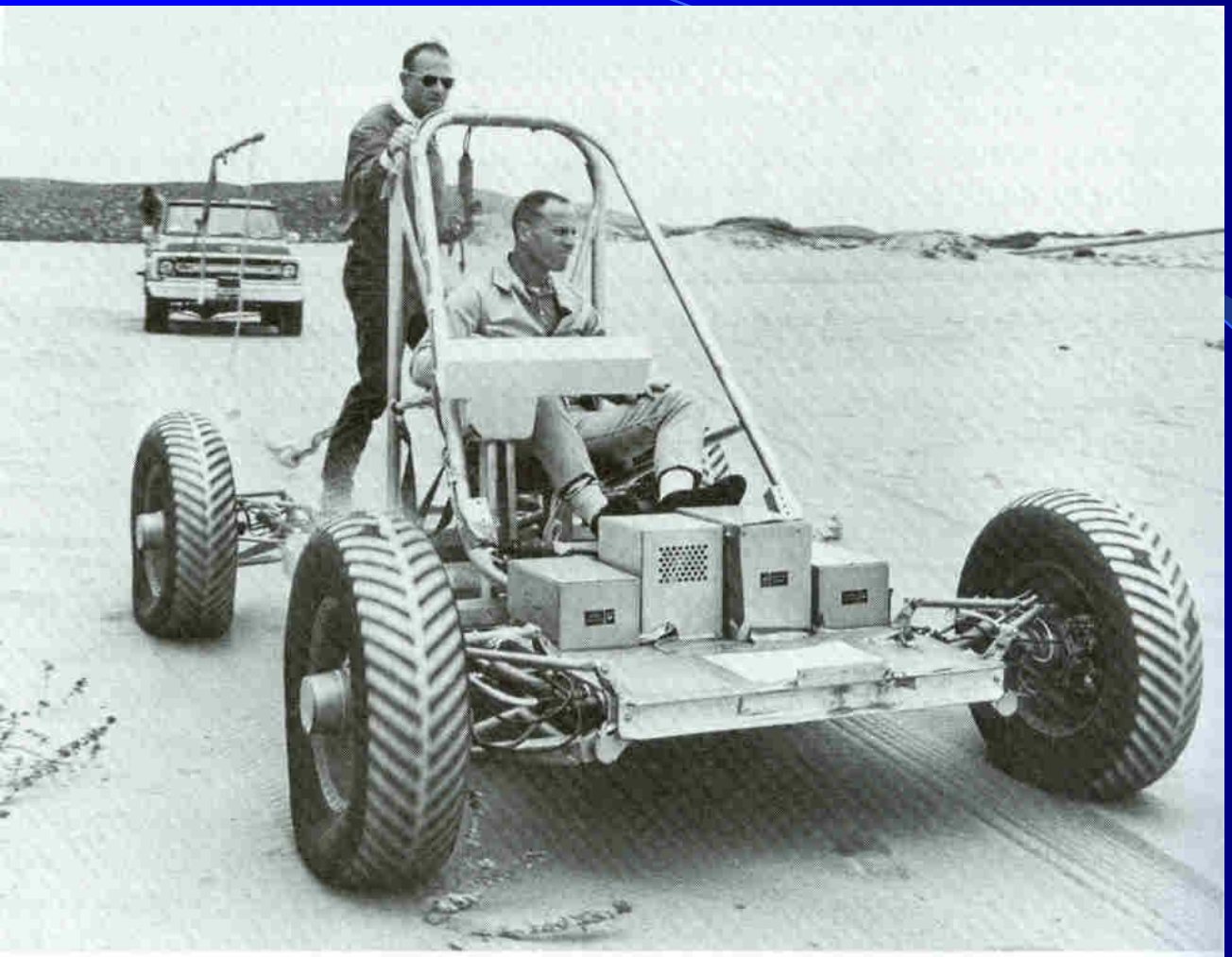
Power

Joseph T. Wunderlich, Ph.D.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*



GM-DRL was responsible for the Mobility and Electrical Power Subsystems of the LRV. The company built this test mule to validate early hardware designs. This vehicle received its electrical power via a cable from the truck following behind. Astronaut Jack Lousma drives, with astronaut Gerald Carr (standing). Both men would later fly on Skylab missions. (Courtesy: NASA/MSFC)

Subsystems Validation

Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

POWER DEMAND

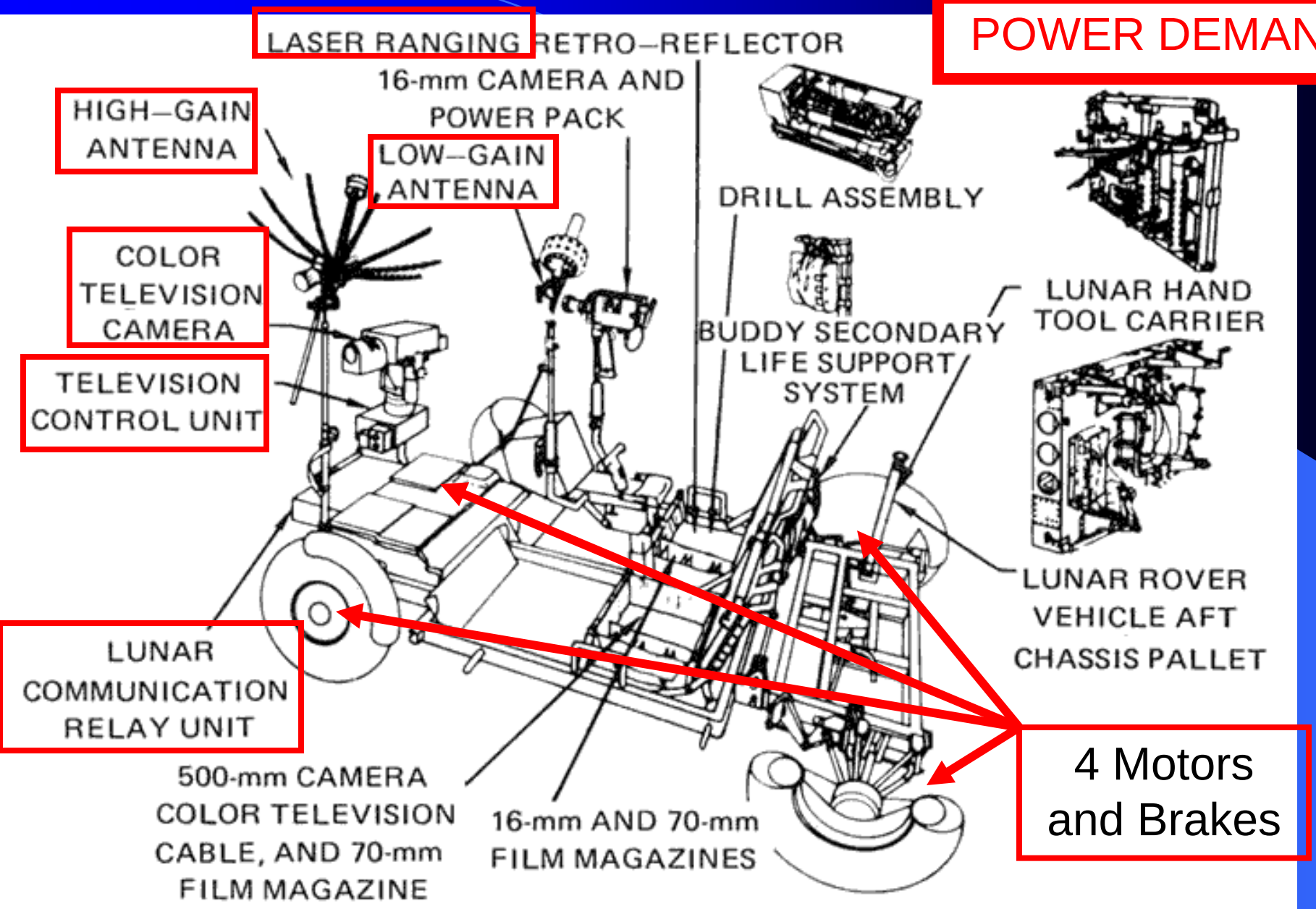
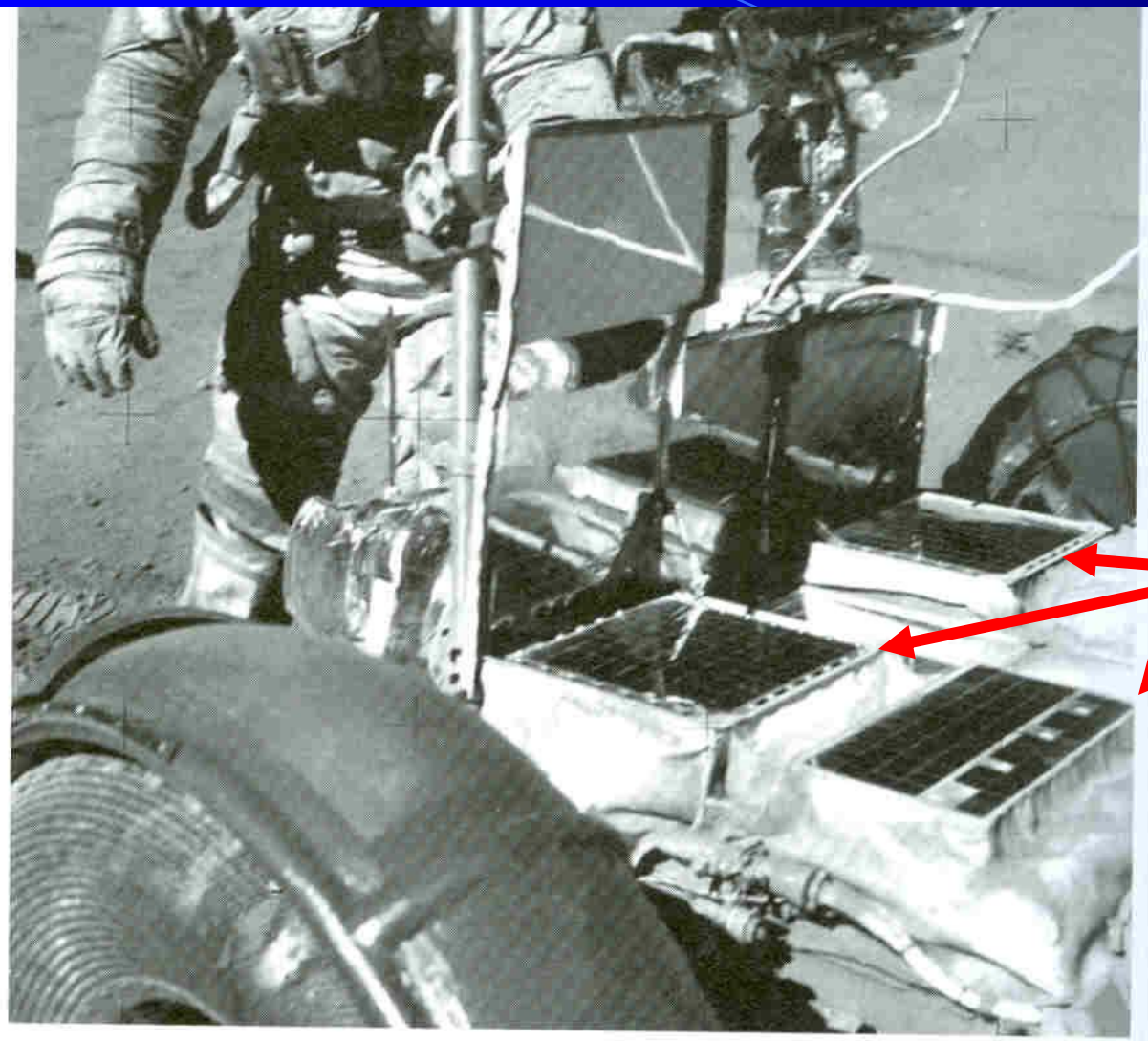


Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*



Young photographed Duke near the front of the LRV at the end of EVA-3. Both battery covers are open and the radiators are clearly visible. (NASA)

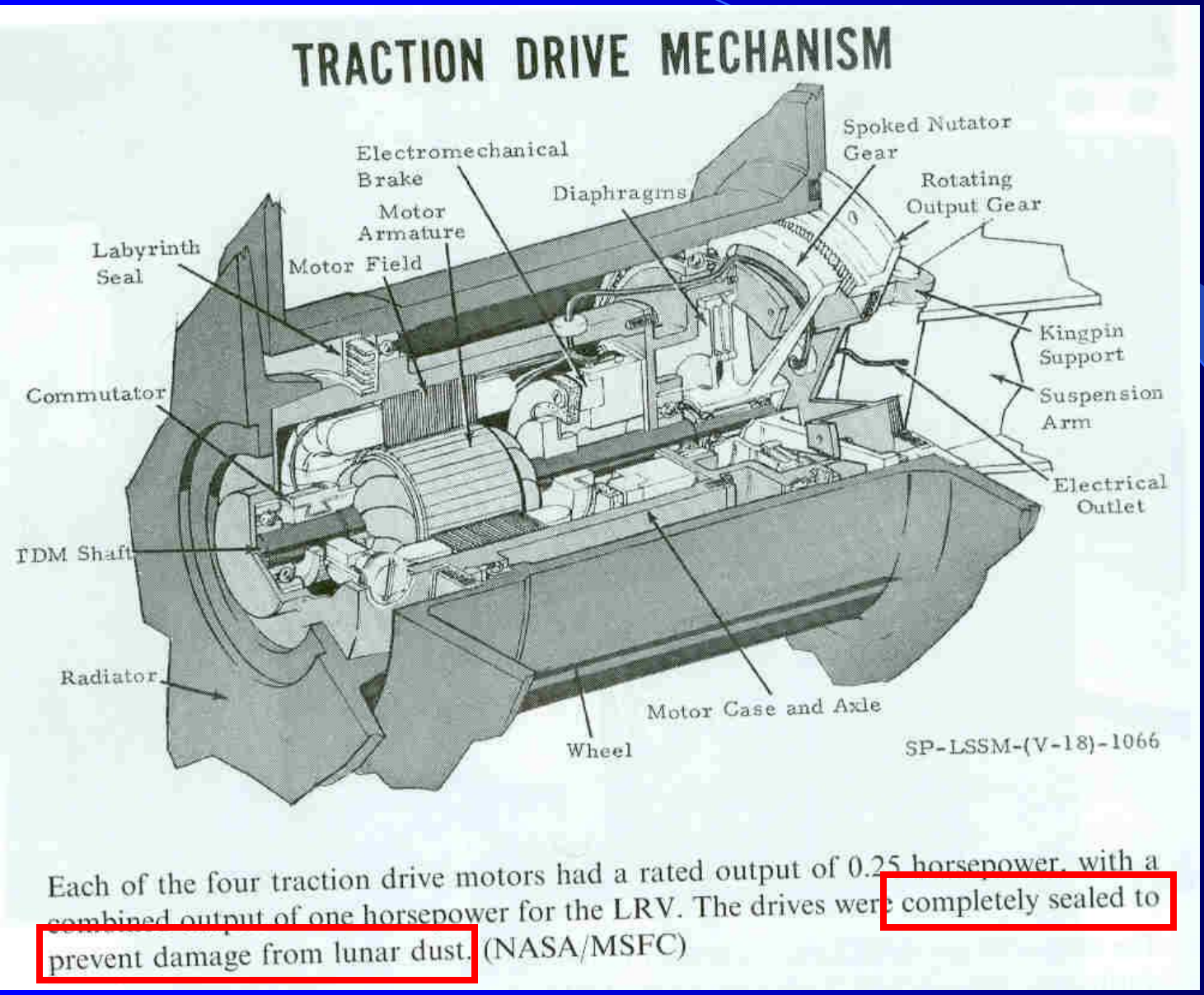
POWER SUPPLY (STORAGE)

NO GENERATION

Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

"Lunar Roving Vehicle" (LRV)

- ELECTRICAL POWER
- HARDENING FOR SPACE



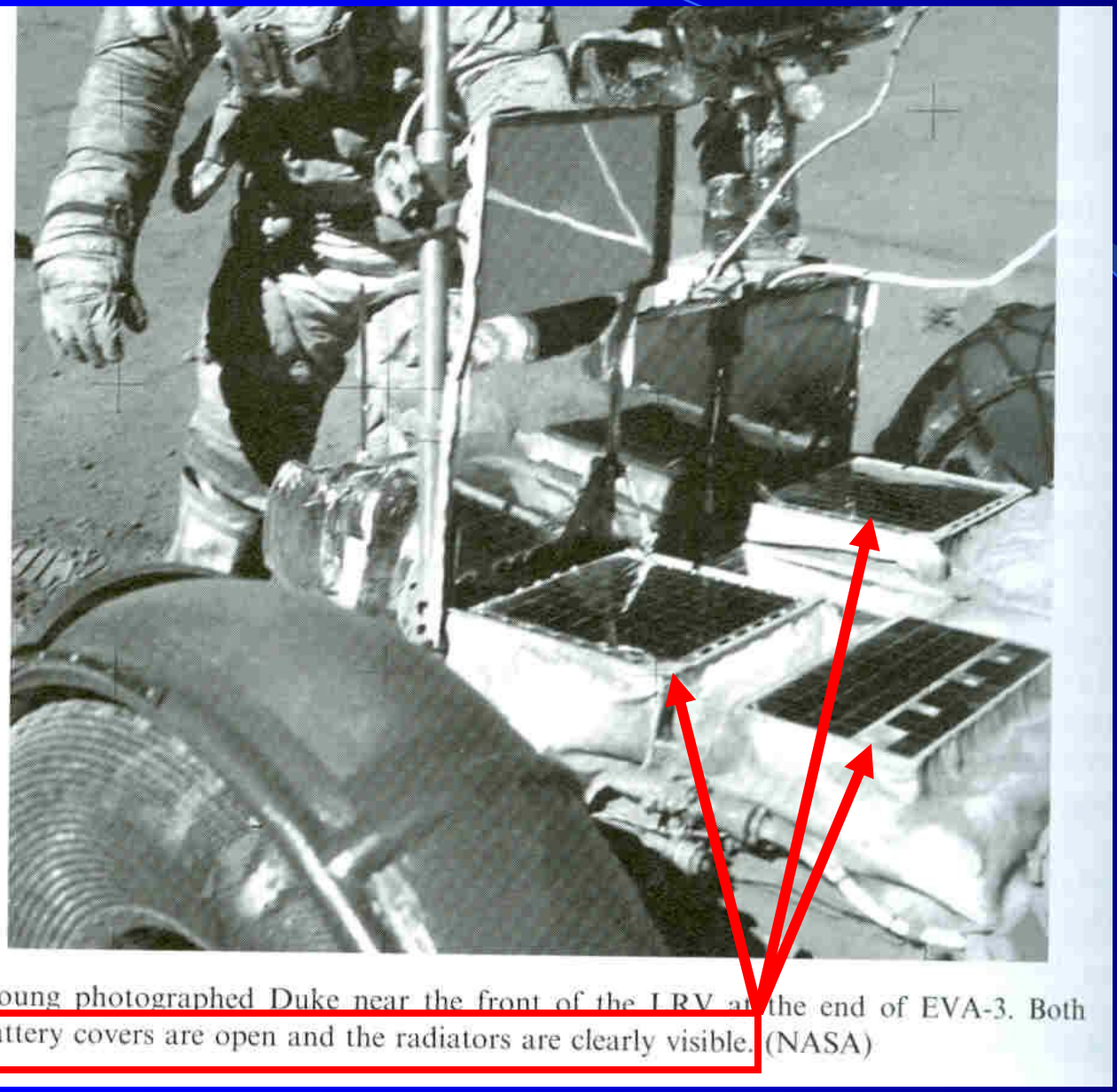
Each of the four traction drive motors had a rated output of 0.25 horsepower, with a combined output of one horsepower for the LRV. The drives were completely sealed to prevent damage from lunar dust. (NASA/MSFC)

Motors

Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

"Lunar Roving Vehicle" (LRV)

- ELECTRICAL POWER
- HARDENING FOR SPACE

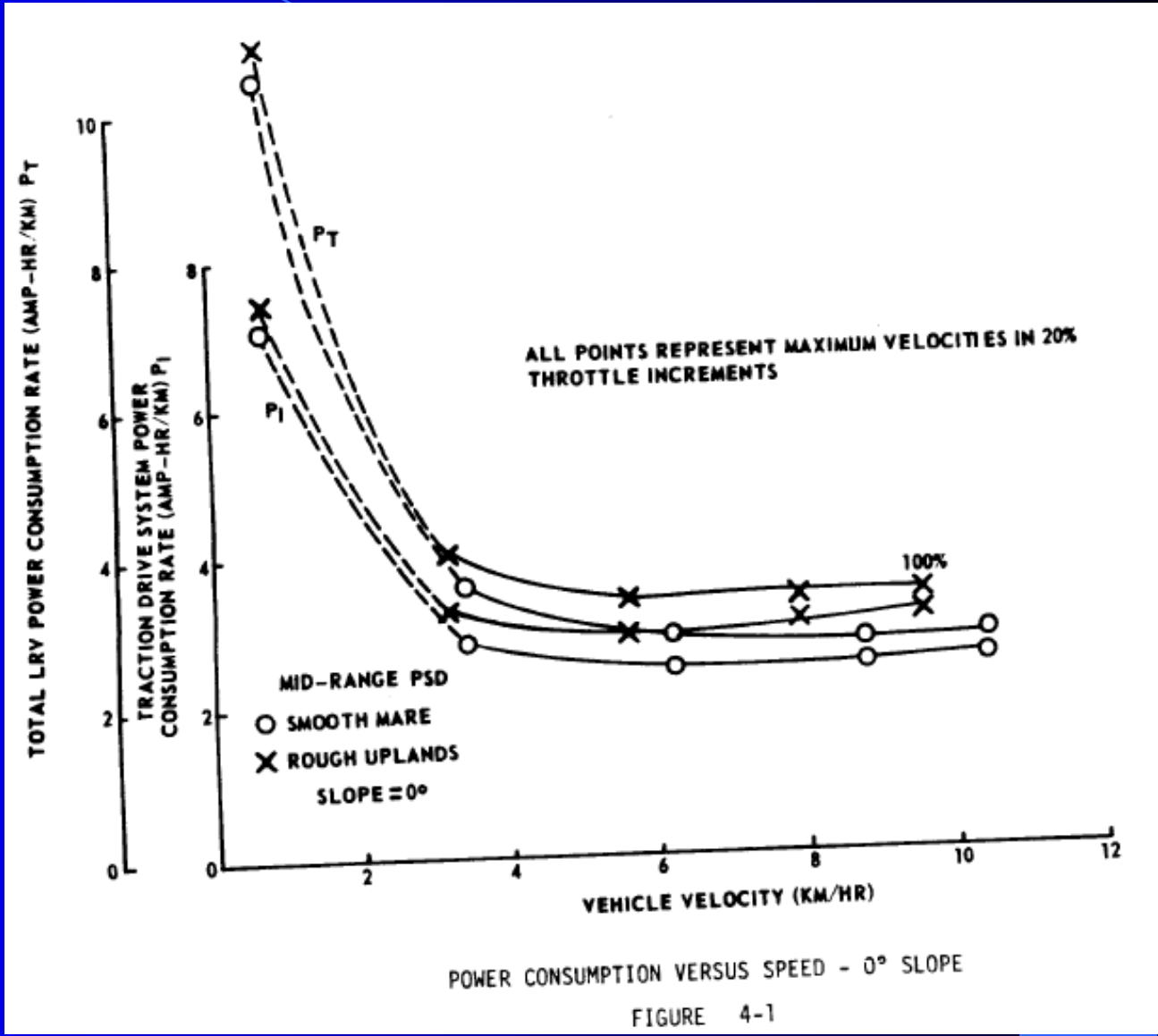


Young photographed Duke near the front of the LRV at the end of EVA-3. Both battery covers are open and the radiators are clearly visible. (NASA)

Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



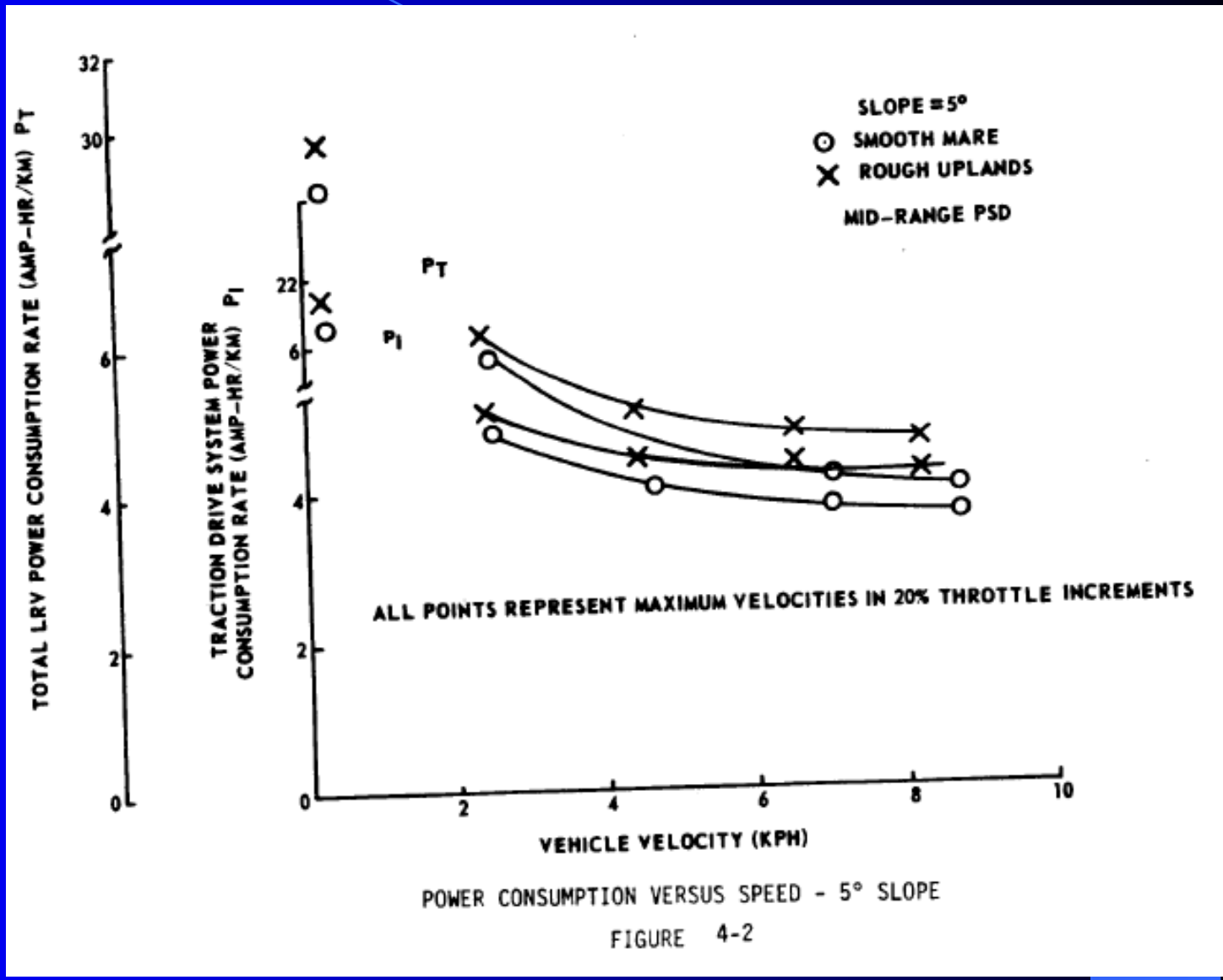
POWER CONSUMPTION VERSUS SPEED - 0° SLOPE

FIGURE 4-1

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



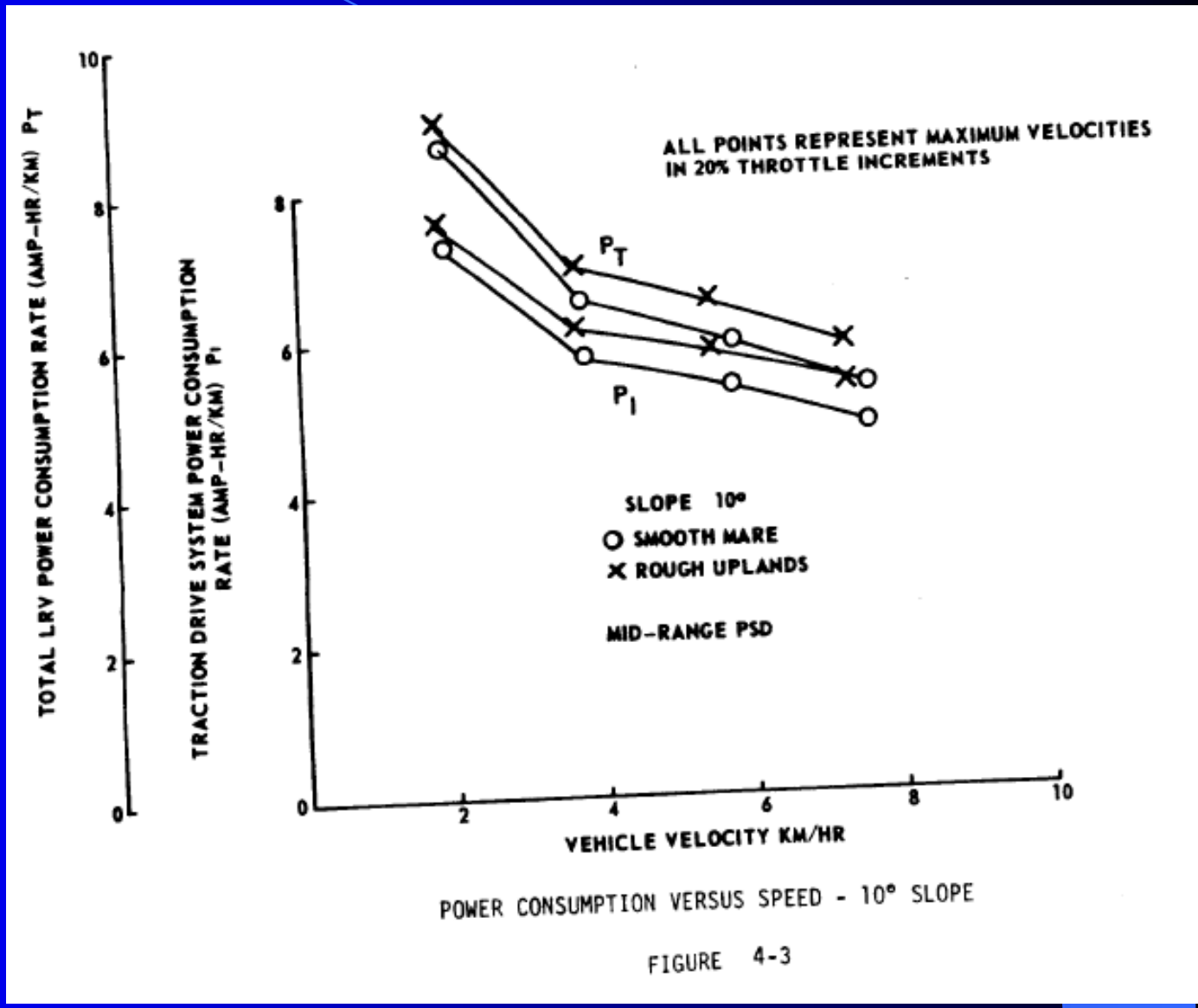
POWER CONSUMPTION VERSUS SPEED - 5° SLOPE

FIGURE 4-2

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



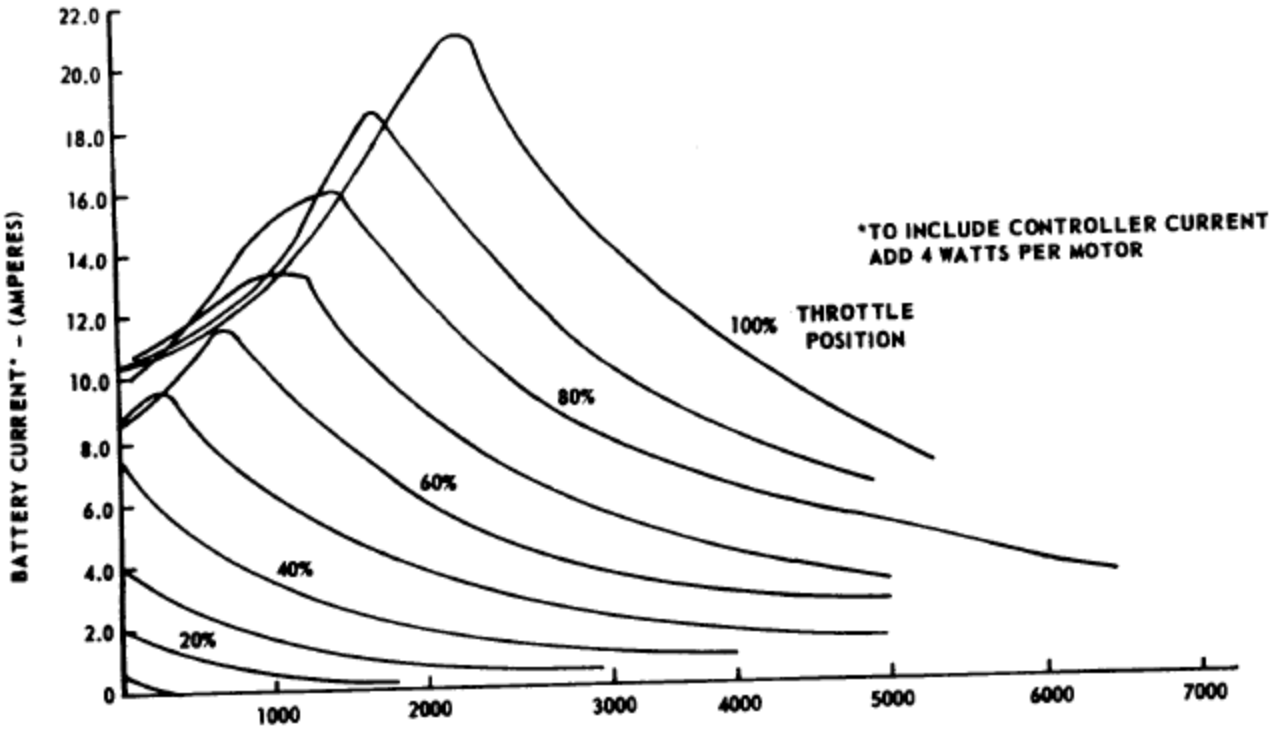
POWER CONSUMPTION VERSUS SPEED - 10° SLOPE

FIGURE 4-3

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



BATTERY CURRENT VS SPEED

FIGURE 4-5

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING

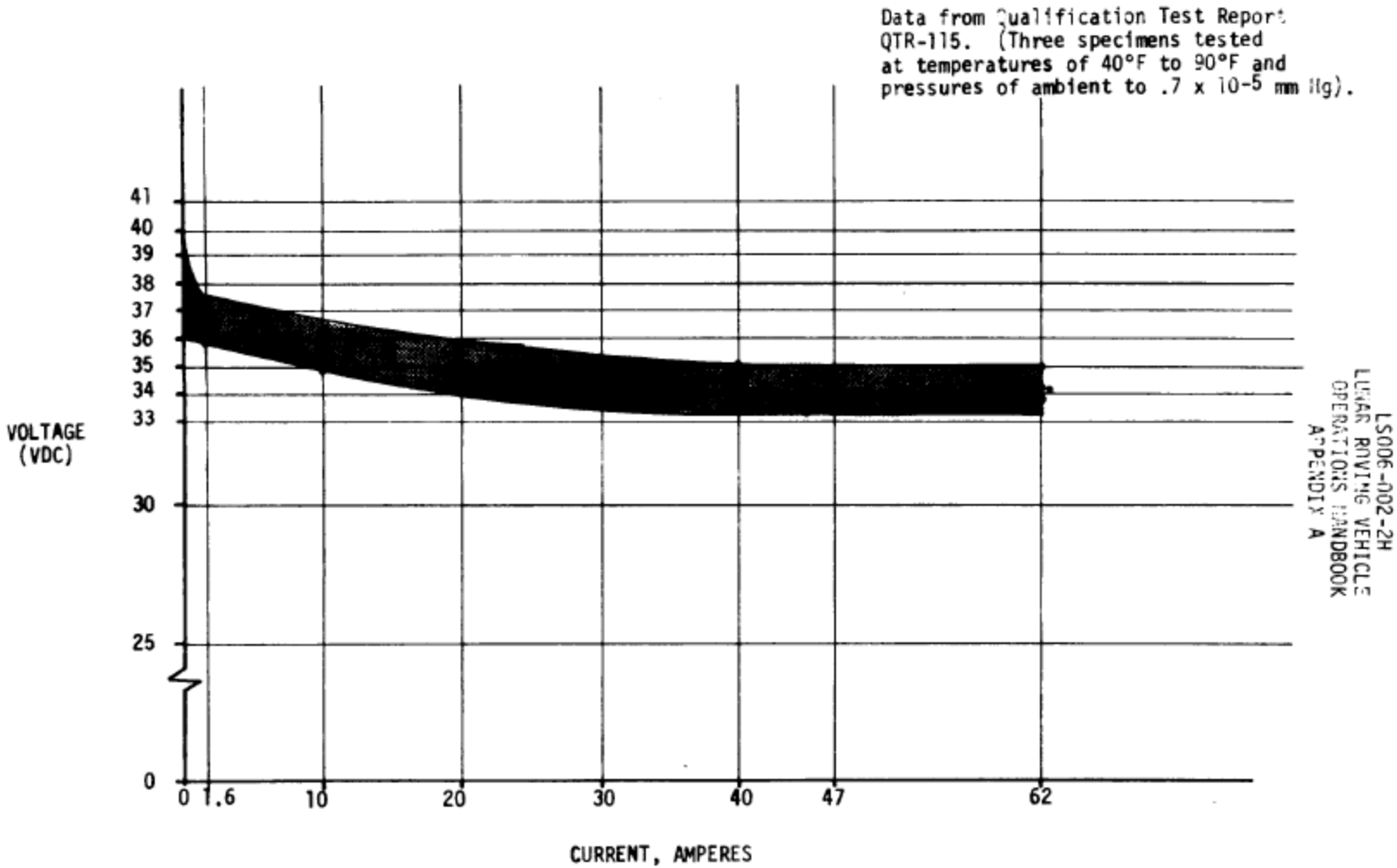


FIGURE 4-13 VOLTAGE VS CURRENT DRAW PER BATTERY

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING

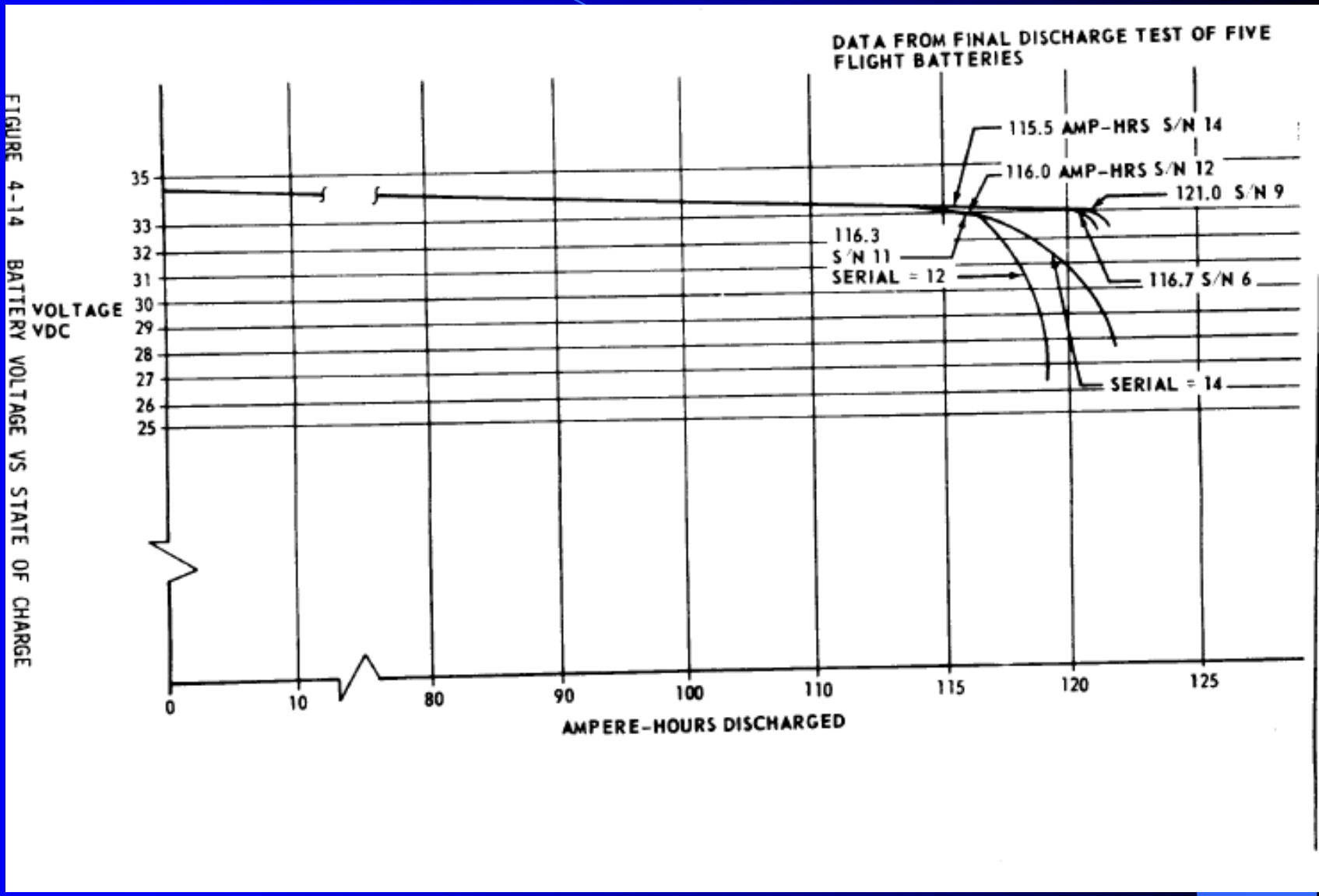
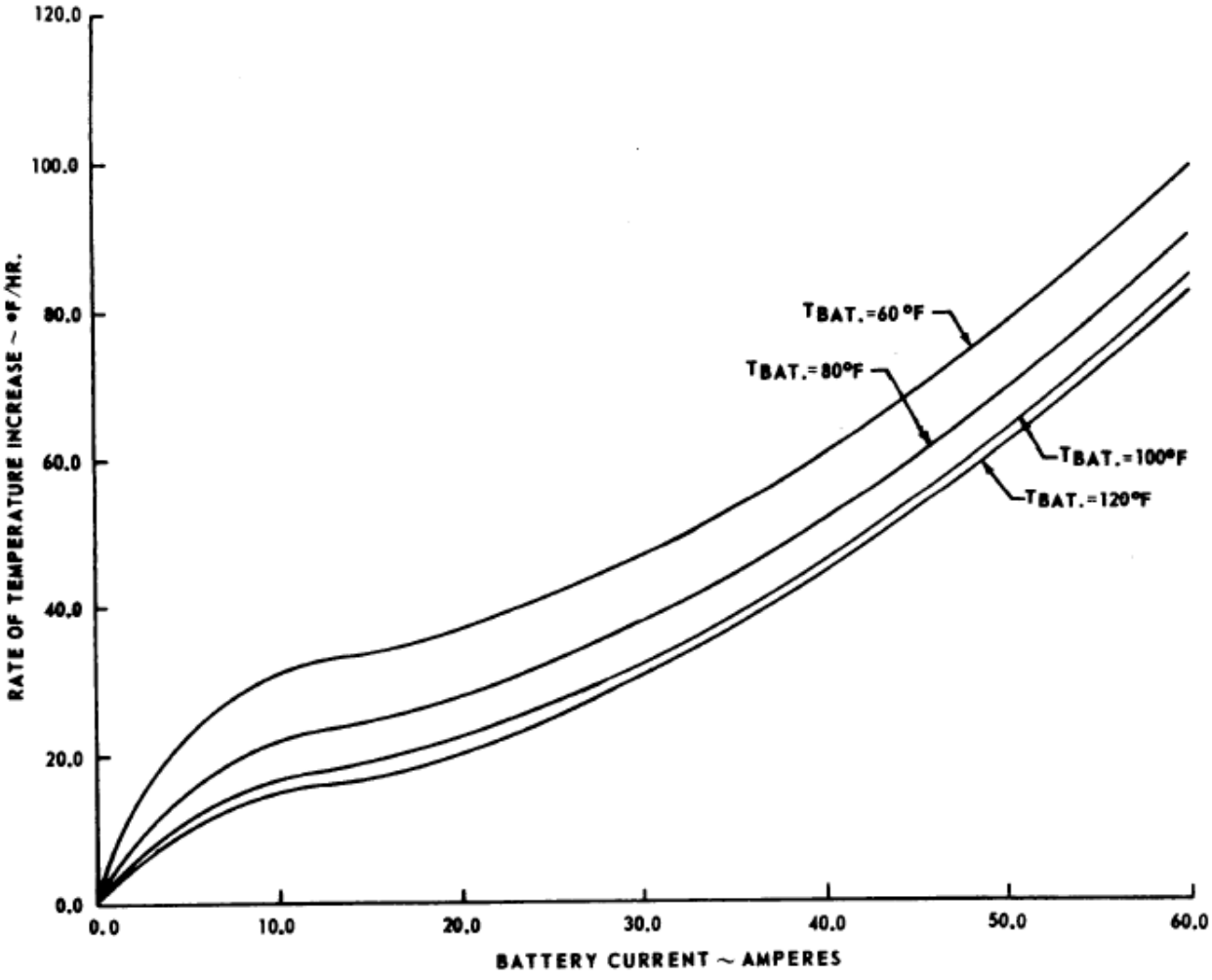


FIGURE 4-14 BATTERY VOLTAGE VS STATE OF CHARGE

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



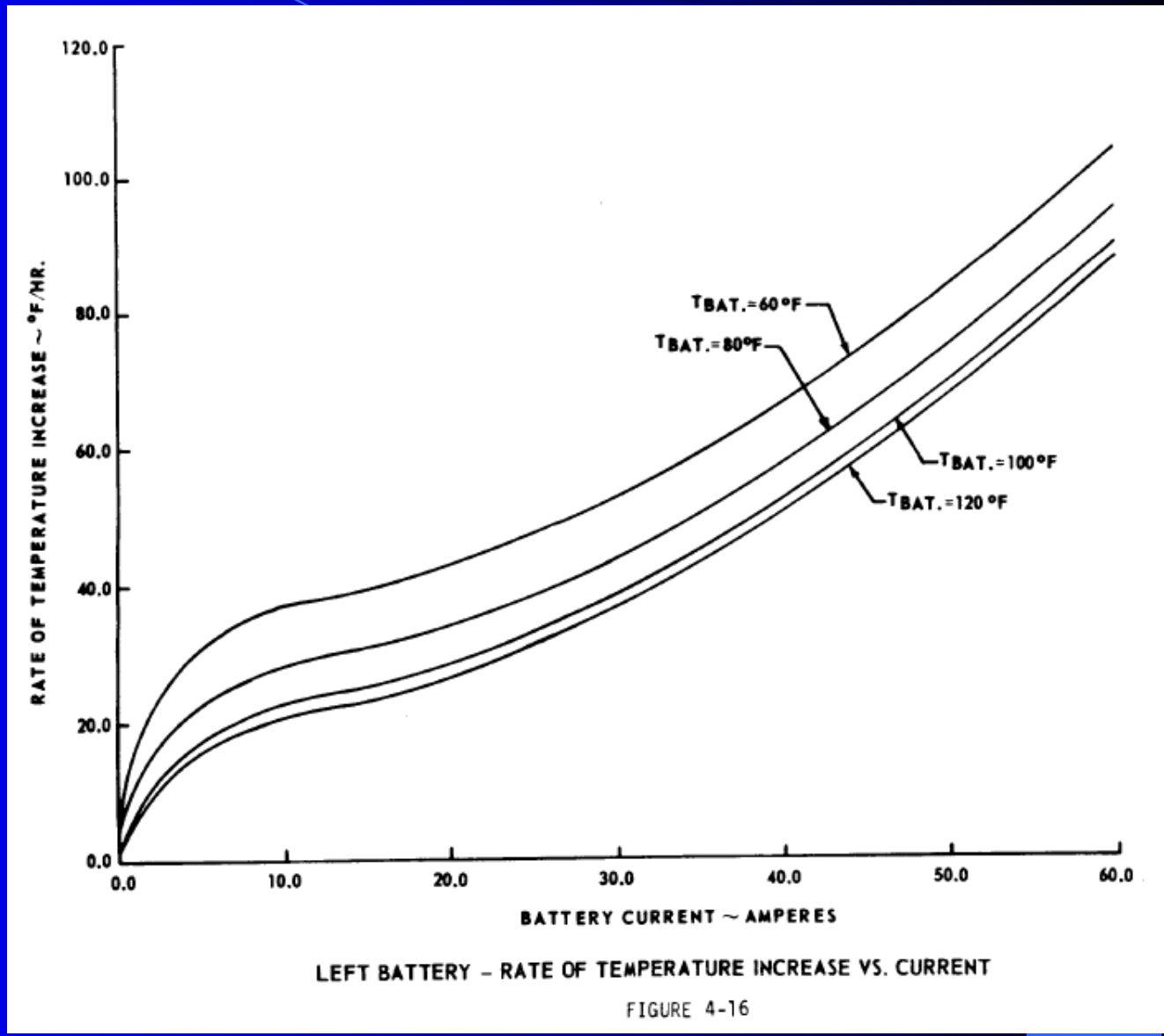
RIGHT BATTERY – RATE OF TEMPERATURE INCREASE VS. CURRENT

FIGURE 4-15

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



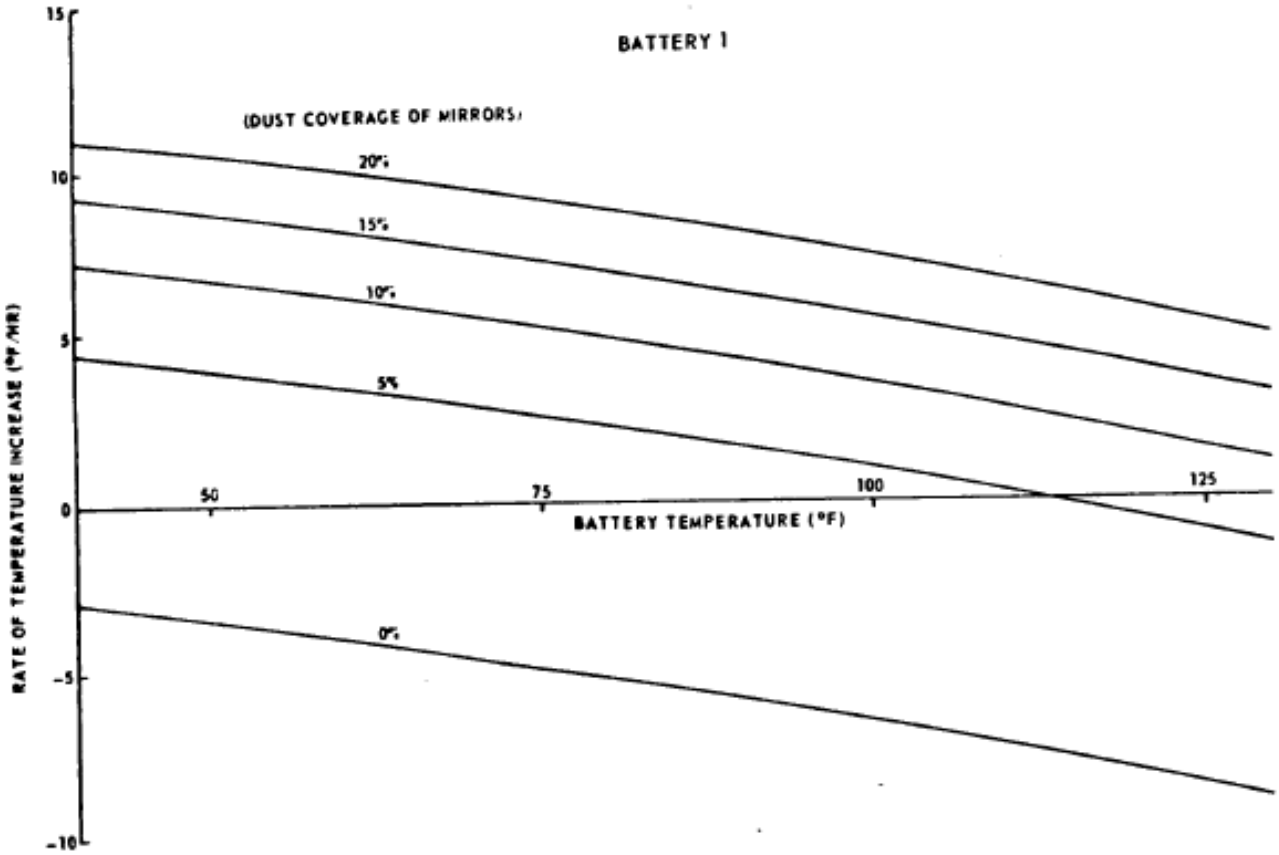
LEFT BATTERY – RATE OF TEMPERATURE INCREASE VS. CURRENT

FIGURE 4-16

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



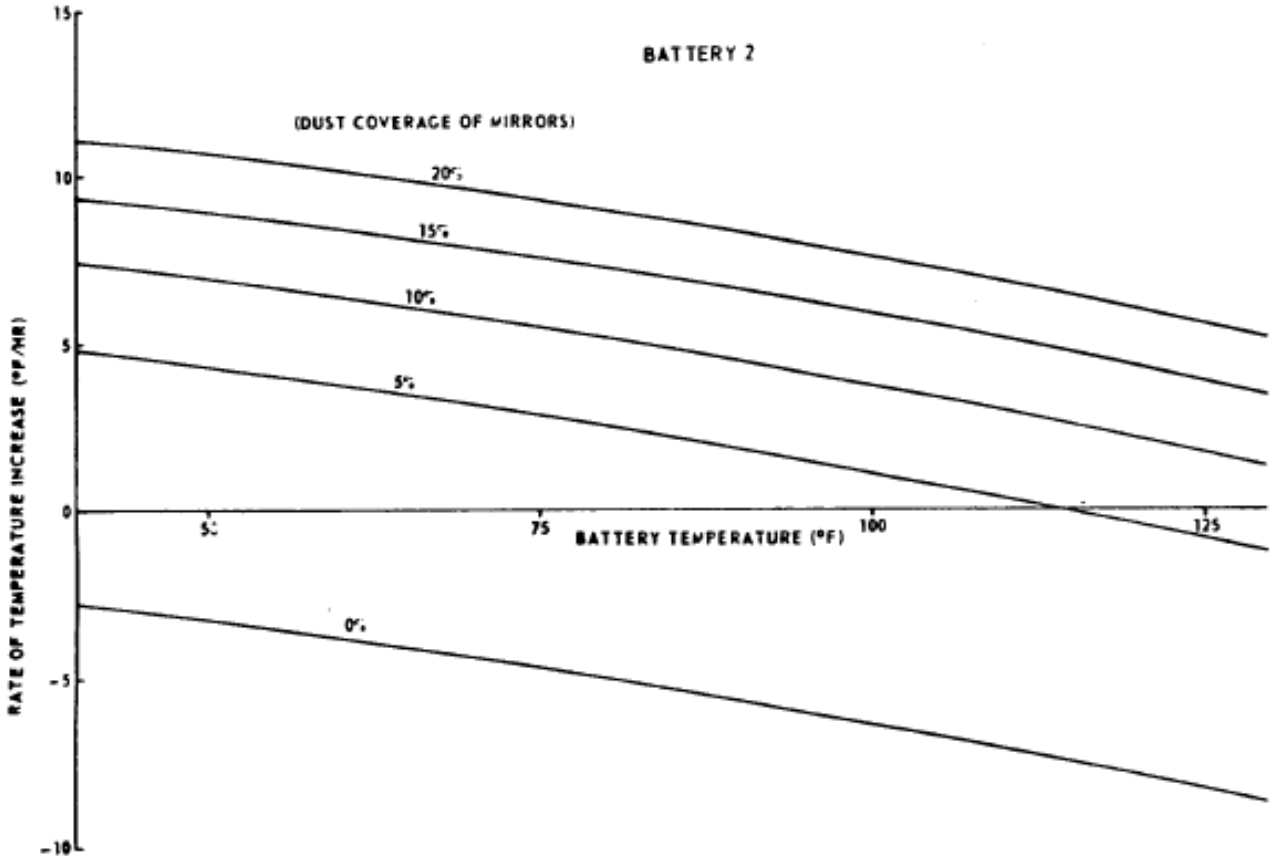
LEFT BATTERY-RATE OF TEMPERATURE INCREASE VS BATTERY TEMPERATURE (DUST COVER OPEN)

FIGURE 4-17

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING



RIGHT BATTERY-RATE OF TEMPERATURE INCREASE VS BATTERY TEMPERATURE (DUST COVER OPEN)

FIGURE 4-18

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING

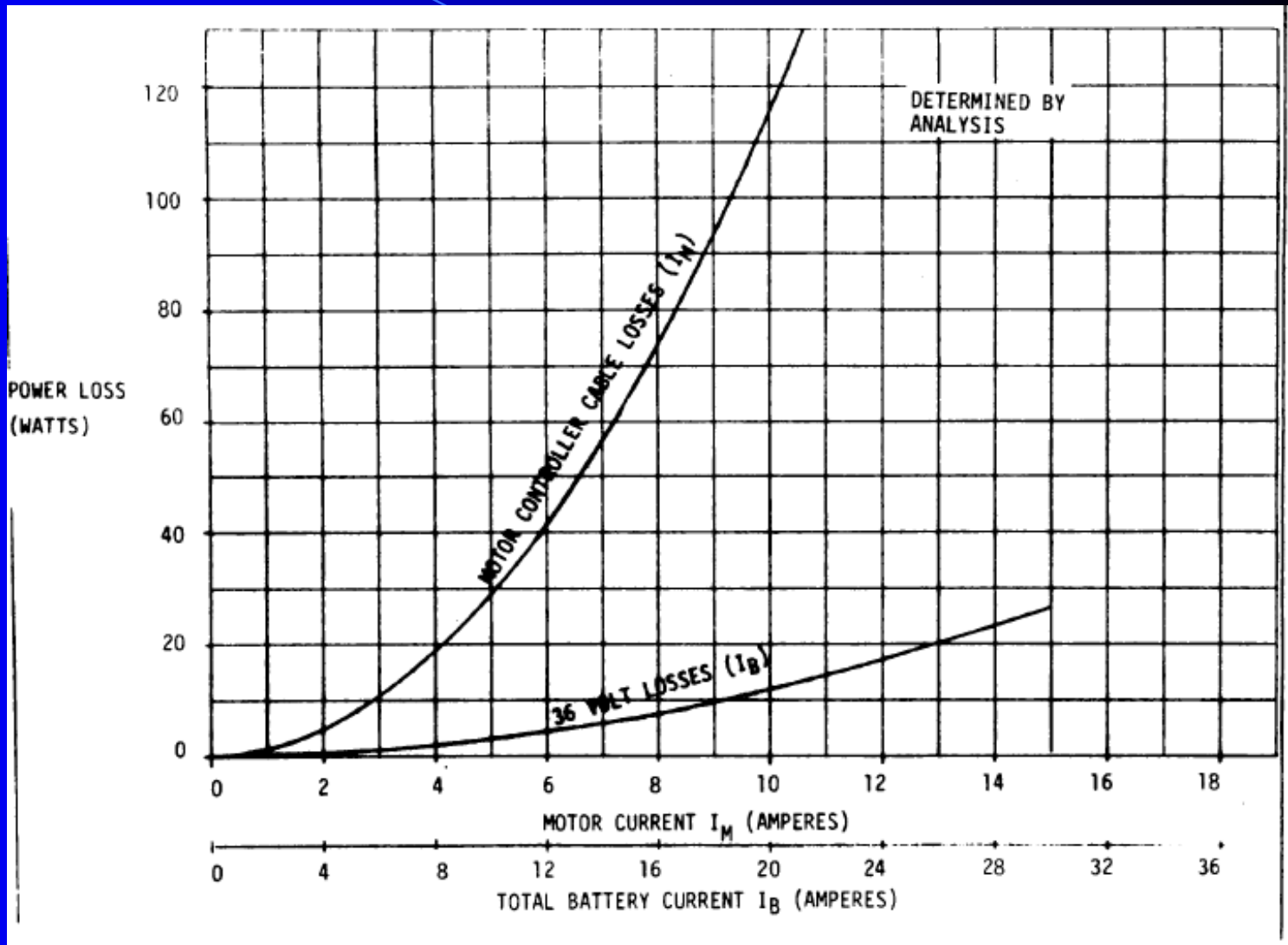


FIGURE 4-19 DISTRIBUTION LOSSES

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

"Lunar Roving Vehicle" (LRV) *ELECTRICAL POWER*

Extensive TESTING

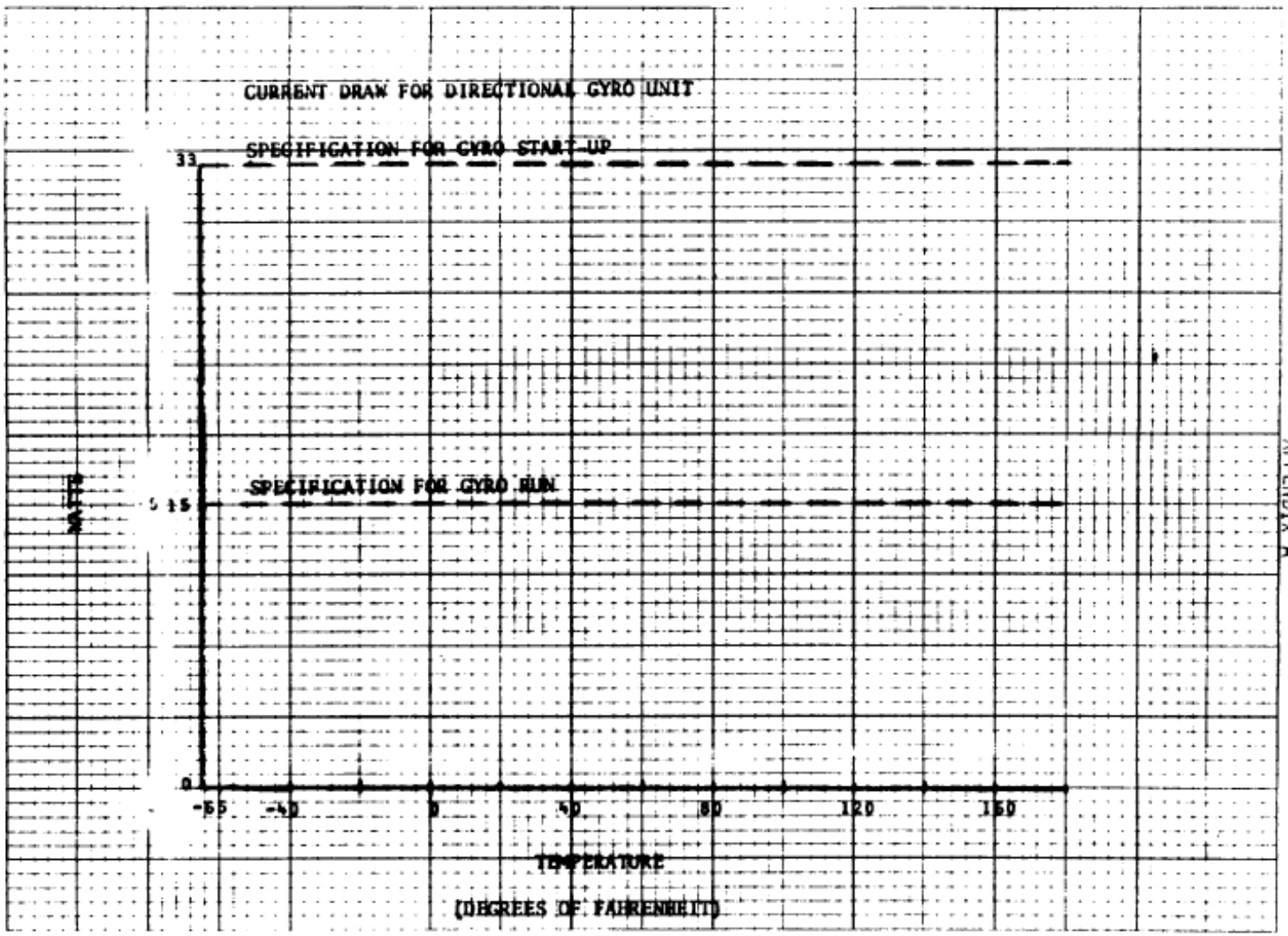


FIGURE 4-20 DGU POWER CONSUMPTION

SOURCE: Boeing Company and NASA (1971) LRV operations handbook, appendix A performance data. Document LS006-002-2H.

Mars Rovers

Mars Pathfinder “Sojourner”

ELECTRICAL POWER

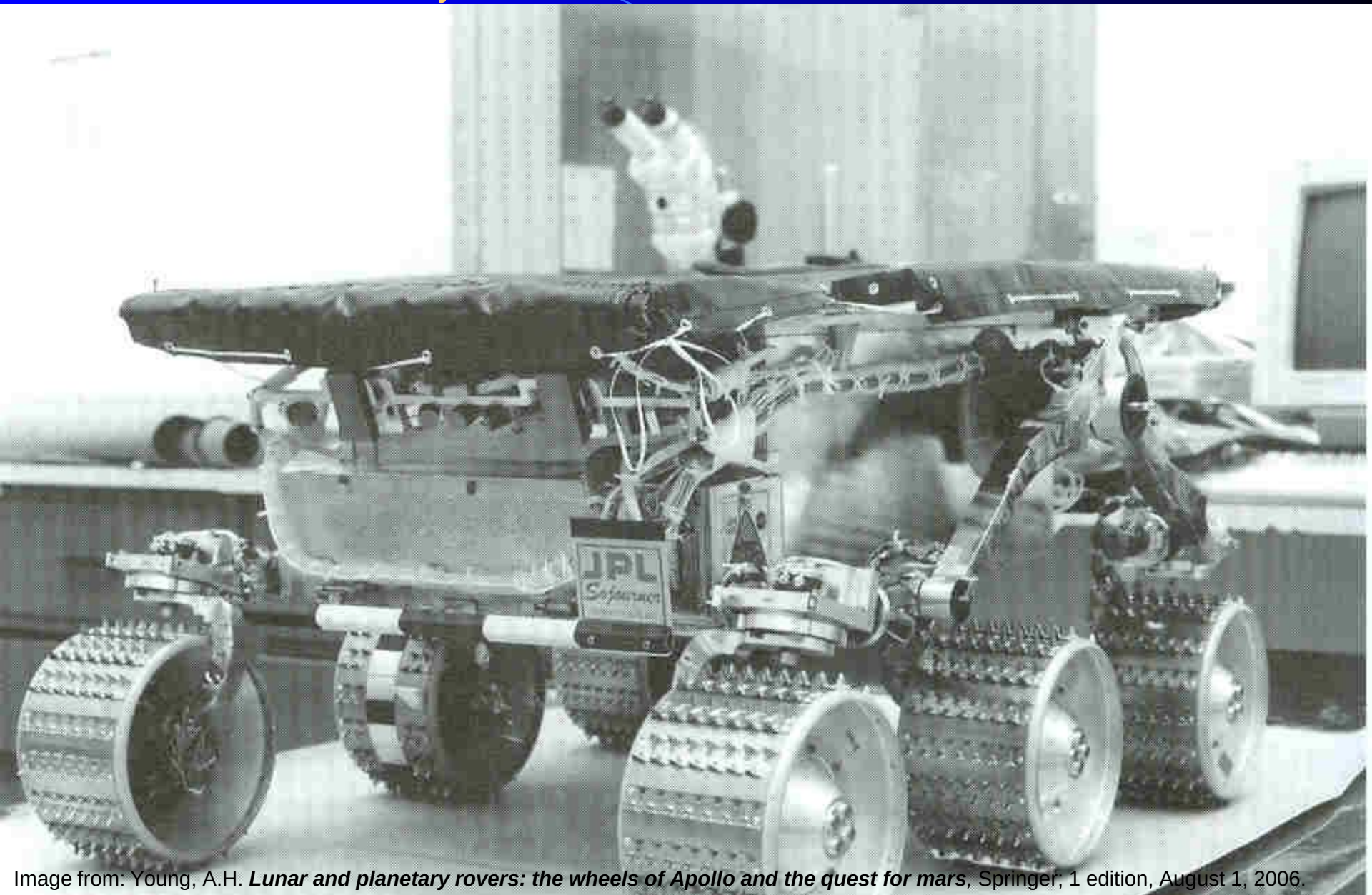


Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

Mars Rovers

Mars Pathfinder "Sojourner"

ELECTRICAL POWER

POWER DEMAND

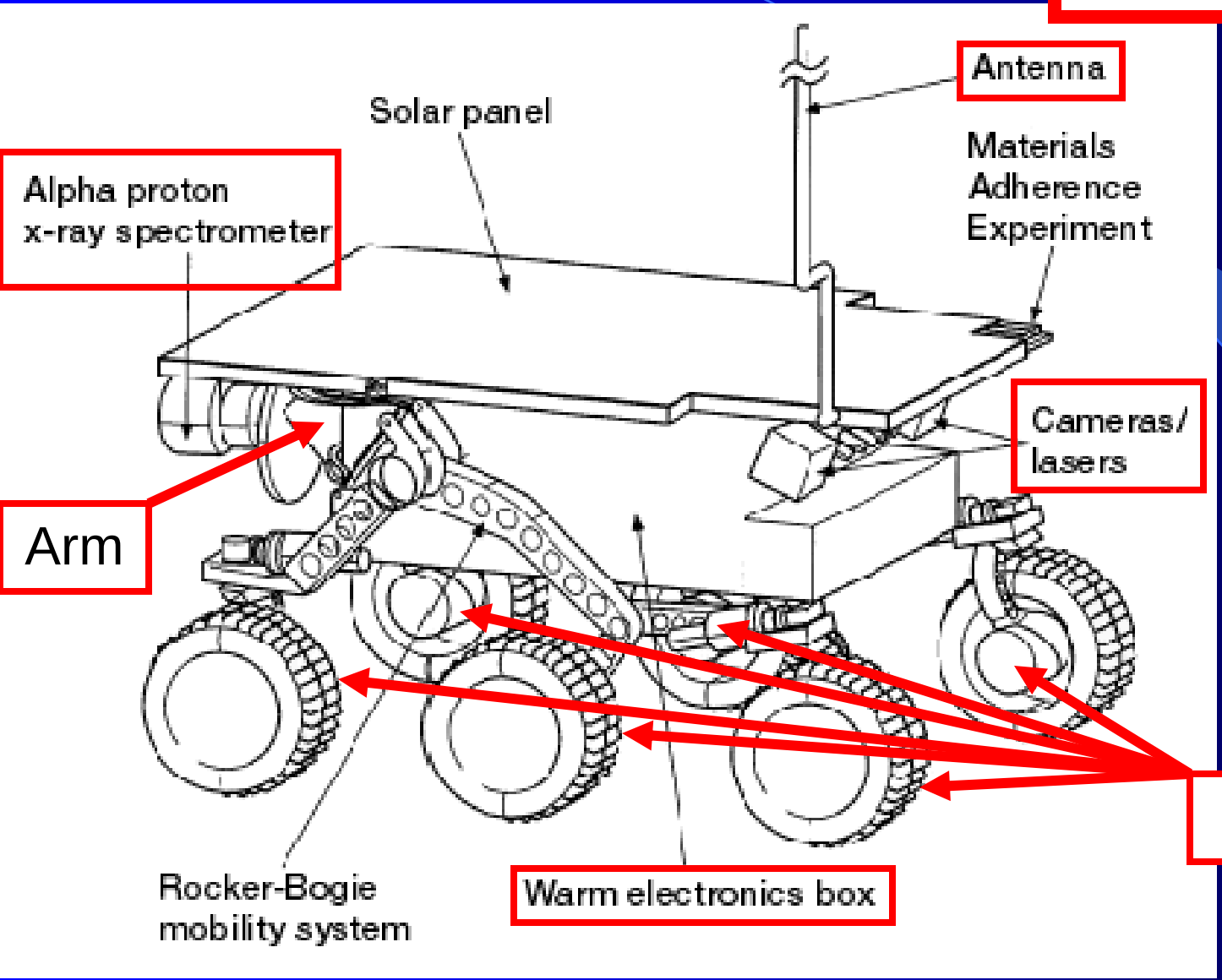


Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

Mars Rovers

Mars Pathfinder "Sojourner"

ELECTRICAL POWER

POWER GENERATION

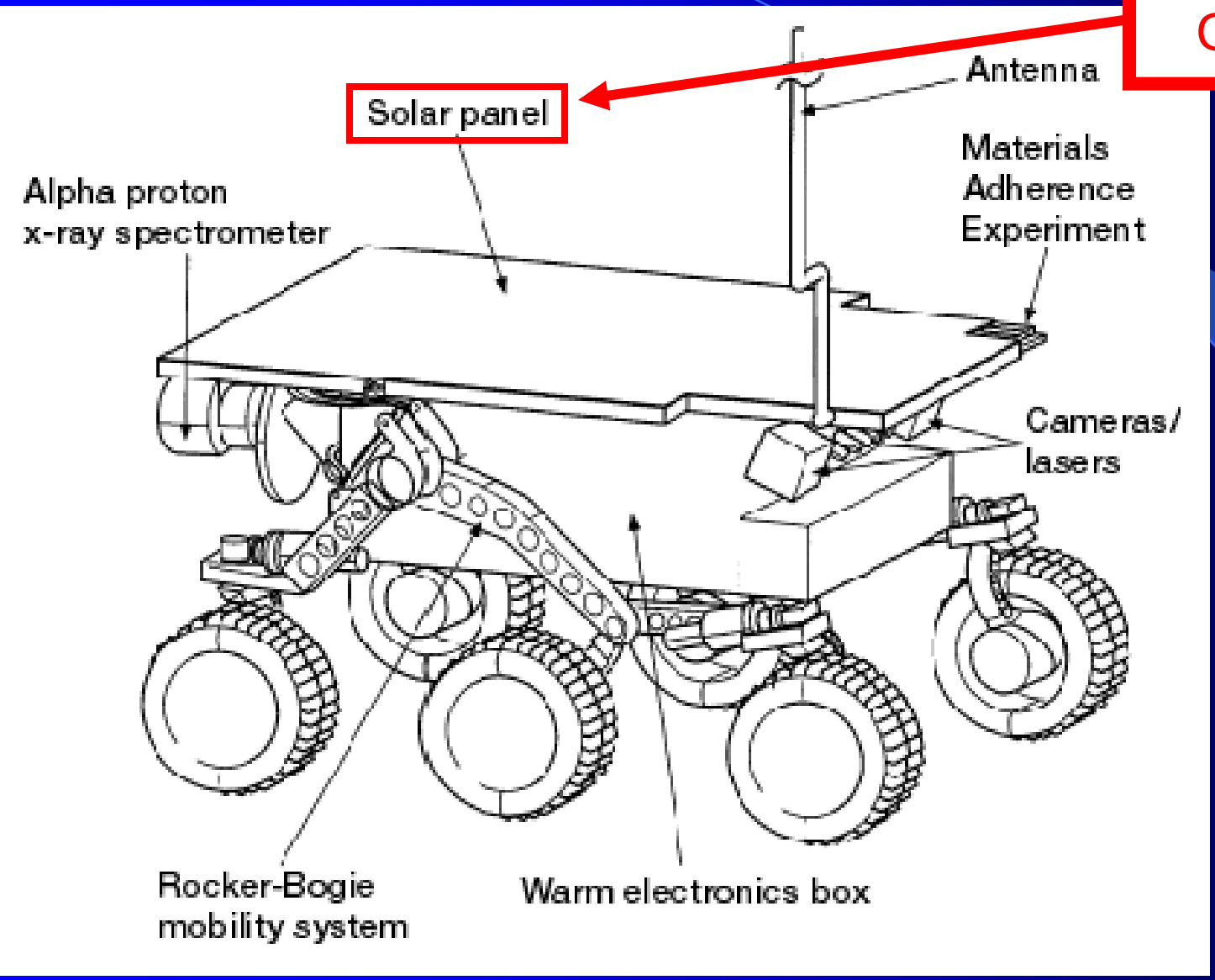


Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

ELECTRICAL POWER

SOLAR POWER GENERATION

DISTANCES FROM SUN:

To Moon = ~1 AU (Astronomical Unit)
To Mars = 1.524 AU
To Europa = ~5.203 AU

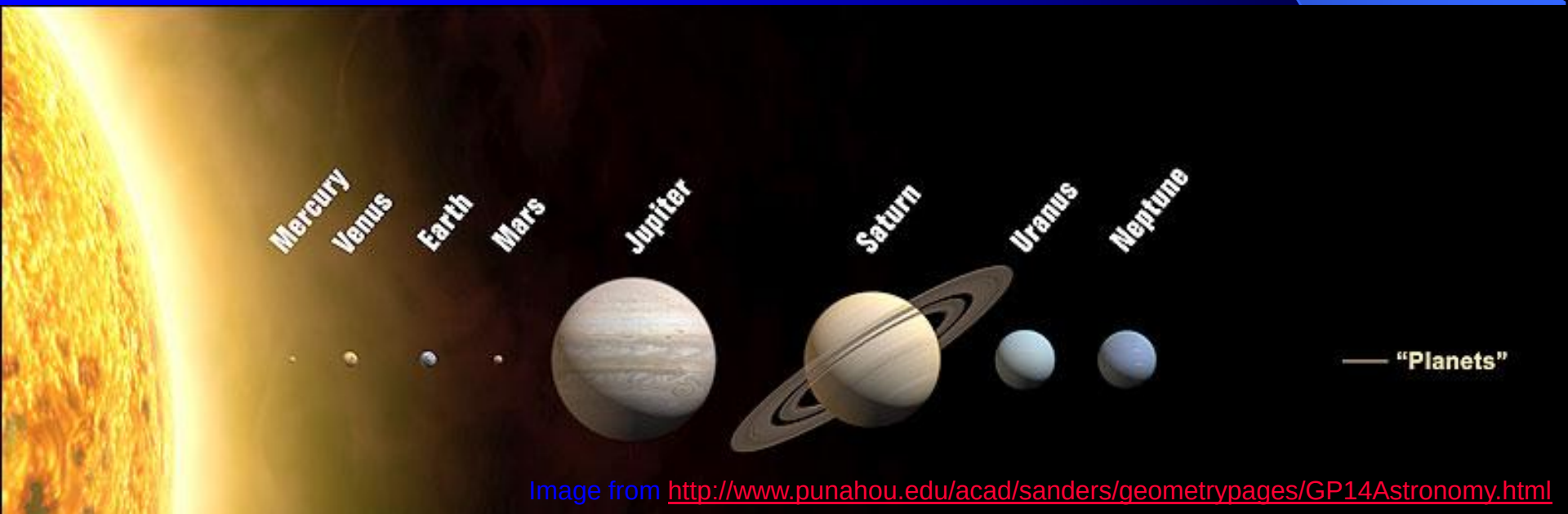


Image from http://www.punahou.edu/acad/sanders/geometrypages/GP14Astronomy.html

ELECTRICAL POWER

SOLAR POWER GENERATION

DISTANCES FROM SUN:

To Moon = ~1 AU (Astronomical Unit)
To Mars = 1.524 AU
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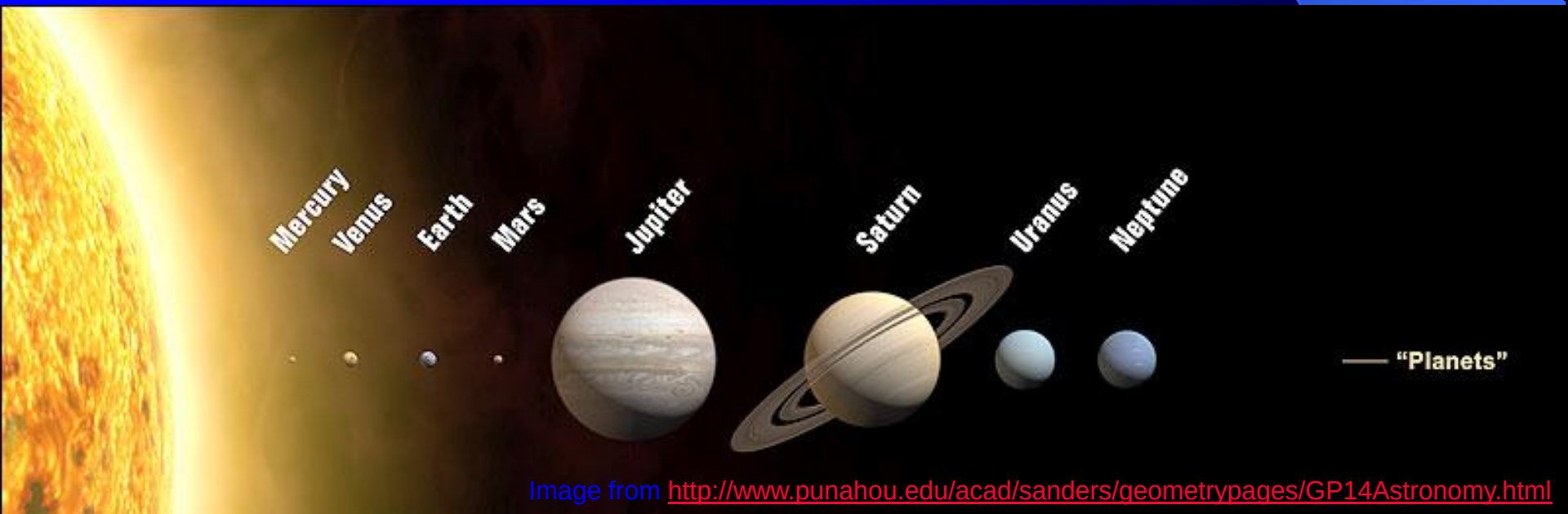


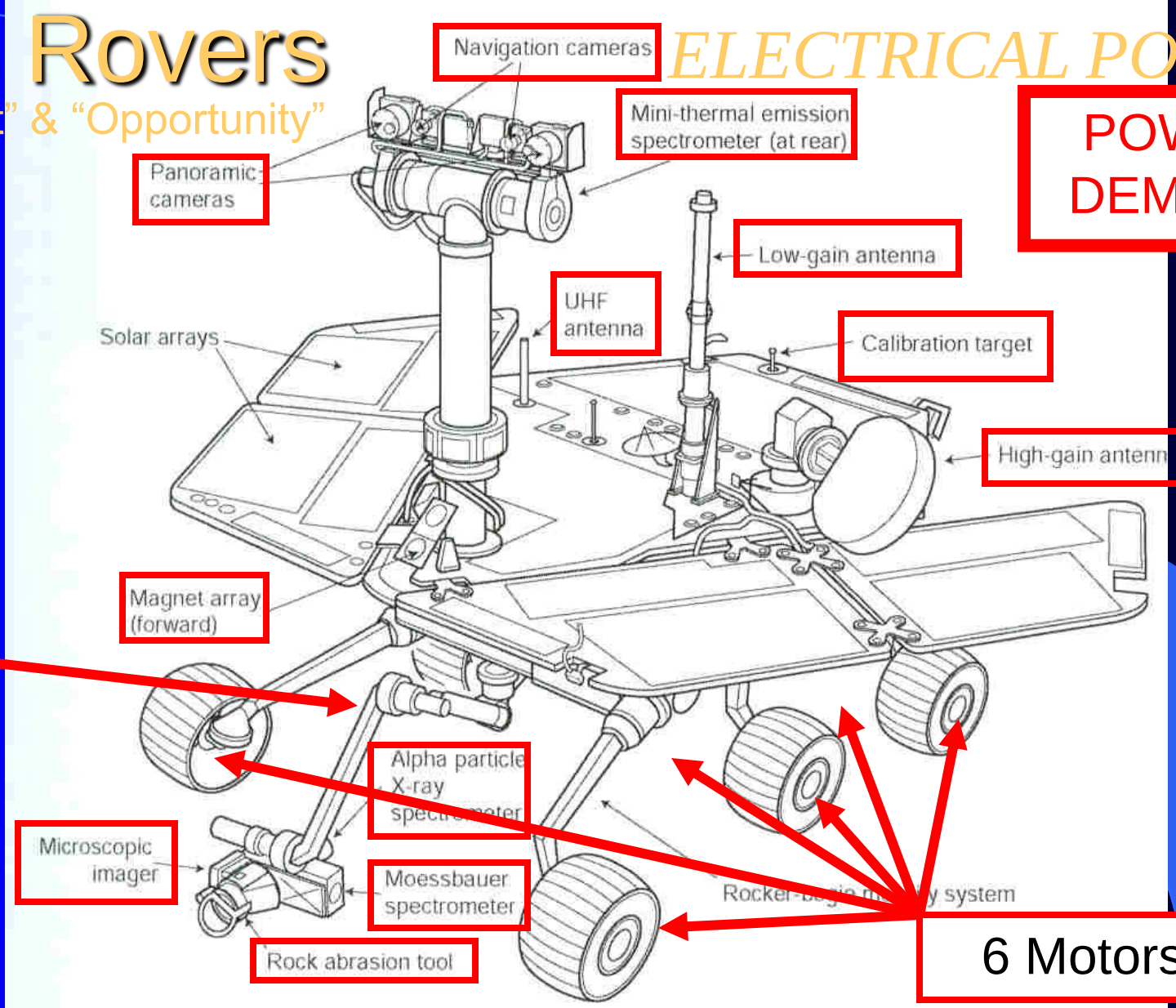
Image from http://www.punahou.edu/acad/sanders/geometrypages/GP14Astronomy.html

Mars Rovers

"Spirit" & "Opportunity"

ELECTRICAL POWER

POWER DEMAND



Arm

6 Motors

This illustration shows key components of the MER rover from the top but does not show the bulk of the electronic equipment inside the body of the rover. (NASA/JPL)

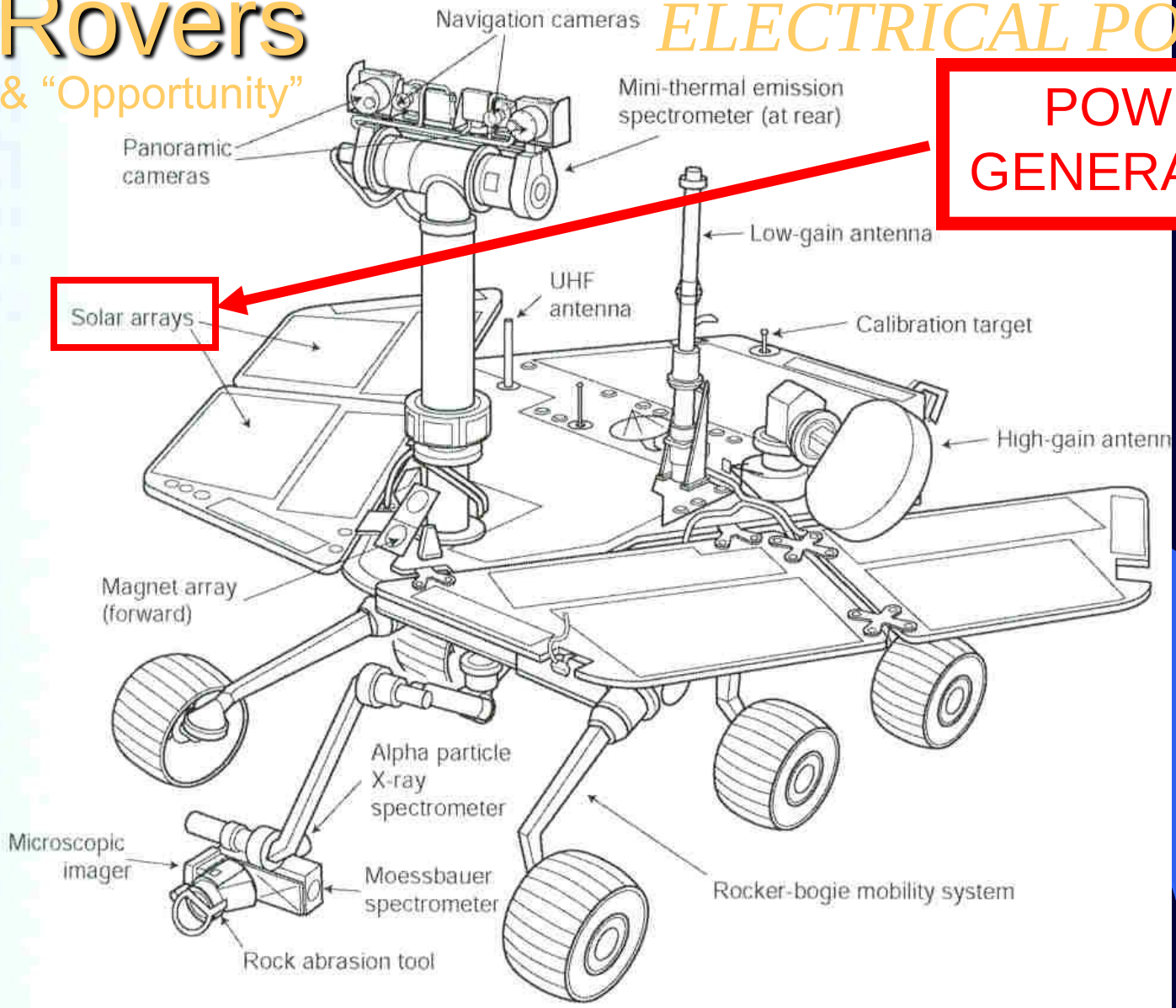
Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

Mars Rovers

"Spirit" & "Opportunity"

ELECTRICAL POWER

POWER GENERATION



This illustration shows key components of the MER rover from the top but does not show the bulk of the electronic equipment inside the body of the rover. (NASA/JPL)

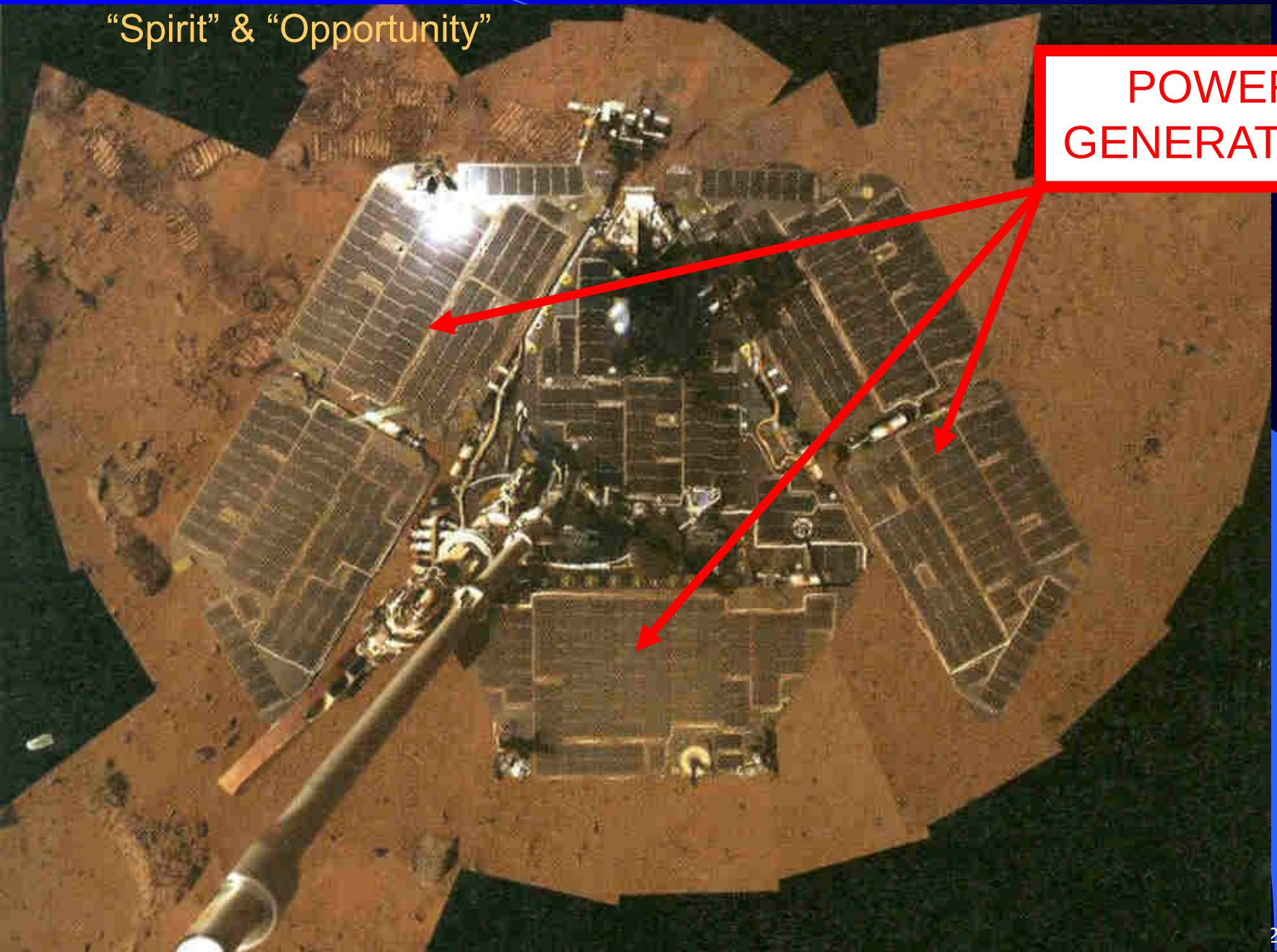
Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

Mars Rovers

"Spirit" & "Opportunity"

ELECTRICAL POWER

2004



2006.

Mars Rovers

Mars Science Lab

ELECTRICAL POWER

POWER DEMAND

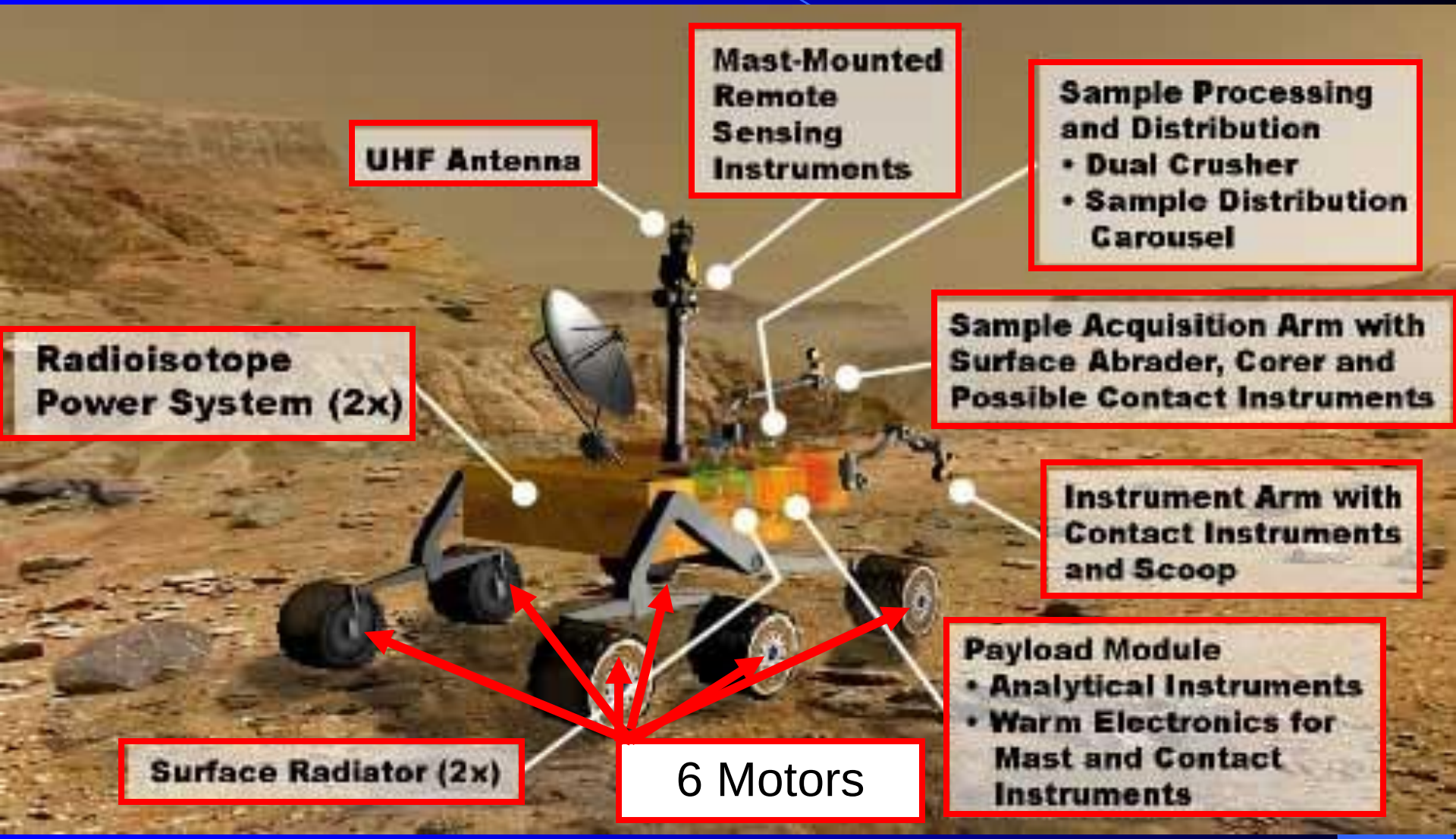


Image from: Young, A.H. ***Lunar and planetary rovers: the wheels of Apollo and the quest for mars***, Springer; 1 edition, August 1, 2006.

ELECTRICAL POWER

SOLAR POWER GENERATION POTENTIAL OK

DISTANCES FROM SUN:

To Moon = ~1 AU (Astronomical Unit)
To Mars = 1.524 AU
To Europa = ~5.203 AU

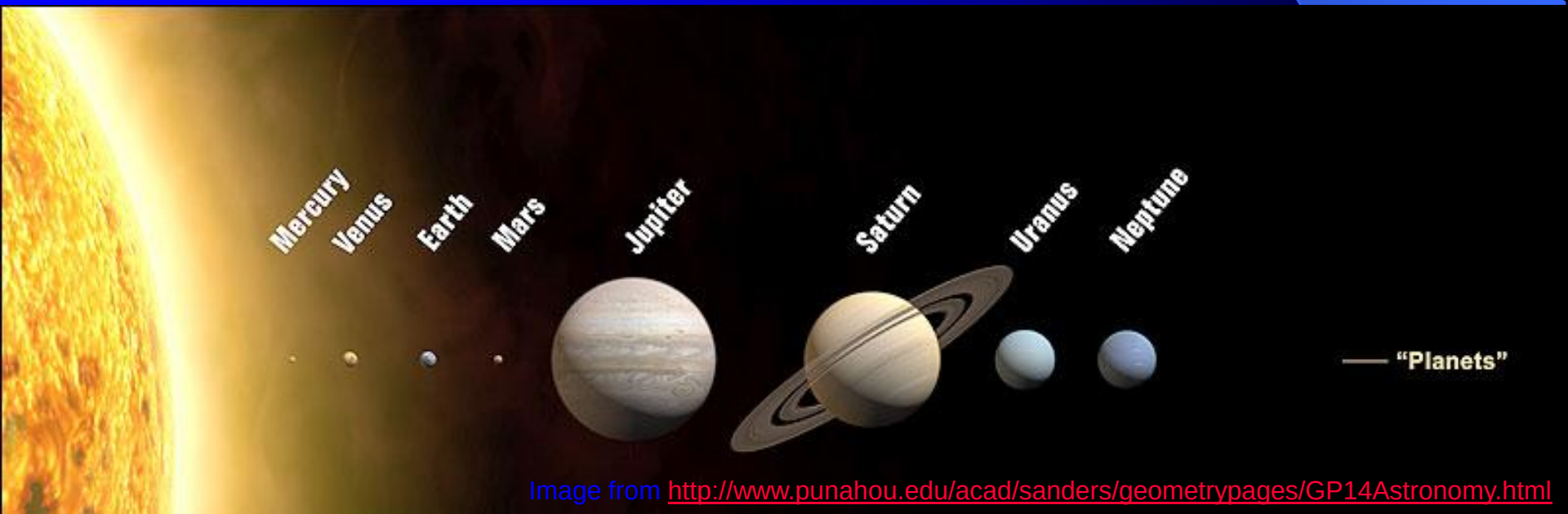


Image from http://www.punahou.edu/acad/sanders/geometrypages/GP14Astronomy.html

Mars Rovers

Mars Science Lab

ELECTRICAL POWER

Nuclear Power

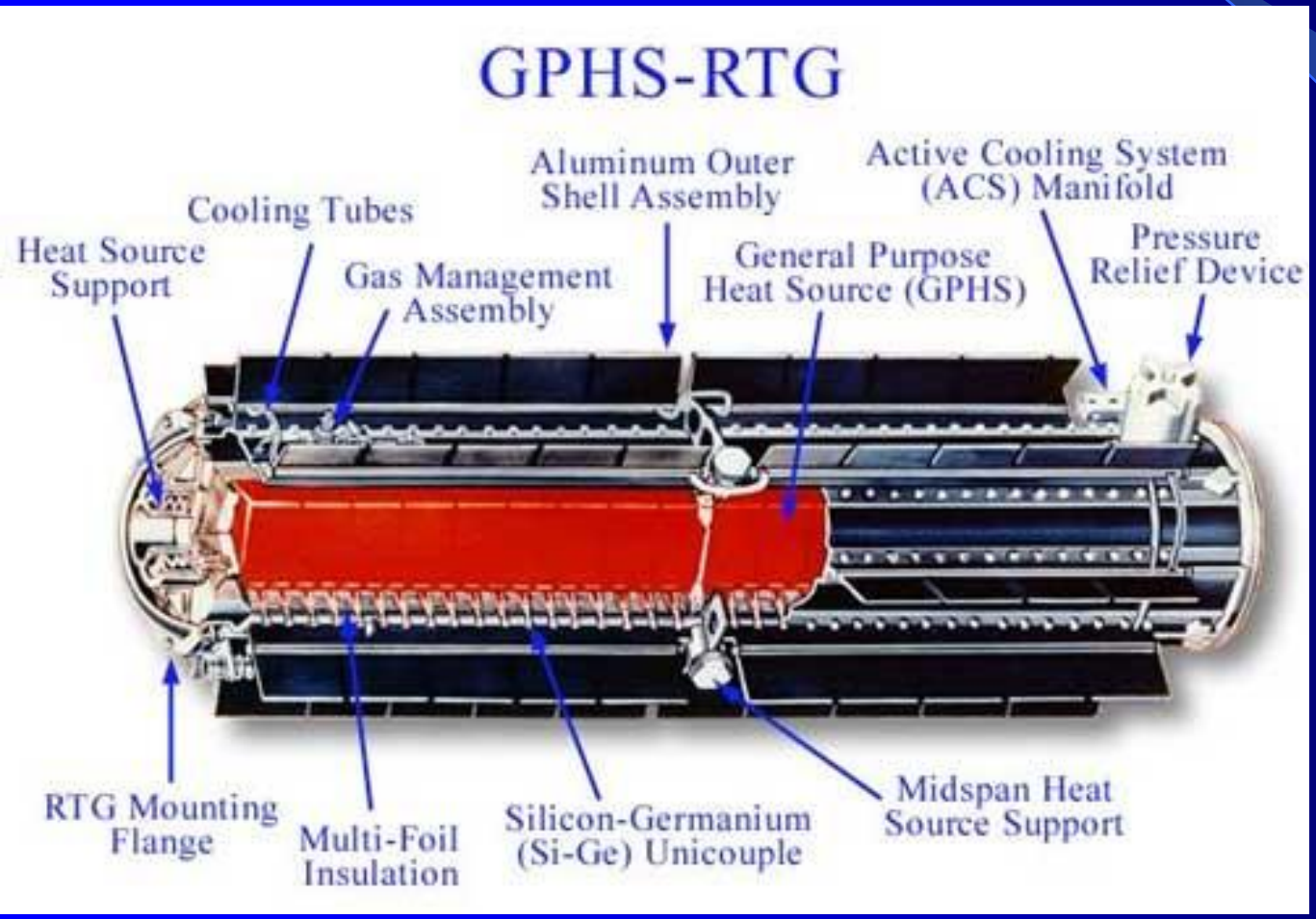


Image from: http://www.space4peace.org/mars/nuke_mars_rover.htm

Nuclear not dependent on Martian day and seasons that effect solar collection

And
there is no need to worry about rover path as a function of obtaining best solar angles

Europa Rover

ELECTRICAL POWER

SOLAR POWER GENERATION
WOULD BE DIFFCULT

DISTANCES FROM SUN:

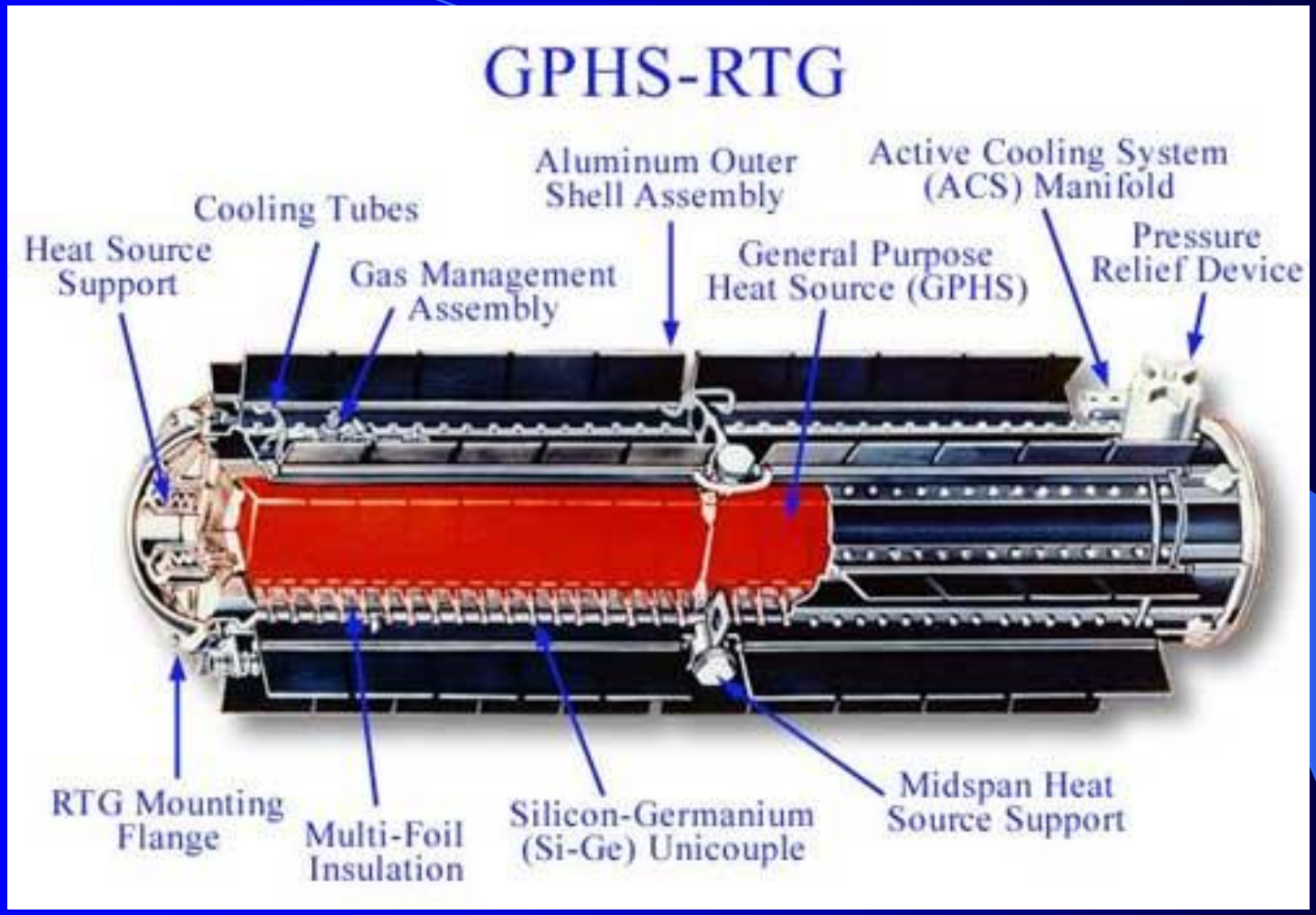
To Moon = ~1 AU (Astronomical Unit)
To Mars = 1.524 AU
To Europa = ~5.203 AU

Optional course project Concept Paper
See course syllabus for details

Image from http://www.punahou.edu/acad/sanders/geometrypages/GP14Astronomy.html

Radioisotope Thermoelectric Generators

ELECTRICAL POWER



See more on these small nuclear power sources (**Radioisotope Thermoelectric Generators**) used in space exploration since 1961 at:
http://solarsystem.nasa.gov/multimedia/downloads/Standard_RPS_Report_Final_011205.pdf

Image from: http://www.space4peace.org/mars/nuke_mars_rover.htm