

# **THE CHECKLIST MANIFESTO**

## **How to Get Things Right**

**ATUL GAWANDE**

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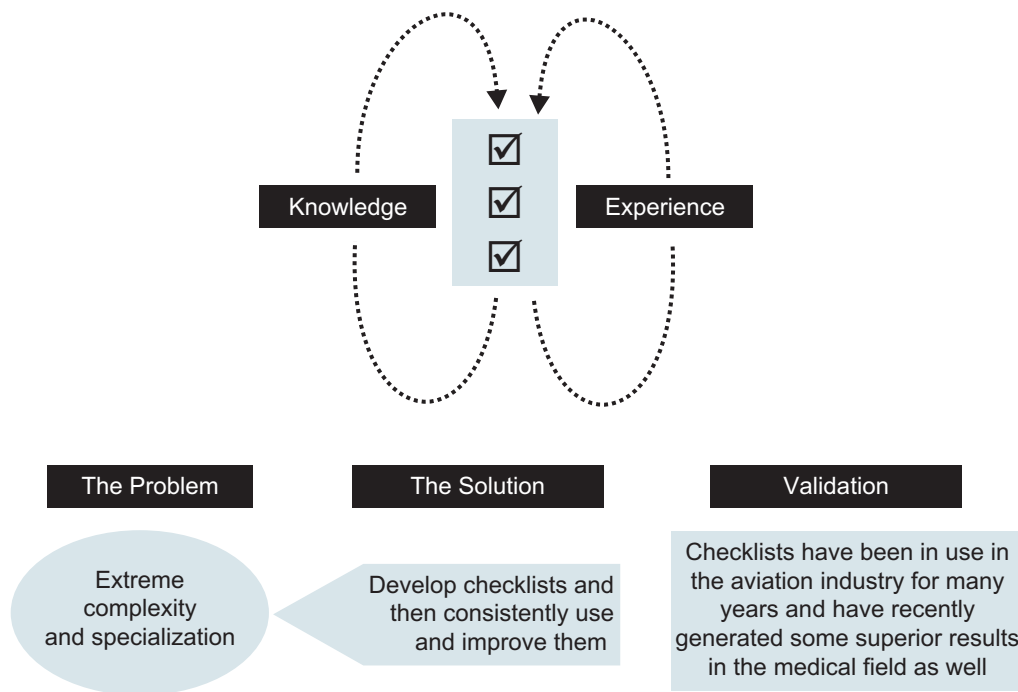
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**MAIN IDEA**

In complex situations – such as those which arise in almost every profession and industry today – the solutions to problems are technical and demanding. There are often a variety of different ways to solve a problem. It's all too easy to get so caught up dealing with all these complexities that the most obvious and common sense immediate solutions are not tried first. To overcome this problem, take a leaf from the commercial aviation industry and develop checklists people can use to make sure every base is covered quickly and concisely. Checklists are a forgotten or ignored business tool. It's time for them to come in from the cold.

*“Here, then, is our situation at the start of the twenty-first century: We have accumulated stupendous know-how. We have put it in the hands of some of the most highly trained, highly skilled, and hardworking people in our society. And with it, they have accomplished extraordinary things. Nonetheless, that know-how is often unmanageable. Avoidable failures are common and persistent, not to mention demoralizing and frustrating, across many fields – from medicine to finance, business to government. And the reason is increasingly evident: the volume and complexity of what we know has exceeded our individual ability to deliver its benefits correctly, safely, or reliably. Knowledge has both saved us and burdened us. That means we need a different strategy for overcoming failure, one that builds on experience and takes advantage of the knowledge people have but somehow also makes up for our human inadequacies. And there is such a strategy – though it will seem almost ridiculous in its simplicity, maybe even crazy to those of us who have spent years carefully developing ever more advanced skills and technologies. It is a checklist.”*

– Atul Gawande



**The Problem** . . . . . Pages 2 - 3

Modern medical care is a good example of how professional fields of expertise have developed in recent years with the coming of the information revolution. Today's medical practitioners are extremely educated and superbly experienced in their areas of expertise, but that increase in specialization is bringing about some unintended consequences. Everyone is getting so busy in their respective areas of expertise some basic and preventable patients deaths are occurring.

**The Solution** . . . . . Pages 3 - 5

Many industries today have entered what could be termed their own “B-17 phases”. Large and growing chunks of what software designers, financial managers, firefighters, police officers and doctors do are now much too complex to be carried out from memory alone. The solution is to follow commercial aviation’s lead and integrate the more systematic use of checklists into day-to-day operations.

**Validation** . . . . . Pages 6 - 8

Checklists may seem like a ridiculously simple concept in a complex world but the evidence is they work. Good checklists get the routine and obvious tasks out of your mind so you can instead focus on the hard stuff. They have been shown to work in venture capital investment just as effectively as they work in commercial aviation and medicine. Chances are they will work their magic in every industry imaginable – and will work even better in the future as everything gets progressively more complex.

The Problem

Extreme complexity and specialization

Modern medical care is a good example of how professional fields of expertise have developed in recent years with the coming of the information revolution. Today's medical practitioners are extremely educated and superbly experienced in their areas of expertise, but that increase in specialization is bringing about some unintended consequences. Everyone is getting so busy in their respective areas of expertise some basic and preventable patients deaths are occurring.

Medical care in the twenty-first century is highly impressive. Saves are made daily of patients who just a few years ago would have faced certain death. For all those achievements, however, a surprising number of patients still die due to some very basic human errors:

- Medical machinery which has not been properly serviced and therefore which is not working when it is needed in an emergency setting.
- Teams that can't get moving fast enough in order to perform a needed procedure.
- Someone somewhere along the line forgets to wash their hands and an infection takes hold with fatal consequences.

The World Health Organization has estimated there are now more than thirteen thousand different diseases, syndromes and types of injury. For nearly all of them, science has provided things that can be done to help – either by curing the disease or by reducing the harm and misery involved. The challenge is for each condition, the treatment steps are different and they are almost always complex. The average clinician has about six thousand drugs and around four thousand medical and surgical procedures to choose from. This is a lot for someone to get right, even someone who has been trained for many years.

On any given day in the United States, around ninety thousand people will be admitted to intensive care. That means over a year, some five million Americans will receive intensive care and almost everyone will get to see the inside of an intensive care unit over the course of their lifetime. According to one study, the average patient in intensive care will require 178 individual actions per day – administering a drug at the right time, turning the patients regularly to avoid bed sores, having someone bathe them and change their sheets without disturbing tubes or lines which may be inserted, etc. Every one of these actions involves risks and doctors and nurses do a remarkable job in minimizing mistakes but even an error of just one percent will mean two mistakes per day per patient are being made.

*“This is the reality of intensive care: at any point, we are as apt to harm as we are to heal. Line infections are so common they are considered a routine complication. ICUs put five million lines into patients each year, and national statistics show that after ten days 4 percent of those lines become infected. Line infections occur in eighty thousand people a year in the United States and are fatal between 5 and 28 percent of the time, depending on*

*how sick one is at the start. Those who survive line infections spend on average a week longer in intensive care. And this is just one of many risks. All in all, about half of ICU patients end up experiencing a serious complication, and once that occurs the chances of survival drop sharply.”*

– Atul Gawande

The medical profession's answer to all this increasing complexity thus far has been:

Specialization → Superspecialization

Areas of specialization have been broken down further into more narrowly focused areas of superspecialization. Clinicians train until they can do one thing better than anyone else. For example, where there were once anesthesiologists who handled pain control and patient stability during operations, today there are pediatric anesthesiologists, cardiac anesthesiologists, obstetric anesthesiologists, neurosurgical anesthesiologists and many more.

In the early twentieth century you could get a license to practice medicine if you had a high school diploma and a one-year medical degree. By the end of the twentieth century, to become a doctor you needed a college degree, a four-year medical degree and then an additional three to seven years of residency training in an individual field of practice like pediatrics, surgery, neurology and so forth. Today, even that level of preparation is inadequate. Most doctors also do fellowships which involve one to three years of additional training. Doctors typically don't start practicing independently until they are in their mid-thirties of older.

*“The result of the recent decades of ever-refined specialization has been a spectacular improvement in surgical capability and success. Where deaths were once a double-digit risk of even small operations, and prolonged recovery and disability was the norm, day surgery has become commonplace. Yet given how much surgery is now done – Americans today undergo an average of seven operations in their lifetime, with surgeons performing more than fifty million operations annually – the amount of harm remains substantial. We continue to have upwards of 150,000 deaths following surgery every year – more than three times the number of road traffic fatalities. Moreover, research has consistently showed that at least half our deaths and major complications are avoidable. The knowledge exists. But however supremely specialized and trained we may have become, steps are still missed. Mistakes are still made. Medicine, with all its dazzling success but also frequent failures, therefore poses a significant challenge: What do you do when expertise is not enough? What do you do when even the super-specialists fail?”*

– Atul Gawande

What's happening in the medical care field is also happening in one industry after another right across the entire economy. In the construction industry, for example, the traditional approach to building anything was to go out and hire a master builder who would design, engineer and then oversee construction from beginning to end. Master builders were responsible for the construction of major buildings like the Empire State Building and the United States Capitol building. By the middle of the twentieth century, however, construction went down the same road of specialization medical care has followed. First architectural and engineering design split from construction and then piece by piece each area of construction know-how got split

off into its own area of specialization. The building industry today has at least sixteen trades including architects, structural engineers, electrical engineers, mechanical engineers, ventilation engineers and so on. The entire industry has been forced to evolve in order to function effectively.

Increasing complexity has also been a problem in the aviation industry. In 1935, the U.S. Army Air Corps held a competition for airplane manufacturers who wanted to build the military's next-generation bomber. Boeing Corporation entered its Model 299 which looked like a figurative "slam dunk" – it carried five times as many bombs as the army had requested and had almost twice the range of previous bombers. On October 30, 1935, a crowd of army brass and manufacturing executives gathered to watch the 299's maiden test flight.

The plane roared down the runway, lifted off smoothly and climbed normally to three hundred feet at which point it stalled, turned on one wing and crashed to the ground in a fiery explosion killing two of its five crew members including the pilot, Major Ployer P. Hill. The army had planned to order sixty-five of the aircraft but in light of the crash, the army ordered Douglas's airplane instead – which almost sent Boeing into bankruptcy.

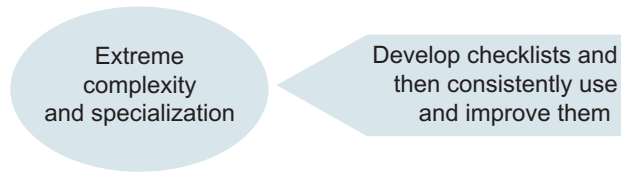
The crash investigation revealed nothing mechanical had gone wrong with the 299 and therefore was attributed to "pilot error." The report also noted flying the 299 was substantially more complex than previous aircraft. The new plane required the pilot to attend to the four engines, each with their own fuel-air mixes to be tuned, to operate the retractable landing gear, wing flaps and electric trim tabs, and to adjust the pitch of the constant-speed propellers. Major Hill had been so busy with these tasks he had neglected to release a locking mechanism on the elevator and rudder controls. As one newspaper summed it up, the Boeing Model 299 was "too much airplane for one man to fly."

The army did ultimately decide to purchase a few Model 299s from Boeing as test planes. A few pilots, who liked the look of the plane, decided to get together and figure out a way to make the 299 more user-friendly. They did not suggest more pilot training was the solution – Major Hill had been the Air Corp's chief of flight testing and it was difficult to imagine someone having more experience and expertise than him. Instead, this ad-hoc group came up with a simple approach to complexity – they created the first pilot's checklist. They decided flying this new plane was too complicated to be left to the memory of any one person, even an expert in their field.

Their checklist wasn't all that complex at first. In fact, it was simple enough and brief enough to fit on a single index card. It listed step-by-step checks to be done before takeoff, during flight and then before landing. It included all the stuff pilots already knew to do including checking the brakes were released, that instruments were set correctly, that doors and windows were closed, that the elevator controls were unlocked and so forth. However, using these simple checklists, the pilots went on to fly the Model 299 a total of 1.8 million miles without one incident.

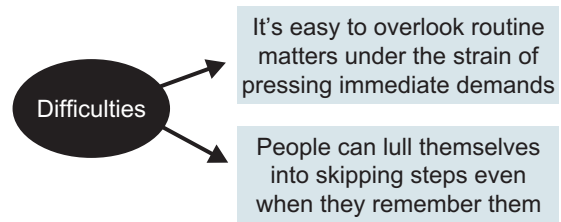
The army ultimately ordered almost thirteen thousand of Boeing's Model 299s which came to be designated as the B-17 or "Flying Fortress". As a result, the United States gained a decisive air advantage in the Second World War. The B-17 would go on to become the backbone of the Allies' devastating bombing campaign which ultimately led to the surrender of Nazi Germany. What started out as a disaster for Boeing ended up being the U.S. trump card during World War II, thanks to the fact pilots were willing to use checklists.

**The Solution**



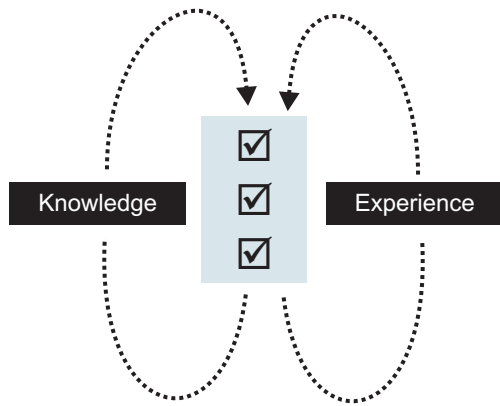
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In a complex high-pressure environment, experts always come up against two main difficulties:



- Human memory can become fallible when there are very serious and pressing events going on. When baking a cake, you might get distracted by a phone call and forget to add one key ingredient. When you've got a patient who is throwing up and a family member demanding to know what's going on, you can forget to check the patient's pulse. When you're preparing for takeoff, you can forget to remove the lock from your flight controls.
- It's similarly easy to talk yourself into skipping steps because most of the time, they won't be critical matters. You might rationalize that for the last fifty patients you saw, measuring their four vital signs didn't really matter. This works just fine until one day a problem slips through which you could have picked up on immediately if you'd just done your routine checks. (By the way, the recording of the four vital signs of a patient didn't become routine practice until the 1960s when nurses embraced the idea and redesigned their patient charts to include the data.)

Checklists provide protection against these two key difficulties. By making the minimum necessary steps explicit and verifiable, a discipline is instilled which can lead to higher levels of performance. Checklists can exist in a number of different formats – anything from forms people fill out themselves to medication timing charts, written care plans for each patient and so forth. Similarly, items on a checklist can be READ-AND-DO (where you read the item and then go do what's specified) or CHECK-ONCE-DONE (where you confirm you've carried out the action specified.) The way checklists can be put together is unlimited and therefore checklists can be developed and then applied to any and all situations.



So why do checklists work? In a nutshell, checklists ensure people are applying all the knowledge and expertise they have consistently well. Furthermore, checklists start a self-sustaining virtuous cycle. The more checklists get developed and used the better they become.

Most people assume checklists only work in routine and repetitive situations like preparing to takeoff in an airplane but that's not always the case. Consider the example of what happened when Hurricane Katrina hit New Orleans on August 29, 2005. Within a matter of just a few hours, the city's telephone lines, cell towers and electrical power went out – making communication difficult. At much the same time, the levees protecting the city were breached.

A lone agent of FEMA (Federal Emergency Management Agency) managed to get a helicopter ride over New Orleans that afternoon and reported seeing widespread flooding, hundreds of people stranded on rooftops and bodies floating in the water. He filed an urgent report by e-mail because all other means of communication had been lost. The only problem with that was FEMA's top official didn't use e-mail and therefore FEMA didn't even know there was an emergency until TV pictures of the disaster were broadcast the following day. By then, 80 percent of the city was flooded, forty thousand refugees were stranded at the New Orleans Superdome and Convention Center, five thousand people were stranded on an overpass on Interstate 10, hospitals were without power and widespread looting had broken out as people became desperate for food and water. For days, the federal government, the state government and the local government then debated who should respond while the situation on the ground steadily deteriorated.

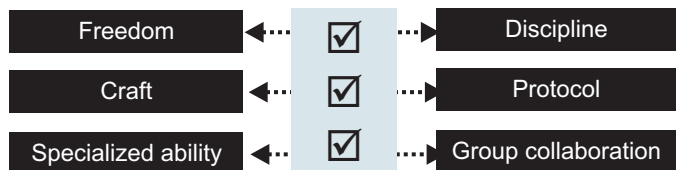
By contrast, Wal-Mart had 126 stores in the New Orleans region closed due to damage and power outages. CEO Lee Scott told everyone, "This company will respond to the level of this disaster. A lot of you are going to have to make decisions above your level. Make the best decision that you can with the information that's available to you at the time, and above all, do the right thing." Within forty-eight hours, twenty thousand Wal-Mart employees and their family members were accounted for and the company's priority shifted to figuring out what could be done to help the people of New Orleans.

Acting solely on their own authority, Wal-Mart's store managers started distributing diapers, water, baby formula and ice to residents affected by the flood. First responders from FEMA were provided with food, sleeping bags, toiletries and rescue equipment even though there was no formal requisition process in place. Instead, a crude paper-slip record system was used to keep track of these supplies.

The assistant manager of one Wal-Mart which had been engulfed by a thirty-foot surge of water ran a bulldozer through the side of the building, loaded it with as much stuff as she could salvage and gave the items away in the parking lot. When the local hospital told her it was running short of drugs, that same assistant manager broke into the store's pharmacy – and was later lauded by upper management for taking the initiative. Wal-Mart set up an emergency response team (which even included a member of the Red Cross) and within two days had tractor trailers loaded with food, water and emergency equipment rolling into New Orleans. Employees set up temporary mobile pharmacies which provided evacuees with free medications. Wal-Mart even managed to supply the National Guard with food and water a day before the federal government could respond. By the end, Wal-Mart would send into New Orleans 2,498 trailer loads of emergency supplies and donate more than \$3.5 million in merchandise to area shelters and command centers.

The moral of this story isn't the suggestion the private sector is better than the public sector in handling complex, emergency situations. Lots of major New Orleans businesses were shown to be inadequately prepared for such an eventuality and the local police and firefighters did an incredible job in serving their communities at a time of great need. The real lesson was that under conditions of true complexity, a centralized command-and-control decision chain doesn't work all that well. Instead, you'll get better results by codifying what needs to happen into a simple checklist and then giving people the freedom to act and adapt using their best judgment while at the same time meeting specified expectations.

Put another way, checklists work well in complex situations because they hit a balance between what usually seem to be conflicting virtues:



Checklists help people achieve a balance between these virtues by supplying a set of checks to ensure the basic, critical stuff is not overlooked while at the same time ensuring people talk and coordinate together around common, shared aims.

*"Under conditions of complexity, not only are checklists a help, they are required for success. There must always be room for judgment, but judgment aided – and even enhanced – by procedure."*

– Atul Gawande

A good example of how checklists can pop up in unusual places with great effect is the story of rock band Van Halen. They were one of the first big name bands to take huge roadshow productions into third-level markets. Whereas the usual stage shows would turn up at a venue with two or three eighteen-wheelers of stage equipment, Van Halen would roll into town with nine eighteen-wheelers packed full of gear. With that much equipment, there was always a worry the stage flooring wouldn't be strong enough or well enough reinforced to take all the extra weight.

To avoid problems, the Van Halen management team would have a contract with concert promoters which was huge – described by some as being like a version of the Chinese Yellow Pages. Buried in that contract was Clause 126 which specified a bowl of M&Ms was to be placed backstage which contained no brown M&Ms. If the brown M&Ms were not removed, the show would be cancelled but full compensation would be paid to the band.

Although at first glance this would appear to be another insane demand of power-mad celebrities, it was actually a checklist item to ensure the promoters had fully understood and complied with the technical requirements of staging the show.

*“When I would walk backstage, if I saw a brown M&M in that bowl, well we’d line-check the entire production. Guaranteed you’re going to arrive at a technical error. Guaranteed you’d run into a problem.”*

– David Lee Roth

One time Van Halen had to cancel a show in Colorado because brown M&Ms alerted them to the fact their staging would have fallen through the arena floor. Other times they found access doors were too small and so forth. By integrating a simple but bizarre sounding checklist item into their performance contracts in this way, the band’s management team were able to tell which promoters had been thorough and which were trying to cut corners.

The other good thing about checklists is they can be used to coordinate the activities of diverse teams quickly and concisely. Take the construction of a skyscraper, for example.

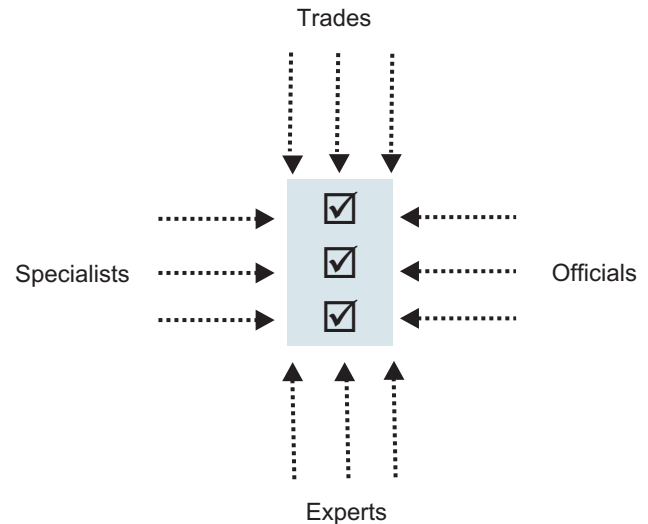
*“In designing a building, experts must take into account a disconcertingly vast range of factors: the makeup of the local soil, the desired height of the individual structure, the strength of the materials available, and the geometry, to name just a few. Then, to turn the paper plans into reality, they presumably face equally byzantine difficulties making sure that all the different tradesmen and machinery do their job the right way, in the right sequence, while also maintaining the flexibility to adjust for unexpected difficulties and changes. Yet builders clearly succeed. They safely put up millions of building all over the globe. And they do so despite the fact that construction work has grown infinitely more complex over the decades. Moreover, they do it with a front-line workforce that regards each particular job – from pile-driving to wiring intensive-care units – much the way doctors, teachers, and other professionals regard their jobs; as specialized domains in which others should not interfere.”*

– Atul Gawande

To keep a construction project organized, a construction schedule is developed which is in essence a very long and highly detailed sequential checklist of tasks to be done. This will be loaded into a computer scheduling package which usually then adds color coding such as making red items the critical steps which need to be completed before other items can be done. Materials delivery schedules and more detailed checklists for the various tradespeople can then be generated from the overall schedule. Subcontractors and other independent experts can then carry out day-by-day checks to verify that everything has been correctly done and to a proper standard of finish.

So what happens when things don’t go to plan or when problems crop up? Well, in simple terms, people from the various trades involved talk with other and figure things out. On most building projects, a schedule will be run alongside the construction time

line proper which details the variances which have cropped up and who will talk to whom by when. Everyone gets together, reviews the possible options for moving forward, make a decision, readjust the construction schedule to allow for what needs to be done and then everyone signs off on what has been done.



In practical terms, the major advance in the construction industry in recent times has been its perfection of tracking checklist items and communication. On most major building projects today, workers can e-mail digital photos of problems which arise to project managers who then forward them on to the main contractors and anyone else who might potentially be required to sign off on the fix. Complexity is reduced by having everyone talk things through as a group, with each trade bringing their specialized knowledge to bear on unexpected problems. Once everyone agrees on the best way forward, the solution is then applied and construction moves forward.

*“The construction industry’s checklist process has clearly not been foolproof at catching problems. Nonetheless, its record of success has been astonishing. In the United States, we have nearly five million commercial buildings, almost one hundred million low-rise homes, and eight million or so high-rise residences. We add somewhere around seventy thousand new commercial buildings, and one million new homes each year. But ‘building failure’ – defined as partial or full collapse of a functioning structure – is exceedingly rare, especially for skyscrapers. According to a 2003 Ohio State University study, the United States experiences an average of just twenty serious ‘building failures’ per year. That’s an annual avoidable failure rate of less than 0.00002 percent. The checklists work.”*

– Atul Gawande

*“It’s unnerving to think we allow buildings to go up in the midst of our major cities, with thousands of people inside and tens of thousands more living and working nearby. Doing so seems risky and unwise. But we allow it based on trust in the ability of experts to manage the complexities. They in turn know better than to rely on their individual abilities to get everything right. They trust instead in one set of checklists to make sure simple steps are not missed or skipped and in another to make sure that everyone talks through and resolves all the hard and unexpected problems.”*

– Atul Gawande

Validation

Checklists have been in use in the aviation industry for many years and have recently generated some superior results in the medical field as well

Checklists may seem like a ridiculously simple concept in a complex world but the evidence is they work. Good checklists get the routine and obvious tasks out of your mind so you can instead focus on the hard stuff. They have been shown to work in venture capital investment just as effectively as they work in commercial aviation and medicine. Chances are they will work their magic in every industry imaginable – and will work even better in the future as everything gets progressively more complex.

*“We don’t like checklists. They can be painstaking. They’re not much fun. But I don’t think the issue here is mere laziness. There’s something deeper, more visceral going on when people walk away not only from saving lives but from making money. It somehow feels beneath us to use a checklist, an embarrassment. It runs counter to deeply held beliefs about how the truly great among us – those we aspire to be – handle situations of high stakes and complexity. The truly great are daring. They improvise. They do not have protocols and checklists. Maybe our idea of heroism needs updating.”*

– Atul Gawande

In 2001, Peter Pronovost, a critical care specialist at John Hopkins Hospital, became frustrated about the incidence of central line infections in intensive care. He came up with a simple checklist of the steps which had to be taken to avoid infections:

- Wash hands with soap before treating the patient
- Clean the patient’s skin with chlorohexidine antiseptic
- Put sterile drapes over the entire patient
- Wear a surgical mask, hat, sterile gown and gloves while carrying out the line insertion
- Put a sterile dressing over the insertion site once the line is in

As simple as these steps sound, the nurses in the ICU noticed about a third of the time, doctors were in such a hurry they skipped a step or two. Armed with this information, Pronovost persuaded the John Hopkins Hospital administration to authorize nurses to stop doctors from putting in a central line if they saw them skip a step on this checklist. Nurses were also encouraged to ask doctors each day whether any of the patient’s lines should be removed so as not to leave them in any longer than was absolutely necessary.

For about a year afterward, Pronovost and his colleagues monitored the results of their experiment and they were astonished by what they found. Within John Hopkins, the ten-day line infection rate went from 11 percent to zero. In fact, only two line infections were recorded in the entire hospital for the next fifteen months. They calculated that in this hospital alone, this simple checklist had prevented forty-three infections, prevented eight deaths and saved two million dollars in costs over a fifteen month period.

Buoyed by that success, Dr. Pronovost started developing more and more checklists for ICUs with equally impressive results. One simple checklist was aimed at ensuring patients were observed for pain every four hours and provided with timely pain medication if required. This reduced from 41 percent to 3 percent the likelihood the patient would endure untreated pain. Another checklist for mechanical ventilators saw twenty-one fewer patients die than in previous years. Within a short period, Pronovost was widely being described as a “genius” and “inspiring” by his colleagues because he had come up with the idea of integrating a to-do list or a checklist into everyone’s ICU daily routine.

Yet, despite the stellar results Pronovost had achieved, when he started traveling around the country to show his checklists to doctors, nurses, insurers and hospital administrators, very few showed any interest in adopting the idea. Physicians were offended by the idea of using a checklist in their work. Others thought the idea wouldn’t work in the typical understaffed and overworked environment of most ICUs where nurses and doctors are in short supply. The idea of filling out yet another piece of paper just sounded like more trouble than it was worth.

Finally in 2003, the Michigan Health and Hospital Administration approached Pronovost about testing his central line checklist throughout the state’s ICUs. Blue Cross Blue Shield of Michigan agreed to give hospitals a small bonus payout if they participated in the program which came to be called the “Keystone Initiative.” Each hospital assigned a project manager and a senior hospital executive to run the program. They also persuaded Arrow International, one of the largest manufacturers of central lines, to produce a new central line kit which had surgical drapes and the antiseptic soap included in the kit.

*“In December 2006, the Keystone Initiative published its findings in a landmark article in the New England Journal of Medicine. Within the first three months of the project, the central line infection rate in Michigan’s ICUs decreased by 66 percent. Most ICUs cut their quarterly infection rate to zero. Michigan’s infection rates fell so low that its average ICU outperformed 90 percent of ICUs nationwide. In the Keystone Initiative’s first eighteen months, the hospitals saved an estimated \$175 million in costs and more than fifteen hundred lives. The successes have been sustained for several years now – all because of a stupid checklist.”*

– Atul Gawande

For real expertise in the power of checklists, however, the poster child for their effectiveness is still the commercial aviation industry. Today’s generation of commercial pilots carry handbooks which are made up of hundreds and hundreds of checklists. They include “normal” checklists for everyday aircraft operations and “non-normal” checklists which cover every conceivable emergency situation a pilot might run into during his or her career. There are literally hundreds of checklists in every pilot’s handbook they hope they will never get to use.

Developing new pilot's checklists has been refined to an art form by Boeing and other airplane manufacturers. On January 17, 2008, as British Airways Flight 38 (a Boeing 777) was approaching London after an eleven hour flight from Beijing, both engines lost power at 720 feet about two miles from the airport. The plane came down about a quarter mile short of the runway, narrowly missing crashing into the roofs of nearby homes and cars driving along a perimeter road around the airport. (It would later turn out by coincidence one of the cars which just avoided getting hit by the crippled 777 was carrying British prime minister Gordon Brown who was just about to fly to China on his first official visit. The 777 missed the prime minister's car by a matter of yards.) As the 777 hit the ground, the nose wheels collapsed and the right main landing gear was torn off and penetrated into the passenger compartment. More than fourteen hundred liters of jet fuel came pouring out but fortunately did not ignite and the 152 passengers and crew managed to deplane with the worst injury being nothing more serious than a broken leg.

Air accident investigators swarmed over the plane to try and determine what had caused the accident. They removed the engines, the fuel system and took the plane apart piece by piece. They found no engine defects, no fuel line blockages, no debris in the fuel tanks, no problems with valves or fuel delivery systems whatsoever. Tests on the fuel also turned up no anomalies or obvious issues either. Finally, after months of looking at the data, they came up with a theory the plane's flight path might have played a role.

*"They proposed an elaborate theory. Jet fuel normally has a minor amount of water moisture in it, less than two drops per gallon. During cold-air flights, the moisture routinely freezes and floats in the fuel as a suspension of tiny ice crystals. This had never been considered a significant problem. But maybe on a long, very smooth polar flight – as this one was – the fuel flow becomes so slow that the crystals have time to sediment and perhaps accumulate somewhere in the fuel tank. Then, during a brief burst of acceleration, such as on the final approach, the sudden increase in fuel flow might release the accumulation, causing blockage of the fuel lines."*

– Atul Gawande

Although this explanation seemed like it was clutching at straws, eight months after the accident that was all the investigators had to go on. They suggested some midflight maneuvers to avoid the problem. Whenever an engine loses power, the pilot's first instinct is to try and rev it more to increase thrust. If ice crystals are in the fuel line, revving the engine will only make matters worse. The investigators determined that if instead the pilots would idle the engine momentarily, fuel flow would be reduced and the airplane's inbuilt heat exchanger would melt the ice in a matter of seconds allowing the engines to recover.

As impressive as the investigative work of those inspectors had been, what happened next was even more awe inspiring. In September 2008, the Federal Aviation Administration issued a detailed advisory about the new procedures pilots should follow to keep ice from accumulating on polar flights and how to recover if icing caused engine failure. They mandated that pilots should learn about these findings and incorporate them into their flight procedures within thirty days. Within two weeks, Boeing had broken the advisory down into modifications to the standard checklists pilots use for polar flights and forwarded these updated checklists (which had been tested extensively in Boeing's flight simulator) to every operator of a Boeing 777 anywhere in the world.

All the various airlines picked up on Boeing's checklist update almost immediately. Some airlines made slight modifications to fit with their existing standard operating procedures while others just adopted the updated Boeing checklists as they stood. Consequently, all airlines had adopted the newly mandated flight procedures well within thirty days. This highly impressive feat was feasible because of the availability of checklists which broke everything down into actionable steps.

*"How this happened – it involved a checklist, of course – is instructive. But first think about what happens in most lines of professional work when a major failure occurs. To begin with, we rarely investigate our failures. Not in medicine, not in teaching, not in the legal profession, not in the financial world, not in virtually any other kind of work where mistakes do not turn up on cable news. A single type of error can affect thousands, but because it usually touches only one person at a time, we tend not to search as hard for explanations. Sometimes, though, failures are investigated. We learn better ways of doing things. And then what happens? Well, the findings might turn up in a course or a seminar, or they might make it into a professional journal or a textbook. In ideal circumstances, we issue some inch-thick set of guidelines or a declaration of standards. But getting the word out is far from assured, and incorporating the changes often takes years."*

– Atul Gawande

The validation of Boeing's new checklists for the 777 came on November 26, 2008 when a Delta Air Lines flight from Shanghai to Atlanta with 247 people on board suffered engine failure due to ice blocking the fuel line over the mountains of Montana. The pilot and copilot got out their checklists and managed to restore engine power without the passengers even noticing anything was amiss. Later investigation showed ice build up in the fuel lines was the cause and Boeing responded by making mechanical changes to the 777 fuel system which would stop the problem from arising again.

*"It is common to misconceive how checklists function in complex lines of work. They are not comprehensive how-to guides, whether for building a skyscraper or getting a plane out of trouble. They are quick and simple tools aimed to buttress the skills of expert professionals. And by remaining swift and usable and resolutely modest, they are saving thousands upon thousands of lives."*

– Atul Gawande

Checklists may sound well and fine for commercial aviation and medicine but business is much too complex for checklists to be viable – right? Well, consider the world of finance where investors are constantly under pressure to buy stock in the next big thing before it actually becomes successful. This is the challenge which faces "value investors" who are not trying to time the market or coattail any speculative bubble which may be brewing in the markets. These investors are simply trying to buy shares in under recognized, undervalued companies and to stay invested for the long run.

The problem is when you're trying to buy shares in a company, it becomes all too easy to go into a mental "greed mode." You start focusing on all the money you're going to make rather than doing the systematic analysis which is really required. It's much more fun to be thinking about the Ferrari you'll buy with your profit than it is to pore over the footnotes of financial reports, to go through a dry analysis of liabilities and risks or to analyze a report on the future prospects of the industry in which the company operates.



Even the world's most successful value investors, Berkshire Hathaway's Warren Buffett and his longtime investment partner Charles Munger, still make mistakes when investing so this isn't an exact science. However, some investors are now starting to improve their performance by developing checklists of things that should be checked before an investment is made. A pre-investment checklist is great because it forces you to be dispassionate and systematic rather than getting carried away in the heat and enthusiasm of the moment.

What kind of items would get included in an investment checklist? One investor has developed his checklist by analyzing every investment Warren Buffett has ever made. His checklist includes these kinds of items:

- Have you analyzed the company's financial statements for the past ten years?
- Have you investigated all the company's liabilities and risks?
- Have you examined the track record of the management team?
- Have you looked at the company's competitors?
- Have you considered the future of the market this company is in?
- Have you looked at whether any insiders are selling their shares in the company?
- Have you read all the footnotes to the company's financial and cash flow statements?
- Have you analyzed whether cash flow and costs match the reported revenue growth?

By using these checklists, savvy investors have found they are able to approach their investment activities far more efficiently and ultimately far more successfully. The checklist approach to investing has enabled them to achieve stellar results.

*"What makes these investors' experiences striking to me is not merely their evidence that checklists might work as well in finance as they do in medicine. It's that here, too, they have found takers slow to come. In the money business, everyone looks for an edge. If someone is doing well, people pounce like starved hyenas to find out how. Almost every idea for making even slightly more money – investing in Internet companies, buying tranches of sliced-up mortgages, whatever – gets sucked up by the giant maw almost immediately. Every idea, that is, except one: checklists."*

– Atul Gawande

In January 2007, the World Health Organization convened a two-day meeting at its headquarters in Geneva, Switzerland to consider how to reduce complications from the more than 230 million major operations which get carried out worldwide every year. Rather than publish an official WHO set of official standards for safe surgical care, it was decided that a safe surgical checklist should be developed. After a few years of fine-tuning, a nineteen point surgery checklist was agreed upon:

- *Seven checks before anesthesia* – confirming the patient's identity, consent, marking of the surgical site, checking for allergies and that equipment and blood is available.
- *Seven checks after anesthesia and before incision* – checking all team members know everyone else, that they have the correct patient and procedure, that antibiotics have been given, that radiology images are displayed and everyone knows what will be happening during the operation.
- *Five final checks before the patient is taken from the room* – whether all sponges and instruments have been accounted for, plans and concerns for the patient's recovery, etc.

This safe surgery checklist was then trailed in eight hospitals around the world starting in spring 2008. The results which came out of this pilot study were released in October 2008 and made for stunning reading:

- Major complications from surgery in all eight hospitals fell by 36 percent after the introduction of the checklist.
- Deaths fell by 47 percent from 435 to just 277.
- Infections fell by almost a half.

When the results of the study were published in the January 2009 issue of the *New England Journal of Medicine*, that set off a flurry of interest. More than a dozen countries publicly committed to implementing versions of the safe surgery checklist in their hospitals. Yet by the end of 2009, only about 10 percent of all American hospitals have adopted the checklist or taken steps to implement it. The ongoing resistance to adopting what is after all a ten-minute checklist which has been proven to save lives is proof of how hard it is for some professions to accept that using a checklist makes sense.

*"We have the means to make some of the most complex and dangerous work we do – in surgery, emergency care, ICU medicine, and beyond – more effective than we ever thought possible. But the prospect pushes against the traditional culture of medicine, with its central belief that in situations of high risk and complexity what you want is a kind of expert audacity – the right stuff. Checklists and standard operating procedures feel like exactly the opposite, and that's what rankles many people. It's ludicrous, though, to suppose that checklists are going to do away with the need for courage, wits and improvisation. The work of medicine is too intricate and individual for that: good clinicians will not be able to dispense with expert audacity. Yet we should be prepared to accept the virtues of regimentation."*

– Atul Gawande

*"We have an opportunity before us, not just in medicine but in virtually any endeavor. Even the most expert among us can gain from searching out the patterns of mistakes and failures and putting a few checks in place. But will we do it? Are we ready to grab onto the idea? It is far from clear."*

– Atul Gawande