

***Subsystem Details for the Fiscal Year 2004 Advanced Life
Support Research and Technology Development Metric***

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1 INTRODUCTION

This document provides values at the assembly level for the subsystems described in the Fiscal Year 2004 Advanced Life Support Research and Technology Development Metric (Hanford, 2004).

2 SUBSYSTEM COMPONENTS IN FISCAL YEAR 2004 ALS R&TD METRIC

Hanford (2004) summarizes the subordinate computational values for the Advanced Life Support Research and Technology Development (ALS R&TD) Metric at the subsystem level, while this manuscript provides a summary at the assembly level. Hanford (2004) lists mass, volume, power, cooling, and crewtime for each mission examined by the ALS R&TD Metric according to the nominal organization for the Advanced Life Support (ALS) elements. The values in the tables below, Table 2.1 through Table 2.8, list the assemblies, using the organization and names within the Advanced Life Support Sizing Analysis Tool (ALSSAT) for each ALS element. These tables specifically detail mass, volume, power, cooling, and crewtime. Additionally, mass and volume are designated in terms of values associated with initial hardware and resupplied hardware just as they are within ALSSAT.

The overall subsystem values are listed on the line following each subsystem entry. These values are consistent with those reported in Hanford (2004) for each listed mission. Any deviations between these values and those in Hanford (2004) arise from differences in when individual numerical values are rounded within each report, and therefore the resulting minor differences should not concern even a careful reader. Hanford (2004) uses the units kW_e and kW_{th} for power and cooling, respectively, while the nomenclature below uses W_e and W_{th} , which is consistent with the native units within ALSSAT.

The assemblies, as specified within ALSSAT, are listed in bold below their respective subsystems. When recognizable assembly components are not listed within ALSSAT, a summary of the assembly is provided on the same line as the entry for the assembly. Assemblies with one or more recognizable components are further described by the indented entries below them. See Yeh, *et al.* (2002), Yeh, *et al.* (2003), and Yeh, *et al.* (2004) for details about ALSSAT organization. Except for the dry food mass listed within the Food Processing, Packaging, and Storage within the Food Subsystem, total values for assemblies would be the sum of their components. The Dry Food Mass, however, is that portion of the food system that was excluded during the computation of the Fiscal Year 2004 ALS R&TD Metric. It is listed here to provide a reference, but it is otherwise ignored in the overall totals. See Hanford (2004) for details of this process and supporting rationale. When applicable, the technology label from ALSSAT is listed in the second column, and the associated abbreviations are listed below in Section 4. For more details of the technologies assumed for each mission, please see Hanford (2004) for descriptions of each subsystem and an overall life support system schematic.

Table 2.1 Subsystem Breakdown for Orbiting Research Facility: International Space Station Upgrade Mission using Current Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		3,908	29,291	4.93	30.15	4,500	2,870	129.58	38,686
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	193.13
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	186.06	0.00	0.44	0.00	559.43	559.43	27.58	678.70
Carbon Dioxide Reduction	None	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Generation	SPE / ISS	400.28	1,188.18	1.05	0.00	3,570.27	1,942.63	101.39	4,045.26
Gaseous Trace Contaminant Control	ISS	68.41	258.81	0.14	3.80	194.35	194.35	0.00	745.48
Atmosphere Composition Monitoring Assembly	ISS	54.30	95.69	0.09	0.16	103.50	103.50	0.00	249.45
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	37.78
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	High Pressure	2,708.66	24,754.17	2.69	24.55	0.00	0.00	0.00	29,279.74
Oxygen Storage	High Pressure	327.67	2,994.58	0.18	1.64	0.00	0.00	0.00	3,443.64
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.61	3.03
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	9.47
Biomass Subsystem		0	0	0.00	0.00	0	0	0.00	0
Crop Storage	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Growth Chamber / Salad Machine	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Subsystem		30,049	0	119.96	0.00	2,930	2,930	0.00	40,395
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/ Frozen	30,048.80	0.00	119.96	0.00	2,932.00	2,932.00	0.00	40,395.44
<i>Dry Food Mass (neglected)</i>		<i>14,582.23</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>14,582.23</i>
Thermal Subsystem		321	430	0.94	1.73	770	770	20.28	1,555
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	575.79
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	154.38
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	59.93
Atmospheric Microbial Control	ISS	100.00	429.53	0.27	1.73	0.00	0.00	20.28	674.55
Internal Thermal Control System		80.26	0.00	0.12	0.00	2.26	2.26	0.00	90.07

Table 2.1 Subsystem Breakdown for Orbiting Research Facility: International Space Station Upgrade Mission using Current Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		3,410	0	93.85	0.00	10	10	0.00	9,681
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	56.23
Solid Waste Processing System									
Solid Waste Treatment	Storage	3,373.83	0.00	93.72	0.00	0.00	0.00	0.00	9,624.95
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		15,857	10,594	14.42	0.00	1,350	1,350	0.00	28,489
Urine / Waste Water Collection System	ISS	4.55	36.56	0.02	0.00	4.00	4.00	0.00	45.64
Water Recovery System									
Water Treatment Process	ISS WRS	452.52	10,332.66	2.35	0.00	712.61	712.61	0.00	11,511.94
Urine, Hygiene & Potable Water, & Brine Storage Tankage		98.76	137.53	0.26	0.00	10.73	10.73	0.00	262.21
Microbial Check Valve		2.01	18.36	0.01	0.00	0.00	0.00	0.00	21.04
Process Controller		36.11	15.46	0.08	0.00	156.18	156.18	0.00	181.83
Water Quality Monitoring		14.07	35.67	0.04	0.00	4.72	4.72	0.00	56.18
Product Water Delivery System		28.14	18.09	0.07	0.00	2.08	2.08	0.00	52.56
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		15,220.50	0.00	11.59	0.00	455.04	455.04	0.00	16,357.54
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		0	0	0.00	0.00	0	0	0.00	0
Maximum Absorbency Garments		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Removal (LiOH)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		17,871	0	69.65	0.00	0	0	0.00	22,517
Clothing		10,643.40	0.00	62.42	0.00	0.00	0.00	0.00	14,806.81
Laundry Equipment									0.00
Washer / Dryer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detergent		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Items		7,227.66	0.00	7.23	0.00	0.00	0.00	0.00	7,709.90
Totals		71,416	40,315	303.75	31.88	9,560	7,930	149.86	141,323

Table 2.2 Subsystem Breakdown for Orbiting Research Facility: International Space Station Upgrade Mission using Advanced Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		1,830	9,598	3.18	12.92	6,149	4,521	129.58	16,932
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	193.13
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	186.06	0.00	0.44	0.00	559.43	559.43	27.58	670.95
Carbon Dioxide Reduction	Sabatier	77.08	0.00	0.14	0.00	84.27	84.27	0.00	153.83
Oxygen Generation	SPE / ISS	400.28	1,188.18	1.05	0.00	3,570.27	1,942.63	101.39	4,016.77
Gaseous Trace Contaminant Control	ISS	68.41	258.81	0.14	3.80	194.35	194.35	0.00	745.48
Atmosphere Composition Monitoring Assembly	ISS	54.30	95.69	0.09	0.16	103.50	103.50	0.00	249.45
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	37.78
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	Cryogenic	784.20	7,166.73	0.75	6.88	1,138.92	1,138.92	0.00	9,370.87
Oxygen Storage	Cryogenic	97.27	888.96	0.23	2.08	425.98	425.98	0.00	1,481.05
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.61	2.86
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	9.47
Biomass Subsystem		0	0	0.00	0.00	0	0	0.00	0
Crop Storage	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Growth Chamber / Salad Machine	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Subsystem		24,002	0	105.79	0.00	960	960	0.00	31,826
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM	24,001.97	0.00	105.79	0.00	960.00	960.00	0.00	31,826.07
<i>Dry Food Mass (neglected)</i>		<i>14,498.11</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>14,498.11</i>
Thermal Subsystem		335	430	0.96	1.73	769	769	20.28	1,565
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	575.79
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	154.38
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	59.93
Atmospheric Microbial Control	ISS	100.00	429.53	0.27	1.73	0.00	0.00	20.28	668.85
Internal Thermal Control System		94.70	0.00	0.14	0.00	2.74	2.74	0.00	106.23

Table 2.2 Subsystem Breakdown for Orbiting Research Facility: International Space Station Upgrade Mission using Advanced Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		1,477	0	38.06	0.00	1,438	1,438	973.33	5,450
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	56.23
Solid Waste Processing System	Combo								
Solid Waste Treatment		1,440.89	0.00	37.93	0.00	1,423.78	1,423.78	973.33	5,393.91
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		784	1,524	2.05	0.00	3,801	1,884	0.00	4,864
Urine / Waste Water Collection System	ISS	4.55	36.56	0.02	0.00	4.00	4.00	0.00	45.64
Water Recovery System									
Water Treatment Process	VPCAR	480.11	988.89	1.43	0.00	3,592.68	1,675.08	0.00	3,817.06
Urine, Hygiene & Potable Water, & Brine Storage Tankage		169.41	235.90	0.44	0.00	16.76	16.76	0.00	448.06
Microbial Check Valve		5.10	46.54	0.01	0.00	0.00	0.00	0.00	52.31
Process Controller		63.00	149.04	0.00	0.00	180.00	180.00	0.00	356.02
Water Quality Monitoring		14.07	35.67	0.04	0.00	4.72	4.72	0.00	56.18
Product Water Delivery System		48.21	30.98	0.11	0.00	3.24	3.24	0.00	89.12
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		0	0	0.00	0.00	0	0	0.00	0
Maximum Absorbency Garments		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Removal (LiOH)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		7,746	53	10.06	0.00	633	633	0.00	8,977
Clothing		438.00	0.00	2.57	0.00	0.00	0.00	0.00	609.42
Laundry Equipment									0.00
Washer / Dryer		80.00	0.00	0.26	0.00	633.33	633.33	0.00	603.94
Detergent		0.01	53.25	0.00	0.00	0.00	0.00	0.00	53.26
Miscellaneous Items		7,227.66	0.00	7.23	0.00	0.00	0.00	0.00	7,709.90
Totals		36,174	11,605	160.10	14.65	13,750	10,205	1,123.19	69,614

Table 2.3 Subsystem Breakdown for Independent Exploration Mission: Mars Transit Vehicle using Current Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		2,199	17	3.11	0.27	4,350	2,790	12.78	3,400
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	141.31
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	185.10	0.00	0.44	0.00	556.21	556.21	2.72	345.42
Carbon Dioxide Reduction	None	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Generation	SPE / ISS	388.97	0.00	1.02	0.00	3,421.67	1,868.34	10.00	1,292.13
Gaseous Trace Contaminant Control	ISS	68.41	17.40	0.14	0.27	194.35	194.35	0.00	143.40
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	83.79
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	35.48
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	High Pressure	1,039.70	0.00	0.93	0.00	0.00	0.00	0.00	1,048.22
Oxygen Storage	High Pressure	300.17	0.00	0.15	0.00	0.00	0.00	0.00	301.54
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.06	1.96
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	7.17
Biomass Subsystem		761	0	17.03	0.00	12,030	12,030	0.00	4,248
Crop Storage		205.88	0.00	0.00	0.00	0.00	0.00	0.00	205.88
Plant Growth Chamber / Salad Machine		555.15	0.00	17.03	0.00	12,025.53	12,025.53	0.00	4,042.22
Food Subsystem		4,158	0	15.12	0.00	2,400	2,400	0.00	4,960
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/ Frozen and Salad	4,157.80	0.00	15.12	0.00	2,396.00	2,396.00	0.00	4,959.99
<i>Dry Food Mass (neglected)</i>		<i>1,427.35</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>1,427.35</i>
Thermal Subsystem		369	0	1.08	0.00	1,070	1,070	2.00	677
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	269.61
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	61.15
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	26.88
Atmospheric Microbial Control	ISS	100.00	0.00	0.27	0.00	0.00	0.00	2.00	104.10
Internal Thermal Control System		128.63	0.00	0.26	0.00	304.88	304.88	0.00	215.47

Table 2.3 Subsystem Breakdown for Independent Exploration Mission: Mars Transit Vehicle using Current Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		393	0	10.03	0.00	10	10	0.00	489
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	41.43
Solid Waste Processing System									
Solid Waste Treatment	Storage	356.43	0.00	9.90	0.00	0.00	0.00	0.00	447.11
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		1,389	1,198	4.18	0.00	1,000	1,000	0.00	2,903
Urine / Waste Water Collection System	ISS	4.55	0.00	0.02	0.00	4.00	4.00	0.00	5.84
Water Recovery System									
Water Treatment Process	ISS WRS	553.31	1,198.37	3.15	0.00	798.65	798.65	0.00	2,001.76
Urine, Hygiene & Potable Water, & Brine Storage Tankage		132.78	0.00	0.34	0.00	13.63	13.63	0.00	139.67
Microbial Check Valve		3.53	0.00	0.01	0.00	0.00	0.00	0.00	3.62
Process Controller		36.11	0.00	0.08	0.00	156.18	156.18	0.00	80.10
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	15.74
Product Water Delivery System		37.83	0.00	0.09	0.00	2.64	2.64	0.00	39.39
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		606.74	0.00	0.45	0.00	21.08	21.08	0.00	616.70
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		0	0	0.00	0.00	0	0	0.00	0
Maximum Absorbency Garments		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Removal (LiOH)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		1,763	0	6.87	0.00	0	0	0.00	1,826
Clothing		1,049.76	0.00	6.16	0.00	0.00	0.00	0.00	1,106.19
Laundry Equipment									0.00
Washer / Dryer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detergent		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Items		712.86	0.00	0.71	0.00	0.00	0.00	0.00	719.36
Totals		11,032	1,215	57.42	0.27	20,860	19,300	14.78	18,503

Table 2.4 Subsystem Breakdown for Independent Exploration Mission: Mars Transit Vehicle using Advanced Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	[W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		1,328	17		0.27	5,488	3,934	12.78	2,799
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	140.61
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	185.10	0.00	0.44	0.00	556.21	556.21	2.72	339.32
Carbon Dioxide Reduction	Sabatier	75.91	0.00	0.14	0.00	82.94	82.94	0.00	99.34
Oxygen Generation	SPE / ISS	388.97	0.00	1.02	0.00	3,421.67	1,868.34	10.00	1,271.47
Gaseous Trace Contaminant Control	ISS	68.41	17.40	0.14	0.27	194.35	194.35	0.00	141.46
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	82.76
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	35.48
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	Cryogenic	302.71	0.00	0.38	0.00	639.20	639.20	0.00	476.86
Oxygen Storage	Cryogenic	89.34	0.00	0.22	0.00	417.75	417.75	0.00	202.89
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.06	1.93
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	7.17
Biomass Subsystem		761	0	17.03	0.00	12,026	12,026	0.00	4,128
Crop Storage		205.88	0.00	0.00	0.00	0.00	0.00	0.00	205.88
Plant Growth Chamber / Salad Machine		555.15	0.00	17.03	0.00	12,025.53	12,025.53	0.00	3,921.96
Food Subsystem		2,109	0	8.16	0.00	960	960	0.00	2,440
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/bulk pkg.	2,109.28	0.00	8.16	0.00	960.00	960.00	0.00	2,440.35
<i>Dry Food Mass (neglected)</i>		<i>1,418.17</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>1,418.17</i>
Thermal Subsystem		373	0	1.09	0.00	1,099	1,099	2.00	678
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	264.31
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	59.40
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	26.27
Atmospheric Microbial Control	ISS	100.00	0.00	0.27	0.00	0.00	0.00	2.00	103.71
Internal Thermal Control System		133.22	0.00	0.27	0.00	332.21	332.21	0.00	224.39

Table 2.4 Subsystem Breakdown for Independent Exploration Mission: Mars Transit Vehicle using Advanced Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		256	0	6.24	0.00	14	14	0.00	317
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	41.29
Solid Waste Processing System	Storage								
Solid Waste Treatment		220.08	0.00	6.11	0.00	0.00	0.00	0.00	276.05
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		897	94	2.40	0.00	4,183	2,008	0.00	2,065
Urine / Waste Water Collection System	ISS	4.55	0.00	0.02	0.00	4.00	4.00	0.00	5.80
Water Recovery System									
Water Treatment Process	VPCAR	550.06	93.71	1.67	0.00	3,970.97	1,796.10	0.00	1,654.07
Urine, Hygiene & Potable Water, & Brine Storage Tankage		201.65	0.00	0.52	0.00	19.51	19.51	0.00	211.62
Microbial Check Valve		6.52	0.00	0.02	0.00	0.00	0.00	0.00	6.70
Process Controller		63.00	0.00	0.00	0.00	180.00	180.00	0.00	111.06
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	15.70
Product Water Delivery System		57.38	0.00	0.13	0.00	3.77	3.77	0.00	59.58
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		0	0	0.00	0.00	0	0	0.00	0
Maximum Absorbency Garments		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Removal (LiOH)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		858	5	1.35	0.00	633	633	0.00	1,044
Clothing		64.80	0.00	0.38	0.00	0.00	0.00	0.00	68.28
Laundry Equipment									0.00
Washer / Dryer		80.00	0.00	0.26	0.00	633.33	633.33	0.00	251.48
Detergent		0.01	5.25	0.00	0.00	0.00	0.00	0.00	5.26
Miscellaneous Items		712.86	0.00	0.71	0.00	0.00	0.00	0.00	719.36
Totals		6,582	116	39.04	0.27	24,403	20,674	14.78	13,471

Table 2.5 Subsystem Breakdown for Independent Exploration Mission: Mars Descent / Ascent Lander using Current Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		1,130	0	2.28	0.00	4,340	2,790	1.07	2,679
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	163.04
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	186.06	0.00	0.44	0.00	559.43	559.43	0.23	424.83
Carbon Dioxide Reduction	None	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Generation	SPE / ISS	387.88	0.00	1.02	0.00	3,407.30	1,861.15	0.83	1,505.37
Gaseous Trace Contaminant Control	ISS	68.41	0.00	0.14	0.00	194.35	194.35	0.00	150.24
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	98.91
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	37.78
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	High Pressure	177.93	0.00	0.17	0.00	0.00	0.00	0.00	189.27
Oxygen Storage	High Pressure	92.26	0.00	0.08	0.00	0.00	0.00	0.00	97.60
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.01	2.08
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	9.47
Biomass Subsystem		0	0	0.00	0.00	0	0	0.00	0
Crop Storage	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Growth Chamber / Salad Machine	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Subsystem		302	0	1.15	0.00	1,860	1,860	0.00	1,072
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/ Frozen	301.61	0.00	1.15	0.00	1,860.00	1,860.00	0.00	1,072.10
<i>Dry Food Mass (neglected)</i>		<i>120.39</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>120.39</i>
Thermal Subsystem		295	0	0.92	0.00	820	820	0.17	662
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	349.31
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	79.68
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	33.89
Atmospheric Microbial Control	ISS	100.00	0.00	0.27	0.00	0.00	0.00	0.17	118.57
Internal Thermal Control System		54.84	0.00	0.10	0.00	51.56	51.56	0.00	80.74

Table 2.5 Subsystem Breakdown for Independent Exploration Mission: Mars Descent / Ascent Lander using Current Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		64	0	0.91	0.00	10	10	0.00	130
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	50.25
Solid Waste Processing System									
Solid Waste Treatment	Storage	28.01	0.00	0.78	0.00	0.00	0.00	0.00	80.04
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		732	10	2.89	0.00	900	900	0.00	1,269
Urine / Waste Water Collection System	ISS	4.55	0.00	0.02	0.00	4.00	4.00	0.00	7.38
Water Recovery System									
Water Treatment Process	ISS WRS	451.88	10.32	2.35	0.00	712.07	712.07	0.00	884.55
Urine, Hygiene & Potable Water, & Brine Storage Tankage		98.86	0.00	0.26	0.00	10.74	10.74	0.00	120.21
Microbial Check Valve		2.01	0.00	0.01	0.00	0.00	0.00	0.00	2.68
Process Controller		36.11	0.00	0.08	0.00	156.18	156.18	0.00	99.70
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	18.50
Product Water Delivery System		28.17	0.00	0.07	0.00	2.08	2.08	0.00	33.61
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		96.15	0.00	0.06	0.00	5.91	5.91	0.00	102.36
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		22	0	0.25	0.00	0	0	0.00	38
Maximum Absorbency Garments		1.04	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Carbon Dioxide Removal (LiOH)		20.70	0.00	0.25	0.00	0.00	0.00	0.00	37.38
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		147	0	0.57	0.00	0	0	0.00	185
Clothing		87.48	0.00	0.51	0.00	0.00	0.00	0.00	121.50
Laundry Equipment									0.00
Washer / Dryer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detergent		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Items		59.41	0.00	0.06	0.00	0.00	0.00	0.00	63.41
Totals		2,692	10	8.97	0.00	7,930	6,380	1.24	6,035

Table 2.6 Subsystem Breakdown for Independent Exploration Mission: Mars Descent / Ascent Lander using Advanced Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		687	0	1.00	0.00	795	795	0.01	1,031
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	161.35
Atmosphere Revitalization System									
Carbon Dioxide Removal	SAVD	135.75	0.00	0.29	0.00	220.86	220.86	0.00	232.17
Carbon Dioxide Reduction	None	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Generation	Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gaseous Trace Contaminant Control	ATCO	2.33	0.00	0.00	0.00	0.00	0.00	0.00	2.33
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	96.42
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	37.78
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	Cryogenic	87.54	0.00	0.08	0.00	117.94	117.94	0.00	134.04
Oxygen Storage	Cryogenic	244.31	0.00	0.20	0.00	280.64	280.64	0.00	355.59
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.01	2.04
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	9.47
Biomass Subsystem		0	0	0.00	0.00	0	0	0.00	0
Crop Storage	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Growth Chamber / Salad Machine	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Subsystem		190	0	0.92	0.00	960	960	0.00	587
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/LMC	190.11	0.00	0.92	0.00	960.00	960.00	0.00	586.51
<i>Dry Food Mass (neglected)</i>		<i>119.76</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>119.76</i>
Thermal Subsystem		278	0	0.88	0.00	781	781	0.17	610
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	336.58
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	75.48
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	32.42
Atmospheric Microbial Control	ISS	100.00	0.00	0.27	0.00	0.00	0.00	0.17	118.36
Internal Thermal Control System		37.83	0.00	0.06	0.00	13.98	13.98	0.00	46.71

Table 2.6 Subsystem Breakdown for Independent Exploration Mission: Mars Descent / Ascent Lander using Advanced Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		65	0	0.91	0.00	14	14	0.00	130
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	49.92
Solid Waste Processing System	Storage								
Solid Waste Treatment		28.16	0.00	0.78	0.00	0.00	0.00	0.00	80.19
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		665	10	2.77	0.00	880	880	0.00	1,167
Urine / Waste Water Collection System	ISS	4.55	0.00	0.02	0.00	4.00	4.00	0.00	7.28
Water Recovery System									
Water Treatment Process	ISS WRS	440.63	10.08	2.29	0.00	702.49	702.49	0.00	848.62
Urine, Hygiene & Potable Water, & Brine Storage Tankage		96.49	0.00	0.25	0.00	10.54	10.54	0.00	116.84
Microbial Check Valve		1.91	0.00	0.01	0.00	0.00	0.00	0.00	2.58
Process Controller		36.11	0.00	0.08	0.00	156.18	156.18	0.00	95.95
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	18.39
Product Water Delivery System		27.49	0.00	0.06	0.00	2.04	2.04	0.00	32.20
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		43.87	0.00	0.02	0.00	0.00	0.00	0.00	45.20
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		22	0	0.25	0.00	0	0	0.00	38
Maximum Absorbency Garments		1.04	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Carbon Dioxide Removal (LiOH)		20.70	0.00	0.25	0.00	0.00	0.00	0.00	37.38
Airlock Recycle Pump for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		147	0	0.57	0.00	0	0	0.00	185
Clothing		87.48	0.00	0.51	0.00	0.00	0.00	0.00	121.50
Laundry Equipment									0.00
Washer / Dryer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detergent		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Items		59.41	0.00	0.06	0.00	0.00	0.00	0.00	63.41
Totals		2,054	10	7.30	0.00	3,430	3,430	0.18	3,748

Table 2.7 Subsystem Breakdown for Independent Exploration Mission: Surface Habitat Lander using Current Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		2,719	1,328	3.81	1.55	5,590	3,410	21.30	5,094
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	138.14
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	185.10	0.00	0.44	0.00	556.21	556.21	4.53	321.60
Carbon Dioxide Reduction	None	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen Generation	SPE / ISS	483.43	115.75	1.27	0.00	4,662.34	2,488.67	16.67	1,389.91
Gaseous Trace Contaminant Control	ISS	68.41	35.00	0.14	0.53	194.35	194.35	0.00	154.64
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	79.14
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	35.48
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	High Pressure	1,321.24	880.83	1.23	0.82	0.00	0.00	0.00	2,220.85
Oxygen Storage	High Pressure	444.10	296.07	0.30	0.20	0.00	0.00	0.00	744.75
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.10	1.92
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	7.17
Biomass Subsystem		898	0	17.03	0.00	12,030	12,030	0.00	3,844
Crop Storage		343.13	0.00	0.00	0.00	0.00	0.00	0.00	343.13
Plant Growth Chamber / Salad Machine		555.15	0.00	17.03	0.00	12,025.53	12,025.53	0.00	3,501.07
Food Subsystem		6,032	0	22.39	0.00	2,400	2,400	0.00	6,793
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/ Frozen and Salad	6,031.86	0.00	22.39	0.00	2,396.00	2,396.00	0.00	6,792.82
<i>Dry Food Mass (neglected)</i>		<i>2,379.28</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>2,379.28</i>
Thermal Subsystem		375	31	1.09	0.13	1,180	1,180	3.33	693
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	245.74
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	53.27
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	24.14
Atmospheric Microbial Control	ISS	100.00	31.33	0.27	0.13	0.00	0.00	3.33	137.51
Internal Thermal Control System		134.46	0.00	0.27	0.00	410.38	410.38	0.00	232.14

Table 2.7 Subsystem Breakdown for Independent Exploration Mission: Surface Habitat Lander using Current Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		686	0	18.17	0.00	10	10	0.00	855
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	40.80
Solid Waste Processing System									
Solid Waste Treatment	Storage	649.27	0.00	18.04	0.00	0.00	0.00	0.00	814.52
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		7,018	2,136	8.51	0.00	1,160	1,160	0.00	9,501
Urine / Waste Water Collection System	ISS	4.55	2.67	0.02	0.00	4.00	4.00	0.00	8.33
Water Recovery System									
Water Treatment Process	ISS WRS	541.63	2,130.67	3.17	0.00	788.76	788.76	0.00	2,884.33
Urine, Hygiene & Potable Water, & Brine Storage Tankage		133.34	0.00	0.35	0.00	13.68	13.68	0.00	139.72
Microbial Check Valve		3.56	2.32	0.01	0.00	0.00	0.00	0.00	5.97
Process Controller		36.11	0.00	0.08	0.00	156.18	156.18	0.00	73.08
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	15.53
Product Water Delivery System		37.99	0.00	0.09	0.00	2.65	2.65	0.00	39.43
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		6,247.11	0.00	4.75	0.00	188.57	188.57	0.00	6,334.37
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		1,292	0	2.91	0.00	2,500	2,500	0.00	1,899
Maximum Absorbency Garments		242.20	0.00	0.00	0.00	0.00	0.00	0.00	242.20
Carbon Dioxide Removal (LiOH)		817.20	0.00	2.43	0.00	0.00	0.00	0.00	839.46
Airlock Recycle Pump for EVA		70.30	0.00	0.14	0.00	1,000.00	1,000.00	0.00	303.58
Oxygen Recharge Compressor Assembly for EVA		162.48	0.00	0.34	0.00	1,500.00	1,500.00	0.00	513.59
Human Accommodations		2,938	0	11.45	0.00	0	0	0.00	3,043
Clothing		1,749.60	0.00	10.26	0.00	0.00	0.00	0.00	1,843.58
Laundry Equipment									0.00
Washer / Dryer		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detergent		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous Items		1,188.11	0.00	1.19	0.00	0.00	0.00	0.00	1,199.01
Totals		21,958	3,495	85.36	1.68	24,870	22,690	24.63	31,722

Table 2.8 Subsystem Breakdown for Independent Exploration Mission: Surface Habitat Lander using Advanced Technologies

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Air Subsystem		1,972	809	3.27	1.26	6,157	4,603	21.30	3,924
Atmospheric Control System									
Atmospheric Pressure Control	ISS	119.40	0.00	0.26	0.00	70.50	70.50	0.00	136.45
Atmosphere Revitalization System									
Carbon Dioxide Removal	4BMS / ISS	185.10	0.00	0.44	0.00	556.21	556.21	4.53	306.76
Carbon Dioxide Reduction	Sabatier	75.91	0.00	0.14	0.00	82.94	82.94	0.00	94.44
Oxygen Generation	SPE / ISS	388.97	82.72	1.02	0.00	3,421.67	1,868.34	16.67	1,011.92
Gaseous Trace Contaminant Control	ISS	68.41	35.00	0.14	0.53	194.35	194.35	0.00	149.97
Atmosphere Composition Monitoring Assembly	ISS	54.30	0.00	0.09	0.00	103.50	103.50	0.00	76.65
Sample Delivery System	ISS	35.11	0.00	0.04	0.00	0.00	0.00	0.00	35.48
Airlock Carbon Dioxide Removal	n/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Storage									
Nitrogen Storage	Cryogenic	383.93	255.96	0.45	0.30	723.50	723.50	0.00	797.25
Oxygen Storage	Cryogenic	652.62	435.08	0.65	0.43	1,002.36	1,002.36	0.00	1,306.08
Fire Detection and Suppression									
Fire Detection System	ISS	1.50	0.00	0.00	0.00	1.48	1.48	0.10	1.85
Fire Suppression System	ISS	6.80	0.00	0.04	0.00	0.00	0.00	0.00	7.17
Biomass Subsystem		898	0	17.03	0.00	12,026	12,026	0.00	3,556
Crop Storage		343.13	0.00	0.00	0.00	0.00	0.00	0.00	343.13
Plant Growth Chamber / Salad Machine		555.15	0.00	17.03	0.00	12,025.53	12,025.53	0.00	3,212.46
Food Subsystem		3,491	0	13.52	0.00	960	960	0.00	3,814
Food Processing, Packaging, and Storage									
Food Processing									0.00
Food Packaging									0.00
Food Storage	STM w/bulk pkg.	3,490.77	0.00	13.52	0.00	960.00	960.00	0.00	3,814.29
<i>Dry Food Mass (neglected)</i>		<i>2,363.98</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>2,363.98</i>
Thermal Subsystem		390	31	1.12	0.13	1,284	1,284	3.33	701
Temperature and Humidity Control									
Common Cabin Air Assembly	ISS	118.08	0.00	0.50	0.00	530.52	530.52	0.00	233.01
Avionics Air Assembly	ISS	12.40	0.00	0.03	0.00	175.00	175.00	0.00	49.07
Atmosphere Circulation	ISS	9.80	0.00	0.02	0.00	61.00	61.00	0.00	22.67
Atmospheric Microbial Control	ISS	100.00	31.33	0.27	0.13	0.00	0.00	3.33	136.42
Internal Thermal Control System		149.28	0.00	0.30	0.00	517.71	517.71	0.00	259.71

Table 2.8 Subsystem Breakdown for Independent Exploration Mission: Surface Habitat Lander using Advanced Technologies (concluded)

Subsystem or Component	Technology	Mass [kg]	Resupply Mass [kg]	Volume [m ³]	Resupply Volume [m ³]	Power [W _e]	Cooling [W _{th}]	Crewtime [CM-h]	Equivalent System Mass [kg]
Waste Subsystem		410	0		0.00	1,558	1,558	160.00	878
Solid Waste Collection	ESDM	36.36	0.00	0.13	0.00	14.00	14.00	0.00	40.46
Solid Waste Processing System	Combo								
Solid Waste Treatment		373.24	0.00	8.10	0.00	1,544.22	1,544.22	160.00	837.11
Solid Waste Processing System Tankage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microbial Check Valve		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Process Controller		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Quality Monitoring		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solid Product Delivery System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Subsystem		909	173	2.44	0.00	4,224	2,021	0.00	1,717
Urine / Waste Water Collection System	ISS	4.55	2.67	0.02	0.00	4.00	4.00	0.00	8.24
Water Recovery System									
Water Treatment Process	VPCAR	557.56	165.96	1.69	0.00	4,011.45	1,808.87	0.00	1,306.87
Urine, Hygiene & Potable Water, & Brine Storage Tankage		205.12	0.00	0.53	0.00	19.81	19.81	0.00	214.10
Microbial Check Valve		6.67	4.36	0.02	0.00	0.00	0.00	0.00	11.21
Process Controller		63.00	0.00	0.00	0.00	180.00	180.00	0.00	100.44
Water Quality Monitoring		14.07	0.00	0.04	0.00	4.72	4.72	0.00	15.42
Product Water Delivery System		58.37	0.00	0.14	0.00	3.83	3.83	0.00	60.45
Water Storage									
Hygiene Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potable Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urine Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Water Storage		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Extravehicular Activity		1,130	0	2.57	0.00	1,000	1,000	0.00	1,361
Maximum Absorbency Garments		242.20	0.00	0.00	0.00	0.00	0.00	0.00	242.20
Carbon Dioxide Removal (LiOH)		817.20	0.00	2.43	0.00	0.00	0.00	0.00	839.46
Airlock Recycle Pump for EVA		70.30	0.00	0.14	0.00	1,000.00	1,000.00	0.00	279.58
Oxygen Recharge Compressor Assembly for EVA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Human Accommodations		1,340	9	1.87	0.00	633	633	0.00	1,498
Clothing		72.00	0.00	0.42	0.00	0.00	0.00	0.00	75.85
Laundry Equipment									0.00
Washer / Dryer		80.00	0.00	0.26	0.00	633.33	633.33	0.00	214.11
Detergent		0.01	8.75	0.00	0.00	0.00	0.00	0.00	8.76
Miscellaneous Items		1,188.11	0.00	1.19	0.00	0.00	0.00	0.00	1,199.01
Totals		10,540	1,022	50.05	1.39	27,842	24,085	184.63	17,449

3 REFERENCES

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4 ABBREVIATIONS AND ACRONYMS

4BMS	four-bed molecular sieve	kg	kilogram (<i>i.e.</i> , units of mass.)
ALS	Advanced Life Support	kW _e	kilo Watt, electric (<i>i.e.</i> , units of electric power.)
ALS R&TD	Advanced Life Support Research and Technology Development (Metric)	kW _{th}	kilo Watt, thermal (<i>i.e.</i> , units of heat transfer rate.)
ALSSAT	Advanced Life Support Sizing Analysis Tool	LMC	low moisture content (food)
ATCO	ambient temperature catalytic oxidizer (for carbon monoxide removal)	m ³	cubic meters (<i>i.e.</i> , units of volume.)
CM-h	crewmember-hour (<i>i.e.</i> , the time from a crewmember for an hour.)	n/a	not applicable
Combo	combination (waste processing approach) consisting of warm-air drying, lyophilization, compaction, and storage	pkg.	(bulk) packaging
ESDM	Environmental Control and Life Support System Design Model (which is an earlier life support sizing tool)	SAVD	solid amine vacuum desorption
EVA	extravehicular activity	SPE	solid polymer (water) electrolysis
ISS	International Space Station (technology from the environmental control and life support system)	STM	Shuttle Training Menu (food system)
		VPCAR	vapor phase catalytic ammonia removal
		w/	with
		W _e	Watt, electric (<i>i.e.</i> , units of electric power.)
		WRS	water recovery system
		W _{th}	Watt, thermal (<i>i.e.</i> , units of heat transfer rate.)