*Notes on:*

Loonshots

How to Nurture the Crazy Ideas That Win Wars, Cure Diseases, and Transform Industries

By Safi Bahcall (2019)

# Definitions

* **Moonshot:** (1) The launching of a spacecraft to the moon; (2) an ambitious and expensive goal, widely expected to have great significant.
* **Loonshot:** A neglected project, widely dismissed, its champion written off as unhinged.

# Prologue

The author starts by putting his key points right at the front of the book. (He said he appreciates when people do this).

1. The most important breakthroughs come from *loonshots*, widely dismissed ideas whose champions are often written off as crazy.
2. Large groups of people are needed to translate those breakthroughs into technologies that win wars, products that save lives, or strategies that change industries
3. Applying the science of *phase transitions* to the behavior of teams, companies, or any group with a mission provides practical rules for nurturing loonshots faster and better.

# Summary

I enjoyed reading this book. I learned as much about history as I did about the theory the author put forward. The examples he includes and the stories he tell contain a wealth of business lessons on both what to do and what not to do. The author spends a bit too much time discussing the science of phase transitions and how water turns to ice, but we can forgive him that. His main theory is that loonshots are much more likely to occur in small, startup companies than they are in large, established companies. But as he digs deeper into this rather intuitive conclusion, he also explains why this is the case and suggests ways for encouraging innovation even in large companies.

He examines incentive structures and explains why middle-level managers in large companies are likely to kill innovative ideas and instead focus on low-risk, “franchise” plays. He shows how this behavior makes rational sense and even builds a mathematical model for it which is rather interesting. The easiest way to nurture loonshots is to keep that part of the business separate from the rest (keep your “artists” separate from your “soldiers”), but he also demonstrates that the free flow of information and cross-pollination between the two is essential for success. He also looks at ways to change incentives within organizations so that innovation can be encouraged to grow even in somewhat larger companies. (The typical cutoff is about 150 employees, but there are ways to increase that.)

He draws a great deal of inspiration from Vannevar Bush and Theodore Vail, two people who he says setup the perfect examples of loonshot environments; the former: in World War 2 and the science foundations that followed; the latter: in Bell Labs. He provides a great summary of what he calls the “Bush-Vail Rules” in Appendix A of his book. I have included this summary verbatim in my notes since it is only a few pages long and full of practical wisdom. If you were to read only one part of these notes I would suggest it be that one. The remaining notes on the lesson from history, the mathematical notes about why 150 is the tipping point of organizations, and the macro-level applications of this theory are interesting, but not as important as the key take-aways from Bush and Vail.

# Part 1 (Lessons Drawn from History)

Much of the book draws on samples and stories from history that are recounted in just-the-right-level of detail so that you feel like you are learning two things at once: history, and lessons learned from history that support the author’s thesis. Some of these stories include:

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| Radar in World War 2 | Radar was the “loonshot” that won the war. Lines of radar stations in Britain allowed them to identify incoming German planes and swam them, defeating a vastly superior and larger air force. Radar deployed on planes over the Atlantic by the U.S. put an immediate end to the U-Boat’s tactical advantage in May of 1943. The first discovery that would lead to this development occurred in 1922, but the Navy didn’t fund it because they didn’t think it was worthwhile. Even once developed in the early years of the war, it was difficult to get the Army and Air Force to use it. It took Vannevar Bush – bridging the worlds between academia and the military – to get this invention into the field and to get feedback from the field to make it practical and useful.  The author uses lessons from Vannevar Bush (and Theodore Vail at Bell Labs) to show how environments for “loonshots” must be created, kept separate from rest of a large organization, but with ideas flowing freely between the two. |
| Akiro Endo and Statins | In the search for a drug that would lower cholesterol and fight heart disease, Akiro Endo screened over 6,000 species of fungi in 1971-1972, finally isolating one that seemed promising. It wasn’t until 1987 that the FDA approved the first statin based on his findings, and the intervening years saw his ideas put down by academia, almost destroyed by negative tests in rats (which were flawed because, unknown at the time, rats don’t have “bad cholestoral”), and a test in dogs where the drug caused cancer. The company funding his research went bankrupt, but the drug resurfaced at Merck, where it turned into a $300 billion industry that prevents half a million heart attacks and strokes each year in the U.S. alone.  The author uses this case to explain that every really good, creative idea has to die 3 times before it can survive. |
| Airlines  (Juan Tripp vs.  Robert Crandall) | Juan Tripp (founder of Pan Am) is held up as an example of a P-Type [Product] innovator. From the first plane he used to fly 3 people at a time out to Manhattan (when other planes only held 1) to several decades of bigger, faster, and more technologically advanced planes, he was always on the cutting edge of innovation. Pan Am even invented early transponders in planes and radio signals from airports that would keep planes from being lost at sea.  When airline deregulation occurred 1978, Robert Crandall of American Airlines demonstrated S-Type [Strategy] innovations. These are innovations that don’t require any new technology or products – just different ways of using existing materials. Crandall invented the frequenty flier program, SuperSaver fares, two-tier employment (a contract with unions that lowered wages of new employees but preserved those of existing ones). He also famously created a computer reservation system that was given to all travel planning companies to help book airlines. Amazingly, it showed all off the flights from all of the airline providers. However, American Airlines was always at the top, and American Airlines also now had one of the first “big data” sets with all kinds of info on customer shopping habits and competitor pricing/operations.  These moves eventually won the airline war, and Pan Am filed for bankruptcy. The lesson is: always watch your blind side. If you are P-Type innovator, watch out for S-Type innovations (and vice versa). |
| Polaroid  (Edwin Land) | Edwin Land, founder of Polaroid was a P-Type innovator who created newer and better camera systems for decades. The big move that Polaroid missed was the move to digital cameras (which is interesting because Land was consulting with the military and a big advocate for digital cameras to be deployed in satellites for higher-resolution images). Land became obsessed with a Polaroid movie camera that would instantly develop a motion picture as you rewound the video you just took. The “Polavision” machines were expensive. No one wanted them. And it almost destroyed the company.  Land is an example of a “Moses” who was completely in charge (and in love with) new innovations in his company. One mis-step by this type of leader can be fatal to a company. It can also be devastating when that person leaves the company. |
| Steve Jobs at Apple  (what not to do) | Steve Jobs famously tore Apple apart in his first run as CEO. He pitted his team of “artists” building the Macintosh against the “bozos” building the Apple II. Steve Wozniak left the company, and Steve Jobs was eventually fired from the company he founded. (The lesson: love your artists and soldiers equally).  Jobs also went on to run NeXT, building a cutting-edge computer that was too expensive and that no one wanted. His state-of-the-art manufacturing plant that was built to sell $150 million of computers the first year, remained largely empty as they sold only 400 in their first year. In the process of buying specialty hardware companies for NeXT, Jobs ended up owning the company that would become Pixar (he bought them for their giant image processing computer, the $10,000 Pixar Image Computer). He would learn a lot from the executives at Pixar an come back to Apple a changed man. |
| Ed Catmull at Pixar | Ed Catmull followed his dream of creating the first fully computer-generated film. He started by creating 3D animated images of a hand in college. Eventually, his dream turned into the company Pixar and their first movie: Toy Story. The environment that Catmull created in Pixar to inspire and nurture creativity is well-documented in his book (Creativity, Inc.). It is a great example of how to nurture “loonshots” and stands in contrast to the large, franchise-oriented company: Disney. Disney acquired Pixar and the lessons they learned from them are also well-documented in Catmull’s book. |
| The Myth of Isaac Newton | Isaac Newton did not invent all the theories he is credited for. Really, he was drawing upon a lot of research others had done. His role was as a great synthesizer of information. (Later in the book the author credits the Royal Society with forming the perfect environment for this kind of synthesis and cross-pollenation though.) Similarly, Steve Jobs did not create everything at Apple. He was a champion of products more than the actual creator of them. Bill Gates said “Steve [Jobs] and I will always get more credit than we deserve, because otherwise the story’s too complicated.”  The author explains that we often hear about the lone inventor who created something amazing, but how that’s almost never the case. Usually there is a long trail of failures along the way (the 3 deaths). The invention may even be passed from one person or company to another before succeeding. However, the victors like to tell the story in a way that makes them look good, so you don’t always get to hear that part. |

# Part 2 (Science, Incentives & The Magic Number: 150)

Just as 32 degrees Fahrenheit is the temperature at which water transitions from its liquid to solid phases, companies transition from those that foster loonshots to those that kill them at some point. The three chapters in this part of the book seek to understand why. They even propose a nice mathematical model that makes a lot of intuitive sense. The intuition behind the model involves asking yourself a simple question:

* What is the return you will get if you invest an extra 10% of effort into your current work project versus investing that extra 10% into politics and trying to convince everyone you should be promoted?

If the return on project work is higher, people will invest themselves into their work, pushing projects and championing them with passion. If the return on politics is higher, they are more likely to play politics, and in fact will make more money by doing this.

The mathematical formula for this is:

M = *Magic Number* (the number at which companies transition from fostering loonshots to killing them).

E = *Equity fraction* (what percentage of your earnings come from equity value your project delivers versus a steady salary that you get no matter the outcome of your projects)

S = *Management Span* (how many people on average report to a single manager) – higher numbers make promotions less likely for each individual

F = *Organization Fitness* (the ratio of project-skill fit to return-on-politics) – this is a multiplier for either your project work or your politics playing.

G = *Salary growth rate up the hierarchy* (what percentage will your salary increase with the next promotion?)

F is the most abstract of these variables. It captures the answer to the question posed earlier: if you spend an additional 10% of your time on your project how much does the value of that project increase. On the other side: if you spend an additional 10% of your time promoting yourself politically, by what probability do your odds of promotion increase? The ratio between these two values is F and capture how “political” a company is. To increase M, you will want to increase the “project-skill” fit – fitting people with the right skills to the right project and increasing their skill level. This will give them a higher return on time invested in their projects. You will also want to decrease the return-on-politics. Examples for doing this include having neutral parties brought in to determine promotions and being as merit-based and objective in the promotion process as possible.

Two numerical examples are discussed, both assuming an average level of politics in the company (F=1). The first has:

E = 50% (half of the employees’ earnings are from equity and half from salary)

S = 6 (studies have found that typical span-of-control is between 5 and 7)

G = 12% (you get a 12% increase in salary with each promotion, which is about average)

In this case:

Deloitte did a study in 2014 that suggested the average span-of-control is now closer to 10. If we put those numbers in and increase the average salary step-up to 33% we get:

[I wonder what this number would be for Kroger. Span-of-control is probably between 6 and 10. The average raise is about 12%. As much as 25% of our income comes from equity, but this equity is not tied directly to our efforts. In fact, there is a lot of complaining that no single team or individual is able to move the needle on the numbers that effect equity. Thus, there is very little of our income that is actually under our control or tied to our project work. I suspect M is very low, and the feeling that one can do “just enough work to not get fired” is widely prevalent. The biggest factor in this calculation would be F, with some people taking great pride in their projects and accomplishments and driving themselves forward for that reason. We might also have a good company that promotes people who succeed on projects and discourages politics – although low-risk projects are the safest way to do that. I also wonder what this would look like at 84.51 – a company that seems to play politics much more than Kroger does. In both cases, I suspect the organizations are much larger than M. Maybe a few pockets exist where this is not the case, but in most areas of the company we are definitely a company that encourages low-risk “franchise” plays over high-risk / high-reward “loonshots.”]

The other doesn’t go much deeper into this, other than saying “that’s interesting”. But he does note that 150 is “Dunbar’s Number”, a theoretical (and perhaps poorly-founded) belief that the maximum social network a human can operate in effectively is about 150. He also notes that military groups tend to organize into groups of this size and that Joseph Smith sent Mormons west in caravans that averaged 150 people. And that the company Gore-Tex builds new facilities with 150 parking spaces. Its president, Bill Gore says: “When people start parking in the grass, we know it’s time to build a new plant.”

The advice then is to keep your loonshot group to no more than 150 people. You can also perhaps increase that number by increasing E, S, and F while decreasing G. He mentions that DARPA sometimes has as many as 100 people reporting to one manager. The idea is to create a flat organization where people are not worried about promotion. They also earn “soft” equity rewards in terms of the awards and recognition they get from their peers for successful projects. They are thus much more invested in their projects succeeding than in playing politics. Their meetings involve status updates on the various projects where teams offer advice to each other freely and can help other teams succeed. It is also important to have a lot of loonshots in your portfolio because most of them are going to fail. DARPA is able to chase after many loonshots at once, and the ones that succeed can be revolutionary. In fact, the author mentions that almost every story in his book was drawn from people who came out of DARPA labs and took their experiences and management philosophy with them. This includes leaders at research groups in Facebook, Google, Microsoft, IBM, Draper Laboratory, and a MIT Lincoln Labs. DARPA has 200 employees, but was the source of: internet, GPS, carbon nanotubes, synthetic biology, pilotless aircraft, mechanical elephants, the Siri assistant in iPhones, and more.

# Part 3 (Macro-level Applications)

The book concludes with a study of macro-level environments whereas the rest of the book looked at environments within a company. At the macro-level we see it is possible for some companies to specialize in franchises while others specialize in loonshots. Examples include:

* The film industry: the large production companies focus on distributing movies throughout the world, promoting them, creating toys and video game spin-offs from them (and even theme parks). The high-risk process of creating a script from scratch, finding actors and talent to shoot the film, occurs in smaller companies. These companies oftentimes sell their projects to the big production companies, effectively serving as the “loonshot” portion of their business while they focus on the “franchise” part.
* Biotech & drug companies: The large drug companies focus on manufacturing drugs at large scale, distributing them, and working through all the logistics of passing regulatory approval in all the countries of the world. If they develop drugs internally they are usually safe bets (such as the next, better “statin”) rather than revolutionary new discoveries (like gene therapy or radically new cancer treatments. These high-risk drugs are usually developed by smaller, biotech companies – companies with no income and no real equity, just hope that their potential drug might succeed. When successful, these smaller companies are often quickly bought by the larger ones.

The author notes how interesting it is to listen to the different types of companies have earnings calls. The larger ones focus on projected sales, profitability, and don’t talk much about individual movies or drugs in the pipeline. The smaller, loonshot companies don’t have any sales or profits. They will talk extensively about their new movies and drug candidates, where they are at in the testing or production pipeline, and whether they will succeed.

He also notes as an investor you would want to diversify across a lot of loonshots. If each one has a 10% chance of succeeding, you would want to own about 12 of them. 12 of them would have a 92% likelihood of at least 1 succeeding, whereas 10 of them would only have a likelihood of 65%. Similarly, regions that want to be a “hub” for these types of companies need to reach a “critical mass” where they have enough new companies that some are likely to succeed, and where talent can move from the failed companies to the new ones.

Finally, he tackles the question of why the world speaks English, when China and India were hundreds of years ahead in the history of many inventions. He credits the diversity of Western Europe and the number of kings who would fund research so that innovators could move from one area to the other and continue their research. He compares two astronomers who proposed a heliocentric theory: one in Denmark and one in China. The one in China fell out of favor with the emperor and had nowhere else to go to continue his research. He ended up living a secluded life by himself with his books. The other one also fell out of favor with the king and had his funding completely cut, but the King of Prague volunteered to continue it. He also mentions the Royal Society as creating the perfect place to spread scientific advances and noticing just how many of the great scientists and great scientific discoveries came out of England from scientists in this group. This critical mass and cross-pollination to grow scientific loonshots is just as critical at the national level as it is for companies. It is the role that DARPA, the NSF, and the NIH play in the U.S. today.

# Summary: The Bush-Vail Rules (Appendix A)

(NOTE: This is copied verbatim from the end of the book with my notes and clarifications in square brackets. It is a great summary of the key points from the book.)

1. **Separate the phases**
   * Separate your artists and soldiers
   * Tailor the tools to the phase
   * Watch your blind side: north *both* types of loonshots [product and strategy]
2. **Create dynamic equilibrium**
   * Love your artists and soldiers equally
   * Manage the transfer, not the technology: be a gardener, not a Moses
   * Appoint and train project champions to bridge the divide
3. **Spread a system mindset**
   * Keep asking *why* the organization made the choices that it did
   * Keep asking *how* the decision-making process can be improved
   * Identify teams with outcome mindset and help them adopt system mindset
4. **Raise the magic number**
   * Reduce return-on-politics
   * Use soft equity (nonfinancial rewards)
   * Incresae project-skill fit (scan for mismatches)
   * Fix the middle (reduce perverse incentives for middle managers)
   * Bring a gun to a knife fight (engage a chief incentives officer)
   * Fine-tune the spans [span-of-control] (wide for loonshot groups; narrow for franchise groups)

**For anyone championing a loonshot, anywhere:**

* Mind the False Fail
* Listen to the Suck with Curiosity (LSC)
* Apply system rather than outcome mindset
* Keep your eyes on SRT: spirit, relationships, time

The first three rules are discussed in part one, charpter 1 through 5. The fourth rule is discussed in part two, chapters 7 and 8.

**1. Separate the phases**

* *Separate your artists and soldiers:* Create separate groups for inventors and operators: those who may invent the next transistor vs. those who answer the phone; those who design radically new weapons vs. those who assemble planes. You can’t ask the same group to do both, just like you can’t ask water to be liquid and solid at the same time.
* *Tailor the tools to the phase:* Wide management spans, loose controls, and flexible (creative) metrics work best for loonshot groups. Narrow management spans, tight controls, and rigid (quantitative) metrics work best for franchise groups.
* *Watch your blind side:* Makes sure your loonshot nursery seeds both types of loonshots, especially he type you are least comfortable with. S-type loonshots are the small changes in strategy no one thinks will amount to much. P-type loonshots are technologies no one thinks will work.

**2. Create dynamic equilibrium**

* *Love your artists and soldiers equally:* Artists tend to favor artists; soldiers tend to favor soldiers. Teams and companies need both to survive and thrive. Both need to feel equally valued and appreciated. (Try to avoid calling one side “bozos” [like Steve Jobs did]).
* *Manage the transfer, not the technology:* Innovative leaders with some successes tend to appoint themselves loonshot judge and jury (the Moses Trap). Instead, create a natural process for projects to transfer from the loonshot nursery to the field, and for valuable feedback and market intelligence to cycle back from the field to the nursery. Help manage the timing of the transfer: not too early (fragile loonshots will be permanently crushed), not too late (making adjustments will be difficult). Intervene only as needed, with a gentle hand. In other words, be a gardener, not a Moses.
* *Appoint and train project champions to bridge the divide:* Soldiers will resist change and see only the warts on the baby-stage ideas from artists. Artists will expect everyone to appreciate the beautiful baby underneath. They may not have the skills to convince the soldiers to experiment and provide the feedback that is crucial for ultimate success. Identify and train bilingual specialists, fluent in both artist-speak and soldier-speak, to bridge the divide.

**3. Spread a system mindset**

* *Keep asking why:* Level 0 teams don’t analyze failures. Level 1 teams assess how product features may have failed to meet market needs (outcome mindset). Level 2 teams probe *why* the organization made the choices that it did (system mindset). They analyze *both* successes and failures because they recognize that good outcomes don’t always imply good decisions (got lucky), just as bad outcomes don’t always imply bad decisions (played the odds well). In other words, they analyze the quality of *decisions*, not just the quality of *outcomes.*
* *Keep asking how decision-making processes can be improved:* Identify key influences – people involved, data considered, analyses conducted, how choices were framed, how market or company conditions affected that framing – as well as both financial and nonfinancial incentives for individuals and for the team as a whole. Ask how those influences can be changed to enhance the decision-making process in the future.
* *Identify team with outcome mindset and help them adopt system mindset:* Analyzing a product or a market may be technically challenging, but it is a familiar and straightforward exercise. Analyzing *why* a team arrived at a decision can be both unfamiliar and uncomfortable. It requires self-awareness from team members; the self-confidence to acknowledge mistakes, especially interpersonal ones; and the candor and trust to give and receive delicate feedback. The process is likely to be more efficient, less painful, when it is mediated by a neutral expert from outside the team.

**4. Raise the magic number**

* *Reduce return-on-politics:* Make lobbying for compensation and promotion decisions difficult. Find ways to make those decisions less dependent on an employee’s manager and more independently assessed and fairly calibrated across the company.
* *Use soft equity:* Identify and apply the nonfinancial rewards that make a big difference. For example: peer recognition, intrinsic motivators.
* *Increase project-skill fit:* Invest in the people and processes that will scan for a mismatch between employees’ skills and their assigned projects, and will help managers adjust roles or employees transfer between groups. The goal is to have employees stretched neither too much nor too little by their roles.
* *Fix the middle:* Identify and fix perverse incentives, the unintended consequences of well-intentioned rewards. Pay special attention to the dangerous middle-manager levels, the weakest point in the battle between loonshots and politics. Shift away from incentives that encourage battles for promotions and toward incentives centered on outcomes. Celebrate results not rank.
* *Bring a gun to a knife fight:* Competitors in the battle for talent and loonshots may be using outmoded incentive systems. Bring in a specialist in the subtleties of the art – a chief incentives officer.
* *Fine-tune the spans:* Widen management spans in loonshot groups (but not in franchise groups) to encourage looser controls, more experiments, and peer-to-peer problem solving.

**For anyone championing a loonshot, anywhere:**

* *Mind the False Fail:* See chapter 2 for the False Fail of Friendster (social networks) and the False Fails of the statins (the spurious results in mice and in dogs). Is a negative outcome due to a flaw in the idea or the test? What would you have to believe for it to be a flaw in the test? How might you evaluate that hypothesis?
* *Listen to the Suck with Curiosity (LSC):* When you have poured your soul into a project, you will be tempted to argue with critics and dismiss whoever challenges you. You will improve your odds of success by setting aside those urges and investigating, with genuine curiosity, the underlying reasons why an investor declines, a partner walks, or a customer chooses a competitor. It’s hard to hear n one likes your baby. It’s even harder to keep asking why. (Chapter 2)
* *Adopt a system rather than an outcome mindset:* Everyone will make wrong turns in navigating the long, dark tunnel through which every loonshot travels. You will gain much more 9and feel much better) by trying to understand the *process* by which you arrived at those decisions. How did you prepare? What influenced you? How might you improve your decision-making process? (Chapter 5)
* *Keep your eyes on spirit, relationships, and time (SRT):* A final word below, which is not in the main text. It’s an added thought for anyone who makes it this far in this book.

When championing a loonshot, it’s easy to lose sight of what’s important, of why you are doing what you are doing. A little obsession can be good. Too much can backfire.

What’s helped me, on occasion, to pull back from the edge – to create a more sustainable and productive level of obsession – is stepping back to think on SRT: spirit, relationships, and time.

*Spirit*

Some people find meaning in serving a higher power. Others find it in serving their country. Still others find it in providing for their families, or spreading joy, or helping others live better, freer lives. Everyone has a mission or noble purpose. William Faulkner, for example, spoke of the noble purpose of the writer and the poet:

I believe that man will not merely endure: he will prevail. He is immortal, not because he alone among creatures has an inexhaustible voice, but because he has a soul, a spirit capable of compassion and sacrifice and endurance.

The poet’s, the writer’s, duty is to write about these things. It is his privilege to help man endure by lifting his heart, by reminding him of the courage and honor and hope and pride and compassion and pity and sacrifice which have been the glory of his past.

When diving deep into a project or career it’s easy for the head and the heart to stray to things that don’t matter. I began in the academic world, in which the noble purpose is to seek truth. I switched to the biotech world, with a mission to improve the lives of patients in need. Both worlds, like all pursuits, offer fool’s gold and true gold. Only by coming back to noble purpose could I tell the two apart.

Purpose feeds spirit, and spirit is the engine that keeps us going. It steadies us for the battles ahead.

*Relationships*

The support needed to survive the long tunnel of skepticism and uncertainty doesn’t come from things. It comes from people. Several years ago, a physician who treats the terminally ill shared an insight with me that had changed his life. In hundreds of end-of-life conversations, he said, he never once heard anyone speak about what kind of car they have in their driveway, or even what kind of driveway they have. They always spoke of family and loved ones.

At the edge of obsession, relationships are often the first to go. But they are usually our most important need. When I catch myself making that mistake, I think back to those end-of-life conversations.

*Time*

The anxiety from championing a crazy idea, challenging experts, and facing repeated rejection can spill over into mindless filling a calendar. Completing urgent, but not important, tasks creates a sense of accomplishment and control. But time is our most precious resource, just as relationships are our most precious source of joy and support.

We all juggle many balls, a wise friend named Philip Lader likes to say, but what makes all the difference is knowing which are made of rubber and which are made of glass. For me, the ones to handle with great care, to avoid dropping and losing forever, have always been spirit, relationships, and time.