Questions

1. What was the difference in the objectives of Operation Sandstone, and Operation Dominic

2. What differentiates a “low altitude” test from a high altitude” test?

3. Name the two delivery systems for nuclear bombs developed by the US military industry

ICBM Intercontinental Ballistic Missiles

Launch, flight, and delivery of a modern Minuteman III ICBM

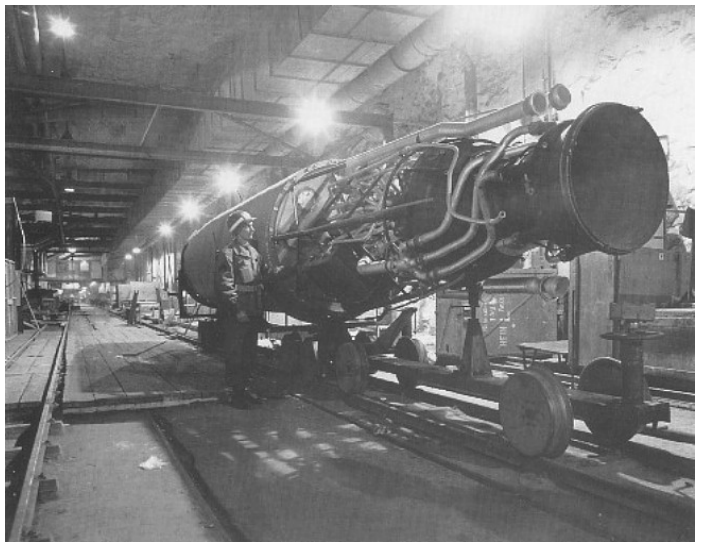
Early planning and developments

Germany invested successfully in long range missile systems during WW II in the believe to invest into a crucial weapon for final victory. However, the

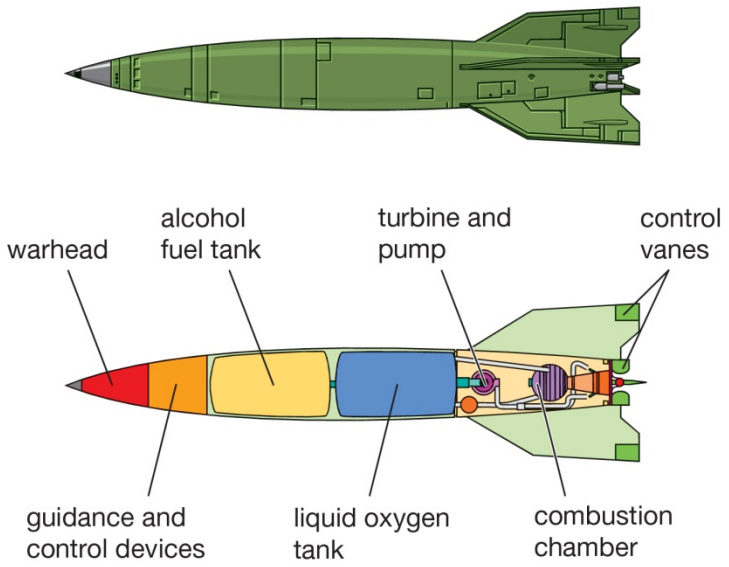
limitations in transport capabilities were too severe to allow sufficient load on explosive material. The production was limited, 3200 V2 missiles were employed, but the final impact on the war development was negligible.

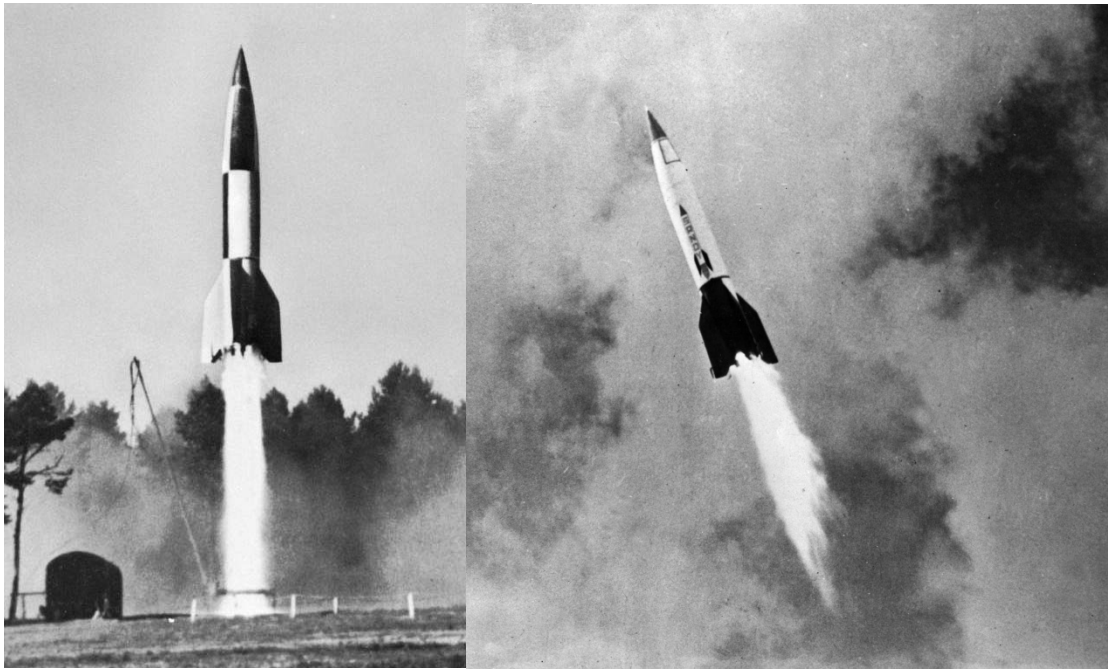
Assembly site Mittelwerk

The Mittelwerk V-2 factory in Nordhausen, Thuringia produced some 4,575 V-2s between August, 1944 and March, 1945—the period in which these rockets were headed for firing batterys (as opposed, earlier on, to development testing). The workers were primarily recruited from concentration camps which were constructed nearby the production facilities. Estimates of the total number of prisoners in the complex at range between 40,000 and 64,000. It is estimated that of the 60,000+ detainees employed in and around the Mittelbau complex over a 20-month period, 26,500 did not survive. Many were shot by SS commands with the advance of the US army towards Nordhausen in March 1945.



The German A-4 (V2) rocket



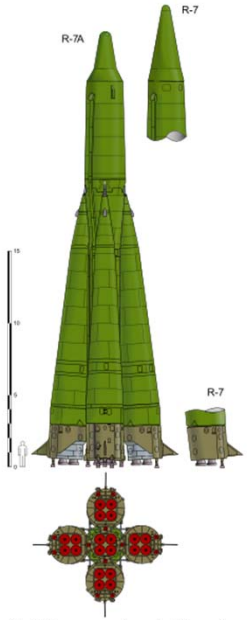


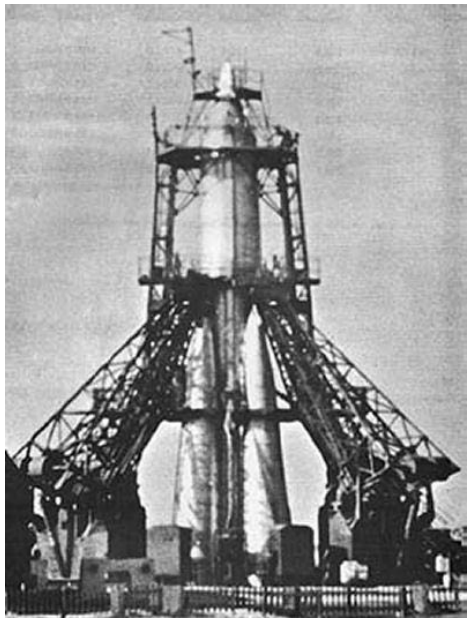
The precursor of modern ballistic missiles was the German V-2, a single-stage, fin-stabilized missile propelled by liquid oxygen and ethyl alcohol to a maximum range of about 200 miles. The V-2 developed and tested at Kummersdorf and Peenemunde under General Walter Dornberger and the civilian scientist Wernher von Braun. The V-2 ushered in a new age of military technology.

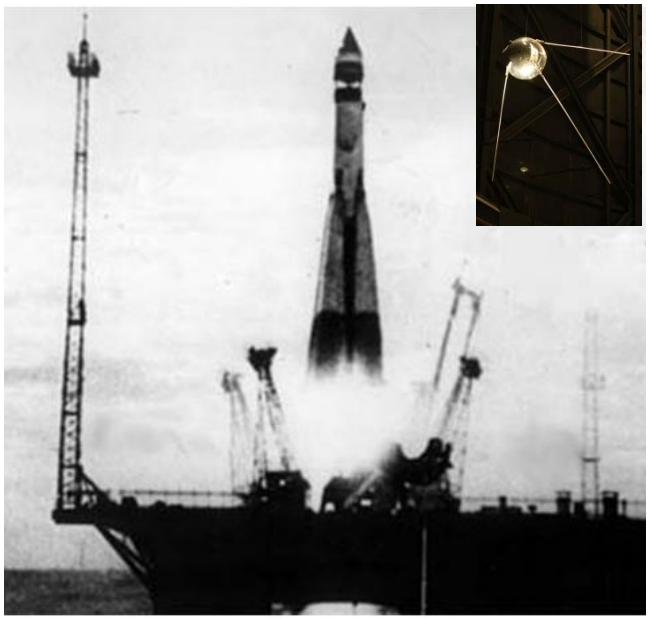
After the war there was intense competition between the United States and the Soviet Union to obtain these new missiles, as well as the German scientists who had developed them. The United States succeeded in capturing Dornberger and von Braun as well as more than 60 V-2s; it is not known what (or whom) the Soviets captured. However, given the relative immaturity of ballistic missile technology at that time, neither country achieved usable ballistic missiles for some time.

Missiles as new Delivery System

In 1957 the Soviets launched a multistage ballistic missile R-7 as well as the first man-made satellite, Sputnik. This prompted the “missile gap” debate in the United States and resulted in higher priorities for the U.S. Thor and Jupiter IRBMs (Intermediate Range Ballistic Missile).







After initial difficulties in the early test phase, these programs were accelerated, with Thor being deployed to England and Jupiter to Italy and Turkey in 1958. Thor and Jupiter were both single-stage, liquid-fueled missiles with inertial guidance systems and warheads of 1.5 megatons. Political difficulties in deploying these missiles on foreign soil prompted the United States to develop ICBMs, so that by late 1963 Thor and Jupiter had been terminated.

IRBM & ICBM developments

After the Soviet success with Sputnik, US sought for development of Intercontinental Ballistic Missiles (ICBM) to complement the bomber fleet and address the new challenge. US military success was limited until NASA took over the missile development.

Success at last!

A modern **intercontinental ballistic missile** (**ICBM**) is a ballistic missile with a long range of greater than 5,500 km or 3,500 miles, primarily designed for nuclear weapons delivery (delivering of one or more nuclear warheads).

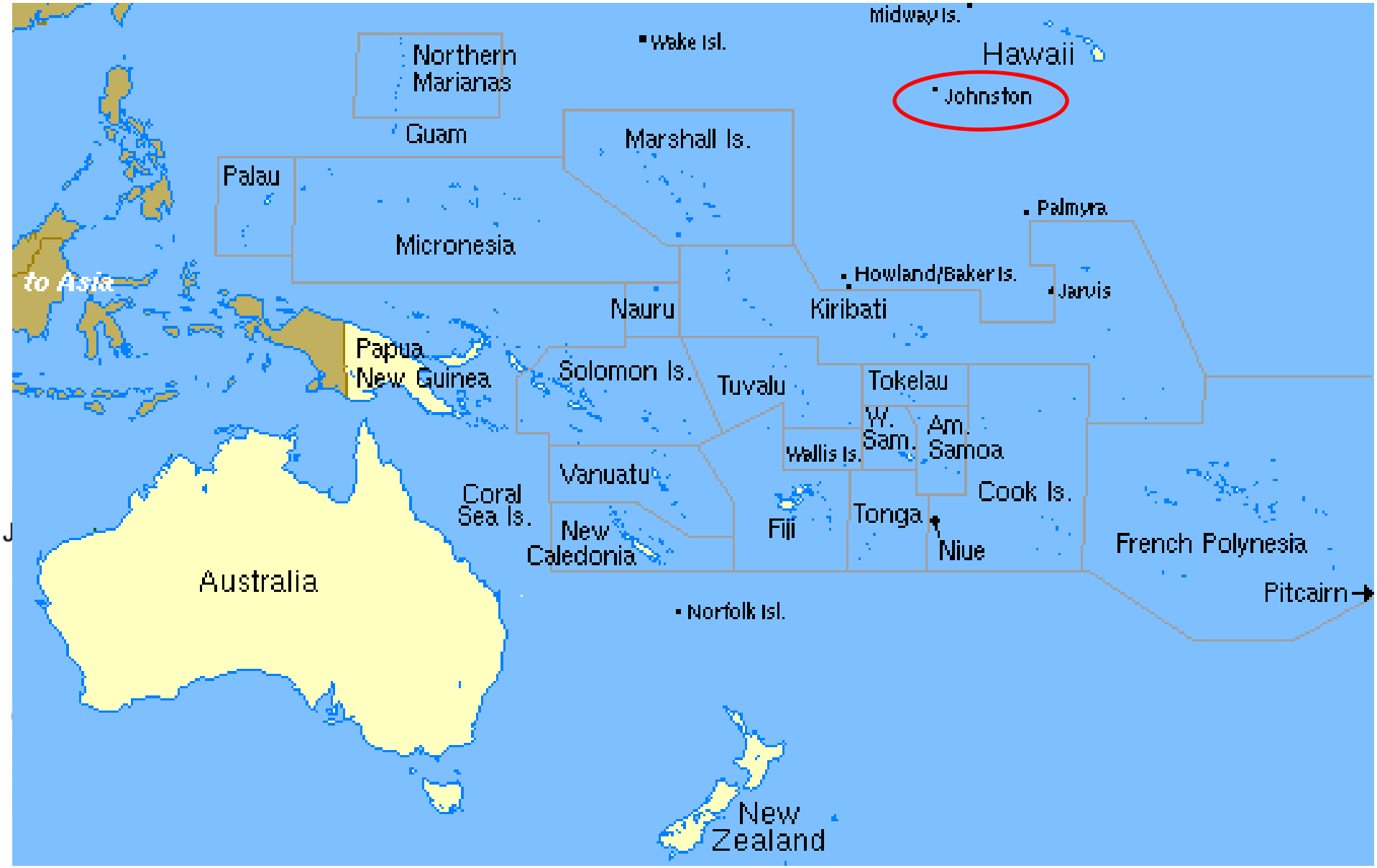
Argus Test 1958

Operation Argus was a secretly conducted test series in the South Atlantic, 1100 miles southwest of Capetown, South Africa. Argus consisted of three very high altitude test shots of the W-25 warhead to investigate the effects of nuclear explosions outside of the atmosphere. The objective was to study how the charged particles and radioactive isotopes released would interact with the Earth's magnetic field and the potential consequences for radar tracking, radio communications, and the electronics of satellites and ballistic missiles. All three shots were launched by a modified Lockheed X-17A three-stage missile fired from the USS *Norton Sound,* operating as part of the 9 ship Top Secret Task Force 88. The W-25 plutonium implosion warhead produced yields of 1.7 kt .

Follow-up high altitude tests with Hardtack II in the Pacific Ocean. Launches took place from Johnston Island site, southwest of Hawaii.

High Altitude Tests

Johnston Island



Operation Dominic

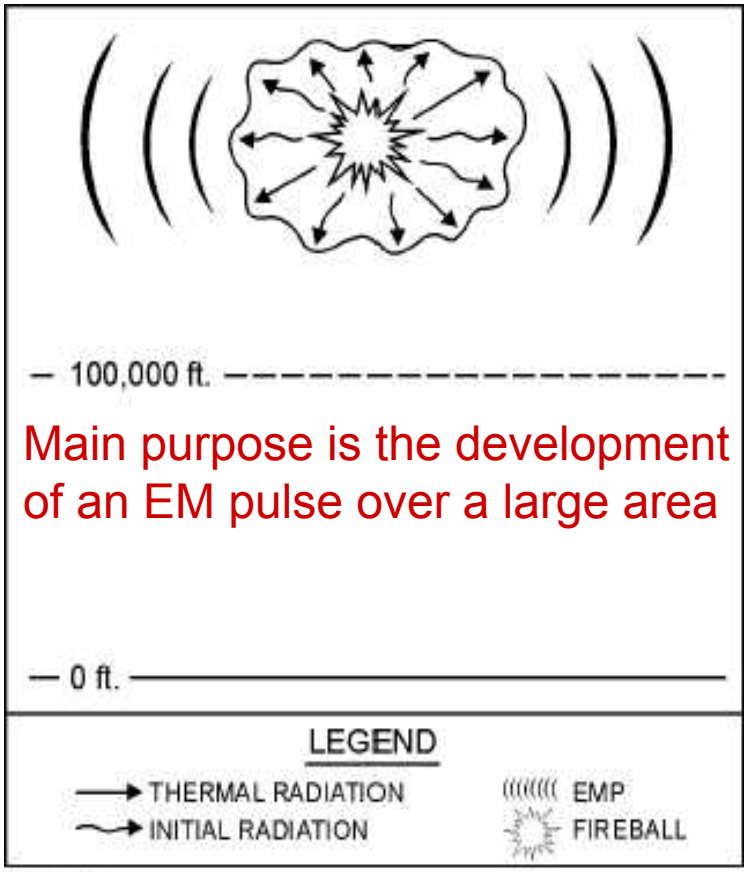
The Line Islands are a group of eleven coral atolls located 2,500 kilometers south of Hawaii in the central Pacific, The group was a British colony from 1888 to 1979. Eight islands are part of the Republic of Kiribati, while three outlying atolls are claimed by the United States. Christmas and Malden Islands were the site of atomic bomb testing by the UK and the US during the late 1950s and early 60s. Christmas Island was the site of operation Dominic

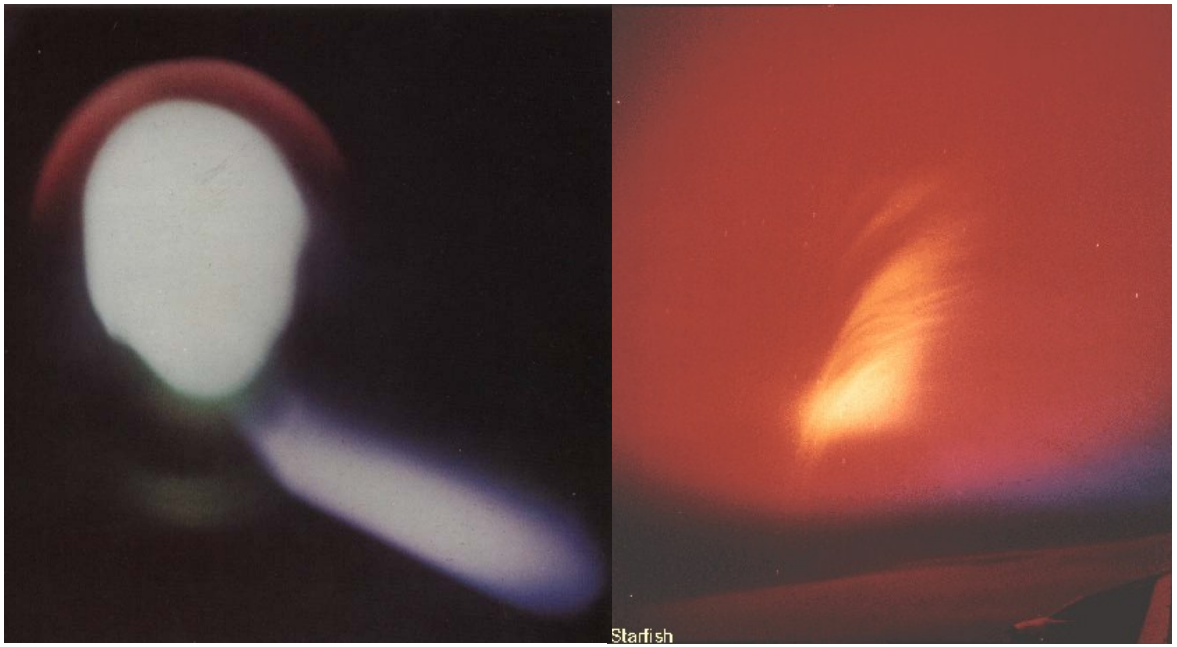
Operation Dominic included 36 tests, in particular a series of high altitude tests known as Operation Fishbowl. These tests were Thor missile launched warheads detonated at very high altitudes (30-248 miles) to evaluate the effects of high yield explosions against ballistic missile RVs and to explore the impact of the EMP on electronic systems.

High Altitude tests

e.g. Dominic tests on the Christmas Island 1962 shortly before test ban in 1963;

The electromagnetic pulse (EMP) from these tests sent power line surges through Oahu, knocking out street lighting, blowing fuses and circuit breakers, and triggering burglar alarms.

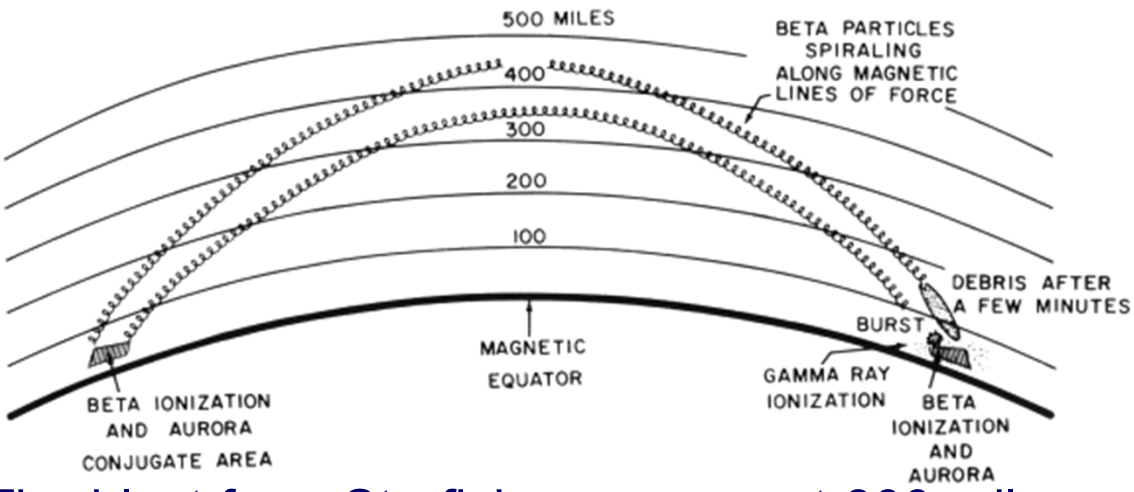


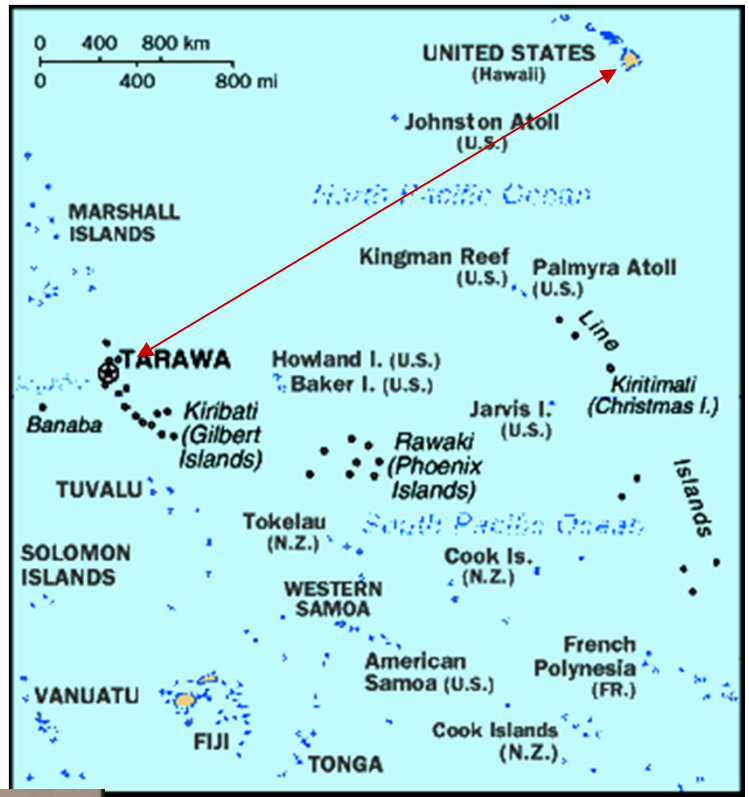


KINGFISH,
1962; 1000 kT
Thor Missile Airburst;
320,000 Feet

STARFISH PRIME,
1962; 1450 kT
Thor Missile airburst;
248 miles,

Long distance observation





The blast from Starfish was seen at 800 miles distance from Honolulu, Hawaii. Originated auroral light phenomena through β-radiation induced excitation effects in atmosphere.

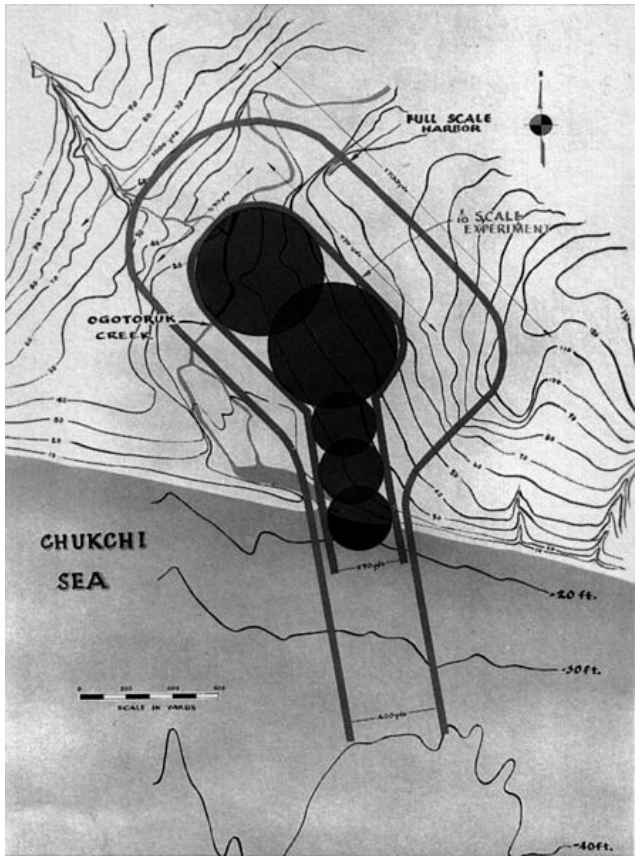
Atmospheric Effects

Civil Engineering with Nukes

Operation Plowshare

Operation Plowshare was the U.S. program for the development of techniques to use nuclear explosives for peaceful purposes. Twenty-eight nuclear blasts were detonated between 1961 and 1973.

One of the first U.S. project proposals that came close to being carried out was Project Chariot, which would have used several hydrogen bombs to create an artificial harbor at Cape Thompson, Alaska. It was never carried out due to concerns for the native populations and the fact that there was little potential use for the harbor to justify its risk and expense.



The Sedan Test

Objectives of Project were the use of nuclear explosions to excavate a second Panama Canal, which would was envisioned as possible by doing a series of bomb explosions across Nicaragua. The largest excavation test experiment for investigating the feasibility of such projects took place in 1962 at the Nevada Test Site. The Sedan nuclear test displaced 12 million tons of earth, creating the largest man-made crater in the world, generating a large nuclear fallout over Nevada and Utah.

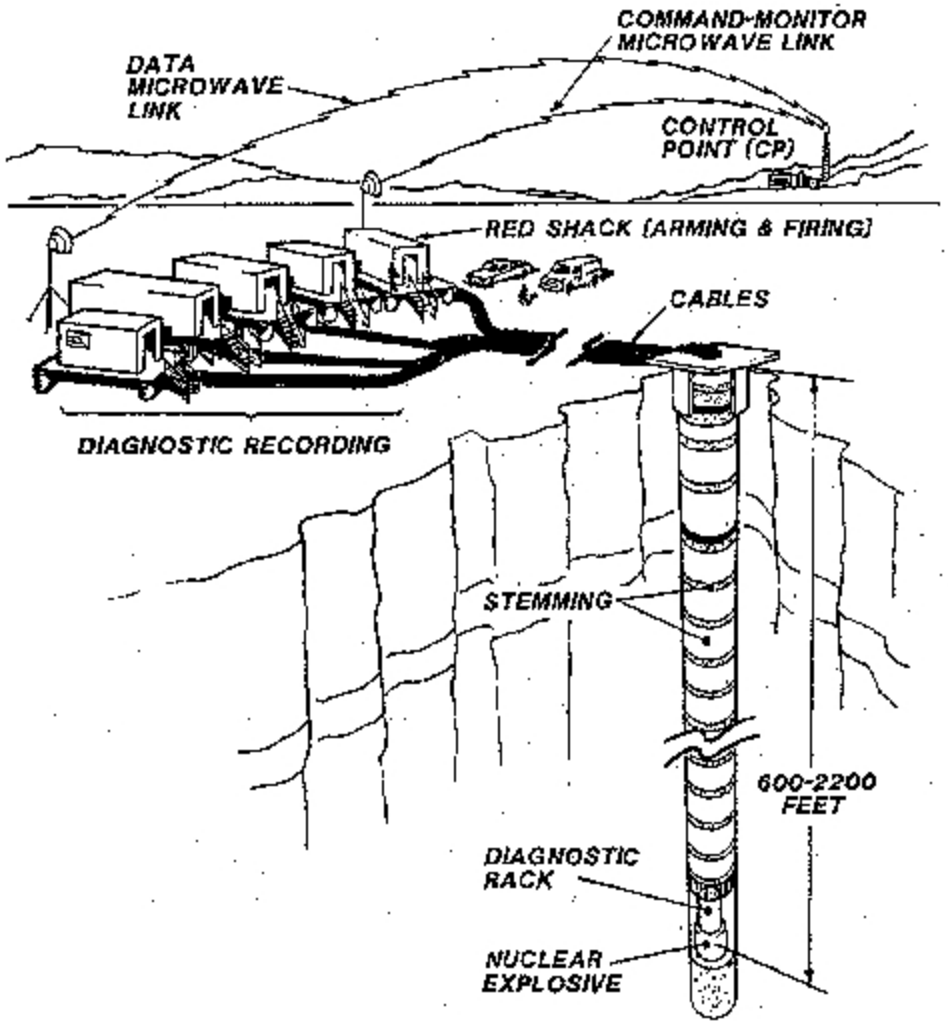
Underground test procedure

Underground tests required careful preparation and monitoring. Hole depth and diameter are dictated by anticipated yield.

Depth range: 600 – 2200 feet
Diameter range: 48 – 120 inches

Containment of radioactivity in hole is required; geological survey is necessary prior to test. The hole is stemmed after device is positioned.

Underground cavity forms after explosion. Cavity drops forming chimney. If the strength of chimney is exceeded by the weight of the overburden, the chimney collapses forming a crater.



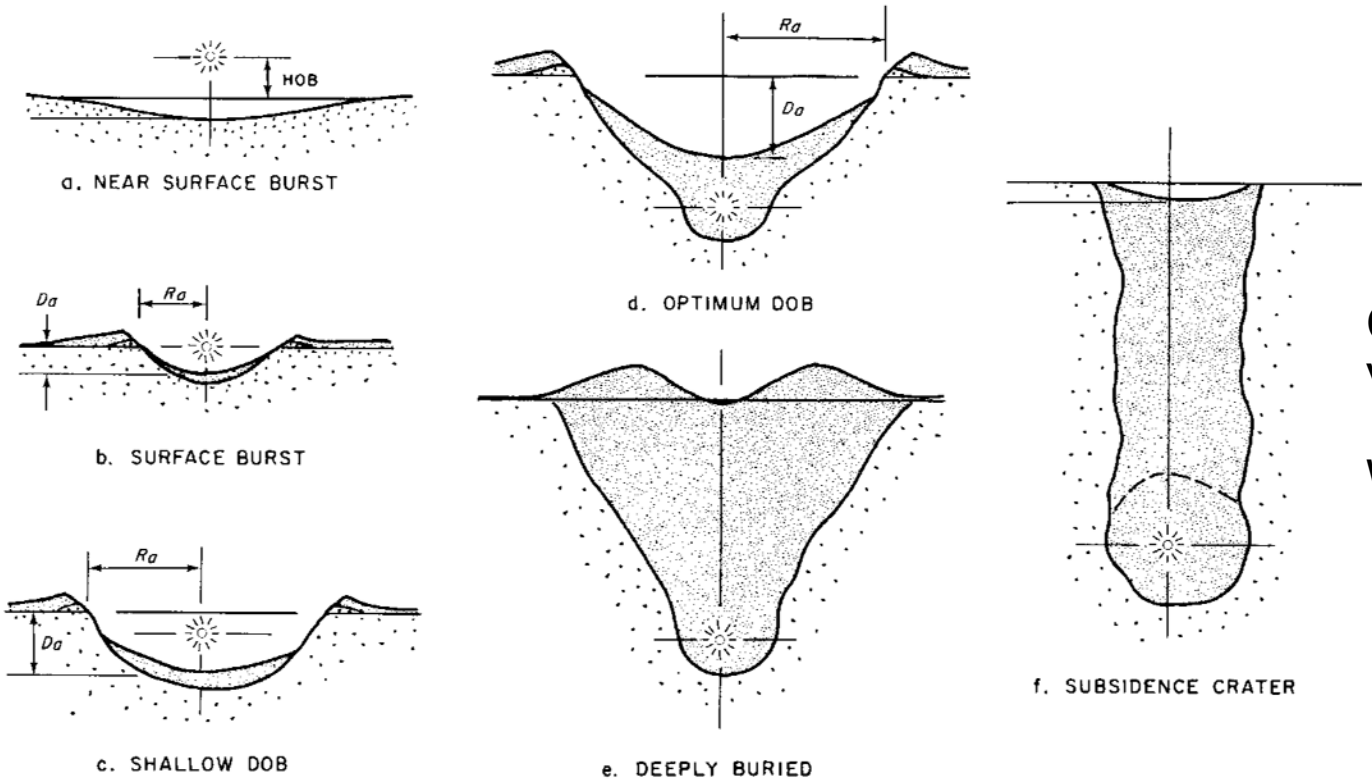
SEDAN Preparations & Success

1962 Test to investigate “peaceful applications such as large scale construction efforts

- Harbor building
- Mountain removal

Underground test

In underground tests most of the released energy goes into crater formation. Only a fraction of the energy goes into blast depending on explosion depth. The shape of the crater depends on depth of explosion; new applications are bunker breaking small nuclear weapon developments.



Relative crater sizes and shapes resulting from various burst depths; R_a and D_a are the apparent radius and depth, respectively, of the crater

Crater volume:
$V_c \approx 10^5 \cdot W\ m^3$

W in kTons


SEDAN EVENT

Sedan test parameters and results

- The **104 kT** thermonuclear device was buried **635 feet** below ground level.
- The force of the detonation released seismic energy equivalent to an earthquake of 4.75 magnitude on the Richter scale.
- The blast moved 6.5 million cubic yards of earth and rock up to 290 feet in the air.
- The resulting crater was 1280 feet across and 320 feet deep.

PROJECT SEDAN

DETONATED ---------- JULY 6, 1962
EXPLOSIVES - THERMONUCLEAR, 70% FUSION, 30% FISSION
YIELD ---------- 104 KILOTONS
MEDIUM ---------- ALLUVIUM
DEPTH OF BURIAL ---------- 635 FT.
EMPLACEMENT HOLE DIAMETER --- 36"

CRATER STATISTICS

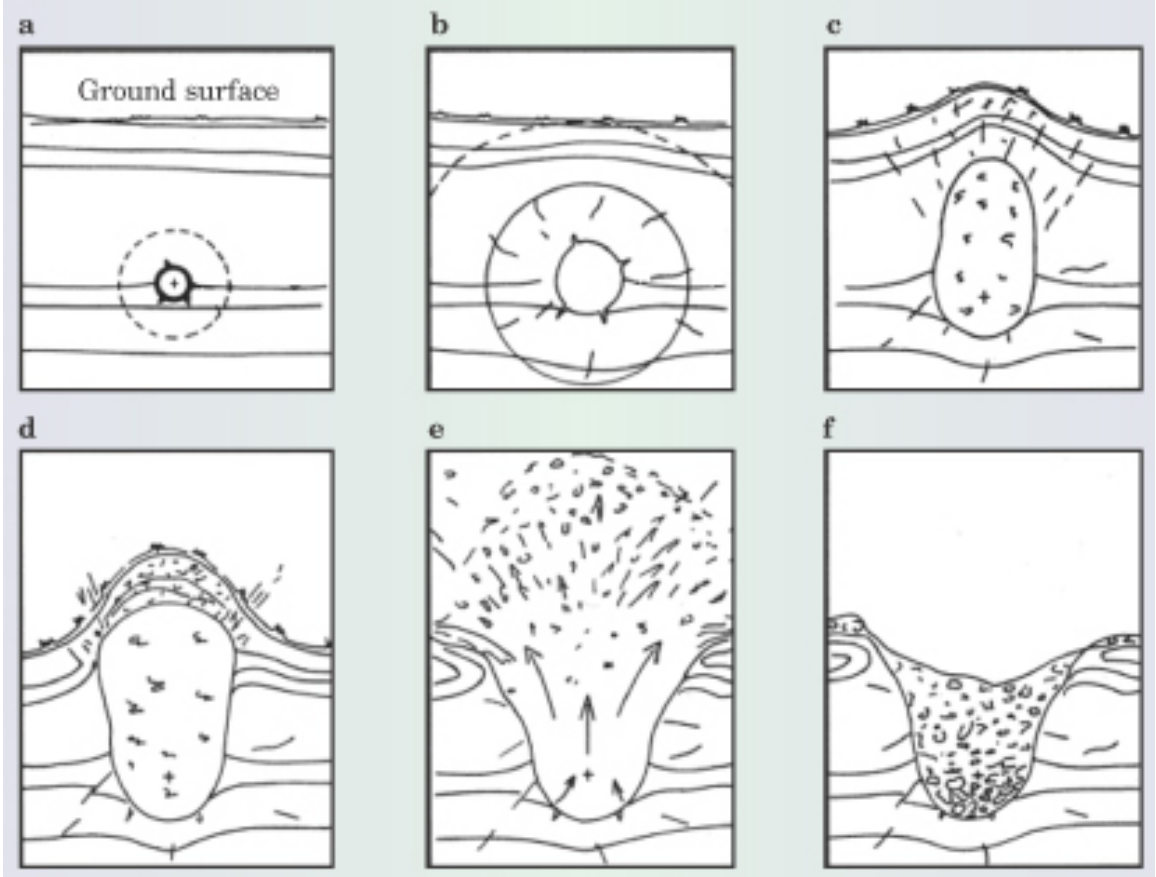
MAXIMUM DEPTH ---------- 320 FT.
MAXIMUM DIAMETER ---------- 1,280 FT.

Crater formation in underground test

Blast vaporizes material within radius $r=2 \cdot W^{1/3}$ m (W in kilotons (kT) of TNT)

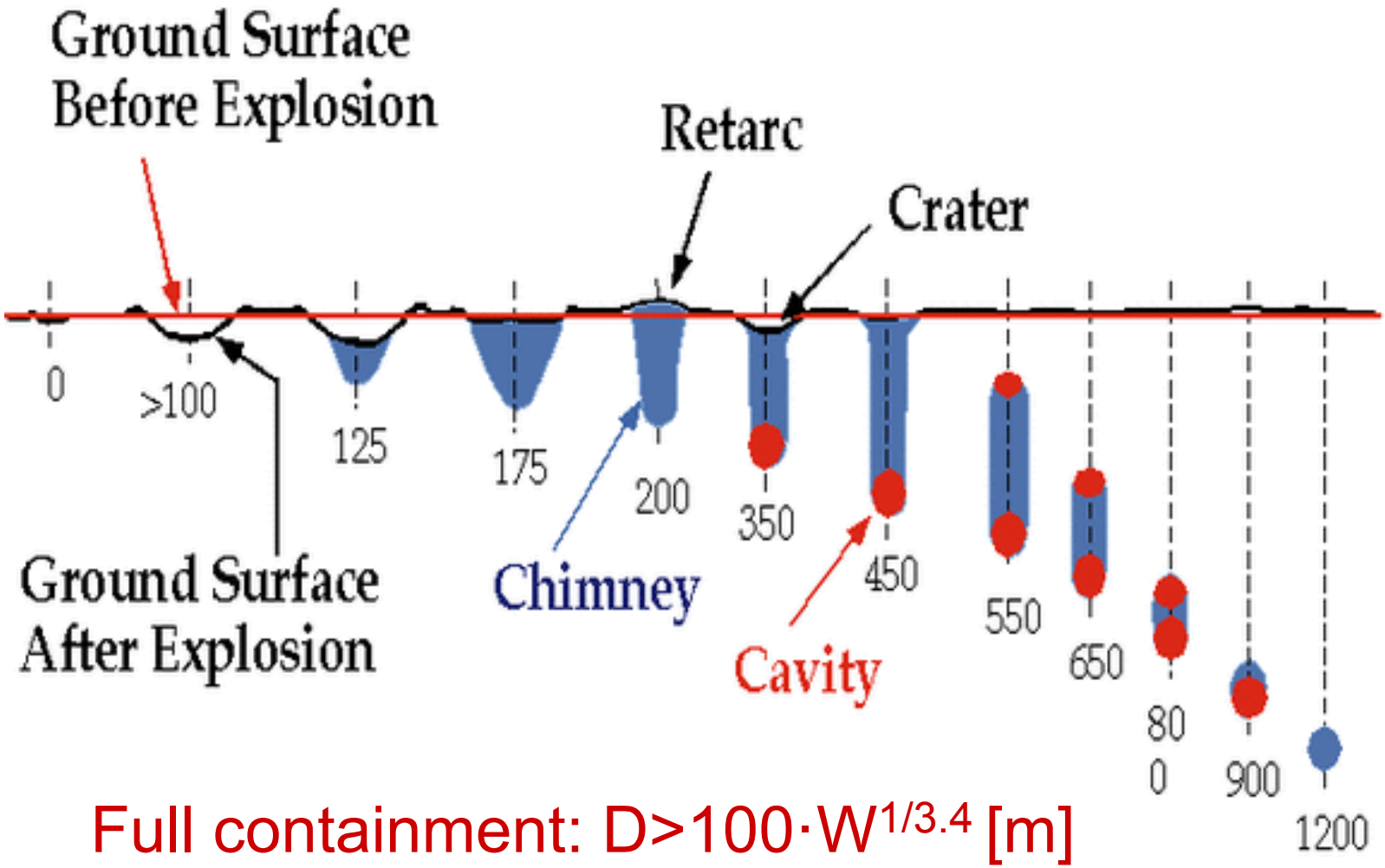
Blast melts material within $r=4 \cdot W^{1/3}$ m

Blast induced seismic shock crushes material within $r=50 \cdot W^{1/3}$ m



Gas release and seismic waves cause eruption and crater formation. Crater volume $V_c \approx 10^5$ W m^3.
Example Sedan ~10million m^3 (104KT)

Nuclear Cratering



Full containment: $D>100 \cdot W^{1/3.4}$ [m]

At these depth conditions, seismic shocks can be generated!

Crater Building

Bomb test characteristics

The effects of Nuclear weapons
Blast damage
Thermal damage
Radiation damage
EM-pulse
Scaling laws
Protection and shielding

Distance effects
Fall-out
Atmospheric distribution

Effects on population
Radiation effects
Fallout conditions
Short range Medical consequences
Long term medical consequences