**The Many Questions of Rocketman**

**with sample inputs from**

**HLV • 4-6/2-6**•MK.3-30 Ver**:** 03-27-2017

**Part 1: The Specs**

***Note: the program will repetitively ask “Discard changes and edit this field again? [y/N]”***

***Just say N or hit enter unless you want to go back and reenter all the data since that question was last asked.***

Do you want to create a new spec file? [y/N] Y

What is the vehicle called (for example: HLV \* 4-8/6-9)? HLV \* 4-6/2-6

MK? 3-30

What is the HLV Gross Lift-Off Weight in Lbm? 15,649,473.68

Does the rocket have a SRB? [Y/n] Y

Does the rocket have a LFB? [y/N] N

What is the ADC K of the SRB? 0.19

What is the weight of the SRB? 6,374,000

How much weight was used during preburn from the SRB? 0

What is the jettison weight of the SRB? <not listed for this example, calculated value>

What is the ADC K of the RLV? 0.701

What is the weight of the RLV? 7,700,000

How much weight was used during preburn from the RLV? <not listed for this example, calculated value>

What is the jettison weight of the RLV? 1,128,263

What is the ADC K of the orbiter? 0.3130

What is the weight of the orbiter? 1,600,000

How much weight was used during preburn from the orbiter? <not listed for this example, calculated value>

earth rotation mph (hit enter for the default value of 912.67)? 912.67

SRB

Select an engine number to add to the SRB:

1) SRM

2) SRMU

3) Finished entering SRB engines

Select an SRB engine number: 1

How many SRMs? 4

Select an engine number to add to the SRB:

1) SRM

2) SRMU

3) Finished entering engines

Select an SRB engine number: 3

orbiter

Select an engine number to add to the orbiter:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering orbiter engines

Select an engine number to add to the orbiter: 3

How many SSMEs? 6

orbiter

Select an engine number to add to the orbiter:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering orbiter engines

Select an engine number to add to the orbiter: 4

How many RL-10A4-2s? 1

orbiter

Select an engine number to add to the orbiter:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering orbiter engines

Select an engine number to add to the orbiter: 7

RLV

Select an engine number to add to the RLV:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering RLV engines

Select an engine number to add to the RLV: 2

How many RD-171Ms? 6

Select an engine number to add to the RLV:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering RLV engines

Select an engine number to add to the RLV: 6

How many RS-68As? 2

Select an engine number to add to the RLV:

1) OME

2) RD-171M

3) SSME

4) RL-10A4-2

5) RD-180

6) RS-68A

7) Finished entering RLV engines

Select an engine number to add to the RLV: 7

Do you want to make more changes to your engine selections? [y/N] N

Do you want to save these specs? [Y/n] Y

**Part 2: The Flight Profile**

What is the version date (hit enter for today's date)? **03-27-2017**

What is the starting throttle for SRM attached to the SRB [min/max/off/0.0-1.0] **1.0**

What is the starting lbf of thrust per engine for SRM [min/max/off/0-inf] **3,600,000**

What is the starting throttle for SSME attached to the orbiter [min/max/off/0.0-1.0] **0.71**

What is the starting throttle for RL-10A4-2 attached to the orbiter [min/max/off/0.0-1.0] **0**

What is the starting throttle for RD-171M attached to the RLV [min/max/off/0.0-1.0] **0** <thrust at liftoff is not listed/this engine is launching with currently unsupported behavior (one of the engines is lit later)>

What is the starting throttle for RS-68A attached to the RLV [min/max/off/0.0-1.0] **0.76**

What is initial alt? **50**

What is tower height? **300**

What is desired V vert target (typically 2000fps)? **2000** <not listed>

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **8**

Giveback V Vert

Select a V Vert giveback target and time to start reducing V vert.

Event start time: **330** <Not listed>

target

Enter the giveback target V vert in fps (typically 1200fps): **1200** <Not Listed>

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **0**

Event end time: **3**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **4**

target

Enter the target throttle: [min/max/off/0.0-1.0] **.7**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **0**

Event end time: **3**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **5**

target

Enter the target throttle: [min/max/off/0.0-1.0] **max**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **0**

Event end time: **3**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **2**

target

Enter the target throttle: [min/max/off/0.0-1.0] **max**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **3**

Event end time: **6**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **4**

target

Enter the target throttle: [min/max/off/0.0-1.0] **max**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **3**

Change Thrust

Change the lbf of thrust of a SRM by a given rate of change

Event start time: **24**

Event end time: **45**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **1**

rate

Enter the change in lbf of thrust per second (use a negative number for a decrease)

Thrust: **-20000**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **6**

Power Down Thrust

Power down a rocket engine based on thrust. This is only used for solid fueled boosters.

Event start time: **99**

Event end time: **114**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **1**

thrusts

Enter the lbf of thrusts in three second time intervals: 99: **2625000**

Enter the lbf of thrusts in three second time intervals: 102: **2120000**

Enter the lbf of thrusts in three second time intervals: 105: **1498500**

Enter the lbf of thrusts in three second time intervals: 108: **1055000**

Enter the lbf of thrusts in three second time intervals: 111: **568570**

Enter the lbf of thrusts in three second time intervals: 114: **0**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **7**

Jettison

Jettison a stage.

Event start time: **114**

stage

Select a stage:

1) SRB

2) orbiter

3) RLV

Select an stage number: **1**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **136**

Event end time: **139**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **4**

target

Enter the target throttle: [min/max/off/0.0-1.0] **0**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **210.3**

Event end time: **213**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **5**

target

Enter the target throttle: [min/max/off/0.0-1.0] **.676**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **7**

Jettison

Jettison a stage.

Event start time: **213**

stage

Select a stage:

1) SRB

2) orbiter

3) RLV

Select an stage number: **3**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **1**

Set Throttle Target

Set the target throttle for all engines (regardless of stage) that match a name

Event start time: **213**

Event end time: **213**

engine

Select an engine:

1) SRM

2) SSME

3) RL-10A4-2

4) RD-171M

5) RS-68A

Select an engine number: **3**

target

Enter the target throttle: [min/max/off/0.0-1.0] **1**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **8**

Giveback V Vert

Select a V Vert giveback target and time to start reducing V vert.

Event start time: **213**

target

Enter the giveback target V vert in fps (typically 1200fps): **1200**

Add events to the flight plan:

1) Set Throttle Target

2) Set Target Throttle By Stage

3) Change Thrust

4) Adjust Weight

5) Adjust Acceleration

6) Power Down Thrust

7) Jettison

8) Giveback V Vert

9) Finished entering events

Select an event number: **9**

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**G**ross **V**ehicle **W**t**: 15,674,000** **Lbm** **T**SL = **26,347,341 Lbf** **HLV**SLFuel Burn Rate**:** **96,137.43223** **Lb/S**

**R-SRB: 4 ea: SRM** (**5** segment**,** Solid Rocket Motors) **ADC K**= **0.1900**

**6,374,000 Lbm**  **SRB:** **840,000** **Lbm** (Unfueled)**;**  **6,360,000** **Lbm** (Fueled)

**T**SL= **14,400,000 Lbf**  Fuel Burn Rate**:** **59,504.13** **Lb/S** @ Sea Level

**Solid Fuel: 5,534,000** **Lbm (1,383,500** **Lbm / SRM)**

**Available Fuel: RD: 4,381,546.51 Lbm RS/SS:**  **2,197,210.4** **Lbm** **SRM: 5,520,000** **Lbm**

**RD/RS-RLV:** Winged Reentry Glider with **6 ea:** RD-171M + **2 ea:** RS-68A + **3 ea:** GE90-115B

**7,700,000 Lbm\*** Fuselage**/**FuelTank**:**  **30.00** ft. wide by **296.00** ft. long with **146.67** ft. wingspan **ADC K**= **0.70100**

**166,464.4923** cu. ft. **RLV: 967,600** **Lbm** (Unfueled)**;** **7,700,000** **Lbm** (Fueled) ***166,730.2968*** cu. ft. (fuel capacity)

**Total Fuel: 6,799,000 Lbm** (includes Jet-A **Fuel: 87,855.516** **Lbm**)

**5-**RD-171M **Fuel: 3,390,227.91 Lbm: 3,653,691 Lbm** + **36,536.91 Lbm** (**1.0**% residual) → **134.00**++sec. burn time

**1-**RD-171M **Fuel: 735,134.1 Lbm: 727,855.5 Lbm** + **7,278.6 Lbm** (**1.0**% residual) → **132.90**++(**+1.0** sec.@ **59.50%** T)sec. burn time

**2-**RS-68A **Fuel: 809,553.784 Lbm: 801,538.4 Lbm** + **8,015.384 Lbm** (**1.0**% residual) → **208.30** sec. burn time

**6-**SSME **Fuel: 1,353,877.72 Lbm: 1,340,472.99 Lbm** + **13,404.7299 Lbm** (**1.0**% residual) → **208.3** sec. burn time

**T**sl **=** **11,947,341 Lbf 5** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **7** ea**:** ssme(**95**%T)**; T**VAC= **15,176,737 Lbf** (**6** ea**:** rd-171)

Fuel Burn Rate**:** **36,633.3 Lb/S**  **5** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **6** ea**:** ssme(**95**%T)

**T**VAC= **6,291,737 Lbf; 1** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **6** ea**:** ssme(**95**%T)**;**  Fuel Burn Rate**:** **15,553.3 Lb/S**

separate from orbiter **at:**  **213.00**  seconds Jettison Wt**:** **1,128,263 Lbm** (includes **7,019.87** **Lbm** post jettison fuel)

**\***includes **24,526.32 Lbm** fuel burned by all engines prior to lift off and not included in gross lift off wt.

(post jettison**:** RD-171**;** 1:ea →**1.0** sec. @ **59.50%** T {**3,135.65 Lbm** }; **0.2333** sec. down to **0.60%** T {**710.1325 Lbm** } )

(post jettison**:** RS-68A**;** 2:ea →**1.0** sec. @ **67.60%** T {**2,601.248 Lbm** }; **0.6333** sec. down to **0.60%** T {**572.8389 Lbm** } )

**Orbiter:** Winged Reentry Glider with **6 ea:** SSME + **1 ea:** RL-10A4-2 + **2 ea:** OME

**1,600,000 Lbm** Fuselage**/**FuelTank**:** **21.00** ft. wide by **141** ft. long with **102.67** ft. wingspan **ADC K**= **0.3130**

**RLV:** **266,3x9**  **Lbm** (Unfueled)**; 1,101,8x9**  **Lbm** (Fueled**;** including **3,000** **Lbm** mmh/nto)

**Fuel: 832,49x**  **Lbm: 816,16x.5**  **Lbm** + **16,32x.3**  **Lbm** (**2.00**% Residual/Reserve)

**T**sl **=** **2,383,341 Lbf;** Fuel Burn Rate**:** **6,435.3 Lb/S** for **6** ea**:** ssme

**T**VAC = **2,943,037 Lbf;** Fuel Burn Rate**:** **6,484.7457 Lb/S** for **6** ea**:** ssme + **1** ea**:** rl-10a4-2

**Drag Coefficient** (K)**:** Maximum Safe Dynamic Pressure **("Max**-**Q") =**> **1600+ Lb/Sq.Ft.**

K= **1.204** at launch Maximum Safe Acceleration **("Max**-**A")** = **4.750** **g**

K= **1.014** after **4 ea:** **SRM** jettison **RS/SS** **Throttle** **Rate-Of-Change** Limits = **+**/-**12%** Per Sec.

K= **0.313** after **RLV** jettison **RD-171** **Throttle** **Rate-Of-Change** Limits = **+**/-**15%** Per Sec.

**HLV Pitch Rate-Of-Change** Limits = **+**/-**9o** Per Sec.

**HLV G**ross **L**ift**-O**ff **W**eight**:** **15,649,473.68** **Lbm** (**1.4672g** @ liftoff**; 1.714g** @ **3.00** sec**.; 1.8163g** @ **12.0** sec.)

At - **1.333** sec. Ignite **2** ea**:** RS-68A engines**;** begin throttle up until **76.00%** thrust by **0.00** sec. (liftoff)

At- **1.00** sec. Ignite **6** ea**:** SSME**;** begin throttle up until **71.00**% thrust by **0.00** sec. (liftoff)

At- **1.00** sec. Ignite **5** ea**:** RD-171 engines**;** begin throttle up until **70.00%** thrust by **3.00** sec.

At  **0.00** sec. (liftoff) Ignite all SRM(**3,600,000** **Lbf /** SRM)

At **24.00** sec. decrease thrust @ - **20,000** **Lbf /** sec.**/** SRM to **3,180,000** **Lbf /** SRMby **45.00** sec.

At **45.00** sec. hold thrust @ **3,180,000** **Lbf /** SRMuntil **99.00** sec.

At **74.233** sec. Ignite **1** ea**:** RD-171 engines**;** begin throttle up until **100.00%** thrust by **77.233** sec.

At **99.00** sec. reduce thrust all SRM until depletedby **114.00** sec. (jettison all SRM)

At **114.00** sec. (altitude =  **113,9x0**  ft., Air Speed (**VAS**) =  **3,5x5**  mph)

At **136.00** sec. begin throttle down **5** ea**:** RD-171 until **56.00**% thrust by **139.00** sec. (cut-off)

At **210.30** sec. begin throttle down **1** ea**:** RD-171 until **59.50**% thrust by **213.00** sec.

At **210.30** sec. begin throttle down **2** ea**:** RS-68Aengines until **67.60**% thrust by **213.00** sec. (Separate)

At **213.00** sec. Ignite **3** ea**:** RL-10A4-2 engines; altitude **=**  **299,x87**  ft.**;** Air Speed (**VAS**) **=**  **8,10x.48**  mph**;** **VV** **=** **1,7x7**  fps**; VH** **=**  **8,9x7**  mph

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for **6** ea**:** RD-171M **T**SL = **9,792,000 Lbf; T**VAC = **10,662,000 Lbf;** Fuel Burn Rate = **32,620 Lb/S**

for **2** ea**:** RS-68A **T**SL = **1,404,000 Lbf; T**VAC = **1,594,000 Lbf;** Fuel Burn Rate =  **3,848 Lb/S**

**total** RD-171M(**5** ea) fuel burned prior to **0.00** sec**.:** **16,600.5 Lbm** rs/ss**:** **460.9270801** cu.ft./sec.

**total** RD-171M(**5** ea) fuel burned prior to **2.00** sec**.:** **44,795 Lbm**

**total** RS-68A(**2** ea) fuel burned prior to **0.00** sec**.:** **3,488.8533 Lbm 2** ea: RS-68A**:** **172.7955547** cu.ft./sec.

**total** RS-68A(**2** ea) fuel burned prior to **2.00** sec**.:** **6,772.48 Lbm**

**total** SSME(**6** ea) fuel burned prior to **0.00** sec**.:** **4,436.97 Lbm 6** ea:ssme**:** **288.1315254** cu.ft./sec.

**total** SSME(**6** ea) fuel burned prior to **2.00** sec**.:** **11,244.84 Lbm**

**A**erodynamic **D**rag **C**ompensation (**ADC**) = **(**V**AS ÷ 1,000)2 x** P**ATM x** K **;**with resultant **ADC** in "**g**" units

Where**:** **VAS** is Air Speed In MPH, **PATM**is Percent Atmospheric Pressure, & **K** is Drag Coefficient

**ADC** K= **1.000** per **3,500** sq. ft. **RLV** cross sectional area

**Orbiter:** Winged Reentry Glider**: 163.33\*\*** foot overall length with **102.667** foot wingspan**;** **(K**=**0.3130)**

**20.33'** i.d./ **21.0'** o.d. (**+37.9**" Ht.) @**163.332** ft. (std)**: 299,761.1554** **Lbm** for6 ss+1+2 → **993,677.1557** **Lbm *44,050*** cu. ft.

Reserve **760 Lbm** MMH/NTO For Initial OME De-orbit Burn to settle LH2/LOX in tanks

Reserve **3,412** **Lbm** LH2/LOX For RL-10A4-2 De-orbit Burn; until ∆ VH = -**134** mph (**6.118** **g**-sec.)

**RD/RD-RLV:** Winged Reentry Glider**:** **300.00** foot overall length with **146.67** foot wingspan

Fuselage**/**Fuel Tank**:** **29.33** foot inner diameter **/ 30.00** foot outer diameter

**29.33'** i.d./ **30.0'** o.d. (+54 " Ht.)@**296.00** ft.**:**  ***672,933.8805*** **Lbm** →***166,730.2968*** cu. ft. tank

**75k Lbm**(**3:**GE90)**+132k Lbm**(**6:**RD-171)**+32k Lbm**(**2:**RS-68A) **+12k Lbm** (jet-a tanks) **= 251,000** **Lbm**

**672,933.88 Lbm +33,666.12 Lbm** (landing gear)**+251,000** **Lbm+10,000 Lbm** (support) **= 967,600** **Lbm** (Dry)

**Note:** **RLV** is ***'tail rudder down'*** during boost phase prior to stage separation**.**

throttle down all **rlv** engines to match orbiter acceleration**;**

switch orbiter LOX**/**LH2 fuel supply from **rlv** to orbiter internal fuel tanks**;** separate **rlv** from orbiter**;**

pitch **rlv** nose up**,** then roll **180°** until ***'tail rudder up'*,** ***'nose forward'*,** to perform shuttle-style reentry**;**

air brake until subsonic**;** blow off jet engine inlet fairings**;** start **3 ea:** GE90-115B**;**

return to Kennedy Space Center**,** Florida under jet powered flight**,** mid-air refuel with Jet-A as needed.

initial Jet-A fuel load**: 87,855.516** **Lbm →** **60.96** minute burn time

jet-a fuel wing tanks have **210,000 Lbm** (**31,194** gallon) capacity

**HLV Motors & Engines: .**

**SRM:** (**210,000** **Lbm**, unfueled) **154** foot L x **146** inch outer diameter with **131.9** sec. max burn time

successfuly tested, **5** segment, (Orbital/Alliant Techsystems Inc.) **S**olid **R**ocket **M**otor

unfueled weight includes recovery system + **srm**-to-**orbiter** supports, +(**10k Lbm** inflatable aft reentry skirt)

space shuttle derived, **SRM** with reconfigured fuel burn profile (new propellant grain geometry)

**T**SL = **3,600,000 Lbf;** I**sp(sl)** =  **242.00** sec.;I**sp(vac)** =  **268.20** sec. **ADC K** = **0.04750/ea**

**RD-171M:**  (**20,503** **Lbm**, dry) **158** inch L x **140** inch dia with **150** sec. max burn time**;** I**sp(sl)** =  **309.68** sec.;I**sp(vac)** =  **337.19** sec.

successful use**:** zenit expendable launch vehicle**;**  **5,270** **Lb/S**  burn rate

**T**SL = **1,632,000 Lbf; T**VAC = **1,777,000 Lbf 2.63 : 1** lox/rp-1 ratio → **65.0989502** **Lb/cu.ft.** combined fuel density

**RS-68A:** (**14,875** Lbm, dry) **205** inch L x **96** inch wide with **332** sec. max burn time**;** I**sp(sl)** =  **364.86** sec.; I**sp(vac)** =  **414.24** sec.

successful use**:** delta-iv**;**   **1,924** **Lb/S**  burn rate

**T**SL = **702,000 Lbf; T**VAC = **797,000 Lbf 5.97 : 1** lox/lh2 ratio→ **22.49178231 Lb/cu.ft.** combined fuel density

**SSME:** (**6,990** **Lbm**, dry) **168** inch L x **96** inch max-dia with **480**+ sec. max burn time**;** I**sp(sl)** =  **370.35** sec.;I**sp(vac)** =  **453.86** sec.

successful use**:** space shuttle**;**  **1,129** **Lb/S**  burn rate (note: limit **ssme** to **95%** throttle to extend life of engine)

**T**SL = **418,130 Lbf; T**VAC = **512,410 Lbf 6.0 : 1** lox/lh2 ratio→ **22.5579377 Lb/cu.ft.** combined fuel density

**RL-10A4-2:** (**375** **Lbm**, dry) **86.4** inch L x **46** inch o.d. with **740**+ sec. max burn time**;** I**sp(vac)** =  **451.00** sec.

restartable, successful use**:** centaur-iii b**;**  **49.4457** **Lb/S**  burn rate

**T**VAC = **22,300 Lbf 5.5 : 1** LOX/LH2 ratio→ **21.43136453 Lb/cu.ft.** combined fuel density

**OME:**  **O**rbital **M**anuevering **E**ngine (**260** **Lbm**, dry) **77** inch L x **46** inch max-dia, **1,250** sec. max burn time**;** I**sp(vac)** =  **316.00** sec.

restartable, successful use**:** space shuttle**;**  **18.993671** **Lb/S**  burn rate

**T**VAC = **6,002 Lbf 1.65 : 1** nto/mmh ratio→ **70.02462 Lb/cu.ft.** combined fuel density

**GE90-115B:** (**18,260** **Lbm** dry) **287** inch L x **135** inch inch o.d. JP-4 fuel density (at **59°** F) = **51.191 Lb/cu.ft.**

**T**SL = **115,300 Lbf; 8.0069444** **Lb/S**  burn rate **(28,825 Lb/Hr)** I**sp(sl)** =  **14,400** sec. **note: -**air breathing jet engine

**HLV • 4-6/2-6**•MK.3-30 Ver**:** 03-27-2017

**▪** Total Weight In Orbit**: 1, ,**  **Lbm** **Useful Payload: ,**   **Lbm** **▪**

**Available Fuel: RD: 4,381,546.51 Lbm RS/SS:**  **2,197,210.4** **Lbm** **SRM: 5,520,000** **Lbm**

**RD/RS-RLV:** Winged Reentry Glider with **6 ea:** RD-171M + **2 ea:** RS-68A + **3 ea:** GE90-115B

**7,700,000 Lbm\*** Fuselage**/**FuelTank**:**  **30.00** ft. wide by **296.00** ft. long with **146.67** ft. wingspan **ADC K**= **0.70100**

**166,464.4923** cu. ft. **RLV: 967,600** **Lbm** (Unfueled)**;** **7,700,000** **Lbm** (Fueled) ***166,730.2968*** cu. ft. (fuel capacity)

**Total Fuel: 6,799,000 Lbm** (includes Jet-A **Fuel: 87,855.516** **Lbm**)

**56,686.44269** cu. ft. **5-**RD-171M **Fuel: 3,390,227.91 Lbm: 3,653,691 Lbm** + **36,536.91 Lbm** (**1.0**% residual) → **134.00++** sec. burn time

**11,292.56406** cu. ft. **1-**RD-171M **Fuel: 735,134.0651 Lbm: 727,855.51 Lbm** + **7,278.555 Lbm** (**1.0**% residual) → **132.90++** (**+1.0** sec.@ **59.50%** T)sec. burn time

**460.7881458** cu. ft. **2-**RS-68A **Fuel: 10,363.94667 Lbm: 10,261.333 Lbm** + **102.6133 Lbm** (**1.0**% residual) → **3.333** sec. burn time

**702.121033** cu. ft. **6-**SSME **Fuel: 15,838.6281 Lbm: 15,681.8 Lbm** + **156.8181 Lbm** (**1.0**% residual) → **3.00** sec. burn time

**390.967222** cu. ft. **2-**RS-68A **Fuel: 8,793.54965 Lbm: 8,706.4848 Lbm** + **87.065 Lbm** (**1.0**% residual) → **2.70** sec. burn time

**142.533293** cu. ft. **2-**RS-68A **Fuel: 3,205.8278 Lbm: 3,174.086933 Lbm** + **31.4087 Lbm** (**1.0**% residual) → **0.00** (**+2 ea: @ 1.0** sec.@ **67.60%** T)sec. burn time

**777.9551187** cu. ft. **6-**SSME(orb) **Fuel: 17,549.0631 Lbm: 17,375.31 Lbm** + **173.7531 Lbm** (**1.0**% residual) → **2.70** sec. burn time

**35,993.31404** cu. ft. **2-**RS-68A **Fuel: 809,553.784 Lbm: 801,538.4 Lbm** + **8,015.384 Lbm** (**1.5**% residual) → **208.30** sec. burn time

**60,017.79675** cu. ft. **6-**SSME **Fuel: 1,353,877.72 Lbm: 1,340,472.99 Lbm** + **13,404.7299 Lbm** (**1.5**% residual) → **208.3** sec. burn time

**T**sl **=** **11,947,341 Lbf 5** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **7** ea**:** ssme(**95**%T)**; T**VAC= **15,176,737 Lbf** (**6** ea**:** rd-171)

Fuel Burn Rate**:** **36,633.3 Lb/S**  **5** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **6** ea**:** ssme(**95**%T)

**T**VAC= **6,291,737 Lbf; 1** ea**:** rd-171 **+ 2** ea**:** rd-68a **+** **6** ea**:** ssme(**95**%T)**;**  Fuel Burn Rate**:** **15,553.3 Lb/S**

separate from orbiter **at:**  **213.00**  seconds Jettison Wt**:** **1,128,263 Lbm** (includes **7,019.87** **Lbm** post jettison fuel)

**\***includes **24,526.32 Lbm** fuel burned by all engines prior to lift off and not included in gross lift off wt.

(post jettison**:** RD-171**;** 1:ea →**1.0** sec. @ **59.50%** T {**3,135.65 Lbm** }; **0.2333** sec. down to **0.60%** T {**710.1325 Lbm** } )

(post jettison**:** RS-68A**;** 2:ea →**1.0** sec. @ **67.60%** T {**2,601.248 Lbm** }; **0.6333** sec. down to **0.60%** T {**572.8389. Lbm** } )

**Orbiter:** Winged Reentry Glider with **6 ea:** SSME + **1 ea:** RL-10A4-2 + **2 ea:** OME

Fuselage**/**FuelTank**:** **20.33** foot inner diameter **/ 21.00** foot outer diameter by **163** foot overall length

Note**:** the "fuel-rich cut**-**off" for **6** ea**:** ssme requires **274.0247** cu. ft. of extra lh2 tank, ∴ reduce

over-all fuel capacity (below) by **4,969.433** **Lbm** to account for fuel displaced by this extra lh2

LH2: **4.4229586 Lb/cu.ft.**

**20.33'** i.d./ **21.00'** o.d. @**120.00** ft.**:**  **234,951.869** **Lbm** for6 ss+1+2 → **680,952.2356 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**125.00** ft.**:**  **242,429.864** **Lbm** for6 ss+1+2 → **717,035.8802 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**130.00** ft.**:**  **249,907.858** **Lbm** for6 ss+1+2 → **753,119.5248 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**135.00** ft.**:**  **257,385.853** **Lbm** for6 ss+1+2 → **789,203.1695 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**140.00** ft.**:**  **264,863.848** **Lbm** for6 ss+1+2 → **825,286.8141 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**145.00** ft.**:**  **272,341.842** **Lbm** for6 ss+1+2 → **861,370.4587 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**150.00** ft.**:**  **279,819.837** **Lbm** for6 ss+1+2 → **897,454.1033 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**155.00** ft.**:**  **299,761.1554** **Lbm** for6 ss+1+2 → **933,537.7480 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**160.00** ft.**:**  **287,297.831** **Lbm** for6 ss+1+2 → **969,621.3926 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.0'** o.d. (**+37.9**" Ht.) @**163.33** ft. (std)**: 244,281.1554** **Lbm** without engines → **993,677.1557** **Lbm** fuel cap. ***44,050*** cu. ft.

**20.33'** i.d./ **21.0'** o.d. @**163.332** ft. (std)**: 299,761.1554** **Lbm** for6 ss+1+2 → **993,677.1557** **Lbm** fuel cap. ***44,050*** cu. ft.

**20.33'** i.d./ **21.00'** o.d. @**165.00** ft.**:**  **302,253.820** **Lbm** for6 ss+1+2 → **1,005,705.037 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**170.00** ft.**:**  **309,731.815** **Lbm** for6 ss+1+2 → **1,041,788.682 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**175.00** ft.**:**  **317,209.809** **Lbm** for6 ss+1+2 → **1,077,872.326 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**180.00** ft.**:**  **324,687.804** **Lbm** for6 ss+1+2 → **1,113,955.971 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**185.00** ft.**:**  **332,165.799** **Lbm** for6 ss+1+2 → **1,150,039.616 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17

**20.33'** i.d./ **21.00'** o.d. @**190.00** ft.**:**  **339,643.793** **Lbm** for6ss+1+2 → **1,186,123.260 Lbm** fuel cap. (**"K"**= **0.3130)** 02Mar17