AD NUMBER
ADC950196
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 11 MAR 2009. Other requests shall be referred to Defense Threat Reduction Agency, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6201.
AUTHORITY
DTRA ltr dtd 12 May 2009; DTRA ltr dtd 12 May 2009

AD NUMBER

ADC950196

NEW LIMITATION CHANGE

TO

Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; 11 MAR 2009. Other requests shall be referred to Defense Threat Reduction Agency, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6201.

FROM

Controlling DoD Organization: Defense Nuclear Agency, Washington, DC 20305.

AUTHORITY

DTRA ltr dtd 11 Mar 2009

AD-C950196

SECURITY REMARKING REQUIREMENTS

DOD 5200.1-R, DEC 78

REVIEW ON 16 JUL 95

UNANNOUNCED

SECRET

Omit from General Bibliographic Listing.

DNA 3670F

HIGH RESOLUTION OPTICAL MEASUREMENTS FOR DNA OPERATION DICE GAME-FIELD REPORT (U)

Technology International Corporation
75 Wiggins Avenue
Bedford, Massachusetts 01730

16 July 1975

Final Report for Period 1 April 1974—1 February 1975

CONTRACT No. DNA 001-74-C-0240

NOT TO BE ANNOUNCED IN DDC TAB
This document is not to be announced, abstracted or cited in any announcement media, secondary publication, or general bibliographic listing.

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER SUBTASK K47CAXHX632-01.

Prepared for

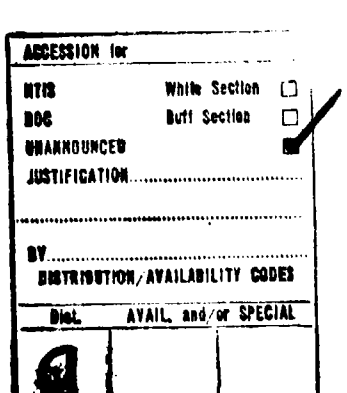
Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

THIS DOCUMENT CONSISTS OF 60 PAGES,
COPY 1 OF 49 COPIES, SERIES A.

NATIONAL SECURITY INFORMATION
Unauthorized disclosure subject to criminal sanctions.

CLASSIFIED BY: DD Form 254, 1 August 1974.
Exempt from General Declassification Schedule of Executive Order 11652. Exemption Category 2.
DECLASSIFY ON: 31 December 2004.

SECRET



When this report is no longer needed, Department of Defense organizations will destroy it in accordance with appropriate procedures. Contractors will destroy the report according to the requirements of the Industrial Security Manual for Safeguarding Classified Information.

Retention of this document by DoD contractors is authorized in accordance with Paragraph 2, Industrial Security Letter 71L-3, dated 17 May 1971.

UNANNOUNCED

SECRET

SECRET

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: DNA 3670F	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): HIGH RESOLUTION OPTICAL MEASUREMENTS FOR DNA OPERATION DICE GAME-FIELD REPORT (U)	5. TYPE OF REPORT & PERIOD COVERED: Final Report, for Period 1 Apr 74-1 Feb 75
	6. PERFORMING ORG. REPORT NUMBER: 774 TIC-774
7. AUTHOR(s): Keith B. Ronnholm, Wallace P. Boquist, Patricia L. Crawley	8. CONTRACT OR GRANT NUMBER(s): DNA 001-74-C-0240
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Technology International Corporation, 75 Wiggins Avenue, Bedford, Massachusetts 01730	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NWET Subtask K47CAXHX632-01
11. CONTROLLING OFFICE NAME AND ADDRESS: Director, Defense Nuclear Agency, Washington, D.C. 20305	12. REPORT DATE: 16 July 1975
	13. NUMBER OF PAGES: 60
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): DNA T. TL K47CAX-1 X632	15. SECURITY CLASS. (of this report): SECRET
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: XGDS(2) (2004)

16. DISTRIBUTION STATEMENT (of this Report): D 57p.

DDC RECEIVED NOV 17 1975 D

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under Subtask K47CAXHX632-01.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Atmospheric Nuclear Tests
Optical Measurements
Fireball Development
Nuclear Debris Clouds

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(S) TIC performed optical measurements on the atmospheric nuclear test series in the Pacific during the summer of 1974. This report describes the choice of instrumentation and operational procedures. Also included are some preliminary results of geometric measurements. Each data record has been reviewed and a summary of each useful record has been included. Five of seven events were observed from one surface platform.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECRET

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECRET

DDC COPY NO 52376

387534

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

18. SUPPLEMENTARY NOTES (Continued)

NOT TO BE ANNOUNCED IN DDC TAB. This document is not to be announced, abstracted or cited in any announcement media, secondary publication, or general bibliographic listing.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION AND BACKGROUND	3
2.0	INSTRUMENTATION PLAN	6
3.0	OPERATIONAL PROCEDURE	15
4.0	PRELIMINARY RESULTS	21
5.0	DISCUSSION	37

1.0 (S) INTRODUCTION AND BACKGROUND (U)

(S) The most recent and believed to be the last planned French atmospheric nuclear test series was conducted during the summer of 1974 in the south Pacific Mururoa Atoll area. The Defense Nuclear Agency sponsored an extensive experimental measurements program aboard the USNS Huntsville (Figure 1) during five of the seven events in this series as part of an existing and continuing nuclear effects study program.

(S) The overall objectives of the DNA sponsored projects were to obtain experimental data relevant to current and anticipated research areas as well as to contribute to the data base of information pertinent to low altitude atmospheric detonations. In the 1974 Operation Dice Game, the priority objectives were oriented towards in-situ measurements of debris particle size and isotope sampling (with the aid of Remotely Piloted Vehicles, RPV's, launched from the Huntsville), as well as radar clutter, doppler shift, and microwave radiation measurements from the Huntsville platform. In addition, other priority objectives to be acquired with optical instrumentation included early time fireball phenomenology and overall debris cloud morphology development.

(S) In order to address these optical data requirements, Technology International Corporation defined the following observational objectives to be attained during the field program.

1. High resolution measurements of early structural characteristics during the time regime from zero (0.0002 sec.) to twenty seconds (or longer, depending upon source strength), and acquistition of data for analysis into source structure, geometry and luminous cross-section.

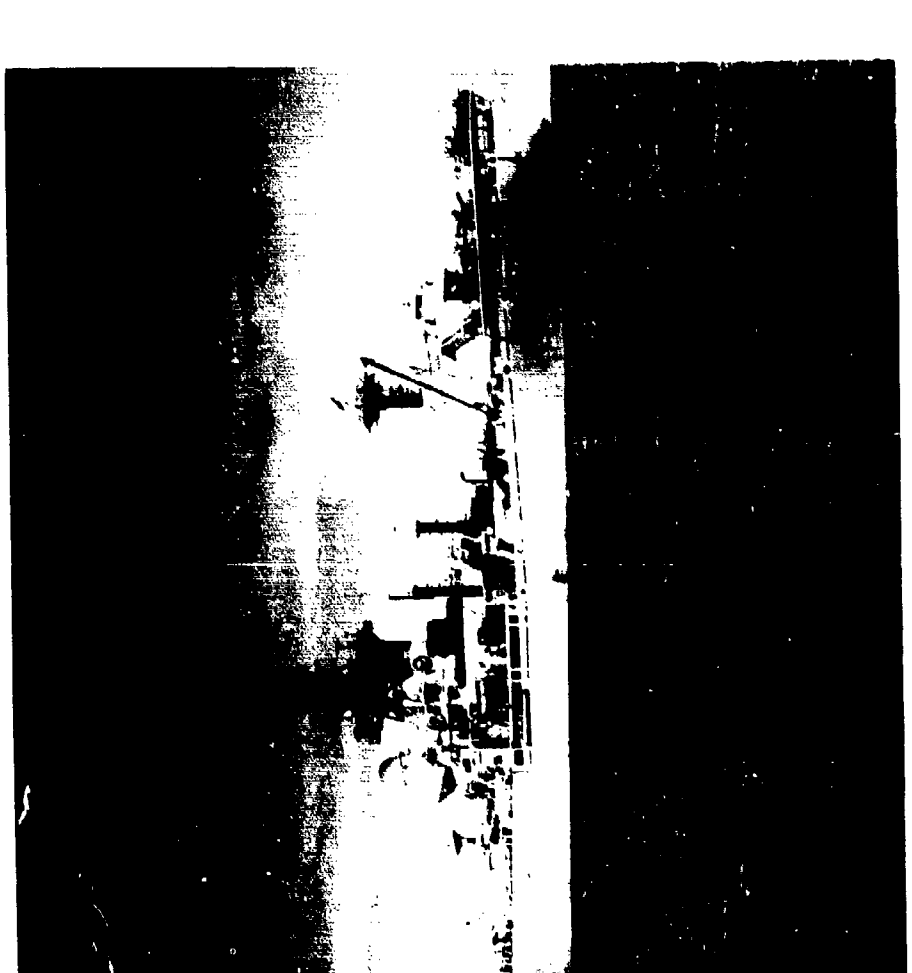


Figure 1 (C) USNS Huntsville on station (C)

(S)

2. Late-time measurements of cloud development and stabilization for periods to no less than twenty minutes and as long as the order of two hours where possible and appropriate.

In addition to the above mentioned measurement objectives, the capability of on-board processing of selected records to permit following day determination of height of burst and initial rise rate was also provided by TIC.

2.0 (S) INSTRUMENTATION PLAN (U)

(S) To provide the coverage necessary to satisfy the aforementioned objectives, TIC utilized a variety of photographic, video and spectrographic instrumentation. Due to the wide range of radiances and dimensional changes inherently characteristic of a nuclear event, along with rapid early temporal development and subsequent debris cloud persistence and extent, many specialized camera systems were employed. The optical instrumentation was generally divided into two separate groups. The first category included the long focal length fast framing cameras whose running duration varied from a few to a maximum of about 60 seconds. Because of the relatively small film format of such cameras (16mm to 70mm), this instrumentation was mounted on a specially modified trainable mount (described subsequently) to compensate for the inherent field of view problem of such cameras.

(U) The second category of cameras included the large format, slow cycling, pulse cameras whose running duration could extend as long as an hour or more. Due to the larger fields of view of the pulse cameras, these were operated in fixed positions in almost all instances. Figure 2 shows the general arrangement of the trainable and fixed cameras in the TIC instrument van.

(U) The TIC optical instrumentation used for primary data acquisition and the special documentation cameras are summarized in Tables I-A, B and C. This instrument plan describes the operational parameters and film types associated with each kind of instrumentation listed. The instrumentation parameters are subject to change between events and should be correlated with the data record summaries (Appendix A) to confirm the film type and lens focal length used in a given event.

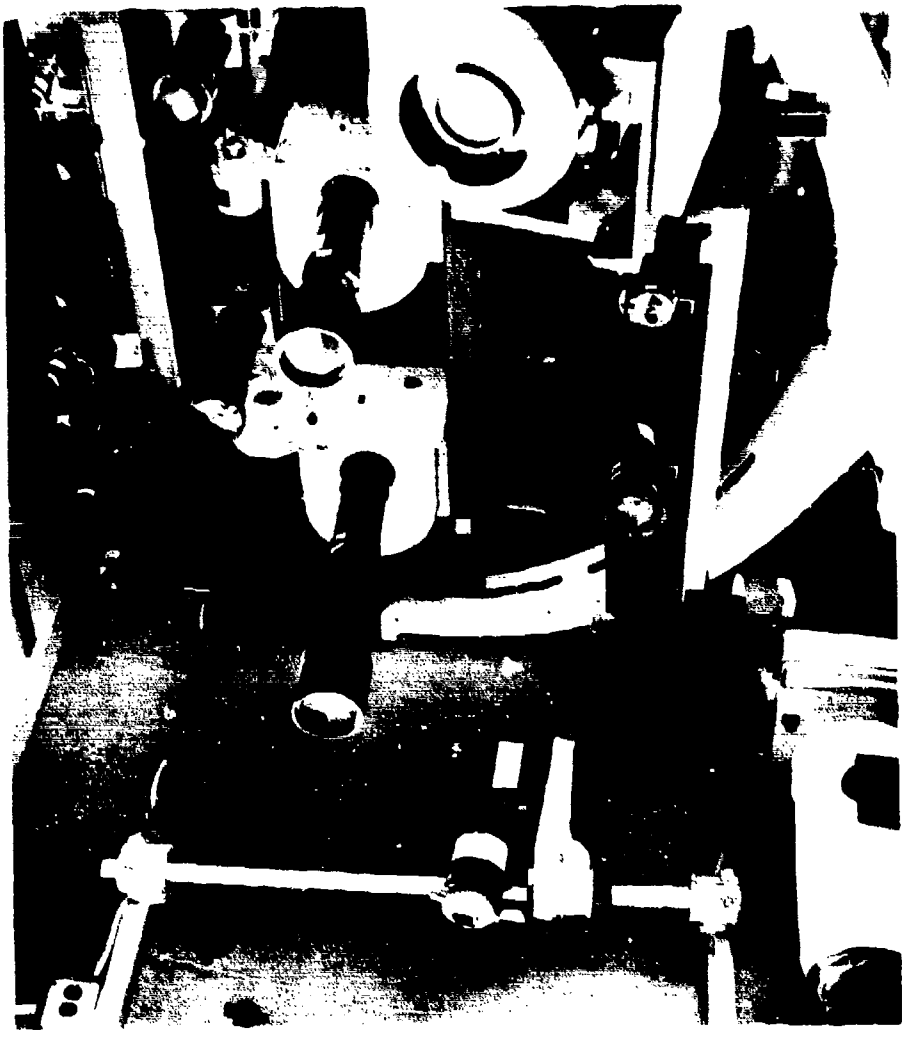


Figure 2 (U) Optical instrumentation on trainable and fixed mounts (U)

TABLE I-A (U)
TECHNOLOGY INTERNATIONAL CORPORATION

INSTRUMENT PLAN (U)

OPERATION: DICE GAME DATE: SUMMER 1974 STATION: SURFACE - TRAINABLE

EVENT: ALL LOCATION: OPAREA PROJ/ENGINEER: DNA

POSITION	INSTRUMENT	FOCAL LENGTH	FILTER	FILM	RUN	SHUTTER/RATE	REMARKS
01	WF - 14	305 MM	ND 2	PXN 16 x 400	3.5SEC	5400 FPS	1.4 x 2°
02	PS - 16 - 1P	102 MM	ND 2	EMS 16 x 200	30 SEC	100 FPS	4 x 6°
03	PS - 16 - 1P	500 MM	W - 12	XR 16 x 200	20 SEC	400 FPS	.9 x 1.2°
04	H.S. MITCHELL	305 MM	ND 2	PXN 35 x 200	32 SEC	100 FPS	3.5 x 4.8°
05	H.S. MITCHELL	509 MM	-	XRM 35 x 200	32 SEC	100 FPS	2.1 x 3°
06	PS - 10A	600 MM	ND 1	PXP 70 x 250	32 SEC	30 FPS	5.4 x 5.4°
07	PS - 10A	800 MM	-	XRM 70 x 200	24 SEC	40 FPS	4.1 x 4.1°
08	KS - 67A	305 MM	-	PXP 70 x 85	66 SEC	6 FPS	11 x 11°
09	KS - 67A	508 MM	ND 1	AMS 70 x 85	66 SEC	6 FPS	6.6 x 6.6°
10	EL - 500	500 MM	-	XRC 70 x 15	70 SEC	1 SEC	
11	EL - 500	500 MM	ND 1	ACN 70 x 15	70 SEC	1 SEC	6.6 x 6.6°
12	MS - SPEC	500 MM	-	IRA 70 x 15	70 SEC	1 SEC	2° DIA
13	FI - 500	250 MM	-	ACN 70 x 15	70 SEC	1.3 SEC	13 x 13°
21	HV - 15S	50-300 MM	W88A	-	PRE	1/30 SEC	9x12-1.42x2°
22	HV - 15S	80-230 MM	ND 4	VIDEO TAPE	POST	1/30 SEC	4.6x6.7-2.1x2.7°

ADDITIONAL INFORMATION:

UNCLASSIFIED

UNCLASSIFIED

TABLE I-B (U)

TECHNOLOGY INTERNATIONAL CORPORATION

INSTRUMENT PLAN (U)

OPERATION: DICE GAME DATE: SUMMER 1974 STATION: SURFACE - FIXED

EVENT: ALL LOCATION: OPAREA PROJ/ENGINEER: DNA

POSITION	INSTRUMENT	FOCAL LENGTH	FILTER	FILM	RUN	SHUTTER/RATE	REMARKS
31	B-C/E	210 MM	-	PXP 70 x 100	30 MIN.	1.25,5,10, 30 SEC.	15 x 20° CLOCK
32	K-17D	915 MM	-	AMS 9" x 125	30 MIN.	1.25,5,10, 30 SEC.	14 x 14°
33	K-17D	610 MM	W 88A	IRA 9" x 125	30 MIN.	1.25,5,10, 30 SEC.	21 x 21°
34	K-17D	154 MM	R.G.D.	AMS 9" x 125	30 MIN.	1.25,5,10, 30 SEC.	74 x 74°

ADDITIONAL INFORMATION: R.G.D. = RADIAL GRADIENT DENSITY

TABLE I-B (CONT) (U)
TECHNOLOGY INTERNATIONAL CORPORATION

INSTRUMENT PLAN (U)

OPERATION: DICE GAME DATE: SUMMER 1974 STATION: SURFACE-FIXED (STBD)

EVENT: LOCATION: OPAREA PROJ./ENGINEER: DNA

POSITION	INSTRUMENT	FOCAL LENGTH	FILTER	FILM	RUN	SHUTTER/RATE	REMARKS
35	K-17 D	153	RGD	AMS 9 x 125'	30 MIN	2 SEC.	74 x 74°
36	EL 500	250	-	XRM 70 x 15'	70 SEC.	1 SEC.	13 x 13°
38	P-2	75	ND3	PXP 70 x 100'		6 FPS	41 x 41°
39	KS-67	150	ND2	PSP 70 x 85'		6 FPS	21 x 21°

ADDITIONAL INFORMATION:

TABLE I-C (U)

TECHNOLOGY INTERNATIONAL CORPORATION

INSTRUMENT PLAN (U)

OPERATION: DICE GAME DATE: SUMMER 1974 STATION: SURFACE

EVENT: DOCUMENTARY LOCATION: OPAREA PROJ/ENGINEER: DNA

POSITION	INSTRUMENT	FOCAL LENGTH	FILTER	FILM	RUN	SHUTTER/RATE	REMARKS
	HB 1000F/CL5	1250 MM		70 MM	10		
	HB 1000F	80 MM		70 MM	10		
	H - 16	300 MM		16 MM CINE	10		
	HB - 1000F/CL8	2500 MM		70 MM	10		

ADDITIONAL INFORMATION:

SECRET

(S) Instrument positions 01, 02, and 03 consisted of three high speed, 16mm format cameras which were incorporated to record the initial fireball development history. Photographic emulsions of widely varying characteristics were used because of the wide dynamic range of fireball intensity in this early time period. As determined by film load and framing rate, approximate coverage times of 3.5, 75 and 20 seconds were predicted for these respective positions.

(S) Positions 04 through 11 and 13 include cameras of 35mm and 70 mm format sizes with framing rates varying from 100 fps down to about 1 fps. These camera systems were planned to record the majority of the post fireball luminous phase of the debris cloud development and utilized film emulsion and filter combinations accordingly. Within this overall group, three positions utilized extended range (XR) films which are capable of recording source brightness variations of over 10^6 to one.

(S) A multi-slit spectrograph was employed to provide extended spatial coverage of the spectral characteristics of the source region. This instrument was designed to provide only moderate spectral resolution in order to achieve an effective field of view on the order of 2^o in two dimensions on a 70mm format. The M-S Spectrograph utilized a transmission diffraction grating and covered a spectral range of 4000A to 8700A. The second order effects were purposely not filtered out to achieve coverage at 4000A. Depending upon the source size during the 0 to approximately 10 second period of operation of the spectrograph, the spectral data would be expected to include the source and surrounding excited air mass for a small event and, possibly, the spectral characteristics of different source regions for a large event. The spectrograph was boresighted with the position 11 camera system to provide ultimate correlation of the spectral data to source size and shape.

(S) The non-trainable, large format, pulse cameras were employed to acquire general morphological and late-time spatial data of the nuclear debris cloud. Camera positions 32, 33, and 34 utilized 9" format camera systems with focal lengths ranging from 150mm to 900mm for which the respective corresponding fields of view varied from 74^{o} to 14^{o}. All three of these large format camera systems were operated synchronously with a 70mm format camera (position 31) which had a built-in clock to provide frame timing for all four cameras. This system of cameras was operated at approximately 2 seconds between exposures at event time to as long as about 60 seconds between exposures at late times.

(S) Because of the extended requirement for the 1974 operation to record the late-time cloud, the time for which the Huntsville could be expected to maintain its initial heading would clearly be exceeded. Thus, a remotely operated starboard mounted group of fixed cameras was included in the Dice Game instrument plan. This starboard group of cameras (positions 35 through 39) was capable of viewing the burst region when required to supplement the other photographic instrumentation. For continuity in timing, the position 35 camera was pulsed with a spare intervalometer signal from the position 31 camera sequence.

(S) In order to facilitate accurate pointing of the trainable azimuth mount containing the cine camera systems, two silicon target video systems were utilized to view the position of the source prior to and throughout all phases of the event. The position 21 vidicon was lightly filtered to view the source prior to detonation (as well as after the luminous phase had subsided), whereas the position 22 vidicon was heavily filtered to display the source with proper exposure immediately following the detonation so that the mount operator would not lose track of the source position. Both of these vidicon systems were recorded on video

(S)
tape for immediate after-the-fact replay when required, and to assess pointing technique performance.

(S) In addition to the optical data instrumentation described above, a variety of documentation cameras used by TIC are summarized in Table I-C. Two unique long focal length cameras included in this group were assembled by TIC to provide coverage of the device package on the morning of each event when weather permitted. Other cameras (still and cine types) were used to document RPV activity, French surveillance, resupply operations, and other desired coverage.

3.0 (S) OPERATIONAL PROCEDURE (U)

(S) All DNA experimental RPV, radar and optical data collection of the 1974 French nuclear test series was conducted from a single surface platform, the USNS Huntsville (Figure 1). TIC operated the majority of its optical instrumentation from one of two 8' x 8' x 20' container vans located on the ship's foredeck (Figure 3). The second container provided laboratory working space for photographic support (film processing, magazine loading) and instrumentation maintenance (check-outs, cleaning, repair). In addition, freezer storage and photographic darkroom space was provided on board the USNS Huntsville.

(U) The instrumentation container was positioned with its longitudinal axis oriented in the port (target) direction. The trainable azimuth/elevation mount and fixed camera systems were positioned inside the double-door end of the container such that each had as optimum field of view as possible consistent with the camera run duration. Special attention had to be afforded severe vibration problems encountered on the ship's foredeck insofar as the trainable mount was concerned. After initial sea trial experience at Port Hueneme, special shock absorbers were incorporated into the trainable mount system which not only diminished the vibration to an acceptable level but also permitted the mount to be trained $\pm$ 15° in azimuth while in place.

(U) An operator sitting behind the mount manually applied elevation corrections and controlled the motor which effected azimuth changes as he viewed the event through the two video systems (Figure 4). Prior to event detonation, the operator would sight the event balloon on a monitor connected to an infrared vidicon system (position 21) which allowed enhanced perception through fog and reasonably dense haze. A

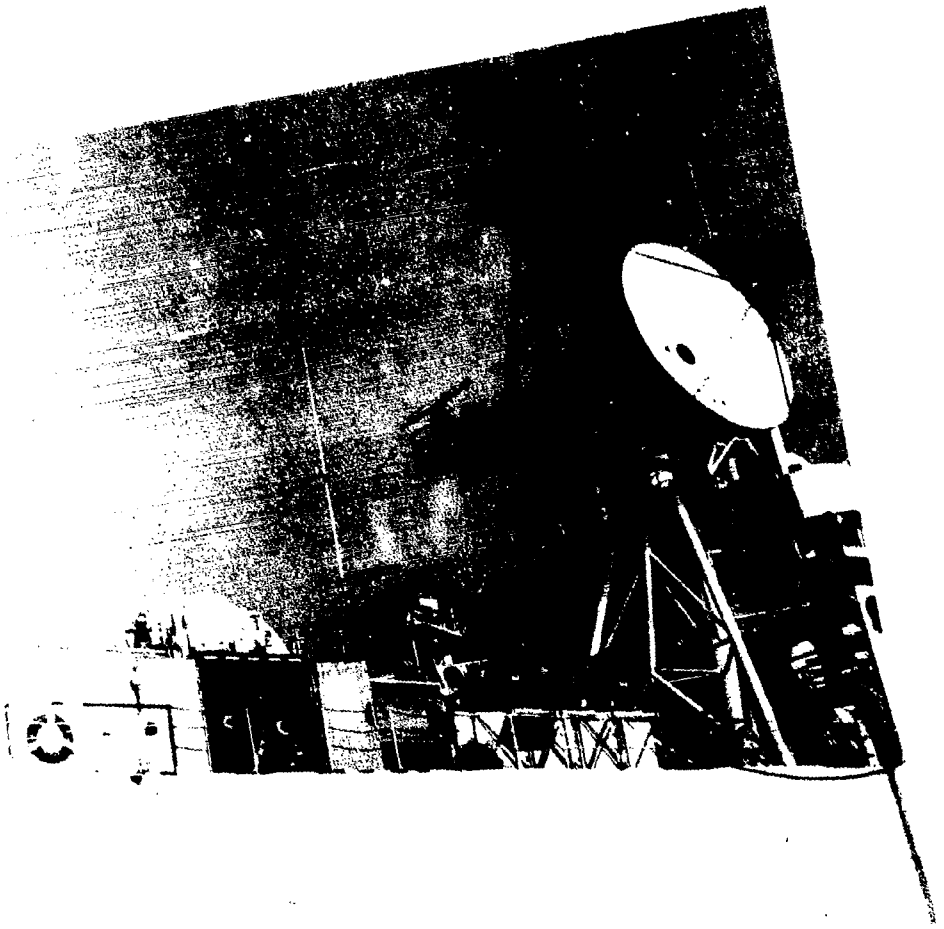


Figure 3 (C) Primary optical instrumentation on port side of USNS Huntsville (C)

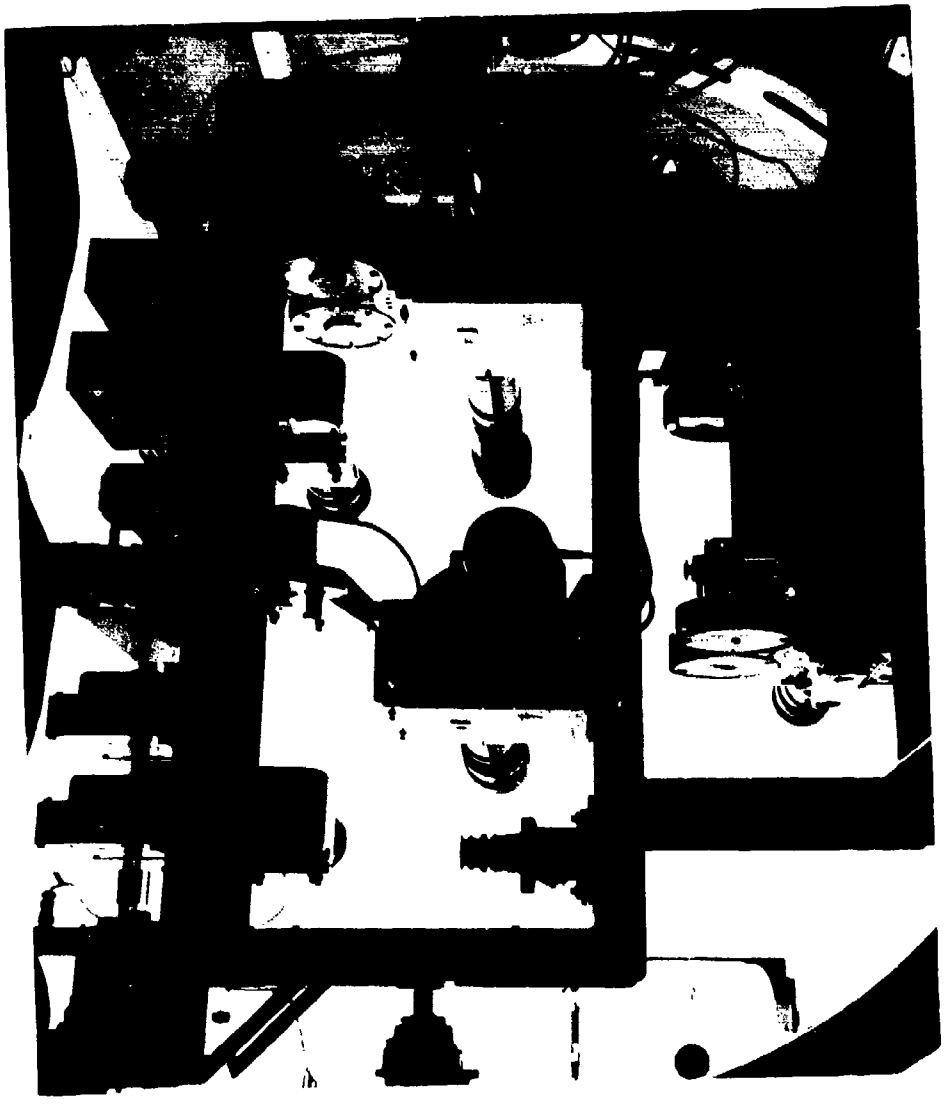


Figure 4 (U) Trainable mount operating position (U)

(U)
relatively long focal length was utilized to keep the target centered within the field of view of even the smallest format early time cine cameras. At detonation, a wider angle, heavily filtered, video system was used temporarily for pointing (position 22) until the source brightness subsided. Although pointing accuracy was concurrently affected by three degrees of ship movement (roll, pitch and yaw), the target could generally be confined within a 1^{o} field of view.

(U) For future reference it should be noted that the camera systems located within the instrument van were an average of about 28 feet above sea level. This figure would vary $\pm$ about 3 feet due to camera position and of course would be further affected by the ship's buoyancy at a given time as well as the effect of sea swells.

(S) In general, the air-conditioned instrumentation and support vans provided the necessary environmental shelter and protection of electronics, video components and optical instrumentation from extreme excesses of heat, humidity and the corrosive action of salt spray. Film in magazines loaded well ahead of an anticipated event countdown were thus properly protected. This was particularly important for those cameras which were operated outside the instrument van on a fixed columnar mount at an elevation approximately 7 feet higher on the starboard side of the ship (positions 35 through 39) (Figure 5). As discussed before, this mount position was established to both supplement data collection by the primary sheltered cameras and to provide a back-up viewing orientation in the event of a questionable last-minute location of an airdrop. These cameras were stored between anticipated event days inside one of the TIC containers.

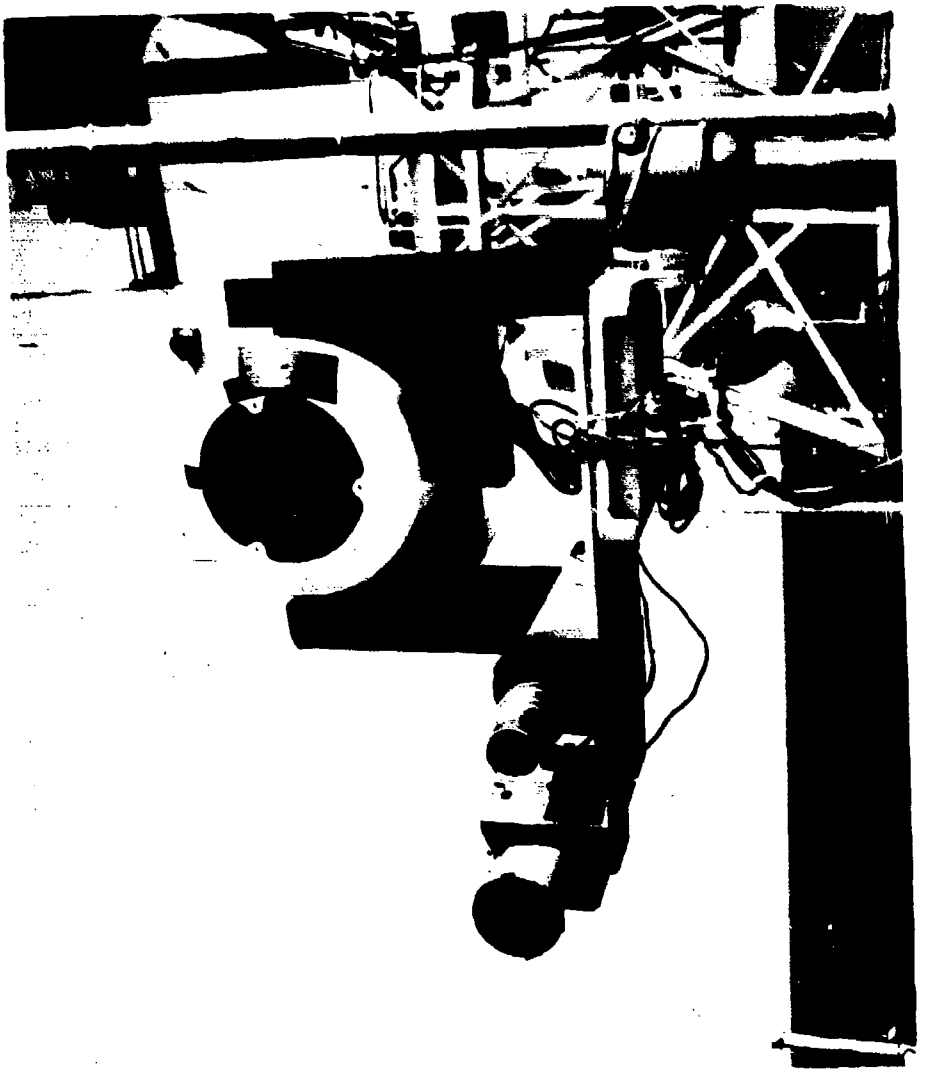


Figure 5 (U) Starboard side optical instrumentation (U)

(U) A detailed TIC check-list and operational sequence schedule, correlated with the "all ship" countdown, was followed before, during and after each event. Thorough system check-out and preparation was initiated from H - 48 hours or thereafter as soon as an event time was pinpointed. Special documentary coverage commenced at approximately H - 2 hours and general mount training at H - 5 minutes after check-out of power input and instrumentation operation. All power, intervalometer and pulsing management was initiated and controlled from a master control panel unit located behind the trainable mount. An exact sequence of start-up for camera operation commenced at H - 20 seconds ending at H - 2 seconds (when position 01 was started to conserve its rapid consumption of film load).

(U) After the detonation, a sequence of operation was subsequently followed to shut off power upon individual camera load terminations and to make the necessary decreasing pulse rate changes for all the large format fixed cameras. Included in this latter group was position 35 on the starboard mount which was remotely controlled from the instrumentation van panel by a long cable to pulse simultaneously with positions 31 through 34. Documentary coverage was scheduled to re-commence by H + 10 minutes and continue as long as necessary.

4.0 (S) PRELIMINARY RESULTS (U)

4.1 (S) General Event Parameters (U)

(S) The DNA sponsored experimenters aboard the USNS Huntsville were on station and able to monitor five of seven reported French nuclear detonations in the 1974 series; these will be identified as Fr 52, Fr 53, Fr 56, Fr 57, and Fr 58. While making an average speed of 4 knots, surveillance and data collection was conducted from about 24 nautical miles distance from either the West or North test sites of Mururoa Atoll. Ship positions around the atoll for each of the five tests observed are identified on the map in Figure 6, and specific position parameters are given in Table II . Of the five events observed by the Huntsville, four were detonated at the West site and one at the North site (Fr 57). Of the two unobserved tests, FR 54 was detonated at the North site on 17 July at 0800 local and Fr 55 was an airdrop that occurred at 0830 on 25 July.

(S) Yields ranged from 4 to 350 kilotons for the 1974 series; Table III summarizes the parameters associated with each event listing event number, date, time, site, yield and general comments. A general account of TIC optical coverage duration for each event is shown in Figure 7. More descriptive and specific comments regarding data coverage is listed by TIC record number in the Data Record Summary pages of Appendix A.

(S) The five nuclear events observed were detonated at heights of several hundred meters above sea level. The nuclear devices were suspended and detonated from gas-filled, fin-stabilized balloons tethered to three barges floating in the atoll. Figure 8 is a sketched version of

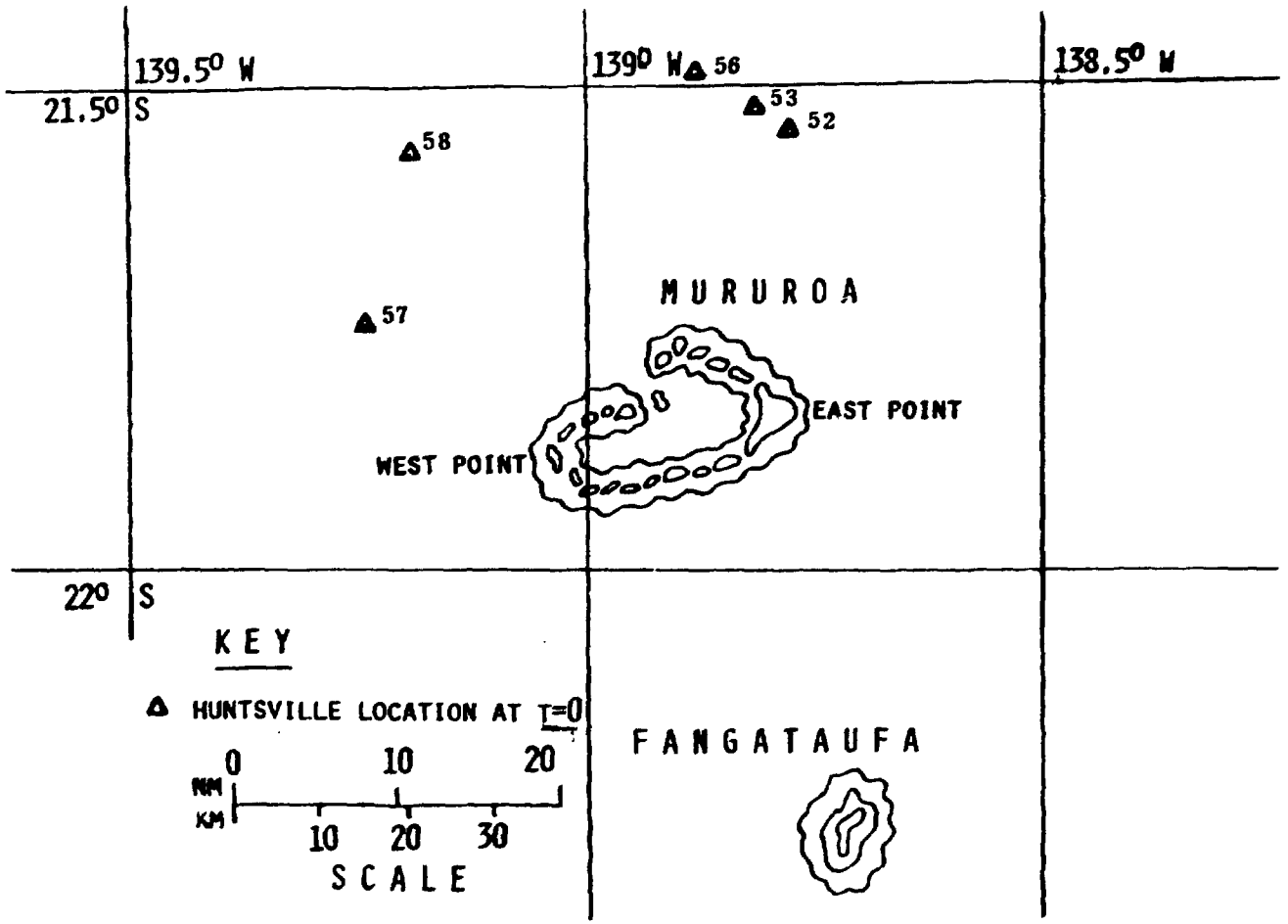


Figure 6 (S) Positions of optical platform at detonation time (U)

TABLE II (S)

PLATFORM POSITION PARAMETERS AT DETONATION TIMES (U)

Event	Fr 52	Fr 53	Fr 56	Fr 57	Fr 58
Detonation Site	West	West	West	North	West
USNS Huntsville					
Range (nautical miles)	22.4	22.8	23.4	19.8	20.7
Lattitude (deg.S)	21.548	21.527	21.491	21.752	21.574
Longitude (deg. W)	138.782	138.813	138.881	139.249	139.197

TABLE III (S) OPERATION DICE GAME EVENT MATRIX (U)

Event	Date	Local Time	Site	Estimated Yield	Comments
52	16 June 1974	0830	West	4	Excellent weather - complete coverage of development to T + 18 minutes
53	7 July 1974	1415	West	170	Coverage to T + 2.3 hours; period T + 20 to T + 60 sec. partially hidden by natural clouds
54	17 July 1974	0800	(North)	4	Not observed by USNS Huntsville
55	25 July 1974	0830	(Airdrop)	8	Not observed by USNS Huntsville
56	14 Aug. 1974	1530	West	110	Good initial coverage; partially obscured by natural clouds until T + 3 min; data to T+ 1 hr. 40 min.
57	24 Aug. 1974	1445	North	14	Visible for 25 seconds; then obscured by natural cloud cover
58	14 Sept. 1974	1430	West	350	Good initial coverage but quickly obscured by natural clouds; clear coverage T + 1 min. to T + 2 hours

SECRET

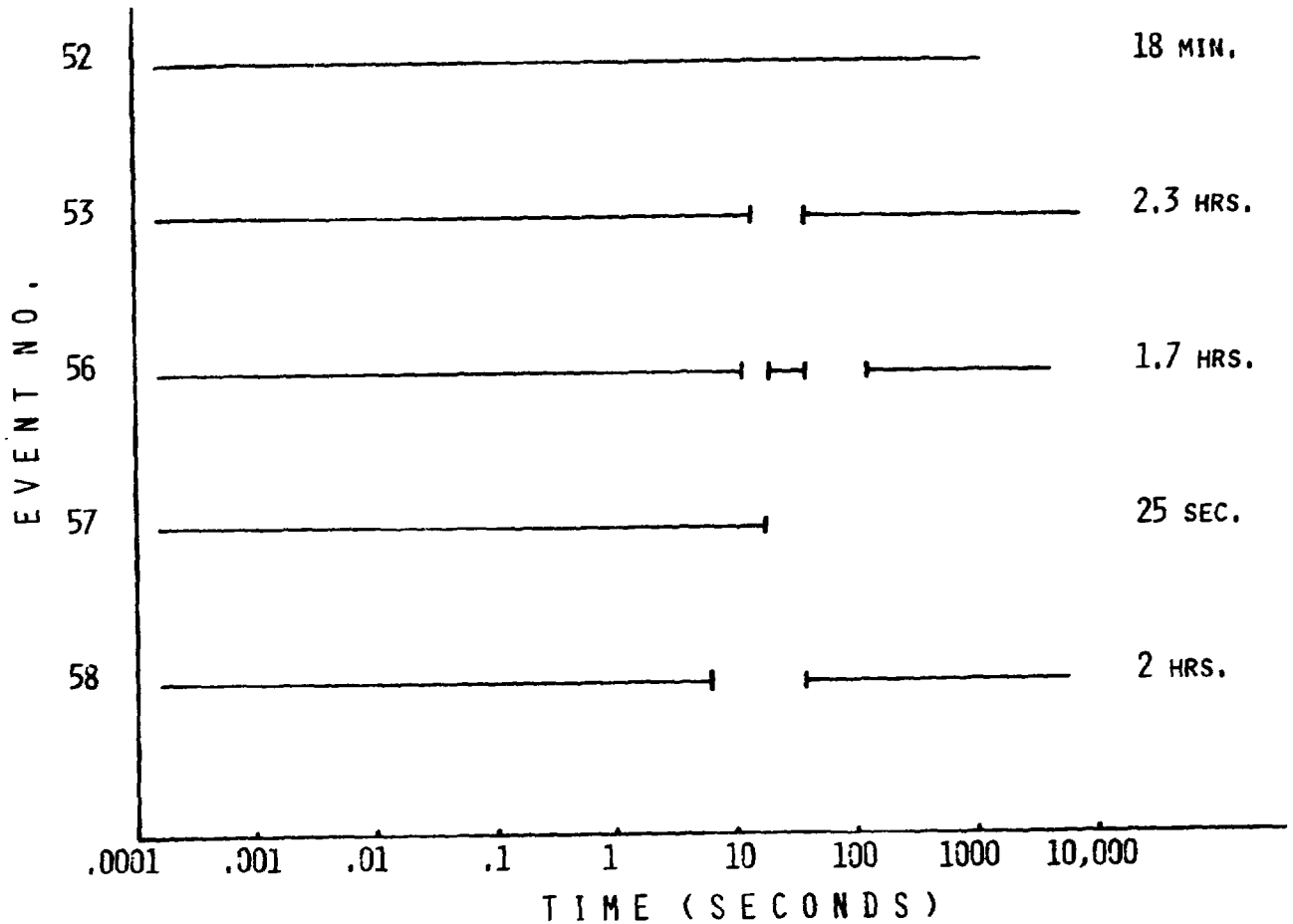


Figure 7 (S) Optical data acquision period (U)

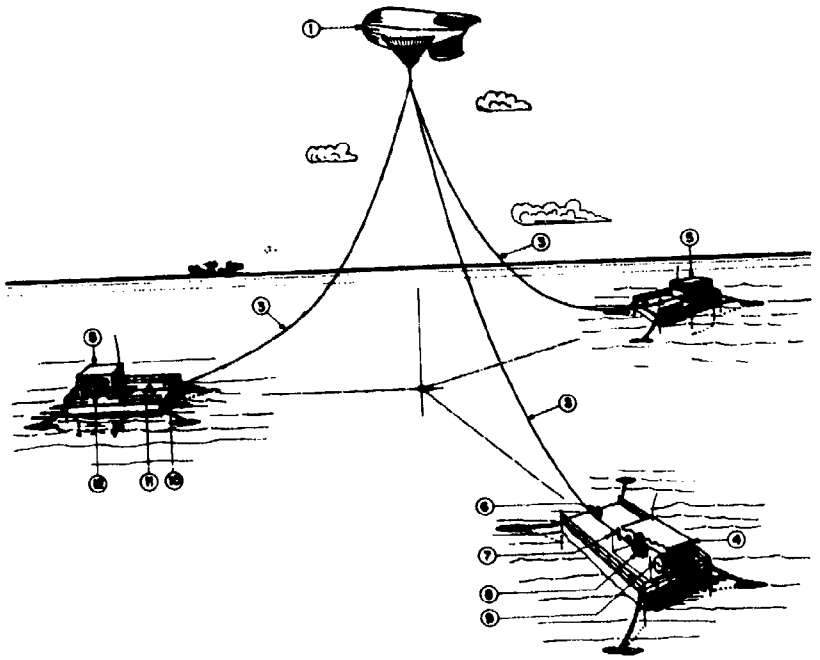


Figure 8 (U) Balloon tethering system (U)

(S)
this French three cable tethering system taken from Proceedings, Sixth AFCRL Scientific Balloon Symposium (October, 1970)(Unclass).

4.1.1 (S) Event Fr 52 - 16 June 1974 (S)

(S) After a false alarm (or possible French rehearsal) encompassing several hours of countdown and holds on 15 June, all systems were operational on 16 June. The countdown, held at 0700, recommenced at 0800, and the event occurred at 0830 local with an estimated yield of 4 kt. The relatively clear, though hazy, weather resulted in complete coverage of all phases of the event through H + 18 minutes.

(S) The slowly rising fireball quickly developed into a dark grey-brown cloud. Of particular significance in this event was the formation of a well-developed symmetrical torus at around H + 4 minutes (Figure 9). The initially thin brown stem developed a dense white cloud area, probably due to condensation related to prevailing humidity and weather conditions; the same phenomena also occurred during very late times at the top of the brown dissipated cloud. Excellent data coverage was obtained with all of the 19 camera systems operated for this event.

4.1.2 (S) Event Fr 53 - 7 July 1974 (S)

(S) Preparations began at 0500 for this 170kt event which finally occurred at 1415 local after several holds. High quality coverage of the luminous "skirt," condensation (Wilson) cloud, "measles" and sea-level phenomena was obtained. Low scattered cumulus clouds obscured the rising cloud between approximately 21 and 44 seconds after detonation. After the cloud reappeared, a white protuberance developed on the

Figure 9 (S) Event FR 52, H + 4 minutes, 50 seconds
Record No. 63131 (S)

(S)
right side at about one minute and gradually moved up to and around the periphery of the cloud top and upper sides. The stem and cloud took on a yellowish tinge at middle-late times then later whitened. Good coverage was also obtained of an ice cap formation at 2 minutes 15 seconds, followed by further expansion of the white debris cloud as it elongated and dissipated while drifting closer to the surface platform. By almost two hours, the cloud manifested itself as a thin, lengthened horseshoe shape. Data was collected until about two hours 18 minutes after zero time.

4.1.3 (S) Event Fr 56 - 14 August 1974 (S)

(S) After several days of shot expectation and some holds in the count on event day, a 110kt detonation occurred at 1530 local on 14 August. Scattered low cumulus clouds obscurred event observation briefly immediately after formation of a large, bright condensation cloud. As the debris cloud emerged from behind natural clouds, an unusually straight stem appeared, suggesting little wind force in that altitude region. Orange-colored areas in the nuclear cloud persisted throughout early development until around H + 36 seconds.

(S) A second ambient cloud layer obstructed data coverage beginning at about 1 minute 5 seconds for 45 seconds during which time only some wispy brown bottom fringe and the orange stem was visible. The cloud and stem retained some degree of orange tint throughout cloud expansion. Data was collected for approximately one hour and 40 minutes.

4.1.4 (S) Event Fr 57 - 24 August 1974 (S)

(S) Fr 57 was detonated at the North site in the Mururoa Atoll at 1445 local on 24 August after some intermittent delay. Very heavy,

(S)
low cumulus cloud cover obscurred all but the first 25 seconds of this relatively small 14kt event. Data was acquired of the moderately sized Wilson cloud and detailed luminous guy wires. Before disappearing behind natural clouds, the nuclear cloud had become dark grey. However, a "secondary detonation" was observed to the side of Fr 57, occurring at about H + 10 seconds. This anomolous feature appeared as a small surface cloud of initially reddish coloration, and was distinctly observed through the infrared video system. This surface cloud expanded into a grey-white cloud and persisted for several minutes after Fr 57 had disappeared behind the heavy cloud layer. All camera systems remained in operation for 30 minutes after zero but no further sign of the Fr 57 cloud was witnessed.

4.1.5 (S) Event Fr 58 - 14 September 1974 (S)

(S) The largest event of the summer occurred after several days of anticipation on 14 September at 1430 local, after an earlier aborted attempt. The generally partially cloudy weather was complemented by a dense, hazy, low altitude cloud bank in the direction of the target. Early data collection of this 350kt event was achieved, however, with accurate pointing, as evidenced by an early time photograph of Fr 58 in Figure 10. This figure demonstrates the measled effect characteristics of most of the five events observed.

(S) Immediately after the formation of a very large condensation cloud, the fireball rapidly rose behind the low, dense cloud layer. After the cloud top reappeared at H + 42 seconds, several pink areas appeared on the cloud and along the extremely straight stem. A small ice cap formed around H + 1 minute 50 seconds, and about 30 seconds later, a larger, layered cap appeared above the characteristically white

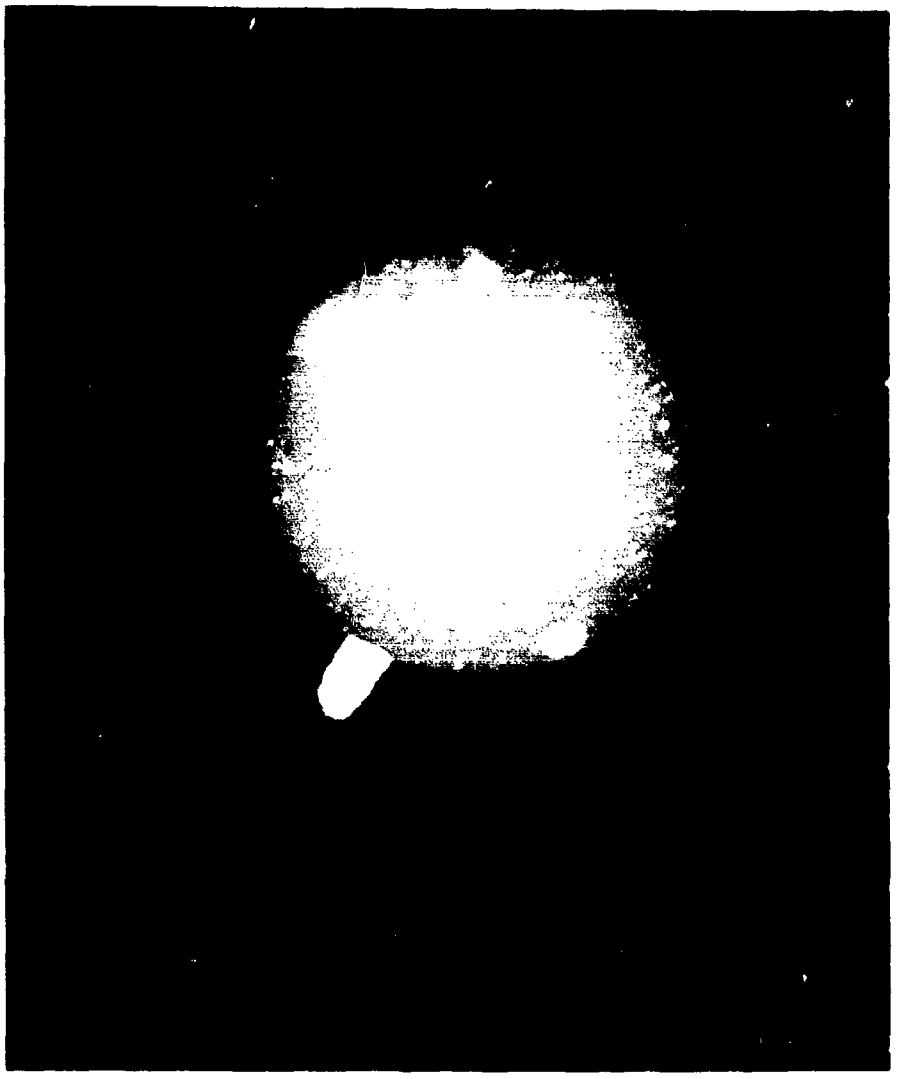


Figure 10 (S) Event FR 58, H + 50.0 msec.,
Record No. 63506 (S)

(S)
debris cloud. This expanding white debris cloud drifted slightly before dissipating at about H+ two hours.

4.2 (S) Initial Geometric Measurements (U)

(S) Analysis of records processed on board the USNS Huntsville yielded useful 24-hour data. Some specific balloon/device dimensions have been measured from records taken through a high resolution, 2100mm Celestron lens usually within hours prior to detonation, and appear in Table IV. Balloon diameters were found to be 22 to 23 meters while the packages were discovered to be suspended between 30 and 44 meters below the balloon. Figure 11 shows one balloon and suspended package configuration taken 11 July 1974, six days before an unobserved event, and is an example of the typical photographs obtained with the aforementioned long focal length system.

(U) Table V shows preliminary height of burst values and correction figures due to earth's curvature and refraction. As will be noticed, these heights differ somewhat from the device package heights presented in Table IV. A possible factor in this discrepancy is that the balloon parameter measurements were taken from data recorded hours before zero time, whereas the preliminary height of burst figures were image measurements taken directly from event records within seconds of H = 0. Other factors which may contribute to this discrepancy might include the sensitivity in determining the focal length of such a high resolution lens as the 2100 Celestron, or possibly the change in height of eye due to sea state.

(U) It should be noted that the height of burst measurements listed in Table V are subject to a total error of $\pm$ 15%. This error margin

TABLE IV (S)

PRE-EVENT DICE GAME BALLOON MEASUREMENTS

(PRELIMINARY) (U)

Event	Range (nmi)	Bottom Height (m)	Diameter (m)	Length (Projection) (m)	Bottom to Package (m)	Package Height (m)	Package Dimension (m)
52	22.4	-	-	Not available	-	-	-
53	22.8	329	22	44	44	285	-
54*	(12.7)	(300)	22	(60)	30	(270)	(2.2 X 1.9)
55	-	-	-	Not available	-	-	-
56	23.4	346	23	33	30	315	3 X 4
57	19.8	306	23	57	34	272	2.5 X 4.5
58	20.7	477	23	36	31	445	-

*Photographed several days before event (on 11 July)

Figure 11 (S) Suspension balloon and device - 11 July 1974 (S)

TABLE V (S)

DICE GAME INITIAL GEOMETRIC MEASUREMENTS

(PRELIMINARY) (U)

Event	Range (nmi)	Uncorrected Hob (m)	Curvature Correction (m)	Refractive Correction (m)	Corrected Hob (m)
52	22.4	160	+57	-21	196
53	22.8	238	+60	-22	276
56	23.4	237	+64	-21	280
57	19.8	227	+39	-15	251
58	20.7	390	+45	-21	414

Errors in these numbers are plus or minus 15 percent.

results from factors such as the changing height of cameras on board a rolling ship, non-standard atmospheric conditions and limits on the accuracy with which an image size on film may be measured. In addition, it should be emphasized that these measurements are preliminary, and more accurate, complete geometric measurements and event dimensions as a function of time will be available at a later time as a result of more definitive measurements.

5.0 (S) DISCUSSION (U)

(S) All the TIC objectives were attained in the collection of data during Operation Dice Game. Operational success of the photographic systems was 100% for all but one event observed by the USNS Huntsville (95% for Fr 53). Coverage extended beyond that anticipated in all cases; particularly noteworthy are data collection durations of 2.3 hours for Fr 53 and over 1.5 hours for Fr 56. However, in all cases, camera magazines were loaded as to event yield expectation, and spare loaded magazines were available and efficiently utilized with no break in data acquisition at such times when cloud persistence warranted extended data collection.

(U) Immediate post-event review of video tapes, as well as later study of all processed film records, has given evidence of great success in operation of the newly designed, gravity-stabilized mount. Mount pointing accuracy was exceptional -- a result of careful operator control in elevation and smoothly powered control of azimuth changes. The physical lay-out of the mount, operator position, and power control panel units proved efficient, especially during the rapid but careful activity needed in managing data collection at critical early event times.

(U) Documentary coverage of pre-event parameters, RVP launches and recoveries, and related operational activities was decidedly thorough and successful. The processing of certain film records on board, and the inclusion of video tape recording capabilities, proved to be assets in providing quick-look analysis and insights into minor exposure adjustments for upcoming events. In general, photographic data collection was extremely successful in all aspects and has yielded many valuable records for future analysis.

APPENDIX A

DATA RECORD SUMMARIES (U)

(U) Appendix A contains a review and comment for each useful data record obtained during Operation Dice Game. These record commentaries have been separated by event and are arranged in the same order as the cameras appear in the relevant instrument plan (Tables I-A and B). The final two digits of the record number correspond to the position numbers of cameras on the intrument plan and may be used to identify the camera employed for a particular record. Within the summary comments, "duration" indicates the maximum time after zero time that data was recorded. "Frame interval" indicates the time elapsed between successive frames, not exposure times and is only listed for cameras whose frame intervals changed during an event. In addition, the focal length of the lens used in exposing each record is listed after the film type, as some lens changes were made from time to time. The film types, their abbreviations, and nominal ASA numbers, used during the Dice Game program are listed below.

Code	Description	Type No.	Nominal ASA/AFS
ACN	Aerocolor Negative	2445	230-320/100
AIR	Aerochrome Infrared	2443	100/40(W12)
EMS	Ektachrome Medium Speed	5256	64
HDA	High Definition Aerial	3414	16/8
IRA	Infrared Aerographic	2424	80/160
AMS	Aerochrome MS	2448	64/32
PXN	Plus-X Negative - 16mm	7231	80

Code	Description	Type No.	Nominal ASA/AFS
PXN	Plus-X Negative - 35mm	5231	80
PXP	Plus-X Pan	5062	125
XR	Extended Range		(200)
XRC	Extended Range Color		Wide Latitude
XRM	Extended Range Modified	SO-167	Wide Latitude

Table A-1 (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 16 June 1974 STATION: USNS Huntsville

EVENT: 52 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63101	Plus-X Negative	305mm	Very good, well-exposed coverage of 1st maximum, minimum and 2nd maximum; balloon, "measles" and guy wires interface easily seen; duration - approx. 0.5 sec. (2900 frames) although image fading.
63102	Ektachrome MS	102mm	Good coverage of first 1.5 sec. of fireball, very small image, slightly overexposed during 2nd maximum, after shows internal structure, luminous support cables.
63104	Plus-X Negative	305mm	Excellent exposure and focus for H + 0 to 0.5 sec., duration - approx. 0.66 sec. (66 frames).
63105	Extended Range Modified	509mm	Well-focused, detailed coverage of early fireball development and Wilson cloud formation except first few frames slightly overexposed. Gradually fading, duration - approx. 28.5 sec. (2800 frames).
63106	Plus-X Pan	800mm	Excellent early time exposures with zero frame showing initial assymetries. Duration - approx. 0.66 sec. (25 frames).
63107	Extended Range Modified	800mm	Excellent, well-exposed and focused record showing details of early fireball internal development, Wilson cloud, luminous guy wires. Duration - approx. 6 sec., gradually fading at end of coverage.
63108	High Definition Aerial	305mm	12 frames of initially slightly dense, useable data of early fireball morphology, duration - approx. 2 sec.
63109	Aerochrome MS	508mm	Good early time coverage of luminous source, duration - approx. 3.33 sec.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 16 June 1974 STATION: USNS Huntsville

EVENT: 52 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63110	Extended Range Color	500mm	Approx. 4.2 sec. (6 frames) of useable early fireball and Wilson cloud morphology.
63111	Aerocolor Negative	500mm	Four frames (4.46 sec.) of well-exposed early time data.
63112	Infrared Aerographic	500mm	Six frames of varying spectral data (approx. 6.7 sec.).
63131	Plus-X Pan	210mm	Good exposure of luminous source and fair contrast of non-luminous cloud, clock reference, useful for timing through end of large format camera. Duration - approx. 18 min. Frame intervals: 1.91 sec. (early times), 3.82, 7.65 (middle times), 15.3, 30.6, 61.2 (late times).
63132	Aerochrome MS	915mm	Very well-exposed record shows pre-zero balloon head-on, four luminous frames, excellent coverage of torus development and general cloud morphology through dispersion, duration - approx. 15 min. Timing is the same as 63131.
63133	Infrared Aerographic	508mm	Initially densely exposed record with five luminous frames gives well-exposed coverage of general cloud morphological development in large field of view (FOV), duration - approx. 18 min. Same timing as 63131.
63134	Aerochrome MS	154mm	Good exposure and coverage of all phases of cloud development; very large FOV renders small image but useful for tracking; duration - approx. 18 min. Timing same as 63131.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 7 July 1974 STATION: USNS Huntsville

EVENT: 53 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63201	Plus-X Negative	305mm	Excellent first frame shows assymetry and internal luminous pin-point. Heavily exposed, but useful at 1st maximum; excellent exposure at minimum but continues to be heavily exposed at 2nd maximum and thereafter through end of 400' film roll, duration - approx. 2.2 sec.
63202	Ektachrome MS	102mm	Very good exposure of luminous phase, fades out thereafter at approx. 3.8 sec.
63204	Plus-X Negative	305mm	Excellent focus and aiming, slightly overexposed for 1st and 2nd maximum but well-exposed for minimum and remainder of coverage after 2nd maximum duration - approx. 16 sec.
63205	Extended Range Modified	509mm	Very good record shows well-defined minimum although 1st and 2nd maximum slightly dense, good detail throughout most of record, duration - approx. 25 sec. although horizon out of FOV well before then.
63207	Extended Range Modified	800mm	Very good, well-exposed and aimed record (although somewhat dense during 2nd maximum), excellent frame at minimum, good coverage of early fireball morphology through massive condensation cloud development and luminous fading out beyond 20 sec.
63208	High Definition Aerial	305mm	Initially overexposed record lacks definition of very early phenomenology but displays very good detail later as luminosity decreases. Duration-approx. 13 sec.
63209	Aerochrome MS	508mm	Initially overexposed record gives good coverage of luminous source, some of the condensation cloud and bright areas on early cloud, duration - approx. 13 sec.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 7 July 1974 STATION: USNS Huntsville

EVENT: 53 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63210	Extended Range Color	500mm	Overexposed for first few frames, thereafter fairly good documentation of early fireball and condensation cloud development, duration - approx. 10 sec.
63211	Aerocolor Negative	500mm	After first 3 dense frames, very good record of luminous phase through and beyond condensation cloud formation, duration - approx. 24.5 sec.
63212	Infrared Aerographic	500mm	Two frames of densely exposed spectral data. Duration - approx. 2.2 sec.
63231	Plus-X Pan	210mm	After first two overexposed frames, fairly well-exposed coverage of early fireball and cloud development until top of cloud leaves FOV at approx. 1.25 min. and entire cloud and stem drifts up out of view at about 15 min., useful for timing large format records. Frame intervals: 1.91 sec. (early times) 3.82, 7.65 (middle times), 15.3, 30.6 (late times).
63232	Aerochrome MS	915mm	Good pre-zero coverage. Thirteen frames of luminous phase (first 3 over-exposed), thereafter this large image, high resolution record gives very good coverage of early cloud development up through approx. 1 min. 15 sec. when top of cloud begins to leave FOV and remainder of record out to about 14 min. gives close-up view of lower stem morphology. Same timing as 63231.
63233	Infrared Aerographic	508mm	Initially overexposed frames during luminous phase, but rest of record is fairly well-exposed documentation of cloud morphology up to about 2 min. when top of cloud leaves FOV, thereafter coverage of lower stem, duration - approx. 14 min. Same timing at 63231.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 7 July 1974 STATION: USNS Huntsville

EVENT: 53 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63234	Aerochrome MS	154mm	Thirteen luminous frames, slightly overexposed initially, thereafter excellent coverage with good exposure showing large condensation cloud, ice cap (2 min. 15 sec.); and late-time morphology. Duration - approx. 14.5 min. before cloud drifts out of FOV. Timing same as 63231.
63235/1	Aerochrome MS	153mm	Seven heavily filtered luminous frames, very good after filter removed at approx. 6 min. showing late-time morphology. Duration - approx. 30 min. Antenna obstructs viewing somewhat at late times. Timing same as 63231.
63235/2	Aerochrome MS	153mm	Very late-time coverage commences immediately after 63235/1 with fair amount of antenna obstruction out to approx. 2.25 hrs. Timing same as 63231.
63236	High Definition Aerial	250mm	Fourteen frames of useable well-focused data (although first frame over-exposed), duration - approx. 12.33 sec.
63239	Plus-X Pan	150mm	Well-exposed record, though small image, of early-time development, duration - approx. 4 sec.

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 August 1974 STATION: USNS Huntsville

EVENT: 56 LOCATION: OPAREA PROJ. ENGINEER: Romnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63301	Plus-X Negative	305mm	Excellent first frame, slightly overexposed at 1st and 2nd maximums, very good coverage of minimum, "measles" and later internal fireball details and skirt phenomena, duration - approx. 2.4 sec.
63302	Ektachrome MS	75mm	Excellent cine coverage of early fireball development showing 1st maximum, minimum and 2nd maximum with good internal detail, small image, duration - approx. 3 sec.
63303	Extended Range	500mm	Pointing too high initially until just after 2nd maximum when developing fireball rises into FOV, focus good throughout but early cloud gradually drifts to the left of the FOV resulting in partial coverage until brightness decreases and image fades from view, duration - approx. 3 sec.
63304	Plus-X Negative	305mm	Excellent focus and pointing, overexposed for first frame and 2nd maximum, excellent for minimum and "measled" effect, and for later skirt and extensive Wilson cloud development, image gradually fades after Wilson cloud has completely engulfed fireball, duration - approx. 6 sec.
63305	Extended Range Modified	509mm	Very good record of early fireball development up through Wilson cloud engulfment, particularly good internal detail of minimum ("measles") and after 2nd maximum (skirt) although slightly overexposed for zero and 2nd maximum, Wilson cloud drifts out of FOV, but early cloud seen coming out from behind the waning Wilson cloud later although no horizon, duration - approx. 16 sec. when cloud disappears behind natural cloud layer.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game
EVENT: 56
DATE: 14 August 1974
LOCATION: OPAREA
STATION: USNS Huntsville
PROJ. ENGINEER: Romnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63306	Plus-X Pan	600mm	Excellent minimum time exposure in first frame (no zero time covered), after some densely exposed 2nd maximum frames, remainder of record presents excellent, well-exposed coverage of all phases of early-time phenomenology up to Wilson cloud obscuration, duration - approx. 4.5 sec.
63307	Extended Range Modified	800mm	Extremely good, well-exposed record (except during 2nd maximum) with excellent documentation of 1st maximum, minimum, skirt phenomena, all phases of early cloud development up to obscuration by Wilson cloud although cloud reappears after Wilson cloud wanes, duration - approx. 10 sec.
63308	Plus-X Pan	305mm	About 23 useable frames of early-time data, duration - approx. 4.2 sec. slightly overexposed initially.
63309	Aerochrome MS	305mm	Similar to 63308, except in color.
63310	Extended Range Color	500mm	Only 3 overexposed early-time frames.
63311	Aerocolor Negative	500mm	Fairly well-exposed (except first frame) early-time data, well focused, duration - approx. 11 sec. (10 frames).
63312	Infrared Aerographic	500mm	Varying spectral data, duration - approx. 22 sec. (20 frames).
63313	Aerocolor	250mm	Though started late, after Wilson cloud obstruction, very well-exposed data of rising cloud up through 21 natural cloud layers, duration - approx. 2 min.

12/70

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 August 1974 STATION: USNS Huntsville

EVENT: 56 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63331	Plus-X Pan	210mm	Although initially overexposed, this timed record provides fairly well-exposed coverage of all phases of development until cloud begins to totally drift out of FOV at approx. 3 min., thereafter intermittently brought back into FOV until 10.75 min. Frame intervals: 1.91 (early times), 3.82, 7.65 (middle times), 15.3, 30.6, 61.2 (late times).
63332	Aerochrome MS	915mm	Seven heavily filtered luminous frames (first overexposed), followed by three more unfiltered frames of luminous phase, thereafter excellent coverage with large image until top disappears behind natural clouds, duration - approx. 10.75 min. Timing same as 63331.
63333	Infrared Aerographic	610mm	Initially overexposed frames during luminous phase but remaining record gives good coverage of general cloud development until top of cloud moves out of FOV after reappearing above 2nd cloud layer. Timing same as 63331.
63334	Aerochrome MS	154mm	Ten luminous frames, first 3 overexposed but rest of record shows general fireball and cloud development with good exposure, in FOV throughout; large FOV provides good coverage of ice cap formation and late-time expansion; duration - approx. 38.5 min. Same timing as 63331.
63335/1	Aerochrome MS	153mm	Seven heavily filtered luminous frames of small image, large FOV, then nothing until filter removed at approx. 37.5 min., thereafter very good coverage of late-time morphology and stabilization, duration - approx. 53 min. Timing same as 63331.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 August 1974 STATION: USNS Huntsville

EVENT: 56 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63335/2	Aerochrome MS	153mm	Good data coverage of very late-time stabilized cloud from about H + 53 min. through to H + 1 hr. 38 min. with some antenna obstruction. Timing same as 63331.
63336	Extended Range Modified	250mm	Well-exposed record showing cloud morphology from zero to approx. H + 35 sec. running at 1.13 fps.
63339	Plus-X Pan	150mm	Seventeen useful frames of data (out to almost 3 sec.), first few frames overexposed, but remaining are good, although small image.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 24 August 1974 STATION: USNS Huntsville

EVENT: 57 LOCATION: OPAREA PROJ. ENGINEER: Bonnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63401	Plus-X Negative	305mm	Very well-exposed and focused record of early time development with particularly good coverage of minimum, "measles" and the intact balloon in the first frame, 2nd maximum slightly overexposed for deciphering internal detail but even luminous vaporized support cables show up well, duration - approx. 1.8 sec.
63402	Ektachrome MS	100mm	Good cine coverage of early development showing 1st and 2nd maximum and minimum, duration - approx. 2 sec. before fireball fades.
63403	Extended Range	500mm	Initially overexposed for 1st and 2nd maximum and apparently started too late for good separation of early time phenomena, although minimum is covered, leaves FOV for short period, thereafter fairly well-exposed coverage out to about 10.5 sec. although image becomes too big for FOV.
63404	Plus-X Negative	305mm	Well-exposed and focused cine record of early time fireball and cloud development, duration - approx. 2.5 sec. (250 frames).
63405	Extended Range Modified	509mm	Very good detailed coverage of early time development past formation of condensation cloud to 2.5 sec. although horizon is out of FOV after 3 sec.
63406	Plus-X Pan	600mm	Initially overexposed record which later yields well-focused and exposed coverage of early cloud phenomenology, duration - approx. 2.6 sec.
63407	Extended Range Modified	800mm	Very good, well-focused coverage presenting good detail of early development, duration - approx. 7.5 sec.

12/70

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 24 August 1974 STATION: USNS Hentsville

EVENT: 57 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63408	Plus-X Pan	305mm	Initially overexposed, well-focused, large FOV, duration - approx. 6 sec.
63409	Ektachrome MS	508mm	Overexposed for approx. first 2 sec., then fair coverage of luminous phase, duration - approx. 7 sec.
63410	Plus-X Pan	500mm	First 2 frames overexposed, after that well-exposed and focused record of event until obscuration by natural clouds at approx. 25 sec.
63411	Aerocolor Negative	500mm	Three frames useable data, first frame slightly overexposed; duration - approx. 3 sec.
63412	Aerochrome Infrared	500mm	Three frames of spectrographic data.
63413	Aerocolor Negative	250mm	Very good coverage up through natural cloud obscuration at approx. 25 sec.
63431	Plus-X Pan	219mm	Fairly well-exposed record of luminous fireball and cloud in large FOV out to approx. 25 sec. after which event is obscured by natural clouds. Clock reference. Frame interval: 1.91 sec.
63432	Aerochrome MS	915mm	Very good, well-exposed coverage (first 2 frames heavily filtered), large image of event cloud. Timing and duration of event coverage same as 63431.
63433	Infrared Aerographic	610mm	Overexposed for approx. first 10 sec. of event, thereafter fairly good data up to natural cloud obscuration. Timing and duration same as 63431.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 24 August 1974 STATION: USNS Huntsville

EVENT: 57 LOCATION: OPARSA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63434	Aerochrome MS	154mm	After overexposed first frame, well-exposed, very large FOV record. Timing and duration same as 63431.
63436	Extended Range Modified	250mm	Fairly well-exposed record filtered with W 12 filter. Duration - approx. 25 sec.
63439	Plus-X Pan	150mm	Initially overexposed, very small image. Duration - approx. 2 sec.

SECRET

52

SECRET

12/70

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 September 1974 STATION: USNS Huntsville

EVENT: 58 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63501	Plus-X Negative	305mm	Good cine coverage of very early fireball phenomenology, slightly over-exposed at 1st maximum, fades away during minimum; as time increases part of fireball goes out of FOV. Duration - approx. 1.3 sec. (7200 frames).
63502	Ektachrome MS	50mm	Overexposed cine record through 2nd maximum, but good coverage thereafter of condensation cloud and bottom stem formation, coverage of fireball between natural cloud layers to approx. 22 sec.
63503	Ektachrome MS	150mm	Very good cine data of early development, although overexposed during 2nd maximum but thereafter good exposure until after fireball disappears behind first cloud layer; shows "measles" and "skirt" features; Duration - approx. 6 sec.
63504	Plus-X Negative	305mm	Excellent, well-focused record featuring good detail of early fireball and cloud developmental phases, although overexposed during 2nd maximum. Duration - approx. 6 sec.
63505	Extended Range Modified	509mm	Initially good record showing "measles" and illuminated guy wires, over-exposed during 2nd maximum, thereafter horizon goes out of FOV but good coverage of event cloud until obscuration by natural cloud layer. Duration - approx. 4.2 sec.
63506	Plus-X Pan	600mm	Very good, well-focused record, although overexposed during 2nd maximum, shows excellent details of "measles" and "skirt" along with "ground" phenomena. Duration - approx. 6.6 sec.

12/70

SECRET

SECRET

Table A-1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 September 1974 STATION: USNS Huntsville

EVENT: 58 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63507	Extended Range Modified	800mm	Very good early frames of 1st maximum and minimum ("measles"), slightly overexposed during 2nd maximum, good coverage continues of "skirt", condensation cloud and fireball entrainment. Duration - approx. 7 sec. (to obscuration by natural cloud layer).
63508	Plus-X Pan	305mm	Initially overexposed then develops into fairly good coverage of condensation cloud growth up through fireball's rise into natural clouds. Duration - approx. 10 sec.
63509	Ektachrome MS	508mm	Excellent first frame shows "measles" close to minimum, overexposed during 2nd maximum, then good coverage through to fireball visibility through slit in natural cloud layer, although underexposed by then. Duration - approx. 18 sec.
63510	Plus-X Pan	500mm	All early coverage is overexposed before natural cloud obscuration, a few fairly good frames of "ground" phenomena after that. Duration - approx. 1 min.
63511	Aerocolor Negative	500mm	Initially overexposed, better after cloud is behind natural cloud layer then gradually fades. Duration - approx. 22 sec.
63512	Infrared Aerographic	500mm	Eight frames of spectrographic data (approx. 10 sec.).
63513	Extended Range Modified	250mm	Fairly well-exposed coverage of fireball rise and condensation cloud formation until just after cloud rise from behind ambient cloud layer. Duration - approx. 54 sec.

12/70

SECRET

SECRET

Table A - 1 (cont.) (S)

TECHNOLOGY INTERNATIONAL CORPORATION

DATA RECORD SUMMARY (U)

OPERATION: Dice Game DATE: 14 September 1974 STATION: USNS Huntsville

EVENT: 58 LOCATION: OPAREA PROJ. ENGINEER: Ronnholm/Goodwin

RECORD NO.	FILM TYPE		RECORD SUMMARY
63531/A	Plus-X Pan	210mm	First few frames overexposed, natural cloud layer obscures data at H + 25 sec. for approx. 15 sec., thereafter fair coverage of developing cloud until 1 min. 50 sec. Clocked record. Frame intervals: 1.91 sec. (early times), 3.82 (middle times).
63531/B	Plus-X Pan	210mm	Data coverage resumes at H + 5 min; however only lower stem is in FOV until H +17 min. Record continues however to provide timing reference with clock for records 63532, 63533, 63534 and 63535. Frame intervals: 7.65 sec. (middle times), 15.3, 30.6, 61.2 (late times).

12/70

SECRET

SECRET

DISTRIBUTION LIST

This document is being sent to the below listed contractors for the use of the individuals listed. Recipient contractors are requested to validate individuals' clearances before forwarding document to same.

DEPARTMENT OF DEFENSE

Defense Documentation Center
2 cy ATTN: TC

Director
Defense Nuclear Agency
ATTN: STSI, Archives
ATTN: DDST
ATTN: RAAE
2 cy ATTN: STTL, Technical Library

Director of Defense Research & Engineering
ATTN: OAD/EPS, Lieutenant Colonel W. A. Whitaker

Commander
Field Command
Defense Nuclear Agency
ATTN: FCPR

Interservice Nuclear Weapons School
ATTN: Document Control

Chief
Livermore Division, Field Command, DNA
Lawrence Livermore Laboratory
ATTN: FCPRL

OJCS/J-3
The Pentagon
ATTN: J-3, Ops. Anal. Br., Colonel Underhill

Weapons Systems Evaluation Group
ATTN: Document Control

DEPARTMENT OF THE ARMY

Manager
Ballistic Missile Defense Program Office
ATTN: John Shea
ATTN: DACS-BMS, Julian Davidson

Commander
Harry Diamond Laboratories
ATTN: AMXDO-NP

Director
U.S. Army Ballistic Research Laboratories
ATTN: AMXBR-CA, Franklin E. Niles

Commander
U.S. Army Nuclear Agency
ATTN: USANUA-W, J. Berberet

DEPARTMENT OF THE NAVY

Director
Naval Research Laboratory
ATTN: Code 7701, Jack D. Brown
ATTN: Code 7750, Timothy P. Coffey

DEPARTMENT OF THE NAVY (Continued)

Commander
Naval Surface Weapons Center
ATTN: Code 1224, Navy Nuc. Prgms. Off.

DEPARTMENT OF THE AIR FORCE

AF Cambridge Research Laboratories, AFSC
ATTN: OPR, Maj J. Reed

AF Weapons Laboratory, AFSC
ATTN: SUL
ATTN: DYT, Capt Daniel A. Matuska

AFTAC
ATTN: TF, Capt Wiley

HQ USAF/RD
ATTN: RDQ

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION

Los Alamos Scientific Laboratory
ATTN: Document Control for Eric Jones
ATTN: Document Control for Herman Hoerlin

DEPARTMENT OF DEFENSE CONTRACTORS

Aerospace Corporation
ATTN: V. Josephson

Calspan Corporation
ATTN: Romeo A. Deliberis

General Electric Company
TEMPO-Center for Advanced Studies
ATTN: Tim Stephens
ATTN: DASIAC
ATTN: Ed Martin

HSS, Inc.
ATTN: Donald Hansen

Information Science, Inc.
ATTN: Walter F. Dudziak

Institute for Defense Analyses
ATTN: Ernest Bauer

Mission Research Corporation
ATTN: Dave Sowle
ATTN: P. Fischer

Photometrics, Inc.
ATTN: Irving L. Kofsky

R & D Associates
ATTN: Richard Latter
ATTN: Forest Gilmore
ATTN: Robert E. Lelevier

PRECEDING PAGE BLANK-NOT FILMED

This document is being sent to the below listed contractors for the use of the individuals listed. Recipient contractors are requested to validate individuals' clearances before forwarding document to same.

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

The Rand Corporation
ATTN: Cullen Crain

Science Applications, Inc.
ATTN: William M. Layson

Science Applications, Inc.
ATTN: D. Sachs

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Stanford Research Institute
ATTN: Walter G. Chestnut

Technology International Corporation
ATTN: W. P. Boquist
ATTN: Keith B. Ronnholm
ATTN: Patricia L. Crowley

Defense Threat Reduction Agency
8725 John J Kingman Road MS 6201
Ft Belvoir, VA 22060-6201

TDANP/TRC

January 14, 2002

MEMORANDUM TO DEFENSE TECHNICAL INFORMATION CENTER
ATTN: OCQ-MR LARRY DOWNING

SUBJECT: DOCUMENT REVIEW OF SPECIAL MARKED DOCUMENTS

Enclosed is the Authority Letter removing the special notation on each document. Please have the documents listed, displayed and available for the Defense Community.

If you have any questions, please call me at 703-325-1034.

Ardith Jarrett

ARDITH JARRETT
Chief, Technical Resource Center

Defense Threat Reduction Agency
8725 John J Kingman Road MS 6201
Ft Belvoir, VA 22060-6201

TD

December 28, 2001

MEMORANDUM TO THE TECHNICAL RESOURCE CENTER
ATTN: MS ARDITH JARRETT

SUBJECT: NOTATION AVAILABILITY

I have reviewed the following documents and determined that the following notation is no longer applicability and can be removed. The notation reads: "NOT TO BE ANNOUNCED IN DDC TAB. This document is not to be announced, abstracted, or cited in any announcement media, secondary publication, or general bibliography listing."

The documents reviewed are:

AFGL-TR-78-0017, Modified Infrared Skymapper Data Summary. (AD-C953729)
SPC-224, Comparison of ABM and ATBM Requirements. (AD-C953311)
DASA-2581, Experimental Mass Removal and Cn of Various Heat Shield Materials. (AD-594895)
DNA-3714F, Data Analysis of High Resolution Photographic Records From DNA Operation Hula Hoop 1973. (AD-C950226)
DNA-2894P2, Proceedings of the underground Nuclear Test Measurement Symposium. (AD-596335)
DNA-3604T, Excitation Temperature Measurements of a Low Altitude Nuclear Explosion-Album B 13KT Yield. (AD-C950195)
DNA-3670F, High Resolution Optical Measurements for DNA Operation Dice Game, Field Report. (AD-C950196)
DASA-2719, TV Material Handbook. (AD-595618)
DASA-625-IS-14, DoD Nuclear Weapons Effects Tests Summary. (AD-594572)
DNA-3625F-1, Technology Assessment for Strategic Options, Volume 1. (AD-C950300)
DNA-3393F, Operation Hula Hoop Optical Measurements HSS Field Program. (AD-C950053)
DNA-3625F-3, Technology Assessment for Strategic Options, Volume 3. (AD-C950302)
GE-TMP-69397, Refraction Panel Report. (AD-595538)
DNA-2894P1, Proceedings of the Underground Nuclear Test Measurements Symposium I. (AD-596403)
DASA-625-IS-13, DoD Nuclear Weapons Effects Tests Summary. (AD-399775)

DON LINGER
Deputy for Technology Programs

DEFENSE THREAT REDUCTION AGENCY
Defense Threat Reduction Information Analysis Center (DTRIAC)
1680 TEXAS STREET SE
KIRTLAND AFB, NM 87117-5669

OP-CSUI (505) 853-0644

11 March 2009

To: DTIC-OQ

Subject: Distribution Review

DTRA has reviewed the following unclassified documents and assigned Distribution Statement C, Admin and Operational Use:

AD-C950036
Optical Measurements for Operation Hula Hoop (U)
26 November 1974. DNA 3395F

AD-C950035
Operation Dial Flower Analysis of High Resolution Optical Data (U)
26 November 1974. DNA 3396F.

The following two documents have been assigned Distribution Statement C, Critical Technology with ITAR Caveat:

AD-C950196
High Resolution Optical Measurements for DNA Operation Dice Game – Field Report (U).
16 July 1975. DNA 3670F

AD-C950226
Data Analysis of High Resolution Photographic Records from DNA Operationa Hula Hoop – 1973 (U)
May 1975. DNA 3714F

Steven Bradford
Program Manager,
Defense Threat Reduction Information Analysis Center (DTRIAC)

DEFENSE THREAT REDUCTION AGENCY
Defense Threat Reduction Information Analysis Center (DTRIAC)
1680 TEXAS STREET SE
KIRTLAND AFB, NM 87117-5669

OP-CSUI (505) 853-0644

12 May 2009

To: DTIC-OQ

Subject: Distribution Review

DTRA has reviewed the following declassified documents and assigned Distribution Statement A, per FOIA Review, 28 April 2009:

ADC950035
Operation Dial Flower Analysis of High Resolution Optical Data (U)
26 November 1974. DNA 3396F

ADC950036
Optical Measurements for Operational Hula Hoop (U)
26 November 1974. DNA 3395F

ADC950196
High Resolution Optical Measurements for DNA Operation
Dice Game – Field Report (U)
16 July 1975. DNA 3670F

ADC950226
Data Analysis of High Resolution Photographic Records from DNA
Operation Hula Hoop-1973 (U)
May 1975. DNA 3714F

for Linda M Dassim
Steven Bradford
Program Manager,
Defense Threat Reduction Information
Analysis Center (DTRIAC)