

#### **METC 111**

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## Original Earth Design and Dimensions to Lift A 5 ton Military Truck

|               | Platform and C | able Dimension  | IS             |              |      |  |
|---------------|----------------|-----------------|----------------|--------------|------|--|
| Length        | 353-4          | inches          |                |              |      |  |
| Width         | inches143.5    |                 |                |              |      |  |
| Height        | 230            | inches          |                |              |      |  |
| Distance from | Dead Center of | Platform to Cal | ble attachment | at each corn | ner= |  |
| Actual Length | of Cable=      |                 |                |              |      |  |
| Ū             |                |                 |                |              |      |  |

3245.049

190.7117 inches 298.7825 inches

Cable Angle from platform=50.33511°This spreadsheet has been designed to calculatethe forces in cables when lifting a M939 5 tonmilitary vehicle that has been driven onto aplatform that can be lifted by a 25' cable thatsplits into 4 individual cables that attach at eachcorner of the platform. The platform is assumedto be the L\*W of the vehicle, plus 20% of the H inall directions. The single supporting cable makesits split into 4 cables at 200% of H above theplatform.

Force per Cable=

 $q_{15}$   $p_{3}$   $p_{$ 

## Mars Cable Calculations

| A= 17   | 76.5 i | 71.25 j                                     | -230   | k  | rAA=  | 298.5   |   |   |   |                     |                      |              |               |                            |        |
|---|--------|---|--|--|---|---|---|---|---|---------------------|----------------------|--------------|---------------|----------------------------|--------|
| B = 17  | 76.5 i | -71.25 j                                    | -230   | k  | rAB =   | 298.5   | W =   | -3773   | lb  |                     |                      |              |               |                            |        |
| C = -17                                       | 76.5 i | -71.25 j                                    | -230   | k  | rAC =   | 298.5   | Fx =  | 0.591201666   | FB  | -0.591201666        | FC                   | -0.5912      | FD            | 0.591201666                | FA     |
| D = -17                                       | 76.5 i | 71.25 j                                     | -230   | k  | rAD =   | 298.5   | Fy =  | -0.238657897  | FB  | -0.238657897        | FC                   | 0.238658     | FD            | 0.238657897                | FA     |
|   |        |   |  |  |   |   | Fz =  | -0.770404438  | FB  | -0.770404438        | FC                   | -0.7704      | FD            | -0.770404438               | FA     |
|   |        |   |  |  |   |   |   |   |   |                     |                      |              |               |                            |        |
|   |        |   |  | ned to calcula   |   |   |   |   |   |                     |                      |              |               |                            | -      |
|   |        | •   |  | ary vehicle tha<br>d by a 25' cabl   |   |   |   |   |   |                     |                      |              |               |                            |        |
|   | •      |   |  | ly attach at eac   |   |   | ΣFz=  | -3.081617752  |   | T                   |                      |              | 6             | 40                         |        |
|   |        |   |  | ed to be the L   |   |   | Positive  | 01001017702   |   |                     |                      | YA           |               |                            |        |
|   |        |   |  | s. The single s  |   |   | Force per   | Cable=  | 1224.36   | lbs                 |                      |              | <u> </u>      |                            |        |
|   |        |   |  | 00% of H abov  |   |   |   |   |   |                     |                      | 510          | NO ARTIFICIAL | COLOURS, FLAVOURS          |        |
|   |        |   |  |  |   |   |   |   |   |                     | Cor Strange          | Statement in |               |                            | 3      |
|   |        |   |  |  |   |   |   |   |   |                     | - de                 | STAT A       |               | A MO                       | 1      |
|   |        |   |  | Platform and Ca  | ble Dimen   | sions   |   |   |   |                     |                      | M. Martin    |               |                            |        |
|   |        |   | Length   | 353.4 inch   | es  |   |   |   |   |                     |                      |              |               |                            |        |
|   |        |   | Width  | 143.5 inch   | es  |   |   |   |   |                     |                      |              |               |                            |        |
|   |        |   | Height   | 230 inch   |   |   |   |   |   |                     |                      |              |               |                            |        |
|   |        |   |  |  |   |   |   |   |   |                     |                      |              |               |                            |        |
|   |        |   |  | from Dead Cent   | er of Platfo  | orm to Ca   | ble attachme  | ent at each corner=   | 190.71  | inches              |                      |              |               |                            |        |
|   |        |   |  | from Dead Cent<br>ngth of Cable=   | er of Platfo  | orm to Ca   | ble attachme  | ent at each corner=   |   | inches              | α=                   | 0.000023     |               | L=α*L*ΔT                   |        |
|   |        |   | Actual Le  | ngth of Cable=   |   |   | ble attachme  | ent at each corner=   |   | inches              | α=<br>Orignal Temp ( |              |               | L=α*L*ΔT<br>Prignal Length | 300 in |
|   |        |   | Actual Le  |  |   |   | ble attachme  | ent at each corner=   |   | inches              |                      |              |               |                            | 300 in |
|   |        |   | Actual Le  | ngth of Cable=   |   | 11 °  |   |   | 298.78  | inches              |                      |              |               |                            | 300 in |
|   |        |   | Actual Le  | ngth of Cable=   |   | L1 °  | esign with co   | nsideration for usag  | 298.78<br>e on Mar  | s.                  |                      |              |               |                            | 300 in |
| OBJEC   | TAC    | CELERATI                                    | Actual Le<br>Cable An  | ngth of Cable=   | m: 50.3351  | Cable d<br>1.) Con  | esign with co   |   | 298.78<br>e on Mar<br>nversior  | s. 5                |                      |              |               |                            | 300 in |
|   |        |   | Actual Le<br>Cable An<br>ON DUE  | ngth of Cable=<br>gle from platfor   | m: 50.3351  | Cable de<br>1.) Con<br>Tons = 4<br>to gravi   | esign with co<br>vert the 5 to<br>I535.92 kg→<br>ty on Mars of  | nsideration for usag  | 298.78<br>e on Mar<br>nversior<br>celeratio   | inches              |                      |              |               |                            | 300 in |
| Earth   |        | 9.8 m                                       | Actual Le<br>Cable An<br>ON DUE  | ngth of Cable=<br>gle from platfor<br>FO GRAVITY (   | m: 50.3351<br>GRAVITY<br>1 G                                    | Cable d<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc   | esign with co<br>vert the 5 too<br>I535.92 kg→<br>ty on Mars of<br>bunds  | nsideration for usag<br>1s to kg for easier cc<br>4535.92 kg times acc<br>5 3.7 m/s² = 16783 N  | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons   | inches              |                      |              |               |                            | 300 in |
| Earth   |        | 9.8 m                                       | Actual Le<br>Cable An<br>ON DUE  | ngth of Cable=<br>gle from platfor<br>FO GRAVITY (   | m: 50.3351  | Cable d<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc<br>2.) Alun   | esign with co<br>vert the 5 tor<br>IS35.92 kg→<br>ty on Mars of<br>uunds<br>ninum was se  | nsideration for usag<br>ns to kg for easier co<br>4535.92 kg times aco<br><sup>5</sup> 3.7 m/s <sup>2</sup> = 16783 N<br>elected as the cable r   | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>material   | s.<br>h. 5<br>n due |                      |              |               |                            | 300 in |
| Earth   |        | 9.8 m<br>1.6 m                              | Actual Le<br>Cable An<br>ON DUE  | ngth of Cable=<br>gle from platfor<br>TO GRAVITY (<br>t/s <sup>2</sup><br>t/s <sup>2</sup>   | m: 50.3351<br>GRAVITY<br>1 G                                    | Cable d<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc<br>2.) Alun<br>because  | esign with co<br>vert the 5 to<br>I535.92 kg→<br>ty on Mars of<br>unds<br>ninum was se<br>e of its stabili  | nsideration for usag<br>1s to kg for easier cc<br>4535.92 kg times acc<br>5 3.7 m/s² = 16783 N  | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>naterial<br>cold(*-19  | s.<br>h. 5<br>n due |                      |              |               |                            | 300 in |
| Earth<br>the Moon                             | n      | 9.8 m<br>1.6 m<br>3.7 m/                    | Actual Le<br>Cable An<br>ON DUE 7<br>Vs <sup>2</sup> or 32 f   | ngth of Cable=<br>gle from platfor<br>TO GRAVITY (<br>t/s <sup>2</sup><br>t/s <sup>2</sup><br>ft/s <sup>2</sup>                            | m: 50.3351<br>GRAVITY<br>1 G<br>.16 G                           | Cable du<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc<br>2.) Alun<br>because<br>conditio<br>Centere  | esign with co<br>vert the 5 to<br>I535.92 kg→<br>ty on Mars of<br>vunds<br>ninum was se<br>of its stabili<br>ons present c<br>ed Cubic cryst  | nsideration for usag<br>ns to kg for easier co<br>4535.92 kg times acc<br>3.7 m/s <sup>2</sup> = 16783 N<br>elected as the cable r<br>ty in the extremely o<br>n Mars because of it<br>caline structure.  | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>material<br>cold(*-19<br>cs Face                                     | inches              |                      |              |               |                            | 300 in |
| Earth<br>the Moor<br>Mars                     | n      | 9.8 m<br>1.6 m<br>3.7 m/<br>9.5 m           | Actual Le<br>Cable An<br>ON DUE 7<br>Vs <sup>2</sup> or 32 ft<br>Vs <sup>2</sup> or 5.3 ft   | ngth of Cable=<br>gle from platfor<br>t/s <sup>2</sup><br>ft/s <sup>2</sup><br>t/s <sup>2</sup>  | m: 50.3351<br>GRAVITY<br>1 G<br>.16 G<br>.38 G                  | Cable di<br>1.) Con<br>Tons = 2<br>to gravi<br>3773 pc<br>2.) Alun<br>because<br>conditio<br>Centere<br>3.) Base                                    | esign with co<br>vert the 5 to<br>1535.92 kg→<br>ty on Mars of<br>unds<br>ninum was se<br>of its stabili<br>ons present c<br>ed Cubic crysi<br>ed on the col  | nsideration for usag<br>ns to kg for easier co<br>4535.92 kg times aco<br>i 3.7 m/s <sup>2</sup> = 16783 N<br>elected as the cable n<br>ty in the extremely o<br>n Mars because of it   | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>material<br>cold(*-19<br>s Face<br>aluminur                          | inches              |                      |              |               |                            | 300 in |
| Earth<br>the Moor<br>Mars<br>Venus<br>Jupiter |        | 9.8 m<br>1.6 m<br>3.7 m/<br>9.5 m<br>24.5 r | Actual Le<br>Cable An<br>ON DUE 7<br>$\sqrt{s^2 \text{ or } 32 \text{ f}}$<br>$\sqrt{s^2 \text{ or } 5.3 \text{ f}}$<br>$\sqrt{s^2 \text{ or } 12.2}$<br>$\sqrt{s^2 \text{ or } 31 \text{ f}}$<br>$m/s^2 \text{ or } 80 \text{ f}$ | ngth of Cable=<br>gle from platfor<br>t/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup> | m: 50.3351<br>GRAVITY<br>1 G<br>.16 G<br>.38 G<br>.88 G<br>2.54 | Cable di<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc<br>2.) Alun<br>because<br>conditio<br>Centere<br>3.) Base<br>shrink 1                        | esign with co<br>vert the 5 too<br>IS35.92 kg→<br>ty on Mars of<br>unds<br>ninum was se<br>e of its stabili<br>ons present o<br>ed Cubic cryst<br>ed on the col<br>3/4 inches, i                    | nsideration for usag<br>ns to kg for easier cc<br>4535.92 kg times acc<br>3.7 m/s <sup>2</sup> = 16783 N<br>elected as the cable r<br>ty in the extremely c<br>in Mars because of it<br>aline structure.<br>d temperature, the a  | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>material<br>old(*-19<br>s Face<br>aluminur<br>the angl               | inches              |                      |              |               |                            | 300 in |
| Earth<br>the Moon<br>Mars<br>Venus            |        | 9.8 m<br>1.6 m<br>3.7 m/<br>9.5 m<br>24.5 r | Actual Le<br>Cable An<br>ON DUE $T$<br>$s^2$ or 32 f<br>$s^2$ or 5.3 f<br>$s^2$ or 12.2<br>$s^2$ or 12.2   | ngth of Cable=<br>gle from platfor<br>t/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup><br>ft/s <sup>2</sup> | m: 50.3351<br>GRAVITY<br>1 G<br>.16 G<br>.38 G<br>.88 G         | Cable di<br>1.) Con<br>Tons = 4<br>to gravi<br>3773 pc<br>2.) Alun<br>because<br>conditio<br>Centere<br>3.) Base<br>shrink 1<br>indicate<br>account | esign with ca<br>vert the 5 to<br>1535.92 kg→<br>ty on Mars of<br>ounds<br>ninum was se<br>e of its stabili<br>ons present o<br>ed Cubic cryst<br>ed on the col<br>3/4 inches, i<br>ed, this shrini | nsideration for usag<br>ns to kg for easier co<br>4535.92 kg times acc<br>3.7 m/s <sup>2</sup> = 16783 N<br>elected as the cable i<br>ty in the extremely of<br>n Mars because of it<br>caline structure.<br>d temperature, the i<br>n order to maintain<br>kage needed to be ta<br>inum cable needs to | 298.78<br>e on Mar<br>nversior<br>celeratio<br>ewtons<br>material<br>cold(*-19<br>cs Face<br>aluminur<br>the angl<br>ken into | inches              |                      |              |               |                            | 300 in |

# Cable design with consideration for usage on Mars.

#### 1.) Convert the 5 tons to kg for easier conversion. 5 Tons \* .38 = 1.9 Tons.

| ODJECI   | ACCELERATION DUE TO GRAVITT                        | GRAVIII |
|----------|--|---------|
| Earth    | 9.8 m/s <sup>2</sup> or 32 ft/s <sup>2</sup>       | 1 G     |
| the Moon | $1.6 \text{ m/s}^2 \text{ or } 5.3 \text{ ft/s}^2$ | .16 G   |
| Mars     | $3.7 \text{ m/s}^2$ or 12.2 ft/s $^2$              | .38 G   |
| Venus    | 9.5 m/s <sup>2</sup> or 31 ft/s <sup>2</sup>       | .88 G   |
| Jupiter  | $24.5 \text{ m/s}^2 \text{ or } 80 \text{ ft/s}^2$ | 2.54    |
| the Sun  | $275 \text{ m/s}^2$ or 896 ft/s $^2$               | 28 G    |

#### OBJECT ACCELERATION DUE TO GRAVITY GRAVITY

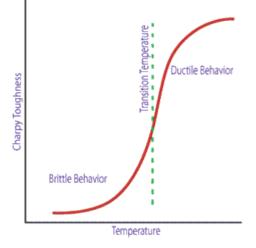
| α=           | 23.0E-6 | ΔL=α*L*ΔΤ | Orignal Length | 300.53 in | -1 3/4 |
|--------------|---------|-----------|----------------|-----------|--------|
| Orignal Temp | 68°F    |           |                |           |        |

3.) Based on the cold temperature, the aluminum will shrink 1 3/4 inches, in order to maintain the angles indicated, this shrinkage needed to be taken into account, so the aluminum cable needs to be cut at a length of 300.53 inches at 68°F.

### Why not a steel cable?

Steels with ferritic or martensitic structures show a sudden change from ductile (safe) to brittle (unsafe) fracture over a small temperature difference. Even the best of these steels show this behavior at temperatures higher than -100 deg C and in many cases only just below zero

This produces a graph of impact toughness for the material as a function of temperature. An impact toughness versus temperature graph for a steel is shown in the image. It can be seen that at low temperatures the material is more brittle and impact toughness is low. At high temperatures the material is more ductile and impact toughness is higher. The transition temperature is the boundary between brittle and ductile behavior and this temperature is often an extremely important consideration in the selection of a material.



## The cable size on Mars is 1/16 in. with Aluminum

|                              | Ε=σ/ε      |     |                  | For Al |
|------------------------------|------------|-----|------------------|--------|
| AI =                         | 10,000,000 | PSI | CSA =            | 1.2E-3 |
| Vehicle weight =             | 1          | ton | <br>Cable size = | 1/16   |
| Vehicle weight =             | 1,200      | lbs |                  |        |
|                              |            |     |                  |        |
| Given =                      | 25         | ft  |                  |        |
| Maximum Allowed elongation = | 10%        |     |                  |        |
| max final length =           | 27.5       | ft  |                  |        |
| no plastic deformation       |            |     |                  |        |
| all materials cost the same  |            |     |                  |        |
| ignore cost of material      |            |     |                  |        |
| ignore weight of structure   |            |     |                  |        |
|                              |            |     |                  |        |
| Assumptions                  | 10%        |     |                  |        |
| Allowed Strain =             | 0.10       |     |                  |        |

 \* 1.) Aluminum was selected as the cable material because of its stability in the extremely cold(\*-195°F) conditions present on Mars because of its Face Centered Cubic crystalline structure.



- With a truck that weighs 5 tons on Earth it will only weigh 1.9 tons on Mars.
- Aluminum is the ideal metal for use the aerospace industry.
- Overall an 1/16 cable would do the job to carry a 2 ton truck on Mars.



## Cable Design