



Evolvable Mars Campaign Development



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Habitation Strategy: Strategic Attributes



Commonality

- Common pressure vessels
 - Logistics
 - Subsystems
 - Crew Descent
- Common subsystems
- Common interfaces

Modularity

- Enables packaging on landers.
 - Limited mass
 - Limited outer dimensions
- Decomposed by functional subsystems
 - EVA Airlock – provides suit maintenance capability
 - Closed Loop ECLSS – reduces consumables
 - Water Reclamation
 - O2 Regeneration
 - Crew Accommodations – improves habitability
 - Power
 - Science

Reusability

- Enables gradual build-up of capabilities on surface over missions.
 - Logistics
 - Subsystems
 - Volume (PV, HV)
 - Power
- Requires systems capable of operating over years/decades.

Habitation Architecture for PDO

- Progressive Development
- Progressive Deployment

Habitation Strategy: Progressive Deployment Options



Pressure Vessel

Modular

Monolithic

Subsystems

Modular	<p>Functionally Common Modules (Apartment Complex)</p> <ul style="list-style-type: none"> • Functionality added at a constant rate. • All functions available from first mission onward. • Can enable limited reactive design iteration and modification. <p><i>Nakagin Capsule Tower</i></p>	<p>Class 2 Monolithic Habitat (Assembled In-Situ)</p> <p>Does not fit within lander geometry constraints for PDO.</p>
Monolithic	<p>Functionally Specialized Modules (Home Expansion)</p> <ul style="list-style-type: none"> • Additional functionality not added at constant rate. • Requires prioritization of functions. • Can help spread technology developments. <p><i>ISS</i></p>	<p>Class 1 Monolithic Habitat (Assembled On Earth)</p> <p>Does not fit within lander mass or geometry constraints for PDO.</p>

Any real future surface system will require some combination of both strategies.

Surface Asset Icon Key



Crew	Crew (1)	
Fixed PV	Common Pressurized Module	
	Descent Module	
Habitat Functions	Airlock	
	C/L Water	
	C/L O2	
	Crew Accommodations	
Consumables and Spares	Consumables (used, cached)	 
	Spares (used, cached)	 
Power Generation	Kilopower (10 kW)	
	PV Arrays (2.5 kW)	
Mobility	Small Pressurized Rover	
	Cargo Transport Platform	

Surface Assets: PDO to 570 day POD



	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6	Mission 7 (POD)
Duration	21 days	21 days	25 days	67 days	167 days	192 days	573 days
Crew							
Fixed PV							
<p>Durations repeat every three missions after mission 7 (110-110-570 days, 4 crew).</p>							
Habitat Functions							
Consumables and Spares							
Power Generation							
Mobility							

Surface Assets: PDO to 430 day POD



	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6 (POD)
Duration	21 days	21 days	25 days	23 days	25 days	443 days
Crew						
Fixed PV						
<p>Durations repeat every other mission after mission 6 (40-430 days, 4 crew).</p>						
Habitat Functions				 	 	
Consumables and Spares					 	
Power Generation						
Mobility						

Surface Assets: PDO to 300 day (Steady State) POD



	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5 (POD)
Duration	21 days	21 days	25 days	67 days	160 days
Crew					
Fixed PV					
<p>Durations repeat every mission after mission 5 at steady state duration (300 days, 4 crew).</p>					
Habitat Functions				 	
Consumables and Spares					
Power Generation					
Mobility					

Surface Assets: PDO to 4-crew ASAP POD

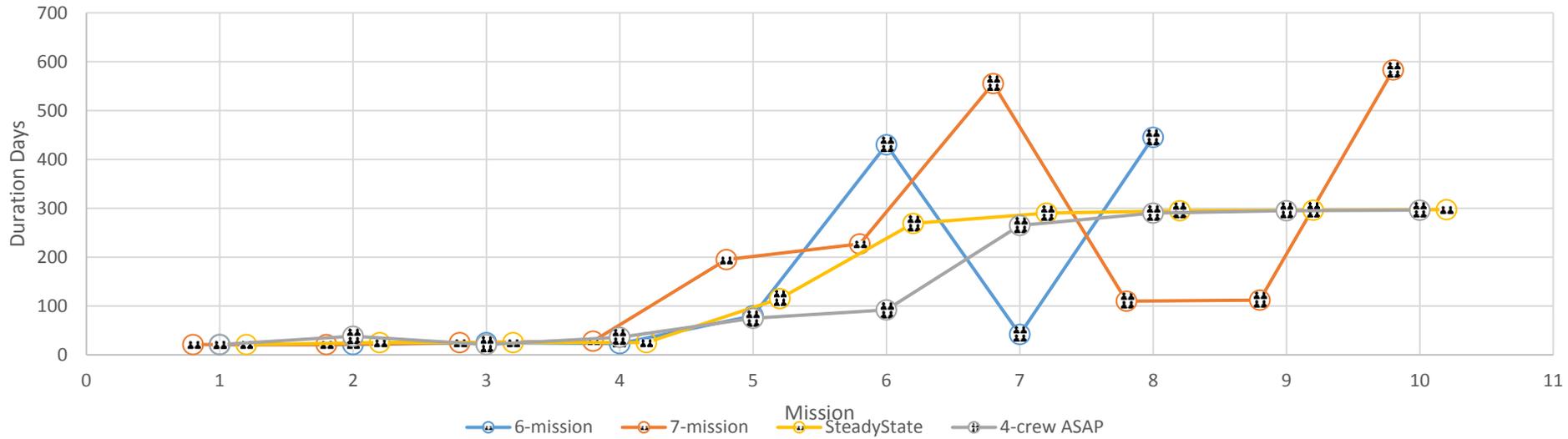


	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Mission 6 (POD)
Duration	21 days	38 days	21 days	36 days	75 days	92 days
Crew						
Fixed PV						
<p>Duration approaches steady state of 4-crew 300 days.</p>						
Habitat Functions			EVA A/L	EVA A/L H2O	EVA A/L H2O O2	EVA A/L H2O C.A. O2
Consumables and Spares						
Power Generation						
Mobility						

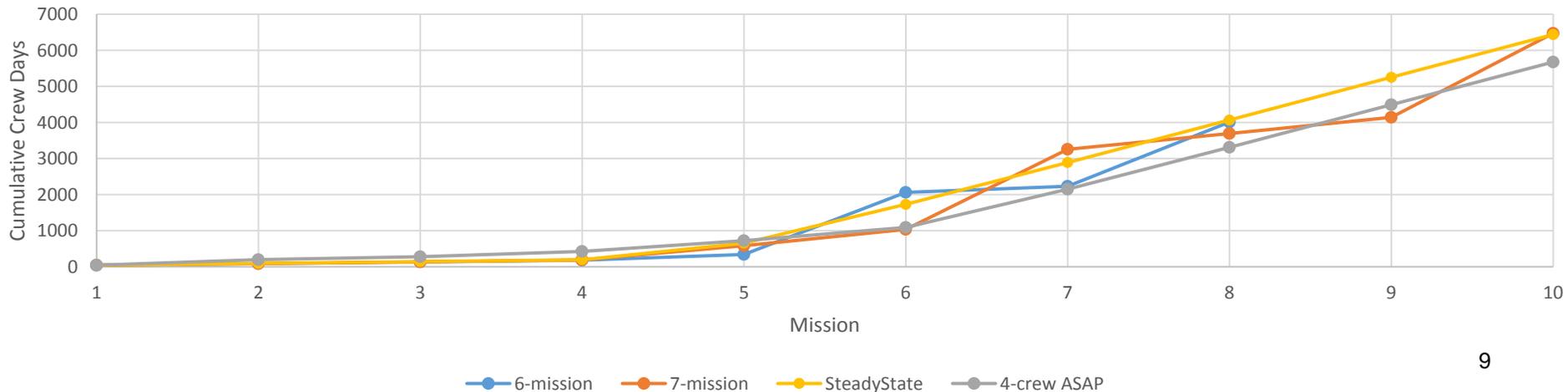
Case Comparison: Mission and Campaign Durations



Mission Durations



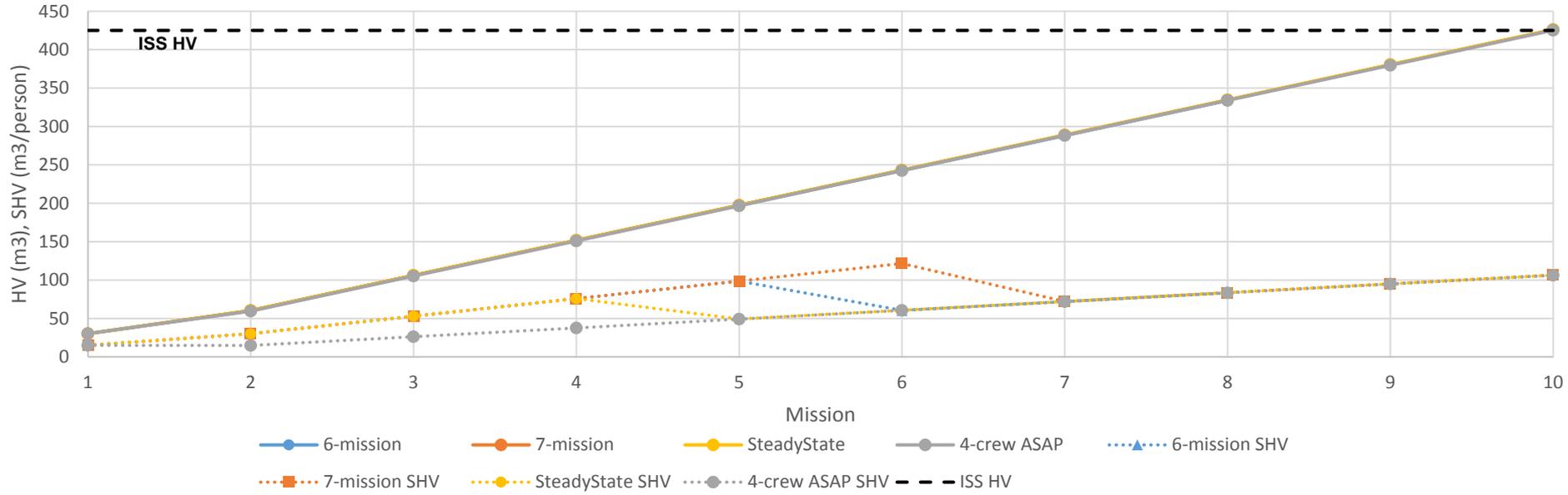
Cumulative Crew-Days



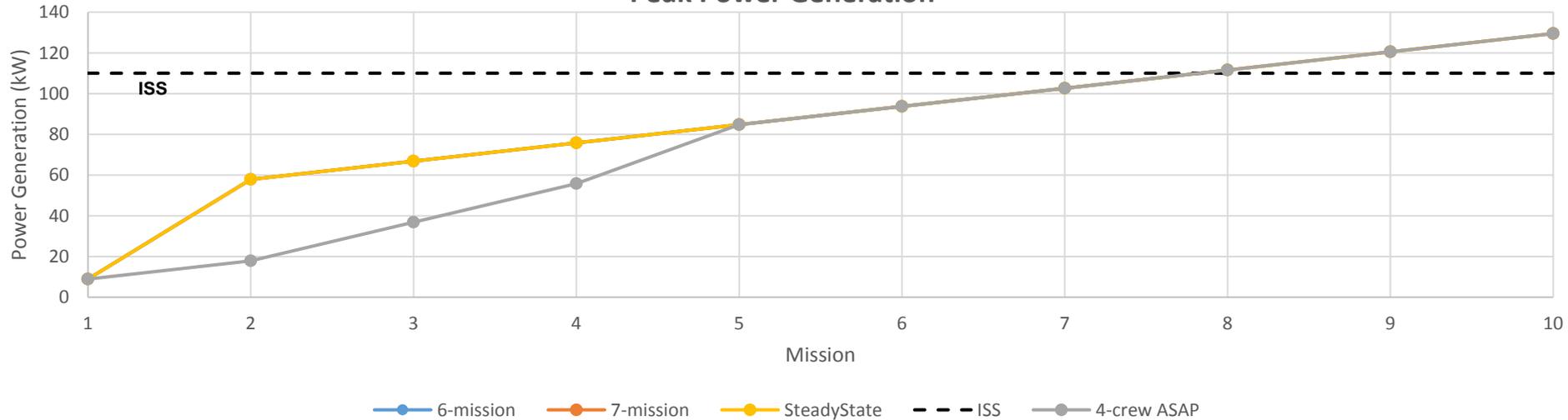
Case Comparison: Habitable Volume and Power



Habitable Volume, Specific Habitable Volume



Peak Power Generation





- **Rate of capability growth is limited by lander**
 - Number of landers per mission.
 - Payload mass capacity.
 - Payload geometry capacity.
- **Sensitivity of mission utility**
 - Surface assets
 - Population
 - Duration
- **Balancing surface capabilities and growth rate**
 - Power
 - Logistics
 - Habitat functions
 - Pressurized volume
 - Mobility
- **Long element lifetimes**
 - Low-level maintenance and repair.
 - Untended health monitoring and dormancy.
 - Logistics caching