Reverse Engineering SpaceX: Accelerate Like Elon

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NOTE: I DO NOT WORK FOR SPACEX*

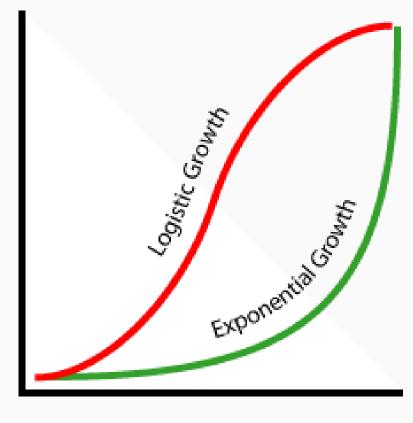
This entire presentation is based on news sources, interviews, and insight into how various companies and inventors work.

It's reverse engineering and reporting of public information. I HAVE NO INSIDE INFORMATION.

* Elon... Call me... ©

The "S Curve of Technology"

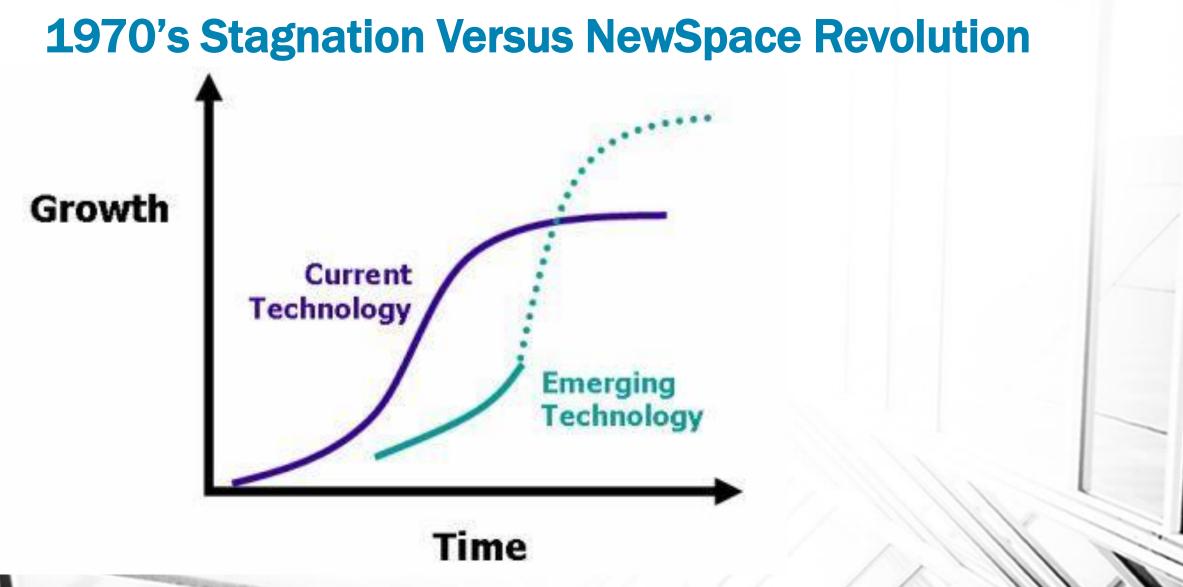
- The aerospace and early electronics revolutions were thought to be exponential.
- During the early space age, this lead to hope of fast solar system settlement.
- Had the curve continued, we would have hit light speed by the year 2010.



Time

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Population size

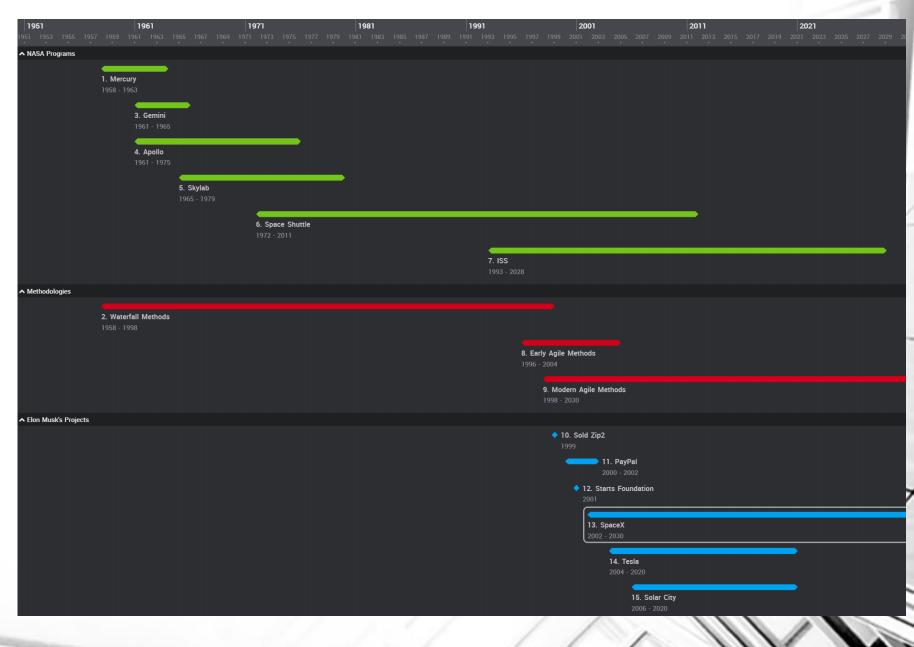


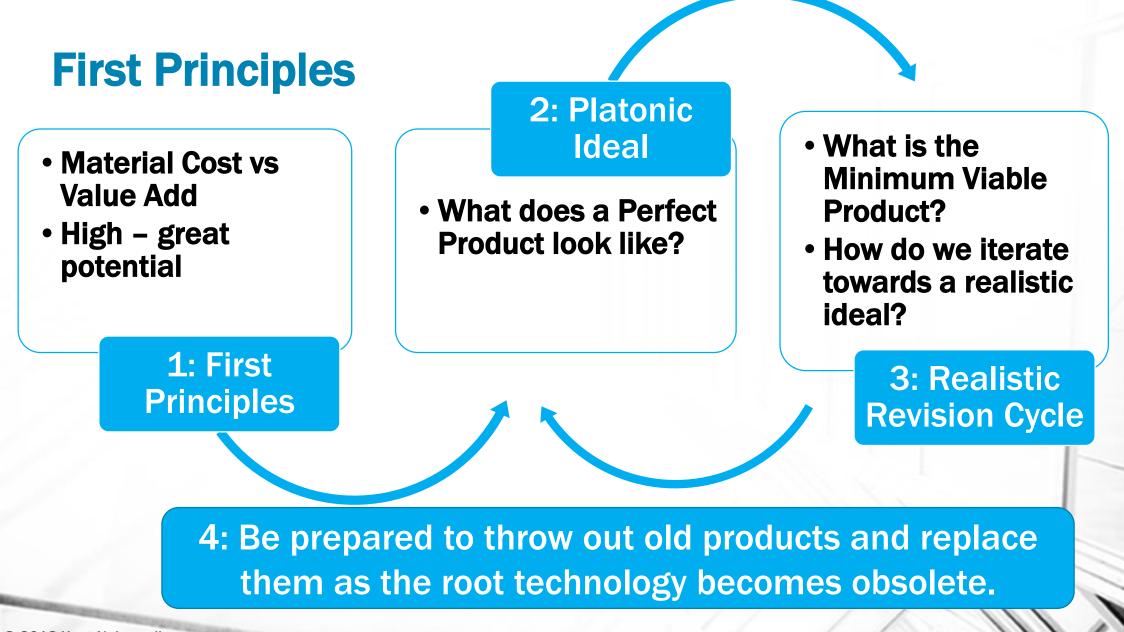
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Methodology History

- Every major Elon Musk project exists entirely in the agile methodology era.
- Every NASA project started during the pre-agile era.



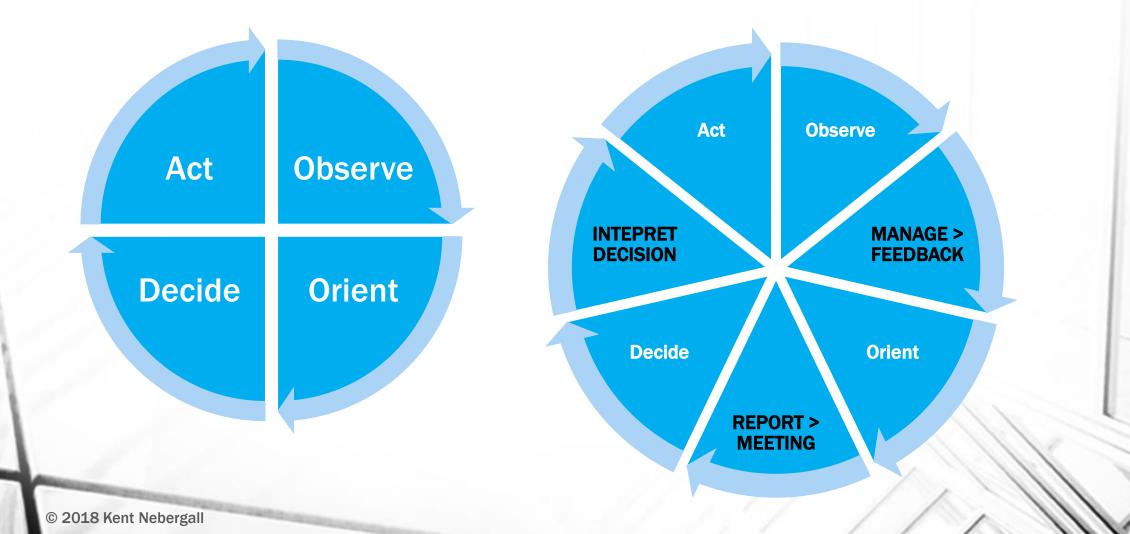


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Skunk Works

- Co-Locate Engineering and Assembly
- Best Talent/Small Group
 - Price's Law (50 percent of work done by square root of team size)
- Brought most production in house
 - SpaceX built a thermal protection system factory in 9 months that exceeded the best in the world.

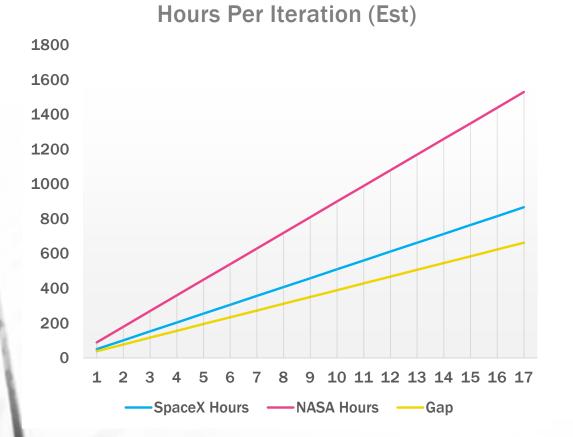
Overworked Engineers vs Committees/Managers

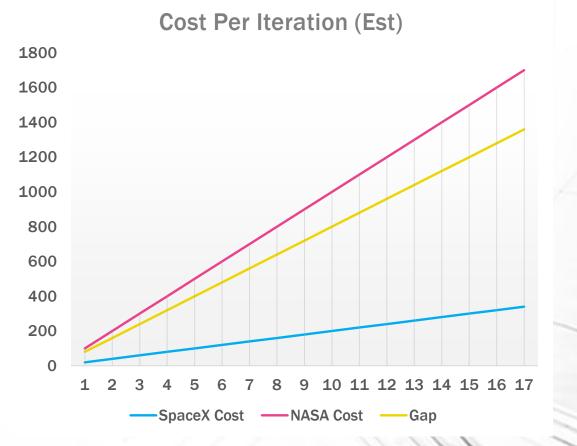


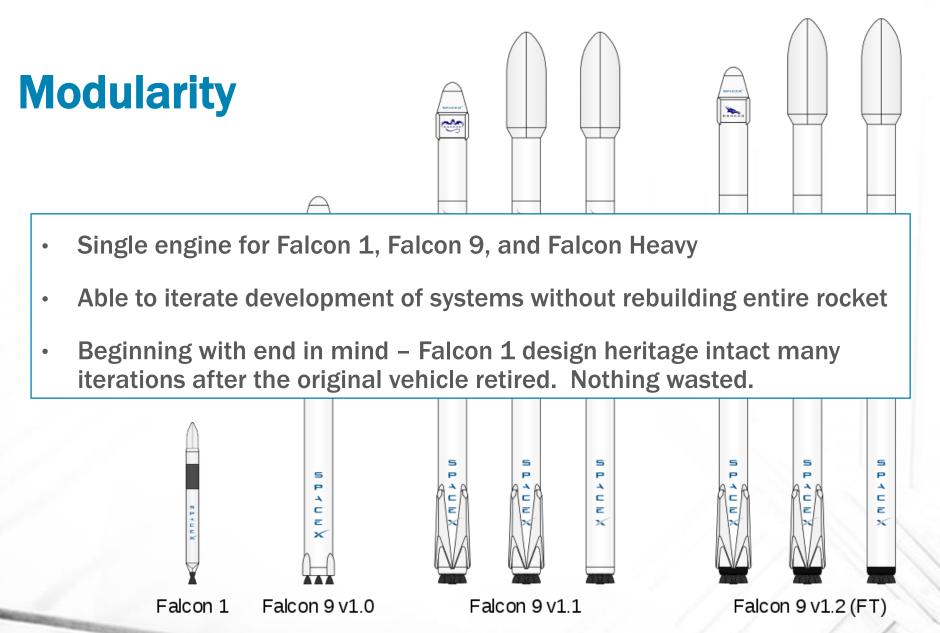
Experimentation – 51 Percent Rule

- SpaceX would rapid prototype and would do tests if the experiment had a 51 percent chance of success (sparse matrix). NASA would have meetings for weeks to minimize any matrix risk before authorizing decisions (full matrix).
- NASA very risk adverse because so few flights and so expensive.
 Engineers may work entire career on no missions or one mission.
- Do at the smallest scale possible to get valid results.
- Would test assertions of engineers to call them on estimates.
- Collaborative design with incentive structure based on stock options (you get paid more when company succeeds, not just your department).
 - Source: https://youtu.be/MxliiwD9C0E Dan Rasky interview on COTS

51 Percent + 80:20 Rule = Escape Velocity



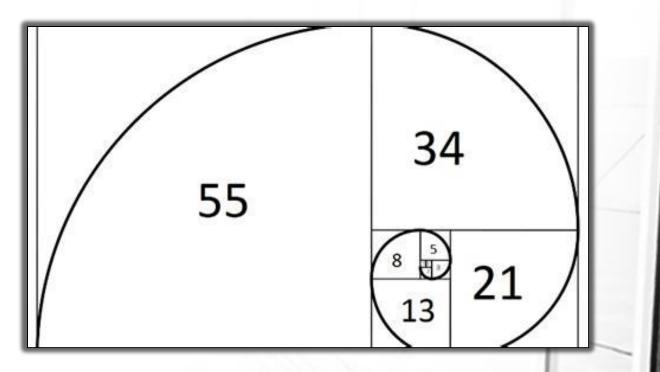




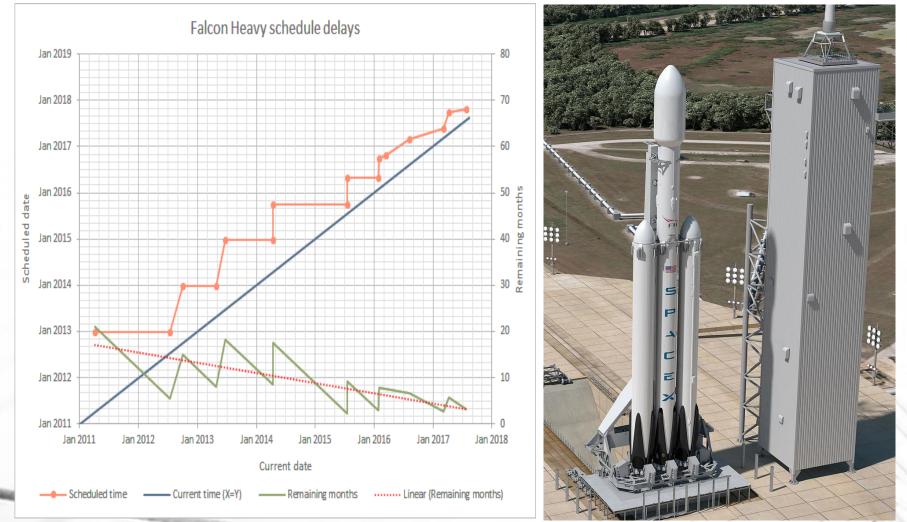
Falcon Heavy

Scrum Story Points and Fibonacci Sequence

- Task Estimates are usually done in Fibonacci sequence, not in equal blocks of hours or days. These blocks are called story points.
- Each block of story points is 62 percent bigger than the next smaller block.
- Projects on a borderline are rounded up to the next level, so 35-55 hours is the same level in this diagram.



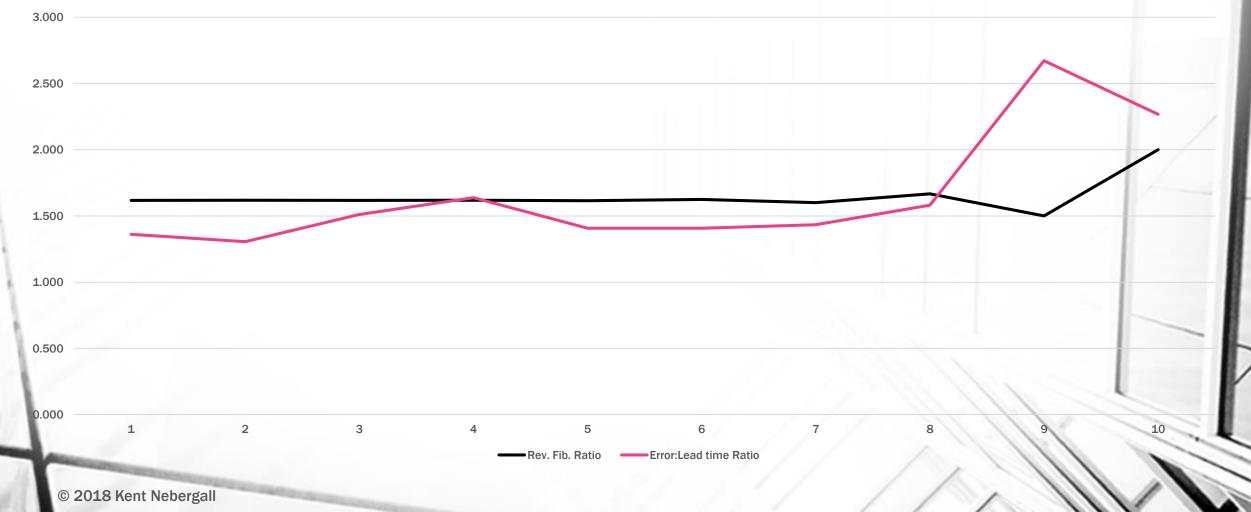
SpaceX FH Delays and Fibonacci Sequence



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SpaceX FH Delays and Fibonacci Sequence

Raw Variable Analysis for Falcon Heavy Projection Accuracy



Predictions for BFR/BFS

- As estimates get closer, and do not slip, the buffer gets smaller.
- Adjusted for Mars launch windows.

2016		2021			2026			2031		2036
										2036
Events										
	Announce Date									
	• 2. IAC 2017 Ann Fri 29 Sep 2017	ouncement								
	 3. SXSW Int Tue 13 Mar 2 									
		st Flight 2018 - Tue 27 Jul 2021								
		Hop Test Flight t 1 Jun 2019 - Fri 21 May 2	2021							
		6. LEO Flight Sun 1 Dec 2019 - Tue 13	3 Sep 2022							
		7. LEO Flight								
		Wed 1 Jan 2020 - Tue 1	15 Apr 2025							
			8. Cargo to M Sun 7 Aug 202	ars 2 - Sat 22 Feb 2031						
			9. Cargo to M Sun 7 Aug 202:	ars 2 - Sat 22 Feb 2031						
			10. Cargo to I Sun 7 Aug 202:	Mars 2 - Mon 11 Apr 203						>
				11. Human Thu 26 Sep	s to Mars 2024 - Sat 22 F	eb 2031				
				12. Humar Thu 26 Sep	s to Mars 2024 - Wed 30	May 2035				

BFS Spaceports (Theoretical)



Blue Origin

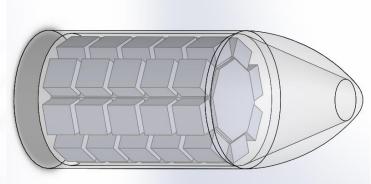
- \$1 Billion in investment
- Massive factory on space coast
 - Currently roughly 1500 employees, will double in next 2-3 years
 - (SpaceX has double that now higher level now)
 - Still finalizing some design issues, getting close to stress testing key parts
- Second Mover Advantage
- 2022 set launch of first paying satellite
- 2020 roll-out (unlikely)

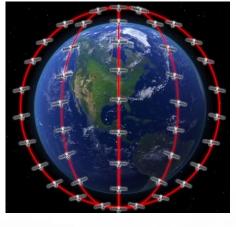


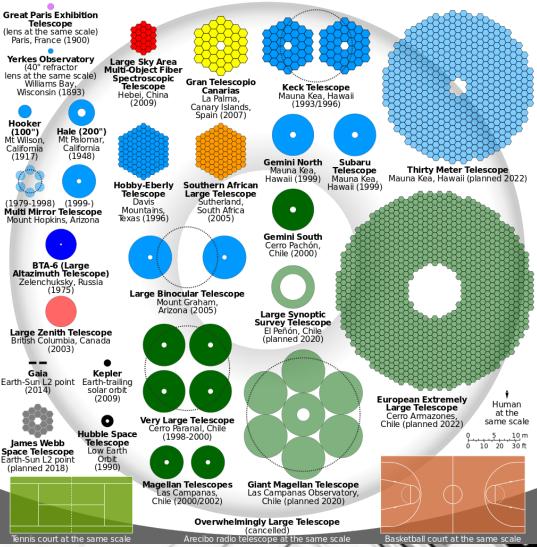
BLUE ORIGIN

The Future of NewSpace - Strengths

- Two is one, one is none
- Ability to launch 10 times the payload
 means larger satellites and constellations
- Ability to launch at 1/10 price means more customers, but not unlimited customers, and some first-wave space tourists



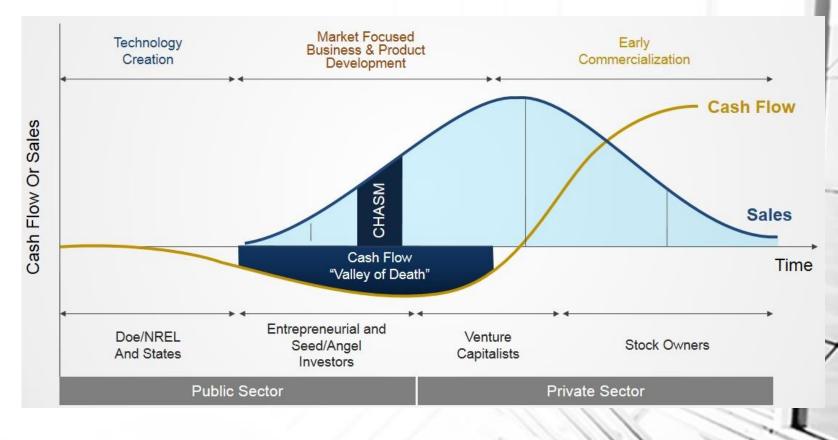




The Future of NewSpace - Threats

The Chasm – After High Speed Internet Constellations, What's Next?

- Asteroid Mining companies
 already fading out
- Most other companies are start-ups with no base funding
- Government Contracts will keep things locked in Early Adopter phase unless price drops
- SpaceX rapid global transport fleet needs expensive, dedicated infrastructure costing billions. With only one "airline" available.



The Grand Challenges of Space Settlement (2014)

Launch/LEO	Deep Space	Moon/Mars	Settlement		
Affordable Launch	Solar Flares	Moon Landing	Air/Water		
Large Vehicle Launch	Galactic Cosmic Rays: Cell Damage	Mars EDL	Fuel		
Mass Fraction beyond Earth Orbit	Medication/ Food Expiration	Spacesuit Lifespan	Power		
Space Junk	Life Support Closed Loop	Reliable Ascent Vehicle	Food		
Microgravity (health issues)	Medical Entropy	Reliable Return Vehicle in Orbit	Assembly		
	Psychology	Flight to Earth	Mining		
	Mechanical Entropy	Earth Reentry	Manufacture		
			1111		
Resolving Now	Being Considered	Being Neglected			

Questions?

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"Play to Strengths"

"It is far more lucrative and fun to leverage your strengths instead of attempting to fix all the chinks in your armor. The choice is between multiplication of results using strengths or incremental improvements in fixing weaknesses that will, at best, become mediocre.

Focus on better use of your best weapons instead of constant repair."

- Tim Ferris. The Four Day Workweek, 2009.

References

- Blue Origin: <u>https://www.reuters.com/article/us-space-blueorigin/bezos-</u> <u>throws-cash-engineers-at-rocket-program-as-space-race-accelerates-</u> <u>idUSKBN1KO0HN</u>
- Assumptions on Spaceport Chart
 - Must be major city near water
 - First ports will be near existing launch facilities
 - Second movers will be major cities near water with reputation of being high tech commerce locations and with no political reason to reject American spacecraft
 - Third wave will be "me too" of other coastal cities with high incomes and coastal access.
 - Number of ports opened also follows standard growth sequence.