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Title:

VASA AND PROJECT MANAGEMENT

Abstract:

In Stockholm, there is an ancient ship called the Vasa which sank in 1628 on its maiden voyage. It was one of the costliest projects of its time. But what does this ship have to do with project management and execution? Many studies have tried to show that its failure was due to project management problems. But in reality, it was more fundamental than that. The failure was due to engineering design deficiencies. This article describes how this came about and what lessons learned can be applied to projects to ensure that all engineering designs will work as intended.

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Vasa and Project Management

Introduction

In Stockholm, there is an ancient ship called the Vasa which sank in 1628 on its maiden voyage. The Vasa was one of the costliest projects of its time. It was an impressively ornate warship, decorated with hundreds of gilded and painted carvings depicting mythical, biblical and historic themes. No cost was spared in building the Vasa as this warship was destined to be the flagship of the powerful Swedish navy that ruled the Baltic Seas. Tragically on that fateful day and travelling a mere 1,400 yds. from its docks, this magnificent ship capsized and sank to a depth of 100 ft. and killing over 50 crew members. This occurred in front of thousands of shocked spectators and dignitaries, horrified to see such an unexpected disaster.

For over four centuries the Vasa rested on the ocean floor until it was re-discovered in 1950 just outside the city limits in the harbor bay. With the aid of modern technology, it was salvaged and then preserved in 1961. Despite being submerged for centuries, the ship survived miraculously intact because the cold, oxygen-poor, brackish water of the Baltic Sea was free of the destructive shipworm. Normally shipworm found in warmer and saltier seas would have eaten away the submerged wood. [1] It was very fortuitous that the Vasa survived. The Swedes are so proud of this warship that they built a museum totally dedicated to it. You can see this amazing ship at the Vasa Museum in Stockholm. It has become Sweden's most treasured tourist attraction with well over 40 million visitors to date.

But what does this ship have to do with project management and execution? Surprisingly, quite a lot as any experienced project manager will be amazed to see the similarities between the problems occurring in its design and construction centuries ago and how these issues continue to be relevant in the engineering and management of our projects today. Many case studies [2][5] have been conducted to speculate what caused the Vasa to sink. There is even a term called "the Vasa syndrome which describes a condition where human problems of project execution, communication and management cause projects to founder and fail." [1] The cause, however, was more basic than that. This article will show the real reasons why the Vasa sank and what lessons learned project management can benefit from.

The Vasa Story

The Vasa was commissioned in 1625 by King Gustavus Adolphus to be built as the flagship of his royal naval fleet. Sweden was at war with Poland, and the Vasa was to be the first of a series of five ships needed for its war effort. It was to be the most powerful and ornate warship of its time. Vasa was a major undertaking for Sweden and the project consumed a significant amount of the country's wealth and resources. No expense was spared. The Vasa was said to have cost more than 200,000 Rex dollars, or a little more than 5% of Sweden's gross national product (GNP) at that time. [5] Putting this cost into context in today's dollars, the GNP of Sweden in

2016 was $495 billion dollars, and 5% of this would be almost $25 billion! That was quite a significant amount spent on just one warship.

A contract was signed in 1625 with Henrik Hybertsson, a Dutch master shipbuilder, to build four ships – two large ones with a keel length of 135 ft. and two smaller ones with 108 ft. keels, to be built over a four year timeframe. Later that year, misfortune struck and the Swedish navy lost ten ships in a vicious storm in the Bay of Riga. This was a major setback for the King and he had no choice but to hurry the construction of the two smaller ships first as they were urgently needed to replace the lost ships. He insisted that the 108 ft. keels be extended to 120 ft. for two mid-sized ships. This presented a problem for the shipbuilders as the timber for the keels had already been cut for one small ship and one large ship. The King decided that one large ship be built with a 135 ft. keel. This became the Vasa.

Warships at that time typically had an armament of 30-36 cannons on a single gun deck. However, the King wanted 60 cannons to be installed on the Vasa, comprising of a mixture of the standard 12 lbs. cannons along with the newer more powerful 24 lbs. cannons. A single gun deck could not accommodate so many cannons on just one level. Hence, a second gun deck was needed, and it was initially designed to have the lighter 12 lbs. cannons fitted on the upper gun deck and the heavier cannons on the lower gun deck. Later on to achieve even greater firepower, the King insisted that 24 lbs. cannons be installed on both gun deck levels. This was done even though the gun ports for the upper deck were initially sized for the smaller 12 lbs. cannons. [5] This presented more problems for the shipbuilders as they had never built a two gun deck ship.

The only two gun deck warship in existence at that time was the Galion de Guisse which was built for the French navy in 1620 by other Dutch shipwrights in Amsterdam. This warship was the flagship for the French navy, and it ruled the Mediterranean Sea. [7] It was extremely doubtful that any of its design and construction details of the Galion de Guisse were ever shared by the Amsterdam shipwrights with Hybertsson for the design of the Vasa. It would be akin to giving away trade secrets to competing countries. The Swedish shipbuilders did the best they could.

In the summer of 1628 when the vessel hull and decks were completed, Admiral Claus Fleming, the King's representative, with the assistance of Captain Sofring Hansson conducted a stability test on the Vasa. Strangely, the shipbuilders were not advised, nor were they invited to attend and witness this test. The ballast had been installed. The cannons were not yet delivered and they were still working on the ship's elaborate and heavy wooden carvings and ornamentation. During this test, 30 seamen ran back and forth from one side of the ship to the other. The ship was so unstable, it rolled very easily from side to side. They had to stop this testing immediately for fear that the ship would capsize. The captain's first mate noted that "the bottom of the ship lacked enough belly", meaning that the ship's hull was not wide enough for the height of the ship. There was no question that the Vasa failed its stability test. Admiral Fleming did not appear too worried when he replied "the shipbuilders have built ships before". [5] No one bothered to tell the King of this failure. Perhaps they all hoped that this instability problem would resolve itself once the ship was completed and fully loaded. Nothing further was done to address this failed test.

The Sinking of Vasa (Figure 1)

FIGURE 1 – EXHIBIT AT VASA MUSEUM

There is an exhibit at the Vasa Museum which shows an exact replica of the Vasa just prior to its infamous sinking. The ship had 48 large 24 lbs. cannons - 24 on the lower gun deck, 22 on the upper gun deck, and one cannon each at its bow and stern. This was lower than the initial 60 cannons wanted by the King due to delivery problems from the foundry.

The Vasa is shown heeling to port under a slight breeze from the right. Only four of its ten sails were unfurled. The ship was already sitting fairly low to the waterline and the cannon port holes were opened as it was intended to fire a full cannon salute when the ship left the harbour. The ship was so unstable that even with the light breeze, it tipped over so quickly that the captain could not release the sails or close the open cannon port holes in time. The water rushed in through the open port holes on the lower gun-deck and flooded the ship.

The Inquiry To Find Fault

On August 24, 1628, King Adolphus was advised that his prized Vasa had sunk. He was furious! "Heads will roll!" An inquiry was set up by the Swedish Privy Council to find out why, but it was more like an inquest to find who was at fault. Captain Hansson was immediately thrown into jail. Were the crew members sober? Yes, they were. Was there enough ballast? Yes, the ship's hold was completely full of ballast and it couldn't take any more. Were the cannons secured properly? Yes, they were all secured in their assigned locations. Did Captain Hansson know how to sail the ship competently? [5] Yes, he did. As a matter of fact, he already knew the ship was so unstable that he had his crew manually lower only four of the ten sails in the light breeze during its maiden voyage. Yet this was enough to cause the ship to heel over easily and sink when the water rushed in through the open cannon port holes on the lower gun deck.

Every one of his crew were questioned and they confirmed what their captain had said. His first mate testified what had happened during the ship's stability test. They could not be blamed, so the shipbuilders were questioned. Why was the ship built to be so unstable? It was apparent to many who saw the Vasa, that its hull or "belly" was not wide enough to keep it stably afloat. [5]

They would have blamed the master shipwright, Henryk Hybertsson, if he were alive. So maybe it was fortunate for him that he had died a year earlier and he couldn't be held accountable. Hybertsson never saw the completion of the Vasa as he fell ill in late 1625. By mid-1626, he could no longer continue the work and his assistant, Hein Jacobsson, took over to complete the task of building the Vasa. Hybertsson died in the spring of 1627. At the inquiry, Jacobsson answered that the Vasa was built exactly in accordance with the King's specification and contract for a warship with a 135 ft. keel length and a 34 ft. wide hull. In fact, he stated that the hull width was even increased by 1 ft. 5 in. when a second gun level was needed to accommodate all the large and heavy 24 lbs. cannons dictated by the King. It was difficult to blame any one individual or group as the total responsibility for building the Vasa was not well defined.

Everyone ended up blaming someone else and no one accepted any responsibility for any part of Vasa's sinking. "So, whose fault is it then?" the court asked. The shipbuilders answered, "Only God knows." [5] No one took responsibility for the failure and no one had any answers why the Vasa sank. No one accepted blame. No one was found guilty and punished. Since no one dared to assign any blame on the King, the conclusion made by the Naval Court of Inquiry was that it was an "act of God". Ultimately, King Adolphus suffered the indignity of this great humiliation and financial loss for his country. So the story goes.

The Historical Context of Shipbuilding and Naval Warfare

Ships built back in those early days depended a lot on the shipbuilder's expertise and experience. No scientific theory on vessel design or stability was available. It relied heavily on empirical data – meaning it was based on the experience and data from ship designs that had been built to date, and what worked well or not. There were no set calculations or drawings that set the design parameters. Most of the design requirements were kept in the head of the master shipwright and executed based on his accumulated knowledge and experience. Such knowledge and expertise was not shared willingly with others. The shipwright made no mathematical calculations, for example, to determine important factors such as a ship's center of gravity, its center of displacement volume (ie., buoyancy), its form or its weight stability. There were no schematics or engineering drawings. Instead, a ship's "reckoning" was used based on ships already designed by the shipwright. It contained sketches of the ship's main dimensions, its principal construction details, and other related facts. [5] Vasa was initially intended to be a single gun deck galleon and it wouldn't have sank if it had been built as such.

The Ship's Center of Gravity

It was common for 17th century warships to be built with intentionally high superstructures to be used as firing platforms and boarding by soldiers in naval combat. This affected the ship's center of gravity. Since the methods to calculate the center of gravity were not known, ballast was simply added to weigh the ship down until its center of gravity was below the water line and the ship was seen to be stable with the ability to right itself. The size of the cavity at the bottom of the ship's hull stored this ballast which consisted of large tightly packed stones. The size of this compartment along with the amount of ballast to be held was estimated by the shipwright's experience. Vasa could carry 120 tons of ballast, but this was not enough to counter its considerable weight of the ship's structure above the water line.

There is also a direct correlation between the ship's center of gravity and its buoyancy. The concept of buoyancy was also done empirically – the wider the ship's hull, the greater the buoyant force to keep the ship afloat. This meant that more ballast could be added to lower the ship's center of gravity without actually lowering the ship. This was not possible with the Vasa as its hull was too narrow and the cannon port holes on the lower gun deck were already sitting very close to the water line. If more ballast were added to other storage areas to achieve stability, the extra weight would have lowered the Vasa to the point where the entire lower gun deck would be below the water line.

Analysis of the Ship (Figure 2)

Because the Vasa was salvaged fully intact, this provided exact details as to how the ship was built. Laser technology was used to measure every single piece of wood in the ship. The measurements are reflected in an exhibit at the Vasa Museum as illustrated in Figure 2:

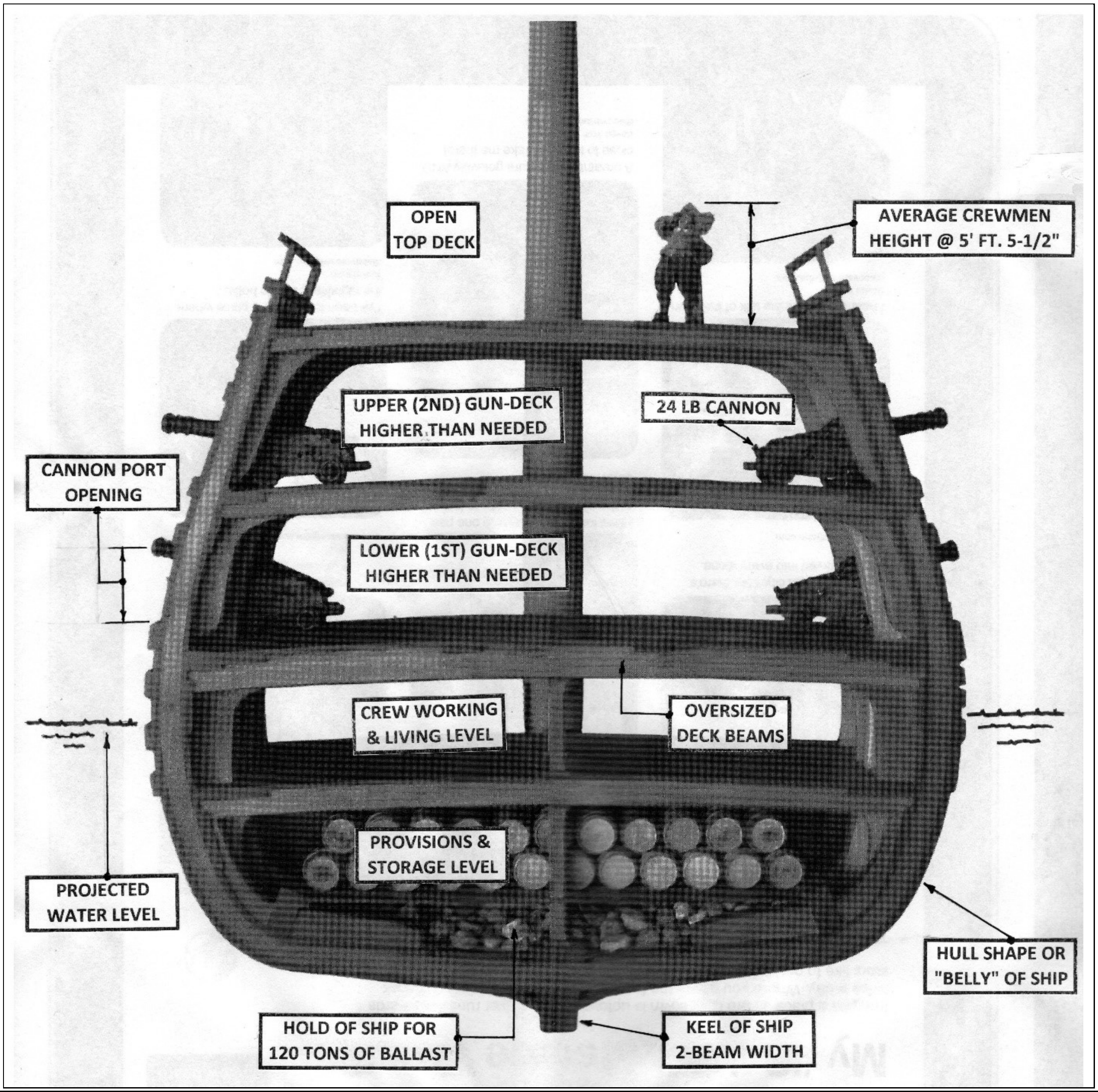

FIGURE 2 - CROSS-SECTION OF THE VASA

- The ship was already sitting low on the water line very close to the cannon port hole openings on the lower gun deck level. Modern calculations confirmed that the ship was so unstable that it would have heeled over at a list of only 10 degrees and that it would not have withstood a light breeze of only 4 knots (about 4.5 mph). [2]

- The compartment for the ballast was completely filled, yet more ballast was needed. Modern calculations have indicated that another 120 tons of ballast was needed to keep the ship stable. The extra ballast could have been added to the bottom deck level where the ship and crew's provisions were to be stored. But doing so would weigh the ship down and put the lower gun deck level below the water line.

- There was much more of the ship's structure above the water line than the portion sitting below the water level. The addition of the second gun deck level made the ship tall, narrow and top heavy with a high center of gravity.

- The structure for the gun deck levels were over designed and the supporting beams for these decks were much larger and heavier than they needed to be for the cannons the Vasa was to carry. The height of the two gun deck levels were also about one foot higher than all the other decks. The typical height of crew members was about 5'-5-1/2" and the lower deck where the crew members lived was much lower in height and the supporting beams were much smaller as compared with the two gun deck levels above. This extra height and weight contributed to the ship's instability.

- The ship was asymmetrical with a tendency to lean towards the port (left) side. Un-ballasted, the ship would be inclined to lean to port. [4] This was due to two different crews of carpenters working on each side of the ship and using different measurement rulers. This wasn't a major problem if this fact were known as the ballast and other loads could have been re-distributed to keep the ship balanced and centered.

There has been speculation that King Adolphus had changed the original design from a single gun deck ship to a two gun decks configuration when the ship was already deep into construction – that this was a late change. The actual measurements and design of the ship showed that the design of Vasa's two gun decks were incorporated from the very beginning and that it was not a late change add-on. In other words, even though the Vasa started as a traditional single cannon deck ship, it quickly evolved to an untried design.

This was confirmed by another exhibit at the Vasa Museum showing the construction of the keel. The keel is the principal structural member of the ship, running lengthwise along the center line from bow to stern and to which the rib frames for the hull are attached to. It was noted that the keel configuration for single gun deck ships built during that period used a keel that was two beams wide. Later in history when two and multi-level gun decks became the norm, the keel width for these ships were three beams wide. This allowed the rib frames for the hull to be made wider which improved the buoyancy and stability of the ship. The Vasa had a keel width of only two beams which was standard for single gun deck ships. Its hull was not wide enough to provide the stability needed when the second gun deck was added. Engineering design problems caused the ship to sink. [1]

Epilogue to the Vasa Story

The Vasa was the first double gun deck ship Sweden ever built and its design was not that far off from being a seaworthy warship. Its sister ship, the Applet, which was built in the years following the disaster, had a hull width 3.1 ft. wider than the Vasa. [5] The wider hull increased the buoyancy of the ship allowing for more ballast to be added to make the ship stable. Although there are few design details recorded for the Applet, it is speculated that the gun deck levels were not over designed to make them made too high or too heavy. The cannons on the upper gun deck were changed back to the original lighter 12 lbs. cannons [5] which helped in lowering the ship's center of gravity to below the water line.

The Applet served the Swedish navy for many years afterwards along with many other multi-level gun deck ships built after the Applet. The lessons learned from the Vasa disaster have definitely been applied. Multi-level gun deck warships in the 17th century became the standard design for all countries once the key design parameters were known, thanks to the Vasa.

Who Was Really at Fault?

The following list some of the key project management problems which could have caused the Vasa to sink. All are true, but which ones had the most impact? All projects could encounter these situations:

- A very demanding client with high and unrealistic expectations
- Lack of a defined project plan and execution strategy
- "Scope creep" from frequent design changes at inappropriate times
- No process to assess or address the consequences of change
- Unclear scope of work and lines and roles of responsibility
- Lack of adequate checks and balances done by qualified personnel
- Intense project schedule pressures – not having sufficient time to do things right
- Lack of communication at the working, management and client levels
- Lack of defined documentation and technical specifications
- Unknown design factors for ships with multi-level gun decks
- Poor supervision of and communication with the various construction crews
- Lack of scientific and documented design methods and calculations
- Untried and untested innovations – designing something not done before

Some say that King Adolphus was at fault because the original contract for the ships, including the Vasa, were to be traditional single gun deck warships. He changed the design to be a two gun deck level ship to accommodate all the cannons that the shipbuilders could not possibly fit on one gun deck. Then he wanted newer cannons twice as heavy than the standard ones. These significant changes were ongoing while the ship was already under construction. The King also insisted that the 500 plus elaborately ornate carvings made from heavy oak be added to the ship. This only made the ship more top heavy and unstable. The King was very demanding in expecting the Vasa to be built in the timeframe he wanted.

The King, however, could not be faulted for wanting and expecting the very best for his country. As cost was not an issue, he could be as demanding as he would like to set whatever schedule he wanted as long as the resources and skills were available to build the Vasa in the timeframe needed. The King did the right thing in seeking the most talented and experienced shipwright to design and build his warships. Hybertsson was the best shipwright in Sweden. He had successfully built ships for the King before and his expertise was respected by the King.

When Hybertsson couldn’t continue to work on the Vasa, the King failed to recognize that this could be a major problem in losing his best talent and project manager. When Hybertsson had to pass his responsibilities to Jacobsson, the King did not question whether Jacobsson was as equally skilled and experienced as Hybertsson to complete such a major undertaking. Perhaps the King assumed that the designs to add another gun deck on the Vasa had already been done by Hybertsson and now, Jacobsson was just completing this work. This was the King’s major oversight. He did not have anyone looking after his interest. He could not be blamed if the engineering design of the ship was flawed. But he could be blamed for his selection of the shipbuilders and how well qualified, or not, they were in building a multi-level gun deck warship which was never done before. History has shown that his expectation for such a new concept for a warship be built successfully the first time was quite naïve and unrealistic, and this contributed to the Vasa’s demise.

So who really is at fault? There are a number of historical facts which point to Jacobsson as the primary person to be blamed for the design of Vasa’s inherent instability. It is not because Jacobsson didn’t try hard enough to do the work or that he was incompetent. The Vasa did end up getting built and it looks very impressive at the museum. Rather, it was a case of not knowing any better, and being thrown into a position where he was simply not as qualified or experienced enough to do what Hybertsson would have done, had he lived.

It was noted that the hull was increased by 1’-5” to accommodate the second gun deck level. This was probably done by Hybertsson . An experienced shipwright would had known that ship’s hull needed to be wider for a higher ship, and he would have tried to keep the right proportions to maintain stability. However, because the keel timbers were already cut, there was only so much he could do to widen the hull and there was no time to rebuilt the keel from scratch. Hybertsson did what he could to make the ship seaworthy, but it was still an educated guess what the hull width needed to be when the ship’s height was not yet known.

When it came to the design of the gun decks, it is doubtful that Hybertsson was well enough to have done the design work. The gun deck levels were way over-designed with a height one foot higher than the other decks and the supporting beams bigger in size with more beams installed than needed for the cannon loads. The best explanation for this is that the design work was done by someone less knowledgeable and skilled than Hybertsson. Jacobsson was the only other person in charge with shipwright experience, and in absence of Hybertsson, there was no other person qualified to review or check Jacobsson’s design work. There is a phenomenon in engineering which still occurs today. When an engineer is assigned to design something that person has not done before, or is not fully qualified or experienced to do such a task, then the design will tend to be over-designed to be on the safe side.

There are two other indications that Jacobsson did the work. During the inquiry, many people and sailors noted that the ship’s “belly” below the water line was insufficient for the ship’s height and structures above the water line. An experienced shipwright would have known what the implications might be for building a high and narrow ship by making the gun deck levels higher and heavier than necessary. Plus the fact that during the stability test done on the ship, Jacobsson was not even invited to witness the results, nor was he aware that such a test was even conducted. An experienced and knowledgeable shipwright would be the first one asking for and taking responsibility for this test.

If Hybertsson were alive, it is doubtful he would have permitted such a ship to be built so unstably in the first place, and he would have definitely advised the King of the outcome and consequences of the failed stability test. He would not have destroyed his own integrity and reputation or do anything which would have so embarrassed the King and jeopardized the well-being of the country. If there was a blame for Hybertsson, it would be that he died prematurely before he could train his successor to be as equally competent as he was, in all facets of shipbuilding design and construction. The sinking of the Vasa was ultimately due to engineering design deficiencies.

The Importance of Engineering Designs

The key variable which is often taken for granted in project management is the quality and accuracy of the engineering designs. Simply stated, ***whatever that has been designed to be built must work as intended.***

1. Designs must be proven to work, reliably and safely in compliance with all standards, codes and regulations.
2. Comprehensive checks and balances must be in place during all engineering designs and associated changes.
3. People must be qualified and experienced to both do and check the required design work. This requires having the right people doing the right things at the right time.
4. Once your design is confirmed to be correct and construction work has started, all stakeholders should resist making major changes to it. This will negatively impact cost and schedule.
5. However, if significant design changes are necessary, ensure that sufficient time and expertise are in place to ensure the revised designs will also work as intended.
6. If it is known that the design won't work, then don't continue building it and suffer the consequences afterwards.

Potential design problems arise when:

- Things are done in a rush. The project being too schedule driven.
- People are not qualified, experienced, nor trained to do the required work.
- Late design changes are made without proper evaluation of the consequences to the original design or project intent.
- Wrong decisions made during the project execution are not discussed, nor challenged, when they can seriously impact the project. Following orders blindly.
- Lack of communications – stakeholders, contractors and disciplines not coordinating items affecting them.

- Getting too complacent. Forgetting to respect inherent risks. Expecting others to take care of the problems.
- Thinking that we know it all – even though it is known that anyone and everyone can make mistakes. No one is perfect, but we should always strive to do the right things.
- Remember Murphy's Law, "If anything can go wrong, it will go wrong. And it will occur at the worst possible moment." The Vasa is a prime example of this

The Real Lessons Learned

The King, as the client, did contribute to the Vasa disaster, but he was not the primary cause. The failure of the Vasa was due to engineering design deficiencies. There is a truth in every successful project that it must start off with competent engineering execution in producing designs that work. If the design doesn't work, then it doesn't matter how much money was spent on the project, or whether the project met or exceeded its target schedule, or if the best materials and construction techniques were used. All will be lost. Everything starts with engineering, and when the design is flawed, all the efforts in project management, procurement and construction will be wasted. At the end, what you have built will be crap!

People make projects and decisions. People influence how well, or not, things are designed and how well projects are executed. Experienced and competent people are needed to achieve good results. But sometimes, the right people may be difficult to find, and personnel do change on projects. The skill here for any project manager is to be able to recognize the right people with the necessary skills and experience and to put them in the key roles to achieve the desired results. Project management is simple when all the elements are in place. People make projects successful.

Projects need the best team possible, the right people with the knowledge and expertise to do the right things. Leaders need to surround themselves with the best people. Equally skilled and experienced replacement personnel must be available when key members of the team are lost or replaced. Innovative designs which are done for the first time will take longer to get right. Schedules may need to be extended as failures are very possible when trying something new. Lessons can be learned from past failures. The Vasa story showed all this to be true!

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