Helium Hokum: Why Airships Will Never Be Part of Our Transportation Infrastructure

By Joseph Dick | May 27, 2011

We've all been fascinated by balloons. As children we used to get a balloon at the circus, and then suddenly, we're magically mystified by the ability of a toy to do the non-obvious and seemingly impossible: Float in something that we ignore and pay no attention to until something floats "in" it.

Torricelli proved the existence of a vacuum by using a closed tube and some mercury, a device we now called a barometer. He recorded his observations thus: "*Noi viviamo sommersi nel fondo d'un pelago d'aria*"—we live submerged at the bottom of a sea of air.

Normal kids discover kites and leave toy balloons behind. They learn to make use of sticks, paper, string, and the moving air to make things go up, up, and away without the complexity of finding a circus—and without the inevitable disappointment of the toy balloon, which quickly looses its umph and eventually sits dead on the floor. Happily, kites provide a universal satisfaction, and they can even be made to fly when there is no wind, simply by running.

Unless of course you're an oddball like me. I loved balloons long after it was "cool." Why? Because it was fun to put a paper cup on the string of my balloon and load the cup with paper clips and then individual staples until it would float just so in the middle of the family room. But not to worry; I did the balloon thing and kite thing at the same time: Balloons for the occasional fascination, and kites for dependable fun—both with an underlying eye to the science of their operation, and always asking, "Why?"

In the history of technology of Western civilization, the balloon was invented twice, in Paris, in the last six months of 1783. These events are usually, and unfortunately, relegated to footnotes, and enjoy an early chapter at best, of most aviation history books.

Even the National Air and Space Museum in Washington, D.C., has eliminated the room dedicated to mankind's first successful voyages into the air since these are apparently of little interest, in the museum's opinion. Never mind that the events of those six months in Paris were, essentially, a miniature precursor of the "Space Race" of the 20th century.

Like most things in transportation technology, it began with what we would today call scale models. This quickly progressed to the first full-sized manned machines. And like the Space Race, there were two contenders: In one corner were the brothers Joseph-Michel and Jacques-Étienne Montgolfier (heirs to a more than lucrative family paper manufacturing enterprise), and in the other corner, Professor Jacques Alexandre César Charles of the Conservatoire National des Arts et Métiers.

The Montgolfier's were well aware—like most of the human race for thousands or even tens of thousands of years before them—that smoke rises from a fire. They concluded, incorrectly, that there was a special gas in the smoke that caused it to rise. Without any experimental evidence of its existence, they proudly named it *Montgolfier Gas*, claiming it contained a special property which they called *levité*.

Subsequently they proceeded to contrive a means to contain it, using (of course) the product that they manufactured: paper. They applied their paper to the inside of a large bag made of cloth; and, in an additional effort to contain their trade-marked special secret gas, they also went to great lengths to ensure that the fires they used to fill their gas bags were dark and sooty—the better to coat the paper and keep their special secret gas contained.

Professor Charles, on the other hand, already knew that hydrogen was lighter than air, and he how to produce it. He'd studied the work of Robert Boyle, who had produced hydrogen in England more than a century before by combining metal and acid. Charles also knew that if he could find a way to make a fabric impermeable to hydrogen, he could make a balloon too. But where to find such a material, n'est-ce pas? Like all good research scientists—or so the story goes—he brought the problem to the attention of his colleagues. This included the brothers Anne-Jean and Marie-Noel Robert, builders of scientific instruments.

The Robert brothers quickly came up with a solution to Charles' problem. In amazingly short order, they delivered an impermeable fabric coated with latex rubber—a process they had developed as part of their secret, high-tech, black market manufacture of condoms—then very much illegal in devout 18th-century Catholic France.

I suspect that, as a chemist, Charles probably knew that the Montgolfiers and their balloon were both full of hot air, figuratively and literally. As a chemist, he probably had a pretty good idea that there was no special gas with the property of "levity" emanating from a common fire. After all, Charles studied the effect of temperature on air, including that heated air tends to rise. Thus, the scientific principle describing how much a Montgolfier hot air balloon can lift is called Charles' Law.

Thus, in a mere six months, the balloon went from concept to prototype; and, just slightly over a year later, the English Channel was crossed for the first time by air in a hydrogen filled balloon by Jean-Pierre Blanchard.

In that very same six-month period of 1783, a young Lieutenant in the French Army Corps. of Engineers—a chap named Jean Baptiste Marie Charles Meusnier de la Place—immediately recognized the obvious: Elongate the *ballon* (so named because it resembled the hand-blown glass retort used by chemists of the day) so that it's resistance to motion would be reduced; put a small air bag, or *ballonet*, inside the balloon to help it keep its shape; add a rudder to make it *dirigable* (steerable); and add large diameter propellers (just like windmills, but in reverse) powered via a crankshaft turned the ballon's crew.

Nice idea, but not practical. It took the watermelon-smashing comedian Gallagher, who enlisted Bill Watson and his colleagues to finally make the first human-powered blimp, the White Dwarf, two centuries later in 1984. It was an entertaining exercise for sure; but it was, as the Germans say, *nur für Spaß*—only for fun.

So Meusnier's airship had to wait for a suitable engine to be developed.

In 1845, a certain chap by the name of Rufus Porter started a weekly magazine called *Scientific American*. Four years later, in 1849, he proposed the use of steam engines to power navigable balloons. This was a year after John Stringfellow built a working model of Henson's proposed "aerial steam carriage," creating the first successful powered prototype airplane in history.

Three years on, Henri Giffard achieved Rufus Porter's proposal. Of course, Giffard's friends advised him against such folly. They knew the dangers hydrogen could present when combined with the sparks thrown up the smokestacks of steam engines devised by the likes of George Stephenson. After all, Pilâtre de Rozier had built a hybrid balloon combining fire-fed hot air with hydrogen his 1785 attempt to cross the English Channel, achieving the expected result: disaster and death.

Undeterred, however, Giffard made a meritage of an elongated balloon, rudder and a propeller, driven by the steam engine that Meusnier longed for—achieving all of about three miles per hour, and barely managing to return from his launch point in a dead calm.

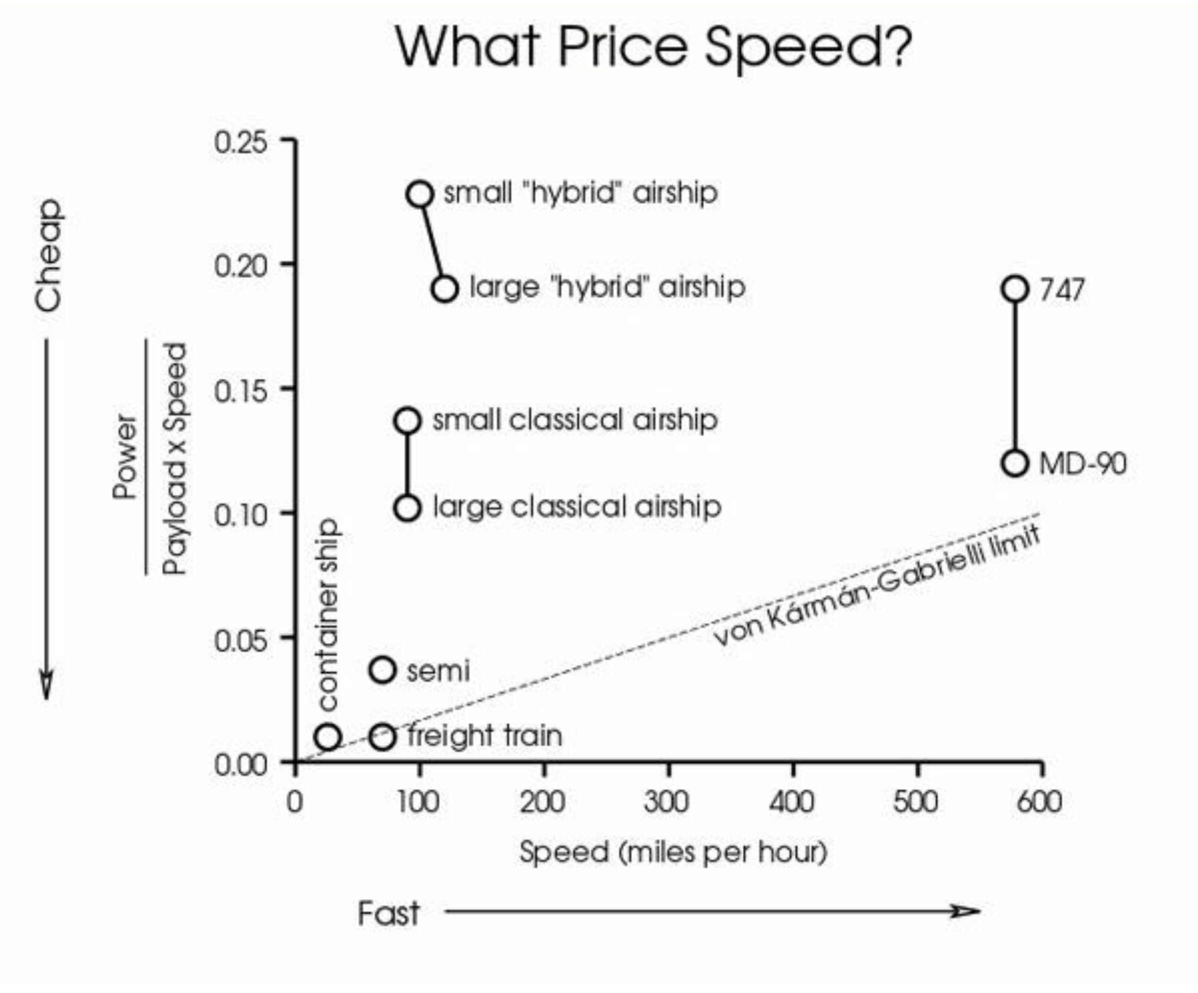
Fast forward to 1898. The Brazilian ex-pat Alberto Santos-Dumont, again in Paris, combined his love of motorcycle racing and ballooning to make a *ballon dirigable* of his own devising—the first successful aircraft to be propelled by an internal combustion engine. A mere year and a bit later, he won the Deutsch Prize for flying from the Paris Aero Club around the Eiffel Tower and back in less than 30 minutes. Parenthetically, because he was too busy with the controls of his machine to check his pocket watch, he did not know if he'd made it in time. He mentioned this to his friend Louis Cartier, and as a result, to this day Cartier SA still sell the "Santos" wrist watch—a mere $7,000 a copy, last time I checked. And for a score more years, if you wanted to get to somewhere far away and come back, the airship was the way to go.

But airships got left behind. Why? They have an Achilles' heel. No, it's not the weather, hydrogen, or the materials of the day—and it's not some conspiracy or a crewman with a bomb on the Hindenburg ruining it for everybody. Like a lot of things, the facts are simple and scientific, and thus boring—unless you're intrigued by simple scientific facts. Either way it's this: airships are inefficient.

The purpose of transportation is to get a thing from one place to another. The measure of any vehicle's efficiency—be it by land or by sea or even by air—is how much it carries vs. how hard you have to push it and how fast it goes. At the end of the day, we all want to get it there fast, and we all want to get it there cheap.

In 1950, Theodore von Kármán, one of the founding fathers of the science of aeronautical engineering, published a paper entitled *What Price Speed? Specific Power Required for Propulsion of Vehicles*. His work so timeless in its basics that it was recently updated by members of the Department of Mechanical Engineering of Imperial College London as What Price Speed—Revisited. In *What Price Speed?*, von Kármán showed that if you take a vehicle's horsepower divided by it's weight and speed you can see how efficient that vehicle is compared to other vehicles. Von Kármán used the total weight of the vehicles he considered because that information was readily available to him at the time. Today, we can more easily take this a step further, dividing the vehicle's horsepower by the weight of the cargo it carries and its speed to gain even more insight.

The following graph does just that, and includes data from some key means of transportation. The original by von Kármán is plotted on a log-log scale and includes performance trends vs. speed. But let's keep things simple, and what engineers and scientists call a "first order of magnitude" analysis, which is a fancy way of saying let's check things out with some simple, rough, easy to calculate numbers. Back before computers were everywhere—when you had to do things by hand with pencil and paper and a slide rule—this is what people did: Get some rough numbers to see if one thing is better or worse than something else, and toss out the bad ideas without wasting valuable time crunching useless numbers—let alone actually build the thing.



So, using information you can readily get today via the Internet, I've plotted a few examples: A container ship, a train, a truck, a couple of airplanes, a couple of old-school airships, and a couple of "modern" airships of the type that keep getting some press every few years, again and again, over the last 40 years or so. These "new" airships are now called "hybrids" because they try to augment the lift of their gasbags with a bit of aerodynamic lift—in short, they try to be part balloon and part airplane at the same time.

Never mind that Charles P. Burgess correctly argued from simple engineering principles in Chapter 10, "Common Airship Fallacies", of his 1927 book *Airship Design*, that this was, and remains, pure folly. But never mind what he said; how about we judge for ourselves?

If you look up how much power each vehicle has, and divide that by what it can carry and how fast it goes, and put those points on a graph, you can learn a lot. You can see, for instance, that a train is roughly as efficient as a container ship—but it goes much faster.

For example, all that's left on the northern leg of the Wabash & Erie Canal—built in the early 1800s and, at 460 miles long, is the longest canal ever built in North America—is now just a over-sized ditch along highway US 24 in Indiana and Ohio. A very short part of that canal, with a working lock and a canal boat has been reconstructed as a museum, next to the Ludwig Mill in Grand Rapids, Ohio. The museum is very interesting. However, when there is land to lay tracks on, ditches full of water are dumb—especially when sides of the canal erode just from towing the canal boats through. This is why we don't use canals; we use roads and railroads.

Along US 24 the old Wabash & Erie Canal towpath is now a road. This is a point of personal interest because my aunt and uncle, Ila and Dale Dick, owned and operated a semi which was equipped with a heavy truck axle designed by my dad Wes and his team—Dana Corporation's first—in the 1970s. Their truck is plotted too. You can see it takes about four times as much power to haul cargo by road at roughly the same speed as a train. Therefore it takes that much more energy to get the cargo from here to there compared to trains and boats. But trucks are more flexible than trains, since you can send them everywhere that roads go; and that's why we use trucks to get it there: It may cost more per mile, but we can get it there by a more direct route.

Then of course there are cargo airplanes. They aren't cheap; you'll need roughly 2.5 to 5 times the energy to get it there compared to a truck, and roughly 10 to 20 times the energy if you used a container ship or train; but you can get it there about 10 times faster than trucks and trains and over 20 times faster than a container ship. So if it's a really important last-minute package or if you want something like a fresh pineapple from Hawaii, it can be worth it.

Finally we have airships. There are classical airships like the Hindenburg and it's little brothers that came before it; and there are the "new" so-called "hybrid airships".

Both types aren't much faster than trucks or trains; and both are dreadfully slow compared to the usual way of getting it there by air, traveling at roughly a fifth the speed of a cargo jet. And in terms of energy cost, large classical airships like the ones that flew in the 1930s are just barely cheaper than the most efficient cargo planes; meanwhile very large "hybrid" airships—using performance numbers published by their proponents, mind you—aren't any cheaper than a 747, let alone as cheap as the old-school airships. And again, in terms of energy, trains, trucks, and cargo ships are a whole lot cheaper.

At the risk of pointing out what you may already have noticed, isn't it fascinating that the proposed (yet never yet built, let alone put into service) high-tech, "hybrid" airships aren't much faster than real airships that flew in the 1920s and 1930s? And isn't it strange that the old-style airships are also a much cheaper way to get it there compared to these new-fangled contraptions?

But they aren't new-fangled at all as it turns out. The 1977 World Book Encyclopedia *Science Year Annual*, on pages 190 through 199, proudly announced "Airships Make a Comeback". Among the ideas touted then and years before as part of our then soon-to-be then future—and mind you, this is going on forty years ago—were such things as these: The "Helium Horse" cargo transport airship. "Deltoid" and flying saucer shaped airships. Airships with four helicopters slung underneath (which ended in the Piasecki Helistat disaster). Airships for transporting gaseous natural gas (can you say *Hindenburg*?). Airships powered by three megawatt nuclear reactors (now can you say *Hindenburg*?). And even a "hybrid in an ellipsoidal shape, which is like a slightly elongated football with rounded ends," proclaimed as the latest and greatest from Boeing—a poor description at best of doing what is yet again being re-hashed all over again today.

Of course, there are also the usual arguments put forth by the proponents of airships for transportation: "This would eliminate building roads" or "you can't build roads to there." Sure, there are places where roads are impassable part of the year; so we do our hauling during the seasons when they are. And roads can be built just about anywhere, despite it being said that they would be too hard to build; hence, the Al-Can Highway.

During my lifetime I've seen, "up close and personal," roughly five billion in today's dollars spent chasing airships for transportation. Five billion dollars can build a lot of road and lay a lot of track; meanwhile, the only tangible evidence of these airship projects is a vast mountain of useless paperwork—most of which ended up in local landfills, only to be recycled in the figurative sense of the word.

The "airship renaissance" has always been just around the corner ever since the end of World War II. There has always been an impending "helium overcast", with a sky so crowded with blimps that it would blot out the sun. But the only real product—if one can call it that—has been employment: employment of a bunch of engineers that just don't get the simple, basic, and straight-forward engineering science so eloquently put forth by von Kármán in *What Price Speed?*

Theodore von Kármán was the first to note that there is an effective realistic limit to how fast you can go for how cheap you want to get it there, by applying rational thought and analysis any and all forms of transport—hence the von Kármán-Gabrielli limit that is, in practice, only exceeded by the efficiency of hard steel wheels rolling on hard steel rails. What would von Kármán think of his eloquent and insightful message falling on the deaf minds of today?

At the circus, the best acts get the center ring. Those who are in the know understand that airships as part of our transportation infrastructure are an old act, relegated to the side show for very good reasons.

Therefore I feel sorry for investors and shareholders that are enticed away from the center ring, spending it all on the hucksters; but only as sorry as one feel for one who's been duped and swindled.

As the Romans used to say, "*Caveat Emptor*."

About the author: Joseph A. Dick is an independent design and systems engineering consultant and an aerospace and automotive systems expert for Robson Forensic, Inc. (http://www.robsonforensic.com/)

The views expressed are those of the author and are not necessarily those of Scientific American.