AIRBORNE REMOTE SENSING in the post World War II era

UMR

- **The F-13A was the designation given to the photo-reconnaissance version of the B-29. A photo reconnaissance system designed by the Air Technical Service Command and Fairchild Photographic Company was installed in B-29 and B-29A aircraft pulled from the assembly lines. America produced 2,132 B-29 bombers.**

F-13 Superfortress

- All 'Foto' B-29s were designated F-13A, no matter what type of B-29 they were based on. At the Continental Air Lines Denver Modification Center a bank of six cameras were installed behind and below the aft crew compartment. These included three K-17Bs, two K-22s, and a single K-18 camera sighting through square windows cut into the bottom and sides of the rear fuselage. Sighting was made through a modified B-3 Driftmeter in the bombardier compartment and operated by the Photo-Navigator. Fuel tanks were installed in the rear bomb bay while the front bomb bay could hold either photo flash bombs or a cargo platform with additional film or special cameras. All defensive armament was retained and the standard eleven man crew was supplemented with a Photo-Navigator and a cameraman.

- **The first F-13A, Tokyo Rose, arrived in the Marianas on October 13th 1944 and flew the first recon mission over Tokyo the same day. The photos proved invaluable during the later attacks on the Japanese capital. F-13As of the 1st and 3rd Photo Reconnaissance Squadrons (PRS) operated from both China and the Marianas until the end of the war.**

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- **The 46th/72nd Reconnaissance Squadron flew modified F-13s out of Ladd Field in Fairbanks, Alaska between 1946-48, establishing a grid system of polar navigation so our strategic air forces could monitor activities within and adjacent to the Soviet Union. All missions maintained radio silence as they began flying over the Polar Ice Cap on August 2, 1946. In 1947 one of these aircraft found itself flying through formations of Soviet Tu-4 Bull bombers inside the Soviet Union, without being noticed!**

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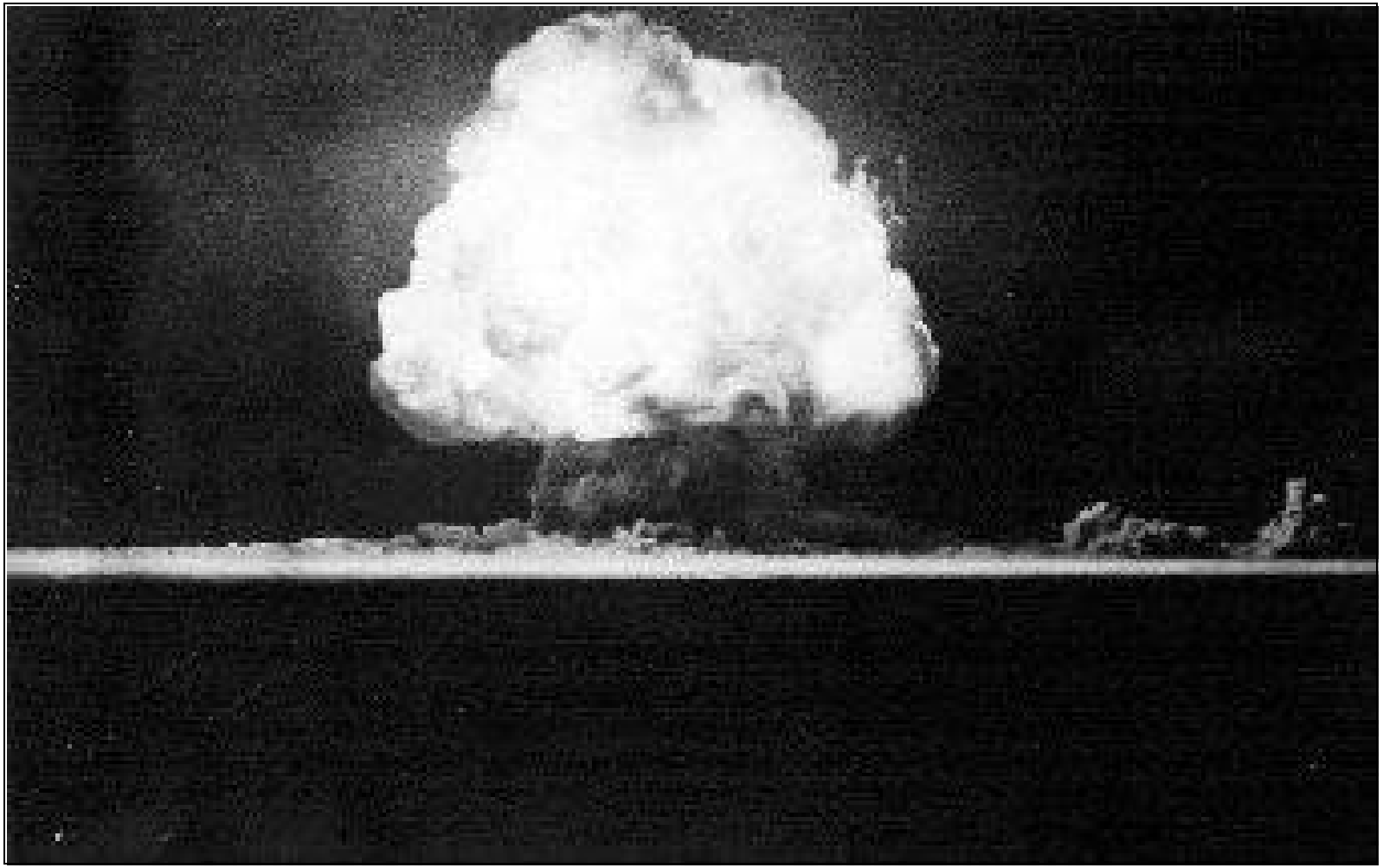
- **WB-29s were modified from production B-29s for weather reconnaissance missions. Besides conducting standard weather data gathering flights, WB-29s were also used as "Hurricane Hunters." The aircraft would fly into the eye of the Hurricane or Typhoon to gather weather data. Some WB-29s were fitted with air sampling scoops to test for airborne radiation levels after nuclear weapon tests conducted above ground.**



- **The first Soviet atom bomb was detonated on 29 August 1949 from a 30m (100 ft) tower 70km south of Semipalatinsk-21. It yielded 20 kilotons**

UMR

- On September 3, 1949 an Air Weather Service WB-29 flying from Japan to Alaska picked up atomic particles in a paper filter. Lab tests revealed that the filter, which had been exposed at 18,000 feet for three hours, contained a significant radiation count of 50 per minute. Subsequent flights revealed counts of up to 1,000 per minute. President Truman announced on September 23, 1949, that the Soviet Union had exploded a nuclear device.

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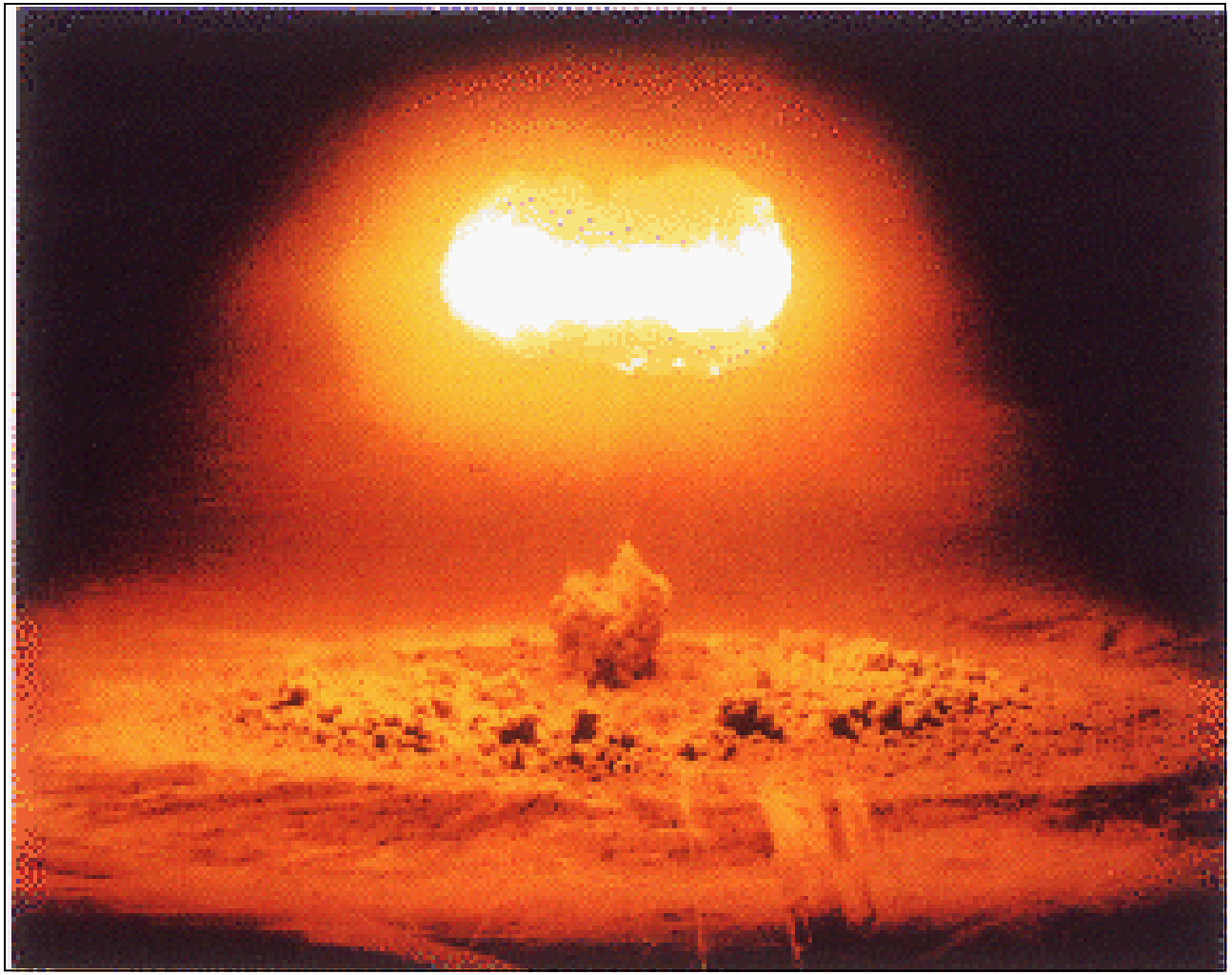
- **The second Soviet atom bomb was also exploded from a tower on 24 September 1951; it was half the weight of the first and yielded 40-50 kilotons. An identical bomb was dropped from a Tu-4 like this one on 18 October 1951. It was their third bomb, but the first aerial drop. The CIA concluded that this was an airburst.**

UMR



- **The Soviet's first aerial drop of an H-bomb was not until 22 November 1955, two years and three months after the first ground-burst H-bomb test. The Americans detonated their first H-bomb on November 1, 1952.**

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- First aerial drop of a Soviet H-bomb was from a jet-powered Tupolev Tu-16 (painted white to reflect blast), because they did not have a plane capable of lifting the 12,000 lb weapon prior to this.

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The Lockheed U-2 spyplane first flew in August 1955 and was designed to fly at altitudes above 60,000 feet, above Soviet air defenses. It was intended to photograph sensitive activities deep within the Soviet Union. It has a high aspect ratio wing with a maximum and minimum speed variance of just 8 knots. It is very difficult to land.

Francis Gary Powers was shot down flying a U-2C on May 1, 1960, creating an international incident.

NASA U-2C is still used as a remote sensing testbed. The Gloster Meteor PR-19 (below) was a British attempt to construct a similar high altitude spy plane

A priority target during the Cold war was the Tyuratam-Baikonur Cosmodrome in the south central Soviet Union. Location map above and detail image at right.

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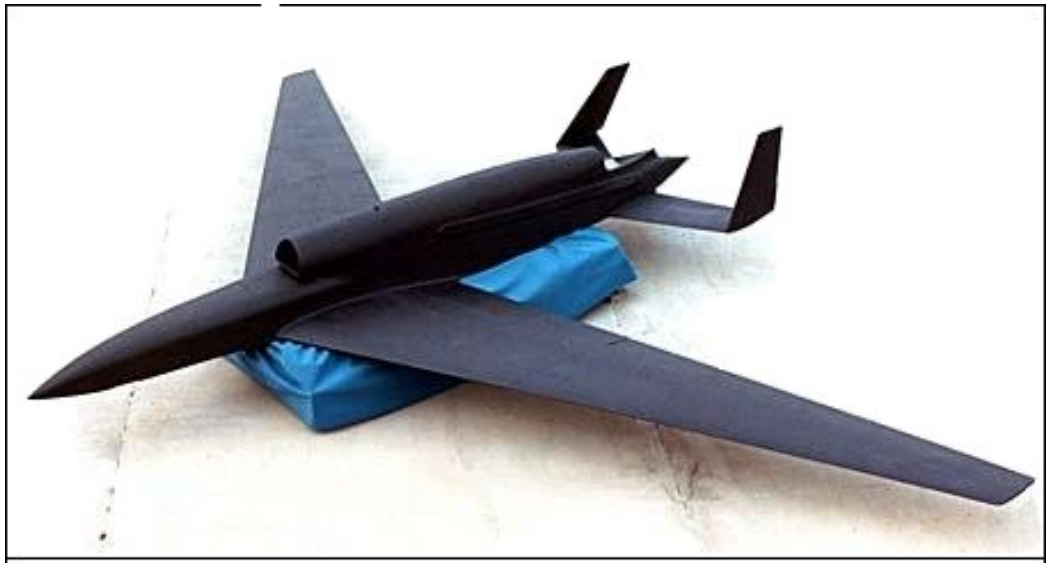
RECONNAISSANCE DRONES

During the Vietnam War, the Firebee target was modified to fly autonomous, pre-programmed, long-range reconnaissance missions

During the early 1960s several Hound Dog cruise missiles were converted into recee drones

MODEL 154 DRONES ON DC-130

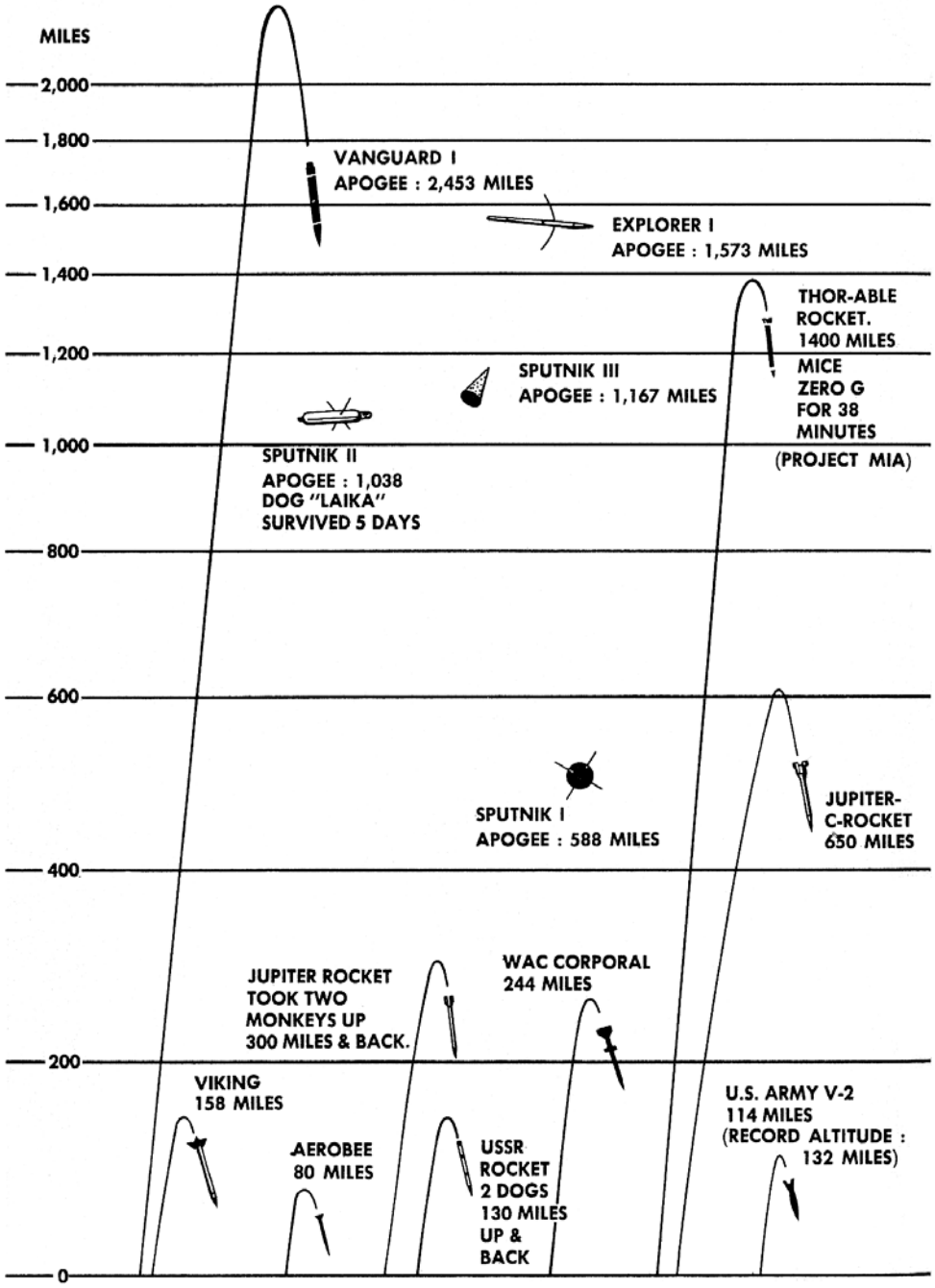


TELEDYNE-RYAN AQM-91A COMPASS ARROW
USAF Museum (http:// www.wpafb.af.mil / museum /)

- Beginning in the 1960s with the Firebee target drone Teledyne-Ryan has built a family of increasingly capable UAVs for the reconnaissance role, which were widely deployed in Southeast Asia

YQM-96A COMPASS COPE UAV (RYAN)

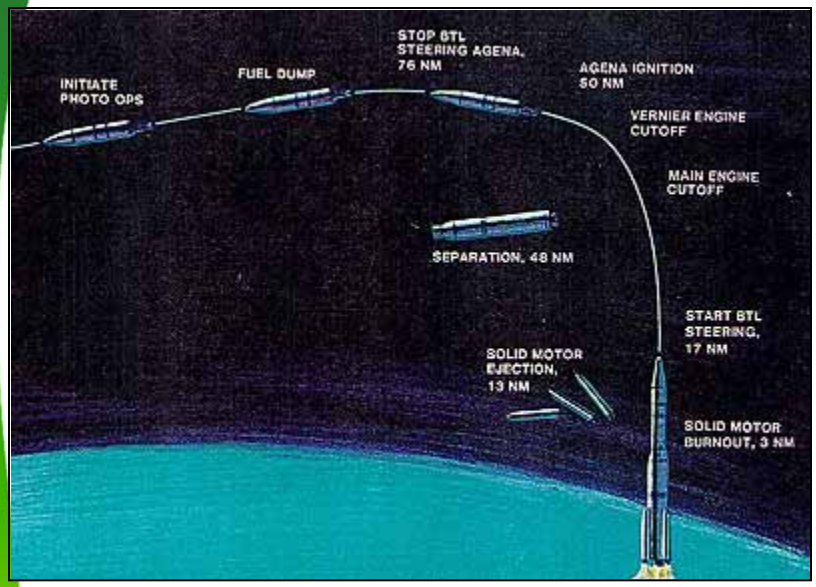
UMR

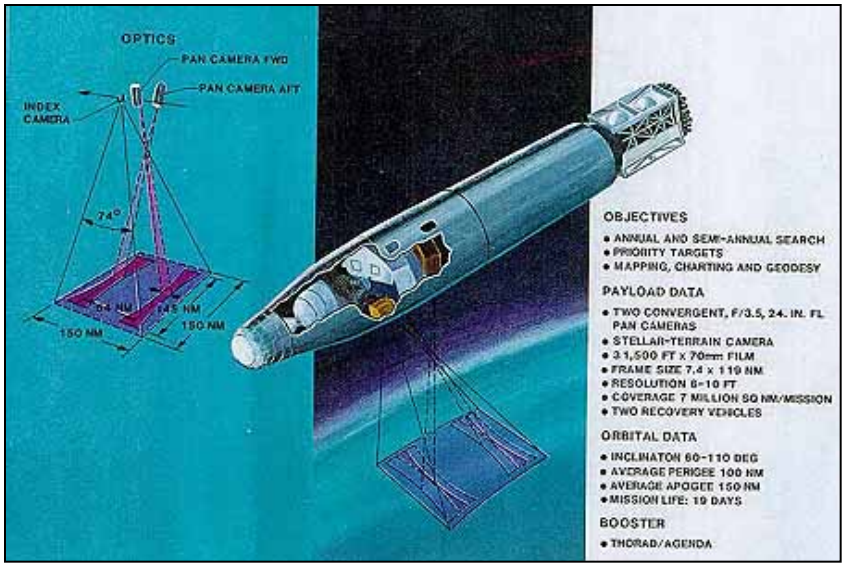


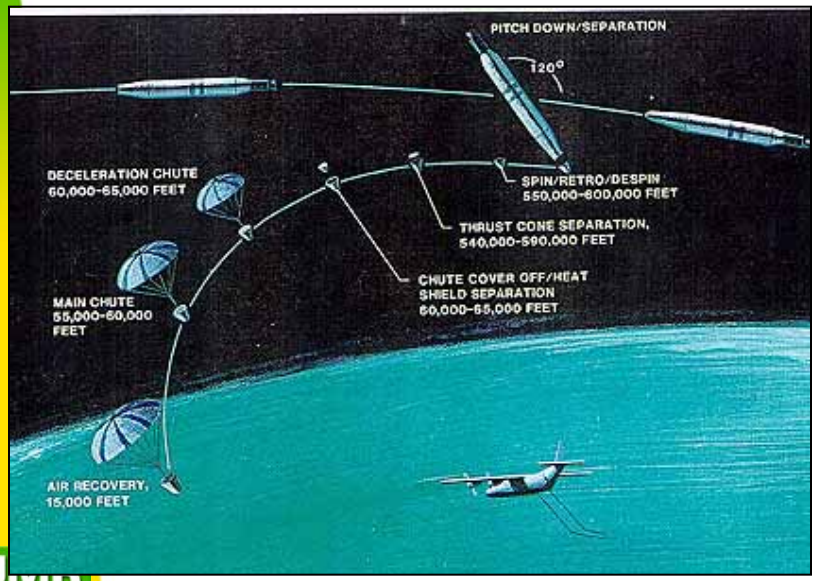
This diagram shows altitudes reached by some of the first well-known rockets and satellites. Men have gone no higher than 850 miles.

- **Missiles began launching payloads to orbital heights in the late 1950s, opening up the possibility for long-term orbital reconnaissance satellites equipped with an array of sensors**

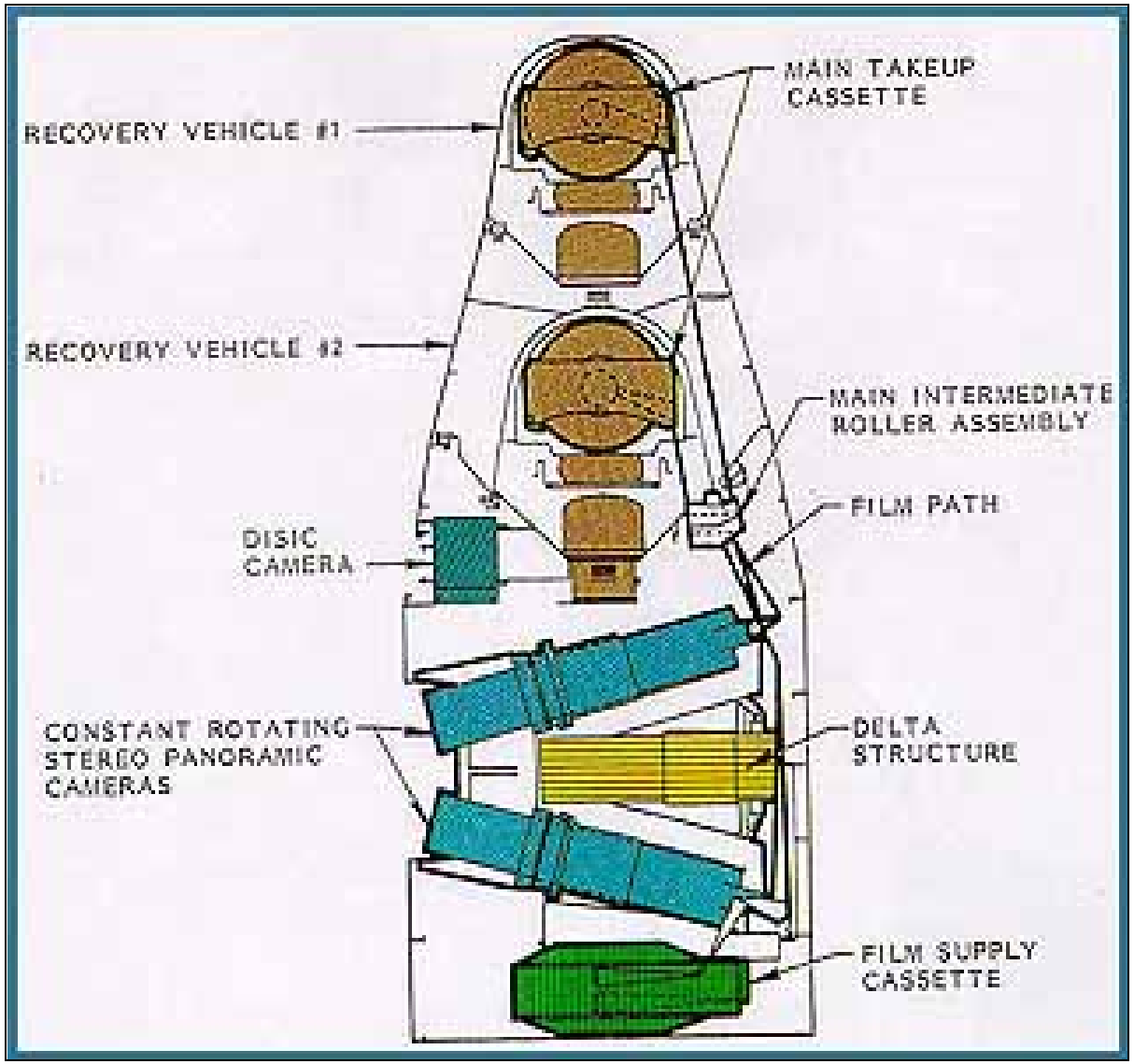
SPACE-BASED IMAGING







Between 1960-1972 the Corona Project collected 800,000 images, using KH-1 thru KH-4B cameras. Film had to dropped to Earth for processing.



A sophisticated set of static and rotating cameras evolved during the Corona Project to maximize coverage of large areas using rolled film from an altitude of 80 nautical miles

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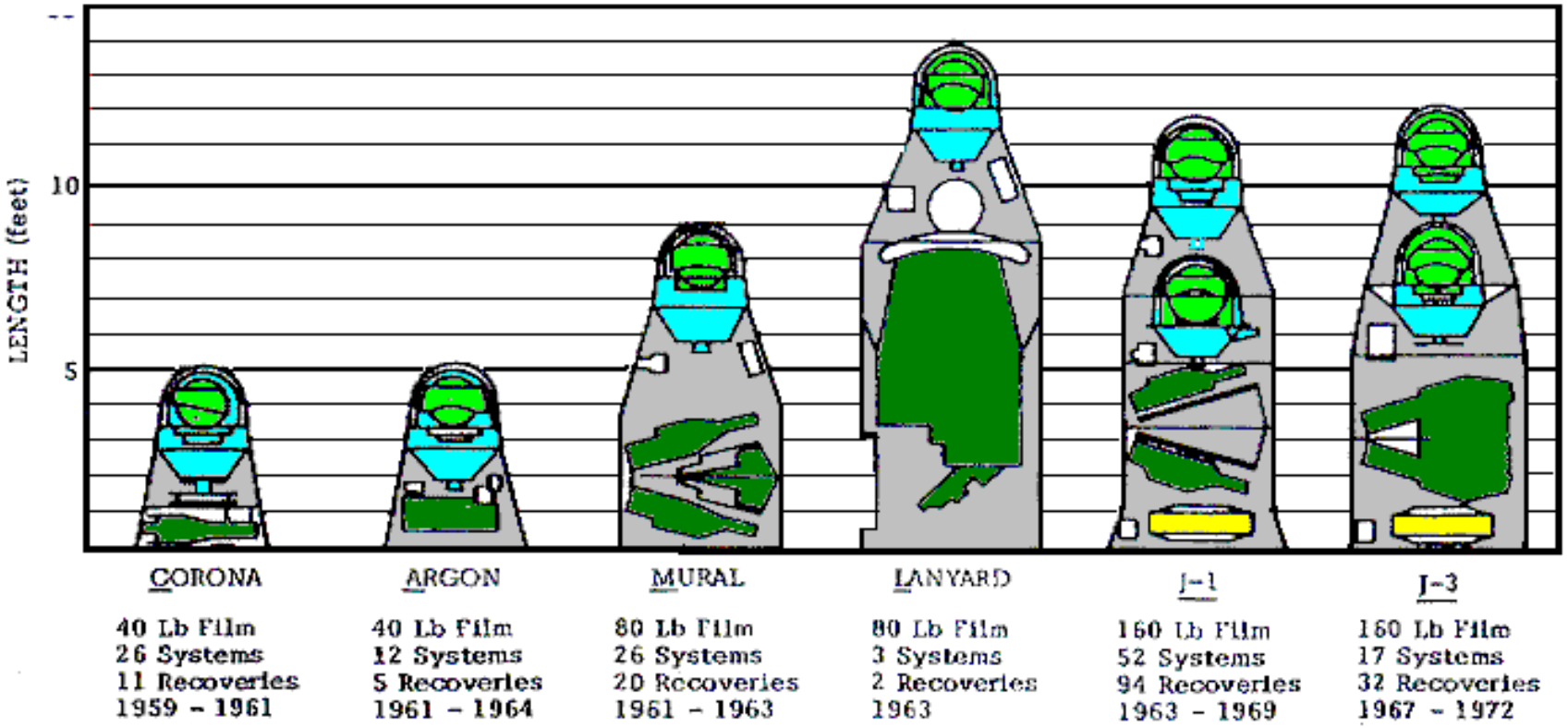

- **Spaced based cameras continued to evolve throughout the 1960s and early 1970s, when digital and multispectral collection began**

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YF-12/SR-71 Blackbird

Created in the wake of the Gary Powers shoot-down, the YF-12A was rolled out at Edwards AFB in 1964, creating a sensation. Designed to fly above 70,000 feet at Mach 3+, it was impossible to shoot down, but expensive to operate and was initially retired in 1993, then again in 1998.

The SR-71 could photograph 100,000 square miles of land (in 72-mile wide swaths) in just 64 minutes, recorded on 10,500 lineal ft of 5-inch wide color transparent film!

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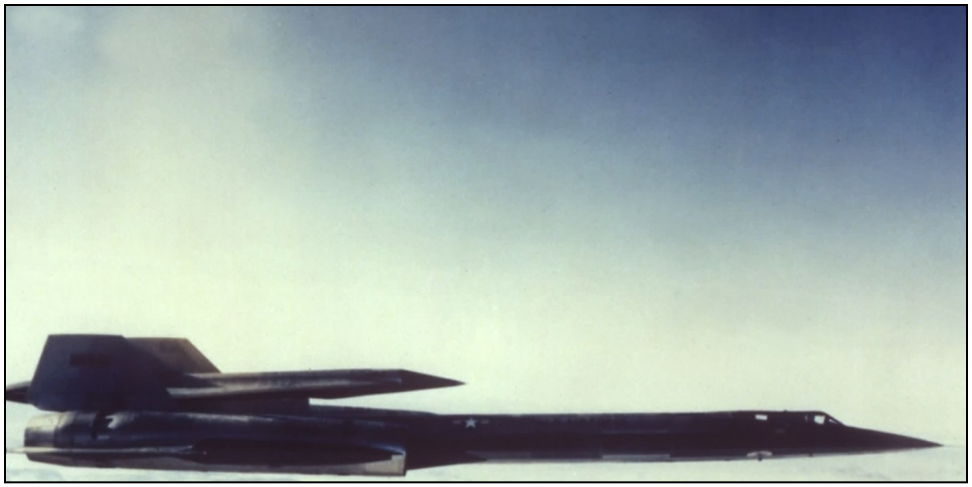
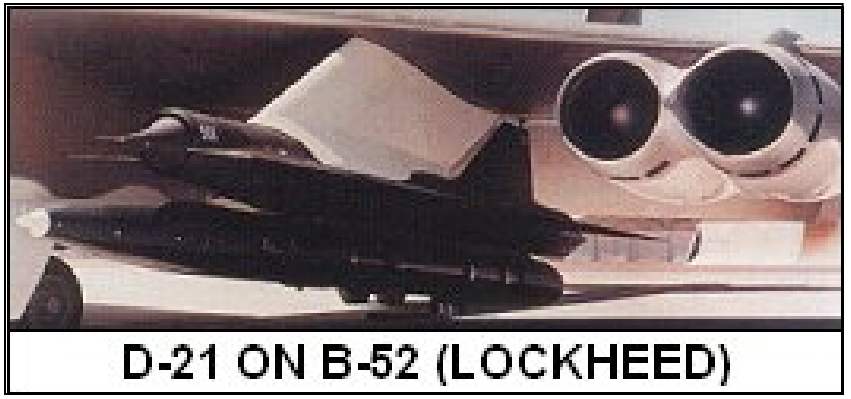
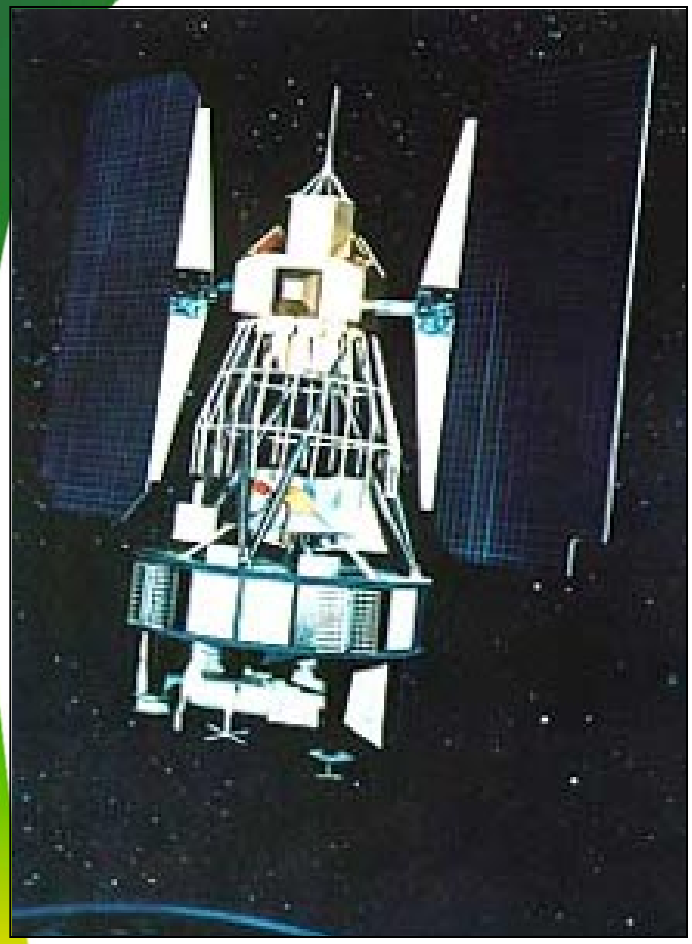
D-21 Drone

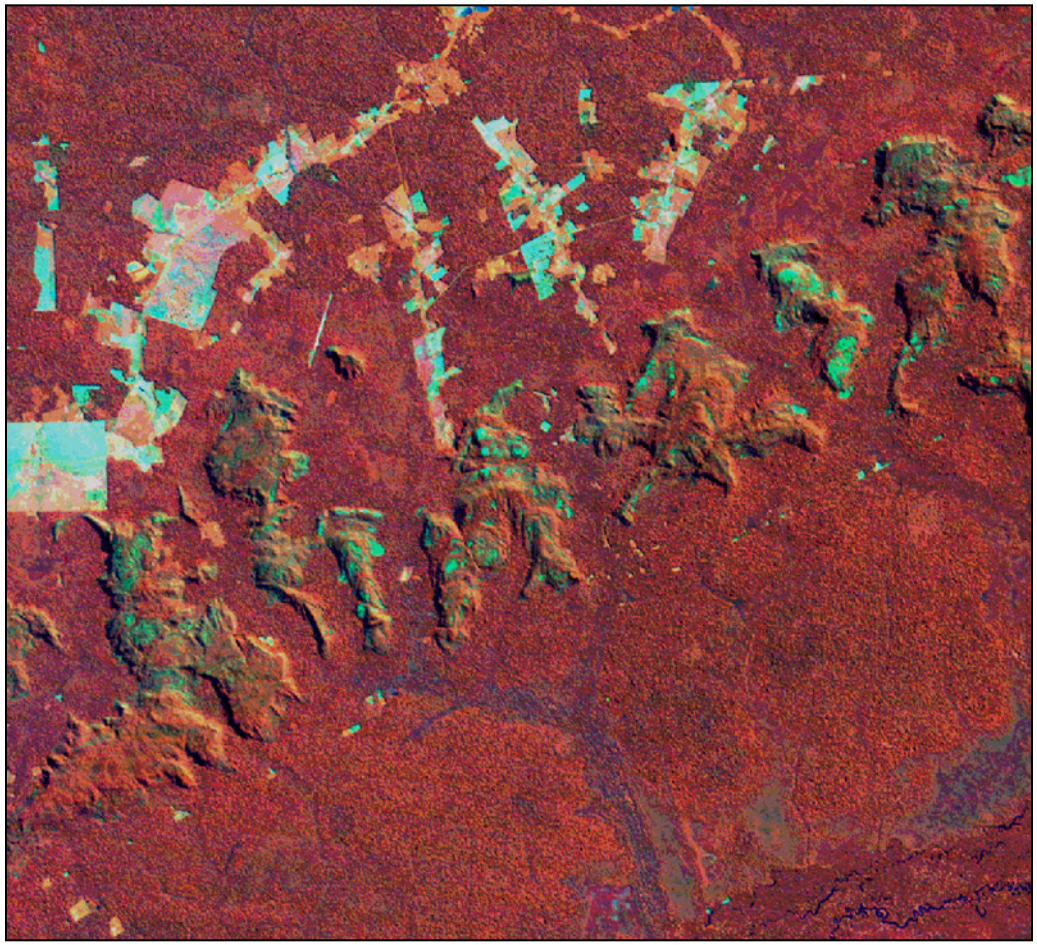




D-21 ON B-52 (LOCKHEED)

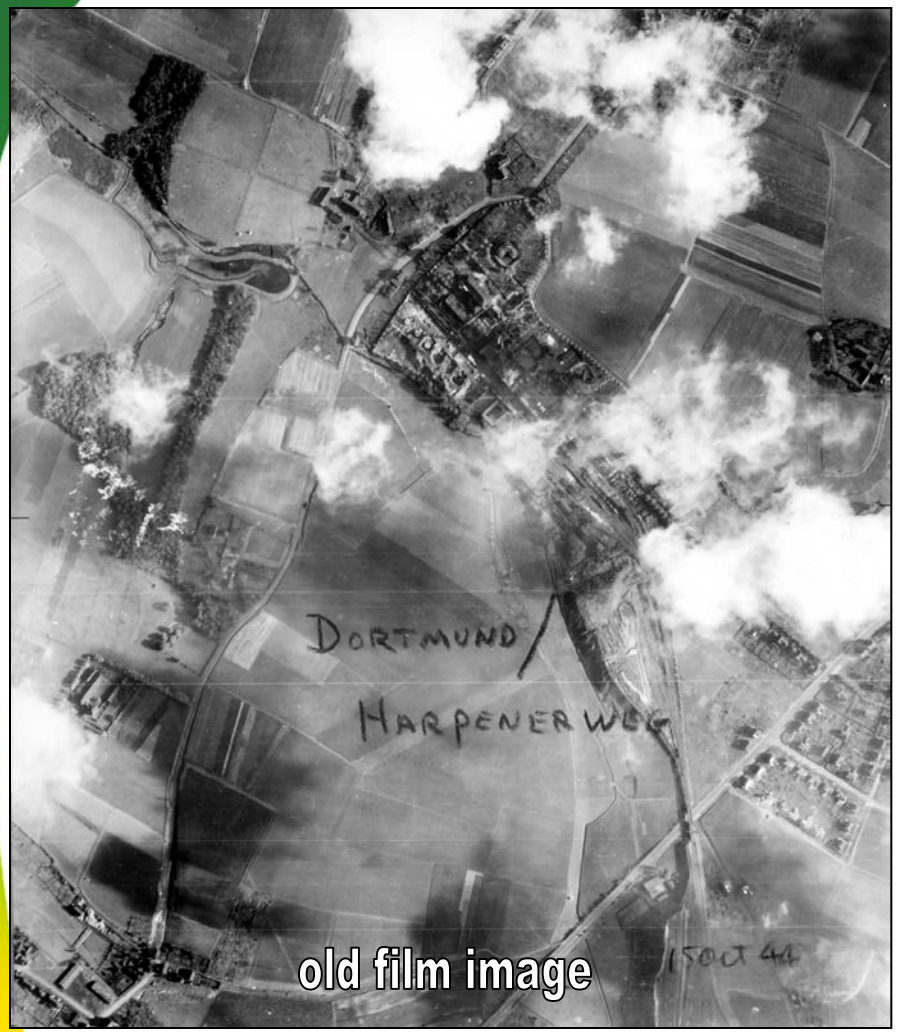
38 D-21 reconnaissance drones were built and were first unveiled at the Davis-Monthan AFB storage facility at Tucson in 1976-77, after their retirement. Details of their deployment remain sketchy.





- Landsat 1 or Earth Resource Technology Satellite (ERTS) was launched in mid-1972; with new launches every 3 years.
- Carried 3 cameras, a near IR scanner and a 4 channel MSS at altitude of about 570 miles
- Digital images measured 111 x 102 miles, but with resolution of only about 100 ft

UMR



After 1989 reconnaissance satellites shifted to Synthetic Aperture Radar, IR and thermal IR, operating between 150 to 600 miles altitude. These systems are capable of sensing through clouds and brush cover.

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HIGHER AND FASTER

- In 1969 the larger U-2R spy plane made its appearance, replacing the older versions. It is 40% larger than earlier versions of the U-2.
- The latest tactical reconnaissance version is the TR-1/U-2R, which first appeared in 1981, with the last delivery being made in 1989.
- It routinely flies missions at 70,000 feet

- **The U-2R underwent carrier landing and takeoff trails aboard the USS America in November 1969, during the Vietnam War. U-2C had undergone similar tests in 1963-64.**

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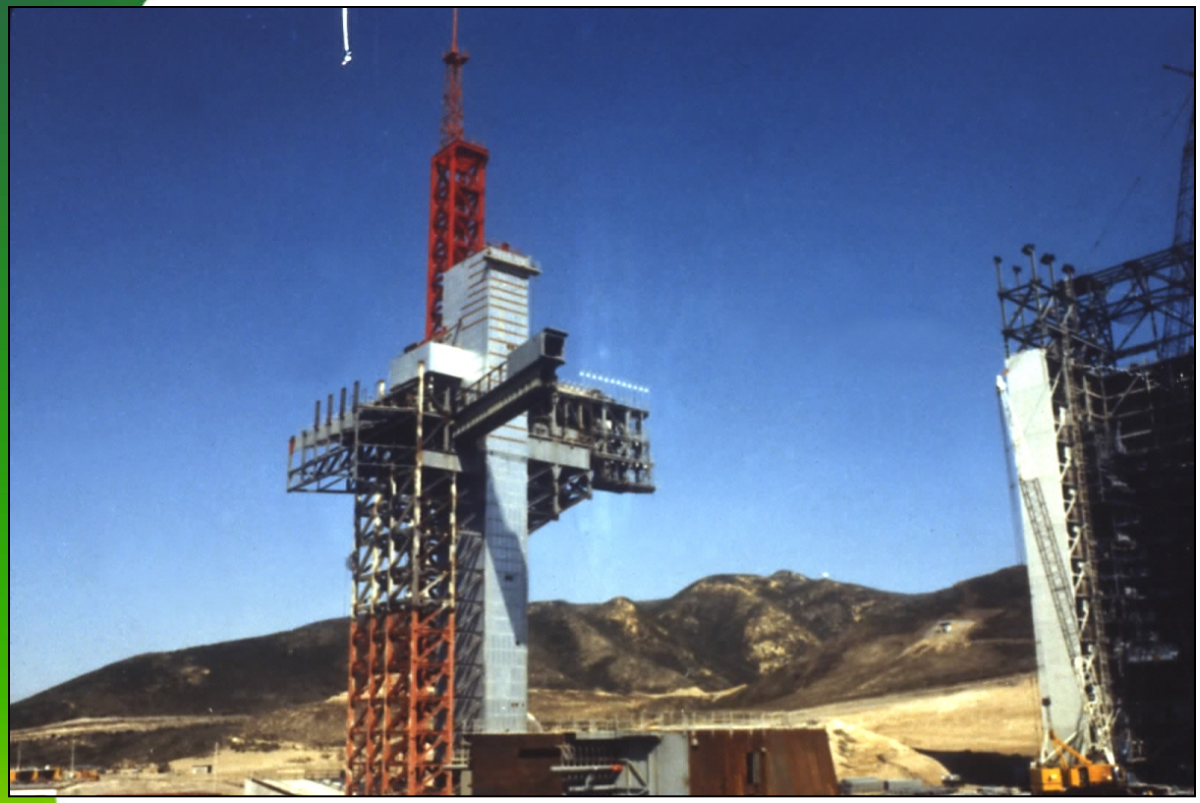
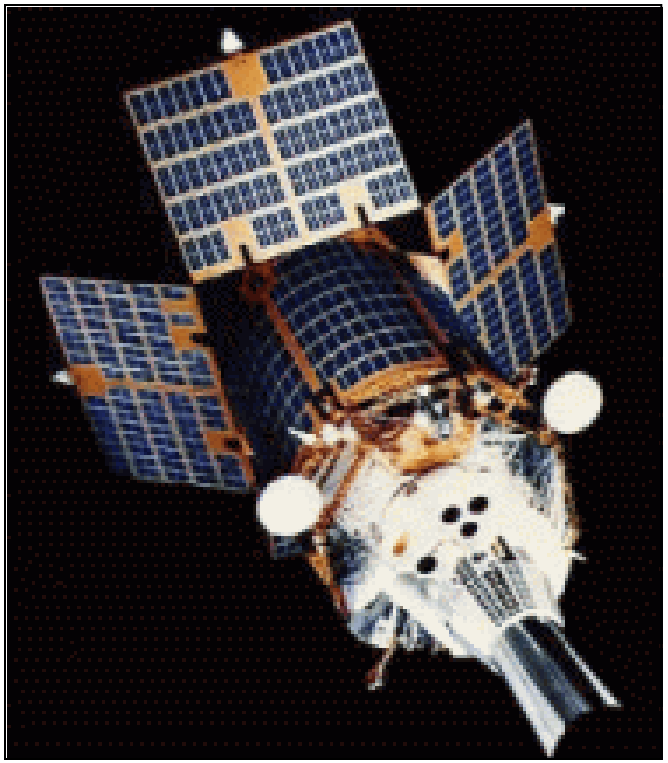
For the past 35 years U-2R's have been routinely deployed to global flash points from their home base at Beale AFB nears Marysville, CA.

- Slated to remain in service until 2020, it is being upgraded by the newer U-2S, equipped with more sophisticated sensing gear and increased range/staying power.

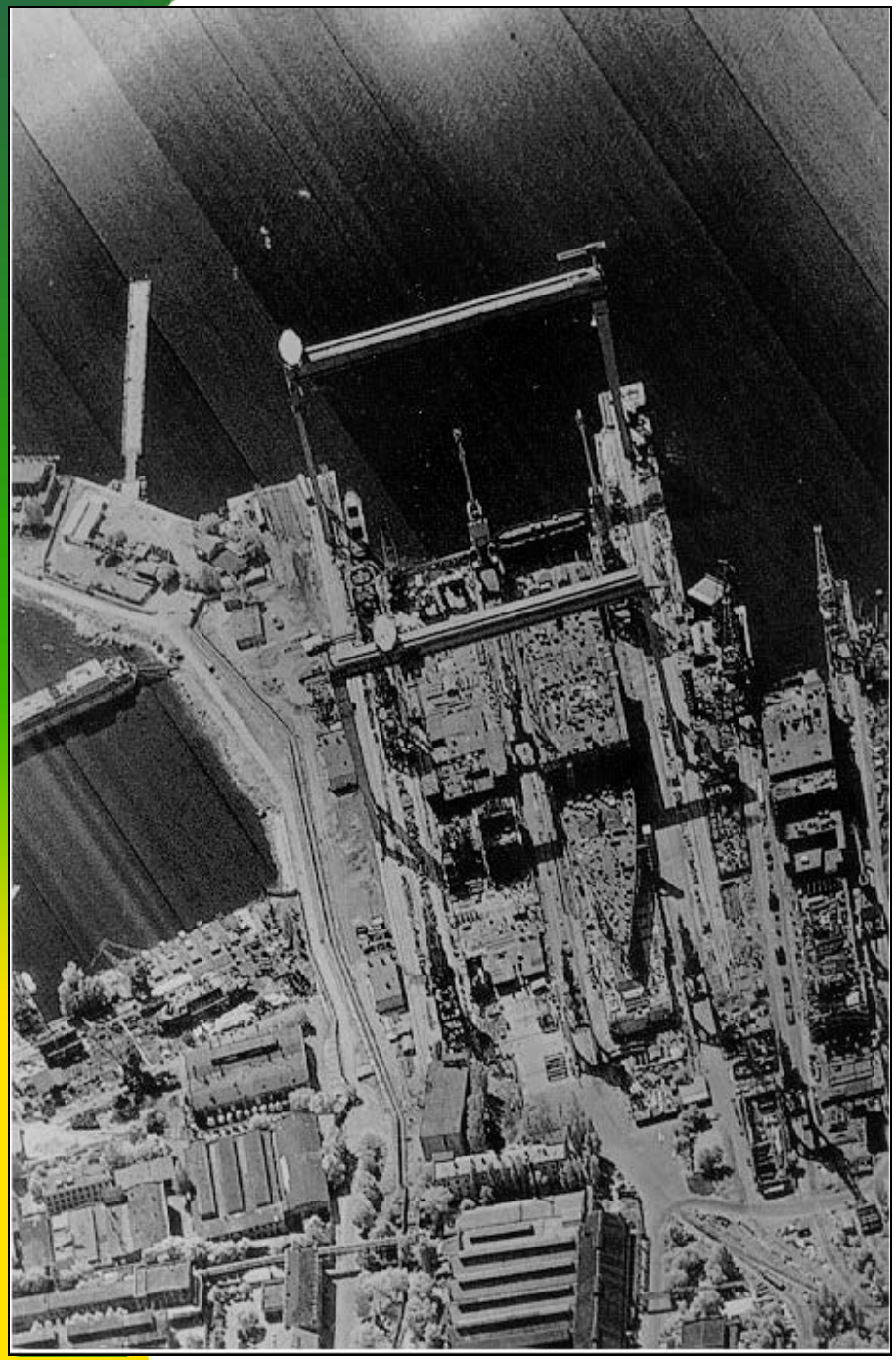
UMR





- Strategic reconnaissance was gradually shifted to satellite based platforms between 1972-85, enabling a wide array of intelligence collection, including imagery, radar, electronic intelligence, communications intelligence and threat intelligence. This Defense Support Program (DSP) satellite tracks missile launches world-wide using infrared sensors. Most classified launches are made from Vandenberg AFB near Lompoc, CA, shown at left.

UMR



Unauthorized release of this 1984 KH-11 image of the Nikolaiev 444 Shipyard on the Black Sea, showing the Kiev class nuclear carrier Kharkov under construction was passed to Jane's Defense Weekly by American analyst Samuel Loring Morison, who was convicted of security breach and sentenced to prison time.

Note the parallel scan lines and obliquity of the image, which exhibits a remarkable level of detail

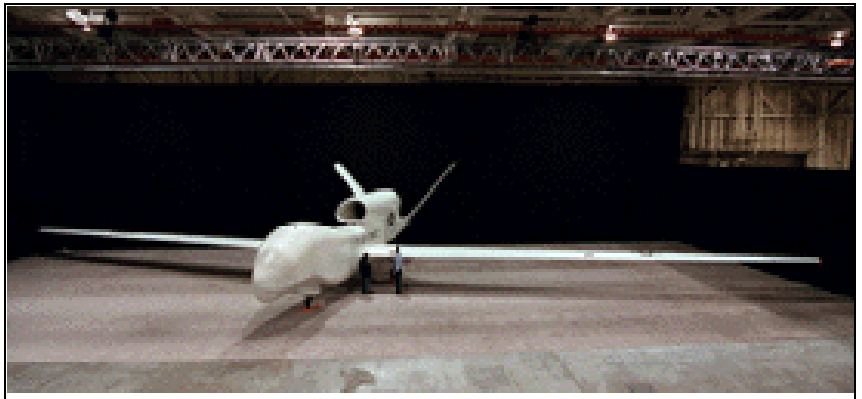
Downgraded or “pixelated” KH-11 images taken from reconnaissance satellites of high interest subjects in Iraq over the last 5 years. This sort of imagery provides reference or “library” coverage for national security. Such images are occasionally released in Pentagon briefings.

NEW GENERATION OF UAVs

The RQ-1 Predator UV went into service in 1994 and has provide exemplary service in Afghanistan and Iraq. It can stay aloft for 6 hours.

Its projected replacement is the Global Hawk, which will be capable of staying aloft for 30 or more hours

The Tier II Plus Global Hawk is intended to be a long-range, high-altitude reconnaissance "workhorse"



Global Hawk has a wingspan of 116 feet

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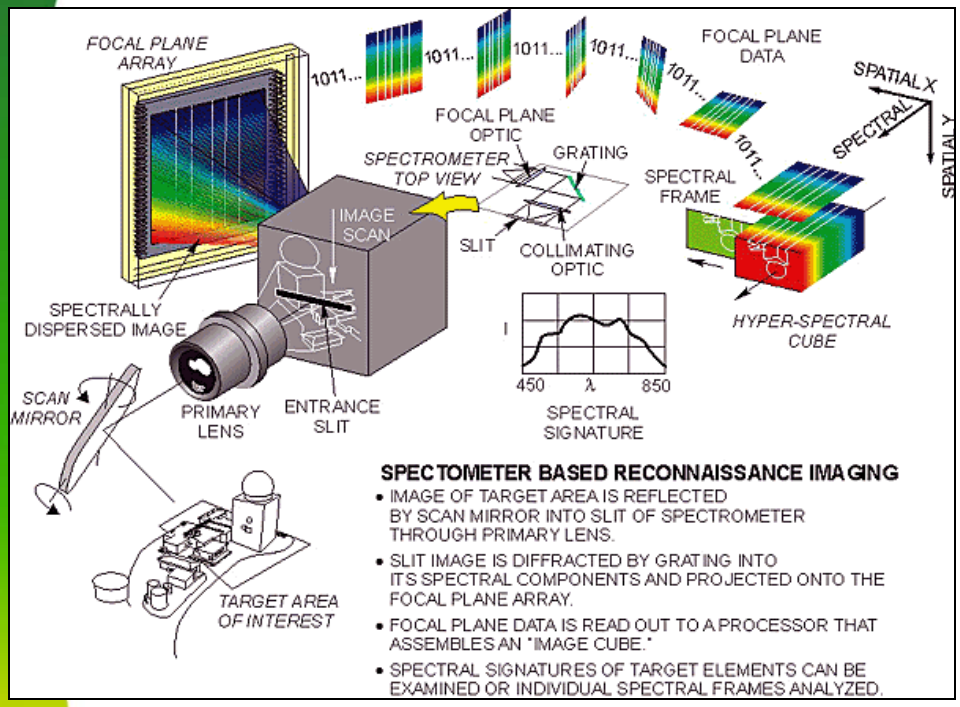
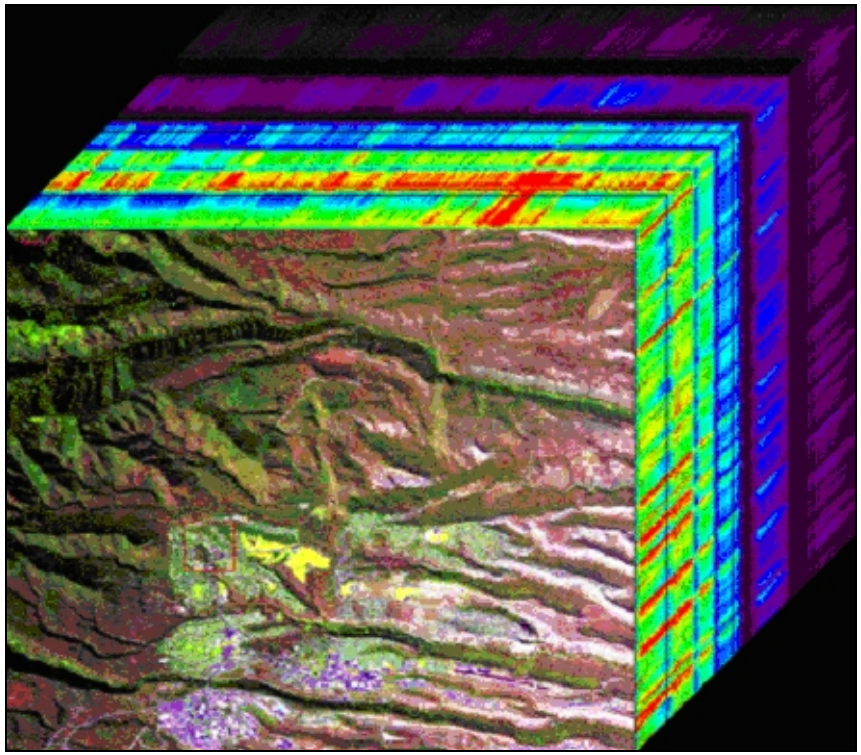
Transition to Hyperspectral Data





Multispectral scanners (MSS) have been increasing deployed on airborne and spaced-based sensing platforms. These allow large files of information to be collected across the electromagnetic spectrum; and will eventually change the way we look at the Earth (e.g. motor tracks across water)

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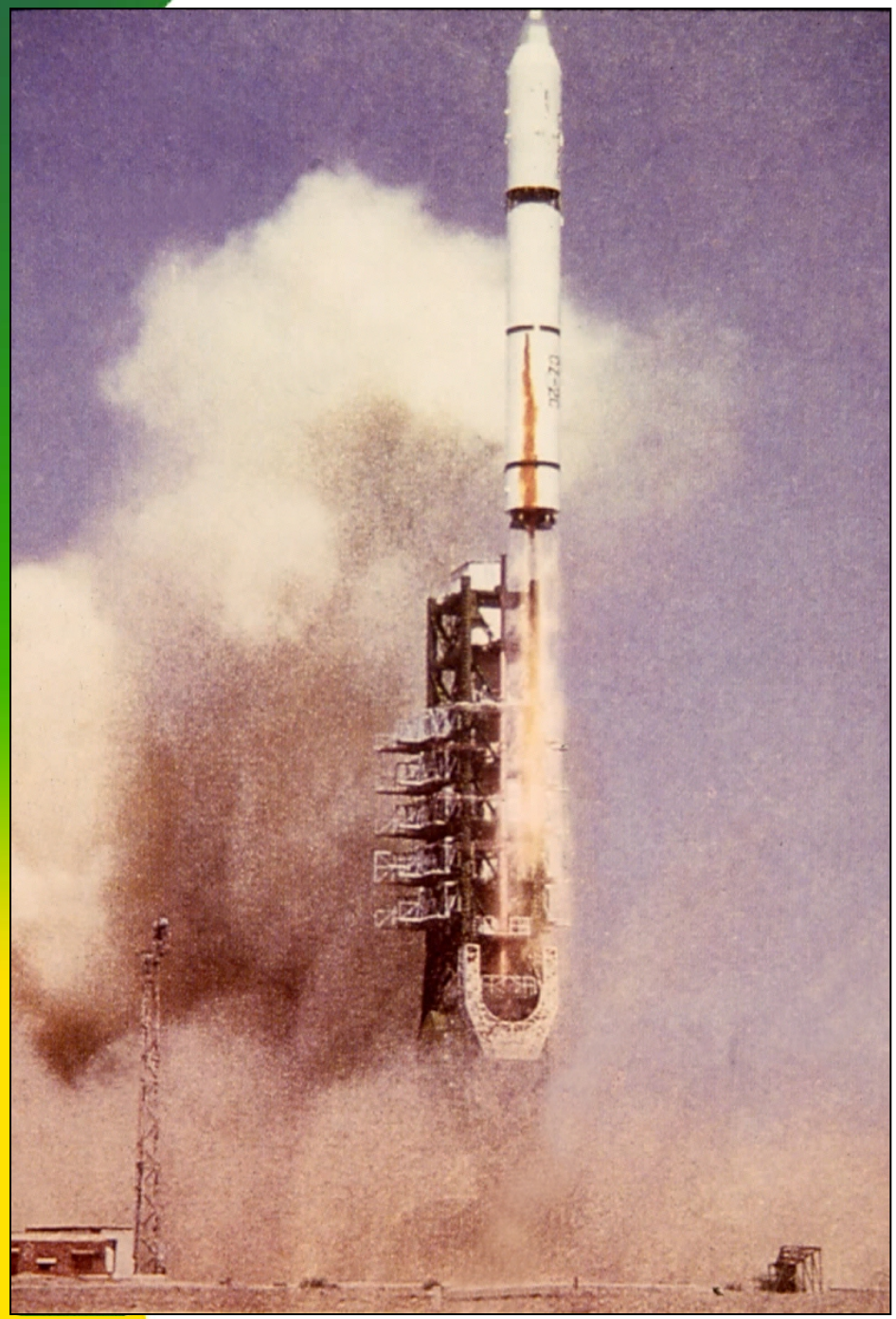
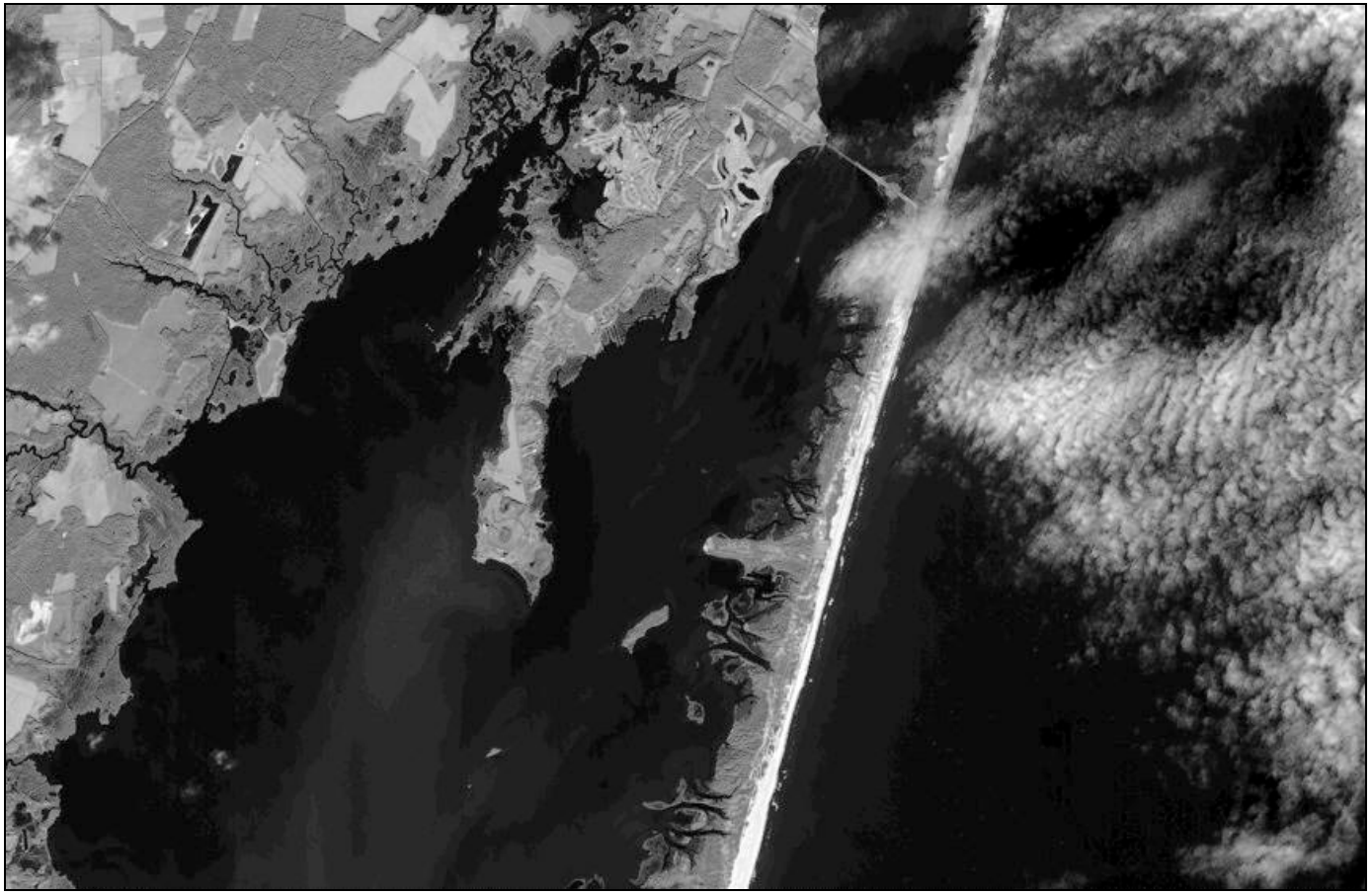
- **Mosul, Iraq as imaged by US reconnaissance satellite using Thematic Mapper Multispectral Scanners. Intelligence platforms are capable of resolutions < 6 inches for high interest areas**

UMR

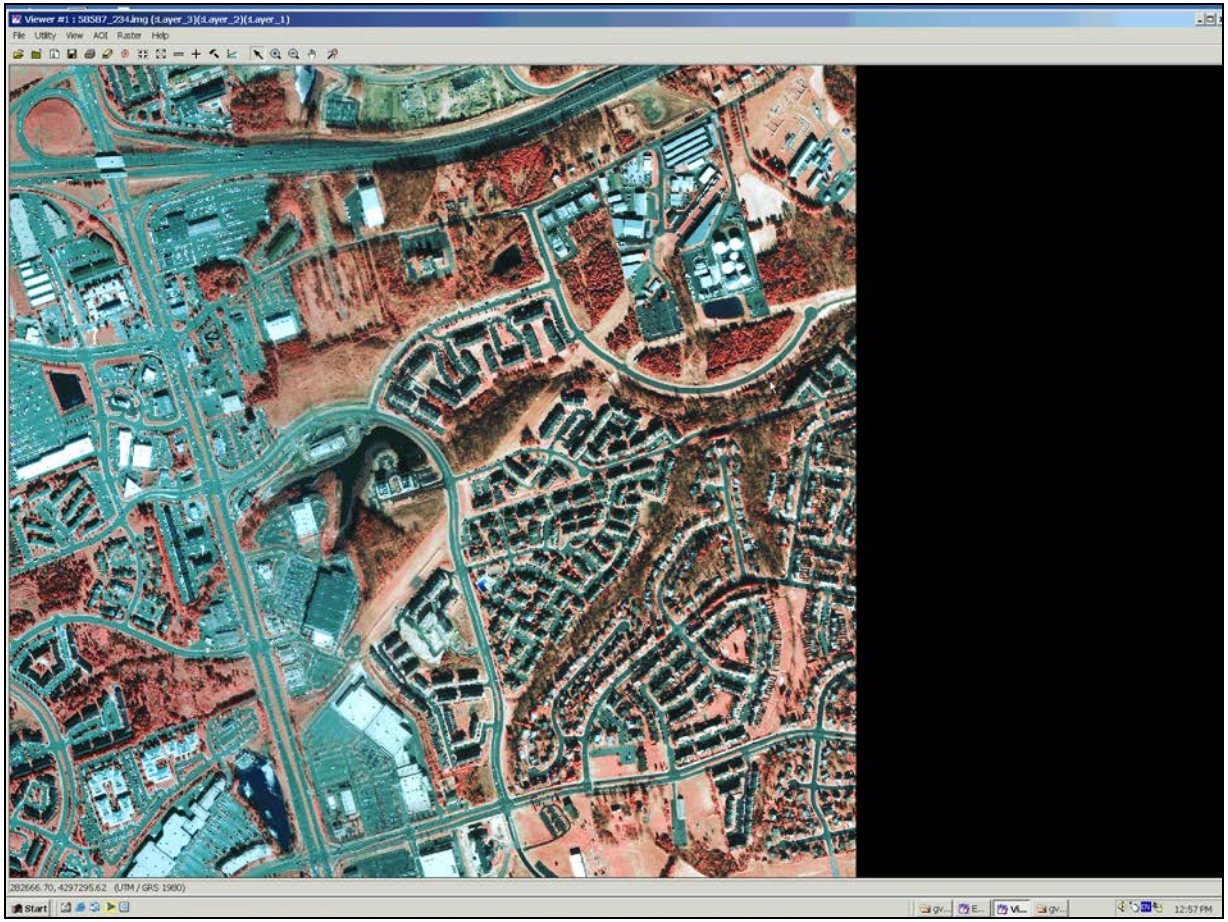


- **The European Space Agency launched one of their first remote sensing satellites in August 1988, beginning of a new era of competitive commercial remote sensing. Since this time there has been increasing competition between EOSAT, the Russians and Americans**



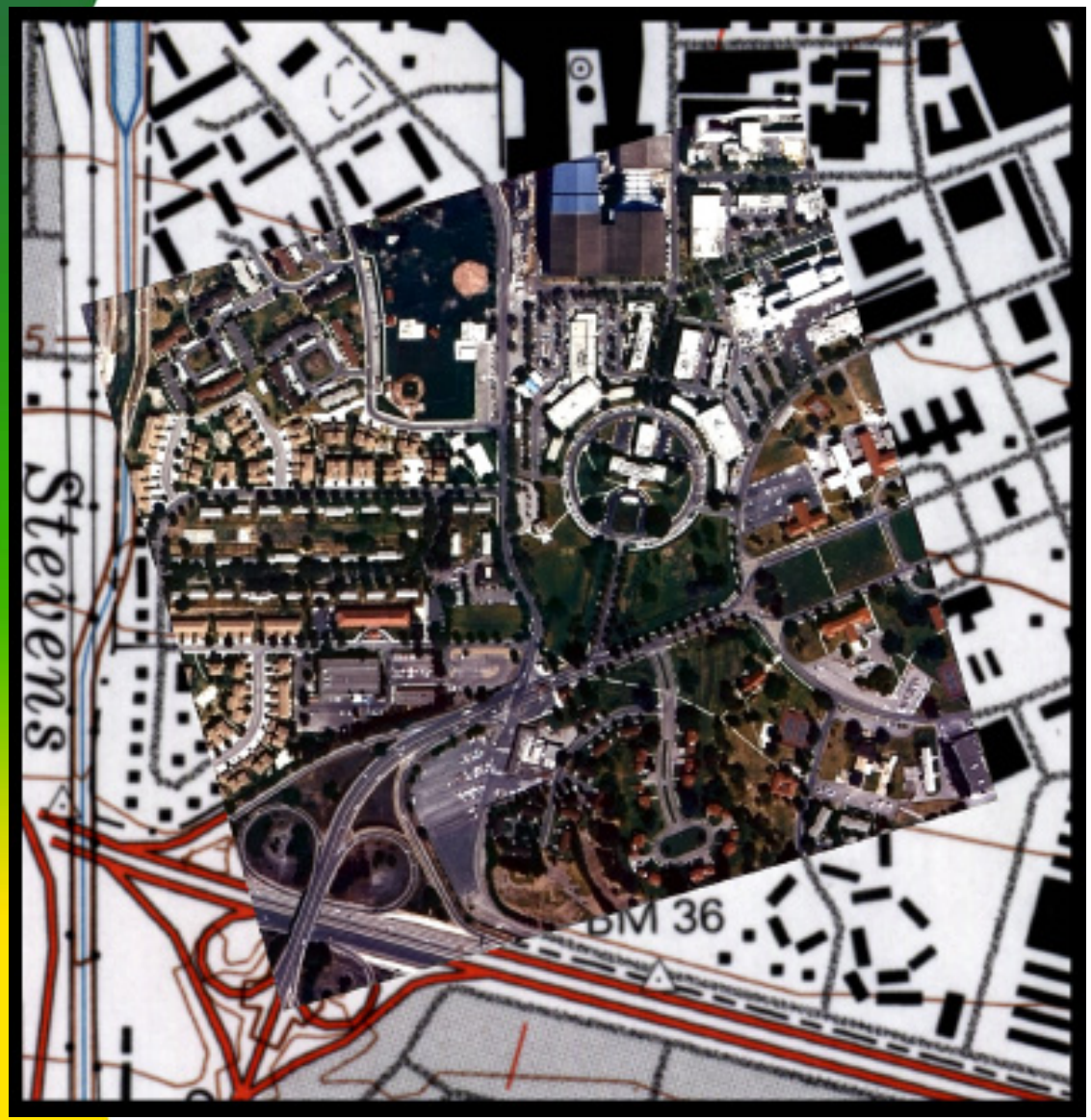
- **In 1999 Space Imaging EOSAT launched Ikonos, offering commercial imagery with 1 m panchromatic and 4 m multispectral images, world wide.**

UMR



- **Ikonos imagery collects MSS data at rate of 2,000 sq km per minute, making fifteen 98- minute orbits each day. They offer digital imagery with RMSE of < 0.9 m for detailed urban analysis.**

UMR



- Modern digital imagery is orthorectified
- This allows manipulation in GIS, integrating countless layers of information

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Orthorectified digital images can be overlain to make meaningful comparisons, as shown here

This shows the Pentagon while under construction in 1940 (at right) and after completion in 1943 (at left)

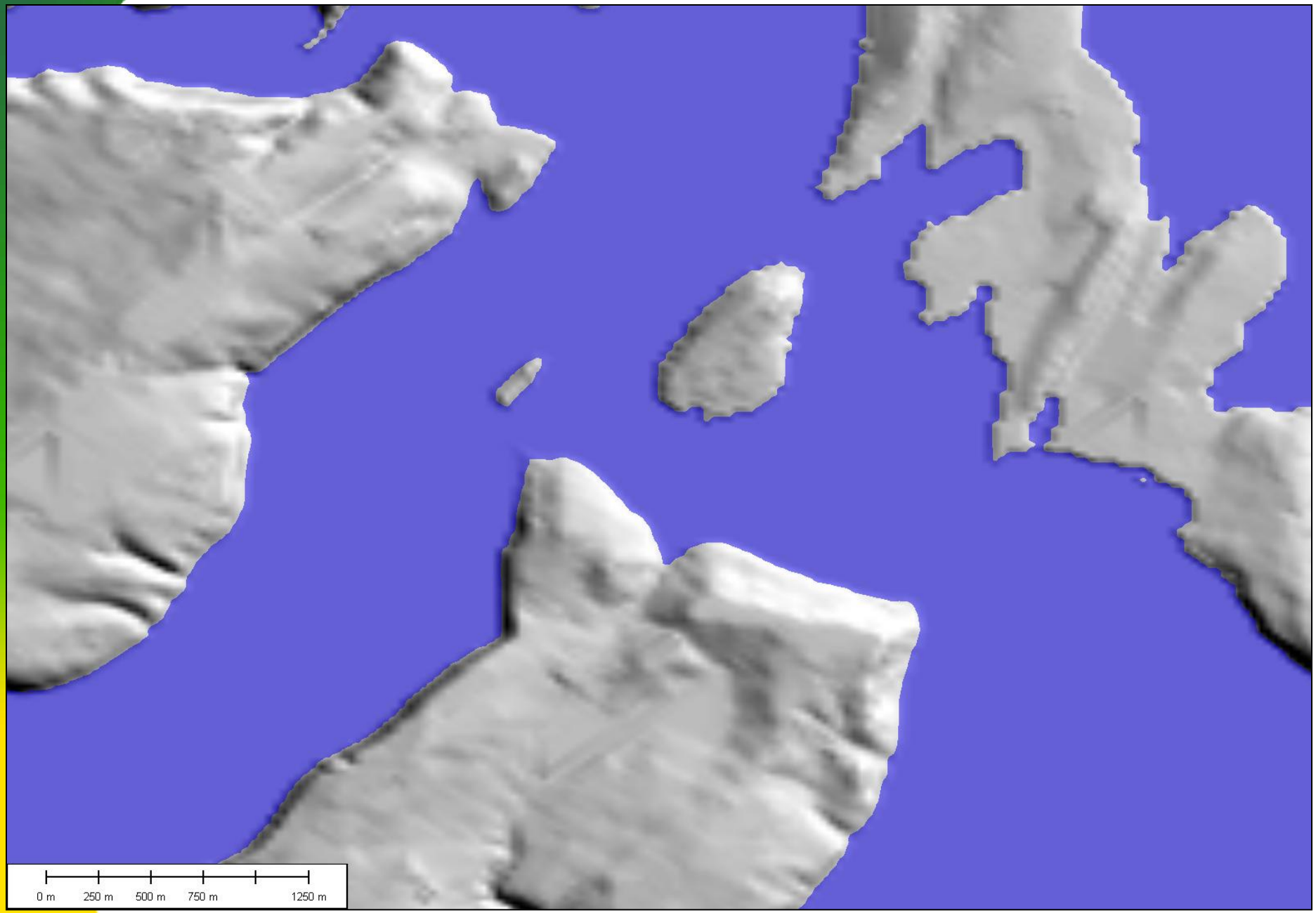
Note details of support and frame layout

UMR

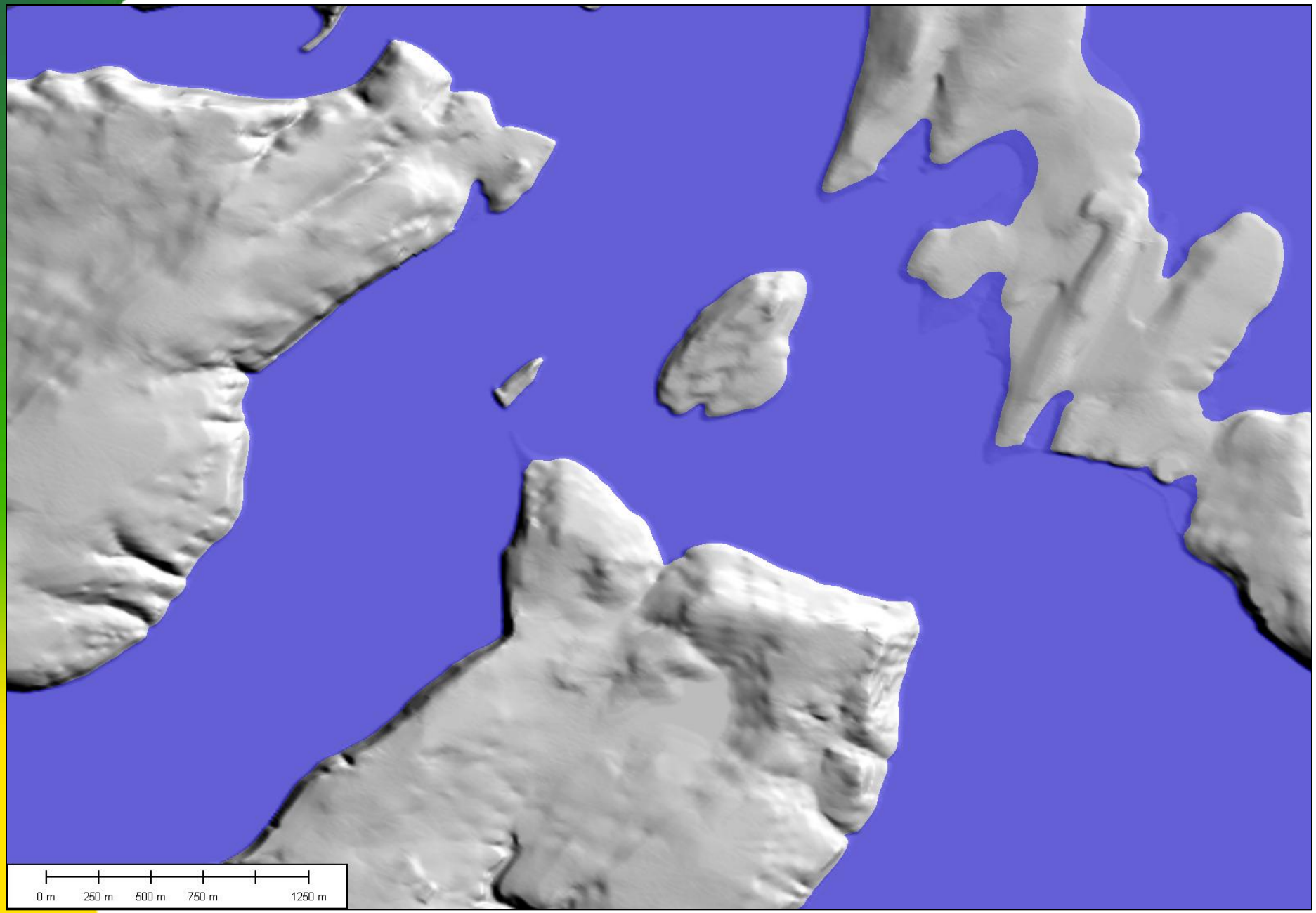
Topographic Surface Imaging Using Light Detection and Ranging (LiDAR)

2m LiDAR DEMs
Squaxin Island
Thurston County, Washington

UMR



USGS 30m DEM



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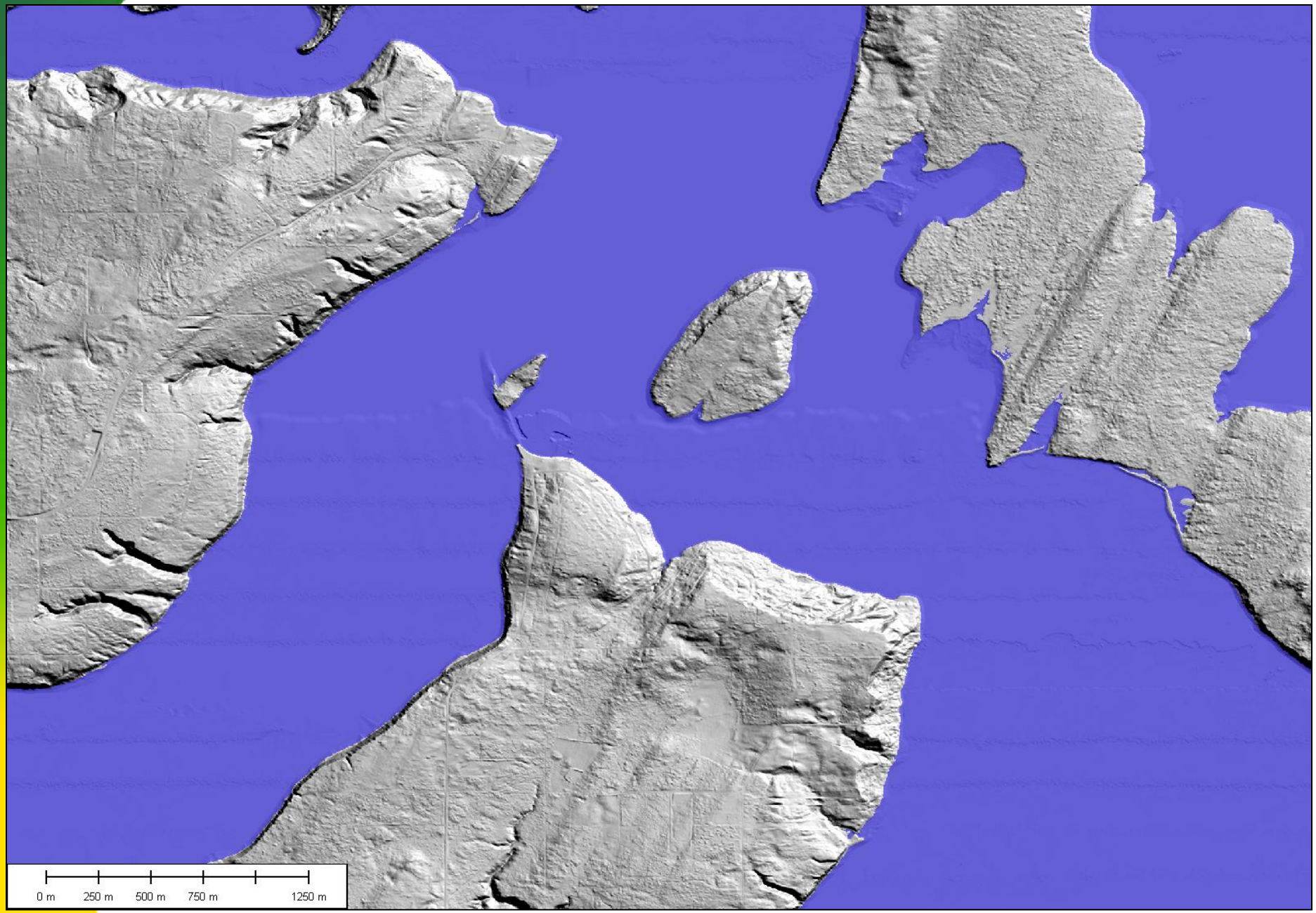
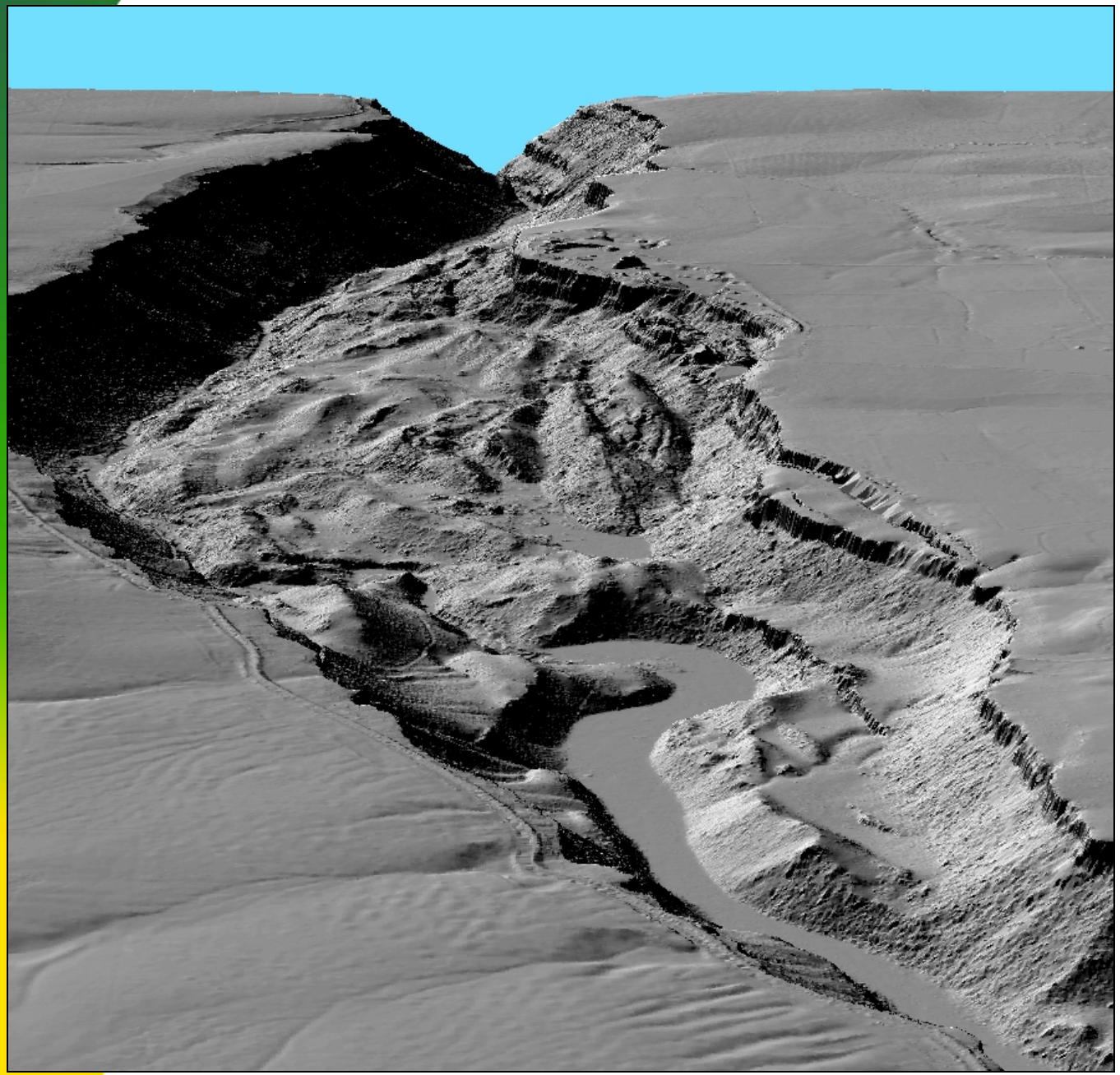
USGS 10m DEM – 9X resolution of 30 m DEM



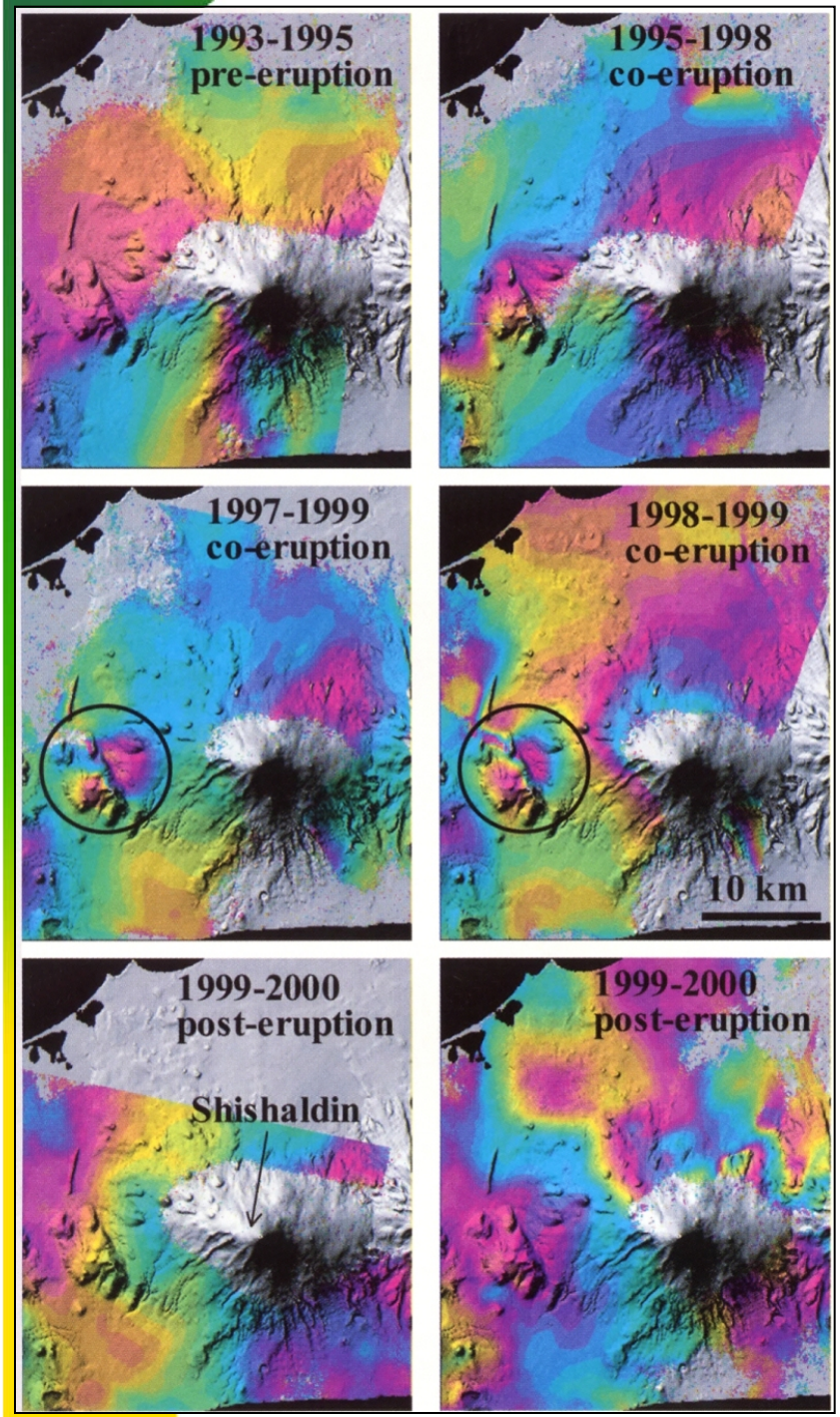
LiDAR 2m DEM – 25X resolution of USGS 30 m DEM



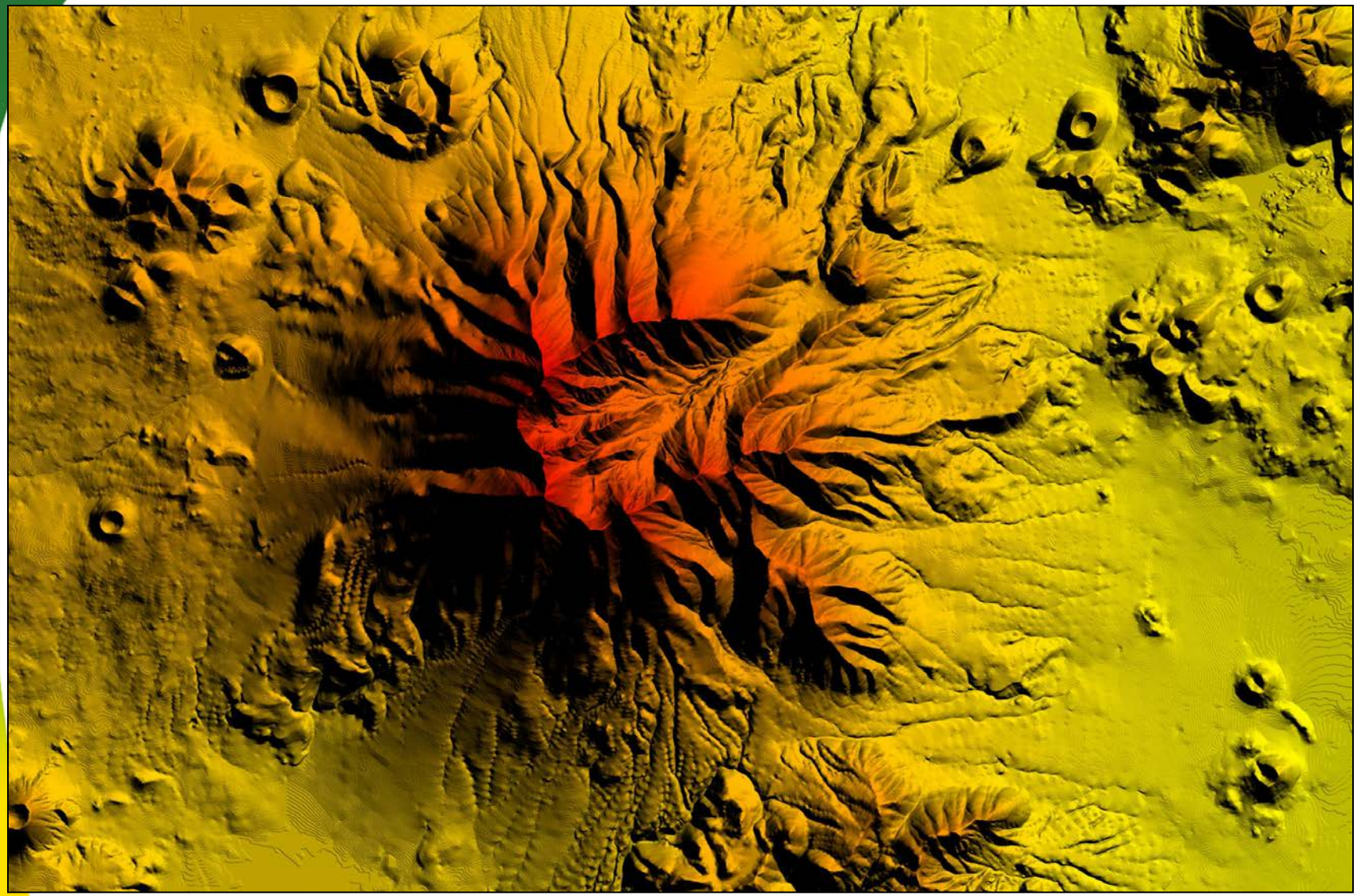
1 m LiDAR posting image of the Salmon Falls Landslide southwest of Twin Falls, ID.

The image is comprised of 13 million data points, which allowed a vertical resolution of 15 cm over a slide area of 0.2 square kilometers.

UMR



- **Repeated INSAR passes allow slight variations in elevation and spatial distribution to be monitored with amazing accuracy**
- **Topo-removed interferograms draped over shaded DEMs of Shishaldin volcano from 1993 to 2000**
- **Circles indicate areas of marked elevation change**



INSAR image of the San Francisco Peak volcanic field near Flagstaff, AZ

UMR