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INSTITUTE FOR DEFENSE ANALYSES

Missile, Bomb, and Projectile Fuze Subtier Assessment

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INSTITUTE FOR DEFENSE ANALYSES

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PREFACE

The Institute for Defense Analyses (IDA) has established an Industrial Analyses Center (IAC) to provide the Office of the Secretary of Defense (OSD) with objective and independent analyses that characterize and assess industrial capabilities for acquisition and support of weapon systems. The IAC performs a range of analyses that address industrial issues associated with changing industry structure, competition, and industrial and technology capabilities, at the prime and subcontractor levels.

Firms reviewed in this study supply much of the information that IDA uses to perform its analyses. IDA may not be able to independently validate material supplied. As a result, future adjustments to these studies may be required to correct information provided by industry sources. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor do its contents necessarily reflect the official position of that Agency.

This document reports on an analysis done by IDA to address industrial issues associated with design, development, and production of fuzes and target detection devices for bombs, missiles, and large-caliber projectiles.

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Fuze Subtier Assessment

- This assessment was undertaken as part of the Industrial Assessment Program task sponsored by Mr. Marty Meth, Director, Industrial Capabilities and Assessments, OSD, and led by Dr. Robert Rolfe of the Institute for Defense Analyses.

Fuze Subtier Assessment

MISSILE, BOMB, AND PROJECTILE FUZE
SUBTIER ASSESSMENT

J. FRASIER, TASK LEADER
J. TRANSUE

F. SAXE

August 1998

Fuze Subtier Assessment

- This is the agenda for the presentation. It begins with an overview of the objectives of the study, followed by background information on fuzes and some details of the study process. Results are then given in terms of the firms in the industry, technical trends and demand as represented by uniformed service procurement plans over the FYDP years 1998 to 2003. The presentation closes with summary observations and conclusions.

PRESENTATION OUTLINE

- Introduction
- What's a fuze?
- Study elements
 - Coverage
 - Fuze classes and supplier taxonomy
 - Activities
- Producer, developer, and supplier assessments
- Design trends
- Demand projection
- Observations and conclusions

Fuze Subtier Assessment

- The purpose of the task was to assess the health and vigor of the fuze business sector with an eye toward weaknesses and problems. Several were found. The sector is under considerable stress as a consequence of downsizing over the last decade or so. The number of firms remaining has become small. Most of these are small businesses, and quite possibly some will leave the sector, potentially reducing competition below desirable levels. Also, there is a paucity of suppliers in several categories of items important to the fuze business.

INTRODUCTION

- Purpose:
 - Map the industry—identify producers and suppliers
 - Identify weaknesses and problems

Fuze Subtier Assessment

WHAT'S A FUZE?

Fuze Subtier Assessment

- The terms *fuze* and *fuzing* are used widely in the munitions community with various specific connotations. Also, there are other descriptors used that connote functions similar or identical to those accomplished by a *fuze*. Fortunately, within the community of users and developers these variations in terminology cause little confusion. For this study, the term *fuze* will be used generally to cover all those items under consideration, but when the occasion warrants, more specific and descriptive terms such as *safe and arm device* and *target detecting device* will be used.

WHAT'S A FUZE?

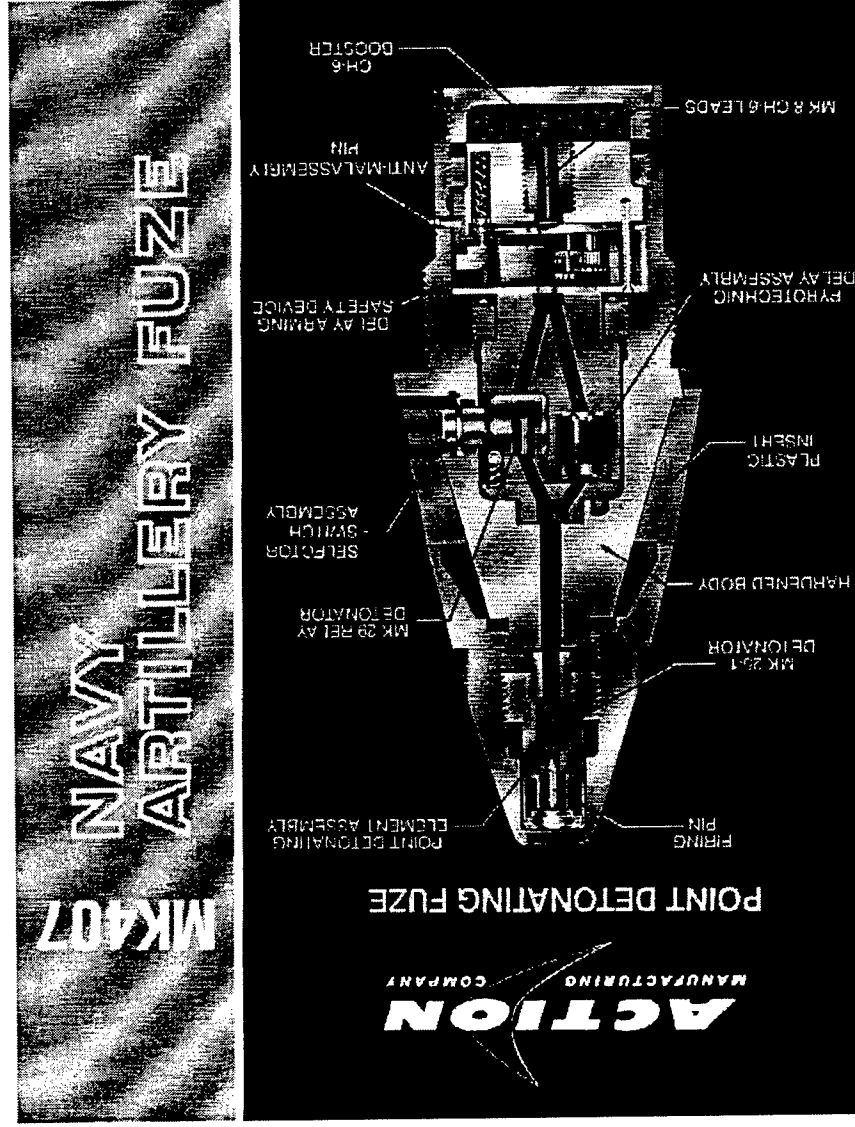
- To avoid confusion, the terms *fuze* and *fuzing* will be broadly used here. This usage will encompass the following functions and terms:
 - A means to start the process of warhead initiation when preset conditions are met. Terms often used include *fuze* and *target detection device*.
 - A means to preclude unintended warhead functioning that would be hazardous to the user of the munition. The term most often used for this function is *safe and arm device (S&A)*. The S&A also is the means by which the warhead is actually initiated.
 - Every warhead has devices that accomplish the above functions.
 - The fuze device and the S&A device may be separate and separated items, or the devices may be integrated into a single item. Their complexity varies widely depending upon application. Examples that display these various features are shown on the next several charts.

Fuze Subtier Assessment

- The MK407 displays the fundamental elements of a fuze. The fuzing functions are initiated when the tip of the device strikes a target, causing the firing pin to strike the detonator. This produces hot gas that activates further energetic elements. Ultimately, the booster is ignited and initiates the explosive charge of the munition. To do so successfully, the arming and safety device must “come into line (alignment)” to provide a pathway for the initiating gasses. The motion occurs during the flight of the projectile, and until it does, the output of the detonators is blocked from the leads and booster to preclude accidental initiation. This is called an “out-of-line” design.

Fuze Subtier Assessment

WHAT'S A FUZE?



Fuze Subtier Assessment

- Electronic time fuzes have many similarities to point detonating fuzes, in that they have a device that signals the start of the initiation process as well as an S&A device. In this particular fuze, used for a rocket munition, the decision to initiate the munition's explosive function is provided by the electronic time-of-flight device seen in the upper section of the item in the center of the picture. The lower section is a mechanical safe and arm device. It is also displayed separately at the sides of the photograph.

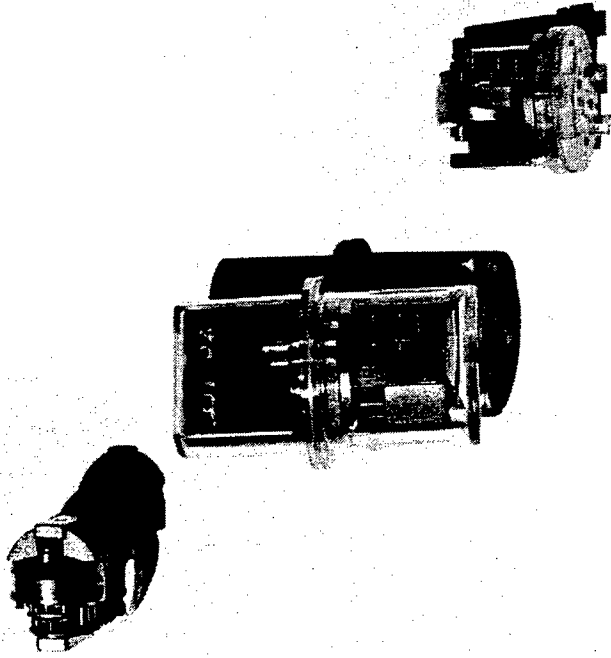
Fuze Subtier Assessment

WHAT'S A FUZE?

ACTION
MANUFACTURING COMPANY

100 East Erie Avenue, Philadelphia, PA 19134 Phone: (215) 639-6400 Fax: (215) 423-7749

M439 Rocket Time Fuze

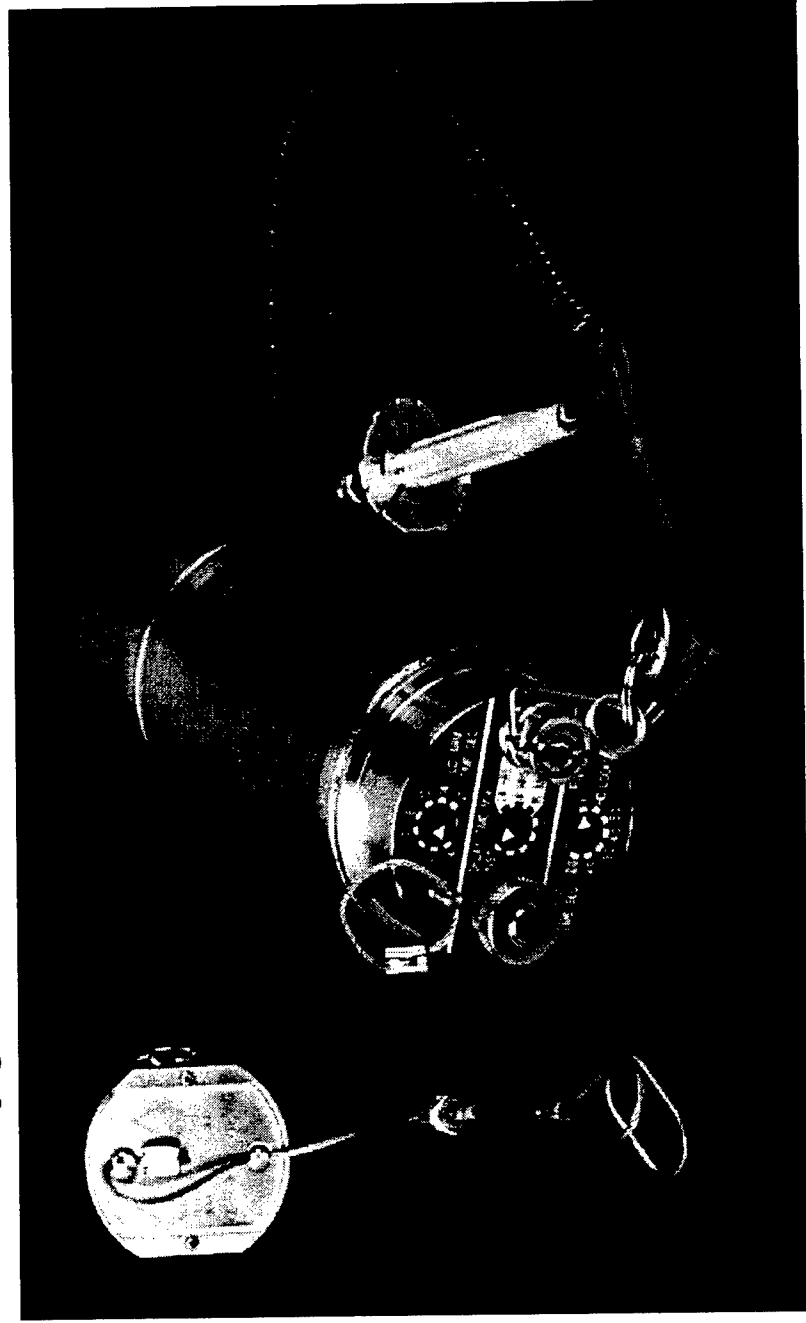


Fuze Subtier Assessment

- The Joint Programmable Fuze is a contemporary, sophisticated device made to satisfy both Air Force and Navy needs for bomb fuzing. It has multiple delay options settable from the cockpit or before flight. Optionally, it also accepts input from the DSU-33 proximity sensor. Its development was recently completed by Motorola under Air Force program management. Production has been awarded to Dayron, Inc.

WHAT'S A FUZE?

- JOINT PROGRAMMABLE FUZE



Fuze Subtier Assessment

- The fuze for the Standard Missile is a complex radar device physically separated from the associated S&A. The “fuze” in this instance is termed the “Target Detection Device” (TDD), and the S&A is an in-line Electronic Safe and Arm Device (ESAD).

Fuze Subtier Assessment

- Design, development, and production of fuzes is a defense-unique activity; there are no civil equivalents to the items. Special performance features are imposed by safety, reliability, load, and environmental requirements. Production has associated with it special tooling and gages. In general, it may be said that that firms that do fuzing are the firms that have done fuzing. Several startups have attempted to capture production contracts. We have heard generally unfavorable reports of quality and deliveries from startups, and financing startups in a declining market appears to be against DoD's long-term interest. Specialized experience is a decided benefit for success in the industry.

FUZES SPECIAL?

- What is special about fuzes and S&A devices?
 - **Practically speaking, defense is the only user of fuzing**
 - Safety reliability must be better than one in a million
 - Stringent requirements on safety, reliability, acceleration loads, and temperature extremes
 - Energetic materials components
- What is special about producing fuzes and S&A devices?
 - Some tooling and gages
 - Specialized parts and suppliers—small metal parts, power supplies, electro-explosive devices
 - **Specialized experience**—start up of new producers has proved to be very difficult in several cases
- What is special about fuze design and development?
 - **Unique features of environments, reliability, and safety** that must be met
 - Specialized knowledge of mechanical, electrical, electronic and energetic material/device technology and design
 - For some fuzes, design for efficient large-quantity production
- What is special about the fuze market?
 - **Defense is the market maker.** A sound, experienced development and producer base is in its best interest

STUDY ELEMENTS

- Coverage
- Taxonomy
- Activities

Fuze Subtier Assessment

- The original tasking for the study only specified consideration of bomb and missile fuzes. From the beginning, however, discussion with individuals from government and industry brought forth many concerns about matters in the large-caliber projectile fuze portion of the business sector. The team decided that since the interest and data were immediately at hand they should be gathered and analyzed. Also, responses to data requests provided some inputs on submunitions carried by cargo bombs, missiles, and projectiles. These were by no means exhaustive, but did represent additional useful information.
- As indicated on the slide, a number of fuze items were not included in the study.

COVERAGE

- Original focus—fuzing for bombs, missiles
- Focus expanded to include large-caliber projectiles
 - Much concern was found over topics in projectile fuzing
 - Information came readily
- Did not cover fuzing for
 - Land and sea mines, torpedoes, and small and medium caliber (<75 mm) ammunition, many submunitions...
 - Nuclear devices

Fuze Subtier Assessment

- Fuzes are sufficiently diverse in the details of their components that a single, work-breakdown-structure-like taxonomy was not found to be particularly convenient. Instead, a classification that keyed on the nature of the technologies used in fuze design was used to categorize fuzes, while a taxonomy that keyed on generic categories of suppliers was used for assessment of the support base to fuze production. This approach is reflected in this chart and the next.
- The TDDs detect the target (or some other object) by a sophisticated remote sensor. Ordinary “prox fuzes” used by artillery and bombs are not termed TDDs because they use relative simple remote sensors.
- The principal defining characteristic of electronic fuzes is the use of electronics for all or some critical part of their functions. Some fuzes classified as “electronic” contain electronic timing and logic circuitry along with mechanical S&A devices.
- The electromechanical class includes fuzes that are entirely mechanical and fuzes with mechanical S&As that use electrical energy to initiate firing, but not to run sensors and logic circuitry.

CLASSES OF FUZES

- The following three classes were found convenient for gathering and analyzing information on the producers and developers of fuzes:
 - Target detection devices
 - Primarily used on missiles such as AMRAAM, Patriot PAC-2, and Standard Missile Block 4A. Use radar, lasers, IR FPAS, etc. The most complex of all classes, with a distinct set of producers. Production rates low; costs high (\$10,000 to \$100,000).
 - Electronic
 - Advanced technology, often highly complex items. Many have high to medium production costs, with associated low to medium production rates and stockpile quantities. Typified by FMU 157 hard target smart fuze and FMU 152B joint programmable fuze for bombs. Lower cost, higher quantity items are typified by the M762/M767 electronic time fuze and the M732A2 proximity fuze for projectiles.
 - Electromechanical
 - Mature technology, complex items. Low to medium cost, large production rates and stockpile quantities. Typified by M745 point detonating fuze and MK407 point detonating/delay naval gun fuze.

TAXONOMY

- The following taxonomy was convenient to capture data on suppliers for all natures of fuzes:
 - Metal parts
 - Machined, stamped, drawn, or cast metal parts. Examples are shafts, plates, springs, casings, escapements, and gears.
 - Non-metal parts (non-energetic)
 - Machined, extruded, or cast non-metal parts. Examples are separators, supports, lenses and windows.
 - Energetic materials and devices
 - Pyrotechnics, explosives, and explosive-driven devices. Examples are pyrotechnic delays, detonators, delay detonators, slapper detonators, leads, boosters, gas generators, bellows, and piston actuators. Initiation is usually electric for bomb and missile fuzes.
 - Power supplies
 - Electrical, chemical, or mechanical energy-storage systems. Examples are charged capacitors, reserve batteries, air-driven or inertia-driven generators, and springs.
 - Electronics
 - Logic, timing, and control circuitry used in electric fuzes and S&A devices. Example components are printed circuit boards, surface-mounted integrated circuits (ICs), microprocessors, hybrid microcircuits, discrete components, and application-specific integrated circuits (ASIC).

Fuze Subtier Assessment

- The approach taken to the study was to develop a framework of information and data needs based upon the classification and taxonomy previously discussed and to reflect this framework in a request for information to be used throughout the appropriate industrial and DoD communities. The questionnaire, in combination with face-to-face, telephone, and e-mail contact, was used to gather all possible relevant information. Seven visits were made to industrial and government sites. Also, the annual meeting of the fuze section of the National Defense Industrial Association was attended. In all instances, the persons contacted were helpful beyond expectations.

STUDY ACTIVITIES

- Develop a request for information
 - Explanation of the task
 - Taxonomy and questions
 - Data sheets
- Establish government and industry contacts
- Gather data through interviews, survey, and DoD budget documents
- Establish databases
- Analyze data and information, establish conclusions
- Report out, August 1998

PRODUCER, DEVELOPER, AND SUPPLIER ASSESSMENTS

Fuze Subtier Assessment

- This chart lists firms that were identified as producers and developers of fuzes, categorized in accord with the previous discussion. The firms associated with TDDs are distinct from those in the other two classes, where there is considerable overlap between the classes. This is a reflection of the large differences in function, design, cost, and application between TDDs and the others. The firms in the business of TDDs are large and diverse, with broad technical sophistication. For the most part, in the other set, the firms are relatively small, with sophistication focused on fuze and fuze-like products.
- It must be noted that firms being grouped together in a category does not imply that they have equivalent breadth or depth of capability. There are very significant differences among them. Alliant Techsystems, for instance, has a very broad capability in electronic fuze design, development, and manufacture. Dayron, on the other hand, has its greatest experience in the production of grenade fuzes and some experience in the production of bomb fuzes. Nonetheless, Dayron was recently awarded the production contract for the FMU 152B, the Joint Programmable Fuze, an achievement of significant proportions which justifies their inclusion on the group of Electronic fuze producers.

PRODUCER/DEVELOPER ASSESSMENT

- **Producers/developers by class**
 - Target detection devices
 - Allied Signal
 - Motorola
 - Raytheon
 - Electronic
 - Alliant Techsystems, Inc.
 - Bulova Technologies, LLC
 - Dayron
 - KDI Precision Products
 - Raymond Engineering Operations
 - Electromechanical
 - Action Manufacturing
 - Alliant Techsystems, Inc.
 - Bulova Technologies, LLC
 - Dayron
 - KDI Precision Products
 - Raymond Engineering Operations

Fuze Subtier Assessment

- This and the following two charts summarize the recent decision of the Motorola Corporation to leave the fuze industry. They were a principal member of the industry, and fallout of their departure is reflected in several portions of this briefing.
- In October of 1997 the firm took the decision to leave the sector to put its resources in other, more promising business opportunities. In light of the major position that they had in the fuze business, this decision was significant for the industry. Among other things, experienced technical staff have gone to other areas and those who held contracts with Motorola have had to arrange for alternate developers and producers.
- Motorola transferred intellectual property, process information, and some tooling for non-missile fuzing to Alliant Techsystems (ATK). This, in combination with ATK's other holdings and competencies, could well put them in a predominant position for development and production of many types of fuzes. Exactly how this will play out depends in part on the results of acquisition strategies adopted by managers of the programs vacated by Motorola. It is interesting to note that the procurement contract for the Joint Programmable Fuze developed by Motorola was awarded to Dayron, in competition with ATK.
- At this writing, Motorola's intellectual property for missile fuzes had not been sold or transferred. A contractual arrangement with the Navy for them to continue the Standard Missile TDD work they had in hand has been agreed to. It is expected to be completed within 5 years, at which time Motorola will no longer participate in the fuze business.

THE MOTOROLA STORY

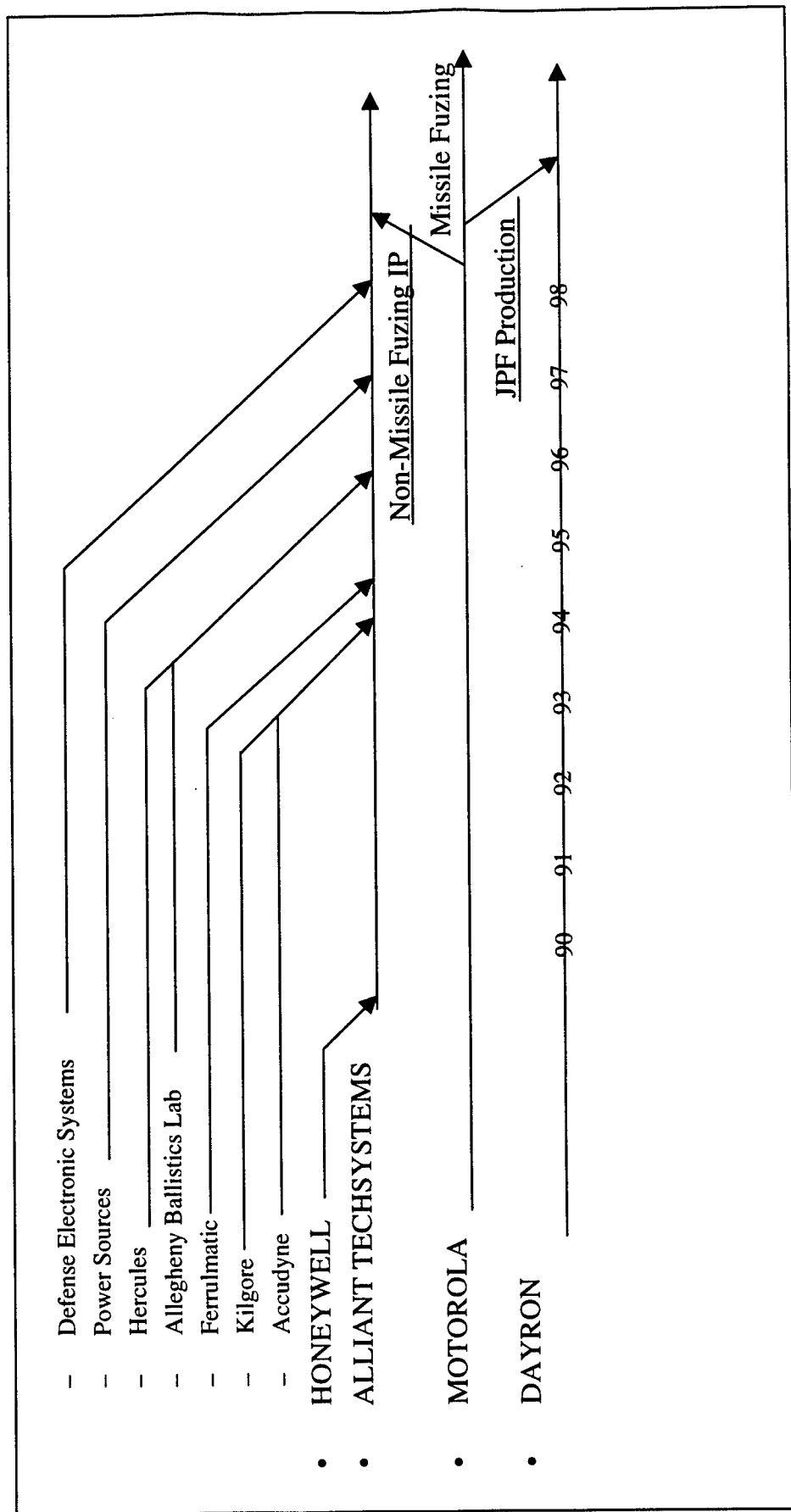
- Through competition, Motorola had gained a dominant position in the development and production of advanced technology fuzing items:
 - Standard missile fuzing—development, product improvement, and production
 - Hard target smart fuze—development and expected production
 - Joint programmable fuze—development and expected production
 - Navy multifunction fuze—development and expected production
- October 1997 Motorola announced it would discontinue its fuze business sector to pursue other business opportunities:
 - Non-missile fuze intellectual property, manufacturing processes, and tooling transferred to Alliant Techsystems.
 - Missile fuze intellectual property on the market. Raytheon was considered the likely buyer, but this has not occurred. Motorola will continue standard missile work for up to 5 years but will not continue beyond.
 - Services elected to compete some of the contracts vacated by Motorola. Outcomes of competition expected this summer. *The process and outcomes will provide a benchmark on fuze industry competitive environment. Current status: JPF production to Dayron, HTSF EMD to Alliant*
 - *The migration of many Motorola technical staff to other sectors is a loss for the fuze sector.*

Fuze Subtier Assessment

- This chart graphically shows the disposition of Motorola fuze business. It particular, it displays the significant capability acquired by Alliant Techsystems through its arrangement with Motorola and through other fuze-related acquisitions.

Fuze Subtier Assessment

MOTOROLA FUZING EVOLUTION



Fuze Subtier Assessment

- This chart details the status and disposition of some of the principal fuze contracts held by Motorola.

Fuze Subtier Assessment

FUZE SUBTIER ASSESSMENT

STATUS OF MOTOROLA FUZE PROGRAMS

ITEM	SERVICE	PROGRAM STATUS	MOTOROLA CONTRACT COMPLETE	FOLLOW-ON CONTRACTOR
JPF	USAF	PROD.	Y	DAYRON
STANDARD MISSILE, MK45	USN	PROD.	N	N/A
MULTI- FUNCTION FUZE	USN	LRIP	Y	ALLIANT TECHSYSTEMS
HARD TARGET SMART FUZE	USAF	EMD	Y	ALLIANT TECHSYSTEMS
DSU-33	USAF	PROD.	Y	ALLIANT TECHSYSTEMS
FMU-140	USN	PROD.	MOTORO. TO COMPLETE	N/A

Fuze Subtier Assessment

- This chart and the next one briefly characterize and assess the close association of TDDs with the prime contractors for missile development and production. Typically, a TDD producer has been the sole supplier of the item throughout its production history. This reflects the complexity of the items, the difficulty and expense of initiating production, and the relatively small quantities in which missile TDDs are procured.

PRODUCER/DEVELOPER ASSESSMENT

- **Target Detection Devices**

- TDD development is normally a part of missile development.
- TDD designs depend on the details of missile flight geometry and dynamics, and the TDDs are sometimes tightly integrated with the missile guidance and communications systems.
- The complexity and tight integration of a TDD with the operation of the host system dictate that the TDD be developed by the system prime or in close cooperation with the system prime.
- Motorola is a nonsystem prime experienced in developing TDDs. Motorola has agreed to remain in TDD development and production to satisfy Navy standard missile needs for up to 5 years but will leave the business when this commitment is completed.
- Allied Signal has recent experience building the TDD for the Patriot PAC-2, which is no longer in production.

Fuze Subtier Assessment

- In the view of the study team, other major firms, notably Lockheed Martin and Boeing, could compete effectively to develop and produce TTDs if they saw a business reason to do so. The absence of firms that compete for TTDs as separate items is not viewed by the study team as a restriction on competition for the missile systems, nor as a limitation on our capability to develop missile systems.

PRODUCER/DEVELOPER ASSESSMENT

- **Target detection devices (continued)**
 - Hughes, General Dynamics, Texas Instruments, and Raytheon (all now part of Raytheon) have developed or specified the design of TDDs.
 - In addition to Raytheon, other missile system prime contractors could develop TDDs if this is in their business interest:
 - Lockheed Martin, as a many-talented system prime with several missile programs could become a developer of TDDs.
 - Boeing (now including the former McDonnell Douglas) could become a developer of TDDs.

Missile system prime contractors have the technology and motivation to provide TDDs as a part of missile systems. The small number of remaining competent TDD contractors precludes competition, except as it is included in missile competitions.

Fuze Subtier Assessment

- This chart summarizes the strengths and size of the six companies that make up most of the industrial base for electronic and electromechanical fuzes for bombs, missiles, and major caliber projectiles.
- In arriving at this judgment of company capabilities, we focused on bomb, missile, and major caliber projectile fuzes; we gave relatively little credit for development or production of medium and small caliber projectile and rocket fuzes.
- Action, Bulova, Dayron, and KDI are all small businesses, with Dayron a small disadvantaged business. Alliant is a large corporation with revenue greater than a billion dollars per year, but the fuze sector within Alliant is only as big as some of their competitors. Raymond Engineering likewise is a part of Kaman Aerospace Corporation, recently acquired by ITT, but is about the size of its competitors.
- For both classes of fuzes, there are at least five companies that have extensive experience and capabilities (facilities and staff) to produce fuzes. And for both classes of fuzes, there are two companies that are very experienced and capable in the design and development of fuzes, and there are two others with less capability that might be able to compete effectively for development of particular fuzes.

Fuze Subtier Assessment

STRENGTHS OF PRODUCERS/DEVELOPERS

FIRM	ELECTRONIC FUZES				ELECTROMECHANICAL FUZES				ANNUAL FUZE REVENUE (million\$)	NUMBER OF EMPLOYEES IN FUZE SECTOR
	DESIGN	EMD	PROD IMPR	PRODUCE	DESIGN	EMD	PROD IMPR	PRODUCE		
Action Manufacturing Co.							M	M	~20	~200
Alliant Techsystems, Inc.	M	M	M	M	S	S	S	S	~45	~200
Bulova Technologies, LLC			S	M		S	M	M	~45	~200
Dayron	S	S	S	M			M	M	~21	~120
KDI Precision Products, Inc.	M	M	M	M	M	M	M	M	~50	~400
Raymond Engineering	S	S	M	M	M	M	M	M	~18	~200

Legend: **M** Major capability and substantial recent experience
S Secondary capability; limited recent experience

Fuze Subtier Assessment

- Some indication of the dramatic, and to some, the traumatic downsizing of the fuze industry is conveyed by this slide. Points to be taken are (1) the capability and determination to be in the fuze business shown by the remaining firms, (2) the implications of Motorola's decision to leave the business—they were THE dominant participant for modern, high-technology fuzes, including production award prospects, but left for greener pastures and thereby improved the prospects for some of the remaining firms, and (3) the downsizing in industry and in government has reduced greatly the national pool of technical talent experienced in fuzing design, development, and production.

Fuze Subtier Assessment

PRODUCER/DEVELOPER ASSESSMENT

- The industry has been undergoing significant restructuring from defense downsizing:
 - Ownership changes, departures, some consolidation.
- By count of the Army Fuze Management Office there were 31 firms in the electronic and electromechanical fuze business in 1987.
- The six remaining are the survivors. This is reflective of their capabilities and determination. By and large they are small businesses focused on fuzing products.
- Motorola was a major player in TDDs and electronic fuzes until October 1997, when they elected to leave the fuze business. The details of how its business share is realigned to other firms will significantly influence the shape of the sector.
- The reduction in business is accompanied by significant reduction in the technical staff that is working and experienced in fuze engineering and technology.
- A parallel reduction has occurred within government development and production support expertise.
- This national erosion of experienced technical staff is an often-voiced concern.

Fuze Subtier Assessment

- In this chart comment is made on the capabilities and specialties of the firms in the electronic fuze sector.

PRODUCER/DEVELOPER ASSESSMENT

- **Electronic fuzes**
 - **Alliant Techsystems**, a large corporation, has “full system” capabilities in fuzing, including production, development, and technology. With the exception of TDDs, they are a dominant player for fuzing.
 - **Bulova Technologies** is principally experienced in the quantity production of artillery projectile fuzes.
 - **Dayron** is experienced in the production and development of medium caliber projectile fuzes and bomb fuzes. Dayron has recently become the developer of a missile fuze (JASSM) and producer of the JPF (FMU-152).
 - **KDI Precision Products** has a major role in the production and development of electronic fuzes and safe and arm items, particularly for missiles.
 - **Raymond Engineering Operations**, an element of Kaman Aerospace Corporation, is principally experienced in the production and development of missile fuzing items.

Fuze Subtier Assessment

- Two of the topics of interest to this study appear in this chart on electronic fuzes. The first is the matter of vertical integration. We found no major problems apparent in this regard, but should point out that Alliant Techsystems has capabilities beyond any of the others in their reserve battery production capabilities. As will be pointed out later, there are components that are available from only one or two suppliers. Potentially, this presents possibilities for a producer to achieve a monopoly position through vertical integration.
- The second matter that appears is that of competitive status. The study did not get into matters of defense procurement policy, but we note that whether there is a de facto competitive situation depends very much on what the government does, e.g., does or does not use sole source, does or does not work to qualify alternate producers in the transition from development to production, does or does not exercise best buy practices, does or does not tolerate broken licensing agreements with foreign governments/firms... No obvious government activity to establish what situation is best for DoD and how to achieve it came to the attention of the study team.

Fuze Subtier Assessment

PRODUCER/DEVELOPER ASSESSMENT

- **Electronic fuzes, cont'd.**
 - The five firms provide adequate competitive basis for most electronic fuze production,
 - **But actual production competition will depend upon government action and policy:**
 - For example, production awards are most likely to go to EMD contract winners.
 - Lack of good technical data package inhibits competition for production.
 - Alliant Techsystems has won four of five recent major awards for fuze development or production.
 - Production capacity is adequate, but several government and industry persons interviewed see meeting stockpile reconstitution needs as problematic.
 - **For development, the competitive basis is marginal in number of experienced firms. Two are very experienced and another two could compete but have less experience.**
 - Motorola had won the competitions for most new fuze development programs over recent years. Their departure from the business withdraws a principal national capability.
 - **Vertical integration is not a current major problem but bears watching.**
 - All firms rely on outside suppliers or on other fuze business firms.
 - Alliant Techsystems has the broadest set of production capabilities.
 - Production orders of electronic fuzes have the potential to maintain a strong production base for current procurement rates.

Fuze Subtier Assessment

- In this chart and the next, comment is made on the capabilities and specialties of the firms in the electromechanical fuze sector.

Fuze Subtier Assessment

PRODUCER/DEVELOPER ASSESSMENT

- Electromechanical
 - **Action Manufacturing** is an accomplished producer of mechanical fuzes.
 - Capabilities include fuze-related energetic material devices.
 - Downsizing since 1986: from 6 production plants and 1,250 employees to 2 plants and 220 employees. No development engineering staff.
 - Foreign sales are ~35% of business. They depend upon this to survive.
 - Continued sparse procurements of Action's products will put the firm under severe stress to continue operations.
 - Coherent business planning difficult due to uncertainties in defense procurement planning.
 - **Alliant Techsystems** folio of capabilities includes electromechanical as well as electronic fuzes.
 - Corporate acquisitions give evidence of strong commitment to fuze business.
 - Capabilities include production of fuze reserve batteries.

Fuze Subtier Assessment

PRODUCER/DEVELOPER ASSESSMENT

- Electromechanical, cont'd.
 - **Bulova Technologies** is a long-time, accomplished producer of electromechanical fuzing products.
 - Much production experience. Limited opportunities/staff for item development. Have expanded their business base to >50% commercial items.
 - Are dedicated to being in the fuze business, *if in their eyes there is a fuze business.*
 - *Absent adequate fuze orders in the near term, could depart the business sector. If commercial alternatives work out they will not return.*
 - **Dayron** is experienced in the production of mechanical medium caliber fuzes.
 - **KDI Precision Products** produces/develops diverse items ranging from missile ESAD's to mechanical fuzes
 - Aggressive in fuze technology and development for new items such as self-destruct fuzes for submunitions. This should help their viability and competitive posture.

Fuze Subtier Assessment

- Currently, the competitive situation for production of electromechanical items is satisfactory, but this could change if Action and/or Bulova leave the sector.
- The situation for development is more restricted. Alliant Techsystems and KDI are in good position, while Bulova would likely find it beneficial to use some nature of teaming arrangement for development activity.

Fuze Subtier Assessment

PRODUCER/DEVELOPER ASSESSMENT

- Electromechanical, cont'd.
 - For production, the six firms provide an adequate competitive base. Not all firms are equally experienced in all natures of fuzes.
 - For development, the competitive basis is marginal because of the number of experienced firms. Two are very experienced, and another two could compete but have less experience.
 - Vertical integration is not seen as a problem.
 - Foreign orders play a significant role in the business base of several of the firms, notably Action Manufacturing and Bulova Technologies.

Fuze Subtier Assessment

- Supplier shortages were identified in the metal part, the energetic device, and the power supply categories as described on this and the next several charts.

Fuze Subtier Assessment

SUPPLIER ASSESSMENT

- **Component and material suppliers**
 - **Metal parts**
 - Action, Dayron, KDI, Primex, Raymond, Tooling Specialists, and many others are suppliers.
 - **The only supplier problem found was for specialized stampings and castings.**
 - Precision stampings of small gears, etc., for fuze mechanical components; some producers cite a single firm available for large quantity orders.
 - Precision die castings of small gears, some producers cite only two reliable firms.
 - **Non-metal parts**
 - Action, Dayron, Hittite, KDI, and many others are suppliers.
 - **No problems** were found with suppliers of non-metal parts.

Fuze Subtier Assessment

Note in editing, 30 March 1999

The U.S. Army awarded a contract in January 1999 to Action Manufacturing to address the problems of large-quantity production of energetic materials devices for fuzes.

SUPPLIER ASSESSMENT

- **Component and material suppliers, cont'd.**
 - **Energetic devices**
 - Two principal producers have left the market—ICI Americas and Dyno-Nobel.
 - Leaving Action Manufacturing, Technical Ordnance, Eagle-Picher, Stresau Laboratories, and others.
 - There are several reliable producers for small quantities (no more than about 1,000 per year, say) of energetic devices such as those needed for missiles and sophisticated bomb fuzes, but
 - **The production base for large quantity devices typical of projectile fuzes (> 10,000 per year, say) is deemed critically inadequate by the U.S. Army.**
 - Causing some fuze delivery delays beyond a year.
 - **The status of this portion of the fuze industry is a major concern.** Through its Fuze Management Office the Army is taking action to get additional producers interested and qualified. Results of this effort should be known by the end of this calendar year. Stockpile reconstitution is an element of the concern.

Fuze Subtier Assessment

- There are only two suppliers of the many batteries used in fuzes and in many weapons. If either of the two should leave the fuze battery business, we would have a sole supplier. If Alliant Techsystems were the remaining firm, there would be a potential vertical integration problem. However, Alliant Techsystems has acted as a merchant supplier of batteries and does not appear to covet a role of exclusion.
- Alinabal builds nearly all the turbine generators. A few are provided by a foreign firm (NFT of Norway). KDI makes the fluidic air generator used in the MLRS and the Extended-Range MLRS.
- Several companies make MMIC chips, but apparently the fuze companies rely on Hittite.

Fuze Subtier Assessment

SUPPLIER ASSESSMENT

- **Component and material suppliers, cont'd.**
 - **Power supplies**
 - Battery producers/suppliers significantly limited—Alliant Techsystems, a fuze producer, and Eagle-Picher are principal players.
 - Alinabal is the only domestic supplier of air-driven turbine generators used in projectile and bomb fuzes.
 - **Electronics**
 - **No lack of supplier base voiced for electronics.**
 - Problems encountered appear to be those common to the electronics industry
 - Components become obsolete before end of production. Producers resort to “lifetime buys.”
 - Fast turnover of technology results in need to change to newer components and retest and qualify the new components and suppliers.
 - Small orders for fuzes make it difficult to have engineering staff available to accommodate/adjust to product changes.

DESIGN TRENDS

IMPLICATIONS FOR THE FUZE INDUSTRIAL BASE

Fuze Subtier Assessment

- Fuze designers are taking advantage of modern electronics and computer technology to develop fuzes that are more versatile, more precise, and that perform more complex sensing and logic functions to determine the best time to initiate the warhead. Several modern fuzes combine in one fuze the capabilities of several older fuzes—the Navy Multi Function Fuze is an example. And with modern electronics, the settings (in a delay fuze, for example) can be numerous and precise. Mission effectiveness is enhanced by making it possible for pilots to select the fuze setting that is best for the particular target being attacked. Artillery can be more responsive when gunners can set the fuze after the round has been chambered. A possible trend to all-up rounds (i.e. projectile and fuze combined) could result in a competitive advantage to any company that acquires or develops both projectile and fuze capability.
- Missiles usually have a separate TDD, but some missiles use the information in the guidance system to determine when the warhead should function. And all recently developed missiles use an ESAD instead of an electromechanical S&A.
- The increasing electronic complexity has added cost in the short term. Increased cost also results from the small quantities now being bought and from the newness of the ESAD approach. In the long term, the new designs might not be much more expensive than the old.

DESIGN TRENDS

Fuzing for projectiles (artillery and mortars) and bombs

- Multiple modes (functions) in single fuze
- Numerous settings
- Cockpit or in-tube settable
- Higher unit cost
- Reduced number of types (ultimately)

Fuzing for missiles

- Guidance integration, including GPS
- Electronic safe and arm devices (ESADs) replacing mechanical safe and arm (S&A)

For all categories studied

- Increasing electronic complexity
- Increasing use of COTS components and packaging technology in electronics

Fuze Subtier Assessment

- Companies that are very capable in modern electronics, especially the application of microprocessors and other digital technology, have an advantage. So far, ESADs have not taken over in projectile fuzes, and they are not pervasive in bomb fuzes, but that is the trend. We expect that some of the current producers will not be able to compete effectively as fuze designs become more electronically sophisticated.

DESIGN TRENDS

- Implications for industrial base
 - Increasing electronic complexity favors electronic high-tech companies for R&D and, to a lesser extent, for production
 - Move to ESADs is reducing need for mechanical S&As, the forte of several current producers

Our expectation is that some “old line” producers will be forced out of the fuze business as more and more of the procurement budget is directed to the new, more versatile fuzes, some of which will use ESADs. This process could extend over 5 to 10 years.

Fuze Subtier Assessment

- The new fuzes, especially those being bought by the Navy and Air Force, are much more expensive than the older fuzes. This can limit inventories, at least in the short term or in a period of reconstitution. For example, the quantity of Multi-Function Fuzes being procured is limited by appropriated funding and the eventual unit cost. More could be procured if the unit cost were lower.
- In the near term we will have to maintain both old and new types of fuzes. This will complicate logistics and training. In the long term the trend to fewer different types of fuzes should yield benefits.

DESIGN TRENDS

- Implications for readiness and warfighting:
 - In a budget-restrained environment, the higher cost of the newer fuzes results in lower procurement rates, leading to a slower pace of modernization and of building war reserves. For example, the Navy's Multi-Function Fuze (MFF) for its 5-inch guns and the Joint Navy/Air Force Programmable Fuze (JPF) for general-purpose bombs cost as much as \$2,000 to \$3,000 each; Hard Target Smart Fuzes (HTSF) cost about \$15,000 each. The fuzes being replaced cost in the range of \$200 to \$1,000, depending upon function and quantity.
 - Multifunction fuzes simplify logistics and training only if they eliminate the need for the earlier types of fuzes. Increasing costs and low production rates militate against realizing the potential logistics and training advantages.

Fuze Subtier Assessment

- The problem of electronic obsolescence was mentioned earlier. It is not unique to fuzes. For the Joint Programmable Fuze (JPF), the Air Force and Navy are using an electronic components database to anticipate obsolescence and identify replacement components.
- There could be a reconstitution problem for some of our fuzes. We have not developed facilities capable of high production rates for new types of artillery and naval gunfire fuzes. Missiles are bought in such small quantities that production rate limitations (aside from financial limitations) are not likely to be a problem.

DESIGN TRENDS

- Implications for readiness and warfighting, cont'd.
 - Increasing use of COTS electronic components and packaging technology can increase the need for redesign and retesting as commercial technology advances (the “obsolescence” problem). Possible DoD measures to minimize this problem are (1) total-program buys of components, (2) shortened production periods with no restarts, and (3) proactive management of electronic parts obsolescence to avoid shortages.
 - Production facilities and processes are being tailored to peacetime demand without provision for surge or rapid replenishment

Fuze Subtier Assessment

DEMAND ASSESSMENT

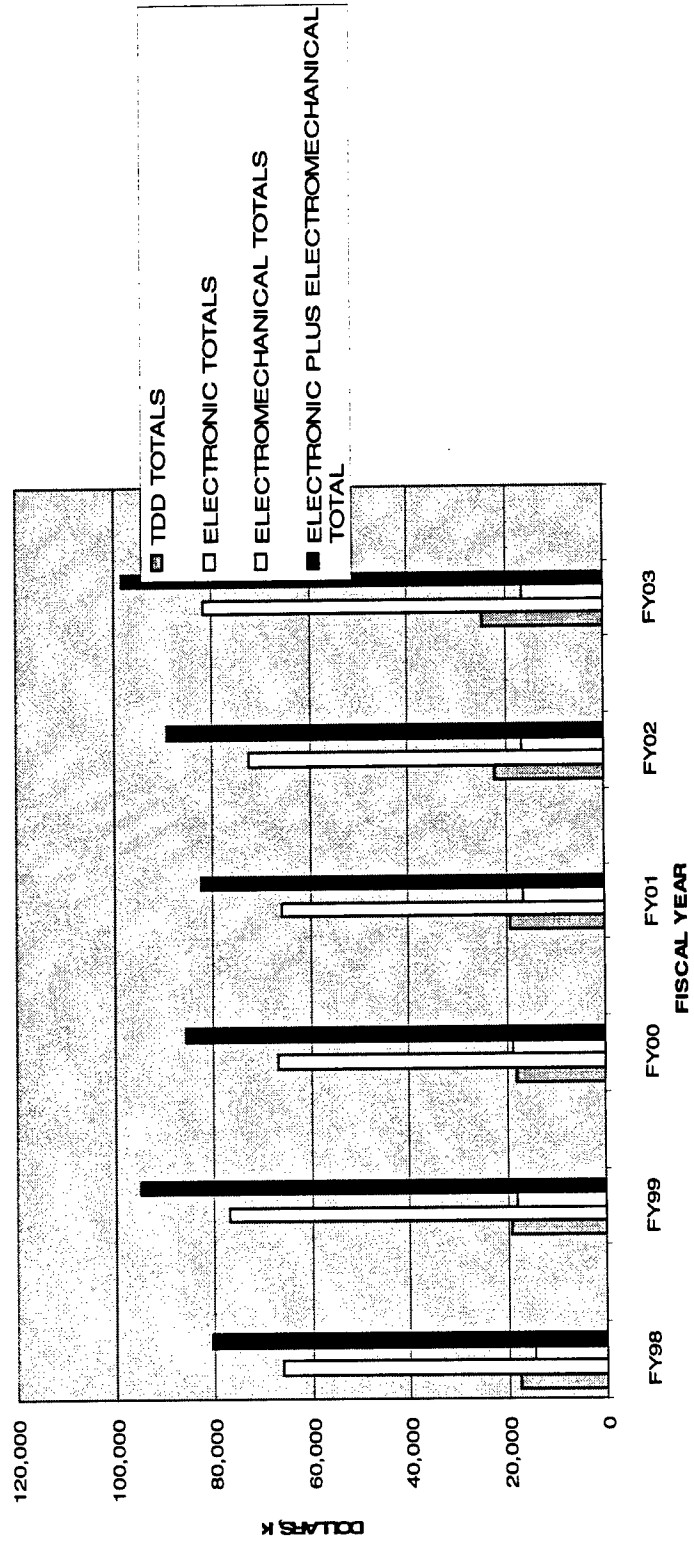
Fuze Subtier Assessment

- The FY99 President's budget submissions of the services were used to grasp the demand base for the items and firms covered by this study. The years FY98 to FY03 are represented. The data are summarized by this chart. The chart certainly does not capture all production business for fuzes (for instance, foreign orders and medium-caliber ammunition fuzes are not included), but it does provide a major indication of the extent and stability of the overall demand for fuze production.

Fuze Subtier Assessment

DEMAND ASSESSMENT

PLANNED TARGET DETECTION DEVICE AND FUZE PROCUREMENTS, FROM FY99
PRESIDENT'S BUDGETS



Fuze Subtier Assessment

- Currently, several significant fuze development programs are underway or were recently completed. Included are the Joint Programmable Fuze (JPF), the Multi-Option Fuze—Artillery (MOFA), the Hard Target Smart Fuze (HTSF), and the Navy's Multi-Function Fuze (MFF). These represent the exploitation of recent technologies and provision of capabilities in a single item that were previously unavailable or that required several distinct fuzes. There are, however, no new fuze development programs scheduled over the years 1998 to 2003 except as part of system development programs. That is, no business opportunities for development of new fuzes were uncovered. Furthermore, investments in generic fuze technology are modest.

Fuze Subtier Assessment

DEMAND ASSESSMENT

- Data gathered are based on the FY99 President's budget submission (FY98-FY03 coverage):
 - All services.
 - Charted data emphasized procurements for bomb, missile, and major caliber projectile fuzes and missile TDDs supplemented with data on rocket, mortar, and submunition fuzes important to the firms studied.
 - No new fuze development programs were identified in the FYDP years (although there are development programs in progress), except as they are included in system programs.
 - Service generic fuze technology base investments are small, probably less than \$10M. The Army program is zero. Nonetheless, advanced technology important for potential fuze applications is being pursued effectively.
 - No comprehensive estimate of foreign demand was developed. Estimates of current foreign orders for some of the firms were obtained.
- It was found that
 - Detailed fuze unit cost information beyond FY99 in the FYDP was limited.
 - There are relatively steady procurement plans of about \$20M/yr throughout the FYDP for target detecting devices and about \$85M/yr for electronic and electro-mechanical fuzes combined.
 - Plans for "lower technology" artillery fuzes are notably few.

DEMAND ASSESSMENT

- The difference between the current business base (~\$200M annually) of the six electronic/electromechanical fuze firms and the procurement plans (~\$85M annually) warrants comment. Likely causes are
 - Account not taken for R&D funding,
 - Account not taken for business between the firms,
 - Foreign sales not fully discovered,
 - Procurements in fuze categories not covered by the study.
- These and other possibilities aside, no reason was uncovered to conclude anything other than that **much of the fuze industry is operating under very austere circumstances. It does not represent an opportunity for growth.**
- Missile TDDs, on the other hand, show moderate growth over the FYDP, but this is business for the missile prime contractors or subcontractors under their close direction. A healthy TDD business base does not help the makers of electronic and electromechanical fuzes and S&As.

OBSERVATIONS AND CONCLUSIONS

Fuze Subtier Assessment

During a visit to Bulova Technologies in the course of this study, the firm's president stated that failure to gain an award in an ongoing competition for a contract would essentially put the firm out of the fuze business. "If you don't have any business, you aren't in the business." It develops that they did get the award. Nonetheless, in a recent conversation (26 March 1999) a representative on the firm characterized their fuze business as "on the ragged edge." Their situation has been confounded by a moratorium put on sales to India and Pakistan and on gaining export licenses for sales to Greece.

Recently (April 1999), Action Manufacturing's business posture was seriously stressed, owing to possible termination of a production contract. Fortunately, the immediate matter has been successfully resolved.

OBSERVATIONS AND CONCLUSIONS

- On the surface, the extent of the fuze sector appears satisfactory, but...
- Much of the national competence in the production and development of electronic and electromechanical fuzes resides in the six firms discussed here.
 - Small businesses or small units in larger firms.
 - Mostly these are fuze specialty firms, but some are developing “escape” routes.
 - Each is a survivor of major sector downsizing over the past decade.
 - Relatively thin engineering staff for production and development.
 - Engineering support formerly available from government personnel is disappearing or gone.
- It is possible that additional firms will depart the sector. Once gone, their capabilities will be very difficult and expensive to replace. Bulova technologies, in particular, has frankly stated its precarious position.

Fuze Subtier Assessment

OBSERVATIONS AND CONCLUSIONS

- If other firms follow Motorola's lead to more attractive business opportunities, the loss of national capability could be immediate. Nonetheless, the national technology and manufacturing bases are adequate to reconstitute the capability, given adequate time and dollars.
- It appears that Alliant Techsystems will dominate the large-caliber projectile fuze business and have a strong position in the bomb fuze business. They have the development contract for the Army's Multi-Option Fuze for Artillery, and they have been awarded the development contract for the Air Force Hard Target Smart Fuze program and the production contract for the Navy DSU-33 proximity sensor for bombs.
- Although there are no current problems from vertical integration, we have identified two product areas that require continuing DoD awareness.
 - For air-driven turbines, there is only one domestic source, Alinabal.
 - Only two domestic sources, Eagle-Picher and Alliant Techsystems, produce nearly all of the batteries used in fuzes.

OBSERVATIONS AND CONCLUSIONS

- The problem of supplies of electro-explosive devices to fuze producers is a critical concern. It has the attention of the Army and should be closely watched. Without these items there are no fuzes and few if any munitions.
- Awareness and concern over the stress on the fuze industry are evident. Nonetheless, the study team could identify no government activity to establish what situation is best for DoD or how to achieve it.
- The business base for missile TDDs is the same as that for the missiles. This base is growing at a moderate rate, and it constitutes business for the two, possibly three, major defense contractors. Competition can be realized as a part of missile system competitions.
- On a number of occasions during the study, individuals from government offices and from industry expressed concern over the adequacy on the fuze production base to meet reconstitution requirements; however, follow-up to these concerns was beyond the scope of this study.

Fuze Subtier Assessment

OBSERVATIONS AND CONCLUSIONS

- Summary assessment
 - Fuzes are a critical and essential element of effective munitions.
 - Fuzes are defense unique; the market is defined by the services and DoD.
 - Development and production of fuzes is a special sector characterized by
 - Unique design requirements from environment, safety, and reliability;
 - People with specialized experience;
 - Specialized production tooling.
 - The survivor firms of the downsizing of the past decade are small and contain the majority of the national base of technical expertise in fuze production and much of that for development.
 - There are no current major difficulties from vertical integration, but there is a potential for problems because there are few suppliers for several critical components.
 - Departure of any of the remaining firms from the business sector will be a noticeable loss to our national capability.
 - While this loss of capability might be acceptable, it should happen only as a result of rational awareness of what is happening in the context of national needs.
 - There is no indication of DoD-wide monitoring and/or control of this dwindling resource.
 - The Army Fuze Management Office appears to have authority to monitor, advise, and influence Army support for the fuze industrial base.
 - Fuze Program Managers in all services appear to be aware of the erosion of the fuze industrial base.

RECOMMENDATIONS

– **Two actions are recommended.**

- Establish procedures to monitor the health of the fuzing development and production business sectors.
- Establish a DoD focal point to ensure the industrial capacity and competitiveness in fuze development and production is adequate to meet national needs.

THANKS

- Well over 50 people from industrial and government sectors were contacted for substantial assistance in the course of this study.
- In every instance we were accorded cordial, forthcoming, and helpful responses.
- Our heartfelt thanks goes to each and every one of them for their aid and for adding so substantially to the experience of doing the task.

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