

LUNAR LANDING RESEARCH FACILITY
AND
LANDING LOADS TRACK

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LUNAR LANDING RESEARCH FACILITY

You are now standing on the vehicle service pad of the Lunar Landing Research Facility, a part of the Spacecraft Research Branch. In front of you is the rocket-powered man-carrying flight-test vehicle and overhead is the gentry structure used to provide lunar gravity simulation. The principles of this simulation technique are described to you at another stop. Here we will point out some of the features of the facility.

The vehicle was designed primarily as a multipurpose flight-test bed equipped with hydrogen peroxide rocket motors to provide the main thrust and attitude control torques. As much currently available hardware and equipment as possible was used so as to expedite the construction in the most economical manner. For example, an H-13 helicopter cab was used for the pilots' compartment. Consequently, this test vehicle is not an exact replica of the Apollo LEM; however, it is essentially the same size and weight as the LEM and will provide, with proper adjustments, the same performance, control characteristics, and cockpit visibility.

The vehicle will be flown by NASA test pilots and astronauts at speeds up to about 17 mph anywhere within the confines of the overhead structure which provides travel of 400 feet down range, 50 feet cross range, and 180 feet vertically. A vertical lifting force equal to $5/6$ of the vehicle's weight is applied by the two support cables to oppose the pull of earth's gravity and simulate the low gravitational force at the moon's surface. These cables are attached overhead to a servo controlled hoist system in the dolly unit mounted under the traveling bridge. The hoist system is controlled automatically by load cells in each support strut. As the vehicle moves down range or cross range in response to the pilot's controls, the bridge and dolly respond to signals from the vehicle and from cable angle sensors at the top of the cables so as to stay directly over the vehicle at all times and keep the cables vertical. The bridge and dolly system are hydraulically driven to provide a very responsive servo controlled system.

At one point in the test program, the vehicle will be hoisted to the overhead platform where tow cables from the trolley units on the lower horizontal truss structure will be prepared for catapulting the vehicle down range at speeds up to 35 miles per hour.

Safety features are provided in this facility to prevent the vehicle from crashing or the bridge and dolly from overrunning their tracks in the event of malfunction of equipment or the pilot exceeding the safety limits of the system.

The facility is currently being checked for final acceptance by NASA and research operations are expected to begin in about 2 months. The test program will include a systematic variation of the vehicle control characteristics, cockpit visibility, flight instrumentation, and piloting techniques. For some tests, the cockpit will be modified to duplicate the actual LEM designed features.

Another phase of the lunar mission which is being studied at this site by the Spacecraft Research Branch is that of the astronauts walking and performing various tasks on the surface of the moon.

The principles of this simulator are described at another stop and will not be described in detail here. The equipment is extremely simple and consists primarily of an overhead 200-foot track and lightweight trolley, a cable suspension system, and an inclined walkway. The test subject is supported by the cables so that his body members are free to move in their normal manner while he is suspended in a nearly horizontal attitude. The walkway has been displaced from directly beneath the overhead track so as to align the subject with the desired component of earth's gravity. Mr. Amos Spady, our test subject for today, will demonstrate some of his self-locomotive capabilities in the simulated lunar gravity beginning with normal walking note that his body leans forward considerably more than is normal but this does not present a particular problem. Next Amos will attempt to run. Note once again the exaggerated body angle but now the feet slip also. This low foot traction caused primarily by the reduced weight in lunar gravity is one of the characteristics of lunar activity. Special footgear features, such as cleats, may be worn by the lunar explorers to alleviate this problem. Next we see what appears to be a more natural way to run on the moon. Note the slow start followed by the long leaping strides which are not at all tiring. Stopping presents the same problem as starting due to the low foot traction.

Vertical jumping is quite dramatic but requires careful timing and coordination in order to prevent loss of balance. Maximum heights of 12 to 14 feet have been obtained and surprisingly enough, no injuries have resulted when subjects have fallen from these heights and landed on their head, or back. The ability to jump over obstacles is increased greatly in the lunar gravity. This should be a valuable asset in exploring the lunar terrain. Climbing under lunar gravity such as egress or ingress of the LEM will be easily accomplished.

Finally, Mr. Spady demonstrates some lunar gymnastics. Similar tests with the subject wearing a typical space suit have demonstrated that he was still able to perform all tasks in a relatively easy manner, even the gymnastics you have just seen. Consequently, it appears that the astronauts will have considerable mobility on the lunar surface and will be able to perform many tasks without the aid of vehicular devices.

LANDING LOADS TRACK

You are now standing alongside the Landing Loads Track. This facility is used to perform research on problems of landing impact, taxiing, braking, and ground handling of aircraft or spacecraft. These problems may involve study of a landing gear, the action of tires on the runway, skids, brakes, loads developed in the craft when encountering bumps on the runway, or the character of the runway surface itself. We have here a high-speed track with a carriage to transport test specimens down the concrete runway in the center. Quantitative measurements are made of all the variables of interest, such as forward speed, vertical impact velocity, vertical and drag load, wheel rpm, etc. Occasionally, research on hydrofoils is performed for the Navy in the adjacent water basin.

The main test carriage for landing gear research is the white tubular structure in front of the hydraulic jet catapult, ready to be propelled up to test speed. The jet catapult can get this carriage up to 150 mph in 3 seconds and in a distance of 300 to 400 feet. After the carriage is up to test speed, the research specimen is impacted on the runway and the test is accomplished as the carriage travels in free roll along the track and is finally stopped by the five cables stretched across the track. All actions aboard the carriage are automatically controlled, and research information is recorded on board for subsequent retrieval.

Our landing work here is concerned chiefly with vehicles which have a high translational velocity at landing or takeoff. Some examples of research which we have been able to accomplish because of our high-speed, straight-run capability are:

1. Shimmy research on the X-15 nose gear on dry, wet, and sand covered concrete.

2. Research on skid materials for application to reentry vehicles, where friction coefficient and wear rate were measured on concrete, on asphalt, and on simulated lakebed.

3. Research on the important effects of tire tread pattern and tire wear on the braking effectiveness of a tire on a wet runway.

4. Research on the retarding effect on tires of a deposit of slush on the runway. This research formed the basis for the present regulation governing the operation of jet transports in slush.

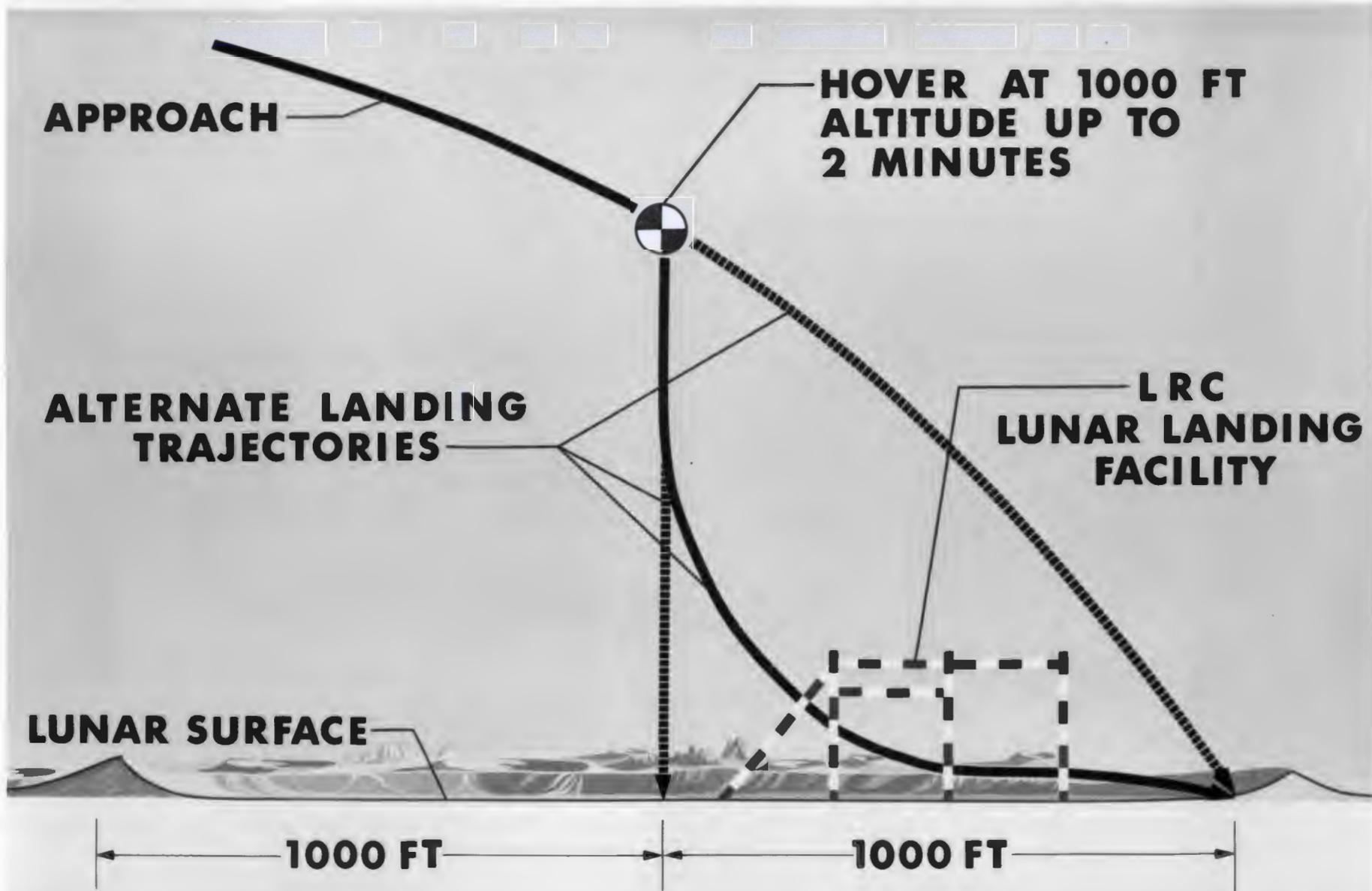
5. More recently, we have been studying the hydroplaning of tires on wet surfaces, a phenomenon of importance to airplanes and automobiles. Hydroplaning may occur at a certain speed in heavy rain and the tire rides up on a film of water and acts like a water ski. We have shown in our studies that hydroplaning speed is proportional to the square root of the tire inflation pressure. For an aircraft tire at an inflation pressure of 100 psi, the hydroplaning speed is 90 knots. At an inflation pressure of 25 psi, typical of your car, the hydroplaning speed is 45 knots, or 52 miles per hour. When a tire

hydroplanes, friction between the tire and the road available for braking or traction, drops to a low value, as does also the vehicle directional control, or steering. As a result, an airplane or a car will suffer a great increase in brake stopping distance, and both would be more adversely affected by crosswinds, and experience a loss in steering. One surprising result of tire hydroplaning is that the tire frequently stops rotating completely without application of brakes and, in fact, brakes are thereby rendered useless.

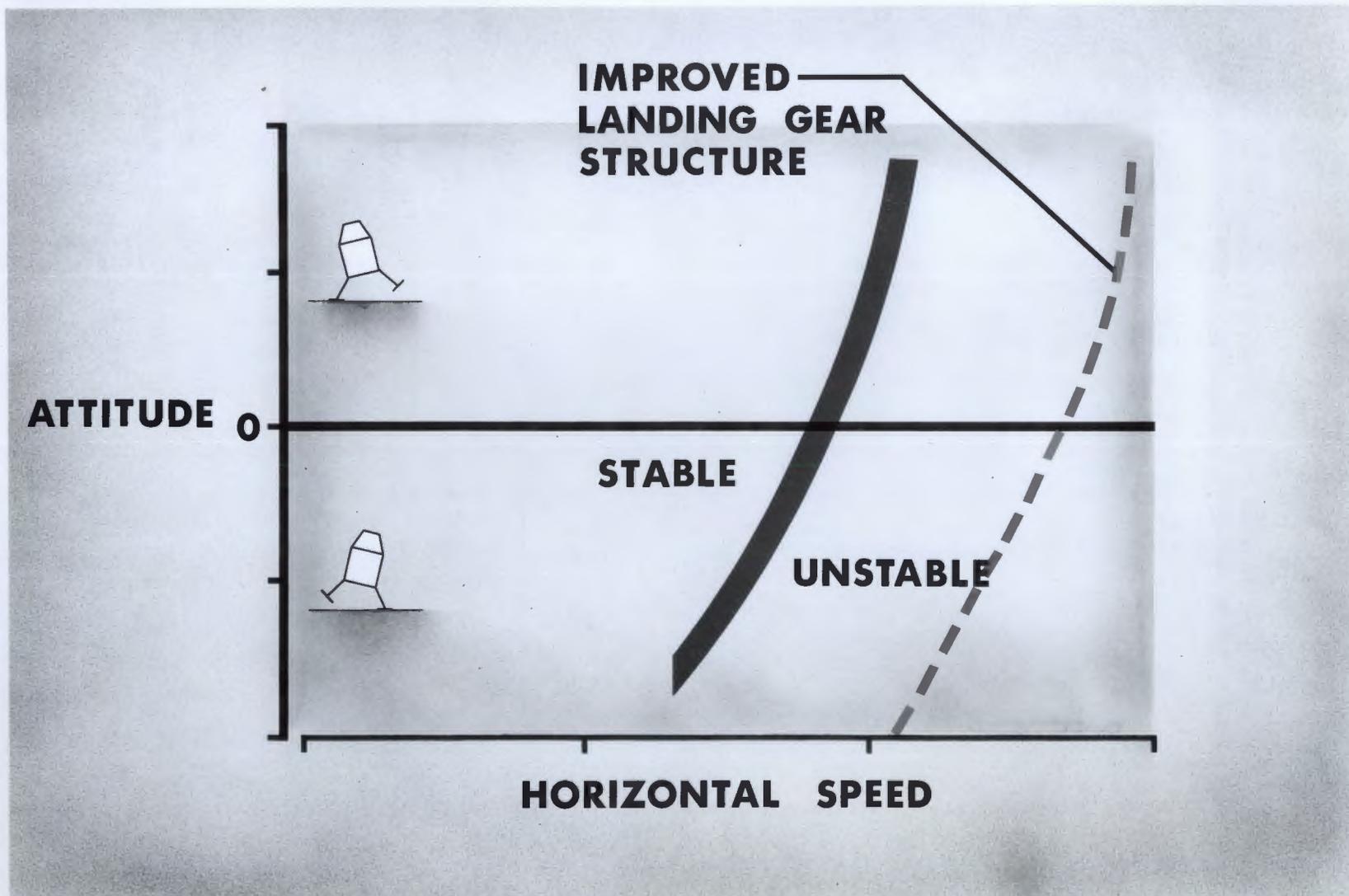
Our demonstration of the Landing Loads Track involves an airplane tire being tested under hydroplaning conditions at 80 knots. You will see the water jet propel the carriage down the track and the arrestment by the cables. As the test tire runs through the water trough, you will see the spray that it throws, but you probably will not be able to see the tire. In this research, we have studied the flow of water in the footprint area and have also studied spray patterns and their effects on water injection into engines and on added airplane drag due to spray impingement.



APOLLO LUNAR-LANDING REQUIREMENTS



LUNAR LANDING



ASTRONAUT

OBSERVE · THINK · ACT

MAN IN

LABORATORY

**{ REDUCE EQUIPMENT COMPLEXITY
INCREASE EXPERIMENT FLEXIBILITY
IMPROVE TEST RELIABILITY**

EXPERIMENT

**{ UNIQUE SENSORY ABILITY
DECISION-MAKING CAPABILITY
MOTOR FLEXIBILITY**