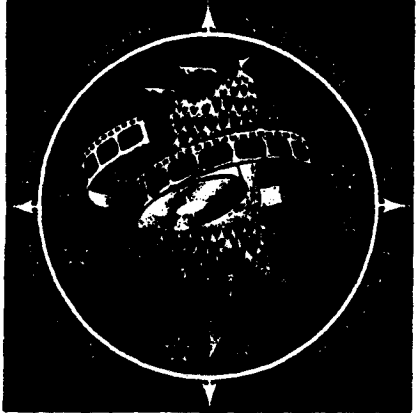


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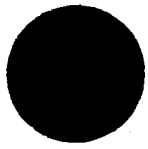
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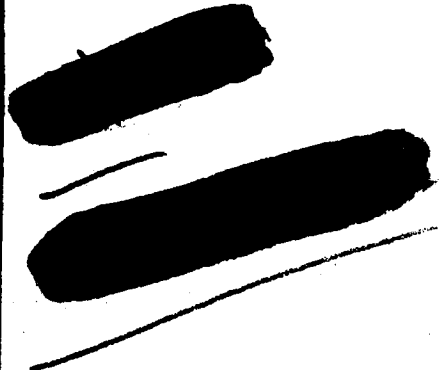
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# PROJECT QUILL EXPLOITATION EVALUATION REPORT



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PROJECT QUILL

EXPLOITATION

EVALUATION

REPORT

AUGUST 1965

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

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AD HOC QUILL EVALUATION COMMITTEE

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Vice Chairman: [REDACTED], NPIC

Project Monitor: [REDACTED], NPIC

Members:

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Major Robert M. McAllister, SAC

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[REDACTED], NPIC

[REDACTED], NPIC

[REDACTED], NPIC

Interpretation Evaluation Team

Chief: Major [REDACTED], NPIC

12 members (see Appendix A)

Technical Evaluation Team

Chief: Mr. [REDACTED], NPIC

4 members (see Appendix B)

Equipment Evaluation Team

Chief: Mr. [REDACTED], NPIC

2 members (see Appendix C)

Intelligence Evaluation Team

Chief: [REDACTED], DIA

4 members (see Appendix D)

Collection System Evaluation Team

Chief. [REDACTED] CIA

4 members (see Appendix E)

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PREFACE

This is a special report on an exploitation evaluation of satellite side-looking radar imagery conducted under the direction of the Ad Hoc QUILL Committee composed of representatives from the CIA, DIA, Air Force, Army, Navy, NPIC, NRO, and SAC. The imagery was obtained from the first satellite radar mission, under Project QUILL, a research and development project of the NRO.

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EXPLOITATION EVALUATION REPORT

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I. PROJECT DESCRIPTION

A. Purpose

The purpose of the exploitation evaluation of Project QUILL is to determine the intelligence worth of satellite side-looking radar imagery as an information collection system (BYE #36346-65 from Director, NRO, to Director, NPIC, and BYE #41652-65, NPIC Project QUILL Evaluation Plan).

B. Objectives

1. "Assess the amenability of the QUILL High Resolution Radar products to interpretation by trained PI's to include problems associated with exploitation techniques in target detection, recognition and identification, training, and interpretation aids."

✓ 2. "Assess the limitations, advantages, and special applications of this type of satellite-derived intelligence product as a supplement to current photographic reconnaissance sensors and as a separate satellite reconnaissance sensor."

✓ 3. "Assess the benefits to be derived from various swath widths, resolutions, and beam depression angles for those applications unique to radar satellite sensors." (It is emphasized that radar sensors were examined from the point of view of image utility only. Operational problems which may be inherent to this type of sensor were not considered.)

C. Materials for Evaluation

The QUILL evaluation materials were obtained from 14 passes of Mission 2355 made over the United States [redacted] from 21 December to 24 December 1964. The mission was flown for research and engineering purposes and not for intelligence collection purposes. Consequently, some of the flight and system information and data that is required for complete interpretation was not obtained and some types of targets of current intelligence importance were not covered.

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In addition, a limited amount of material was collected employing an airborne high resolution radar to map some of the target complexes contained in the QUILL product. This material was used to supplement the QUILL material employed only in the Intelligence Worth evaluation.

1. Radar Imagery Recorded

The material for evaluation, obtained from the 14 passes, was recorded by 3 methods.

a. Recovered Imagery

Physically recovered from the vehicle in the form of a Doppler History Record and converted to human readable imagery in a correlator. This material was from the first 7 passes only.

b. Transmitted Imagery

Transmitted and recorded as a Doppler History Record and fed into a correlator. This coverage was from all 14 passes.

c. Transmitted and Taped Imagery

Transmitted by data-link, recorded on magnetic tape, and later transformed into a Doppler History Record and fed into the correlator. This coverage was from all 14 passes.

2. Reproductions Received for Evaluation

Radar imagery was received in two forms:

a. Contact print on 70 mm film.

b. 2.6X enlargement on 9.5 inch film.

3. Imagery Evaluated

a. The primary evaluations were made of Recovered imagery.

b. A select sampling was made from all 3 methods of recording and was given a comparative evaluation to determine the relative losses of information.

c. The 2.6X enlargement received a technical evaluation but was omitted from interpretation evaluation because of its degradation and poor quality.

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## II. DISCUSSION

### A. General

This discussion is a summary of the results of the efforts of 5 teams charged with attaining the objectives of the QUILL evaluation. The detailed reports of the teams are included as appendixes A thru E, which also contain results and conclusions beyond the basic objectives of the project evaluation.

### B. Interpretation Evaluation (See Appendix A)

The interpretation effort involved the overlapping functional categories of mission plotting and scanning, target indexing, preliminary analysis of significant targets, and the detailed analysis of selected targets.

Mission plotting and target indexing were accomplished without difficulty with the aid of charts and maps. The continuous-scan format, the lack of atmospheric interference, and the photo/map similarity of the QUILL imagery facilitated the performance of these functions.

Target descriptive information of a general nature was readily derived during both the preliminary and the detailed analyses without the use of collateral information. The information derived from the QUILL imagery included the determination of activity levels of ports and rail yards, the occupancy of vehicle parks, and the approximate counts of aircraft at airfields. The use of collateral information and comparative visible spectrum imagery, i.e., KEYHOLE, added considerably to the reliability and the amount of detail derived from the QUILL imagery. Although targets not indicated on maps or in collateral were detected in the QUILL imagery, the derivation of substantive descriptive information was extremely difficult in many instances without the use of comparative visible spectrum imagery. The detailed analysis obtained from visible spectrum imagery was enhanced through its comparison with subsequent QUILL imagery to include target change detection.

Significant target information, such as aircraft and vessel counts, was derived from the QUILL imagery. Although this information is inherently less defined in nature than that obtained from visible spectrum imagery, this factor does not necessarily detract from the significance of the information derived from QUILL imagery.

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Similar detail on most of the targets was derived from both the Recovery and Transmitted imagery. However, the degradation of the imagery from the Transmitted-tape format resulted in the loss of significant target detail.

The variables involved in the radar return from a given target and the relatively general nature of the information derived from QUILL imagery affect the accuracy of such information as aircraft and vehicle counts and functional determinations. However, reasonable estimates can be derived. The accuracy of these estimates is improved considerably through comparison with visible spectrum imagery and the maximum use of collateral information.

C. Technical Evaluation (See Appendix B)

The evaluation of the technical aspects of the QUILL material included a study of its characteristics determined by an analysis of the film quality and study of problems associated with plotting, titling, ephemeris data, and general handling.

The mensuration analysis included the determination of scale, the measurement of long distances, and the measurement of target dimensions. The QUILL mission was primarily a research and engineering test mission having no particular regard for target measurement requirements. In the majority of cases, precise measurements from QUILL imagery could not be obtained. This was partly due to the lack of reference data, such as normally received from a satellite reconnaissance mission, and partly due to the peculiarities of radar imagery. This resulted in a technically incomplete mensuration analysis. Nevertheless, the evaluation indicated that the QUILL imagery can be measured with reasonable accuracy from point to point and that the degree of measurement accuracy increases in the longer distances.

Accurate measurement of small targets is difficult because of the lack of sharpness of image edges and because of inaccuracy in establishing the image reference points of positive-return targets which are rarely imaged in their actual configuration.

The absence in the film format of mission reference data similar to that provided in the KEYHOLE program was a serious handicap to mensuration, but it is subject to ready correction through the application of techniques and equipments such as are used in other satellite systems.

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D. Equipment Evaluation (See Appendix C)

The exploitation equipment currently on hand in interpretation facilities, such as the NPIC, is capable of handling QUILL mission material when it is exploited in a manner similar to a KEYHOLE read-out.

The development and installation of an in-house optical data processor (correlator) capable of enhancing target imagery detail would considerably improve the exploitation capability with regard to providing flexibility and timeliness to the detailed read-out.

In the event that a requirement for near real-time exploitation capability is generated by the collection system's real-time image transmission capability, the addition of correlating, multiple mission viewing, and automatic information retrieval would be required in the exploitation center. The nature, sophistication, and extent of such equipment would depend upon the real-time requirements, the volume and nature of the imagery of Doppler History Record received, and the type of read-out.

E. Intelligence Worth Evaluation (See Appendix D)

1. The estimated intelligence worth of a radar sensor was established through an evaluation of the following 4 major considerations.

- a. The potential information collection capability of such a sensor against selected Essential Elements of Information (EEI) under certain operating conditions.
- b. The advantages of the system which supplement photo sensors.
- c. System limitations.
- d. Special applications of such a system within selected international environments.

The collective evaluation of these considerations indicated that radar sensors could be extremely valuable as a supplemental imagery collection system during Cold War and Crisis situations and would be almost completely satisfactory as a separate system during a General War environment for the purpose of Strike Effectiveness Assessment (SEA).

2. The potential information collection capability was evaluated

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for QUILL as well as QUILL-Improved (resolution approximately 10 feet in both range and azimuth) products. Furthermore, each of the preceding was evaluated as separate and supplemental collection systems. It was estimated that QUILL products were, at most, marginal information-producing materials during Cold War and Crisis situations, particularly as a separate system. However, they were estimated to be most productive for SEA during a General War environment, even as a separate system. QUILL-Improved products were considered to have substantially more information potential when compared with QUILL, particularly as a separate collection system for SEA. As a separate system, even these materials have limited information potential during Cold War and Crises; however, when employed as a supplemental system, their potential is significantly enhanced. The evaluation relative to scientific and technical information potential revealed that even QUILL-Improved products held little promise of providing anything of significance. Consideration was also given to a Post Attack Reconnaissance (PAR) mission during General War, and it was determined that the relative information potential would be almost identical to the Crisis situation.

3. The major advantages of a radar system, as a supplement to photo sensors, were considered to be threefold. They would be:
  - a. An essentially all-weather system.
  - b. A day-night system.
  - c. A potentially "quick response" system.

All of these advantages make a radar sensor invaluable where short response time is a major consideration.

4. The evaluation indicated a major limitation as an intelligence collection system. A radar sensor is extremely limited in providing meaningful information on previously unknown targets.

5. There were significant special applications for a radar sensor in each of the 3 international environments considered. During Cold War, changes or new construction activity could be detected, although not identified, in areas where weather or light conditions precluded photo acquisition, thereby increasing the efficiency of the operation of photo sensors for search and surveillance purposes. During both Crisis and General War, the quick-response characteristic makes its application most significant.

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F. Collection System Evaluation (See Appendix E)

The objective of the Collection System Evaluation Team was to assess the limitations imposed upon the QUILL imagery as a result of collection equipment characteristics and to determine which characteristics might be improved in order to enhance the intelligence yield of the product.

As a result of this study, a number of system characteristics have been isolated and analyzed with regard to their influence on imagery quality and utility. To a large extent, these analyses have been subjective in nature since a sufficient quantity of QUILL data is not available.

It is clear that in order to proceed with the optimum design and development of an advanced radar system, a better quantitative understanding of the relationships between image utility and the various system parameters must be achieved. The primary parameters which require quantitative, experimental investigation are:

Range and azimuth resolution  
Signal-to-Noise Ratio  
Depression angle  
Dynamic range  
Radar frequency and polarization combinations

Although there are other characteristics which require study, it is considered essential that sufficient quantitative data be acquired on these 5 characteristics in order to design a system which would produce optimum imagery.

III. CONCLUSIONS

- A. The QUILL High Resolution Radar products are amenable to interpretation by trained interpreters. Interpretation is enhanced by correlation of the QUILL products with collateral.
- B. Previously known targets can be located, identified, and described, significant target changes and activities can be discerned, and previously unknown targets can be detected.
- C. The analysis of QUILL imagery is enhanced significantly by variable processing with an optical data processor (correlator).

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- D. The exploitation of QUILL imagery on a near real-time basis with simultaneous comparison of visible spectrum imagery of selected targets is feasible.
- E. In addition to the consideration of ground resolution as a separate and important factor influencing the information produced by radar imagery, the factors of dynamic range, look-angle, and frequency spectrum should also be considered.
- F. A radar sensor would be of value in supplementing visible spectrum sensors in Cold War for search and surveillance purposes.
- G. A radar sensor would be of definite value as a supplement to visible spectrum sensors for indications during a Crisis and for Post Attack Reconnaissance (PAR) during General War.
- H. A radar sensor would be of very high value, even as a separate system, during General War for Strike Effectiveness Assessment (SEA).
- I. The collection system employed on this QUILL mission represented a significant technological achievement. It demonstrated that very good quality radar imagery can be acquired from an orbital system during bad weather and darkness. It also demonstrated that near real-time strategic intelligence acquisition is feasible.
- J. Notwithstanding the success of the collection system on this mission, it is highly probable that it can be greatly improved to produce much better imagery.
- K. A QUILL-Improved system (10 feet in range and azimuth resolutions) seems justifiable.

#### IV. RECOMMENDATIONS

These recommendations are based on the assumption that satellite side-looking radar will be used operationally.

- A. It is recommended that a thorough study be made of the requirements for the exploitation facility and exploitation procedures to include a near real-time capability.
- B. It is recommended that a test program be initiated to investigate various parameters of the collection system in order to optimize the quality and utility of the resultant imagery.

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APPENDIX A

INTERPRETATION EVALUATION TEAM REPORT

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INTERPRETATION EVALUATION TEAM REPORT  
PRELIMINARY REPORT, PHASE I

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## I. REFERENCE

Interpretation Evaluation Plan, Phase I

## II. GENERAL

As indicated in the reference above, this report is based on preliminary analysis of data derived from Phase I. The comments presented in Section III below will be directed only toward those aspects of the evaluation which pertain directly to the QUILL imagery (herein referred to as test imagery or imagery) plotting task. Comments related to other aspects of the evaluation are presented in Section IV and will be elaborated on in subsequent phase reports as appropriate.

## III. OBJECTIVE

Plot all "Recovery" imagery, determining the complexities involved with regard to imagery format and quality, the utilization of various map formats, and handling equipment.

### A. Sub-Objective 1

Determine the amenability of test imagery to initial orientation and subsequent scanning orientation.

1. It was determined that, given a general location for the head of each pass, it was reasonably simple to orient the initial point on most passes. Exceptions were those passes over sparsely settled areas which lacked topographic detail.

2. The continuous scan format of the imagery and the relative freedom from atmospheric interference are distinct advantages in plotting since they permit continuous map tracking and facilitate "back tracking" between well-defined points, thus permitting reasonably accurate plotting of nondescript or vague areas.

3. The narrow swath width of the imagery is a disadvantage in plotting since it precludes accurate plotting of coverage in those areas where identifiable features occur infrequently or where map detail is lacking. This disadvantage is offset in large part by the continuous-

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4. The lack of appreciable effect from obliquity serves as an advantage in plotting with the Richardson viewer in that the imagery may be scanned either horizontally, vertically, or diagonally, thus facilitating image-to-map orientation.

5. The composition and normal quality of the imagery lend themselves to plotting because the features normally used for orientation are prominent on the imagery. These are, in most cases, the features which are prominent on most map series. This feature is discussed in more detail in Sub-Objective 2 below.

B. Sub-Objective 2

Determine the adaptability of test imagery to plotting techniques, utilizing various map series.

1. The basic map used in Phase 1 was the USAF Operational Navigation Chart (ONC) (1:1,000,000) supplemented by AMS Series 1301 (1:1,000,000), USAF Pilotage Charts (1:500,000), AMS Series V501 (1:250,000), US Air Target Charts, Series 200 (1:200,000), and USGS Topographic Series (1:24,000).

2. While the basic map (ONC) was adequate for plotting most passes it was found to have serious shortcomings with regard to desolate areas due to the lack of terrain detail portrayed. The most satisfactory map for plotting such area coverage was AMS Series V501, primarily because of the topographic detail portrayed.

3. It was determined that a much higher degree of accuracy in plotting coverage limits could be achieved on all passes utilizing AMS Series V501 and the USGS Topographic Series. Two map detail factors contributed to this accuracy -- the obvious increase in detail of naturally occurring features and the higher degree of similarity between patterns and shapes of man-made features portrayed on those maps and the patterns and shapes portrayed on the imagery.

4. The primary advantage in using the Air Target Charts, Series 200, was the ease in correlating specific returns on the imagery with the radar-return annotations on the charts. This advantage is more useful in locating specific points in large complexes and in identifying isolated returns assuming that a general location is known than in mission plotting.

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C. Sub-Objective 3

Determine the adaptability of the test imagery to the various items of equipment and techniques utilized in normal plotting and scanning processes.

1. Two primary items of equipment, the Richardson Viewer and the Richards GFL-940 Light Table with B&L Zoom Mono Viewer, were utilized during Phase 1.

2. Though both items of equipment were utilized initially, the Richardson Viewer was utilized almost exclusively in those areas where the image quality was reasonably good. It was necessary in some cases where the quality deteriorated (pass 9) to use the light table in order to delineate image limits. The deterioration was manifested as a darkened area which necessitated adjustment of illumination under sharp focus. A displacement or inversion of the image format added to the problem but was resolved through combined viewing utilizing both viewing devices.

3. The Richardson Viewer affords the distinct advantage of rotating the imagery to an attitude which will orient best with maps and other graphic orientation aids which may be used in the plotting task.

4. Utilization of both the Richardson Viewer and the Richards 940 Light Table in combination permits the plotting team to simultaneously scan two variations in density, thus insuring easier extraction of image limits in areas of varying tone. This technique has greater significance in target scanning and detailed studies and will be commented on in detail in subsequent phase reports.

5. Initial difficulty was encountered in mounting the film for viewing. It was found that when the film is viewed so that the format titling data (word RECOVERY and pass number) reads properly the terrain image is reversed. This probably can be corrected without difficulty.

6. The scribed reference points annotated by TID along the film border were most helpful in Phase 1 and will be extremely useful in Phase 2. A similar titling system keyed to sensor-induced fiducial marks appears advisable.

7. The most satisfactory enlargement factor utilized on the Richardson Viewer is 15X. This factor permits observation of good detail at an adequate scale. It was found that

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at 30X a diffusion of light through the brighter image areas caused an excessive loss of detail and hindered detailed plotting. The 5X position offered no advantage over the 15X and was more difficult to work with due to the relatively smaller scale.

8. It was found that etching the limits and centerline of the imagery on the viewing screen so that they could be used as reference points in locating and plotting returns expedited and simplified the plotting task. The etched lines superimposed over the projected imagery need not be positioned with a high degree of accuracy since they are used as a general guide to help locate more definitive points.

9. Some difficulty was encountered initially as a result of shifting or offsetting of the image track in range due to changes in Pulse Repetition Frequency (PRF). This range shift does not present a serious plotting problem when detected. However, if it is not recognized at the point of occurrence it could lead to difficulties. Since PRF changes are made by the operator, this problem can be avoided by furnishing the plotting teams with the locations of such changes.

#### IV. PRELIMINARY OBSERVATIONS

Incident to the conduct of Phase 1, certain observations not directly applicable to the plotting task were made. These are presented below as preliminary observations and will be evaluated further in subsequent phases.

##### A. Light Diffusion in Bright Image Areas

As indicated previously, some loss of definition was experienced at 30X apparently due to a diffusion of light passing through the lighter images, causing them to fuse together. This may be corrected to some degree through fine illumination control but may be best resolved by strictly controlled printing on paper format. This should only be necessary for detailed analysis.

##### B. Tone Contrast

While related to some degree to the problem outlined in A above, this comment is directed to the use of various (at least 2) density duplicate positives for MCI scanning and limited detailed studies. Significant loss of detail was noted in several instances on both light and heavy (relative) density duplicate positives. Since significant targets will image to varying degrees across the entire spectrum of the dynamic range of the system, from negative (dark) returns such as

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airfield runways and, presumably, silo covers flush with the ground to positive (bright) returns such as tall missile gantries and most buildings, it appears essential that the first and second phase read-out teams should utilize at least 2 density variations to insure maximum extraction of data.

V. SUMMARY

Preliminary analysis of the results of Phase 1 indicates that no significant problem areas exist with regard to accomplishing the plotting task involved in the exploitation of this type imagery operationally. In fact, certain advantages, such as continuity of scan and lack of atmospheric interference, are apparent.

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INTERPRETATION EVALUATION TEAM REPORT  
PRELIMINARY REPORT, PHASE II

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I. REFERENCES

- A. Interpretation Evaluation Plan, Phase II
- B. Preliminary Report, Phase I, QUILL Imagery Interpretation Evaluation

II. GENERAL

This report is based on preliminary analysis of data derived from Phase II. The comments presented in Section III below will be directed only toward those aspects of the evaluation which pertain to the performance of first and second phase mission read-out functions utilizing the "Recovery" imagery. The comments presented in Section IV below will be directed toward those aspects of the evaluation which pertain to the relative amenabilities of the various types of QUILL imagery (Transmitted, Transmitted-taped, and Recovery) to those same functions. Comments related to other aspects of the evaluation are presented in Section V and will be elaborated on in subsequent phase reports or in the final report as appropriate.

III. OBJECTIVE 1

Scan selected passes of "Recovery" imagery to determine the extent to which normal first and second phase target reporting information can be derived, to include location and identification of both known and previously unknown targets, description of targets including significant changes, and description of activity such as air, naval, and ground order of battle information (See Table 1 for list of target types).

A. Sub-Objective 1

Determine the amenability of test imagery to location and identification of previously known targets, utilizing only map and series 200 target sheet references:

1. It was determined that target areas are readily located under most conditions. Notable exceptions are relatively small target areas located in larger areas of high return where imagery detail was either in smaller negative return areas or melded in smaller high return areas. It was found that railroads, which are commonly used in locating known target areas, are not readily discernible when they fall perpendicular to the

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