DEPARTMENT OF THE NAVY
OFFICE OF THE SECRETARY
1000 NAVY PENTAGON
WASHINGTON DC 20350-1000

6 July 2001

The Honorable Bob Stump
Chairman, Committee on
Armed Services
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The Fiscal Year 2000 House Armed Services Committee Report 106-162 directed the Secretary of the Navy to assess Department of Defense's (DoD) requirements for advanced vacuum electronics technology programs and to report the results of that assessment and the long-term funding plan.

In our interim report submitted on March 7, 2000, we indicated that a detailed parametric assessment was underway in order to develop a long-term investment strategy and road map for future vacuum tube electronics and solid state technology activities. We also indicated that we would submit the results with our Fiscal Year 2002 President's Budget request.

Enclosed are the results of the Navy's assessment of DoD's requirements for vacuum electronics technology and the future years funding plan. Our funding strategy shows steady and deliberate progress in the exploitation of solid state technologies within existing radio frequency system architectures. We plan to transition, where applicable, from vacuum to solid state electronics as well as support the development and continual support of each technology within their specific domain of warfighting utility and capability.

A similar letter has been sent to Chairmen Levin, Inouye, and Lewis. As always, if I can be of any further assistance, please let me know.

Sincerely,

Gordon R. England
Secretary of the Navy

Enclosure

Copy to:
The Honorable Ike Skelton
Ranking Minority Member

Report to the Congress

Assessment of Vacuum Electronics

Technology Program

Prepared by the Office of Naval Research

Arlington, Virginia 22217

June 2001

Introduction

The Fiscal Year 2000 House Armed Services Committee Report 106-162 directed "… the Secretary of the Navy to assess the Department's requirements for advanced vacuum electronics technology and to report the results of that assessment and the long-term funding plan for the Department's vacuum electronics technology program to the Congressional defense committees with the submission of the fiscal year 2001 budget request."

The Navy, working with the Air Force, Army, and Defense Agencies conducted a year-long assessment of the long-term investment strategy in vacuum electronics technology. This assessment was done in light of the overall investment strategy in microwave and millimeter wave power amplifiers which includes the alternate and increasingly competing solid state power amplifier technology. Hence, the investment described below addresses both vacuum electronics and solid state technologies. A comprehensive report is being prepared based upon this study, but the general conclusions are provided below.

The Department must pursue a balanced research investment that includes both the vacuum electronic technology base as well as the recent advancements in solid state technology. Both will have a role for some time in the radio frequency products that support the warfighter. It is the focus of our investment strategy to exploit the advances in solid state technologies that have come from both the military as well as the commercial market. However, it must be recognized that there is not a similar commercial market in the vacuum electronics market. Therefore, the burden on military investments must be more closely scrutinized, both to protect current critical capabilities as well as provide for future capabilities where it is understood that vacuum electronics will be the technology of choice.

Background

Radio frequency electronic technologies provide critical components for modern military electromagnetic systems. Radar, missile guidance, communications, electronic warfare, and navigation systems currently perform the functions necessary for the warfighter to dominate space, own the battlefield, and rule the seas. Today, most of our legacy electromagnetic systems utilize vacuum electronics technology although some use gallium

arsenide based solid state technology. In order to maintain our operating forces competitive advantage, many of the new electromagnetic systems under development will require the fielding of more advanced types of radio frequency amplifiers. Wide bandgap (e.g., silicon carbide and gallium nitride) semiconductor device technology is a promising candidate for many of these new radio frequency systems. However, to maintain and extend today's operational capabilities, both legacy and new systems must continue to be supported under the Navy's applied research investment plan.

Review Process

To address the issue of the best investment balance in this area, numerous tri-service meetings were held during Fiscal Years 2000 and 2001. In addition, two focused workshops were held in the Summer and Fall of 2000. The first addressed present and future Department of Defense (DoD) requirements for radio frequency transmitters. The second addressed the comparative state of the art for vacuum electronics and solid state devices along with science and technology opportunities and enabling operational capabilities. This is the most comprehensive comparison and study of the two competitive approaches to microwave power amplifiers ever undertaken by DoD. A comprehensive report is being prepared based upon this study, but the general conclusions are provided below.

Summary of Review Findings

- Both legacy systems and enabling new capabilities must be addressed.

- Vacuum electronics devices are currently the most cost effective approach to electronic warfare systems, especially those employing one dimensional beams and for single function communications systems.

  Vacuum electronic devices are the only feasible technology in the near future for millimeter wave radio frequency systems due to the short wavelength and the limitations in solid state monolithic microwave integrated circuits production capabilities at these high frequencies.

- Future electromagnetic systems operating in the microwave frequency domain require active electrically scanned arrays with amplifiers at each element that can only be affordably satisfied using solid state technology.

- Wide bandgap semiconductor solid state device technologies must be developed to enable new radar systems and multifunctional electronics systems to meet projected requirements and reduce system life cycle costs.

- For the next decade, vacuum electronics devices will continue to dominate legacy high power transmitter systems in the microwave and millimeter-wave spectrum while solid state technology will increasingly play a larger role in the microwave part of the spectrum below 25 GHz.

Future Funding Plan

The applied research funding for vacuum electronics devices and solid state devices has been set as follows:

	FY01	FY02	FY03	FY04	FY05	FY06	FY07
USN 6.2 Vacuum Radio Frequency Amplifiers	7.5	4.5	4.5	4.5	4.5	4.5	4.5
USN 6.2 Radio Frequency Solid State Amplifiers	3.4	2.5	2.5	2.5	2.5	2.5	2.5
USAF Vacuum Radio Frequency Amplifiers	0.1	0.0	0.0	0.0	0.0	0.0	0.0
USAF Radio Frequency Solid State Amplifiers	1.2	0.6	0.0	0.0	0.0	0.0	0.0
USA Radio Frequency Solid State Amplifiers	2.0	2.5	2.8	0.0	0.0	0.0	0.0
Total Estimated Funding	14.2	10.1	9.8	7.0	7.0	7.0	7.0

The above funding profile shows our steady and deliberate progress in the exploitation of solid state technologies within our existing radio frequency system architectures. We transition, where applicable, from vacuum electronics to solid state technologies as well as support the development and continual support of each technology within their specific domain of warfighting utility and capability.

While total funding will decrease in the outyears, solid state technology will be reduced at a lesser percentage, reflecting its increasing application for future acquisition program requirements.