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**Overview
of the
Defense Programs
Research and Technology
Development Program
for
Fiscal Year 1993**

***Appendix
Materials***

September 30, 1993

US Department of Energy
Assistant Secretary for Defense Programs
Deputy Assistant Secretary for Military Application
Office of Research and Advanced Technology
Research and Technology Development Division
Washington, DC 20585

MASTER

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PROGRAM ELEMENT PLAN SUMMARIES

The pages that follow contain summaries of the nine R&TD Program Element Plans for Fiscal Year 1993 that were completed in the Spring of 1993. The nine program elements are aggregated into three program clusters as follows:

Design Sciences and Advanced Computation:

- Conceptual Design and Assessment
- Physics
- Computation and Modeling

Advanced Manufacturing Technologies and Capabilities

- System Engineering Science and Technology
- Electronics, Photonics, Sensors, and Mechanical Components

Advanced Materials Sciences and Technologies

- Chemistry and Materials
- Special Nuclear Materials
- Tritium
- Explosives

Each program element plan is divided into three parts. The first part is the key challenges to be faced within the next ten years, along with the near term milestones. The second part consists of these milestones placed into Gantt charts for ease of viewing.

These plans define the science and technology areas currently being coordinated through the efforts of the Research and Technology Development Division. These

capabilities represent a unique national resource, accumulated over roughly half century of dedication to meeting vital national security needs through scientific and technological excellence. Today, the Division is coordinating the capabilities necessary for the appropriated reduction of the stockpile, while continuing our efforts to preclude the possibility of technological surprise.

While the laboratories have and excellent record of stewardship over the nuclear weapons stockpile, we continue to work not only to enhance the capabilities needed to support and maintain the enduring stockpile but also to support national objectives in a number of areas where nuclear weapons expertise is directly applicable. For example, these include arms control and verification efforts, conventional military and security issues, domestic manufacturing methodology, new and specialty materials, alternative energy sources, combustion research, advanced drilling technologies, advanced computer modeling, support to educational institutions, technology for the exploration of space, and advanced transportation modeling.

DESIGN SCIENCES AND CAPABILITIES CLUSTER

PROGRAM ELEMENTS

**CONCEPTUAL DESIGN AND ASSESSMENTS
PHYSICS
COMPUTATION AND MODELING**

CONCEPTUAL DESIGN AND ASSESSMENTS

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
IHE, FRP safety and security upgrade design for enduring stockpile: LANL	● Stockpile Stewardship	● testing completed (4Q 96)
3D accident response assessments: LANL	● Stockpile Stewardship	● 3D analysis completed (4Q 94)
disablement device	● Nonproliferation ● Arms Control	● disablement design completed (4Q 95)
virtual design: LANL	● Test Ban Readiness	● first virtual design cycle completed (4Q 96)
UGT/AGEX bridging experiments: LANL	● Test Ban Readiness	● bridging experiments completed (4Q 96)
NIMP device mix determination: LANL	● Test Ban Readiness	● testing completed (4Q 96)
Stealthy Standoff Bomb: SNL	● Stockpile Stewardship	● conceptual design definition completed (2Q 94)
global verification and location system (GVLS): SNL	● Stockpile Stewardship ● Nonproliferation	● complete design definition for GPS-based system (4Q 94)
strike assessment and remote enable system (SCREAMER): SNL	● Stockpile Stewardship	● complete design definition (4Q 94)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Conceptual Design and Assessments

ID	Key Challenges	1993					1994				1995				1996				1997			
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
1	IHE,FRP Safety Sec: LA																					
2	3D Acc Resp Assess: LA																					
3	Disablement Device																					
4	Virtual Design: LA																					
5	Bridging Experiments: LA																					
6	NIMP Device Mix: LA																					
7	Stealthy Standoff Bomb: S																					
8	GVLS: S																					
9	Strike Assess & Loc Sys: S																					

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

PHYSICS

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
hydrodynamic instability, turbulent mix physics on Nova: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● understanding of mode coupling and multi-mode growth of turbulence (4Q 93) ● measure mix width in turbulent regime (4Q 94)
Implosion Hydrodynamics: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness ● ICF 	<ul style="list-style-type: none"> ● perform hydrotest exps. using pit material (4Q 93) ● complete hydrotest exps. using several SNM simulants (4Q 97)
plutonium melt curve determination: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● measure melt curve for pressures up to 300 GPa and temp. up to 6,000K (4Q 93)
equation of state for hot expanded plutonium: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● measure for 12-18 g/cm³ and 0.2-1.0 eV (4Q 94)
radiation physics experiments: LANL, LLNL, SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● complete series of exps. on Saturn to benchmark codes over extended range of temp. (4Q 97)
high-Z opacity measurements: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness ● ICF 	<ul style="list-style-type: none"> ● complete series of exps. on Nova and/or Saturn (4Q 95)
high-Z opacity models: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness ● ICF 	<ul style="list-style-type: none"> ● improve accuracy and benchmark using Nova (4Q 94)
energy levels and oscillator strengths for key transitions and benchmark transport codes: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness ● Tech. Surprise 	<ul style="list-style-type: none"> ● expand the data base for Z up to 92 (4Q 97)
vision science and pattern recognition: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Nonproliferation ● Stockpile Support 	<ul style="list-style-type: none"> ● apply new understanding to applications for robotics, process control, chemical sensor arrays, and LIDAR (4Q 94)
plasma etching predictive capability: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● apply to adaptive process control of microelectronic processing equipment (1Q 95)
pulsed power components enhancements: SNL	<ul style="list-style-type: none"> ● Test Ban Readiness ● ICF 	<ul style="list-style-type: none"> ● demo contacting tech. for 10⁶ shot photoconducting semiconductor switch (4Q 93) ● demo scalable triggered plasma opening switch (4Q 93) ● demo 10⁷ shot 50 kV/cm photoconducting semiconductor switch (4Q 95) ● demo cathode tech. for 2 MV/cm without electron emission (4Q 96)
ultra-short pulse laser: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo 1 J, 100 fsec, 10²⁰ W/cm² capability (4Q 96)

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
time resolved gamma spectroscopy: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo 1-25 MeV, 100 keV spectral resolution, 250 psec. temporal resolution capability (4Q 94)
FXR upgrade: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo greatly reduced spot size and 2X increased current (4Q 94)
interface stability physics: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 	<ul style="list-style-type: none"> ● gain greatly improved understanding of the underlying physics (4Q 98) ● apply to design of reliable components (ongoing)
nano-size cluster science and applications: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Stewardship ● Site Restoration 	<ul style="list-style-type: none"> ● demo application to at least one micro- or opto-electronic device (4Q 94) ● apply to clean up of waste streams (4Q 95)
triggerable plasma opening switch for pulsed power systems: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo of less than 3 nsec jitter on the MITE accelerator (4Q 95)
assess the utility of the Angara V (Russian) imploding plasma system: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo of utility on Saturn (4Q 96)
solid-state megavolt, high-current, low-inductance switches: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● demo utility to replace gas- and liquid-dielectric spark gaps on low-impedance accelerators (4Q 98)
high-average-power ion beam systems for SNM production: SNL	<ul style="list-style-type: none"> ● Complex 21 	<ul style="list-style-type: none"> ● complete design definition of system (4Q 99)
Jupiter: an imploding plasma load for 15-30 KeV x-ray simulator: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● complete characterization and optimization and transfer system to users (4Q 01)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Physics

4 Qtr'98

Project: Program Elements FY 93

Date: 10/20/93

Critical

Noncritical

Progress

Milestone

Summary

Rolled Up

Subtask

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Physics

ID	Key Challenges	1993					1994				1995				1996				1997			
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
24	Nano-size-cluster Sci: S																					
25	Demo Application																					
26	Apply to Waste Streams																					
27	Plasma Switches: S																					
28	Angara V: S																					
29	Mvolt Low Ind Switch: S																					
30	High-power Ion Beams: S																					
31	Jupiter: S																					

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

Program Element: Physics

1998				1999				2000				2001				2002				2003				2	
Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

Subtask	
1	Identify the main idea of the passage.
2	Identify the supporting details of the passage.
3	Identify the author's purpose in writing the passage.
4	Identify the author's tone in writing the passage.
5	Identify the author's point of view in writing the passage.
6	Identify the author's bias in writing the passage.
7	Identify the author's style in writing the passage.
8	Identify the author's audience in writing the passage.
9	Identify the author's message in writing the passage.
10	Identify the author's theme in writing the passage.

COMPUTATION AND MODELING

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
3D Eulerian codes for shear and distorted-flow simulation and nuclear safety assessments: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● shear/distorted-flow code completed (2Q 94) ● 3D HE initiation model applied to nuclear safety assessments (1Q 96)
3D coupled hydro-structural codes: LANL, SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	<ul style="list-style-type: none"> ● limited capability (3Q 94) ● used in most areas of weapon designs (1Q 97)
parallel libraries for solutions of large linear systems: LLNL, LANL, SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● 10-fold increase in capability to solve complex problems (1Q 94) ● 100-fold increase in capability (1Q 97) ● 1000-fold increase in capability (1Q 2000)
direct simulation of turbulence, turbulent combustion, and deflagration-to-detonation transition for design and safety assessments: LLNL, SNL, LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● used in weapon design and safety assessments (1Q 96)
codes for simulating the unsteady fluid dynamics of an inflating parachute: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● used in parachute design (1Q 96)
improved fragmentation response model: SNL	<ul style="list-style-type: none"> ● Emergency Response 	<ul style="list-style-type: none"> ● meets requirements (2Q 95)
smart adaptive software capable of self-programming of robots in manufacturing, stockpile maintenance, and dismantlement: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● limited capability for selected operations (1Q 94) ● greatly expanded capability (1Q 96) ● applicable to most processes in Complex 21 (1Q 99)
computational fluid dynamics: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● 3D calculations with 10^8 cell and 1 day turnaround on problems (1Q 96) ● predictive model for complex-geometry CVD systems (1Q 96) ● predictive model for majority of welding applications (1Q 95)
crash simulations model to predict response of structures in accidents: SNL, LANL, LLNL	<ul style="list-style-type: none"> ● Safeguards & Security 	<ul style="list-style-type: none"> ● 10-fold improvement in complexity capability (1Q 95) ● 100-fold improvement (1Q 97) ● 1000-fold improvement (1Q 99)
accident response codes in 3D for nuclear weapons: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● Massively parallel processing allows realistic assessments of nuclear weapon accident scenarios (1Q 96) ● evaluation of stockpile safety (ongoing, beginning in 1Q 96)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Computation and Modeling

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Computation and Modeling

1998				1999				2000				2001				2002				2003				2	
Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Computation and Modeling

ID	Key Challenges		1993					1994				1995				1996				1997			
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
22	Crash Sim: S,LS,LL																						
23	10-fold Improvement																						
24	100-fold Improvement																						
25	1000-fold Improvement																						
26	Accident Codes: LA																						
27	Parallel Processing																						
28	Eval of Safety																						

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Design Sciences and Capabilities

Program Element: Computation and Modeling

1998				1999				2000				2001				2002				2003				2	
Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

Project: Program Elements FY 93
Date: 10/20/93

Critical

Progress

Summary

Subtask

Noncritical

Milestone

Rolled Up

ADVANCED MANUFACTURING TECHNOLOGIES AND CAPABILITIES CLUSTER

PROGRAM ELEMENTS

**SYSTEM ENGINEERING SCIENCE AND TECHNOLOGY
ELECTRONICS, PHOTONICS, SENSORS, AND MECHANICAL
COMPONENTS**

SYSTEM ENGINEERING SCIENCE AND TECHNOLOGY

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
robust standard-design neutron generator with a greatly increased lifetime: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Stockpile Support 	<ul style="list-style-type: none"> ● proof of concept of 50-year lifetime (1Q 96) ● proven manufacturing process that meets costs goals (1Q 98)
direct optical initiation (DOI) firing set: SNL, LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● complete prototype design of DOI architecture (1Q 95) ● take hand-off of proof-of-concept demonstration from the Explosives (EX)PE in 1Q 95 and complete design definition and certification (1Q 2000)
transferable insensitive paste main explosive: LLNL, SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● take hand-off of proof-of-concept demonstration from the Explosives (EX)PE in 1Q 96 and complete design definition and certification (1Q 2000)
integrated advanced use-control architecture into the Nuclear Command and Control (NCC) system, includes remote real-time PAL recode and inventory: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Safeguards & Security 	<ul style="list-style-type: none"> ● proof of concept 2-way communication architecture (4Q 93) ● complete design definition 2-way system (4Q 94) ● design definition of integrated NCC/PAL (4Q 96)
fire-resistant pits (FRP): LLNL, LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● proof of concept demo using reuse pits (4Q 94) - LANL ● FRP containment temperature proof of concept demo (2Q 95) - LLNL
automatic planning & programming of intelligent machines for agile manufacturing: SNL	<ul style="list-style-type: none"> ● Stockpile Support ● Complex 21 	<ul style="list-style-type: none"> ● on-factory-floor demo (1Q 98)
advanced command and control architecture: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Nonproliferation 	<ul style="list-style-type: none"> ● demo of prototype satellite system (1Q 97)
imaging radar: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Nonproliferation 	<ul style="list-style-type: none"> ● precision guidance demonstration (4Q 94) ● ground penetration experiments (1Q 96)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Advanced Manufacturing Technologies and Capabilities

Program Element: Systems Engineering Science and Technology

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Advanced Manufacturing Technologies and Capabilities

Program Element: Systems Engineering Science and Technology

1998				1999				2000				2001				2002				2003				2	
Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

ELECTRONICS, PHOTONICS, SENSORS, AND MECHANICAL COMPONENTS

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
miniaturized solid-state laser for the direct optical initiation (DOI) firing set: SNL	● Stockpile Stewardship	● 2X size reduction & certified for weaponization (1Q 96) ● 5X cost reduction (1Q 97)
ferroelectric-nonvolatile memory integrated with CMOS: SNL	● Stockpile Stewardship ● Non-Proliferation	● 256-bit DRAM demo (3Q 93) ● 4-K bit DRAM demo (2Q 95)
clock fabrication using silicon micromachining technology: SNL	● Stockpile Stewardship ● Non-Proliferation	● demo (4Q 93)
plasma etch capability for next generations of ICs: SNL	● Stockpile Stewardship ● Non-Proliferation	● 0.3 μ m lines & spaces (2Q 94) ● 0.1 μ m lines & spaces (2Q 97)
optically controlled thyristor with compensated gate capable of switching 250 volts: SNL	● Stockpile Stewardship	● complete phase-3 equivalent demo (4Q 93)
broadly tunable compact ultraviolet source based on optical parametric technology: SNL	● Non-Proliferation ● Site Restoration ● Emergency Response	● proof of concept demo (1Q 94) ● LIDAR field demo (2Q 95)
vertical-cavity surface-emitting diode laser: SNL	● Stockpile Stewardship	● diffraction-limited demo (4Q 93) ● 1 watt demo (2Q 95)
optical coherent image correlator: SNL	● Non-Proliferation ● Stockpile Stewardship	● feasibility demo for individually addressable arrays of logic elements (2Q 97)
predictive capability for inflation of unsteady parachutes: SNL	● Stockpile Stewardship	● complete (2Q 95)
chemically selective sensors: SNL	● Complex 21 ● Site Restoration ● Stockpile Stewardship ● Stockpile Support ● Non-Proliferation	● demo 6-element array and advanced pattern recognition capability (2Q 94) ● demo 20-element array and high-specificity pattern recognition capability (4Q 95)
radiation-hard SONOS-based electronically erasable read-only memory with a 100 year retention time: SNL	● Stockpile Stewardship ● Non-Proliferation	● WR deliveries (4Q 93)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Advanced Manufacturing Technologies and Capabilities

Program Element: Components

Project: Program Elements FY 93
Date: 10/20/93

Critical Progress Summary Subtask
 Noncritical Milestone Rolled Up

MATERIALS SCIENCES AND TECHNOLOGIES CLUSTER

PROGRAM ELEMENTS

**CHEMISTRY AND MATERIALS
SPECIAL NUCLEAR MATERIALS
TRITIUM
EXPLOSIVES**

CHEMISTRY AND MATERIALS

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
diamond-like coatings and materials for protected volume (PV) and electronic thermal-management (TM) applications: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation ● Stockpile Support 	<ul style="list-style-type: none"> ● acceptable mechanical properties for PV (4Q 94) ● acceptable cost process for TM (1Q 95) ● acceptable cost process for simple geometry PV (1Q 96) ● capability to coat complex PV surfaces (2Q 97)
defect-free ferroelectric materials for radiation-hard nonvolatile memories: SNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	<ul style="list-style-type: none"> ● certified process (2Q 95)
replacement for methylenedianiline (MDA) and toluene di-isocyanate (TDI) curing agents: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● elimination of MDA and TDI in the NW production complex (1Q 95)
lead-free and fluxless soldering capabilities for all NW components: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● certified capability (1Q 96)
greatly expand the SMARTWELD tool kit, an electronic data base for welding to reduce the time required to develop welding protocols and integrate into CAD/CAM: SNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● 10X enhancement (2Q 94) ● 100X enhancement (2Q 95)
demonstrate practical methods to transmute mixed waste and spent reactor fuel using energetic ion beams: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Nuclear Waste Management 	<ul style="list-style-type: none"> ● proof of concept (4Q 94)
composite materials made up of diamond-like carbon fibers at acceptable cost for high strength and thermal management: SNL & LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	<ul style="list-style-type: none"> ● scientific proof of concept (4Q 95) ● practical process demo (4Q 97)
FRP test facility: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● operational (4Q 95)
on-site customized pit fabrication capability: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● operational (4Q 96)
on-site Be machining capability: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● operational (4Q 97)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies

Program Element: Chemistry and Materials

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

SPECIAL NUCLEAR MATERIALS

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
develop precision gravity casting process for PUJ: LANL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● complete full-scale demo and documentation (4Q 93)
method to recover Pu from mixed residues and destroy organics: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● production-scale demo (4Q 94) ● design definition of production-scale system (4Q 95)
calorimeter for determining SNM contents of pits: LANL	<ul style="list-style-type: none"> ● Complex 21 	<ul style="list-style-type: none"> ● completion (4Q 93)
precision investment casting of SNM: LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● benchmark 3-D mold-filling and solidification code (4Q 93)
near-net-shape casting of Uranium: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● process demonstration (1Q 96)
Uranium chemical recovery and residue elimination: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● process demonstration (1Q 97)
direct cast uranium alloys: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● process demonstration (1Q 96)
R&D line for salt fabrication: LANL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● process demonstration (1Q 98)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies
Program Element: Special Nuclear Materials

		1993					1994					1995					1996					1997				
ID	Key Challenges	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4				
1	Pu Casting: LA																									
2	Pu Recovery: LA																									
3	Demo																									
4	Prod System																									
5	SNM Pit Calorimeter: LA																									
6	SNM Casting: LL																									
7	Uranium Casting: LA																									
8	U Chem Recovery: LA																									
9	Direct Cast U Alloys: LA																									
10	R&D Salt Fab: LA																									

4 Qtr '98

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

TRITIUM

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
develop ion-beam production capability to meet all future tritium needs: LANL, SNL	● Complex 21 ● Stockpile Stewardship	● proof of concept (1Q 95)
fire-safe valve: SNL, LANL	● Stockpile Stewardship	● certified for stockpile retrofit

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies

Program Element: Tritium

ID	Key Challenges	1993					1994				1995				1996				1997			
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
1	Ion Beam Prod. : LA, S																					
2	Fire-Safe Valve: S, LA																					

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

EXPLOSIVES

KEY CHALLENGES AND MILESTONES

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
direct optical initiation (DOI) firing set: SNL, LANL	● Stockpile Stewardship	● prototype demonstration (2Q 95)
laser diode ignition (LDI) of pyrotechnics: SNL	● Stockpile Stewardship	● certified for stockpile retrofit (1Q 96)
paste explosive system for nuclear initiation: LLNL, SNL	● Stockpile Stewardship	● certified for stockpile retrofit for selected applications (1Q 95) ● certified for main charge function (1Q 96)
energetic polymers for high-energy and improved safety: LANL	● Stockpile Stewardship ● Complex 21	● proof of concept (3Q 93) ● certification for use (1Q 95)
latex binders for waste minimization: LANL	● Stockpile Stewardship ● Complex 21 ● Stockpile Support	● proof of concept (2Q 94) ● certification for use (2Q 95)
transferable cast insensitive explosive for main charge: LLNL, SNL	● Stockpile Stewardship	● proof of concept demo (3Q 94) ● certification for use in weapons (1Q 96) ● full-scale demonstration (1Q 96) ● implementation in stockpile (1Q 2003)
IHE with energy density like HMX: LLNL, LANL	● Stockpile Stewardship	● identification (1Q 95) ● certification of performance (1Q 96) ● manufacturing process defined (1Q 98) ● manufacturing capability (1Q 2000)
predictive models for HE-performance: SNL, LANL, LLNL	● Stockpile Stewardship	● 3D multiple shock reactive HE burn model (4Q 93) ● complete validation of TIGER EOS data base (4Q 94) ● predictive capability for XDT/SDT/DDT (4Q 95) ● coupled thermal/mechanical chemistry predictive capability to assess behavior in all credible accident scenarios (1Q 96)
retirement and disposal technologies: SNL, LANL, LLNL	● Waste Management ● Complex 21 ● Stockpile Support	● Proof-of-concept demo (1Q 95) ● commission pilot plant for reuse/disposal capability (1Q 97)
composite explosives: LLNL, SNL	● Stockpile Stewardship ● Stockpile Support	● formulation of HE with desired properties for NW applications (4Q 96) ● commission pilot plant for production (1Q 99)

KEY CHALLENGE	MAJOR DP INITIATIVES SUPPORTED	MAJOR MILESTONES (EXPECTED DATE OF COMPLETION)
advanced diagnostics capabilities to characterize behavior of energetic materials: SNL, LANL, LLNL	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● technology to measure key intermediate species during XDT/SDT/DDT for code validation (1Q 96) ● femtosecond time resolution characterization capability to benchmark predictive codes (1Q 97)
environmentally conscious manufacturing of new energetic materials: LANL, SNL, LLNL	<ul style="list-style-type: none"> ● Complex 21 ● Stockpile Support 	<ul style="list-style-type: none"> ● "green" design selected applications identified and demonstrated (3Q 95) ● first selected product line available for stockpile use (1Q 97)

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies

Program Element: Explosives

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies

Program Element: Explosives

1998				1999				2000				2001				2002				2003				2	
Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM ELEMENT SCHEDULES

Program Cluster: Materials Sciences and Technologies

Program Element: Explosives

Project: Program Elements FY 93
Date: 10/20/93

Critical
Noncritical

Progress
Milestone

Summary
Rolled Up

Subtask

ADDITIONAL CRITICAL TECHNOLOGY SUMMARIES

The pages that follow contain critical technologies from the 1992 DOE Defense Critical Technologies Plan which were not otherwise contained in the FY 1993 update to the Program Element Plans. The nine program elements are aggregated into three program clusters as follows:

Design Sciences and Advanced Computation:

- Conceptual Design and Assessment
- Physics
- Computation and Modeling

Advanced Manufacturing Technologies and Capabilities

- System Engineering Science and Technology
- Electronics, Photonics, Sensors, and Mechanical Components

Advanced Materials Sciences and Technologies

- Chemistry and Materials
- Special Nuclear Materials
- Tritium
- Explosives

As explained in the FY 1993 Program Element plan update, these plans define additional science and technology areas currently being coordinated through the efforts of the Research and Technology Development Division. These capabilities represent a unique national resource, accumulated over roughly half century of dedication to meeting vital national security needs through scientific and technological excellence. Today, the Division is coordinating the capabilities

necessary for the appropriated reduction of the stockpile, while continuing our efforts to preclude the possibility of technological surprise.

While the laboratories have and excellent record of stewardship over the nuclear weapons stockpile, we continue to work not only to enhance the capabilities needed to support and maintain the enduring stockpile but also to support national objectives in a number of areas where nuclear weapons expertise is directly applicable. For example, these include arms control and verification efforts, conventional military and security issues, domestic manufacturing methodology, new and specialty materials, alternative energy sources, combustion research, advanced drilling technologies, advanced computer modeling, support to educational institutions, technology for the exploration of space, and advanced transportation modeling.

DESIGN SCIENCES AND CAPABILITIES CLUSTER

PROGRAM ELEMENTS

**CONCEPTUAL DESIGN AND ASSESSMENTS
PHYSICS
COMPUTATION AND MODELING**

CONCEPTUAL DESIGN AND ASSESSMENTS

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
optimization of parameters for complex systems	● Stockpile Stewardship	routine analysis of every new system for optimal parameter choices
passive protection system	● Non-Proliferation	proof of concept demonstrated
access delay for facilities and transportation systems	● Stockpile Stewardship ● Non-Proliferation	proof of principle
nonlethal weapons and weapons for remote response	● Stockpile Stewardship ● Non-Proliferation	greatly enhanced capabilities
graduated, automated remote response with nonlethal incapacitants	● Stockpile Stewardship ● Non-Proliferation	proof of principle

PHYSICS

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
enhanced and extended nuclear data	● Stockpile Stewardship	extended nuclear libraries for all necessary isotopes for all relevant cross sections
3D time-dependent EM propagation in complex environments	● Stockpile Stewardship	3D code validation against laboratory experiments
greater spatial and density resolution in high-density assemblies	● Stockpile Stewardship	dual-axis radiographs with 2 to 4x improvements in spatial and density resolutions
increased analytical sensitivity and expanded detector suite for radiochemical diagnostics	● Stockpile Stewardship	increased sensitivity and improved mix phenomena diagnostics
enhance imaging diagnostics	● Stockpile Stewardship	0.5 mm with 200:1 dynamic range and 200-ps resolution
detection of trace species of complex molecules using laser spectroscopy	● Arms Control	portable system with detectivity of 1 ppb
tunable UV laser sources	● Stockpile Stewardship	tunable from 50 to 300 nm
high-power semiconductor lasers for LIDAR and direct optical initiation	● Stockpile Stewardship	100-W CW coherent at 10X less cost
1% efficient copper laser technology	● Stockpile Stewardship	10-kW demonstration with 10X increase in lifetime
efficient source of tunable radiation using rf LINAC technology	● Stockpile Stewardship	tunable from 10 to 200 nm
more efficient and reliable harmonic converters and optical parametric oscillators and amplifiers	● Stockpile Stewardship ● ICF	● multi-kJ per-pulse, multiple-pulsed lasers ● tunable from 200 to 3000nm
high-power optical coatings	● Stockpile Stewardship	10X increase in damage threshold at wavelengths from vacuum UV to far-infrared
X-ray imaging optics	● Stockpile Stewardship	10nm resolution over a 2-cm diameter field
coherent x-ray source	● Stockpile Stewardship	1-W average power
laser or light ion beam fusion	● Stockpile Stewardship	● ignition ● technology validation for laboratory microfusion facility
high-average power accelerators	● Stockpile Stewardship	complete technology of accelerator and target
imploding-plasma x-ray sources	● Stockpile Stewardship	● relevant laboratory XRL for XRL weapon code development ● 1 MJ of soft x-ray in tens of nanoseconds

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
Advanced nuclear weapon-effects simulators	● Stockpile Stewardship	● complete technology validation for externally driven nuclear assembly (EDNA) ● complete technology validation under DNA leadership of DECADE x- ray effects simulator
Electromagnetic launcher	● Stockpile Stewardship	20 km/s with > 10g solid projectile

COMPUTATION AND MODELING

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
suite of simulations representing the SNM manufacturing complex	<ul style="list-style-type: none"> ● Complex 21 ● Waste minimization 	fully integrated set of simulation models
capability to design best effective physical security systems for the DOE complex	<ul style="list-style-type: none"> ● Complex 21 	simulations of security systems for the SNM complex
intelligent interfaces to automate analysis of results and to set up input for successive simulations	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 	selected classes of simulations run and analyzed by intelligent software
massively parallel computing and software	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 	<ul style="list-style-type: none"> ● teraflop performance ● complete computer-integrated design and manufacturing system
massively parallel models for electronic structure and for molecular dynamics and Monte Carlo simulations	<ul style="list-style-type: none"> ● Stockpile Stewardship 	integrated computer-based materials design system
ability to solve dense signal processing and data fusion systems with hundreds of thousands of unknowns	<ul style="list-style-type: none"> ● Stockpile Support 	real-time system for intelligence data processing and interpretation
automated inventory and site data	<ul style="list-style-type: none"> ● Stockpile Stewardship 	routine cost
modeling of HE response	<ul style="list-style-type: none"> ● Stockpile Stewardship 	improved ignition, detonation, and hydro models
design assistance modeling and automation	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● demonstrated functional design assistants ● reduced design cycle time ● improved design quality ● weapon component designed with design assistants
production processes modeling and automation	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● incorporation of flexible work cells in NWC ● reduced production setup costs ● reduced unit costs ● work cell reconfiguration ● sensor-controlled NC machines

ADVANCED MANUFACTURING TECHNOLOGIES AND CAPABILITIES CLUSTER

PROGRAM ELEMENTS

**SYSTEM ENGINEERING SCIENCE AND TECHNOLOGY
ELECTRONICS, PHOTONICS, SENSORS, AND MECHANICAL
COMPONENTS**

SYSTEM ENGINEERING SCIENCE AND TECHNOLOGY

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
predisabled and/or separable components	<ul style="list-style-type: none"> ● Stockpile Support ● Stockpile Stewardship 	proven
fault-free electrical nuclear detonation safety	<ul style="list-style-type: none"> ● Stockpile Support ● Stockpile Stewardship 	100% of stockpile with predictable electrical safety
alternate manufacturing sources for protected volume components	<ul style="list-style-type: none"> ● Non-Proliferation ● Complex 21 	alternatives identified
an all-optical (power and data) weapon use control interface	<ul style="list-style-type: none"> ● Non-Proliferation 	demonstrated
a secure operating system for microprocessor-based use control systems	<ul style="list-style-type: none"> ● Non-Proliferation 	demonstrated
weapons permitting a broader choice of use control techniques (e.g., self-destruct without releasing hazardous materials into the environment)	<ul style="list-style-type: none"> ● Non-Proliferation ● Stockpile Stewardship 	mature and weaponizable
weapon designs and engineering approaches for separating critical components from weapon so that they may be stored external and separate from rest of weapon	<ul style="list-style-type: none"> ● Non-Proliferation 	mature and weaponizable
automated positive personnel entry, detection, and tracking control	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	deployed
intrusion detection and assessment for insider protection	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	deployed
reduced signature of on-site operations	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	demonstrated
reduced weapon exposure to compromise during handling and transportation	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Non-Proliferation 	deployed
identification of signatures that may be useful in treaty monitoring and proliferation control	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	real-time remote based monitoring capability
low-cost satellites for treaty monitoring and technology development	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	verification system near deployment
developed or modified existing low-cost aircraft for sensor deployment for crisis or inspection	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	deployable capability
ground-based satellite imaging at 2X diffraction limit	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	on-the-shelf capability

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
nonintrusive surveillance of weapons	<ul style="list-style-type: none"> ● Stockpile Support ● Arms Control ● Non-Proliferation 	low-cost/reliable treat verification
tags and seals for identification of legal treaty-limited items	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	on-the-shelf capability
tamper protection and data authentication technologies	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	on-the-shelf capability applied to sensor systems
radiation and chemical detectors in pinpoint NCB weapons in suspect areas	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation 	on-the-shelf capability
seismic monitoring for monitored treaties that limit underground nuclear testing	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation ● Test Ban Readiness 	improved discrimination of nuclear explosions vs. other seismic events
nonseismic confirmation and detection of low-yield nuclear tests	<ul style="list-style-type: none"> ● Arms Control ● Non-Proliferation ● Test Ban Readiness 	systems fielded for complementing existing nuclear detection capabilities

ELECTRONICS, PHOTONICS, SENSORS, AND MECHANICAL COMPONENTS

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
massively parallel graphics engines capable of 3D visualization in real time	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 	instantaneous 3D visualization for science and engineering
weapons designed to respond safely to cookoff and nearby detonation environments	<ul style="list-style-type: none"> ● Stockpile Support 	demonstrated cookoff-safe and sympathetic detonation-safe weapons
protective volume sensor technology	<ul style="list-style-type: none"> ● Non-Proliferation 	<ul style="list-style-type: none"> ● Committable to applications ● Demonstrated technical maturity
microprocessor-based volume control electronics	<ul style="list-style-type: none"> ● Non-Proliferation 	demonstrated
protected volume power sources	<ul style="list-style-type: none"> ● Non-Proliferation 	higher density power sources demonstrated through deployment
detection of presence and amount of SNM associated with nuclear materials production	<ul style="list-style-type: none"> ● Non-Proliferation ● Arms control 	facility and treaty monitoring capability
area security sensors to detect intrusion	<ul style="list-style-type: none"> ● Non-Proliferation 	a suite of sensors
high-bandwidth detectors and recorders	<ul style="list-style-type: none"> ● Stockpile Stewardship 	10-GHz system based on photonic system
microelectronics manufacturing capability for national security	<ul style="list-style-type: none"> ● Stockpile Stewardship 	0.25- μ m Si, 0.1- μ m GsAs high-reliability manufacturing capability
high-density microelectronics packaging	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● high-reliability, 50% IC by volume packaging technology ● packages for 5-GHz intrachip signal transmission
manufacturable, high-resolution flat-panel display	<ul style="list-style-type: none"> ● Stockpile Stewardship 	manufacturable 3-in diagonal display by 1995;; 14-in diagonal by 1977; 60-in diagonal by 2000
radiation-hard, cosmic-ray-upset resistant silicon technology ICs	<ul style="list-style-type: none"> ● Stockpile Stewardship 	200-mm wafers supporting 0.25- μ m geometries
production realization of compound semiconductor long wavelength detector arrays	<ul style="list-style-type: none"> ● Stockpile Stewardship 	product realization of a 10×20 element array with $D^* \sim 10^{11}$ ($k=16$ μ m) in SLS III-V compounds
neural-network data-processing for automatic target recognition	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● optical neural-network computer ● miniature form and flight test in 1998
integrated optoelectronic technology for high-speed communications and computing	<ul style="list-style-type: none"> ● Stockpile Stewardship 	manufacturable massively parallel optical computer
1.06 to 1.5- μ m high-sensitivity optical radiation detection	<ul style="list-style-type: none"> ● Stockpile Stewardship 	1.3- μ m wavelength sensitive optical streak camera

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
picosecond transient recording for testing	● Stockpile Stewardship	multichannel electrooptical modulators on a single chip
compact weapons safing and arming systems with integrated electronics	● Stockpile Stewardship	<ul style="list-style-type: none"> ● stockpile monitoring systems ● miniature security devices ● onboard valve systems
high-speed interconnects and electronics for computing, telecommunications, etc.	● Stockpile Stewardship	employed in high performance computers
high-speed, high-voltage, high-temperature electronics	● Stockpile Stewardship	in commercial and defense production for special applications
rad-hard components compatible with telecommunications standards	● Stockpile Stewardship	rad-hard k = 1.3 lm source and electrooptic modulator
high data-rate links for weapons testing	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Test Ban Readiness 	1Gbit/s link with sufficient radiation hardness for weapons testing
high-bandwidth transmission of weapons test data	● Stockpile Stewardship	1-W, 12-GHz amplifier
ultralow power, high-speed digital circuitry	● Stockpile Stewardship	10-gigaflop single-chip processors
superconducting digital circuits	● Stockpile Stewardship	<ul style="list-style-type: none"> ● 30-GHz signal processor performance ratio ● Computational engine with 10^{15} operations per second
sensor technology for waste management	● Stockpile Stewardship	● detection of capabilities below levels of human danger for all hazardous wastes

MATERIALS SCIENCES AND TECHNOLOGIES CLUSTER

PROGRAM ELEMENTS

**CHEMISTRY AND MATERIALS
SPECIAL NUCLEAR MATERIALS
TRITIUM
EXPLOSIVES**

CHEMISTRY AND MATERIALS

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
thermal, chemical, and physical stability against cookoff	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Stockpile Support 	quantitative database for hazard analysis
inherently safe weapon systems with 25-50 yr component life	<ul style="list-style-type: none"> ● Stockpile Support 	system design and testing
lithium recycle processing	<ul style="list-style-type: none"> ● Complex 21 	incorporate into reconfigured production complex
toughened ceramic, polymeric, and metallic materials	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● increased toughness by 10X ● thin films in production ● ceramic-metal composites having long life at $T > 1200^{\circ}\text{C}$ ● new continuous fiber materials ● improved, lightweight, thick structural elements ● novel ceramics, metals, cermets, and ceramic/metal composites with grain sizes $< 0.1\ \mu\text{m}$
surface coatings and bonding	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● phase-out of cadmium plating process for environmental safety ● electrical interconnects bonded to alumina ● increased life ● decreased down-time of radiation-handling equipment ● stable IR detectors having high detectivity ● reflectivities $> 64\%$ at $130\ \text{\AA}$ and $> 20\%$ at $70\ \text{\AA}$ ● thin-film, multilayer batteries ● exploding foils for application of hard refractory coatings ● acceptable cleanup without current ES&H concerns
automatically engineered, multilayered materials	<ul style="list-style-type: none"> ● Stockpile Stewardship 	available in large area ($> 1\ \text{cm}^2$)
polymers/adhesives and encapsulants	<ul style="list-style-type: none"> ● Stockpile Stewardship 	<ul style="list-style-type: none"> ● reduced ES&H risks ● non-solvent based, dry adhesives ● CTEs $< 200 \times 10^{-7}/^{\circ}\text{C}$ ● Reduced costs, increased lifetime of structural materials ● insulative applications ● carbon batteries and capacitors ● environmental remediation processing applications

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
certification science and technology	● Stockpile Stewardship	<ul style="list-style-type: none"> ● certified high-yield, low-cost engineered materials ● reliable compatibility diagnostics under actual conditions ● real-time analysis and feedback on hazardous nature of industrial effluents and fiber-optic systems for process monitoring and control
process control and evaluation automation	● Stockpile Stewardship	<ul style="list-style-type: none"> ● automated production ● certified process, not product ● sensor-controlled NWC production machines ● on-line 3-D NDT imaging and inspection ● real-time tracking of all process and stockpile materials ● technologies, materials, and processes in place to achieve zero release
part cleaning and finishing automation	● Stockpile Stewardship	<ul style="list-style-type: none"> ● 80% reduction in mixed waste ● fluxless and leadless soldering ● full recovery of water ● improved functional coatings ● substitution for Cr^{+6}, Cd, and cyanide in electroplating baths ● 80% reduction in concentrated plating waste ● non-acid cleaning of stainless steel ● reusable cleaning materials
automated material recovery and disposal processes	● Stockpile Stewardship	<ul style="list-style-type: none"> ● direct chip reuse ● identification of bacteria for waste biodegradation ● direct recovery of molten chloride salts ● reusable HEPA filters
waste separation and treatment	<ul style="list-style-type: none"> ● Stockpile Stewardship ● Complex 21 	manufacturing processes with no legacy on the environment

SPECIAL NUCLEAR MATERIALS

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
robotics manipulators, mobile vehicles and surveillance	● Non-Proliferation	● automation of Pu and HEU operations ● demonstrated robotic guard systems ● integration of automated robotic system with current verification system
assembly/fabrication robots to reduce radiation exposure	● Complex 21	implementation into reconfigured production complex
modern foundry processing	● Complex 21	incorporation into reconfigured production complex
machining and forming	● Complex 21	incorporation into reconfigured production complex
aqueous and pyrochemical processing	● Complex 21	incorporation into reconfigured production complex
hydride/dehydride processing	● Complex 21	incorporation into reconfigured production complex
mixed-waste processing	● Complex 21	incorporation into reconfigured production complex
robotic waste management to reduce worker exposure	● Stockpile Stewardship	totally automated processes

TRITIUM

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
high-strength and fire-resistant containment systems	● Stockpile Support ● Stockpile Stewardship	incorporate into design
safe, long-term solid tritium storage	● Stockpile Support ● Stockpile Stewardship	development of improved materials
ES&H compliance for tritium handling, transport, and component manufacturing	● Stockpile Support ● Stockpile Stewardship ● Complex 21	material certification capability

EXPLOSIVES

ADDITIONAL CRITICAL TECHNOLOGY GOALS FOR THE YEAR 2000

GOALS	MAJOR DP INITIATIVES SUPPORTED	MILESTONE-2000
synthesis and formulation of new explosives	● Stockpile Stewardship	● replacement of HMX/RDX/TNT in current explosive blends ● more energetic, less sensitive paste and extrudable cast explosives
mitigate hazards in fast/slow cookoff to ensure long stockpile life	● Stockpile Stewardship	quantitative database for hazard analysis

DATE

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4/28/94

END