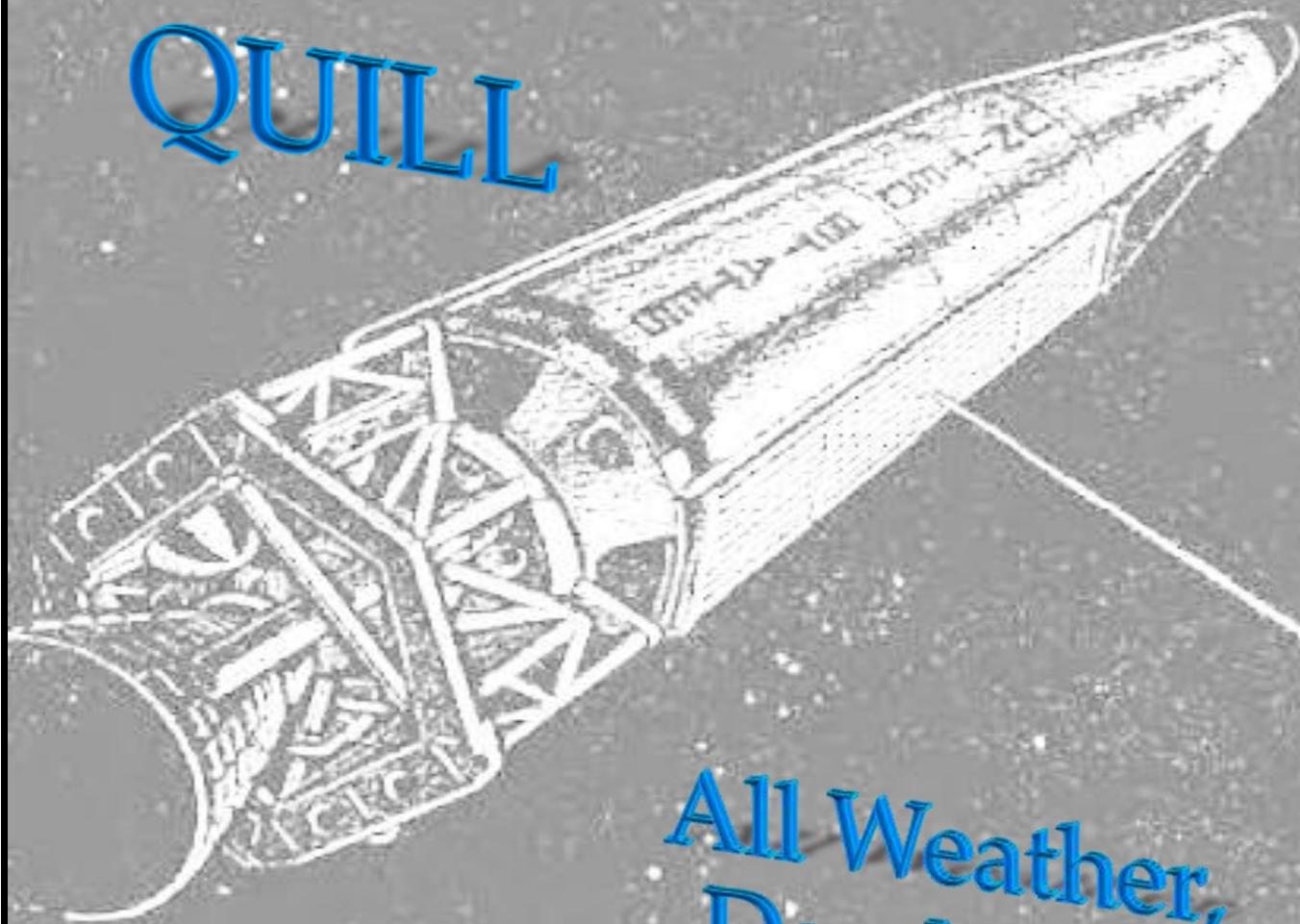
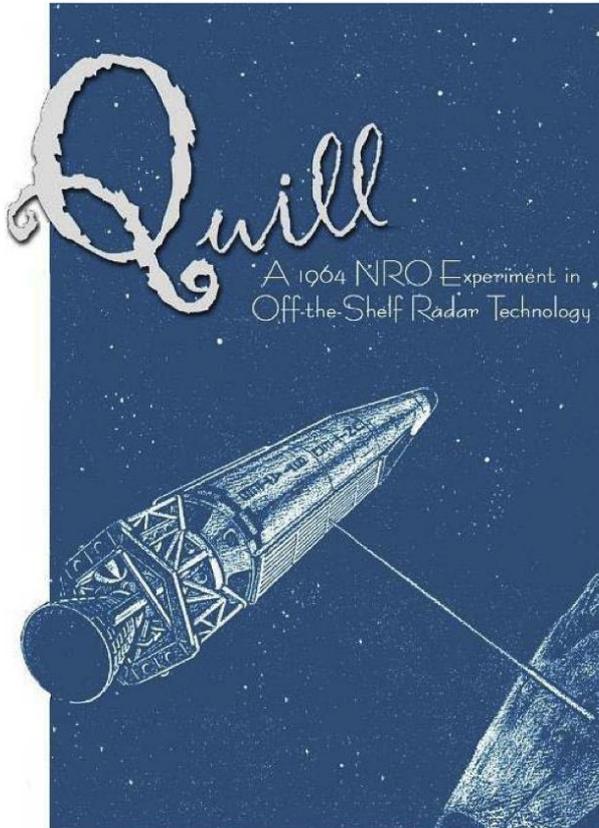


QUILL



All Weather,  
Day-Night  
Imaging



## Fact Sheet

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The Quill experimental synthetic aperture radar (SAR) satellite was the world's first imaging radar satellite.

### System Names:

- P-40: SAR proof-of-concept program
- QUILL: The satellite

**Launch:** 21 December 1964 at 11:08am PST from VAFB

**Re-entry:** 11 January 1965 at 10:27 UTC

### SAR unit:

- Designated KP-II: A modified AN/UPQ-102 pulsed-Doppler system

### Achievements:

- Azimuth Resolution: 7.5 feet
- Slant Range Resolution: Approximately 80 feet
- Coverage: Approximately 100,000 square miles
- Useful Images: Nearly 80 percent of the area illuminated

# Background

- In early 1962, Lockheed and Goodyear Aerospace proposed a satellite imaging radar demonstration based on proven components
  - Air Force launch vehicle used for Corona
    - Douglas Thor
    - Lockheed Agena
  - General Electric reentry vehicle used for Corona film return
  - Air Force RF-4 synthetic aperture imaging radar
    - Goodyear Aerospace modified pulse doppler AN/UPQ-102 system developed for RF-4C
- DNRO Dr Charyk in November 1962 approved a two-vehicle demonstration program under BGen Robert Greer, Director of the NRO's Air Force element, Program A
  - The program was conducted under the BYEMAN Security Control System as QUILL with Maj Dave Bradburn in charge

# QUILL Program Plan

- Acquire two sets of flight hardware
  - One for the demonstration mission & one backup
  - Douglas Thor, Lockheed Agena, Goodyear Radar, & GE reentry vehicle
- Lockheed to modify the Agena to accommodate the imaging radar payload and serve as the integrating contractor
- Goodyear Aerospace to adapt their proven RF-4 imaging radar system for the space-based demonstration
  - Analog imaging radar data transmitted to the ground demonstrating an operational system
  - Same analog data converted to a beam of light and recorded on film on board the satellite
  - Exposed film recovered in the air like the CORONA film return capsules
  - Recovered film data converted to a radar image and compared to the radar image produced from the transmitted analog data

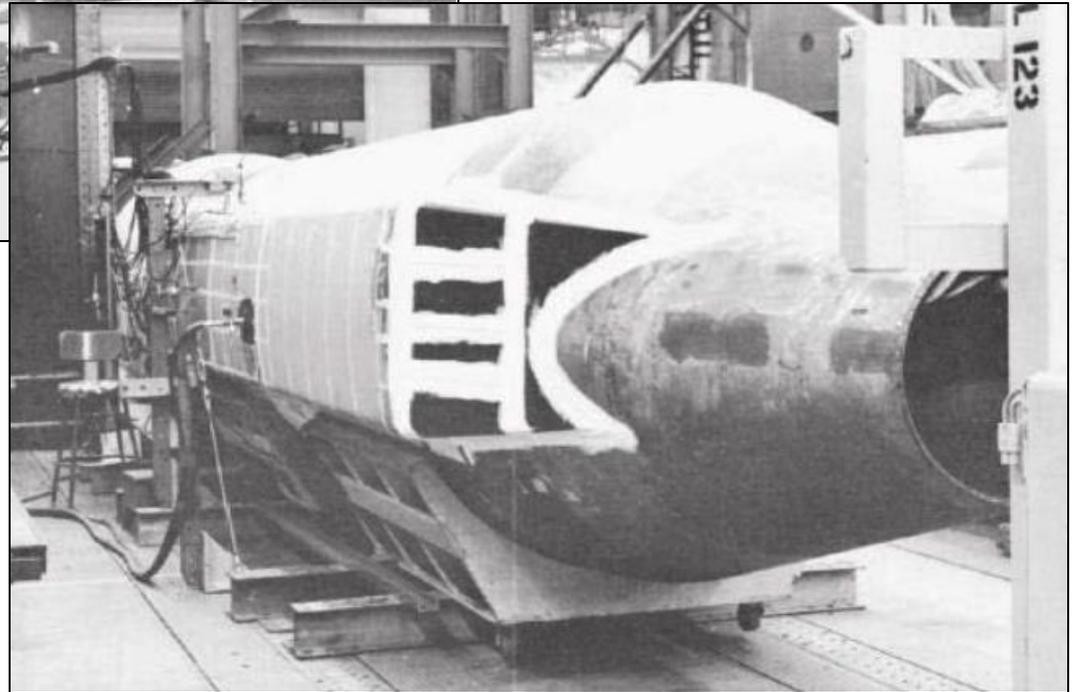
# QUILL Operations Plan

- Quill transmitted its analog data to Vandenberg Tracking Station or New Boston Tracking Station in real time
  - This limited imaging to within 900-mile line of site to the tracking station
    - Imaging operations were essentially all within the CONUS
  - Imaging data was also converted to an optical signal and recorded on film
    - The film was recovered recovered in the air near Hawaii the same way CORONA buckets were recovered
- The 15-meter-long radar antenna was mounted to the right side of the Agena
  - Agena flew with its engine forward and RV aft
  - Imaging was to the left of the flight path

# QUILL Antenna

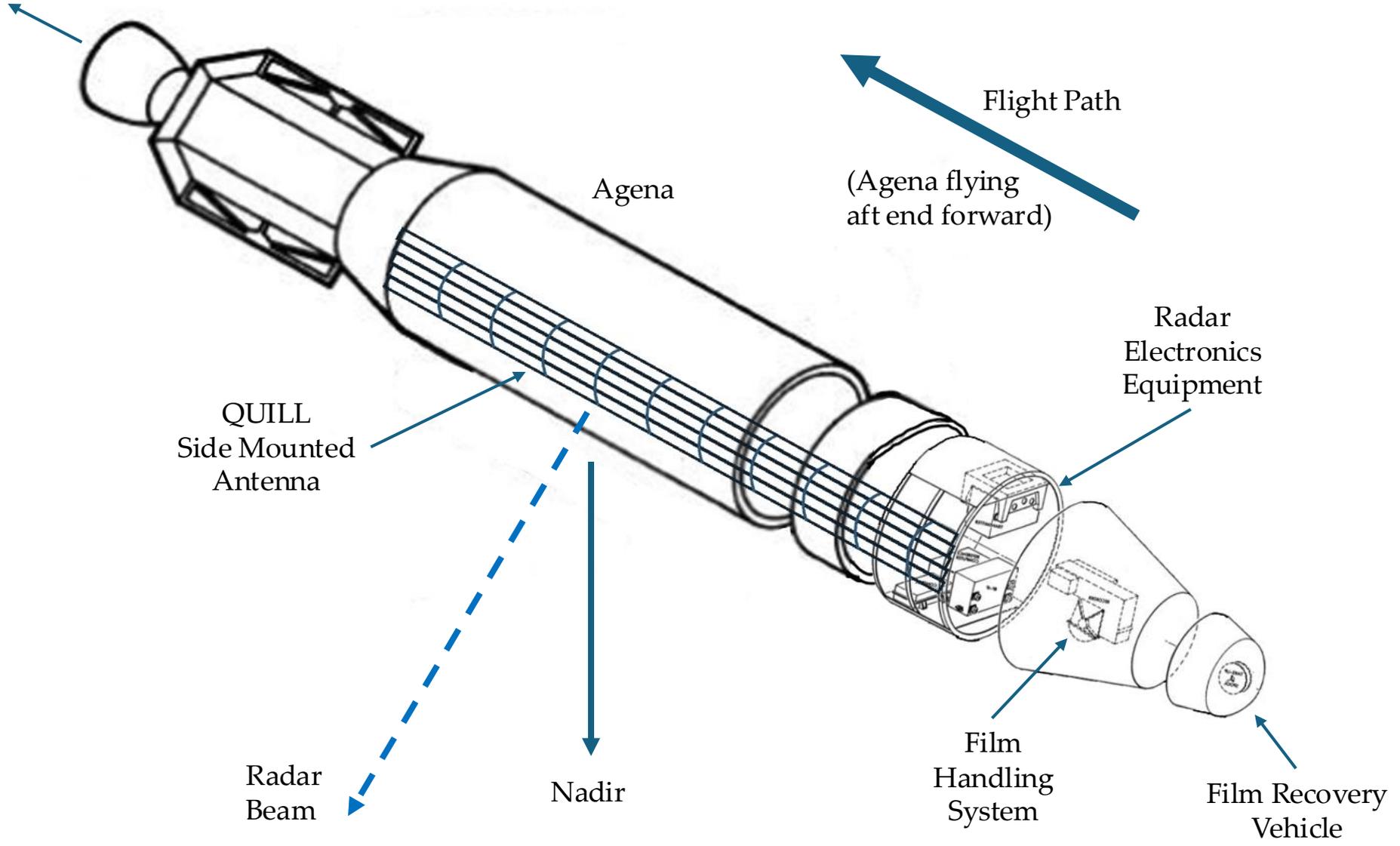


15-foot Quill antenna on test stand



Quill antenna under flight fairing on right side of Agena

# QUILL Satellite



# QUILL Launch

THOR AGENA D 425/2355, 75-1-1, 21 DEC 1964



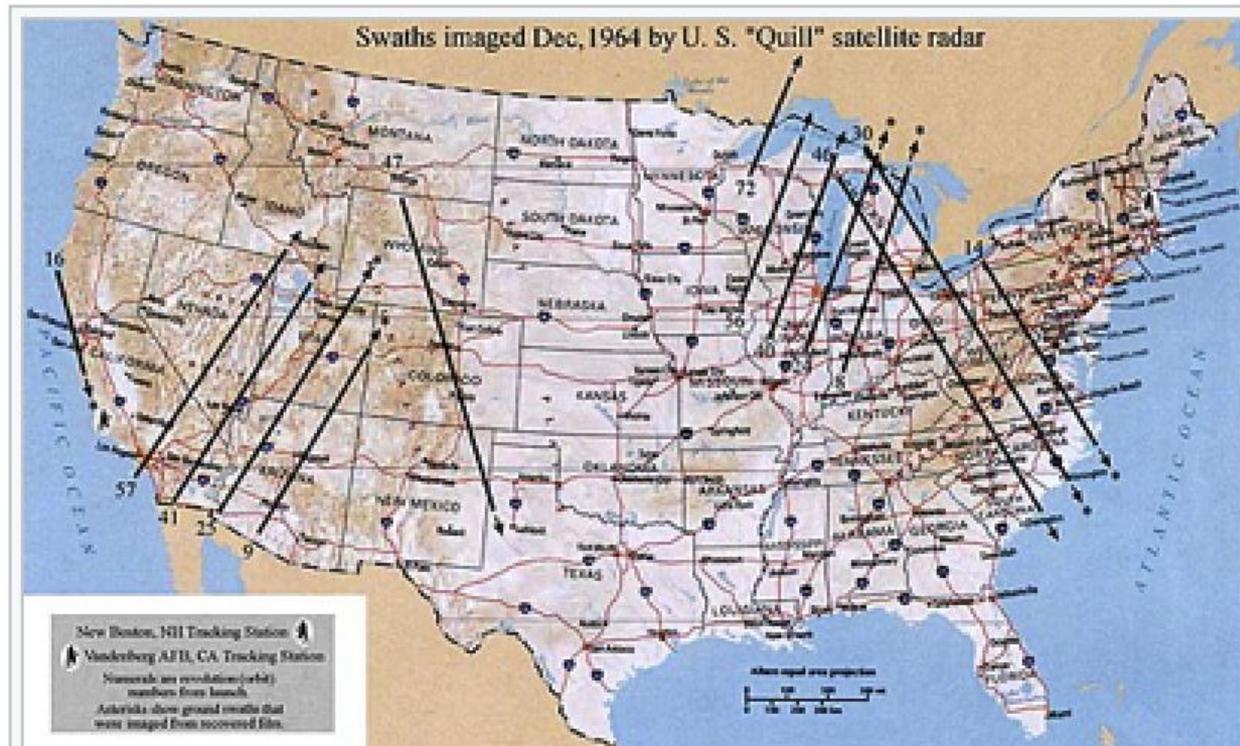
- Liftoff: 11:08 PST
- Inclination: 70.1 degrees
- Apogee:
- Perigee:
- Period: 89.4 minutes



# QUILL Summary

- Total of 96 hours of operations – limited by 3 silver zinc battery power
  - Limited to no more than 5 minutes per orbit
  - No more than 3 imaging orbits in a row
  - No more than 80 minutes of radar imaging operations total
- Quill acquired radar images over 14 passes over the CONUS between 22 and 26 December 1964
  - 9 ascending (night) and 5 descending (daylight) orbits
    - 8 within sight of New Boston and 6 within sight of Vandenberg
  - Last imaging recorded on film on orbit 30
  - Final radar images on orbit 72
  - Longest imaging pass, about 1000 miles, on orbit 30
    - Downlink time was 3.6 minutes
- Exposed film was recovered on 22 December 1965
- Vehicle reentered on 11 January 1966 on its 333<sup>rd</sup> orbit

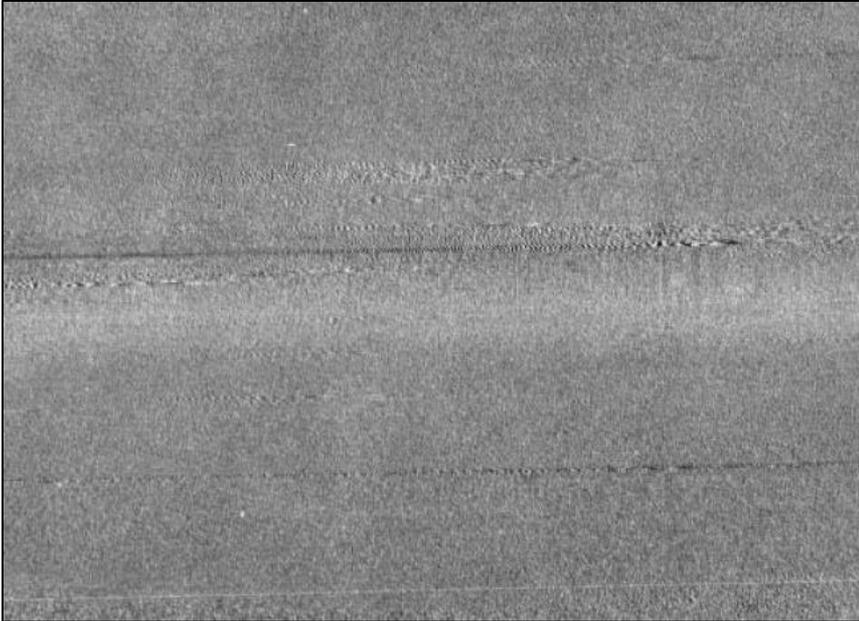
# QUILL Imaging Passes



The swaths imaged December 1964 by U. S. "Quill" satellite radar.

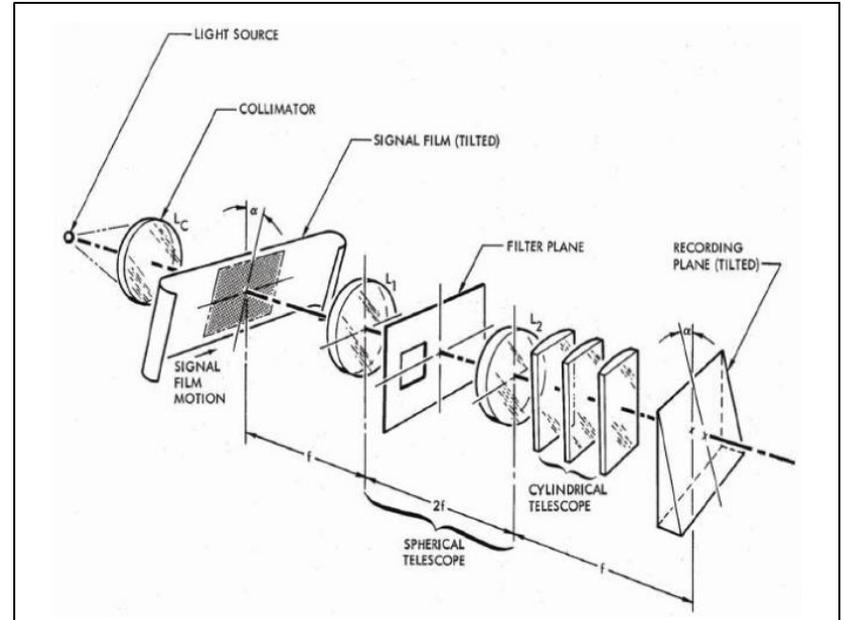
- All descending passes were in daylight
- All ascending passes were at night

# Quill Image Processing



Photograph of analog video data

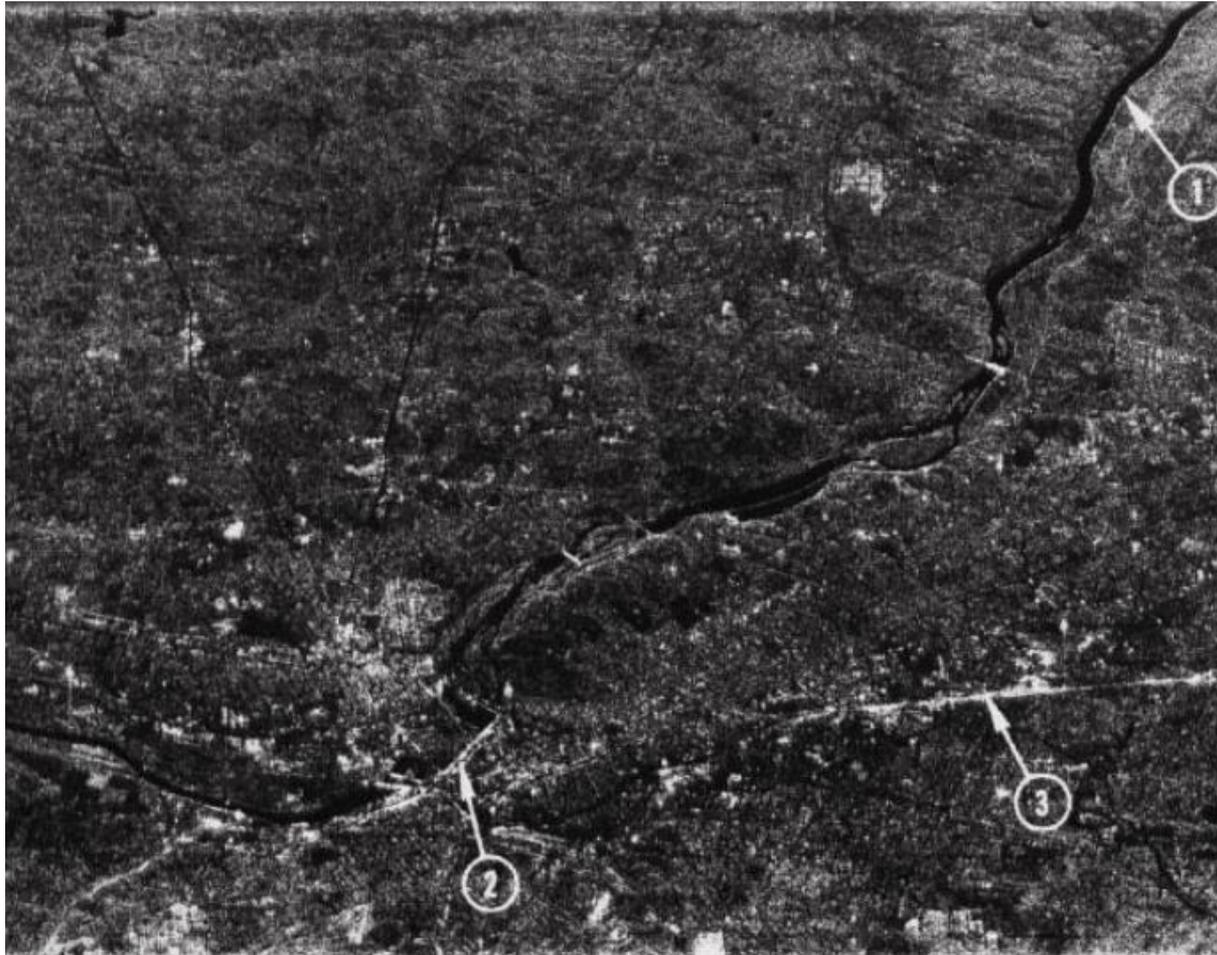
- Film image is just white noise
- Analog era – no digital computers to analyze data



Precision Optical Processor

- An optical computer required to transform analog data to a visual image
- A Precision Optical Processor, developed by the University of Michigan, provided the optical fourier transform to reconstruct the visual radar image

# QUILL Radar Image



Visual reconstruction of QUILL image of Richmond Virginia area produced by the Precision Optical Processor

# QUILL Summary

- QUILL satellite was the first demonstration of radar imaging from space
- Demonstrated that satellite radar imaging could satisfy SAC's long-standing requirement for near-real-time bomb damage assessments
- Demonstrated the ability to acquire all weather, day night imagery from a satellite
  - Ahead of its time and technology – analog limitations awaiting a digital world
- Produced radar maps of 80,000 square miles at less than 15 feet in-track and 88 feet cross-track in 80 minutes of imaging operation
- Best resolution of 7.5 feet was about 3 times better than the visible imagery originally produced by CORONA
- Pathfinder for NASA SeaSat (1978) and Shuttle Imaging Radar – A (1981) systems that followed