MARS MISSION COMPARISON

1. Mars One
2. Boeing
3. Fast Track to Mars
4. Space X
5. Affordable Human Exploration of Mars Program (kbd512 proposal)

	1. MARS ONE	2. BOEING	3. FAST TRACK TO MARS
MISSION SIZE	Groups of 4 commencing in:	3-6	6 (two crews of 3)
PRE-MISSION CONTENT	2018: Demonstration mission. 2 Mars Coms satellites one in Mars Orbit one in Sun orbit.	No more than 2 launches per annum in run-up. Cargo is sent (with transhab and kickstage for return) some two years ahead of the	Coms system to be developed in consultation with NASA/ESA. Up to 8 pre-lander missions (over ten years) to deliver cargo to the Mars

	2022: Rover with trailer launched; separate Cargo launch. When the settlement location is determined, the Rover prepares the surface for arrival of the Cargo missions. It also clears large areas where solar panels will lie. The Rover takes the Life Support Units to the landing site.	human mission. Takes 500 days to reach Mars.	landing site (approx. 10kms in diameter) in relatively small loads – between 2-3 tonnes. Small two seater pressurised Rover to be included in pre-landing delivery . Cargo includes oxygen making machines, water collection, and laying out of power assemblies There would be test missions to the Moon during the build-up involving 8 month flights between Earth and the Moon (and in earth/lunar orbits), and extended stays on the lunar surface where operational of equipment would be checked. Also this would allow the health of the crew to be checked after 8 months in zero G followed by simulated 1G (using lead suits during the stay on the Moon surface). Options for landing: Option A - a Mars Lander "cradle" – essentially a retro-rocket assembly will be put into Mars orbit. Option B - A Red Dragon style vehicle will be used for the descent. The ascent vehicle will be pre-landed.
LAUNCH	Several rocket launches will be needed to take payloads into Earth orbit and then onto Mars. Payload may be satellites,	Space Launch System (SLS) used for both cargo and human launch.	Space X's Falcon 9 Heavy Assembly in LEO.

	rovers, cargo or humans. Mars One anticipates using Space X Falcon Heavy, an upgraded version of the Falcon 9, which is in use by Space X currently.	Spiral out to EML2 for assembly.	
TRANSIT TO MARS	Seven months (215 days) journey time. Mars Transit Vehicle comprises of four parts which are docked in Earth orbit: two propellant stages, a Transit Habitat and a Lander (variant of the Dragon Capsule). The propellant stages are used to propel the Transit Vehicle from Earth orbit to Mars. When near Mars, the crew enter the Lander which is then disconnected from the Transit Habitat. The Transit habitat and the propellant stages are left behind to orbit the Sun. The Lander is the only component that sets foot on Mars, with the astronauts inside. The Transit habitat has a mass of about 20,000 kg. It will carry close to 800 kg of dry food, 3000 liters of water and 700 kg of oxygen on board. No water or Oxygen will be recycled, because the trip lasts only 210 days. Not recycling these components eliminates the need for recycling systems, backups, spare components and reduces power and cooling requirements. The 3000 liters of water is also used for radiation shielding.	256 days out and 204 days on return. Mars Transit Vehicle consists of: Solar Electric Plug (SEP) tug, fuel module, Orion Multi-Purpose Crew Vehicle, Trans Hab and Lander. 4 launches required? Lander uses inflatable heat shield. (Cargo vehicle has SEP tug and cargo module).	Mars Transit Vehicle (x 2) consists of Trans Hab, Lander , supply module, rocket module.
ENTRY, DESCENT AND LANDING/ASCENT/RETURN	Not specified. Presumably reliant on Space X development of landing & ascent capability.	Lander separates. Uses heat shield and retro rockets to land.	Option A - Lander separates from the MTV and docks with retro rocket cradle, which then lands using retro

		Ascent vehicle part of lander (similar to Apollo Lander configuration). Ascent vehicle rendezvous with SEP tug in Mars orbit – heads back to Earth. Apollo style parachute landing in ocean. Also a cargo return.	rockets. For the ascent some of the mass can be unloaded and the retro rocket cradle can be refuelled on the surface with ISRU rocket fuel. Option B – A Red Dragon style vehicle lands.
ENERGY AND LIFE SUPPORT	Use of solar (photovoltaic panels). Water is extracted as ice from Mars soil which is fed into life support units by Rovers.	Solar (photovoltaic panels).	Solar (photovoltaic panels) with solar concentration. Methane manufacture for energy storage and vehicular/rocket propulsion. Concentrated solar heating (steam power). Wind power (experimental) Oxygen extracted from CO2 or H2O.
MISSION CONTENT	This is a **no return** mission. Strong ISRU element. Emphasis will be on importation of tools and equipment. Mars water supply. Water used to create oxygen. Use of local construction facilities to create more habs. For a long time, the supply requests from the outpost will be for computers, clothing	This is a return mission. 454 days of surface ops. Two unpressurised rovers. The landed mass for both the crew and cargo lander is ~40 tons.	This is a return mission but with continued occupation (so after two years, the first settlers would return to Earth and others would arrive to replace them and take up new, prepared habitats). Rather than a full scale colonisation proposal on a Space X scale, it offers a "continued settlement" model, with much more modest numbers than Musk's. The aim would be to slowly grow the settlement and in the early stages most settlers would spend a limited time on Mars before returning

	and complex spare parts, which cannot be readily reproduced with the limited technology on Mars.		to Earth. The aim would be to develop a settlement of about 200 residents within 10 years. Strong ISRU element. First mission will conduct pilot projects in: Methane manufacture. Brick making. Glass making. Basalt shaping. Steel making. ISRU hab construction. Artificial soil manufacture. Indoor farming/hydroponics (artificial lighting). Textile manufacture. Polymer production.
COST/INCOME	”Billions required” Costs to be recovered through crowd funding, TV programme sales, TV rights, commercial sponsorship etc, .	$50billion?	**COST:** Assume requirement to put up to 300 tonnes into LEO orbit. Launch costs = around $4.5 billion (using F9 Heavy prices) . Development costs for the transhab, lander, cargo modules, rover and other technologies – estimated at $3

			billion. Assume equivalent of 2,000 people being employed at average $200,000 per annum = $400m per annum or $4 billion over ten years. Payments to agencies for coms and other leased facilities est at $1billion. Total cost: $12.5billion. Allow for 50% cost overrun = c$19billion total (over 10 years – or $1.9 billion per annum, average). **INCOME (OVER 10 YEARS):** $3.5billion for various commercial sponsorship deals. $1.5billion for special TV rights (over ten years). $1billion through scientific experiment agreements with Universities and research establishments. $2 billion through sale of meteorites and regolith and other returned artefacts. $7 billion from space agencies ($1 billion per crew member; remainder in participation fees).

			$1 billion in participation fees from aerospace companies. $1 billion in art and public involvement projects. $4 billion as a loan.
OTHER ASPECTS	The communications system will consist of two communications satellites and Earth ground stations. It will transmit data from Mars to Earth and back. No new technology developments are required to establish a human settlement on Mars. Mars One has visited major aerospace companies around the world to discuss the requirements, budget and timelines with their engineers and business developers. The current mission plan was composed on the basis of feedback received in these meetings. Advanced pressurized rover will not be sent to Mars until large enough rockets exist	Suggested Deimos Precursor Example Mission.	Would involve establishment of a Mars Mission Consortium. Would include representatives of Space X, Boeing, Lockheed, NASA, ESA, JAXA, ISA, and other space agencies.

	4. SPACE X (MARS COLONIAL TRANSPORTER)	**5. AFFORDABLE HUMAN EXPLORATION OF MARS PROGRAM (kbd512 proposal)**	
MISSION SIZE	Eventually the MCT will be able to carry 100 people at a time to Mars.	4 Astronauts per mission	
PRE-MISSION CONTENT	Prior to transfer of people to Mars, a number of cargo missions would take place to provide the required equipment, habitats and supplies. This would include machines to produce fertilizer, methane and oxygen from Mars' atmospheric nitrogen and carbon dioxide and the planet's subsurface water ice, together	Three Phased 5 Year Development and Demonstration Programs: Phase I: Deep Space Habitat (DSH) with Artificial Gravity (AG)	

	with construction materials to build transparent domes for crop growth.	Closed-Loop Environmental Control and Life Support System (CL-ECLSS) High Efficiency Solar Cell and Battery Systems Passive Radiation Shielding System (PRSS) Phase II: SEP Cargo Transfer Vehicle (SEP-CTV) SEP Integrated Transfer Vehicle (SEP-ITV) Mars Surface Habitat (MSH) Adaptable Deployable Entry and Placement Technology (ADEPT) Phase III: Trans-Mars Injection (TMI) and Trans-Earth Injection (TEI) Kick Stages Mars Descent Vehicle (MDV) / Mars Ascent Vehicle (MAV) Active Radiation Shielding System (ARSS) Mechanical Counter-Pressure Space (MCP) Suits	

LAUNCH	Will use super-heavy Space X rockets using methane Raptor engines (probably in a cluster of 9).	Phase I Demonstrators: DSH-1 (LEO) DSH-2 (L1) Phase 2 Demonstrators: CTV-1 (150kW-class SEP 30t cargo transfer of 1 MSH using ADEPT for aerocapture and reentry) Phase 3 Demonstrators: CTV-2 (150kW-class SEP 40t cargo transfer of 1 TEI stage to LMO) CTV-3 (150kW-class SEP 30t cargo transfer of 1 MAV to Mars using ADEPT for aerocapture and reentry) DSH-3 (tele-robotically operated DSH-ITV equipped with ARSS transfers to Mars using TMI stage, captures in LMO, tele-robotically operated MAV simulates transfer of crew after completion of surface missions, CTV-2 mates TEI stage to DSH-3, transfers to Earth using TEI stage, and captures at L1)	
TRANSIT TO MARS	The first mission is envisaged for the 2020s	7 Month transfer to Mars using chemical kick stage followed by DSH-ITV spiral into LMO	

ENTRY, DESCENT AND LANDING/ASCENT AND RETURN	Not clear as yet. Possibly humans will be ferried to the Mars surface by a retro-rocket version of the Dragon space capsule (using cantilevered rockets). Musk has ruled out using the Dragon. He has indicated they may land the "whole thing" i.e. the MCT.	3t MDV (pressurized MAV without fuel tanks and engines for ascent) transferred to Mars using SEP-CTV, docked to DSH-ITV for crew transfer after DSH-ITV arrives in LMO, and landed using ADEPT / super-sonic parachute / retro-rocket ASCENT: 15t pressurized MAV transferred to Mars using SEP-CTV and landed using ADEPT / super-sonic parachute / retro-rocket RETURN: MAV docked to DSH-ITV for crew transfer, TEI mated to DSH-ITV, capture at L1 using SEP 7 Month transfer to Earth using chemical kick stage followed by DSH-ITVE spiral in to L1	
ENERGY AND LIFE SUPPORT	Musk has made reference to the need to develop Mars greenhouses for agriculture, suggesting he is looking to a direct sunlight approach.	DSH-ITV uses solar panels for power DSH-ITV is equipped with next-generation CL-ECLSS, intended to replace current ECLSS on ISS, for life support MSH uses solar panels for power MSH equipped with next-generation CL-ECLSS, intended to replace current ECLSS on ISS, for life support	

		MSH equipped with oxygen generation demonstrator MSH equipped with Martian regolith water extraction demonstrator	
MISSION CONTENT	Musk is focussed on creating an autonomous human civilisation on Mars. It appears therefore to assume mostly a "no return" approach – that people will be willing to colonise Mars and live out their days there. His aim is to create an initial 80,000 strong community. That's some 800 MCT flights. The emphasis is on achieving high levels of self-sufficiency from Day One.	Focuses on technology development that maximizes use of critical path technologies already identified by NASA for human exploration of Mars Directs funding towards payload, rather than launch vehicle development Sacrifices some measure of simplicity to avoid further launch vehicle development Permits sustainability initiatives (ISRU and ISPP) for permanent habitability of Mars, but does not rely on sustainability to land humans on Mars Intended to achieve the goal of landing humans on Mars for surface exploration, not colonization Each major mission hardware component has a replacement as backup Uses commercial launch services and capsules for affordability	

COST/INCOME	No specific detail but it is envisaged colonists would pay around $500,000 each to migrate to Mars (enough to cover their costs). The cost of transporting 80,000 colonists would therefore be at least $40 billion.	This plan requires present levels of funding for NASA. Each 5 year technology development phase spreads the cost of research, development, and demonstration as evenly as possible, given the logical horse/cart requirements for achieving the ultimate goal of landing humans on Mars. Development phase costs are estimated in the $50B to $75B range, over the course of 15 years. At the high end, that's 25% of NASA's budget. Considered reasonable for NASA to devote a quarter of their budget towards a real space exploration program. NASA has repeatedly said that Mars is the prize. This proposal calls for them to put their money where their mouth is.	
OTHER ASPECTS		It is considered reasonable to orbit a constellation of advanced TDRS and GPS satellites over a planet which we intend to make our own. Whilst there is still a way to go to establishing an infrastructure required to colonize Mars, the first steps have to be taken and must be taken by our government. Subsequent missions can land advanced pressurized rovers for mobile surface exploration and various sustainability experiments, but the first order of business is to simply prove that we can get there and come back. This mission	

		architecture is intended to do that and nothing further.	