N87-17756

MANNED MARS MISSION
SURFACE TRANSPORTATION ELEMENTS

S. Gregg McDaniel
Jack Mulqueen
Marshall Space Flight Center
Marshall Space Flight Center, AL

ABSTRACT

The necessity and advantage of surface transportation was well demonstrated by the Apollo 15, 16, and 17 missions. Baseline surface transportation elements for further studies are Lunar Rover, Elastic Loop Mobility System, Mobile Laboratory, Airplane, and Rocket Powered Flying Vehicles.

INTRODUCTION

Metabolic expenditures required for walking and working are predicted to be nearly the same on Mars as Apollo missions were on the lunar surface. The supporting evidence for this is that most of the effort for movement was exerted in simply overcoming the suit resistance. The difference in gravity (Mars vs. Moon) will be equalled by the less resistive suits being developed. For the lunar surface, normal walking required an average expenditure of 950 BTUs per hour. Fast walking required 1400-1500 BTUs per hour. These rates increased when coupled with even slight hill climbing or obstacle negotiation. A more desirable expenditure would be approximately 550 BTUs per hour. The desire for lower metabolic rates and additional speed, range, and science equipment for data gathering indicate the need for surface transportation.

DISCUSSION

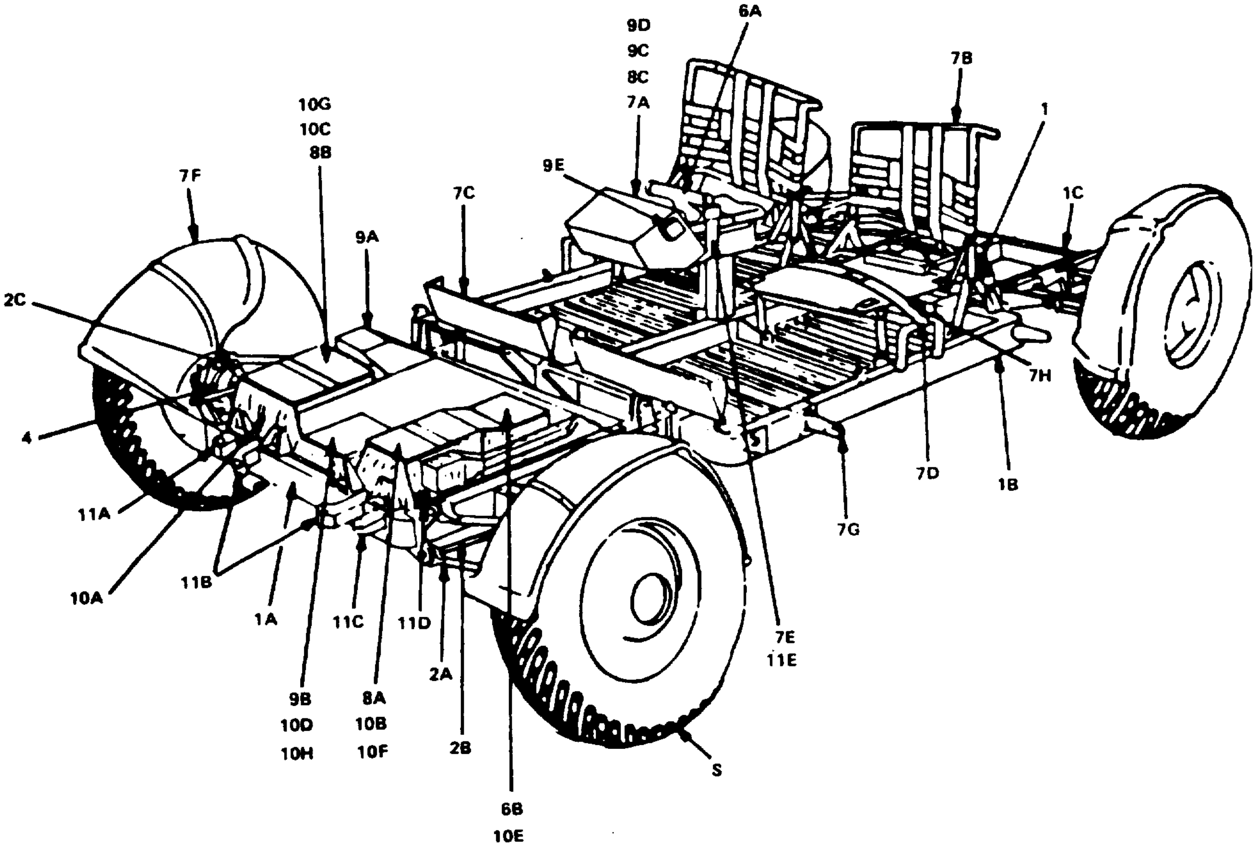
Surface Rovers

The most developed form of surface transportation is the surface rover. The advantage of surface rovers was well demonstrated by the Apollo 15, 16, and 17 missions. Two classes of surface rovers are discussed.

Small Rovers

The small two-man type rover would be applicable to all types of missions (Sortie, Mobile-base, Fixed-base). A candidate small rover is obviously the MSFC-developed wheeled Lunar Roving Vehicle[1] (LRV). See Figure 1. The LRV specifications are: (1) 1014 kilograms (460 pounds), (2) 2381 kilograms (1080 pounds carrying capacity), (3) 78 hours life-

3099–85



1 CHASSIS

- A. FORWARD CHASSIS
- B. CENTER CHASSIS
- C. AFT CHASSIS

2 SUSPENSION SYSTEM

- A. SUSPENSION ARMS (UPPER AND LOWER)
- B. TORSION BARS (UPPER AND LOWER)
- C. DAMPER

3 STEERING SYSTEM (FORWARD AND AFT)

4 TRACTION DRIVE

5 WHEEL

6 DRIVE CONTROL

- A. HAND CONTROLLER
- B. DRIVE CONTROL ELECTRONICS (DCE)

7 CREW STATION

- A. CONTROL AND DISPLAY CONSOLE
- B. SEAT
- C. FOOTREST
- D. OUTBOARD HANDHOLD
- E. INBOARD HANDHOLD
- F. FENDER
- G. TOEHOLD
- H. SEAT BELT

8 POWER SYSTEM

- A. BATTERY #1
- B. BATTERY #2
- C. INSTRUMENTATION

9 NAVIGATION

- A. DIRECTIONAL GYRO UNIT (DGU)
- B. SIGNAL PROCESSING UNIT (SPU)
- C. INTEGRATED POSITION INDICATOR (IPI)
- D. SUN SHADOW DEVICE
- E. VEHICLE ATTITUDE INDICATOR

10 THERMAL CONTROL

- A. INSULATION BLANKET
- B. BATTERY NO. 1 DUST COVER
- C. BATTERY NO. 2 DUST COVER
- D. SPU DUST COVER
- E. DCE THERMAL CONTROL UNIT
- F. BATTERY NO. 1 RADIATOR
- G. BATTERY NO. 2 RADIATOR
- H. SPU THERMAL CONTROL UNIT

11 PAYLOAD INTERFACE

- A. TV CAMERA RECEPTACLE
- B. LCRU RECEPTACLE
- C. HIGH GAIN ANTENNA RECEPTAC
- D. AUXILIARY CONNECTOR
- E. LOW GAIN ANTENNA RECEPTAC

LRV WITHOUT STOWED PAYLOAD
FIGURE 1

time, (4) 92 Km total range, (5) Two 36-volt silver-zinc batteries, (6) Obstacle negotiation: (a) 30 centimeters (one-foot) high from standing start with both front wheels in contact, (b) 71 centimeters (28-inch) crevasse, and (c) 25 degree slope.

The obstacle-negotiation limits are prohibitive, especially for surfaces similar to the Viking I and II landing sites. A redesign using the LRV as a baseline would be prudent. Changes would need to include wheel size and power requirements.

Another candidate for the small rover is the MSFC-developed Elastic Loop Mobility System[2] (ELMS), a tracked vehicle without the conventional "tracks" shortcomings of high internal losses, mechanical complexity, and heavy weight. See Figure 2. The advantages over wheeled vehicles are: (1) High static stability through low c.g. location, (2) Better traction in soft soil which results in better slope climbing capability, (3) Reduced drive torque requirements for obstacle negotiation, (4) Simpler stowage and deployment concept, and (5) Smoother ride characteristics due to large footprint.

ELMS obstacle negotiation: (1) 30 degree slope, (2) 46 centimeters (>18 inch) step obstacle, and (3) 102 centimeters (40 inch) crevasse.

Further development is desirable for manned expeditions with surface conditions similar to the Viking I and II landing sites.

Large Mobile Laboratories

The mobile laboratory[3] (MOLAB), whether two-man or three-man, would be applicable to the fixed-base mission. The MOLAB should be capable of traversing a relatively smooth surface. The small rover would be used to gather specimens and data from the less friendly regions. The MOLAB should also be capable of maintaining astronaut life support and science equipment, including a mini-laboratory, for 30 days with a range of 100 Km.

Atmospheric Rovers

Greater range is a desirable for exploration of the Martian surface. Range extension can be achieved by taking advantage of the atmosphere and low gravity. A probable requirement for an atmospheric vehicle would be the vertical take-off and landing (VTOL) capability (this requirement could perhaps be eliminated for the fixed-base mission).

3100–85

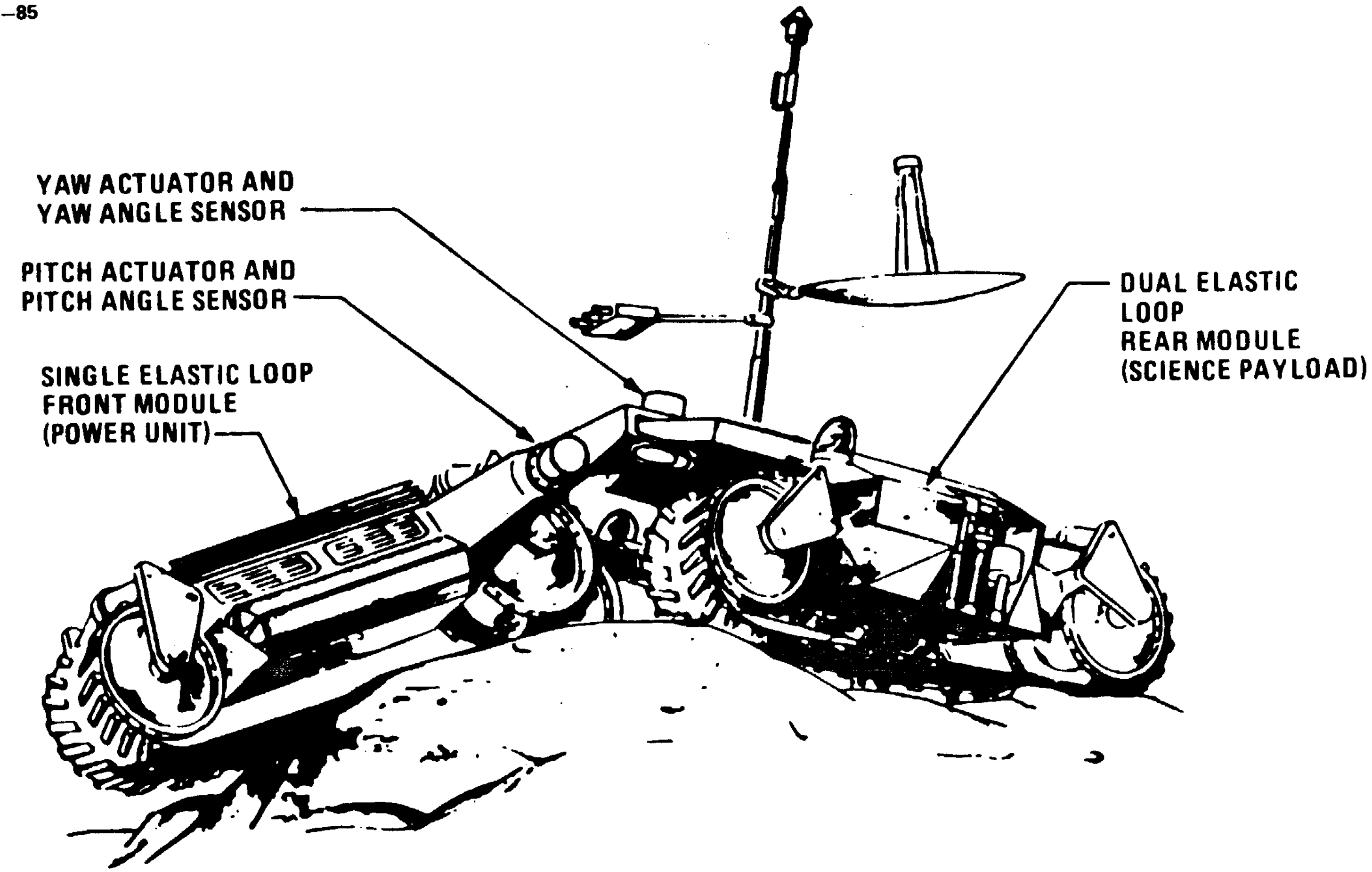


FIGURE 2
ELASTIC–LOOP MOBILITY SYSTEM (ELMS)

Helicoptor

A Martian helicopter was investigated and deemed inappropriate due to basic aerodynamic lift requirements and thin Martian atmosphere.

Airplane

A baseline has been established in the JPL design[4]. Some changes to be considered are: (1) Manned operability, (2) Load carrying weight, and (3) VTOL capability.

Preliminary missions to determine atmospheric conditions at various altitudes would be required.

Rocket Powered Flying Vehicles

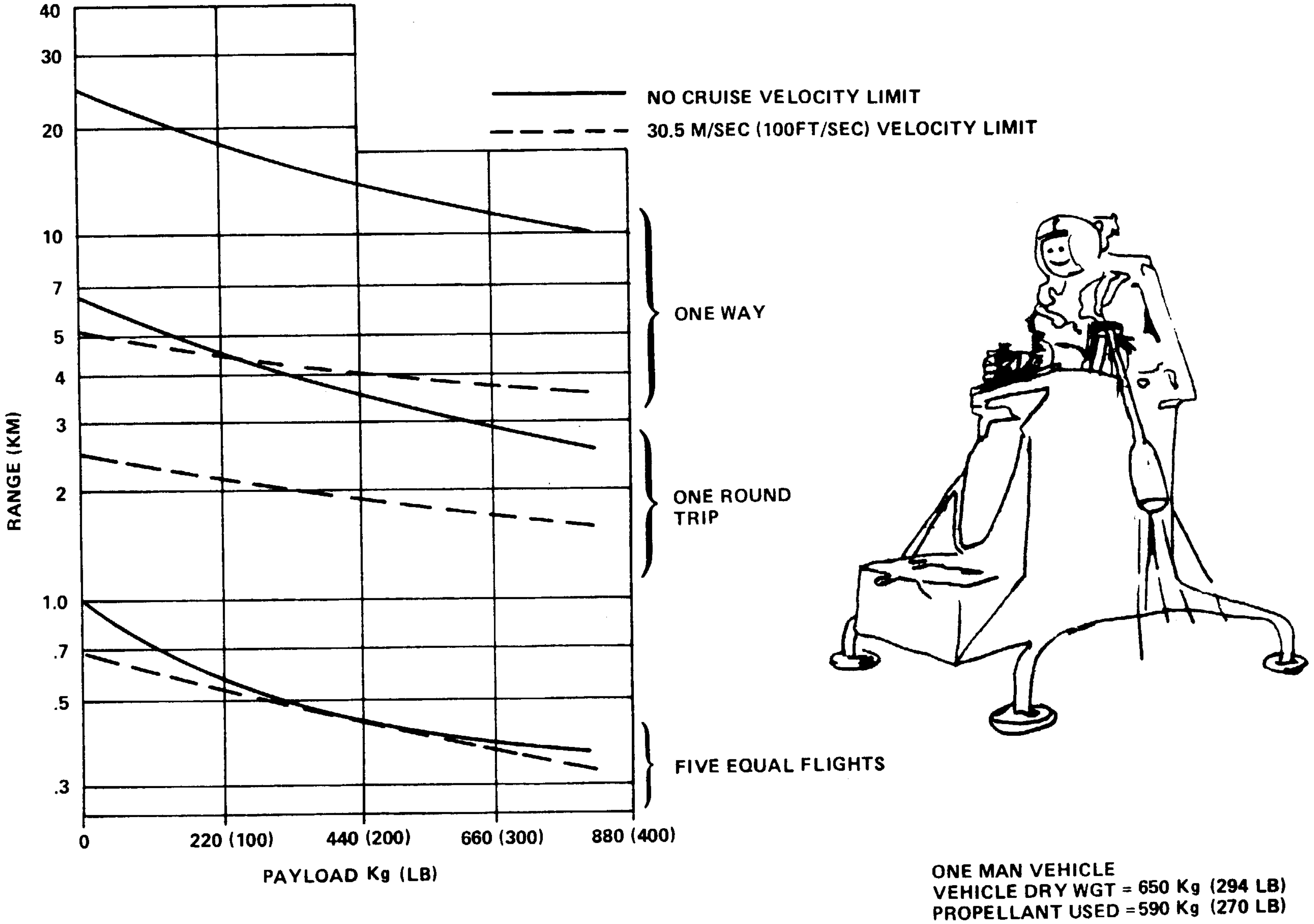
Rocket powered flying vehicles offer some advantages over surface vehicles since they do not have to contend with many of the obstacles on the rugged martian surface. This type of vehicle has many applications and can range in size from one-man platforms to mobile bases.

A one-man vehicle similar to a one-man flying vehicle shown in Figure 3 could aid in increasing the mobility of the astronauts in the vicinity of the Mars base. This vehicle is propelled by two side mounted rockets and is controlled manually by the pilot. The graph in Figure 3 shows that this type of vehicle would have a payload of several hundred pounds and a range of 1 to 7 kilometers.

A larger rocket powered flying vehicle could be designed to carry two astronauts over greater distances. Such a vehicle could be patterned after the Apollo Lunar Ascent Module[6]. It would have a dry weight of about 11,000 kilograms (5,000 pounds) and a gross weight on the order of 22,000 kilograms (10,000 pounds). This type of vehicle would have a round trip range of 20 to 100 kilometers as shown in Figure 4.

A final option for rocket powered flying vehicles would be to provide mobile bases on the surface of Mars. These vehicles would be fairly large, with a dry weight of about 88,100 kilograms (40,000 pounds) and a one way range on the order of 500 to 800 kilometers as shown in Figure 5. This type of vehicle would require large amounts of propellants and would have a gross weight near 220,400 kilograms (100,000 pounds). As manned presence on Mars increases and propellant is manufactured on Mars this option may prove beneficial.

ROCKET POWERED FLYING VEHICLE PERFORMANCE



ONE MAN VEHICLE
VEHICLE DRY WGT = 650 Kg (294 LB)
PROPELLANT USED = 590 Kg (270 LB)

FIGURE 3

5136–85

VEHICLE GROSS WEIGHT AS A FUNCTION OF VEHICLE DRY WEIGHT FOR A ROCKET POWERED MARS FLYING VEHICLE

- I_{SP} = 300 SEC
- ASSUME BALLISTIC TRAJECTORIES
- ROUND TRIP

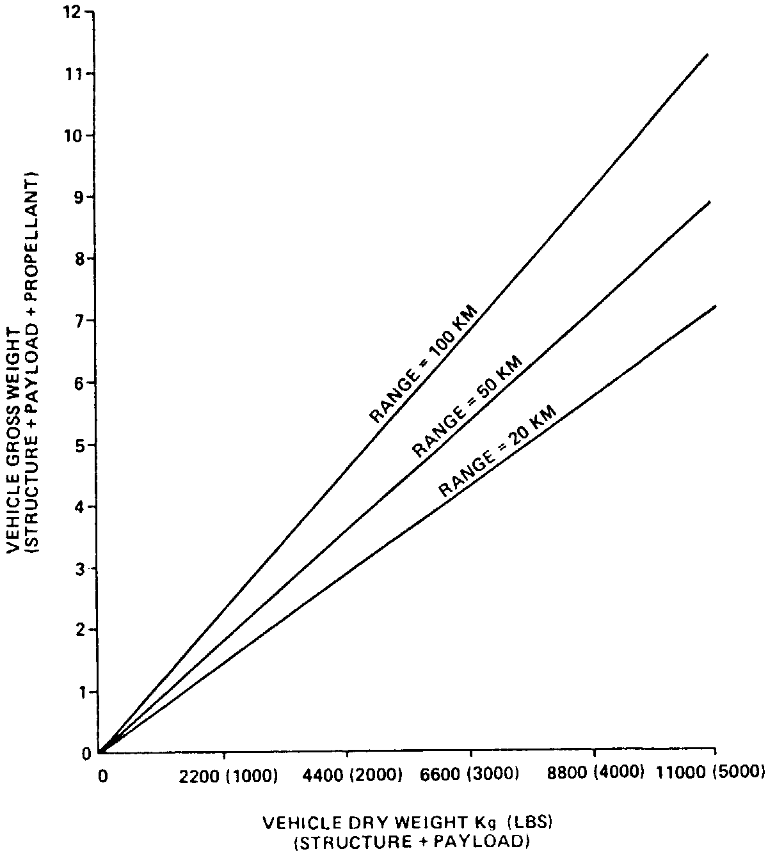


FIGURE 4

5135–85

VEHICLE GROSS WEIGHT AS A FUNCTION OF VEHICLE DRY WEIGHT FOR A ROCKET POWERED MARS FLYING VEHICLE

- I_{SP} = 300 SEC
- ASSUME BALLISTIC TRAJECTORY
- ONE WAY TRIP

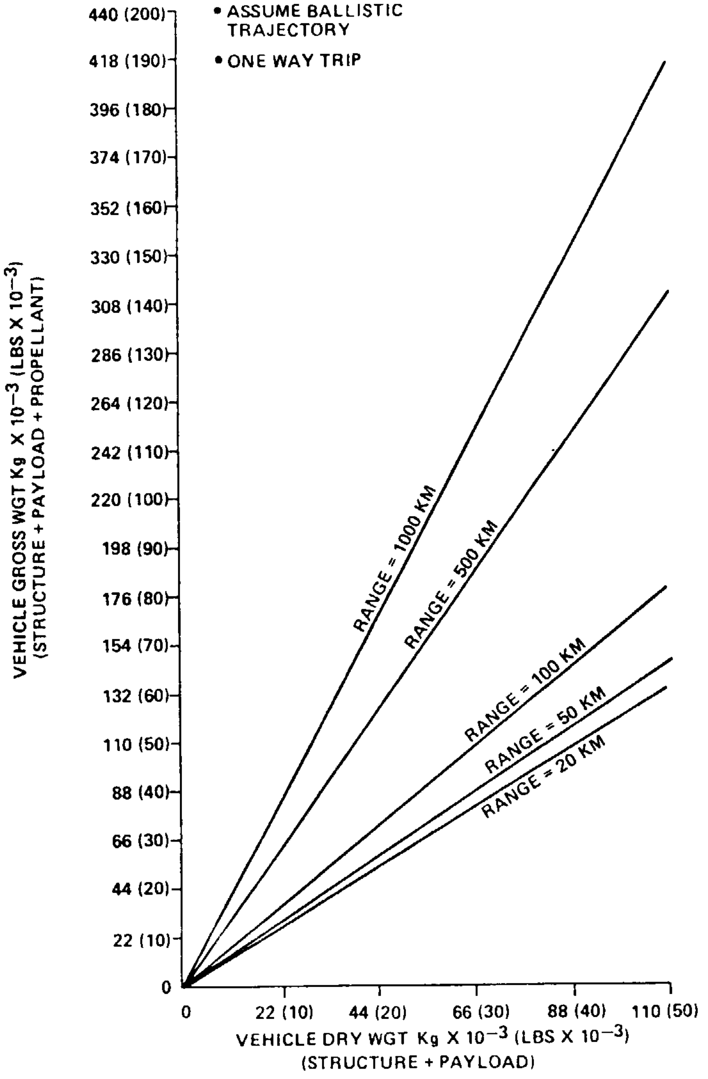


FIGURE 5

CONCLUSION

Starting points for further in-depth studies of surface transportation elements have been identified. For ground rovers, tracked vehicles of the ELMS nature look promising. For atmospheric rovers, Rocket Powered Vehicles with VTOL capabilities could prove quite beneficial.

REFERENCES

1. "Lunar Roving Vehicle", Boeing
2. "Performance Evaluation of a Second-Generation Elastic Loop Mobility System", K.J. Melzer and G.D. Swanson, U.S. Army Engineer Waterways Experiment Station
3. "Lunar Surface Mobility Systems Comparison and Evolution Study (MOBEV)", Bendix, October 1966
4. "Airplane", V. Clarke, Jet Propulsion Laboratory, Pasadena, CA
5. "One-Man Lunar Flying Vehicle Study", Final Review, Bell Aerostems, NASA-CR-101943, July 1969.
6. Childs, A. Gary and Ernest S. Armstrong, "Analysis of Maximum Range Trajectories for a Rocket-Propelled Lunar Flying Vehicles in a Uniform Gravitation Field", NASA-TN-D-5475, October 1969.