SR-71 Blackbird Operations Manual

"I was extremely impressed by the level of detail in your display of 955. *Everything looks true to form. You obviously take great pride in getting things right and you've succeeded on the SR-71."*

Richard H Graham, Col. USAF
(Retired, SR-71 Pilot, Squadron Commander and 9th SRW Commander)

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Introduction & Brief History

The Birth of an aviation legend began in September 1959 when the DOD, CIA and USAF decided that Lockheed would build a U-2 follow on aircraft under the codename 'Oxcart'.

The design team lead by Kelly Johnson designed and built the A-12 - a single seat Mach 3+ capable aircraft that was way ahead of its time. The aircraft coupled with the awesome power of twin Pratt & Whitney J-58 Continuous Bleed Afterburning Turbojets was like nothing seen before. Designed to operate in full afterburner for an hour at a time before descending to refuel, it's engines were extraordinary. The J-58 propulsion system and inlet combination were to realise the performance of the airframe since the inlet cone itself at Mach 3+ provided more thrust than the engine itself. It was likened to being a Turbo-Ram jet.

The high speed of the aircraft necessitated the use of exotic materials. Titanium and composites were used and expansion joints were designed into the airframe to allow for the 6 inches of growth due to the extreme heat soak received at High speed.

The A-12 was used with great success over North Korea during the Vietnam war operating from Kadena AB, on Okinawa Japan. The pilot workload on the A-12 was much higher than other reconnaissance types due to the high speed, and the fact that the pilot not only had to control an aircraft travelling at 30 miles per minute, but he also had to operate the camera systems and ECM gear.

Lockheed in the meantime proposed both Bomber and Interceptor variants of the A-12 - the F-12 and the RB-12. The F-12 reached prototype stage known as the YF-12 and went on to launch several AIM-47 missiles (incidentally these were later adapted into the Phoenix missile system used on F-14 Tomcats). The YF-12 project was cancelled in favour of equipping frontline interceptor squadrons with F-106 aircraft which were more bang for the buck.

The YF-12 Prototypes went on to have a distinguished career with NASA as test aircraft.

Another of Lockheed proposals was to bring an end to the CIA crewed A-12, and bring the Reconnaissance capability into the USAF. This was achieved by the design of a heavier two seat variant, initially known as the RS-71. The project (codenamed Seniorcrown) was officially announced by the White House Press Office on 25th July 1964 as the SR-71.

Moving towards it's first flight the SR-71 was delivered by truck from Burbank to Palmdale Air Force Plant 42 in California. From here the final preparations were made and the first SR-71 #17950 was rolled out of the hangar on 22nd December 1964. With Bob Gilliland (call sign Dutch 51) at the controls #950 got airborne from runway 25.

While the testing process had begun, the hunt was now on to find suitable aircrew. Exceptional Pilots and navigators from various SAC units and fast jet types were initially selected. This trend continued throughout its career - only the best aircrew made it through selection. Still, two trainer aircraft were deemed necessary - #17956, and #17957 were converted to trainer variants on the production line. Unfortunately the second SR-71B #957 met an untimely end in a field on final approach in January 1968. #956 would soldier on right to the end as the sole training aircraft.

In December 1967 Defence Secretary Cyrus Vance directed that the overt SR-71 replace the covert A-12 at Kadena and to begin covering the Vietnam theatre. The 1st SRS was set-up and the ferry flights of the SR-71s began from Beale. Codenamed Glowing Heat these missions would begin by the crews flying to just north of San Francisco where the crew would make a high altitude, high speed dash to test all the systems before making the flight across the pacific.

Unfortunately Kadena and the 1st SRS lost a couple of SR-71s. Notably 17978 with its Playboy bunny motif was destroyed in a high crosswind landing accident after a failed approach. More recently 17974 had the distinction of being the last SR-71 crash. #974 crashed near the Philippines after catastrophic engine failure - fortunately in both incidents both crew survived.

Aircraft 17974 was the last SR-71 to be lost. USAF Photo

Aircraft at OL-8 Kadena were rotated on detachment from then until the aircrafts first retirement in 1990.

During the early 1980's the SR-71 made several deployments to Det 4 at RAF Mildenhall in Suffolk England. Det 4 whose normal trade were U-2 operations would later lose their U-2s to RAF Alconbury to be the second detachment base for the SR-71.

Conducting missions using the various sensors and radar in the aircraft's chines and the detachable nose cone enabled the SR-71 to track movement of various 'targets' including Russian submarine pens in the North Cape area, as well as flying complicated missions up the Baltic coast and along the German border.

Often shadowed by Mig 25 Foxbats, and Swedish JA-37 Viggens the SR-71s flew a couple of missions per week from RAF Mildenhall. It was determined that Russian Spy Trawler vessels in the North Sea were able to pick up radio transmissions from Mildenhall and this provided some notice to the Russian air force that an SR-71 mission was being staged. Because of this, procedures were changed and the SR-71's crew were communicated to via a spotlight from the control tower, and the mobile car. (Mobile car has two SR-71 crew members in it to provide support throughout the entirety of the mission).

In April 1986 both SR-71s launched from Mildenhall to conduct post strike reconnaissance in support of operation Eldorado Canyon - the USAF mission to retaliate against Libyan funded bombing of US personnel in Germany. One of the aircraft that was involved from Det 4 at Mildenhall was aircraft #960, which now resides at the Castle Air Museum, Atwater, California. A very peaceful spot (except for the occasional freight trains nearby!) for an aircraft that had flown more operational sorties than any other SR-71.


17960 at Castle Air Museum, CA.

During the life of Det 4 there were several diversions to airbases in Norway, the most noteworthy was flown into Bodo AB, when it returned to Mildenhall wearing 'The Bodonian Express' tail art.

In the mid 1980's the annual Mildenhall Air Fete became one of the UK's largest air shows drawing in crowds from across Europe and in fact the world. Often the mere rumour of an SR-71 participating in an air show would draw huge crowds who were fascinated by the aircraft. In 1987 aircraft #973 was over-stressed during that years Air Fete and was flown straight back after the show direct to Palmdale AF Plant 42 where the aircraft is now on display at the Blackbird Airpark just outside the facility along with an A-12 and an early U2.

Due to what many feel to be political motives the SR-71 lost favour with high ranking staff at the Pentagon, and although the SR-71 managed to survive a few more years of service, time and politics were catching up with it.

Since the USAF did not use most of the data provided by the SR-71, the aircraft had not been in favour for a while - the US Navy and CIA were the main customers of the data provided by the detachments.

In 1990 the SR-71 was retired from the USAF inventory, 6 aircraft were put in storage, of these 3 were loaned to NASA for high speed research, the other 3 were meant to have been kept in airworthy status i.e. the cycling of engines and systems periodically. However the prevailing attitude at the time was to kill the SR-71 for good and therefore the remaining 3 were left in open storage at Palmdale. These aircraft were only protected by engine covers.

17962 Over RAF Mildenhall, UK, in 1985

In the intervening period and the first Gulf War there were several requests for information on high long it would take to reactivate the SR-71 - all of which did not materialise - however it was proof if proof were needed that the SR-71 offered a unique system unmatched by other aircraft.

In 1995 funding was given to bring back 3 SR-71s. Aircraft spares and sensors were distributed across the US after the shutdown in 1990 but were brought back to Palmdale and Edwards AFB. 17967 and 17971 were the aircraft chosen to be reactivated along with the SR-71B which would be shared with NASA. These aircraft were each given the upgrades denied to them before 1990, which included the ASARS 1 system and the vital data link providing near real time transmission of data from the SR-71 to ground commanders. However the SR-71 did not get the opportunity to prove these systems operationally - and this effectively killed the program again. The final USAF SR-71 flight occurred on the 10th October 1997, followed by the last NASA flight 30th June 1999.

All remaining SR-71s were shipped to museums across the United States, and one #962 to the Imperial War Museum at Duxford, Cambridge, England.

SR-71 Walkaround


Forward sword like nose profile.


Radar Warning Receivers clearly visible on sides of nose.


Wing heat expansion joint built in to the airframe.


Lower Radar Warning Receivers.


Nosewheels used cockpit air conditioning and didn't need special heat treatment.

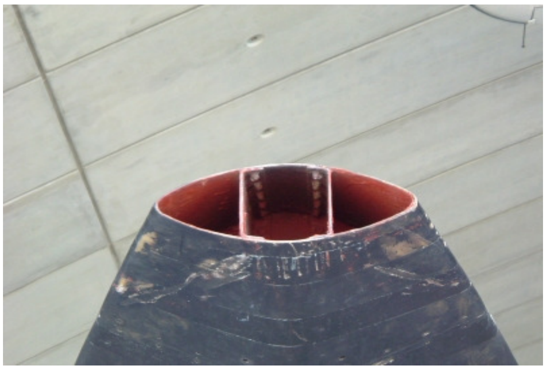

Main gear wheels were impregnated with aluminium powder to help protect them against heat at high speed.

Free floating exhaust petals.

The incredible Pratt & Whitney J-58 designed for continuous afterburner, was only one part of the engine.

The intake spike and various other inlet devices. The intake shifted 26 inches and at Mach 3+ speeds accounted for 80% of engine thrust.

The front windshield knife edge device was installed to help dissipate heat generated from high speed flight.



Fuel Dump at the end of the 'boat' tail.

All moving Rudders canted inwards at 15 degrees. Note the tertiary doors - these closed above Mach 1.5.

Glowingheat SR-71 Features

1. Incredibly authentic flight model based on the SR-71 Pilots manual
2. Drooping Elevons and refuel door on Hydraulic pressure loss
3. Shiny wet look tyres in wet or snowy conditions
4. Fuel transfer & Centre of Gravity control panel
5. Full VC night lighting (panel light on and landing light on for gauge lighting)
6. Exterior cockpit night lighting
7. Automatic Engine inlet Spike control system
8. Independent engine controls and afterburners
9. Afterburner and vapour effects
10. Animated Technical Objective cameras in external view
11. Crew access ladder (on canopy open and parking brake)
12. Animated Engine Start Carts (parking brake)
13. Brake cooling fans (parking brake & Spoiler)
14. Air refuel switch (tops up your tank to 100%
15. Animated Pop out anti-collision lights as per the real aircraft
16. Fully Mach 3+ and 80,000+ feet capable
17. Realistic undercarriage with authentic retraction sequence
18. Realistic looking VC & 2D panels (includes additional wide screen .bmp)
19. Authentic Afterburner free floating exhaust petal animation
20. Animated engine tertiary doors at Mach 1.5
21. Realistic Drag chute movement based on Alpha and Beta values (spoiler)
22. Functional VC (see Virtual Cockpit Gauges & Switches)
23. SR-71B Trainer model with its own unique flight model
24. See the FS9 world as only the SR-71 can!

Glowingheat SR-71A/B Flight Procedures

Note: The following pages can be accessed using the kneeboard facility in FS9.

Flight Characteristics

The SR-71 is unlike any other aircraft ever made. Flying it is a completely different experience from any other aircraft. For the most realistic experience possible, we recommend purchasing an actual SR-71 flight manual and using the actual procedures. The flight model and cockpit controls were exhaustively researched and will provide a highly realistic flight experience if actual procedures are followed.

From the SR-71 manual:

"SR-71 aircraft operate in an exceptionally large Mach and altitude envelope, but the equivalent airspeed, angle of attack, and load factor envelope is narrow. Typical takeoff and landing speeds are 210 knots and 155 knots, respectively; climbs are at 400 to 450 KEAS, and normal supersonic cruise is from 310 to 400 KEAS. These aircraft obtain maximum cruise performance near Mach 3.2 at altitudes from 74,000 to 85,000 feet. The external configuration, air inlet system, power plant, and fuel sequencing are optimized for Mach 3.20. True airspeeds attained are near 1850 knots. For stability considerations, a three-axis stability augmentation system (SAS) is an integral part of the aircraft control system and is normally used for all flight conditions."

Most people have the idea that the SR-71 is some kind of "super plane" capable of all kinds of outrageous speed and maneuvering. Indeed, it is a true "super plane" but only in a very narrow range of operation. It has a very broad speed range in terms of Mach number, but a narrow range with regard to indicated airspeed. This makes it very challenging to fly because the engines make a great deal of thrust and it is very easy to exceed either the maximum indicated airspeed or the maximum aircraft loading values.

The SR-71 can only be flown by a very exacting pilot. The airframe, engines and entire design of the plane are very unforgiving of errors that would be completely inconsequential on any other plane. Here is just a short list of areas where you can easily get in trouble with the Blackbird:

The G limits are 2.5 maximum positive G, and only -0.2 negative G. You are greatly challenged by this because the plane is so fast that you will want to haul back on the stick to slow down, but you can't, because you will break the aircraft. You'll need to throttle back, but that creates other problems such as compressor stalls and flameouts at higher angles of attack and lower indicated airspeeds. Exceeding 10 degrees angle of attack on the AoA gage may result in one or both engines failing at airspeeds of less than 300 KIAS at altitudes above 25,000 feet.

In terms of indicated airspeed, the minimum flying speed is very high, but the maximum flying speed is quite low. In fact, a P-51 Mustang has the same maximum indicated airspeed, only 460 knots IAS. At 140,000 pounds this plane will stall at 190 knots IAS, but it cannot be flown any faster than 460 KIAS. Thus, there is only a range of 270 knots within which to operate. With those powerful engines and very low drag you can exceed redline in a heartbeat, but don't try to pull up, because you'll overstress the airframe and break your plane, or stall an engine and crash. Bear in mind you cannot fly the SR-71 anywhere near its actual stalling speed unless you are very close to the ground and in "ground effect". If you are above 100 feet AGL you will need to be flying the plane at an indicated airspeed of at least 250 KIAS or you will exceed the maximum AoA, and the plane will pitch up and you will lose control. So in truth you really have a usable range of airspeed of just about 210 knots..."knot" very forgiving at all.

The plane is not at all agile. The stick forces are quite high by design to keep a pilot from inadvertently overstressing the airframe.

If you get this plane at too high of an angle of attack, greater than 14 degrees, instead of having the nose want to naturally pitch down, the nose will suddenly begin to pitch up even more, and it is very difficult, if not impossible, to recover. You will need full forward stick and perhaps all the trim you can wind in to get the nose to come back down, if you catch it soon enough. Ejection is usually the answer here. Needless to say, it is beyond the scope of this checklist to describe every operational limitation and characteristic of this aircraft, but most of the key features are modelled. We recommend the purchase of an actual SR-71 manual to get the most out of this simulation.

Aircraft Limitations

The aircraft is of a delta wing design and does not stall in the classic sense. There is a maximum angle of attack that should not be exceeded which varies from 14 degrees at subsonic speeds to only 8 degrees at supersonic speeds. There is a "STALL" warning light which will illuminate at 14 degrees AoA, but the plane could become uncontrollable at much lower values. Monitor your angle of attack closely to avoid loss of control and/or engine flameouts.

Minimum flying speed:	230 KIAS (140,000 lbs.)
Maximum IAS, below 7,500 feet:	460 KIAS
Maximum subsonic airspeed (above 7,500 feet):	500 KEAS
Maximum supersonic airspeed:	450 KEAS
Maximum Mach:	3.4 (aft CG limit of 23.6%)
Maximum gear extension:	300 KIAS
Gear damage:	350 KIAS
Maximum G:	+2.5, -0.2

Main Panel

The main panel appears conventional at first glance but actually contains a number of gages uniquely modified to suit the supersonic mission of the SR-71.

Please review the function of these gages carefully.

Upper (Standby) Attitude Indicator

This gage is primarily used for takeoffs and landings and to determine proper cruise attitude, as it is a high-resolution gage. The unique feature of this gage is that it is set to indicate a nose-level condition when the plane is flying at an angle of attack of 6 degrees, which is normal for this aircraft at scheduled cruise Mach, both subsonic and supersonic. Thus, the gage will seem to be set improperly when the aircraft is on the ground, but will indicate properly when in flight.

Triple Display Indicator (TDI)

The triple display indicator displays altitude, true Mach number, and knots equivalent airspeed (KEAS), which is calibrated airspeed adjusted for compressibility effects. KEAS is the value used to determine all scheduled flight parameters with the exception of certain subsonic operations, takeoff, and landing. KEAS is approximately KIAS/1.12, so this value will be considerably lower than your indicated airspeed in knots. This display is invaluable in executing a tactical climb and is the primary gage for assessing flight conditions.

Indicated Airspeed Display

This display shows knots indicated airspeed and indicated Mach number. It also shows the autothrottle speed hold setpoint in KIAS rather than KEAS which is very helpful in setting approach speeds. Use the adjusting knob in the lower right-hand corner of the gage to adjust the indicated airspeed setpoint as desired in KIAS. When using the mouse to do this, the actual speed hold setpoint in knots IAS will be displayed. This is the preferred way to set approach speeds. The setpoint will also be displayed on the autopilot in KEAS. In the above image the speed hold is set to 400 KIAS. There is also a red arrow indicating the maximum speed below 7,500 feet of 460 KIAS. A warning light will also illuminate on the main panel if 460 KIAS is exceeded below 7,500 feet. This gage is used mostly for takeoffs and landings to observe scheduled IAS values and to see Mach number at a glance. Use the TDI to get the most accurate Mach number readout. The tooltip for this gage provides KIAS, KEAS, and Mach number.

MiniPanel

This aircraft features a minipanel that is of great use in landing the aircraft, as it enhances the field of view tremendously. It has all instruments and controls needed for an ILS approach. View the minipanel by cycling through the panel views (W key).

Center Panel

1. Angle of Attack (14 degrees maximum)
2. Upper attitude indicator
3. Clock
4. Dual airspeed indicator
5. Flight Director
6. Altimeter
7. Triple Display Indicator
8. Horizontal Situation Indicator
9. Instantaneous Vertical Speed Indicator
10. Steering, Overspeed, and Fuel Door warning lights
11. SHAKER (AoA) warning light
12. Master caution lights (click to view annunciator panel)

Above the dual speed indicator are the nosewheel steering, overspeed, and altitude deviation indicator warning lights, in that order. Above the clock are the master caution lights and the SHAKER warning light which illuminates if the plane exceeds 14 degrees AoA or if the plane is in an accelerated stall, whichever AoA value is less.

Left Main Panel

1. Cockpit Temperature Gage
2. Drag chute activation handle
3. Dual compressor inlet temperature gage
4. Dual inlet air pressure gage

Switches marked with an "X" are not functional.

Right Main Panel

1. RPM indicators (shows actual engine RPM)
2. Popup icons
3. Exhaust nozzle position indicators (tracks throttle position)
4. Fuel totalizer and selectable tank contents indicator
5. Dual fuel flow indicator
6. Dual oil pressure gage
7. Autopilot master light/toggle

Annunciator Panel

Use this popup when you see a master caution warning to find out what the trouble is. Click on either master caution light to view this popup.

Autopilot, Speed Hold, Flight Director, and Trim Controls

To display the autopilot, use the autopilot master light/toggle (7) located just to the right of the altimeter and above the left engine RPM indicator. This red indicator light will illuminate when the autopilot is on. The autopilot and speed hold work in the usual way, with the exception that the speed hold display on the autopilot panel displays computed knots equivalent airspeed (KEAS) rather than indicated airspeed. (You can also adjust the speed in in KIAS, by using the adjusting knob on the indicated airspeed gage to adjust the speed hold value in KIAS. This is only used for subsonic operations such as takeoff and landing - all other operations use KEAS). Due to a limitation in Flight Simulator, the Mach indicator will not display a value higher than 3.00 unless a corresponding KEAS value is entered first that results in a calculated Mach value greater than 3.00. For example, 352 KEAS = Mach 3.2 at 80,000 feet. Enter 352 in the EAS select window when the speed selector switch is set to EAS. Then select Mach hold. The Mach value will automatically be calculated and displayed as 3.2. The reverse is true if you choose to enter the Mach value first when Mach hold is selected, but you will be unable to enter a value more than 3.0. To close the autopilot window, use the icon under the pitch trim wheel or use the autopilot master light on the main panel.

Power Schedule

Your throttle slider will provide an accurate and realistic way to set power in the SR-71. The range from 0-50% of the throttle position (NOT the percent of engine RPM) will provide power from IDLE to full military (MIL) power. At exactly 50% throttle position, 7350 RPM will be obtained which equals MIL power. Above 50% throttle and 7350 RPM is the afterburning range, which is the most important range for a supersonic aircraft. A full 50% of the range of the throttle control is available to set exactly the right amount of afterburner power and this can be very finely adjusted. Keep in mind that engine RPM remains more or less constant within a narrow band while the afterburners are on. The actual thrust is determined by the amount of fuel being sprayed into the burner cans, not from the engine RPM. However, higher engine RPM does correspond to higher thrust. Engine RPM can be read as RPM or to 0.01 of a percent, and is easily set and easily repeatable.

Set the power by using the ECU and the RPM gages. The ECU will show the actual position of your throttle slider in percentage, and the RPM gages provide a tooltip which will give you a numerical value of both the exact RPM and the percentage of RPM. Halfway up the throttle travel, to the white line, is MIL power. Beyond that line, the engines will be in the minimum afterburning range. There is a lag between the time the throttles are positioned and when the afterburners actually light. Review the images below to become familar with the controls and instruments.

Engine Control Unit

In addition to the throttles and usual controls, the ECU also contains light switches, electrical switches, and engine start switches. One unique feature of this unit is that the engines can be stopped by using the mouse to pull the throttles back beyond the idle position, to a negative value. This cuts fuel to the affected engine. There is also a DME slaved to the NAV2 radio on this popup.

RPM Indicators

These gages show actual corrected engine RPM, not the percentage of RPM. The tooltip reading will provide both corrected RPM and the percentage of corrected RPM. 7425 RPM (101.00 percent) will be the maximum achievable RPM under optimum conditions.

Fuel Management - Weight and Balance

This aircraft has six fuel tanks which can be monitored and selected either individually or as pairs. The fuel feed can be set to fully automatic by setting all fuel selectors for individual tanks or tank pairs to OFF. In this position the tanks will feed in the normal Flight Simulator sequencing until all tanks are dry with no interruption of the fuel supply. With this sequencing, the Nose tank and aft fuselage tanks will drain first followed by the Tail tank and forward fuselage tanks. This will result in a dangerous CG condition if not checked by manually managing the fuel supply.

It will be necessary to manually select individual tank or tank pairs for feeding in order to adjust the center of gravity. When flying at supersonic speeds, a CG of 25% is optimal, so it is desirable to select the forward fuselage tank pair for climbing, which will shift the CG aft as the aircraft climbs. With full tanks, the takeoff weight is 140,000 pounds and the CG is 22 percent, which is ideal. After takeoff, select the forward fuselage tank pair for feeding during the climbout. This will shift the CG aft to a more desirable value for supersonic flight and leave the nose tank full for balance purposes or to be transferred later to adjust the CG.

During supersonic cruise, select the nose balance tank or the aft balance tank as desired to maintain the proper CG at approximately 25-27 percent. The bulk of the fuel is in the forward pair of fuselage tanks, so draining these first is the recommended procedure. Use the forward/aft fuel transfer as needed to shift the CG. The "AUTO" position will automatically and constantly feed fuel from the forward fuselage tanks to the Tail Balance tank until these tanks are dry, thus shifting the CG aft. Placing the transfer switch in the manual "AFT" position will accomplish the same thing, and placing it in "FWD" will transfer fuel from the Tail Balance tank to the forward fuselage tanks, shifting the CG forward. Note: the aft CG limit is decrease by 0.7% for each increase in Mach number of 0.1, above Mach 3.2. Thus, for a Mach number of 3.4 the aft CG limit is 23.6%.

The following table shows the effects of various fuel tank conditions on the aircraft center of gravity. (The tank contents are listed as a percentage of the total of each tank, CG is percentage of mean aerodynamic chord):

CG Percent	Nose Tank	FWD fuselage	AFT fuselage	Tail Tank
21.6%	Empty	Empty	Empty	Empty
19.6%	100%	100%	100%	100%
20.5%	75%	75%	75%	75%
21.0%	50%	50%	50%	50%
21.4%	25%	25%	25%	25%
17.5%	100%	100%	Empty	100%
16.9%	100%	100%	100%	Empty
20.1%	100%	Empty	Empty	100%
21.7%	Empty	50%	Empty	50%
21.8%	Empty	100%	100%	Empty
22.8%	Empty	100%	Empty	100%
24.8%	100%	Empty	100%	100%
20.6%	Empty	20%	Empty	20%
11.8%	Empty	Empty	Empty	Empty
16.3%	Empty	100%	Empty	Empty
26.2%	Empty	Empty	100%	Empty
26.5%	Empty	100%	100%	100%
27.1%	Empty	Empty	50%	50%
28.1%	Empty	Empty	Empty	100%
31.8%	Empty	Empty	100%	100%

KEY:

Acceptable for takeoff.
Acceptable for subsonic flight.
Acceptable for supersonic flight.
Dangerous - prohibited values (warning light will illuminate).
Optimum configuration for landing.

If automatic fuel sequencing is used, beginning with completely full tanks, the initial CG will be 19.6%, which will increase to a maximum of 22.8% when the Nose and AFT fuselage tanks are empty. At this point the Tail tank will drain, followed by the FWD fuselage tanks. If this sequencing is allowed to continue without interruption, the CG will move forward to a dangerously low value of 16.3% when the Nose, Tail, and AFT fuselage tanks are empty and the FWD fuselage tanks are full. Monitor the fuel tank contents and CG values to ensure this is avoided. If the aircraft weight is below 100,000 pounds and the airspeed is reduced 350 KEAS, operation with a CG less than 17% is permissible.

During a descent, feed from the aft balance and/or aft fuselage tanks, and monitor/adjust CG as required. A forward CG of 22 percent is desirable for subsonic cruising and takeoff/landing operations as the aircraft is more stable.

Each tank has an individual gage. The contents of each tank can be read in pounds, and the tooltip will provide an exact amount. The capacities of the tanks are as follows:

Nose Balance Tank: 15,725 pounds
Tail Balance Tank: 14,921 pounds
Tank 2 (FWD fuselage): 13,227 pounds
Tank 3 (FWD fuselage): 16,481 pounds
Tank 4 (AFT fuselage): 9,740
Tank 5 (AFT fuselage): 11,780
Total fuel capacity: 81,874 pounds
Note: Tanks 2 & 3 and tanks 4 & 5 work as connected pairs and can only be selected and drained as pairs.

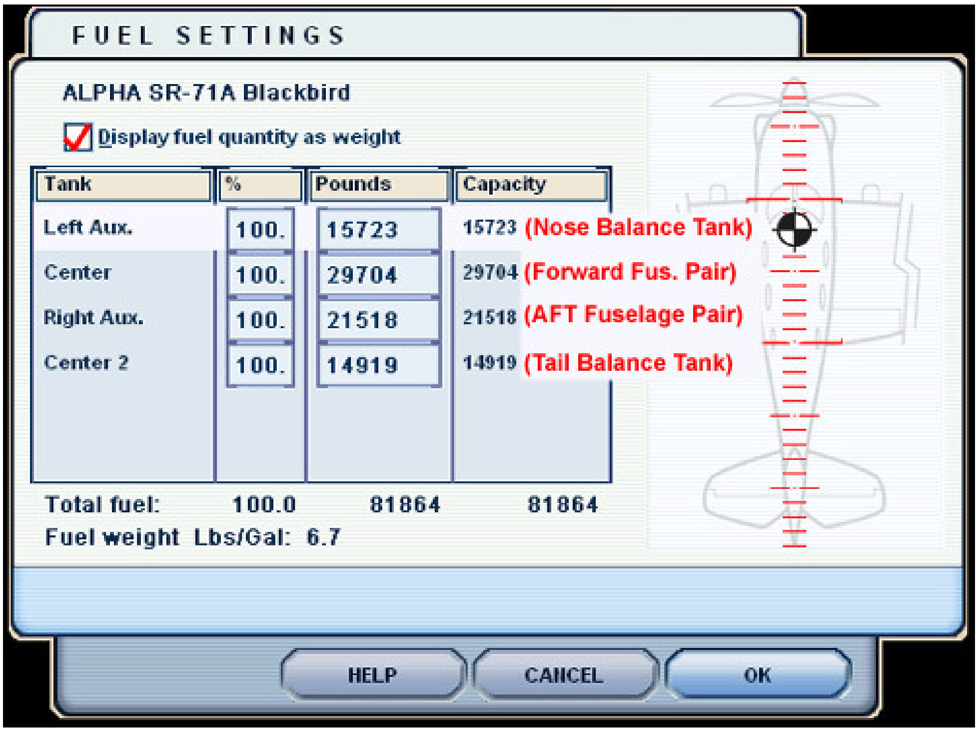
The virtual cockpit also features a selector switch which allows viewing of the contents of each tank but does not select which tanks are used to feed the engines. See Virtual Cockpit pages.

Fuel Supply Warning

The Master Warning light will illuminate if the total fuel supply of the aircraft is less than 8,000 pounds. Individual tank warning lights (located at the lower right portion of the main panel in the VC) will show which tanks, if any, are empty by lighting up.

Flight Simulator Fuel Management

Tanks 2 & 3 and tanks 4 & 5 are "virtual" tank pairs which exist only as a single tank in the flight model but are displayed as linked pairs of tanks in the aircraft. See the image below for clarification. The corresponding tank in the SR-71 is noted in red to the right of the tank displayed in the fuel settings menu.



When you call up the Flight Simulator fuel settings window, the fuel settings menu will show the tanks in proper order with respect to their position in the plane. This makes it easy to adjust the plane's center of gravity; to increase weight in the plane's nose and shift the CG forward, add fuel to either the Left Aux. or Center tanks in the fuel settings display. Likewise, to add weight to the rear of the plane and shift the CG aft, add fuel to either the Right Aux. or Center 2 tanks in the fuel settings display. Removing fuel from any of the tanks will have the opposite effect, of course.

Flight Characteristics

The SR-71 flies much like any other airplane in terms of stability and response with no unusual quirks. It is not especially agile by design, and care must be taken not to exceed load limitations, which are very modest. Turns and maneuvers should be made carefully and planned in advance. Fly it like you would fly an Airbus and you will have no problems.

Unusual Traits

This aircraft will experience an accelerated tendency to continue pitching up if the maximum angle of attack of 14 degrees is exceeded. It may be impossible to regain control even with maximum nose-down trim. The aircraft will experience compressor stalls at angles of attack above 10 degrees at altitudes above 25,000 feet if the indicated airspeed is below 300 KIAS. These stalls will result in a flameout of the affected engines. The delta wing creates a high level of "float" or ground effect on landing, and the stick must be pushed forward a bit rather than used to round-out or flare just before the ground is contacted, about 50 feet AGL.

Control Authority - Surface Control Limiter

Control authority is sufficient for all flight requirements. Above 300 KIAS the surface control limiter will activate automatically and there will be a marked reduction in control authority.

Spike Inlet Vane, and Bypass Door Operation

Operation of these functions is always fully automatic and cannot be overridden. Spike movement can be confirmed by visual observation as the plane passes through the scheduled Mach numbers.

Prohibited Maneuvers

Stalls, spins, and inverted flight are prohibited. No acrobatics of any kind are approved for this airplane.

Engine Start

Use Ctrl-E (autostart) to start the aircraft, or:

1. Set parking brake.
2. Advance throttle to just above IDLE.
3. Turn OFF Avionics and Deice switches.
4. Turn all generators OFF.
5. Turn on Master Battery switch.
6. Turn on the main fuel supply to all engines (Ctrl-Shift-F4).
7. Turn on fuel supply to Engine 1.
8. Start Engine 1 using the engine start switch.
9. Monitor oil pressure and temperature - wait until all annunciator and caution lights go out.
10. Turn on Generator 1.
11. Repeat for remaining engine.

Takeoff (140,000 lbs.)

1. Make sure fuel is sufficient and CG is within limits (20-22 percent).
2. Select FWD fuselage tanks for takeoff and climb.
3. Confirm nose wheel steering is active (check annunciator light on panel).
4. Check brakes during taxi.
5. Check flight controls (Surface Limiter OFF - note full control deflection).
6. Set all trim controls neutral.
7. Check autopilot master OFF. Set altitude and speed for scheduled operations.
8. Check and set flight instruments.
9. Check drag chute safe.
10. Set radio frequencies according to operational requirements.
11. Check master caution and warning lights OFF.
12. Check annunciator panel and all warning lights.
13. Check engines at MIL power.
14. Line up on runway.
15. Hold brakes.
16. Advance throttles to MIL power.
17. Check inlet guide vane lights come on (below RPM gages).
18. Advance throttles to maximum.
19. Ensure afterburners are at maximum power (7425 RPM).

20. Release brakes.
21. Use rudders for directional control.
22. Apply smooth, constant back pressure 15-25 KIAS before rotation speed.
23. Rotate smoothly at 210 KIAS to 8-10 degrees pitch up.
24. Retract gear after establishing a positive rate of climb.
25. Reduce power to minimum afterburner (7360 RPM or about 55% throttle position).
26. Increase speed to 400 KEAS and follow planned climb schedule.

Tactical Climb and Transonic Flight - Level Flight Technique

Follow the general procedure above for takeoff and set power to minimum afterburner (7360 RPM). Climb at 400 KEAS until intercepting 0.9 Mach. Climb at this Mach number until reaching 30,000 feet. Level out on autopilot and set engines to maximum afterburner. Accelerate to 1.25 Mach. This will take 3-4 minutes. Begin your climb to the desired supersonic cruising altitude using either the 400 KEAS or 450 KEAS climbing schedule. Manage your speed using the autopilot and speed hold controls.

Tactical Climb and Transonic Flight - Descending Flight Technique

At altitudes higher than 30,000 feet, or at very high aircraft weights, it may be necessary to climb to 33,000 feet at 0.90 Mach, level off, and then descend to 30,000 feet at to quickly break through the sound barrier. Follow the general procedure above for takeoff and set power to minimum afterburner for the climb (7360 RPM). Climb to 33,000 feet and level off. Advance throttles to maximum afterburner and set altitude hold to 30,000 feet and vertical speed hold to -3,000 fpm. Be ready to throttle back after the aircraft passes through Mach 1.25 as it will accelerate very quickly beyond that speed. Resume your climb when the speed reaches 1.25 Mach (450 KEAS) and do not exceed 450 KEAS at any time. Manage your speed using the autopilot and speed hold controls as well as the throttles.

Tactical Climb and Transonic Flight - Maximum Performance

1. Begin with full tanks and aircraft weight of 140,000 lbs.
2. Maximum afterburner (full throttle) is used throughout except for those areas where some throttle modulation is needed.

3. Autothrottle cannot be used for this procedure because the plane is so fast it cannot respond quickly enough.
4. Follow the normal procedures for preparing for takeoff.
5. Bring up both the ECU and the autopilot popups.
6. Set AP alt hold to FL330 (33,000 feet).
7. Set VS hold to +500 fpm.
8. Leave altitude hold switch OFF but be prepared to turn ON.
9. Set brakes and run engines to max AB.
10. Release brakes. (Time is counted from brake release to arrival at FL800)
11. Rotate at 200 KIAS to 10 degrees pitch up BRISKLY using the upper attitude gage.
12. The instant you see a positive rate of climb pull up the gear. There is no lag in the IVSI.
13. As gear comes up, pitch up smoothly but briskly to 30 degrees. This should take seven seconds from the 10 degrees initial pitch. Too slow and you overspeed, too quickly and you don't reach climbing KEAS fast enough, and too many corrections will be need to made to the attitude hold.
14. The instant you reach 30 degrees, turn ON the autopilot. This will engage the attitude hold and the wing leveler and maintain the climb pitch with wings level.
15. You need to have joystick buttons or keys assigned to increase or decrease the attitude hold pitch reference.
16. Increase or decrease the pitch reference to maintain 450 KEAS (use the triple display).
17. This can be done manually but it takes great care in adjusting pitch to manage airspeed.
18. Maintain 450 KEAS until reaching 0.9 Mach at about 10,000-12,000 feet. It is quite difficult to hold exactly 450 KEAS because the plane is not responsive to small pitch adjustments, so some variation in speed is to be expected. Use the throttles if necessary to avoid overspeeding.
19. Hold 0.9 Mach after reaching that speed. The aircraft will be very stable at this airspeed.
20. At exactly 19,500 feet turn ON the altitude hold. If the plane is stable at 0.9 Mach (+/- 0.01) the VS will wind down at precisely the rate needed to intercept your 33,000 foot altitude at the exact moment it levels out. If you wait until 20,000 it will overshoot and if you turn it on too early you will have a slow climb to 33,000, both of which will hurt your time.
21. The moment the plane stabilizes at FL330, quickly change the ALT hold

setting to 30,000 feet and set the VS hold to -3,000 fpm. (Maintain maximum afterburner throughout this process.)

22. The plane should descend to 30,000 feet and at the exact moment (within a couple of seconds) it reaches FL300, it should also reach 450 KEAS and 1.25 Mach. This has been repeated many times in actual testing of this flight model.
23. The moment you reach FL300 and 1.25 Mach, set the ALT hold to 80,000 and the VS hold to the maximum of 9,999 fpm.
24. Back off the throttles right away because you will overspeed if you don't (see next step).
25. Monitor your KEAS. If you go above 455, reduce the throttle setting to about 75-80 percent throttle position (not engine RPM).
26. Use the throttles to maintain 450 KEAS. It is not too difficult if you practice and learn how much lead/lag you need.
27. You may need to wheel the rate of climb setting back as far as 6,000 fpm once you reach full throttle again.
28. Once you pass through 1.8 Mach the plane will start to accelerate very quickly and you will again need to wind the ROC up to maximum fpm and pull the throttles back to 80 percent because it will accelerate very quickly. Adjust as needed.
29. At 54,000 feet, 2.2 Mach, and 92 percent throttle the plane will stabilize briefly.
30. At 2.4 Mach, the plane will need full throttle. Start reducing the ROC in 1,000 fpm increments, because the plane will slow rapidly through this region.
31. At 67,000 feet you should be at about 3.0 Mach and 450 KEAS and the plane will again stabilize briefly.
32. Once 3.0 Mach is reached, ignore KEAS and climb based on Mach number 3.0 - maintain and do not exceed 3.0 Mach until reaching FL800.
33. The plane will start to accelerate quickly again after passing through 3.0 Mach so wind up the VS hold to 10,000 fpm again and adjust the throttles as needed.
34. KEAS will drop to below 400 but this is no concern as we are flying by Mach number now.
35. Once you reach about 78,000 feet, set the Mach hold to 3.0 Mach and reduce your ROC so you make a smooth level-off.
36. Mark your time when 80,000 feet is reached.

Cruising

Use autopilot/autothrottle to set cruise parameters. The "autothrottle" button indicated below will arm the speed control. Select either speed hold or Mach hold as desired. When reaching cruising altitude, reduce vertical speed gradually to intercept the desired altitude smoothly and with minimum of pitching. If pitching up and down (porpoising) occurs, simply turn off the autopilot, stabilize the aircraft at the desired altitude, and then turn the autopilot back on, ensuring that your altitude hold value is the same (within a few feet) as the altitude at which you have stabilized.

Cruise data figures will vary with aircraft weight and fuel on board. Figures are for standard conditions.

Altitude	Airspeed	Fuel Consumption	Nautical miles / 1000 lbs	Approximate Range/Endurance
30,000 ft	0.81 Mach	21,300 pounds/hour	22.5 nm	3 hours
71,500 ft	2.8 Mach	40,800 pounds/hour	39.5 nm	1.2 hours
80,000 ft	3.2 Mach	39,500 pounds/hour	46.5 nm	1.3 hours

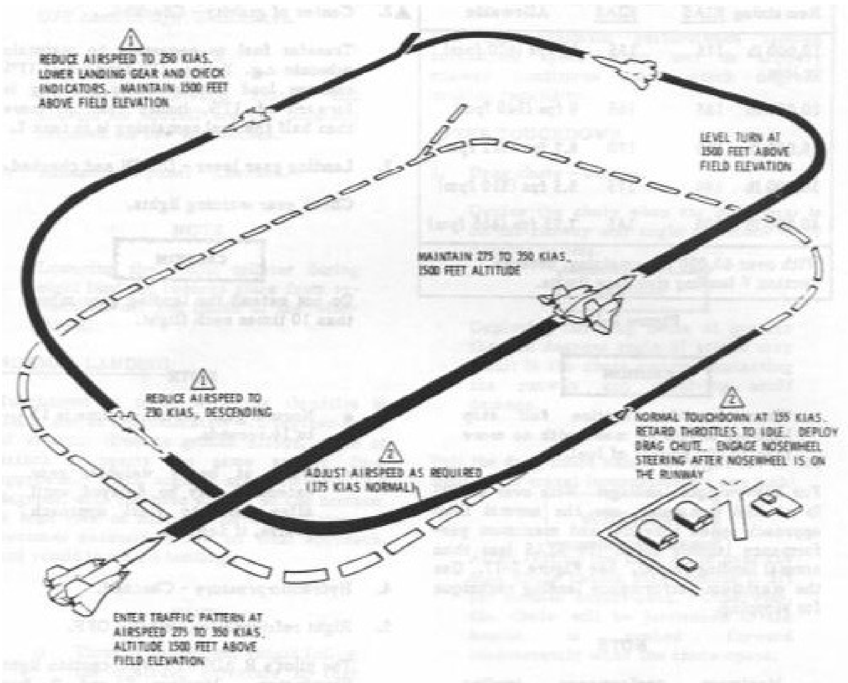
Descent

1. Calculate the distance required to slow down and descend.
2. Initial descent should be at about 1 degree at high altitudes/Mach numbers.
3. Angle will increase to 7 degrees at medium altitudes just above 1.0 Mach.
4. Retard throttles as needed to reduce speed to a final value of 365 KEAS.
5. Maintain 350-365 KEAS for the remainder of the descent.
6. Set throttles to IDLE for maximum deceleration.
7. Use of the autopilot and speed hold is recommended.
   Landing

Before-landing checks (50-100 miles from field):

- Fuel supply adequate and tank selectors in auto or as desired.
- Calculate aircraft weight and CG within limits. 68,000 pounds and 22 percent are optimal.
- Airspeed 350-365 KEAS.
- Surface Control Limiter in automatic (default, cannot be changed).
- Altitude, heading, and descent rate as scheduled.
- Engine instruments nominal.
- Weather conditions checked.
- Clearance obtained.
- Align aircraft with runway heading at sufficient distance from field.
- Check instruments: ILS/DME, flight director, and HSI operation.
- Check annunciator panel for warnings and cautions.

The design landing weight is 68,000 pounds with a 600 fpm sink rate. The optimum aircraft configuration for landing is to have 6,000 pounds of fuel in the aft fuselage tanks and 3,000 pounds of fuel in the Tail balance tank, which results in an aircraft weight of 68,002 pounds and a CG of 20.6 percent (see the chart above for fuel tank and CG values). For higher weights, follow the schedule below. Maintain an angle of attack of less than 8 degrees for the turn to base and less than 9 degrees for the turn to final. The angle of attack on final approach should not exceed 10 degrees. The following image shows a standard landing pattern with speeds posted for the design landing weight.



1. Enter traffic pattern on runway heading at airspeed 275-350 KIAS, altitude 1500 feet above field elevation.
2. Maintain 275-350 KIAS, 1500 feet AGL when directly over runway.
3. Make a level crosswind turn maintaining 1500 feet AGL.
4. Make a level turn to downwind, maintaining the angle of attack at less than 8 degrees.
5. On downwind reduce speed to 250 KIAS and lower gear. Maintain 1500 feet AGL.
6. Make a descending turn to base and reduce airspeed to 230 KIAS. 7. Angle of attack should not exceed 9 degrees in the turn.
7. Turn to final, not exceeding 9 degrees angle of attack, and reduce speed to 175 KIAS. Angle of attack on final should not exceed ten degrees.
8. Normal touchdown is at 155 KIAS. Angle of attack for touchdown should be 9.5 degrees, almost the same as for final approach due to significant ground effect. Stick must be pushed forward slightly when ground effect is encountered to maintain proper angle of attack. Do not round out or flare as this will lead to excessive float and bouncing.
9. Retard throttles and deploy drag chute. Brake only as needed after nosewheel contacts runway.

NORMAL LANDING SPEED SCHEDULES

Approx Fuel Remaining	Final Approach KIAS	Landing Speed KIAS	Max Sink Rate Allowable
10,000 lb or less	175	155	10 fps (600 fpm)
20,000 lb	185	165	9 fps (540 fpm)
25,000 lb	190	170	8.7 fps (522 fpm)
30,000 lb	195	175	8.5 fps (510 fpm)
40,000 lb	205	185	7.75 fps (465 fpm)
With over 40,000 lb remaining, observe Section V landing sink rate limits.			

Figure 2-17

CAUTION

When feasible, routine full stop landings should be made with no more than 10,000 pounds of fuel.

For heavyweight landings: With over 40,000 lb of fuel remaining, use the normal final approach speed schedule and maximum performance landing speed (10 KIAS less than normal landing speed). See Figure 2-17. Use the maximum performance landing technique for stopping.

Shutdown

1. Secure aircraft in the parking area desired.
2. Turn off all electrical loads.
3. Shut off generators.
4. Shut down engines by using the mouse to pull each throttle handle below the idle stop.

Virtual Cockpit Gauges & Switches

Centre Panel (above) Yellow Numbers - Gauges

1. Strip Compass
2. Back Up Attitude Indicator
3. Angle Of Attack (AOA) Indicator
4. Clock
5. Attitude Indicator
6. CIT Temp Indicator
7. Airspeed Meter
8. Altitude Indicator
9. Engine 1 RPM
10. Engine 2 RPM
11. RAM Air Temperature
12. Triple Display Indicator (TDI) Knots, Altitude, Mach
13. HSI Indicator
14. Vertical Speed Indicator
15. Engine 1 Exhaust Gas Temperature
16. Engine 2 Exhaust Gas Temperature
17. Total Fuel Quantity
18. Intake Spike Position Indicator

19.	Accelerometer - G Force Indicator
20.	Engine 1 Nozzle Position
21.	Engine 2 Nozzle Position
22.	Yaw, Pitch and Bank Indicators
23.	Spike Hydraulic Pressure
24.	Engine 1 and 2 Fuel Flow Indicators
25.	Control Surfaces Hydraulic Pressure
26.	Engine 1 and 2 Oil Pressure Indicators
27.	Centre of Gravity Indicator
28.	Fuel Tank Empty warning lights
29.	Fuel Tank Pressure
30.	Nitrogen Dewar 1 and 2 Quantity
31.	Nitrogen Dewar 3 Quantity
32.	L and R Engine Forward Bypass door position indicator
33.	Compressor Inlet Pressure (CIT)
34.	KEAS speed warning lamp and Nose Wheel Steer available
35.	Compressor Inlet Pressure (CIT)

White Numbers - Switches and warning lamps

1.	Open/Close Aerial Refueling door
2.	Stall warning, Master Caution and Master Warning Lamps
3.	Sim Icons
4.	Middle Marker Lamp
5.	Engine 1 Inlet Guide Vane Lamp
6.	Engine 2 Inlet Guide Vane Lamp
7.	Fuel Transfer Switch (Fore and Aft)
8.	Battery Switch
9.	Engine 1 Generator Switch
	Engine 2 Generator Switch
10.	Drag Chute Handle (above 55 knots and lower than 210)
11.	Landing Light Switch
12.	Landing Gear Position Lamps
13.	Landing Gear Lever
14.	Moving Map Display on/off switch
15.	Pitot Heat Switch
16.	Fold Right Batwing sunshade - left shade is also clickable!
17.	Fuel Quantity Indicator Tank Selector knob
18.	Left and Right Engine Inlet Spike position knob
19.	L and R Engine Fuel Shut Off switches (open cover first)

20. Left and Right Flameout/unstart engine restart switches

Left Panel (above)

1. Throttle Levers
2. Rotating Beacon lights switch
3. Navigation light switch
4. Instrument Lighting
5. Flood lights (Panel lighting)

Right Panel (above)

1. Pitch Trim Wheel

2. Elevon Trim Wheel
3. Canopy Lever

Annunciator Panel

During your flight you may encounter either the Master Caution or Master Warning Lamp displayed next to the back up Attitude gauge at the top of the centre panel. To determine what flight condition has caused either lamp to display you must check the Annunciator panel. The Master Caution light illuminates yellow, while the Master Warning lights up red. By using corresponding colours on the Annunciator it is quicker to determine the cause of the malfunction.

In the 2D panel you can access the simplified Annunciator Pop up by pressing Shift - 6 or clicking on either a master warning lamp or master caution lamp.

In the Virtual Cockpit the Annunciator panel is in front of the Pilots control column at the bottom of the centre panel - just below the pilots moving map display. This has exactly the same warning lamps but in the correct layout as per the real SR-71. Most of the lamps are self explanatory - each of the Hydraulic lamps light when there is a loss of hydraulic pressure from the related engine. A and L Hyd are for the left engine and B and R the right. Fuel quantity lights when the total fuel state is less than 10%. L & R Generator lights are illuminated when the related generator fails, or is switched off. Pitot failure causes the Pitot lamp to light, as does the drag chute deployment and Canopy open lamps with their unsafe lamps.

However, the Centre of Gravity lamp is not as straight forward and depends on two flight conditions for illumination.

If the aircrafts Centre of Gravity is too far forward or too far aft the CG Annunciator lamp will light up along with the master caution lamp. In order to have the lamps turn off you must adjust your aircrafts Centre of Gravity using the fuel transfer knob (1) - this must be used in conjunction with the CG gauge (2). To monitor the progress of fuel transfer in each specific fuel tank you can change the fuel tank quantity indicator gauge (3) to read the quantity of each of the 6 tanks using the tank quantity indicator selector knob (4) - the knob has 6 positions - left click turns the knob anti-clockwise, right click turns it clockwise. There are also warning lamps (5) that illuminate when each tank is almost empty.

To ensure the Master Caution lamp remains unlit, you must make sure that the CG never falls below 16.4% and doesn't exceed 25.6%. Remember to read the checklists thoroughly as this will explain in more detail why the CG is so important.

Fuel Management and CG gauges and switches

Flameouts and Unstarts

During flight if a pilot puts the aircraft into a condition where flameouts/unstarts occur they run the risk of being overworked with trying to keep the aircraft under control while running the emergency checklist procedures. During an unstart the checklist begins with a call out - "Alpha within limits" - this means that the pilot must maintain Alpha control in order to prevent a high speed pitch up which in turn would lead to the aircraft disintegrating. If the pilot can maintain Alpha control he has a chance of recovering the aircraft and continuing the mission. When an engine unstarts ie the shockwave is expelled from the inlet, the forces can be so great that the asymmetrical thrust can cause severe yaw moments which in turn can lead to a pitch up condition if not detected and corrected early enough.

Restart switches

To make your job easier during our simulated flameouts, we have provided restart switches that, once switched to on, will restart the failed engine/s provided the Alpha is within limits. If the Alpha is not within limit's the engine will still be flamed out and cannot be restarted until a safe attitude is gained.

In real life these switches controlled the engine intake spike position during an unstart or flameout. The inlet needed to be restarted to capture the expelled shockwave. We have adapted this since unstarts are not possible in Flight Simulator.

The Tail numbers included & their individual history

17955 - Aircraft flew the flight test mission wearing the Skunk Works badge on the fins. The test ship flew until it was deemed as being too costly to rework it to the fleet standard - it had been over modified! In 1983 17955 visited the UK repainted as 17962 as a cover to hide the fact that it was testing the ASARS-1 high definition ground mapping radar.

17956 - The only trainer SR-71B in existence, this aircraft was one of two SR-71A's on the production line that was converted to a B model. 17957 crashed on approach to landing - both crew members survived the double generator failure and flameout. 17956 went on to serve NASA as 831 in high speed research programs and remained there until the programs end.

17962 - Was the last SR-71 aircraft to leave Kadena AB in 1990, featuring RIP Det 1 gravestone artwork. Earlier on in its career it flew into Diego Garcia where one of Beale AFB Barns had been reconstructed. Its purpose was to test out the new facilities which checked out fine however no subsequent flights to Diego Garcia were made. 17962 was selected as one of the aircrafts the USAF would use to set speed and altitude records.

17964 - Diverted into Bodo AB as the first SR-71 ever to visit a continental European base, 17964 diverted due to low engine oil - a mandatory abort item on the checklist, either a subsonic flight all the way back to Mildenhall with the possibility of a seized engine, or a little diversion into a 'friendly' base. 17964 was perhaps one of the most photographed SR-71s other than the trainer.

17967 - This aircraft was one of the three SR-71s put in storage when the Blackbird program was shutdown in 1990. It was to return in 1995 sporting new BB insignia on the tail and had the much needed real time datalink pod modification. It rejoined the inventory with 17971 at Det 2 at Edwards AFB alongside NASAs trainer and the SR-71 simulator.

17968 - Won the Mackay trophy for the most meritorious flight of 1971, and the Harmon Trophy for the most outstanding international achievement in the art/science of aeronautics for flying 15,000 miles in 10 hours 30 minutes. 17968 was held in storage until 1999 when the program ended.

NASA 844 - The last SR-71A built, NASA 832 was 17980 in its previous life with the USAF. This aircraft mainly operated from Det 4 at Mildenhall and was the primary SR-71 on the first ‘Eldorado Canyon’ post strike reconnaissance mission. It left Mildenhall adorned with the Det 4 dartboard artwork on the fin when its USAF service ended in 1990.

Credits

The SR-71 Team
It would not have been possible without:

Flight Dynamics & Checklist Procedures
Jay McDaniel

XML Gauge Programming
Herbert Pralle

Special Effects, Gauge Artist and flight test pilot
Luis Costa Pereira

SR-71 model and exterior textures
David Bushell

Sound Effects
Christoffer Petersen

Bibliography & Web links

For those interested in further reading,
I thoroughly recommend the following fantastic books:

SR-71 Blackbird, Beyond the Secret missions
Paul F Crickmore

SR-71 Revealed & SR-71 Stories, Tales and Legends
Richard H Graham, Col. USAF
(Retired, Pilot, Squadron Commander and 9th SRW Commander)

Sled Driver & The Untouchables
Brian Shul & Walt Watson
(Pilot & RSO)

I also recommend these great websites that contain a vast wealth of information - many of which feature never before published photographs that you won't find anywhere else:

www.habu.org

www.sr-71.org

www.wvi.com/~lelandh/sr-71~1.htm

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