups with ample technical resources.18 Third, the overthrow of the Taliban and the disruption of al Qaeda’s old central command structure certainly reduced al Qaeda’s chances of pulling off such a complex operation – though that capability may be growing again, as al Qaeda reconstitutes in the mountains of Pakistan.19

### B) Nuclear Security is strong and even more reforms are coming

Bunn 2008 [Matt, Associate Professor of Public Policy at the Belfer Center, “THE RISK OF NUCLEAR TERRORISM – AND NEXT STEPS TO REDUCE THE DANGER”, 4/2/8, elfercenter.ksg.harvard.edu/files/bunn-nuclear-terror-risk-test-08.pdf, TT]

Fourth, nuclear security is improving. While there is a great deal yet to be done, the fact is that at scores of sites in Russia, the former Soviet Union, and elsewhere, security is dramatically better than it was fifteen years ago. Security upgrades are scheduled to be completed for most Russian nuclear warhead and nuclear material sites by the end of this calendar year. HEU is being removed from sites all around the world, permanently eliminating the risk of nuclear theft at those sites. An alphabet soup of programs and initiatives – Cooperative Threat Reduction (CTR), the Materials Protection, Control, and Accounting (MPC&A) program, the Global Threat Reduction Initiative (GTRI), the Global Initiative to Combat Nuclear Terrorism (GI), the International Atomic Energy Agency’s Office of Nuclear Security, the Domestic Nuclear Detection Office (DNDO), and many more – are each making real contributions.20 There can be no doubt that America and the world face a far lower risk of nuclear terrorism today than they would have had these efforts never been begun. These programs are excellent investments in U.S. and world security, deserving strong support; Americans and the world owe a substantial debt of gratitude to the dedicated U.S., Russian, and international experts who have been carrying them out. Securing the world’s stockpiles of nuclear weapons and the materials needed to make them is a big job, and a complex job, but it is a doable one, as the progress already made demonstrates.

### C) States won’t arm terrorists with nuclear weapons— Not worth the risk or giving up their power

Bunn 2008 [Matt, Associate Professor of Public Policy at the Belfer Center, “THE RISK OF NUCLEAR TERRORISM – AND NEXT STEPS TO REDUCE THE DANGER”, 4/2/8, elfercenter.ksg.harvard.edu/files/bunn-nuclear-terror-risk-test-08.pdf, TT]

Fifth, hostile states are highly unlikely to consciously choose to provide nuclear weapons or the materials needed to make them to terrorist groups. Such a decision would mean transferring the most awesome military power the state had ever acquired to a group over which it had little control, and potentially opening the regime to overwhelming retaliation – a particularly unlikely step for dictators or oligarchs obsessed with controlling their states and maintaining power.

### D) Creating a weapon would take months of research and a few full scale nuclear tests

Mark et al. No date cited [Carson, member of the NRC’s advisory committee on reactor safeguards, “Can Terrorists Build Nuclear Weapons?”, http://www.nci.org/k-m/makeab.htm, TT]

For persons new to this business, as it may be supposed a terrorist group is, there is a great deal to learn before they could entertain any confidence that some small, sophisticated device they might build would perform as desired. To build the device would require a long course of study and a long course of hydrodynamic experimentation. To achieve the size and weight of a modern weapon while maintaining performance and confidence in perfor mance would require one or more full-scale nuclear tests, although consid erable progress in that direction could be made on the basis of nonnuclear experiments. In connection with an effort to reduce overall size and weight as far as possible, it would be necessary to use fissile material in its most effectiveform, plutonium metal. Moreover, while reducing the weight of the assembly mechanism, which implies reducing the amount of energy available to bring the fissile material into a supercritical configuration, it would not be possible at the same time to reduce the amount of fissile material employed very much. In this case, the amount of fissile material required in the finished pieces would be significantly larger than the formula quantity. Alternatively, in an implosion device without a reduction in weight and size, it would be possible to reduce the amount of nuclear materials required by using more effective implosion designs than that associated with the crude design. In either case---a small or a large sophisticated device---the design and building would require a base or installation at which experiments could be carried out over many months, results could be assessed, and, as necessary, the effects of corrections or improvements could be observed in follow-on experiments. Similar considerations would apply with respect to the chem ical, fabrication, and other aspects of the program. The production of sophisticated devices therefore should not be consid ered to be a possible activity for a fly-by-night terrorist group. It is, however, conceivable in the context of a nationally supported program able to provide the necessary resources and facilities and an established working place over the time required. It could be further imagined that under the sponsorship of some malevolent regime, a team schooled and prepared in such a setting could be dispatched anywhere to acquire material and produce a device. In such a case, although the needs of the preparation program might have been met, the terrorists would still have to obtain and set up the equipment needed for the reduction to metal and its subsequent handling and to spend the time necessary to go through those operations.

### No impact to dirty bombs— localized impact, minimal spread of radiation and no ARS

Boston University 2004 [“News & Terrorism – Radiological Attack”, 2004, http://www.bumc.bu.edu/ep/newsandterrorism/, TT]

WHAT DO RDDS DO? The Area Affected Most dirty bombs and other RDDs would have very localized effects, ranging from less than a city block to several square miles. The area over which radioactive materials would be dispersed depends on factors such as: ■ the amount and type of radioactive material dispersed. ■ the means of dispersal (e.g. explosion, spraying, fire). ■ the physical and chemical form of the radioactive material. For example, if the material is dispersed as fine particles, it might be carried by the wind over a relatively large area. ■ local topography, location of buildings, and other landscape characteristics. ■ local weather conditions. Spread of a Radioactive Plume If the radioactive material is release as fine particles, the plume would spread roughly with the speed and direction of the wind. As a radioactive plume spreads over a larger area, the radioactivity becomes less concentrated. Atmospheric models might be used to estimate the location and movement of a radioactive plume. WHAT IS THE DANGER? Immediate Impact to Human Health Most injuries from a dirty bomb would probably occur from the heat, debris, radiological dust, and force of the conventional explosion used to disperse the radioactive material, affecting only individuals close to the site of the explosion. At the low radiation levels expected from an RDD, the immediate health effects from radiation exposure would likely be minimal. Health Effects of Radiation Exposure Health effects of radiation exposure are determined by: ■ the amount of radiation absorbed by the body. ■ the radiation type (see “What is ionizing radiation?,” p.1). ■ the means of exposure—external or internal (absorbed by the skin, inhaled, or ingested). ■ the length of time exposed. The health effects of radiation tend to be directly proportional to radiation dose. If a reasonable estimate can be made of a person’s dose, a lot is known about the health effects at that dose. Acute Radiation Syndrome (ARS) ARS is not likely to result from a dirty bomb. It is a short-term health effect that begins to appear when individuals are exposed to a highly radioactive material over a relatively small amount of time. The chart shows that an estimated 10% of the population may exhibit signs of ARS if they are exposed to large radiation doses of 100 rems or more. Principal signs and symptoms of ARS are nausea, vomiting, diarrhea, and reduced blood cell counts.

# Proliferation Advantage

## 1NC—Proliferation Advantage

### No proliferation— NPT empirically successful at stopping proliferation— It is so successful that it can stop non-members

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

In the 1960s it was widely assumed at there would be 30-35 nuclear weapons states by the turn of the century. In fact there were eight - a tremendous testimony to the effectiveness of the Nuclear Non-Proliferation Treaty (NPT) and its incentives both against weapons and for civil nuclear power, despite the baleful influence of the Cold War (1950s to 80s) which saw a massive build-up of nuclear weapons particularly by the USA and the Soviet Union. The nuclear non-proliferation regime is much more than the NPT, although this is the pre-eminent international treaty on the subject. The regime includes treaties, conventions and common (multilateral and bilateral) arrangements covering security and physical protection, export controls, nuclear test-bans and, potentially, fissile material production cut-offs. The international community can apply pressure to states outside the NPT to make every possible effort to conform to the full range of international norms on nuclear non-proliferation that make up this regime. This was seen over 2007-08 with India.

### No internal link— NPT stops production of nuclear weapons from used fuel

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

Over the past 35 years the International Atomic Energy Agency's (IAEA) safeguards system under the Nuclear Non-proliferation Treaty (NPT) has been a conspicuous international success in curbing the diversion of civil uranium into military uses. It has involved cooperation in developing nuclear energy while ensuring that civil uranium, plutonium and associated plants are used only for peaceful purposes and do not contribute in any way to proliferation or nuclear weapons programs. In 1995 the NPT was extended indefinitely. Its scope is also being widened to include undeclared nuclear activities. Most countries have renounced nuclear weapons, recognising that possession of them would threaten rather than enhance national security. They have therefore embraced the NPT as a public commitment to use nuclear materials and technology only for peaceful purposes. The successful conclusion, in 1968, of negotiations on the NPT was a landmark in the history of non-proliferation. After coming into force in 1970, its indefinite extension in May 1995 was another. The NPT was essentially an agreement among the five nuclear weapons states and the other countries interested in nuclear technology. The deal was that assistance and cooperation would be traded for pledges, backed by international scrutiny, that no plant or material would be diverted to weapons' use. Those who refused to be part of the deal would be excluded from international cooperation or trade involving nuclear technology. At present, 187 states are party to the NPT. These include all five declared Nuclear Weapons States (NWS) which had manufactured and exploded a nuclear weapon before 1967: China, France, the Russian Federation, the UK and the USA. The main countries remaining outside the NPT are Israel, India and Pakistan, though North Korea has moved to join them. These all have weapons programs which have come to maturity since 1970, so they cannot join without renouncing and dismantling those. In 2008 special arrangements were agreed internationally for India, bringing it part way in.\

### Availability of resources don’t matter— Political pressure and deterrence checks

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

The most important factor underpinning the safeguards regime is international political pressure and how particular nations perceive their long-term security interests in relation to their immediate neighbours. The solution to nuclear weapons proliferation is thus political more than technical, and it certainly goes beyond the question of uranium availability. International pressure not to acquire weapons is enough to deter most states from developing a weapons program. The major risk of nuclear weapons' proliferation will always lie with countries which have not joined the NPT and which have significant unsafeguarded nuclear activities, and those which have joined but disregard their treaty commitments.

### IAEA checks and sanctions solve

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

The IAEA was set up by unanimous resolution of the United Nations in 1957 to help nations develop nuclear energy for peaceful purposes. Allied to this role is the administration of safeguards arrangements. This provides assurance to the international community that individual countries are honouring their treaty commitments to use nuclear materials and facilities exclusively for peaceful purposes. The IAEA therefore undertakes regular inspections of civil nuclear facilities to verify the accuracy of documentation supplied to it. The agency checks inventories and undertakes sampling and analysis of materials. Safeguards are designed to deter diversion of nuclear material by increasing the risk of early detection. They are complemented by controls on the export of sensitive technology from countries such as UK and USA through voluntary bodies such as the Nuclear Suppliers' Group. Safeguards are backed up by the threat of international sanctions.

### Nuclear power and reprocessing have nothing to do with proliferation— Nations were going to proliferate regardless

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

Civil nuclear power has not been the cause of or route to nuclear weapons in any country that has nuclear weapons, and no uranium traded for electricity production has ever been diverted for military use. All nuclear weapons programmes have either preceded or risen independently of civil nuclear power\*, as shown most recently by North Korea. No country is without plenty of uranium in the small quantities needed for a few weapons. Former US Vice-President Al Gore said (18/9/06) that "During my eight years in the White House, every nuclear weapons proliferation issue we dealt with was connected to a nuclear reactor program. Today, the dangerous weapons programs in both Iran and North Korea are linked to their civilian reactor programs." He is not correct. Iran has failed to convince anyone that its formerly clandestine enrichment program has anything to do with its nuclear power reactor under construction (which is fuelled by Russia), and North Korea has no civil reactor program. In respect to India and Pakistan, which he may have had in mind, there is evidently a link between military and civil, but that is part of the reason they are outside the NPT. Perspective is relevant: As little as five tonnes of natural uranium is required to produce a nuclear weapon. Uranium is ubiquitous, and if cost is no object it could be recovered in such quantities from most granites, or from sea water - sources which would be quite uneconomic for commercial use. In contrast, world trade for electricity production is almost 70,000 tonnes of uranium per year, all of which can be accounted for. There is no chance that the resurgent problem of nuclear weapons proliferation will be solved by turning away from nuclear power or ceasing trade in the tens of thousands of tonnes each year needed for it.

## A2: Rogue States

### No wildfire proliferation by rogue states— The fact we know nations like North Korea have proliferated prove the system works

World Nuclear Organization 2011 [International organization studying nuclear power and weapons, “Safeguards to Prevent Nuclear Proliferation”, June 2011, <http://www.world-nuclear.org/info/inf12.html>, TT]

Iraq, Iran and North Korea illustrate both the strengths and weaknesses of international safeguards. While accepting safeguards at declared facilities, Iraq and Iran had set up elaborate equipment elsewhere in an attempt to enrich uranium, in Iraq's case, to weapons grade. North Korea used research reactors (not commercial electricity-generating reactors) and a reprocessing plant to produce some weapons-grade plutonium. The weakness of the NPT regime lay in the fact that no obvious diversion of material was involved. The uranium used as fuel probably came from indigenous sources, and the key nuclear facilities concerned were built by the countries themselves without being declared to the IAEA or placed safeguards arrangements. Iraq, as an NPT party, was obliged to declare all facilities but did not do so. Nor, more recently, did Iran. In North Korea, the activities concerned took place before the conclusion of its NPT safeguards agreement, using a Russian "research" reactor and clandestine reprocessing plant. Nevertheless, the activities were detected and in Iraq and North Korea, brought under control using international diplomacy. In Iraq, a military defeat assisted this process, but North Korea posed possibly the most intractable situation confronted by the IAEA. This has since been matched by Iran. So, while traditional safeguards easily verified the correctness of formal declarations by suspect states, in the 1990s attention turned to what might not have been declared, outside the known materials flows and facilities.

# Solvency

## 1NC—Solvency Frontline

### Current rockets already solve – new tech like lasers haven’t been tested out yet

Coopersmith, 5/2/11 [Jonathan Coopersmith; Associate professor of history of technology at Texas A&M; “The cost of reaching orbit: ground-based launch systems”, Space Policy Vol. 27 Issue 2, May 2011, pp. 77-80, <http://www.sciencedirect.com/science/article/pii/S026596461100035X>]

Like any technology in its formative phase, a range of possibilities exists, including beamed energy propulsion (BEP), space elevators, light gas guns, and magnetic levitation. The good news is that concepts for these ground-based systems exist; the bad news is that these concepts remain in the laboratory. In BEP a microwave or laser beam from the ground station strikes the bottom of the capsule. The resultant heat compresses and explodes the air or solid fuel there, providing lift and guidance. The concept is more than theoretical. In October 2000 a 10-kW laser boosted a 50-g lightcraft over 70 m at White Sands Missile Range in New Mexico, proving the underlying feasibility of the concept.11 Researchers at the University of Tokyo demonstrated the feasibility of microwave transmission in 2010.12Space elevators employ a thin tether attached to a satellite serving as a counterbalance thousands of kms above the Earth. A platform would crawl up the elevator. Generating more publicity than BEP, this concept depends on advances in materials strong and light enough to serve as the tether. Magnetic levitation and magnetic propulsion systems would provide a high initial velocity for capsules which would then propel themselves into orbit.13The idea of employing a gigantic gun to launch space capsules received a very public unveiling from Jules Verne in his 1865 From the Earth to the Moon. Serious development occurred a century later with the American and Canadian governments funding the High Altitude Research Project (HARP) by Gerald Bull in the 1960s and the Super High Altitude Research Project (SHARP) at Lawrence Livermore Laboratory in the 1980s and 1990s.14If these systems are so promising, why have they not been developed? First, rockets have fulfilled existing demand adequately. Why invest in radically different technologies if the existing technology works sufficiently well? Second, although tests have demonstrated proof of concept, these technologies remain in the laboratory. On the nine-stage TRLs used by NASA and the US Air Force to plot how close to practical application a technology is, GBS technologies are at TRL 1–2, still in the early stages of proving their practicality and worth.15In 2003, LiftPort was formed to produce a working space elevator by 2018. In 2006 that deadline was changed to 2031; 2035–45 may now be a more realistic guess. As Michael Laine, the founder of LiftPort, stated, “I really do believe that we haven’t even scratched the surface of all the potential problems out there. We just don’t know enough to ask the right questions yet, so it’s clear we couldn’t possibly have all the answers.”16All these areas have shown progress, as the papers at the six International Symposia on Beamed Energy Propulsion indicate. More concretely, in November 2009, NASA awarded LaserMotive $900,000 for meeting a space elevator challenge, and a startup, Quicklaunch, Inc., is trying to commercialize the SHARP-based gas gun.17Such progress, however, is limited by lack of sustained support and patrons. For GBS to rise up the TRL scale and move from the laboratory to a mature functioning system will require a sustained commitment of billions of dollars over many years. While launch costs will be low, the R&D, testing and infrastructure construction will demand significant resources. Let’s not delude ourselves, the public, or Congress. Turning GBS into a reality will be expensive. The issue is whether the benefits will be worth the costs.

### Lasers can’t provide enough energy

Kare, ‘04[Jordin T. Kare, “Modular laser launch architecture: analysis and beam module design”, 5/18/04, <http://www.niac.usra.edu/files/studies/final_report/897Kare.pdf>]

Laser launch uses a large ground-based laser system to power small rocket vehicles loaded with inert propellant.  Laser launch has many potential advantages over other launch technologies in performance and cost.  Its disadvantage is the need for a very large laser, with an output power of roughly one megawatt per kilogram of payload size -- tens to hundreds of megawatts for practical payloads.  Developing such a laser and its associated large beam director has always involved costs and risks at least comparable to those of developing a new launch vehicle.   Laser propulsion has therefore remained a laboratory curiosity, limited to tests with existing lasers at power levels of at most a few kilowatts.

### It’ll take at least 50 years to develop working laser technology

Murph, ‘11[Darren Murph, “NASA considering beamed energy propulsion for space launches”, 1/25/11, <http://www.engadget.com/2011/01/25/nasa-considering-beamed-energy-propulsion-for-space-launches/>]

Truth be told, it probably does take a rocket scientist to truly understand the scope of what NASA is currently investigating, but the gist of it isn't hard to grok. America's premiere space agency is purportedly examining the possibility of using beamed energy propulsion to launch spacecraft into orbit, and while we've seen objects lofted by mere beams before, using a laser to leave the atmosphere is a whole 'nother ballgame. The reasons are fairly obvious: a laser-based propulsion system would effectively nix the chance of an explosive chemical reaction taking place at launch, and it would "make possible a reusable single-stage rocket that has two to five times more payload space than conventional rockets, which would cut the cost of sending payloads into low-Earth orbit." We're told that the study should be concluded by March, but only heaven knows how long it'll be before we see any of this black magic used to launch rockets. Sadly, we can't expect any Moon missions to rely on lasers for at least 50 or so years, but we're guessing that timeline could be shortened dramatically if Sir Richard Branson were to get involved.

### The plan fails without international cooperation

NRC, ’01 [National Research Council Board on Radioactive Waste Management, *Disposition of High-Level Waste and Spent Nuclear Fuel:The Continuing Societal and Technical Challenges*, 2001, <http://www.nap.edu/openbook.php?record_id=10119&page=114>]

International Cooperation After extensive presentations of national programs and discussions on international exchanges at the 1999 Irvine Workshop, the following conclusions were drawn about the role of cooperation between countries in radioactive waste management: Cooperation is universally agreed to be valuable or even essential. Efforts to strengthen interactions may be expected to increase in the future. In some areas, for example, transport across boundaries or security of fissile materials, cooperation is essential. Organizations such as the NEA and IAEA play important roles; there are overlaps in their areas of responsibility, but these are not great. Underground laboratories are key mechanisms for collaboration. The trend is now to longer-time-scale projects aimed at demonstrating disposal technology. Production of generic data (e.g., thermodynamic databases) is of wide interest, and more could be done. International peer review activities are seen to be important and could be expanded with a focus on confidence building. The value of collaborative projects is very case specific. The most positive examples have had clear aims, strong management, and high-quality, timely reporting. Smaller national programs can benefit most, and these generally utilize collaboration more efficiently. For both small and large countries, international work should be fully integrated within the national program and not treated as an add-on option. International technical cooperation will facilitate developing a consensus on international standards for the safety, security, and reliability of long-term storage facilities and geological repositories. It could be useful to review the roles of existing international organizations and assess the potential value of new coordination groups such as EDRAM (Environmental Disposal of Radioactive Materials), a group including nations with large geological disposal programs. International cooperation has been very heavily weighted toward the scientific and technical areas. Given the growing appreciation that major problems in waste management today lie in the sociological and public arenas (see Chapter 5 and Chapter 8 ) as well in institutional design, it would be worthwhile to consider the role that cooperation across national boundaries could play here also.

## 2NC—SQ Solves

### Current technology solves – and new ones would cost too much

Coopersmith, ‘06[Jonathan Coopersmith, Associate professor of history of technology at Texas A&M; “Nuclear waste disposal in space: BEP’s best hope?”, 2006, <http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=APCPCS000830000001000600000001&idtype=cvips&prog=normal>]

The BEP (beamed energy propulsion) community faces several challenges.  The focus of this conference is the technical: How can BEP develop into a feasible technology?  Other challenges, however, will be equally daunting but less amenable to engineering skills.  Most importantly, BEP must find a market.   Why should users of existing launch vehicles switch from a developed technology that launches payloads into orbits reasonably well to an undeveloped technology that promises to do the job better?  What can BEP offer to justify the switch from the massive infrastructure in place and function to a new way of reaching orbit?  Why should anyone – probably a government – invest the billions of dollars needed to turn BEP from dream into a reality?   I am assuming development and construction of a BEP system capable of placing payloads in orbit will demand billions of dollars.  I would be delighted to be wrong.  If we assume $10 billion, the rough number estimated to create a working space elevator, that is both a lot and a little money [1].  In space terms, it’s not that much.  To a parliament or congress, whose approval is needed, that is a lot of money.  What arguments can the BEP community advance to win the resources to develop BEP?   The assembled delegates have enough experience in aerospace to know that many promising technologies never realize their potential, often for reasons irrelevant to the actual technology.  Having a better technology is not enough.  History is filled with examples of technologies that were not developed or adopted because existing technologies proved adequate.  The good is often the enemy of the best, especially if the good technology is already operating, has a well established infrastructure (physical, social, and political), and is seen as economically feasible.

## 2NC—Tech Barriers

### Laser propulsion has never been tested to work

Kellet et al, ‘08[BJ Kellett et al, “Space polypropulsion”, 2008, <http://researchspace.csir.co.za/dspace/bitstream/10204/2312/1/Kellett_2008.pdf>]

Hybrid space propulsion has been a feature of most space missions. Only the very early rocket propulsion  experiments like the V2, employed a single form of propulsion. By the late fifties multi-staging was routine and the  Space Shuttle employs three different kinds of fuel and rocket engines. During the development of chemical rockets,  other forms of propulsion were being slowly tested, both theoretically and, relatively slowly, in practice. Rail and  gas guns, ion engines, “slingshot” gravity assist, nuclear and solar power, tethers, solar sails have all seen some real  applications. Yet the earliest type of non-chemical space propulsion to be thought of has never been attempted in  space: laser and photon propulsion. The ideas of Eugen Saenger, Georgii Marx, Arthur Kantrowitz, Leik Myrabo,  Claude Phipps and Robert Forward remain Earth-bound. In this paper we summarize the various forms of non-  chemical propulsion and their results. We point out that missions beyond Saturn would benefit from a change of  attitude to laser-propulsion as well as consideration of hybrid “polypropulsion” – which is to say using all the rocket  “tools” available rather than possibly not the most appropriate. We conclude with three practical examples, two for  the next decades and one for the next century; disposal of nuclear waste in space; a grand tour of the Jovian and  Saturnian moons –  with Huygens or Lunoxod type, landers; and eventually mankind’s greatest space dream: robotic  exploration of neighbouring planetary systems.

### Tech barriers – fuel block materials and aerodynamics & Massive environmental impacts

Cramer, ‘87[John G. Cramer, Professor of physics at University of Washington, “Laser propulsion and the four P’s”, 1/9/87, <http://www.npl.washington.edu/AV/altvw21.html>]

What are the problems with the scheme? The biggest one, of course, is getting that big laser to use. Free electron laser technology will be discussed a bit later. A second problem is finding a suitable fuel block material that will operate efficiently and that will not be eroded too rapidly. Ice, plastic, and lithium metal have been discussed, but more research is needed. The structural and hydrodynamic effects of the detonation waves must be understood. And of course the aerodynamics of the vehicle will have to be carefully considered. It will require attitude-control hardware, vanes or jets perhaps, to keep it oriented properly in the beam. The laser tracking to orbit will also require careful design. When the vehicle had reached some altitude and velocity, it must be turned so that the back surface of the fuel block is at an angle to the incoming laser beam. This allows the proper tangential velocity to be added to achieve a stable orbit. Notice that the thrust in the tilted configuration remains at right angles to the block surface and is quite independent of the laser beam angle. If this technology is to become widespread, the environmental effects of noise pollution from the launch site, the atmospheric effects of the laser beam (e.g., nitrous oxide generation), interference with air traffic, etc., must also be carefully studied. But at present the biggest problem is to find a funding agency that will pay for this research. Unfortunately NASA is reportedly not interested. Let's now turn to the technology of the free electron laser (FEL). It's a spinoff, just 10 years old, of accelerator technology developed for nuclear physics basic research in the past few decades. Basically an FEL is a large electron linear accelerator that accelerates perhaps 10 amperes of electrons to nearly the speed of light, giving them energies around 100 million electron volts. At such energies an electron weighs about 200 times more than it would at rest due to relativistic mass increase. The acceleration of the electrons may either be continuous, using resonant electrical cavities powered by high frequency electrical power, or it may be pulsed with a set of microwave "transformers" that use the electron beam as the effective secondary winding. The latter acceleration scheme appears to be the more useful for LSD wave propulsion, which requires a pulsed laser beam in any case. After acceleration the electron beam passes into a "wiggler", an intense and rapidly alternating set of static magnetic fields. The wiggler efficiently converts the energy contained in the electron beam to coherent photons and a few hundred megawatts of coherent light energy emerges from the machine. The FEL's conversion of electrical energy to light energy is remarkably efficient. Overall efficiencies of 20% or more have already been achieved with low power FEL devices. A low power FEL was first demonstrated at Stanford University a decade ago, but until the SDIO made FEL development a national priority, it progressed rather slowly. But now with SDI funds as the driving force, two national laboratories and several aerospace companies are in a development horse race. A major facility to test high power FEL devices is being constructed at White Sands Proving Grounds in New Mexico. It's curious to consider that that site, where captured V-2 rockets were tested after WWII, may eventually become our first laser spaceport.

### Multiple tech barriers

Repetti, ‘91[Thomas E. Repetti, previous principal systems engineer for Raytheon, “Application of reactor-pumped lasers to power beaming”, Oct. 1991, <http://www.osti.gov/bridge/servlets/purl/5657378-dBa40S/5657378.pdf>]

There are a many technical and societal obstacles which must be overcome in the coming decades if the power beaming concept is to be successful. Among these issues are: Beam quality and pointing accuracy. Transmitting power beams over large distances requires extremely precise beam conditioning and pointing. The quality of the beam emitted by an array of solid state lasers is essentially determined by the degree to which one can control the phases of the array elements; the phases must combine coherently for enough of the beam’s energy to arrive at the receiver. Development of these phased arrays is crucial to the power beaming concept. Pointing accuracy must be achievable to within 0.05 microradians for the long distances between power satellites and user assets, which eliminates the option of mechanical beam steering. These areas are the subject of intense research in this country. Environmental and health physics. The environmental impact of beaming power either to or from the Earth has yet to be determined. Zones of exclusion may have to be established around receiver stations on the ground and in the airspace above, and any potential hazards from beam scatter in the atmosphere must be evaluated. There is some uncertainty as to the OSHA safe power levels for exposure to microwave beams. Space applications carry similar concerns for human exposure but environmental impacts are lessened. Atmospheric losses and weather. Bad weather (rain, snow, smog, dust) significantly attenuates a transmitted power beam; even clear weather atmospheric transmission is only 80% efficient. These problems may be overcome by advances in adaptive optics which can compensate for atmospheric distortions. Solid state research. As stated above, solid state laser and receiver arrays are the leading candidates for power beaming but need to be further developed. Their efficiency, lifetime, susceptibility to damage form dust, and temperature stability need to be significantly improved before power beaming goals can be achieved. A great deal of research is being performed in these areas. System studies. There are many tradeoffs in designing a power beaming architecture, some of which are: efficiency, mass, development and operation costs, lifetime, reliability, availability, and maintenance. Assigning weights to each aspect is complicated by the need for more research in several key technologies and the interdependence of the various system elements. (Development of an extremely efficient laser, for example, is not useful to a power beaming system if the laser has an unreasonably high mass or if its wavelength cannot be efficiently converted to electricity by a photovoltaic receiver or if the its reliability is so low that the overall system availability falls blow specifications.) System studies have been performed on power beaming architectures, but it is crucial to understand the caveats involved and the uncertainties in the numbers which are generated. Many of the numbers used in system studies (mass, efficiency, cost, availability) are projections of future capabilities and have yet to be realized. Note too that the weights given to each system aspect depend on the system’s mission, which is unclear at this point and is likely to remain unclear given the current economic social and political situation in the U.S. and the world. Economics. A space power beaming infrastructure will not be built if it is not shown to be economically competitive with the current technique of using onboard power supplies for each space asset. The aerospace industry is understandably hesitant to risk hundreds of millions of dollars by embracing untried technologies. Current estimates for the overall cost of establishing a power beaming network are tens to hundreds of billions of dollars. Politics. Power beaming is often seen as a technology which will require an international effort to develop and sustain because of its high cost and its application to international power needs on a global scale. A terrestrial power beaming network would require six to ten sites spaced around the globe, which guarantees the need for international cooperation. International access to and exploration of space also mandates international control of power availability in space. Perhaps the greatest liabilities facing power beaming are the currently strong antinuclear sentiment in the U.S. and the perceived need to spend tax dollars “at home” instead of in space. The American public does not embrace nuclear power or feel the need to spend money to alleviate long-term problems such as power availability. NASA’s recent string of technical problems has severely damaged its public reputation; the agency no longer enjoys the Congressional support that it did in the Apollo era and will have a difficult task in obtaining the level of funding envisioned by the power beaming community.

### Tech barriers – beam broadening

Cook, 08[Joung R. Cook, director of Navy’s High energy office, “Laser propulsion – Is it another myth or a real potential?”, 2008, <http://scitation.aip.org.proxy2.cl.msu.edu/getpdf/servlet/GetPDFServlet?filetype=pdf&id=APCPCS000997000001000109000001&idtype=cvips&prog=normal>]

A laser propulsion concept requires a laser, a beam control system, and a prime power source in addition to a traditional propellant and a thrust conversion system. However, if the laser, beam control system, and prime power source could be placed external to the flight system, only the propellant and thrust conversion system need to be onboard. The energy can be beamed to the flight system. The size and weight advantage is so great that such a concept could theoretically outperform most chemical propulsion concepts. The primary limitation of such a beamed energy propulsion concept is the ability to control the beam and deliver a useful level of energy with desired beam characteristics to the thrust conversion system in the flight vehicle. The spatial and temporal characteristics of the laser beam at the target, therefore, have the controlling importance in determining the system performance. The beam propagation becomes the fundamental enabling issue. Two obvious limits exist: (1) the delivered beam irradiance approaches the background radiation level and (2) the beam size at the target is so large that harnessing energy from the beam becomes impractical. At such limits, beamed energy would serve no useful purpose. The beam divergence or beam broadening is the primary contributor to limiting the effective range of beamed energy laser propulsion. Realistic demonstrations or applications of laser propulsion may be many years away since the availability of an integrated laser and beam control system appropriate for the application are very few and far in between.

### Lasers only 50% energy-efficient at best

Cook, ‘08 [Joung R. Cook, director of Navy’s High energy office, “Laser propulsion – Is it another myth or a real potential?”, 2008, <http://scitation.aip.org.proxy2.cl.msu.edu/getpdf/servlet/GetPDFServlet?filetype=pdf&id=APCPCS000997000001000109000001&idtype=cvips&prog=normal>]

The laser is the only means to transfer the energy from a prime power source to the application. There are losses associated with the energy transfer process. The laser propagation through atmosphere suffers significant extinction; 20% to 30%, depending on the atmospheric conditions and laser wavelength [15]. Only a fraction of the laser energy projected to the target plane is expected to be useful. The beam collector efficiency will likely be less than 100% as well as the energy conversion efficiency from collected laser beam energy to thrust. The energy transfer process is expected to be less than 50% efficient at best. Table 1 assumes 50% efficiency of beamed energy transfer, which is rather an optimistic assumption.

## 2NC—Long Timeframe

### Laser technology remains decades away at best

Cook, ‘08[Joung R. Cook, director of Navy’s High energy office, “Laser propulsion – Is it another myth or a real potential?”, 2008, <http://scitation.aip.org.proxy2.cl.msu.edu/getpdf/servlet/GetPDFServlet?filetype=pdf&id=APCPCS000997000001000109000001&idtype=cvips&prog=normal>]

The beam broadening directly affects the usefulness of the laser beam in delivering the power and energy to the application. The usefulness of the laser diminishes as the projected irradiance approaches the background radiation level from the broadening, so as the projected area becomes too large to be practical to harness the energy. For instance, a diffraction limited laser with 1-micron wavelength and 1-m diameter (geosynchronous altitude). About two thirds of the laser energy would be contained within the 1/e irradiance contour, which is about a 57-m diameter area. About one third and/or having less than a perfect beam delivered to this altitude will fill a larger area, and presents a considerable challenge in harnessing the energy from the projected laser beam. Once a reasonable real world factors are considered, such as system jitter and less than perfect laser beam quality, the impact of the effects are dramatically unlikely able to project irradiance above the solar constant at geosynchronous altitude mostly as a result of beam broadening. Space travel involves very large distances with respect to the beam broadening consideration. Beamed energy propulsion for space travel using an external laser can be eliminated from consideration solely based on beam broadening. Research and meaningful validation of the heavy lifting propulsion application area, i.e. space launch, is severely limited by availability of integrated high-energy laser and beam control system. Based on the current pace of research activities, this may be many decades away, or never, unless the level of potential payoff of a new laser propulsion concept is high enough to inspire research and development funding of high-energy lasers at en appropriate energy level (and wavelength) and a beam control system to support the application.