# Accelerate Like Elon (ALE):
# 2022 October Update (2.0)

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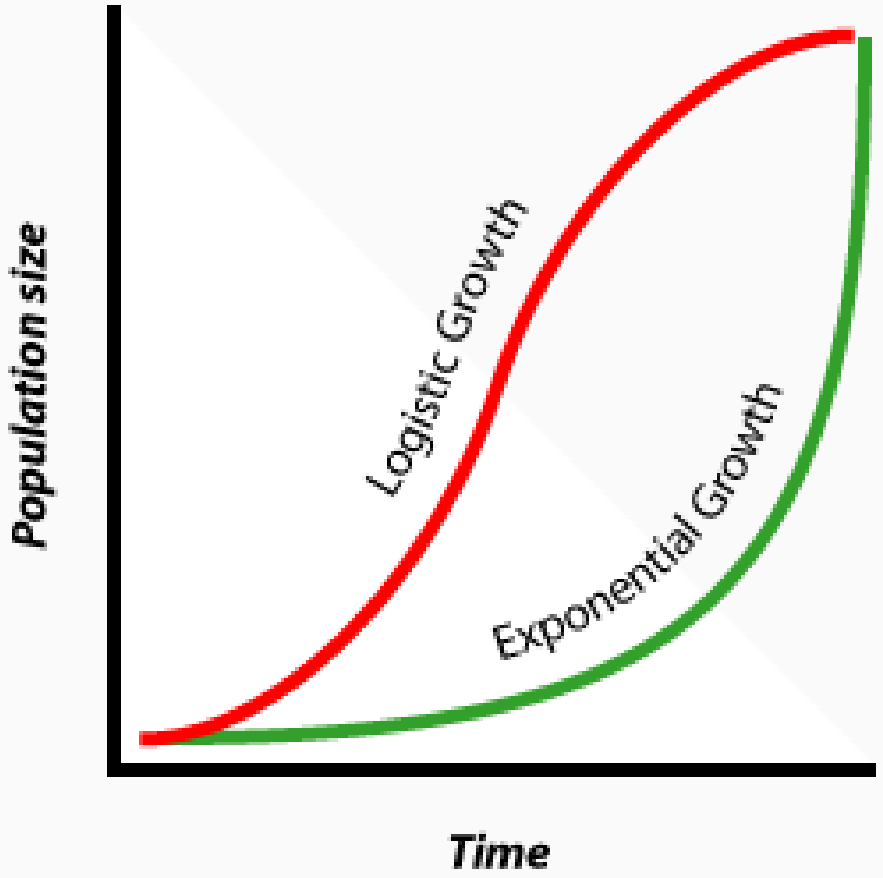
# Abstract

The methods used by Elon Musk's enterprises radically outperform competition and push back the edges of the technology curve. This talk is an update of the popular "Accelerate Like Elon" speech from 2018 (14,000 views on YouTube after being described in the blog Next Big Future). Classical methods such as first principles and Platonic ideals are merged with modern concepts of entrepreneurship such as minimum viable products and agile. We also review new information from SpaceX and Tesla, both announced and observed, that refine and expand these methods. Finally, we will assess how it is going and any strengths or weaknesses the enterprises will face in the future. The goal is to describe the templates that others can follow to build enterprises that will democratize space settlement. There must be thousands of such businesses at every scale to fill the solar system with life.

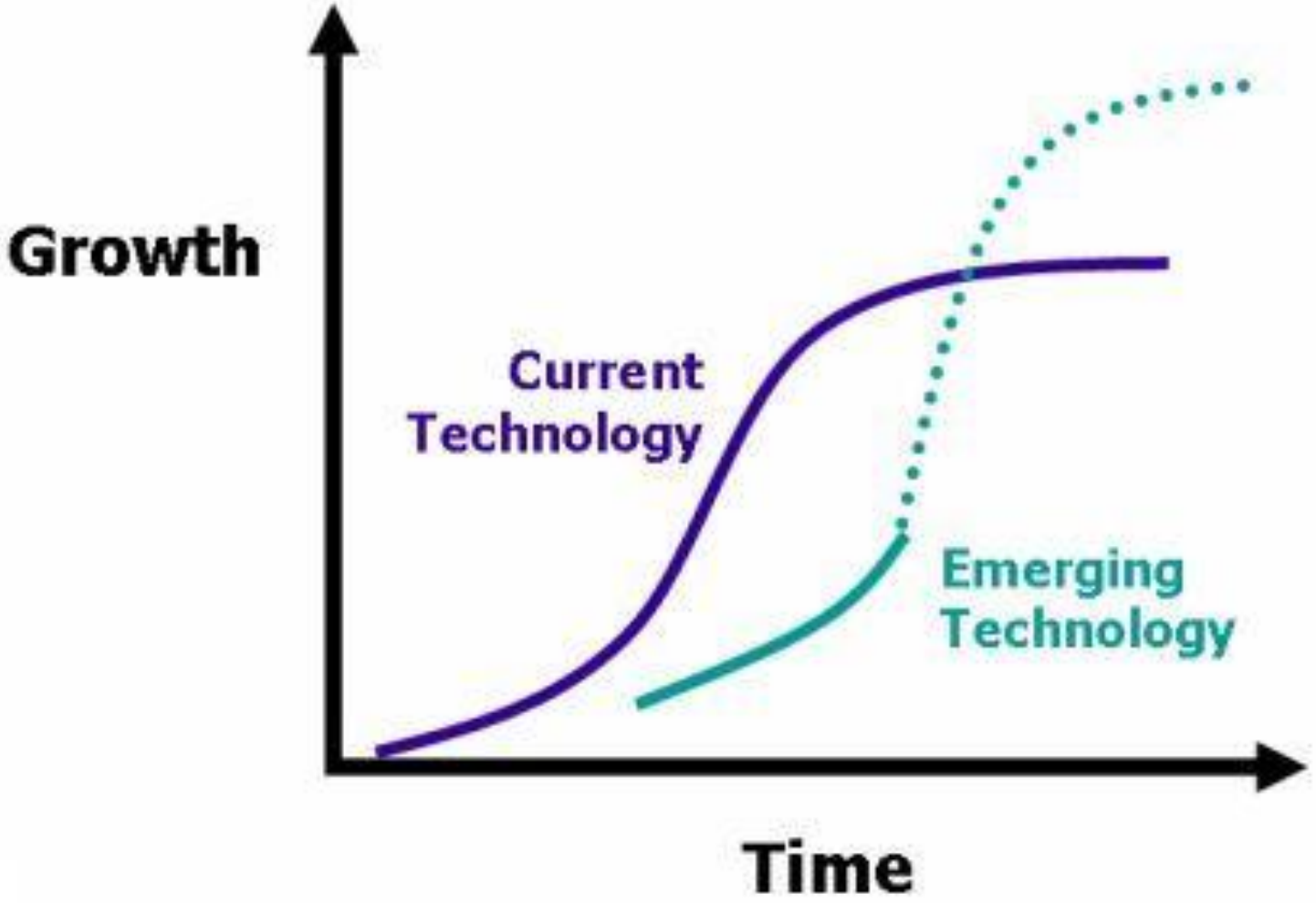
# Technology Revolutions 101

# 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.

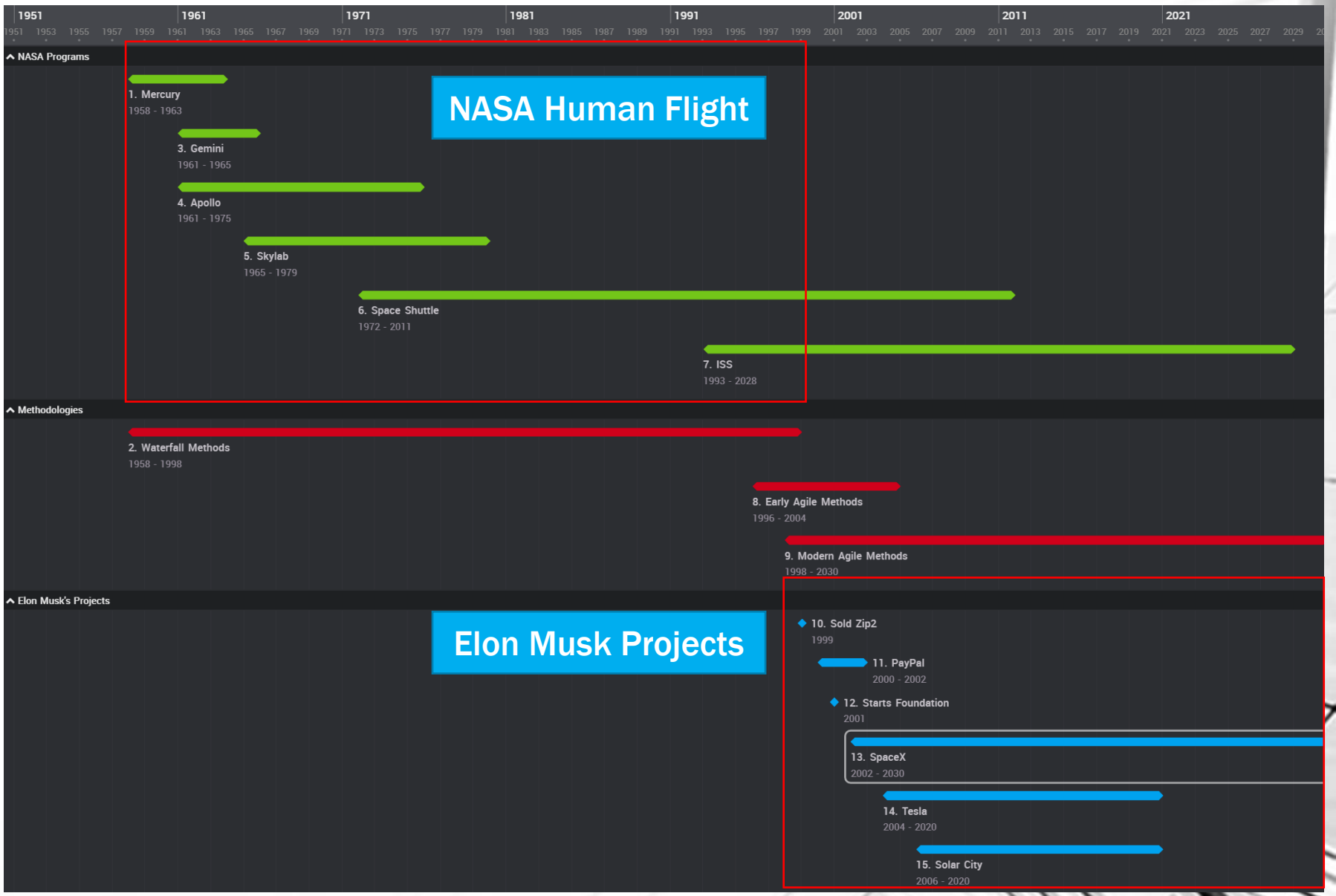


# 1970's Stagnation Versus NewSpace Revolution



# Methodology History

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



# Empowering Technology Revolutions

## Energy

- Higher Density
- Affordable, Consistent, Safe

## Invention and Convergence

- Capacity Envelope Expansion (Superpowers)
- Factorial complexities (2!=2, 3!=6, 4!=24, 5!=120, etc.)

## Information

- Science Drives Engineering. Vice Versa.
- Communication Drives Factorial Expansion

## Affordability (Efficiency)

- Applies to All of the Above

## Excitement

- Boring Science and Technology Doesn't Explode Interest
- Superpowers, Comfort, Novelty

# What Elon Has Said Directly

Interviews and Speeches Summarized

# First Principles

- Material Cost vs Value Add
- High – great potential

**1: First Principles**

**2: Platonic Ideal**

- What does a Perfect Product look like?

- What is the Minimum Viable Product?
- How do we iterate towards a realistic ideal?

**3: Realistic Revision Cycle**

**4: Be prepared to throw out old products and replace them as the root technology becomes obsolete.**

# Dying Companies

- Repeat existing designs
- No innovation or invention

**1: Reason From Analogy**

**2: Minimum Refinements**

- Copy other established players with cheaper clones

- Delete features to reduce costs
- Innovate as little as possible

**3: Minimal Revision Cycle**

**4: Keep products on market well into obsolescence to maximize return on original investment.**

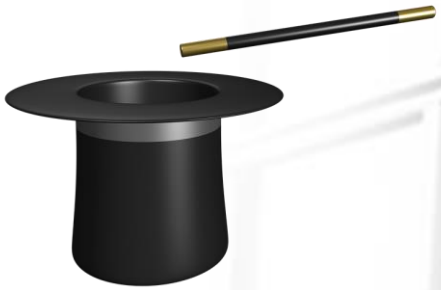
# Other Design Principles

| Principle | Notes |
|---|---|
| **Ask the Right Questions with Precision** | "It took us a long time to even frame the question correctly. Once we could frame the question correctly… the answer flowed once the question could be framed with precision."<br><br>He often gives the example of the Deep Thought computer from the Hitchhiker's Guide to the Galaxy as someone stating the question so poorly that the answer was meaningless. |
| **Simplification** | "The best part is no part". |
| **Real Estate Minimization** | Both the Tesla Factory and the Dojo computing centers are constantly packing more equipment into smaller spaces while increasing productivity by huge margins. |
| **Modularity** | Reuse the parts in different systems at different scales. Merlin Engine was developed with Falcon 1, then 9, then 9H and so on. |

# Five Step Process:
# Tim Dodd (Everyday Astronaut) Interviews 2022

| | Principle | Notes |
|---|---|---|
| 1 | **Make your requirements less dumb.** | No matter who gave them to you. If a smart/authoritative person gave them, that's especially dangerous.<br>Every requirement must come with a name, not a department. Otherwise the reason for them will be lost. |
| 2 | **Delete a part or process.** | If you aren't forced to add things back in, you aren't cutting enough.<br>You need to run tight margins for things that have never been tried successfully before. |
| 3 | **Simplify or optimize what is left.** | Always do this after the first two steps, or you may optimize something that shouldn't exist in the first place. |
| 4 | **Accelerate cycle time** | Again, don't go faster until you do the other steps.<br>"A high production rate cures many ills." |
| 5 | **Automate** | If you put in test steps for a problem, remember to remove them after you verify you fixed the problem. |

# Core Principles, Psychology and Magicians



| Principle | Elon Musk - Rocket Scientist | Collin Key – Stage Magician* |
|---|---|---|
| **Make your requirements less dumb.** | The smarter the designer, the more overcomplex the solution.<br>Also solicit negative feedback (Ted Talk interview). | **Misconceptions** –<br>People assume a difficult problem has a complex solution.<br>Children are harder to fool with stage magic than intelligent adults. |
| **First Principles vs Analogy** | Boil things down to fundamental truths and reason up from there. Reasoning by analogy is doing what others have done with slight variations. But if you want to do something new, you [must] start with the physics approach. | **Assumptions** –<br>We use information based on past experience, not the actual parameters. |
| **Ask the Right Questions** | "It took us a long time to even frame the question correctly. Once we could frame the question correctly… the answer flowed once the question could be framed with precision. " | **Expectations** –<br>The answer we expect to find limits and prevents us from seeing what's really going on. |



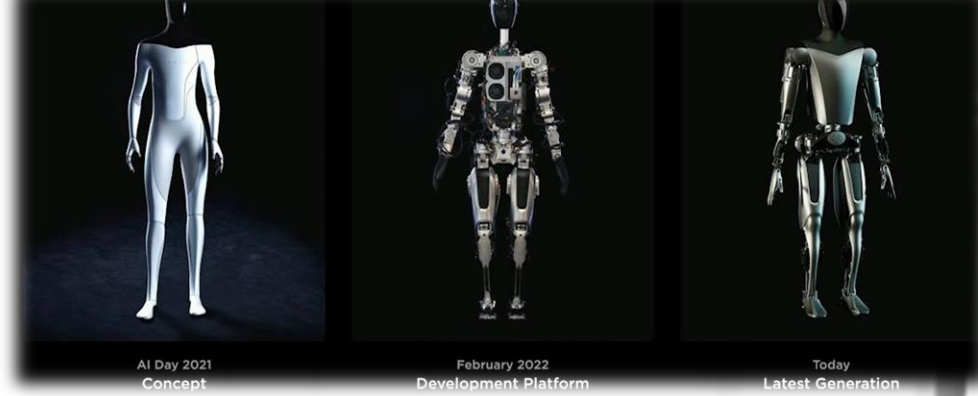
* Collin Key – TedX Talk in 2017


# Battery Day (2020)

| Principle | Notes | |
|---|---|---|
| **Core Goal** | **Cut the cost per kilowatt hour by half.** | **50** |
| **Vertical Integration** | Tesla owns everything from land to mine lithium to factory spaces.<br>Lithium is refined as little as possible and specifically for factory | 12 |
| **4680 Battery** | Electrons travel much shorter length, better power to weight.<br>Five times the energy, six times the power, with better range. | 14 |
| **Manufacturing Process** | Assembly line 75 percent in size of assembly line per kw/hour<br>Ten times better than state of the art. | 18 |
| **Car Design Changes** | New alloy and giga-press to reduce steps in building.<br>Structural battery. Safer car with less weight, longer range. | 7 |
| **Input Material Changes** | Silicon: holds 9 times more than Graphite, but has drawbacks.<br>Cathode: Higher nickel and lower cobalt content<br>Lithium: Avoid redundant steps in manufacturing by power-to-film | 5 |

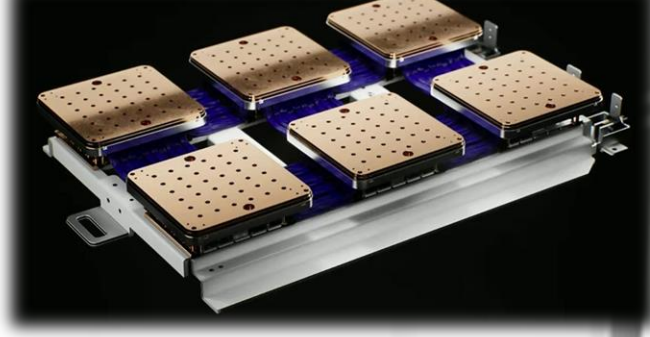
**RESULT: 56 Percent**

# AI Day (Optimus Robot)




| Principle | Notes |
|---|---|
| **Development Speed** | • Concept to walking prototype in six months (Bumble C), with parallel work on in-house engineering. Goal is millions of units and less than $20K. |
| **Optimus Software** | • Real time computer vision of situational awareness of volume and identity of objects. Visual navigation indoors. Natural movements. |
| **Convergence** | • Used vehicle design systems, even crash tests, and applied to robot.<br>• Same AI hardware as Tesla FSD computer.<br>• Very advanced in house actuators, hand designs. |
| **Economy Impact** | "Productive entities (capita) times productivity. So if no limit on Capita, there is abundance without limit of products and services." |

# AI Day (Dojo)



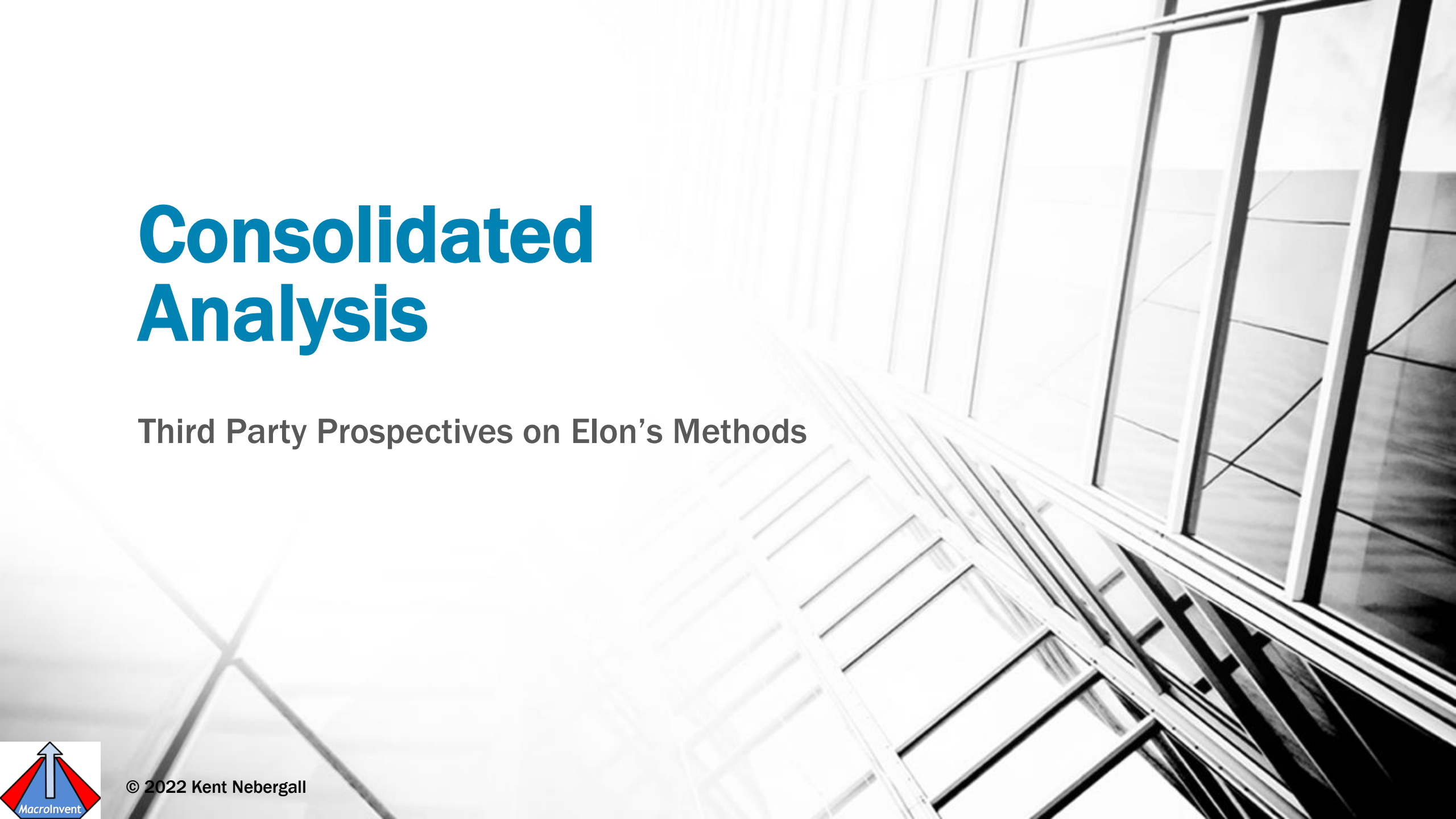
| Principle | Notes |
|---|---|
| **Full Self Driving** | • Interdependencies and situational “semantics” to anticipate people running red lights, turning out of sequence, etc.<br>• Drives in real world and simulation of world, with labeling, etc. |
| **Dojo Density and Focus Optimization** | • Combination of better methods and Dojo massive supercomputer to dramatically improve technology growth.<br>• Building “training tiles” at rate of 1 per day.<br>• Density focus at every level – power, training tiles, interfaces, etc.<br>• 30 times faster than GPU systems at one sixth the price.<br>• Four Dojo cabinets replace 72 GPU racks. |
| **Capacity Planned** | • Exopod – 10 cabinets (double capacity of current GPU setup)<br>• 7 Exopods planned for Palo Alto - 14 times the labeling capacity by 2024 |

# Competitive Strength:
# Jay Leno Interview, Sept 2022

| Principle | Notes |
|---|---|
| "Patents are for the weak" | They are land mines in warfare. They keep people from following you, but they don't advance things. |
| Auto Industry | Good at Manufacturing |
| Aerospace industry | Good at Materials |
| Cross-pollination of the two companies benefits both product lines. | |

# Consolidated Analysis

## Third Party Prospectives on Elon's Methods

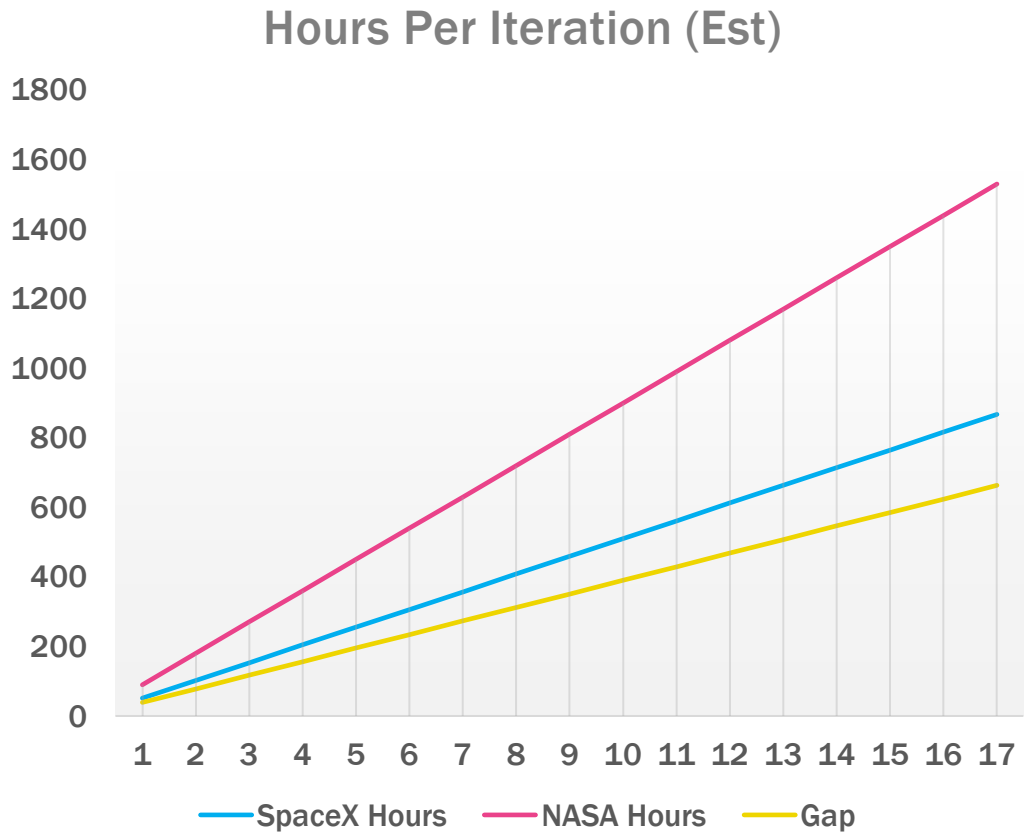


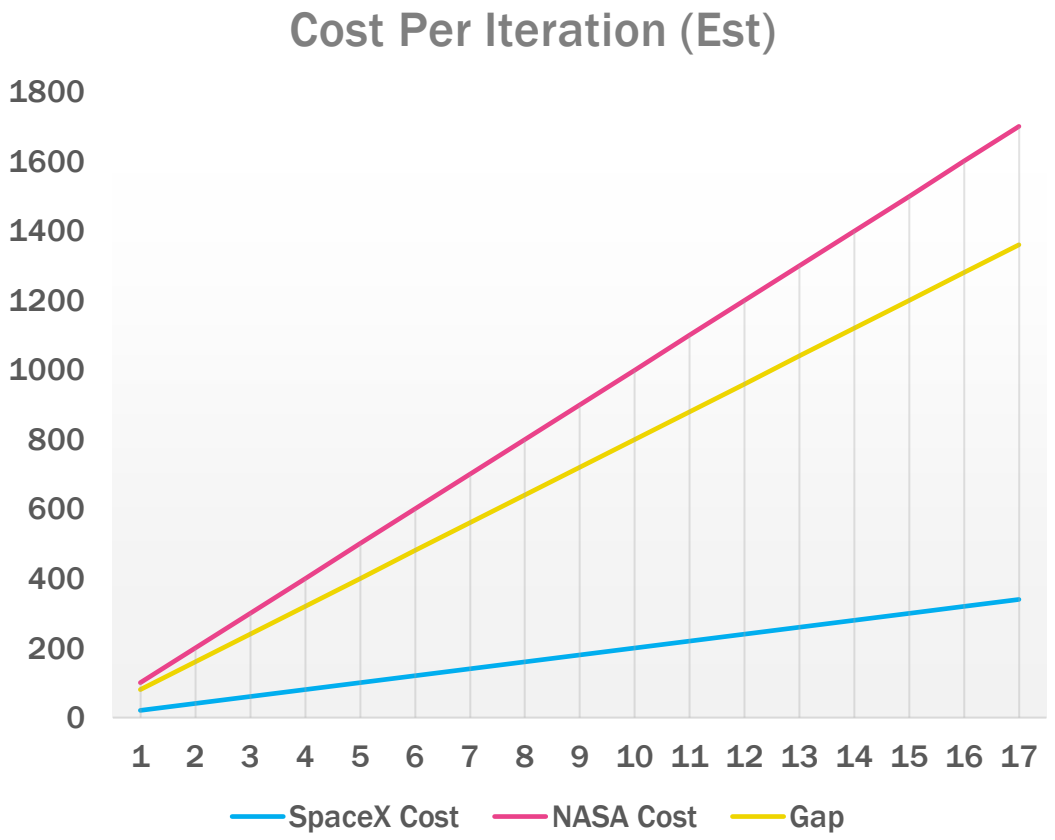
# The 51 Percent Rule of Experiments

| Factor | NASA | SpaceX |
|---|---|---|
| **Chance of Success** | As high as possible | 51 Percent chance of success |
| **Decision Matrix** | Full (weeks of meetings) | Sparse (1 meeting if enough evidence) |
| **Experiment Scale** | As few experiments as possible to get key results. | Experiments as small as possible to get valid results, so a lot more data points on curves. 80:20 Rule on cost of testing |
| **Purpose** | Expand art of the possible | Test engineers' assertions to refine estimates. |
| **Why** | Very risk adverse.<br>Flights are rare and expensive.<br>Engineers can spend entire career on one mission. | Collaborative design with incentive structure based on stock options<br>You get paid more when company succeeds, not just when your department succeeds. |

Source: https://youtu.be/MxliiwD9C0E - Dan Rasky interview on COTS

# 51 Percent + 80:20 Rule = Escape Velocity



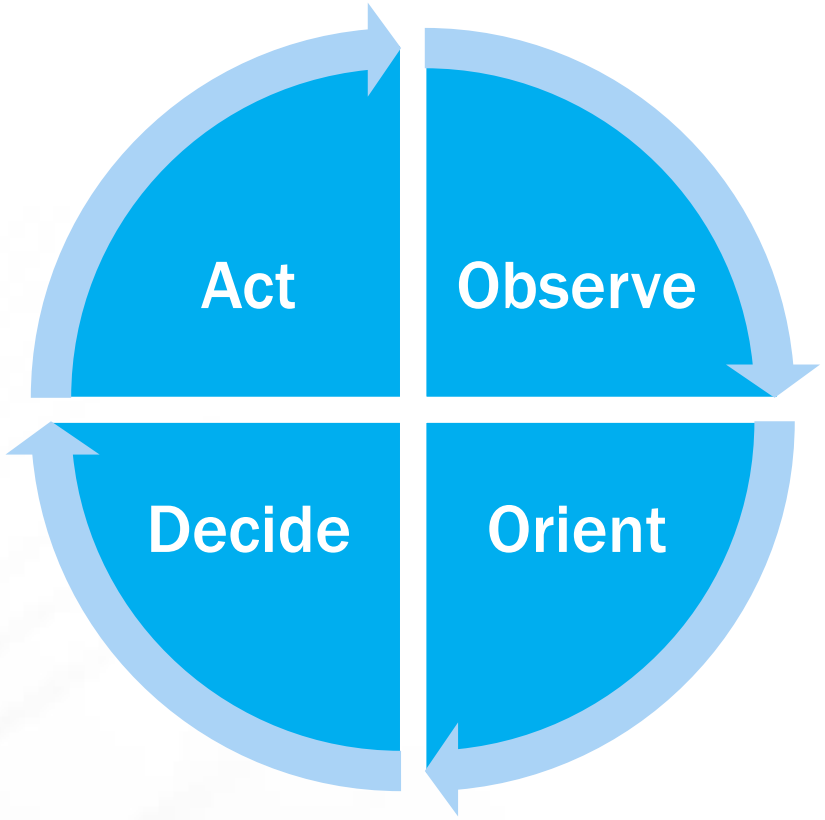



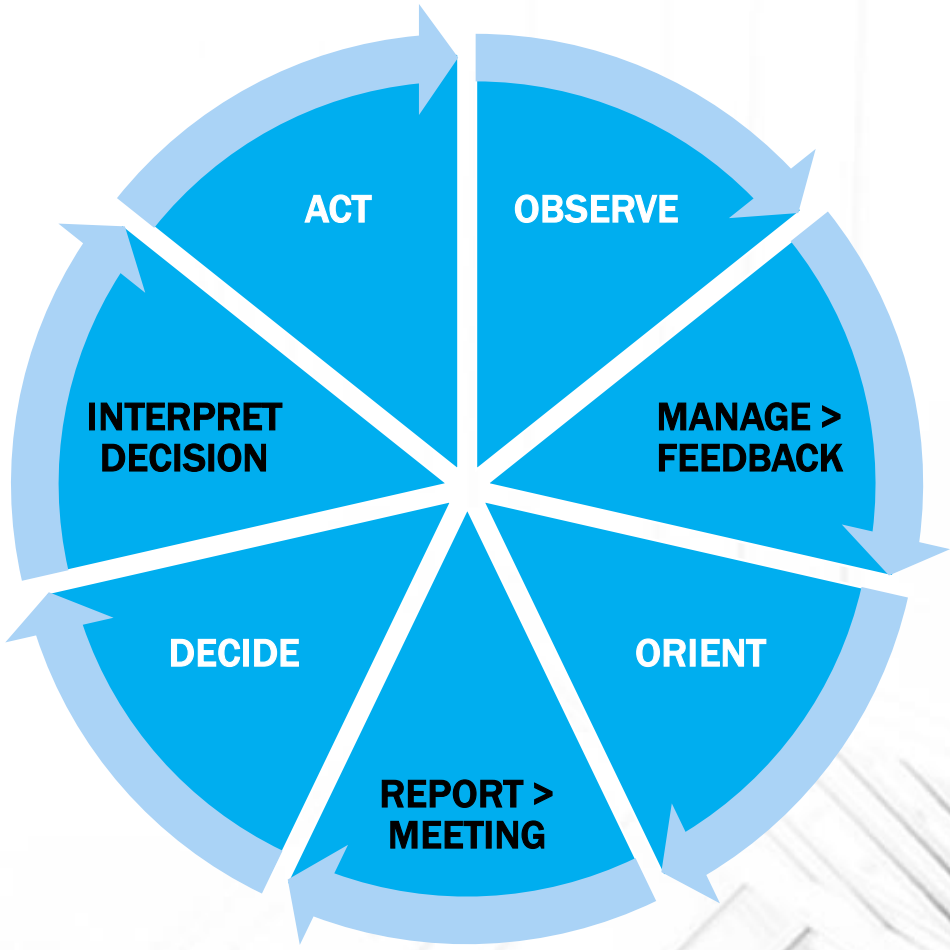
# Concentrated Talent Pool

- Best Talent/Small Group
  - Price's Law (50 percent of work done by square root of team size)
  - SpaceX high demand work hours self select for Price's Law workforce only. Only the best apply and survive.

| Factors | Traditional Factory | Musk Factory |
|---|---|---|
| Labor/Engineering | 40-hour week | 120 hour week, 2 shifts |
| Labor Productivity | Conventional | Squared |
| Productivity Gain | 3X Hours, Squared | 9X productivity on talent pool ALONE (decade per year engineering progress) |

# Overworked Engineers vs Committees/Managers



# Peter Thiel book *Zero to One (2014)*

| The … Question | Notes |
|---|---|
| **Engineering** | Can you create tenfold breakthrough technology instead of incremental improvements? |
| **Timing** | Is now the right time to start your business? |
| **Monopoly** | Are you starting with a big share of a small market? |
| **People** | Do you have the right team? Elon's company attract people willing to work long hours at high skill levels. |
| **Distribution** | Do you have a way to not just create but deliver your product? Vertical integration is key here. |
| **Durability** | Will your market position be defensible 10 and 20 years into the future? |
| **Secret** | Have you identified a unique opportunity that others don't see? |

# Phases of Growth (Individual Companies)

## Inception

- Reason from First Principles
- Start with an ideal concept but a realistic first product
- Attract best people with high demand/reward

## Establishment

- Vertically integrate supplies and production
- Modular systems at multiple scales
- Factory/materials/design optimization adds up

## Acceleration

- Become your own convergence technology revolution
- Open sourcing IP can spread foundations
- Simple processes automated at scale are untouchable

# Phases of Manifestation

## Bits First, then Atoms

- Started in software and data because there is no unit cost of electrons
- Reinvested each enterprise to build the next one.

## Follow Established Talent

- Built first factories in area with lots of aerospace engineers and an existing factory floor.
- Use vertical integration to accelerate and be self sufficient in your supply chain during downturns.

## Attract Talent to Low-Cost Areas

- Become the attractor to remote areas with low land costs.
- Extend vertical markets all the way to mining and refining materials (lithium, etc.)

# Challenges and Competition

"We convert the impossible to late."

- Elon Musk

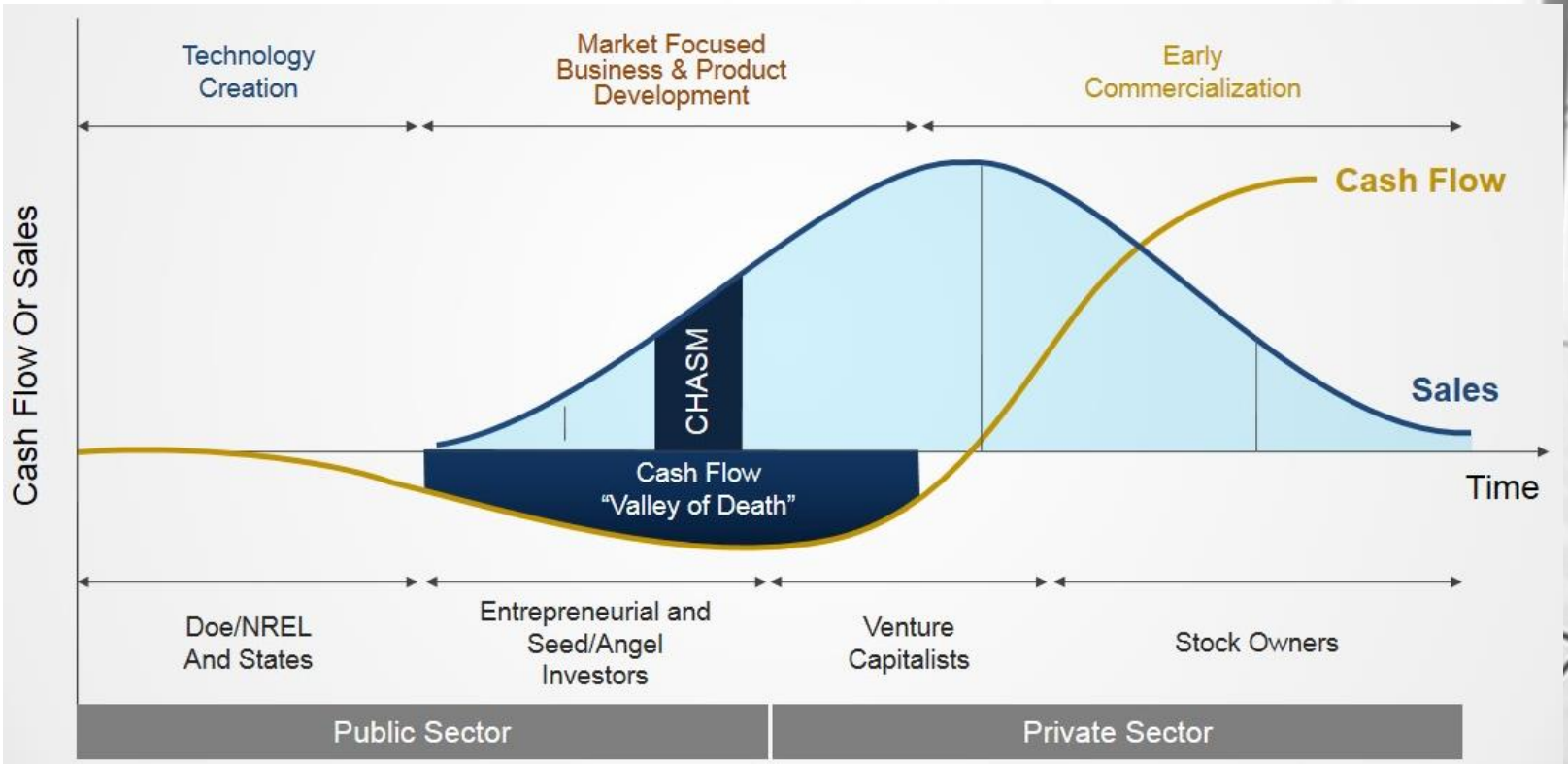
# The Grand Challenges of Space Settlement (2014)

| 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 |
| Resolving Now | Being Considered | Being Neglected | |

# The Future of NewSpace - Threats

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

- Asteroid Mining companies died.
- Governments are slow to realize potential of five times the payload at a fraction of the price.
- SpaceX rapid global transport fleet needs expensive, dedicated infrastructure.
- Single "airline" will be taxed heavily in many countries.



# SpaceX and Blue Origin

| Capacity | Blue Origin | SpaceX |
|---|---|---|
| Employees (2018) | • 1500 | • 3000 |
| Employees (2022) | • 6,000 (Doubled) | • 12,000 (Quadrupled) |
| Smaller Business | • New Shepherd<br>• Suborbital Space Tourism | • Falcon 9<br>• Satellite Launch |
| Satellites | • Kuiper Systems<br>• 2 planned for 2022 | • Starlink<br>• 2300 live sats, 500K subs |
| Medium Rocket | • Engines for ULA Vulcan<br>• Delivery 2023 (years late) | • Falcon Heavy<br>• 3 launches, 4 planned |
| Next Gen Rocket | • New Glenn<br>• 3+ Years Late in 4 years<br>• At least 2 years to go | • Starship<br>• 2 Years Late in 5 years<br>• Months to go |
| New Projects | • Orbital Reef LEO Station | • Human Lunar Lander |

# History and Precedent

| Principle | Notes |
|---|---|
| **Applying automotive fast assembly to other industries** | The US intentionally applied the rules of automotive manufacturing learned during the optimizations of assembly lines to other industries like aircraft and ship building before and during World War II.<br>Starship is in many respects a “Liberty Ship” (welded and able to be built en masse in a week once the factories get going) as opposed to the older WWI battleships that took longer to build than the Saturn V. |
| **Vertical integration and Engineers on Assembly Lines** | This was pioneered by Lockheed Skunkworks during the U2 and SR-71 development projects.<br>Vertical integration was pioneered by David Rockefeller with Standard Oil. |

# Questions?

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