HUMAN MARS MISSION

WEIGHTS AND MASS PROPERTIES

CHEMICAL DRM v4.0a ARCHITECTURE
NUCLEAR DRM v4.0a ARCHITECTURE
SEP DRM v4.0a ARCHITECTURE
CARGO FLIGHTS 1 AND 2
CREW TAXI STAGE
X-38 MANNED VEHICLE

FINAL REPORT

REF: Order Number H-28653D
(Part I)

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Submitted to:
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TRANS-EARTH INJECTION STAGE HMM CHEMICAL DRM v4.0a WEIGHT BREAKOUT

The TEI stage weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Transit Habitat module which along with the Ascent/Earth Return Capsule and the Return Science Payload from the Ascent stage chart and the Crew from the Descent stage chart make up the payload for the TEI stage.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the TEI stage along with the TMI stages to insure the mission could be completed successfully. The misc. / margin shown next tells how the TEI Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

ChemMsss

Human Mars Mission: Chem v4.0 – 2011/2014

JSC "v4" Cargo Masses on 80-84 mt LV (w/ Hank's Manifest & C_3s)

9/29/99 8:00

Performance Assessment

	Description	2011 Cargo Flight 1	2011 Cargo Flight 2	2014 Cargo Flight 4	2014 Piloted Flight	Totals	
TEI Stage	Transit Habitat (mt)				27.122		
LOx / LH_2	Burnout Mass (mt)				7.084		
I_{sp} = 466 sec	Propellant Mass w/ ? m/s (mt)				27.148	**34**	Prop Brian
	Misc. / Margin				**1.342**		
	Propulsion System				1.027		
	pressurant tanks(9)				0.171		Prop Brian
	valves,filters,regulars & misc				0.129		Prop Brian
	RL10B-2 engines(3)				0.694		Prop Brian
	RCS thrusters(24)				0.033		Prop Brian
	Propulsion Sys. Residuals/Pressurants				0.588		Prop Brian
	RCS Propellant				[illegible]		
	Thermal				0.373		
	MLI				0.130		Therm Reggie
	Foam / purge				0.040		Therm Reggie
	Cooler				0.087		Therm Reggie
	Radiator				0.116		Therm Reggie
	Main engines gimbal system(TVC)				0.105		Sys Bobby
	GN&C				0.083		
	IMU				0.038		Avionics Ron
	Star Trackers				0.014		Avionics Ron
	Sun Sensors				0.003		Avionics Ron
	GPS				0.007		Avionics Ron
	VGS				0.022		Avionics Ron
	Communications				0.006		
	S-Band system						Avionics Ron
	UHF System				0.006		Avionics Ron
	Data System				0.010		
	Flight computers						Avionics Ron
	Remote Terminals				0.010		Avionics Ron
	Data Bus Couplers				0.000		Avionics Ron
	Electrial Power				0.140		
	Primary batteries						Power Ron
	pwr ctr boxes & cabling				0.140		Power Ron
	Tankage				0.608		
	Fuel tanks				0.352		Struct Al
	Oxidizer tanks				0.257		Struct Al
	Structures				1.706		
	tank support (kg)				1.312		Struct Al
	engine support (kg)				0.194		Struct Al
	stage interface (kg)				0.200		Struct Al
	Payload interface (kg)						Struct Al
	Contingency(10%)				0.336		Sys Bobby
V_{∞} = 11.4	Propellant Mass Fraction				0.793		

Larry Kos /PD32
9/29/99

ASCENT STAGE HMM CHEMICAL DRM v4.0a WEIGHT BREAKOUT

The Ascent stage weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Ascent/Earth Return Capsule which along with the Return Science Payload Mass and the Crew from the Descent stage chart make up the payload for the Ascent stage.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the Ascent stage along with the Descent stage all of Cargo flight 4 and which are intergrated together to insure the mission could be completed successfully. The misc. / margin shown next tells how the Ascent Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

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	Description	2011 Cargo Flight 1	2011 Cargo Flight 2	2014 Cargo Flight 4	2014 Piloted Flight	Totals	
Ascent Stage	Ascent/Earth Return Capsule (mt)			0.000	5.115		
LOx / LH_2	Burnout Mass (mt)			4.911			
I_{sp} = 466 sec	Propellant Mass (mt, ΔV_{asc} = ? m/s)			19.968			Prop Brian
	Misc. / Margin			-0.160			
	Propulsion System			1.027			
	pressurant tanks			0.171			Prop Brian
	valves,filters,regulars & misc			0.129			Prop Brian
	RL10B-2 engines(3)			0.694			Prop Brian
	RCS thrusters			0.033			Prop Brian
	Propulsion Sys. Residuals/Pressurants			0.588			Prop Brian
	RCS Propellant			0.104			
	Thermal			0.278			
	MLI			0.130			Therm Reggie
	Foam / purge			0.040			Therm Reggie
	Cooler			0.108			Therm Reggie
	Radiator			0.000			Therm Reggie
	Main engines gimbal system(TVC)			0.105			Sys Bobby
	GN&C			0.083			
	IMU			0.038			Avionics Ron
	Star Trackers			0.014			Avionics Ron
	Sun Sensors			0.003			Avionics Ron
	GPS			0.007			Avionics Ron
	VGS			0.022			Avionics Ron
	Communications			0.006			
	S-Band system						Avionics Ron
	UHF System			0.006			Avionics Ron
	Data System			0.010			
	Flight computers						Avionics Ron
	Remote Terminals			0.010			Avionics Ron
	Data Bus Couplers			0.000			Avionics Ron
	Electrial Power			0.140			
	Primary batteries						Power Ron
	pwr ctr boxes & cabling			0.140			Power Ron
	Tankage			0.608			
	Fuel tanks			0.352			Struct Al
	Oxidizer tanks			0.257			Struct Al
	Structures			1.706		1.3	
	tank support (kg)			1.312			Struct Al
	engine support (kg)			0.194			Struct Al
	stage interface (kg)			0.200			Struct Al
	Payload interface (kg)						Struct Al
	Contingency(10%)			0.327			Sys Bobby
	Return Science Payload Mass (mt)			**0.090			
	Propellant Mass Fraction			0.803			

DESCENT STAGES HMM CHEMICAL DRM v4.0a WEIGHT BREAKOUT

The Descent stages weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown for Cargo Flights 1 and 2 is the Surface / On-orbit Payload Masses which are the payloads for each of the Descent stages.The total burnout mass of each of the Descent Systems (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants (shown above the stage mass fraction at the bottom of the chart) to check the performance of the Descent stages along with the TMI stages of each respective Cargo Flight to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stage substem weights have increased or decreased since the performance computations were made.

The first weight shown for Cargo Flight 4 Descent stage payload is the Surface Habitat Module which along with the Crew and the Ascent/Earth Return Capsule and the fully loaded Ascent stage from the Ascent stage chart complete the payload.The total burnout mass of the Dscent System (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants (shown above the stage mass fraction at the bottom of the chart) to check the performance of the Dscent stage along with the TMI stages all of Cargo flight 4 to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

The mass of the Aerobrake which brakes the Mars flight payload into Mars orbit for each of the four flights are shown on this chart. The total weight of each flight braked into Mars orbit consists of all the weights shown in each column for that flight excluding the weight of the TMI stages shown on the next chart. The piloted flight consisting of the TEI stage,Ascent / Earth return Capsule, Crew, and On-orbit payload are braked into Mars orbit where the TEI stage and On-orbit payload remain in Mars orbit, but the Crew and the Ascent / Earth Return capsule go with the Descent stage of cargo flight 4 to the Mars surface.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

ChemMsss

	Description	2011 Cargo Flight 1	2011 Cargo Flight 2	2014 Cargo Flight 4	2014 Piloted Flight	Totals	
Descent Stage	Crew (Piloted Mission Only, mt)				0.600		
LOx / LH_2	Surface Habitat Module Mass (mt)			20.897			
I_{sp} = 466 sec	Surface/On-orbit Payload Mass (mt)	13.569	13.569		12.337	**39**	
Nuclear Surf. Pwr.	LH2 for Water Cache & Asc Prop (mt)						
	Aerobrake Mass (√Mp*(a+b*Ve)+Ms, mt	5.800	5.800	13.400	13.400	**38**	
	Descent System (Dry+chutes+LL) (mt)	5.798	5.798	13.178		**25**	
C_3= ?, ?	Misc. / Margin	**0.766**	**0.766**	**2.853**			
	Propulsion System	1.114	1.114	1.686		3.9134	
	pressurant tanks	0.019	0.019	0.076			Prop Brian
	valves,filters,regulars & misc	0.137	0.137	0.189			Prop Brian
	RL10B-2 engines	0.925	0.925	1.388			Prop Brian
	RCS thrusters(24)	0.033	0.033	0.033			Prop Brian
	Propulsion Sys Residuals/Pressurants	0.063	0.063	0.253		0.378	Prop Brian
	RCS Propellant	0.210	0.210	0.848		1.268	
	Main engines gimbal system(TVC)	0.140	0.140	0.210			Sys Bobby
	Thermal + Boil-off (prior to TMI)	0.323	0.323	1.443		2.09	
	MLI	0.107	0.107	0.406			Therm Reggie
	Foam / purge	0.040	0.040	0.159			Therm Reggie
	Cooler	0.069	0.069	0.258			Therm Reggie
	Radiator	0.107	0.107	0.620			Therm Reggie
	GN&C	0.083	0.083	0.083		0.249	
	IMU	0.038	0.038	0.038			Avionics Ron
	Star Trackers	0.014	0.014	0.014			Avionics Ron
	Sun Sensors	0.003	0.003	0.003			Avionics Ron
	GPS	0.007	0.007	0.007			Avionics Ron
	VGS	0.022	0.022	0.022			Avionics Ron
	Communications	0.006	0.006	0.006		0.0167	
	S-Band system						Avionics Ron
	UHF System	0.006	0.006	0.006			Avionics Ron
	Data System	0.010	0.010	0.010			
	Flight computers						Avionics Ron
	Remote Terminals	0.010	0.010	0.010			Avionics Ron
	Data Bus Couplers	0.000	0.000	0.000			Avionics Ron
	Power	0.200	0.200	0.200			
	Primary batteries	0.130	0.130	0.130			Power Ron
	pwr ctr boxes & cabling	0.070	0.070	0.070			Power Ron
	Tankage	0.171	0.171	0.513		0.8547	
	Fuel tanks	0.086	0.086	0.342			Struct Al
	Oxidizer tanks	0.086	0.086	0.171			Struct Al
	Structures	1.050	1.050	2.362		4.4614	
	tank support (kg)	0.656	0.656	1.968			Struct Al
	engine support (kg)	0.194	0.194	0.194			Struct Al
	stage interface (kg)	0.200	0.200	0.200			Struct Al
	Payload interface (kg)						Struct Al
	Contingency(10%)	0.213	0.213	0.512		0.9	Sys Bobby
	Parachute system	0.700	0.700	0.700			
	Landing Legs (mt)	0.750	0.750	1.500		**3**	
	Propellant Mass (mt, ΔVdesc = 632 m/s)	2.877	2.877	11.651		**17**	Prop Brian
	Propellant Mass Fraction	0.305	0.305	0.443			
	Payload Mass Subtotal (mt)	**28.043**	**28.043**	**84.006**	**92.806**	**233**	

Larry Kos /PD32
9/29/99

TRANS-MARS INJECTION STAGES HMM CHEMICAL DRM v4.0a WEIGHT BREAKOUT

The TMI stages weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Payload Mass Subtotal (mt) which is the payload for the TMI stages.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown near the bottom of the chart above the stage mass fraction) to check the performance of the TMI stages to insure the mission could be completed successfully. The misc. / margin shown next tells how the TMI Stages substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart. The HMM team member who derived the component weights is shown out to the right side of the chart.

The Total TMI Stage Mass (mt) is shown (after the stage mass fraction) which adds with the Payload Mass Subtotal at the top of the chart to show the Total IMLEO (mt) . The Number of 80 mt LV Flights for each of the four Mars Flights are shown as the last line of the chart.

ChemMsss

	Description	2011 Cargo Flight 1	2011 Cargo Flight 2	2014 Cargo Flight 4	2014 Piloted Flight	Totals	
Chemical TMI	Total Burnout Masses (mt)	9.930	9.930	21.064	21.064	62	
Stages, LOx / LH_2	Misc. / Margin	-0.168	-0.168	-3.629	-3.629		
I_{sp} = 466 sec	Propulsion System	2.018	2.018	3.030	3.030		
	Pressurant Tanks	0.343	0.343	0.800	0.800		Prop Brian
	Valves,Filters,Regulars, & Misc	0.255	0.255	0.347	0.347	1.2	Prop Brian
	RL10B-2 Engines	1.388	1.388	1.851	1.851		Prop Brian
	RCS Thrusters(12)	0.033	0.033	0.033	0.033	0.1	Prop Brian/Kos
	Propulsion Sys. Residuals/Pressurants	1.176	1.176	2.988	2.988	8.3267	Prop Brian
	RCS Propellant	[illegible]	[illegible]	[illegible]	[illegible]	2.8035	
	Main engines gimbal system(TVC)	0.210	0.210	0.279	0.279		Sys Bobby
	GN&C	0.122	0.122	0.122	0.122		
	IMU	0.076	0.076	0.076	0.076		Avionics Ron
	Star Trackers	0.027	0.027	0.027	0.027		Avionics Ron
	Sun Sensors	0.005	0.005	0.005	0.005		Avionics Ron
	GPS	0.014	0.014	0.014	0.014		Avionics Ron
	Thermal	0.369	0.369	1.127	1.127		
	MLI	0.110	0.110	0.299	0.299		Therm Reggie
	Foam / purge	0.137	0.137	0.149	0.149		Therm Reggie
	Cooler	0.000	0.000	0.216	0.216		Therm Reggie
	Radiator or Boiloff	0.122	0.122	0.464	0.464		Therm Reggie
	Data System	0.062	0.062	0.062	0.062		
	Flight computers	0.033	0.033	0.033	0.033		Avionics Ron
	Remote Terminals	0.019	0.019	0.019	0.019		Avionics Ron
	Data Bus Couplers	0.010	0.010	0.010	0.010		Avionics Ron
	Communications	0.000	0.000	0.041	0.041		
	S-Band system			0.030	0.030		Avionics Ron
	UHF System			0.011	0.011		Avionics Ron
	Electrial Power	0.470	0.470	0.800	0.800		
	Primary batteries	0.260	0.260	0.520	0.520		Power Ron
	pwr ctr boxes & cabling	0.210	0.210	0.280	0.280		Power Ron
	Tankage	1.216	1.216	6.847	6.847	16.1	
	Fuel tanks	0.703	0.703	4.479	4.479		Struct Al
	Oxidizer tanks	0.513	0.513	2.368	2.368		Struct Al
	Structures	3.411	3.411	6.677	6.677	20.2	
	tank support (kg)	2.623	2.623	4.220	4.220		Struct Al
	engine support (kg)	0.388	0.388	0.375	0.375		Struct Al
	stage interface (kg)	0.400	0.400	2.082	2.082		Struct Al
	Contingency(10%)	0.649	0.649	1.713	1.713		Sys Bobby
	Total Propellant Masses (mt)	**42.034**	**42.034**	**138.903**	**138.903**	**362**	Prop Brian
C_3 = 9.1, 12.82	Propellant Mass Fraction	0.809	0.809	0.868	0.868		
	Total Stage Mass (mt)	**51.964**	**51.964**	**159.967**	**159.967**	**424**	
	TOTAL IMLEO (mt)	**80.007**	**80.007**	**243.973**	**252.773**	**656.8**	
Number of **80** mt LV Flights (75%-100% packing efficiency)		**1**	**1**	**3**	**3**	**8**	

** Gathered samples & rocks; # Fits in ? launches until transportation packaging assessment is completed.

Larry Kos /PD32
9/29/99

TRANS-EARTH INJECTION STAGE HMM SEP DRM v4.0a WEIGHT BREAKOUT

The TEI stage weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Transit Habitat module which along with the Ascent/Earth Return Capsule and the Return Science Payload from the Ascent stage chart and the Crew from the Descent stage chart make up the payload for the TEI stage.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the TEI stage along with the TMI stages to insure the mission could be completed successfully. The misc. / margin shown next tells how the TEI Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with componets which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

Human Mars Mission: SEP DRM v4.0a – 2011/2014

"v4" Cargo Masses on 80-84 mt LV (w/ 13.8 Cargo & 18.4/14.8 Piloted C_3s)

		mt	mt	mt	
	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	**Totals**
TEI Stage	Transit Habitat (mt)			27.122	
	Burnout Mass (mt)			6.290	
	Propellant Mass w/ 500 m/s (mt)			26.043	
	Misc. / Margin			-0.715	
LOX/LH2	Propulsion System			0.752	
	pressurant tanks(8)			0.152	Prop Brian
	valves,filters,regulars & misc			0.104	Prop Brian
Isp=466 sec	RL10B-2 engines(2)			0.463	Prop Brian
	RCS thrusters(24)			0.033	Prop Brian
	Propulsion Sys. Residuals/Pressurants			0.561	Prop Brian
	RCS Propellant			0.761	
	Thermal			0.655	
	MLI			0.211	Therm Reggie
	Foam / purge			0.070	Therm Reggie
	Cooler			0.180	Therm Reggie
	Radiator			0.193	Therm Reggie
	Main engines gimbal system(TVC)			0.070	sys Bobby
	GN&C			0.083	
	IMU			0.038	Avionics Ron
	Star Trackers			0.014	Avionics Ron
	Sun Sensors			0.003	Avionics Ron
	GPS			0.007	Avionics Ron
	VGS			0.022	Avionics Ron
	Communications			0.006	
	S-Band system				Avionics Ron
	UHF System			0.006	Avionics Ron
	Data System			0.010	
	Flight computers				Avionics Ron
	Remote Terminals			0.010	Avionics Ron
	Data Bus Couplers			0.000	Avionics Ron
	Electrial Power			0.140	
	Primary batteries				Power Ron
	pwr ctr boxes & cabling			0.140	Power Ron
	Tankage			0.932	
	Fuel tanks			0.621	Str AL
	Oxidizer tanks			0.311	Str AL
	Structures			2.562	
	tank support (kg)			1.968	Str AL
	engine support (kg)			0.194	Str AL
	stage interface (kg)			0.200	Str AL
	Payload interface (kg)			0.200	Str AL
	Contingency(10%)			0.475	Sys Bobby
	Propellant Mass Fraction			0.805	

ASCENT STAGE HMM SEP DRM v4.0a WEIGHT BREAKOUT

The Ascent stage (which goes only on Cargo Flight 2) weight breakout into the component level of each subsystem is given on this chart. The second Ascent / Earth Return Capsule which goes to Mars orbit with the Piloted Flight is used to transfer the crew from Piloted Flight to the Surface Habitat Module of the Cargo Flight 1 which is waiting in Mars orbit. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Ascent/Earth Return Capsule which along with the Return Science Payload Mass and the Crew from the Descent stage chart make up the payload for the Ascent stage.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the Ascent stage along with the Descent stage (all of Cargo flight 2) which are intergrated together to insure the mission could be completed successfully. The misc. / margin shown next tells how the Ascent Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with componets which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

	Description	TI Cargo Flight 1	TI Cargo Flight 2	TI Piloted Flight	Totals
Ascent Stage	Ascent/Earth Return Capsule (mt)		5.115	5.115	
	Burnout Mass (mt)		4.799		
	Propellant Mass (mt, ΔV_{tot} = 5625 m/s)		*39.500		
	Misc. / Margin		-0.452		2.177
LOX/LCH4	Propulsion System		1.455		
	pressurant tanks		0.210		Prop Brian
	valves,filters,regulars & misc		0.170		Prop Brian
Isp=377 sec	RL10B-2 engines(4)		1.043		Prop Brian
	RCS thrusters		0.033		Prop Brian
	Propulsion Sys. Residuals/Pressurants		0.843		Prop Brian
	RCS Propellant		0.204		
	Thermal		0.129		
	MLI		0.070		Therm Reggie
	Foam / purge				Therm Reggie
	Cooler		0.059		Therm Reggie
	Radiator		0.000		Therm Reggie
	Main engines gimbal system(TVC)		0.140		sys Bobby
	GN&C		0.083		
	IMU		0.038		Avionics Ron
	Star Trackers		0.011		Avionics Ron
	Sun Sensors		0.003		Avionics Ron
	GPS		0.007		Avionics Ron
	VGS		0.022		Avionics Ron
	Communications		0.006		
	S-Band system				Avionics Ron
	UHF System		0.006		Avionics Ron
	Data System		0.010		
	Flight computers				Avionics Ron
	Remote Terminals		0.010		Avionics Ron
	Data Bus Couplers		0.000		Avionics Ron
	Electrial Power		0.140		
	Primary batteries				Power Ron
	pwr ctr boxes & cabling		0.140		Power Ron
	Tankage		0.621		
	Fuel tanks		0.311		Str AL
	Oxidizer tanks		0.311		Str AL
	Structures		1.333		
	tank support (kg)		0.874		Str AL
	engine support (kg)		0.259		Str AL
	stage interface (kg)				Str AL
	Payload interface (kg)		0.200		Str AL
	Contingency(10%)		0.287		Sys Bobby
	Return Science Payload Mass (mt)		**0.090		
	Propellant Mass Fraction		0.892		

DESCENT STAGES HMM SEP DRM v4.0a WEIGHT BREAKOUT

The Descent stages weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown for Cargo Flights 1 is the Surface Habitat Module which along with theSurface Payload Mass and the Crew are the payload for the Descent stage.The total burnout mass of each of the Descent System (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants to check the performance of the Descent stage along with the TMI stage of Cargo Flight 1to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stage substem weights have increased or decreased since the performance computations were made.

The first weight shown for Cargo Flight 2 Descent stage payload is the Surface Payload Mass which along with the Ascent/Earth Return Capsule, Surface Payload Mass from the Piloted Flight, and the fully loaded Ascent stage from the Ascent stage chart complete the payload.The total burnout mass of the Dscent System (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants to check the performance of the Dscent stage along with the TMI stage all of Cargo flight 2 to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stasge substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

The mass of the Aerobrake which brakes the Mars flight payload into Mars orbit for each of the three flights are shown on this chart. The total weight of each flight braked into Mars orbit consists of all the weights shown in each column for that flight excluding the weight of the TMI stages shown on the next chart. The piloted flight consisting of the TEI stage,Ascent / Earth return Capsule, Crew, and Surface Payload Mass are aerobraked into Mars orbit where the TEI stage remains in Mars orbit but the Crew and Surface Payload Mass with the use of the Ascent / Earth Return capsule transfer to the Surface Habitat Module with the Descent stage of cargo flight 1 to descent to the Mars surface.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	Totals	
Descent/Ascent	Crew (Piloted Mission Only, mt)			0.600		
and Descent	Surface Habitat Module Mass (mt)	22.786				
Only Stages	Surface Payload Mass (mt)	9.861	20.316	3.645	34	
	Inflatable lab module	3.100				
	ISRU sys		2.371			
	Surface power sys		12.118			
	Power sys envelope	4.761	1.437			
	DIPS power cart		1.500			
	COMM sys envelope		0.320			
	Tele-operable rovers	1.300	1.500			
	Science payload added	0.700	1.070			
	LH_2: Water Cache & Asc Prop (mt)		4.107			
	Aerobrake ($\sqrt{M_o}*(a+b*V_e)+M_{ss}$, mt)	9.800	9.800	13.100	33	
	Descent System (Dry+chutes) (mt)	5.781	5.781		12	6.585
	Landing Legs (mt)	1.500	1.500		3	
	Propellant Mass (mt, ΔV_{tot}=632 m/s)	11.807	9.879		22	
	Misc. / Margin	-0.396	1.719		1.32	6.177
LOX/LCH4	Propulsion System	1.880	0.699			
	pressurant tanks	0.076	0.095			Prop Brian
	valves,filters,regulars & misc	0.206	0.082			Prop Brian
ISP=377 sec	RL10B-2 engines	1.565	0.522			Prop Brian
	RCS thrusters	0.033	0.000			Prop Brian
	Propulsion Sys. Residuals/Pressurants	0.256	0.278			Prop Brian
	RCS Propellant	0.561	0.561			
	Thermal	0.076	0.053			
	MLI	0.033	0.000			Therm Reggie
	Foam / purge					Therm Reggie
	Cooler	0.031	0.000			Therm Reggie
	Radiator	0.012	0.053			Therm Reggie
	Main engines gimbal system(TVC)	0.210	0.070			Sys Bobby
	GN&C	0.083	0.000			
	IMU	0.038				Avionics Ron
	Star Trackers	0.014				Avionics Ron
	Sun Sensors	0.003				Avionics Ron
	GPS	0.007				Avionics Ron
	VGS	0.022				Avionics Ron
	Communications	0.006	0.000			
	S-Band system					Avionics Ron
	UHF System	0.006				Avionics Ron
	Data System	0.010	0.010			
	Flight computers					Avionics Ron
	Remote Terminals	0.010	0.010			Avionics Ron
	Data Bus Couplers	0.000	0.000			Avionics Ron
	Electrical Power	0.140	0.105			
	Primary batteries					Power Ron
	pwr ctr boxes & cabling	0.140	0.105			Power Ron
80	Tankage	0.311	0.000			
	Fuel tanks	0.155				Str AL
	Oxidizer tanks	0.155				Str AL
	structures	1.663	1.404			
	tank support (kg)	0.875	0.874			Str AL
	engine support (kg)	0.388	0.129			Str AL
	stage interface (kg)	0.200	0.200			Str AL
	Payload interface (kg)	0.200	0.200			Str AL
	Contingency (10%)	0.281	0.182			Sys Bobby
	Parachutes	0.700	0.700			
	Propellant Mass Fraction	0.619	0.576			
	Payload Mass Subtotal (mt)	**61.535**	**61.297**	**81.916**	**204.7**	

TRANS-MARS INJECTION STAGES HMM SEP DRM v4.0a WEIGHT BREAKOUT

The TMI stages weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Payload Mass Subtotal (mt) which is the payload for the TMI stages.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants to check the performance of the TMI stages to insure the mission could be completed successfully. The misc. / margin shown next tells how the TMI Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included near the bottom of the chart. The LH2 tank length (meters) of each TMI Stage which has a 7.4m diameter is shown next. The HMM team member who derived the component weights is shown out to the right side of the chart.

The Total TMI Stage Mass (mt) is shown (after the LH2 tank length) which adds with the Payload Mass Subtotal at the top of the chart to show the Total IMLEO (mt) . The Number of 80 mt LV Flights for each of the three Mars Flights are shown below the chart. The TMI SEP dry mass and SEP Xenon usable propellants are shown as an add-on to this chart for each of the three flights to complete the SEP DRM Weight Breakout.

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	Totals	
TMI Stage	Burnout Mass, a_{apo}= 67,200 km (mt)	4.225	4.225	5.849	14	
	LOx / LH, Propellant Mass (mt)	18.250	17.984	31.557	68	
C_3= 13.8, 18.4	Misc. / Margin	-0.357	-0.357	-1.585	-2.30	
LOX/LH2	Propulsion System	0.710	0.710	0.794		
	pressurant tanks	0.114	0.114	0.191		Prop Brian
	valves,filters,regulars & misc	0.100	0.100	0.108		Prop Brian
ISP=466 sec	RL10B-2 engines	0.463	0.463	0.463		Prop Brian
	RCS thrusters(24)	0.033	0.033	0.033		Prop Brian
	Propulsion Sys. Residuals/Pressurants	0.395	0.395	0.681		Prop Brian
	Boil-off (prior to TMI)	0.000	0.000	0.000		
	RCS Propellant	0.043	0.043	0.681		
	Thermal	0.471	0.471	0.783		
	MLI	0.148	0.148	0.229		Therm Reggie
	Foam / purge	0.053	0.053	0.078		Therm Reggie
	Cooler	0.129	0.129	0.206		Therm Reggie
	Radiator	0.141	0.141	0.270		Therm Reggie
	Main engines gimbal system(TVC)	0.070	0.070	0.070		sys Bobby
	GN&C	0.061	0.061	0.061		
	IMU	0.038	0.038	0.038		Avionics Ron
	Star Trackers	0.014	0.014	0.014		Avionics Ron
	Sun Sensors	0.003	0.003	0.003		Avionics Ron
	GPS	0.007	0.007	0.007		Avionics Ron
	Communications	0.000	0.000	0.020		
	S-Band system			0.015		Avionics Ron
	UHF System			0.006		Avionics Ron
	Data System	0.031	0.031	0.031		
	Flight computers	0.017	0.017	0.017		Avionics Ron
	Remote Terminals	0.010	0.010	0.010		Avionics Ron
	Data Bus Couplers	0.005	0.005	0.005		Avionics Ron
	Electrical Power	0.140	0.140	0.685		
	Solar array power sys			0.271		Power Ron
	Primary battery sys			0.245		Power Ron
	pwr ctr boxes & cabling	0.140	0.140	0.170		Power Ron
	Tankage	0.621	0.621	0.932		
	Fuel tanks	0.466	0.466	0.621		Str AL
	Oxidizer tanks	0.155	0.155	0.311		Str AL
	Structures	1.706	1.706	2.362		
	tank support (kg)	1.312	1.312	1.968		Str AL
	engine support (kg)	0.194	0.194	0.194		Str AL
	stage interface (kg)	0.200	0.200	0.200		Str AL
	Payload interface (kg)					Str AL
	Contingency (10%)	0.335	0.335	0.527		Sys Bobby
	Propellant Mass Fraction	0.812	0.810	0.844		
	LH2 Tank Length (Diam. = 7.4 m)	8.7	8.6	13.8		
	Total Stage Mass (mt)	**22.475**	**22.209**	**37.406**	**287**	
	TOTAL IMLEO (mt)	**84.010**	**83.506**	**119.322**	**468.74**	
Number of 80 mt LV Flights (75%-100% packing efficiency)		3	3	3		
TMI (SEP)	SEP Dry Mass (mt)	21.6	21.6	5.1	48	
Kr I_{sp} = ? sec	SEP Xenon Prop Mass (mt)	48.4	48.4	36.8	134	
					468.74	

* Produced at Mars using ISPP, ** Gathered samples & rocks.

 # Fits in ? launches until transportation packaging assessment is updated.

CREW TAXI STAGE HMM SEP DRM v4.0a WEIGHT BREAKOUT

The crew taxi weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available. The first weight shown is the total dry mass of the vehicle (including residuals and res propellants) which was used along with the total usable propellants (shown next) to check the performance of the vehicle with the other stages to insure the mission could be completed successfully. The misc. / margin shown next tells how the substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart. A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight		Totals
CREW TAXI S	Dry Mass w/rcs prop (mt)				3.848	Perm Kos
	LOx / LH$_2$ Propellant Mass (mt)				13.538	Perm Archie
	Misc. / Margin				**0.016**	
LOX/LH2	Propulsion System			0.689		
	pressurant tanks(5)				0.095	Prop Brian
	valves,filters,regulars & misc				0.098	Prop Brian
ISP=466 sec	RL10B-2 engines(2)				0.463	Prop Brian
	RCS thrusters(24)				0.033	Prop Brian
	Boil-off prior to start			0.000		
	RCS Propellant			0.147		Perm Vince
	Residuals inc He			0.224		Centaur/Brian
	Thermal			0.207		
	lox mli				0.015	Therm Reggie
	lh2 mli				0.142	Therm Reggie
	inter thermal control				0.050	Therm Reggie
	Main engines gimbal system(TVC)			0.070		sys Bobby
	GN&C and AR&C					
	Avionics			0.075		
	remote data units(2)				0.018	Avionics Ron
	data bus coupler(18)				0.003	Avionics Ron
	tvc controller(4)				0.018	Avionics Ron
	tvc actuators(4)				0.036	Avionics Ron
	Power			0.404		
	power distr unit(3)				0.135	Power Ron
	battery(6)				0.162	Power Ron
	battery(3)				0.027	Power Ron
	wiring				0.080	Power Ron
	Tankage			0.859		
	lh2 tank (mt)				0.396	Str AL
	lox tank (mt)				0.463	Str AL
	Structures			0.885		
	fwd skirt (mt)				0.228	Str AL/Kos
	aft skirt(mt)				0.175	Str AL
	thrust structure(mt)				0.267	Str AL
	stage misc. (mt)				0.214	Str AL
	Contingency (10%)			0.273		Sys Bobby
	Propellant Mass Fraction				0.779	

TRANS-EARTH INJECTION STAGE HMM NUCLEAR DRM v4.0a WEIGHT BREAKOUT

The TEI stage weight breakout into the component level of each subsystem is given on the TMI Chart. The Piloted Flight TMI Stage (which is sized to do the TMI burn and also the TEI burn) is a NTP Stage.

The first weight shown is the Transit Habitat module which along with the Ascent/Earth Return Capsule and the Return Science Payload from the Ascent stage chart and the Crew from the Descent stage chart make up the payload for the TEI stage burn.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the TEI stage burn along with the TMI stage burn to insure the mission could be completed successfully.

Human Mars Mission: NUCLEAR DRM v4.0a – 2011/2014

"v4" Cargo Masses on 80-84 mt LV (w/ 13.8 Cargo & 18.4/14.8 Piloted C_3s)

		mt	mt	mt	
	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	**Totals**
NTP TMI	Transit Habitat (mt)			27.122	
Stage, LH_2	Burnout Mass (mt)			0.000	
I_{sp} = 955/940 sec	Propellant Mass w/ 500 m/s (mt)			0.000	
	Misc. / Margin			**0.000**	
	Propulsion System			0.000	
	Propulsion Sys. Residuals/Pressurants			0.000	
	RCS Propellant			0.000	
	Thermal			0.000	
	GN&C			0.000	
	Communications			0.000	
	Data System			0.000	
	Electrial Power			0.000	
	Tankage			0.000	
	Structures			0.000	
	Contingency(10%)			0.000	
	Propellant Mass Fraction			0.000	

ASCENT STAGE HMM NUCLEAR DRM v4.0a WEIGHT BREAKOUT

The Ascent stage (which goes only on Cargo Flight 2) weight breakout into the component level of each subsystem is given on this chart. The second Ascent / Earth Return Capsule which goes to Mars orbit with the Piloted Flight is used to transfer the crew from Piloted Flight to the Surface Habitat Module of the Cargo Flight 1 which is waiting in Mars orbit Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Ascent/Earth Return Capsule which along with the Return Science Payload(near the bottom of the chart) and the Crew from the Descent stage chart make up the payload for the Ascent stage.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants (shown next) to check the performance of the Ascent stage along with the Descent stage (all of Cargo flight 2 and which are intergrated together) to insure the mission could be completed successfully. The misc. / margin shown next tells how the Ascent Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	Totals	
Ascent Stage	Ascent/Earth Return Capsule (mt)		5.115	5.115		
	Burnout Mass (mt)		4.799			
	Propellant Mass (mt, ΔV_{asc} = 5625 m/s)		*39.500			
	Misc. / Margin		-0.452			
LOX/LCH4	Propulsion System		1.455			
	pressurant tanks		0.210			Prop Brian
	valves,filters,regulars & misc		0.170			Prop Brian
ISP=377	RL10B-2 engines(4)		1.043			Prop Brian
	RCS thrusters		0.033			Prop Brian
	Propulsion Sys. Residuals/Pressurants		0.843			
	RCS Propellant		0.204			
	Thermal		0.129			
	MLI		0.070			Therm Reggie
	Foam / purge					Therm Reggie
	Cooler		0.059			Therm Reggie
	Radiator		0.000			Therm Reggie
	Main engines gimbal system(TVC)		0.140			sys Bobby
	GN&C		0.083			
	IMU		0.038			Avionics Ron
	Star Trackers		0.014			Avionics Ron
	Sun Sensors		0.003			Avionics Ron
	GPS		0.007			Avionics Ron
	VGS		0.022			Avionics Ron
	Communications		0.006			
	S-Band system					Avionics Ron
	UHF System		0.006			Avionics Ron
	Data System		0.010			
	Flight computers					Avionics Ron
	Remote Terminals		0.010			Avionics Ron
	Data Bus Couplers		0.000			Avionics Ron
	Electrial Power		0.140			
	Primary batteries					Power Ron
	pwr ctr boxes & cabling		0.140			Power Ron
	Tankage		0.621			
	Fuel tanks		0.311			Str AL
	Oxidizer tanks		0.311			Str AL
	Structures		1.333		0.9	
	tank support (kg)		0.874			Str AL
	engine support (kg)		0.259			Str AL
	stage interface (kg)					Str AL
	Payload interface (kg)		0.200			Str AL
	stage misc. (kg)					Str AL
	Contingency(10%)		0.287			Sys Bobby
	Return Science Payload Mass (mt)		**0.090			
	Propellant Mass Fraction		0.892			

Larry Kos/PD32, 9/29/99

DESCENT STAGES HMM NUCLEAR DRM v4.0a WEIGHT BREAKOUT

The Descent stages weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown for Cargo Flights 1 is the Surface Habitat Module which along with the Crew and theSurface Payload Mass are the payload for the Descent stage.The total burnout mass of the Descent System (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants to check the performance of the Descent stage along with the TMI stage of Cargo Flight 1to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stage substem weights have increased or decreased since the performance computations were made.

The first weights shown for Cargo Flight 2 Descent stage payload are the Surface Payload Mass and LH2 (water cache & Asc Prop) which along with theSurface Payload Mass from the Piloted Flight, and the Ascent/Earth Return Capsule and the fully loaded Ascent stage from the Ascent stage chart complete the payload.The total burnout mass of the Dscent System (including landing legs, parachute system, residuals, and rcs propellants) which was used along with the total usable propellants to check the performance of the Dscent stage along with the TMI stage all of Cargo flight 2 to insure the mission could be completed successfully. The misc. / margin shown next tells how the Descent Stasge substem weights have increased or decreased since the performance computations were made. The major systems are shown with componets which add up to give the total for that system. The HMM team member who derived the component weights is shown out to the right side of the chart.

The mass of the Aerobrake which brakes the Mars flight payload into Mars orbit for each of the two cargo flights are shown on this chart. The total weight of each flight braked into Mars orbit consists of all the weights shown in each column for that flight excluding the weight of the TMI stages shown on the next chart. The piloted flight consisting of the TMI stage(less propellants used for TMI burn),Ascent / Earth return Capsule, Crew, and Surface Payload Mass are braked into Mars orbit by the TMI stage where the TMI stage remains in Mars orbit, but the Crew and Surface Payload Mass with the use of the Ascent / Earth Return capsule transfer to the Surface Habitat Module with the Descent stage of cargo flight 1 to descent to the Mars surface.

A contingency of 10 percent is added for all the dry weights(excluding the RL10 engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The stage mass fraction is included at the bottom of the chart.

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	Totals	
	Crew (Piloted Mission Only, mt)			0.600		
Descent	Surface Habitat Module Mass (mt)	22.786				
Stage	Surface Payload Mass (mt)	9.861	21.723	0.100	32	
	Inflatable lab module	3.100				
	ISRU sys		2.371			
	Surface power sys		12.118			
	Power sys envelope	4.761	1.437			
	DIPS power cart		1.500			
	COMM sys envelope		0.320			
	Tele-operable rovers	1.300	1.500			
	Science payload added	0.700	2.477			
	LH_2: Water Cache & Asc Prop (mt)		4.107			
	Aerobrake ($\sqrt{M_o}$*(a+b*V_e)+M_s, mt)	9.730	9.790	0.000	20	
	Descent System (Dry+chutes) (mt)	5.781	5.781		12	
	Landing Legs (mt)	1.500	1.500		3	
	Propellant Mass (mt, ΔV_{req}=632 m/s)	10.850	9.380		20	
	Misc. / Margin	-0.376	1.739		1	
LOX/LCH4	Propulsion System	1.880	0.699			
	pressurant tanks	0.076	0.095			Prop Brian
	valves,filters,regulars & misc	0.206	0.082			Prop Brian
ISP=377	RL10B-2 engines	1.565	0.522			Prop Brian
	RCS thrusters	0.033	0.000			Prop Brian
	Propulsion Sys. Residuals/Pressurants	0.237	0.259		1.1	
	RCS Propellant	0.561	0.561		1.1	
	Thermal	0.076	0.053			
	MLI	0.033	0.000			Therm Reggie
	Foam / purge					Therm Reggie
	Cooler	0.031	0.000			Therm Reggie
	Radiator	0.012	0.053			Therm Reggie
	Main engines gimbal system(TVC)	0.210	0.070			Sys Bobby
	GN&C	0.083	0.000			
	IMU	0.038				Avionics Ron
	Star Trackers	0.014				Avionics Ron
	Sun Sensors	0.003				Avionics Ron
	GPS	0.007				Avionics Ron
	VGS	0.022				Avionics Ron
	Communications	0.006	0.000			
	S-Band system					Avionics Ron
	UHF System	0.006				Avionics Ron
	Data System	0.010	0.010			
	Flight computers					Avionics Ron
	Remote Terminals	0.010	0.010			Avionics Ron
	Data Bus Couplers	0.000	0.000			Avionics Ron
	Electrical Power	0.140	0.105			
	Primary batteries					Power Ron
	pwr ctr boxes & cabling	0.140	0.105			Power Ron
	Tankage	0.311	0.000		3.1	
	Fuel tanks	0.155				Str AL
	Oxidizer tanks	0.155				Str AL
	structures	1.662	1.404		1.7	
	tank support (kg)	0.874	0.874			Str AL
	engine support (kg)	0.388	0.129			Str AL
	stage interface (kg)	0.200	0.200			Str AL
	Payload interface (kg)	0.200	0.200			Str AL
	stage misc. (kg)					Str AL
	Contingency (10%)	0.281	0.182			Sys Bobby
	Parachutes	0.700	0.700			
	Propellant Mass Fraction	0.598	0.563			
	Payload Mass Subtotal (mt)	**60.508**	**62.195**	**32.937**	**156**	

TRANS-MARS INJECTION STAGES HMM NUCLEAR DRM v4.0a WEIGHT BREAKOUT

The TMI stages(which are NTP stages) weight breakout into the component level of each subsystem is given on this chart. Futher information is contained for some items as to the number of each item or in some cases the item may consists of several smaller items which are listed by weight and number in the microsoft excel macro cell where each weight is computed and shown. This information may be seen using the computer generated microsoft file that is available.

The first weight shown is the Payload Mass Subtotal (mt) which is the payload for the TMI stages.The total burnout mass of the vehicle (including residuals and rcs propellants) which was used along with the total usable propellants to check the performance of the TMI stages to insure the mission could be completed successfully.The Piloted TMI Stage Propellant Mass includes propellants for the TMI burn, the Aerobrake burn, and the TEI burn. The misc. / margin shown next tells how the TMI Stage substem weights have increased or decreased since the performance computations were made. The major systems are shown with components which add up to give the total for that system. A contingency of 10 percent is added for all the dry weights (excluding the NTP engines) which should be adequate at this time since all the equipment and structures were sized and estimated from exsisting materials and technology. The weight contingency for the NTP engines is already included in the engine weight. The stage mass fraction is included near the bottom of the chart. The LH2 tank length (meters) of each TMI Stage which has a 7.4m diameter is shown next. The HMM team member who derived the component weights is shown out to the right side of the chart.

The Total TMI Stage Mass (mt) is shown (after the LH2 tank length) which adds with the Payload Mass Subtotal at the top of the chart to show the Total IMLEO (mt) . The Number of 80 mt LV Flights for each of the three Mars Flights are shown below the chart.

	Description	'11 Cargo Flight 1	'11 Cargo Flight 2	'14 Piloted Flight	Totals	
NTP TMI	Burnout Mass (bi-modal, mt)	25.79	25.79	***44.55	**96**	
Stage, LH_2	Propellant Mass (mt)	46.26	47.14	90.86	**184**	
I_{sp} = 955/940 sec	Misc. / Margin	**-1.747**	**-1.767**	**-3.187**	**-6.7**	
	Propulsion System	8.168	8.168	8.659		
	RCS thrusters(12)	0.016	0.016	0.016		
	RCS Tanks	0.314	0.314	0.684		
	pressurant tanks	0.114	0.114	0.191		
	valves,filters,regulars & misc	0.052	0.052	0.097		
	14.75 klb_f NTP engine (T/W = 3.1)	7.672	7.672	7.672		
	Propulsion Sys. Residuals/Pressurants	0.000	0.000	0.000		
	Boil-off (prior to TMI)	0.000	0.000	0.000		
	RCS Propellant	1.790	1.810	4.460		
	Fuel cell O2 reactant	0.490	0.490	0.490		
	Radiation shields(3)			3.240		
	LH2 Refrigeration sysstem	0.340	0.340	0.340		
	Avionics & Aux Power	1.070	1.070	1.070		
	Brayton Power System(50 kWe)	1.550	1.550	1.550		
	CORE STAGE LH2 Tank & Structure	12.530	12.530	12.530		
	"In-Line" LH2 Tank & Structure			12.500		
	Contingency (10%)	1.599	1.599	2.898		Sys Bobby
	Propellant Mass Fraction	0.642	0.646	0.671		
	LH2 Tank Length (Diam. = 7.4 m)	19.4	19.7	36.3		
	Total Stage Mass (mt)	**72.050**	**72.934**	**135.410**	**436**	
	TOTAL IMLEO (mt)	**132.558**	**135.129**	**168.347**	**436.03**	
Number of **80** mt LV Flights (75%–100% packing efficiency)		**3**	**3**	**3**		

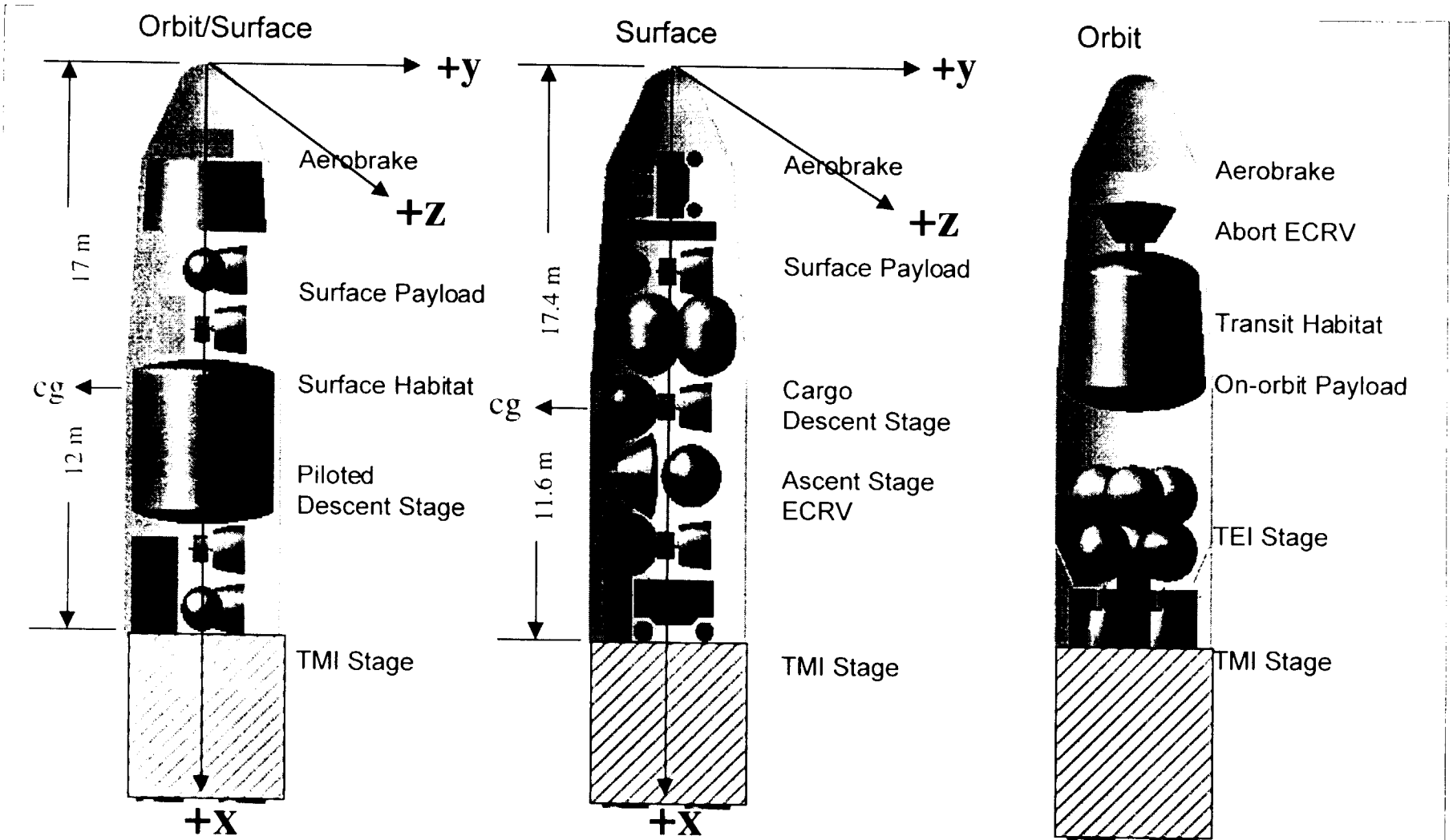
* Produced at Mars using ISPP, ** Gathered samples & rocks. *** Includes 3240 kg external radiation shield.

 # Fits in ? launches until transportation packaging assessment is updated.

HMM MASS PROPERTIES COORDINATE SYSTEM

The coordinate system used to generate the HMM mass properties for cargo flights 1 and 2 for the payloads that are forward of the TMI stages is shown on this chart. The orgin and axes were selected to produced a right handed all positive x coordinate system.The piloted flight mass properties will be worked later as required.

HMM MASS PROPERTIES COORDINATE SYSTEM



Bobby Brothers / Alpha Tech
Ena Nishimuta / MSFC
6/2/99

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP MISSION MASS PROPERTIES

The mass properties for flight # 1 are shown on this chart as configurated in the previous chart which shows the general layout of the payload equipment and modules. The x-cg is located 18.4m from the center of the forward end of the shroud nose cone which is the orgin of the coordinate system. This is 63 % of the 29 meter length of the payload configuration.The mass properties were provided to the performance team members for use in their analysis.

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP MISSION MAY 24,1999
MASS PROPERTIES FLIGHT # 1

DESCRIPTION	LAUNCH WEIGHT (KG)	XCG (M)	YCG (M)	ZCG (M)	INERTIAS REFERENCED FROM INDIVIDUAL ITEM CG IXX KG M^2	IYY KG M^2	IZZ KG M^2
AEROBRAKE	9730	16.39	0.00	0.00	163659	763740	763740
UNPRESS ROVER(FWD)	650	4.14	0.00	0.00	826	460	609
UNPRESS ROVER(AFT)	650	13.41	-1.40	0.00	460	826	609
INFLATABLE LAB MOD	3100	6.81	0.00	0.00	19225	12868	12868
DESCENT STAGE (FWD	3641	11.84	0.40	0.00	17392	22673	15984
DESCENT PROP(FWD)	5425	10.46	0.00	0.00	20072	20072	4258
DESCENT STAGE (AFT	3641	26.44	0.40	0.00	17392	22673	15984
DESCENT PROP(AFT)	5425	27.62	0.00	0.00	20072	20072	4258
SURFACE HABITAT MOD	23486	19.14	0.25	0.00	221550	232613	232613
POWER SYS ENV	4761	26.44	-2.30	0.00	17846	24511	10863
TOTAL PAYLOAD	60508	18.40	-0.05	0.00	527431	3240391	3210603

Brothers

Coordinate system referenced from center of fwd end of shroud nose cone

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP MISSION MASS PROPERTIES

The mass properties for flight # 2 are shown on this chart as configurated in the chart showing the coordinate system and the general layout of the payload equipment and modules. The x-cg is located 18.69m from the orgin which is 64 % of the length of the payload configuration. These mass properties were provided to the HMM team members for their use as required.

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP MISSION
MASS PROPERTIES FLIGHT #2

MAY 25,1999

DESCRIPTION	LAUNCH WEIGHT (KG)	XCG (M)	YCG (M)	ZCG (M)	INERTIAS REFERENCED FROM INDIVIDUAL ITEM CG IXX KG M^2	IYY KG M^2	IZZ KG M^2
AEROBRAKE	9790	16.39	0.00	0.00	164668	768450	768450
TELE-OPER ROVERS(3)	1500	5.82	-1.40	0.00	397	1686	1686
DIFS POWER CART	1500	5.82	0.40	0.00	1102	2039	2039
COMM SYS ENVEL	320	8.10	0.00	0.00	1178	606	606
ISRU SYS -LH2 TKS	1871	10.06	-1.10	0.00	3544	3544	200
LH2 SEED + TKS	4607	13.81	0.00	0.00	23588	17937	17937
SURFACE POWER SYS(2	12118	27.22	0.55	0.00	61489	53024	23850
POWER SYS ENVELOPE	1437	25.45	-2.30	0.00	3428	8614	5566
SCIENCE PAYLOAD	2477	20.50	0.00	0.00	413	413	413
DESCENT STAGE(FWD)	2427	10.06	0.00	0.00	16055	9848	9848
DESCENT PROP(FWD)	3127	10.06	-2.10	0.00	1801	1801	1801
DESCENT STAGE(MID)	2427	16.97	0.00	0.00	16055	9848	9848
DESCENT PROP(MID)	3127	16.97	-2.10	0.00	3202	3202	3202
DESCENT STAGE(AFT)	2427	24.07	0.00	0.00	16055	9848	9848
DESCENT PROP(AFT)	3127	24.07	-2.10	0.00	3202	3202	3202
ASCENT STAGE	9915	20.05	0.00	0.00	50765	33843	33843
TOTALS PAYLOAD	62197	18.69	-0.32	0.00	418656	3326218	3342367

Coordinate system referenced from center of fwd end of shroud nose cone

Brothers

HMM 2011 CARGO / 2014 PILOTED NTP MASS PROPERTIES RECONFIGURATED

The mass properties for flight # 1 were recomputed for an alternate configuration in an attemp to move the x-cg forward to help the areobraking part of the mission The lighter inflatable lab module was moved aft of the heavier surface hab module and equipment which could be moved forward was moved. The resulting x-cg of 17.05m from the orgin was obtained which is 59 % of the length of the payload configuration. The x-cg during aerobraking will be a problem, but the center of pressure may be moved aft to control the flight and alleviate this cg problem. The cg costraints during launch can be worked out with the configuration layout and the launch vehicle cg requirements.

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP JUNE 8,1999
MASS PROPERTIES FLIGHT #1

DESCRIPTION	LAUNCH WEIGHT (KG)	XCG (M)	YCG (M)	ZCG (M)	INERTIAS REFERENCED FROM INDIVIDUAL ITEM CG IXX KG M^2	IYY KG M^2	IZZ KG M^2
AEROBRAKE	7672.0	14.91	0.00	0.00	435435	757486	757486
UNPRESS ROVER	650.0	4.14	0.00	0.00	826	460	609
UNPRESS ROVER	650.0	9.86	-1.40	0.00	460	826	609
INFLATABLE LAB MOD	3100.0	21.70	0.00	0.00	19225	12868	12868
DESCENT STAGE (FWD S	3640.5	8.29	0.40	0.00	17392	22673	15984
DESCENT PROP(FWD)	5425.0	6.91	0.00	0.00	20072	20072	4258
DESCENT STAGE (AFT S	3640.5	26.44	0.40	0.00	17392	22673	15984
DESCENT PROP(AFT)	5425.0	27.62	0.00	0.00	20072	20072	4258
SUFACE HABITAT MOD	23486.0	15.59	0.25	0.00	221550	232613	232613
POWER SYS ENV	4761.0	26.44	-2.30	0.00	17846	24511	10863
TOTAL PAYLOAD	58450.0	17.05	-0.05	0.00	799201	3592464	3562671

Coordinate system referenced from center of fwd end of shroud nose cone

HMM 2011 CARGO / PILOTED BIMODAL NTP DETAIL MASS PROPERTIES

The detail mass properties for flight # 1 are shown on this chart. These mass properties are the same as the previos chart, but they are shown in the english system and they are expanded to show the product of inertia, the principal moment of inertria, and the new principal coordinate system angles referenced from the selected system and centered at the cg of the configuration. These data were made available to the HMM study team members.

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP MISSION — JUNE 8,1999

MASS PROPERTIES Flight #1

ITEM	WEIGHT POUNDS	CENTER OF GRAVITY STATION =INCHES X	Y	Z	MOMENT OF INERTIA SLUGS = FT2 IX	IY	IZ	PRODUCT OF INERTIA SLUGS -FT2 IXY	IXZ	IYZ
100 Aerobrake	16914.	587.0	0.0	0.0	321159.	558697.	558697.	0.	0.	0.
200 Unpress rover(fwd)	1433.	163.0	0.0	0.0	609.	340.	449.	0.	0.	0.
300 Unpress rover(aft)	1433.	388.0	-55.0	0.0	340.	609.	449.	0.	0.	0.
400 Inflatable lab mod	6834.	854.0	0.0	0.0	14179.	9491.	9491.	0.	0.	0.
500 Descent stage(fwd)	8027.	326.0	15.8	0.0	12830.	16725.	11790.	0.	0.	0.
600 Descent prop(fwd)	11960.	272.0	0.0	0.0	14804.	14804.	3140.	0.	0.	0.
700 Descent stage(aft)	8027.	1040.9	15.8	0.0	12830.	16725.	11788.	0.	0.	0.
800 Descent prop(aft)	11960.	1087.4	0.0	0.0	14804.	14804.	3140.	0.	0.	0.
900 Surface habitat mod	51778.	614.0	9.8	0.0	163408.	171567.	171567.	0.	0.	0.
950 Power sys env	10496.	1040.9	-90.6	0.0	13162.	18078.	8012.	0.	0.	0.
999 TOTAL PAYLOAD	128862.	671.3	-2.1	0.0	589458.	2649706.	2627721.	-76639.	0.	0.

PRINCIPAL MOI 1= 0.586611063E+06 2= 0.265255275E+07 3= 0.262772125E+07 SLUG = FT2

	X	Y	Z
AXIS 1 COSINES	0.999310732E+00	-0.371219665E-01	0.000000000E+00
2	0.371219665E-01	0.999310732E+00	0.000000000E+00
3	0.000000000E+00	0.000000000E+00	0.100000000E+01
AXIS 1 ANGLES	0.212743545E+01	-0.878725739E+02	0.900000000E+02
2	0.878725739E+02	0.212743545E+01	0.900000000E+02
3	0.900000000E+02	0.900000000E+02	0.000000000E+00

IAVG = 0.26401E+07

MU = 0.16540E+03

Coordinate system referenced from center of fwd end of shroud nose cone

1

HMM 2011 CARGO / 2014 PILOTED NTP MASS PROPERTIES RECONFIGURATED

The mass properties for flight # 2 were recomputed for an alternate configuration also in an attemp to move the x cg forward to help alleviate the cg / cp problems during aerobraking. The resulting x cg of 17.38m from the orgin was obtained which is 60 % of the length of the payload configuration. This is a small improvement to the cg which was orginally at 64 % of the configuration length.The cp during aerobraking will have to be controlled to alleviate these problems. The cg costraints during launch can be worked out with the configuration layout and the launch vehicle cg requirements.

HMM 2011 CARGO / 2014 PILOTED BIMODAL NTP
MASS PROPERTIES FLIGHT #2

JUNE 8,1999

DESCRIPTION	LAUNCH WEIGHT (KG)	XCG (M)	YCG (M)	ZCG (M)	INERTIAS REFERENCED FROM INDIVIDUAL ITEM CG IXX KG M^2	IYY KG M^2	IZZ KG M^2
AEROBRAKE	7672.0	14.91	0.00	0.00	435435	757486	757486
TELE-OPER ROVERS(3)	1500.0	5.82	-1.40	0.00	397	1686	1686
DIPS POWER CART	1500.0	27.22	0.55	1.22	2039	1102	2039
COMM SYS ENVEL	320.0	8.10	0.00	0.00	1178	606	606
ISRU SYS -LH2 TKS	1871.0	10.06	-1.10	0.00	3544	3544	200
LH2 SEED + TKS	4607.0	13.81	0.00	0.00	23588	17937	17937
SURF PWR SYS CART	6059.0	5.82	0.40	0.00	5817	9094	9094
SURF PWR SYS CART	6059.0	27.22	0.55	-1.22	9094	5817	9094
POWER SYS ENVELOPE	1437.0	25.45	-2.30	0.00	3428	8614	5566
SCIENCE PAYLOAD	2477.0	20.50	0.00	0.00	413	413	413
DESCENT STAGE(FWD)	2427.0	10.06	0.00	0.00	16055	9848	9848
DESCENT FUEL(FWD)	2084.0	16.97	-2.10	0.00	2068	2068	2068
DESCENT STAGE(MID)	2427.0	16.97	0.00	0.00	16055	9848	9848
DESCENT LOX	7296.0	20.50	1.26	1.65	7239	7239	7239
DESCENT STAGE(AFT)	2427.0	24.07	0.00	0.00	16055	9848	9848
ASCENT STAGE	9915.0	20.05	0.00	0.00	50765	33843	33843
TOTAL PAYLOAD	60078.0	17.38	0.07	0.11	660162	3383608	3387591

Coordinate system referenced from center of fwd end of shroud nose cone

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