Graphene is lighter than a feather yet stronger than steel.

Graphene

by Larry Rhodes

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GRAPHENE

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The End of an Era

Naval Air Station Lakehurst, New Jersey, May 6, 1937

George Schultz stomped his feet to bring some circulation back. He was a member of the air station ground crew waiting for the Hindenburg airship to arrive. It was over six hours late due to an unseasonably cold and wet weather front that covered most of New England. The ground crew alternated between waiting at the mooring tower and trying to stay warm in the hangar. The Hindenburg had been forced to deviate from its predetermined course and circle the landing field, waiting for the weather to clear enough to allow the huge ship to attach to the mooring tower and winch its way

to the ground. Schultz was only nineteen and had been in the navy for a year. This was a temporary position until new naval vessels under construction were completed, and he could join one as a seaman.

The weather cleared some, and the crew received word the huge ship would land soon. They quickly resumed their pre-appointed positions near the tower and waited. Schultz was far from an expert on lighter-than-air vessels, but the rapid turns the Hindenburg was making as it neared the tower seemed excessive. Surely the Zeppelin Company's experienced flight crew knew what they were doing.

Schultz watched a new storm front looming on the western horizon and hoped they could complete the landing before it arrived. Someone yelled, and he glanced up at the ship. Was that a fire on the top? Maybe it was St. Elmo's fire? Suddenly, a huge fireball appeared near the tail of the ship, and pieces of flaming debris rained down on the waiting ground crew.

Most of the crewmen scattered, but Schultz saw someone dangling on one of the mooring ropes. He knew he had to help the people on board if possible. The flames were now spreading quickly to the midsection of the ship, and it turned nose up just before the tail section rammed into the ground. He saw some passengers breaking windows, and he motioned to them to jump. They were less than twenty feet from the ground; however, in a panicked state, they probably believed they were much higher. A young boy saw him and jumped. Schultz caught him and ran away from the ship. Schultz

saw others trying to jump and returned several times to help drag people away from the burning debris still raining down on them.

With a final groaning noise, the huge ship slowly settled on the ground. Most of the ship's structure was now visible as the outer skin, and the "gas bags" holding the hydrogen had burned off. Diesel leaking from the engines was now burning, and several small explosions completed the tragic crash of the once enormous vessel.

Schultz didn't even notice his shirt was on fire until someone covered him in a blanket. He passed out. The next morning, he woke up in a hospital, to the relief of his fiancée, who filled him in on the terrible loss of life. She told him there was a rumor he would receive a citation for the lives he saved. When he told his fiancée he would have quite a tale to tell their children, she was so relieved she cried.

2

Designing the Future

Max Brita settled into a comfortable high-back chair in his well-appointed Manhattan office for a long afternoon. Longtime friend and business colleague Tom Babineaux entered with a cup of gourmet coffee and another stack of proposals submitted for his biannual "Designing the Future" contest. The winner would receive every inventor's dream, a presentation to an interested room full of investors, hoping to receive funding to build a prototype, or make the next big step in increasing the size of their company. Fortunately, the contest proposals were limited to ten pages, including drawings, so Max hoped to make it through the last batch of entries and still make it to dinner with Jill Thornton.

As an experienced angel investor, Max had seen thousands of proposals from early concepts to small operating companies, hoping for funding to take them to the next level. Max breezed through most of the proposals. He had seen similar proposals countless times, and few offered the possibility of the next big thing that would make the lucky investor and the angel investor fabulously wealthy. The minimum expectation for an angel investor was at least a quick ten-to-one return on investment.

As he neared the bottom of the stack of last-minute proposals, a drawing caught his attention. It was a colorful 3-D rendering of a lighter-than-air airship with such detail it almost seemed to pop out from the page. Most of the proposal dealt with the engineering aspects of the ship, rather than the business purpose or profit potential. Normally, he would have tossed the proposal onto the large reject pile, but it had piqued his interest enough to search the Internet for more information about the lighter-than-air concept. While Max would consider almost any technology, he was most comfortable funding new types of materials, information technology and biotechnology proposals. This was so far outside the range of projects he normally dealt with that he wanted to know more. He highlighted the author's name and contact information and looked at his watch. He realized he might be late; traffic in Manhattan was always a challenge. He quickly stuffed the proposal in his briefcase and hurried to meet his girlfriend. She didn't like it when he was late.

3

The Concept

Max Brita and Tom Babineaux arrived without fanfare at the headquarters of Armstrong Aeronautics in Clear Lake City, near Houston. Founded by a group of ex-NASA engineers, Armstrong Aeronautics specialized in the design of small- to medium-size business jets. Normally, Max would have been escorted directly to the president's office and treated almost like royalty. Besides his angel investments, he also managed a huge hedge fund that was the second largest stockholder in Armstrong Aeronautics, after the founder Jack Armstrong. Vice presidents of the company jostled to meet him and shake his hand. More than once, he had steered a potential client their way who later became a major customer. They owed him.

Today, Max was just another visitor. Tom Babineaux had made the arrangements in his name, and only a few people at Armstrong knew him. Upon their arrival, they were informed that Alex Schultz was still in a meeting and would probably not be available for another hour. Tom was embarrassed that Max had to wait, but he waved off Tom's apology with a magazine and settled into a large comfortable chair in the visitor's lobby.

Jeanne Wellman, the secretary of the design department, soon appeared to fetch them to Alex's office. Always observant, Max noticed that, while Jeanne wasn't someone you would easily pick out of a crowd, she had a nice smile, expressive large green eyes, long brown hair, and a slender build. Max guessed she was about thirty years old, and he skillfully pumped her for information about Alex.

"How long have you known Alex?" he asked.

Jeanne glanced at him as they neared Alex's office. "Oh… over five years."

Just as they arrived at Alex's office, Max inquired, "Is he a lead designer?"

A confused expression ran over Jeanne's face for a second, and she started to reply when she saw Tom smiling and shaking his head. She immediately understood and smiled back at them. "Uh…yes, for small projects. Alex should be here any minute. Would you like some coffee?"

Max declined, but Tom accepted her offer. "I'll go with you if you don't mind."

He watched them for a moment and then entered Alex's office. He slowly smiled at the Hindenburg memorabilia that virtually covered the walls of the small office. Her computer even used the famous film footage of the Hindenburg's last moments as a screensaver. His attention was drawn to a three-foot-long scale model of the Hindenburg resting atop a file cabinet. Pictures of the crew and its designers were mixed with interior photographs of the most famous dirigible in the world. He also noticed a long shelf on one wall that was lined with various collegiate athletic trophies. He was trying to read the inscription on one of them in the dim office lighting as Tom and Jeanne returned. A few curious cubemates overheard Tom and Jeanne's discussion about Alex and followed them from the coffee station.

Alex had just finished leading a scheduled early morning one-hour design meeting that had lasted two hours, and she was exhausted. She hoped to have some time to rest in her office before a scheduled afternoon meeting. Her e-mail inbox was almost full, and she had missed the notice from her admin for a scheduled meeting with some "investors." She noticed several people standing outside her office and assumed it was an informal hallway meeting. When they saw her, they moved aside to let her in her office…Strange. A salesman was waiting for her and examining one of her collegiate trophies, and her admin was chatting with another salesman.

"Can I help you?" she asked icily.

Max quickly returned the trophy to the shelf and turned to her. Alex was wearing jeans, a red blouse, and a pair of comfortable tennis shoes. She had light blue eyes, and he guessed her to be in her late twenties to about thirty years old. Her honey-blond hair was slightly curled and fell softly around her shoulders. She was slender, about five and a half feet tall, and was carrying a large roll of design drawings. He instinctively took her for an engineering assistant—a very attractive engineering assistant.

"Yes, I'm here to see Alex Schultz. Would you know when he would be available? I understand he's in a meeting."

Alex had assumed he was a salesman who, like most, thought she was a man based on her nickname.

"I'm Alexandra Schultz," she replied.

"No, I mean…" It suddenly dawned on him. "Oh…"

She offered her hand, and he quickly shook it. He hadn't been this embarrassed in quite some time.

"It's okay," she said. "It happens all the time. Now…how can I help you?"

Jeanne and Tom smiled at each other, while Max quickly gathered his thoughts. "I'm Max Brita, and this is my colleague Tom Babineaux. We read your proposal for a lighter-than-air airship built with today's technology. While it's an intriguing idea, what I guess we didn't see in the proposal is a business justification for doing it."

She was stunned. She was certain her proposal would be lost among the thousands of proposals that Brita was certain to

receive for each contest. Her mind leapt to the demonstration cases she had put together in the unlikely possibility that one of her proposals would generate interest. Where were they? Were they in the trunk of her car?

"Before we can talk about that, I first need to show how today's technology can apply to the lighter-than-air concept, then how this technology can provide a new way of looking at the travel and entertainment industry. I have a presentation prepared to do that, which should also answer all your business-related questions."

Max nodded. "Great. Let's get started."

Alex turned to Jeanne, who had been chatting with Tom, and was too fascinated with the events to leave. The other employees who had wandered over to see what was going on heard Max introduce himself and Tom.

"Jeanne, could you find an empty conference room for about a two-hour meeting?"

"Of course, Alex. Just give me a few minutes," she replied automatically. She also needed to find something better for Max than the free coffee available at the coffee stations. Jeanne knew who Max was as she had once set up a meeting for Jack Armstrong with Max when Jack's secretary was on vacation.

As Jeanne returned to her desk, Max and Tom sat down in visitor chairs in Alex's office. Max noticed several large 3-D drawings of a lighter-than-air airship that had even more detail than the drawings in her proposal. The 3-D drawings were mixed in with a sizable photo gallery of the Hindenburg.

"You have quite a collection of Hindenburg memorabilia," he commented.

He laughed when she replied, "This is nothing. You should see my apartment."

Alex had instinctively assumed he would be much older. He was wearing a dark expensive suit and appeared to be in his early to midthirties, with dark hair and eyes, and, she guessed, about six feet tall. He seemed to be physically fit. She wondered how he had made so much money so quickly. His colleague, Tom Babineaux, was probably the same age as Max. He was also about six feet tall, slender, with blond hair and blue eyes, and wearing a dark expensive suit. She had to admit, they were both good-looking.

4

Concept and Application

Tom and Max settled into comfortable chairs in the well-appointed "client" conference room, and Max sipped on a cup of gourmet coffee as he watched Alex place several small aluminum suitcases on empty chairs. Tom pulled out a notebook to take notes as she opened one suitcase and handed Max a small swatch of light-gray material.

"I'd like to begin by comparing the materials used to construct the Hindenburg with the modern materials available today. This is the fabric that covered the basic structure of the Hindenburg. Earlier dirigibles used cotton as the base, but the Hindenburg used silk covered with many layers of gelatin."

Max examined the small piece of material carefully, rubbing it between his fingers. It was very light and soft to the touch yet unexpectedly rigid.

Alex handed him another small piece of white fabric. "And this is a new polymer that resulted from the space program." The fabric was extremely light and almost seemed to glow in the soft white light of the conference room. He briefly wondered what it would look like in bright sunlight. While he examined the polymer, Alex pulled two large folded pieces of material from the small suitcase and handed one of them to him when he looked up. "This is one square meter of the Hindenburg material, or about ten square feet." She then handed him the other. "And this is one square meter of the new polymer. Feel the difference in weight?"

Max held them both in his hands. The polymer seemed much lighter and more flexible. It was so smooth and slippery it was hard to hold on to and slipped out of his hand. He had to grab it quickly with both hands to keep it from falling to the floor. He handed both samples to Tom, who examined them closely.

"Image the difference in weight multiplied by the thousands of square meters needed for the entire skin of a dirigible."

Max had hardly digested this when Alex placed a shiny fabricated piece of metal on the table in front of him. "This is what a section of a strut of the Hindenburg looked like. It's made of duralumin, an alloy of aluminum, copper, and

magnesium. Some things today are still made of duralumin." As he picked it up, Alex laid a smaller, shinier piece on the table. "This design carries the same structural strength as the other, but it's made of a titanium alloy, similar to the type used today in many aircraft frames."

He picked the smaller piece up. Its shape was radically different than the first and much lighter. He immediately had a mental vision of a World War II bomber sitting next to a modern military fighter. While he was inspecting the smaller piece, Alex commented, "Titanium is actually one and a half times as heavy as duralumin, but you need a lot less for the same structural strength."

When he looked up, Alex was waiting with her arms folded. "Okay. I'm convinced you can make a dirigible lighter today, but why would you?"

"For every pound saved in the design of the ship, I can lift one more pound of cargo or, in this case, one more pound of passenger. So for a ship the same size as the Hindenburg, this would mean more than sixty thousand pounds or three hundred more passengers than the fifty to seventy passengers and forty to fifty crewmen the Hindenburg could carry."

He still appeared confused. "But…why do it at all? It couldn't possibly compete with today's jets that cross the oceans in a few hours."

She paced as she replied, "Imagine a young couple. They are considering a cruise around the Caribbean when they see an ad for a new type of travel—aboard a lighter-than-air airship with virtually no limitations as to where it can travel."

She paused as Max and Tom glanced at each other.

"A cruise ship leaves Los Angeles and travels to Alaska to view the glaciers. This ship could make the same trip—but fly *over* the glacier. On the way back, it flies near the coastline—a much better view than driving along the coast."

She could see a spark of interest in their faces as she continued, "Imagine flying *over* the pyramids in Egypt or *over* the Great Wall of China or *over* Machu Picchu or *over* an active volcano in Hawaii or *over* the Rocky Mountains or *over* the rain forests of the Amazon or even *over* African deserts…virtually anywhere in the world. The possibilities are endless." She had to take a deep breath to calm down, but she was certain she had two new converts. Max jumped up.

"Yes! This is a step-change innovation." Then his expression changed. "But…what about the cost? If this vacation could only be taken by a few wealthy people, we would never recover engineering and manufacturing costs."

"I've done some preliminary calculations. I'm pretty sure the cost to construct and operate one would be no more than the cost of a new medium-size cruise ship."

"Medium size?"

"One that would hold from seventy hundred and fifty to one thousand passengers and perhaps a crew of three hundred."

Max was pacing the floor, and Tom and Alex didn't dare interrupt his thoughts. He finally stopped and sat back down. "How big would it be?"

They laughed when she smiled and said, "I happen to have a preliminary design…"

She lifted a projector onto the conference table and plugged her laptop into it. A few seconds later, a three-dimensional image framed a screen that Tom had lowered.

They stared at a massive lighter-than-air airship floating over the Statue of Liberty in New York to enable a comparison of its size. The actual length was a little more than 1,100 feet. Max's gaze shifted to a cutaway view on the side of the image. The cross section of the ship was actually an ellipse instead of a circle, the width being twice the height.

"Why is the basic shape an ellipse, instead of a circle?"

"Mainly to enhance the passenger decking and to reduce the height of the hangars required for maintenance."

Alex pressed a button on the laptop. "This is a view of the passenger decking. A floor in the bottom of an ellipse would be much wider than in the bottom of a circle, allowing much more floor space. This design would also maximize the number of passenger compartments with windows. The deck runs almost the entire length of the ship."

While they were thinking about that, Alex elaborated on the height issue. "If the ship's structure were round and the same length, it would have to be thirty to forty percent taller and would require a much taller hangar to contain it, wherever it is based. This would make the ground facilities at all hangar bases much more expensive."

Tom wondered how the ship would land. He had seen movies about the Hindenburg. "A cruise ship can dock in almost any coastal port or tender in. Would this ship require special landing facilities? That could be expensive."

"Yes and no. A small mooring facility would be required at any predetermined landing site, but in an emergency, the ship could fire anchors into the ground and winch down anywhere. There would have to be at least one hangar for refurbishing and maintenance—not all that different from a ship that periodically has to go into dry dock."

Max thought that one over for a moment. "Okay. I think you said there were about one hundred passengers and crew on the Hindenburg, and it was gigantic. Wouldn't this ship have to be a lot bigger to lift thirteen hundred passengers and crew and their luggage?"

"Yes, the structure is much lighter, but the volume of lift gas would still have to be multiplied by a factor of ten. The volume of gas in the Hindenburg was about seven million cubic feet, so this ship would have to utilize about seventy million cubic feet."

Tom was shocked. He knew that small quantities of helium were very expensive, but he didn't have a clue on the cost if millions of cubic feet had to be purchased. "Seventy million cubic feet! Isn't that, millions of dollars?"

"Yes, but that's the initial purchase. After that, you are only buying gas to replace what's lost through leaks."

Max wanted to take a step back. "For those that haven't studied this field, could you elaborate a little on the lighter-than-air concept?"

Alex gazed at him for a few seconds while she gathered her thoughts. "Okay, for a lift comparison, think of a typical storage locker that's ten feet long, ten feet high, and ten feet deep. That's one thousand cubic feet. If it's filled with air at sea level, the air in the locker would weigh a little over eighty pounds, or eight-hundredths of a pound per cubic foot. If it's filled with helium, the weight is about eleven pounds, or about seven times lighter. And hydrogen is even lighter at about five and a half pounds, or about sixteen times lighter. So a fixed volume will want to rise until the outside density is the same as the density inside. It's the same principle as a hot air balloon. The hot air in the balloon is less dense than the colder air outside and wants to rise to an altitude where the densities are the same."

They still seemed to be following her, so she continued, "In the locker example, one thousand cubic feet of helium could lift the difference between air at eighty pounds and helium at eleven pounds or sixty-nine pounds until the densities equalize. Hydrogen could lift even more at seventy-five pounds. So all we need to know is the weight we have to lift to figure the volume of helium or hydrogen we need. The Zeppelin Company actually used sixty-seven pounds per one thousand cubic feet in their helium lift calculations to allow for impurities in the gas and humidity in the air. However,

in the thirties, the US had the world's largest supply of helium, and when the Nazis came to power, the US cut off their supply of helium. This forced the Zeppelin Company to use hydrogen as the fill gas. There is a huge trade-off with hydrogen. It's fifty percent lighter than helium, so the same volume will lift more weight, but it's highly flammable, so you have to take every precaution to avoid catching it on fire. Today most people think the Hindenburg went up in flames because it was filled with hydrogen. That's not true, but I wouldn't begin to propose we fill this new vessel with hydrogen. There would just be too many people who would think it's not safe."

She paused to regain her original point. "The Hindenburg was about one hundred and thirty-five feet in diameter and eight hundred feet long. This vessel would have to be at least one hundred and eighty feet high, about four hundred feet wide, and about eleven hundred feet long to provide the needed lift capacity for the passengers and crew and their luggage of course."

Max was staring at the image on the screen. "Is that feasible? A vessel more than a football field wide and almost four football fields long?"

"It is, with today's technology like this." She was holding the titanium strut.

"How long would it take to fabricate it?"

"I'm not an expert in that area, but all the materials needed are readily available so I think it would take about a

year to build a factory to make the parts and another year for actual fabrication, then another six months for trial runs and certification by the FAA and other authorities."

"How long would it take to design it?"

"That could be done while the factory is being built."

Max walked to the projector screen for a closer view of some of the details. "You said the cost would be similar to a medium cruise ship. What number are you basing that on?"

Without hesitation, she replied, "Most cruise ships that carry one thousand passengers cost about one billion to build."

He turned to her. "Billion?"

She nodded.

He returned to his chair to think about the whole lighter-than-air issue. "Most people come to angel investors to take their entrepreneurial business to the next level whether it's building a small prototype or to expand. They are usually looking for a few million dollars. This is just a concept, isn't it? And…you are looking for a billion dollars?"

She laid a larger suitcase on the table. "I have a small prototype to demonstrate the concept."

"Great, let's see it."

She opened the suitcase and took out a complex maze of small titanium sticks and something that resembled a deflated Mylar balloon. They were soon standing next to her as she quickly assembled a six-foot-long metal structure that resembled a small dirigible with the deflated balloon inside. She took a small cylinder of helium out of another suitcase

and started inflating the Mylar "gas bag" inside the wire frame structure. She hooked a cable to the helium cylinder when the dirigible started floating. The small dirigible continued to rise and lifted the cylinder off the table.

"Lifting the cylinder wouldn't be possible for a prototype of the same size made with Hindenburg-type materials. I would like to have built a larger prototype, but I didn't have the money. A friend has a metal fabrication shop. He made the metal parts for this prototype as a favor."

Max returned to his chair to think about the next step. Was this concept worth investing a significant amount of time and money? Would he be able to convince his usual group of investors to fund a full-blown dirigible? He needed a better demonstration. "I don't know if I could sell the concept without a much larger prototype. Have you estimated the cost of a small dirigible, perhaps one that could carry about a dozen people?"

"Yes, of course." She pulled out a notebook from a suitcase, opened it, and handed it to him. Tom was soon standing behind him to study the drawing. There was an extremely detailed estimate of the cost of materials for a prototype dirigible about two hundred feet long and sixty feet in diameter. There was a hand sketch of the prototype showing a gondola hanging underneath that would hold ten people. The materials were less than two million dollars.

Tom noticed there was no estimate for labor. "What about the labor required?"

"I can't estimate that as no one outside of Germany or Switzerland has any practical experience building a large LTA vessel. The successor to the original Zeppelin Company builds small vessels today for day tours."

Max was still staring at the prototype drawing. "Is your friend capable of making the structural parts for this prototype if we paid him his usual rates?"

Alex's heart sped up a few beats per minute. At least he was interested. "Yes, I'm sure he is."

"If we didn't have the gondola, how much weight could this vessel lift?"

"About thirty-five hundred pounds. Do you mind if I ask why?"

"I think if you lifted something heavy, like a truck or a car, it would impress my investing group more than lifting ten people, even though the full-size vessel would carry people."

Alex made a sketch in the notebook and showed it to him. "We could do both. I could make the gondola removable, and we could lift something and carry people on a test ride."

"That's perfect. How long would it take to build the prototype?"

She thought for a moment. She knew a factory that supplied airframe materials that could be easily modified for this project. "Not too long, less than eight months."

"Okay. I'm willing to fund the prototype on my own. How soon can you start?"

She seemed embarrassed. "Immediately, but I would have to work on this at night and on weekends, which makes the eight-month deadline pretty tight."

"Okay, consider this an overtime assignment. Keep track of the hours you spend supervising the prototype's construction, and I'll pay one and a half times whatever your equivalent hourly rate is here at Armstrong—if you can have the dirigible ready in six months. You can hire as many workers as you need."

That seemed very difficult, adding this to her already busy workload, but she didn't want to tell him no. "That would be great. Thanks."

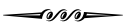
Max looked at Tom. "If the full-size vessel is a billion dollars, that's well beyond the range of angel investing. Is it even possible if we included the silent partners along with our private capital group?"

Tom hesitated. "We probably would have to go to an even bigger group. Maybe form a consortium, but we need to sell the concept first. No one will fund it if they don't believe it's feasible and profitable."

They were both looking at Alex when Max asked her, "Are you up to this? This is your concept. You will face a lot of skeptics and have to answer some really hard questions."

She had never had an anxiety attack before, but she imagined it was a lot like what she was feeling. She took a deep break and replied firmly, "I can answer any technical question. Y'all would have to answer the investment questions."

"Okay. Let's see if the concept and the prototype will fly." Tom laughed but Alex didn't. Max held out his hand to seal the deal. She hoped her hand wasn't too sweaty.



Tom was driving on the way back to the airport while Max was studying Tom's notes and summarized the presentation from his perspective and asked him what he thought.

Tom thought for a moment. "I think she's cute too."

Max stared at Tom. Tom rarely spoke about his own relationships or Max's girlfriends or women in general, so this was a total surprise. What had he said that led to Tom's comment?

5

Armstrong Support

Alex felt drained of energy; but as she returned to her office, she found Jack Armstrong, the founder of Armstrong Aeronautics, and two other people she recognized from corporate bio photos as vice presidents of the company waiting in her office.

Jack was a hard-hitting, no-nonsense type of guy and wasted no time. "Alex, what the hell is going on? Why would our largest investor show up without warning, not even say hello to anyone on the management team and come directly to your office?"

Alex swallowed hard. "I can assure you it had nothing to do with the company. I submitted an idea to one of Mr.

Brita's Designing the Future contests, and he just showed up to ask some questions."

Armstrong glanced at his vice presidents.

"What's the nature of the proposal?"

"As you can see, I have a strong interest in dirigibles, and the Hindenburg in particular."

"That's obvious."

"I had an idea to make a modern lighter-than-air cruise ship out of materials available today and gave him a presentation with some materials I've gathered, hoping someone would take an interest in the idea."

"What was his reaction?"

"He wants to build a prototype first to demonstrate the potential and then present the idea to a group of investors."

"If Brita is interested, I'm interested. Could you give us the same presentation you gave him?"

"Of course, sir."

He looked at his watch. "It's almost noon. We'll clear our calendars and meet you in the client conference room after lunch at 1:00 p.m."

"Yes, I'll be ready."

As soon as Armstrong and his VPs left Alex's office, Jeanne slipped in and closed the door. Alex noticed she was carrying a soft drink can and a paper bag with a local deli's emblem—coincidentally her favorite local restaurant for lunch.

"So how did it go with Mr. Hunk and Mr. Gorgeous?"

Alex just stared for a moment. "What?"

"Max Brita and Tom Babineaux are just about the most eligible bachelors in the world, silly."

"It was a business presentation, Jeanne."

"Sure it was. I brought your favorite from Sorrento's Deli so you don't have to go out for lunch, and you can tell me all about it, and I can tell you what it seems you don't know about them."

Later that day, Armstrong called Max's cell phone and asked if Armstrong Aeronautics could do all the engineering on the new LTA dirigible, if the proposal were funded. He agreed on the condition that Alex would be the lead designer. Jack quickly agreed. After all, no one else at Armstrong Aeronautics had a clue about designing a dirigible, but they had a strong team of engineers who could take Alex's basic designs and do all the necessary material, structural, and weight calculations. Tom Babineaux was already arranging a presentation to their usual group of investors in Manhattan—home to many private capital investors and venture capitalists.

Armstrong passed the full-scale vessel concept to his internal estimating group for a rough estimate that was probably within 20 percent of the actual cost of the vessel and supporting facilities, a new manufacturing facility to make all the needed parts, and a hangar where the vessel would be assembled and returned for periodic maintenance. When the first estimates for construction of the dirigible, factory,

hangar facilities, and all ancillary supporting functions came in from Armstrong Aeronautics, Max was forced to expand the potential list of investors to cover the huge start-up costs. The vessel alone was probably more than a $1 billion, and total costs, more than $3 billion once the cost of the factory, hangar, and engineering costs were included. Construction of a fleet of LTA vessels might be required to recover their engineering and manufacturing costs.

6

Prototype Dirigible

After the go-ahead from Max, Alex immediately stopped by Ed's Metal Fabrication shop. The owner had been a friend of her father for many years, and Alex wanted him to be the first to know the exciting news she had obtained funding for a large prototype.

"How big is the prototype?"

She showed him her notebook with the sketch and materials list. He stared at the list with thousands of strut pieces required. "You can't be serious. I can't do that, Alex."

"It's not a favor, Ed. You'll be paid your usual shop rate."

"But…two thousand struts!"

"And four hundred and thirty-five, to be exact. Ed, there is a factory that can deliver about a thousand thirty-foot long

titanium angle struts to your shop in two to three months. You only have to cut them and fabricate the ends so they can be bolted together…in three months."

"But…fabricate more than two thousand pieces in three months!"

"Can't you pay your guys overtime?"

Ed did some quick mental math. "Sure, but that's over thirty a day!"

"Please…"

That was a lot of work, but Ed had known Alex since she was little, and he didn't want to disappoint her. "All right, Alex."

She hugged him and hurried back to her apartment to work on a detailed design for the prototype. Ed Jenkins scratched his head as he watched Alex drive away. He was happy to have the work, but he hoped he hadn't promised more than he could deliver.

Jack Armstrong approved the assembly of the prototype in a large field behind his company's main admin building. Once the first pieces arrived from the metal fabrication shop, he periodically visited the assembly site. A few weeks later, he stopped by Alex's office to ask her if she could still meet Max's deadline. Finding Alex asleep at her desk, Jack decided to help her build the prototype. He stopped by Alex's direct supervisor and asked him to reassign her other work

until the prototype was complete but pay her salary from a development account. From his discussions with Max, Jack knew the importance of the prototype in convincing investors to fund the full-size vessel, and he wanted his company to be involved in all aspects of its design and construction.

From that point on, Alex was always at the assembly site, directing the workers. It would be close, but her estimating spreadsheet predicted the prototype would be ready just in time for the demonstration to the potential investors. Some days, after the workers left for the day, she would walk around the partially assembled skeleton of the airship, shake some of the struts, and tweak a few guy wires. She knew the engineering calculations confirmed the vessel would fly, but few people outside Germany had ever attempted to fabricate an LTA vessel this large in decades, and she had some lingering doubts she just couldn't seem to shake.

Max, Tom, a camera crew, and a handful of close friends and investors arrived at Armstrong Aeronautics one week short of six months to view the new prototype. The visitors met Jack and Alex in the visitor's conference room to review the days proposed tests, then exited the back of the building. Max noticed that Alex was wearing a dark blue dress and her skin was bronzed from spending many hours in the sun supervising the prototype's construction. Max knew all the technical details of the prototype but couldn't help being

a little awestruck when he saw it floating about ten feet in the air. The 60-foot diameter, 210-foot-long prototype held about 500,000 cubic feet of helium. There was no outer cover or anything that absolutely didn't have to be on the vessel to maximize the weight it could lift. Two small engines were integrated into the structure to provide forward motion.

For the first test, the gondola had been removed, and four cables were connected to Jack Armstrong's full-size pickup truck. He volunteered his truck to show his faith in the LTA concept and Alex's calculations. Alex held a remote control with a few buttons and several joysticks. She began the test by remotely adding more helium from several onboard compressed cylinders to the ten gas bags inside until the ship rose and lifted the pickup truck. A small group of contractors who had worked on the construction were gathered for the test and cheered when the wheels of the truck left the ground. The motors sped up, and the camera crew recorded the ship as it moved forward and rose into the sky. At about one thousand feet, Alex turned the ship, and it circled the company's main building. Max congratulated her and asked about giving the investors a ride. The prototype descended much like a plane landing until the wheels on the pickup truck touched the ground. Several contractors unhooked the cables on the pickup truck one at a time and reconnected them to mooring anchors. A larger truck arrived, carrying the gondola on a flatbed, which was quickly attached to the prototype. When the truck left, she winched the prototype

down to a few feet, and a contractor hooked a ladder onto the gondola. Alex, Max, Jack, Tom, the visitors, and the camera crew climbed on board. Alex signaled to the contractors to release the mooring cables, and the prototype lifted off and sped forward. She took them on a short ride over the city of Clear Lake (home of NASA's Johnson Space Center) and returned to the mooring site outside the Armstrong building. Inside the gondola, one investor excitedly declared the ride was much better than a hot air balloon, because a dirigible could take them wherever they wanted to go.

At the end of the test, they all gathered in the conference room to review the results of the tests. All the investors said the tests were convincing enough for a meeting to fund the full-scale vessel.

7

Challenge Session

One day before the presentation to the pool of investors, Max and Alex met with cruise industry consultant Joe Boyles to prepare them to face skeptics with tough questions. Joe was an expert on cruise ship economics but was asked to sign a confidentiality agreement and was told to challenge the dealmaker's proposal, which would deal with a lighter-than-air cruise vessel. He knew nothing about that, so he tried to read up on it in advance of the meeting. In effect, Joe would act as a devil's advocate. Joe was a big man at six and a half feet tall and muscle bound from lifting too many weights. He was surprised when he entered a conference room at Max's Manhattan hedge fund office, and Max Brita (whom he recognized from occasional business news reports) was there

with a cute woman he assumed was Max's girlfriend. He was getting paid, so what did he care?

After brief introductions, Joe began with the usual challenges like why is this better than conventional cruise ships, would fares be competitive, what is the payout period to cover start-up costs, how many LTA vessels would be required to recover the engineering and manufacturing facilities, and so on. All of which, Max answered. When he shifted from the economics of the proposal to the vessel's engineering, Alex started answering. Max was known for dating models and movie stars, and Joe was skeptical that she knew much about engineering or design, and his prejudice soon showed as he deviated to a more personal attack on Alex.

"How are you even qualified to design an LTA vessel?"

She wasn't bothered at first. "I have been designing small business jets for several years."

"How does that qualify you to design LTA vessels, little lady?"

"I've also been working on designing LTA vessels for ten years."

"How do we know the vessel will even fly?"

"I lead a team of designers. It's a team comprising many engineering disciplines: structural, weight, materials, and so on. The vessel will fly."

"But how are you qualified to lead that team, little lady?"

She was becoming angry at his attitude. "I have a master's degree in engineering."

"But how does that qualify you in LTA vessels, which no one today designs, little lady?"

She stood up and faced him directly. "If you call me little lady one more time, I'll have to put my foot up your ass!"

Max chuckled, and Joe laughed loudly. "I used to be a wrestler in my college days. I don't think that will happen."

Max didn't like the way the meeting was heading and interjected, "You are supposed to challenge the concept, not insult the presenters."

"I'm just questioning her qualifications to lead the design effort that's all." He returned to Alex. "You didn't answer my question, missy."

"I can *explain* it to you, but I can't understand it *for* you."

It took a few seconds to sink in, and Joe frowned and jumped up. "Are you calling me stupid?"

When Joe jumped up, Max instinctively jumped up as well. Max had grown up on the streets of New York, and he would not let this oaf get aggressive.

She was not the least bit intimidated by Joe's size. "You don't seem to be the sharpest knife in the drawer."

"Why, you…"

Joe tried to grab her, but before Max could intervene, Alex dodged him, and in a move so fast Max couldn't even see what she did, Joe was quickly lying facedown on the floor, and Alex was sitting on him and holding his right arm behind his back. Joe struggled mightily but couldn't break her hold.

"You didn't ask my qualifications to whip your ass, so I'll tell you. I'm a certified Krav Maga instructor and used to teach women self-defense against Neanderthals like you."

Max was surprised how quickly she put Joe down, but he needed to end the meeting. He was quickly next to her. "Alex, please let him go. I think we are done here."

As soon as she let go and backed up, Joe jumped up and took a swing at her. She easily dodged him and stepped on his foot and punched him in the face. He fell back and landed on a small refreshments table, knocking it down. She looked at Max. "Life's hard. It's even harder when you're stupid."

Joe would not let a small woman make a fool of him. He came at her again, and she dodged him and punched him in the throat. He gagged.

"That will hurt for a while. If you want more, I can give it to you."

That was enough for Max. He opened the door, grabbed Joe who was still gagging, threw him out, and closed the door behind him. "Sorry, Alex. This was supposed to be an intellectual challenge, not a bar fight. By the way, that was a pretty impressive show."

"I've dealt with guys like that all my life. They usually wise up long before that guy. He probably has some wanted posters in his family tree."

Max smiled. He had already alerted security about Joe. "Can I take you to lunch?"

"Sure. Just give me a minute to clean up."

Joe was waiting outside the door and tried to grab her. She dodged him again, pinned his arm behind, and slammed his face into a wall, then tripped him. "I've faced better, dipstick," she said to Joe, who was sitting on the floor and rubbing his face. As she walked off, building security showed up to escort Joe out of the building.

Over lunch, Alex asked Max about his hedge fund business. "Max, someone told me you manage some big ole hedge fund. What is that?"

He smiled. "There are several ways to invest if you're wealthy. Besides stocks and bonds, there are exchange traded funds or ETFs, which are a pool of stocks you can trade like a stock. All of those are highly regulated by the government—mainly to protect inexperienced investors. Wealthy investors that can afford to lose a lot of money can invest in more risky companies that manage hedge funds, private equity firms, and venture capital firms. The government doesn't regulate those types of investments. Those investors can take big risks, but they want big rewards in return."

"Don't you also have a venture capital company that sponsored the Designing the Future contest?"

"Yes, I do both."

"Why both?"

"Hedge funds invest in companies that offer a promise of a big return, but they have balance sheets and are usually

profitable already. We know a lot about them. Angel investors are looking at individuals with big ideas and tiny companies that need some money to expand their business, build a plant, and so on. Managing both gives me a complete view of all types of possible investments. Hedge fund managers also can earn ten to twenty percent of the profits in their investments as a fee, besides the standard management fee of one to two percent. So I use that money to help fund my angel investments."

Alex was trying to absorb all that while he continued eating.

"What role does Tom play in your investments?"

"Tom and I have been together for a long time. He executes the business side of all my venture capital and private money deals. He makes everything work."

After a while, she asked about the consortium.

"Why did Tom say you may have to set up a consortium to fund the lighter-than-air airship and factory? Why not use the hedge fund?"

"Hedge fund investors are risk-takers, but they aren't quite ready to invest in the type of investments that angel investors do. Most angel investments turn out to be worthless in a few years. I work with a pool of investors willing to take more risk than hedge fund investors. Anyone in the pool can make a proposal, and individuals or small companies then decide to invest in the idea or pass on it. If the amount needed is very large, we may decide to form a consortium, and they can join it as active or passive investors. Passive investors take no

active role in running the company. They leave that to the active investors."

"So you would be an active investor if a consortium is formed?"

"Yes, someone has to manage the business."

"So you would be the boss then?"

"I have a company that actually would provide business services for the consortium investors—sort of like a contractor. Tom is the president of that company. We provide accounting, payroll, human resources, purchasing services, and so on. All the things needed to make a business work."

"But you would be the boss?"

"Technically, yes."

Alex was glad she was working for an established company like Armstrong Aeronautics. The thought of working for a consortium that might only exist for a few years and then disappear if it didn't make money was kind of terrifying.

The Presentation

Max Brita had presented many unusual proposals to his friends and a small group of investors, but there would be some new faces at this morning's meeting. Max and Alex would have to be on the top of their game to pull this one off. Alex was wearing a black business suit, and when he suggested she looked more like a lawyer than an engineer, she blushed. He took a deep breath and opened the conference room door for Alex. Tom Babineaux had made all necessary

preparations, and several displays were located around the conference room, covered with white opaque cloths.

The business and technical presentations, along with Alex's small prototype and the video of the test prototype carrying the pickup truck while it circled the Armstrong building and the ride over Clear Lake City, impressed even the most skeptical investors. They knew they were being asked to fund a totally new type of vessel that would enter into one of the most competitive travel and entertainment fields in the world. Many cruise ships would lose money on every voyage if not for liquor, casino, art gallery, tours, and gift shop sales.

Bob Stevens walked out the conference room, preparing an amazing story to tell Brad Wilson, the CEO of one of the largest cruise lines in the world. Brad had heard a rumor that Max was planning a new venture in the travel and entertainment industry, and he hoped to use his considerable resources to beat Max to whatever he was planning. Brad was shocked when he received the full details of Max's proposal. He had the infrastructure in place to build another cruise ship—but no clue about LTA technology or how his company could design, build, and launch such a vessel—*and* beat Max to the punch. He quickly made some phone calls.

8

Post-presentation Dinner

Max entered the Four Seasons Hotel lobby in Manhattan, still angry over the stupid fight he had just had with Jill. He had opted out of an evening with her to introduce an engineer of his latest project to some of his private investors. Through a confidential source, she found out the engineer was actually a young woman and suspected him of working on his next relationship. When confronted with it, he of course denied that the evening was anything but business. Jill angrily stormed out of his apartment, and he was further convinced he would never understand women. He glanced at his watch. Traffic in lower Manhattan had nearly ground to a halt, and he was already a few minutes late.

He walked briskly around the lobby crowded with wealthy tourists and patrons waiting for companions prior to dinner, concert, and theater engagements. He strained to find Alex but couldn't. Frustrated that he forgot to ask for her cell phone number, he headed for a table with a housephone, passing behind an attractive blond in a black shoulderless evening gown, obviously waiting for her escort. He wished briefly he were available for the evening. She might have accepted an invitation. He picked up the phone and dialed the hotel operator who put him through to Alex's room. As he glanced around the lobby while her phone rang, he almost dropped the receiver. The attractive blond waiting for an escort was Alex! Their eyes met, and she smiled at him. *What an idiot I am!*

He tried not to ogle her as he approached. Alex had spent the afternoon getting her hair and nails done. Slim and tanned, she was easily the most beautiful woman in the room. She smiled at his fawning over her.

"I'm sorry I didn't recognize you. I've never seen you like this. You're stunning, Alex." She had read an article in a magazine that Max rarely complimented women, but she sensed he was sincere this time. "Thanks. Shall we go?" She took his arm, and he led her to his waiting limousine.

The evening was a blur to Alex. Max introduced her to numerous friends who often invested in his lucrative schemes. He had a near-perfect success rate in picking new investment opportunities and had many friends eager to share in his

current interests as silent partners. After dinner, they attended a play and visited a night club for a few nightcaps. He escorted her to her room and, in an awkward moment, asked if he could kiss her good night. She surprised him by wrapping her arms around him and kissing him strongly. Just as quickly, she said good night and closed the door behind her. He stared at the door for a moment, then headed back to his waiting limo. He was still shaking his head as he approached the waiting limousine. Roger, his chauffeur, noticed. "Something wrong, Mr. Brita?"

"No, Roger, everything's fine," he replied, but her perfume lingered in his consciousness, and he couldn't help thinking of her all the way back to his penthouse apartment.

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by Larry Rhodes