CSM / LM Lighting

Intro/Objectives

- Identify the types and uses of the various lighting components
  - Interior (CM, LM)
  - Exterior (CSM, LM)
- Explain the purpose and locations of electroluminescent (EL) and radioluminescent (RL) lighting techniques
- Understand the use of various D&C lighting components
- Understand in-flight anomalies

Development

- Many lighting studies and mockup evaluations were conducted between 1963-68 to assure that the lighting conditions were appropriate
  - Started with Gemini pilot inputs
  - Used lighting laboratory calibrations and standardized the light spectrum distribution early in development
  - Established the types of lighting fixtures, the locations, and the light intensity
  - Lighting subsystem performed well due to continuous reviews and mockup evaluations by astronauts, contractors, and hardware manufacturers

Overview: Interior Lighting

- Interior work area floodlights
  - CM: Fluorescent & incandescent lamps
  - LM: Incandescent lights
- Integral panel and numerics lighting
  - CM: electroluminescent (EL) materials
  - LM: EL & radioluminescent (RL) materials
- Supplementary
  - CM/LM: pen flashlights
  - LM: utility lights
  - Window shades

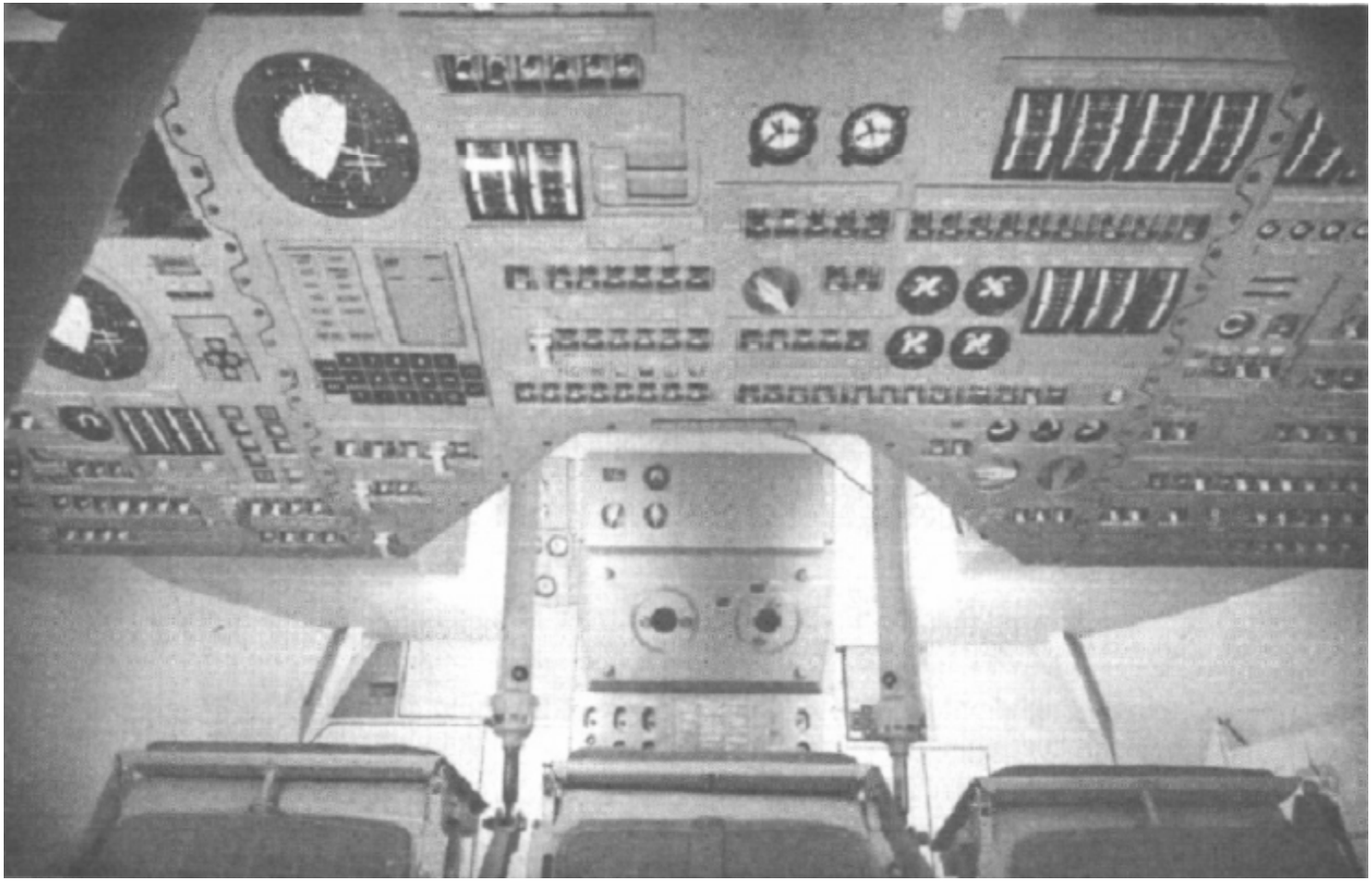
Overview: Exterior Lighting

- CM Exterior lighting
  - Spotlight, running lights, rendezvous beacon, EVA floodlight
  - Docking target and associated lights
- LM Exterior lighting
  - High-intensity tracking light, docking lights
  - Radioluminescent docking target

CM Interior Floodlights

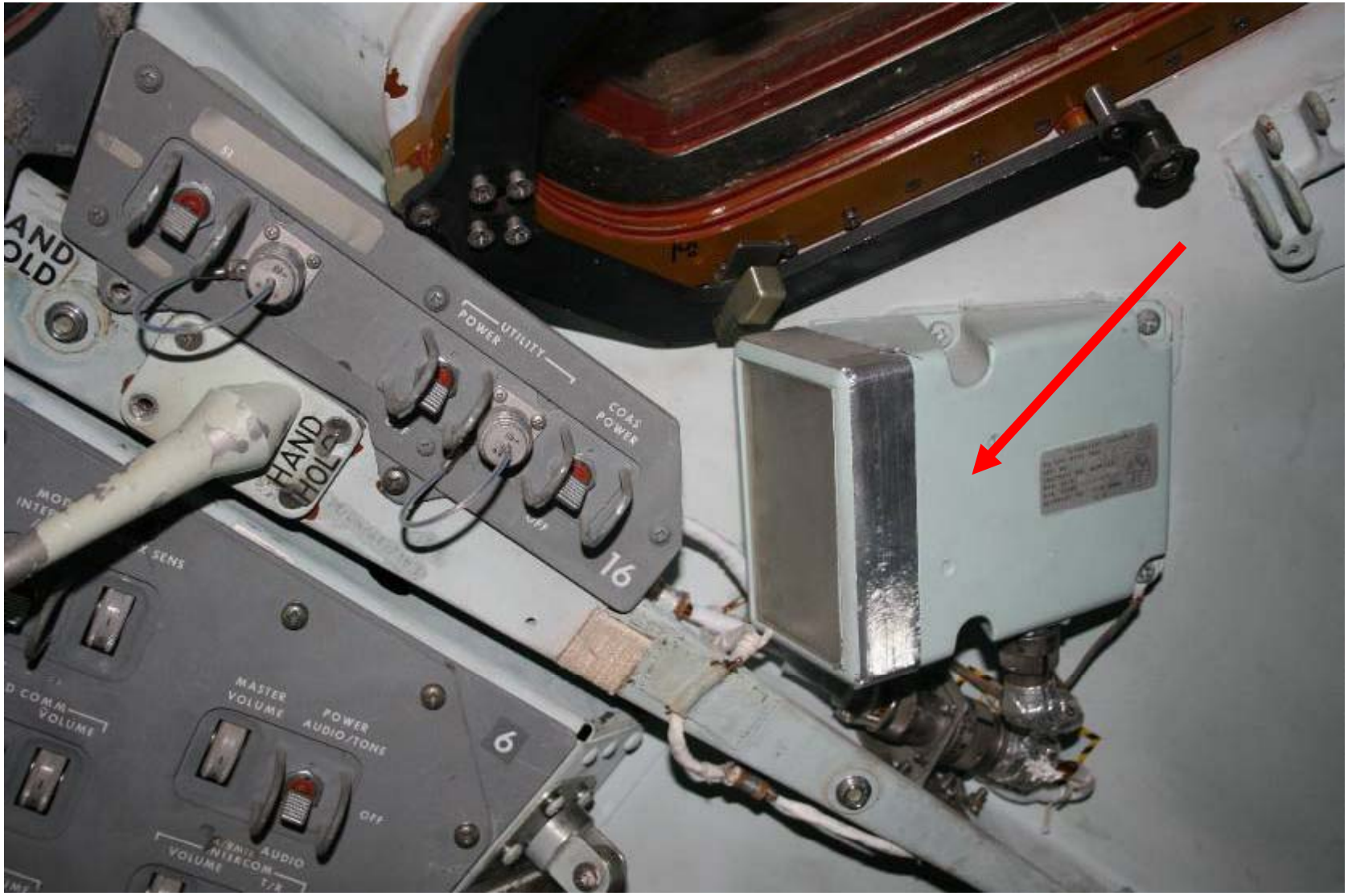
- Fluorescent floodlights
  - Primarily for the left and right display and control (D&C) panels and lower equipment bay
  - Dual-powered/dual-filament design for redundancy
  - Primary lights dimmable, backup lights on/off
  - Color chosen to simulate incandescent light for photography/video
- Incandescent lights
  - Tunnel lighting (3 fixtures)

CM Display Panel, Illuminated by Floodlights



CM Overhead Floodlights

CM Floodlight Assembly (side)

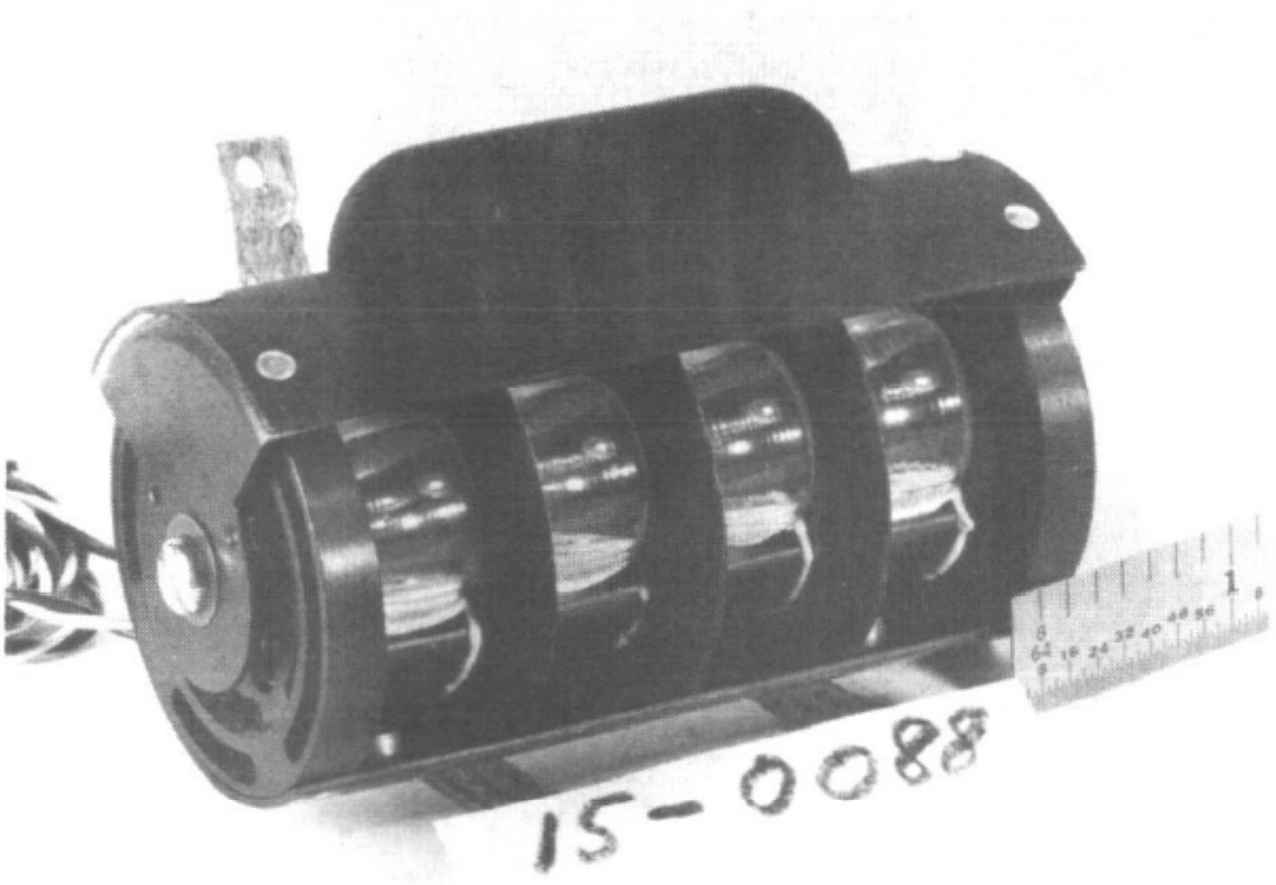


CM Floodlight Assembly (front)

LM Interior Floodlights

- LM used only incandescent lighting, which was primarily a redundant, secondary lighting system in case of panel and instrument integral lighting failure.
  - Overhead lights (2, dimmable)
  - Forward lights (2, dimmable)
  - Side-panel (31, non-dimmable)

LM Interior Floodlight



LM Overhead Floodlights

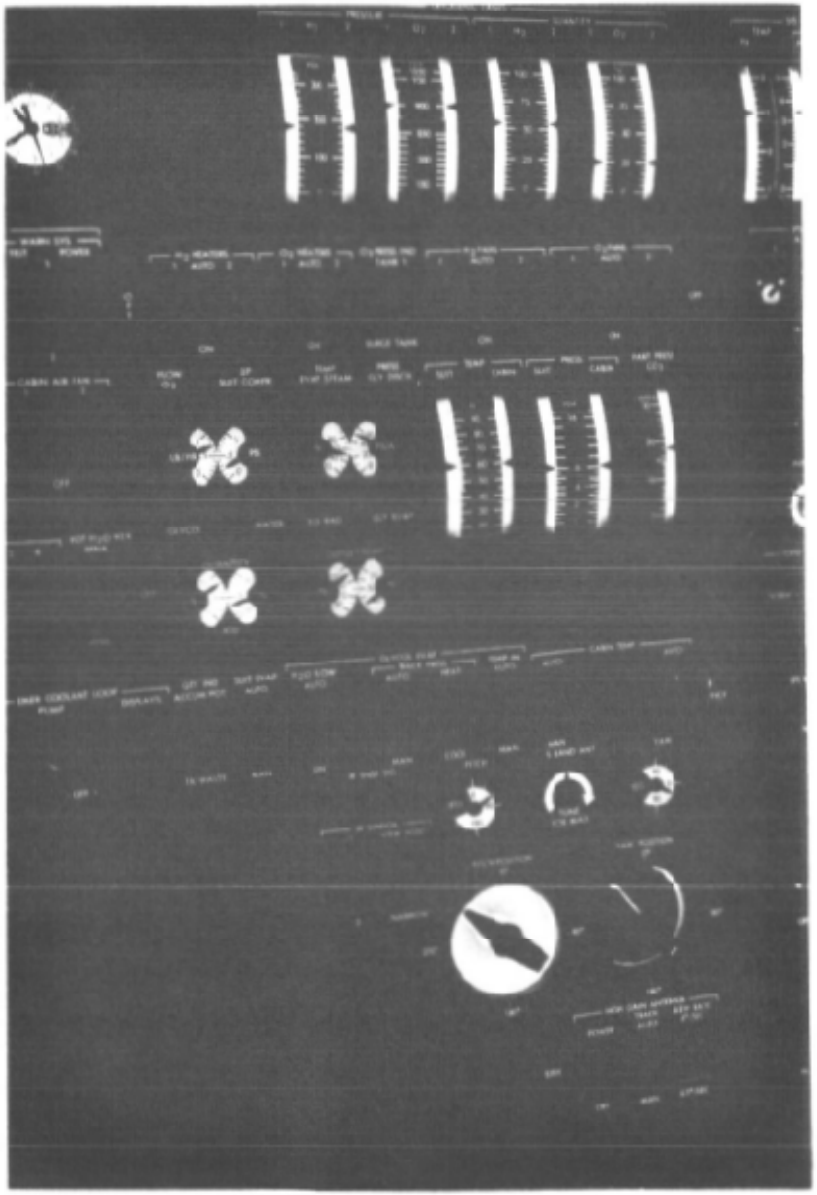
LM Side Panel Lights

NASA photo AS17-145-22224

CM/LM Displays & Controls (D&C)

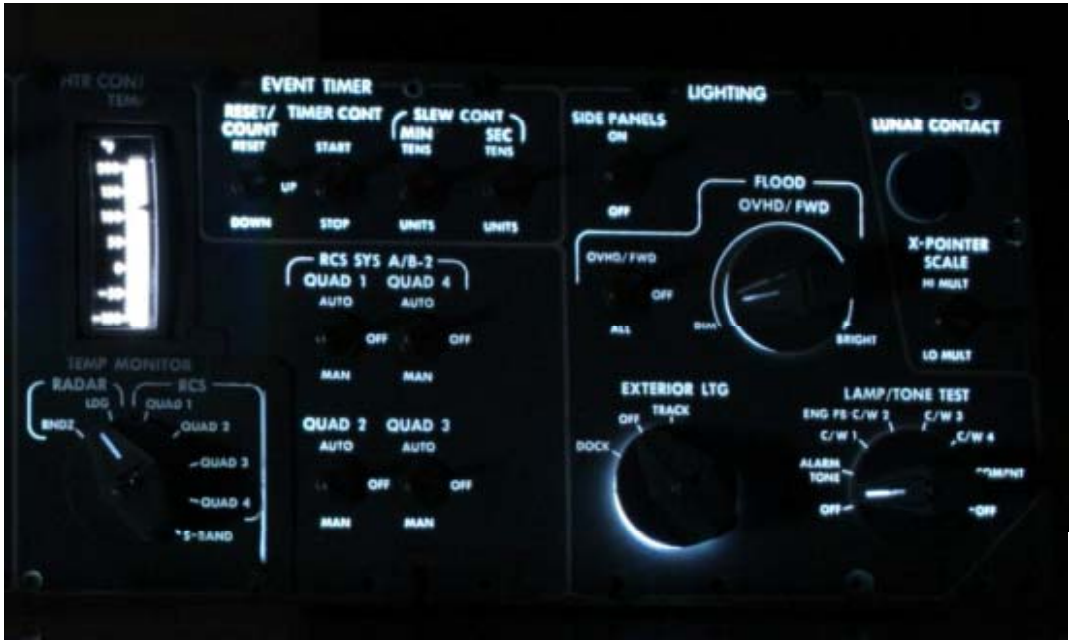
- First spacecraft to use “transillumination” (backlighting)
  - White for nomenclature and instruments, Green for alphanumerics, Red for warning, Yellow for caution
  - Used for lighting of indicators, controls, read-outs, displays, system switches, nomenclature, annunciator pushbuttons, numerics, and signal lights
  - Negligible afterglow (instant change) and heat dissipation, low power consumption
- Colors dimmable via rheostat rotary
  - Each rotary control switch had a mechanical stop which prevented the switch being positioned to OFF

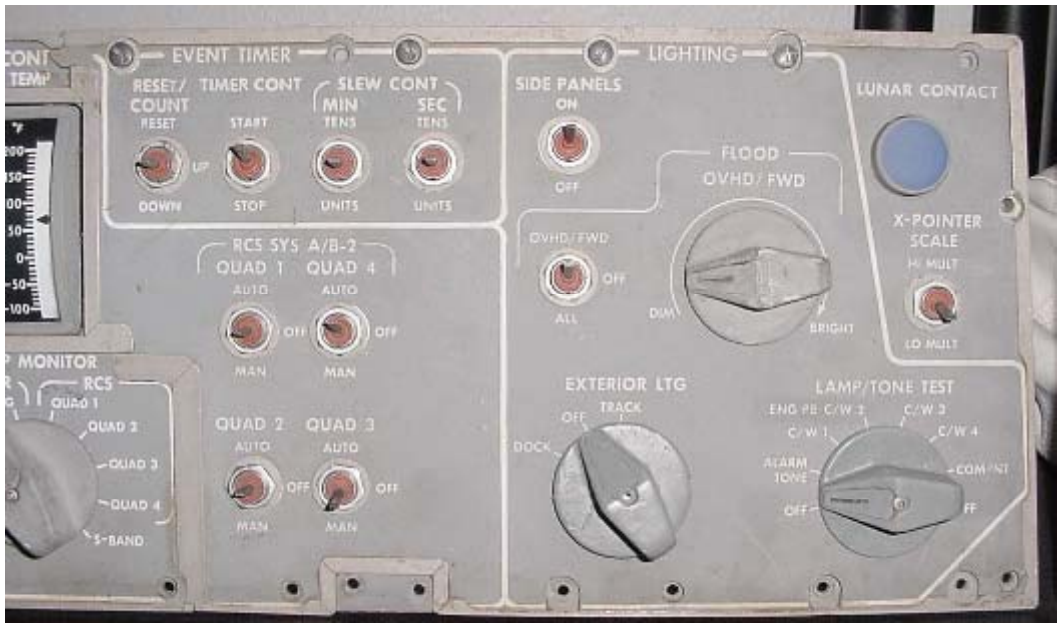
CM D&C Panel Lighting



LM D&C Panel Lighting

LM Integral Lighting





- LM Panel 3 (partial)
  - Backlighting
  - Floodlights

CM Lighting D&C, Alert Lights

- Panel 1

CM Lighting D&C, typical

- Panel 2

Mechanical stop

- Panel 5

- Panel 226

LM Lighting D&C, Alert Lights

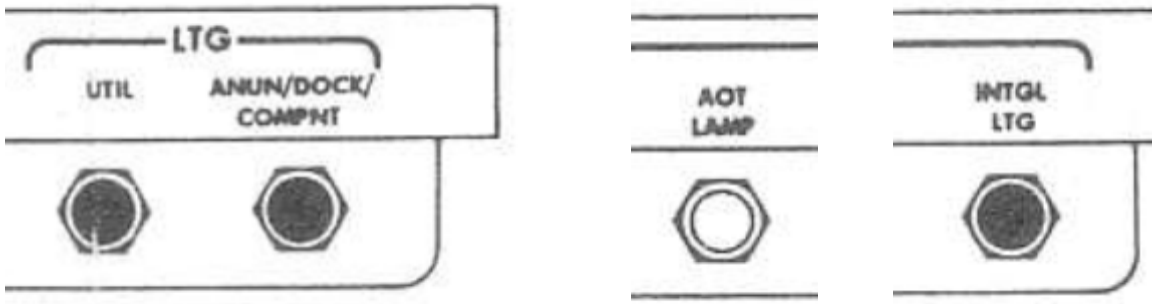
LM Lighting D&C, typical

Panel 3, on LMP's side of the cockpit (right)

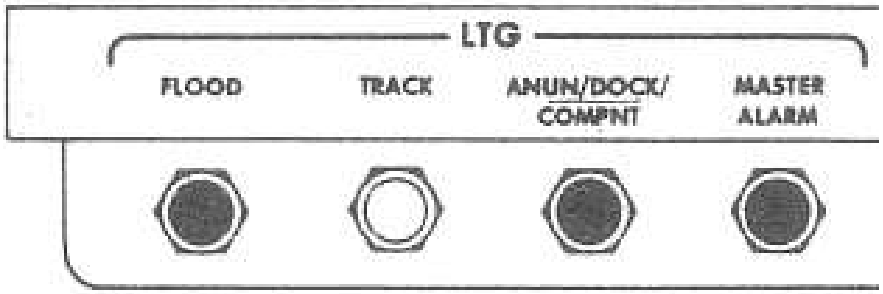
Panel 5, on CDR's side of the cockpit (left)

LM Lighting D&C, Panels 11 & 16

- Panel 11 (partial) – CDR's left side



- Panel 16 (partial) – LMP's right side



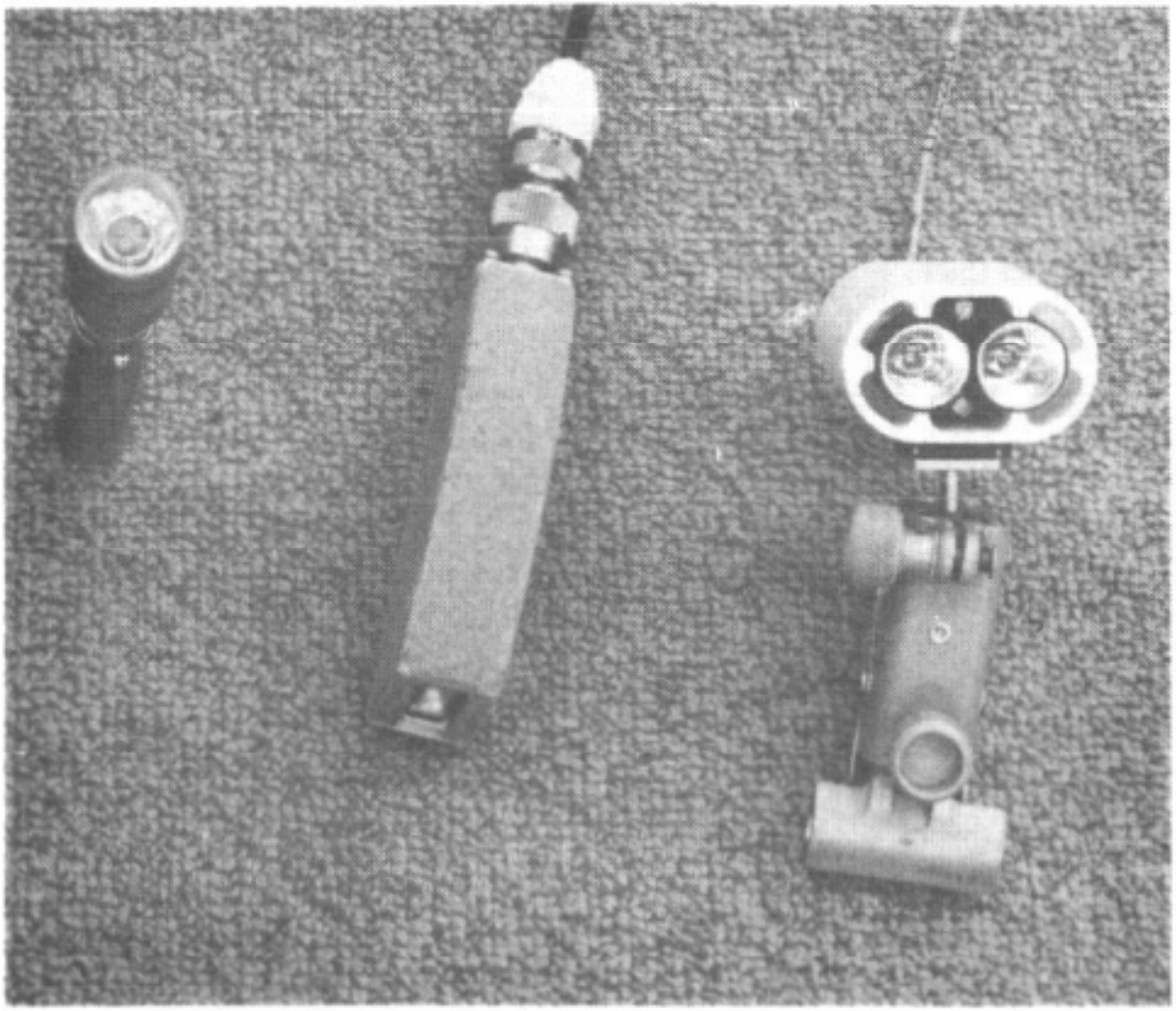
LM D&C, Radioluminescent

- Radioluminescent material
  - LM only (CM had enough ambient light that it didn't need switch lights)
  - Promethium-147, with 18-month half-life
  - Encapsulated inside glass capsules sealed inside acrylic toggle switches

Supplementary Lighting

- Penlights
  - Three per crewman, due to penlight life and reliability issues (lasted hours to weeks)
- Plug-in utility lights on clamps
  - One light per crewman, with 8-foot cable that connected to a 28-volt DC outlet (with associated circuit breaker and switch)
- Opaque window shades
  - Reflective to sunlight and heat
  - Prevented sunlight from breaking dark adaptation

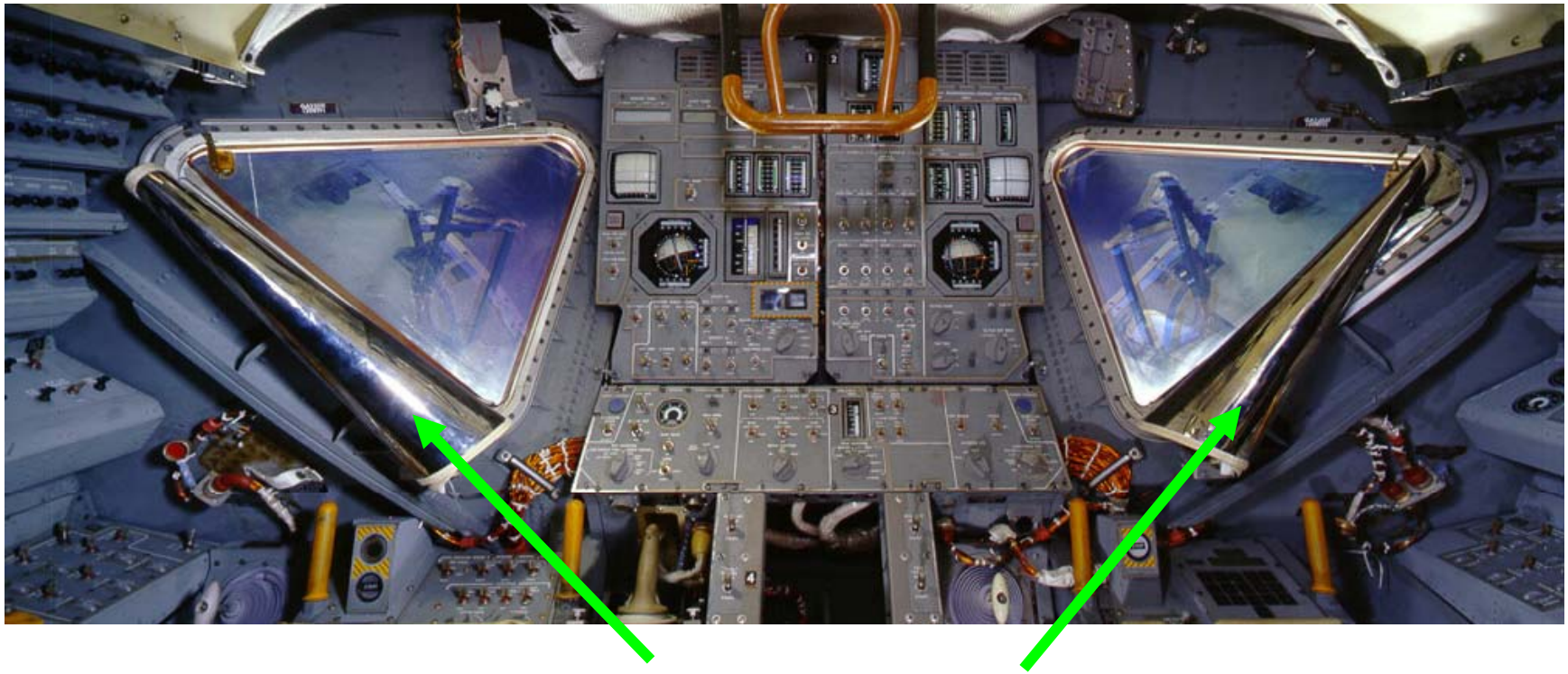
CM/LM Utility Lights, Penlight



CM Window Shades

- Basic window-shade concept
  - 1/32-inch (0.8 mm) thick aluminum sheet configured to the shape of the CM window
  - 1/2 inch (12.7 mm) velcro around perimeter of shade

LM Window Shades

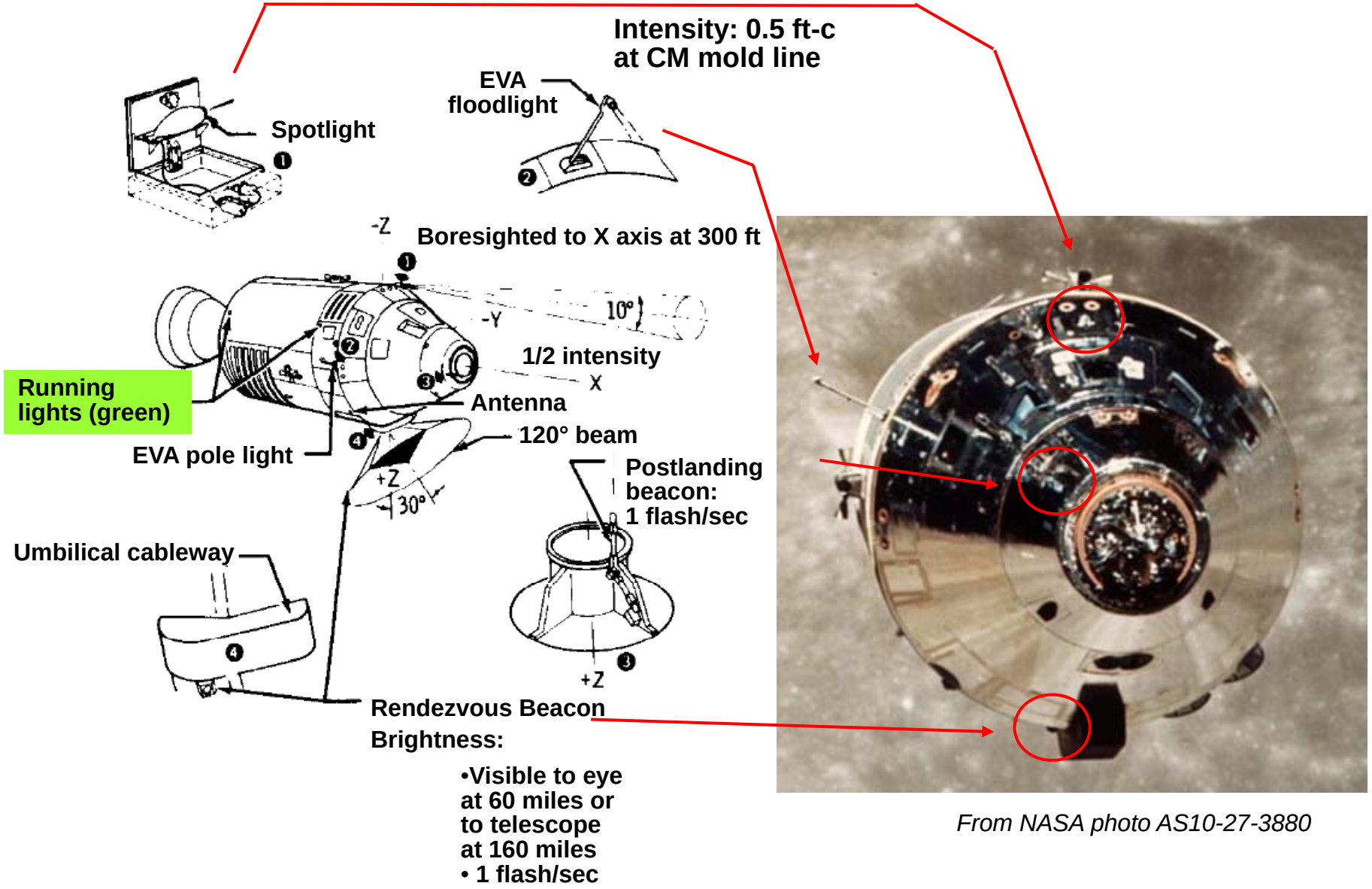


Shades shown rolled back

CM Exterior Lights

- 1 Xenon rendezvous beacon
  - Detected with optical aids at 160 nm (296 km)
  - At 60 nm (111 km), as bright as third-magnitude star
- 8 running lights for orientation
- 1 docking spotlight
  - Used for stationkeeping, 500 to 50 ft (152 – 15 m)
- 1 docking target
  - Mounted inside the right-hand rendezvous window, cross resolvable at 75 ft (23 m)
- 1 EVA floodlight
  - Illuminated the CM hatch, right-side EVA handrails, and LM EVA transfer handrails

CSM Exterior Lights

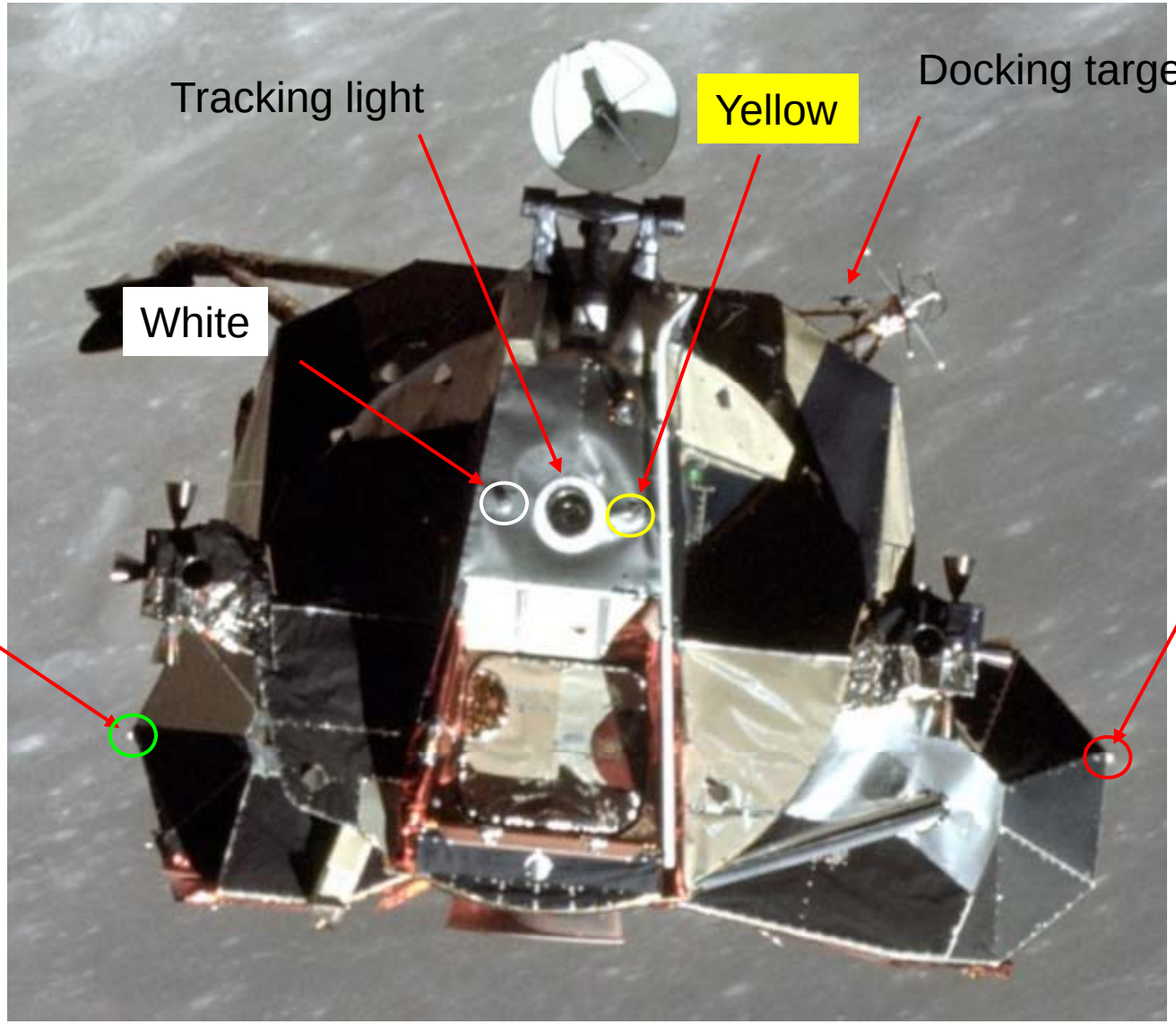


From NASA photo AS10-27-3880

LM Exterior Lights

- 1 Xenon high-intensity tracking light
  - Visible at 420 nm (778 km) with the aid of the CM sextant, naked-eye visible at 140 nm (259 km)
- 5 docking lights for orientation
  - Red, green, yellow, white for approach lights
  - White for docking
  - Detectable at 2000 ft (610 m), colors could be discriminated at 1000 ft (305 m)
- 1 radioluminescent docking target

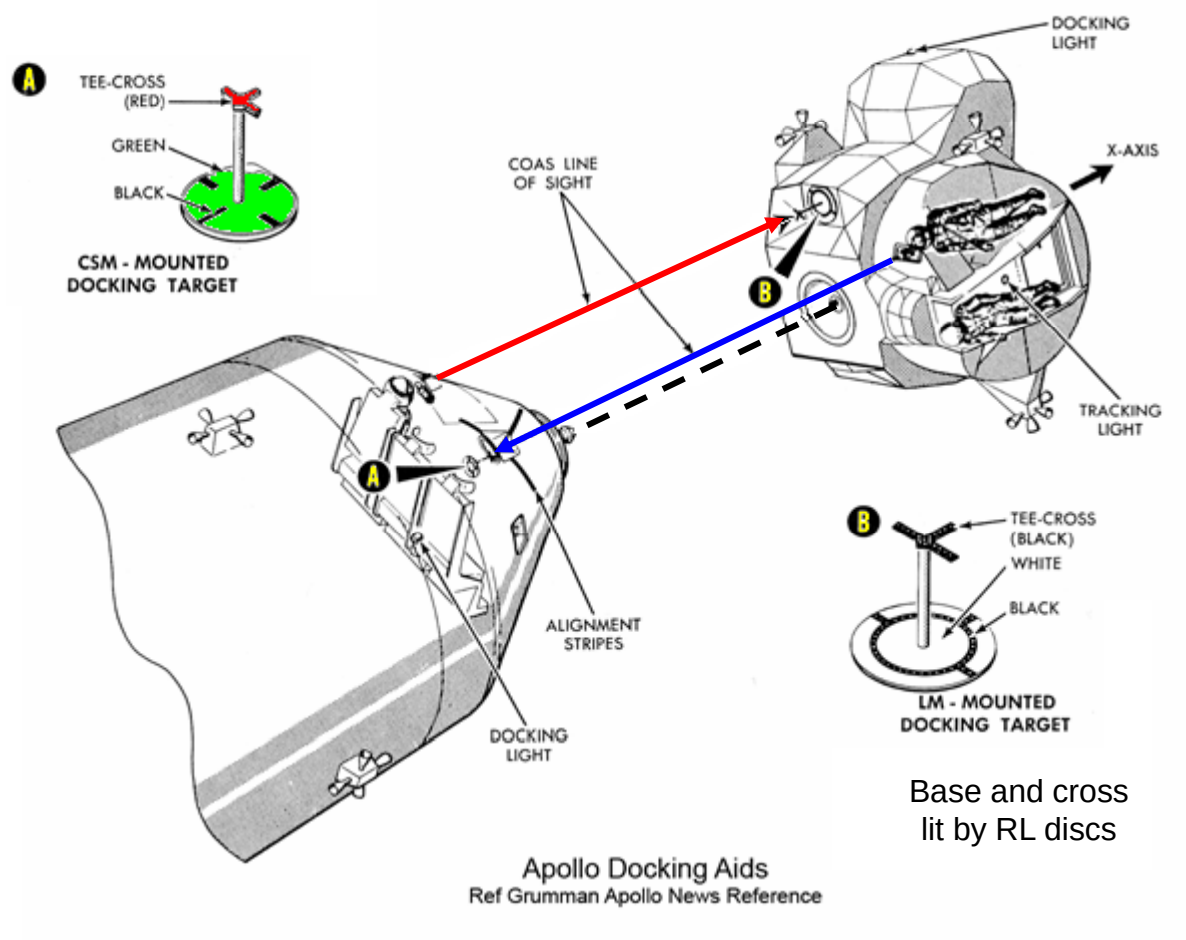
LM Exterior Lights (Approach)



From NASA Photo AS11-44-6642HR

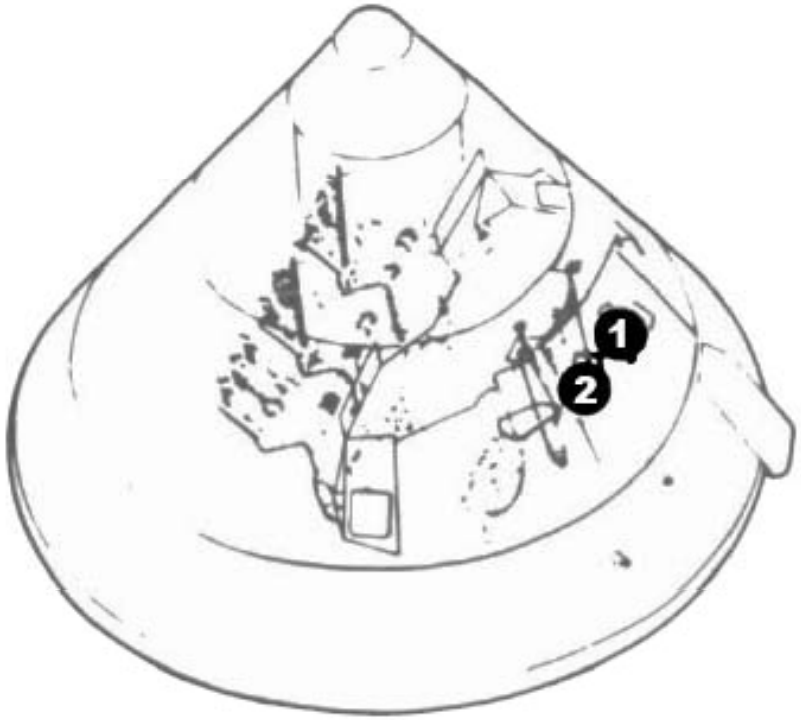
Lighting for Docking

Base lit by a green EL light (backlit),
cross lit by incandescent red light

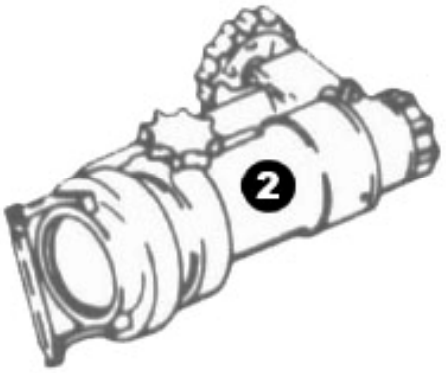


Base and cross
lit by RL discs

CM-Mounted Docking Target



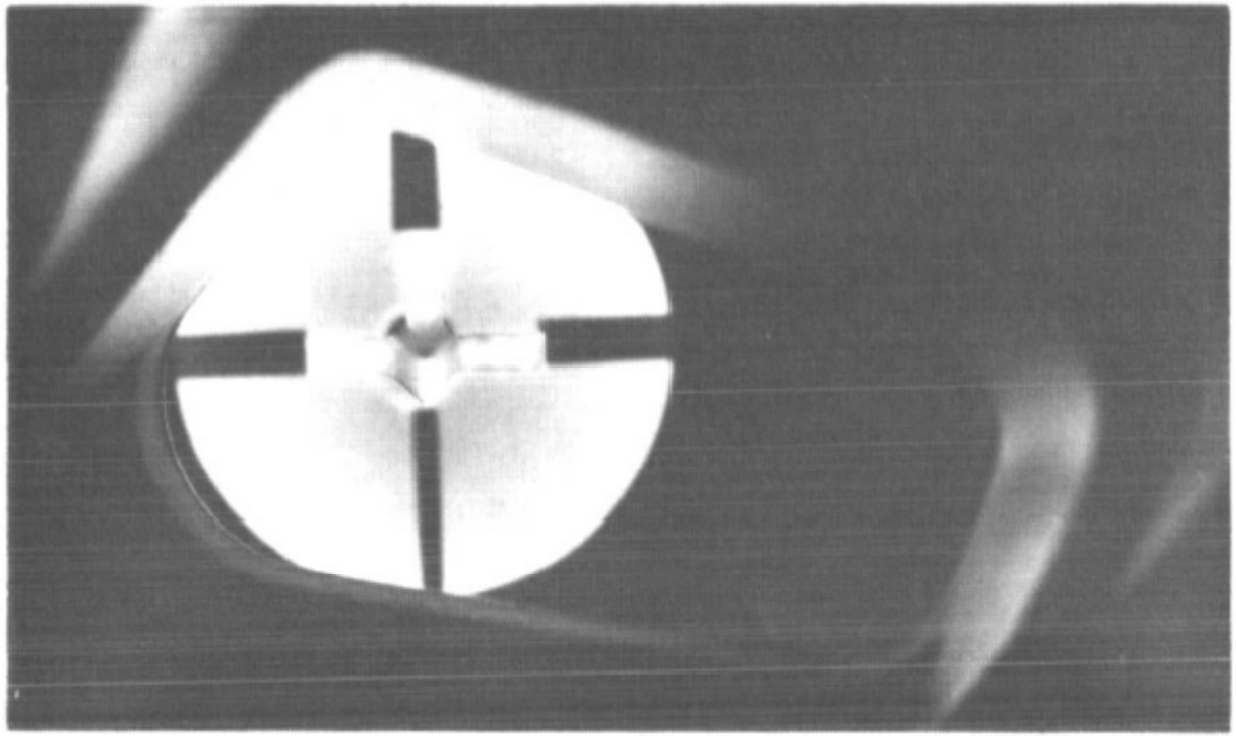
LM active docking target



Crewman optical alignment sight

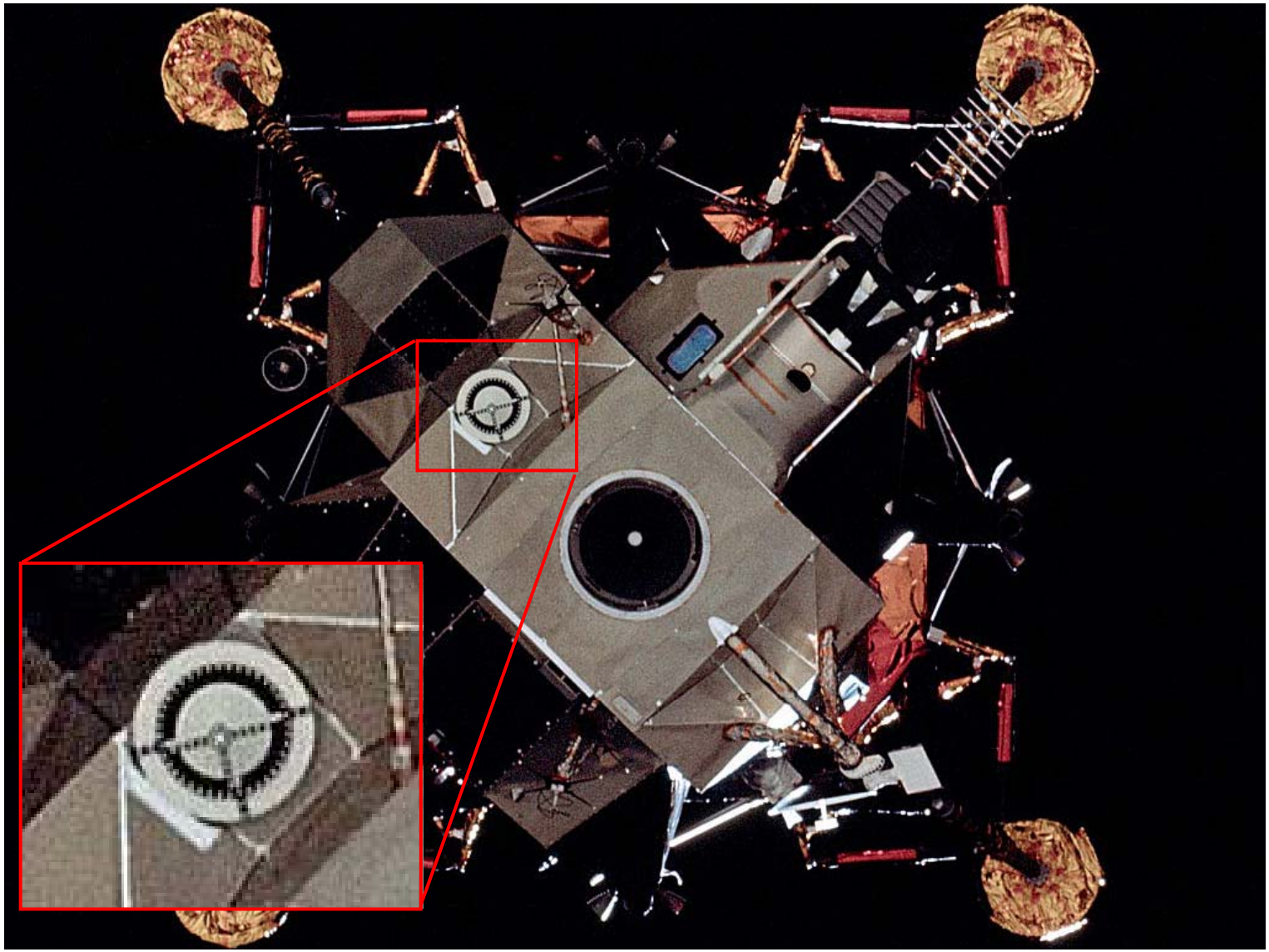
(COAS)

CM-Mounted Docking Target



Docking target on the CM as seen from the LM

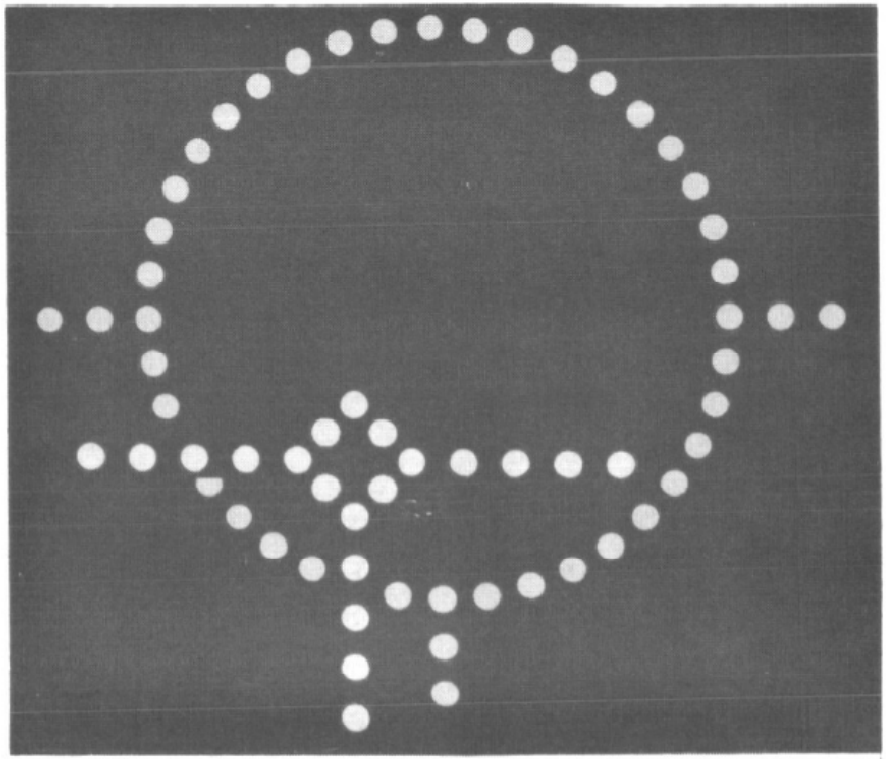
LM-Mounted Docking Target (in daylight)



LM-Mounted Docking Target

From NASA photo AS12-50-7374

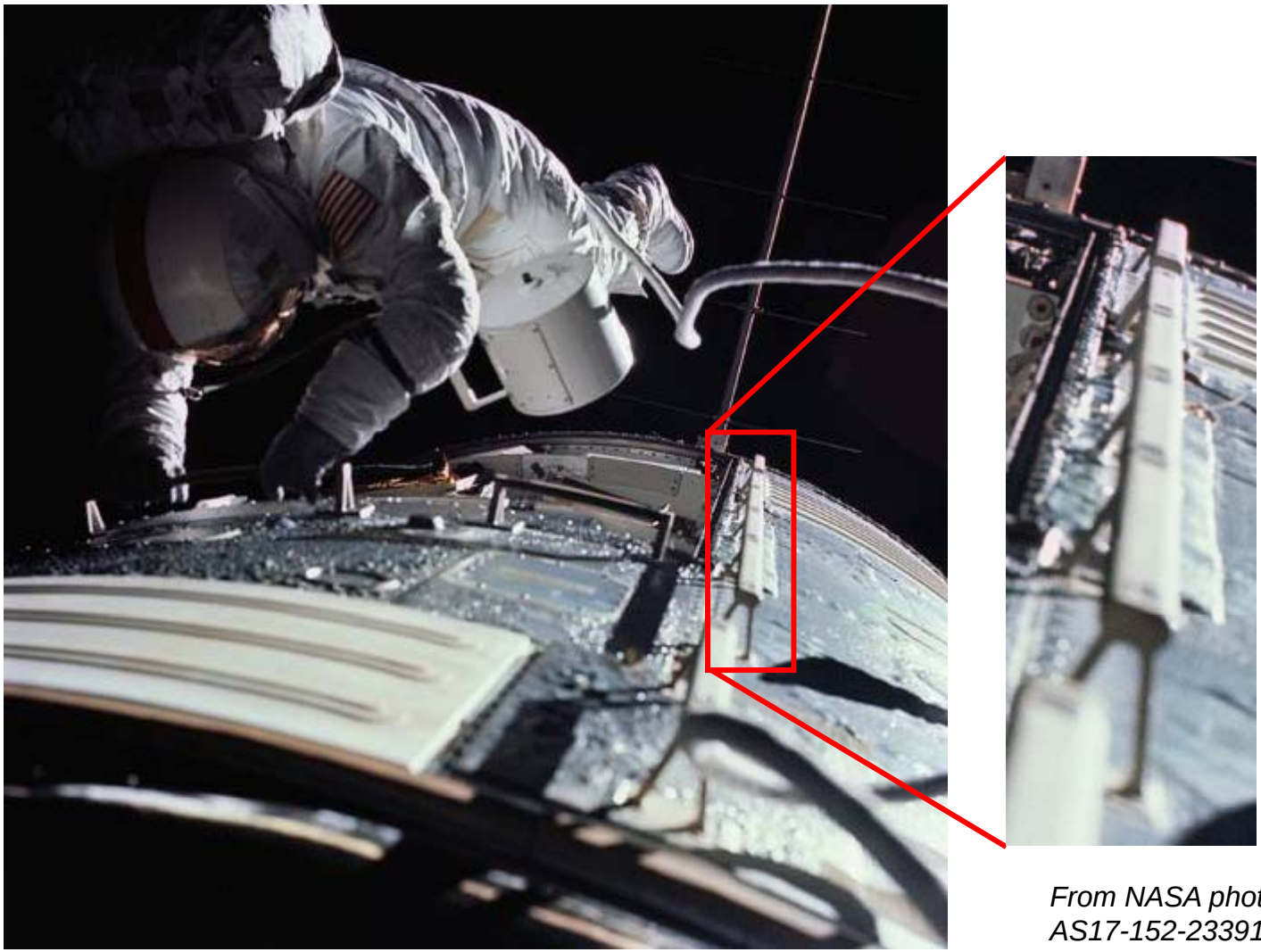
Daylight



Darkness

EVA Lighting

- Radioluminescent (RL) discs
  - On EVA handrails (below), near ECLS exterior dump valve, hatch opening mechanism and handle



From NASA photo AS17-152-23391

Few In-Flight Anomalies

- Apollo 7
  - Secondary lamp of a floodlight in the lower equipment bay failed
- Apollo 9
  - When dual floodlights used, lens heated up to 170°, exceeding touch temperature limits
    - Subsequent flights used just one light or used both for less than 30 min
  - Docking spotlight on the CSM was inoperative due to an error in the Flight Data File
    - Circuit breaker not pushed in prior to light activation
  - LM tracking light failed
    - Occurred due to insufficient protection at the lamp terminals, resulting in burnt-out terminals

For More Information

- Apollo Operations Handbook
  - Block II Spacecraft, Volume 1: Spacecraft Description, last revised Jan. 1970
  - LM Subsystems Data (LMA790-3-M), Feb. 1970
- Apollo Experience Reports
  - Lunar Module Display and Control System, NASA Technical Note TN D-6722, March 1972
  - Crew Station Integration, Volume I: Crew Station Design and Development, NASA Technical Note TN D-8178, March 1976
  - Crew Station Integration, Volume V: Crew Lighting Considerations, NASA Technical Note TN D-7290, June 1973
- Apollo Wiki

Special Thanks

Special thanks to the
Kansas Cosmosphere and Space Center
for the closeup photographs of the CM (Apollo 13) and LM Trainer panels.

http://www.cosmo.org/