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Article

The Dvaraka Initiative: Mars's First Permanent Human Settlement Capable of Self-Sustenance

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1. Pre-Initiative Mission

Table S1. Contents and cost of the first five missions.

Missions	Equipment	Material Cost estimation	Weight (kg)	Transport cost	Total cost
Mission-1	Unpressurized rovers	$350,000,000	225,000	$112,500,000	$1,287,500,000
	Load carrying trucks	$575,000,000			
	Nuclear generator	$100,000,000			
	Fuel processing equipment	$150,000,000			
Mission-2	Pressurized rovers	$745,000,000	340,000	$170,000,000	$1,096,300,000
	Cooling equipment	$65,000,000			
	Heavy duty equipment	$116,300,000			
Mission-3	Water extraction equipment	$575,000,000	340,000	$170,000,000	$1,037,000,000
	3D printing parts	$70,000,000			
	Heating equipment	$222,000,000			
Mission-4	Air processing equipment	$555,000,000	340,000	$170,000,000	$1,330,000,000
	Water processing equipment	$475,000,000			
	Raw materials	$130,000,000			
Mission-5	Bricks making equipment	$385,000,000	340,000	$170,000,000	$1,075,000,000
	Infrastructure parts	$150,000,000			
	Electronic parts	$370,000,000			

Table S2. Contents and cost of the second five missions.

Missions	Flights	Material cost estimation	Weight (kg)	Total cost
Mission-6	100 people	$692,611,900.00	170,000.00	$783,363,900.00
	Food	$90,000.00		
	Space Suits	$37,500,000.00		
	Drugs and Sanitary Items	$2,312,000.00		
	Medical Equipment	$850,000.00		
	Fertilizers	$50,000,000.00		
Mission-7	200 people	$1,385,223,800.00	255,000.00	$1,537,723,800.00
	cargo	$152,500,000.00		
Mission-8	200 people	$1,385,223,800.00	255,000.00	$1,537,723,800.00
	cargo	$152,500,000.00		
Mission-9	200 people	$1,385,223,800.00	255,000.00	$1,537,723,800.00
	cargo	$152,500,000.00		
Mission-10	200 people	$1,385,223,800.00	255,000.00	$1,537,723,800.00
	cargo	$152,500,000.00		
Mission-11	100 people	$692,611,900.00	170,000.00	$845,111,900.00
	cargo	$152,500,000.00		

2. Colony Fuel Usage

Table S3. Colony Fuel Usage.

Fuel Needed for Tourism =	3991038.24							
Fuel Needed for Deuterium =	167588.8837							
Fuel Needed for asteroid Mining =	4415325							
Fuel Needed to send Platinum =	971371.5							
Total Fuel Used Every year =	9545323.624	kg						
Total Fuel Needs to be produced every day =	26151.57157							
Total Methane required =	5811.460349							
Total Oxygen Required =	20340.11122							
Water Consumption needed by a person =	8	kg	per day					
With Margin	9.6	kg	per day					
For 1200 people	11520	kg	per day					
Mol Mass of CO2	44.01							
Mol Mass of H2	2.01588							
Mol Mass of CH4	16.04							
Mol Mass of H20	18.01528							
Reaction =	CO2	+	4 H2	=	CH4	+	2H20	
Number of Molecules required =	2.18183E+26		8.72734E+26		2.18183E+26		4.36367E+26	
Kg of each molecule required =	15945.28491	kg per day	2921.497927	kg per day	5811.460349	kg per day	13054.25005	kg per day
Methane required everyday =	5811.460349	kg						
Water produced everyday =	13054.25005	kg						
One machine can dig upto =	68.2	kg/hr						
One machine can dig upto in one day =	1691.36	kg						
Water required for h2 =	26293.48135	kg						
Number of Machine =	16							
Oxygen produced from electrolysis =	23371.98342	kg						
Oxygen produced for fuel =	20340.11122	kg						
Oxygen for life support =	3031.872197	kg						
Prop Produced per year =	26151.57157	kg						
Prop Produced every year =	9545323.624	kg						

3. Asteroid Mining Propellant Expenditure

Table S4. Fuel and payload calculations for Asteroid Mining.

Mass Ratio, from Mars=	**4.463**						
Payload To Asteroid Belt =	3750000	kg	=	3750	tons		
Total Dry Mass =	750000	kg	=	750	tons		
Total propellant to and from the asteroid =	26491950	kg	=	26491.95	tons		
Tankage weight =	18544365	kg	=	18544.365	tons		
Total Mass one way (with asteroid propellant) =	49536315	kg	=	49536.315	tons		
Mass Ratio Required =	1.35						
Payload from 16 pshye	7500000	kg					
Total Dry Mass	1500000	kg	=	1500	tons		
Propellant Mass	3150000	kg	=	3150	tons		
Total Payload brought =	7500000	kg	=	7500	tons		
At 75% Efficiently Processing =	5625000	kg	=	5625	tons		
At 25% Platinum =	1406250	kg	=	1406.25	tons		
Remaining Pay load =	4218750	kg	=	4218.75	tons		
Number of Transits =	2.75			per year			
Kg that can be transported per trip =	85000	kg			=	85	tons
Dry Mass =	17000	kg		Assumption: 2 cargo ships every 2 year	=	17	tons
Propellant Mass =	353226	kg		Assumption: 85000kg can be transported	=	353.226	tons
Tankage mass =	247258.2	kg			=	247.2582	tons
Total Mass of the S/c =	702484.2	kg			=	702.4842	tons
Cost of Platinum on Earth =	26,500.00	$					
Cost of Transport Per ship =	140496840	$					
Cost of Transport Per Year =	386366310	$					
Estimated Cost of our payload =	6,194,375,000.00	$					
Revenue generated in one year =	5,808,008,690.00	$					

4. Different Tourist Schemes

Table S5. Tourism Cost Scheme A.

TOURISM COST SCHEME A - 95 days journey								
Fuel production on Mars per day =	9545323.624	kg		No. of tourists (per trip)=	100	people		
				Number of days travel =	22			
Mass Ratio, from Mars=	4.463			Payload per person=	147	kg		
Mass Ratio, from Earth =	29			Total payload weight =	14700	kg		
Total dry mass =	(20% of the total payload)	2940	kg					
Propellant, from Mars=		61087.32	kg	Frequency =	**4**	**in**	**1**	years
Propellant, from Earth		493920	kg					
Total Propellant Required =		555007.32	kg					
Tank Weight =	(7% of total propellant required)	345744	kg					
Total Weight S/C from Earth=		857304	kg					
Total Weight S/C from Mars=		424471.32	kg					
Rate of exports from E =		500	$/kg					
Rate of exports from M =		200	$/kg					
Cost from Earth =		428652000	$					
Cost from Mars =		84894264	$					
Total Cost (per trip) =		513546264	$					
Cost per tourist (per trip) =		5135462.64	$					
SP per tourist (per trip) =		19000000	$					
Revenue generated per tourist =		13864537.36	$					
Total revenue (per trip) =		1386453736	$					
TOTAL REVENUE =		5545814944	$					

Table S6. Tourism Cost Scheme B.

TOURISM COST SCHEME B - 160 days								
Fuel production on Mars per day =		9545323.624	kg		No. of tourists (per trip)=	100	people	
					Number of days travel =	84		
Mass Ratio, from Mars=	4.463				Payload per person=	364	kg	
Mass Ratio, from Earth =	20				Total payload weight =	36400	kg	years
Total dry mass =	(20% of the total payload)		7280	kg				
Propellant, from Mars=			151263.84	kg	Frequency =	**4**	**in**	**1**
Propellant, from Earth			829920	kg				
Total Propellant Required =			981183.84	kg				
Tank Weight =	(7% of total propellant required)		580944	kg				
Total Weight S/C from Earth=			1454544	kg				
Total Weight S/C from Mars=			775887.84	kg				
Rate of exports from E =			500	$/kg				
Rate of exports from M =			200	$/kg				
Cost from Earh =			727272000	$				
Cost from Mars =			155177568	$				
Total Cost (per trip) =			882449568	$				
Cost per tourist (per trip) =			8824495.68	$				
SP per tourist (per trip) =			16000000	$				
Revenue generated per tourist =			7175504.32	$				
Total revenue (per trip) =			717550432	$				
TOTAL REVENUE =			2870201728	$				

Table S7. Tourism Cost Scheme C.

TOURISM COST SCHEME C								
Fuel production on Mars per day =	9545323.624	kg		No. of tourists (per trip)=	200	people		
				Number of days travel =	120			
Mass Ratio, from Mars=	4.463			Payload per person=	490	kg		
Mass Ratio, from Earth =	15.8			Total payload weight =	98000	kg		
Total dry mass =	(20% of the total payload)	19600	kg					
Propellant, from Mars=		407248.8	kg	Frequency =	**4**	**in**	**1**	years
Propellant, from Earth		1740480	kg					
Total Propellant Required =		2147728.8	kg					
Tank Weight =	(7% of total propellant required)	1218336	kg					
Total Weight S/C from Earth=		3076416	kg					
Total Weight S/C from Mars=		1743184.8	kg					
Rate of exports from E =		500	$/kg					
Rate of exports from M =		200	$/kg					
Cost from Earh =		1538208000	$					
Cost from Mars =		348636960	$					
Total Cost (per trip) =		1886844960	$					
Cost per tourist (per trip) =		9434224.8	$					
SP per tourist (per trip) =		13000000	$					
Revenue generated per tourist =		3565775.2	$					
Total revenue (per trip) =		713155040	$					
TOTAL REVENUE =		2852620160	$					

Table S8. Tourism Cost Scheme D.

TOURISM COST SCHEME D - 450 days								
Fuel production on Mars per day =		9545323.624	kg		No. of tourists (per trip)=	100	people	
					Number of days travel =	240		
Mass Ratio, from Mars=	4.463				Payload per person=	910	kg	
Mass Ratio, from Earth =	6				Total payload weight =	91000	kg	
Total dry mass =		(20% of the total payload)	18200	kg				
Propellant, from Mars=			378159.6	kg	Frequency =	**4**	**in**	**1** years
Propellant, from Earth			546000	kg				
Total Propellant Required =			924159.6	kg				
Tank Weight =		(7% of total propellant required)	382200	kg				
Total Weight S/C from Earth=			1037400	kg				
Total Weight S/C from Mars=			869559.6	kg				
Rate of exports from E =			500	$/kg				
Rate of exports from M =			200	$/kg				
Cost from Earh =			518700000	$				
Cost from Mars =			173911920	$				
Total Cost (per trip) =			692611920	$				
Cost per tourist (per trip) =			6926119.2	$				
SP per tourist (per trip) =			10000000	$				
Revenue generated per tourist =			3073880.8	$				
Total revenue (per trip) =			307388080	$				
TOTAL REVENUE =			1229552320	$				

5. Examples of Different Tourist Schemes

Table S9. Different Tourist Trip Trajectories in the year 2035.

2035 TRIPS									
Earth_Departure	Dest_Arrival	Dest_Departure	Earth_Return	Stay time (days)	Duration (days)	Total DV (km/s)	Reentry speed (km/s)	Route	Mass Ratio
Jan-07-2035	Feb-01-2035	Feb-11-2035	Apr-17-2035	10	100	9,72	11,21	EA-AE	28,55
Jan-07-2035	Jan-27-2035	Feb-01-2035	Apr-07-2035	5	90	9,86	11,09	EA-AE	29,96
Jan-07-2035	Feb-16-2035	Feb-26-2035	Jun-01-2035	10	145	8,15	11,18	EA-AE	16,62
Dec-13-2035	Apr-21-2036	May-01-2036	Jun-10-2036	10	180	9,36	12,56	EA-AE	25,22
Feb-01-2035	May-12-2035	Jun-01-2035	Nov-28-2035	20	300	7,92	11,87	EA-AE	15,35
Feb-11-2035	Jun-01-2035	Jun-26-2035	Nov-28-2035	25	290	8,26	12,1	EA-AE	17,26
Mar-18-2035	Aug-10-2035	Aug-30-2035	Jan-02-2036	20	290	7,93	11,55	EA-AE	15,40
Mar-28-2035	Feb-01-2036	Mar-02-2036	Sep-23-2036	30	545	4,76	11,7	EA-AE	5,16
Oct-04-2035	Mar-12-2036	Apr-01-2036	Sep-28-2036	20	360	5,65	11,63	EA-AE	7,02

6. Cost Plan

Table S10. A complete Cost Plan Analysis.

Phase	Year	Details	Outflow Cost estimation	Total Outflow	Outflow 5% margin	Inflow cost estimation	Total Inflow	Inflow 5% margin
Pre-Initiative	2034	MADE member's investments		$41,525,800,000.00	$43,602,090,000.00	$5,000,000,000.00	$40,366,666,665.00	$42,384,999,998.25
		MADE infrastructure	$1,860,000,000.00					
		Spacecraft manufacturing	$1,500,000,000.00					
		MADE operating cost	$3,200,000,000.00					
	2036	MADE member's investments				$5,000,000,000.00		
		MADE infrastructure	$1,860,000,000.00					
		MADE operating cost	$3,200,000,000.00					
		Spacecraft manufacturing	$1,500,000,000.00					
		Broadcasting				$183,333,333.00		
		Mission-1	$1,287,500,000.00					
	2038	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Spacecraft manufacturing	$1,500,000,000.00					
		Mission-2	$1,096,300,000.00					
		Broadcasting				$183,333,333.00		
	2040	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Spacecraft manufacturing	$1,500,000,000.00					
		Mission-3	$1,037,000,000.00					
		Broadcasting				$183,333,333.00		
	2042	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Spacecraft manufacturing	$1,500,000,000.00					
		Mission-4	$1,330,000,000.00					
		Broadcasting				$183,333,333.00		
	2044	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Spacecraft manufacturing	$1,500,000,000.00					
		Mission-5	$1,075,000,000.00					
		Broadcasting				$183,333,333.00		
End of Pre-Initiative phase								-$1,217,090,001.75
Settlement	2046	MADE member's investments		$129,047,524,170.00	$135,499,900,378.50	$5,000,000,000.00	$221,889,060,244.50	$232,983,513,256.73
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Mission-6	$783,363,900.00					
		Mars mining				$746,575,239.00		
		Broadcasting				$366,666,666.60		
	2048	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Mars mining				$746,575,239.00		
		Mission-7	$1,537,723,800.00					
		Asteriod mining	$5,500,000,000.00					
		Broadcasting				$366,666,666.60		
	2050	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Mars mining				$746,575,239.00		
		Mission-8	$1,537,723,800.00					
		Broadcasting				$366,666,666.60		
	2052	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Mars mining				$746,575,239.00		
		Mission-9	$1,537,723,800.00					
		Broadcasting				$549,999,999.90		
	2054	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Training program at MADE	$1,260,000,000.00			$3,150,000,000.00		
		Mars mining				$746,575,239.00		
		Mission-10	$1,537,723,800.00					
		Broadcasting				$549,999,999.90		
	2056	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Mars mining				$746,575,239.00		
		Tourism	$15,901,810,848.00			$28,400,000,000.00		
		Mission-11	$845,111,900.00					
		Broadcasting				$366,666,666.60		
	2057	Toursim	$15,901,810,848.00			$28,400,000,000.00		
		Broadcasting				$366,666,666.60		
	2058	MADE member's investments				$5,000,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Mars mining				$746,575,239.00		
		Toursim	$15,901,810,848.00			$28,400,000,000.00		
		Asteriod mining	$386,366,310.00			$6,194,375,000.00		
		Broadcasting				$733,333,333.20		
	2059	Tourism	$15,901,810,848.00			$28,400,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Asteriod mining	$386,366,310.00			$6,194,375,000.00		
		Broadcasting				$366,666,666.60		
	2060	Tourism	$15,901,810,848.00			$28,400,000,000.00		
		MADE operating cost	$3,200,000,000.00					
		Broadcasting				$549,999,999.90		
		Asteriod mining	$386,366,310.00			$6,194,375,000.00		
		Mars Mining				$746,575,239.00		
End of settlement phase								$97,483,612,878.23
Payback to MADE member's investment							-$65,000,000,000.00	$32,483,612,878.23
Self-Sustaining phase	2061	Tourism	$15,901,810,848.00	$21,421,495,252.00	$22,492,570,014.60	$28,400,000,000.00	$35,890,950,238.90	$37,685,497,750.85
		Made Operation cost	$5,000,000,000.00					
		Broadcasting				$549,999,999.90		
		Asteriod mining	$386,366,310.00			$6,194,375,000.00		
		Mars Mining	$133,318,094.00			$746,575,239.00		

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