

# **The Panama Canal: An Engineering Miracle**

**Quest Club paper by David Bennett**

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The weather was warm and muggy on the December afternoon when elected officials, business leaders, and other dignitaries gathered in a small Central American country to celebrate the launch of a development project that would connect the Pacific and Atlantic oceans with a water route that could accommodate the largest cargo ships in the world.

Each person at the groundbreaking envisioned the results that a successful canal would bring. The business leaders were developing what they hoped would be a profitable commercial project; the local elected officials coveted the new jobs and increased revenue. And the dignitaries from the large and wealthy country which was promoting the endeavor – a country which had only recently achieved world superpower status – viewed the canal as a vital strategic military and commercial link between the world's two largest oceans.

But the groundbreaking for this canal project does not refer to Teddy Roosevelt's support of the Panama Canal project in 1903, or even the French efforts of 1880. Rather, this transoceanic canal would be built through the country of Nicaragua, and the ceremony occurred in December of 2014. The business leader who would oversee the project was Wang Jing, a Chinese multi-billionaire, and the local government leader was Nicaraguan president Daniel Ortega. Eight-thousand miles away, in Beijing, Chinese leader Xi Jin-Ping watched carefully as work began on the project that would give his country unfettered access to their own Path Between the Seas.

Of course, the only canal currently linking the Atlantic with the Pacific is the Panama Canal, completed in 1914. In this paper, we'll look at the Panama Canal: the first failed efforts by the French, the successful American effort culminating in the opening in 1914; changes in the last 100 years, and efforts currently underway by the Chinese to build a second transoceanic canal.

A few facts about the canal which surprised me. Between 13,000 and 14,000 ships use the canal every year. American ships use the canal the most, followed by those from China, Chile, Japan, Colombia and South Korea.

Ships entering the Canal from the Atlantic side pass through Colon, and then begin a 47-mile journey through the Gatun Locks, across Gatun Lake, through the Culebra Cut, past the Pedro Miguel Locks, across Miraflores Lake and then through the Miraflores Locks to exit at Panama City on the Pacific side.

Due to the shape of the Isthmus of Panama at this point, a ship making the journey from the Atlantic to the Pacific actually travels southeast. In addition, while we here in the Midwest commonly think of the Central American region as being to the west of us, Fort Wayne is actually about 300 miles to the west of the entrance to the Panama Canal.

Initial attempts to build a canal had to face a question that to us would seem obvious: Is the Atlantic Ocean the same level as the Pacific? After much research, they eventually concluded that both oceans were at the same level. With more accurate testing devices, we now know that, due to differences in temperature and water density, the Pacific Ocean is, in fact, 20 centimeters higher than the Atlantic.

Every vessel that transits the canal must pay a toll based on its size and cargo volume. Freighters pay \$82 per container; a cruise ship pays \$134 per bed. The largest toll ever paid by a single ship was \$450,000. The smallest toll ever paid was 36 cents, plunked down in 1928 by American adventurer Richard Halliburton, who swam the length of the canal. Today, nearly \$2 billion in tolls are collected annually.

On average, it takes a ship 8 to 10 hours to pass through the canal. While moving through it, a system of locks raises each ship 85 feet above sea level. Ship captains aren't allowed to transit the canal on their own; instead, a specially trained canal pilot takes navigational control of each vessel to guide it through the waterway. In 2010, the one-millionth vessel crossed the canal since it first opened in 1914.

Of course, the Panama Canal is one of hundreds of canals around the world. The economics of a canal are simple. A canal will be economically viable if it reduces the cost of transporting people or freight from one place to another.

Canals have existed for more than 2,000 years. China contains the oldest canal in the world: The Grand Canal, a 1,100 mile waterway linking Beijing with Hangzhou. The oldest parts of the canal date back to the 5<sup>th</sup> century BC. The canal changes elevation numerous times thanks to the technological innovation of the canal lock, which was invented by a Chinese civil servant in the 10<sup>th</sup> century.

In North America, canals became popular nearly 200 years ago. In the early part of the 19th century, transportation across land was limited to horseback, horse-drawn carriages, or on foot. Water transportation had been in existence for thousands of years, and large ships often carried heavy loads

across long distances. But land transportation was much slower and more cumbersome. Canals were seen as the solution.

In the United States, the completion of the Erie Canal in 1825, linking New York City with Lake Ontario, spurred interest across the nation in improving the canal systems.

Thanks in part to that success, planners looked for a cheaper and faster transportation route between the Great Lakes and New Orleans. Such a route would improve the delivery of goods from Europe, which could travel down the St. Lawrence Seaway to the Great Lakes.

The eastern edge of Lake Erie at the mouth of the Maumee River near Toledo was viewed as the most important starting point for the new canal system. Plans were laid to extend water transportation from Lake Erie to the Ohio River. There was a clear economic advantage to extend a canal through Fort Wayne. Once a boat reached Fort Wayne, it was very short passage of just 7 miles before connecting to the system of rivers that led to the Wabash to the Ohio to the Mississippi and to New Orleans. In fact, George Washington, a big fan of canals, wrote a letter to his Secretary of War, Henry Knox, which stated that the very short portage between the Maumee and the Wabash near Fort Wayne was “the most feasible point for water communications between the Ohio River and Lake Erie.”

Hoping to duplicate the success of the Erie Canal, the state of Indiana, in the Mammoth Internal Improvements bill of 1836, appropriated the funds necessary to build the canal linking Toledo with the Wabash through Fort Wayne.

Had the state of Indiana relied an economist to determine the best route for the canal, there was a chance that the project could have been successful. However, as money was appropriated by the state, each area of the state, even those for whom a canal did not make sense, asked to be part of the Wabash and Erie Canal system. Indiana eventually defaulted on the bonds issue to build the canal.

Despite the poor judgment and setbacks, the Wabash and Erie Canal was opened in 1843 and the first transportation along the route began in that year. For nearly two decades, the canal became a major transportation hub, linking transportation from the Great Lakes to the Wabash River and eventually to New Orleans.

Yet just when the canal system began to become profitable, a new transportation system known as the railroad began to grow in earnest. Once railroad tracks were laid, the steam engine could transport goods at less cost and faster than could a canal boat. Not only were they faster, but railroads could operate year-round, whereas canals tended to freeze in winter.

The success of the railroad led to the demise of the canal in much of the United States. In fact, railroad tracks are often laid on canal right of ways. We have an example of this in Fort Wayne today, as when you look at a map of the route of the Norfolk Southern train line that train track is precisely where the Wabash and Erie Canal once brought passengers and freight by canal boat. And, of course, as Questor Mac Parker reminded us last night during a program at the Civic Theater, the Landing in downtown Fort Wayne gets its name from the fact that it was the landing place for canal boats from 1843 until the canal closed in 1880.

Despite the success of the railroad, there were still parts of the world where it made economic sense to build a canal. For hundreds of years, travelers and explorers had dreamed of a more convenient passage between the Atlantic and Pacific oceans.

In 1513, the Spanish explorer Balboa became the first European to discover that the Isthmus of Panama was just a slim land bridge separating the Atlantic and Pacific oceans. Balboa's discovery sparked a search for a natural waterway linking the two oceans. In 1534, after no such passage across the isthmus had been found, Charles V, the Holy Roman emperor, ordered a survey to determine if one could be built, but the surveyors eventually decided that construction of a ship canal was impossible.

The idea remained a dream for more than 300 years. But the birth and growth of the United States would force maritime attention once again on a canal.

The California Gold Rush of 1849 brought a large influx of new settlers to California and the West Coast. A ship traveling from New York to San Francisco around Cape Horn and the Drake Passage in South America must travel 13,000 miles, much of it icy and stormy waters. That same trip through a central American canal would be less than half the distance through warm tropical waters.

To accommodate the increased travel due to the Gold Rush, a railroad across Panama was completed in 1852. Passengers could arrive at Colon, take the train to Panama City, and board another ship for San Francisco. But this solution was not economically feasible for freight, and an efficient path between the Atlantic and Pacific was still needed.

Events on the other side of the world would once again spur interest in a transoceanic canal. On November 17, 1869, the Suez Canal, linking the Mediterranean with the Indian Ocean, was opened to navigation. The immediate success of the Suez Canal would spur new interest in a canal across Central America.

The Suez Canal was built by a team of French engineers and investors. That same French team became the logical choice, then, to build a canal across Central America. After investigating several sites, the French chose to build the canal through Panama.

But the French success at Suez distorted their perceptions of the difficulty of building at Panama. It's true that a canal across Panama would be less than half the length of the 105-mile long Suez Canal. But at Suez the land is flat and mostly near sea level. There were no rivers to cross, no jungles to chop down, no mountains to excavate. The weather at Suez was hot but generally dry. The soil in Suez is sand, in Panama, it was mostly rock.

The first attempt to construct a canal through what was then Colombia's province of Panama began on January 1, 1880. It soon became clear to the French the jungle, the rivers, and the tropical climate made Panama a much more significant challenge than Suez. But the French effort was doomed for one more reason. A very tiny reason, really. That reason was the mosquito.

In the 1880s, medical science had not progressed to the point of understanding that mosquitos were a very effective mechanism for spreading deadly diseases such as malaria and yellow fever. But the French had no idea what caused the disease.

Workers who traveled to Panama in the 1880s died by the hundreds. A ship with thirty-three Italian workers arrived in 1885; within three weeks, twenty-seven were dead. In October 1886 thirty French engineers arrived at Colon; in just four weeks, thirteen of them died. The French appointed Jules Dingler to head the entire project in 1883. He moved his wife, his son, his daughter and his daughter's fiancé into a large home overlooking the project. Within a few months all of them except Jules Dingler were dead, and Dingler returned to France a broken man.

It is estimated that 22,000 workers died between 1881 and 1889. By that year, the French had had enough. And the project declared bankruptcy. In just under a decade, the French had sunk more than \$260 million into the canal venture and excavated more than 70 million cubic yards of earth. But the canal remained unfinished.

But ten years later it would be the United States that would take up the challenge of completing the canal. At the dawn of the 20<sup>th</sup> century, America would be led by a man who had the energy and the vision to complete just such a project. The history of the Panama Canal might have been quite different had anyone else other than Theodore Roosevelt been president. It is hard to imagine William McKinley, William Howard Taft or even Woodrow Wilson undertaking such a bold and risky venture.

Teddy Roosevelt had the knowledge, the history, and the personality to finish what the French had started.

Alfred Mahan's book, *The Influence of Sea Power on History*, greatly influenced Teddy Roosevelt. Mahan argued that strong navies would be crucial to a successful military strategy by any global



superpower. Britain, France, Germany and Japan all incorporated Mahan's theories into their military planning; Roosevelt was determined that the United States would, as well. Building and controlling a canal across central America would undoubtedly be a critical part of US naval strategy.

Roosevelt himself had written a book on the importance of sea power in the War of 1812. His knowledge led to his appointment as Assistant Secretary of the Navy, just a year before the battleship Maine exploded in Havana harbor.

Roosevelt's experience in the Spanish-American war also increased his knowledge of the challenge of working in a tropical climate. In that War, 280 US soldiers were killed in hostile action. Another 2,883 died from yellow fever, malaria and typhoid fever. In his own unit, the Rough Riders, more men died of disease than of hostile action. Teddy knew the risk of disease in Panama.

But mostly, Theodore Roosevelt had the courage and the fortitude to undertake the challenge of such an enormous and risky venture. Roosevelt would write, "Far better it is to dare mighty things, to win glorious triumphs, even though checkered by failure, than to take rank with those poor spirits who neither enjoy much nor suffer much, because they live in the gray twilight that knows not victory or defeat."

In one of the first act of his presidency, Roosevelt would take up the challenge where the French had failed. "It is not the critic who counts; nor the one who points out how the strong person stumbled, or where the doer of a deed could have done better," Roosevelt wrote, "The credit belongs to the person who is actually in the arena; whose face is marred by dust and sweat and blood." Roosevelt would take the United States into the arena of the Panama Canal.

Roosevelt's audacity would lead to one more historic footnote. A palindrome is a sentence that reads the same both backward and forward. No one really seems to know who wrote this first, but Teddy Roosevelt's leadership would result in the creation of the most famous palindrome in history: A man, a plan, a canal – Panama.

After considering a Nicaraguan canal, the United States chose to purchase the assets still held by the French after their bankruptcy. But Roosevelt still faced the challenge that, in 1903, Panama was not a separate country but was part of Columbia, and Columbia refused to give the United States the right to finish the canal.

At this point, even from a distance of more than 100 years, the events which led to the creation of the separate country of Panama remain murky. The United States would pay France \$40 million for their assets at Panama, so the French became a US ally in the bid for Panamanian independence.

A French diplomat named Phillipe Bunau-Varilla – who also happened to be the largest shareholder in the bankrupt French effort – now entered the picture. Bunau-Varilla arranged for the fire department in Panama City to seize control of the local government. Columbia dispatched nearly 500 troops led by General Esteban Huertas to Colon with orders to put down the insurrection. They were to board the train at Colon and take it to Panama City, where the local fire department had seized control.

But Roosevelt had different ideas. As Columbian troops neared Colon, the gunboat USS Nashville appeared on the horizon. Commanding officer John Hubbard led a small contingent of troops to the railroad station with orders to prevent the Columbians from boarding the train. The situation remained

tense until General Huertas was informed that the United States had agreed to make payment of \$65,000 to General Huertas personally, and \$50 to each of his men, if they would return to Columbia. Huertas agreed.

The United States then entered into negotiations with the newly-created country of Panama for control of the area around the canal. The United States would take possession of a 50-mile long strip of land that stretched for five miles on either side of the canal. The treaty called for the United States to build the canal, administer it and defend it “in perpetuity”.

The favorable terms were agreed to in just three weeks for two important reasons. First, the Panamanians were genuinely pleased to have the United State take up the effort to finish the canal. But also, the man who the United States recognized as speaking for the Panamanians was none other than Phillipe Bunanavarilla.

Three weeks later, in his annual State of the Union message to Congress, Roosevelt said, “the experience of over half a century has shown Colombia to be utterly incapable of keeping order on the Isthmus. Only the active interference of the United States has enabled her to preserve so much as a semblance of sovereignty. Had it not been for the exercise by the United States of the police power in her interest, her connection with the Isthmus would have been sundered long ago.”

To this day, most Panamanians approve of Roosevelt’s actions. The country still celebrates two independence day holidays: They celebrate their independence from Spain on November 28, 1821, and separation from Colombia on November 3, 1903.

Many years later, during the administration of President Jimmy Carter, the United States would negotiate a treaty that returned the Canal Zone to Panamanian Control. On the floor of the US Senate, Senator S.I. Hayakawa, who was a distinguished linguist and knew exactly what he was saying, spoke in favor of the United States retaining control. "We should keep the Panama Canal", Senator Hayakawa said. "After all, we stole it fair and square."

So more than 20 years after the French abandoned their efforts, the United States took up the challenge of completing the canal. Perhaps no part of the difficulty of building the canal illustrates the technological challenge better than an area known as the Culebra Cut.

The Culebra Cut is the valley that cuts through the Continental Divide in Panama and is a mountain of rock rising 210 feet above sea level. The French had excavated some 18,000,000 cubic yards of material from the cut, and had lowered the summit from 210 feet above sea level to 193 feet.

The United States took over on May 4, 1904. A vast amount of new earthmoving equipment was imported, and a comprehensive system of railways was constructed for the removal of the immense amounts of earth and rock.

The scale of the work was massive. Hundreds of large steam drills bored holes in which were planted tons of dynamite, which blasted the rock of the cut so that it could be excavated by steam shovels. Dozens of trains took the spoil from the shovels to the landfill dumps, about 12 miles away. In a typical day, 160

trainloads of material were hauled away from a cut. At the busiest times, there was a train going inbound or outbound almost every minute.

In addition, engineers had difficulty estimating how much earth would need to be removed to prevent landslides. Eventually, the Americans would lower the summit of the cut from 193 feet to just 39 feet above sea level, at the same time widening it considerably.

No description of the challenge of building the Canal would be complete without describing the efforts that were made to contain the diseases carried by the mosquito. When the French lost 22,000 workers in 8 years to malaria and yellow fever, they blamed the spread of the disease on an undefined “miasma” rising from the swampy land, and even on poor moral habits among infected workers.

Yellow Fever was not a disease that existed only in tropical areas. In 1793 there was an epidemic of in Philadelphia that killed about ten percent of the city and was a key reason why our nation’s capital was moved from Philadelphia to Washington. In 1853 there was an outbreak in New Orleans that was so bad that the city authorities suppressed the news of it. In 1879 there was an epidemic of yellow fever in Memphis it killed a third of the city. One historian called the Memphis outbreak the worst urban disaster in American history.

Success in Panama depended on a breakthrough in finding the cause of and a cure for yellow fever. A team of American scientists led by Dr. Walter Reed finally proved conclusively in 1900 that the mosquito was the transmission mechanism for Yellow Fever. Dr. Reed’s insight was one of the greatest

breakthroughs in medical history. Unfortunately, Dr. Reed would never live to see the results of his success in Panama. He died in 1902 of a ruptured appendix at the age of 51.

But discovering the cause of the disease was only the first step in blocking its transmission. A small army of workers constructed mosquito netting, sprayed oil on standing water, and spread insecticide to try to eradicate the mosquitos. By the time American construction began the spread of Yellow Fever had been largely eradicated.

Of course, the recent outbreak of the Zika virus reminds us that diseases spread by mosquitos remain a serious crisis to public health. Mosquitos have worked hard to earn the nickname “deadliest animal on earth.” Mosquitos each year kill far more people than snakes, spiders, and crocodiles. Even with advances in medicine, Mosquitos are still blamed for more than 700,000 deaths annually around the world.

Eventually, the American efforts would overcome the jungles, the rivers, the mountains and the mosquito. The Panama Canal officially opened on August 15, 1914. Yet despite this momentous occasion, no ranking dignitaries from the United States attended.

Events on the other side of the globe drew the world’s attention elsewhere. On 28 June 1914, Austrian Archduke Franz Ferdinand was assassinated in Sarajevo. And on July 28 of that year, Austria-Hungary declared war on Serbia. When the Canal opened two weeks later it received little attention, for World War I had begun.

But after the war ended, the Canal proved to be a great success. When the Second World War began, 65,000 American troops were based in and around the Panama Canal to prevent an attack that would never come. The Germans, in fact, had developed a plan with the codename Operation Pelikan that was designed to cripple the canal. Two Stukas airplanes would be disassembled and then transported to a deserted island in the Caribbean where they would be reassembled and loaded with bombs. The bombs would destroy the Gatun and Mará Flores locks, disabling the canal. But the Germans never had the chance to implement their plan.

Over time, tensions increased between America and Panama over control of the canal and the surrounding Canal Zone. In 1964, Panamanians rioted after being prevented from flying their nation's flag next to a U.S. flag in the Canal Zone. In the aftermath of the violence, Panama temporarily broke off diplomatic relations with the United States. In 1977, President Jimmy Carter negotiated and signed treaties that transferred control of the canal to Panama in 1999 but gave the United States the right to use military force to defend the waterway against any threat to its neutrality. That treaty passed the Senate in 1978 with just one vote to spare for the required two-thirds majority. Indiana senator Dick Lugar voted "no", while Senator Bayh voted "yes". (By the way, for you younger Questers, that Senator Bayh is Birch, not Evan.)

Control of the canal was transferred peacefully to Panama in December 1999, and the Panamanians have been responsible for it ever since.

Today, the Panama Canal has just completed a \$5 billion expansion that will allow it to handle today's megaships. Before the expansion, the largest ship that the Canal could handle was appropriately called a

Panamax ship, which could carry 5,000 20-foot containers. With the expansion, the Canal can now handle ships that contain 14,000 20-foot containers.

However, while the new locks will be able to fit many modern ships, they still won't be super-sized enough for some vessels, such as the new Triple E class ships, the planet's biggest container ships, which measure 194 feet wide and 1,312 feet long, with a capacity of 18,000 20-foot containers.

Which leads us to recent efforts by China to build a second canal across Nicaragua. Much of this project remains a mystery. While it was announced with much fanfare in December of 2014, four years later no work has begun on the project.

The technological aspects of a Nicaraguan canal are just as daunting as Panama's. The Nicaraguan canal would be three times as long and twice as deep as Panama. It would be the largest movement of earth in the planet's history. Plus, the world pays much more attention to fragile ecosystems and virgin forests today than it did in Teddy Roosevelt's day.

Adding to the pessimism is the fact that Chinese businessman Wang Jing, whose company is building the canal, has lost 80% of his \$10 billion fortune in the last two years.

But some observers contend that Wang Jing is only the visible face of a project that is being secretly backed by Xi Jin-Ping and the Chinese government. One look at a map will make it clear why the Chinese would like their own transoceanic canal just 500 miles north of Panama. The canal could be used as a demonstration of Chinese power in wooing the affection of Central and South American nations. And



just as the American success in 1914 highlighted for all the rise of America as a global superpower, the Chinese may feel that their canal would show that world that China, not the United States, will be the supreme world superpower in the next century.

My wife and I had the opportunity to visit the Panama Canal in 2007. The City of Colon does not appear to have changed much in the last hundred years, with architecture and commerce that was probably more in tune with the fashion of the early 20<sup>th</sup> rather than the early 21<sup>st</sup> century. The canal itself was impressive, with thick jungle spreading as far as you could see in either direction.

Will the Chinese be successful in building a Nicaraguan canal? They likely have the resources and the patience to make it happen. There's a Chinese proverb that says, "A journey of a thousand miles starts with a single step," and they have taken the first step in building a second transoceanic canal.

The United States should be justifiably proud of their role in the engineering miracle that is the Panama Canal. The challenge for my children and my grandchildren will be a task far more important. They will need to engineer a world where the great superpowers prosper, and trade, and survive together, in peace.

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