DoD INSENSITIVE MUNITIONS PROGRAM

Department of Defense Energetic Materials Hazards

Initiation Assessment Team (EMHIAT)

Assessment Review Workshop

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DoD INSENSITIVE MUNITIONS PROGRAM

ABSTRACT

The insensitive munitions program, begun by the Navy in 1984, has not only spread DoD-wide but also has become international in scope. The total FY 1987 funding of insensitive munitions technology is $39 million. This paper discusses how the insensitive munitions program fits into the overall DoD effort on conventional weapons and munitions.

INTRODUCTION

The Department of Defense (DoD) Insensitive Munitions (IM) program essentially began with an edict by the Chief of Naval Operations in May 1984 that all Navy munitions would have less sensitive components by 1995 ~~(Figure 1)~~. This action was triggered by fires on aircraft carriers over 20 years that had taken over 200 lives and cost nearly $200 million. There were existing programs on low vulnerability ammunition and increasing emphasis on 1.3 propellants at the time but these efforts lacked top level focus. The Navy decision created a strong top down motivation that did not go unnoticed by a small cadre of technologists who were ready to assume a strong bottom up proponentcy. Management had recognized a need and there was a group that had been lanquishing for funding that was prepared to fill this need.

The Navy quickly identified a group of weapons that needed to be improved. Some of these weapons were used by the Marine Corps. However, since the Marine Corps obtained most of its land attack weapons from the Army, the Army had to become involved. The Army was also accelerated into the insensitive munitions arena with the Pershing II - incident in Germany and other recent missile events. Since the Navy and the Air Force use common weapons, especially in air-to-air combat, the Air Force, too, had to become a player. The Air Force was also suddenly faced with changing requirements to store munitions on air bases and started their Insensitive High Explosive (IHE) Program. Many of the insensitive munitions programs developed into joint cooperative programs and were reviewed before The Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Chemical Propulsion Committee. Moreover, many U.S. weapons are sold to our allies overseas. A little over a year ago insensitive munitions suddenly became of interest to NATO AC/310 on Safety and Suitability for Service of Munitions and Explosives. Just recently the Technical Cooperation Program Subgroup W on Weapons Technology approved a new Weapons Action Group (WAG-11) on Hazards of Energetic Materials and their Relation to Munitions Survivability. What began as a Navy initiative in 1984 has grown into both a DoD as well as an international effort.

The scope of the current DoD program on insensitive amunitions is incredibly complex. It is an outstanding example of a program that touches every aspect of how DoD conducts its business. In order to understand how the DoD insensitive munitions program fits into the scheme of things, it is necessary to take a look at the overall DoD program on conventional weapons technology. In fact, it is appropriate to step back even further and take a look at how DoD scales-up technology in general.

TECHNOLOGICAL PROCESS

An effort has been made by the author over the past ten years to define the generic building blocks of a technological process. The intent has been to identify the stages, if they exist, of the evolution of something from its initial idea to the final product. During 1983 to 1987, a deliberate attempt was made in the Office of the Deputy Under Secretary of Defense for Research and Advanced Technology to manage over $500 million per year of conventional weapons technology programs of the Army, Navy, Marine Corps, and Air Force using a specific definition of a technological process. That is why the approach is called a management experiment.

The specific model of a technological process which was defined to represent the different stages of development of hardware products is given in Figure 2. Each of the columns will be briefly explained.

Stages: The six levels in this column indicate the six stages that are usually required in the evolutionary cycle of the development of a product.

Facility: The author was trained as a chemical engineer to scale up the manufacture of chemicals from test tube to tank car quantities with the facility stages in this column. These stages are in wide use in the chemical industry. The development of most solid, liquid, or gaseous materials follow these stages. This language is frequently used in the scaling up of insensitive munitions ingredients.

Quantity: In transitioning a material from the laboratory to production, the measure of progress is usually in terms of the ability to make a particular quantity per day, per month, or per year. The quantities in this column, all in grams, represent the scaling up in six stages from milligrams to grams, pounds, hundreds of pounds, tons, or multi-tons. Arbitrary bands of three orders of magnitude were chosen as a general rule of thumb. Variations from this scale may be used as an informal standard by different industries or companies. For example, the scaling of the manufacture of rocket propellants is dictated by the sizes of commercial mixers and the safety rules for handling quantities of explosive materials in a given facility and varies somewhat in the quantities for each of its stages.

Configuration: During 1984 a review was made of all DoD research and development program element descriptions. This review indicated a common vocabulary that was used to refer to the progressive development of technology. The vocabulary was not always used uniformly to represent the same stages in Figure 2, but the use of the vocabulary consistently implied that there were stages that represented different levels of maturity of technology. The configurations indicated in Figure 2 were culled from the many equivalent representations of the different stages referred to in the program element descriptions. These configuration terms have been adopted as the primary way of defining the six stages of the technological process. For this reason, it is appropriate to define each configuration. Most of the following definitions are taken from a glossary of definitions used by the Defense Systems Management College (DSMC).

Concept. There is no general agreement on the beginning term for the technological process. No other stage designation met with so much disagreement. The concept is the initial idea, device, gadget, demonstration of phenomena, breakthrough invention, reduction to practice, or material sample preparation.

Breadboard. An experimental device (or group of devices) used to determine feasibility and to develop technical data. It will normally only be configured for laboratory use to demonstrate the technical principles of immediate interest. It may not resemble the end item and is not intended for use as the projected end item.

Brassboard. An experimental device (or group of devices) used to determine feasibility and to develop technical and operational data. It will normally be a model sufficiently hardened for use outside of laboratory environments to demonstrate the technical and operational principles of immediate interest. It may resemble the end item, but is not intended as the end item. There are a number of euphemisms for a brassboard: advanced technology demonstrator (ATD), or "tech demo" for short: proof-of-principle test; test bed; flight weight model; pre-pilot; or even pre-prototype.

Prototypes. A prototype is a model that is suitable for evaluation of design, performance, and production potential.

Full Scale. This is the last stage of the scaling up of the development process. It is the transition from development to production. The design is complete.

Production. The conversion of the raw materials into products and/or components through a series of manufacturing processes. It includes functions of production engineering, controlling, quality assurance, and the determination of resource requirements.

Form: The last four columns in Figure 2 are all given in percentage bands that represent an estimate of the percent of the final production configuration. These numbers were repeatedly adjusted over three years as the result of the review of Figure 2. Moreover, it is the addition of these numbers to the definitions of Form, Fit, Function, and Mil Spec that give a more quantitative definition of the configurations in Figure 2 that have been defined in the past with only words. Form is interpreted to refer to such things as weight, thickness, materials of construction, parts counts, and manufacturing parameters in general.

Fit: Fit relates to packaging, space assignment, and dimensions.

Function: Function is concerned with the operational mission that the component, sub-system, or system is meant to perform.

Mil Spec: Mil spec is short for military specification and means any officially recognized government standard, drawing procedures, or recognized commercial standards for non-development items.

The definitions of each of the columns in Figure 2 essentially constitute the structure of the technological process. Some minor adjustments may have to be made for particular industries. Some of the stages may be grouped together under some common management umbrella. Nevertheless, each of the stages must still be satisfied. The technological process operates independently of any organizational, funding, or policy structure. On the other hand, nothing is accomplished except by people working together under some structure. The technological process must be interfaced somehow with that structure.

A side-by-side comparison of the technological process, DoD budgetary process, and DoD acquisition process is given in Figure 3. The technological process is represented only by the six stages and the corresponding configurations given in Figure 2. Since the configurations used in Figure 2 were based upon the vocabulary commonly used in budgetary and acquisition documents, there should be no surprises with the correlations in Figure 3. The one-to-one comparison of the different stages in Figure 3 are very idealistic and often are not representative of the real world.

The budgetary process in Figure 3 is indicated by the research and development (R&D) budget activity that corresponds to Stages 1-5. These stages are technically referred to as "categories" within the R&D "activity." The Procurement budget activity supports Stage 6, Production. Two research and development budget categories are omitted: 6.5 Management and Operations: and Operational Systems (product improvement funds). These categories are omitted because they are primnarily supportive or parallel the stages indicated.

The budgetary process which DoD uses was established in 1962 by Mr. Charles Hitch Under Secretary Robert McNamara. There was no 6.3a in the original "Hitch Package." It was added in 1972 because many people realized the need to perform non-systems technology demonstrations. Technology also needed to be matured without the need for a formal requirements document that was associated then with 6.3 funding in the budgetary process.

The acquisition process in Figure 2 is described in DoD Directive 5000.1, "Major System Acquisition," and dozens of supplemental directives and instructions. The acquisition process is a four step process that has been structured as a threshhold-reaching or gate-passing process. Mission need is stated in a Justification for a Major System New Start (JMSNS), which fulfills Milestone O. Milestone I represents a decision point for "concept selection and entry into the demonstration and validation phase." Milestone II is the decision for "program go-ahead and approval to proceed with full-scale development." The decision to enter production is made at Milestone III. There are variations on Milestone III called IIIA and IIIB involving concurrency, long lead items, and low rate initial production. there are few if any statements in any of the DoD regulations on the acquisition process that relate this process to the budgetary process. Funding of the acquisition process is very ad hoc. The placement of the acquisition process milestones in Figure 3 is based upon common vocabulary and going backwards from production. Milestones O, I, and II are usually funded under 6.3B. In some cases all four milestones are done under 6.4. Revisions of 5000.1 and the acquisition process are currently being made.

The horizontal dashed lines in Figure 3 represent critical transition periods in all three processes. The lower line is the hand-off from research and development (R&D) to production. There is a transition in management and budgetary responsibilities within DoD at this point. Within industry this transition involves a change from essentially handmade to hard tooling of products. The learning curve for manufacture begins here as the production rate builds up. Although there is general agreement in all three processes about the development to production transition, that is not the case in the transition earlier in the process. The primary issue concerns the definition of the technology base. Different definitions of the technology base are used under different circumstances involving combinations of 6.1, 6.2 and parts or all of 6.3A.

There are on-going efforts on insensitive munitions at every stage in Figure 3. That is what makes it so difficult to track what is going on. Although the primary interest here is in the technology base part, there is a very close coupling with feeding results into early systems applications.

MANAGEMENT EXPERIMENT

The actual management experiment to find out whether the technological process would be of value in measuring the products of the DoD conventional weapons technology base was organized and performed over 1984 to 1987. Each of the Army, Navy, Marine Corps, Air Force and Defense Advanced Research Projects Agency (DARPA) program element managers in conventional weapons technology was given a description of the technological process and was asked to tag all of their programs according to the matrix in Figure 4. Efforts on insensitive munitions fell mostly into technology programs on warheads, fuzes, energetic materials, gun, and missile/rocket propulsion.

In addition, the Services were asked to breakdown all of their technology programs into whether they resulted in supporting technology, breadboards, and brassboards. All funding in the technology base had to be in one of these three classes. Supporting technology was obtained by adding up all the breadboards and brassboards and subtracting from the total funding.

During this management experiment, insensitive munitions technology tended to fall into six areas of emphasis (Figure 5). In general, the breadboard and brassboard (bench scale and pre-pilot plant) results are being generated in the synthesis and scale-up of insensitive munitions ingredients and formulations. Some of the technology base work is even prototype/pilot plant in nature. Most of the insensitive munitions program in the development of test methods, performance of tests, establishment of new system design procedures, and even system design corrections are categorized as supporting technology. Mitigation techniques, such as venting, and storage and packaging tend to be buried in supporting technology.

Just about all 6.1 efforts, which were not included in this management experiment, would also fall into the supporting technology category. It has been noted as a general observation that supporting technology is very difficult to make visible to the user and to the general public. Supporting technology is usually technology generated for the use of other technologists. Breadboards, and especially brassboards, are easier to justify and to use to show a product resulting from investing resources.

A report is being prepared that summarizes this four-year management experiment.

FUNDING

The amount of funding available for insensitive munitions research and development is not as large as it is made out to be, but it is substantial. Some statistics about the funding of munitions (Figure 6) will explain why this is so. The Office of Munitions in the Office of the Secretary of Defense has assembled a data base on the procurement and research and development funding of all munitions. Munitions are defined as conventional non-nuclear small arms, automatic cannons, tank guns, field artillery, dispensers, launchers, stores release, bullets, projectiles, penetrators, bombs, mines, grenades, missiles, rockets, mortars, submunitions, torpedos, special operations weapons, pyrotechnics, propellant/cartridge activated devices, fuel air explosives, and enhanced blast munitions. Munitions put metal or a blast wave on a target. Funding data are based upon costs of the entire weapon round and any launcher interfaces. Gun tubes are included in research and development but not in procurement.

The total DoD procurement of munitions in FY 1987 is $11.4 billion for all Services. Procurement of munitions only represents 12.8 percent of all DoD procurement of $89.2 billion. The Navy has estimated that 10 percent of the annual procurement investment will be required to convert all munitions to insensitive configurations. This $1.1 billion is not visible. Total DoD research, exploratory development, advanced development, engineering development, and operational systems improvements of munitions is $3.3 billion. Munitions research and development is only 8.7 percent of the overall FY 1987 investment of $37.4 billion in research, development, test and evaluation (RDTE). The other 77.2 percent of DoD procurement and 91.3 percent of DoD RDTE goes for platforms, target acquisition, command, control, communications and support activities.

Munitions technology base funding defined in the management experiment on conventional weapons technology, is as follows: the total FY 1987 funding of 6.2 and 6.3a budget program lines primarily concerned with conventional weapons technology munitions is $695 million. If we add about $148 million of 6.1 (recommended as 15 percent of total 6.1 by 6.1 source, and $102 million of relevant Conventional Defense Initiative/Balanced Technology Initiative funding and $89 million of DARPA programs, the total DoD munitions technology base for FY 1987 is $1,028 million. The munitions technology base is $31.6 percent of the overall DoD RDTE on munitions and 20.8 percent of the entire $4.941 billion DoD Science and Technology base (does not include Strategic Defense Initiative). The management experiment indicated the following distribution of the munitions technology base:

- 31% Brassboards (86 for $314 million)
- 13% Breadboards (119 for $134 million)
- 32% Supporting Technology
- 24% Non-munitions Support

All funding had to be accounted for and no double counting was acceptable. About half of the non-munitions support funds other technologies in predominantly munitions budget line items. The other half goes for base operations. There is a tendency by Congress to selectively reduce the funding of brassboards and, consequently, prevent the maturing of technology. Non-technologists do not understand supporting technology and tend to not support efforts which do not produce brassboards.

Within the munitions technology base, $157 million is spent on warheads, fuzes, energetic materials, guns and tactical rocket propulsion. Depending on the audience, much of this funding is called insensitive munitions. Sorting out all of the above and, being very specific about tagging insensitive munitions technology base programs, only $39 million of insensitive munitions technology could be identified. In fact, the management experiment surfaced just eight breadboard and two brassboards demonstrations for $22 million. A flakier estimate would indicate that insensitive munitions programs funded from all sources is about $60 million. An audit trail is available for all of the numbers in Figure 6 but this last one.

CONCLUSIONS

There are a few trends associated with the insensitive munitions program. The need for insensitive munitions has spread from the Navy to the other Services. It is no longer a single Service program but is now DoD-wide. The Department of Energy is also involved. There is a growing international interest in insensitive munitions that is supported by a number of active international committees and agreements.

The funding of insensitive munitions is coming from many sources and from almost every budget activity and category. The Navy is still the predominant funder of insensitive munitions programs. They are very well organized and issue an excellent monthly report of all activities. The Army and Air Force do not have a very well defined or funded program. There is no current central direction of the insensitive munitions program by OSD. The very nature of insensitive munitions means that any work on any new munition that is safer could be interpreted as coming under the insensitive munitions umbrella. Based upon this interpretation, any munitions program could be called an insensitive munitions program. In essence, we are headed in that direction with new standards of safety dictated as the basic design criteria for any new weapon. In time, just about all of our gun, rocket propellants, explosives and pyrotechnicss will be impacted by the criteria for insensitive munitions. The concept of insensitive munitions is here to stay and will receive increasing emphasis and funding.

Finally, there is an increasing awareness that the achievement of many of the goals of insensitive munitions will require the answers to several fundamental technological and scientific questions. We are back to basics in the theories of initiation, deflagration, detonation, and the structure of chemical moieties that make up energetic materials. We have better instrumentation capabilities to achieve these answers than we did a few years ago. Contributions in the form of new theories, increased understanding of phenomena, and the synthesis of new explosives can only mean better and safer munitions in the hands of US and allied troops.

"ALL US NAVY MUNITIONS WILL BE DESIGNED TO MINIMIZE THE EFFECTS OF UNPLANNED STIMULI. THEY WILL INCORPORATE INSENSITIVE ENERGETIC MATERIAL WHICH MEET OR IMPROVE UPON PUBLISHED INSENSITIVITY STANDARDS ... OPERATIONAL CAPABILITY MUST BE MAINTAINED, BUT EVERY EFFORT MUST BE MADE TO MEET OPERATIONAL REQUIREMENTS WITH THE LEAST SENSITIVE MATERIAL AVAILABLE."

ADMIRAL JAMES D. WATKINS, USN
CHIEF OF NAVAL OPERATIONS
18 MAY 1984

FIGURE 1

DEFINITION OF THE TECHNOLOGICAL PROCESS

STAGE	FACILITY	QUANTITY (GRAMS)	CONFIGURATION	FORM*	FIT*	FUNCTION*	MIL SPEC*
1.	LABORATORY	10^{-3}-10^{0}	CONCEPT	0+	0+	0-50	0+
2.	BENCH	10^{0}-10^{2}	BREADBOARD	0-20	0-10	50-80	0-10
3.	PRE-PILOT PLANT	10^{2}-10^{4}	BRASSBOARD	20-60	10-30	80-100	10-50
4.	PILOT PLANT	10^{4}-10^{6}	PROTOTYPE	60-100	30-100	90-100	50-75
5.	SEMI-WORKS	10^{6}-10^{8}	FULL SCALE	100	100	100	75-100
6.	PRODUCTION	10^{8}+	PRODUCTION	100	100	100	100

*NUMBERS ARE PERCENT OF PRODUCTION CONFIGURATION

FIGURE 2

COMPARISON OF TECHNOLOGICAL PROCESS, BUDGETARY PROCESS AND ACQUISITION PROCESS

STAGE	TECHNOLOGICAL PROCESS	BUDGETARY PROCESS	ACQUISITION PROCESS	PRIMARY PERFORMER
1.	CONCEPT	6.1 RESEARCH	—	UNIVERSITY
2.	BREADBOARD	6.2 EXPLORATORY DEVELOPMENT	—	GOVERNMENT LABORATORY
3.	BRASSBOARD	6.3A NON-SYSTEMS ADV DEV	MILESTONES 0-I	INDUSTRY
4.	PROTOTYPE	6.3B SYSTEMS ADV DEV	MILESTONE I-II	INDUSTRY
5.	FULL SCALE DEVELOPMENT	6.4 ENGINEERING DEVELOPMENT	MILESTONE II-III	INDUSTRY
6.	PRODUCTION	PROCUREMENT	MILESTONE III+	INDUSTRY

FIGURE 3

TECHNICAL AREA CONTENT

GUIDANCE AND CONTROL

- ACOUSTIC
- RF/MICROWAVE
- MILLIMETER WAVE
- EO/INFRARED
- MULTI-SPECTRAL
- MIDCOURSE GUIDANCE
- MANEUVER CONTROL
- OTHER G&C

ORDNANCE

- INTEGRATED WEAPONS
- WARHEADS
- FUZES
- ENERGETIC MATERIALS
- FIRE CONTROL
- LAUNCHER/DISPENSER
- THREAT INTERACTION
- OTHER ORDNANCE

PROPULSION

- GUN
- MISSILE/ROCKET
- RAMJET
- TORPEDO
- OTHER PROPULSION

FIGURE 4

INSENSITIVE MUNITIONS EMPHASIS

- REVISED SYSTEM DESIGNS
- DEVELOPMENT OF TEST METHODS
- SYNTHESIS AND SCALE-UP OF INGREDIENTS
- DEVELOPMENT OF MITIGATION TECHNIQUES
- INVESTIGATION OF STORAGE AND PACKAGING CONCEPTS

FIGURE 5

FUNDING OF MUNITIONS

	FISCAL YEAR 1987 (DOLLARS IN MILLIONS)
o MUNITIONS PROCUREMENT	11,418
o MUNITIONS RESEARCH AND DEVELOPMENT	3,253
o MUNITIONS TECHNOLOGY BASE	1,028
o WARHEADS, FUZES, ENERGETIC MATERIALS, GUN/ROCKET PROPULSION TECHNOLOGY BASE	157
o INSENSITIVE MUNITIONS TECHNOLOGY BASE	39
o TOTAL INSENSITIVE MUNITIONS FUNDING	60

FIGURE 6

INSENSITIVE MUNITIONS TRENDS

- SPREADING FROM NAVY TO OTHER SERVICES
- GROWING INTERNATIONAL INVOLVEMENT
- FUNDING FROM MANY ACTIVITIES
- INVOLVING ALMOST ALL PROPELLANTS, EXPLOSIVES AND PYROTECHNICS
- INCREASING NEED TO UNDERSTAND FUNDAMENTALS

FIGURE 7

DOD INSENSITIVE MUNITIONS PROGRAM

DR. ROBERT J. HEASTON
STAFF SPECIALIST FOR WEAPONS TECHNOLOGY
OFFICE OF THE SECRETARY OF DEFENSE

7-3848

"ALL US NAVY MUNITIONS WILL BE DESIGNED TO MINIMIZE THE EFFECTS OF UNPLANNED STIMULI. THEY WILL INCORPORATE INSENSITIVE ENERGETIC MATERIAL WHICH MEET OR IMPROVE UPON PUBLISHED INSENSITIVITY STANDARDS ... OPERATIONAL CAPABILITY MUST BE MAINTAINED, BUT EVERY EFFORT MUST BE MADE TO MEET OPERATIONAL REQUIREMENTS WITH THE LEAST SENSITIVE MATERIAL AVAILABLE."

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THESIS

ALL OF THE PRODUCTS OF MODERN HIGH TECHNOLOGY SOCIETY ARE THE RESULT OF A MULTI-STAGE EVOLUTIONARY PROCESS THAT CONVERTS AN INITIAL, INCOMPLETE CONCEPT INTO A FINAL, MATURE DESIGN.

7 3166

DEFINITION OF THE TECHNOLOGICAL PROCESS

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1.	LABORATORY	10^{-3}-10^{0}	CONCEPT	0+	0+	0-50	0+
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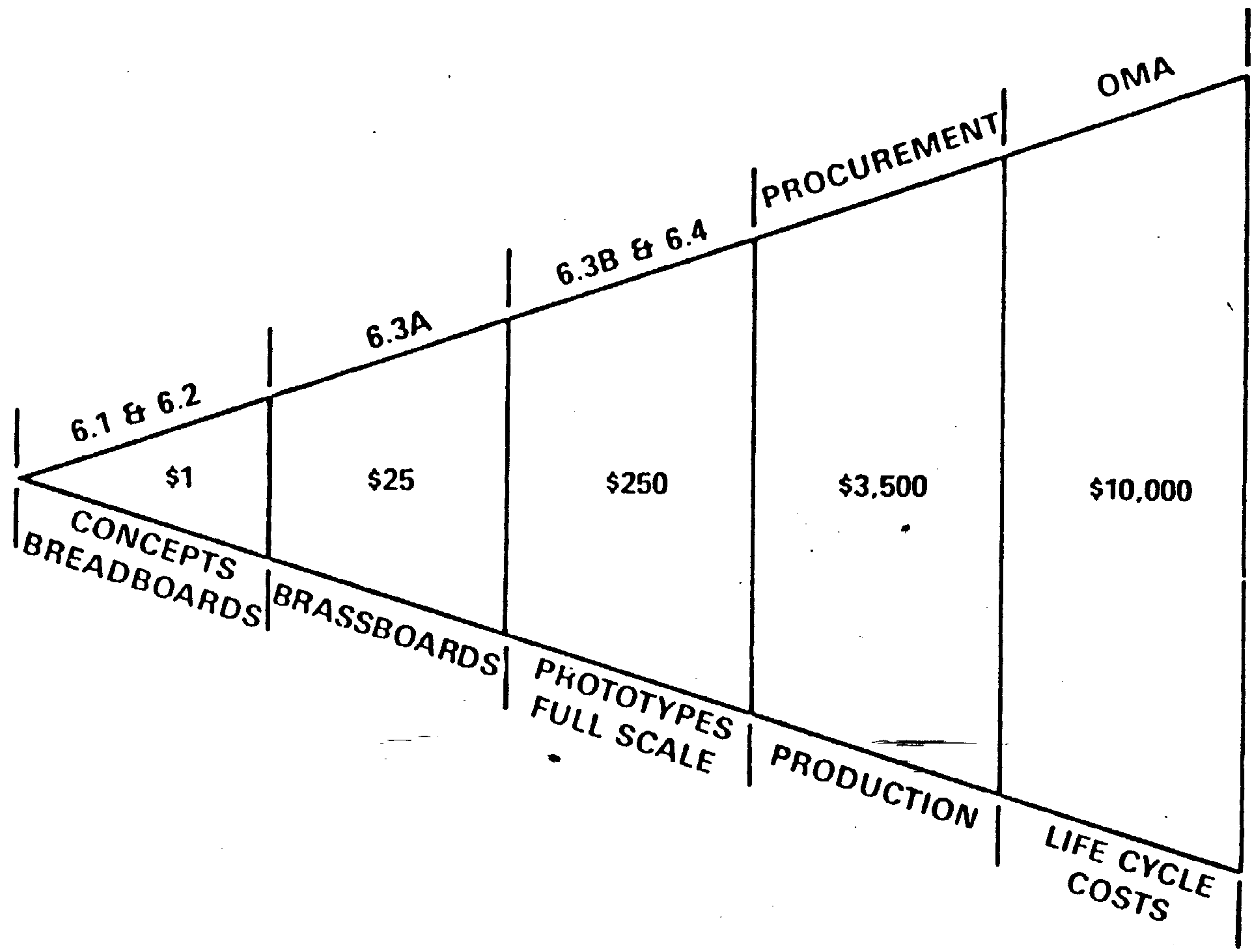
RELATIVE COST LEVELS FOR COMBAT VEHICLES



WEAPON SYSTEMS CYCLE

GENERATIONS	NOW	NEXT	NEW
TIME TO IOC	–20 TO 0 YEARS	0 TO 10 YEARS	5 TO 20 YEARS
WEAPONS STATUS	OPERATIONAL	DEVELOPMENTAL	TECHNOLOGY BASE
FUNDING CATEGORY	O & M/PROCUREMENT	6.3B/6.4/6.7	6.1/6.2/6.3A
DESIGN MATURITY	PRODUCTION COLD BASE/ MOBILIZATION	PROTOTYPE FULL SCALE DEVELOPMENT	CONCEPT BREADBOARD BRASSBOARD
OSD RESPONSIBILITY	ASD (P&L)	DUSD (S&TNF) DUSD (TWP)	DUSD (R&AT) DUSD (IP&T) DARPA
ACQUISITION PROCESS INPUT	MILESTONE III	MILESTONE I & II	MILESTONE 0

? 1166

MANAGEMENT EXPERIMENT

- SUPPORTING TECHNOLOGY
- BREADBOARDS
- BRASSBOARDS

7-3848

TECHNICAL AREA CONTENT

GUIDANCE AND CONTROL	ORDNANCE	PROPULSION
• ACOUSTIC	• INTEGRATED WEAPONS	• GUN
• RF/MICROWAVE	• WARHEADS	• MISSILE/ROCKET
• MILLIMETER WAVE	• FUZES	• RAMJET
• EO/INFRARED	• ENERGETIC MATERIALS	• TORPEDO
• MULTI-SPECTRAL	• FIRE CONTROL	• OTHER PROPULSION
• MIDCOURSE GUIDANCE	• LAUNCHER/DISPENSER	
• MANEUVER CONTROL	• THREAT INTERACTION	
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