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AUTHORITY

NAWCAD memo dtd 22 Feb 2017

U. S. NAVAL AIR DEVELOPMENT CENTER

JOHNSVILLE, PENNSYLVANIA

Anti-Submarine Warfare Laboratory

REPORT NO. NADC-AW-L5902 24 MAR 1959

PHASE REPORT, INVESTIGATION OF
A TOWED-CAPSULE INSTALLATION OF THE
AN/ASH-2 CONDENSATION NUCLEI DETECTOR

BUREAU OF AERONAUTICS
TED Project No. ADC EL-46012.3

Paul M. Moser

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Naval Air Development Center

Warminster, PA 18974

Code 50C

6 Oct 1987

MEMORANDUM

From: 50C

To: 8131

Subject: Declassification/downgrading of certain NAVAIRDEVCEN reports

References: (a) NAVAIRDEVCEN (S) Report No. NADC-AW-N6207 "Airborne Infrared Oceanographic Mapping (U)" of 3 May 1962 (S620748)

(b) NAVAIRDEVCEN (S) Report No. NADC-AW-6312 "Submarine Wake Detection, Flight Trials of the AN/AAD-2 over the Gulf of Mexico, 12-15 March 1962 (C)" of 9 Sep 1963 (S631041)

(c) NAVAIRDEVCEN (C) Report No. NADC-AW-L5902 "Investigation of a Towed-Capsule Installation of the AN/ASH-2 Condensation Nuclei Detector" of 24 Mar 1959 (5901817)

(d) NAVAIRDEVCEN (C) Report No. NADC-AE-6718 "Flight Evaluation and Analysis of AN/AAS-10(XE-1), Reconofax VI and Reconofax IX Infrared Mapping Sets (U)" of 18 Aug 1967

1. I have reviewed, from the point of view of security classification, references (a) through (d), which were either prepared by me or prepared under my cognizance.

2. References (a) and (b) should be downgraded from SECRET to CONFIDENTIAL; these two documents were eligible for automatic downgrading to CONFIDENTIAL on 3 May 1974 and 9 Sep 1975, respectively. This reduced classification level is consistent with that of other documents of similar content on the same subject. The classification of the title of reference (b) should be downgraded to UNCLASSIFIED.

3. References (c) and (d) should be downgraded from CONFIDENTIAL to UNCLASSIFIED. The subject matter of reference (c), which antedates automatic downgrading, was declassified many years ago. Reference (d), which describes 1960's technology, was eligible for automatic declassification on 18 Aug 1979.

Paul M. Moser

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
24-03-1959	Phase Technical	Jan 1957 - Mar 1959

4. TITLE AND SUBTITLE
Investigation of a Towed-Capsule Installation of the AN/ASH-2 Condensation Nuclei Detector

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Moser, Paul M.

5d. PROJECT NUMBER
ADC EL-46012.3

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Air Development Center
Johnsville, Warminster, PA 18974

8. PERFORMING ORGANIZATION REPORT NUMBER
NADC-AW-L5902

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Bureau of Aeronautics
Department of the Navy
Washington, 25 D.C.

10. SPONSOR/MONITOR'S ACRONYM(S)
BuAer

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The AN/ASH-2 condensation nuclei detector was developed for use in naval aircraft for detecting snorkeling submarines by sensing the invisible, persistent trails of exhaust products they produce while operating under diesel power. It samples air in its path at a 5/s rate, humidifies it, and suddenly expands it, thereby causing cooling and supersaturation. If there are particles present, e.g., hydrocarbon fragments, water droplets condense about them, forming a fog. The number of droplets are "counted" by measuring light forward-scattered in the expansion chamber. This report presents results of flight tests of a dual installation (inboard and towed capsule) of the ASH-2 in detecting trails of a cargo ship and a snorkeling submarine.

15. SUBJECT TERMS
Submarine, Detection, Snorkel, Exhaust Trail, Diesel, Airborne, Towed Capsule, Condensation Nuclei, Atmospheric Contaminants, Antisubmarine, Nonacoustic

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*
unclassified	unclassified	unclassified	unlimited	14	

BACKGROUND AND SUMMARY

The AN/ASH-2 condensation nuclei detector was developed for use in naval aircraft for detecting invisible, persistent trails of exhaust products from submarines operating under diesel power. Air to be examined is drawn from the outside atmosphere by a pump and passed over a water-saturated wick to increase its humidity to nearly 100%. It then passes into a black, baffled expansion chamber in which the pressure is suddenly reduced; this produces a sudden decrease in temperature, supersaturation of the air and, if condensation nuclei (such as fragments of hydrocarbon molecules) are present, a water droplet surrounding each nucleus. The number of water droplets in the resulting cloud is "counted" by measuring the amount of light from an external incandescent source that is forward-scattered through the chamber and detected by a multiplier phototube. Five air samples are examined per second. The amplified output of the phototube is displayed as a continuous line on a strip chart recorder. The device is amazingly sensitive, being capable of detecting as few as 50 condensation nuclei relative to 2.7E19 molecules of air per cubic centimeter.

A representative exhaust trail may exist as a "ribbon" about 2000 ft wide and 300 to 600 ft thick at an altitude up to 600 ft at a range of about 5 nmi downwind of a snorkelling submarine, depending upon the wind and the temperature lapse rate. The purpose of these tests was to investigate possible advantages that might accrue from towing the AN/ASH-2 behind and below the aircraft. One set was installed in an NADC HTM-9 towed capsule (which was developed for use with magnetic anomaly detectors) and a reference set was installed in the towing P2V-7 aircraft. Flight tests were conducted on 21 Mar 1957 and on 5 and 18 June 1958. Exhaust trails were recorded from a cargo ship consistently on both equipments at ranges of 3.5 to 40 nmi. On 31 crossings of the trail of a snorkelling submarine at ranges out to 15 nmi, the inboard equipment failed to detect the trail only one time whereas the towed equipment failed six times. In the majority of cases, however, both equipments performed equally. It appeared that with the aircraft operating at altitudes of 250 to 600 feet, the towed equipment passed below the trail.

It was concluded that the complexity added by towing the AN/ASH-2 is not justified in terms of improved performance.

Anti-Submarine Warfare Laboratory

24 Mar 1959

C O UNCLASSIFIED I A L
REPORT NO. NADC-AW-L5902

PHASE REPORT, INVESTIGATION OF A TOWED-CAPSULE INSTALLATION OF THE AN/ASH-2 CONDENSATION NUCLEI DETECTOR

BUREAU OF AERONAUTICS
TED Project No. ADC EL-46012.3

- -

Ref: (a) BUAER Conf ltr Aer-EL-44 ser 013317 of 1 Aug 1956

1. TED Project No. ADC EL-46012.3 was established by reference (a) to study and investigate the possibility of installing the AN/ASH-2 condensation nuclei detector in a towed capsule to improve its capability to detect submarine exhaust trails.

2. The bases for the investigation were:

a. Flight experiences with the AN/ASH-2 have indicated that the best altitude to search for submarine exhaust trails might be below 100 ft, and a towed capsule would permit safe operation of the equipment at this low altitude.

b. The task of detecting and following trails might be reduced from a three-dimensional to a two-dimensional problem if it could be shown that a component of the more dense particulate matter of the submarine's trail always exists at low altitudes.

c. Salt nuclei churned up by a submarine might be detectable at low altitudes.

d. Operation of the AN/ASH-2 equipment at an altitude different from that of the aircraft might reduce the possibility of confusion between the aircraft trail and the submarine trail.

3. It was decided to install the detector and amplifier units in a Naval Air Development Center HTM-9 towed capsule, figure 1, and a remote control console and an RD-47A recorder in a P2V-7 aircraft. The installation required mechanical and electrical modification of the AN/ASH-2 and mechanical modification of the existing capsule. A mechanical reconfiguration of the equipment was necessary to fit it into the capsule and to effect proper weight and balance. Electrical

modifications were necessary to provide power and to control the equipment from the aircraft.

4. The cables designed for the towed magnetic anomaly detection system were used. These 250-ft long cables consisted of fifteen 0.04-ohm-per-foot conductors and a strain member. The cable conductors also served as transmission lines for control signals to the equipment in the capsule and for data transmission from the equipment in the capsule to the recorder in the aircraft.

5. The maximum power requirements of the AN/ASH-2 are 115-V ac 400 cps, single phase at 2.8 amp, and 28 V dc at 25 amp. Several methods of transmitting power down the cable were investigated. Two methods, which did not require a transformer in the capsule, were tested but were not acceptable because of the wide variety of environmental conditions under which the equipment was to be operated.

6. The method used was to transform the 115-V, 400-cps power available in the aircraft to 460 V, and transmit it down the cable to the capsule. In the capsule, this high voltage was transformed into 115 V and 31 V. The 115 V was used to power the amplifier unit of the AN/ASH-2. The 31 V was rectified to provide 28 V dc to operate the vacuum pump motor on the decoder unit.

7. The installation of a transformer and a selenium rectifier in the capsule aggravated the weight problem. A dummy load was installed in a capsule and flight-tested. The results were satisfactory but difficulties were encountered in re-securing the capsule in its rack. The arresting mechanism was redesigned and subsequent tests proved satisfactory.

8. The AN/ASH-2 equipment was then installed in the HTM-9 towed capsule (figure 2) and operated in the laboratory. The equipment was found to overheat seriously and a small air scoop was installed in the capsule to improve ventilation. A maximum-reading thermometer was mounted on the detector unit and another check was made with a fan blowing on the air scoop. The equipment operation proved satisfactory.

9. The first flight test with the operating AN/ASH-2 in the towed capsule was made on 21 March 1957. The output of the standard inboard AN/ASH-2 installation in P2V-7 aircraft

BuNo. 135551 and that of the towed equipment were fed to the two pens of a single RD-47A recorder for comparison. Both equipments were adjusted to yield nearly equal recorder readings while sampling the same air. No attempt was made in this first flight to gain operational data. Instead, the background condensation nuclei level was monitored on the two equipments as the aircraft flew over New Jersey and a short distance out to sea. The capsule was let out with 100 ft of cable, providing a vertical separation between aircraft and capsule of approximately 50 ft. Except for a short time-lag in the towed AN/ASH-2 output, the two recorder pens tracked together, indicating that the performance of the equipment had not suffered in the encapsulation process. Additional flights could not be made at this time because the aircraft was due for overhaul.

10. After the plane returned from overhaul, towed AN/ASH-2 exercises with controlled submarines were scheduled as part of the SUDEX II operations for 17 and 19 June 1957 in the Bermuda area, 27 June 1957 off the New Jersey coast, and 10 July 1957 in the New London area. Unfortunately, on 12 June 1957 the towed capsule retrieving rack was inadvertently jettisoned from the aircraft during a flight test of sonobuoy launching equipment. Another rack was available but it was the only one of its kind in existence and a complete set of engineering drawings of it did not exist. Thus it was decided not to risk its possible loss. As a result, the scheduled towed AN/ASH-2 exercises were cancelled and the remaining rack was kept as a guide in the fabrication of a new rack. The new rack was completed in October 1957.

11. Because of the requirements of higher priority projects for the aircraft, it was not possible to schedule further towed AN/ASH-2 flights until June 1958.

12. On 5 June 1958 a second towed AN/ASH-2 flight was made with the exhaust trail of a cargo ship as a target. The exhaust trail of this ship was tracked back without difficulty on both inboard and towed equipments for a distance of 40 mi. (It is believed that it could have been tracked further except that another ship was in the trail of the first ship at this 40-mi point.) Seventeen crossings of the trail were made at a variety of altitudes and distances from the ship. In 16 of these cases, signals of approximately equal magnitude were obtained from both equipments; in one case (a crossing only 1 mi away from the ship) the towed AN/ASH-2

signal was appreciably stronger. See figure 3. For these runs a cable of 150-ft length was used, and it produced a vertical separation between aircraft and capsule of about 75 ft.

13. The following is a summary of additional data associated with the exercises of 5 June 1958:

Time of flight:	0944 to 1330 EDT
Operating area:	30 to 50 mi off Long Island
Target:	Cargo ship approximately 700 ft long on course 060 at about 12 k.
Weather:	Partly cloudy, clouds at 800- to 1300-ft altitude, visibility unlimited, air temperature 15 to 16° C.
Surface wind at NAS Johnsville (at 0930):	160 deg at 8 k.
Estimated surface wind in operating area:	065 deg at 10 k.
AN/ASH-2 gain setting:	8000 condensation nuclei per cu-cm full scale.
Average condensation nuclei level in operating area:	1600 condensation nuclei per cu-cm.
Altitudes at which abrupt changes in condensation nuclei occurred:	1300 and 1900 ft.

14. On 16 June 1958, a third towed AN/ASH-2 flight was made with the exhaust trail of submarine SS-320 as a target. Thirty-one crossings of the trail were made at aircraft indicated altitudes ranging from 250 to 600 ft. On this flight the aircraft's altimeters were behaving erratically; it is believed that on some of the crossings the towed capsule was as low as 50 ft. Once again a cable length of 150 ft was used. The exhaust trail was tracked back for its full length of 15 mi. See figure 4.

15. The following is a summary of additional data associated with the exercises of 16 June 1958:

Time of flight:	1640 to 2020 EDT
Operating area:	20 to 30 mi south of Montauk Point, Long Island
Target:	Submarine SS-320 snorkeling into the wind at 5 k.
Weather:	Partly cloudy, about 25% cloud cover, visibility unlimited, air temperature 22 to 23° C. Sea choppy.
Surface wind at NAS Johnsville (at 1630)	310 to 320 deg at 20 to 25 k.
Estimated surface wind in operating area:	240 to 260 deg at 18 to 22 k.
AN/ASH-2 gain setting:	32,000 condensation nuclei per cu-cm full scale.
Average condensation nuclei level in operating area:	8000 condensation nuclei per cu-cm and essentially constant over altitude range of 250 to 1500 ft.

16. The breakdown for inboard and towed AN/ASH-2 signal intensities for the exercises of 16 June 1958 is as follows:

Results	No. of Trail Crossings	Percent of Total No. of Trail Crossings
Inboard and towed AN/ASH-2 signals of essentially equal intensity.	16	52
Towed AN/ASH-2 signal appreciably stronger.	3	10
Inboard AN/ASH-2 signal appreciably stronger.	5	16
Trail detected by inboard AN/ASH-2 but not by towed AN/ASH-2	6	19
Trail detected by towed AN/ASH-2 but not by inboard AN/ASH-2	1	3

17. For the types of meteorological conditions encountered in these towed AN/ASH-2 exercises, in general both equipments gave indications of the same magnitude. Occasionally, however, one equipment would detect the trail while the other would miss. There appears to be a slight advantage in operating two equipments separated by some distance in that there is an enhanced probability that one of them will pass through an exhaust trail. It is believed that if a longer tow cable had been available (approximately 300 ft) detection probability would have been improved.

18. It was also noted in these exercises that the pilots were reluctant to fly the towed capsule at altitudes lower than those at which they would be willing to fly the plane itself without the towed capsule.

19. The following conclusions can be drawn:

a. In general (even along the North Atlantic coast, where the low altitude effect was suspected), the lowest altitude is not necessarily the best altitude for conducting a search for exhaust trails. The most dependable way to find the optimum altitude for conducting a search is to cross repeatedly at various altitudes through the exhaust trail of a known source of contamination (such as a surface vessel) at a distance of 5 to 10 mi and select the altitude which yields the best signals.

b. It is not possible to specify a single altitude as the best altitude at which to fly in searching for trails. The optimum altitude varies with geographical location and climatic conditions.

c. No conclusions could be reached regarding an increase in concentration of atmospheric salt nuclei associated with a submarine wake. If such an effect does exist, it is below the operating altitude considered safe for the towed capsule (estimated as 50 ft for daytime operations). Consideration is being given to installing an AN/ASH-2 in a helicopter or on a surface craft to investigate this possibility.

d. Operation of the AN/ASH-2 in the towed capsule reduces the probability of confusing the aircraft exhaust trail with that of the submarine. This problem has not been

considered a serious one and in these exercises no situations rose to demonstrate the problem. Fresh aircraft trail signals have a relatively sharp signature as compared with those of a submarine. Additionally, the pilot generally knows when he has flown through his own trail.

Reported by: Paul M. Moser
Paul M. Moser
Special Methods Division

Approved by: C. T. Brown
C. T. Brown, Superintendent
Special Methods Division

H. D. Huey
H. D. Huey
Technical Director

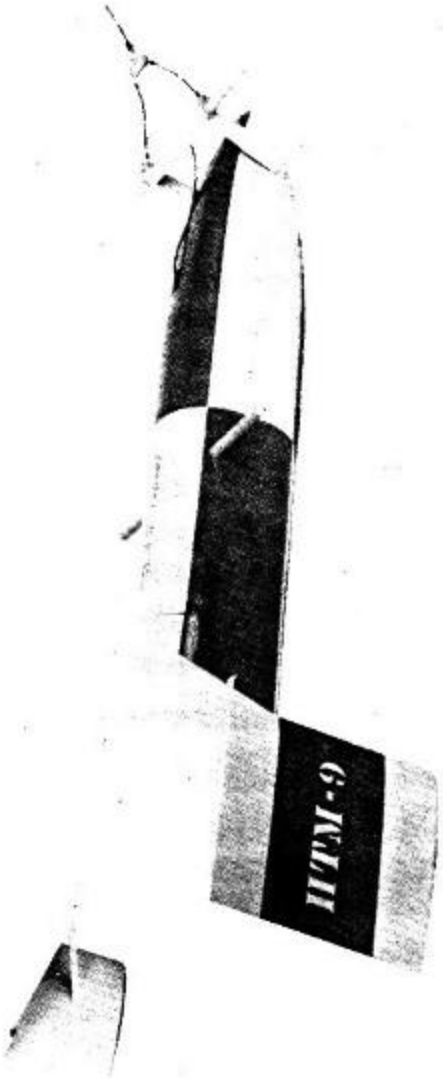

FIGURE 1 - HTM-9 Capsule

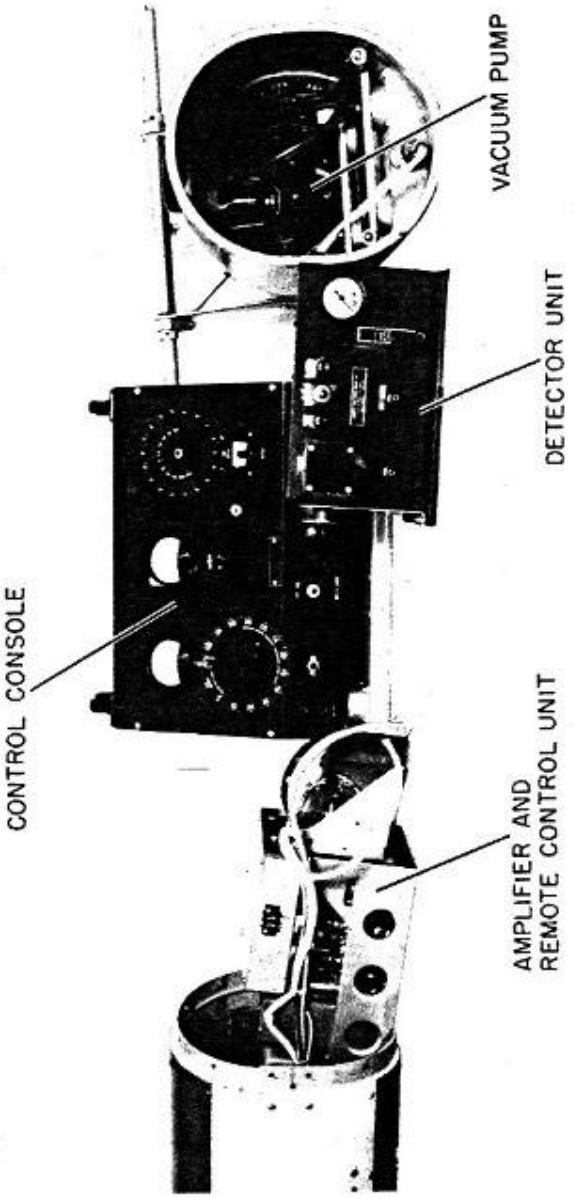

FIGURE 2 - Open HTM-9 Capsule and AN/ASH-2 Equipment

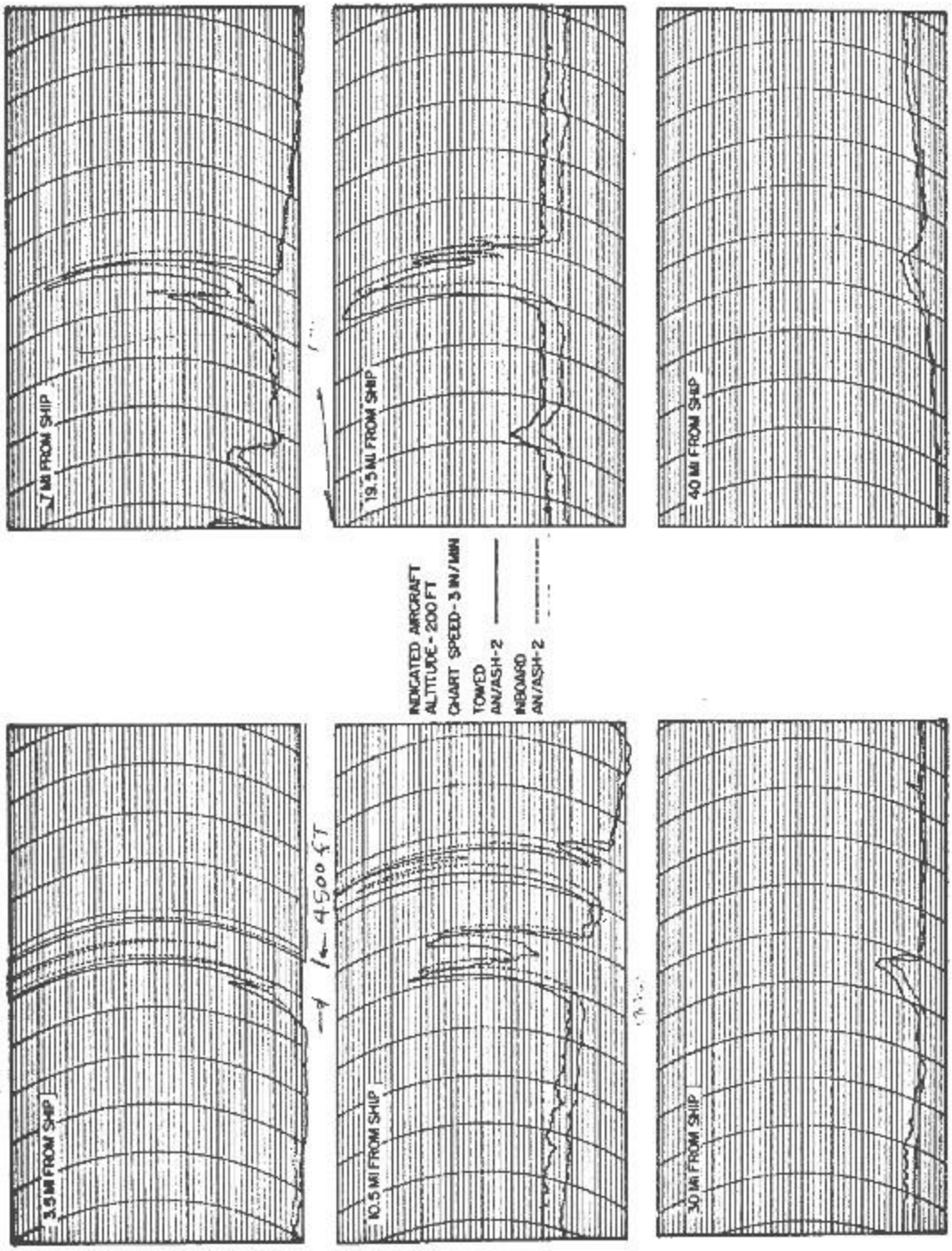

FIGURE 3 - Crossings of Exhaust Trail of a Ship

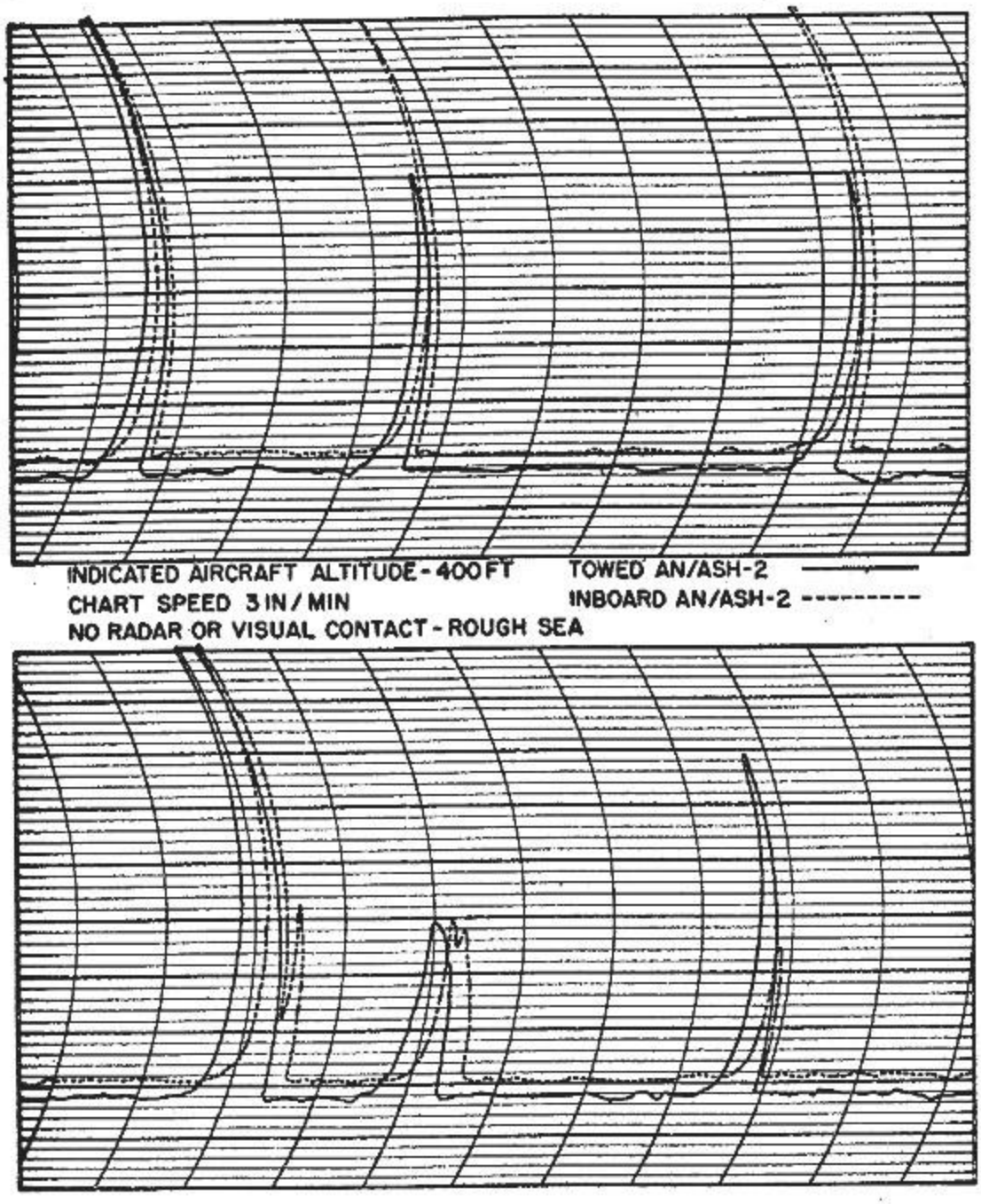

FIGURE 4 - Six Crossings Through Trail of Snorkeling Submarine

D I S T R I B U T I O N L I S T

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22 Feb 2017

MEMORANDUM FOR THE RECORD

FROM: Division Director EO & Special Mission Sensors, Avionics, Sensors and E* Warfare Dept (AIR 4.5.6)

TO: Office of Counsel, Naval Air Warfare Center, Aircraft Division (NAWCAD)

Subj: SECURITY RECOMMENDAION FOR FOIA REQUEST, DON FOIA CASE FILE NUMBER 2015-008952

Ref: (a) SECNAVINST 5720.42F, DON FOIA Program, 06 Jan 99

(b) Executive Order 13526

1. Releasable Recommendations. The following documents were reviewed by AIR 4.5.6. Each of the following documents were found to be releasable in their entirety:

   a. Document (1) of Subj. NAVAIRDEVCEN Report No. NADC-AW-L5902, 24 Mar 1959, "Investigation of a Towed-capsule Installation of the AN/ASH-2 Condensation Nuclei Detector" (AD-B966296)
   b. [redacted]
   c. Document (16) of Subj. NAVAIRDEVCEN Report No. NADC-AE-6759, 16 Jan 1968, "Modified Reconofax VI Infrared Mapping Set with Real Time Inflight Display" (AD-387513)
   d. Document (17) of Subj. NAVAIRDEVCEN Report No. NADC-AE-6828, 12 Nov 1968, "Modified AN/AAD-2(XE-2) Infrared Detecting Set with Real-Time Inflight Display (AD-500493)
   e. Document (18) of Subj. NAVAIRDEVCEN Report No. NADC-72167-AE, 10 Apr 1973, "Index of Performance for FLIR (Forward Looking Infrared) Imaging Devices" (AD-525116)

2. Partially Releasable Recommendations. AIR 4.5.6 recommends pages 27 through 68 are releasable the following report: Document (20) of Subj. Naval Research Laboratory Memorandum Report 3240, Proceedings of the Electro-Optics/Meteorology Meeting on 7 Aug 1975, Mar 1976 "FLIR Performance Modelling and its Dependence upon Climatology and Meteorology "(AD-D516929L). All other data in this report is not under the technical authority of AIR 4.5.6.

3. [redacted]

4. Basis of Recommendation. All information was reviewed with current class guides and what is considered open source information. Appropriate recommendations made above with respect to findings. Documents found with portions releasable were sanitized based on class guides and reference (b). Such disclosure of Department of the Navy classified information would give potential adversaries insight that would present a significant threat to national security.

5. Exemptions Utilized. Two separate exemptions were utilized in the determination of what information should be sanitized or exempted from release via Freedom of Information Act (FOIA) request process. All current Classified Military Information (CMI) has been sanitized out of the document under FOIA Exemption 1, Executive Order 13526 Section 3.3(4). This Executive Order Section covers CMI that was originally classified over 25 years ago from date of this memorandum. Subject matter experts within AIR 4.5.6 were utilized in making the exemption determinations.

6. Point of Contact. The point of contact for this security review and recommendation is Mr. Paul W. Reimel, AIR 4.5.6 Division Director, paul.reimel@navy.mil, 301-342-0100.

2/28/2017

X Paul W. Reimel

Paul W. Reimel

Signed by: REIMEL.PAUL.W.1229241016

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