

Launch Pad Escape System Design (Human Spaceflight):

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A launch pad escape system for human spaceflight is one of those things that everyone hopes they will never need but is critical for every manned space program. Since men were first put into space in the early 1960s, the need for such an Emergency Escape System (EES) has become apparent. The National Aeronautics and Space Administration (NASA) has made use of various types of these EESs over the past 50 years.

Early programs, like Mercury and Gemini, did not have an official launch pad escape system. Rather, they relied on a Launch Escape System (LES) of a separate solid rocket motor attached to the manned capsule that could pull the astronauts to safety in the event of an emergency. This could only occur after hatch closure at the launch pad or during the first stage of flight. A version of a LES, now called a Launch Abort System (LAS) is still used today for all manned capsule type launch vehicles. However, this system is very limited in that it can only be used after hatch closure and it is for flight crew only. In addition, the forces necessary for the LES/LAS to get the capsule away from a rocket during the first stage of flight are quite high and can cause injury to the crew. These shortcomings led to the development of a ground based EES for the flight crew and ground support personnel as well. This way, a much less dangerous mode of egress is available for any flight or ground personnel up to a few seconds before launch.

The early EESs were fairly simple, gravity-powered systems to use when things go bad. And things can go bad very quickly and catastrophically when dealing with a flight vehicle fueled with millions of pounds of hazardous propellant. With this in mind, early EES designers saw such a passive/unpowered system as a must for last minute escapes. This and other design requirements had to be derived for an EES, and this section will take a look at the safety design aspects for a launch pad escape system.

Historic Apollo and Shuttle Program EESs:

The first EES for the Saturn V rocket was to use the existing launch tower elevators to the base of the mobile launcher platform. Personnel would then transfer to a slide tube that ended in an underground rubber room. They would then walk over to a sealed blast room beneath the pad and wait out the emergency, or wait for rescue personnel to arrive. A few years later another EES was built for the Saturn V rocket. This second system was a single cab on a slidewire that egressed the Astronauts

from the capsule level of the launch tower to the ground outside the pad's perimeter fence, see Figure 1. Up to nine personnel could load into this cab and ride down a steel cable to a landing site 2400 feet away. They would then exit and enter a bunker and wait for rescue personnel to arrive.

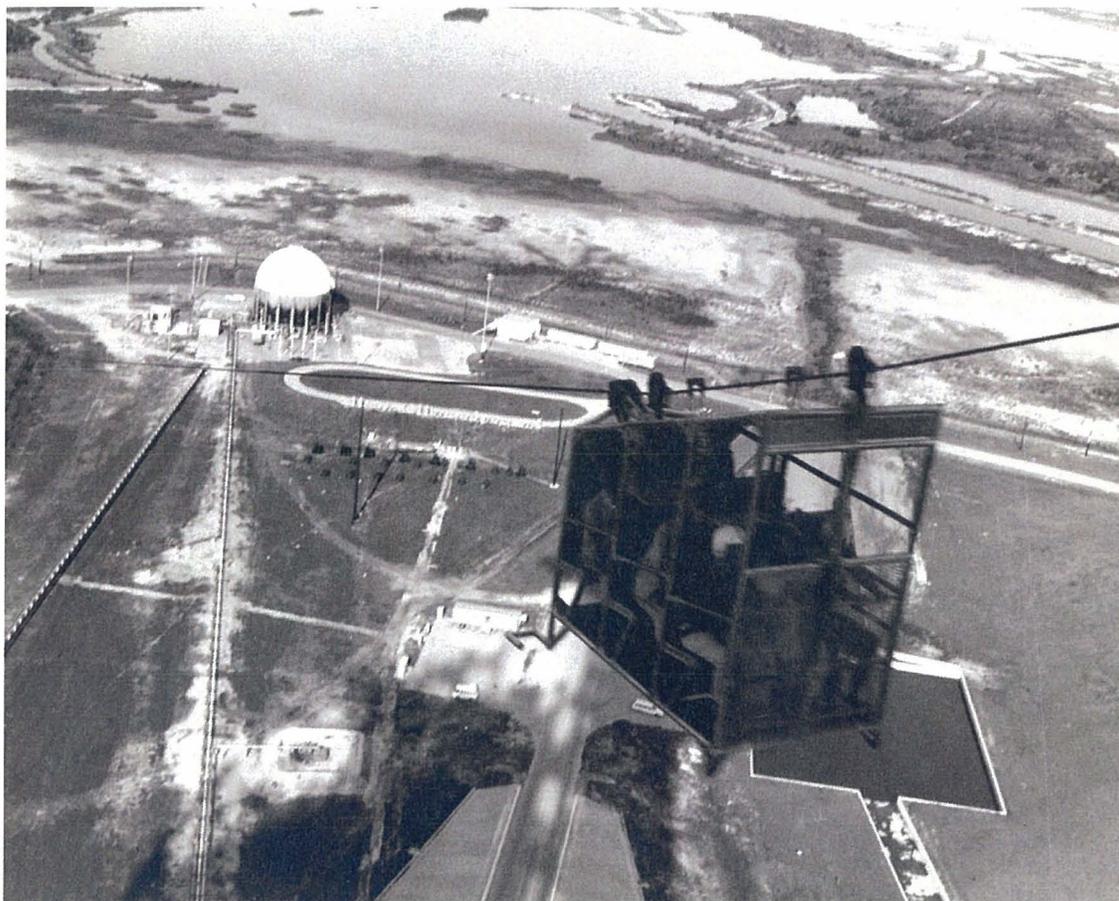


Figure 1: Apollo Slidewire System at Launch Pad

The Space Shuttle system was no different than Apollo in its need for a safe means of escape from the launch pad. Shuttle expanded upon the slidewire system from Apollo since they did not have a LAS on the vehicle. This meant the EES was the only method of emergency egress at the pad. They installed 5 slidewires to the launch tower (and later expanded it to 7) with baskets that could hold up to 4 people each. These slidewires ended at the same Apollo bunkers outside the BDA where personnel could wait out the disaster or transfer to an armored vehicle (M-113) and drive to a triage site where they could be met by rescue personnel.

Key design safety factors for new EES:

Over the years, there were safety-related design attributes that evolved ever since the manned space program has begun. Here is a list of safety requirements that must be considered and determined feasible or not depending on the type of rocket, launch tower, ground personnel, hazards present, flight crew size, and program customer needs:

- Quick egress time; which is the desired complete evacuation of all crew members to a safe haven in just a few minutes from the time the emergency egress is called
- Must be able to handle incapacitated personnel
- System must be passive, which means either unpowered or have available back-up systems independent of launch pad systems
- Must accommodate flight crew plus any ground support personnel and rescue personnel present during the time of flight crew insertion into the vehicle
- The system must accommodate pressurized and non-pressurized space suits, rescue suits/gear, and any special ground support personnel suits
- G-forces (or gravity induced forces) on egressing personnel need to be limited in order not to result in further injuries.
- The EES needs to be single fault tolerant at a minimum, so that there could be one failure and the system still needs to operate within requirements
- Remove personnel away from the disaster or outside the Blast Danger Area (BDA). The BDA is a circular 'stay-out' area around a rocket, that if it were to explode anything in this area would be affected.

The original EES designed for the Saturn V rocket met most of these, but was lacking in a few requirements. Specifically it did not handle incapacitated personnel well since there was a transfer from the elevators to a slide tube, and it did not remove personnel away from the disaster. The second Saturn V EES and Shuttle's EES slidewire system solved both of these problems.

Design of Future EESs:

NASA's Constellation Program designed the most advanced EES that manned space flight has ever seen. It consisted of a multi-car high speed rail system and used gravity to get personnel to a safe haven, see Figure 2. It was very accommodating to incapacitated crew members as well as limited g-

forces on the people riding the cars with a passive electromagnetic braking system. There was even an option to extend the rails to an area outside the BDA directly into a triage site. For this system NASA relied on many different areas of expertise: Safety, Medical, Operations Personnel, and the Astronaut Office. This helped to meet all of the customer's design requirements.



Figure 2: Constellation Program Rail EES, Conceptual Image

Other considerations and lessons learned for an effective EES:

Other important safety factors needed for a good EES design deal with how the crew is extracted from the launch vehicle by rescue personnel:

- Limit or eliminate any steps or changes in elevation for walking personnel until they enter the EES.
- Provide rescue aides like platforms that are quickly put in place to help extract crew from the vehicle. And have these available in close proximity to the crew hatch. Another item along

these lines is to provide hand holds to help in getting incapacitated crew out of the vehicle as well.

- Provide ample room for two-way traffic on an access arms or platforms in the egress path so as not to create a traffic jam of egressing personnel leaving and rescue personnel arriving. In addition, incapacitated crew rescue usually requires the use of a rolling rescue-chair, see Figure 3. So those need to be stored near the crew level of a launch tower and there needs to be room to accommodate them in an egress path.
- Keep the egress path shielded against possible fire and debris in order to block the heat from a burning vehicle.
- Recommend use of a water deluge system for the entire egress path on a launch tower to help with any fires or chemical leaks near the egress path. However, point any deluge nozzles away from the egressing crew's face and field of vision. In addition, provide a non-slip surface for egress that the water may make slippery, like grating or anti-skid flooring.
- Provide emergency battery powered lights along the egress path to help guide personnel, especially during night launches. Along with this should be very visible directional floor markings to show the egress path.
- There needs to be communication (point-to-point) at the vehicle exit and in the safe haven with the Launch Control Center.
- Mission management also needs to know where the crew is at all times, so cameras placed along the egress path are usually required as well.

Keeping in mind these key safety requirements and lessons learned from past and current EES designs ensures an effective EES for future programs to come.



Figure 3: Rescue Chair Entry into Slidewire Basket for Shuttle Program.