
Apollo Recovery Operations

Objectives

Describe the organization of recovery force command and control and landing areas.

Describe the function and timeline use of the Earth Landing System (ELS).

Describe Stable 1 vs Stable 2 landing configurations and the function of the Command Module Uprighting System.

Explain the activities of the helicopter and swimmer teams in egress and recovery of the crew.

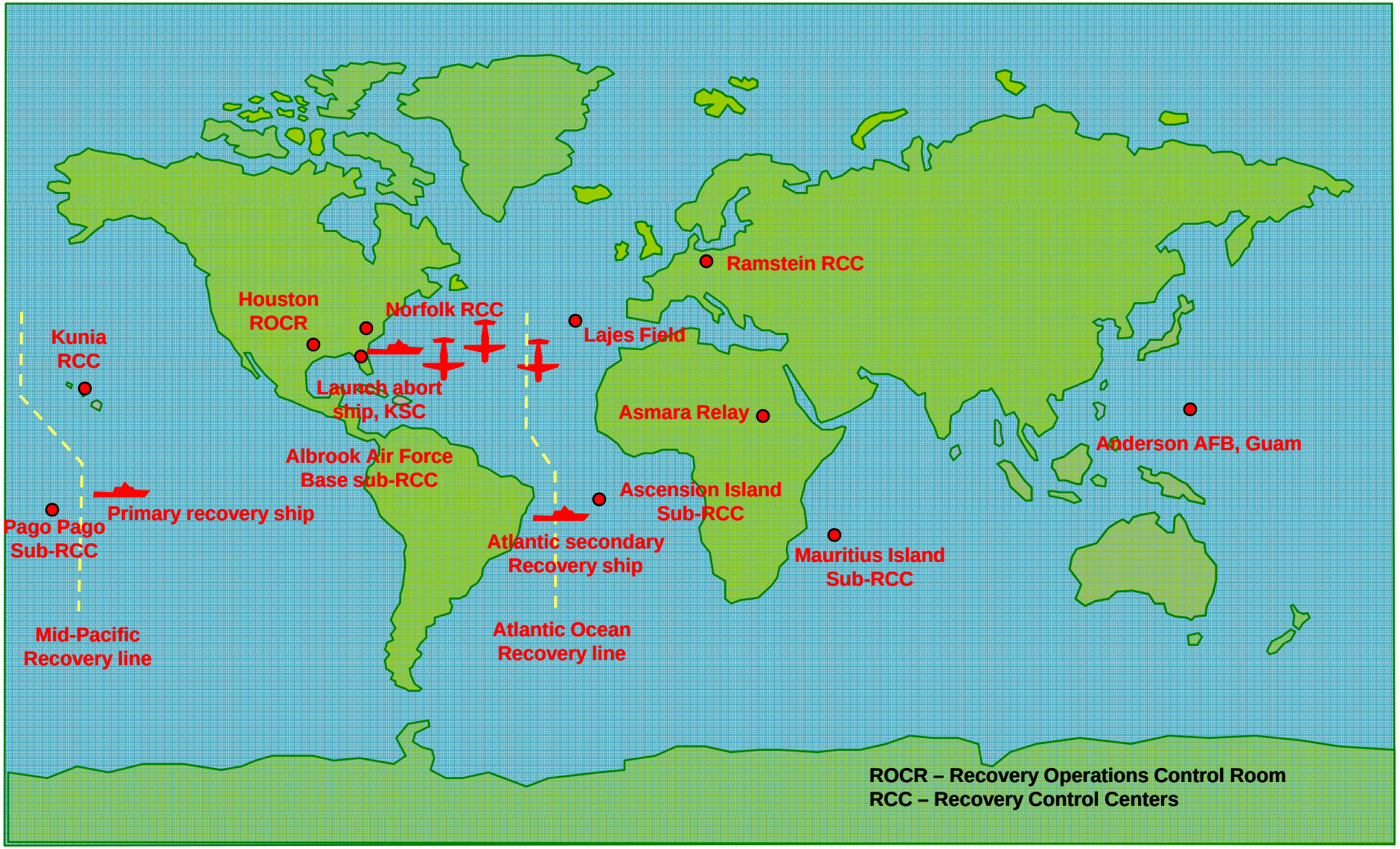
Explain the activities of the swimmer teams and primary recovery ship in recovery of the Command Module.

Describe several landing incidents that occurred during Apollo.

Recovery Operations Overview

- **Recovery Force Organization**
  - **Location of Operations/Landing Areas**
- **Walkthrough of Recovery Activities**
  - **ELS/Parachute Timeline**
  - **Stable 1 or 2 Attitude**
    - **Recovery into Stable 1 Attitude**
  - **Finding the Command Module**
  - **Helicopter Operations**
  - **Swimmer Operations**
    - **Flotation Collar**
    - **Recovery Raft**
    - **Crew Egress and Air Lift**
    - **CM Recovery Operations**
- **Apollo 16 Recovery Timeline**
- **Apollo Landing Incidents**
  - **Apollo 15 ELS Incident**

Recovery Force Areas



Earth Landing System (ELS)

Consisted of various parachutes and deployment mechanisms to decelerate the Command Module for a safe landing.

- **Forward Heat Shield Separation Parachute (Apex Cover)**
- **2 Drogue Parachutes**
- **3 Pilot Parachutes**
- **3 Main Parachutes**

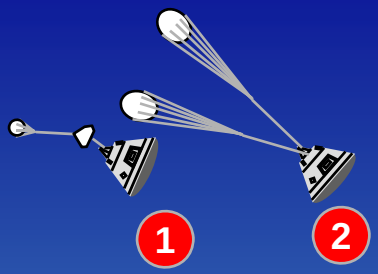
Activation of system through barometric switches and time delays, as well as backup crew switches.

System was designed to safely operate with only two main chutes.

Parachute Timeline

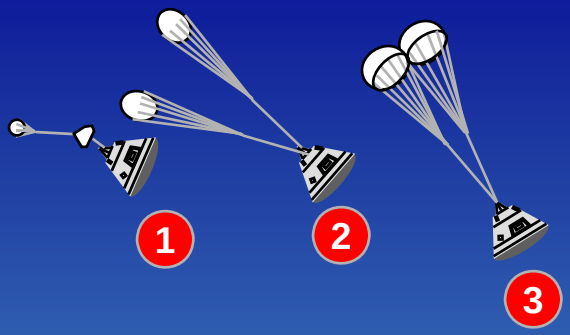
1. **Apex cover jettisoned at 24,000 ft.**

Parachute Timeline



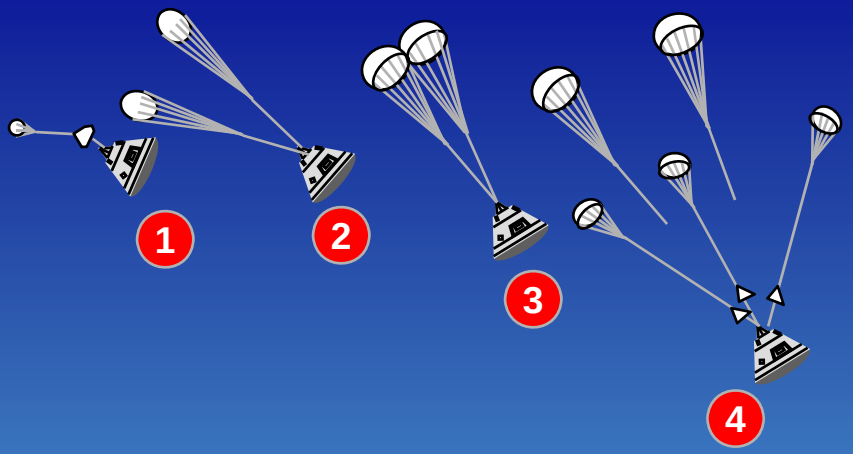
2 **Drogue parachutes deployed reefed at 24,000 ft +2 sec.**

Parachute Timeline



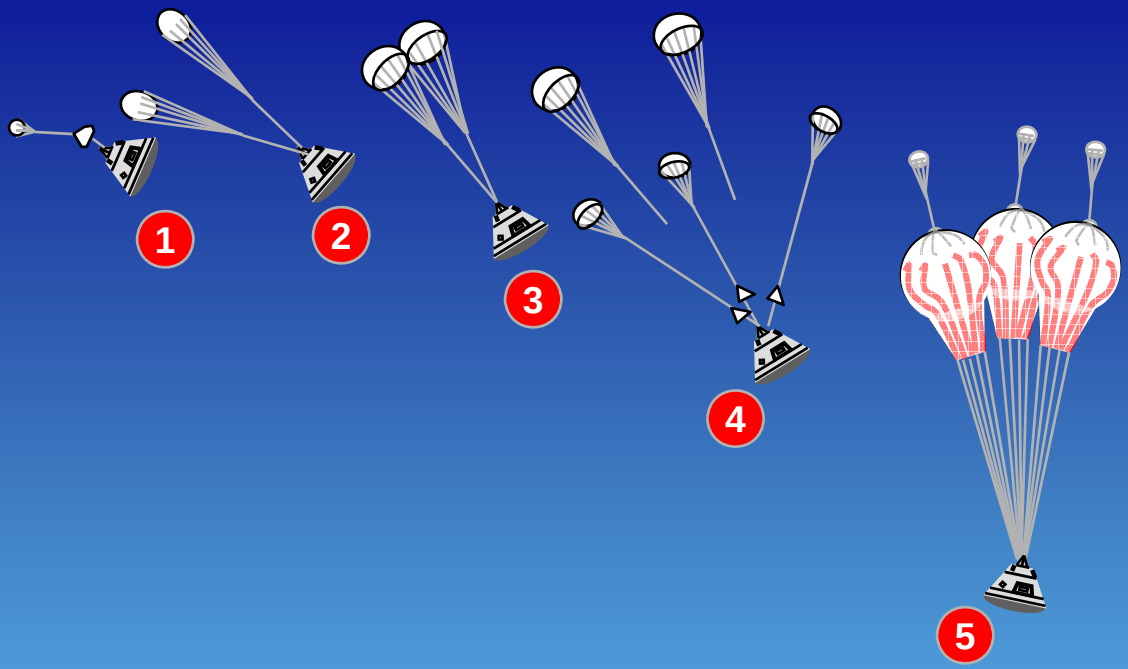
3 **Drogue parachute single-stage disreef (10 sec after deployment).**

Parachute Timeline



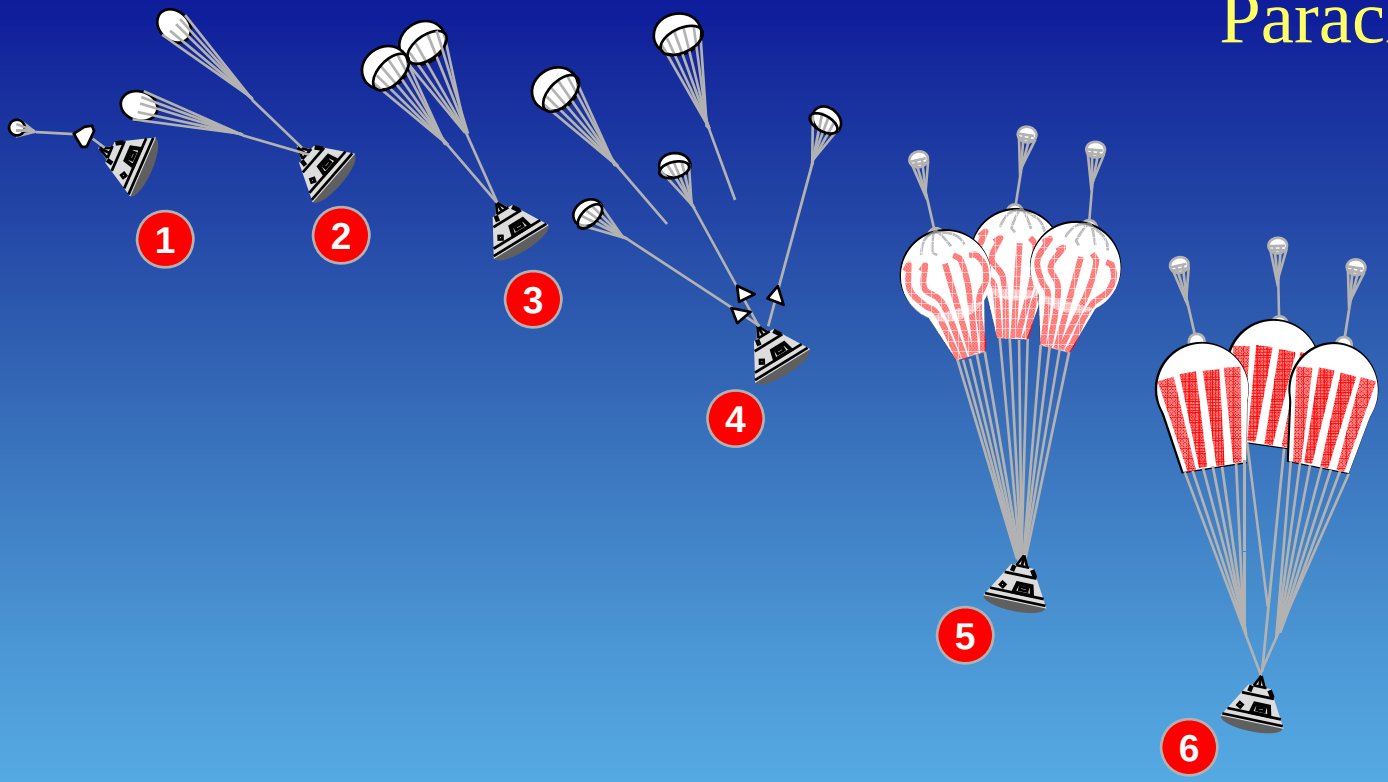
4 **At 10,000 ft. the drogue were released and the main parachutes were deployed reefed via three pilot parachutes.**

Parachute Timeline



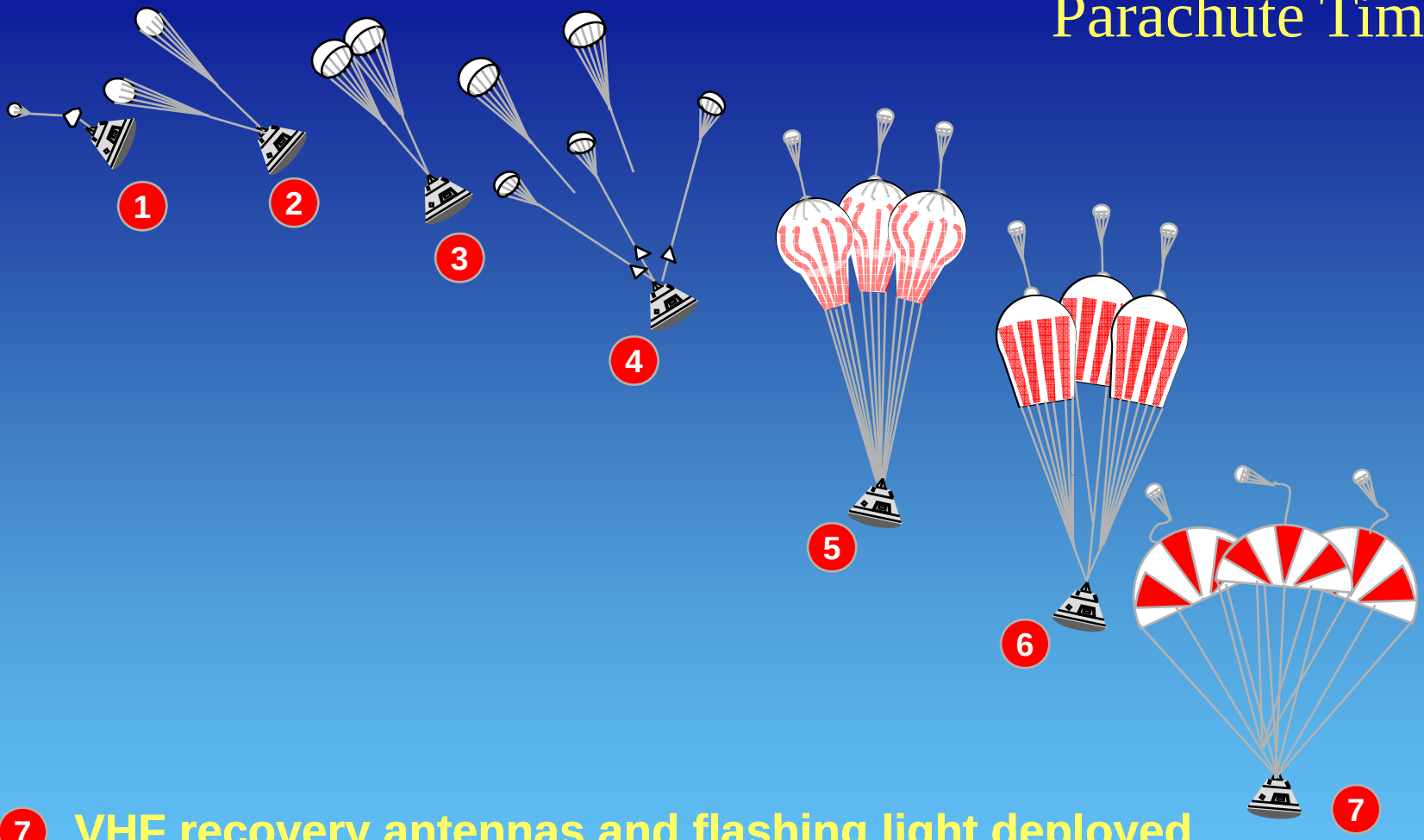
5 Main parachute initial inflation.

Parachute Timeline



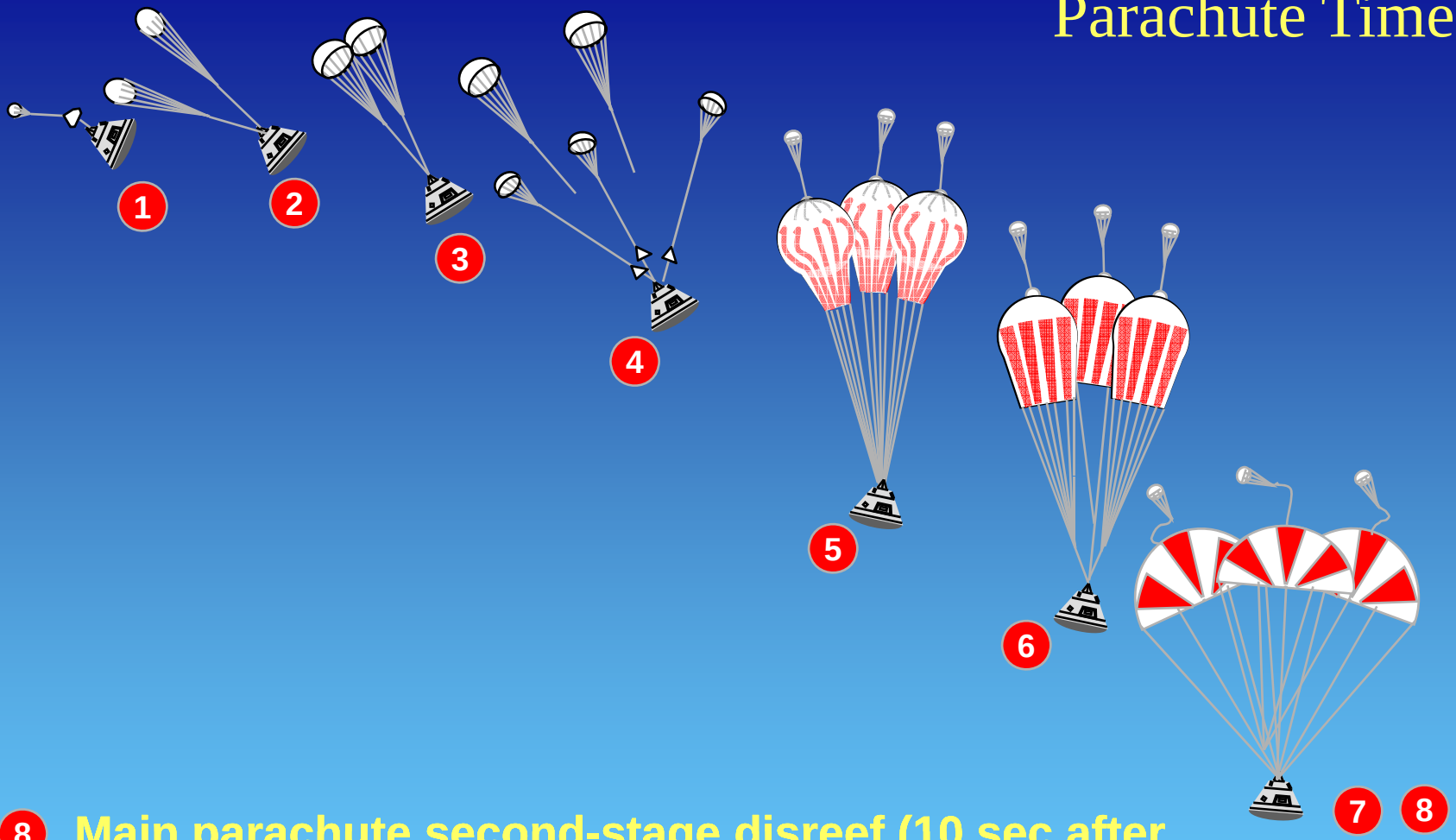
6 **Main parachute first-stage disreef (6 sec after deployment).**

Parachute Timeline



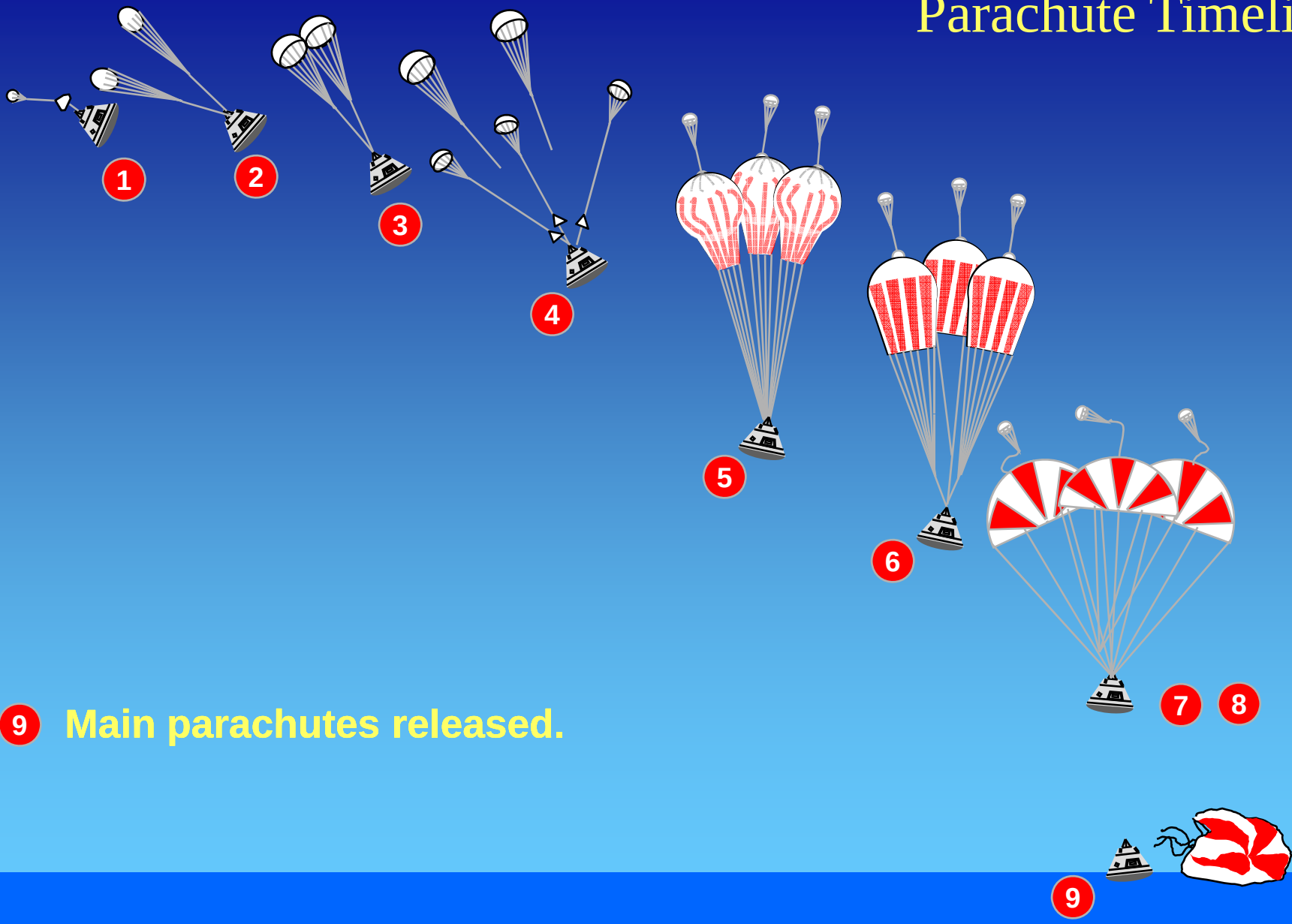
7 **VHF recovery antennas and flashing light deployed (8 sec after main parachute deployment).**

Parachute Timeline



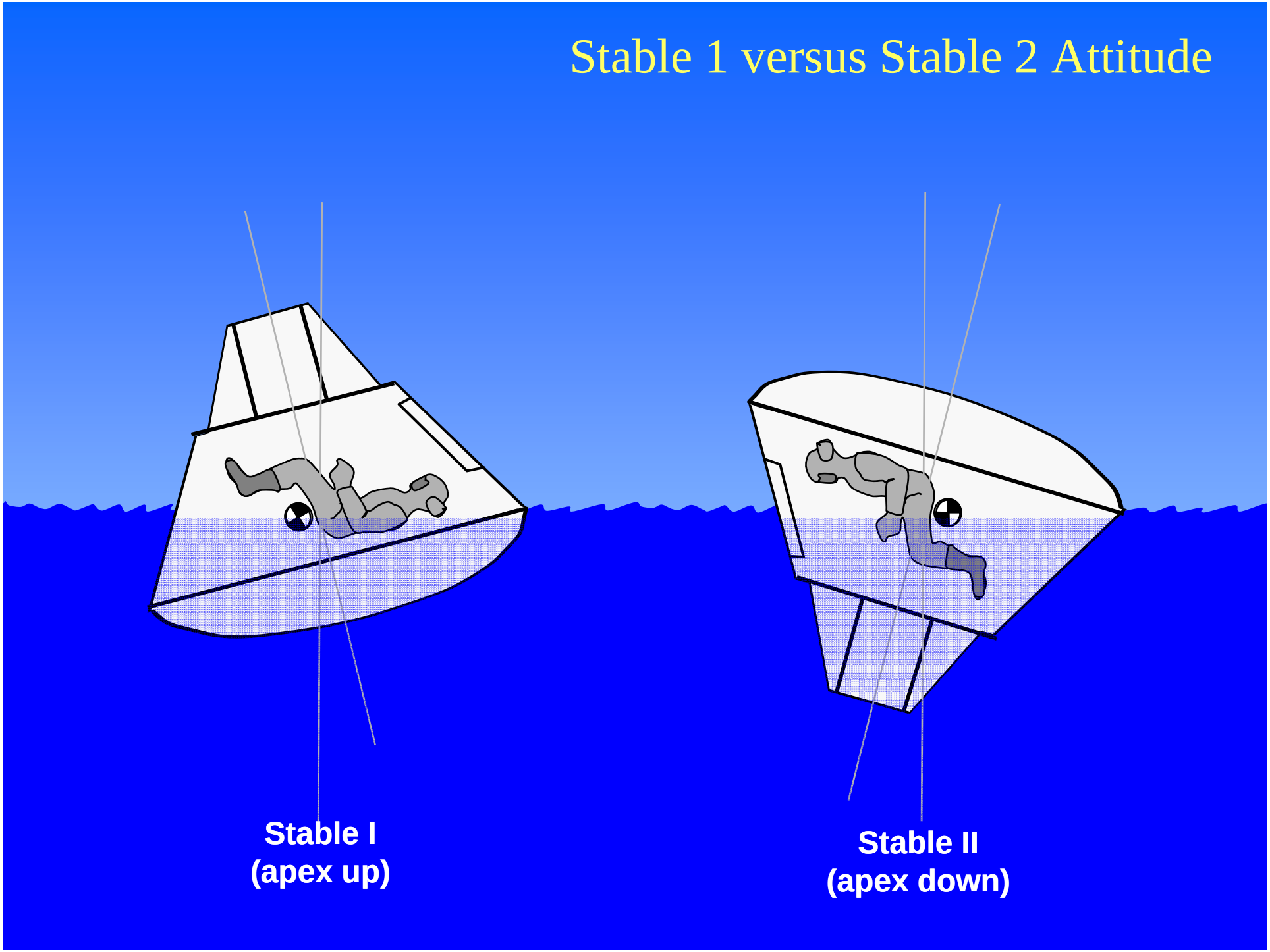
8 **Main parachute second-stage disreef (10 sec after main parachute deployment).**

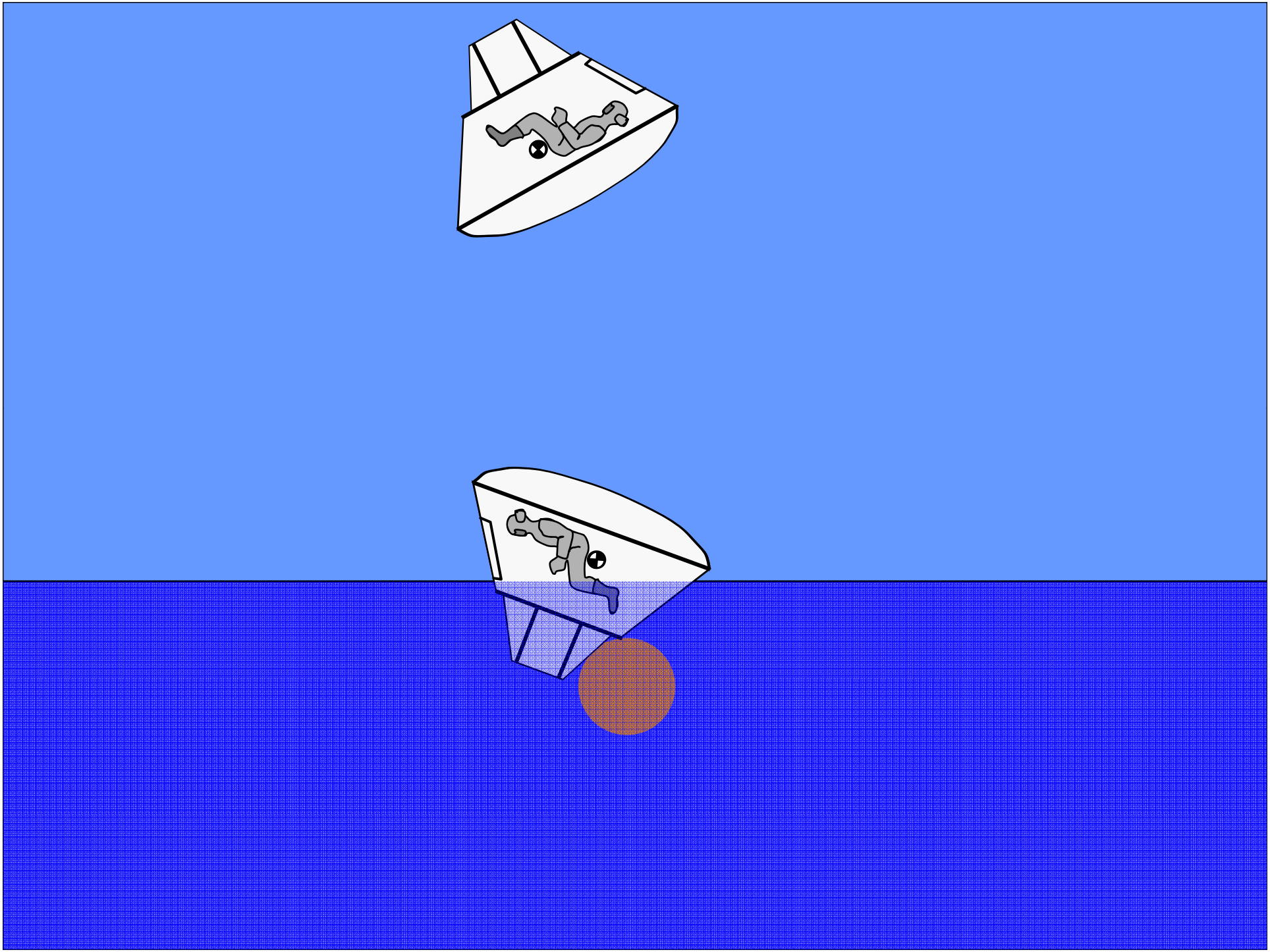
Parachute Timeline



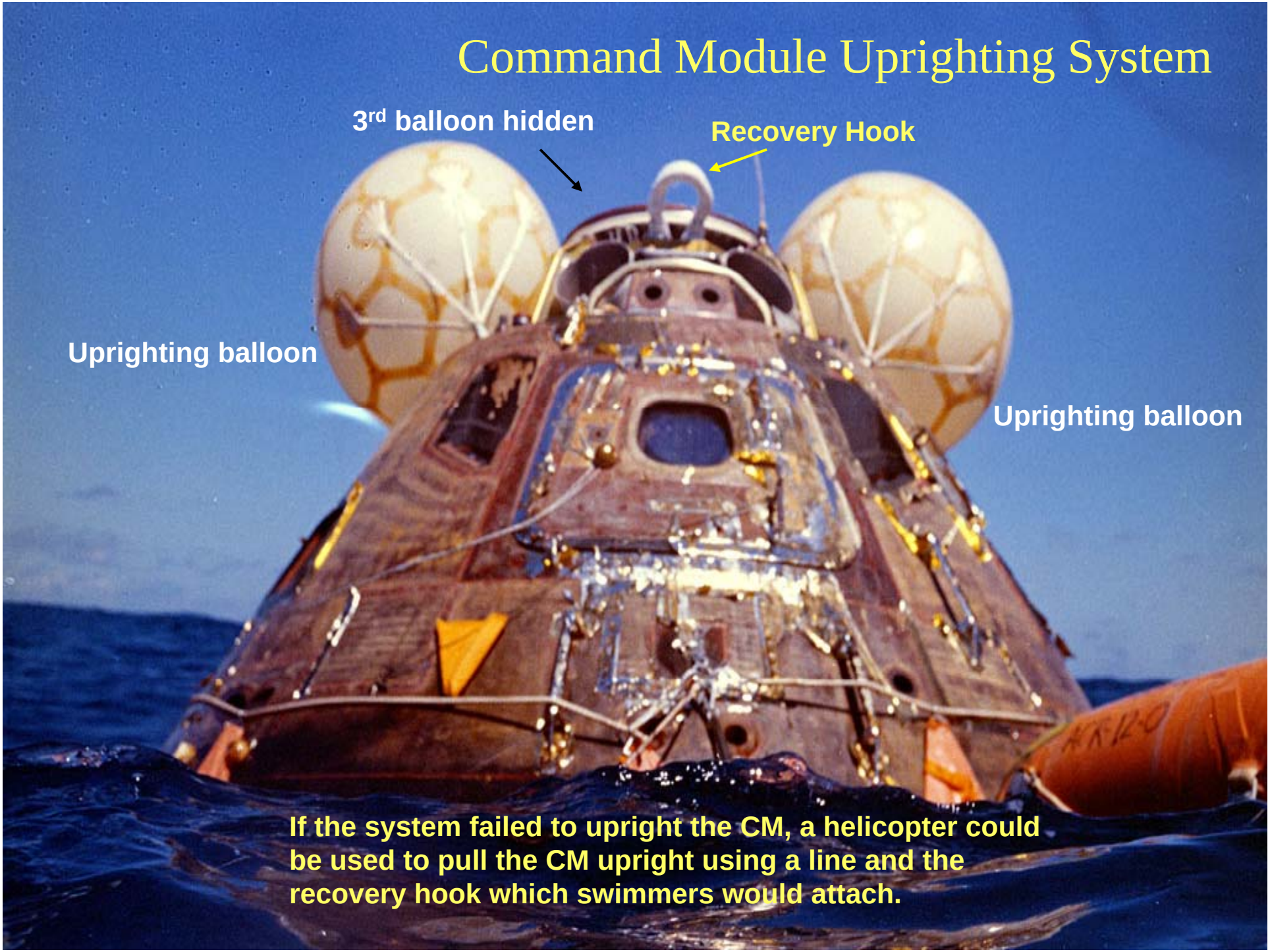
9 Main parachutes released.

Stable 1 versus Stable 2 Attitude



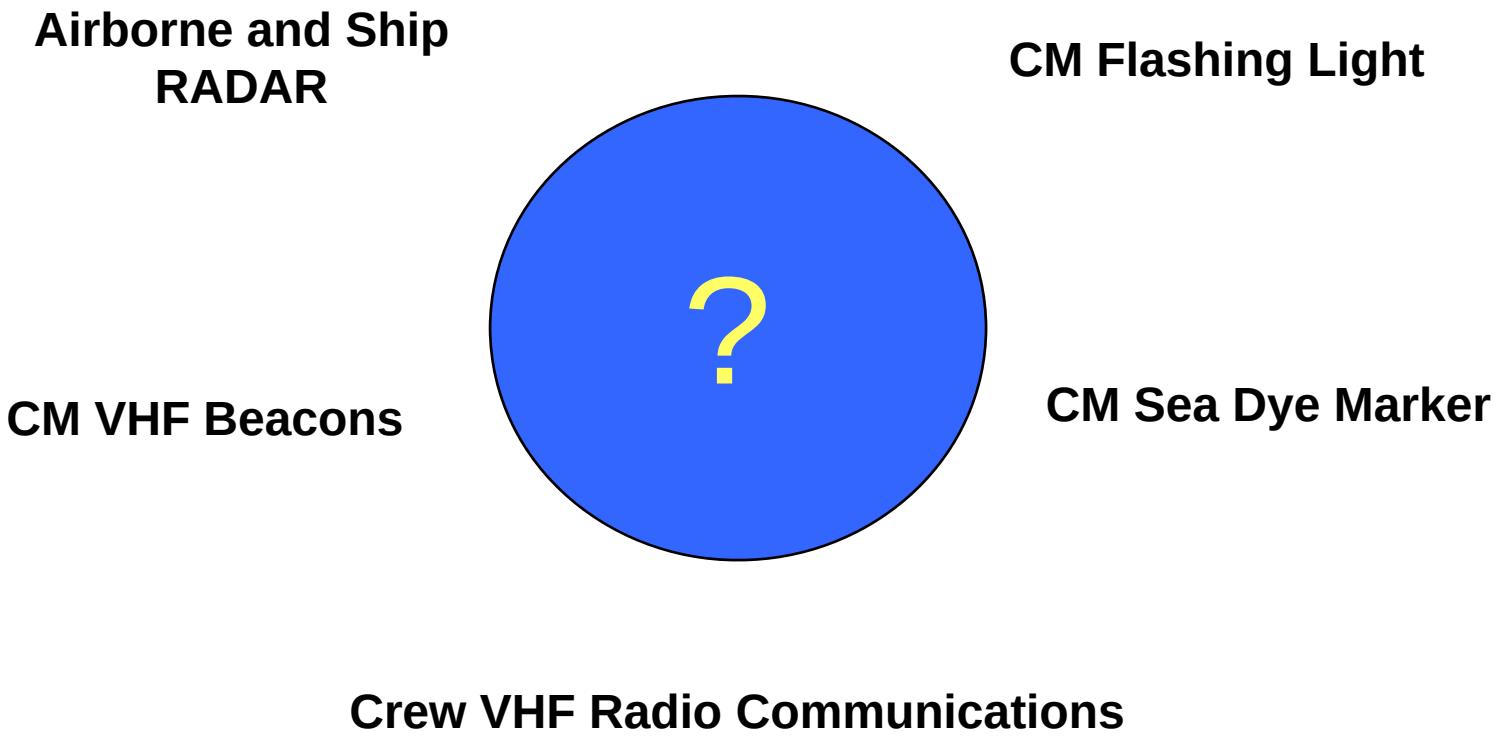


Command Module Uprighting System



If the system failed to upright the CM, a helicopter could be used to pull the CM upright using a line and the recovery hook which swimmers would attach.

Finding the Command Module



Finding the Command Module

Airborne and Ship RADAR

CM Flashing Light

Apollo 10	**=**	**5.4 km**	**(3.3mi)**
Apollo 11	**=**	**24 km**	**(14.9mi)**
Apollo 12	**=**	**7.2 km**	**(4.5mi)**
Apollo 13	**=**	**6.4 km**	**(4mi)**
Apollo 14	**=**	**7 km**	**(4.4mi)**
Apollo 15	**=**	**10 km**	**(6.2mi)**
Apollo 16	**=**	**5 km**	**(3.1mi)**
Apollo 17	**=**	**6.4 km**	**(4mi)**

CM VHF Beacons

CM Sea Dye Marker

Crew VHF Radio Communications

Helicopter Support

				
“Recovery”	**“Swim”**	**“ELS”**	**“Apex”**	**“Photo”**
Primary helicopter for crew retrieval	**Backup to the prime recovery helicopter**	**Recover the Main Chutes**	**Recover drogue chutes and apex cover**	**Provide photographic support**

Swimmer Operations

Sea Anchor attachment

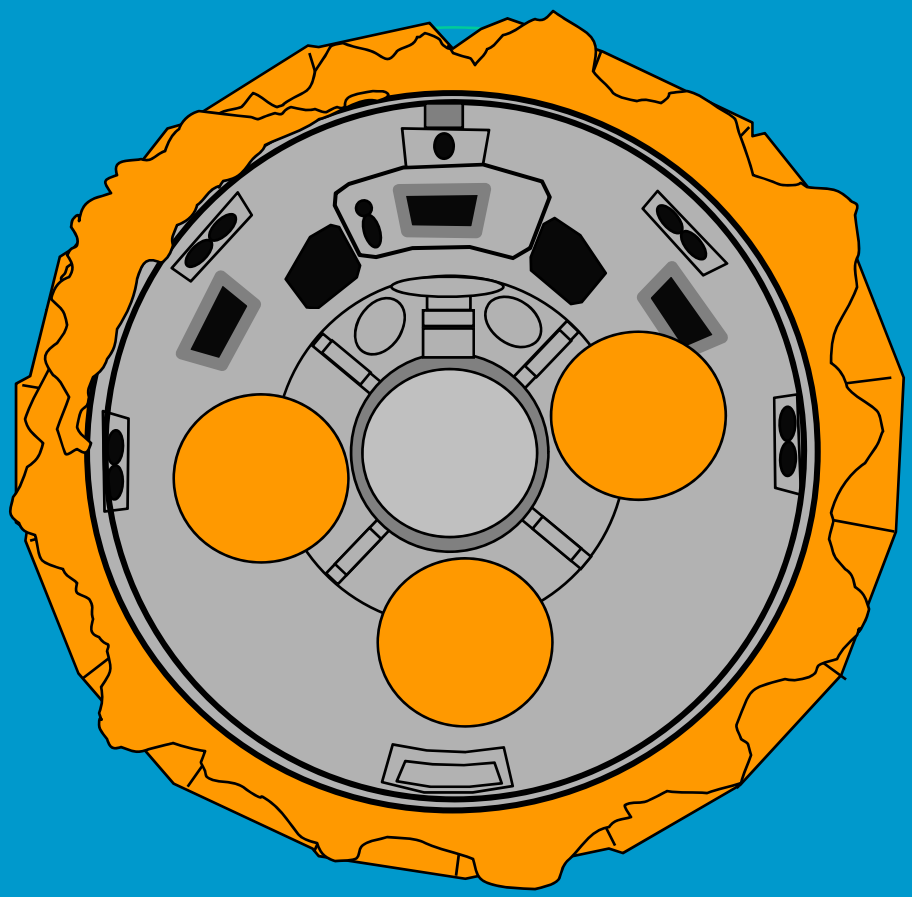
Flotation Collar attachment

Recovery Raft attachment

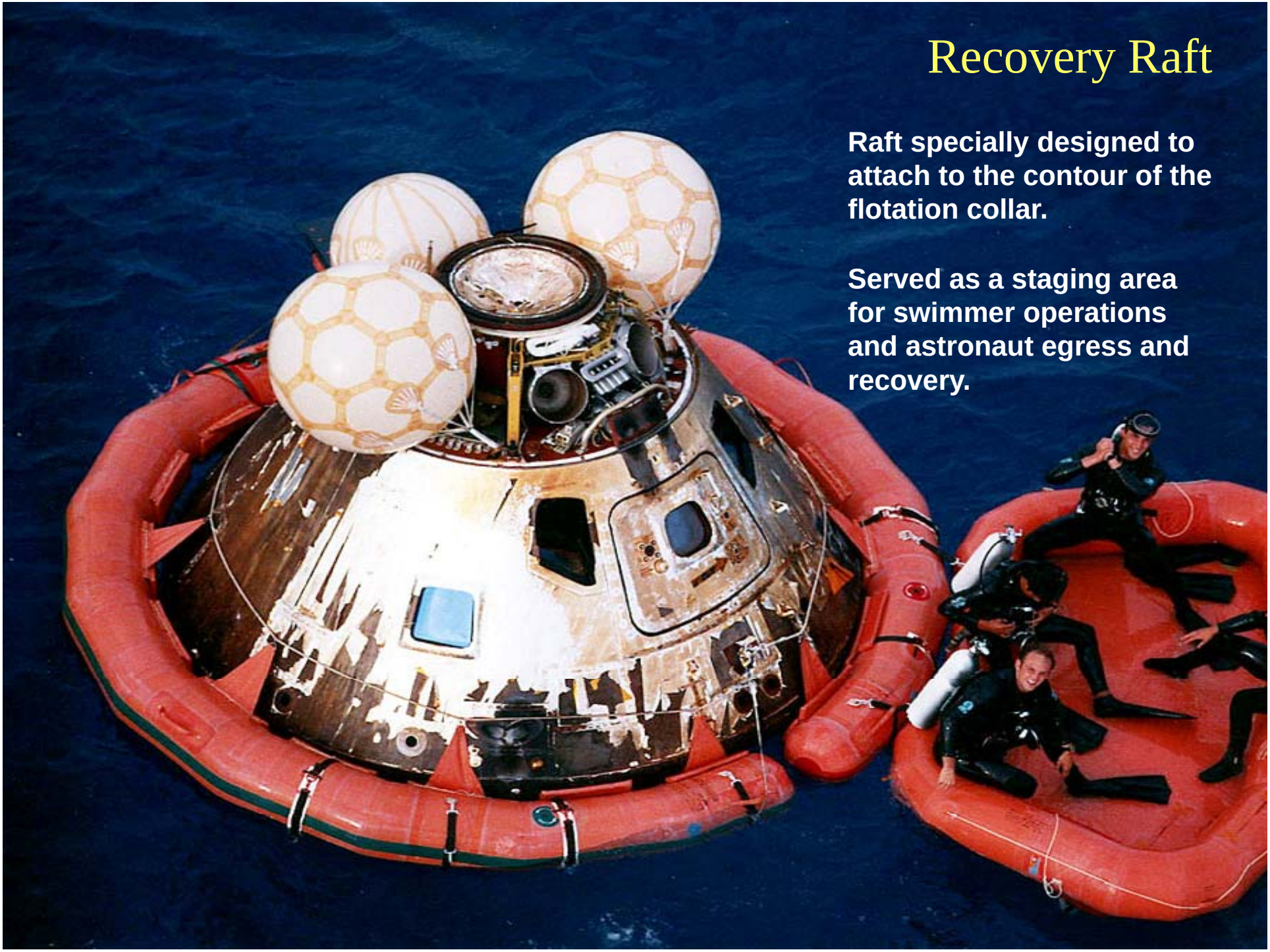
Assist with Astronaut Egress from CM

Assist with Astronaut Retrieval by Helicopter

Assist with CM Ship Recovery



Recovery Raft



Raft specially designed to attach to the contour of the flotation collar.

Served as a staging area for swimmer operations and astronaut egress and recovery.

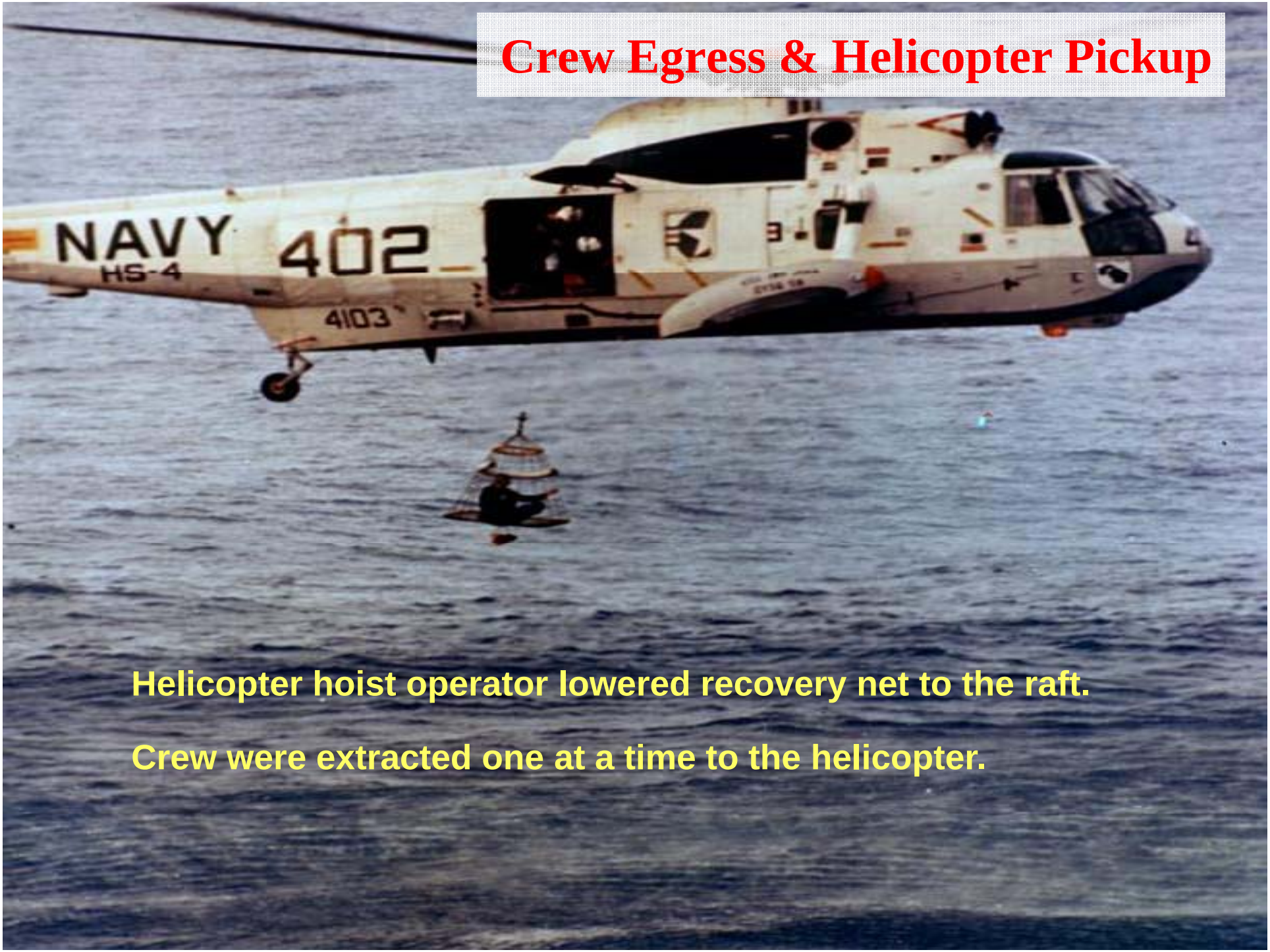
Crew Egress & Helicopter Pickup

After recovery raft was attached to the flotation collar, the crew opened the hatch and received life vests from the swimmer.

Swimmer assisted astronauts into the recovery raft.

Swimmer signaled recovery helicopter to move in and recover the crew.

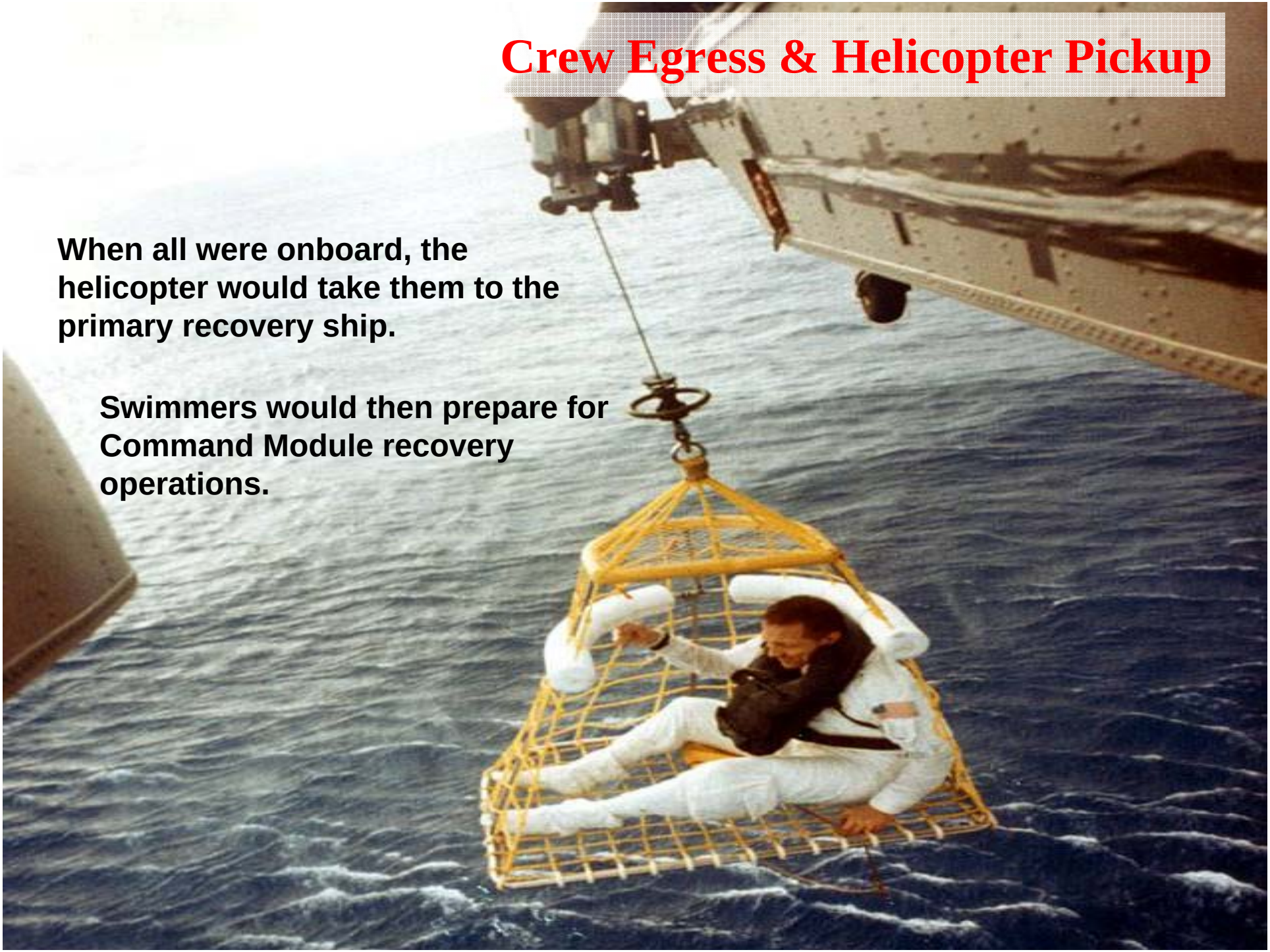
Crew Egress & Helicopter Pickup



Helicopter hoist operator lowered recovery net to the raft.

Crew were extracted one at a time to the helicopter.

Crew Egress & Helicopter Pickup



When all were onboard, the helicopter would take them to the primary recovery ship.

Swimmers would then prepare for Command Module recovery operations.

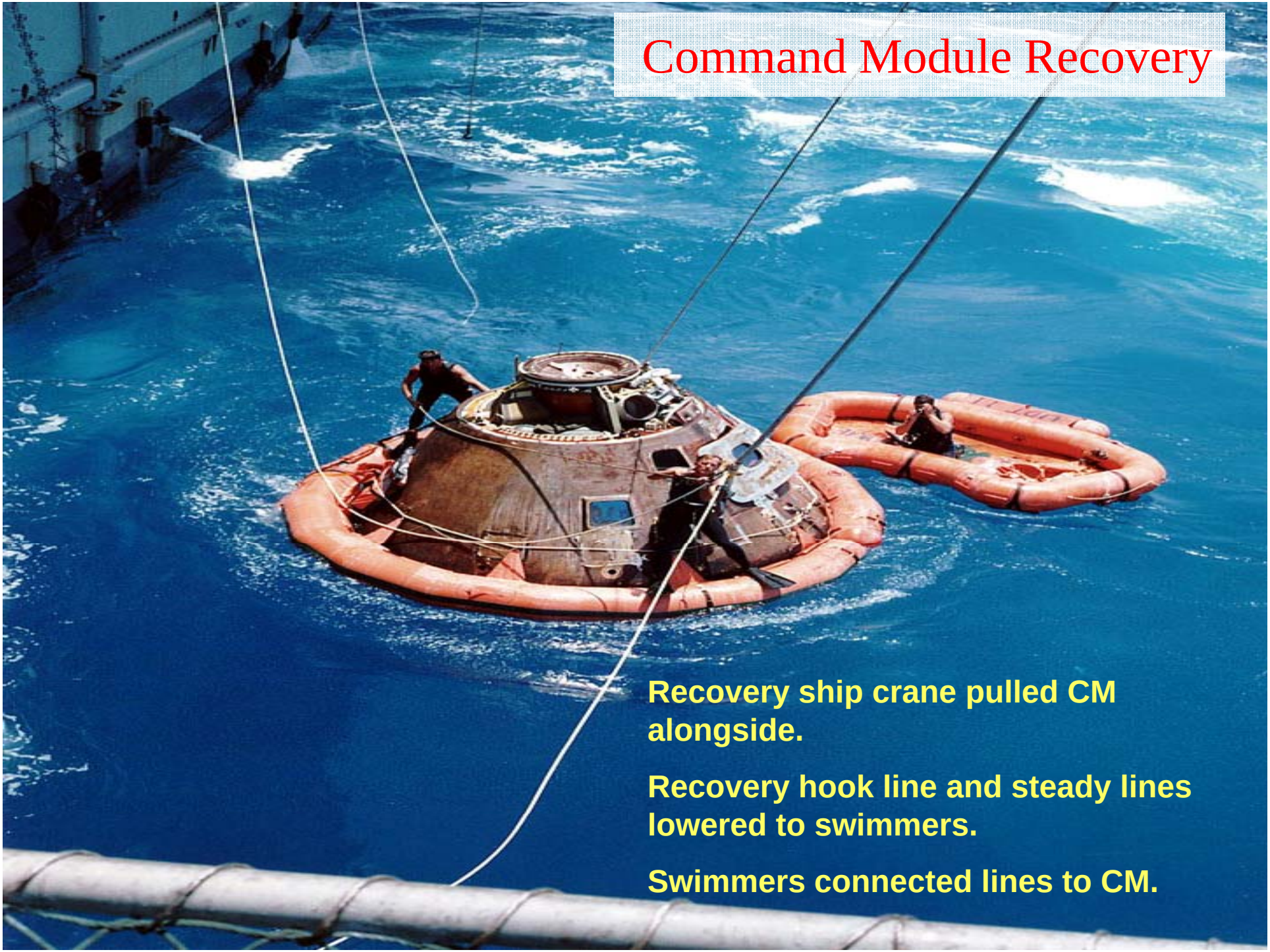
Command Module Recovery

Recovery ship maneuvered to within 100-200 ft of CM.

In-Haul line was shot to swimmers.

Swimmers attached in-haul line and deflated the sea anchor.

Command Module Recovery



Recovery ship crane pulled CM alongside.

Recovery hook line and steady lines lowered to swimmers.

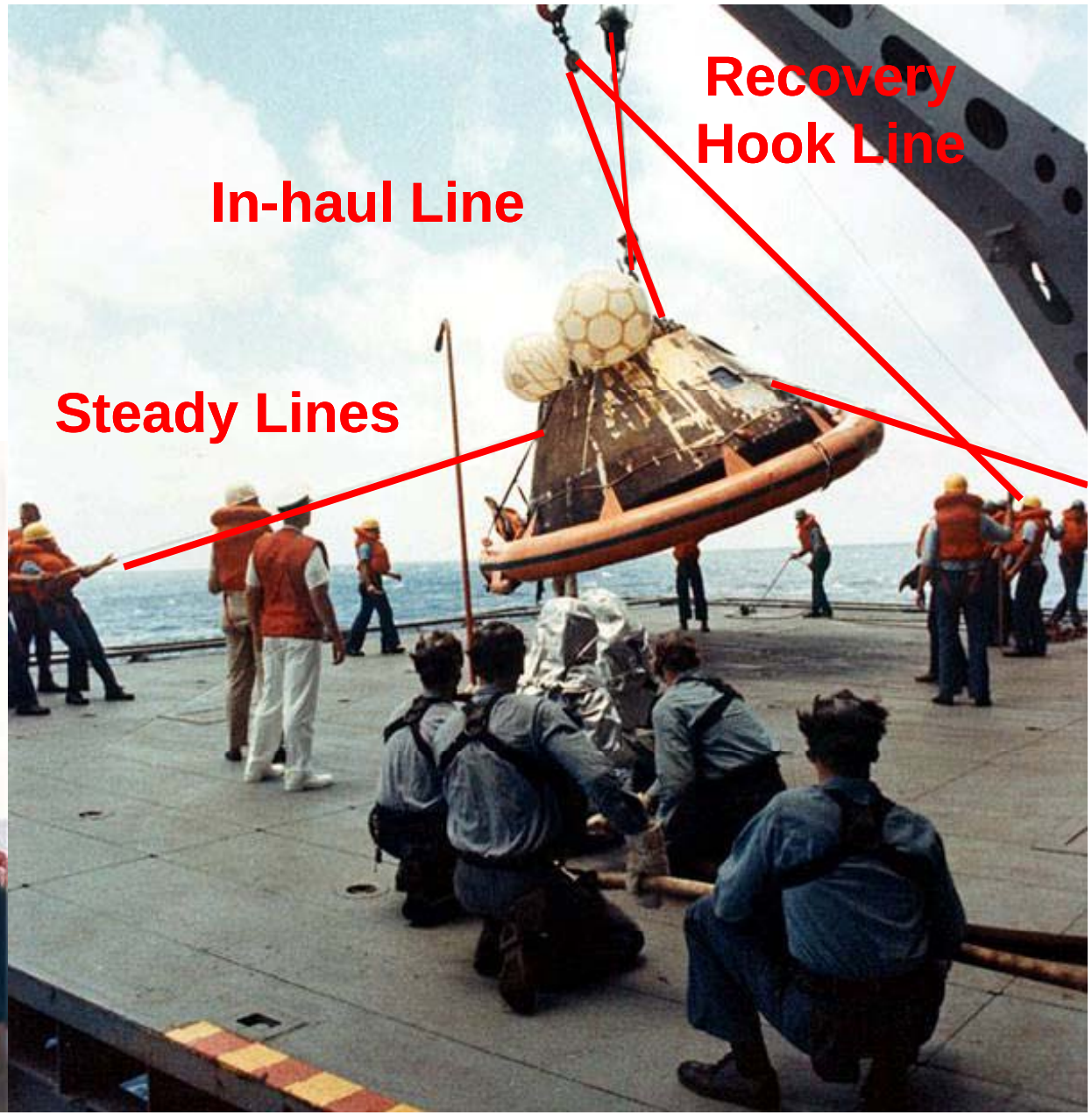
Swimmers connected lines to CM.

Command Module Recovery

CM lifted onto recovery ship.

Flotation collar removed.

The CM was then placed on the Apollo CM Transport Dolly.

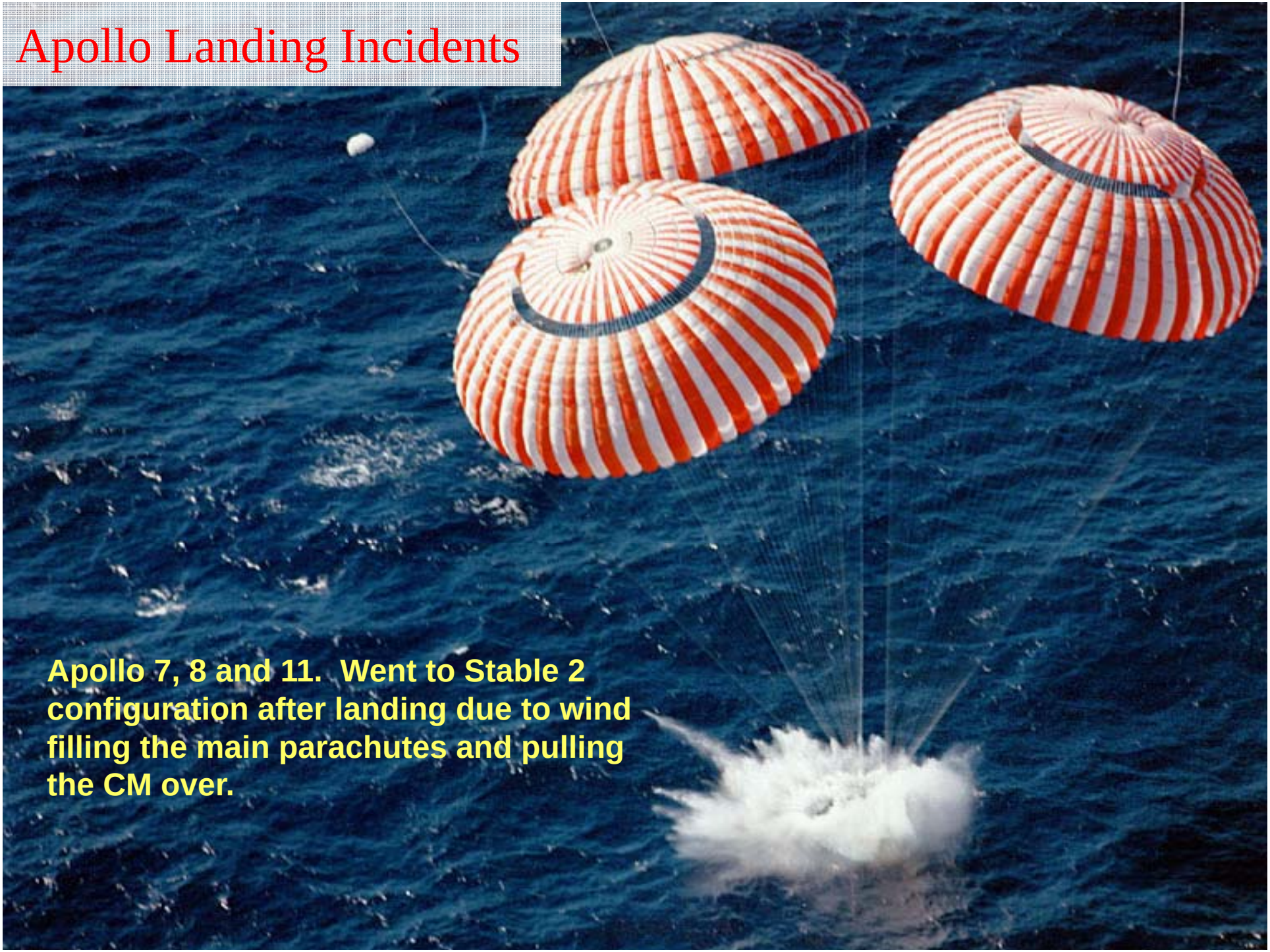


Apollo 16 Recovery Timeline

EVENT	Landing Time hh/mm
RADAR contact by Ticonderoga	-00:11
Visual Contact	-00:06
VHF recovery beacon contact by Ticonderoga	-00:05
Voice contact with Apollo 16 crew via VHF	-00:04
Command module landing	00:00
Swimmers deployed to command module	00:05
Flotation collar installed and inflated	00:15
Hatch opened for crew egress	00:19
Flight crew aboard helicopter	00:31
Flight crew aboard Ticonderoga	00:37
Command module aboard Ticonderoga	01:39

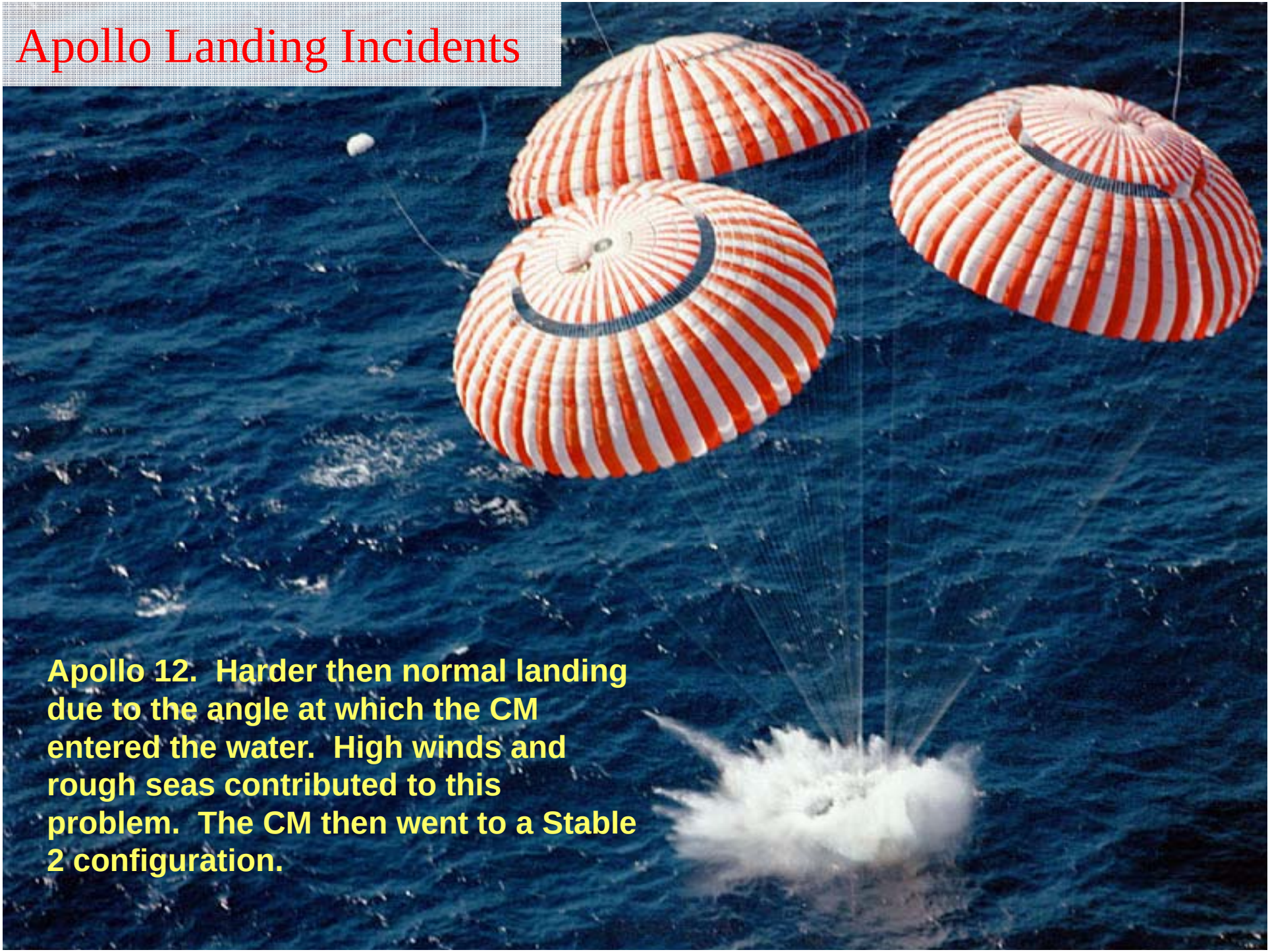
Average recovery time was a little over two hours

Apollo Landing Incidents



Apollo 7, 8 and 11. Went to Stable 2 configuration after landing due to wind filling the main parachutes and pulling the CM over.

Apollo Landing Incidents



Apollo 12. Harder then normal landing due to the angle at which the CM entered the water. High winds and rough seas contributed to this problem. The CM then went to a Stable 2 configuration.

Apollo Landing Incidents

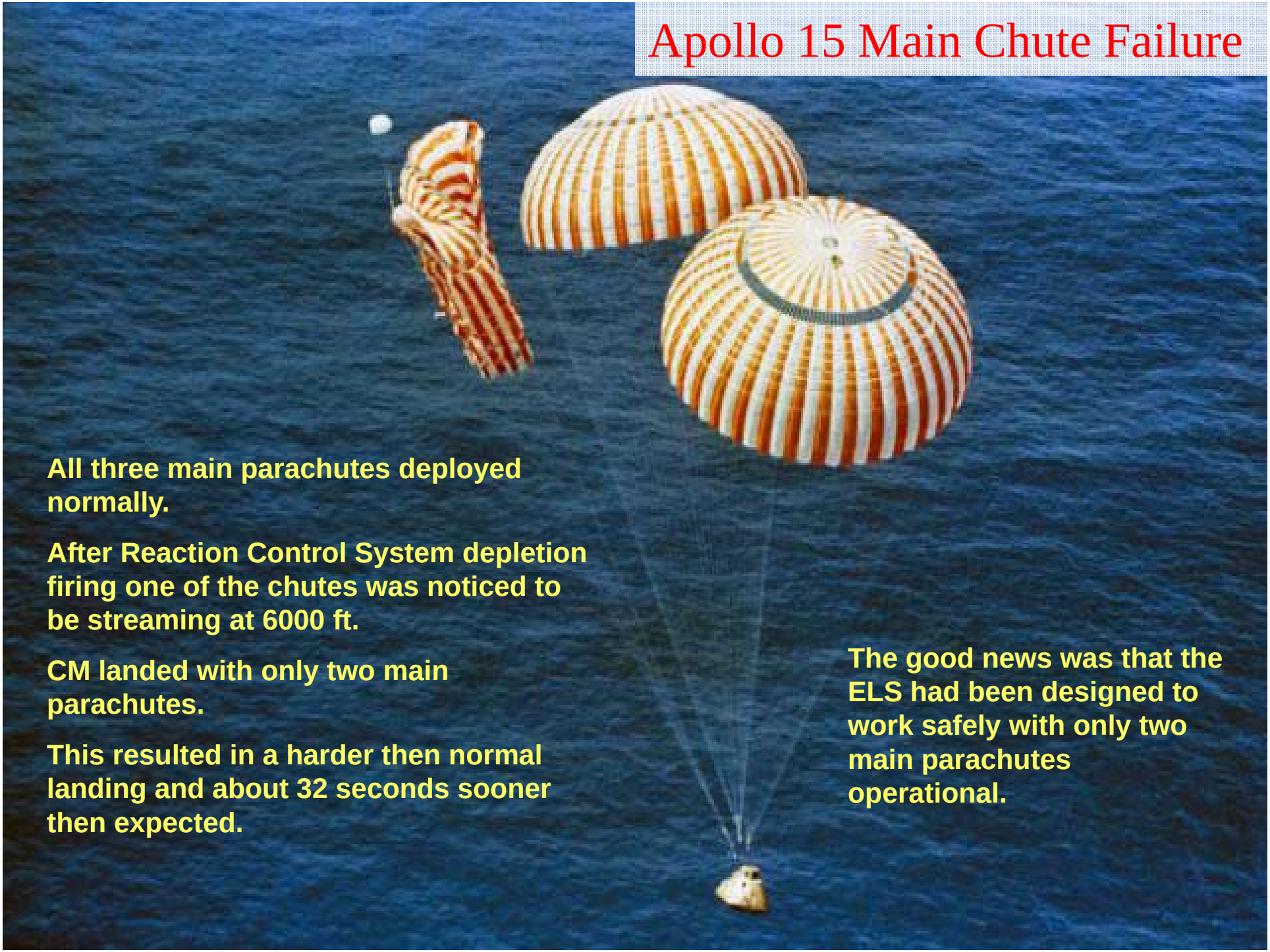
Apollo 15. Loss of a main parachute.
(More on this incident in a moment.)

Apollo Landing Incidents

Apollo 16. Went to a stable 2 configuration. Uprighting was initiated, but the crew reported that it seemed to delay in a partially uprighted position for longer then expected.

This was caused by the center uprighting bag only being partially inflated.

Apollo 15 Main Chute Failure



All three main parachutes deployed normally.

After Reaction Control System depletion firing one of the chutes was noticed to be streaming at 6000 ft.

CM landed with only two main parachutes.

This resulted in a harder then normal landing and about 32 seconds sooner then expected.

The good news was that the ELS had been designed to work safely with only two main parachutes operational.

Apollo 15 Main Chute Failure

The prime suspect was the propellant damage from the RCS depletion firing.

A couple of other possibilities were looked at, tested, and discarded as cause.

RCS testing had shown that cold/raw fuel (monomethyl hydrazine) expulsion through a hot engine would burn.

The failed parachute was positioned above one of the roll engines during the fuel expulsion.

Based on RCS testing they determined that propellant damage from the RCS depletion firing probably caused the failure.

To mitigate this issue:

- **Landings could now occur with propellants onboard.**
- **Biasing the propellant load to provide a slight excess of oxidizer.**

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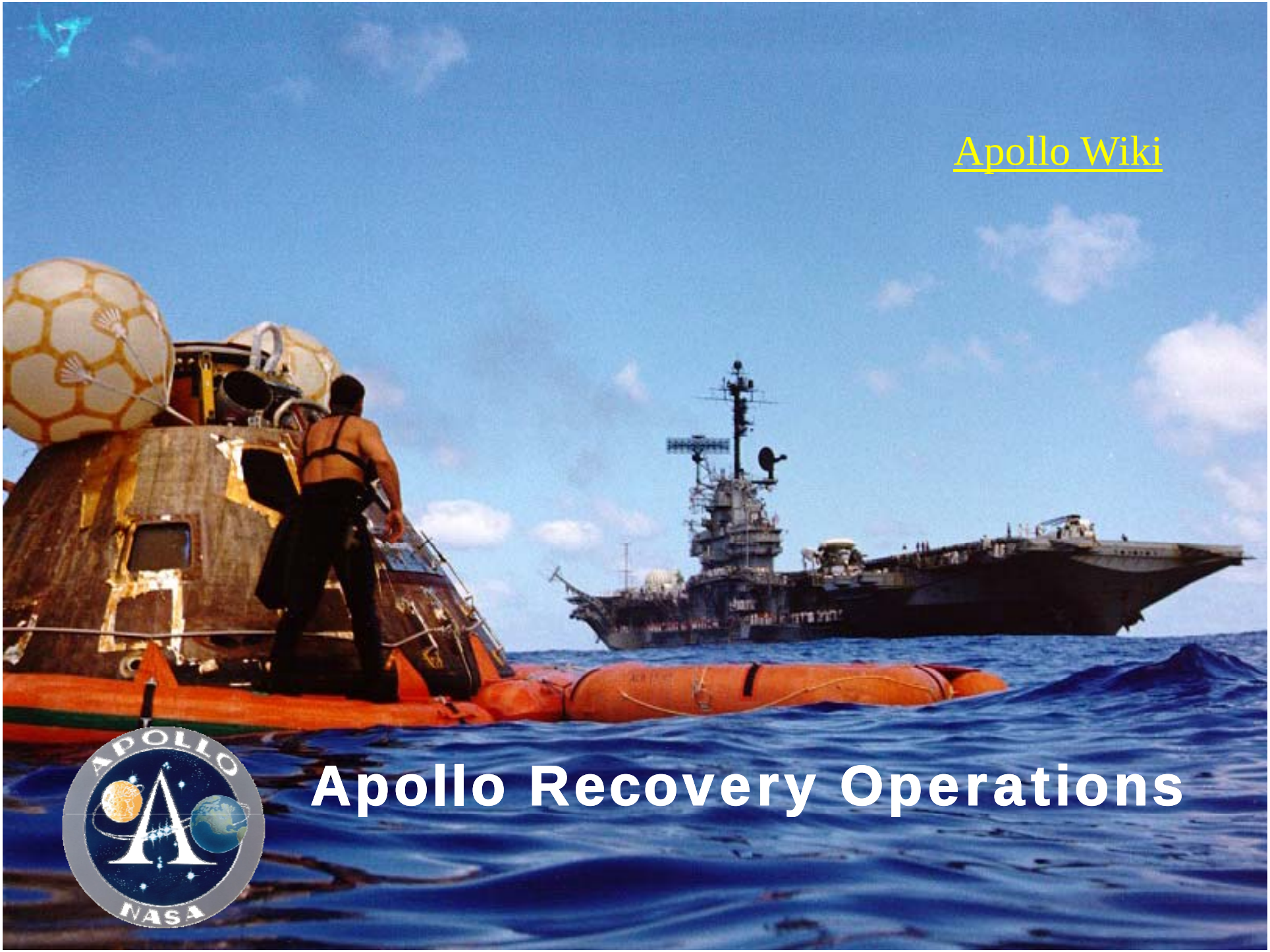
Apollo Wiki
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