WORKSHOP ON

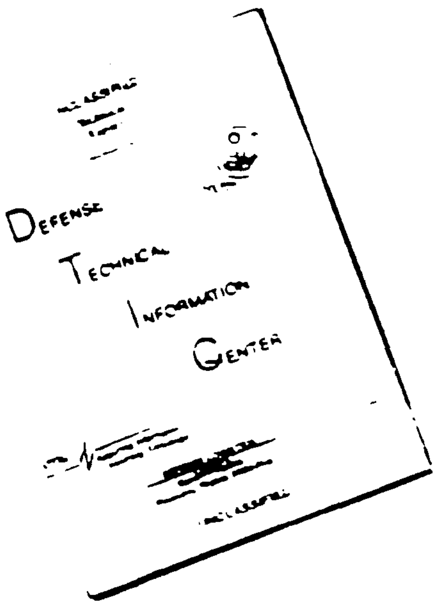
COMMERCIALIZATION OF PULSED POWER SCIENCE AND TECHNOLOGY

PROCEEDINGS

August 18-20, 1993

San Francisco Airport Hilton
San Francisco, CA

DISCLAIMER NOTICE



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WORKSHOP ON

COMMERCIALIZATION OF PULSED POWER SCIENCE AND TECHNOLOGY

PROCEEDINGS

Statement A per telecon
Gabriel Roy ONR/Code 1132
Arlington, VA 22217-5000
NWW 14 Mar 94

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COPPSAT University Government Industry

Workshop on Commercialization of Pulsed Power Science and Technology

Organizing Committee

Gabriel D. Roy, Chair
Office of Naval Research

Arthur Guenther
Sandia National Laboratories

Martin Gundersen
University of Southern California

Magne Kristiansen
Texas Tech University

Stephen Levy
PEACE/EPRI

Karl H. Schoenbach
Old Dominion University

Group Leaders:: W. Hofer, *US Dept. of Energy* (Medical, Materials, Other)
B. Penetrante, *LBL* (Environmental Applications)
E. Chu, *Maxwell Labs.* (Power Electronics)

Sponsored by:

Office of Naval Research

Local Arrangements:
CK & Associates
Albany, California

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Foreword

The new international environment has opened opportunities for pulsed power research that were not possible a few years ago. Pulsed power technology developed with Department of Defense support was primarily directed towards Department of Defense goals — perhaps more so than other areas of critical technology. There are, however, many significant applications for pulsed power in the commercial sector. The ability to tailor power pulse shapes and sequences and efficiently deliver *energy* in a pulsed, rather than DC or traditional AC mode, opens new horizons for commercial applications of lasers, accelerators, in medicine and pollution control, advanced motor control, and many other areas. There will be many applications for efficient, long-lived, reliable pulsed power that can be matched to applications requiring specialized voltage and current.

The 1993 Workshop on Commercialization of Pulsed Power Science and Technology brought together experts in the full range of problems facing technology transfer to discuss the issues facing commercialization and marketing. Those involved represented in addition to pulsed power expertise, experience in licensing, development, product engineering and marketing of new technology. The Workshop Proceedings provides a summary of discussion and expertise in all these areas.

We think the Workshop looks realistically towards the future. International development of products utilizing pulsed power is impressive, and the opening of this area for the commercial sector is, in our opinion, one with important consequences for the technological health of the nation. The areas cited above, and discussed in the Proceedings, such as power generation, efficient uses of power in industry and vehicles, and products for food processing and medical applications, will over the next decades impact jobs in market areas that are worth billions of dollars. It is extremely important that research, engineering, and product development be first rate, if we are to achieve substantial market-share in the future.

It seems clear that there is an important role for the organizations that have for so long supported the research that has produced the present level of expertise. As products develop, so do issues of a proprietary nature. Companies, after all, rise and fall depending on their ability to develop markets in very competitive environments. The support for research that will lead to new applications, in an open environment, must not be lost. Delicate proprietary issues must continually interface with the need for open research. The quality in engineering and the applied sciences, research results and an incredible level of quality in the skills of the scientists and engineers coming from government-supported university programs, largely the result of DoD support, is the envy of the world. We must maintain this — while continuing to foster commercial competitiveness — and we must address the needs of private companies that bring these results to the marketplace. Clearly, there will be many important and difficult problems for research management for years to come.

Martin Gundersen
Gabriel Roy
Karl Schoenbach

WORKSHOP ON
COMMERCIALIZATION OF PULSED POWER SCIENCE AND TECHNOLOGY

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August 18-20, 1993

Attendee List

1 Mr. John Allan
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2 Dr. Edmund Y. Chu
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Pulsed Power Systems & Technology
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Buffalo, NY 14260

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501-3B28
Pittsburgh, PA 15235

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28 Dr. Barry Weinman
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Suite 720
San Francisco, CA 94111

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Oceaneering Technologies, Inc.
2465 Portola Road
Ventura, CA 93003

WORKSHOP ON COMMERCIALIZATION OF PULSED POWER SCIENCE AND TECHNOLOGY

SAN FRANCISCO AIRPORT HILTON
SAN FRANCISCO, CA

AUGUST 18-20, 1993

AGENDA

WEDNESDAY, AUGUST 18

8:00 - 8:30 a.m.	Registration
8:30 - 8:45 a.m.	**"Introduction and Objectives"** G. Roy, Office of Naval Research
8:45 - 9:15 a.m.	**"Repetitive Pulsed Power Technology and Commercial Applications"** K. Prestwich, Sandia National Laboratories
9:15 - 9:45 a.m.	**"Commercialization of Pulsed Power Technology at Maxwell, Part II"** E. Chu, Maxwell Laboratories
9:45 - 10:15 a.m.	*Coffee Break*
10:15 - 10:45 a.m.	**"Overview of the Federal Technology Commercialization Program"** N. Montanarelli, Technology and Applications Program, BMDO
10:45 - 11:15 a.m.	**"Technology Transfer and Venture Capital"** B. Weinman, Newtec Ventures
11:15 - 11:45 a.m.	**Discussion, Formation of Working Groups**
12:00 - 1:30 p.m.	*Lunch*
1:30 - 5:00 p.m.	**Working Group Meetings** a) Power Electronics b) Environment c) Materials Treatment d) Medical Applications e) Other Applications

Pulsed power researchers will have the opportunity to present their ongoing or planned work (with respect to its commercialization). Potential users of pulsed power technology will present their views on the applicability of pulse power technology for their particular applications. The discussion will focus on the assessment of the technical and commercial potential of proposed technologies and on new applications for existing technologies.

6:30 p.m.	**Reception**
7:30 p.m	*Dinner/Speaker* **"Technology Transfer through Licensing"** J. Sandelin, Stanford University

THURSDAY, AUGUST 19

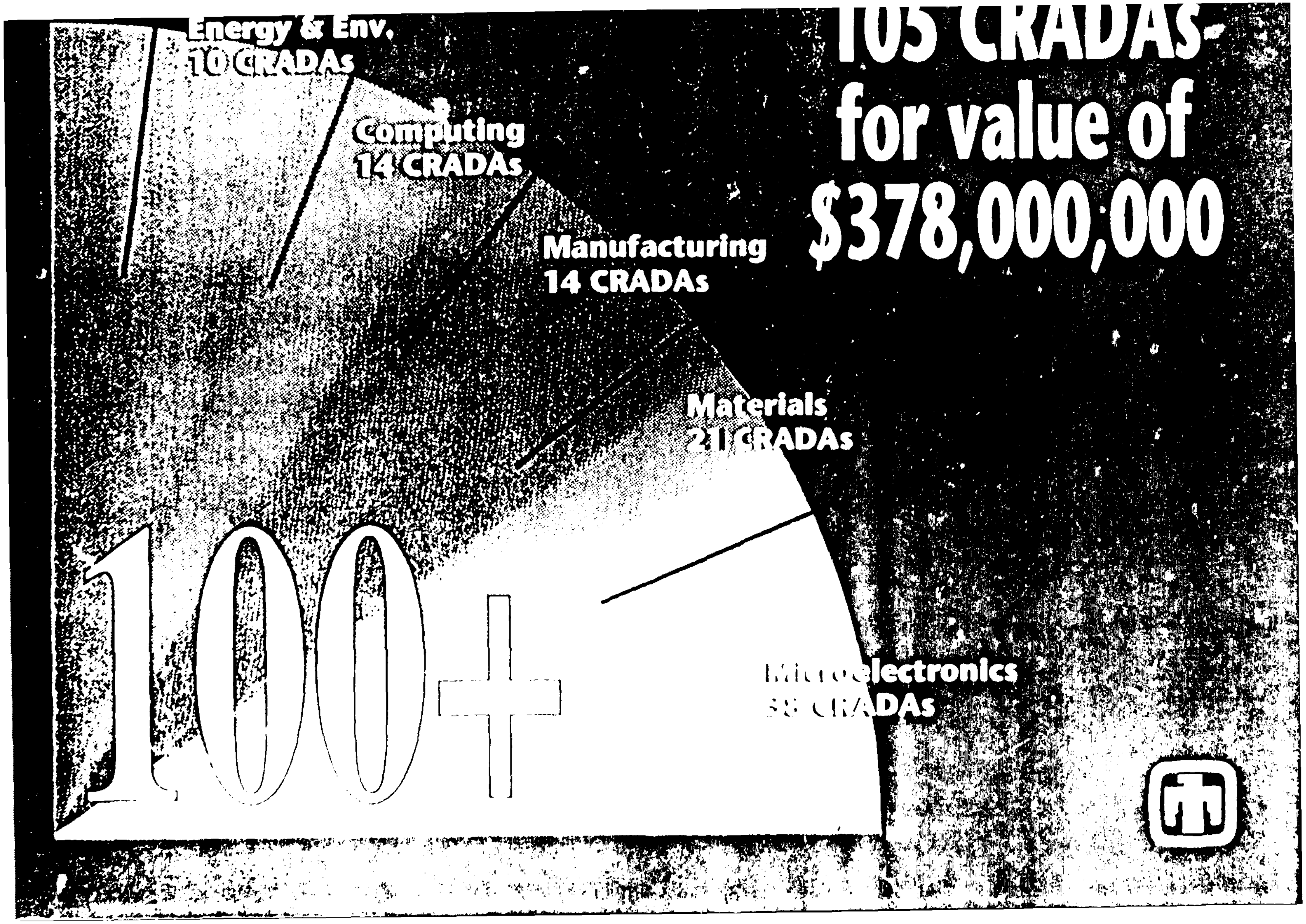
8:00 - 10:00 a.m.	**Group Report Preparation**
10:00 - 10:30 a.m.	*Coffee Break*
10:30 - 12:30 p.m.	**Group Reports and Discussion**
12:30 - 2:00 p.m.	*Lunch*
2:00 - 3:30 p.m.	**Panel Discussion** **Topics:** - Potential of Discussed Pulsed Power Technologies - New Applications/Markets - Networking - Technology Transfer Paths - Patents, Licensing **Participants:** - Pulsed Power Researchers (National Labs, Companies, Universities), Users, Government Representative, Investors
3:30 - 4:00 p.m.	*Coffee Break*
4:00 - 5:00 p.m.	**Discussion, Recommendations**

FRIDAY, AUGUST 20

8:30 - 12:00 p.m.	**Workshop Organizing Committee Meeting** Draft meeting report
12:00 p.m.	**Adjournment**

REPETITIVE PULSED POWER TECHNOLOGY AND COMMERCIAL APPLICATIONS

K. Prestwich
Sandia National Laboratories

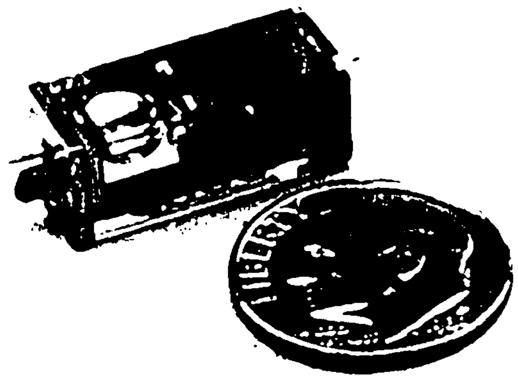

105 CRADAs
for value of
$378,000,000
Energy & Env.
10 CRADAs
Computing
14 CRADAs
Manufacturing
14 CRADAs
Materials
21 CRADAs
Microelectronics
100+

Some Sandia Technologies with Major Commercial Applications

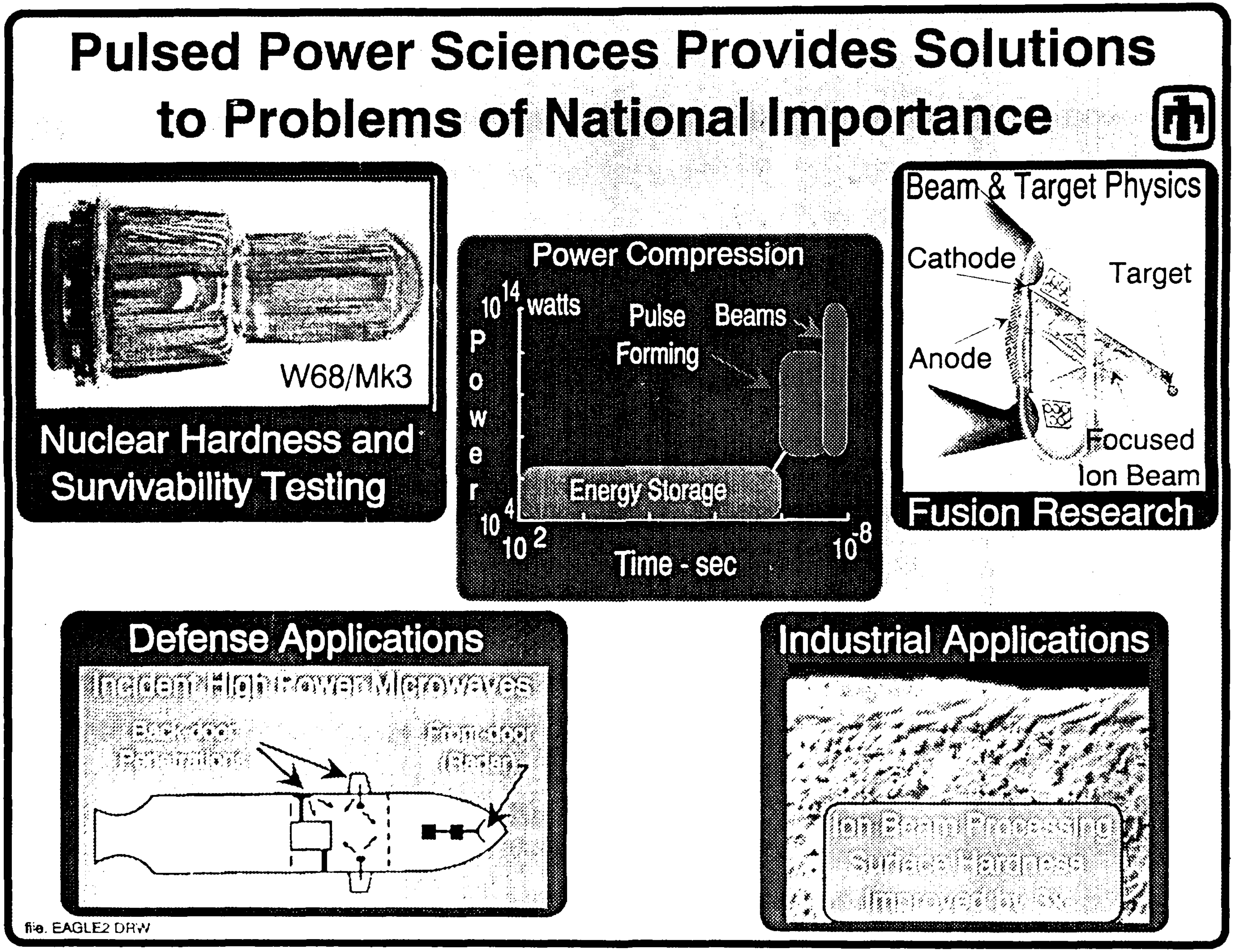
Polycrystalline Diamond Drill Bits

Whitfield Laminar Flow Clean Room

Liquid Solder Leveler for Printed Circuit Boards



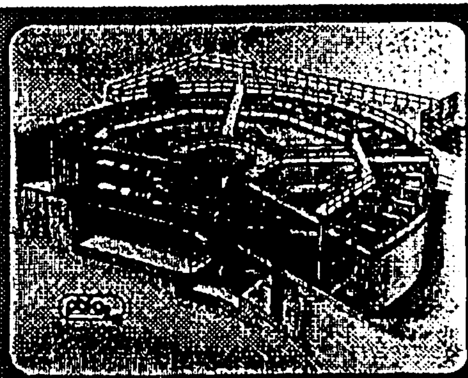
Rolamite Inertial Switch for Automobile Airbags


Pulsed Power Sciences Provides Solutions
to Problems of National Importance
W68/Mk3
Nuclear Hardness and
Survivability Testing
Power Compression
10^{14} watts
Power
10^{4}
Pulse Forming
Beams
Energy Storage
10^{2}
Time - sec
10^{-8}
Beam & Target Physics
Cathode
Target
Anode
Focused
Ion Beam
Fusion Research
Defense Applications
Incident High Power Microwaves
Industrial Applications
Ion Beam Processing
Surface Hardness
file. EAGLE2 DRW

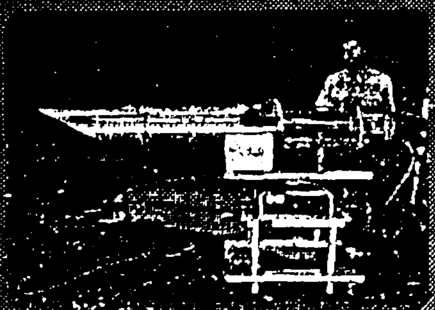
Pulsed Power Sciences Has a Broad Spectrum of Capabilities

Hermes III 20 MeV Radiation Simulator

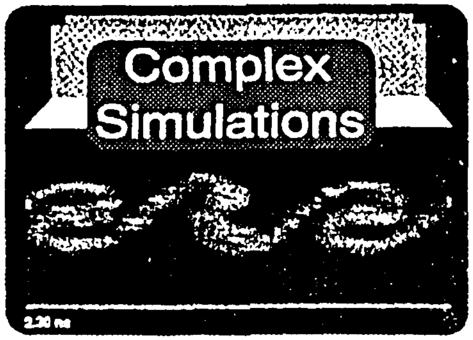
- Beam and plasma physics
- Simulation and modeling
- Component, code, and diagnostics development
- Systems Engineering
- Testing



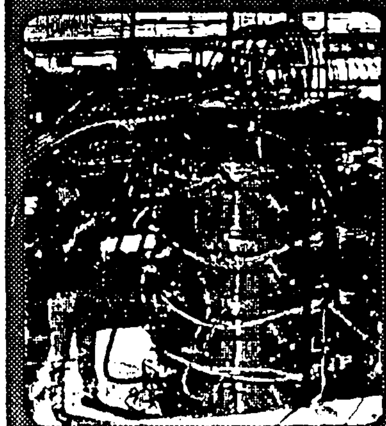
PBFA II ICF Driver



Split Cavity Oscillator Microwave Source



Complex Simulations



RHEPP 1 MeV 250 kW Beam Source

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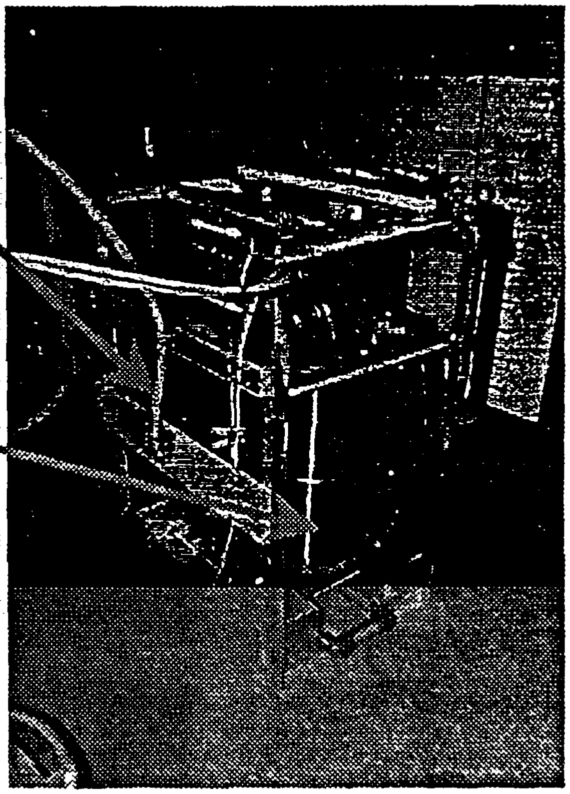
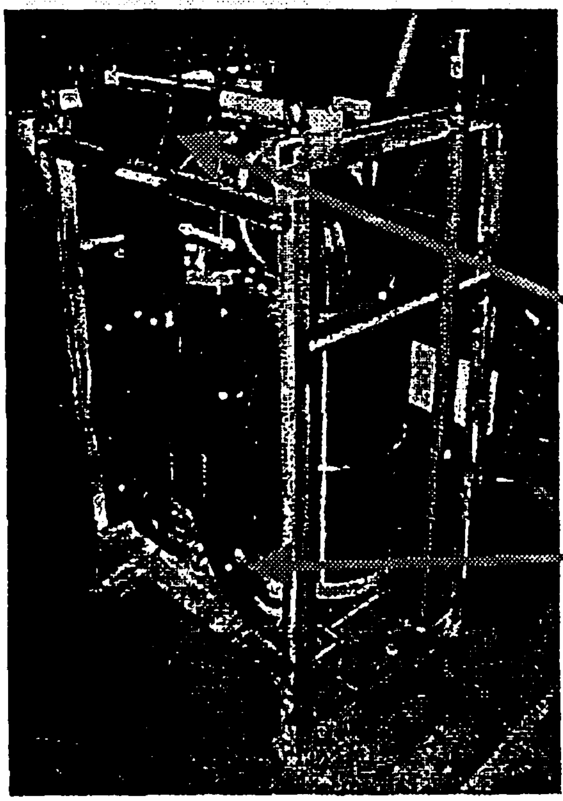
WESTINGHOUSE DESIGNED 15 KV TO 270 KV PULSE TRANSFORMER IS ASSEMBLED

Sandia National Laboratories

OUTPUT LEAD

4 PARALLEL
WIRE SECONDARY
WINDINGS





INPUT LEADS

4 PARALLEL
COPPER SHEET
PRIMARY WINDINGS

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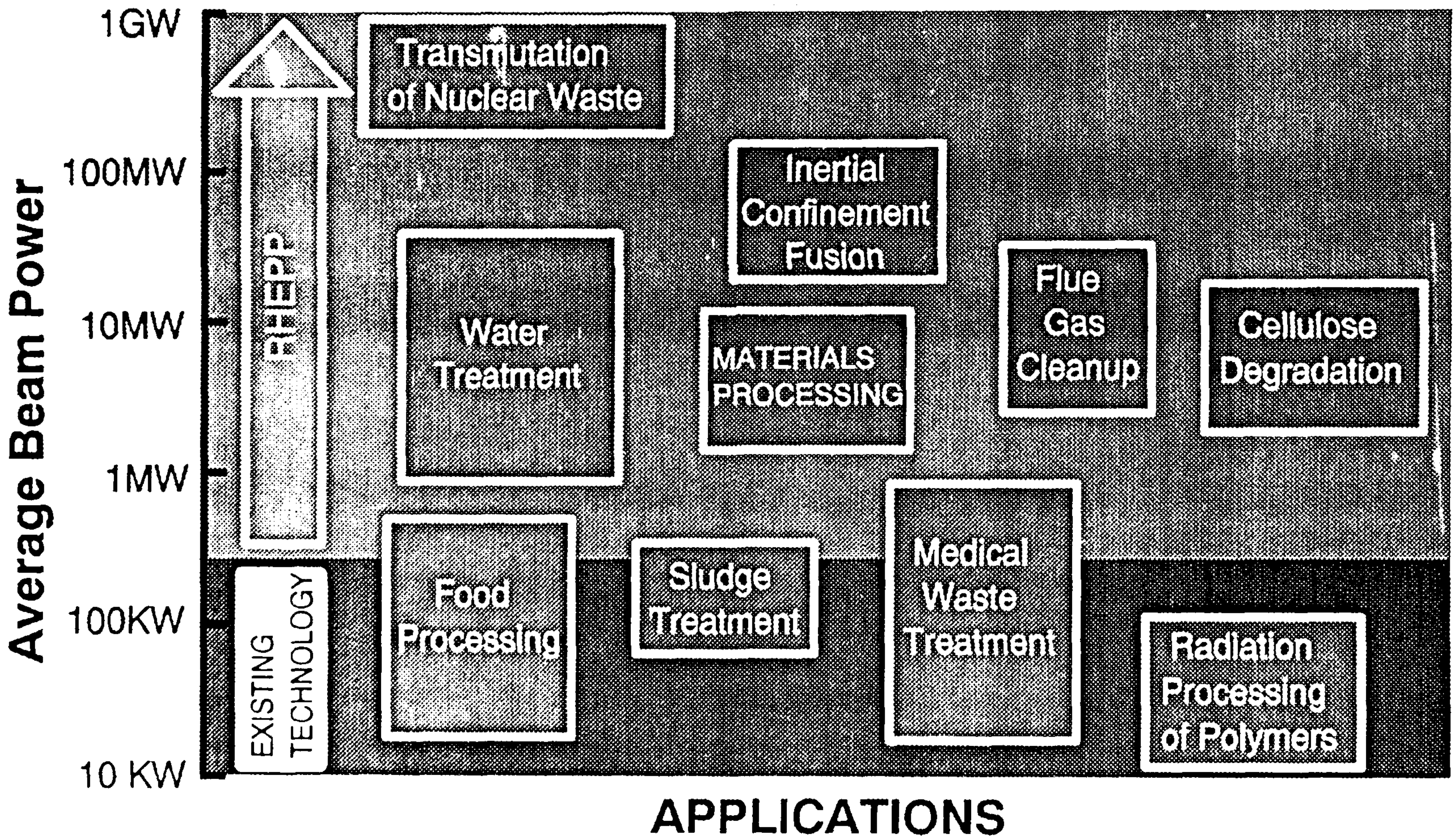
POSSIBLE APPLICATIONS REQUIRE ACCELERATORS WITH HIGH AVERAGE POWER CAPABILITIES

Sandia National Laboratories



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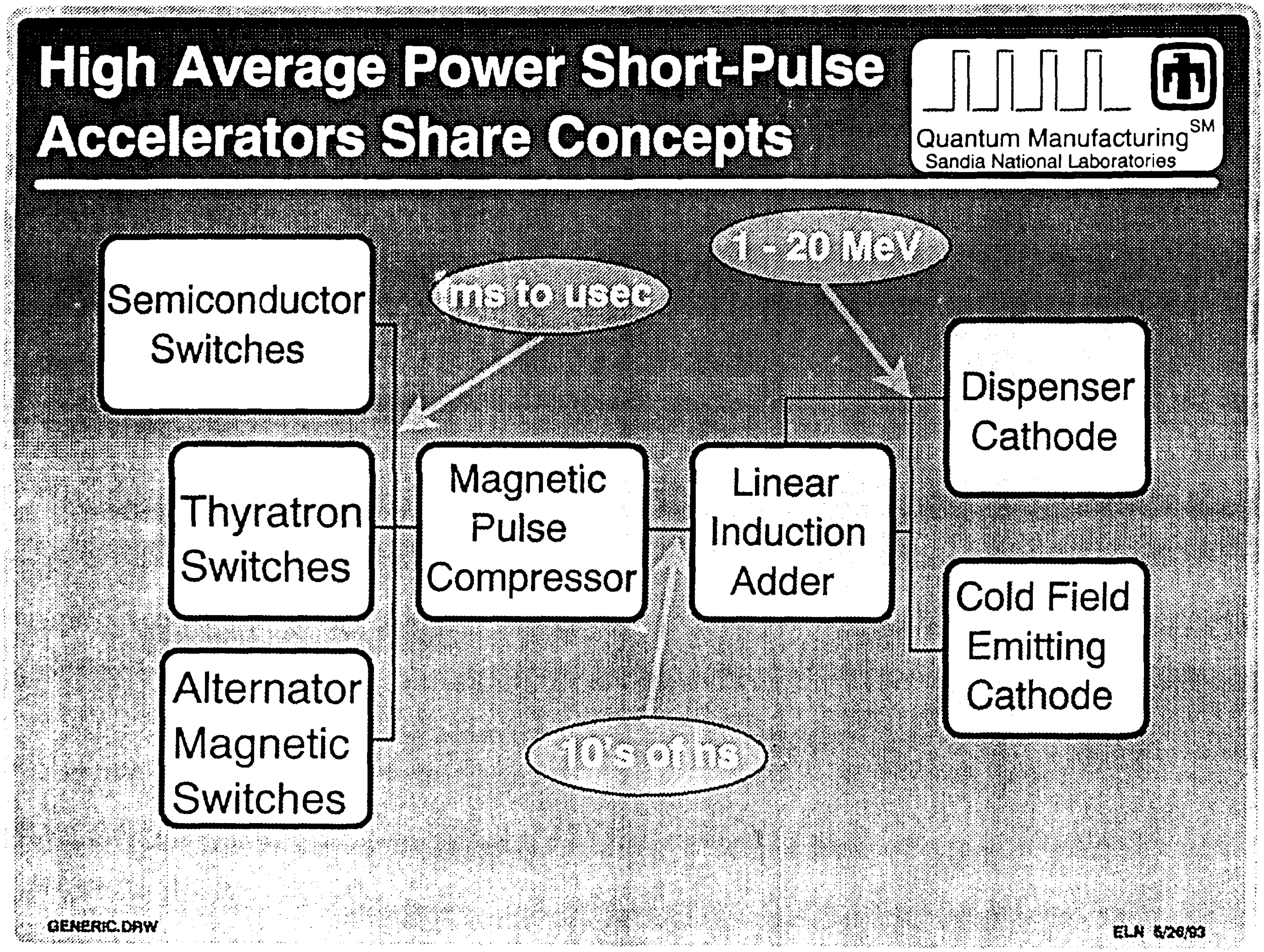
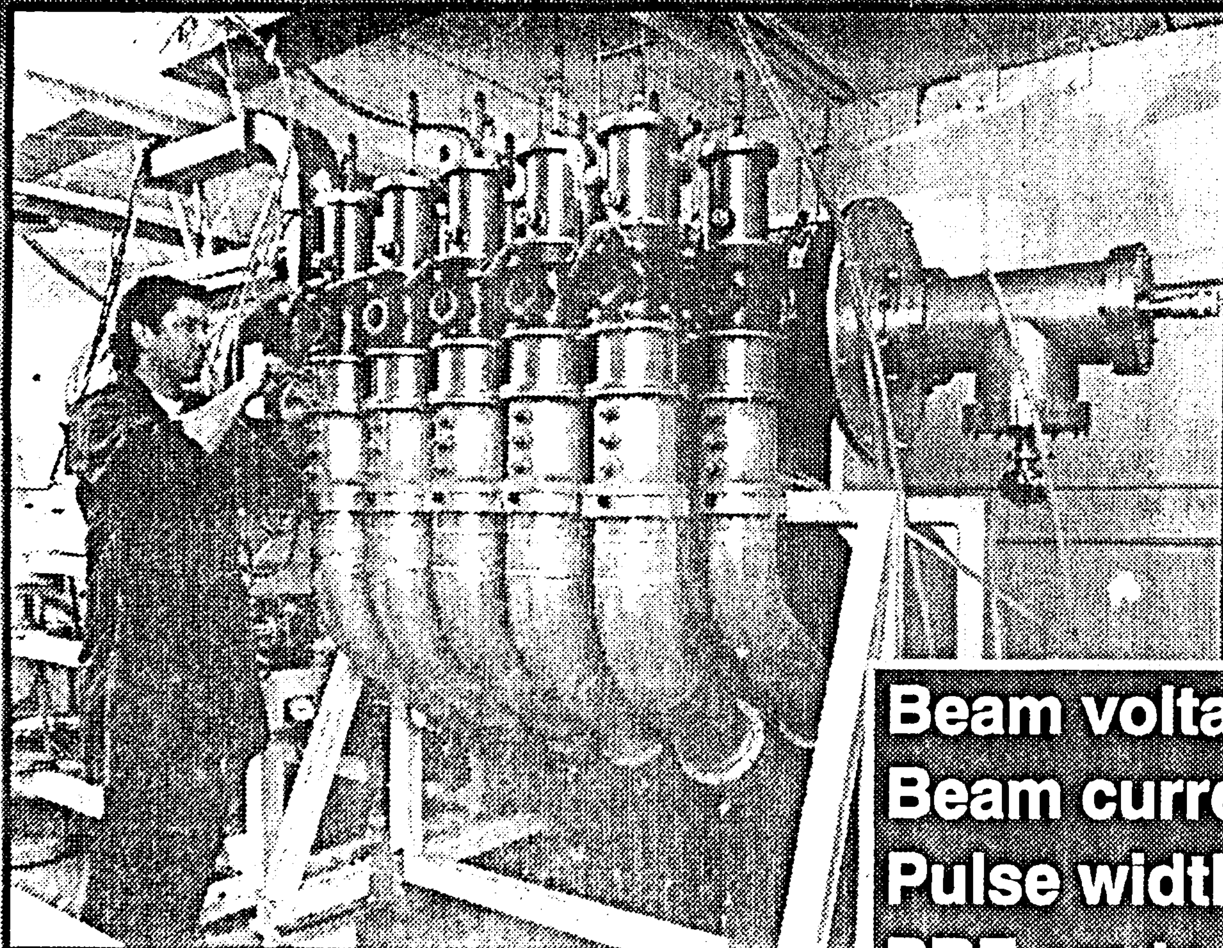

High Average Power Short-Pulse Accelerators Share Concepts
Quantum Manufacturing SM
Sandia National Laboratories
Semiconductor Switches
Thyratron Switches
Alternator Magnetic Switches
ms to usec
Magnetic Pulse Compressor
10's of ns
Linear Induction Adder
1 - 20 MeV
Dispenser Cathode
Cold Field Emitting Cathode
GENERIC.DRW
ELN 5/26/93

The Physics International CLIA Accelerator Uses Thyratrons and Magnetic Switches



Pout = 120 kW

Beam voltage = 750 keV
Beam current = 10 kA
Pulse width = 100 nS
PRF, up to 250 Hz

Courtesy of S. Ashby

The Magnetic Pulse Compressor can drive a Pulse Forming Network with high voltage cable output

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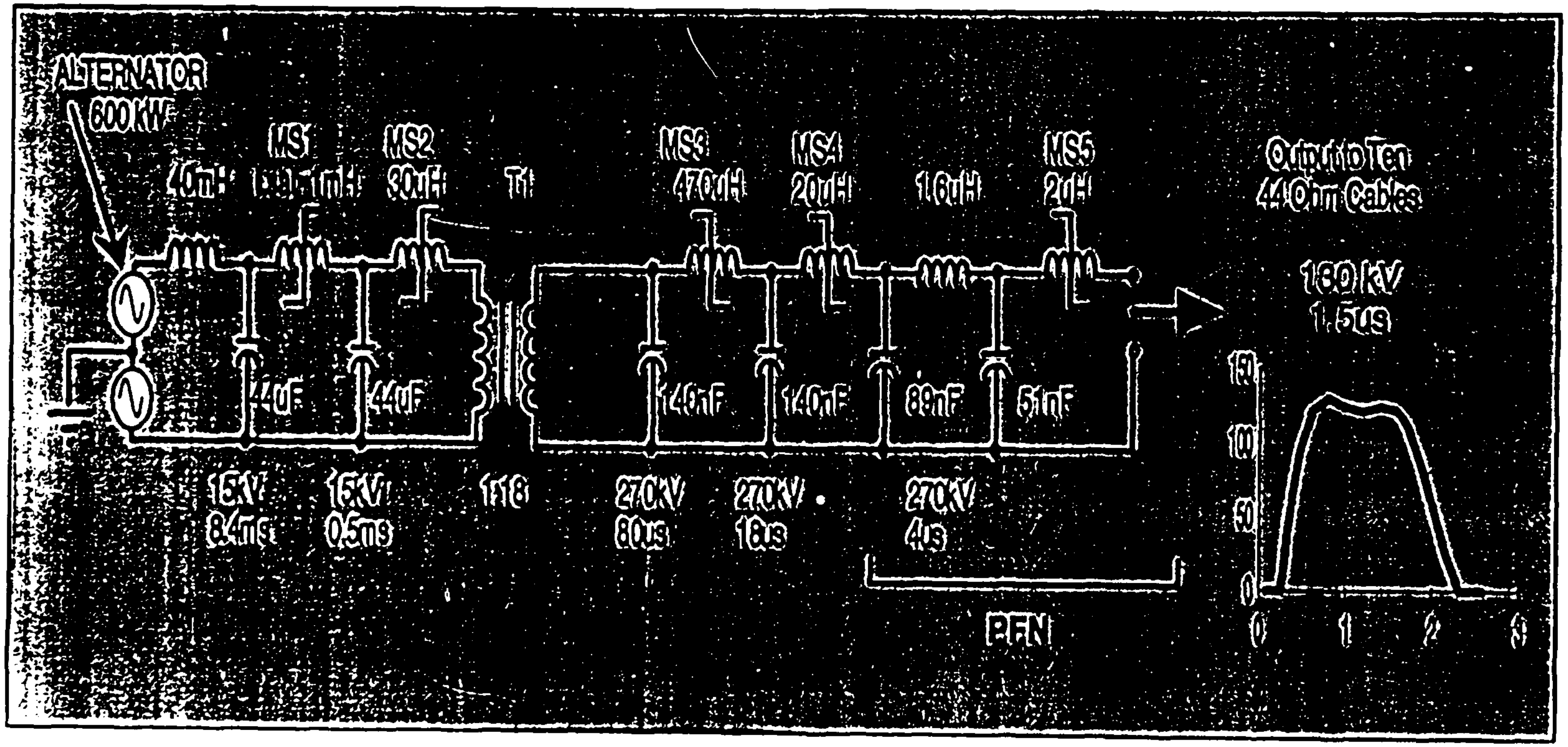
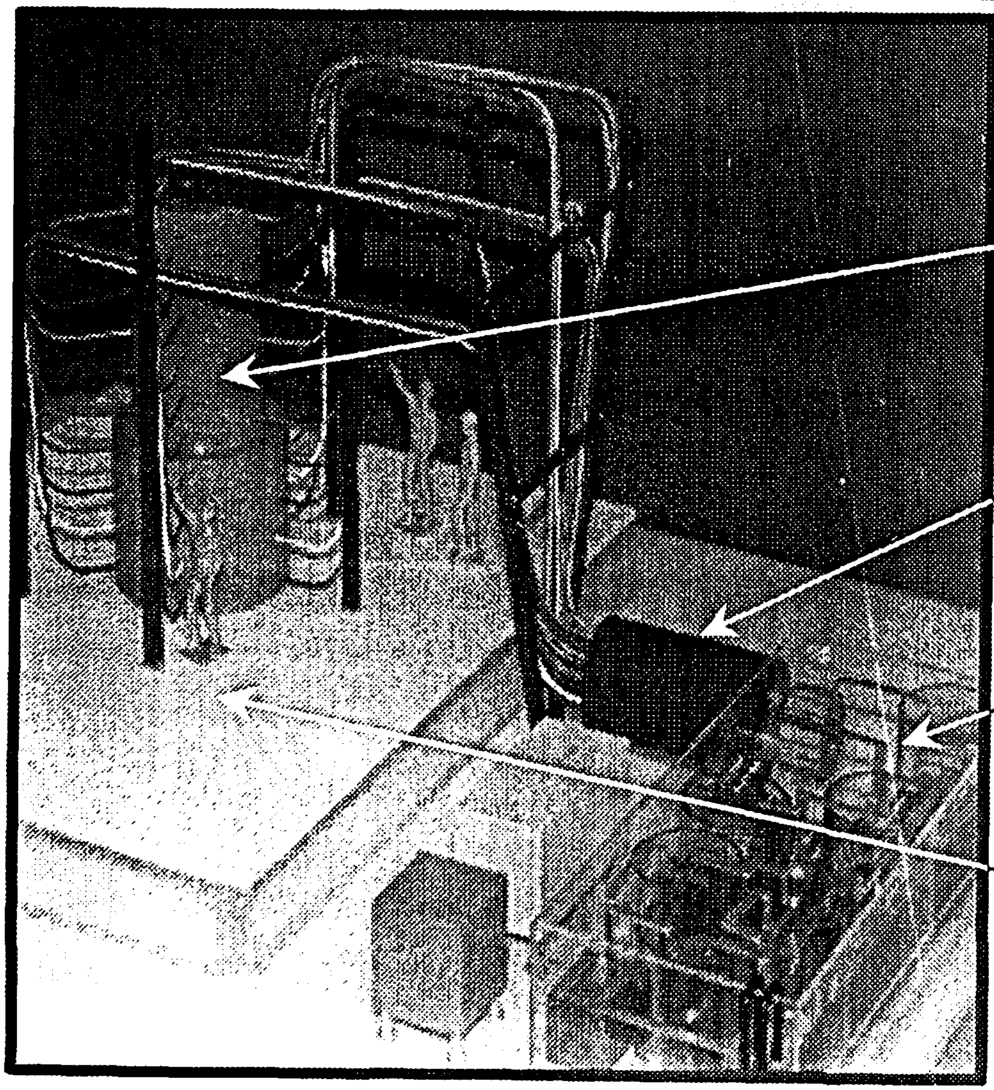


C DSHRDATA SMKSTK KHPPFN DKA

DLJ 9.16.92

RHEPP SYSTEM WILL GENERATE 400 KW BEAMS

Sandia National Laboratories



2.5 MV, 10 STAGE INDUCTION ADDER

60 NS PULSE COMPRESSOR

1 μSEC PULSE COMPRESSOR

DIODE & CONVERTER BELOW SHIELD BLOCKS

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ELN 7/8/92

FIRST STAGE SWITCH USES SILICON IRON CORES AND OIL COOLED WIRE WINDINGS

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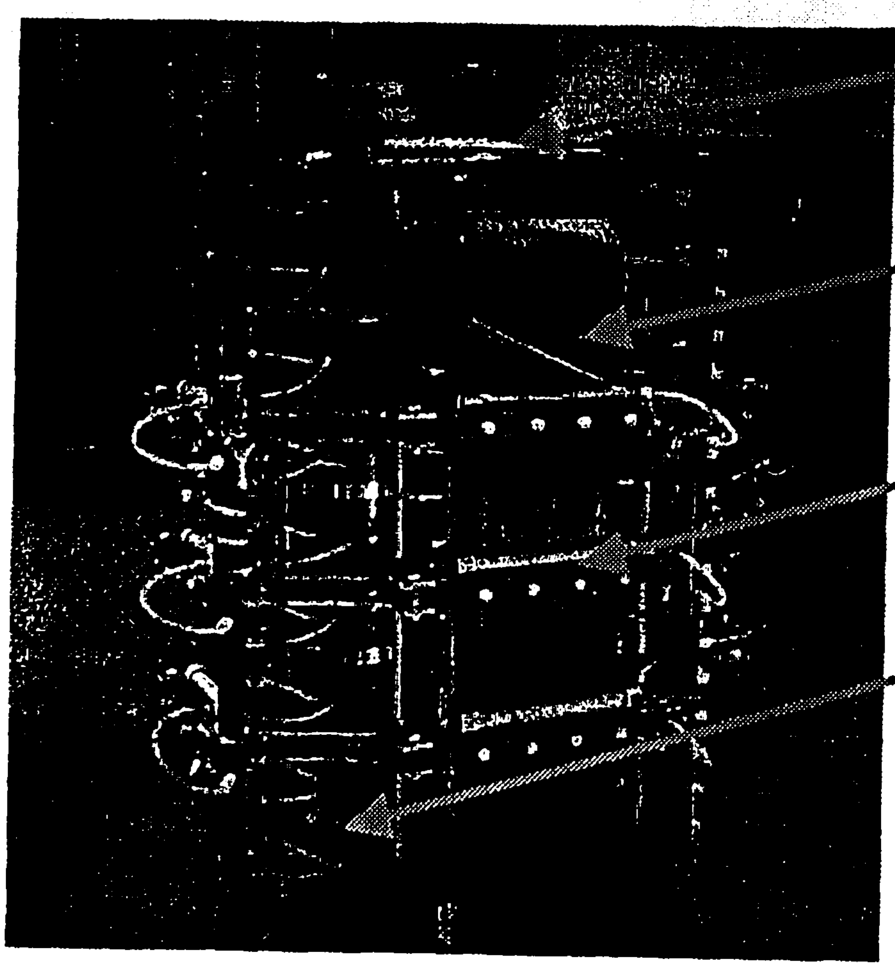

RESET WINDINGS

WIRE WINDINGS

OIL COOLING PORTS

SILICON-IRON CORES

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ELN 5/20/92

FIRST 250 KV MAGNETIC SWITCH IS OPERATIONAL AT 600 KW POWER LEVEL

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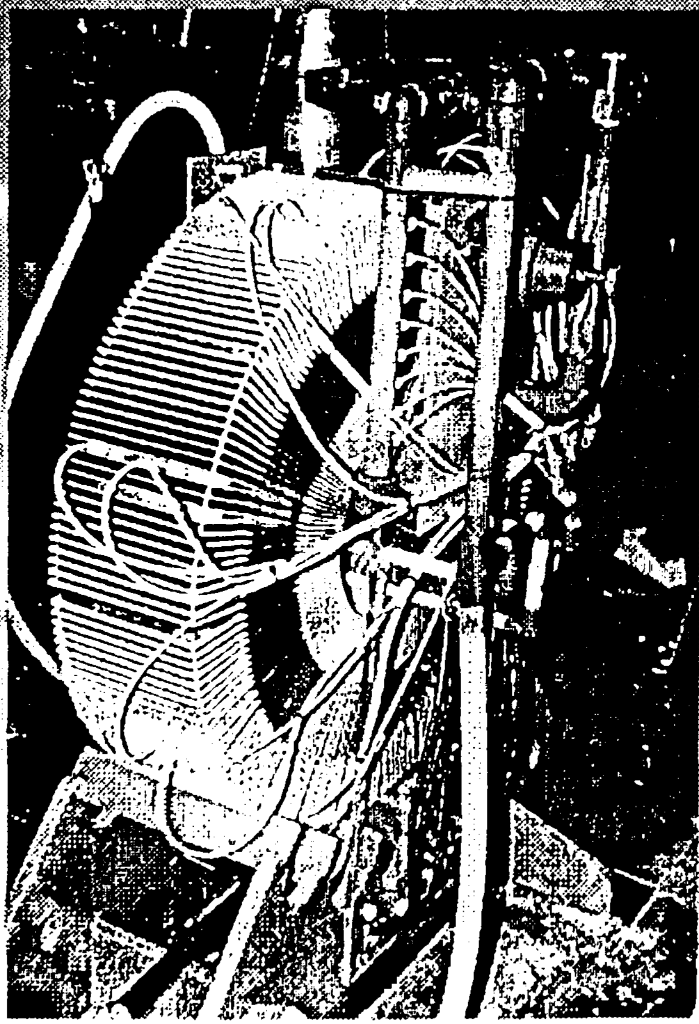

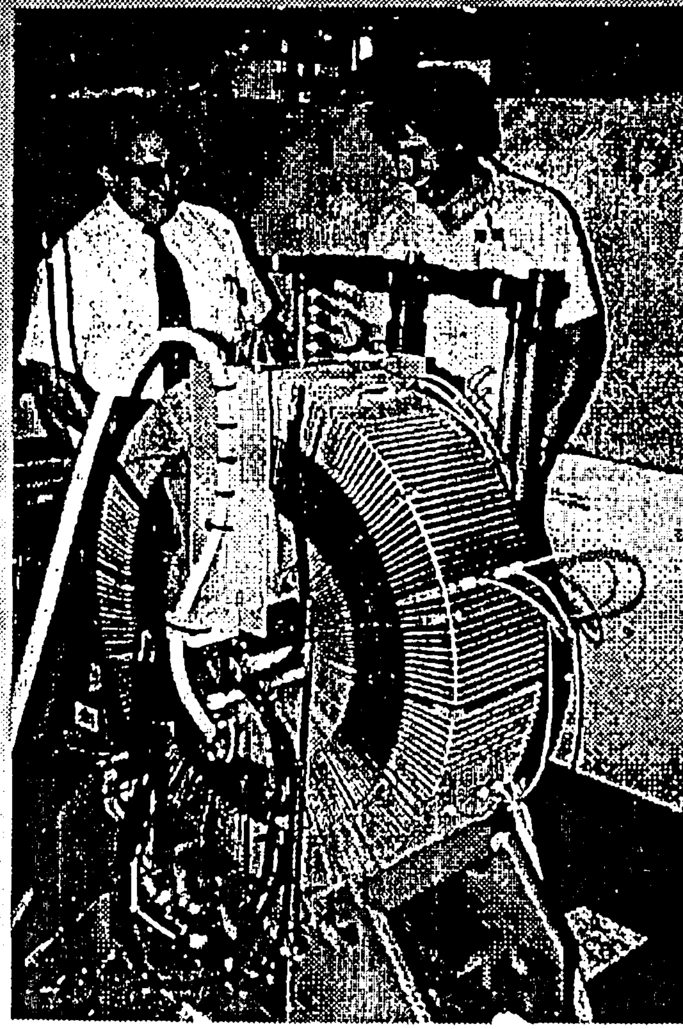

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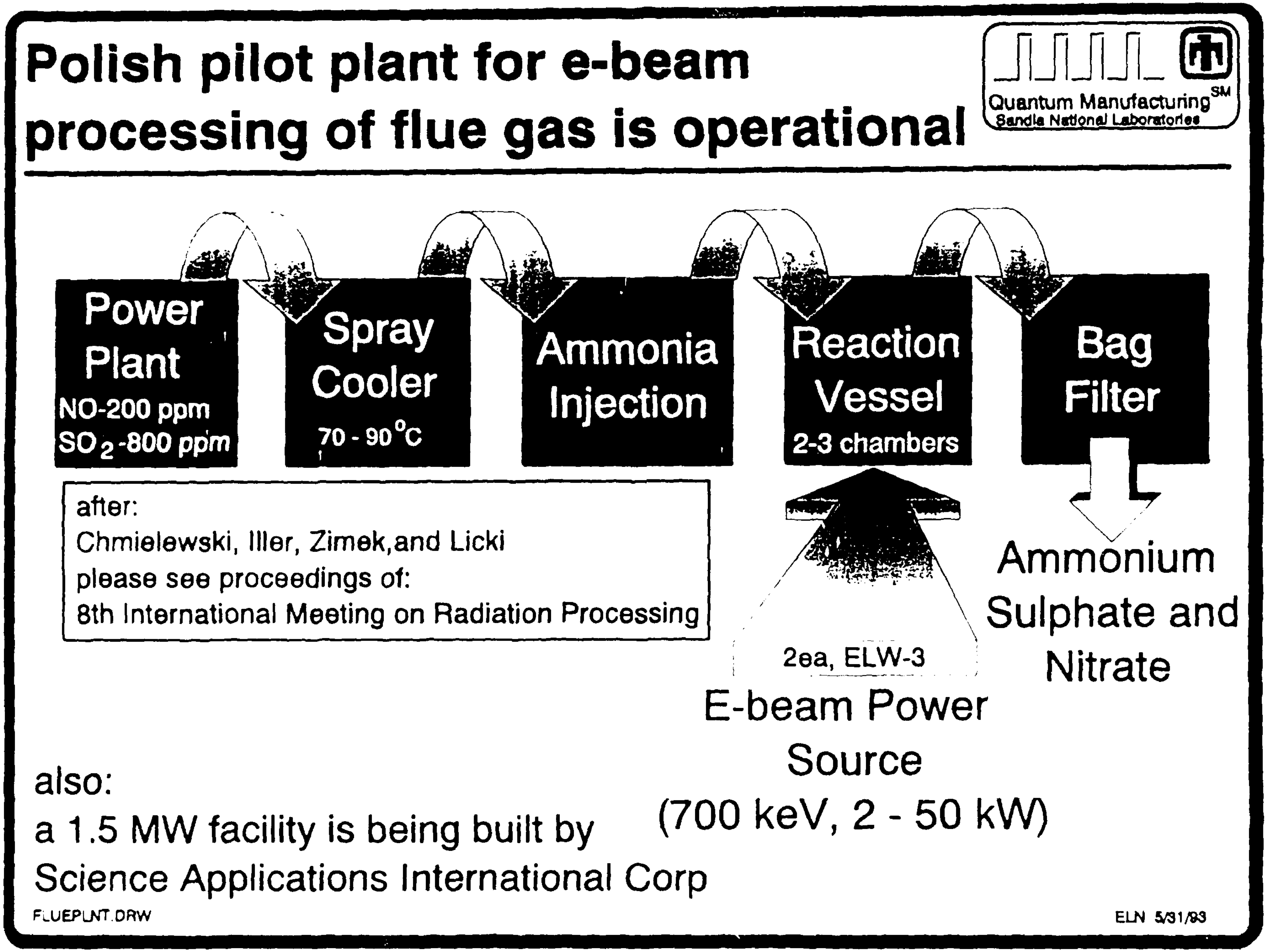

Polish pilot plant for e-beam processing of flue gas is operational
Quantum Manufacturing SM
Sandia National Laboratories
Power Plant
NO-200 ppm
SO_2-800 ppm
Spray Cooler
70 - 90 °C
Ammonia Injection
Reaction Vessel
2-3 chambers
Bag Filter
Ammonium Sulphate and Nitrate
after:
Chmielewski, Iller, Zimek, and Licki
please see proceedings of:
8th International Meeting on Radiation Processing
2ea, ELW-3
E-beam Power Source
(700 keV, 2 - 50 kW)
also:
a 1.5 MW facility is being built by
Science Applications International Corp
FLUEPLNT.DRW
ELN 5/31/93

Pulsed plasma reactors can destroy NO_X, additives improve process

Quantum Manufacturing[SM]
Sandia National Laboratories

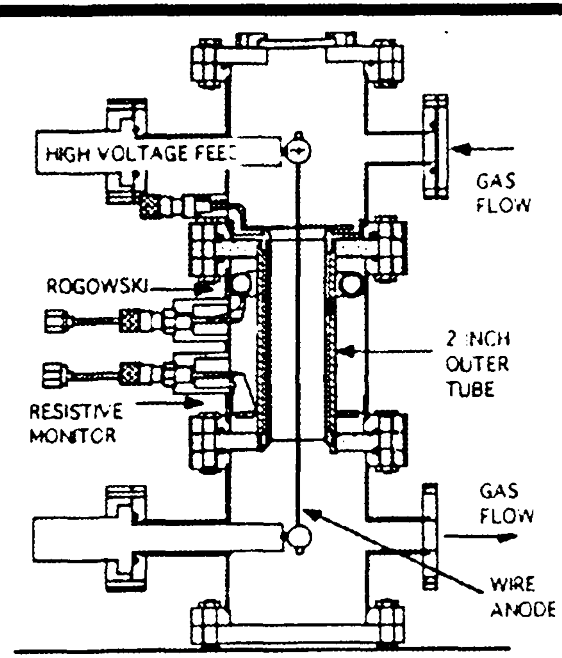

Figure 2 Processor

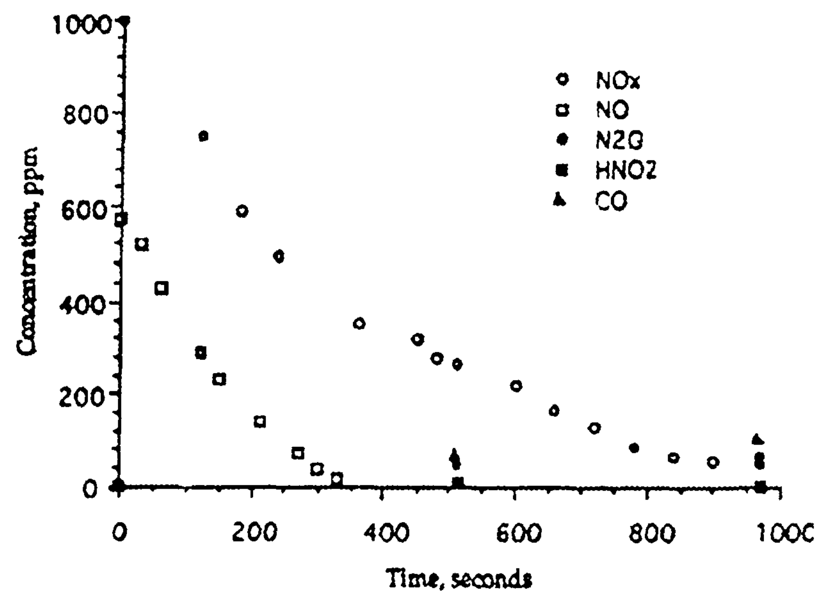

Figure 7. Pulsed Plasma Processing of NO_X in Wet Air with n-Octane

Pulsed reactor:
Vp ≐ 50 kV,
FWHM < 200 ns

NO_X destruction vs time with n-Octane additive

from: G. E. Vogtlin, LLNL

VOGTPROC.DRW

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THE PFL PROVIDES PULSE SHAPING & TWO STAGES OF MAGNETIC PULSE COMPRESSION

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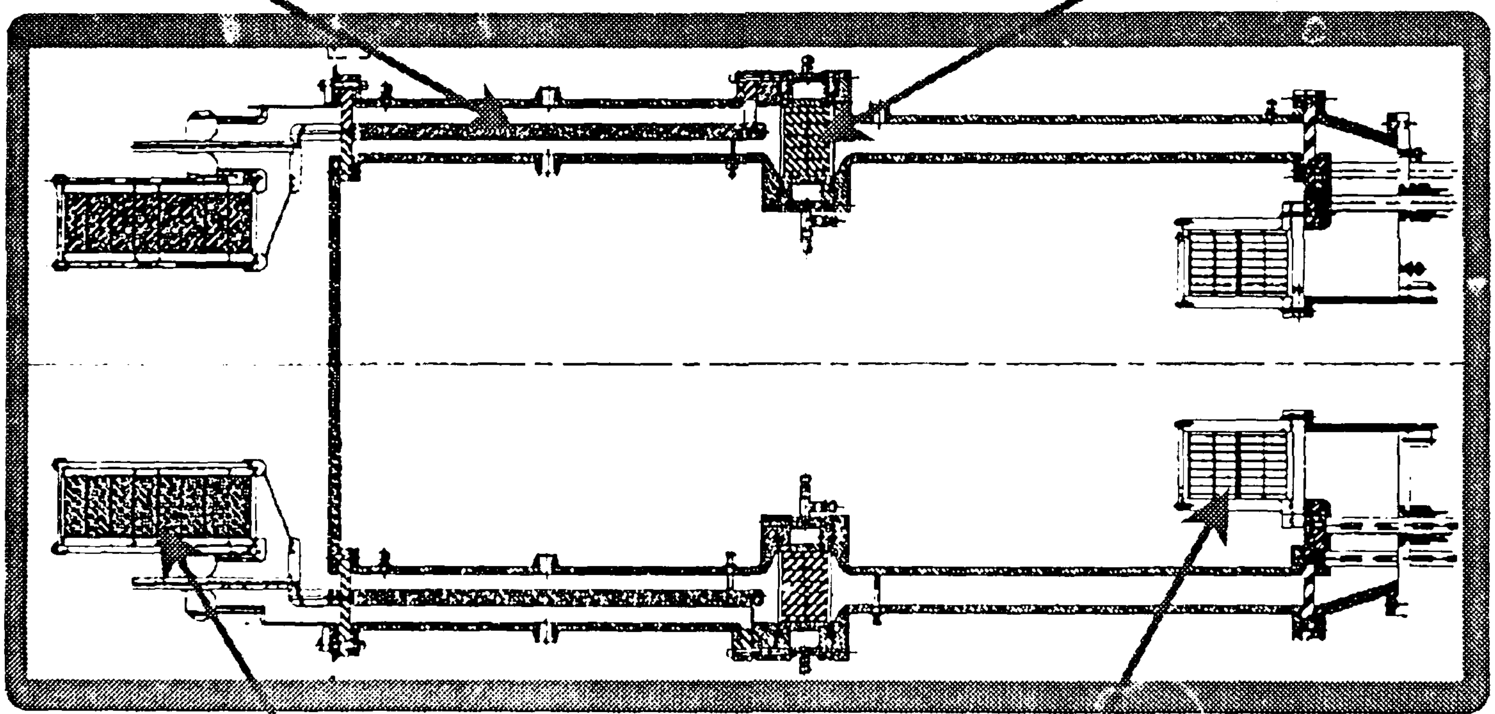

EFFICIENCY = 90%

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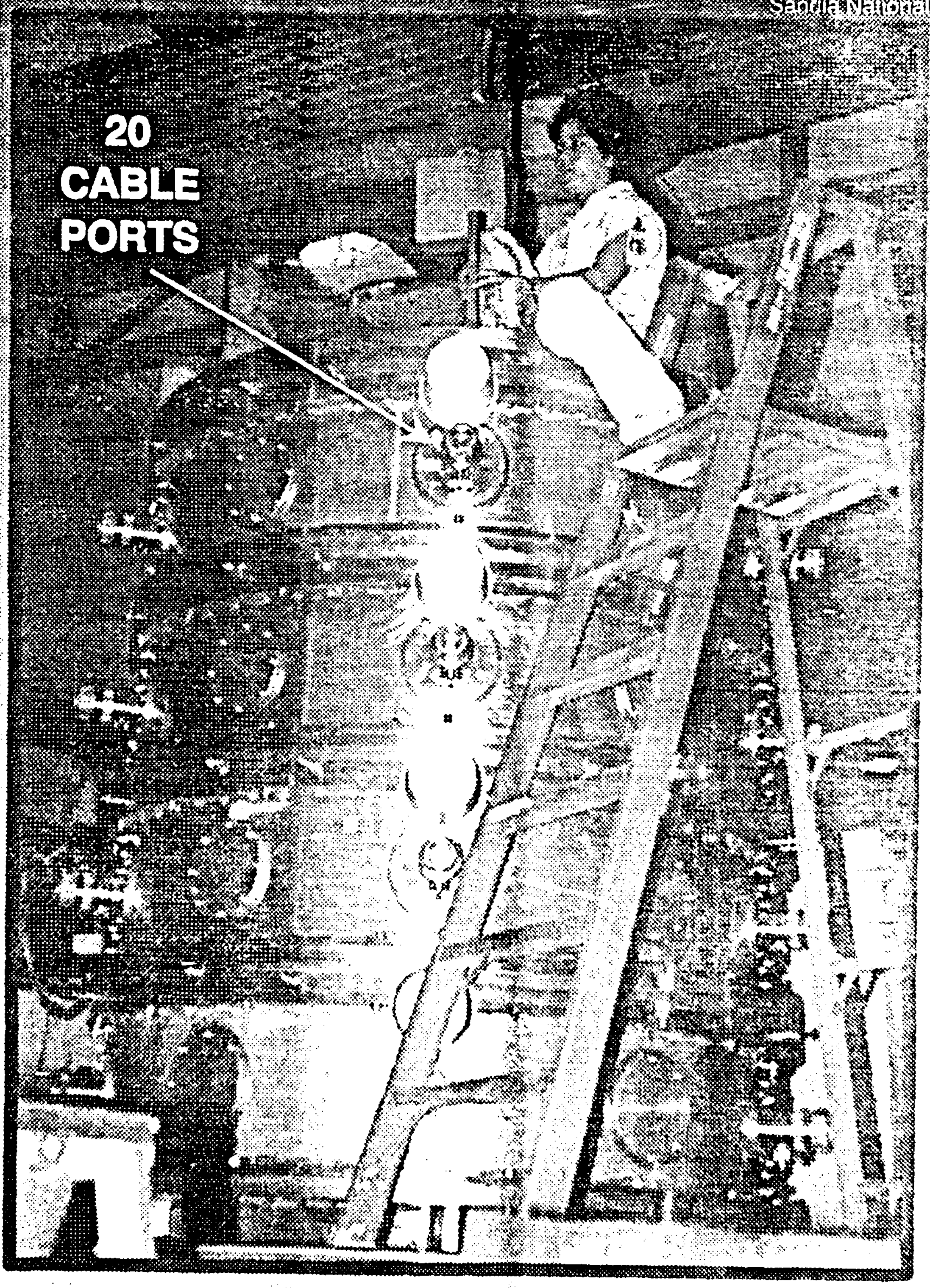
RWW 6/18/92

1 MV, 4 STAGE, LINEAR INDUCTION ADDER IS ASSEMBLED ON SHIELDING PIT

Sandia National Laboratories

LIVA



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REPETITIVE INDUCTION ADDERS USING AN MITL OR VACUUM INSULATION NEEDED FOR HV ACCELERATORS

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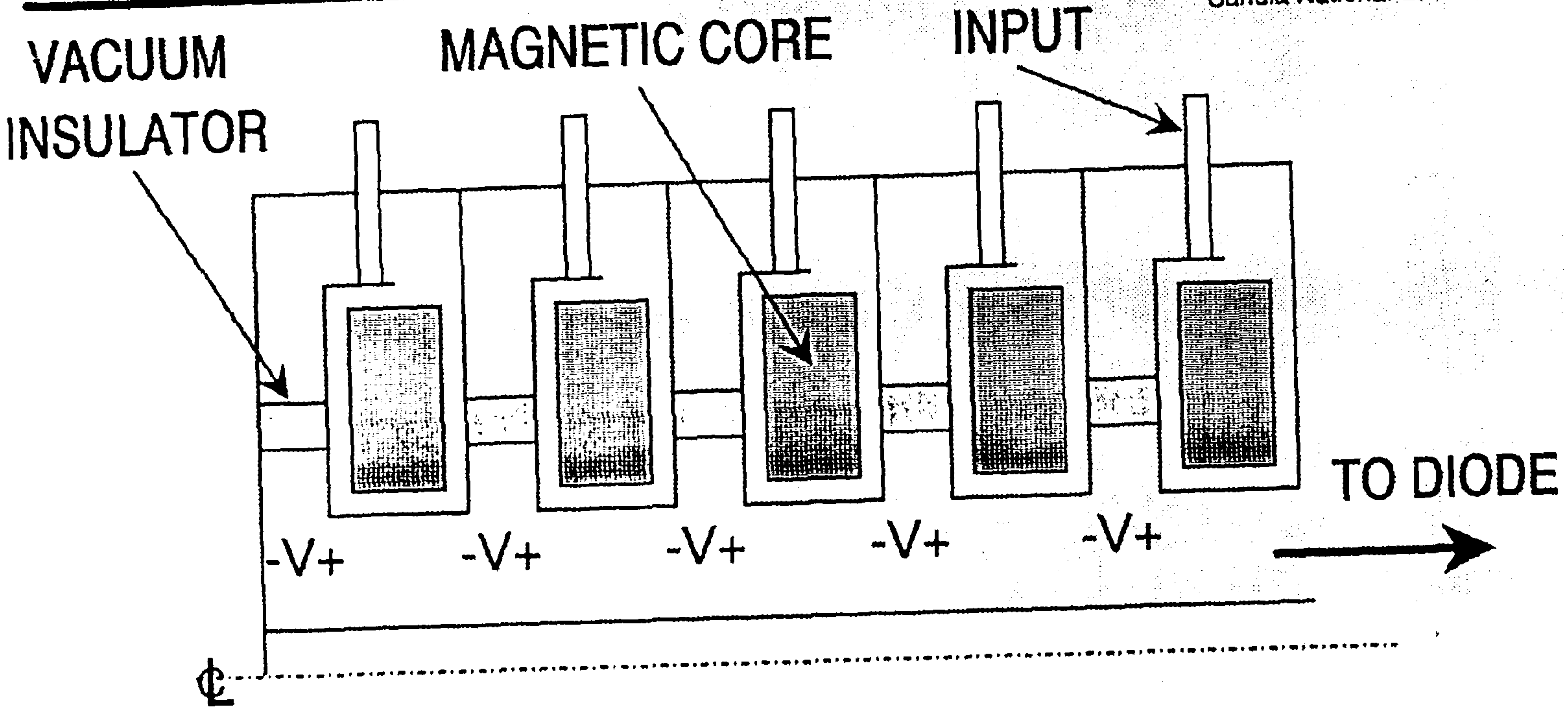

A) EXAMPLES - HELIA, HERMES III, RHEPP

B) PARAMETERS (SINGLE SHOT DEMONSTRATED)

VOLTAGE: 4 TO 20 MEV

CURRENT: 10 TO 700 KA

ELN 7/9/92

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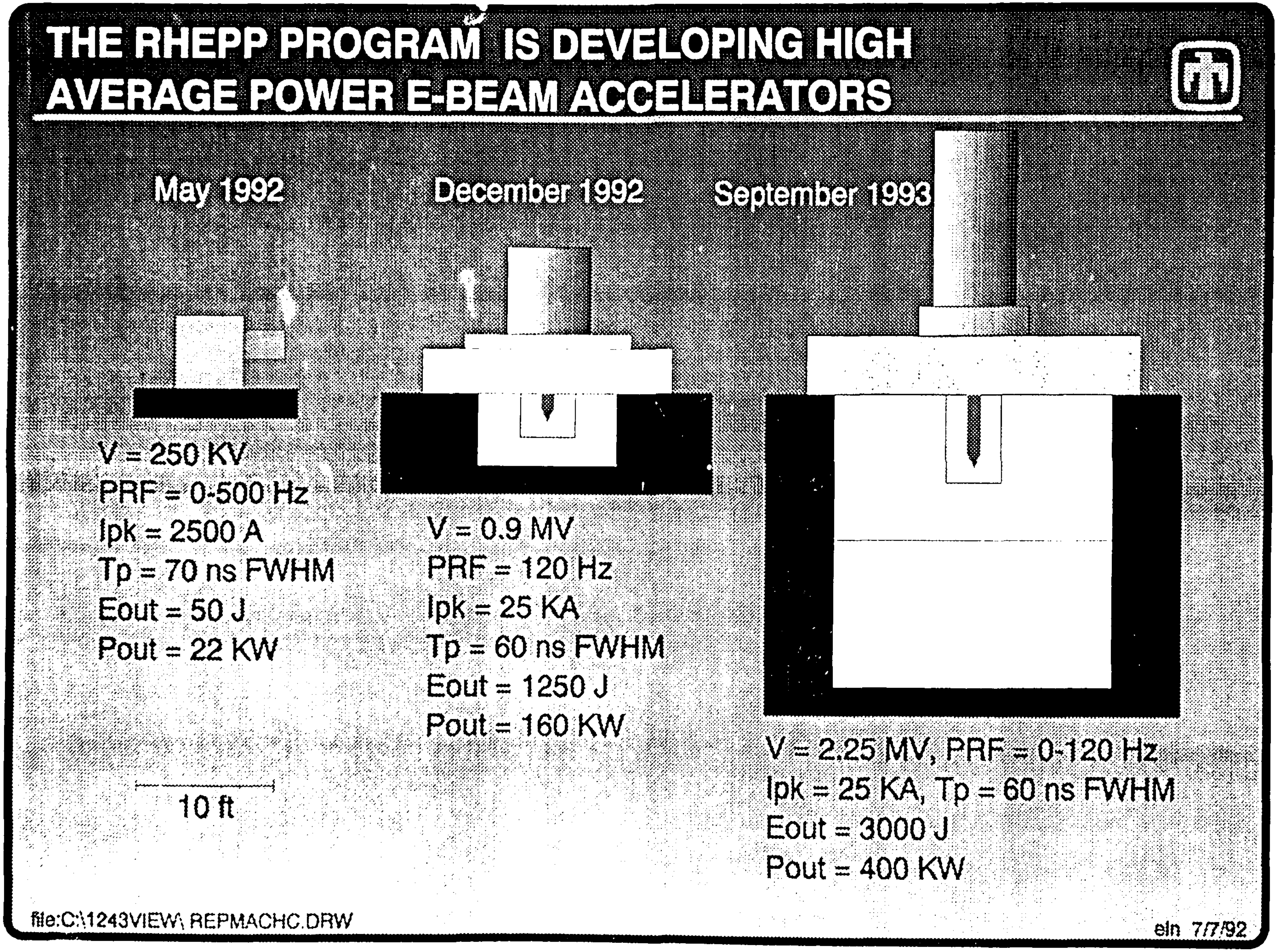

THE RHEPP PROGRAM IS DEVELOPING HIGH AVERAGE POWER E-BEAM ACCELERATORS
May 1992
December 1992
September 1993
V = 250 KV
PRF = 0-500 Hz
Ipk = 2500 A
Tp = 70 ns FWHM
Eout = 50 J
Pout = 22 KW
V = 0.9 MV
PRF = 120 Hz
Ipk = 25 KA
Tp = 60 ns FWHM
Eout = 1250 J
Pout = 160 KW
V = 2.25 MV, PRF = 0-120 Hz
Ipk = 25 KA, Tp = 60 ns FWHM
Eout = 3000 J
Pout = 400 KW
10 ft
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eln 7/7/92

The MAP ion beam system on RHEPP is compact, easy to maintain

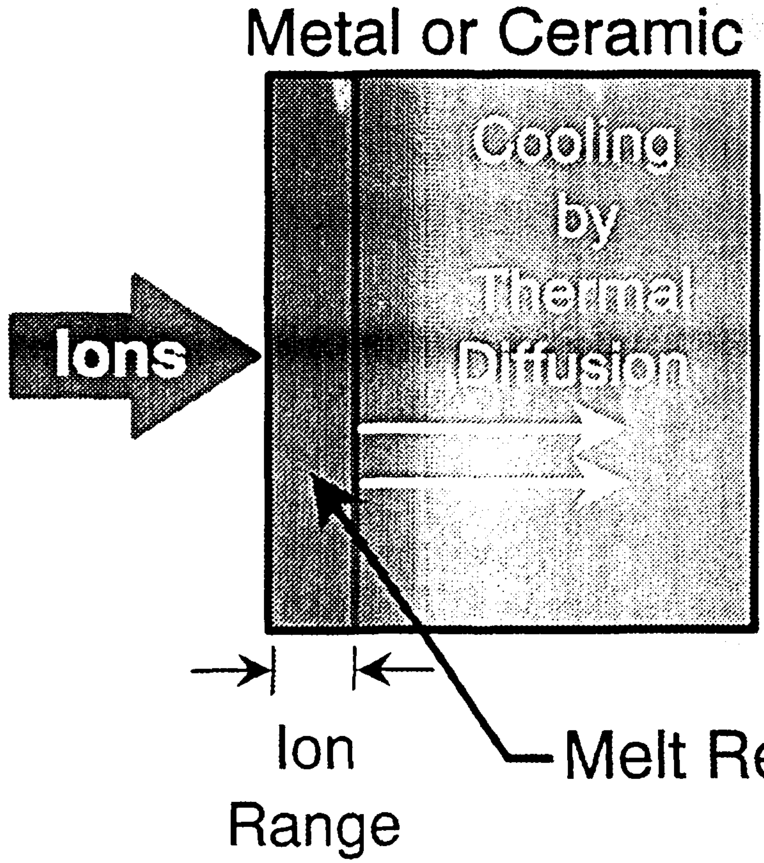
Quantum Manufacturing
Sandia National Laboratories

The Cornell Magnetically-confined Anode Plasma ion beam system is designed for repetitive operation on RHEPP at 1 MeV and 50 kA.

This initial version is designed for operation in burst mode only.

IBEST Uses Pulsed Ion Beams to Melt and Modify Surfaces

Quantum Manufacturing[SM]
Sandia National Laboratories



Ion BEam Surface Treatment

- H^+ beam at 0.5 - 1 MeV
- Ion range of 3 - 7 micrometers
- 2 - 8 J/cm^2 for melt
- Rapid cooling (10^{10} °K/s) due to thermal diffusion into substrate

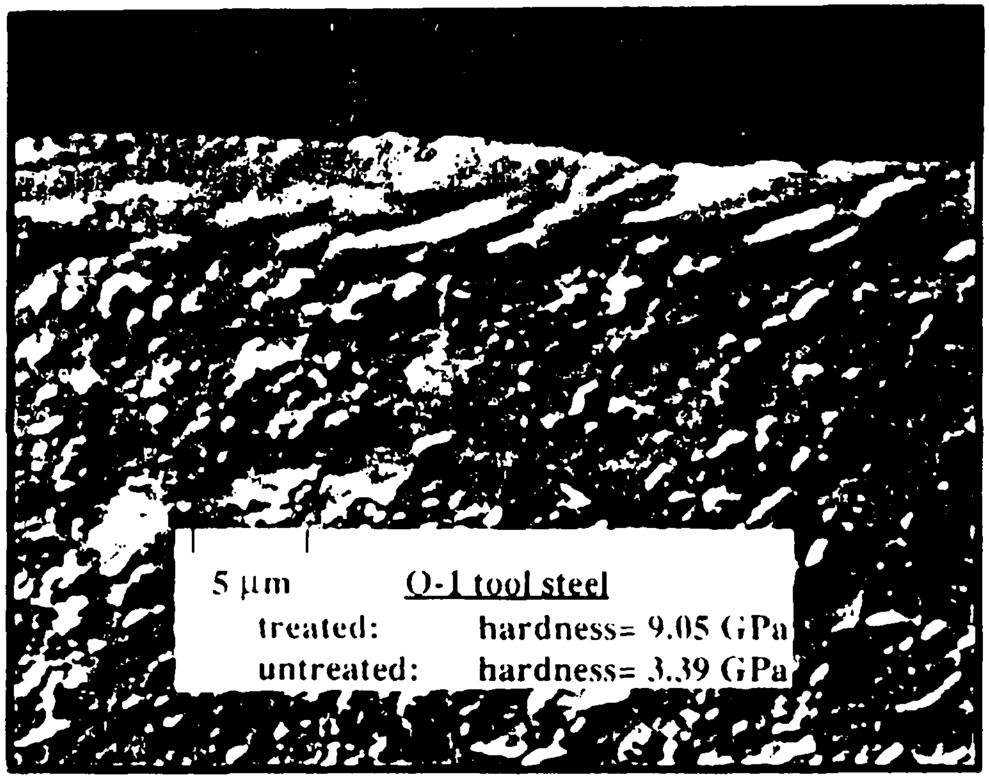
IBESTMLT.DRW

ELN 5/27/93

IBEST Modifies Material Surfaces and Increases Hardness

Quantum Manufacturing[SM]
Sandia National Laboratories

Titanium machined surface



Tool steel surface hardening

ELN 5/27/93
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Many scientific studies and conferences have shown the advantages of irradiation for food safety.

Sandia National Laboratories

AGRICULTURAL RESEARCH INSTITUTE

Safeguarding the Food Supply through Irradiation Processing Techniques

An International Conference
on
Facilitating the Commercial Adaptation of Food Irradiation Technology

October 25-31, 1992

Sheraton World Resort
Orlando, Florida USA

Presented by
The Agricultural Research Institute
9650 Rockville Pike
Bethesda, MD 20814 USA

- Ionizing radiation treatment
- Increases food safety by effectively controlling pathogenic bacteria growth:
  - Salmonella
  - Trichinae
  - E. coli
  - Vibrio Vulnificus
- No residual radioactivity
- Effective for insect disinfestation
- Can reduce spoilage and extend shelf-life
- No harmful chemical changes
- Insignificant adverse effect to nutritional value

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LOW DOSES OF RADIATION CAN BE USEFUL IN CONTROLLING FOOD BORNE DISEASES

Sandia National Laboratories

IN THE UNITED STATES, FOOD BORNE DISEASES:

- CLAIM 7000 LIVES PER YEAR
- CAUSE 24-81 MILLION CASES OF DIARRHEAL DISEASES AT A COST OF $5B - $17B (FDA)
  (CENTER FOR DISEASE CONTROL)

DOSES OF 0.1 TO 1 MRAD CONTROL THE PATHOGENIC BACTERIA

- (CODEX ALIMENTARIUS COMMISSION)

APPROVED IN 37 COUNTRIES

- 40 FOOD PRODUCTS
- 24 COUNTRIES HAVE COMMERCIAL OPERATIONS
  (ELECTRONS ARE USED TO IRRADIATE DEBONED CHICKEN IN FRANCE)

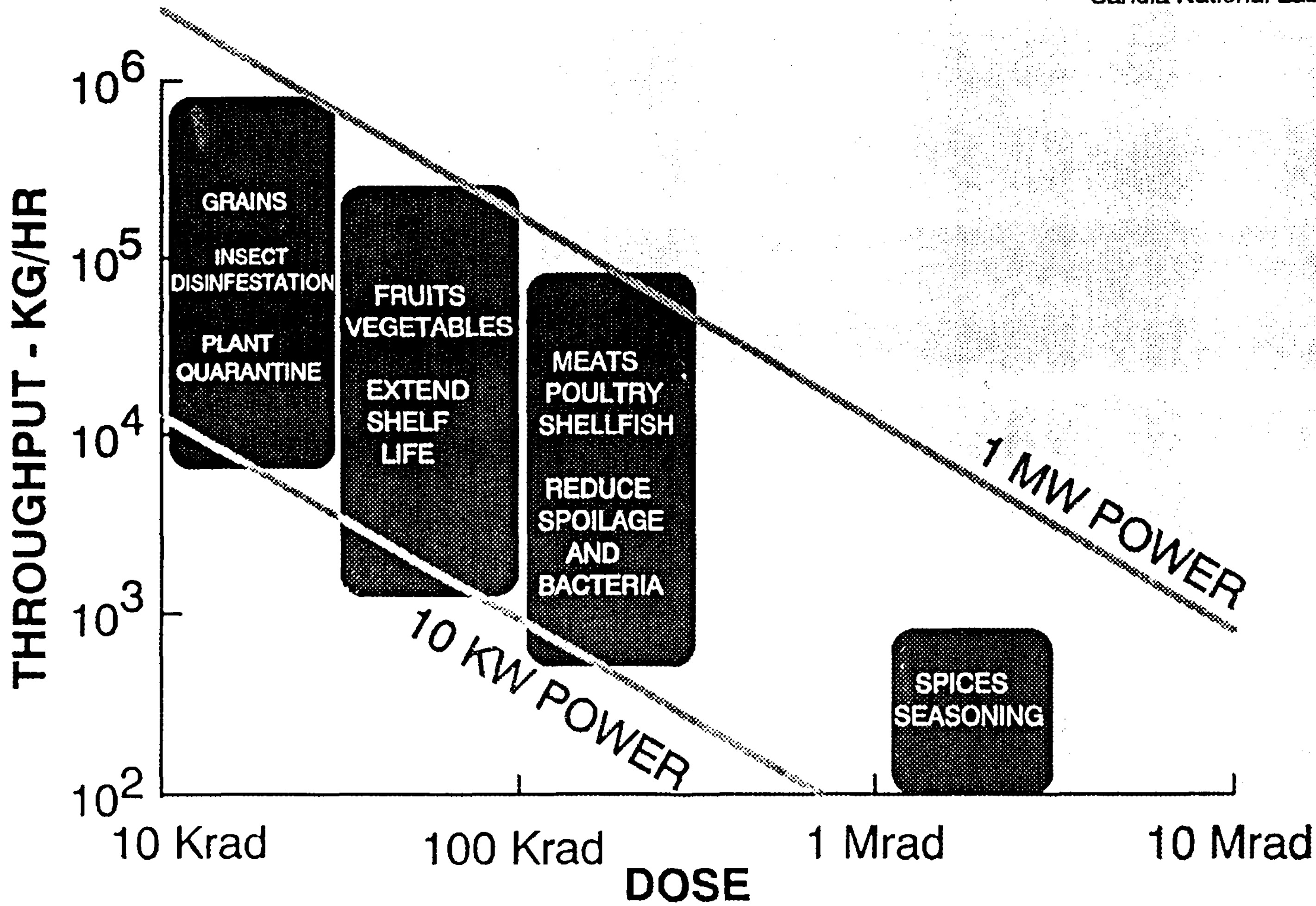
[SOURCE - INTERNATIONAL CONSULTATIVE GROUP ON FOOD IRRADIATION]

C:\1243VIEW\DISEASE.DRW

ELN 1/19/93

HIGH AVERAGE POWER X-RAY GENERATORS ARE REQUIRED FOR VOLUME FOOD PROCESSING

Sandia National Laboratories



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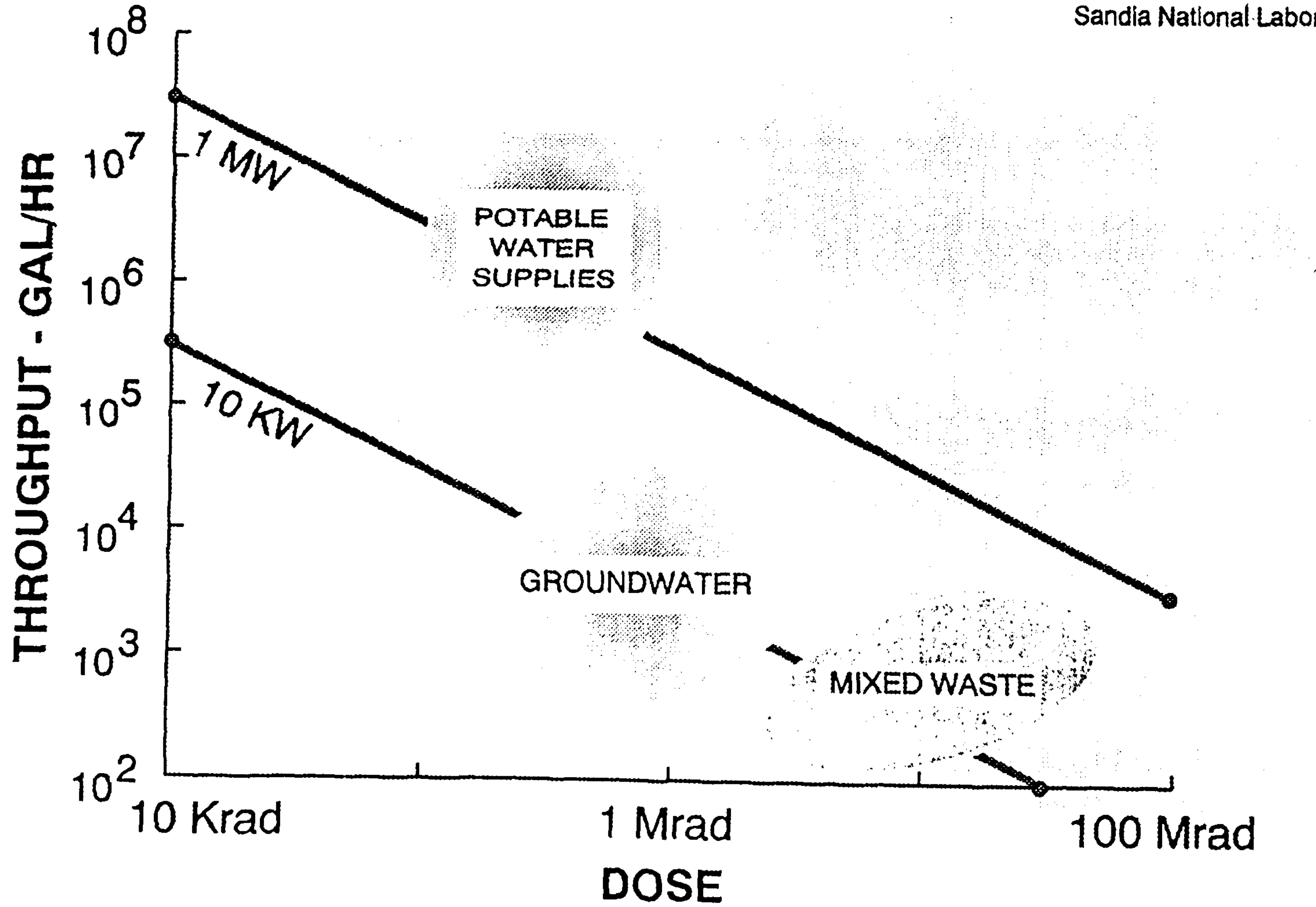
ELN 1/19/93

IRRADIATION WITH E-BEAMS CAN EFFECTIVELY DESTROY VARIOUS ORGANIC CONTAMINANTS

Sandia National Laboratories



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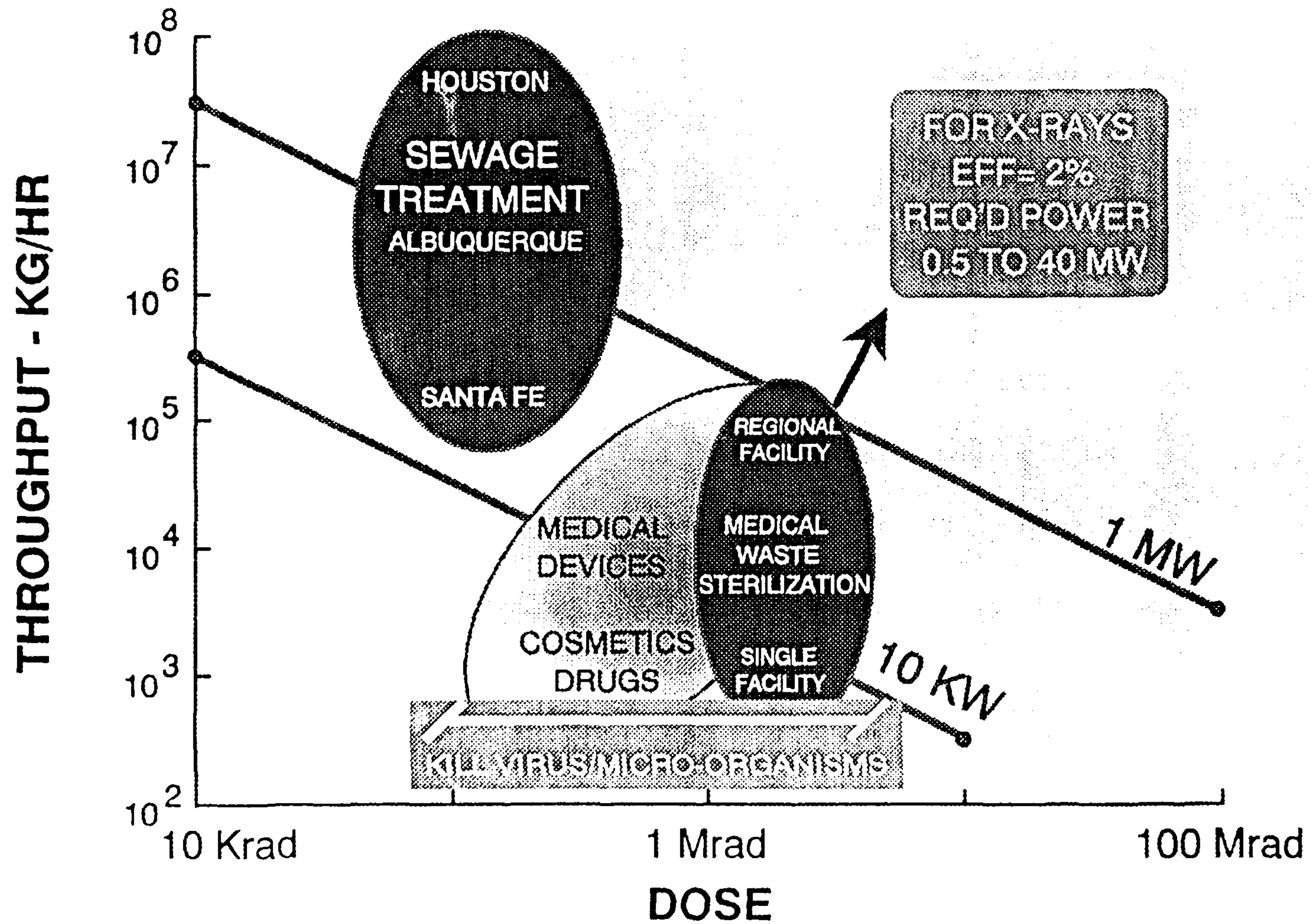
ELN 1/19/93

BEAM STERILIZATION OF BIOLOGICAL HAZARDS BECOMES FEASIBLE AT REALISTIC FLOW RATES

Sandia National Laboratories



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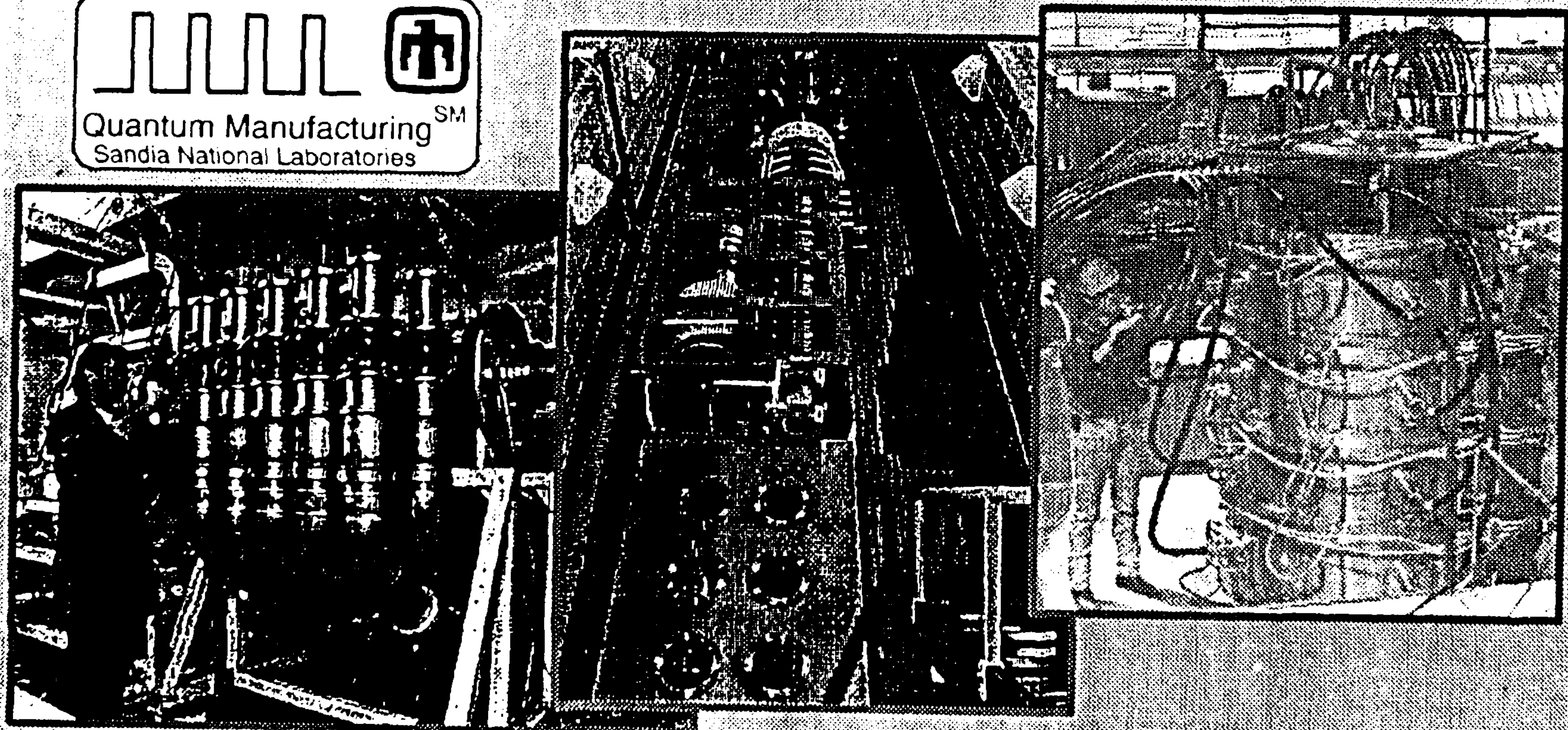
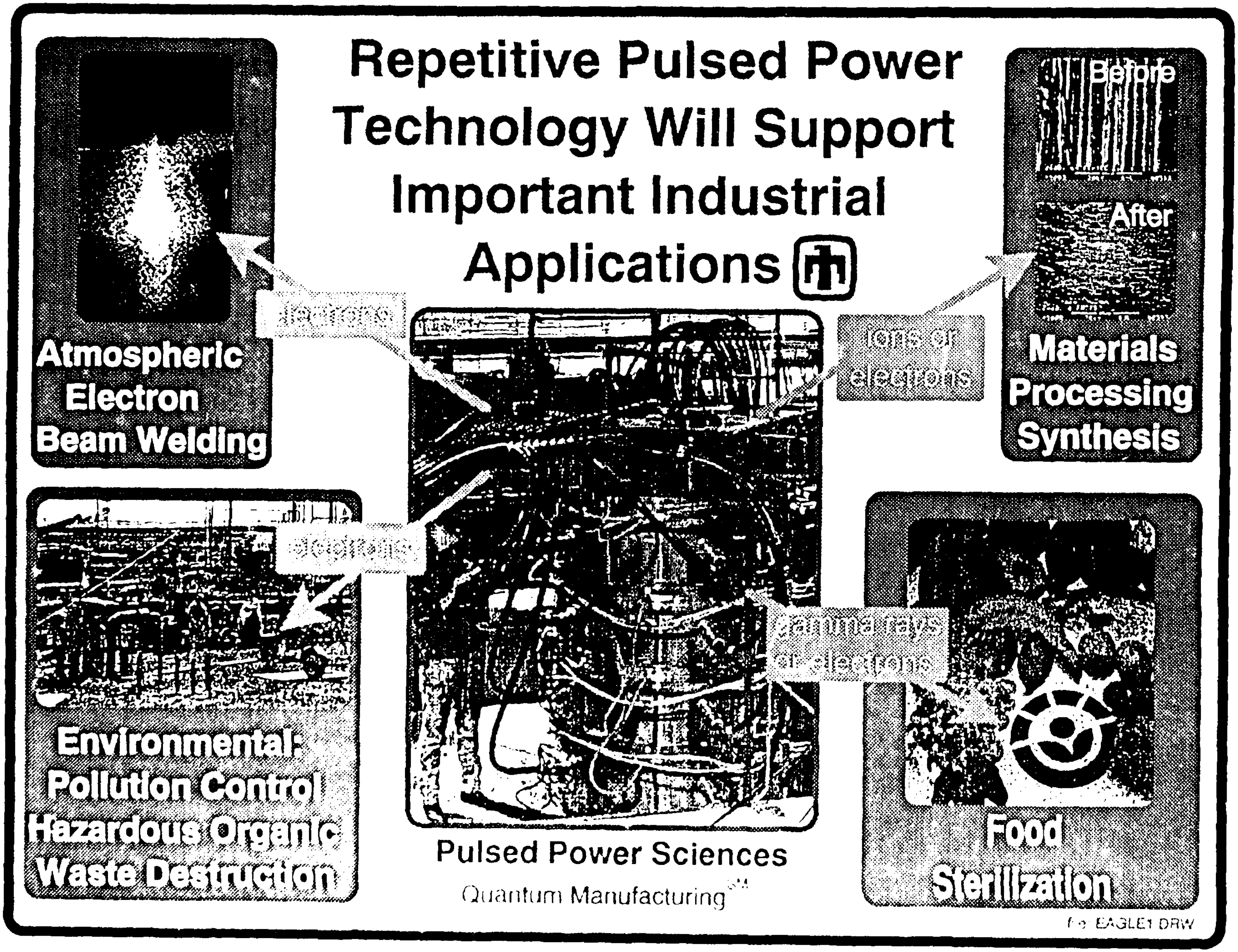
ELN 6/20/92

The near term availability of short-pulse high average power accelerators is opening the door for new environmental and industrial applications.

Quantum Manufacturing^SM
Sandia National Laboratories




Repetitive Pulsed Power Technology Will Support Important Industrial Applications
Atmospheric Electron Beam Welding
electrons
Before
After
ions or electrons
Materials Processing Synthesis
electrons
Environmental: Pollution Control Hazardous Organic Waste Destruction
gamma rays or electrons
Food Sterilization
Pulsed Power Sciences
Quantum Manufacturing SM
EAGLE1.DRW

MAXWELL
BALBOA Division

COMMERCIALIZATION OF PULSED POWER AT MAXWELL, PART II

PRESENTED BY

EDMOND Y. CHU

MAXWELL
BALBOA Division

PRESENTATION OVERVIEW

- BRIEF DESCRIPTION OF MAXWELL
- QUESTIONS WE HAD PRIOR TO COMMERCIALIZATION
- THINGS WE LEARNED TO DATE
- CHALLENGES AHEAD OF US

MAXWELL
BALBOA Division

BRIEF HISTORY OF MAXWELL

- FOUNDED IN 1966 TO DEVELOP AND MANUFACTURE HIGH ENERGY DISCHARGE CAPACITORS
- DEVELOPMENT OF PULSED POWER TECHNOLOGY HAS BEEN DRIVEN BY DNA'S NEED TO DEVELOP NUCLEAR WEAPON EFFECTS SIMULATOR
- WE HAVE ALSO BEEN BUILDING VARIOUS CUSTOM DESIGNED PULSED POWER SYSTEMS FOR CUSTOMERS SUCH AS: GOVERNMENT AGENCIES, NATIONAL LABORATORIES, AEROSPACE COMPANIES.

MAXWELL
BALBOA Division

THE YEARS OF GROWTH

- 1984, MAXWELL MADE ITS FIRST ACQUISITION -- S-CUBED, A COMPANY THAT DERIVED MOST OF ITS REVENUE FROM GOVERNMENT
- IN THE SUBSEQUENT YEARS, WE ACQUIRED:
  - BROBECK, AN ACCELERATOR TECHNOLOGY COMPANY
  - PART OF IRT
  - I-BUS, A PC-BASED CONTROL ELECTRONICS COMPANY
  - SIERRA, A HIGH RELIABILITY, LOW VOLTAGE CAPACITOR COMPANY
- HAVE ALSO SPUN OFF THE FOLLOWING BUSINESS UNITS:
  - BUSINESS SYSTEMS: BUSINESS ACCOUNTING SOFTWARE
  - FOOD CO: FOOD PACKAGE STERILIZATION
- ORIGINAL MAXWELL HAS BECOME THE BALBOA DIVISION, WHICH STILL DERIVES MOST OF ITS REVENUE FROM GOVERNMENT (DIRECTLY OR INDIRECTLY)

MAXWELL
BALBOA Division

STRATEGIC GOAL FOR THE BALBOA DIVISION

ACCELERATE COMMERCIAL BUSINESS GROWTH IN ORDER TO ACHIEVE A MORE BALANCED GOVERNMENT AND COMMERCIAL BUSINESS BASE

MAXWELL
BALBOA Division

QUESTIONS WE HAD A FEW YEARS AGO REGARDING COMMERCIALIZATION

- HOW?
  - BY DEVELOPING NEW PRODUCTS?
  - THROUGH ACQUISITION?
- WHAT BUSINESS/PRODUCT?
- DO WE HAVE THE RIGHT PEOPLE?
- DO WE HAVE THE RIGHT CULTURE?
- DO WE HAVE THE RESOURCES?
- DO WE KNOW HOW TO SELL TO COMMERCIAL MARKET?
- WILL WE BE COMPETITIVE?
- ......

MAXWELL
BALBOA Division

WHAT WE LEARNED ABOUT TECHNOLOGY?

- RELIABILITY
- LONG LIFE
- CUSTOMER FOCUSED

MAXWELL
BALBOA Division

WHAT WE LEARNED ABOUT MANUFACTURING?

- HIGHEST QUALITY
- LOWEST COST
- RESPONSIVENESS

MAXWELL
BALBOA Division

MARKETING/SELLING

- BE CLOSE TO THE CUSTOMER
- LISTEN WELL

MAXWELL
BALBOA Division

THE THREE-RING CIRCUS MODEL FOR PRODUCT/BUSINESS DEVELOPMENT GIVEN LIMITED RESOURCES

- THREE SETS OF CLOSELY COORDINATED ACTIVITIES:
  - TECHNOLOGY/ENGINEERING
  - MANUFACTURING
  - MARKETING/SELLING
- DIFFERENT STAGES OF THE DEVELOPMENT REQUIRE MORE EMPHASIS ON PARTICULAR SET OF ACTIVITIES
- BY FOCUSING RESOURCES ON ONE SET OF ACTIVITIES AT A TIME, DESIRABLE GROWTH CAN BE ACCOMPLISHED IN SPITE OF LIMITED RESOURCES

MAXWELL
BALBOA Division

PROPER ENVIRONMENT & CULTURE IS ESSENTIAL FOR GROWTH

- DEVELOP AND FOLLOW THE VISION
- UNDERSTAND THE GOAL
- TEAM WORK
- OWNERSHIP AND EMPOWERMENT
- PERSONNEL DEVELOPMENT
  - COMMUNICATIONS
  - PROBLEM SOLVING SKILLS
  - PRIORITY MANAGEMENT
- MEASURING AND REWARDING GREAT PERFORMANCE

MAXWELL
BALBOA Division

UNDERSTANDING THE NUMBERS

- ACTIVITY BASED COST ACCOUNTING
    - PROFIT = REVENUE - EXPENDITURE
- INCREASING SHAREHOLDER VALUE IS KEY
- INVESTMENT RISKS

(41)

MAXWELL
BALBOA Division

STRATEGIC ALLIANCE CAN OFFER LEVERAGE

- TRUST, COMMITMENTS, AND COMMUNICATIONS ARE KEY
- THE RELATIONSHIP MUST BUILD ON CORE STRENGTHS OF TEAM MEMBERS
- A LOT OF WORK AND WILLINGNESS TO COMPROMISE TO MAKE IT WORK
- "THERE IS NO FREE LUNCH"

MAXWELL
BALBOA Division

WHAT CHALLENGES AHEAD FOR US?

- CONTINUE TO EXPAND EXISTING PRODUCTS AND DEVELOP NEW PRODUCTS TO ASSURE ORGANIZATION STAYS "YOUNG"
- MANAGING CONFLICTS BETWEEN DIFFERENT TYPES OF BUSINESSES
- IMPROVE THE SPEED OF CHANGE
- BALANCE BETWEEN SHORT TERM AND LONG TERM PROFITABILITY

MAXWELL
BALBOA Division

CONCLUSION

- IT IS POSSIBLE FOR A COMPANY THAT HAS BEEN DOING PREDOMINANTLY GOVERNMENT BUSINESS TO COMMERCIALIZE PULSED POWER TECHNOLOGY
- LEADERSHIP, CULTURAL CHANGE, AND TRAINING ARE CRUCIAL IN SUCCEEDING THE TRANSITION
- MUST BE STRONG IN TECHNOLOGY, MANUFACTURING, AND SELLING IN ORDER TO SURVIVE AND EXCEL IN THE NEW WORLD. BEING GOOD AT ONLY ONE OF THESE AREAS IS NOT ADEQUATE ANY MORE.

PULSED POWER FOR CIVILIAN APPLICATIONS

By

George Frazier
Physics International Company
San Leandro, California

(Originally presented at the Joint Workshop:
Power Semiconductor Coordination Committee (PSCC)
and Inter-Agency Power Group (IAPG)
February 8 - 11, 1993
EPRI Conference Center
Palo Alto, California)

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Pulsed Power for Civilian Applications–Outline

- Basic message
- Pulsed power background
- Converting defense-related pulsed power technology into civilian use or dual use
- Vision for the future and summary

Olin

Basic Message

- The Departments of Defense (DoD) and Energy (DoE) have been investing in defense-related pulsed power technology for over 50 years. There is a tremendous body of knowledge and expertise available.

Defense Agencies	Service Labs	National Labs	Universities	Contractors
DNA	ARL	SNLA	South Carolina	PI
DARPA	NRL	LLNL	Tennessee	MLI
SDIO	NSWC	LBL	Texas Tech	Titan
(NASA)	Phillips	LANL	UT-Austin and Arlington	SRL
	AFWAL	INEL	SUNY Buffalo	SAIC
			Auburn	W
			Old Dominion	ITT

- The world has changed. Defense cutbacks are affecting pulsed power companies and jobs. Overcapacity looms.

- Potential civilian applications are numerous but undeveloped. Defense conversion is key to preserving pulsed power capabilities. Organizations like EPRI, PSCC, and IAPG are vital to success.

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Pulsed Power Background

- Definition and Advantages
- Defense-related Applications
- Examples of Defense Technology Base

<u>What is Pulsed Power</u>?

The technology of producing precisely shaped electrical pulses. Peak-to-average power ratios are high.

<u>Typical Parameter Ranges (Current SOA)</u>

Peak Power:	100 MW to 100 TW	(10^8-10^{14} watts)
Average Power:	10 W to 10 MW	(10^1-10^7 watts)
Peak Voltage:	10 kV to 10 MV	(10^4-10^7 volts)
Peak Current:	1 kA to 10 MA	(10^3-10^7 amps)
Energy per Pulse:	1 J to 60 MJ	(10^0-6 x 10^7 joules)

Three to seven orders of magnitude in each parameter.

759.93.01

Olin

Unique Advantages of Pulsed Power

Precise Electrical Energy Delivery:

- Can exploit rate-dependent effects
- Can optimize system responses

High Peak-to-average Power Ratio

- Can exploit threshold effects
- Can excite non-linear effects
- Can minimize unwanted heating (more efficient than dc)

Short Pulse Timing Advantages

- Can deliver energy, then wait (e.g., for chemical reactions)
- Can exploit time domain (e.g., radar)
- Can avoid competing processes (e.g., breakdown)

Environmentally Friendly

- May replace toxic chemicals for some applications
- Little or no residual radioactivity

759.93.01

Basic Elements of a Pulsed Power or Power Modulator System

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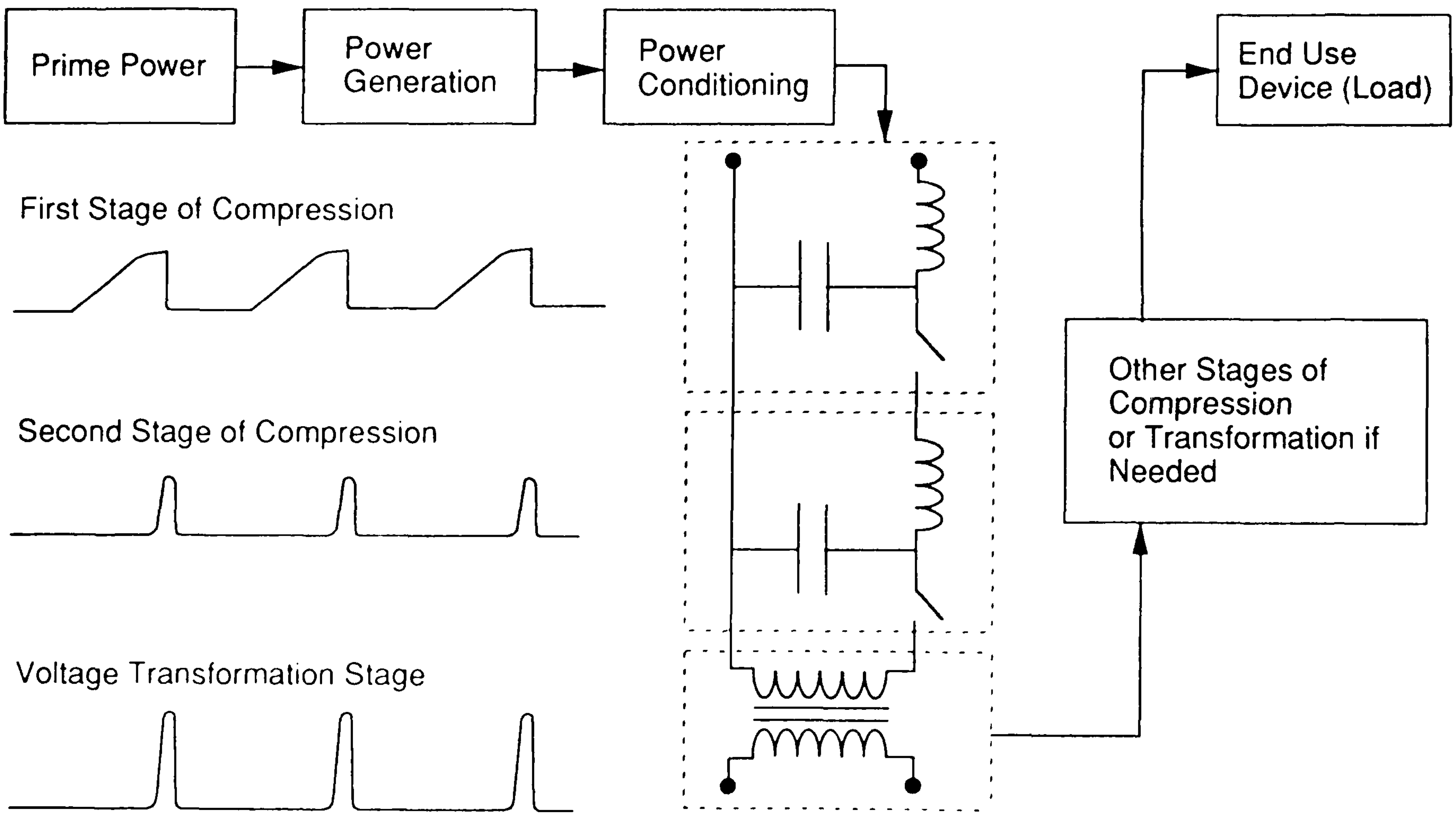
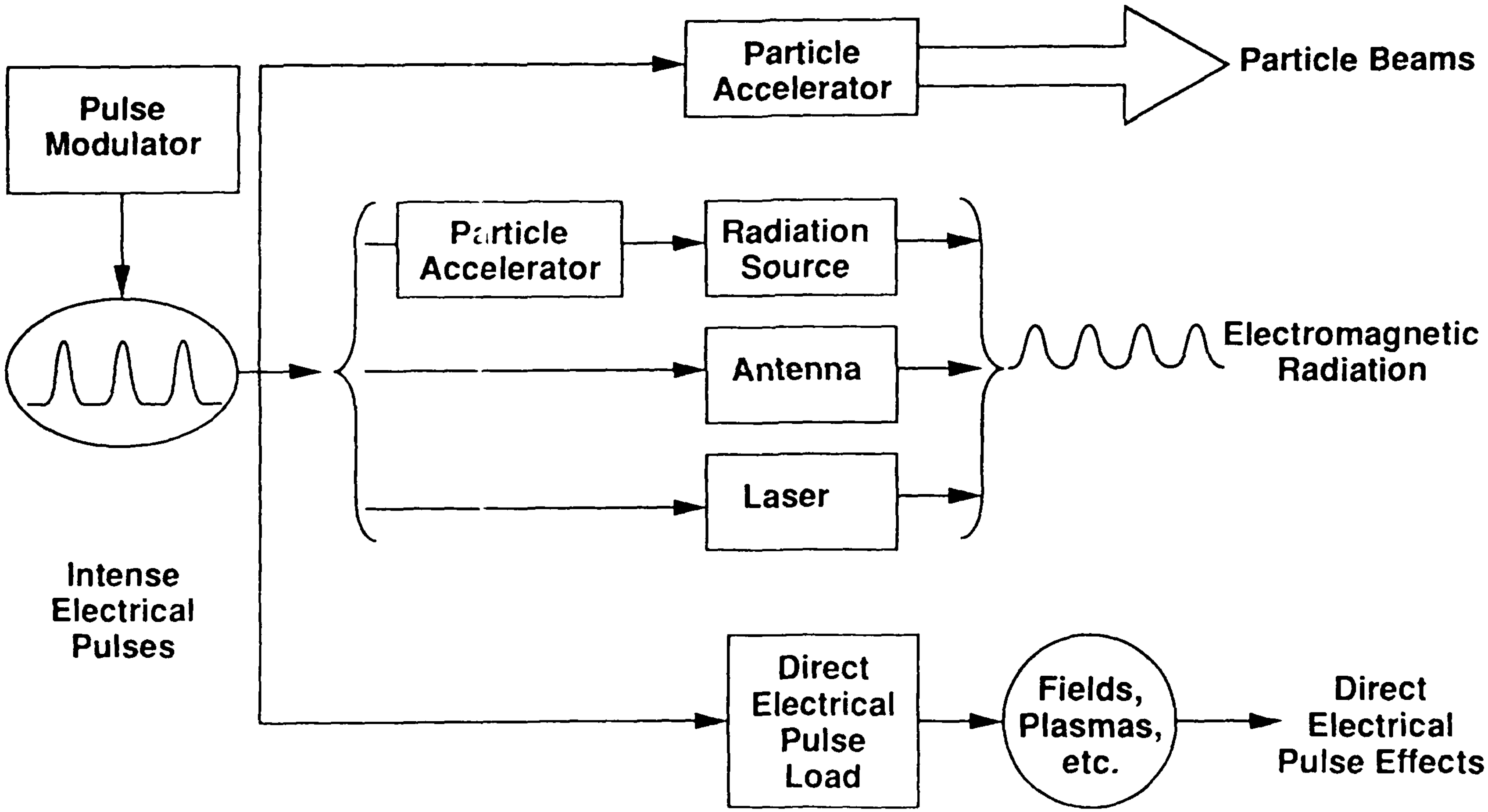
Prime Power	Power Generation	Power Conditioning	Pulse Modulation	End Use Device (Load)
• Starting point • Usually a mechanical device: - Gas Turbine - Engine - Hydro-turbine • Usually gives shaft horse-power out	• Produces electrical power • Usually an electromechanical device: - Alternator - Generator • Usually uses shaft horse-power • Usually provides ac electricity out	• Converts electricity to a more usable form • Types of Conversion: -ac to ac -ac to dc -dc to ac -dc to dc • Matches voltage requirements of modulator to output of generator	• Produces a train of electrical pulses • Makes pulse characteristics match load requirements	• Uses modulated pulses to produce: • Particle beams • Electromagnetic radiation • Direct electrical pulses

Commercial power grid unless system is transportable

A Simplified Pulse Modulator Circuit Showing Energy Storage, Switching, Compression and Transformation



There are Three General Categories of Intense Pulses Produced by Pulsed Power Systems



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Direct Electrical Pulses Can Support a Wide Range of Physics and Chemistry

Direct Electrical Pulse Load		Fields, Plasmas, etc.
Specially configured electrodes: plates, wires, coaxes, etc.	→	Electric Fields
Specially configured conductors: magnets, transmission lines, etc.	→	Magnetic Fields
Electrodes connecting to load: EM guns, current injectors, etc.	→	High Currents
Hot-dense Z-pinches, imploding plasmas, electric arc discharges	→	Thermal Plasmas
Pulsed corona discharges	→	Non-thermal Plasmas
Pulsed magnets or electrical discharges	→	Acoustic Shocks

7597/93 01

A Wide Variety of Pulsed Power Devices Produce Beams and Radiation

Pulsed rf and induction accelerators or channel sparks	Electrons Ions Neutrals	Particle Beams
Accelerator driving radiation converters	X-rays/γ-rays	Electromagnetic Radiation
Lasers	Coherent light (IR to UV)	Electromagnetic Radiation
Flashlamps	Incoherent light	Electromagnetic Radiation
Relativistic microwave sources: magnetrons, klystrons, BWOs, etc.	High Power Microwaves/RF	Electromagnetic Radiation
Conventional microwave tubes: magnetrons, klystrons, TWTs, etc.	Conventional Microwaves/RF	Electromagnetic Radiation
Radiating antennae and transmission lines	Impulses/EMP	Electromagnetic Radiation

7597/93 01

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Defense-Related Pulsed Power Applications

Categories of Intense Pulsed Output \ Defense-related Applications	Nuclear Weapon Effects Simulation	Non-nuclear Effects Testing	Directed Energy Weapons: HPM RF and Impulse	Directed Energy Weapons: Lasers	Directed Energy Weapons: Particle Beams	Electric Armaments: EM Guns	Electric Armaments: ET Guns	Electric Armaments: Armor	Remote Sensing and EW: Radar and Jamming	Remote Sensing and EW: Ultra Wideband Radar	Remote Sensing and EW: Decoy Detection	Remote Sensing and EW: Sonar	Laser Isotope Separation
Particle Beams:													
• Electrons	x				x								
• Ions	x				x								
• Neutrals	x				x						x		
Electromagnetic Radiation:													
• X-rays/γ-rays	x	x											
• Coherent Light (IR-UV)	x			x					x				x
• Incoherent Light				x									
• High Power Microwaves/RF	x	x	x										
• Conventional Microwaves/RF	x	x							x				
• Impulses/EMP	x	x	x						x	x			
Direct Electrical Pulses													
• Electric Fields								x					
• Magnetic Fields					x			x					
• High Current	x					x	x						
• Thermal Plasmas	x						x						
• Non-thermal Plasmas													
• Acoustic Shocks		x										x	

7597/93 01

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Pulsed Power Defense Conversion: Contrasts Between Military and Civilian Programs

DoD/DoE Pulsed Power → Conversion → Commercial Pulsed Power

DoD/DoE Pulsed Power

- Performance is paramount
- Cost is secondary (at most)
- Technology is usually cutting edge
- "ilities" relate to battlefield:

1. Lethality
2. Survivability
3. Vulnerability
4. Transportability

Mission-related

5. Reliability
6. Maintainability
7. Affordability
8. Lifetime

Important but secondary to mission

- "ilities" are largely undeveloped. Except for radar, there is no weaponized pulsed power system. Most systems support R&D.

Commercial Pulsed Power

- Only sufficient performance is needed
- Cost is paramount
- Proven technology is needed
- "ilities" relate to cost:

1. Affordability
2. Lifetime
3. Maintainability
4. Reliability

life-cycle cost

- There is little large scale commercial use of pulsed power yet, but some examples exist (e.g., defibrillaters), others are emerging.

7597-93 01

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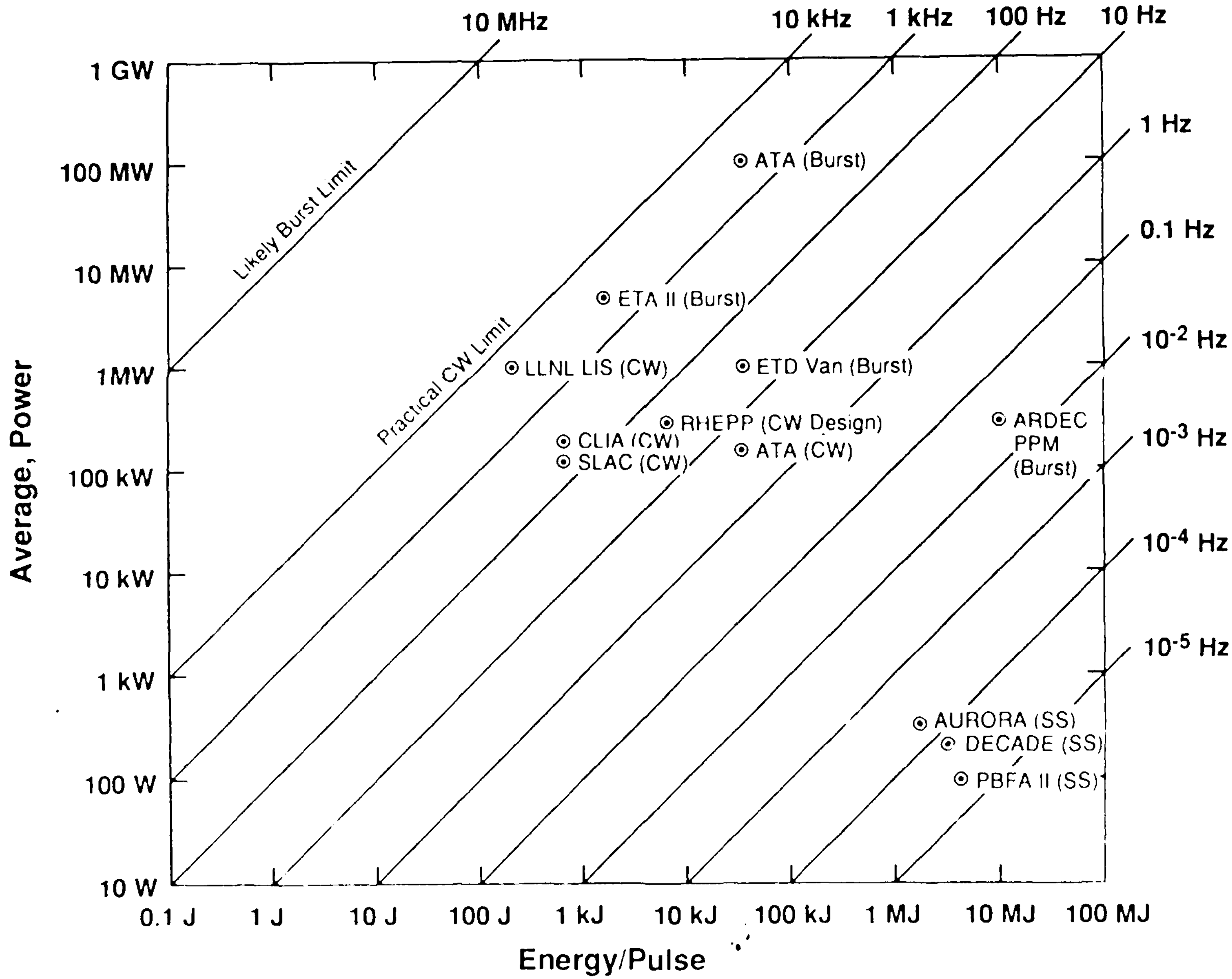
Existing Defense - Related Pulsed Power Parameter Space



7597-93-03

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Many Potential Commercial Applications for Modulator and Pulsed Power Technology Have Been Identified*

The EPRI Power Electronics Applications Center (PEAC) identified 66 applications in a study last year. More are being added in all six categories:

1. Industrial
2. Medical
3. Agricultural
4. Environmental
5. Transportation
6. Chemical

A cursory study of a few selected applications reveals significant overlap in technical requirements.

* See "Commercial Applications for Modulators and Pulsed Power Technology," by S. Levy, M. Nikolich, I. Alexeff, M. Rader, M. T. Buttram, W. J. Sargeant.

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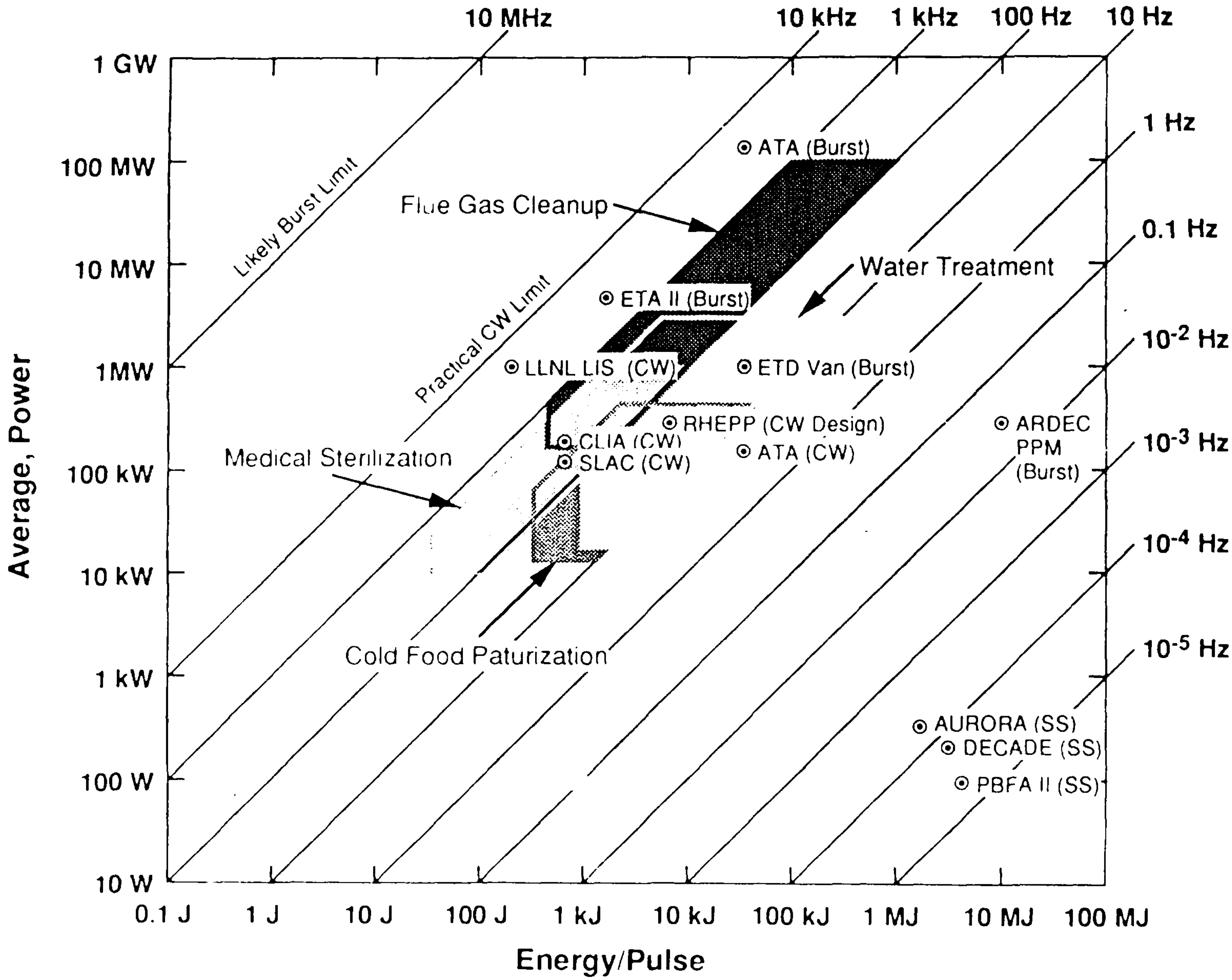
Approximate Requirements for Selected Commercial Applications



7597-93-03

Olin

Some Issues for Military-to-Civilian Use Transition

Must engineer systems for long life, high reliability and low life-cycle cost

Military	Civilian Use	Examples
1. System concepts are well developed. Many components have a reliability data base.	Many systems and components can be adapted with little or no development	• Control systems and sensors • Power supplies • Magnets • High voltage insulation
2. Some critical components have been demonstrated at high energy, high power • But often work to design margins and have limited life (ok for R&D)	Long life, practical thermal management, maintainability are more important: • ≈1 year (10^7-10^9 shots) maintenance cycle • 10-20 years lifetime Switches, capacitors, transformers are some of critical components: • Some development is needed	Need to select high margin, derated designs: • SCRs demonstrated >800,000 hr life and >9,000 hr MTBF (LLNL LIS Cu Laser System) • Low energy density capacitors should demonstrate better life dependence on voltage, i.e. better than V^{-7} • Pulse transformers need cooling and derating for continuous use
3. Machines directed at trained and sophisticated users	• Easy operation and troubleshooting essential • Operate unattended, limited access for rapid repair	• Need built-in self diagnostics • Fool proof, automatic protection and shutdown

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Summary and Comments on the Future

- Defense-related pulsed power has great potential for commercial use.

- There is a military-civilian gap that must be bridged:

Military R&D		Civilian Applications
• High-risk, high payoff	G	• Low-risk, reliable
• Government funds and assumes most risk	A	• Private industry assumes risk
• Performance paramount	P	• Economics paramount
• Custom designs, mainly R&D related		• Standard designs, mainly production related

- Bridging the gap can be accomplished through joint ventures, CRADAs, and partnerships.

- Funds for the process must come from the government (defense conversion and transition programs) and private investment.

- This process has started (e.g., SERDP, EPRI work, etc.) but needs further support.

OVERVIEW OF THE FEDERAL TECHNOLOGY COMMERCIALIZATION PROGRAM

N. Montanarelli
Technology and Applications Program
BMDO

BALLISTIC MISSILE DEFENSE ORGANIZATION

Technology Applications Program

pj-35363 / 052693

BALLISTIC
MISSILE
DEFENSE
ORGANIZATION

FY 93 NATIONAL DEFENSE AUTHORIZATION ACT

Technology Reinvestment Project (TRP)

- Dual Use Critical Technology Partnerships
- Commercial Military Integration Partnerships
- Regional Technology Alliances Assistance Program
- Defense Advanced Manufacturing Technology Partnerships
- Manufacturing Extension Programs
- Defense Dual Use Assistance Extension Program

Total FY 93 Funding - $475M

pj 30520a / 080593

OFFICE OF TECHNOLOGY TRANSITION (OTT)

- Authorized By The National Defense Authorization Act Of FY 93
- Established April 1993, Within OSD / DDR&E
- Status
  - Report To Congress "Encouragement Of Technology Transfer"
  - Defense Technology Transfer Working Group (OSD, Services, BMDO, DNA And ARPA)
    - Identify DoD T^2 Activities And Accomplishments
    - Assess DoD Labs Core Competency In Dual Use Technologies
    - Investigate Existing Barriers To T^2
    - Provide Recommendations To Streamline The T^2 Process

pj 37081 / 080593

BALLISTIC
MISSILE
DEFENSE
ORGANIZATION

DoD TECHNOLOGY TRANSFER

Post Cold War Environment

Past

- Stevenson-Wydler / Technology Transfer Acts
  - Laboratory Offices Of Research And Technology Application (ORTA)
  - Cooperative Research And Development Agreements (CRADAs)
  - Small Business Innovative Research (SBIR) Reauthorization

Influencing Factors

- Defense Budget Reductions
- DoD Laboratory Consolidation

Status

- Strength: Defense T^2 Successes
  - Robust SBIR Program
  - Defense Technology Commercialization
  - CRADA Quantity And Quality
- Weakness: OSD Lacks Strong T^2 Policy
  - No Funding For T^2 Activities
  - Services' Non-standard T^2 Implementing Procedures
  - No Measurement Standards For T^2 Success

pj 37082 / 080693

PRESIDENT CLINTON'S TECHNOLOGY INVESTMENT PLAN

*"Technology For America's Economic Growth
A New Direction To Build Economic Strength"*

- A National Industrial Policy
  - Boost America's Global Economic Competitiveness
- Approach
  - Accelerate Development / Application Of Commercially Viable Technologies
- Technology Goals
  - Create Jobs And Protect The Environment
  - Make Government More Efficient And Responsive
  - Obtain World Class Leadership In Science, Math, And Engineering
  - Start New Initiatives To Build Economic Strengths

Ballistic
Missile
Defense
Organization

FEATURES OF THE TECHNOLOGY PLAN

- Emphasis On
  - Dual Use Technology Commercial Applications
  - Cost-shared Government - Industrial Partnerships
  - New Technology Demonstration (Pilot) Programs
  - National "Information Superhighway" Network
  - Access To Existing And Emerging Technology "Know-how"
  - Research And Development / Manufacturing Extension Centers
  - Flexible Manufacturing Processes
  - Enhanced Basic Science Research
  - Permanent Research And Experimental Tax Credit

pj 37506 / 083093

ITEM	CONCEPT	COMMERCIALIZATION	TIME GAP
Fluorescent Light	1852	1934	82 years
Ball Point Pen	1888	1938	50 years
Helicopter	1904	1936	32 years
TV	1907	1936	29 years
Transistor	1940	1950	10 years
Zipper	1891	1923	32 years
Radar	1887	1933	46 years
Diesel Locomotive	1895	1934	39 years

Z124

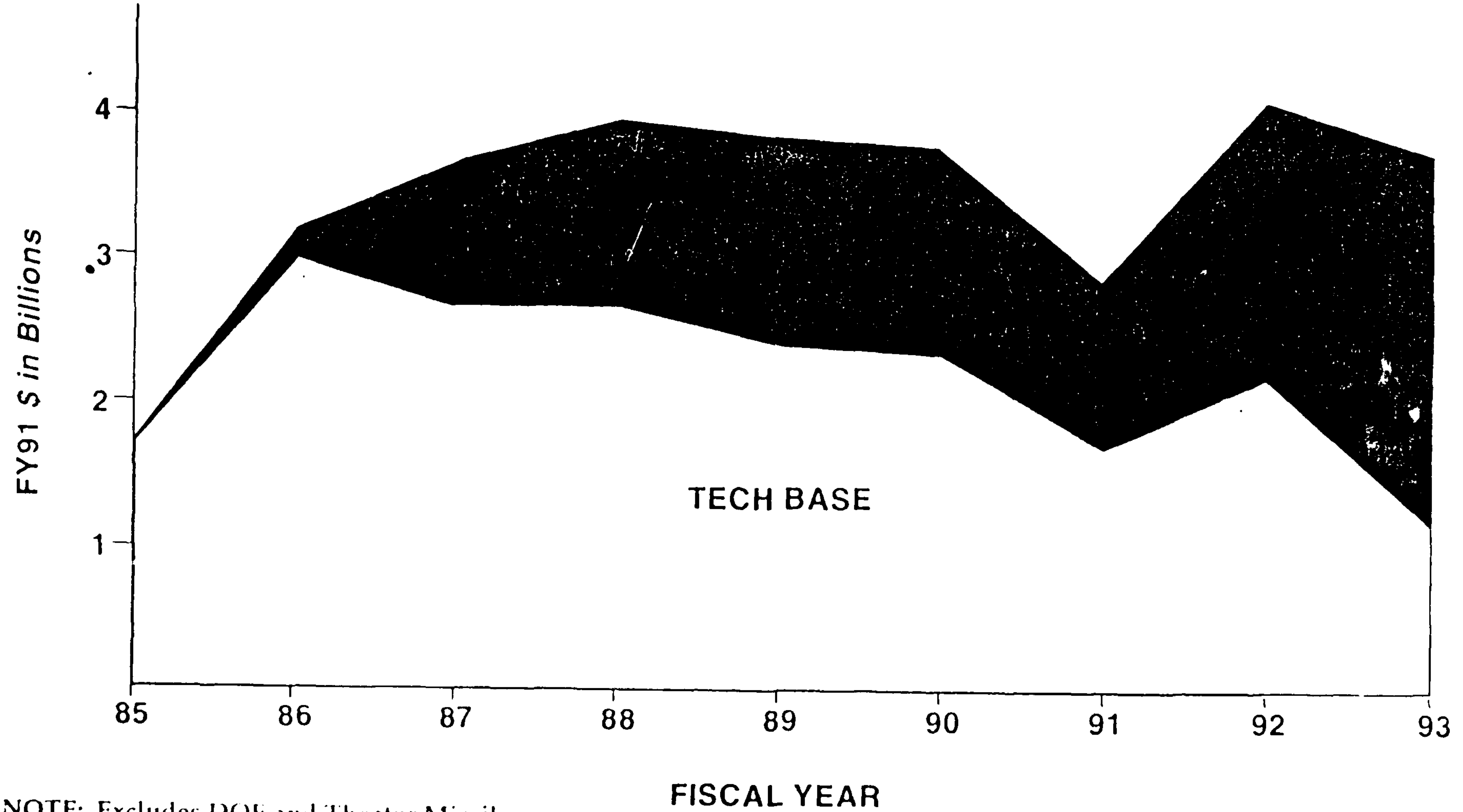
BUZZ WORDS

- Strategic Partnerships
- Dual Use Technology
- Defense Conversion
- Industrial Consortia
- Regional Alliances
- Manufacturing Technology

- Technology Transfer
- Technology Applications
- Technology Utilization
- Technology Transition
- Spin-offs

SDIO/SE001/8

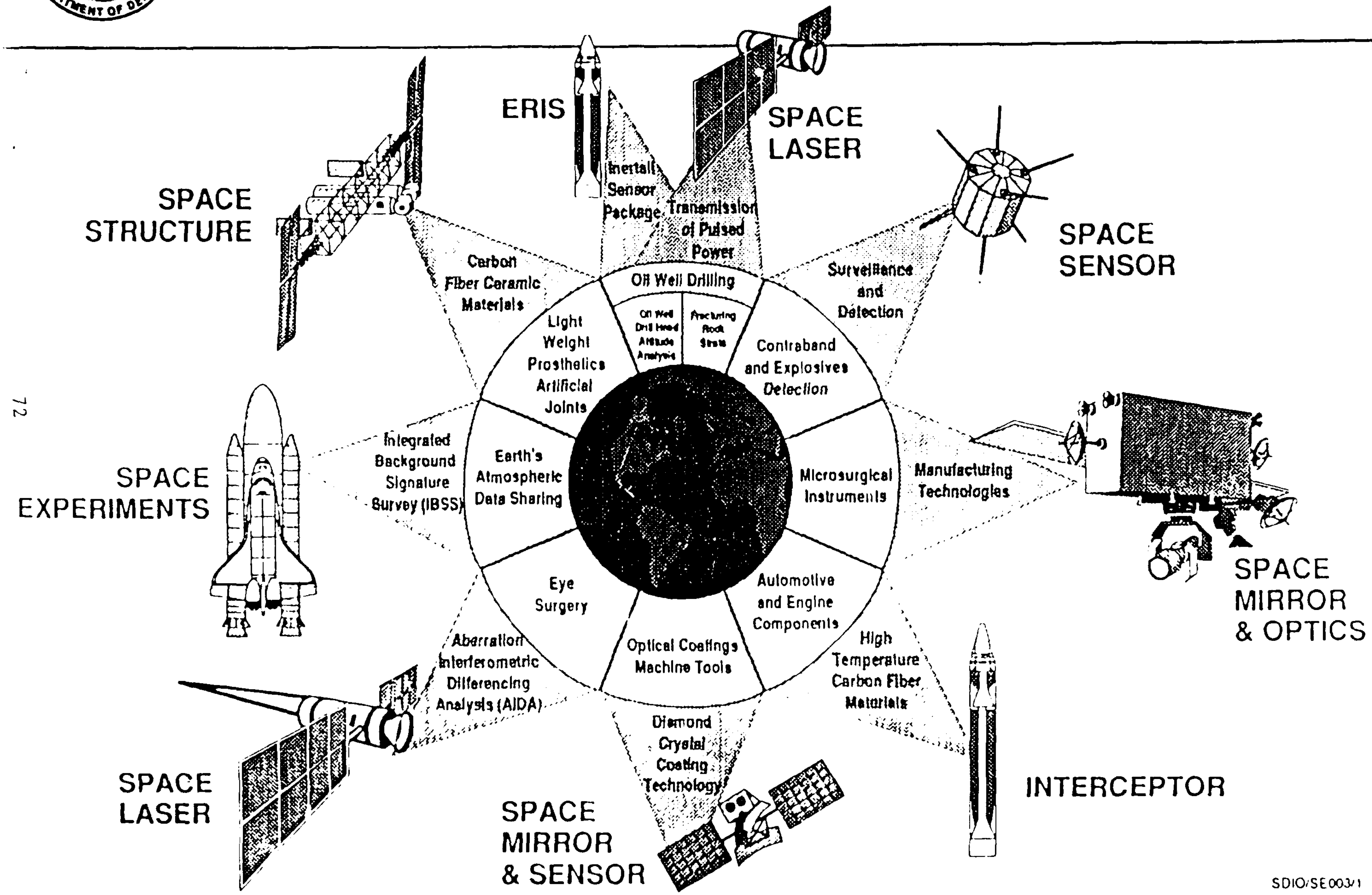
STRATEGIC DEFENSE INITIATIVE BUDGET EVOLUTION



NOTE: Excludes DOE and Theator Missile Defense (TMD) Funding

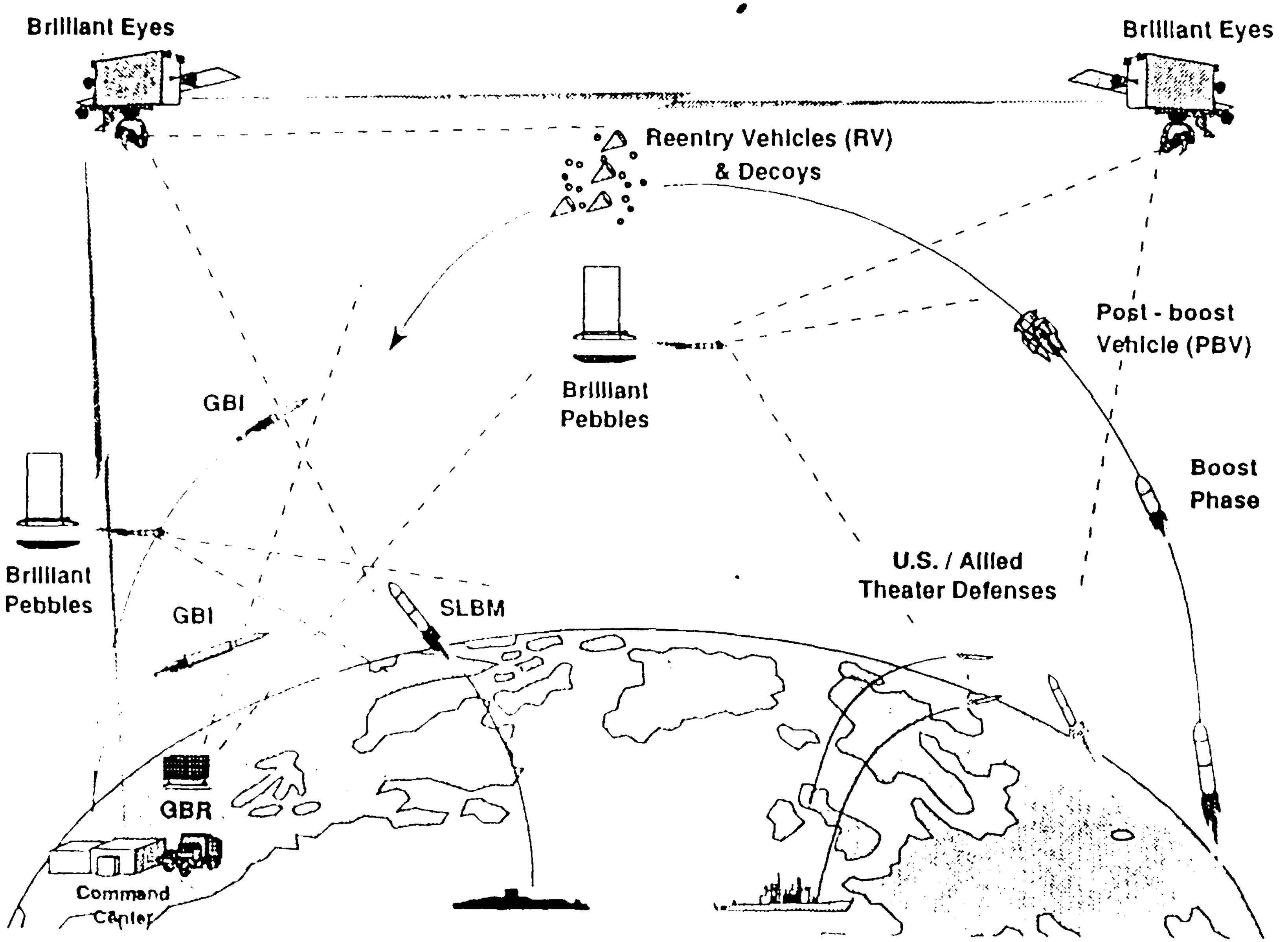
SDIO/SE001/2

SDI TECHNOLOGY APPLICATIONS



SDIO/SE003/1

GPALS ELEMENTS
STRATEGIC AND THEATER



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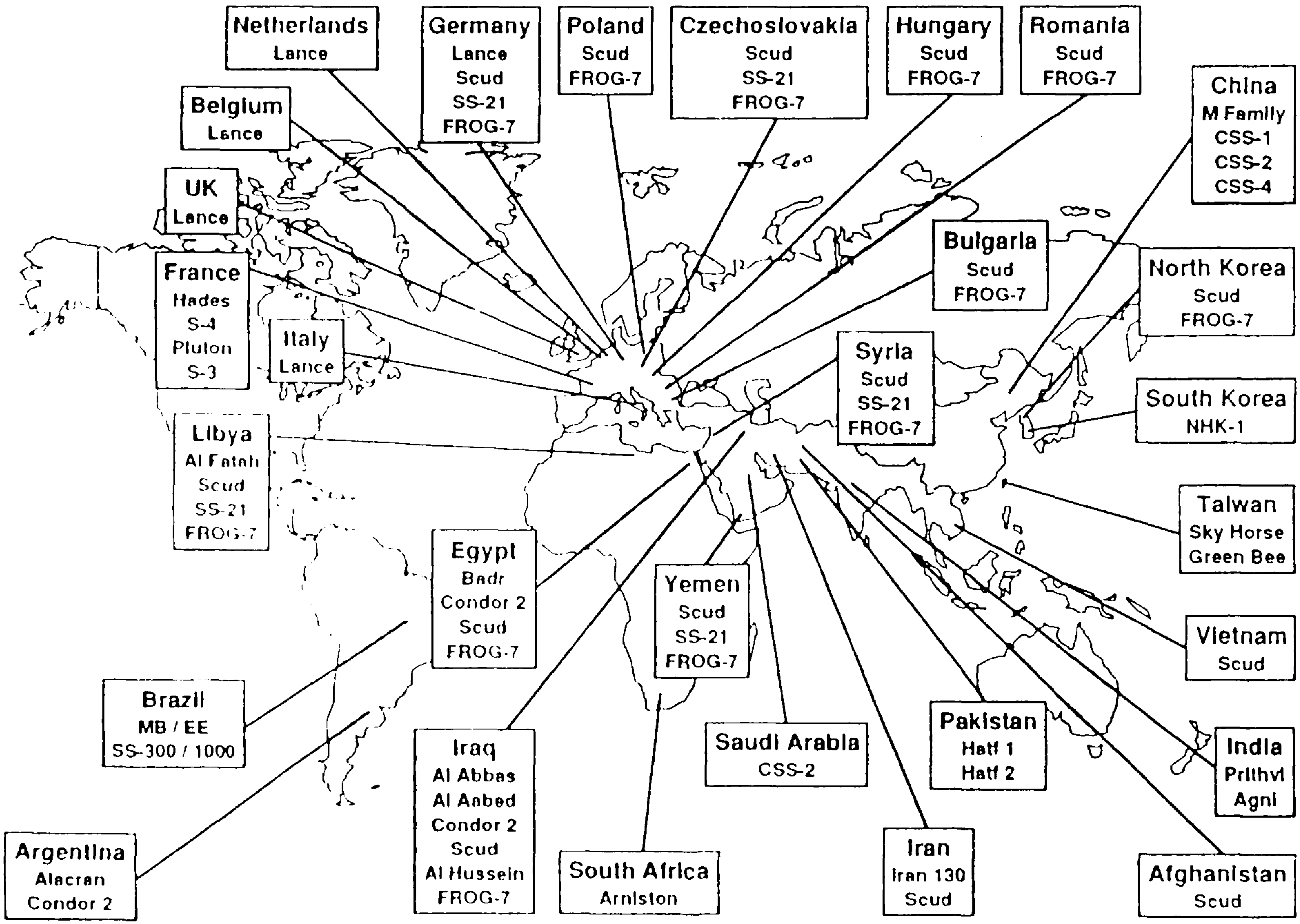
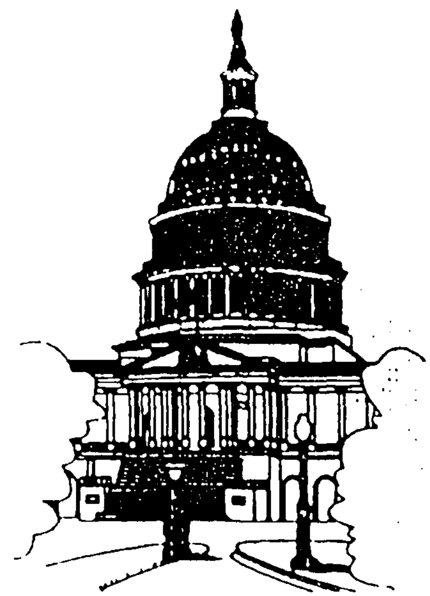
EVOLVING BALLISTIC MISSILE CAPABILITY



- 1980 Stevenson - Wydler Technology Innovation Act
- 1982 Small Business Innovation Development Act
- 1986 Federal Technology Transfer Act
- 1987 National Defense Authorization Act (DoD Direction)
- 1987 Presidential Executive Order 12591
- 1988 Technology Competitiveness Act



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SDIO OFFICE OF TECHNOLOGY APPLICATIONS

MISSION: Facilitate the Transfer of DoD-Funded R&D to the Commercial Market Place and to Other Federal Programs

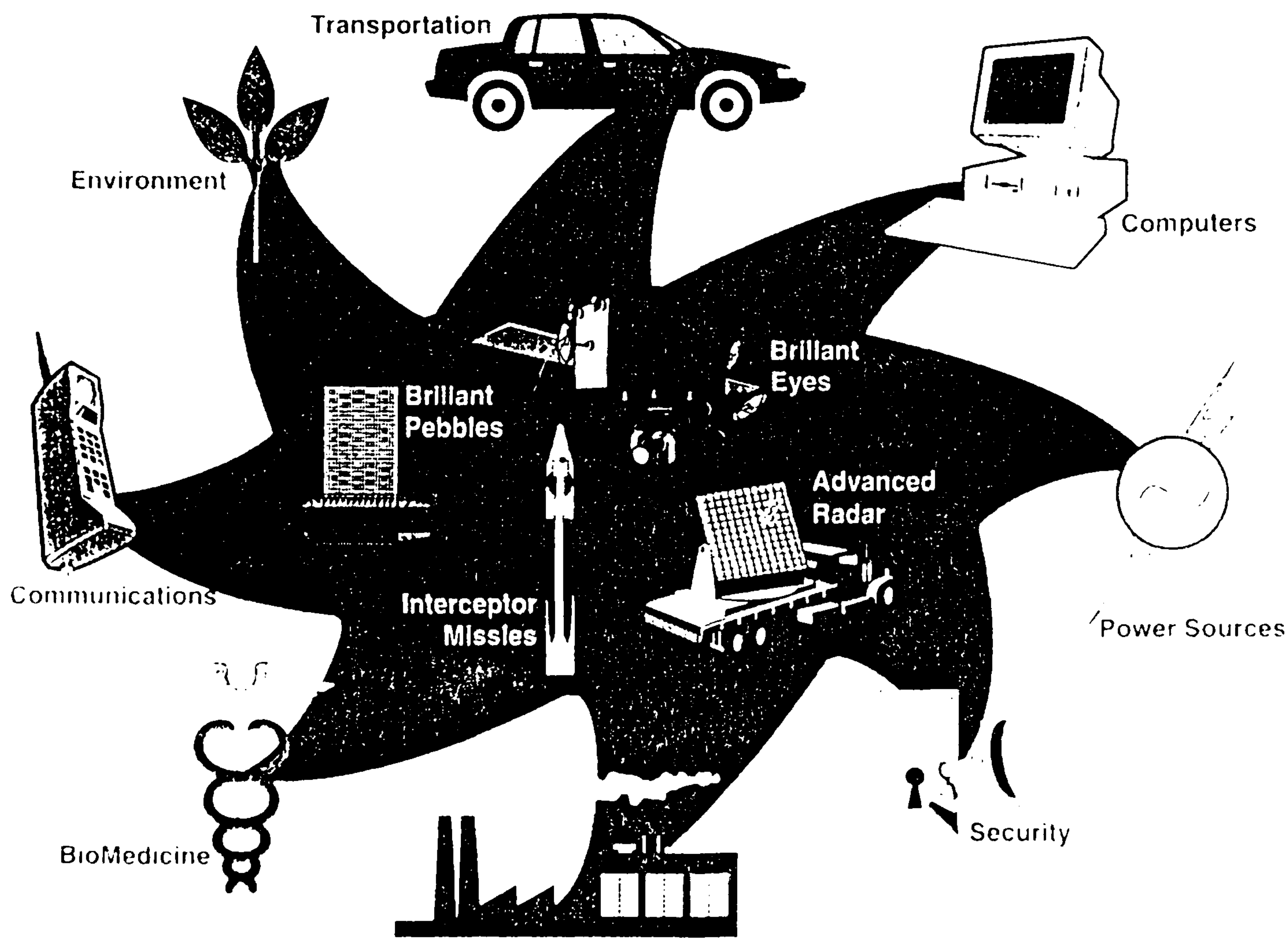
APPROACH: Implement a Proactive Program to Match Technical Needs with DoD Technologies

OBJECTIVES:

- Improve U.S. Industrial Capabilities
- Enhance U.S. Global Competitiveness
- Strengthen U.S. National Security
- Provide Return on Taxpayer's Investment in R&D

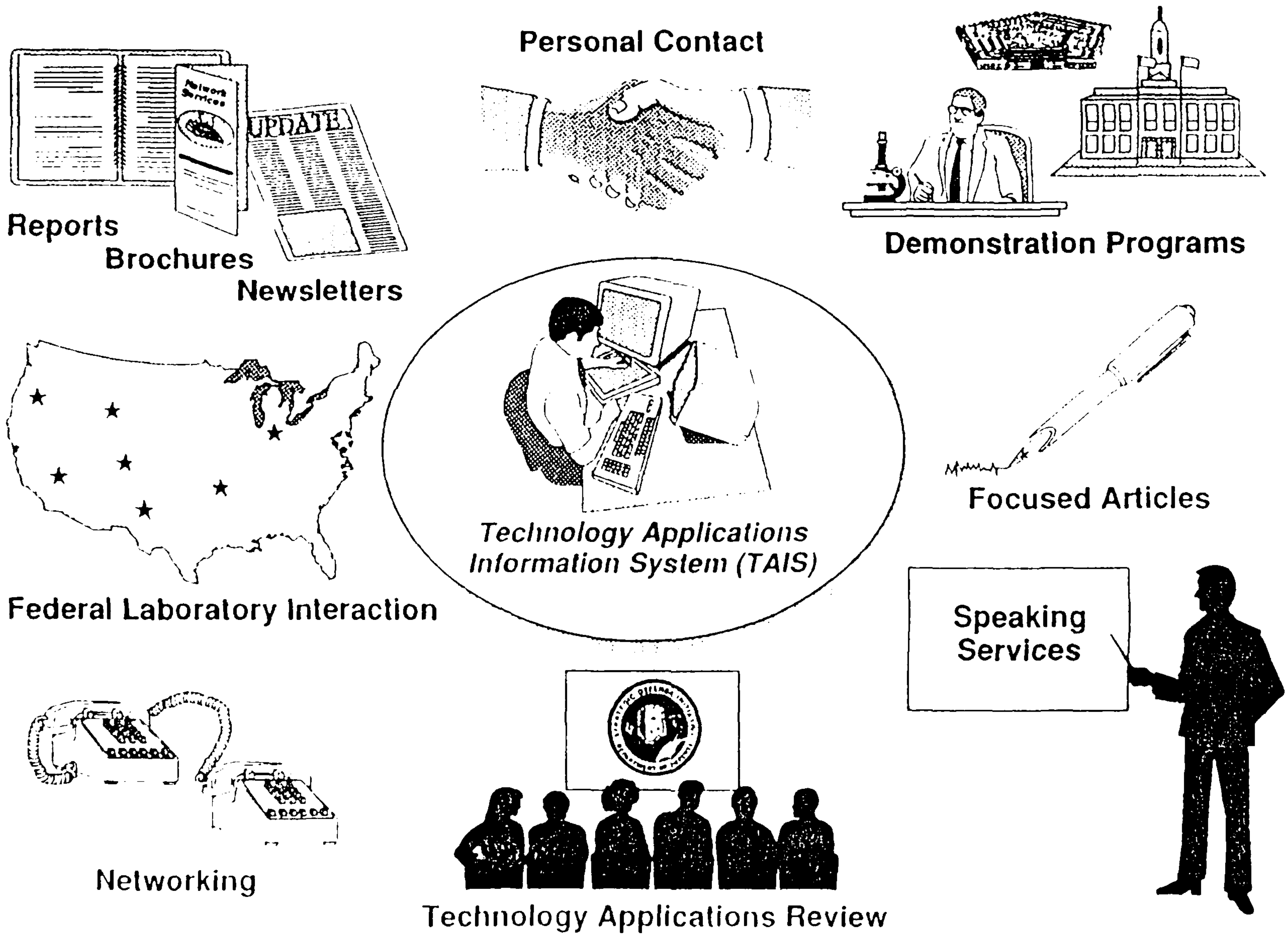
Z117/3

SDI TECHNOLOGY TRANSFER



SDIO SE001 1

TECHNOLOGY APPLICATIONS PROGRAMS



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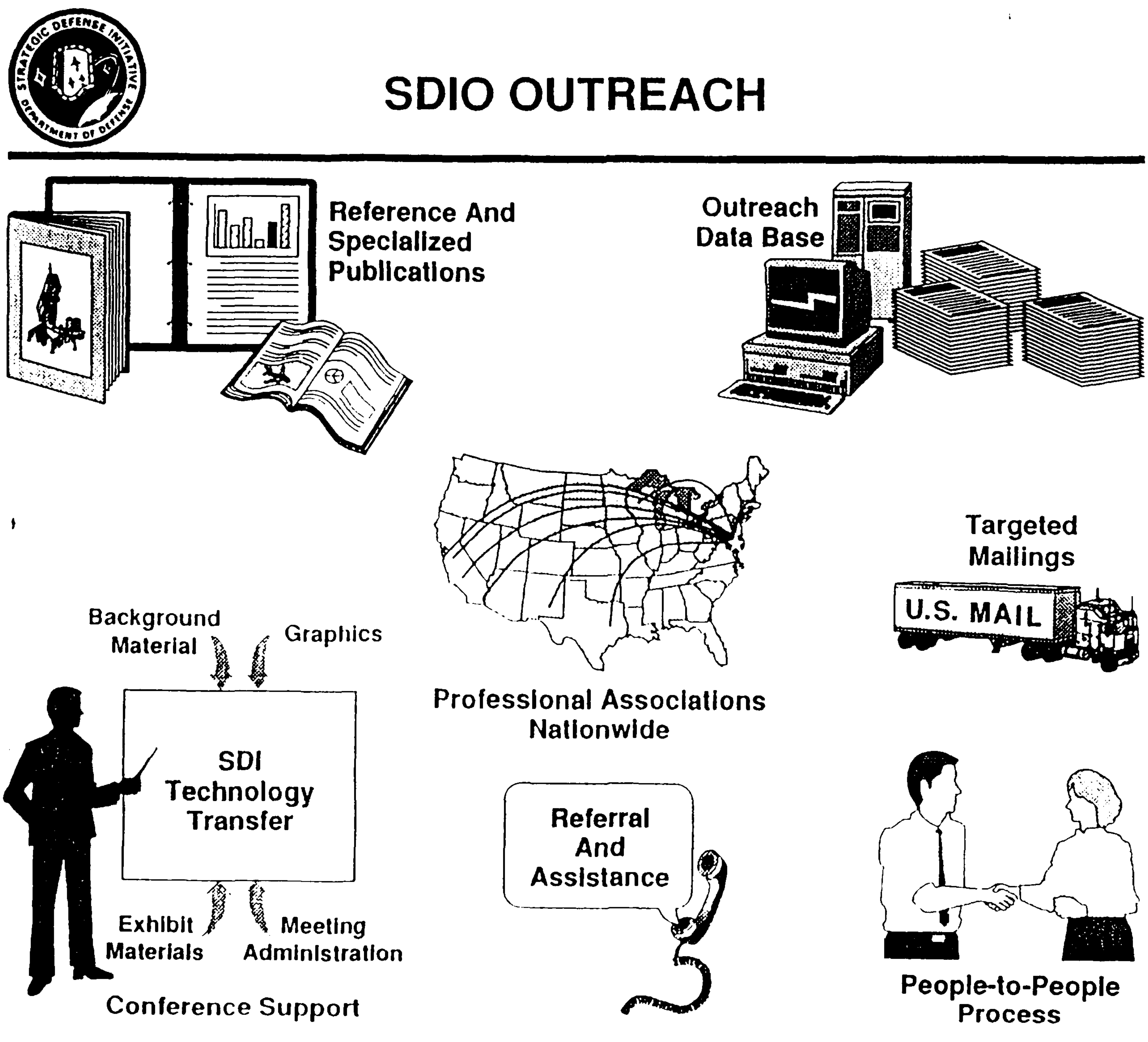
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Outreach Data Base
Professional Associations Nationwide
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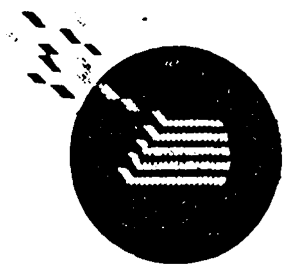
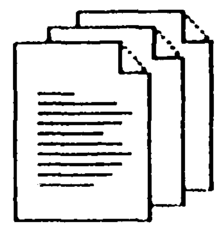
Background Material
Graphics
SDI Technology Transfer
Exhibit Materials
Meeting Administration
Conference Support
Referral And Assistance
People-to-People Process
jm 30979 / 112092

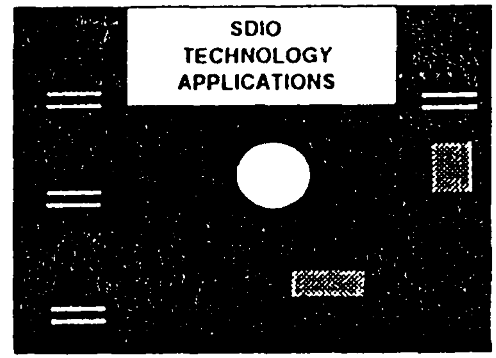
SDIO TECHNOLOGY APPLICATIONS
OTHER ACTIVITIES



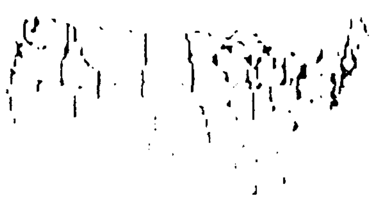
National Technology Transfer Center



Cooperative Research and Development Agreements (CDRA)

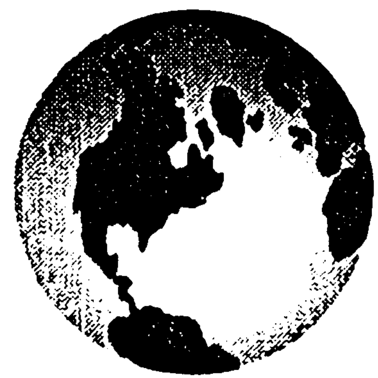


Conferences and Exhibits



Federal Laboratory Consortium

Interaction with Other Departments and Agencies



International Technology Transfer

DoD OFFICE OF TECHNOLOGY TRANSITION
(WITHIN OSD / DDR&E)

- Authority: 1993 Defense Authorization Act (P.L. 102-484)
  - Modeled After SDIO Technology Applications Program
- Function: Promote Commercialization Of Defense Technology
- Resources Required For
  - Adequate Personnel To Expedite Military / Commercial T^2
  - DoD T^2 Policy And Directives
  - National Database Of Defense Technologies
  - T^2 Demonstration Projects
  - T^2 Assistance To Industry, State / Local Governments, And Academia

jm 34070 · 040293

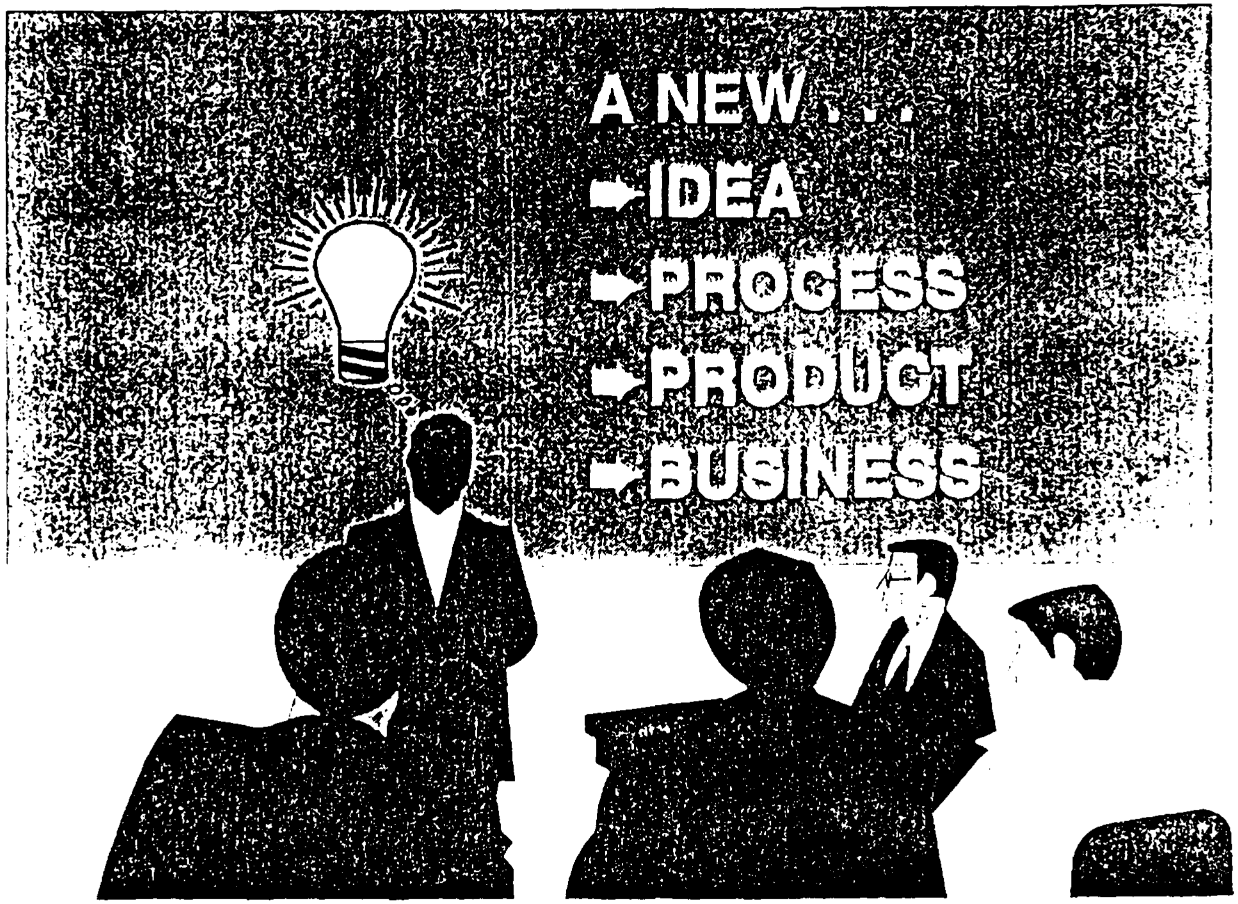
TECHNOLOGY APPLICATIONS REVIEWS

STANDING PANELS

- Power
- Electronics
- Optics & Sensors
- Biomedical
- Materials

AD HOC PANELS

- Superconductivity
- Environment
- Transportation



PANEL MAKEUP

Government • Academia • Industry • Marketing • Venture Capital

- License to Others
- Partnerships
- Joint Ventures
- Spin-off New Companies

212V1

COM ATION

- **Protect Your Idea**
  - Nondisclosure Agreements, Patents, Trademarks, Copyrights, and Trade Secrets.
- **Understand the Market and Identify the Competition**
  - Perform market analyses to identify potential market size, user needs, players.
- **Develop a Business Plan**
  - Plan should build upon market analyses and present a sound approach to the market place.
- **Implement the "Right" Plan**
  - "Right" varies by company, technology, product, market, financing, etc.
  - Continuously measure progress and keep your finger on the market pulse. Be prepared to react to market changes.

2/21/2

TECHNOLOGY TRANSFER CONSIDERATIONS

- Commercial availability and vendor support
- Flexibility to current and future applications
- Process and equipment stability
- Purchase cost
- Maintenance cost
- Installation cost and time
- Adaptive and retrofit functionality
- Integration to existing operations

INDUSTRY ROLE IN GUIDING SDI COMMERCIAL STRATEGY

Representative SDIO Technology Transfer Network

- American Bearing Manufacturers Association (ABMA)
- American Defense Preparedness Association (ADPA)
- American Society of Metals International (ASM Int'l)
- Armed Forces Communications & Electronics Association (AFCEA)
- Electronic Industries Association (EIA)
- Industrial Research Institute (IRI)
- Institute of Electrical and Electronics Engineers (IEEE)
- Manufacturers Alliance for Productivity and Innovation (MAPI)
- National Business Incubators Association (NBIA)
- National Coalition for Advanced Manufacturing (NACF ›M)
- National Center for Advanced Technologies (NCAT)
- National Center for Manufacturing Sciences (NCMS)
- National Electrical Manufacturers Association (NEMA)
- National Tooling and Machining Associ:ation (NTMA)

SDIO/SE005/1

SMALL BUSINESS INNOVATION DEVELOPMENT ACT 1982 P.L. 97-219

Major Features

- Reserves a fraction of the R&D budgets of Federal agencies for smaller Enterprises.
- Establishes Small Business Innovation Research (SBIR) Programs.
- Stressed benefits through job creation as well as technical innovation.
- Bypasses most of the federal competitive review and procurement procedures.

SDIO/SE001/11

DEPARTMENT OF DEFENSE SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

CURRENT PROGRAM:

- 1.25% of Extramural R&D Budget available for SBIR awards

FUTURE PROGRAM:

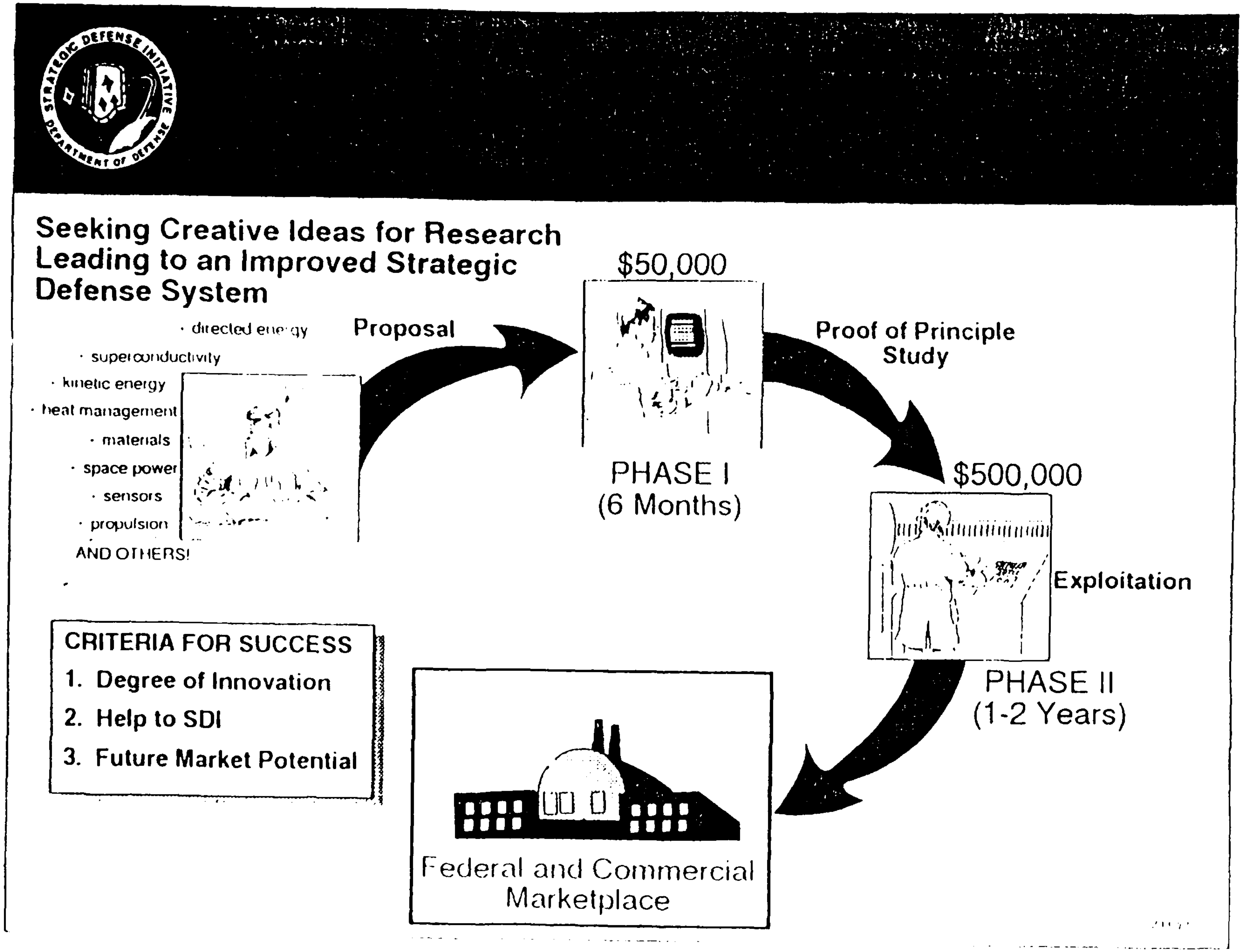
- 2.5% of Extramural R&D Budget by 1998

FY 93 PROGRAM:

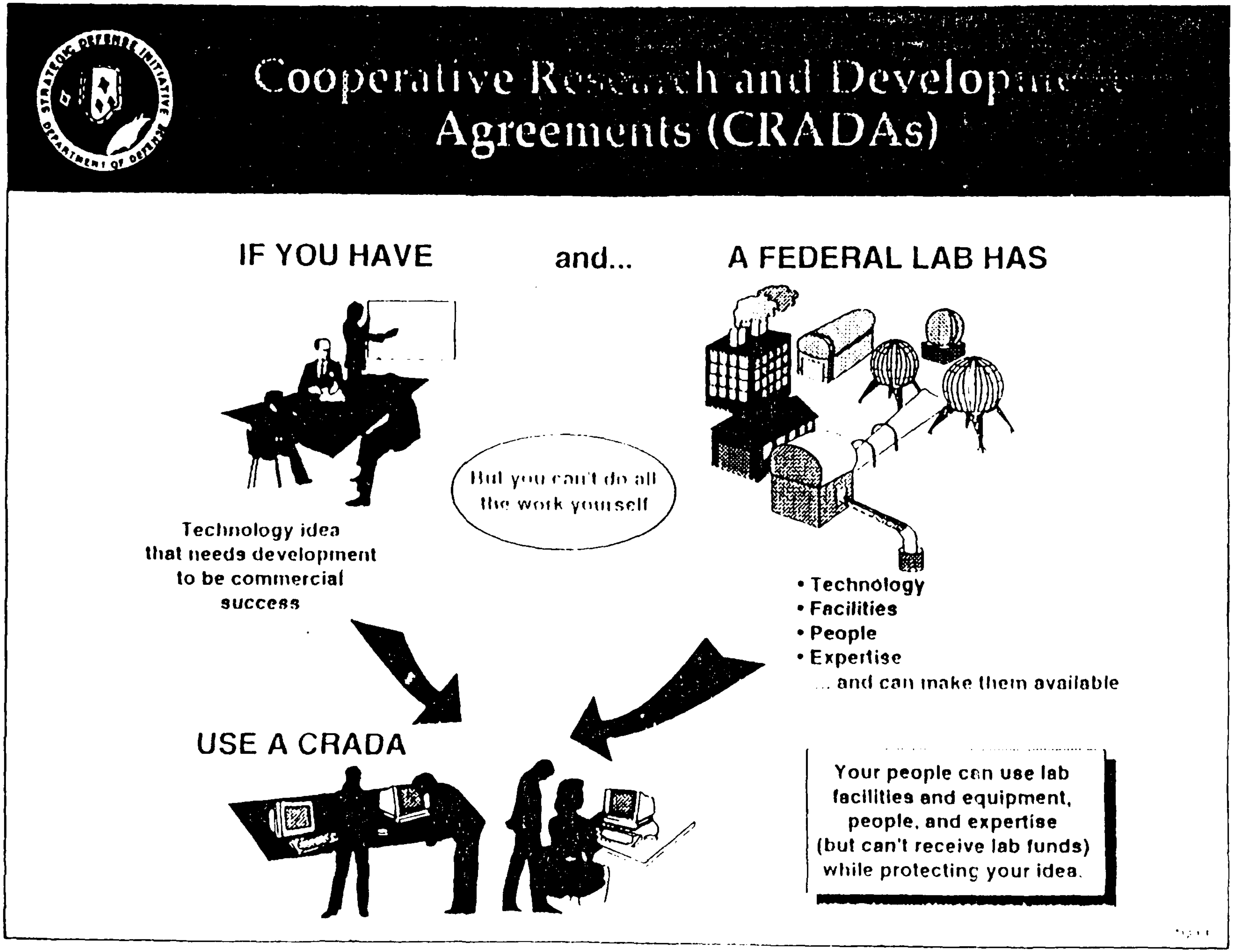
- Funds: Approximately $240M
- Topics: 424 for all DoD Agencies

CONTACT:
Small Business Administration
1-800-225-DTIC or (703) 274-6902

SDIO/SE0034



Seeking Creative Ideas for Research Leading to an Improved Strategic Defense System
· directed energy
· superconductivity
· kinetic energy
· heat management
· materials
· space power
· sensors
· propulsion
AND OTHERS!
Proposal
$50,000
PHASE I
(6 Months)
Proof of Principle Study
$500,000
Exploitation
PHASE II
(1-2 Years)
Federal and Commercial Marketplace
CRITERIA FOR SUCCESS
1. Degree of Innovation
2. Help to SDI
3. Future Market Potential


Cooperative Research and Development Agreements (CRADAs)
IF YOU HAVE
and...
A FEDERAL LAB HAS
But you can't do all the work yourself
Technology idea that needs development to be commercial success
• Technology
• Facilities
• People
• Expertise
... and can make them available
USE A CRADA
Your people can use lab facilities and equipment, people, and expertise (but can't receive lab funds) while protecting your idea.

COOPERATIVE RESEARCH and DEVELOPMENT AGREEMENTS (CRADAs)

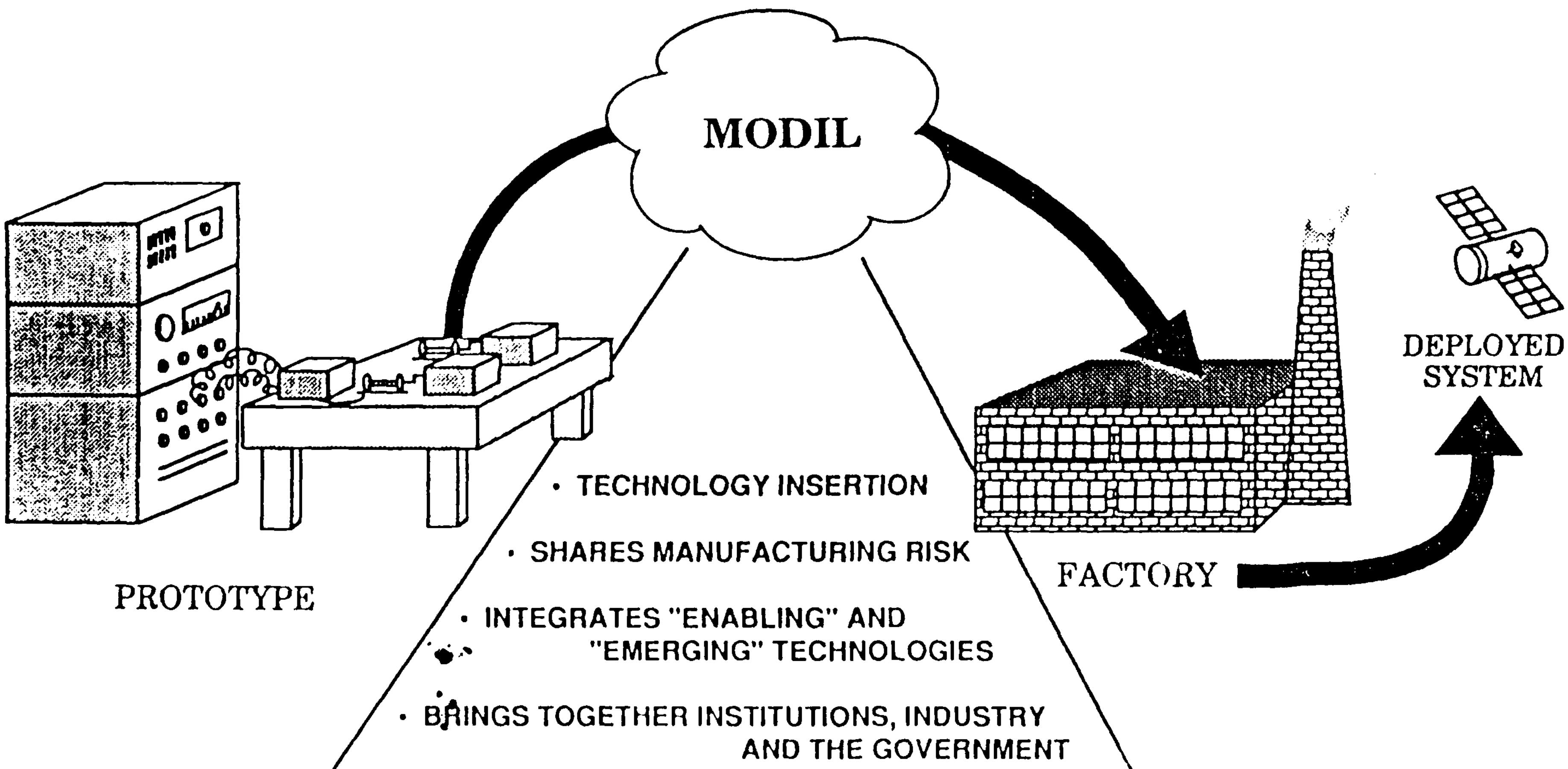
	Fiscal Years					
Departments	1987	1988	1989	1990	1991	1992
Defense	2	11	41	113	193	303
Agriculture	9	51	98	128	177	240
Commerce	0	9	44	82	115	177
Energy	0	0	0	1	43	152
EPA	0	0	2	11	31	35
HHS	22	28	89	110	144	241
Interior	0	0	1	12	11	10
Transportation	0	0	0	1	9	13
VA	0	0	1	2	8	4
Total	33	99	276	460	731	1,175

Z117/13

SDIO MODIL

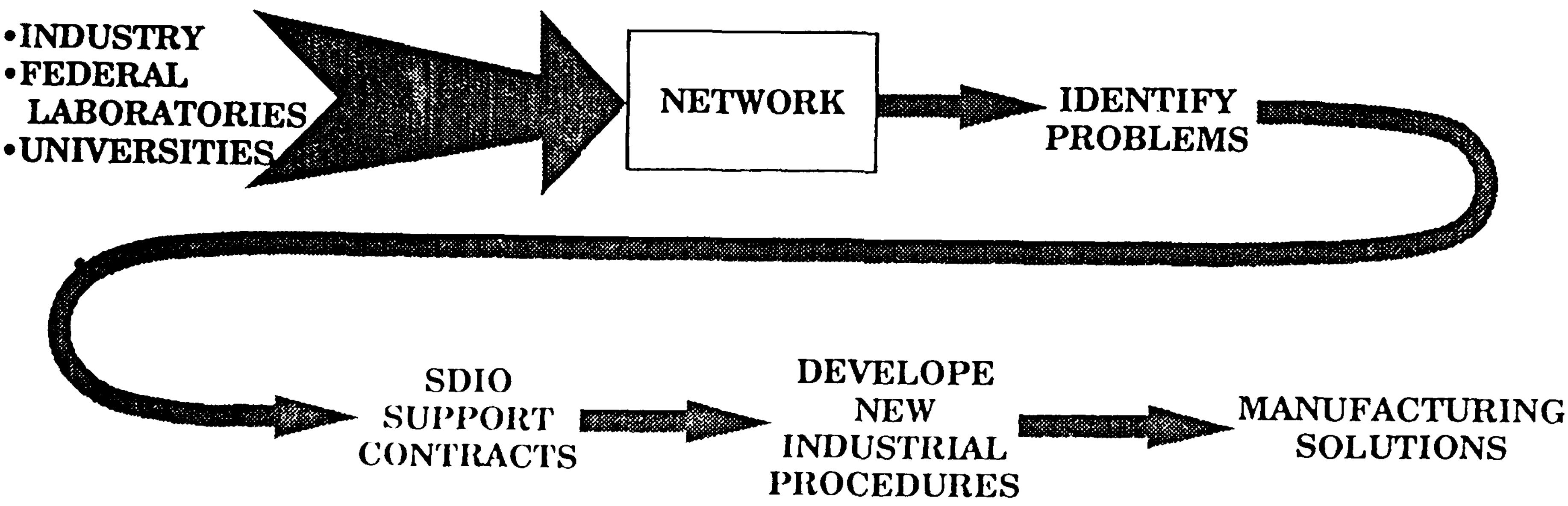
Manufacturing Operational Development and Integration Laboratories

Problem: How do you get from a prototype technology to a deployed, highly reliable system?



Z19

MODIL



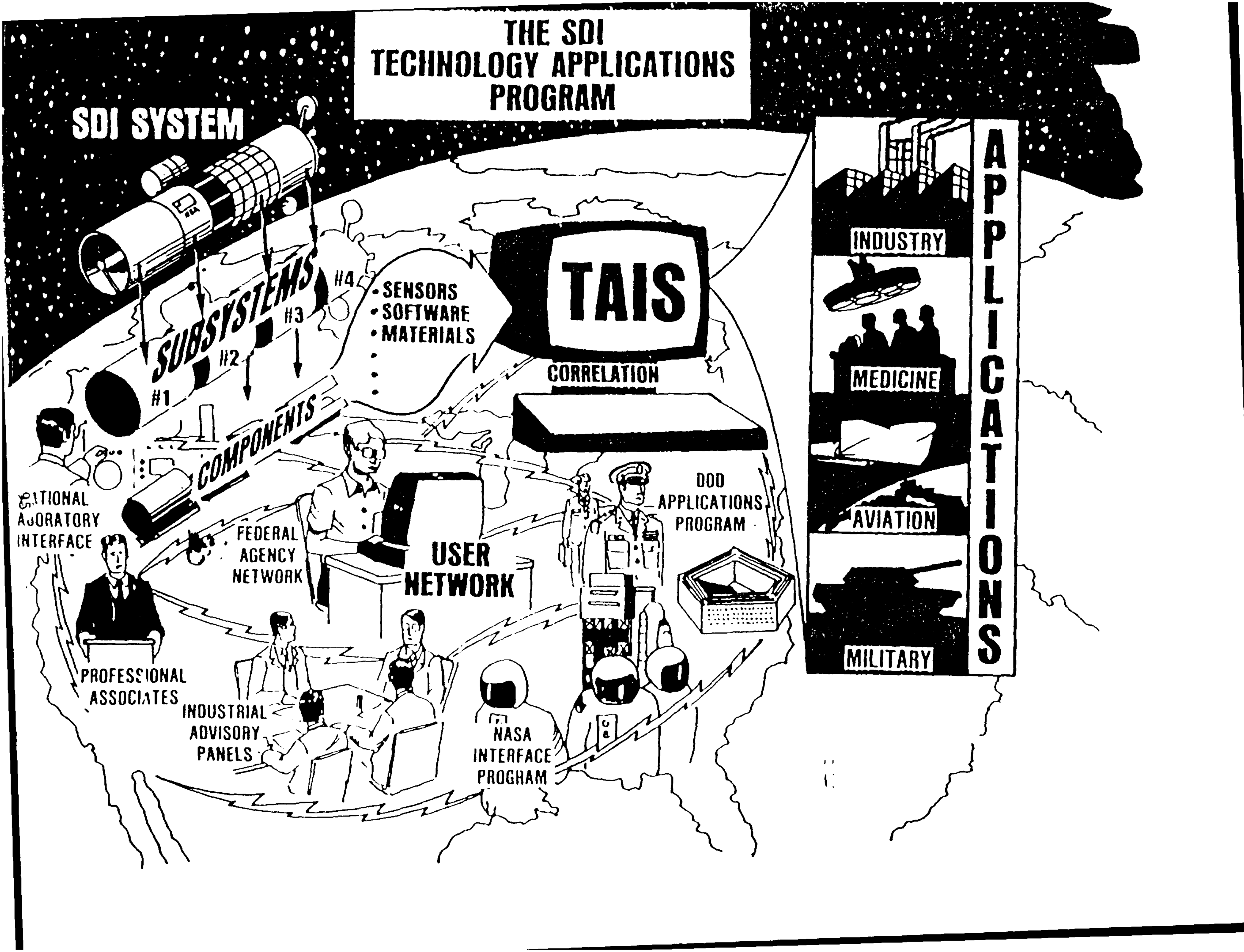
RESULT: An Affordable, Reliable, Deployable Space Defense System

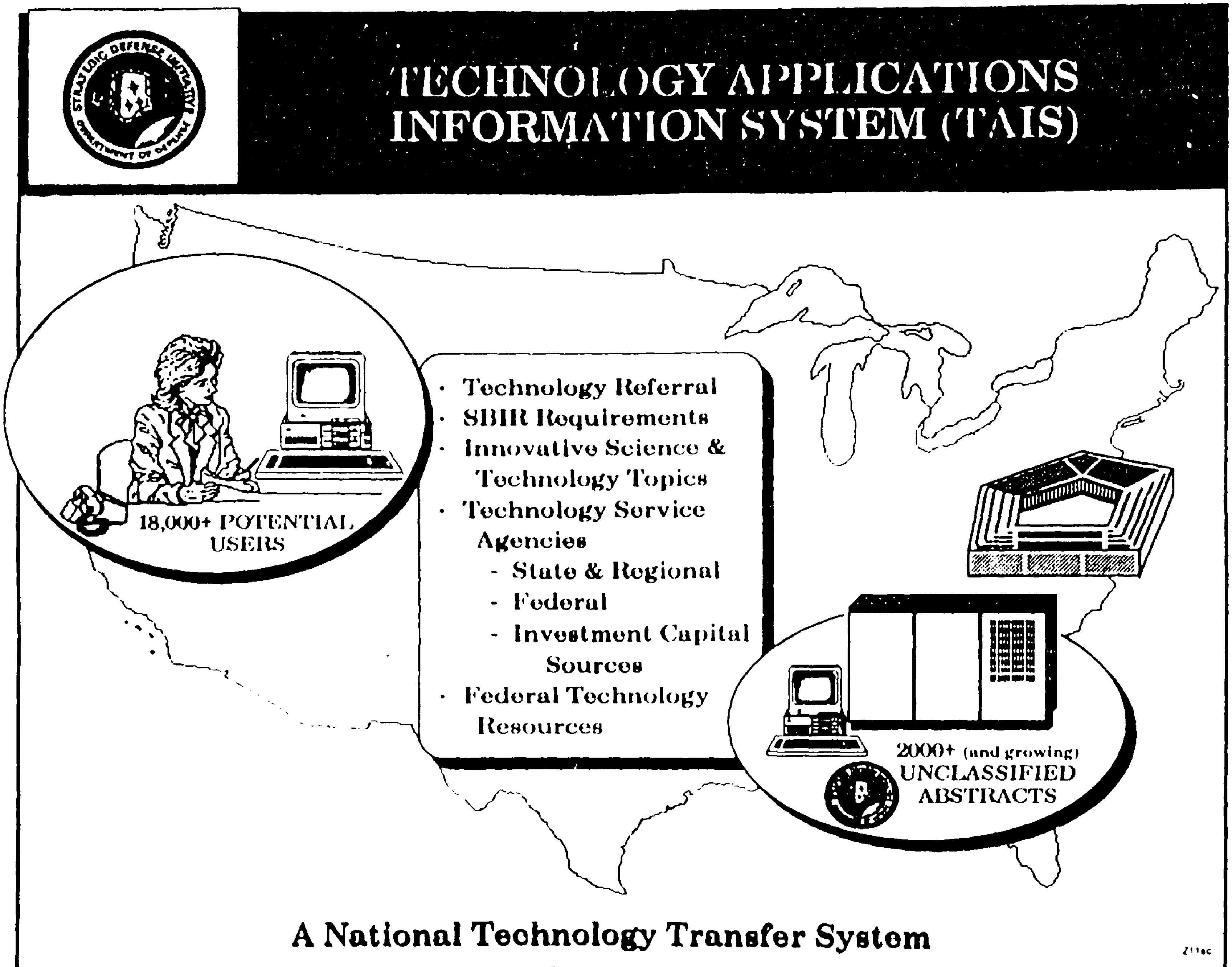
Z18

MODIL MANAGERS

• Survivable Optics MODIL Bill Martin	Oak Ridge National Laboratory (615) 574-8356 (615) 574-9407 (Fax)
• Electronics and Sensors MODIL Peter Winokur	Sandia National Laboratory (505) 844-3013 (505) 844-2991 (Fax)
• Spacecraft Fabrication and Testing MODIL Ted Saito	Lawrence Livermore National Laboratory (510) 422-1553 (510) 423-7914
• Software Producibility MODIL Arnold Johnson	National Institute of Science and Technology (301) 975-3247 (301) 590-0932

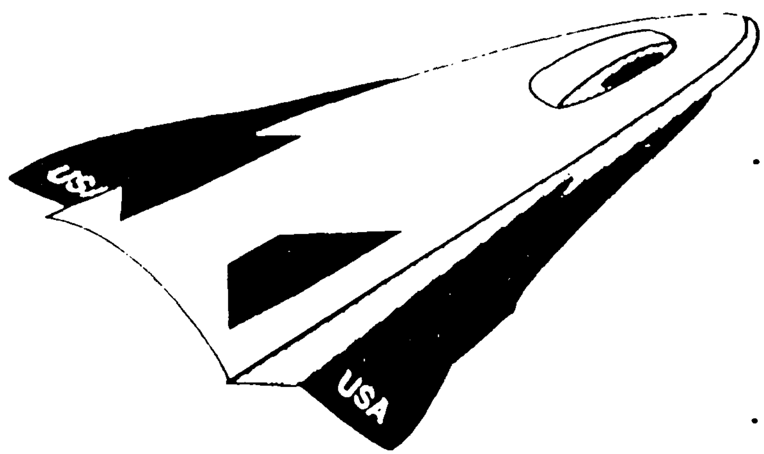
SDIO/SE003/5


THE SDI
TECHNOLOGY APPLICATIONS
PROGRAM
SDI SYSTEM
SUBSYSTEMS
#1
#2
#3
#4
COMPONENTS
• SENSORS
• SOFTWARE
• MATERIALS
TAIS
CORRELATION
USER NETWORK
INTERFACE
FEDERAL AGENCY NETWORK
PROFESSIONAL ASSOCIATES
INDUSTRIAL ADVISORY PANELS
NASA INTERFACE PROGRAM
DOD APPLICATIONS PROGRAM
APPLICATIONS
INDUSTRY
MEDICINE
AVIATION
MILITARY


TECHNOLOGY APPLICATIONS
INFORMATION SYSTEM (TAIS)
18,000+ POTENTIAL USERS
• Technology Referral
• SBIR Requirements
• Innovative Science & Technology Topics
• Technology Service Agencies
- State & Regional
- Federal
- Investment Capital Sources
• Federal Technology Resources
2000+ (and growing) UNCLASSIFIED ABSTRACTS
A National Technology Transfer System

NATIONAL AERO-SPACE PLAN (NASP) COOPERATIVE TECHNOLOGY TRANSFER

SDIO/NASP MEMORANDUM OF AGREEMENT IN EFFECT



- NASP Technologies Resident on the SDIO Technology Applications Information System (TAIS)
- NASP Technology Transfer Brokers have Access to Additional Technical Details
- NASP Brokers Share Advisor's E-Mail System
- Other Cooperative Initiatives Being Discussed

STATUS OF ALLIED CONTRACTS

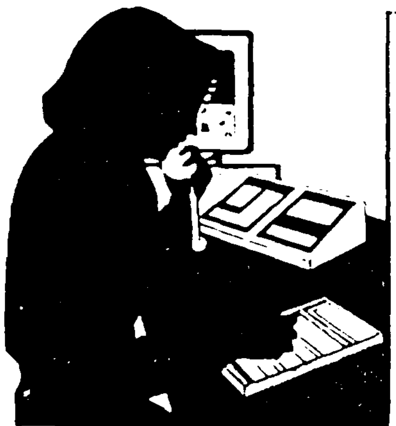
Country	Number Of Contracts	$ Values (M)
United Kingdom	158	150.27
Germany	49	90.24
Israel	25	311.07 *
Italy	25	16.08
Japan	20	7.10
France	22	21.15
Canada	22	14.98
Belgium	4	0.52
Denmark	1	0.03
The Netherlands	3	19.43 **
Total	329	$768.00

* Includes $137.160 Million Contribution By Israel

** Includes $7 Million Contribution By The Netherlands

jm-1098e / 112492

TECHNOLOGY TRANSFER LESSONS LEARNED



A Responsive Methodology

- Person-to-Person . . . NOT Data to Person
- Easy, Low Cost, Efficient Access

A Proactive Approach

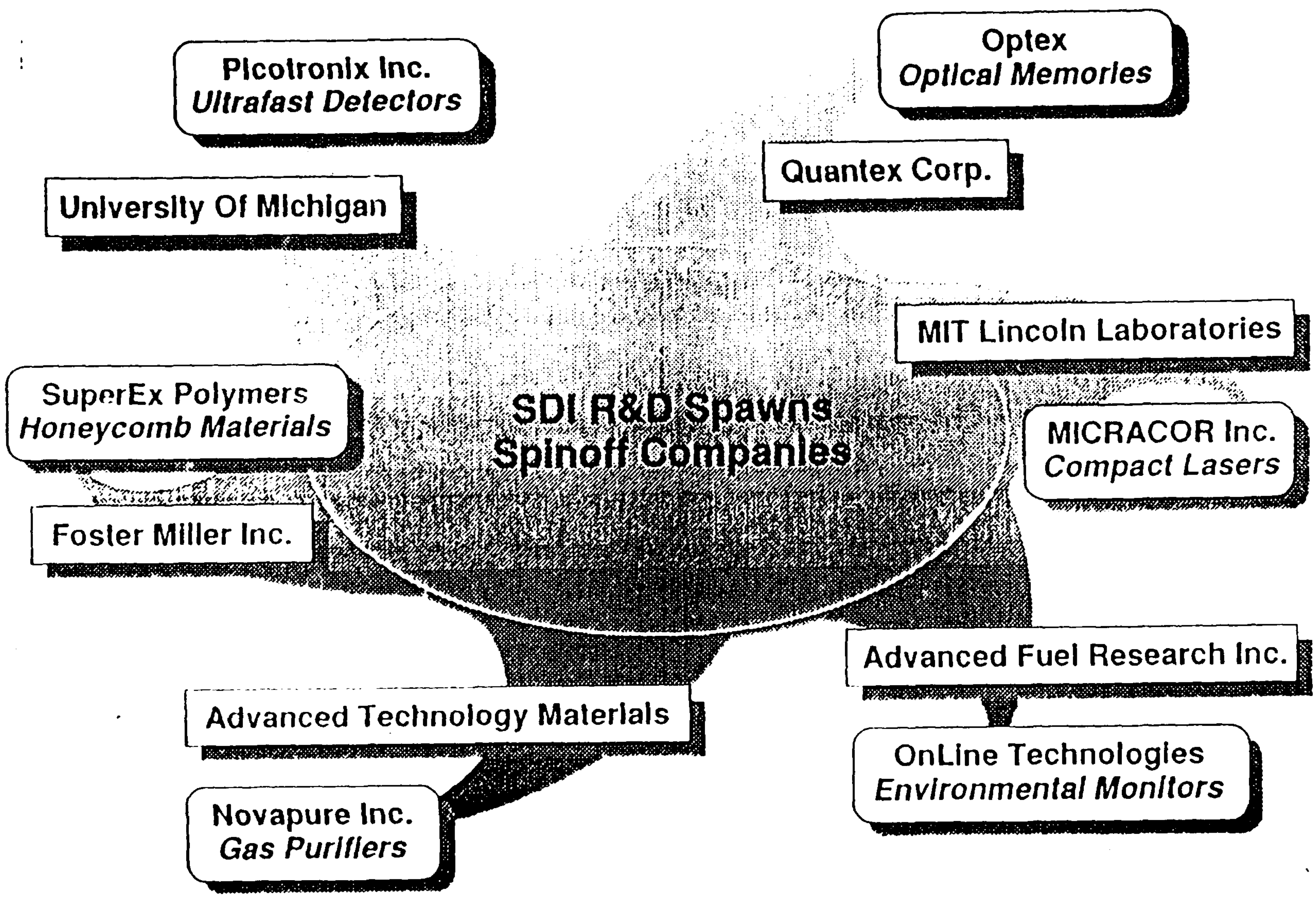
- Technology Push
- Market Pull
- Tracking and Follow-up

Leads to . . .

- Increased U.S. Productivity
- Increased U.S. Competitiveness in the World Marketplace

A PEOPLE TO PEOPLE PROCESS

SPINOFF COMPANIES *GENERATE* NEW PRODUCTS FOR THE MARKETPLACE



jm-33873 / 032593

FEDERAL TECHNOLOGY TRANSFER (T^2) POINTS OF CONTACT

Department Of Defense

- Army - Cliff Lanham
  - (301) 394-4210
- Navy - Ron Culpepper
  - (703) 696-4448
- Air Force - Chuck Chatlynne
  - (703) 695-3891
- BMDO - Nick Montanarelli
  - (703) 693-1671
- ARPA - Rick Dunn
  - (703) 696-2407
- DTIC - Dave Appler
  - (703) 274-9313

National Technology Transfer Center

- Thomas Clinton
  - (304) 243-2456
  - (800) 678-NTTC

Federal Laboratory Consortium

- Dr. Andy Cowan
  - (206) 683-1005

DOC / NIST (ATP)

- George Uriano
  - (301) 975-5187

NASA Regional T^2 Centers

- Northeast - Dr. W. Gasko
  - (508) 870-0042
- Mid-atlantic - Lani Hummel
  - (412) 648-7000
- Southeast - J.R. Thornton
  - (904) 862-3913
  - (800) 225-0308
- Midwest - Dr. Joseph Ray
  - (216) 734-0094
- Mid-continent - Gary Sera
  - (409) 845-0538
- Far West - Robert Stark
  - (213) 743-6132

pj 37151 / 090193

STRATEGIC DEFENSE INITIATIVE
DEPARTMENT OF DEFENSE

I WANT YOU

TO

THINK SPINOFFS!

Z116/18

TECHNOLOGY TRANSFER

AND

VENTURE CAPITAL

PRESENTED BY:

BARRY M. WEINMAN
GENERAL PARTNER OF NEWTEK VENTURES

NEWTEK VENTURES

FINANCING TECHNOLOGY DEVELOPMENT AGENDA

I. INTRODUCTION

NEWTEK VENTURES

BARRY WEINMAN

II. TRADITIONAL METHODS

III. VENTURE CAPITAL

IV. SOME OTHER IDEAS

NEWTEK VENTURES

INTRODUCTION TO NEWTEK VENTURES

FOUNDED:	MARCH 1983
$$ MANAGED:	OVER $60M
INTEREST:	EARLY STAGE HIGH-TECH BREAKEVEN AND POISED FOR CHANGE
CRITERIA:	EXCELLENT MANAGEMENT COMPELLING MARKET HIGH MARGIN PRODUCT OR SERVICE FOCUS & SENSE OF URGENCY "UNFAIR ADVANTAGE"
INITIAL $:	$250K TO $1M PLUS SYNDICATION HELP
PORTFOLIO STATUS:	36 COMPANIES 9 IPO'S 1 ACQUISITION 3 WRITE-OFFS A FEW SICKIES

BARRY WEINMAN

B.S.	CLARKSON UNIVERSITY
M.A.	UNIVERSITY OF SOUTHERN CALIFORNIA

"BIG COMPANY"

AT&T	MANAGEMENT TRAINEE
U.S. NAVY	OPERATIONS OFFICER
	SPEECHWRITER
FAIRCHILD	SEMICONDUCTOR PRODUCTION
IBM	MARKETING

"SMALL COMPANY"

IAI	FOUNDER, CEO
	MANUFACTURING SOFTWARE
BATTERY SYSTEMS	FOUNDER, PRESIDENT
	NICKEL-ZINC BATTERY

NEWTEK VENTURES TURN-AROUNDS

PHASE II	AUTOMATION
ITERE	TEST EQUIPMENT
KEY LOGIC	SYSTEMS SOFTWARE

BOARD OF DIRECTORS RESPONSIBILITIES

HUNTER SYSTEMS
KEY LOGIC
NEXT CENTURY POWER
PALM COMPUTING
BE, INC.

NEWTEK VENTURES

TRADITIONAL SOURCES

I. **R & D**

SBIR GRANTS
- DARPA
- NIH
- DOE
- NSF

CORPORATIONS
- DIRECTED DEVELOPMENT
- GREYHAWK
- CHOLESTECH

II. **PRODUCTIZATION**

STRATEGIC PARTNERS
- CONNOR PERIPHERALS
- NEUREX

BIRD FOUNDATION
- HUNTER SYSTEMS

III. **MARKET READY**

VENTURE LEASING
RECEIVABLES FINANCING
JOINT VENTURES

NEWTEK VENTURES

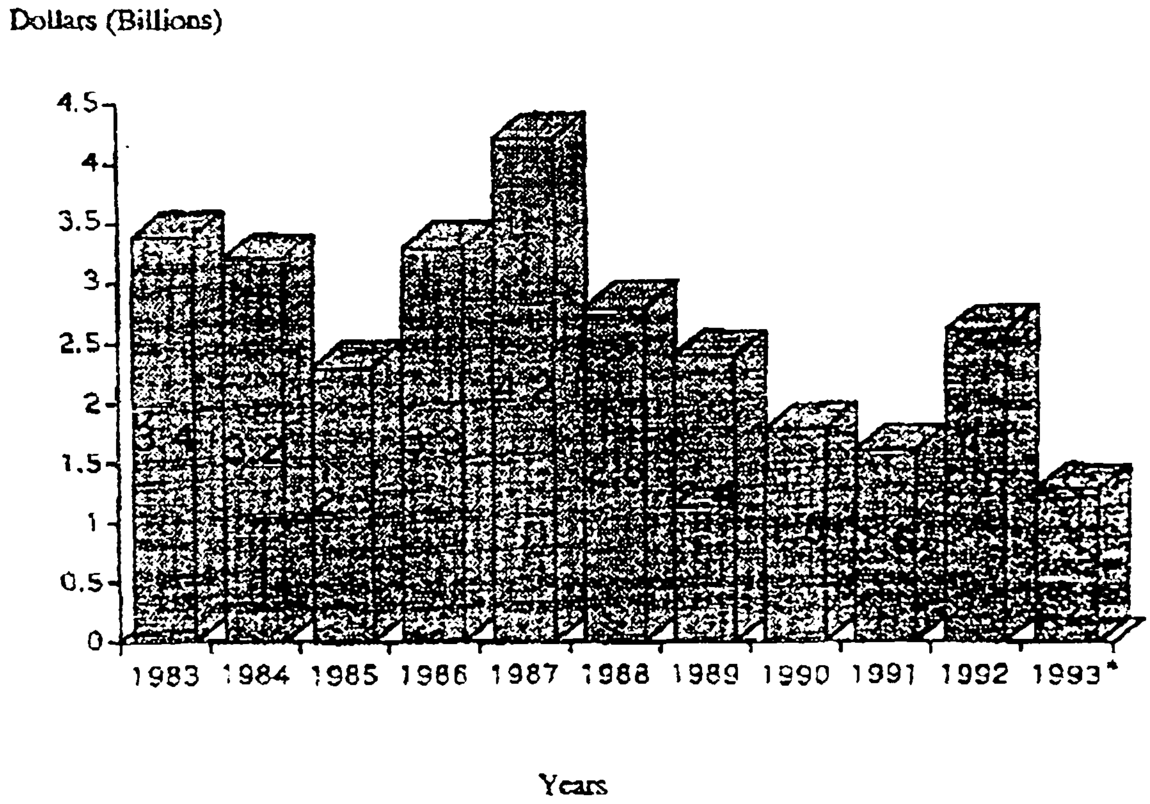
VENTURE CAPITAL STATISTICS

INDUSTRY SIZE:	644 FIRMS
NO. OF PROFESSIONALS:	APPROX. 2,000 (1/2 PARTNERS)
GROWTH RATE:	4.4%
MONEY RAISED:	
1989:	$2.4B
[illegible]	$1.8B
1991:	$1.3B.
1992:	$2.3B
COMMITMENTS:	
1989:	$3.4B (1,600 DEALS)
1990:	$1.9B (1,018 DEALS)
1991:	$2.0B (1,200 DEALS)
1992:	$2.5B (1,207 DEALS)

1993 AVAILABLE $ POOL: $29.5B

NEWTEK VENTURES

VENTURE CAPITAL DOLLARS RAISED BY YEAR



*Through June 1993.

Source: *Venture Economics*

NEWTEK VENTURES

VENTURE CAPITAL PROCESS

(KISSING LOTS OF FROGS)

I. WE RAISE MONEY

II. [illegible]D'EM -- MIND'EM

A. FIND DEALS

B. STRUCTURE TERMS & CONDITIONS

C. HELP DEVELOP VALUE

III. RETURN CAPITAL & PROFIT

IV. RAISE NEW FUND OR CHANGE CAREERS

NEWTEK VENTURES

WHAT VENTURE CAPITALISTS LOOK FOR IN A COMPANY

- ✔ EXPERIENCED MANAGEMENT
- ✔ SENSE OF URGENCY!!!
- ✔ COMPELLING MARKET
- ✔ STRATEGIC FOCUS
- ✔ TECHNICAL EXCELLENCE
- ✔ REASONABLE FINANCING
- ✔ EXIT STRATEGY

NEWTEK VENTURES

VENTURE CAPITALISTS
WILL

- HIRE & FIRE THE CEO
- HELP SET STRATEGIC DIRECTION FOR THE COMPANY
- MAKE INTRODUCTIONS TO FINANCIAL, BUSINESS AND OTHER POTENTIAL CONTACTS USEFUL TO THE COMPANY
- LEAD FUTURE FINANCINGS
- ASSIST THE CEO THINK THROUGH HOW TO GROW THE COMPANY

VENTURE CAPITALISTS
WILL NOT

- RUN THE COMPANY
- DEFINE NEW PRODUCTS
- SET THE ORGANIZATION STRUCTURE
- PREPARE BUSINESS PLANS
- BE INVOLVED IN DAY-TO-DAY OPERATIONS

NEWTEK VENTURES

FIRST RULE OF INVESTING

MANAGEMENT
MANAGEMENT
MANAGEMENT

WORKED TOGETHER
- "CHEMISTRY"
- ACKNOWLEDGE LEADER
- CLEAR CUT RESPONSIBILITY/ AUTHORITY

BUILT A COMPANY

SIGNIFICANT PERSONAL INVESTMENT
- ENTREPRENEURS AS INVESTORS
- HOW MUCH IS YOUR CAR WORTH?

BUILD ON PREVIOUS EXPERIENCE
- DO IT RIGHT
- BE FOCUSED

NEWTEK VENTURES

ACHIEVING RETURN ON INVESTMENT

- DEFENSIBLE AND PROFITABLE BUSINESS (NOT JUST A PRODUCT)
- AN EXCELLENT MANAGEMENT TEAM
  (EXPERIENCED, FLEXIBLE, TENACIOUS AND HONEST)
- ABILITY TO "EXIT" THE INVESTMENT (IPO, ACQUISITION, ETC.)
- FAIR INITIAL PRICING (VALUATION) OF THE COMPANY
- A GROWTH PLAN YIELDING A 10X RETURN ON INVESTMENT IN 5 YEARS
  (60% PER YEAR COMPOUNDED)

NEWTEK VENTURES

SOME OTHER IDEAS

CONNECT: UCSD

- TECHNOLOGY FORUMS
- MEET THE RESEARCHER
- SEMINARS: MANAGING HIGH TECH START-UPS

AEA UNIVERSITY ASSOCIATES PROGRAM

- PARTNERSHIP TO LEVERAGE RESEARCH
- AEA R&D FORUM

STANFORD PROGRAM

- PARTNERING:
  - CONSULTING / PART-TIME WORK
  - LICENSING

PUBLIC DOMAIN CONCEPT (PROTOCOL ENGINES)

- LICENSE: FREE AND NON-EXCLUSIVE
- TECH FORUM: $25K/YEAR $500/SESSION
- CONSULT: EXPERTS IN TECH
- EQUITY IN START-UPS
- NEWSLETTER SUBSCRIPTION

NEWTEK VENTURES

WORKING GROUP REPORTS

WORKSHOP ON COMMERCIALIZATION OF

PULSED POWER SCIENCE AND TECHNOLOGY

San Francisco, CA, August 18-19, 1993

Working Group on Medical, Materials, Other

Participants

Gunter Hofmann	BTX
Tom Naff	P.I.
Kris Kristiansen	TTU
Gabriel Roy	ONR
Nick Montanarelli	BMDO
Roseanne Dutton	USC
Wayne Hofer	DOE/LLNL

EXCITING OPPORTUNITIES FOR PULSED POWER IN MEDICINE AND MATERIALS ... BUT NEED TO ADAPT, COMMUNICATE, AND ORGANIZE

- Applications
- Cultural issues
- "Packaging" the technology
- "Selling" the technology
- A success story

APPLICATIONS:

Medical

- Imaging - P.E.T., ultrasound, FEL
- Lasers - burn treatment, tatoo removal, photodynamic therapy, plastic surgery, bone cutting, and healing
- Dry sterilization (plasmas, ionbeam)
- Surface treatment (surgical instruments)
- Electroporation
- Pulsed lithotripsy - focused shockwaves
- Waste treatment:
    - e-beam
    - x-ray
    - microwave

Materials/Other ... welding, surface treatment, sub-terrainean radar, treatment of mixed waste, biofouling

The medical customer is different than the U.S. government!

CULTURAL ISSUES:

- The "human factor" - hesitation or unwillingness to risk
- NIH (not invented here) factor
- Proper credentials - "MD"
- Time-lag to acceptance - may be necessary to "start off-shore"
- Liability
- Regulatory agencies

"SELLING THE TECHNOLOGY" TO A SOMETIMES WARY CUSTOMER:

- Work through medical schools, trade associations, and professional societies

- Publish and promote in trade journals

- Participate in medical conferences and seminars

- "Special issues" of leading publications

- Recruit/convert an MD/PhD who likes advertising and R&D ..."the thought leaders"

- Work with Health Industry Manufacturing Association (HIMA)

- Industrial/University recruit Congress

- Identify industry pull

PACKAGING THE TECHNOLOGY IS CRUCIAL:

- Need a new, readily comprehended technology descriptor - not "pulsed power"

- Clearly identify the differentiators:

    - may need x100 improvement
    - an entirely new capability

- User-friendly - not "high-tech":

    - reliable
    - easy to set up and maintain
    - customer focused

WORKSHOP ON COMMERCIALIZATION OF PULSED POWER SCIENCE AND TECHNOLOGY

San Francisco, CA, August 18-19, 1993

Working Group on Environmental Applications

Participants

Jeffrey M. Cukr	Defense Nuclear Agency
George B. Frazier	Physics International
Mike Grothaus	Naval Surface Warfare Center
Myron Jones	Electric Power Research Institute
David A. Goerz	Lawrence Livermore National Laboratory
George F. Kirkman	Integrated Applied Physics
Axel Wolf Kratel	California Institute of Technology
Kenneth R. Prestwich	Sandia National Laboratories
Bernie M. Penetrante	Lawrence Livermore National Laboratory
Karl H. Schoenbach	Old Dominion University
Howard W. Shaffer	Westinghouse Electric Corporation
Leonard T. Whitlock	Oceaneering Technologies

Sampling of Participants' Objectives

- get ideas that may lead to new business
- interested in diversifying and broadening business base in pulsed power; environmental applications is one of new target areas
- find out where the pulsed power community is headed
- gather opinions on the best way to get the technology to the market
- learn about the capabilities of the pulsed power community and match them with the needs of various industries
- seek new opportunities; find how national labs, industry and univerties can cooperate
- find out about the capabilities of the pulsed power community, with special interest in groundwater treatment
- gather information and learn the state of the art in pulsed power, with interest in the remediation of ground water
- interest in expanding funding programs on environmental pulsed power applications

COMMENTS

- the urgent environmental applications of pulsed power are already known to most people

- there are already on-going activities resulting from the community's effort to survive
    - we have to change this
        - Survival should not be the goal. It should be the by-product.

- there is a lack of data and understanding to convince the users that pulsed power is the right solution

- there is a need for comparison of technologies, and an open and honest discussion of the best solution

- Is the solution really pulsed power?

APPLICATION OF PULSED POWER TO NON-THERMAL PLASMA PROCESSING

Needs

- pulsed power generators for pulsed corona
- accelerators for pulsed electron beam
- power modulators for dielectric barrier discharge
- concepts for atmospheric-pressure microwave discharge

Applications

- simultaneous NO_X/SO_2 removal in power plant flue gas
- NO_X control in internal combustion engines
- treatment of volatile organic compounds in industrial off-gases
- demilitarization of high explosives
- water treatment

Issues

- power consumption
- capital cost
- lifetime and reliability

Novel Concepts

- hybrid types of plasmas
- pulsed discharge = e-beam with bad emittance ?

APPLICATION OF PULSED POWER TO NON-THERMAL PLASMA PROCESSING

Whether e-beam or discharge,

pulsing is the means for attaining

high power and high electron energies.

- high power required because of large volume flow rates
- high electron energies required in order to increase processing efficiency

DEVELOP RELATIONSHIPS that will help us find commercial markets for pulsed power.

Focus on a specific goal that will accelerate the development and application of pulsed power for environmental applications.

CULTURAL CHANGE IS NEEDED

- if this technology is so wonderful, how come industry is not craving for it
- we still need to sell the technology to the users

DEVELOP A SENSE OF URGENCY

Invest in pilot plant demonstrations to show that DOE, DOD and industry are serious about this technology.

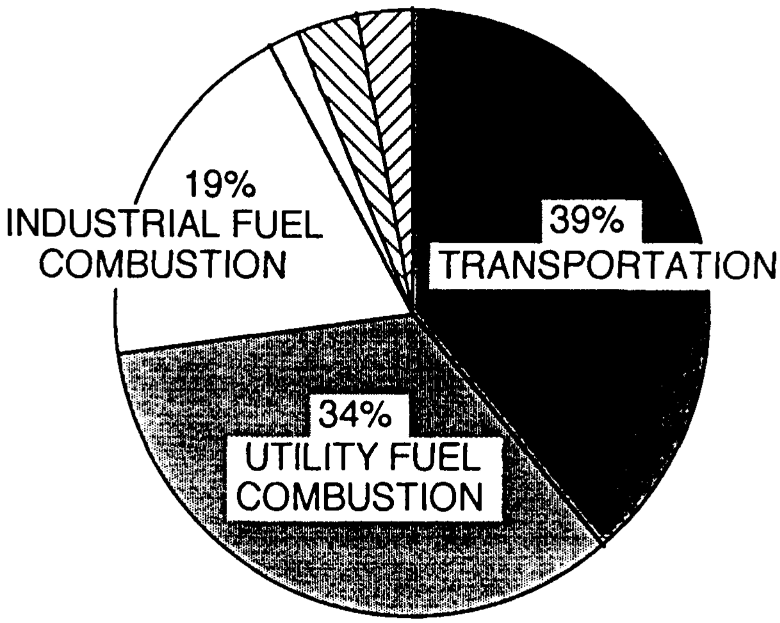
- concentrate on applications with requirements that can be met with existing or near-existing technologies
    - e.g., industrial boilers instead of utility power plants

APPLICATION OF PULSED POWER TO AIR POLLUTION CONTROL

HOW BIG IS THE MARKET ?

TOTAL U.S. EMISSIONS OF NO_x

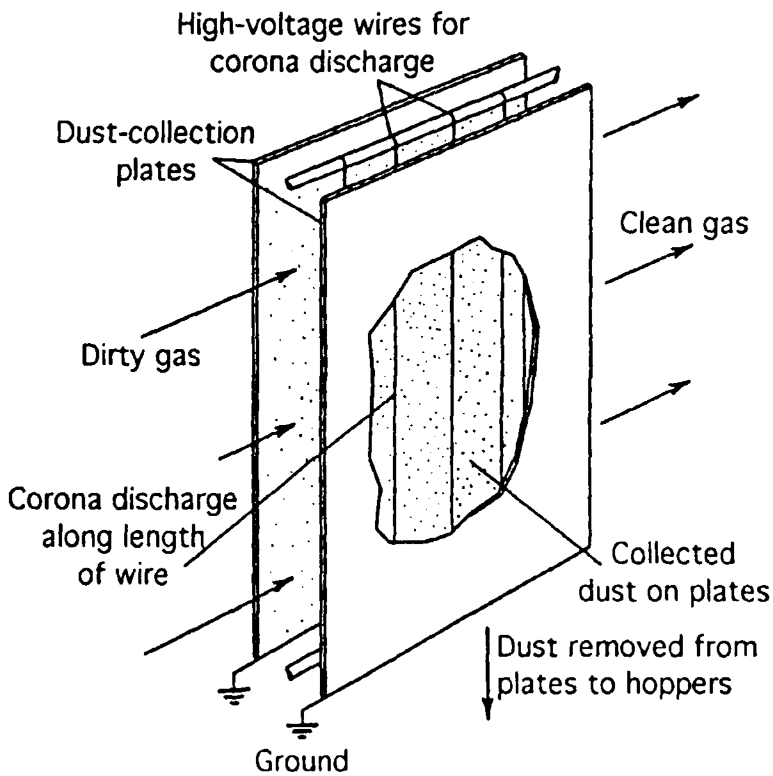
24 million tons per year



reduce to 2 million tons per year

In the US alone, the total emission of NO_X amounts to 24 million tons per year. About 53% of this is emitted from utility and industrial fuel combustion. The Clean Air Act of 1990 demands that the NO_X emissions be reduced to 2 million tons per year (92% reduction).

Even with particulate removal devices having an average removal efficiency of 99%, the worldwide emission to the atmosphere is still 30 million tons of solid particulates per year. Forecasts suggest thai by year 2000, the world coal consumption will increase by 35%. To keep the total emissions of solid particulates constant, the collection surface of electrostatic precipitators have to be doubled.



Simplest form of an electrostatic precipitator. When a high voltage is applied to the wire, the electric field created produces a corona region consisting of electrons and ions. The drift field established between the corona region and the collection plate extracts ions. These ions interact with the particulates, imparting charge to the dust which is then driven to the collecting plate. Maximum particle collection requires maximum charges on the particles and maximum precipitation fields. Large particle charges can be attained only by applying very high peak voltages, while rapid collection of the charges requires high time-averaged values of the voltage.

APPLICATION OF PULSED POWER TO FLUE GAS CLEANUP

$$N_2, O_2, H_2O \xrightarrow{\text{electrons}} N, O, OH$$

$$SO_2 \xrightarrow[HO_2]{OH,\ O} H_2SO_4$$

$$NO_x \xrightarrow[H_2O]{OH,\ O} HNO_3$$

$$NO \xrightarrow{N,\ NH_2} N_2$$

$$H_2SO_4 \xrightarrow[H_2O]{NH_3} (NH_4)_2SO_4$$

$$(NH_4)_2SO_4 \xrightarrow[HNO_3]{NH_3,\ H_2O} (NH_4)_2SO_4 \cdot 2NH_4NO_3$$

Simplified model of reaction mechanisms for the simultaneous removal of SO_2 and NO_x from flue gas by electron beam irradiation. Stage 1 represents radical production from the interaction of electrons with the flue gas. Stage 2 represents the conversion of SO_2 and NO_x to their respective acids, and the reduction of NO to N_2. Stage 3 represents the formation of salt by-products which are then collected by an electrostatic precipitator or baghouse. The same mechanisms apply to the pulsed corona process, but the relative amounts of initial radicals and final by-products are different because the mean electron energies are lower.

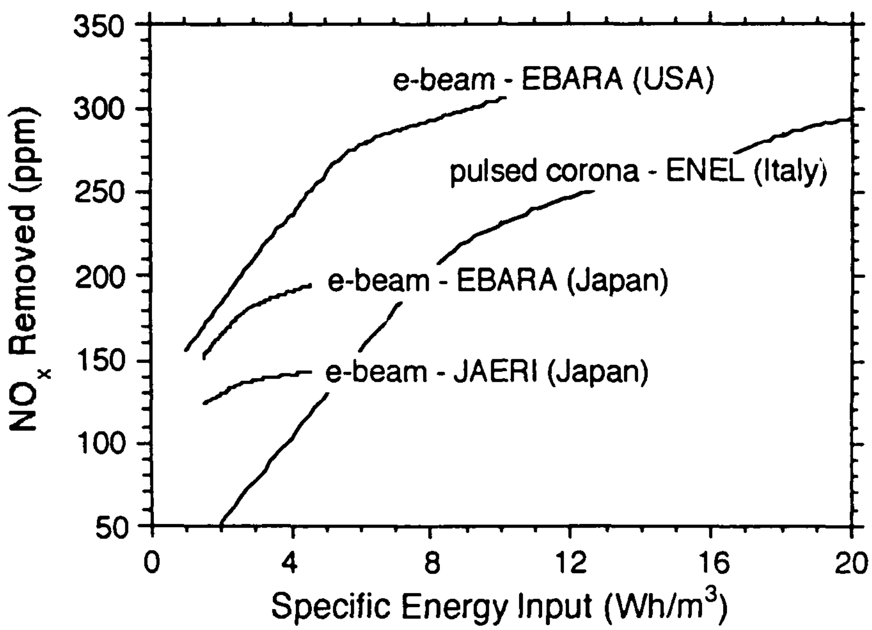
APPLICATION OF PULSED POWER IN ELECTROSTATIC PRECIPITATORS

Pulsed systems could be used to optimize precipitator efficiency by allowing one to precisely adjust and control both the duration and frequency of the current pulses. The use of pulsed power makes it possible to achieve higher peak voltage and higher sparking voltage.

Pilot plant tests in the US, Japan and Italy showed that the use of pulsed power leads to an increase in the precipitation efficiency without having to increase the area of the collecting electrodes. Furthermore, pulsed powering leads to a higher over-all electrical efficiency.

Pulsed power will become more important for particulate control as the world consumption of coal increases.

PILOT PLANT RESULTS ON ELECTRON BEAM AND PULSED CORONA FLUE GAS TREATMENT



Amount of NO_x removed as a function of the specific energy input. The pulsed corona result obtained at ENEL (Italy) was for initial NO_x of 300-550 ppm, and gas flow rates of 500-600 Nm^3/h. The electron beam result obtained at Ebara (USA) was for initial NO_x of 270-390 ppm, and gas flow rates of 4000-5200 scfm. The result obtained at Ebara (Japan) used 3-stage electron beam irradiation with initial NO_x of around 200 ppm. The result obtained at JAERI (Japan) used triple stage irradiation with initial NO_x of 150 ppm and gas flow rate of 15 Nliter/min.

POWER REQUIREMENT OF ELECTRON BEAM FLUE GAS TREATMENT

500 MW power plant burning 194 tons per hour of midwestern coal.

Typical flue gas flow rate is 10^6 scfm or 4.7×10^8 cm^3/s.

The gas is polluted with 350 ppm of NO_x and 2000 ppm of SO_2.

Both laboratory and pilot plant tests show that it is relatively easy to remove SO_2. The power consumption for the combined removal of NO_x and SO_2 is determined mainly by the removal of NO_x.

The required rate of NO_x removal is

$$350 \text{ ppm} \times 10^{-6} \times 4.7 \times 10^8 \text{ cm}^3/\text{s} \times 2 \times 10^{19} \text{ molecules/s} =$$
$$3.3 \times 10^{24}\ NO_x\text{-molecules per second}$$

The best value of specific energy consumption for deNO_x achieved by the electron beam process is

$$14 \text{ eV}/NO_x\text{-molecule} \qquad (\text{de}NO_x \text{ by e-beam}).$$

The power requirement for the electron beam process is thus

$$14 \text{ eV}/NO_x \times 3.3 \times 10^{24}\ NO_x/\text{s} = 4.6 \times 10^{25} \text{ eV/s} = 7.4 \text{ MW}$$

This represent 1.5% of the power plant output.

POWER REQUIREMENT OF PULSED CORONA FLUE GAS TREATMENT

500 MW power plant burning 194 tons per hour of midwestern coal.

Typical flue gas flow rate is 10^6 scfm or 4.7×10^8 cm^3/s.

The gas is polluted with 350 ppm of NO_x and 2000 ppm of SO_2.

Both laboratory and pilot plant tests show that it is relatively easy to remove SO_2. The power consumption for the combined removal of NO_x and SO_2 is determined mainly by the removal of NO_x.

The required rate of NO_x removal is

$$350 \text{ ppm} \times 10^{-6} \times 4.7 \times 10^8 \text{ cm}^3/\text{s} \times 2 \times 10^{19} \text{ molecules/s} =$$
$$3.3 \times 10^{24} \text{ NO}_x\text{-molecules per second}$$

The best value of specific energy consumption for $deNO_x$ achieved by the pulsed corona process is

50 eV/NO_x-molecule (deNO_x by pulsed corona).

The power requirement for the pulsed corona process is thus

$$50 \text{ eV/NO}_x \times 3.3 \times 10^{24} \text{ NO}_x/\text{s} = 1.7 \times 10^{26} \text{ eV/s} = 26.4 \text{ MW}$$

This represent 5.3% of the power plant output.

COSTS OF FLUE GAS TREATMENT USING ELECTRON BEAM AND PULSED CORONA

Cost analysis shows that in order for electron beam processing to be competitive with the FGD/SCR method, the accelerator has to cost around $2 per watt.

A 500 MW power plant will require a 7.4 MW accelerator (or set of accelerators) costing $15 million.

Assuming that pulsed power generators can be manufactured at a cost of $1 per watt, the same 500 MW power plant will require a 26.4 MW pulsed power system costing $26 million.

LESSONS FROM HISTORY

(1) Pulsed power has already been successfully demonstrated in a large scale for improving the efficiency of electrostatic precipitators. Pulsed power will undoubtedly become essential as the world consumption of coal for energy production increases.

(2) Many pilot plant tests of electron beam processing for NO_x/SO_2 removal have been, and continue to be, conducted around the world. Coal-fired pilot plant tests with gas flow rates as large as 25,000 Nm^3/h have been conducted. Scale-up of electron beam accelerators using pulsed techniques are now being conducted. The use of pulsed electron beams is essential to meet the beam power requirements and to reduce the cost of the accelerators.

(3) Demonstration of the pulsed corona process for NO_x/SO_2 removal in a large scale has been hampered by the absence of suitable pulsed power generators. The pulsed power requirements for pulsed corona reactors are much more demanding than those for electrostatic precipitators. The largest pilot plant test conducted using pulsed corona is only 1,000 Nm^3/h. Larger scale tests are essential to learn not only what the scalability of the process is, but also what the typical investment and operating costs are at full-scale industrial facilities.

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- WHAT SHOULD THE RESOURCE GROUPS DO TO HELP THE COMMERCIALIZATION OF PULSED POWER SCIENCE & TECHNOLOGY?
- HOW TO BE IN TOUCH WITH THE WORLD/CUSTOMERS BETTER?
- MATCHING APPLICATIONS/MARKETS TO TECHNOLOGIES

TOPICS OF DISCUSSION FOR THE POWER ELECTRONICS WORKING GROUP

COPPSAT WORKSHOP

- INDUSTRY
- UNIVERSITY
- GOVERNMENT LABS
- GOVERNMENT FUNDING AGENCIES
- NOT-FOR-PROFIT ORGANIZATIONS

WHO ARE THE RESOURCE GROUPS?

- ➪ MORE INTERACTIONS BETWEEN INDUSTRY AND UNIVERSITY:
  - INFLUENCE FACULTY RESEARCH INTEREST
  - EXPOSES STUDENTS EARLY TO THE PROBLEMS AND CHALLENGES
  - GOVERNMENT COULD PROVIDE POST-GRADUATE FELLOWSHIP TO ENCOURAGE INTERACTIONS
- ➪ MORE INTERACTIONS BETWEEN INDUSTRY AND NATIONAL LABORATORIES

WHAT SHOULD THE INDUSTRY DO?

COPPSAT WORKSHOP

- UNIVERSITIES HAVE DEMONSTRATED SUCCESSFUL INDUSTRIAL SPIN-OFFS, e.g. SILICON VALLEY
- FACULTIES COULD IMPROVE COMMUNICATIONS TO THE WORLD ON MERITS OF PULSED POWER TECHNOLOGY, e.g. BY WRITING MORE ARTICLES TO TRADE JOURNALS AS OPPOSED TO PROFESSIONAL JOURNALS
- CHANGE PERFORMANCE MEASURES FOR THE FACULTIES
- INDUSTRIAL ADVISERS ON GRADUATE STUDENTS THESIS COMMITTEES
- MODIFY DEGREE REQUIREMENTS TO REFLECT MORE REAL WORLD PROBLEMS
- MANDATORY INTERNSHIP PROGRAMS
- ATTRACT INDUSTRIAL USAGE OF UNIVERSITY FACILITIES & RESOURCES THROUGH FORMALIZED EFFORT

WHAT SHOULD THE UNIVERSITIES DO?

COPPSAT
WORKSHOP

- ➪ WORK ON PROBLEMS THAT MAY BE TOO COSTLY FOR INDUSTRY TO UNDERTAKE, e.g. RELIABILITY/LIFE IMPROVEMENT/TESTING
- ➪ EMPLOYEE EXCHANGE PROGRAMS WITH INDUSTRY AND UNIVERSITY:
  - PROMOTE CULTURE AND TECHNOLOGY EXCHANGE
  - A FAIR EXCHANGE WILL ELIMINATE THE CONCERN OF LABS PROVIDING FREE LABOR TO INDUSTRY

WHAT SHOULD THE GOVERNMENT LABS DO?

- CONTINUE TO EMPHASIZE DUAL USE
- ADOPT SUCCESS IN PROMOTING DUAL USE AS A CRITERION FOR BONUS IN MERIT PAY SYSTEM FOR FUNDING AGENCY EMPLOYEES
- DEVELOP METRIC FOR DUAL USE PERFORMANCE

WHAT SHOULD GOVERNMENT FUNDING AGENCIES DO?

COPPSAT WORKSHOP

- MORE PARTICIPATIONS FROM NOT-FOR-PROFIT ORGANIZATIONS (e.g. EPRI, American Water Works Association, National Gas Research Institute, etc.) IN WORKSHOPS TO DISCUSS APPLICATIONS

WHAT SHOULD THE NOT-FOR-PROFIT ORGANIZATIONS DO?

COPPSAT WORKSHOP

- MORE SERIOUS PARTICIPATION IN INTERNATIONAL CONFERENCES/WORKSHOPS THAT ARE NOT RELATED TO PULSED POWER
- MAKE ASSESSMENTS OF TRENDS AND TECHNOLOGY MORE READILY AVAILABLE
- BE PROACTIVELY EXPOSED TO OTHER AREAS
- FORM STRATEGIC PARTNERSHIPS BETWEEN DIFFERENT INDUSTRIES

HOW TO BE IN TOUCH WITH THE WORLD/CUSTOMER BETTER?

COPPSAT WORKSHOP

- REFER TO PAPER:

  "COMMERCIAL APPLICATIONS FOR MODULATORS AND PULSE POWER TECHNOLOGY"

  BY S. LEVY, M. NIKOLICH, I. ALEXEFF, M. RADER, M.T. BUTRAM, AND W.J. SARJEANT

APPLICATIONS/MARKETS FOR PULSED POWER