Search

NATIONAL RECONNAISSANCE OFFICE

- NRO Home
- What's New
- About the NRO
  - The National Reconnaissance Office
  - Leadership
  - NRO Launches
  - NRO Innovation
- History and Studies
- Working at the NRO
- Offices at the NRO
- News and Information
- Freedom of Information Act (FOIA)
- Declassified Records
- No FEAR Act
- Kids' Pages
- Contact the NRO

About the NRO

Develop. Acquire. Launch. Operate.

When the United States needs eyes and ears in critical places where no human can reach – be it over the most rugged terrain or through the most hostile territory – it turns to the National Reconnaissance Office (NRO). The NRO is the U.S. Government agency in charge of designing, building, launching, and maintaining America's intelligence satellites. Whether creating the latest innovations in satellite technology, contracting with the most cost-efficient industrial supplier, conducting rigorous launch schedules, or providing the highest-quality products to our customers, we never lose focus on who we are working to protect: our Nation and its citizens.

From our inception in 1961 to our declassification to the public in 1992, we have worked tirelessly to provide the best reconnaissance support possible to the Intelligence Community (IC) and Department of Defense (DoD). We are unwavering in our dedication to fulfilling our vision: Vigilance From Above.

- **The National Reconnaissance Office**
- **Leadership**
- **NRO Launches**
- **Business Opportunities**
- **No Fear Act**

http://www.nro.gov/history/index.html

Site Policies | Links | Site Map | Site Support

Launch of 8th US InSAR Satellite - December 5, 2013 NROL-39

A classified U.S. spy payload rocketed into orbit from California on an Atlas 5 launcher Thursday (Dec. 5), joining the nation's eyes and ears in the sky to supply intelligence to the government's national security agencies.

The satellite is owned by the National Reconnaissance Office, but government officials do not disclose the identities of the NRO's spacecraft, only saying the payload will serve national security purposes.

But independent satellite-watchers believe the spacecraft will join the **NRO's fleet of spacecraft with radars** to penetrate cloaks of clouds and darkness and reveal what adversaries are doing regardless of weather or time of day.

According to top secret budget documents leaked by Edward Snowden and published by the Washington Post in August, the radar spy satellites are given the codename "Topaz" and replace a previous generation of radar-equipped "Onyx" spacecraft.

by Stephen Clark, Spaceflight Now, Dec. 7, 2013.

Search

NATIONAL RECONNAISSANCE OFFICE

CORONA

CORONA was the nation's first photo reconnaissance satellites, operating from August 1960 until May 1972. The program was declassified at the request of the Central Intelligence Agency in February 1995. The **Index of the Declassified CORONA, ARGON, and LANYARD Records** are available.

Press Releases & Abstracts

- **CORONA Star Catchers: Interviews with the Air Force Aerial Recovery Flight Crews of the 6593d Test Squadron (Special), 1958 - 1972**
- **Intelligence Revolution: 1960: Retrieving the CORONA Imagery That Helped Win the Cold War**
- **Pioneer Spy Satellites to be Lauded**
- **President Orders Declassification of Historic Satellite Imagery**
- **Executive Order**
- **CORONA: Success for Space Reconnaissance** - Abstract from Photogrammetric Engineering & Remote Sensing Vol 61, No. 6, June 1995

CORONA Information:

- **Fact Sheet**
- **Imagery**
- **System Information**
- **Video Library**
- **Pioneers in the Field**
- **CORONA Interactive Model**

Adobe® Reader® is needed to view Adobe PDF files. If you don't already have Adobe Reader installed, you may download the current version at www.adobe.com (opens in a new window).

http://www.nro.gov/history/csnr/corona/index.html

CORONA Fact Sheet

"Firsts" in History	• 1^{st} photo reconnaissance satellite in the world • 1^{st} mid-air recovery of a vehicle returning from space • 1^{st} mapping of earth from space • 1^{st} stereo-optical data from space • 1^{st} multiple reentry vehicles from space • 1^{st} reconnaissance program to fly 100 missions • 1^{st} reconnaissance satellite program to be declassified
Imagery Statistics	• Imaging resolution was originally 8 meters (25 feet), but improved to 2 meters (6 feet) • Individual images on average covered an area of approximately 10 miles by 120 miles
Production Statistics	• Operated for nearly 12 years • Over 800,000 images taken from space • Collection includes 2.1 million feet of film in 39,000 cans

CORONA Launches – from: Eye in the Sky, Day et al., 1998

#	date	operation	result
1	1959 FEB 28	FLYING YANKEE	Agena failed to orbit?
2	1959 APR 13	EARLY TIME	SRV lost in Spitzbergen
3	1959 JUN 03	GOLD DUKE	Agena fell in Pacific
4	1959 JUN 25	LONG ROAD	Agena fell in Pacific
5	1959 AUG 13	FLY HIGH	SRV shot to higher orbit
6	1959 AUG 19	HURRY UP	SRV lost in reentry
7	1959 NOV 07	CARGO NET	SRV failed to separate
8	1959 NOV 20	LIVID LADY	Agena overburn, SRV sank
9	1960 FEB 04	HUNGRY EYE	Agena fell in Pacific
10	1960 FEB 19	DERBY DAN	Thor destroyed
11	1960 APR 15	RAM HORN	SRV destroyed in reentry
12	1960 JUN 29	RED GARDER	Agena fell in Pacific
13	1960 AUG10	FROGGY BOTTOM	SRV recovered from Pacific
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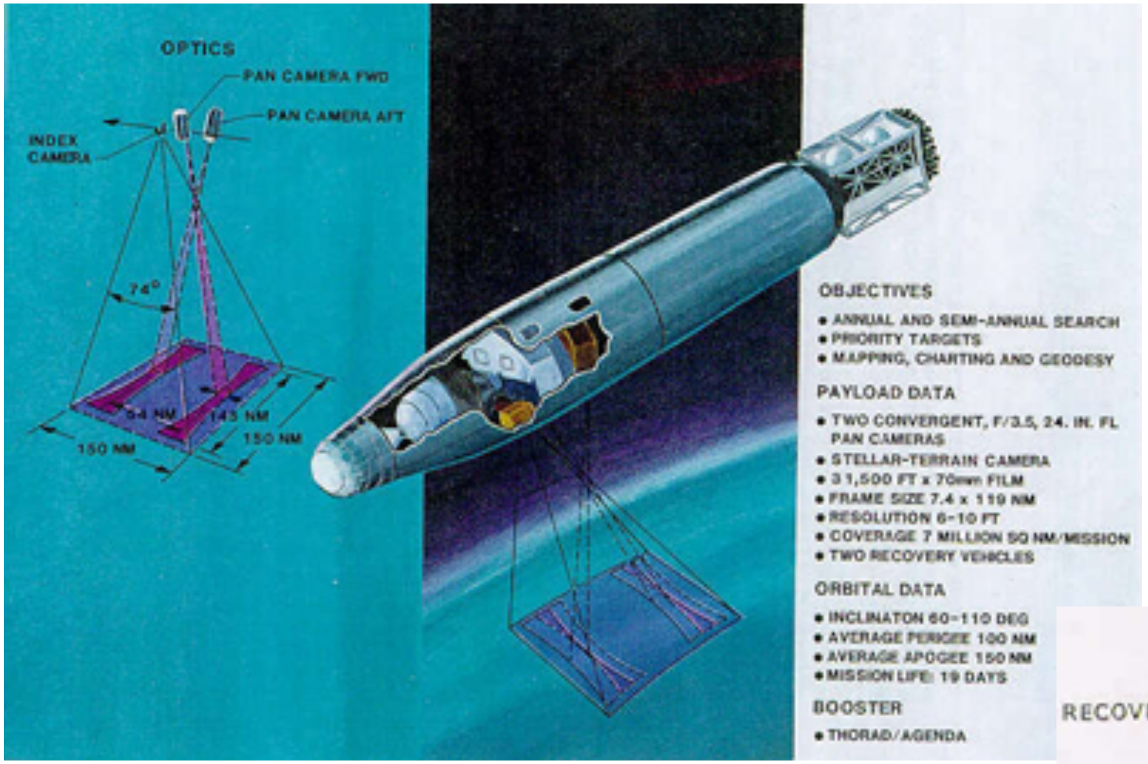
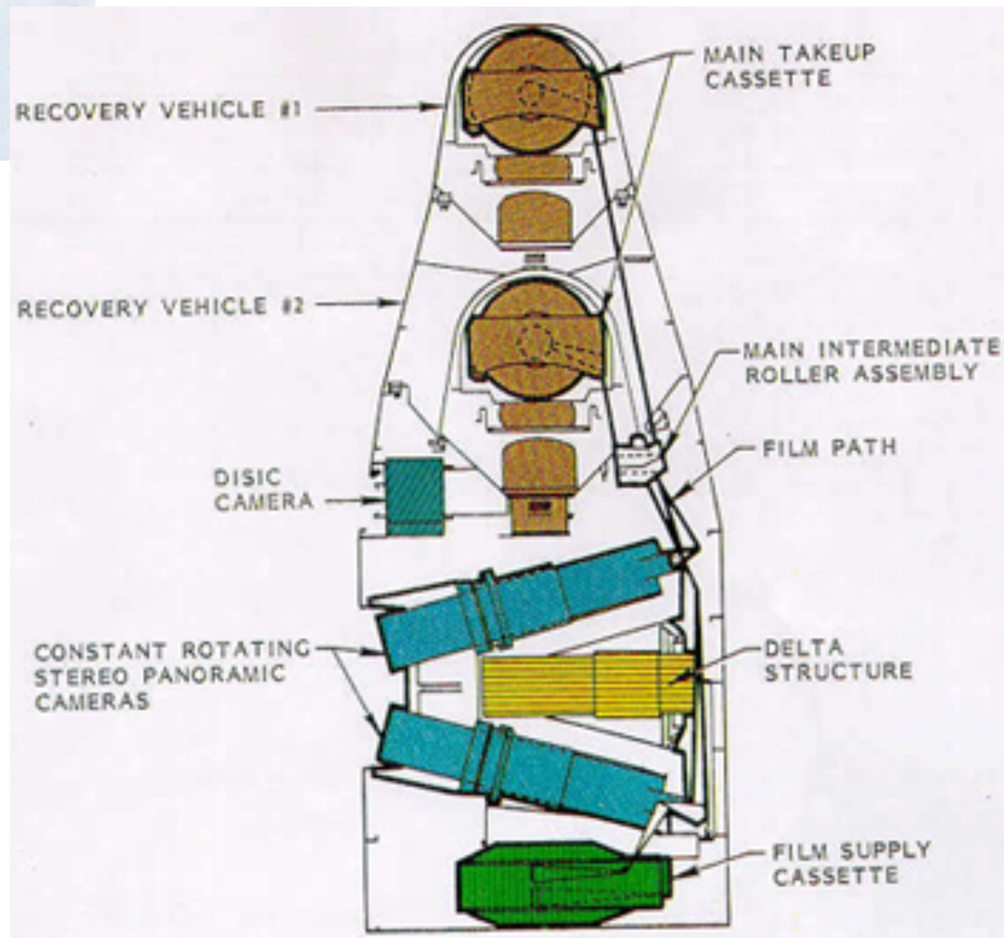
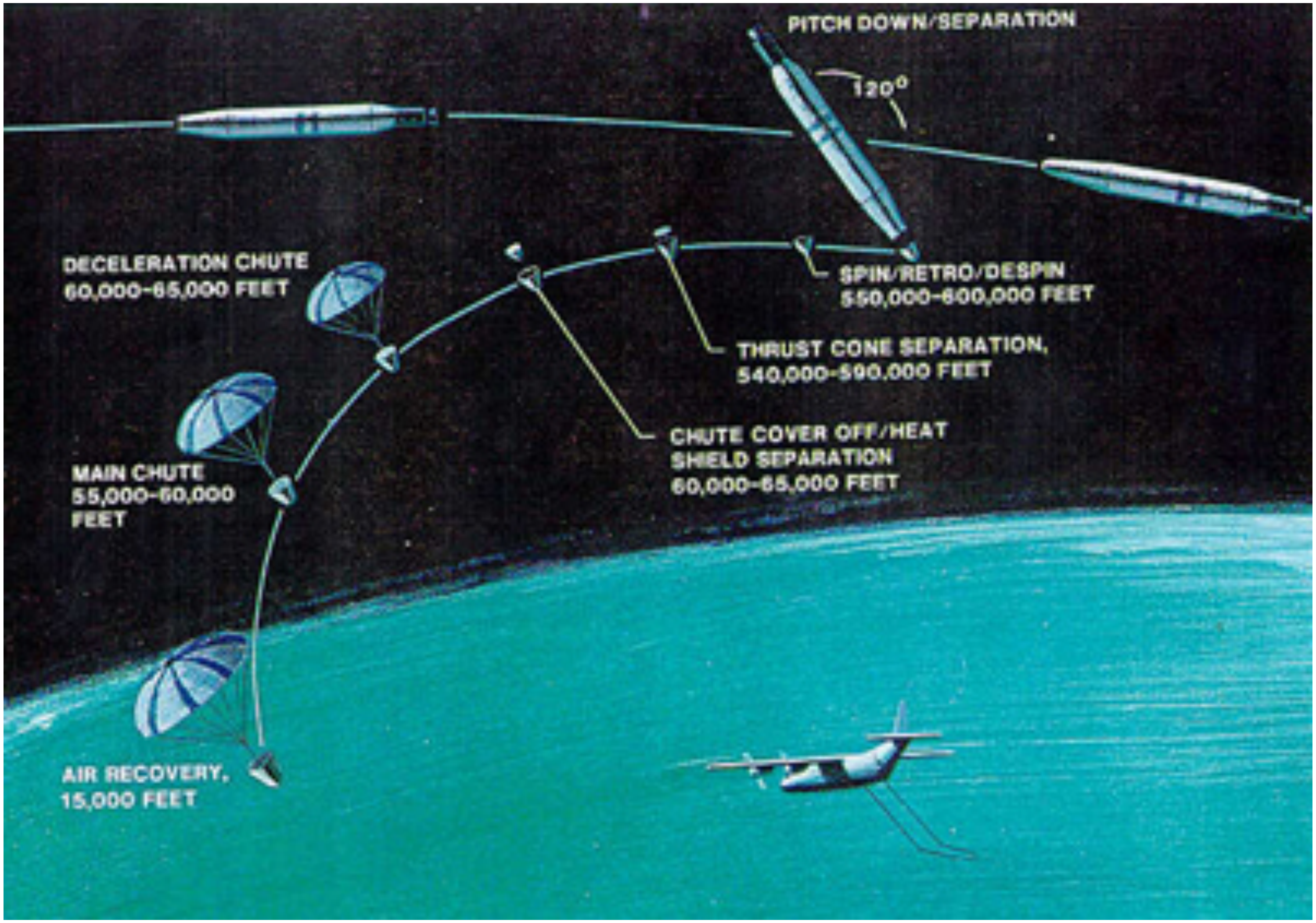
.			
145	1972 MAY 25	6371	SRV-1 and SRV-2 recovered

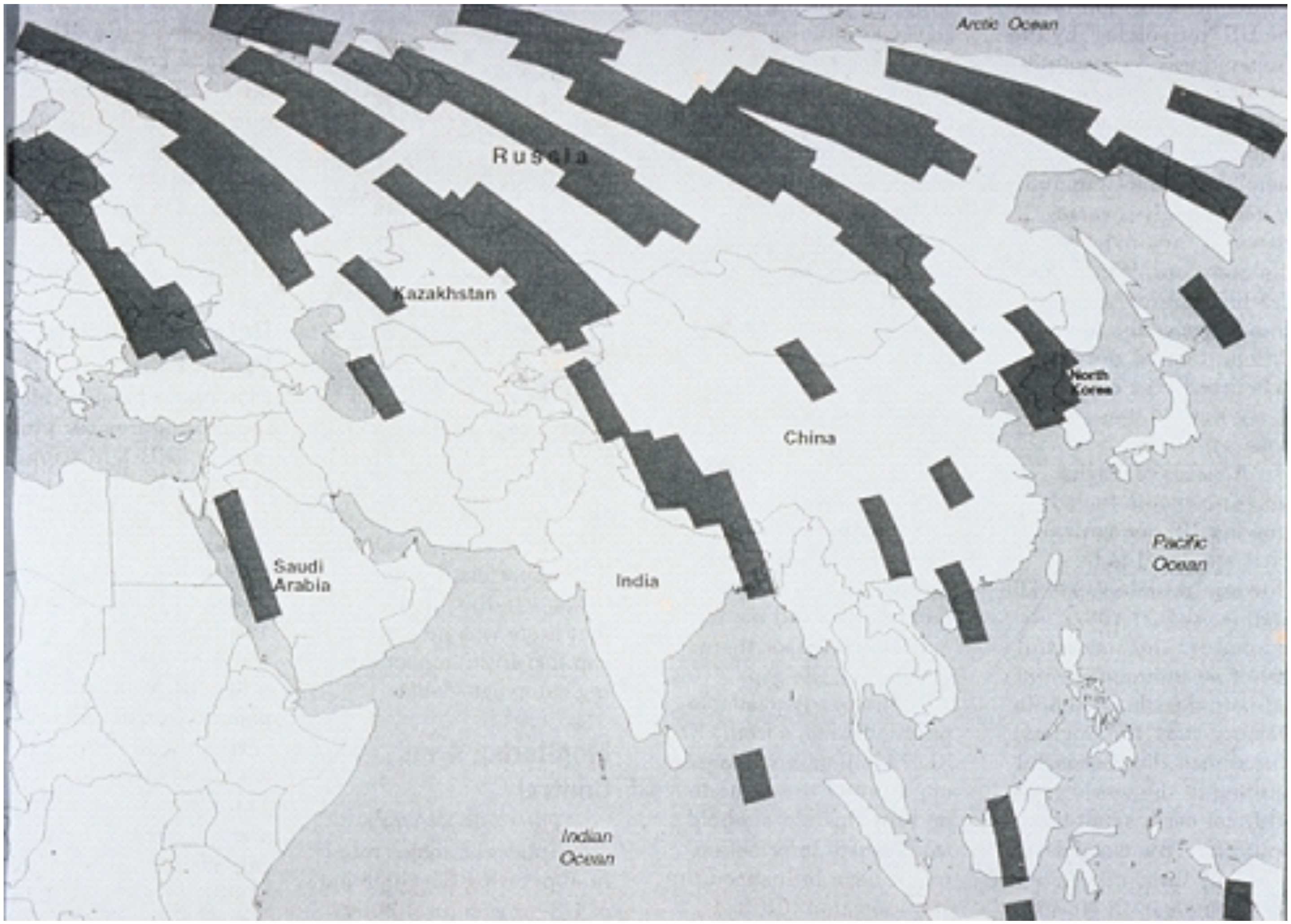
CORONA Cameras





CORONA Film Recovery

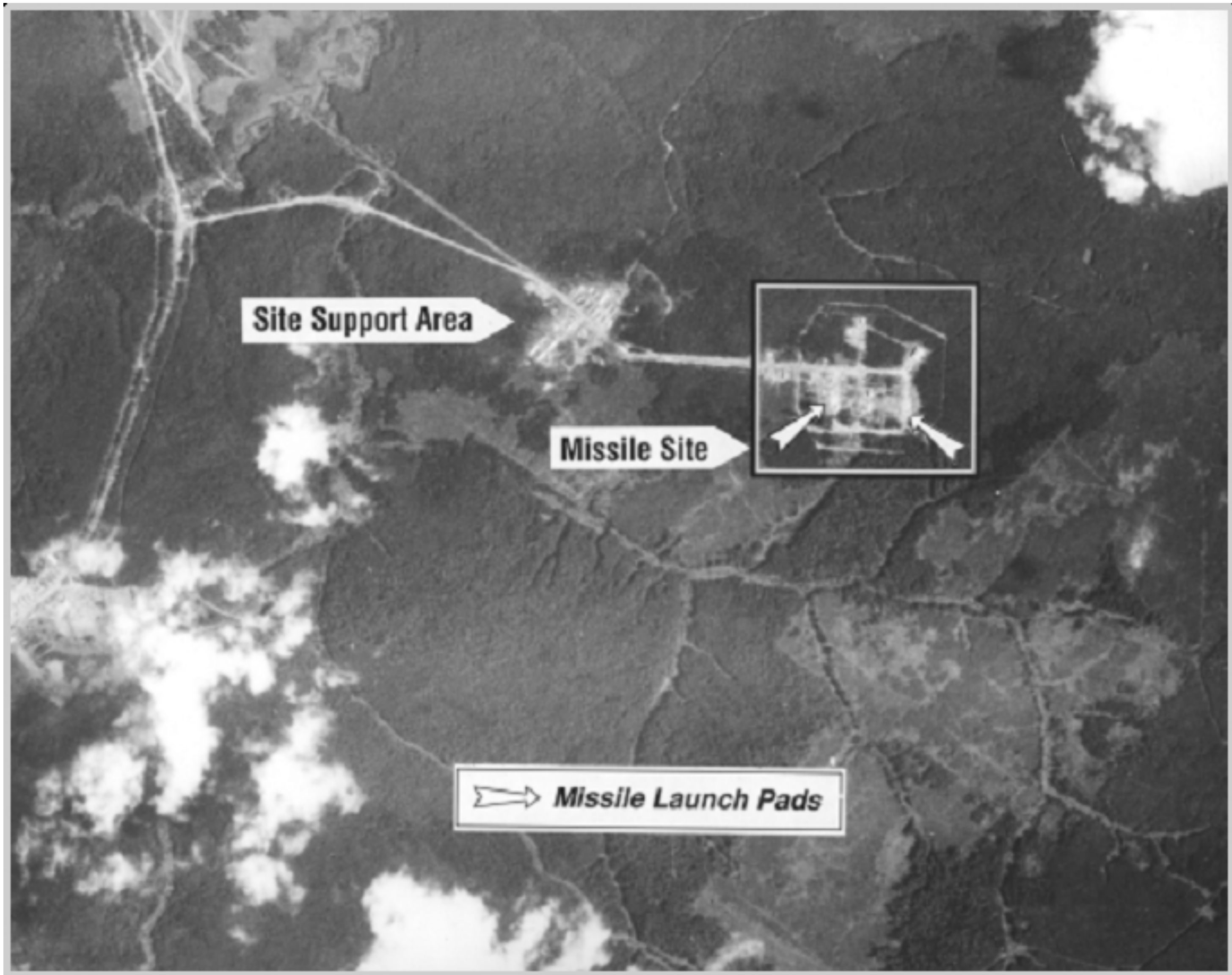




Example of Four-Day Coverage of Eurasia During KH-4A Mission 1017

CORONA Imagery

An SA-2 Launch Site Near Chelyabinsk, USSR 8 Feb 1969



Yurya ICBM Complex Showing Construction of an SS-7 Launch Site (Mission 9038, June 28, 1962)

President Lyndon Johnson, March 16, 1967

“I wouldn’t want to be quoted on this but we’ve spent 35 to 40 billion dollars on the space program. And if nothing else came out of it except the knowledge we gained from space photography, it would be worth 10 times what the whole program cost. Because tonight we know how many missiles the enemy has and , it turned out, our guesses were way off. We were doing things we didn’t need to do. We were building things we didn’t need to build. We were harboring fears we didn’t need to harbor. Because of satellites, I know how many missiles the enemy has.”

Glacier changes in the Siberian Altai Mountains, Ob river basin, (1952–2006) estimated with high resolution imagery

A B Surazakov[1], V B Aizen[1], E M Aizen[1] and S A Nikitin[2]

1 Department of Geography, The University of Idaho, Moscow, ID 83844-3025, USA
2 Glacio-Climatological Laboratory, Tomsk State University, Lenina 36, Tomsk 634050, Russia

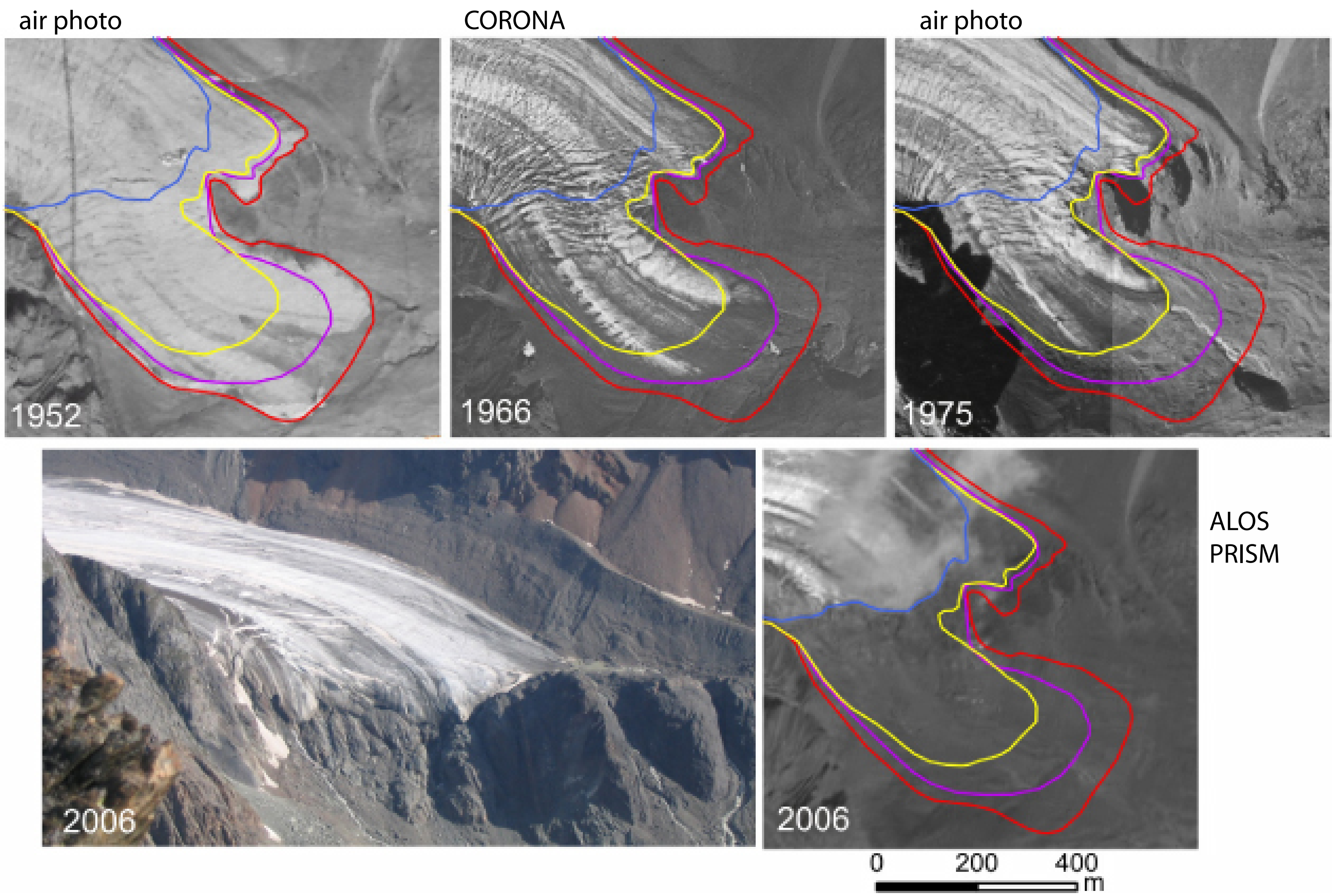
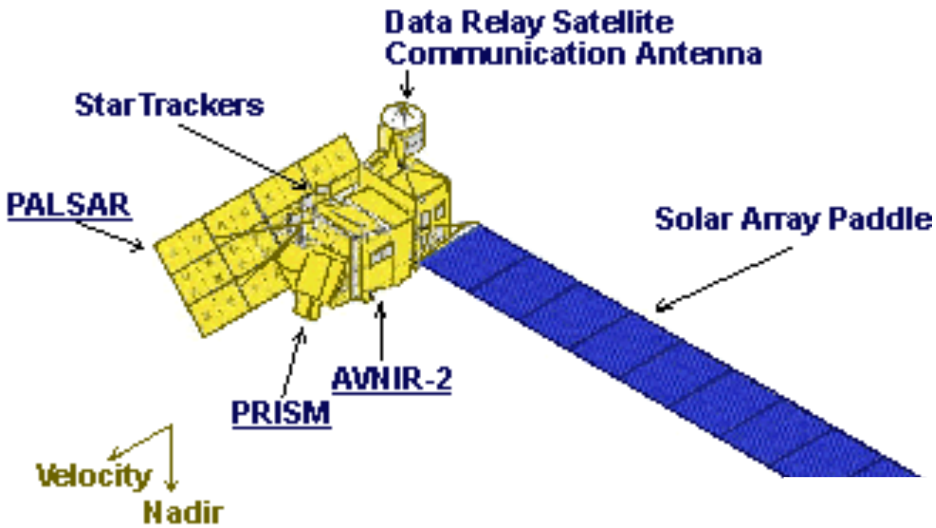


Figure 3. Multitemporal boundaries of the Leviy Aktru glacier terminus overlaid on the orthorectified imagery. On the 2006 PRISM image a light cloud partly obscured the glacier boundary. The lower left image is an oblique photograph taken during the 2006 field work.

Advanced Land Observing System
JAXA 2006

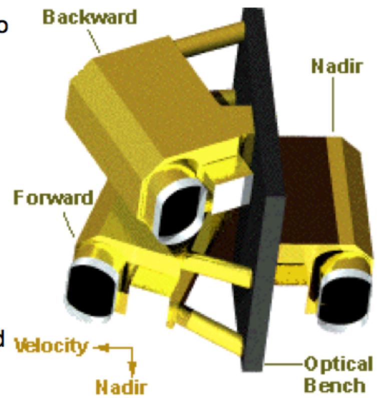


ALOS Characteristics

Launch Date	Jan. 24, 2006
Launch Vehicle	H-IIA
Launch Site	Tanegashima Space Center
Spacecraft Mass	Approx. 4 tons
Generated Power	Approx. 7 kW (at End of Life)
Design Life	3 -5 years
Orbit	Sun-Synchronous Sub-Recurrent
	Repeat Cycle: 46 days Sub Cycle: 2 days
	Altitude: 691.65 km (at Equator)
	Inclination: 98.16 deg.
Attitude Determination Accuracy	2.0×10^{-4} degree (with GCP)
Position Determination Accuracy	1m (off-line)
Data Rate	240Mbps (via Data Relay Technology Satellite) 120Mbps (Direct Transmission)
Onboard Data Recorder	Solid-state data recorder (90Gbytes)

PRISM

Panchromatic Remote-sensing Instrument for Stereo Mapping



The Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) is a panchromatic radiometer with 2.5m spatial resolution at nadir. Its extracted data will provide a highly accurate digital surface model (DSM). PRISM has three independent optical systems for viewing nadir, forward and backward producing a stereoscopic image along the satellite's track. Each telescope consists of three mirrors and several CCD detectors for push-broom scanning. The nadir-viewing telescope covers a width of 70km; forward and backward telescopes cover 35km each.

The telescopes are installed on the sides of the optical bench with precise temperature control. Forward and backward telescopes are inclined +24 and -24 degrees from nadir to realize a base-to-height ratio of 1.0. PRISM's wide field of view (FOV) provides three fully overlapped stereo (triplet) images of a 35km width without mechanical scanning or yaw steering of the satellite. Without this wide FOV, forward, nadir, and backward images would not overlap each other due to the Earth's rotation.

PRISM Characteristics

Number of Bands	1 (Panchromatic)
Wavelength	0.52 to 0.77 micrometers
Number of Optics	3 (Nadir; Forward; Backward)
Base-to-Height ratio	1.0 (between Forward and Backward view)
Spatial Resolution	2.5m (at Nadir)
Swath Width	70km (Nadir only) / 35km (Triplet mode)
S/N	>70
MTF	>0.2
Number of Detectors	28000 / band (Swath Width 70km) 14000 / band (Swath Width 35km)
Pointing Angle	-1.5 to +1.5 degrees (Triplet Mode, Cross-track direction)
Bit Length	8 bits

HOMEWORK 5 - due May 7. Please hand in paper for homework and e-mail matlab files for labs.

1) (a) Calculate the minimum repeat cycle time needed to completely image the earth at 5 m resolution with an optical sensor in a sun synchronous orbit at 800 km altitude. The data downlink rate is 30 megabytes per second. The sensor has a single band that requires 1 byte per pixel for data storage. Assume that all the data are collected during the ascending cycles which cross the equator at noon, local time. (b) How does the minimum repeat cycle time change if the resolution is changes to 10 m?

2) (a) Make two different 3 by 3 filters that can be used to smooth or low-pass filter an image. (b) How can these same filters be used to roughen or high-pass filter an image.

3) (a) Explain what is meant by a station mask of a satellite receiving station. (b) What is meant by georeferencing a satellite image?

4) (a) How can a 1-byte array of numbers be used to represent a region where the overall elevation change is -1000 m to 1000 m. (b) What is the vertical step-size that can be represented in this case.

5) Develop a formula for measuring the height of a building h using a single optical image from a satellite orbiting at an altitude of H. The focal length of the camera is f. Assume that the building height h is much less than the altitude of the satellite. Using this formula explain why this technique will fail when the picture is taken directly above the building.

DESIGN OF MODERN OPTICAL SATELLITE – ALOS PRISM