

# SOLID ROCKET BOOSTERS



Solid Rocket Boosters Presentation

## OVERVIEW

Two solid rocket boosters provide the main thrust to lift the Space Shuttle off the pad. They are the largest solid-propellant motors ever flown, the first designed for reuse.



The two SRBs provide the main thrust to lift the Space Shuttle off the pad and up to an altitude of about 150,000 feet, or 24 nautical miles (28 statute miles). In addition, the two SRBs carry the entire weight of the external tank and orbiter and transmit the weight load through their structure to the mobile launcher platform. Each booster has a thrust (sea level) of approximately 3,300,000 pounds at launch. They are ignited after the three space shuttle main engines' thrust level is verified. The two SRBs provide 71.4 percent of the thrust at lift off and during first-stage ascent. Seventy-five seconds after SRB separation, SRB apogee occurs at an altitude of approximately 220,000 feet, or 35 nautical miles (41 statute miles). SRB impact occurs in the ocean approximately 122 nautical miles (141 statute miles) downrange.

The SRBs are the largest solid-propellant motors ever flown and the first designed for reuse. Each is 149.16 feet long and 12.17 feet in diameter.

Each SRB weighs approximately 1,300,000 pounds at launch. The propellant for each solid rocket motor weighs approximately 1,100,000 pounds. The inert weight of each SRB is approximately 192,000 pounds.

Primary elements of each booster are the motor (including case, propellant, igniter, and nozzle), structure, separation systems, operational flight instrumentation, recovery avionics, pyrotechnics, deceleration system, thrust vector control system, and range safety destruct system.

Each booster is attached to the external tank at the SRB's aft frame by two lateral

## SOLID ROCKET BOOSTER SEGMENT MOVE



The solid rocket booster segments arrive at KSC via rail from Brigham City, UT, and are offloaded at that Rotation Processing and Surge Facility (RPSF) just north of the Vehicle Assembly Building (VAB).

## TRANSFER FOR STACKING

With a Security escort, the first Solid Rocket Booster (SRB) aft skirt for mission STS-114 nears the Vehicle Assembly Building on its transfer to the Rotation Processing and Surge Facility for stacking. At the facility, an aft motor segment and an external tank attach ring will be installed. The stack will then be moved to the Vehicle Assembly Building for further build-up.



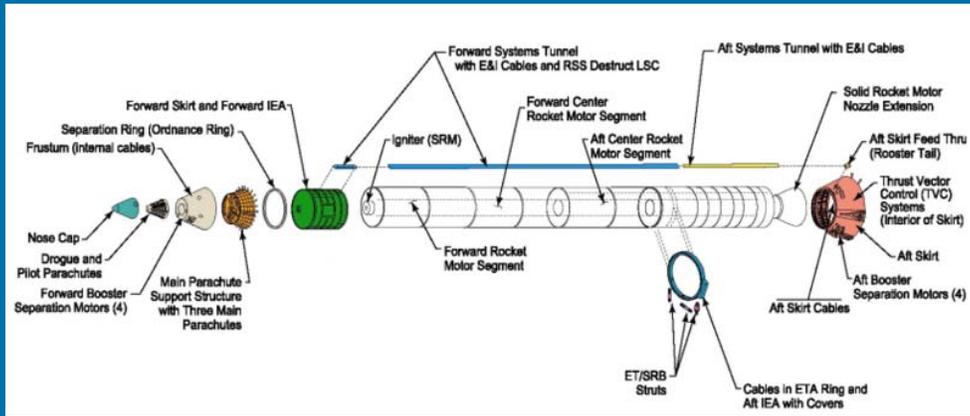
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# STACKING SRB



These are two videos that help explain the stacking process. Both videos should open in a new window and require Real Player.

# SRB DIAGRAM



Can you imagine being responsible for stacking all of this? Phew!

## SRB TRANSPORT TO PAD

Eight attach posts, four on the aft skirt of each SRB, support and hold the Space Shuttle on the Mobile Launcher Platform. These posts fit on counterpart posts located in the Platform's two solid rocket booster support wells. The space vehicle disconnects from the Platform by explosive nuts that release the giant studs linking the solid rocket attach posts with the Platform support posts.



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## HOLD-DOWN POSTS

Each SRB has four hold-down posts securing it to the launch platform. At the T -0:00:0 mark, the SRBs are ignited and the eight giant hold-down posts on the SRBs are released. At that instant, liftoff occurs.



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# SRB IGNITION

The Shuttle's three main engines (SSMEs) are sequentially started at approximately the T-7 second mark. When the engine controllers indicate that they are all running normally, the twin solid rocket boosters (SRBs) are ignited at the T-0 mark. A sequence of events occurs within a few seconds before launch, leading up to SRB ignition and liftoff.

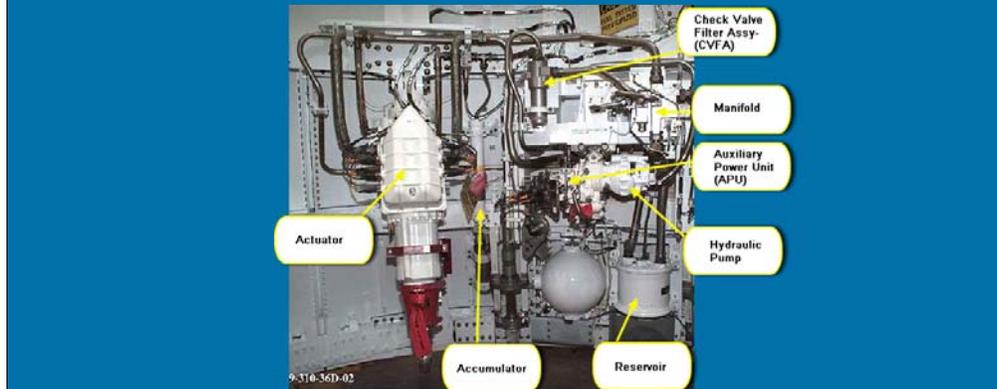


Terminal Countdown	-9:00.0
Arm Solid Rocket Boosters	-5:00.0
Auto Sequence Start	-0:31.0
Main Engine Start	-0:06.6
SRB Ignition	0:00.0
Liftoff	0:00.3

The final 31 seconds of countdown are the busiest, as the Shuttle's on-board computers take over the count, and every system on the vehicle operates on internal power. The Shuttle's three main engines (SSMEs) are sequentially started at approximately the T -7 second mark. When the engine controllers indicate that they are all running normally, the twin solid rocket boosters (SRBs) are ignited at the T -0 mark. A sequence of events occurs within a few seconds before launch, leading up to SRB ignition and liftoff.

# HYDRAULIC POWER UNITS

Each SRB has two self-contained independent hydraulic power units. The purpose of the SRB Hydraulic system is to supply the required hydraulic flow and pressure to extend and retract the actuator piston. The end of the piston is attached to the nozzle of the solid rocket motor to provide thrust vectoring during the mission. This system is called Thrust Vector Control (TVC), and it provides 80% of steering for the integrated vehicle during ascent. A similar system vectors the main engine nozzles, providing the other 20% of the steering control.



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# THRUST VECTOR CONTROL

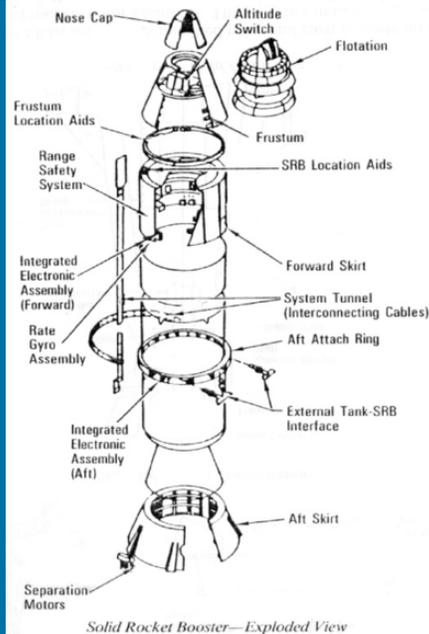
Each SRB has two hydraulic gimbal actuators that provide the force and control to gimbal the nozzle for thrust vector control (TVC).



Each SRB has two hydraulic gimbal servoactuators: one for rock and one for tilt. The servoactuators provide the force and control to gimbal the nozzle for thrust vector control.

# SRB RATE GYRO ASSEMBLIES

Each SRB has two Rate Gyro Assemblies (RGAs) that provide attitude data to the orbiter computers during ascent.



Each SRB contains two RGAs, with each RGA containing one pitch and one yaw gyro. These provide an output proportional to angular rates about the pitch and yaw axes to the orbiter computers and guidance, navigation, and control system during first-stage ascent flight in conjunction with the orbiter roll rate gyros until SRB separation. At SRB separation, a switchover is made from the SRB RGAs to the orbiter RGAs.

The SRB RGA rates pass through the orbiter flight aft multiplexers/demultiplexers to the orbiter GPCs. The RGA rates are then mid-value-selected in redundancy management to provide SRB pitch and yaw rates to the user software. The RGAs are designed for 20 missions.

# SRB SEPARATION



Explosive bolts separate the SRBs from the external tank when fuel has been expended. These videos may make you dizzy!



SRB separation is initiated when the three solid rocket motor chamber pressure transducers are processed in the redundancy management middle value select and the head-end chamber pressure of both SRBs is less than or equal to 50 psi. A backup cue is the time elapsed from booster ignition.

The separation sequence is initiated, commanding the thrust vector control actuators to the null position and putting the main propulsion system into a second-stage configuration (0.8 second from sequence initialization), which ensures the thrust of each SRB is less than 100,000 pounds. Orbiter yaw attitude is held for four seconds, and SRB thrust drops to less than 60,000 pounds.

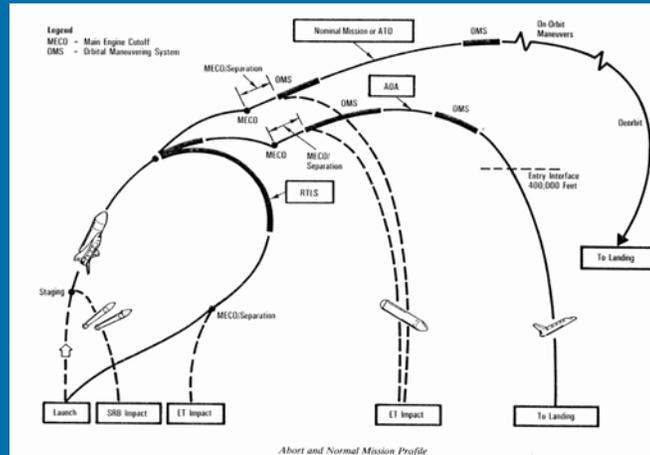
The SRBs separate from the external tank within 30 milliseconds of the ordnance firing command.

The forward attachment point consists of a ball (SRB) and socket (ET) held together by one bolt. The bolt contains one NSD pressure cartridge at each end. The forward attachment point also carries the range safety system cross-strap wiring connecting each SRB RSS and the ET RSS with each other.

The aft attachment points consist of three separate struts: upper, diagonal, and lower. Each strut contains one bolt with an NSD pressure cartridge at each end. The upper strut also carries the umbilical interface between its SRB and the external tank and on to the orbiter.

# RANGE SAFETY SYSTEM

The vehicle has three RSSs, one in each SRB and one in the external tank. If the vehicle violates a launch trajectory red line, the ground can command them to self-destruct.



The Shuttle vehicle has three RSSs. One is located in each SRB and one in the external tank. Any one or all three are capable of receiving two command messages (arm and fire) transmitted from the ground station. The RSS is used only when the Shuttle vehicle violates a launch trajectory red line. Maximum dynamic pressure is reached early in the ascent, nominally approximately 60 seconds after liftoff. Approximately 1 minute later (2 minutes into the ascent phase), the two SRB have consumed their propellant and are jettisoned from the external tank. This is triggered by a separation signal from the orbiter.

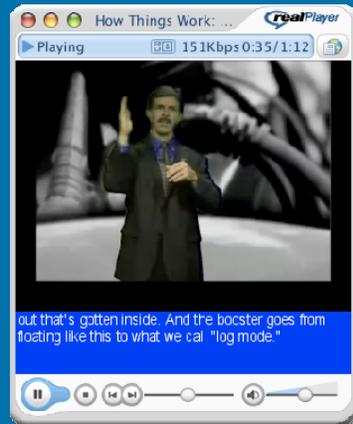
An RSS consists of two antenna couplers, command receivers/ decoders, a dual distributor, a safe and arm device with two NSDs, two confined detonating fuse manifolds, seven CDF assemblies, and one linear-shaped charge.

The antenna couplers provide the proper impedance for radio frequency and ground support equipment commands. The command receivers are tuned to RSS command frequencies and provide the input signal to the distributors when an RSS command is sent. The command decoders use a code plug to prevent any command signal other than the proper command signal from getting into the distributors. The distributors contain the logic to supply valid destruct commands to the RSS pyrotechnics.

The NSDs provide the spark to ignite the CDF, which in turn ignites the LSC for shuttle vehicle destruction. The safe and arm device provides mechanical isolation between the NSDs and the CDF before launch and during the SRB separation sequence.

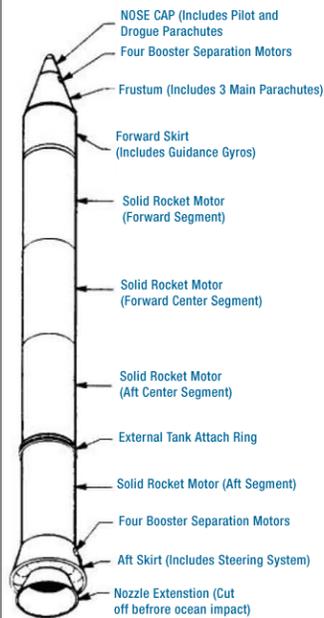
# SRB DESCENT AND RECOVERY

Exactly 295 seconds after they separate from the vehicle, both SRBs fall into the Atlantic Ocean, where they are recovered for reuse.



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# TERMINOLOGY/ACRONYMS



SRB - Solid Rocket Booster  
RGA - Rate Gyro Assemblies  
TVC - Thrust Vector Control  
RSS - Range Safety System  
RPSF - Rotation Processing and Surge Facility  
CVSA - Check Valve Filter Assembly  
APU - Auxiliary Power Unit

Here is a review of the SRB and some important acronyms you learned about today.



## Descent and Recovery

The recovery sequence begins with the operation of the high-altitude baroswitch, which triggers the functioning of the pyrotechnic nose cap thrusters. This ejects the nose cap, which deploys the pilot parachute. This occurs at 15,704 feet altitude 225 seconds after separation. The 11.5-foot-diameter conical ribbon pilot parachute provides the force to pull the lanyard activating the zero-second cutter, which cuts the loop securing the drogue retention straps. This allows the pilot chute to pull the drogue pack from the SRB, causing the drogue suspension lines to deploy from their stored position. At full extension of the 12 95-foot suspension lines, the drogue deployment bag is stripped away from the canopy, and the 54-foot-diameter conical ribbon drogue parachute inflates to its initial reefed condition. The drogue disreefs twice after specified time delays, and it reorients/stabilizes the SRB for main chute deployment. The drogue parachute can withstand a load of 270,000 pounds and weighs approximately 1,200 pounds.

After the drogue chute has stabilized the vehicle in a tailfirst attitude, the frustum is separated from the forward skirt by a charge triggered by the low-altitude baroswitch at an altitude of 5,975 feet 248 seconds after separation. It is then pulled away from the SRB by the drogue chute. The main chutes' suspension lines are pulled out from deployment bags that remain in the frustum. At full extension of the lines, which are 204 feet long, the three main chutes are pulled from the deployment bags and inflate to their first reefed condition. The frustum and drogue parachute continue on a separate trajectory to splashdown. After specified time delays, the main chutes' reefing lines are cut, and the chutes inflate to their second reefed and full open configurations. The main chute cluster decelerates the SRB to terminal

















