National Reconnaissance Office

QUILL Declassification Guidance

Preface

This document contains *general guidelines* for the protection of National Reconnaissance Office (NRO) equities involving the QUILL study. It is meant as a starting point for those planning events and publications associated with this study.

All government and contract employees are obligated to protect national security information. The NRO's Prepublication Review process is intended to carefully control and monitor the release of UNCLASSIFIED NRO information to the public. This process, if followed, will minimize the chances of releasing information potentially damaging or harmful to national security.

Any unclassified material proposed for public release by any means, which deals with our organization, its mission or its functions, MUST be submitted to the NRO's Information Access and Release Team (IART) for prepublication review processing.

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Chantilly VA 20151

On an individual basis, The IART will field questions from industry partners regarding other releasable information not covered in these guidelines. Please call (703)227-9411.

For those individuals approached by the media for interviews regarding QUILL and their association with the study or are considering contacting the media themselves, please call the NRO Office of Corporate Communication at 703-808-1198.

What was QUILL?

Quill was an experimental Synthetic Aperture Radar (SAR) satellite, based on Corona satellite and available SAR hardware, which flew in 1964. Because of diplomatic and security concerns the brief mission imaged only selected targets within the United States. Those targets could be inspected on the ground to validate the intelligence value of orbital SAR without alerting the Soviets to the capability or touching off diplomatic protest over active illumination of sovereign territory. The mission provided proof-of-concept.

The following is released:

1. Release the fact of the Quill experimental synthetic aperture radar satellite as the world's first imaging radar satellite.

2. Release photographs and drawings of the Quill satellite and associated hardware only after Systems Engineering Directorate, Imagery Intelligence Systems Acquisitions Directorate, and the Office of Security and Counterintelligence have certified that the specific image in question offers no substantial assistance to potential adversaries and represents no substantial risk to currently operational systems. Such certification renders the image releasable in the absence of additional concerns.

3. Release the fact that Quill's synthetic aperture radar technology emerged from the work of Louis Cutrona's team at the University of Michigan's Environmental Research Institute of Michigan (ERIM), publicized in 1960 when the U.S. Army released images of American cities captured by the airborne AN/UPD-1 SAR system.

4. Release the fact that in the late fall of 1961 Col. William G. King, Director, Program A, began examining the possibility of launching an experimental proof-of-concept SAR satellite. Release fact that King assigned then-Major David D. Bradburn to investigate the potential utility and merits of such an experiment.

5. Release the fact that Director of the National Reconnaissance Office (DNRO) Joseph V. Charyk approved the proposed proof-of-concept experiment in mid-November 1962.

6. Release the fact that the SAR proof-of-concept program was identified as "P-40" and that the satellite itself was identified as "Quill".

7. Release the fact that Quill used technology from the CORONA program, including the Agena space vehicle and the physical return of data on optical film.

8. Release the fact of and facts about the optical correlator technology which, in the absence of adequate electronic computer technology, used optics to process SAR data into useful analog images.

9. Release the fact that P-40 called for the launch of two identical Quill vehicles, designated 2355 and 2356, with first launch planned for April 1964. Release the fact that a third vehicle's payload was also prepared, with no booster identified for it.

10. Release in relation to Quill the fact that original project goals included 50-foot resolution in both azimuth and slant range; quantitative evaluations of radar system performance, including azimuth-direction; limitations imposed by design parameters; in-flight performance; vehicle attitude behavior; impact of atmospheric conditions; data link design and performance; data on target field reflectivity; general engineering parameters for aerospace radar system designs used or available to the public during the Quill program; and ground recording and processing capabilities.

11. Release the fact that Maj. Bradburn subsequently determined that range resolution would not be a significant project goal.

12. Release the fact that Quill's SAR unit, designated KP-II, was a modified version of the AN/UPQ-102 pulsed-Doppler system Goodyear produced for the RF-4C reconnaissance aircraft. Release the fact that modifications included removing unnecessary aerial or operational system components, such as lateral motion compensation and swath modification capabilities, from the original design.

13. Release the fact that the fifteen feet long by two feet wide SAR antenna, covered by a protective fairing during launch, was flush-mounted on the Agena bus, protruded 2.5 inches from its surface, and was fixed at a 55-degree downlook angle. Release that three of the four antenna mounts slid along fixed tracks to account for thermal stress.

14. Release the fact that the SAR unit's klystron used a heat sink in the form of an aluminum plate about ten inches long and

five inches high, painted with a special thermally conductive white paint, with several copper fingers braised to its back. The plate bolted to the anode of the klystron, and the copper fingers conducted heat to another metal heat sink, placed next to the satellite's skin so the klystron's heat could radiate into space.

15. Release the fact that the experimental mission was intended to last only 96 hours, with the radar operating no longer than five minutes per orbit, for no more than three orbits in succession, and for no more than 80 minutes altogether. Release the fact that three silver-zinc batteries provided power, without provision for recharging, and so determined the duration of the experiment.

16. Release the fact that Quill employed the same Agena upper stage used as a bus for the CORONA imagery satellite. Release the fact that Quill launched on an augmented Thor missile, like a Corona satellite. Release that this Agena-Thor combination was expected to support effective operation of the SAR experiment, with an anticipated ±0.4 degrees of attitude uncertainty and ±0.25 degrees limit cycle in pitch, yaw, and roll, with rates of change not greater than .002 degrees/second in pitch, .005 degrees/second in yaw, and .003 degrees/second in roll.

17. Release the fact that in Quill's KP-II radar unit the reflections from each signal pulse produced a line on the display of a cathode ray tube. The line's length fluctuated according to the intensity of the return. Photographic film recorded an image of the display, with varying densities on the film corresponding to the varying intensity of the radar returns. The film moved across the display to record successive intensity trace displays as adjacent positions on the film. Engineers anticipated an aspect ratio of roughly 6:9 between range and azimuth scales.

18. Release the fact that ground tests showed the system capable of achieving slant range resolution of 25-35 feet.

19. Release the fact that Quill conveyed radar data to the ground in two ways. As in Corona, exposed film went into an Itek take-up cassette in a General Electric re-entry vehicle for recovery by special Air Force C-130 teams. This approach to data recovery had appeared in a 14 October 1958 Aviation Week article. The other method employed a UHF wideband data link to transmit radar data to recorders at the Vandenberg, California, and New Boston, New Hampshire, tracking stations used for

Corona. Each station translated the data into a cathode ray tube image and recorded it on film, using equipment identical to that on the satellite. Preflight engineering analysis considered this task simple and straightforward. Each location thus had a recorder identical to the one on Quill, together with control systems for establishing synchronized reception from the satellite.

20. Release the fact that the product of either method of data transmission was a film transparency. This film preserved the Doppler-coded return signal from the KP-II radar unit. Technicians could convert the preserved analog information into visual imagery using a purpose-built device, the Precision Optical Processor. Release the unclassified fact that ERIM's Lou Cutrona had developed this technique for processing SAR Doppler data in the 1950's, using analog optics to perform a task beyond the capabilities of that era's digital electronic computers.

21. Release the fact that the Precision Optical Processor used optical lenses to perform fast Fourier transforms. The film defracted a laser beam into three emerging waves, two of them producing images at focal lengths varying with the SAR data's slant range. An amorphic telescope focused the resulting images, which could then be photographed in high resolution to produce intelligible imagery.

22. Release the fact that the complete Quill system filled the Agena's three payload sections: barrel, conical, and nose. The KP-II radar system, weighing 370 pounds, went in the barrel section, which measured five feet across with structure rings 15 inches apart and a .06-inch skin. The recorder system, including the recorder and the film-supply cassette, weighed approximately 99 pounds and went in the conical section, which tapered 15 degrees from a five-foot diameter at its base, where it joined the barrel section, through its height of 32.95 inches. The reentry capsule, located in the vehicle's nose cone, protected exposed film containing the raw data until it arrived safely back on Earth.

23. Release the security procedures used to transfer CORONA materiel to Quill.

24. Release the fact that Quill followed a typical CORONA mission profile. The Agena vehicle would rotate 180 degrees after reaching orbit, flying tail first to facilitate film recovery and terrestrial coverage. The antenna would then be oriented with the main lobe of the radar pointed 55 degrees

below horizontal at a strip that would be 93 miles to the left of the satellite's ground track and 10 nautical miles wide.

25. Release the Quill program schedule and schedule changes. Release the fact that an approaching train threatened the scheduled 21 December 1964 launch from Vandenberg Air Force Base. Release that the launch occurred at 11:08 am Pacific Standard Time.

26. Release the fact that Quill was identified and registered as Satellite 1964 87a.

27. Release that the Quill mission lasted four days, as planned, before battery failure during orbits 72-73. Release that the radar operated fourteen times in orbit between 0644 Coordinated Universal Time (UTC) 22 December 1964 and 0618 UTC 26 December 1964, imaging large swaths of the northeastern and western United States.

28. Release orbital ephemeredes and ground traces for the Quill mission.

29. Release the fact that data from the fourteen radar passes went to the ground station in view, either Vandenberg or New Boston, over a wideband (UHF) data link in real time and that the onboard film recording system captured data from the first seven radar passes. Release the fact that on 23 December, during the 33rd orbit, the satellite jettisoned its reentry capsule for a successful recovery. Release the fact that technicians developed the film at Westover Air Force Base and dispatched it to a facility that ran it through the specially made Precision Optical Processor and produced image films.

30. Release only general descriptions of the ground calibration tests.

31. Release the fact that the Quill system achieved azimuth resolution of 7.5 feet, the theoretical maximum for the 15-foot antenna, surpassing its 10-foot goal. Release the fact that it achieved slant range resolution of approximately 80 feet, limited by available bandwidth, and had illuminated approximately 100,000 square miles, producing useful images of nearly 80 percent of the area illuminated. Release the fact that approximately 63 percent of the images produced were of the best possible quality that the Precision Optical Processor could provide; the rest were degraded for radar testing or by slight errors in setting the pulse repetition frequency. Release that

the Quill system lost only 4 percent of its captured images unintentionally.

32. Release the fact that the resulting imagery revealed terrain features and human construction, holding promise for strategic reconnaissance. Release that weather had minimal affect on image quality.

33. Release the fact that the satellite re-entered the atmosphere at 1027 UTC 11 January 1965, on orbit 333.

34. Release the fact that DNRO Brockway McMillan ordered the second Quill vehicle removed from the launch schedule on 5 Jan 1965 pending full review of the first mission. Release that Program A Director Maj. Gen. Robert Greer subsequently recommended cancellation of the launch program, having achieved its experimental proof-of-concept objectives. The program was suspended with DNRO McMillan's concurrence and substantial unexpended funds remaining. The Thor-Agena launch vehicles were recycled into the CORONA program, and the radar equipment was destroyed.

35. Release, per their concurrence, the role of mission partners Goodyear, General Electric and Lockheed Missile and Space Company in the Quill program, including previously acknowledged company locations and the names of senior corporate and corporate project management staff.

36. Release [subject to CIA concurrence] the fact that the CIA developed Quill security procedures through the Office of Special Activities.

37. Release LMSC (Hiller) in association with QUILL. Hiller Helicopter plant, also known as the Advanced Projects Integration Facility, or Advanced Projects Facility (APF, or simply AP), in Palo Alto, California, served until 1969 as a cover in which the CORONA second stage Agena satellites, Itek cameras, EKC film, and General Electric reentry capsules were assembled and tested before shipment to Vandenberg AFB.

38. Release AFSSPL was the Laboratory and AFSPPF was the proposed processing facility for the film.