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TECHNICAL REPORT

EG&G INC.

UNCLASSIFIED

EGG-1183-400

#30

12 October 1967

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DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW

1ST REVIEW DATE: 9/25/96	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: DADC	1. CLASSIFICATION RETAINED
NAME: [illegible]	2. CLASSIFICATION CHANGED TO:
2ND REVIEW DATE: 01/17/97	3. CONTAINS NO DOE CLASSIFIED INFO
AUTHORITY: ADD	4. COORDINATE WITH:
NAME: Donald Wagler	5. CLASSIFICATION CANCELLED
	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY): TCG-BOT-1

10/6/98

EG&G PARTICIPATION OPERATION PADDLEWHEEL (U)

[redacted]

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[redacted]

UNCLASSIFIED

EASTERN SCIENCE & TECHNOLOGY

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Control No. C-G2598

TECHNICAL REPORT

EG&G INC.

UNCLASSIFIED

NUMBER B-3624
EGG-1183-400

12 October 1967

COPY 1

16 pages

EG&G PARTICIPATION
OPERATION PADDLEWHEEL

Submitted by Donald J. Barnes

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Deputy Commander
Joint Test Group 8. 1. 6

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The broad objectives of the EG&G participation on Paddlewheel were fourfold: (1) to determine readiness to resume nuclear testing on an air-drop program, (2) to test specific support capabilities in the forward area, (3) to maintain and improve operational and technical proficiency, and (4) to obtain such scientific and technical data as are required by the AEC, JTF-8, and the laboratories (LASL, LRL, and Sandia). In terms of these objectives, EG&G feels that Paddlewheel has been a valuable exercise and that the prescribed sixty-day readiness to conduct a nuclear air-drop program has been reaffirmed.

With relation to the specific objectives governing EG&G activities on Paddlewheel, more detailed qualifying comments are made herein. The specific objectives are enumerated as follows:

1. To provide operational support to all participants in the air-drop program. Such support was based at Hickam AFB and included (a) coordination and scheduling of ground and flight operations, (b) housekeeping services, (c) secretarial services, and (d) shipping and receiving of Paddlewheel-associated equipment.

2. To provide direct technical support, based at Johnston Atoll, to the LRL B-57C Program. Such support was concerned essentially with the maintenance and operation of the LAPQ-1 cloud-mapping radar systems installed on the sampling aircraft.

3. To provide direct technical support, based at Johnston Atoll, to LASL for the operation and maintenance of diagnostic equipment on RB-57F aircraft and of associated ground equipment.

4. To provide direct technical support, based at Barbers Point, Oahu, to Sandia for the assembly, installation, checkout, and maintenance of Test Vehicle equipment, including DME, HRT, telemetry,

and communications equipment.

5. To provide timing, communications, television, and command data display support on Johnston Atoll for the Paddlewheel drop missions.

6. To perform general support functions via EG&G instrumentation in the NC-135 diagnostic aircraft. Such support functions encompassed the areas of timing, control, and communications and were so directed as to meet the needs of JTF-8 and the AEC laboratories.

7. To provide, operate, and maintain close-in (Hickam AFB) and mountaintop (Mauna Loa) simulation facilities for NC-135 systems check. Such facilities included instrumentation for simulation of EM radiation, Teller-light, and fireball light.

8. To gather data on the pre-drop and drop missions. Such data included (a) that from which fireball yield could be calculated were the mission drops nuclear, (b) that from which in-flight yield numbers could be calculated on nuclear detonations, (c) that from which test vehicle height of burst can be calculated, (d) that from which an overall calibration and collimation of the EG&G photographic and photometric system can be effected, and (e) that from which EM and simulated Teller-light field strength and time-interval measurements could be calculated. In addition, EG&G permanently recorded critical event times (release, arm baro, and zero) and calculated test vehicle time-of-fall.

Data obtained by EG&G in fulfillment of its technical and scientific responsibilities are contained in the following mission reports and are, therefore, not included herein. These reports have been submitted to the Associate Scientific Deputy, JTF-8.

EGG 1183-396:	EG&G Systems Operation, Paddlewheel/ Phalanx

EGG 1183-397:	EG&G Systems Operation, Paddlewheel/ Plaudit
EGG 1183-398:	EG&G Systems Operation, Paddlewheel/ Dedo
EGG 1183-399:	EG&G Systems Operation, Paddlewheel/ Saco

Presented in the following sections are summary statements pertinent to (1) EG&G support and technical objectives enumerated above and (2) EG&G's Paddlewheel conclusions and recommendations.

EG&G is well satisfied with the performance of its technical support services on Paddlewheel. Basic objectives were fulfilled in areas of (1) operational support, including coordination and scheduling of ground and flight activities and (2) direct technical support rendered to the LASL and LRL B-57 programs and to the Sandia TV program. General comments on NC-135 communications and simulator operations follow.

Communications (interphone, interplane, and aircraft to ground) were generally satisfactory on Paddlewheel. Nominal transceiver and intercom problems were encountered on Phalanx and Plaudit, and on the Mountain-Top/Sunshine missions. For both Dedo and Saco, operation of the communications nets was excellent, difficulties encountered on previous flights with the FM-2 transceiver and the EG&G radio patch panel having been corrected.

Operation of both the close-in (Hickam) and mountaintop (Mauna Loa) simulator stations was satisfactory. During the first mountain-top flight (Pre-Plaudit system checkout and calibration), the 250-kV EM pulser failed and was replaced temporarily with the 50-kV pulser to maintain the system in an operational status. Approximately one-half hour after the malfunction, the 250-kV system was back in operation; however, the time interval between the Fidu and EM pulses was erratic. Post-mission investigation uncovered a faulty trigger unit, which was replaced prior to the second mountain-top mission (Pre-Saco system checkout and calibration). Operations were normal on the second mission. Coordination between the Mauna Loa station and the aircraft was satisfactory on both missions.

The timing and distribution systems on the three diagnostic aircraft operated as programmed on the Dedo and Saco drops, and all signals were transmitted to the users as required. On Plaudit the T&C systems functioned normally on Aircraft 370 and 371; however, timing difficulties were encountered on Aircraft 369. The Sandia release and arm baro signals were received and printed out; though the EG&G programmer was in the enable condition, it was not started by either signal. Post-flight checkout of the programmer did not reveal the cause of the apparent malfunction. On the next mission, Dedo, operation of this programmer was normal. On Phalanx, the programmers ran normally until the "Breakaway" signal was originated by the B-52; at this time they were reset to predicted release time, and further instructions from the Scientific Commanders were awaited. Since evasive maneuvers effectively canceled planned coverage of the drop, SciCom did not request restart of the programmers.

Prior to the Phalanx, Plaudit, and Dedo drops, EG&G established alternate modes of programmer operation in the event that the Sandia arm baro signal was not received at the expected time. On Dedo, the Aircraft 369 T&C system utilized the panic mode for programmer start. Other programmer start signals were generated by the normal Sandia arm baro. For Saco, the EG&G programmers were activated routinely at -600 seconds, stopped thirty five seconds before predicted release, and then manually restarted upon receipt of "Release" from the B-52. Camera start signals were programmed in accordance with the predicted time of fall since Sandia did not, by design, utilize its HRT to generate the normal arm baro and fiducial signals.

Details relative to the timing and distribution system and the critical event data recorded by EG&G are contained in the individual mission reports referenced in Section 1 herein.

The airborne bhangmeter systems were not triggered from the H. E. on either Plaudit or Saco or from the flares on Dedo. The bhangmeters were, however, operated successfully on dry runs preceding each mission, and on a nuclear air-drop program would have recorded light-time behavior for the purpose of in-flight yield determination.

The primary EG&G responsibility of obtaining "fireball" photography was successfully fulfilled on the Plaudit, Dedo, and Saco drops. Operation of the EG&G camera complements was outstanding. Of the 102 cameras programmed to record the H. E. detonation (ignition of flares on Dedo), only four malfunctioned. No loss of potential fireball data resulted from these malfunctions. EG&G concludes, without qualification, that good yield data would have been obtained had these drops been nuclear. Tracking accuracy and aircraft positioning showed a definite improvement over previous air-drop exercises. HRT tracking continues to be smoother than AIL and was generally chosen for use on the drops. Greater than normal excursions were encountered on the Dedo low-altitude drop orbit but did not cause any significant loss of data. Image-positioning information, contained in the individual mission reports, confirms tracking accuracy. EG&G now feels confident that relatively long focal-length lenses can be used to optimize data gathering on the simulated air drops.

Height-of-burst was calculated for the three successful drops utilizing (1) theodolite records from Plaudit and Saco and (2) high-speed Mitchell and Photo-Sonics 4B records from Dedo. The calculations on the latter event were based on images of the third flare and its reflection on the water, since this technique provides maximum optical accuracy for low-altitude bursts.

EG&G considers that both Sunshine missions were successful. The major analysis effort will not be made, however, until the 70-mm film and the color records have been processed at the Boston laboratory. The preponderance of color film exposure on the missions was consistent with present emphasis on radiometric data requirements for high-altitude testing and the consequent need for calibration information about the camera/lens systems which would be used to obtain such data.

Aircraft flight patterns were entirely adequate for the visual and photographic collimation effected on both the outbound and inbound legs of each mission. Considerable statistical tracking data were gathered on Aircraft 369 and 370 in an attempt to accurately evaluate the true tracking capabilities of the aircraft detector systems. At Los Alamos request, detailed analysis of the detector bench tracking was accomplished and graphical presentations of the data were submitted to LASL. A Multidata camera, mounted in a detector position, was operated during both HRT and AIL tracking to record, time-wise, the position of the target aircraft with reference to the camera optical axis.

Successful exercise of the EG&G time-interval measurement system in Aircraft 370 was effected on both the Plaudit and Saco drops. Since no simulation was included in either the Phalanx or Dedo packages, the system was run on these missions for only dry run and training purposes, with low-level EM and ambient light measurements being made in the drop area. Checkout and calibration of the system was accomplished on the two mountain-top missions. For Plaudit and Saco, complete EM, Teller light, and time-interval data were obtained. The five channel, twenty oscilloscope system functioned normally on Saco; though two EM channels were lost on Plaudit, complete data were recorded. EM and Teller-light field strengths were approximately as specified; these measurements and the time-interval information are included in reports EGG 1183-397 (Plaudit) and EGG 1183-399 (Saco).

Customary photo processing services were performed on Paddlewheel to support the EG&G time-interval measurements program and the photo instrumentation program. Processing of all black and white cut film and 35-mm records was accomplished by D + 1. This scheduling was initiated to affirm readiness on a nuclear air drop program. EG&G photo processing personnel also accomplished camera magazine loading and unloading to meet the requirements of the Paddlewheel schedule.

During the exercises, EG&G photographic processing facilities at Hickam were augmented by the addition of a portable roller transport processor (Recordak Prostar). This machine, built to accommodate up to 100 feet of both 16- and 35-mm film widths, was used (1) to process short sections of color film and 70-mm film (split to 35-mm width) for confirmation of satisfactory camera operation and (2) to process collimation and Navigation Data film during the post-mission period in which the Triese machine was required for priority work on the EM and "fireball" film data.

In addition, EG&G photo processing personnel undertook an extensive program to obtain further chemical analysis of its developers. This qualitative study of developer constituents and depletion rates was effected to determine replenisher solutions which would optimize developer life and thus refine EG&G's sensitometrically controlled processing techniques. Specific gravity, hydrogen-ion concentration, and total alkalinity tests were conducted to analyze the effects of film development on such processing constituents as Elon, hydroquinone, and potassium bromide. The on-site research work has provided valuable information on (1) replenishment rates, (2) developer behavior relative to the volume of film processed,

(3) developer stability versus time under various storage conditions, and (4) aerial oxidation effects.

From the standpoint of data gathered and equipment performance, Paddlewheel was a marked photo instrumentation success. Improvement in camera operation is attributed to modifications made during the last year to the camera control module. Refinement of this module has virtually eliminated camera jams. Improvements in the camera tracking system were realized by virtue of a newly designed magnetic amplifier, which has relieved the electrical interaction interference problem and provided the tracking system with increased acceleration, making it possible for the benches to follow the radar inputs more closely. In addition, recent servo system modifications, and particularly the new magnetic amplifiers, have appreciably reduced the current drain without adversely affecting the tracking system response.

During the first four Paddlewheel missions, HRT tracking on the aircraft was very good, but AIL tracking in elevation was only acceptable, the problems being caused by the inability of the camera bench to follow the jitter signals generated by the radar. After the fourth mission, further changes were made to the elevation magnetic amplifier in Aircraft 370 to increase the acceleration capabilities of the bench so that it could better follow the radar inputs. This change resulted in very good AIL tracking on Aircraft 370 during the fifth mission (Dedo). The same changes were then made in Aircraft 369 and 371 for Saco, but the tracking did not improve as much on these planes as it had on Aircraft 370, since the AIL jitter on Aircraft 369 and 371 was of a higher amplitude than that encountered on Aircraft 370.

During Paddlewheel, the EG&G Photo Instrumentation Group employed a new zero-time light detector (DT-67) designed to trigger on flares and H. E. and thus supply a real zero pulse as opposed to the existing programmed zero. Use of this detector makes possible a more realistic exercise of the photo system, since Dynafax and theodolite shutters can be triggered by "bomb light". Complete statistics on the success of the device are not yet available; however, it appears to have triggered each time the detonation occurred within its field of view. Present plans are to redesign the detector so that it can be mounted on the tracking bench and thus be assured of having the H. E. within its field of view at zero time.

On Paddlewheel, EG&G successfully exercised approximately 85% of its maintained air drop capabilities and can reaffirm that it would be ready to resume atmospheric testing within the prescribed sixty days. Comments and recommendations relating to the current operation are presented as follows:

(1) Continuation of Paddlewheel-type exercises is considered essential to EG&G's maintenance of a sixty-day response capability. EG&G feels that it does achieve the proper readiness level on these off-continent exercises; however, neither CONUS exercises nor scientific missions test the EG&G systems sufficiently to guarantee that a sixty-day readiness posture is being maintained. In the light of normal personnel turnover and decay of proficiency, EG&G thus recommends continuation, on a one-per-year basis, of off-continent Paddlewheel-type exercises.

(2) The Paddlewheel events posed a new challenge to the EG&G fireball recording system in that the time windows of potential detonation were relatively wide. The customary attempts to cover the window with fireball yield cameras (a policy adopted some years ago to guarantee data acquisition should a combination of parachute and arm baro telemetry system failures occur) led to the conclusion that the available combinations of camera start up times were too limited because of power surge problems. It was decided to refrain from using on any event combinations of camera start programs which had not been flight tested since such combinations might result in a loss of all camera coverage from an aircraft. EG&G is undertaking a study of the power surge problem caused by the camera start sequence and hopes to identify a number of additional camera start sequences for coverage of wide detonation-time windows.

(3) The Saco event, without FM/FM telemetry, proved that the manually operated signal system internal to the NC-135's is capable of completely adequate fireball diagnostic-data acquisition. The Saco operating mode, based only on audio countdown information and predicted time-of-fall data, provided good coverage of the H. E. detonation. It should, however, be noted that without the FM/FM signals, EG&G has lost a basic safeguard in the data acquisition signal system and that there is a consequent increase in the probability of failure in this system.

(4) On certain Paddlewheel events (those with potentially wide detonation windows) it would have been desirable to have had the Sandia arm baro (camera programmer start signal) come earlier than 5.2 seconds before zero. EG&G has approached Sandia and will pursue jointly the problem of establishing flexibility in the time of transmission of this signal.

(5) The Sunshine experiments continue to be excellent simulation checks of the fireball recording systems, and their continuation on future exercises is considered to be as essential as are the mountain-top flybys to checkout and calibration of the EM and optical recording systems.

(6) Age, obsolescence, and wear are becoming increasingly obvious in the airborne systems. Because of budget cutbacks in EG&G's off-continent readiness program, it has not been possible during the last few years to commit adequate funds to equipment maintenance and replacement. These cutbacks are now being sorely felt. Paddlewheel afforded the first opportunity in a year to test the systems under a strenuous, realistic schedule, and the trend of equipment decay was apparent.

EG&G is preparing a review of aircraft equipment and will present an estimate of costs to bring the system to a state of operational quality. The decision to implement system changes will, of course, be subject to Use Committee review and budget limitations and is certainly dependent on decisions relative to the future of the readiness program.

(7) The scheduling of Paddlewheel missions was most satisfactory to EG&G, and it is recommended that the three-day turn-around be continued and that the decision time for dual capability (either of two early morning events) be maintained at 1200 on D-1.

(8) To afford proper testing of EG&G's time-interval measurement system on Aircraft 370, it is recommended that full simulation be employed on as many as possible of the drop packages and on at least two drops per exercise.

(9) For optimum data analysis and photo instrumentation programming, the H. E. should be included in as many test vehicles as possible.

(10) The practice of employing WB-47 aircraft as cloud spotters on targetless array missions should be reviewed. Operation of two of these aircraft along the tracks of two of the NC-135's does not insure cloudless lines-of-sight to the burst point.

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