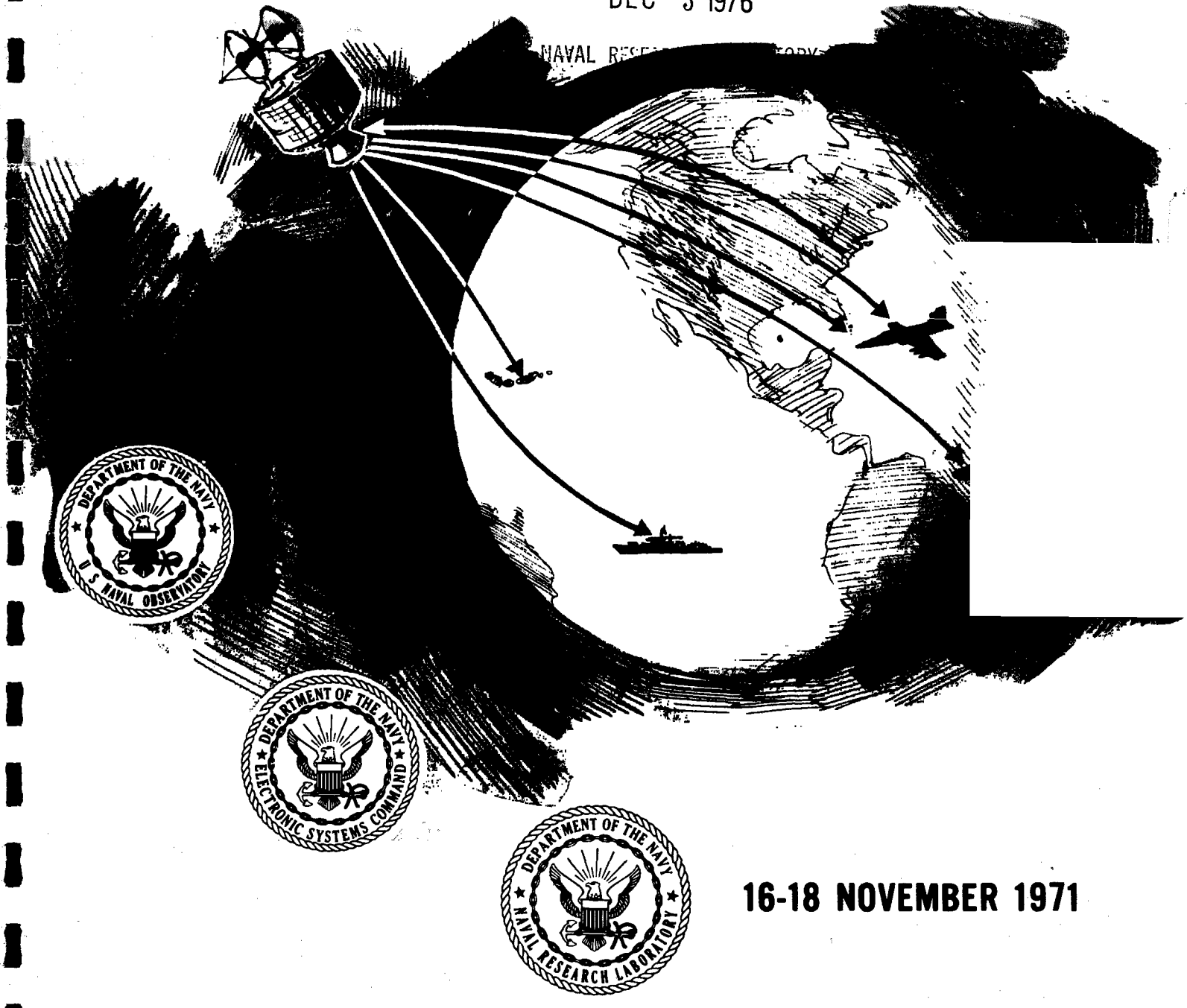
PROCEEDINGS OF THE THIRD ANNUAL DEPARTMENT OF DEFENSE PRECISE TIME AND TIME INTERVAL (PTTI) STRATEGIC PLANNING MEETING



16-18 NOVEMBER 1971

FOREWORD

The Third Annual Department of Defense (DOD) Precise Time and Time Interval (PTTI) Strategic Planning Meeting, sponsored by the U.S. Naval Observatory was held November 16-18, 1971 in Washington, D.C., to accomplish the following objectives:

- Exchange of practical information associated with PTTI.
- Review present and future requirements for PTTI.
- Review status of current and planned systems for PTTI dissemination.
- Acquaint systems engineers and/or managers with precise time and frequency technology and its problems.

Each presentation was invited and a status report was given concerning the various techniques and systems involving PTTI rather than presenting novel concepts and results in the pattern of professional engineering conferences.

Annual engineering conferences of the PTTI community are also held regularly under the auspices of the U.S. Army Electronics Command and are known as "The Annual Frequency Control Symposium, Atlantic City." Copies of those proceedings are available from Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006. Additional information is available from Dr. Erich Hafner, Leader, Frequency Control Devices Team, Electronics Technology and Devices Laboratory, U.S. Army Electronics Command, Fort Monmouth, New Jersey 09703.

The Annual DOD PTTI Strategic Planning Meetings supplement each other rather than repeat items on which there is little or no change to report. It is therefore recommended that interested persons consult the Proceedings of the Second Annual DOD PTTI Strategic Planning Meeting, December 10-11, 1970, Volume I (Unclassified) and Volume II (Secret), which are available from the Defense Documentation Center (DDC) as AD 881014-L and AD 514056-L, respectively.

This report contains a summary of PTTI topics discussed during the 16-18 November 1971 meeting. The unclassified Conference Proceedings are contained in this volume for distribution. Copies of the classified presentations may be obtained by writing the U.S. Naval Observatory, Technical Officer, Washington, D.C. 20390.

Harold N. Acrivos
Precise Time Operations Officer
Time Service Division
U.S. Naval Observatory
Washington, D.C. 20390

CONTENTS

OPENING ADDRESS

by

Dr. Alan Berman

Dr. Berman is Director of Research, Naval Research Laboratory, Washington, D.C.

Good morning. On behalf of the Naval Research Laboratory, it is my pleasure to welcome you to the Third DOD Precise Time and Time Interval Strategic Planning Conference. One of my responsibilities is to welcome meetings that are held at NRL. This Laboratory is a busy place with all sorts of people meeting on all sorts of things. I'm usually a little hard put to think of what to say. One can always state the usual amenities, hope that the attendees will be comfortable, and state that you are sure they will have an interesting program. I find today's introduction to be easy to make because my early professional life was devoted to time standards and frequency measurement.

I was an impoverished graduate student in 1947 when I went to work for Professor I. I. Rabi in his Molecular Beams Laboratory at Columbia. At that time he entertained the idea that one could tell time by using the precession period of the cesium atom in a magnetic field. Needing an assistant to build an atomic beam machine for him, which would function as a frequency standard, he gave me a summer job designing an atomic beam cesium system, which could be used for this purpose. These plans were turned over to a gentleman at Oak Ridge who had it built. The machine actually functioned, and, in a sense, it was the first cesium clock that was built. The machine existed and was used for some years as a frequency standard. Eventually it was turned over to the Smithsonian Institution as

an early frequency standard. You can see it today in the Hall of Science and Technology.

On a Sunday afternoon a few years ago, I took my children to the Smithsonian, and we inadvertently came upon this device. I very proudly pointed out to my five-year old son that I had designed it and that it was the first cesium frequency standard. He looked at the device and then at me and said, "Gee, that sure is an olden time frequency standard, isn't it, Dad?" I was crushed.

Until I had the simple joys of becoming a Laboratory Director, I spent most of my life worrying about problems related to precise time and frequency. I worked with Professor Kusch on the early measurements of the hyperfine structure anomaly in hydrogen and found that the problems of maintaining a decent frequency standard were much more difficult than measuring hyperfine structure anomalies in hydrogen cesium, rubidium, or thallium.

I have very recently had an experience relative to U.S. Navy sponsored research on frequency standards. During the first week in November 1971 I was in the Middle East, and I had occasion to visit an Israeli General. He was a real tough cookie--the sort of man who comes to work in fatigues and combat boots, with a machine gun thrown over his shoulder. If you go to Israel these days, people will start the small talk in the conversation with two things. First, they will give you a hard time as to why the U.S. is not giving Israel more F-4 Phantoms. The second topic invariably pertains to cesium clocks that Americans are flying around the world. Apparently this experiment received remarkable publicity in Israel. Israelis want to know why the American Navy spends money worrying about the relativistic twin paradox. True to form, the Israeli General rather bluntly told me that in Israel they only had money to do relevant research and they did not mess around with clocks. In the meantime, standing next to him was a very polite young engineering aide of the gruff General, and

he said, "But General, we do do research in this country on time." Somewhat surprised, the General growled, "Why do we?" The aide said, "Well, we have problems with cryptology, we have problems with time difference of arrival of signals, and we have problems with our aircraft collision avoidance." He then enumerated 10 or 12 additional areas where the Israeli and, for that matter, all modern military establishments need precise time and time interval measurements. The General finally admitted defeat and grunted, "Yeah, I guess so, but at least we don't measure the age of twins."

In any case, I do think the work you are doing is important to the U.S. Navy. Your program is remarkably impressive, and I'm looking forward to hearing as much of it as I can in the next three days. If there is any way we can make you comfortable, be sure to talk to one of the natives here, and we'll do everything we can to make your stay useful. Thank you.

INTRODUCTION TO THE PROCEEDINGS

by

Capt John Hankey

CAPT John Hankey is Superintendent of the U.S. Naval Observatory, Washington, D.C.

I would like to welcome you to the conference on behalf of the Naval Observatory. I also want to thank the Naval Research Laboratory, especially Dr. Berman, for the opportunity of holding this conference in their very nice facilities here. I would also like to extend to you an invitation to visit the Naval Observatory, which is located in Northwest Washington, D. C. It is a site of considerable physical attraction and it is also a site that contains a certain amount of equipment and material which I think you would find of interest, even in the daytime. By the way, before I proceed, LCDR Atwood would be more than happy to arrange a tour of the Observatory for you if you will leave your name with him at any time during the next couple of days.

Time has always been a subject of considerable concern to our culture. This is very plainly evident in all the proverbs, sayings, and maxims that have enriched not only our language, but also many previous ones. Time is not only as important to us as it was to our ancestors, but it is going to become even more so. The fact, of course, is that the number of time-ordered systems is increasing, at an almost astronomical rate. I must confess that when I first came to the Naval Observatory my experience of time was not much better than that of the Israeli General to whom Dr. Berman referred when he welcomed you here. Thanks to Dr. Winkler and his assistants, I have been exposed to a rather liberal

education on time and time interval. I find myself almost a one-man crusade occasionally when talking with my line contemporaries and superiors, convincing them that time is important--even more important than is implied by the motto on our old sun dials, *It is later than you think*. But since time is important, I am not going to waste very much of yours by giving you any personal reminiscence. Instead, I'm going to proceed to introduce our first speaker -- a Naval officer of considerable technical background, particularly following his receipt of the Masters Degree in Science at the Massachusetts Institute of Technology in 1946. Since that time, Admiral Schneider has had a variety of highly responsible positions in technical areas, in the Bureau of Aeronautics, the Naval Air Technical Development Command, the Bureau of Naval Weapons, and the Naval Air Systems Command. Currently, he is serving as the Vice Commander of the Naval Electronic Systems Command. It is my pleasure to introduce Admiral Schneider.