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Paper Session I-A - Neutral Particle Beam Overview

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NEUTRAL PARTICLE BEAM OVERVIEW

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The goal of the Neutral Particle Beam (NPB) technology program is to develop a multimission directed energy weapon (DEW) system which can function as an effective component in a Strategic Defense System. The NPB has the capability to be used as both a weapon and discriminator platform. It can kill missiles and reentry vehicles in the boost, post-boost, and mid-course portion of an ICBM trajectory as well as discriminated objects during the midcourse phase. Objects from those boosters and "buses" not engaged in the boost and post boost phase would be engaged once the reentry vehicles and decoys have been deployed, i.e. during the midcourse phase of the trajectory. The NPB can be used to provide a passive, active, and interactive discrimination capability against these targets. Passive discrimination is accomplished by viewing visible, ultraviolet (UV) and/or infrared (IR) emissions from targets and decoys using on-board acquisition sensors. Active discrimination is accomplished by illuminating targets and decoys with a laser tracker on-board the NPB; while interactive discrimination is accomplished by illuminating the target with the NPB which results in the emission of X-rays and neutrons which are proportional to the mass of the target. These emitted particles are measured by a free flying detector to determine the mass of the objects. During the discrimination process target state vectors (position and velocity) can be determined which can be handed over to space-based or ground-based interceptors. All the sensors are on the same platform. This reduces data processing since sensor-to-sensor correlation is not required.

The NPB is difficult, if not impossible, to countermeasure in both the kill and discrimination role since it penetrates in-depth into the target. Analysis and tests have been conducted to verify that the entry level NPB can defeat all proposed counter-measures to the beam-target interaction. It is also effective against homing direct assent ASATs which allows the NPB to defend itself and other space-based assets.

The NPD technology development is divided into three areas--component technology, integration of these component technologies in ground demonstrations, and space demonstrations to address space operability issues.

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Component Technology

The NPB component technology to implement a NPB system is making rapid progress. It builds on the experience of the high energy physics accelerator community's efforts which have been ongoing for almost forty years. The physics is well understood. The American Physical Society (APS), in its 1985 report on directed energy weapons in 1985, indicated the NPB development issues are engineering issue. The need is to build lightweight, high brightness, low divergence accelerators, with the magnetic optics to keep these beams focused while minimizing divergence growth and aberrations. Lightweight efficient neutralizers and accurate beam seeing technology is also required.

NPB beam line components are illustrated in figure 2, while hardware which has been tested is shown in figure 3. Ion sources have been developed with the brightness and duty factor to meet weapon requirements, but both brightness and duty factor have not been met simultaneously. Technology programs are in place to develop ion sources which simultaneously meet both the brightness and duty factor requirements. The Soviet-developed concept of the radio frequency quadrangle (RFQ) provides lightweight technology for the low-energy portion of the accelerator. This concept bunches and begins to accelerate the negative ions to a couple of million election volts (MeV). Acceleration of the particles to weapon level is completed by the ramped gradient, cryogenic drift tube linear accelerator (LINAC) sections. These components have been integrated and tested on the Accelerator Test Stand (ATS) at Los Alamos National Laboratories.

A space qualified ion source, with electronics, RFQ, gas neutralizer and solid state power supplies were recently built, tested, and flown in space on the Beam Experiment Aboard a Rocket (BEAR). The magnetic optics shown in Figure 3 were designed and built at Los Alamos and recently tested on the Argonne National Laboratories 50 MeV Neutral Beam Test Stand (NBTS). The wire shadow beam sensing hardware also built by Los Alamos is currently being tested in conjunction with the magnetic optic on the NBTS at Argonne. Lightweight efficient foil neutralizers have been developed and tested for thermal loading & survivability. Through these development programs the issues raised with respect to the NPB in the APS DEW report have been addressed.

Ground Integration

Programs are now in place to perform the ground integration of these components. This will be accomplished through three programs - the Ground Test Accelerator (GTA), the Continuous Wave Deuterium Demonstrator (CWDD), and the Power System Demonstrator (PSD). GTA will demonstrate performance with hydrogen at low duty factor. CWDD will provide CW operation with deuterium, and the Power System Demonstrator will integrate space traceable power technology.

The GTA is a space traceable design and will be built in two phases. The first phase GTA-24 provides the first complete integration of an NPB beamline. The energy will be 24 MeV. GTA will be operated in a pulsed mode. The second phase will be the construction of the GTA-High Energy. The GTA facility for both GTA-24 and GTA High Energy was completed in FY89. CWDD will be built at Argonne National Laboratories in Argonne, Illinois. CWDD, like GTA is a space traceable design which operates in a continuous wave mode. CWDD will provide the integrated system to address the thermal management issues associated with CW operation and will develop the technology for operation with deuterium as an alternative particle to the hydrogen used in GTA. Building CWDD to address the CW operation has resulted in a significant cost savings in the overall program. Operating GTA CW would have added significantly to the overall program development cost.

Several recent articles have indicated "power units would be far too heavy and expensive for practical applications". Power requirements for near-term NPB platforms can be met with power technology available within the near-term and within cost and weight constraints established by the NPB concept definition studies. Technologies to be used include turbogenerators, fuel cells, klystrodes and solid state radio frequency power components being developed by the SDIO power technology program. These technologies will be integrated in an NPB Power System Demonstrator (PSD) by the mid 1990s. The power systems on GTA and CWDD are not space traceable. The PSD provides the integration of space traceable power technology for the NPB system.

Space Integration

The Beam Experiment Aboard a Rocket (BEAR) program was the first step in addressing the space operability issues. The BEAR experiment was successfully launched on a suborbital trajectory from while Sands Missile Range, New Mexico on 13 July 1989. The integration of a government, industry, and national laboratory team resulted in a major success for the NPB program. Significant accomplishments included the space qualification and automated control of the accelerator beamline and associated diagnostics. The test also demonstrated the ruggedness of the NPB technology.

A misfire of the booster on the first launch attempt resulted in a sudden overpressure of the accelerator on the launch pad. Only a ruptured protective vacuum burst disk was replaced. There was no affect on accelerator performance. The BEAR mission was flown with no further maintenance on the payload. The payload was parachute recovered after the successful flight. Flight quality accelerator operation was demonstrated with no system repairs following recovery.

The BEAR flight showed no "show stoppers" for NPB. Spacecraft charging was observed in the hundreds of volts with no breakdowns. Beam propagation was as predicted by classical physics and neutral effluents caused no significant effect on beam propagation.

A follow-on space experiment is being planned to further address these issues. This experiment will be a low to medium risk experiment. The GTA-24 and CWDD will provide the ground proven beamline technology, while Starlab and the Midcourse Sensor Experiment/Rapid Optical Beam Steering (ROBS) will provide the technology base for the capture, tracking and pointing. The goal of this second experiment is to address those NPB issues which can only be addressed in space.

The design and performance definition (A specification) for the NPB system will be completed in FY90. The development schedule and acquisition strategy (Figure 4) provide for the transition of the NPB technology from laboratory to industry through the coordination of an effective government, national laboratory, and industry team.

In summary, a well structured program is in place to develop the component technology, and ground and space integration for an effective near-term Neutral Particle Beam system. "The Neutral Particle Beam is a program vital to our national defense. A high technology non-nuclear response to the threat of nuclear arms. A device designed to generate a beam useful in space, yet incapable of harming the Earth below. A defensive concept impossible to use against the Earth in an aggressive role. The Neutral Particle Beam System is a powerful guardian of peace, armed and ready not to fight people but to destroy weapons."[3]

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[3]White Horse, narrated by Charlton Heston, (Los Alamos, NM: Los Alamos National Laboratories, 1986), videotape - 15 min.

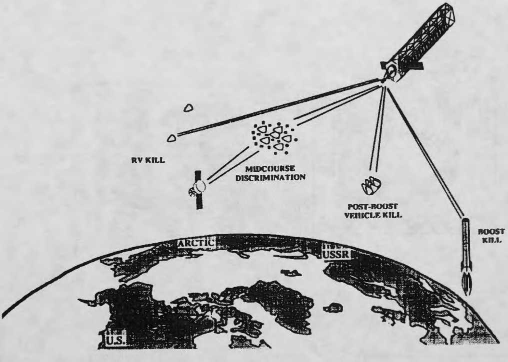

Figure 1 (U) Space-Based Neutral Particle Beam Concept

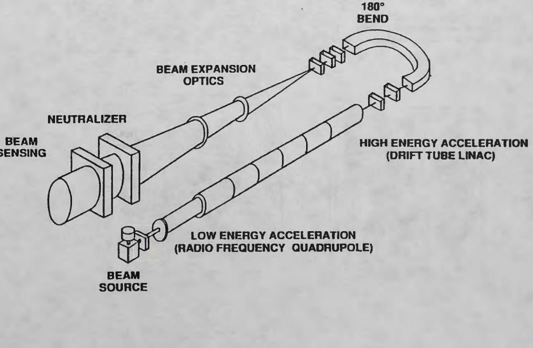

Figure 2 (U) NPB Beamline Components

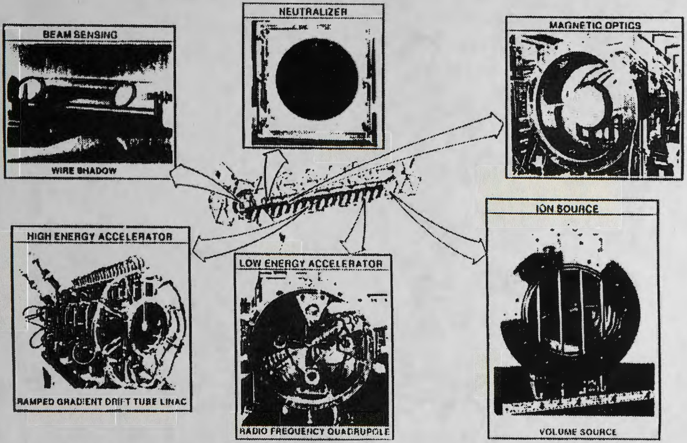

Figure 3. (U) NPB Technologies

- UTILIZE EXISTING ACCELERATOR FACILITIES FOR COMPONENT DEVELOPMENT
  - ACCELERATOR TEST STAND - LANL - (ACCELERATOR)
  - NEUTRAL BEAM TEST STAND - ARGONE (BEAM SENSING & CONTROL)
  - NPB TEST FACILITY - BROOKHAVEN (NEUTRALIZER & BEAM SENSING)
- BUILD GROUND INTEGRATION FACILITIES TO SHOW CONCEPT FEASIBILITY
  - GROUND TEST ACCELERATOR (GTA)
  - CONTINUOUS WAVE DEUTERIUM DEMONSTRATOR (CWDD)
  - POWER SYSTEM DEMONSTRATOR (PSD)
- CONDUCT SPACE EXPERIMENTS BASED ON PROVEN GROUND TECHNOLOGY PROGRAM
  - BEAR: COMPONENT TECHNOLOGY - ION SOURCE. RFQ, NEUTRALIZER
  - PEGASUS: GTA 24/ATP
- TRANSITION TECHNOLOGY FROM LABORATORY TO INDUSTRY BY ESTABLISHING COOPERATIVE EFFORTS
  - COMPONENT TECHNOLOGY & BEAR: LAB DESIGN INDUSTRY MANUFACTURE
  - GTA: LAB LEAD WITH INDUSTRIAL PARTNER
  - CWDD: INDUSTRY DESIGN AND BUILD AT LAB
  - PSD: INDUSTRY DESIGN & BUILD
  - PEGASUS: INDUSTRY DESIGN & BUILD

Figure 4 (U) NPB Acquisition Strategy