UHC SR-71 Overview

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UHC Docent

-Background

- Development

- Operations

- Vignettes

- Questions

Background

DEFINITIONS: Spying & Reconnaissance

HISTORY

-Humint

-Technology

-- Hot air Balloons

--- Civil War

--Aircraft

--- WWI - Caudron G4, & Spad XVI

--- WWII – Spitfire, P-38(F-5 recon Variant)

--- High altitude recon challenges – cold & moisture

COLD WAR - Soviet Union – Closed Society

- Modified current aircraft – limited Success

- Kelly Johnson – Skunk Works

  -- P-38, P-80, F-104, U-2, & finally SR-71

      --- U-2 – First a/c designed & built for Reconnaissance

      --- Over Flight and Political consequences - Pres Eisenhower

-SURVIVABILTY STUDY 1957 – CIA Led

 -- U-2 at Risk – RADAR & SAM DEVELOPMENT

 -- SPACE PROGRAMS - yet to deliver Corona Program

 -- TO SURVIVE – need Speed, Altitude and Reduced Radar Signature – NEW MANNED AIRCRAFT NEEDED

Kelly Johnson – Master of the Lockheed Skunk Works

Famous Lockheed Skunk Works Logo

-Logo Started in WW II

- Kelly Johnson's development of P-80 Jet Fighter in Top Secrecy – Partition off part of Lockheed plant

-Fighter production was 37/day -

- Based on Lil Abner character

- 972 last years was as a test asset at the Skunk Works at Palmdale, Calif

SR-71 –Push Technology

-Goal: Mach 3+, above 80,000ft, & Low RCS
- Achieved 3.3Mach+, 85,000 ft, 2200 mph, 1 Sq Meter Radar Cross Section(RCS) return
-Kelly Johnson considered this his greatest Challenge and Achievement
- A-11 Archangel - Leads to 2 fielded programs
  -- A-12 Ox Cart – CIA Led
    --- Single seat- primarily Imagery
    --- 13 built – 5 lost
    --- Was lighter & Flew Higher than SR-71
  -- SR-71 Senior Crown - USAF
    --- 2 Crew members & Multi-Intelligence
    --- 32 built/12 lost
    --- Unsurpassed technology
    --- National policy – Who will do over flights?

SR- 71 Aircraft Characteristics

-Last major U.S. Aircraft designed with Slide rule

-America's first stealthy Aircraft

-Tremendous heat environment drives whole new technologies

-- Titanium 93% of A/C – Russian sponge source

-- Special Fuel –JP-7

-- Fleet of dedicated tankers - KC-135Qs plus on call KC-10s

-- Liquid Nitrogen Dewars for inerting fuel tanks

-- Special Hydraulic fluids – normal system 3200 psi

-- Fuel used as Hydraulic for Engine Nozzle control

SR-71 Surface Temperature Profile

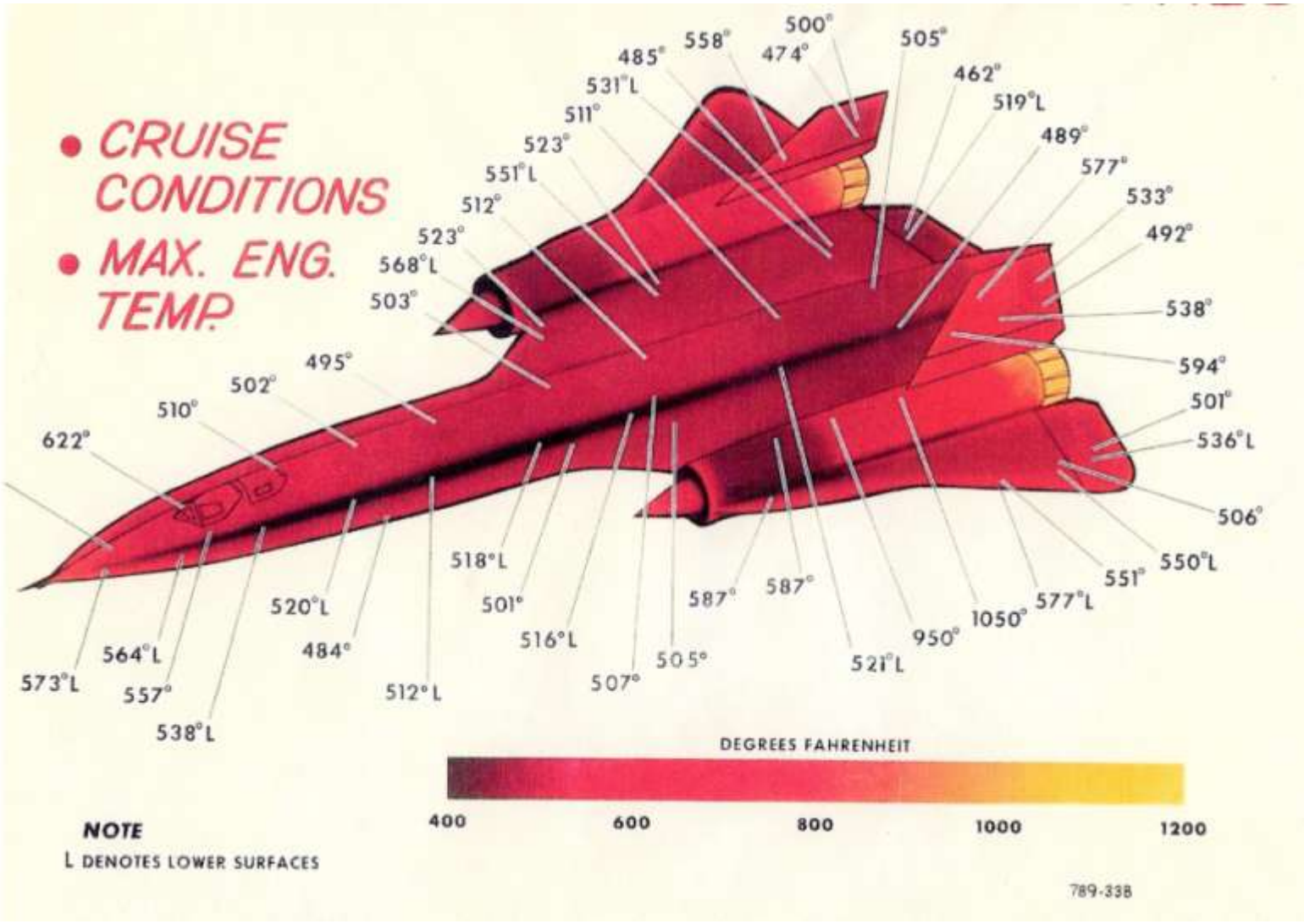
-Ave Temp around 600F

-Surface Temp Range 400-1200F

- Pilot's Pie Windows 620F

-A/C Growth
L 3-4 Inches
W 1-2 Inches

- Graphite composites used on Edges to defeat Radars



Heat Environment During Cruise

-Blue Black paint – radiate heat away from aircraft surface and reduces surface temperature by up to 50F degrees at 3.2 Mach, Provides some Visual Protection against a black sky, & Minute Ferrite Particles in paint help Defuse Radar Energy

-Glass – Quartz laminated glass 2.0 inches thick

-Oil a solid at 32 degrees – Preheat engines to 70F before start

-Fuel used as Coolant thru Heat Exchangers for aircrew, sensors, oil & hydraulics systems

-Special Electrical wire to withstand the heat

SR-71 Graphite Airframe Material

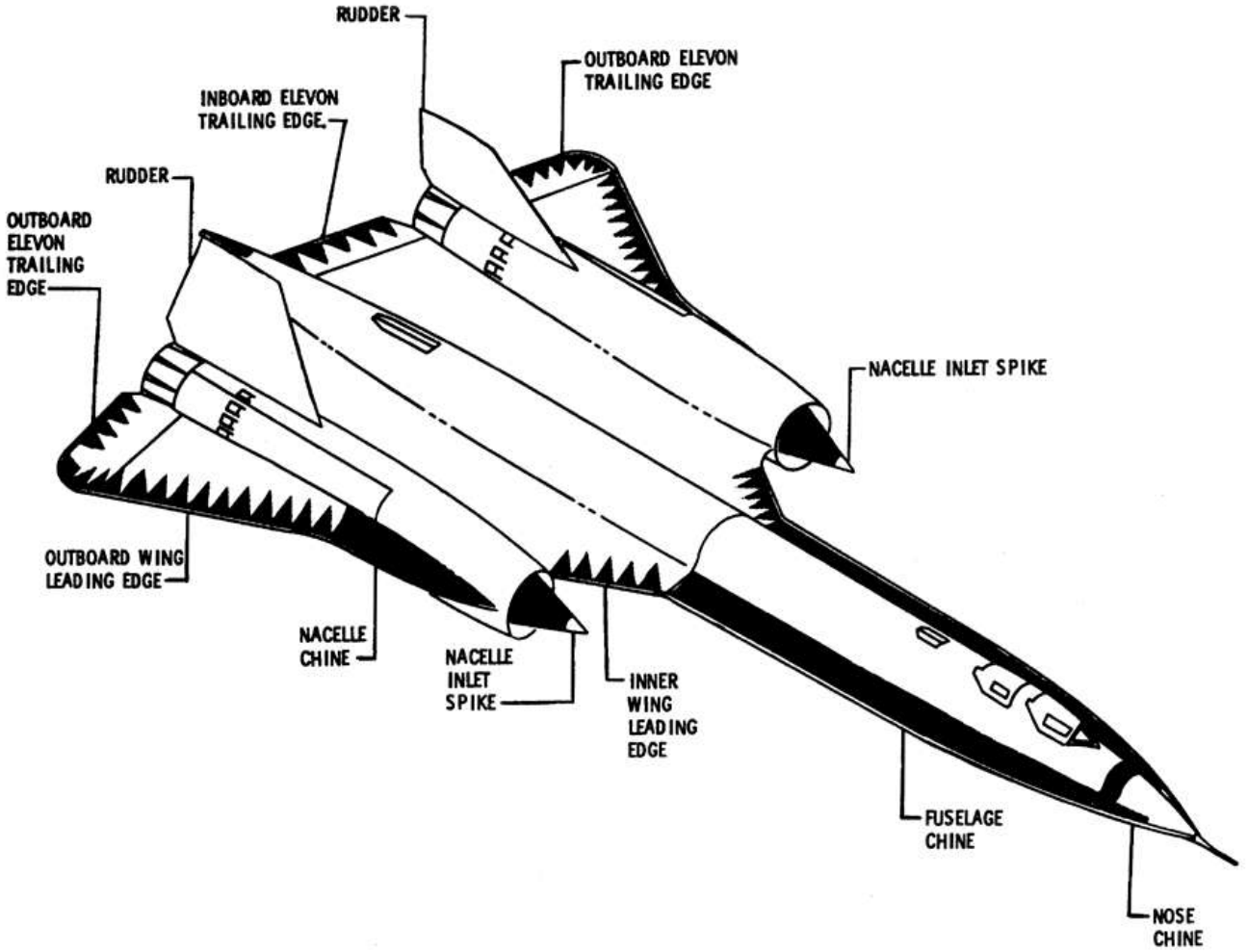


Figure 4-5. Composite-Honeycomb Areas of the SR-71

R203-183(1)(a)

Aerodynamic Characteristics

Double Delta Wing Design

Forward Lifting Body- 35% lift @ 3.2 Mach

Fly higher Altitude and make Steeper turns – 45 deg

Cruise with nose up to create lifting body effect – Engines Level

Sonic Boom - Sound of Freedom

Elevons Mixer Assembly – blend pitch & roll inputs to back surfaces

Dryden Flight Research Center EC97-43933-4 Feb1997
This head-on view is what the aerial tanker boom operator or "boomer" sees as NASA Dryden's SR-71A #844 approaches for refueling. (NASA/Jim Ross)

SR-71 Mission Recorder System Data

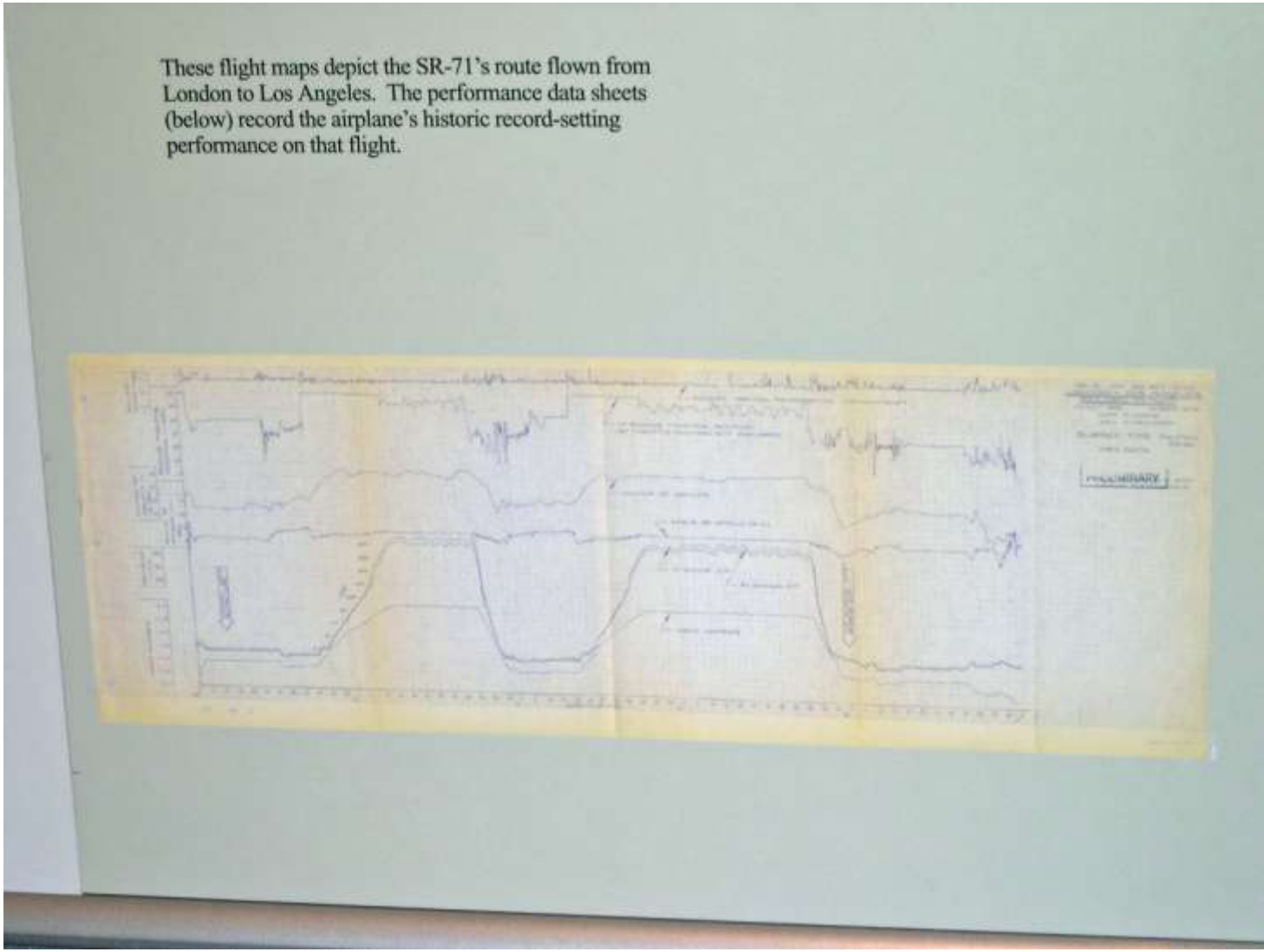
-Records over 650+ Specific Flight & Sensor activities

-On when power is on aircraft

-Data points recorded at set intervals depending on system needs

-Voice recording part of system

- Key factor in achieving almost 95% maintenance operational mission success



Landing Gear & Tires

- **Largest Titanium Forging on aircraft**
- **Tires BF Goodrich 22 ply**
- **Aluminum Silver coating to reduce thermal stress**
- **Pressure 425 PSI filled With N2**
- **Good for about 15 landings**
- **One of the most sensitive operational parts of aircraft**
- **Three aircraft lost due to tire failures. 1 Max Brake Test – 950 & Max Weight Takeoff - 954 at Edwards AFB & 977 at Beale AFB. A fourth aircraft, 978, was lost on landing at Kadena AB, Japan and tire failure was a large contributor**

Wheel Basket protector in Landing Gear Well

-Enclosed Main Wheel protector

-- Protects aircraft from possible tire explosion inside landing gear well as this area had major hydraulic lines routed through it

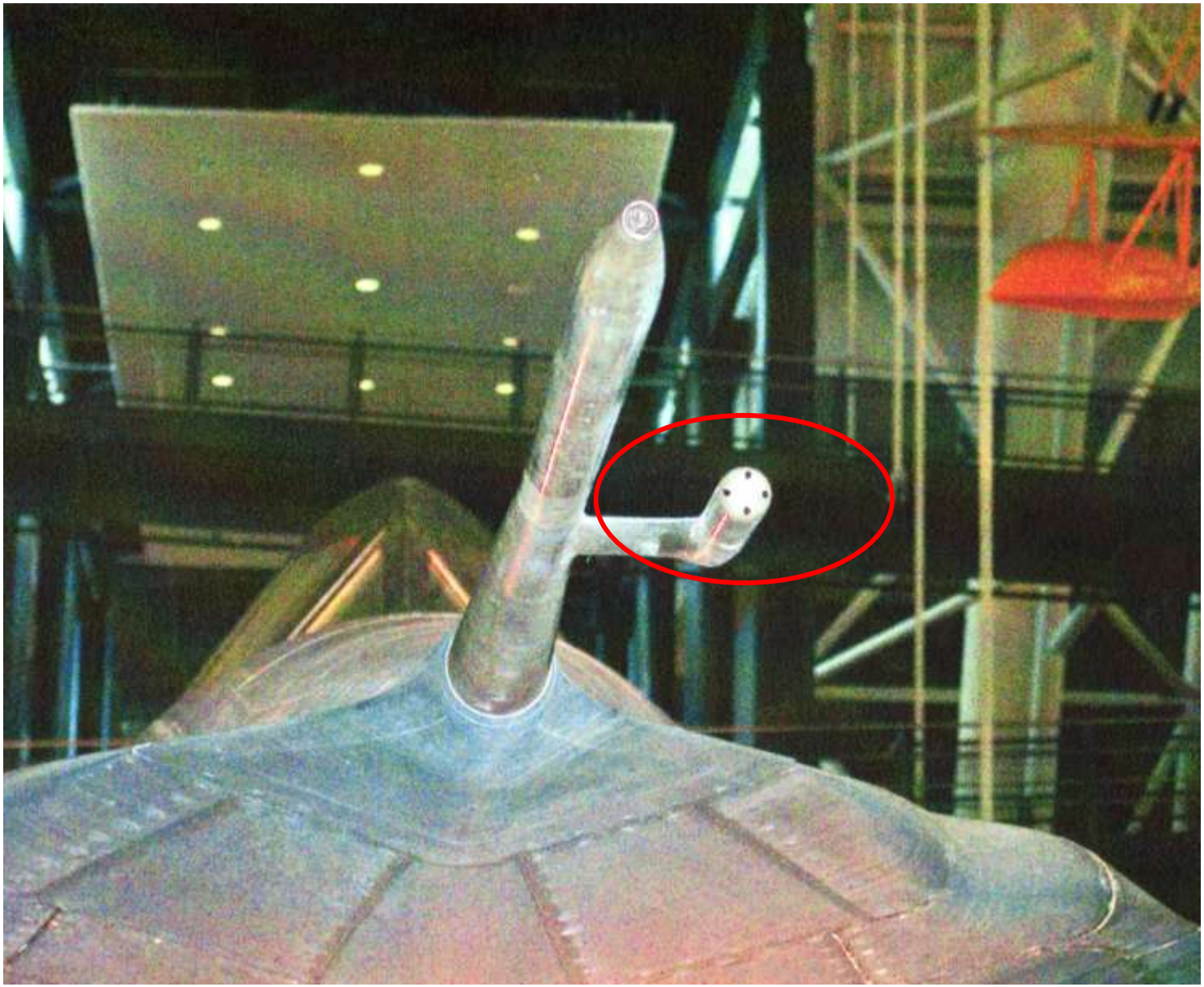
-- Reduces heat stress on main tires by insulating them from hot exterior temperatures – critical consideration for operating this aircraft

Lockheed Skunk Works SR-71 production line

SR-71 Stability Issues – Pitch & Yaw Divergent

-A/C shows divergent stability in Pitch & Yaw axis

-Pitot Static Tube Ys to provide Airspeed from center shaft & Constant Pitch & Yaw inputs for Stability Augmentation System from side shaft



Steam Cockpit with mostly round dials & Analog displays

-Typical late 50s cockpit – Steam Round Dials

--Map projector in lower middle- great innovation- not in A-12 cockpit

- Triple display Indicator had Mach, Altitude and Knots Equivalent Airspeed(KEAS)

-Could manually adjust Engine Temp

- Laser Peripheral Vision Display

SR-71 Electronic Defensive Systems

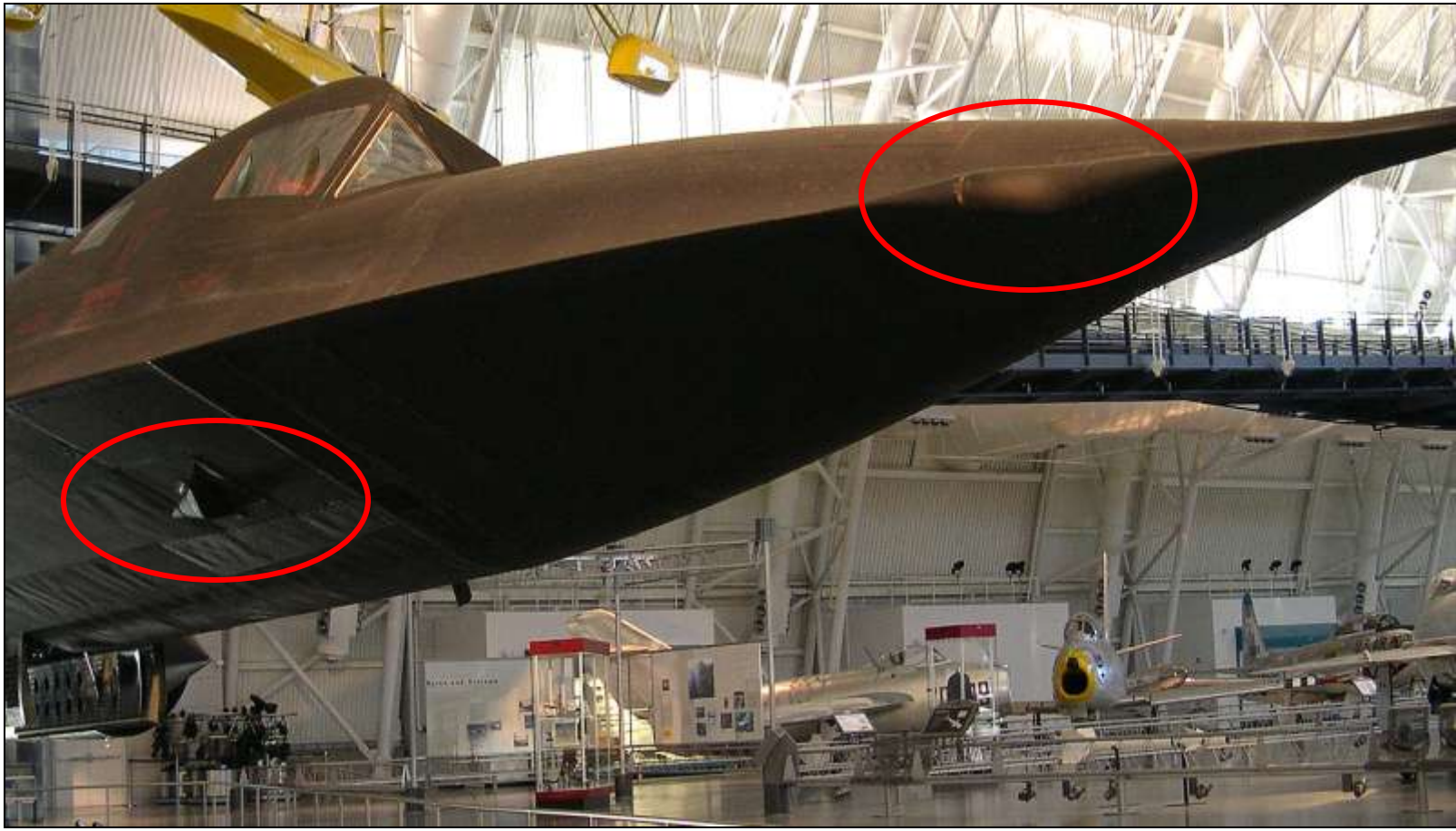
- Powerful Electronic DEF Systems provide SAM & Air -to- Air Missile Protection

- 100s SAMs fired at aircraft

- Numerous Fighter intercept attempts

- Nose ant Threat receiver

- Lower ant Threat Jam transmitter



PRIMARY -2 UHF COMNAV 50 Radios – Forward antenna

-UHF Antennas – Left forward and aft right blades

-UHF Secure comm and tanker ranging info

- Fix Tanker position beyond 300nm with COMNAV 50 range & ADF bearing function present with ARA-48

- HF ARC-190 radio using nose and pitot boom as antenna

SR-71 VHF Radio ARC-186

-VHF radio antenna location under left rear chine near where the wing joins

- Note rearward whip like antenna extension

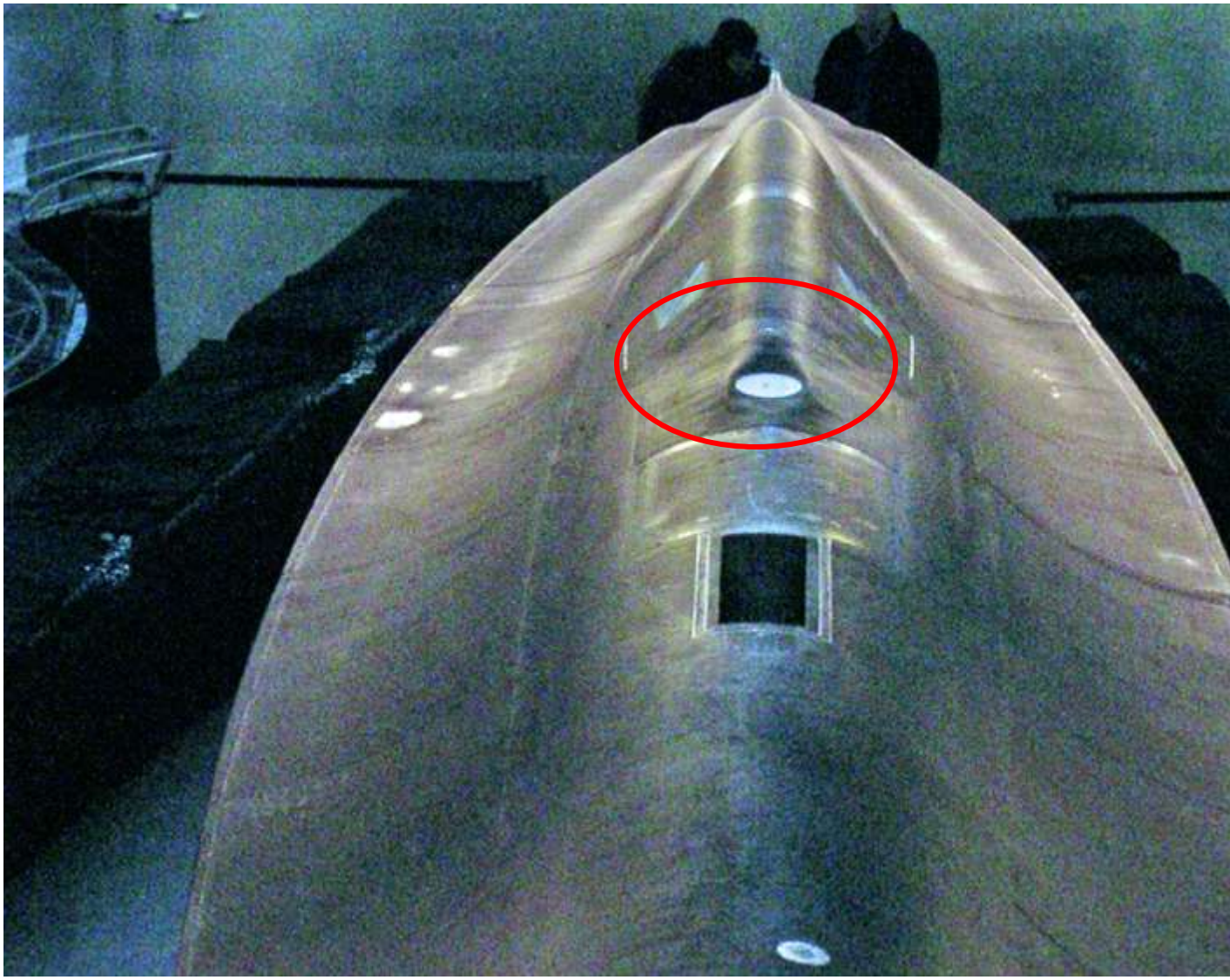
SR-71 Astro-inertial Computer/Navigation System

-Geodetic marker in each Hangar for alignment reference

-Computer loading tapes and alignment 1 hour & 45 minutes+ prior to Engine start

- Astro tracker behind RSO would track three stars on clear day within 30 seconds after leaving hangar – precision location

- Guaranteed President 300 ft anywhere in world traveling at 2200 mph+ BEFORE GPS



PYROPHORIC to Ignite JP-7 Fuel

TEB – Triethylborane

-TEB being loaded by Maintenance with the Fire Department standing by.

- Each engine must be serviced separately to the TEB tank mounted on that engine

Engine Start

- **Mechanical start with two Buick Wildcat engines under aircraft**

-Chemical Engine Ignition –Start & A/B initiation

-- TEB - Triethylborane that Ignites with air @ 3000F degrees

-- Highly toxic & unstable compound

-- 16 guaranteed ignition shots with counter on each throttle

SR-71 P & W J58 Engine

Weight 6,000Lbs

Thrust 34,000 lbs

Bleed Bypass Turbojet Engine with Afterburner

Normal Idle RPM 3975

6 By-pass tubes create part of the High Mach Ram effect

- Air from 4th stage compressor is dumped in front of A/B section for additional thrust & cooling

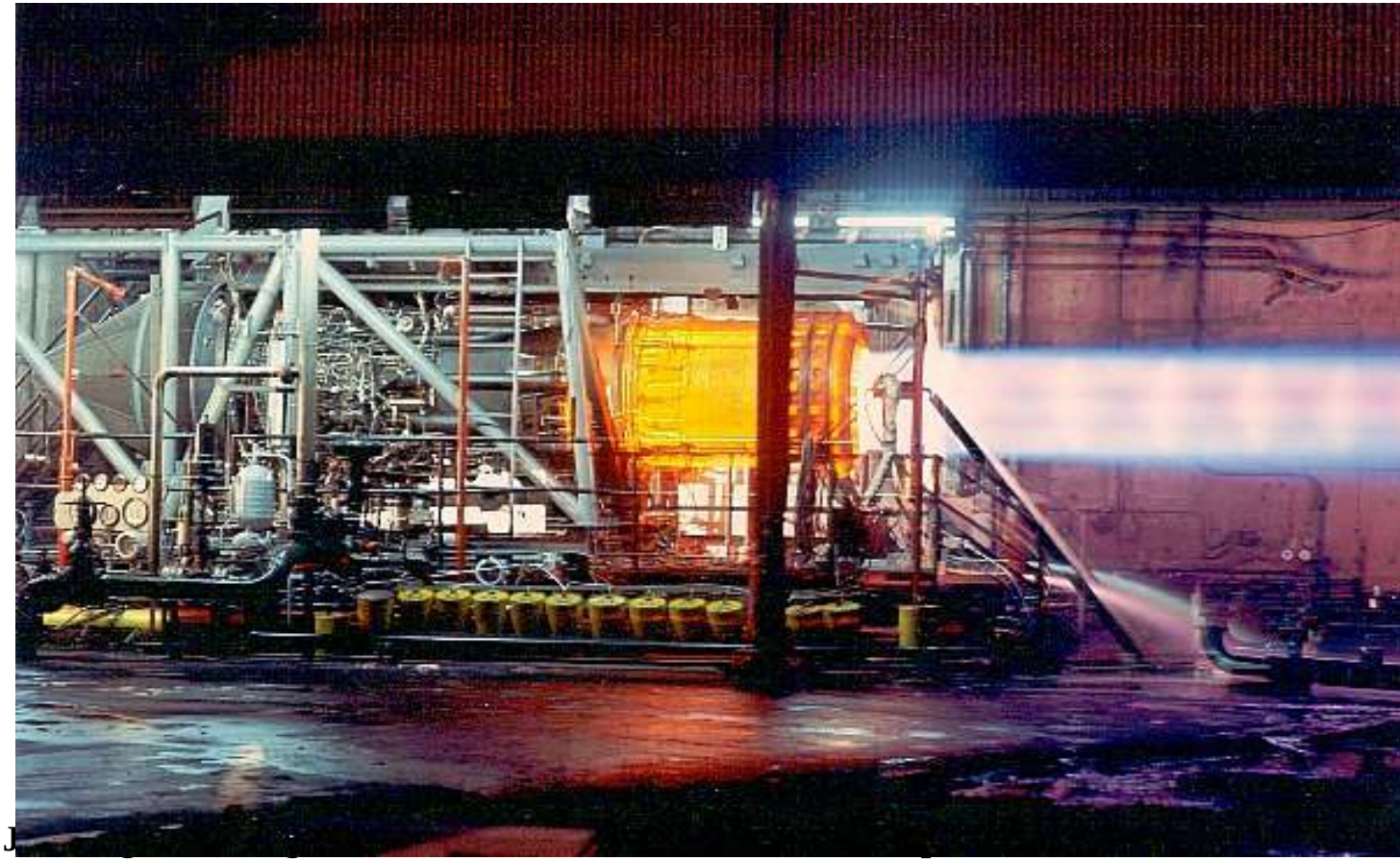
J58 Engine run in full afterburner

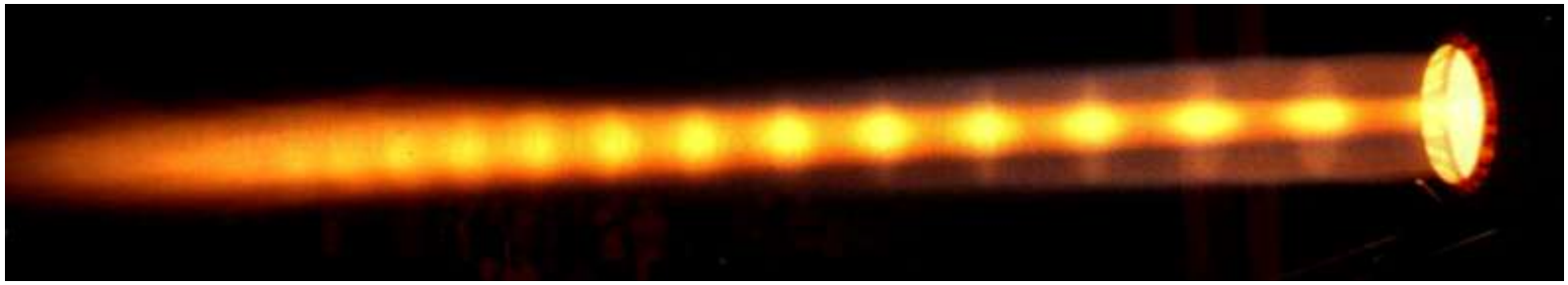
-First Engine capable of sustained A/B use 1.25 – 1.75 hrs during Climb & Cruise

-Rocknite ceramic coating in A/B section helps protect afterburner metal liner

- 13 A/B pressure Jewels in perfectly operating engine

-Core Engine Temp 3400F





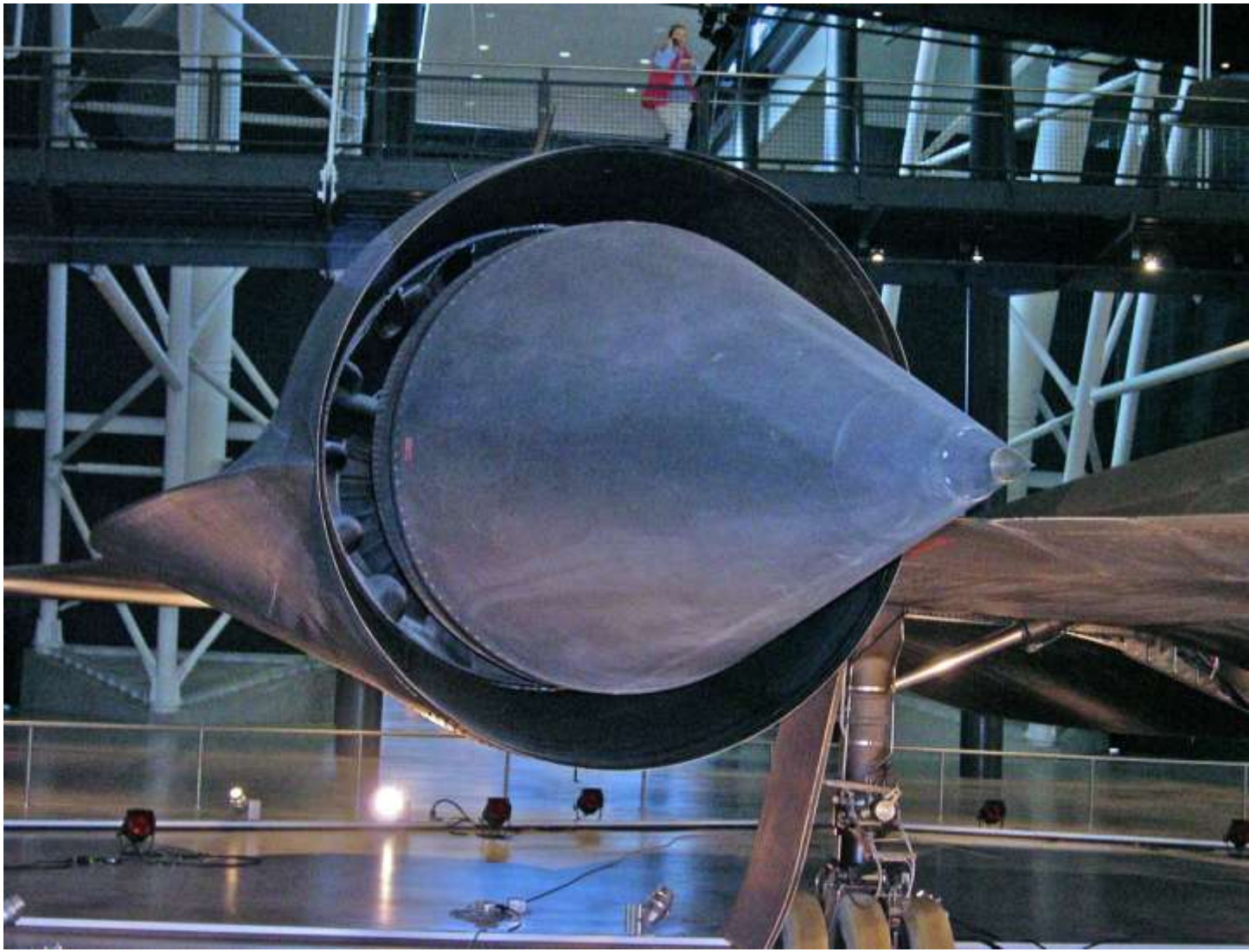
Air Inlet Spike for Controlling the Shock Waves

-Mechanical Spike starts moving aft at 1.6 Mach with 1 5/8 inch movement for each tenth of a Mach

-Total movement at 3.2 Mach is 26 inches

-Shock wave is actually carried inside to reduce drag

-Opens inlet entry area by 112% and closes down inlet throat by 54% by 3.2 mach



Engine/Inlet Controls

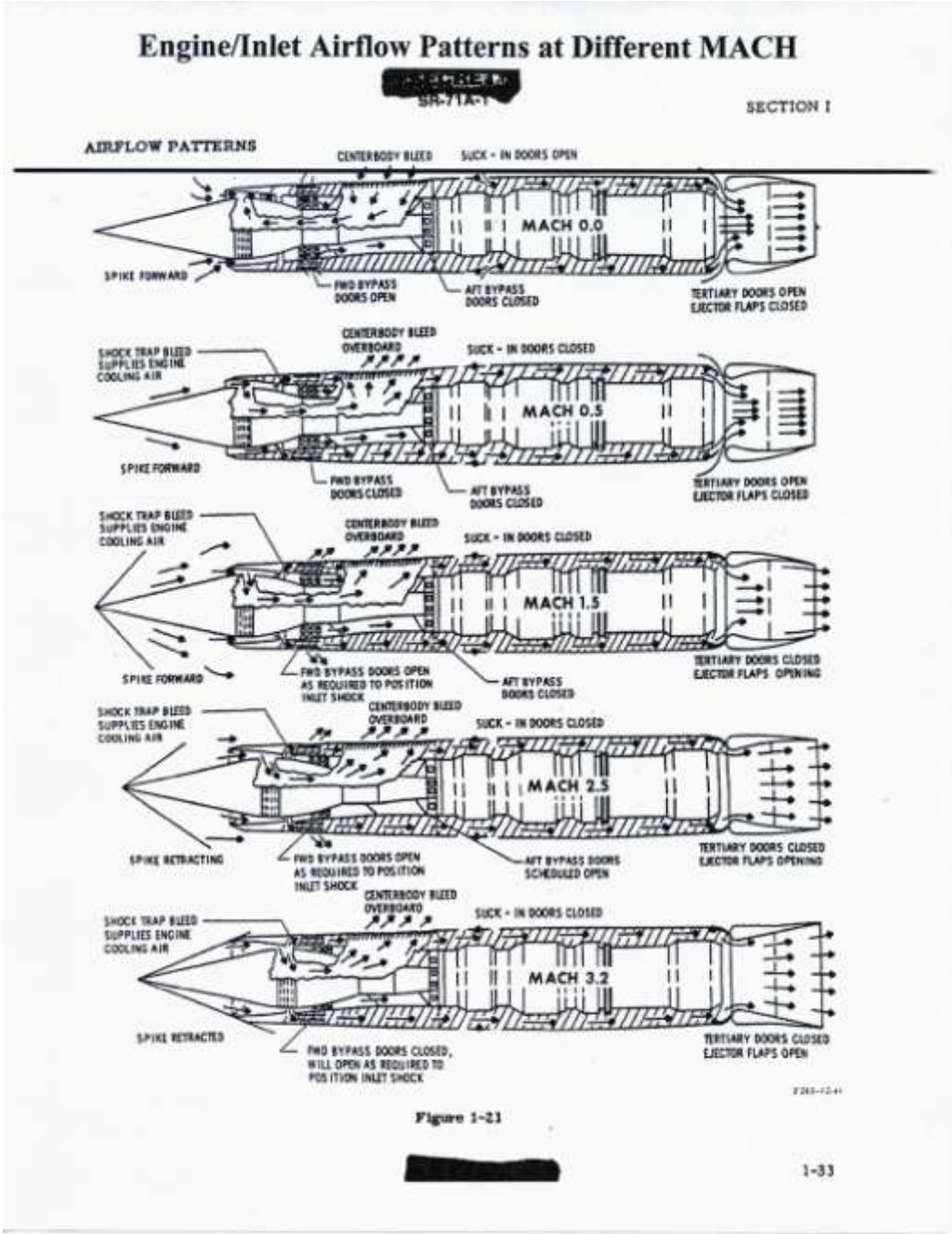
-Forward Bypass doors automatic – normally

-Aft Bypass doors have manually set positions – Closed, 15%, 50% and open

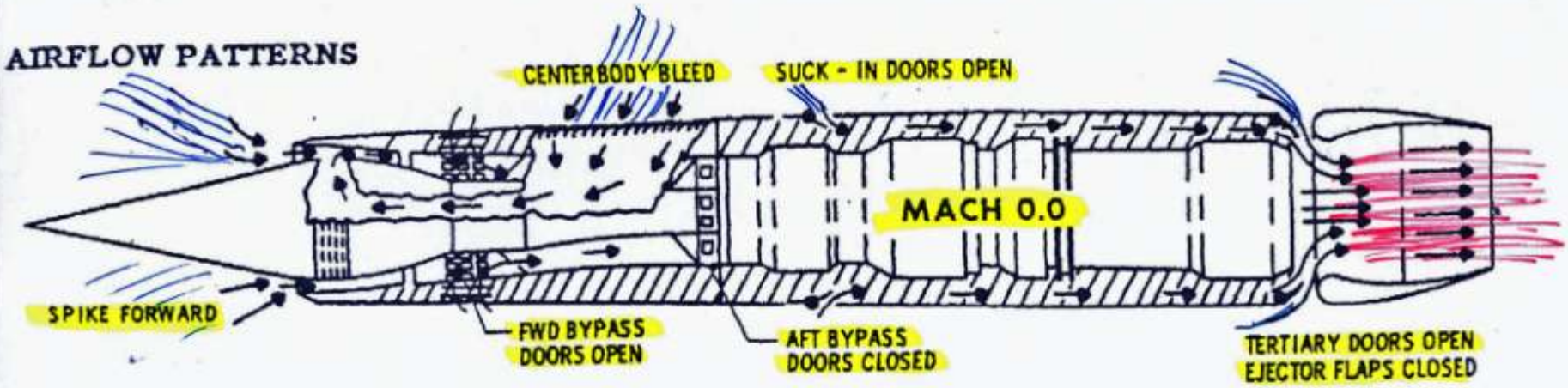
-Suck-in doors, Tertiary Doors and ejector Flaps are controlled by relative pressures

-Engine Internal Guide Vanes (IGVs) shift to sustain supersonic cruise and provide additional thrust for take-off

-- IGV in Axial position subsonic to about 1.7-2.3 Mach. Cambered for Higher Mach cruising

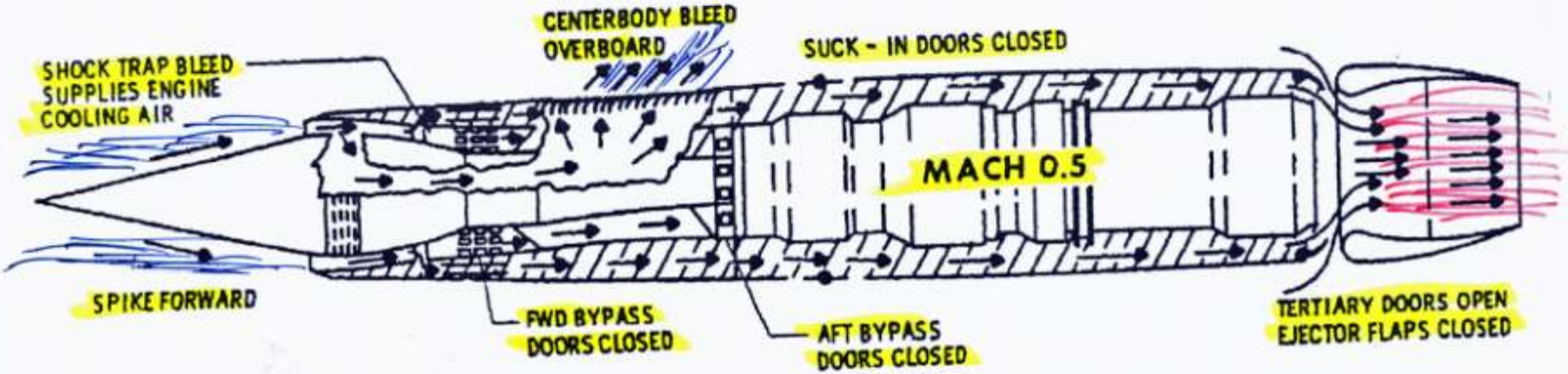


No Air Movement – Spike locked forward, most doors open to get extra air to engine. AFT Bypass doors & Ejector Flaps closed

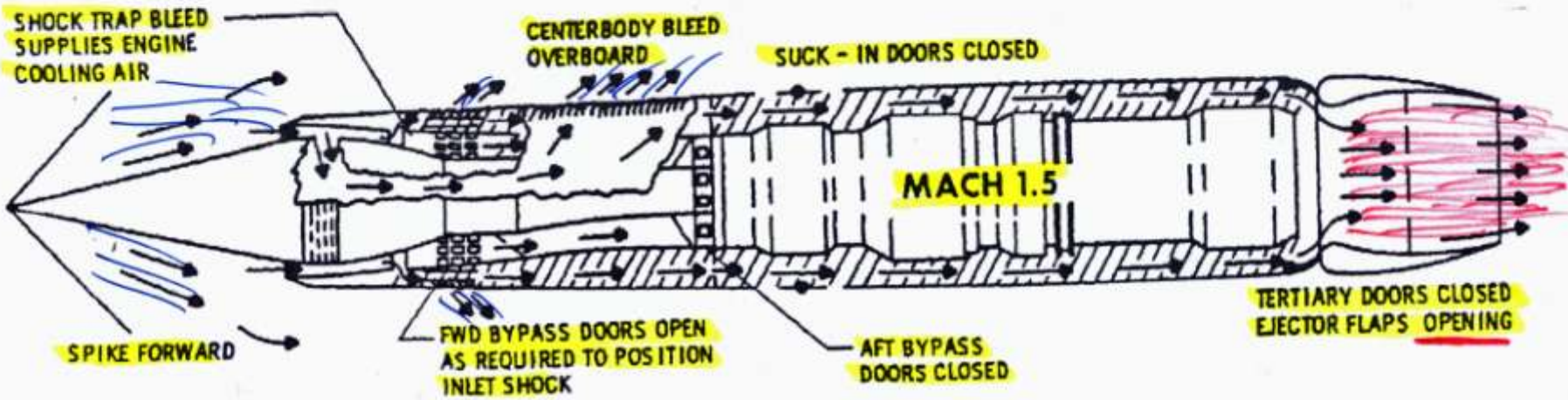


Ambient pressure at sea level 14.7 psi

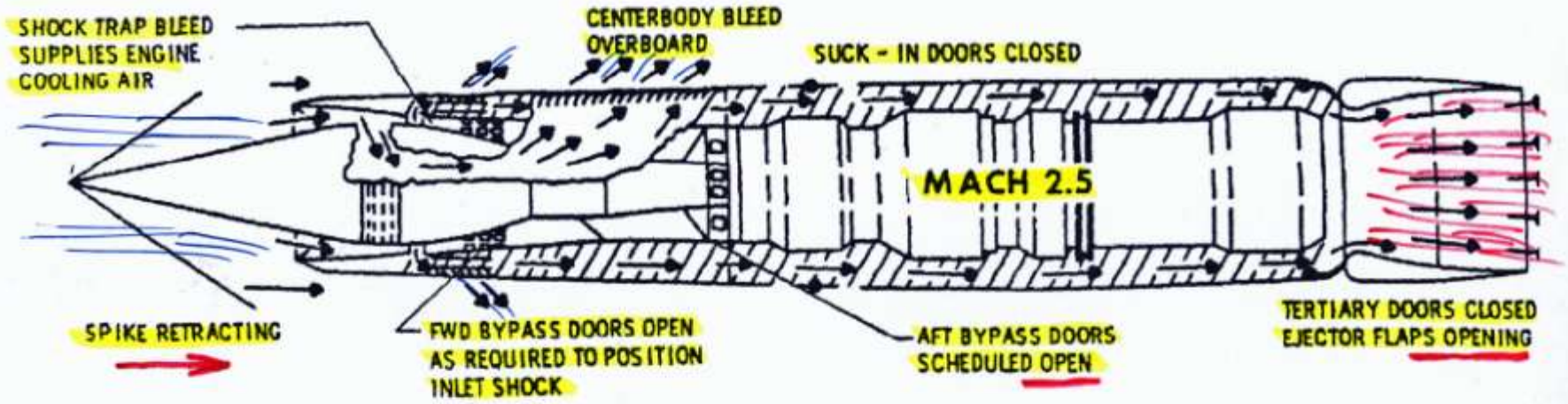
Mid- Subsonic air flow - Spike locked forward, Forward Bypass doors closed, Aft Bypass doors closed, Tertiary doors open and ejector Flaps closed



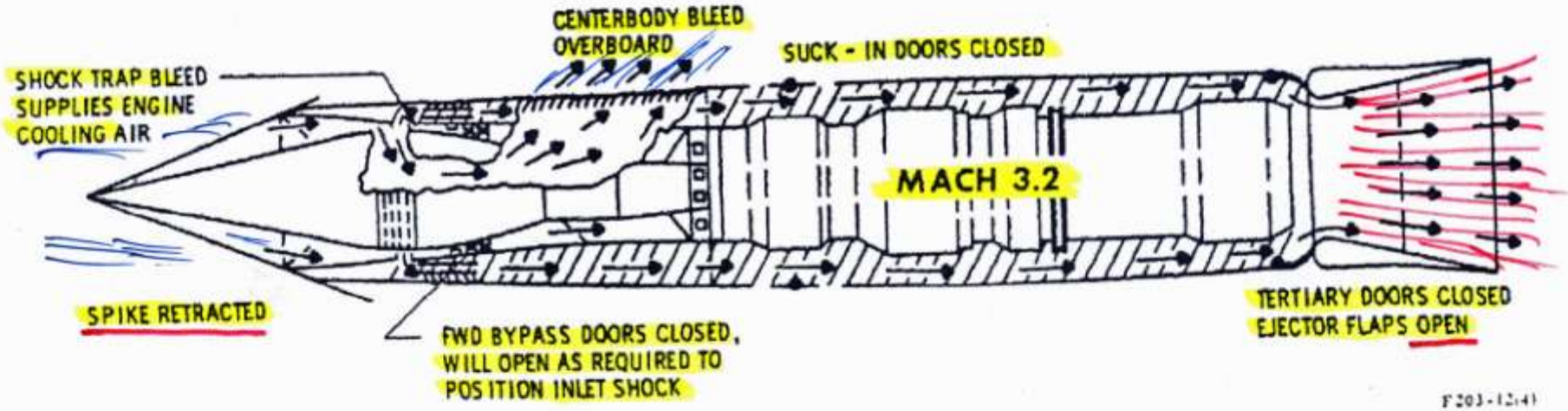
Low supersonic airflow – Spike locked forward, suck –in doors and tertiary Doors closed. Ejector flaps opening depending on engine thrust pressure & forward bypass doors modulating as required



RAM THRUST EFFECT starting to become noticeable- Spike translating aft as speed increases, Aft Bypass probably 15% open & Forward Bypass modulating. Ejector Flaps now further open



Design Top Speed -Inlets tight – Spike full aft, Aft Bypass doors closed, Forward Bypass just barely modulating, ejector flaps normally full open



Ram Effect Comparison –

Outside Pressure at 80,000 ft 0.4psi - at Compressor face 14-16 psi

2.2 Mach Thrust contributors Engine 73%, Inlet 13% & Ejectors 14% - Ram effect 27%

3.2 Mach Thrust contributors Engine 17%, Inlet 54%, & Ejectors 29% - Ram effect 83%

SR-71 Training - A CONSTANT

Special Unit – All volunteers

1 Year initial training

Continuing training: Home: each month - 3 SR flights, 1 Simulator & up to 8 T-38 Companion trainer flights

Overseas - you fly SR-71 as required by Operations & Maintenance

Defining Moments

Your first Crew picture

You are now recognized as part of the crew force – all be it still in training

- Significant milestones: First flight, First Mach 3 flight, First Crew flight, 1st 3.2 Mach Flight, 45 Degree High Bank Turns Flight and finally Night checkout

Aircrew Mission Responsibilities

Pilot – Aircraft Commander, ultimately accountable for aircraft & mission Flies A/C, Engine Inlet control, Air Refueling, Fuel management

Reconnaissance System Officer - Navigator – had Navigation, Sensor Controls, Tanker Rendezvous, Defensive Systems operation, Checklist execution, & most radio calls

Original Gemini Based Suit

-About same weight. Suits either White or Chocolate Brown

-More restricted movement

-Note stir-ups on boot heels – attach to lanyard to bring heel against ejection seat during ejection to prevent collision with cockpit

-Rocket ejection seat one of the safest ever made. No USAF fatalities during program

- Seat tested from on the ground during take-off roll to 80,000ft at full speed of the aircraft

-8-10 minutes controlled fall from 80,000ft to 15,000ft. Here large parachute automatically opened and 15 minutes to descend to sea level

- Suit provided crewmember all the protection they needed from air blast

1030 SR-71 Pressure Suit

-Required for flight above 50,000ft
-David Clark Co. created
-Suit life around 12 years and cost about $250,000
-Suit weighs about 45 lbs
-Suit Basically four layers
 -- Inner nylon layer for comfort
 -- Rubber bladder for inflation
 -- Adjustable fish net to give the suit its shape
 -- Outer layer of Fipro, fire resistant material good to about 800 F
-You flew with the suit deflated at your 26,000 ft cockpit altitude. Only pressurized during an emergency

1030 SR-71 Pressure Suit

-Shoulder area expanded for greater cockpit flexibility

-Velcro used to loosely attach checklists

-Right valve is vent control where ventilating air came in

-Left control is pressure valve to inflate the suit for comfort or during an emergency

-Strap in center is to keep helmet from riding up with suit inflation. Could literally pull your head out of helmet without it

-Boots about 1-2 sizes larger than you normally wore

-Mae West in parachute harness that inflated automatically with water contact

SR-71 Helmet & Gloves

-Helmet weighs about 10 lbs

-Special face plate glass for pilot – distortion free and Plexi-glass for RSO

-Both have fine gold mesh heating elements to prevent fogging

-Dual O2 systems

-Water/food access port on Right hand side. Turn head to use

-Microphone in front of mouth

-Gloves are three layers Cotton surgical glove, rubber layer, and leather/fipro layer

SR-71 shoulder patch worn only by each SR-71 Pilot and Reconnaissance System Officer on the left shoulder of their pressure suits

- PRESSURE SUIT COST of $250,000 included: Suit, Helmet, Parachute Harness, oxygen regulator and suit pressure controller

-

SR-71 HABU patch worn by SR-71 Pilots and Reconnaissance System Officers on their normal flight suits.

This acknowledged that you had flown an operational mission in the SR-71

HABU was the unofficial name given the aircraft by the Okinawans – In Japanese means deadly Cobra like snake

Symbol of SR-71 team. This patch was worn by anyone working in some capacity on the program. It was truly a team with the Pilot & RSO playing one of the few highly visible roles

-Included Aircraft maintenance, Physiological Support Division, Sensor Support, Mission planning, Film & SIGINT Recorder processing, Intelligence, & many other wing personnel

SR-71 Survival Kit

-Packed into seat Kit the aircrew members sat on

-Kit included individual life raft

- Kit was manually deployed after ejection when near the ground or water

- Survival kit was about the same as the USAF kits of this time other than a special life raft for boarding in a space suit

Speed Run Route from London to Los Angeles

3 Hours & 48 minutes -Average Speed – 1438 MPH

-Typical map the aircrew would have carried on flight and used as back-up reference

-Would be in computer mission planning packet for review before mission

- Not much room in cockpit to carry many materials and awkward to use in Pressure suit

Normal Flight Day - Process

-Report 2 ½ Hours prior to Takeoff

-Short Physical

-High protein & low residue meal of Steak & Eggs

- 1:15 hour+ change into Cotton Long Johns to start suiting up process

-Suit is laid out on floor and you pull suit over yourself from the back of suit

-With help of two Physiological Support technicians – everything was command & response

Donning Process Continues

-Donning(suiting –up) process normally took 10-15 minutes to complete

- Here final adjustments are made before helmet and gloves are donned

-Three layers of glove significantly reduced your sense of feel. Had to be very careful as you moved switches, etc

-Each of us had two complete pressure suits with helmets

Pressure Suit Functional Checks

Checks

-Oxygen Sys

-Suit Pressuri-zation

-Communi-cation

-Inner suit seals between helmet and suit , entry zipper & glove seals for overall suit pressure integrity

-Face Heat

Inflated Suit Check

-Suit tested for pressurization and any leakage

-Held your breath and felt like the Pillsbury Doughboy

-To feel the suit at this point it felt very rigid

-Final adjustments are made to the suit and the ejection seat stir-ups are installed on boots

- Most common leak area was at the glove seals

-1030 suit bulkier but more comfortable than Gemini suits

-This “business” work suit was not for the claustrophobic

-In Pressure suit for up to 13 hours – normally more like 4-6 hours

Used slow deliberate movements so that the suit went with you and then the suit did not fight or restrict your movements

This suit was later used on the Space Shuttle test flights

Lockheed Test Pilot Bob Gilliland – 1st to Fly SR-71 22 Dec 1964

-Note access ramps on both sides of aircraft to install crew members into cockpit

-Bob is wearing the original Silver Pressure suit

- Silver was used to reflect the heat away to protect the aircrew member

- Portable suit cooler is right beside him. Start heating up in less than 10 minutes without this

Physiological Support people Installing Pilot in Cockpit

Strapping in Flight Crew

Engine Start –Buick Wildcats

-A pair of Buick Wildcat Engines connected in tandem drive a manual drive shaft to turn over the large J58 engines from underneath the aircraft

-At 1000 rpm engine ignition is started with a shot of TEB as the Throttle is set to idle

-At around 3200 rpm the shaft senses engine acceleration and automatically disengages

Ready to Taxi

-Engine Start 30 min prior to Take Off

-Faceplates down – 100% O2 – 30 minute breathing O2 reduces N2 in blood by 50% to reduce possible Bends

-Taxi route & length critical to A/C tires

-Flight control checks here

- Note JP-7 fuel on hangar floor- Always leaking

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC95-43075-4 Date: 1995

SR-71 - Taxi on Ramp with Engines

Takeoff & Climb Data

-Take-off - one of your greatest senses of speed and power Release brakes, select A/Bs – always asymmetrical lights –20 seconds thru 4,500 ft and lift off at 210 knots (~240 mph)

-Pass thru 20,000ft in about 2 minutes after brake release

-Climb/accelerate to 75,000ft+ will take another 17 minutes, consume 1/3 of your fuel, and roughly fly about 360 nautical miles

-Level off and establish a cruise climb profile as you burn down fuel

-Hostile over flight must be 75,000ft+ & 3.15 Mach to enter enemy airspace

SR-71 View from 80,000ft +

-Curvature of earth

-See 350+ miles

-Black sky over head as most of air is below you (97%)

-16 miles up with no real sense of speed

-Quiet because you are in Space suit and Supersonic - noise is behind you

View from U-2 at 70,000 ft +

-Almost same curvature

-Better view of land – Lake Tahoe California below with Sierra Nevada Mountains

-Give museum guests better sense of the magnificent view from on high

-Spectacular Starry night view as 90% of the stars at altitude are not visible on the ground

SR-71 Sensor Combinations

-Multiple sensor combinations

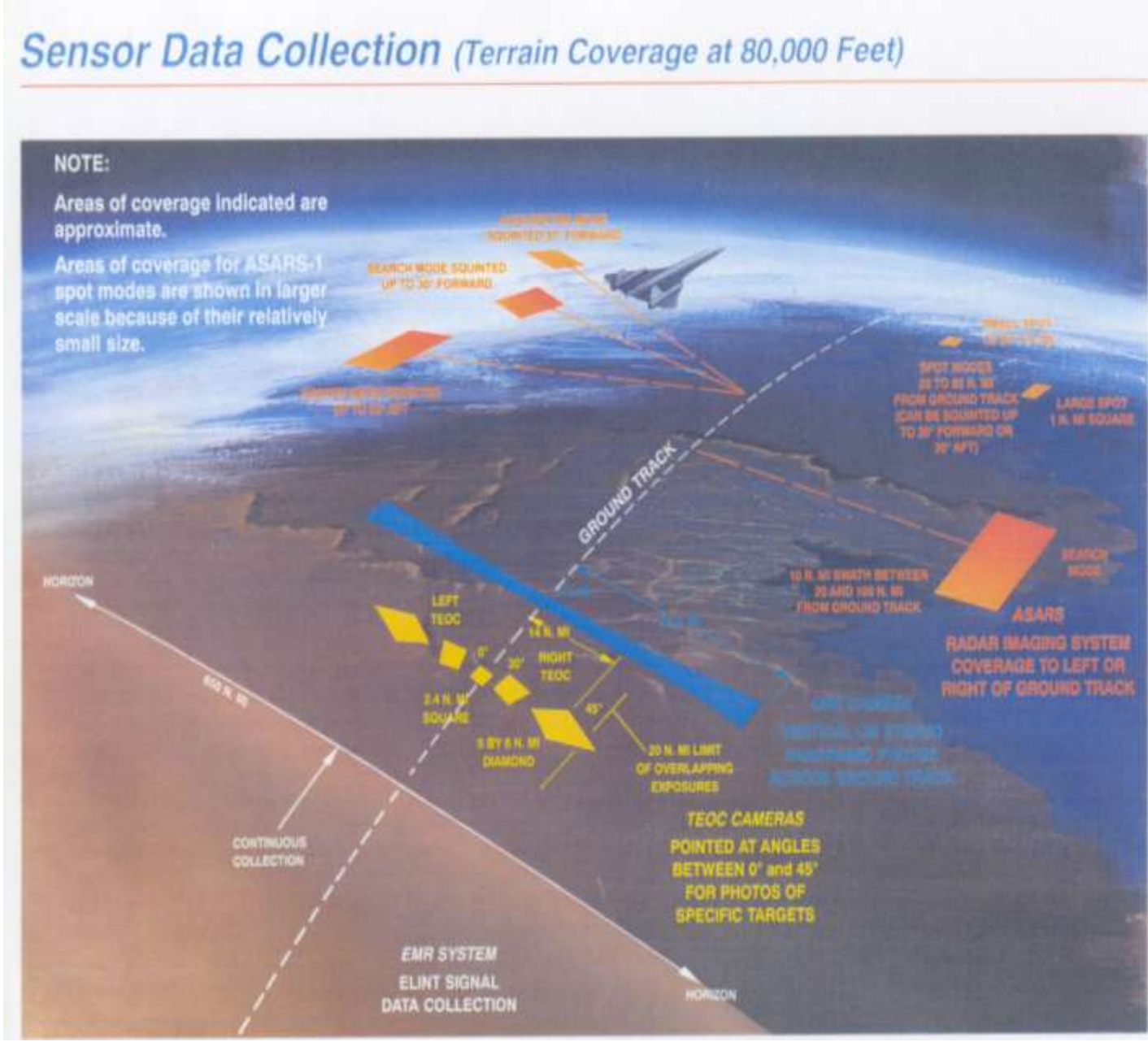
-- Nose- Training, Synthetic Aperture Radar, & Optical Bar Camera

-- Side bays -Technical Objective Pointing Cameras, Electromagnetic (ELINT) Reconnaissance System (EMR) , mission recorders, Radar recorders, etc

-- Center bay Terrain Camera

-Nose – Optical Bar Camera (OBC) – film 100,000sq miles/hr, film image 72 miles wide, & film length 10,500ft OR Synthetic Aperture Radar (SAR) with 12” res in spot mode 25-85 NM either side. Can do 10 nautical wide swaths either side of aircraft at 20-100 nm with 10ft res – Technical Objective Cameras- Mounted both sides of Chine controlled by computer – 100s of targets/mission with sub 12” res possible – out to 20 nm on side mounted - Electromagnetic Recon Sys - Electronic horizon 600nm+ Greatest ELINT gatherer of its time

SR- Used as stimulating aircraft of enemy on Coordinated Missions



Toughest missions -Not over flights because political risk already taken , but right on the border @ Mach 3+ flights with no over flight authority – even in the case of an emergency. Very strict Rules of Engagement

Descent planning – Slow and cool down aircraft

-Start down 220+nm back and it will take 10 minutes to 25,000ft

-Carefully come out of A/B

-Narrow speed & altitude profile to maintain during descent to assure A/C cooling and prevent engine compressor stalls

-Figure every two hours and 2800nm (~3200 Statue miles) it's time to refuel or land

SR-71 Air Refueling Receptacle

-Air Refueling receptacle puts you well under the tanker

- Transfer about 6,000 lbs/min (1000 gals/min)

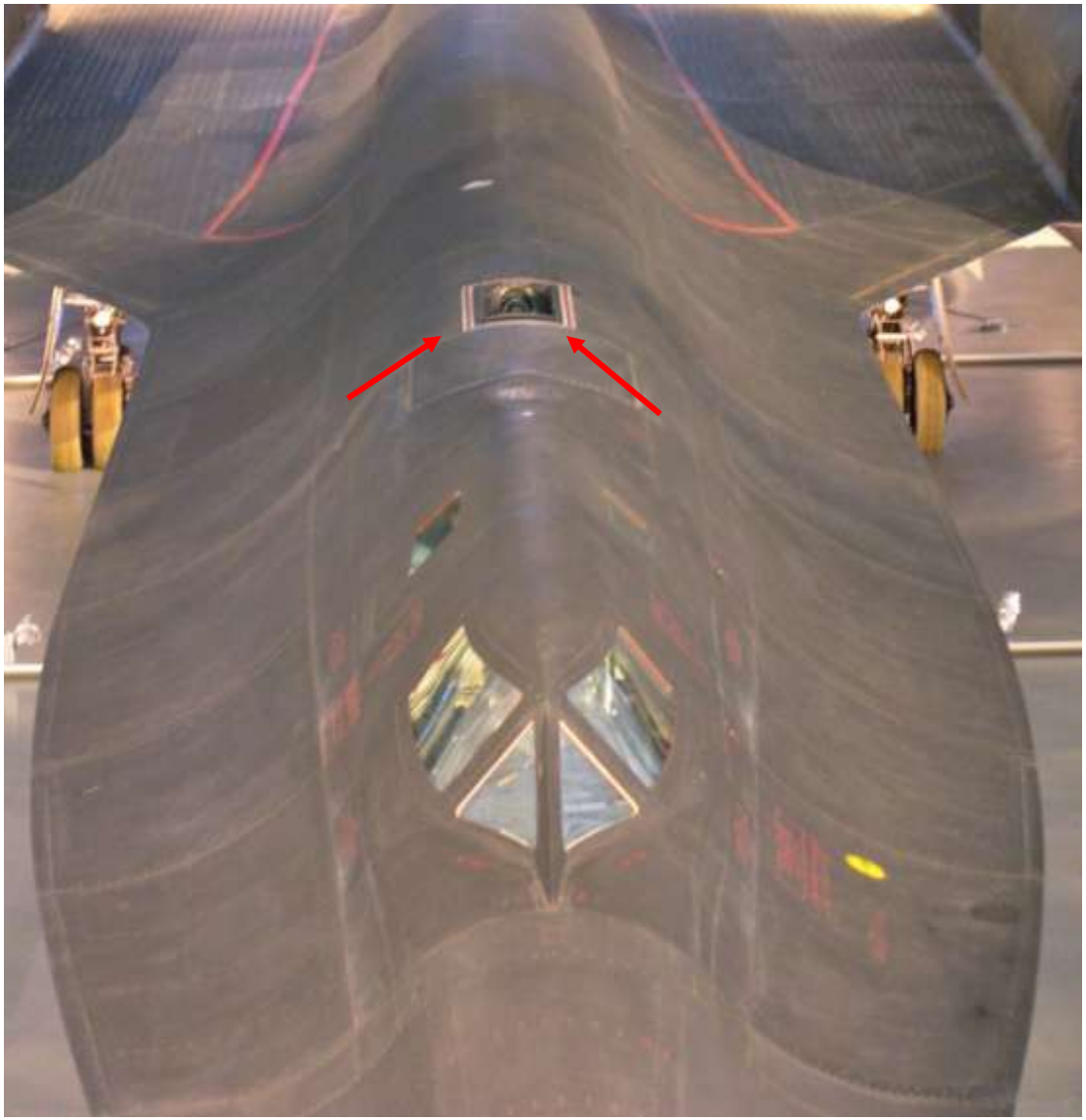
-Refueling normally 12-15 minutes

- One of the more demanding parts of the Pilot & RSO training
-- Pilot to handle the SR-71 under tanker in contact position & using A/B at higher fuel load weights

-Normally lighting an A/B while remaining in contact – timing on air refuelings was often critical

-RSO to plan and execute supersonic rendezvous with descent and guidance to hook-up

-Operational missions were normally radio silent; maintaining a listening watch



KC-135Q Tanker refueling SR-71 - 952

KC-10 Refueling SR-71

Normally Multiple Tankers for Air Refueling

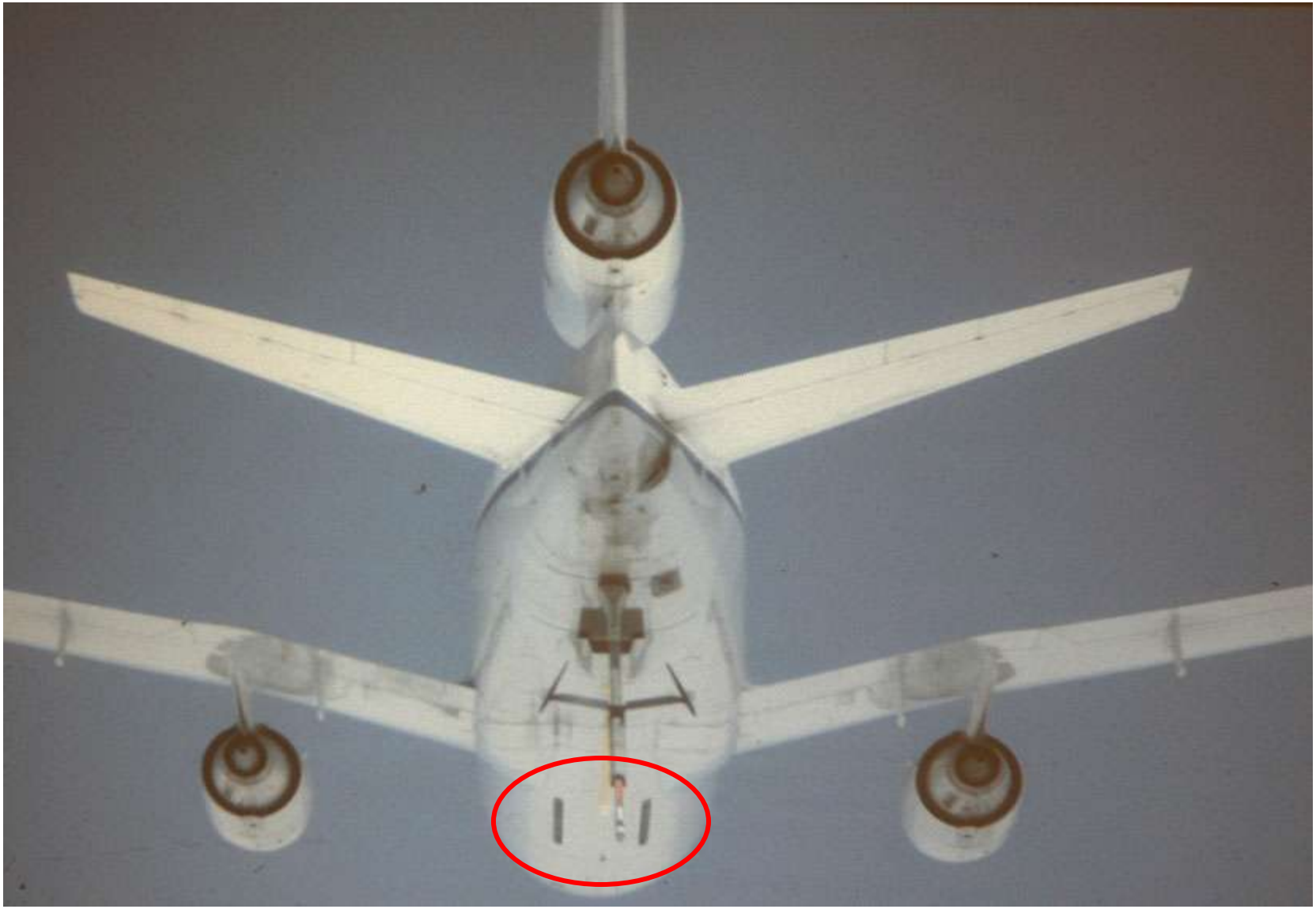
-Multiple tankers for practice

-Overseas many times distant A/R tracks too far for single tanker to cover SR-71 fuel off-load

-Extra tanker in case of Tanker abort because of equipment malfunction during refueling

-California to Northern Coast of Russia & Back – tapped 15 tankers during 5 air refuelings on a 10.4 hour mission off-loading 72,000 gals plus – covering 15,000 miles

Approaching tanker to position yourself in contact position



Note director lights on belly of Tanker aircraft – Boomer in window

SR-71 refueling from KC-135 Q – View from SR-71 Cockpit

Air Refueling Limits & Guidance

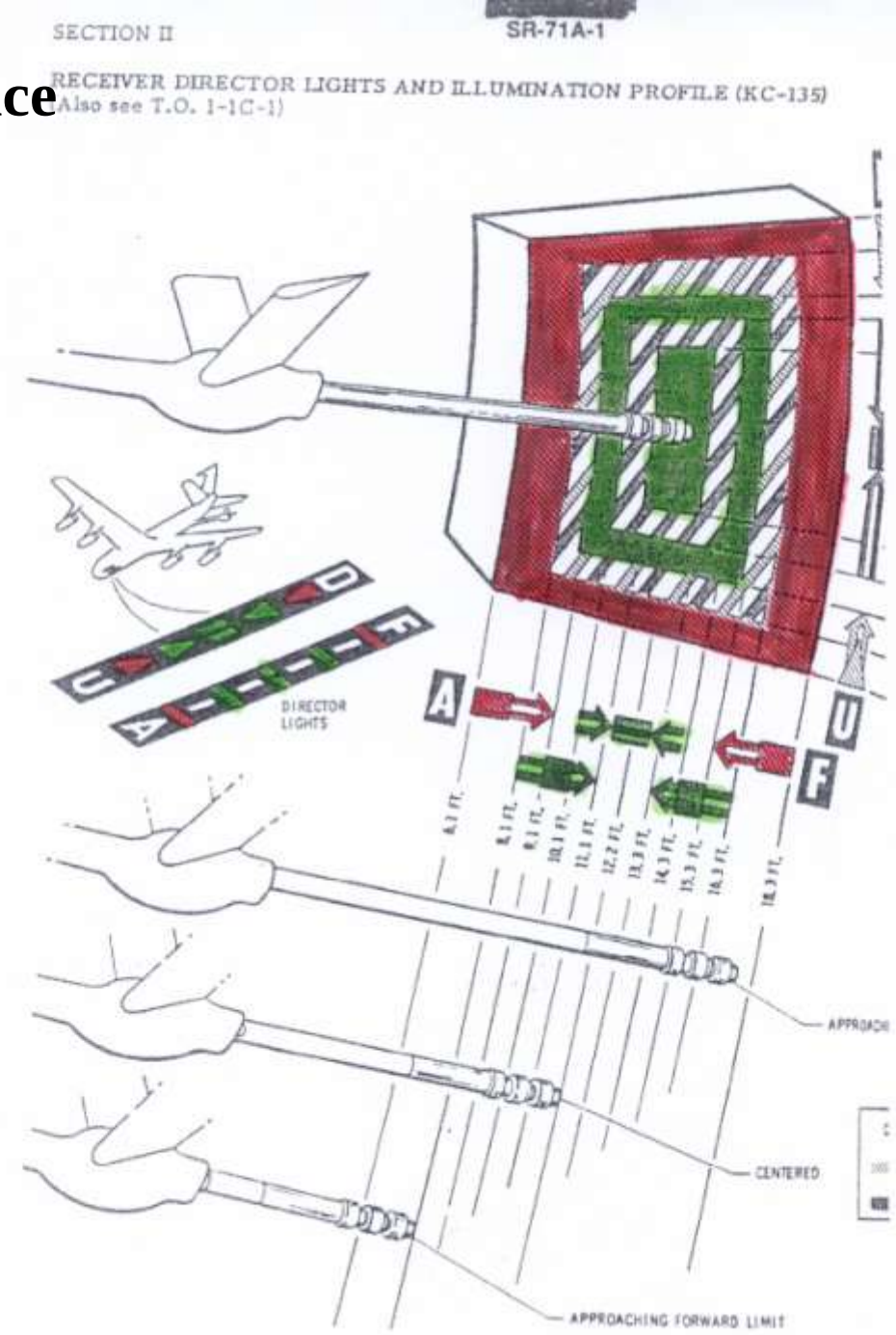
-Center yellow strip on tanker belly to give center line reference

-Director lights on forward belly of tankers
– Captains bars in center mark desired aircraft contact position

---- Up & Down on left side
----Right side guides Forward & Aft

- Critical to have full fuel tanks at the end of the air refueling track

-Many missions had also a critical end air refueling time to make good a directed time in the objective area

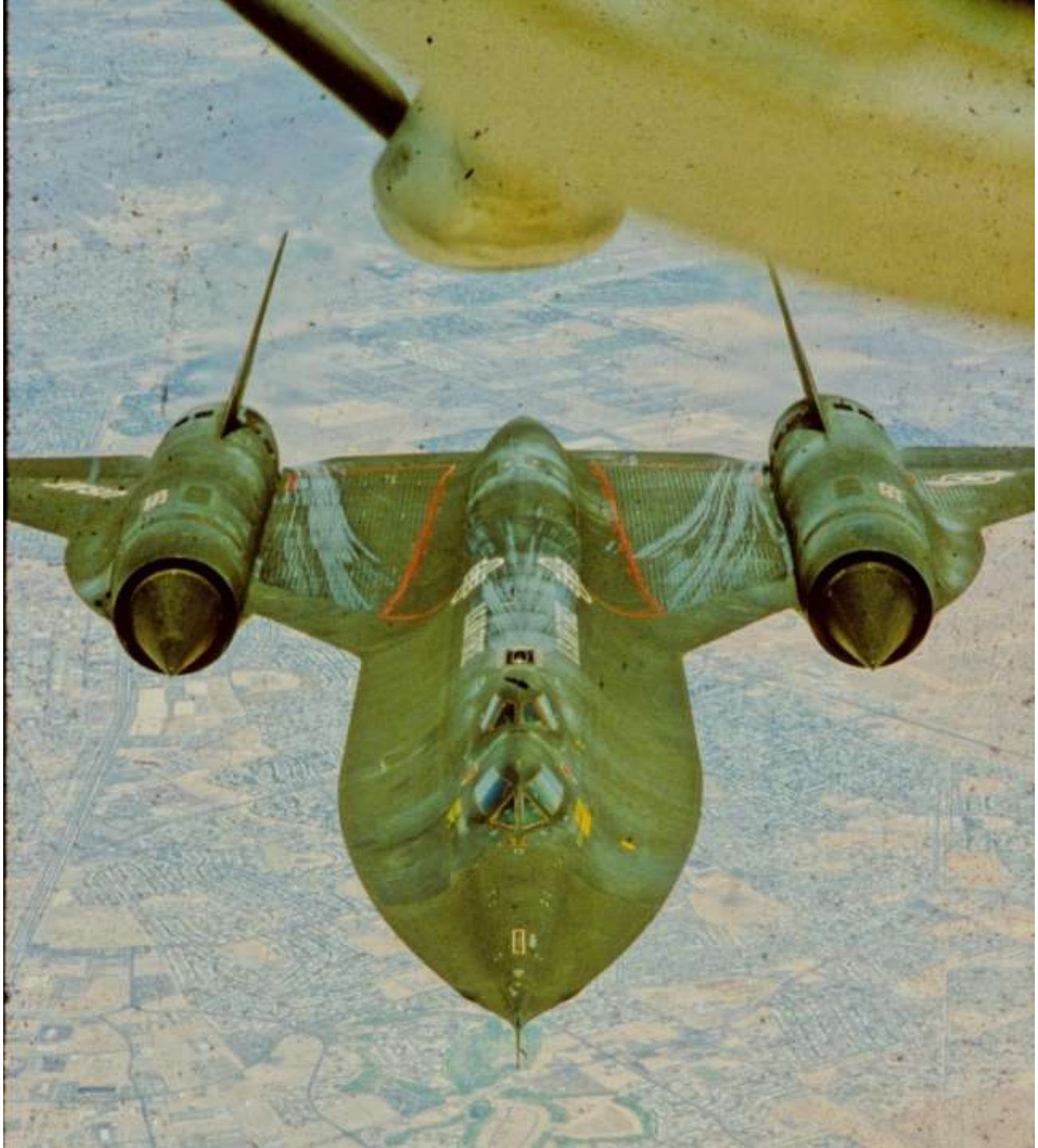


SR-71 Refueling in the Contact Position

SR-71 B-Model completing refueling over El Paso, Texas

B- Model SR-71 Trainer aircraft had dual controls in the front and back seats for initial & continuation pilot training, check rides, and VIP orientation flights

Note fuel leaking from wing tanks & elevated rear cockpit for Instructor Pilot



SR-71 Approach & Landing

-Land with normally less than 10,000lbs fuel

-Approach A/S 175 knots + fuel

-Land 155 knots + Fuel (~ 170+ MPH)

-Crosswind landing critical on tires

-Deploy drag chute on landing –jettison by 55 knots

-Roll-out 4-5,000 ft on 10,000ft runway

After Taxing & Parking in SR-71 Shelter

As Engines are shut down cooling air is applied to the hot aircraft brakes

The brakes were actually undersized for the aircraft's weight to save on weight – creating a critical aircraft operating factor

Sensor download after Engine shut down

-Here an Objective Technical Camera is downloaded from a side bay onto a dolly which will then be wheeled into the photo facility for film down loading

-Aircraft optical sensor systems were complete units which included the Quartz optical glass window & would be installed into a side bay or with the panoramic camera being installed as one of the interchangeable noses.

-Aircraft nose had three configurations, training as you see at the UHC, SAR radar which externally looks the same or optical which had large glass windows in the center bottom of the nose

Initial Dark Room film assessment - preprocessing

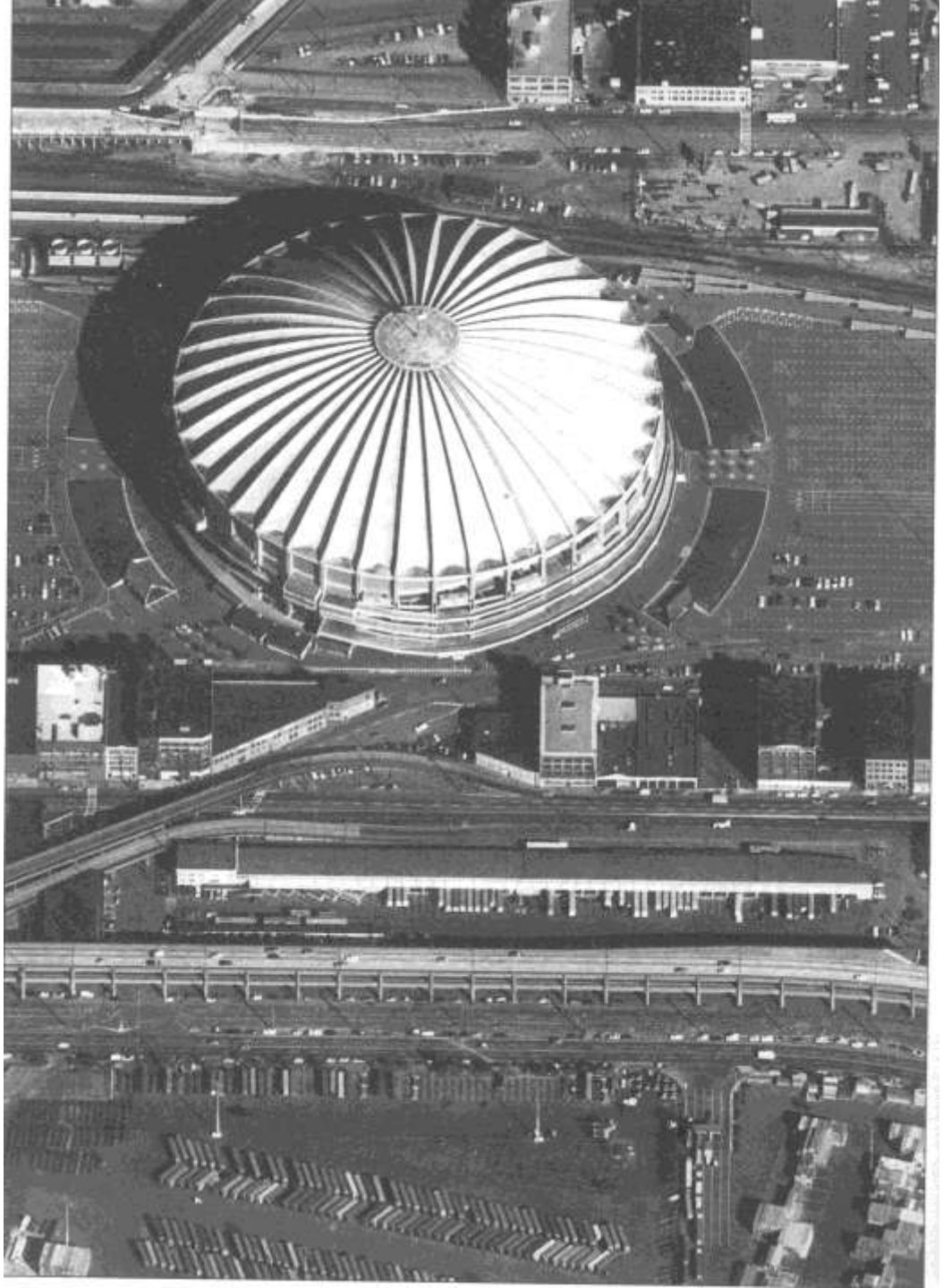
-All film had to be inspected by hand to detect torn or broken film

-Color film had to be done in pitch black conditions

-Film cut into 500 ft lengths with headers and tails spliced on for processing This insured speedy processing and if there were an accident only a limited amount of film might be effected

-SR-71 picture of Seattle Kingdom from 80,000ft +

- Black & White as a single emulsion thick gives the best film resolution – sub 12 inches possible



Rare Color picture of Beale AFB from 85,000 ft

-Used mostly Black & White film as the resolution was much better and much less expensive

-Color film excellent for camouflage detection but had much longer processing time

Patch of the 9th Strategic Reconnaissance Wing

Wing For SR-71s and KC-135Qs. Later gained U-2s which they are still flying today. The USAF's Global Hawk, Unmanned Aerial Vehicle, is assigned with them at Beale AFB - Home of High Altitude Recon for USAF

FIRST STRATEGIC RECONNAISSANCE SQUADRON

The Only SR-71 Squadron. It's linage went back to the first Military Aero squadron in the Army Signal Corp formed in 1913

Some Good SR-71 BS – Stuff that tours are made of

FAREWELL – Last Shot of SR Fleet before being dispersed

Why Retirement? … Cold War over -Threat diminished, Too Costly -$85,000/hour, & Never had a real time data link to bring the information immediately to the decision maker