

PRIVATE-COMMERCIAL SPACE, ENGINE OF ANOTHER GOLDEN AGE OF FLIGHT

As we stand at the threshold of private-commercial space enterprise, the similarities and lessons from the Golden Age of Flight can be an inspiring roadmap, I was privileged to have Allan Lockheed, founder of Lockheed Aircraft Company, as my Father. I grew up with a heritage of flyers and aviation entrepreneurs who built the aviation industry as we know it today. The parallels and lessons of Dad's time provide useful insights today.

Dad was born in 1889 near Los Gatos, CA and was 55 when I was born in 1944. In 1911 in Illinois, he flew a Curtiss pusher in exhibitions, until it nearly succeeded in its fond wish to kill him. Then, he came home to Northern California to build much better aircraft.

Dad was the middle son of Flora Haines Loughhead's 4 children. Oldest brother Victor was a prolific writer on science and technology, who invented a process for making tool bits with integral artificial diamonds. I'm told that DeBeers liked the process well enough to purchase it and let it disappear. Brother Malcolm invented 4 wheel hydraulic brakes, stood up the Lockheed Hydraulic Brake Company, worked with Dad on all phases of machining and manufacturing Lockheed aircraft, and briefly maintained President Carranza's one and only airplane of the Mexican Air Force. Sister Hope also carried the vision of expanding the human potential through technology, hard work, insights, and study. Her married name became Ledford, and Ledford family members worked with Dad in almost every aviation venture.

From 1890 to 1910 around Los Gatos, access to formal education was limited. Dad gained a 6th grade education, and Malcolm received a 9th grade education. But, Flora embedded high standards of self-directed education in all her kids. As ordinary Americans like the Wright brothers, her kids were obligated to do extraordinary things. They were expected to research and experiment with any subject or technology they found interesting, via library, mail order books, and tools they made in the workshed. Thanks to the farming, ranching, and orchard community, the kids grew up confident of their ability to build, maintain, and repair machinery.

Their confidence in learning STEM principles and for fabrication of just about anything, plus a well-nurtured imagination for worthwhile inventions, led them their whole life. When Malcolm was snowed in for many days, he passed the time reading the encyclopedia. He learned that liquid exerts equal pressure in all directions, and immediately began sketching design notes, which became the fundamental hydraulic brake patents!

I love that story. It demonstrates a core human truth. When imagination and curiosity focus on expanding human potential, STEM and fabrication skills become the tools of imagination. The result is INNOVATION!

I knew Dad as some kids are privileged to grow up with a favorite Grandfather, and so I learned the spirit of the person and the age. He lived the values and vision which led him and his trusted colleagues to create a Golden Age of Flight in the 1930's. They opened the skies for pioneers, visionaries, businessmen, and entrepreneurs, who literally put wings on their imagination. From their enterprise and sacrifices, humanity gained a wider perspective of the earth, its people, art, insights, and culture. Their footprints are seen today on the airways and airports which link the world together.

Now, we live on the threshold of another Golden Age of Flight, when newly enabled pioneers, adventurers, explorers, and entrepreneurs blaze footprints on new spaceways, spaceports, resources beyond the Earth, and even on the Moon. The products, services, insights, and innovations of this age can enhance prosperity and culture for future generations--as the last one did!

The Lockheed Aircraft Company was created in 1927, founded on aircraft fabrication technology created by Dad, Malcolm, Tony Stadlman, and the young Jack Northrop. Malcolm's immediate recognition of the ideal properties of hydraulics for brakes, led to a lot of hard work inventing reliable and functional technology. Similarly, the aircraft team innovated the molded plywood, monocoque construction technologies of the Lockheed Vega.

The Vega's spruce molded plywood construction foreshadowed today's vacuum bagged, composite fabrication. Golden Age Lockheeds used wood and casein glue rather than man-made fibres with plastic resins, making the Vega the most streamlined, lightest weight, highest performing, and easiest to mass produce aircraft in the world. And, it had the strength to weight ratio of mild steel.

It also had great market timing. The production prototype came to life just as Charles Lindbergh crossed the Atlantic Ocean in "Spirit of St Louis". Though he was not the first to do so, he WAS the first to fly solo, as a private enterprise, in a private aircraft. That accomplishment kindled the imagination of pioneers, explorers, sportsmen, entrepreneurs, and adventurers of both sexes around the world.

That imagination was re-kindled by SpaceShip 1!

The Vega also found perfect timing to exploit new powerplant technology. The Vega was one of a few aircraft ideally positioned to grow with radial engine development. Ultimately, Lockheeds flew with 220 to 750 HP, and engine sizes from 700 to 1,820 cubic inches. Like White Knight 2, Lockheeds met the needs of many markets.

The Vega, and later models--Orion, Air Express, Sirius, and Altair--enabled private enterprise pioneers to explore, map, and circle the world for the first time, while discovering the Jet Stream. Clearly, then as now, the means were in place to link the world and its people together in new, exciting ways. Entrepreneurs pioneered the methods of doing so.

The spirit of that Golden Age is best illustrated by Charles and Anne Morrow Lindbergh, on the 1931 flight which Anne documented in "North to the Orient". Pan Am commissioned the Lindberghs to map the great circle airway from Canada to China, via Alaska, the Kamchatka Peninsula, the Kurile Islands, Tokyo, and ultimately to Nanking China. As they arrived, China was wracked by the worst floods in memory. The Lindberghs immediately volunteered themselves and their Lockheed Sirius, "Tingmissartog", for flood relief missions. They flew sun up to sundown, surveying damage, and delivering doctors and medicine to stranded communities. Their tireless relief mission ended only when Ting' was damaged beyond local repair.

The vision of most aviation pioneers was for expansion of human capabilities, knowledge, opportunity, prosperity, and cooperation through the air. The Lindberghs' exemplary vision is alive and well today in their descendants, and the activities of the Lindbergh Foundation.

That Golden Age Vision is also alive and well in the actions and imagination of ISPCS participants. Now, the vision extends beyond the Earth. In the 1930's there were aviation market needs for vehicles, services, instruments, and products. Today, there are new markets for commercial space transport, linking the world, its people, the resources of space, and enterprises together to live, work, and play.

As Pan Am created worldwide airways linking people and enterprises, service depots for Clipper planes were set up. Where possible, the depots were strategically located near centers of commerce, culture, recreation, tourism, and/or governance. However in many cases, geography and/or politics required depots be established in virtual wilderness. Today, EVERY service depot location is a center of habitation and activity. Airports created cities, just as docks created seaports. In this next Golden Age, SpacePorts will inevitably create hubs of human enterprise.

It is up to us, to imagine and innovate the new opportunities of SpacePort commerce, industry, art, science, and access to the resources of space. I feel particularly blessed to be living on the threshold of this Golden Age of Flight--Going Out! Wish Dad could see it, but, maybe he can.

We have the opportunity--perhaps an obligation--to set up places on Earth where the motto is "From this place, the Stars are your heritage, if you will it so!"

This presentation relates to the growing opportunities in private-commercial space, often referred to as "New Space". That title seems ironic to me. New Space actually reprises much of the spirit and energy of Dad's Golden Age in the 1930's.

What is sometimes referred to as "Old Space", I see as the vital business sector of DoD-NASA space enterprise.

New Space provides commercial products and services to market demands, as cost-effectively as possible. Ground-breaking technology to achieve maximum performance is only necessary to lower cost and/or provide higher value services.

New Space products and services:

- Meet entrepreneurs' understanding of market needs and available technology

- Are privately capitalized, rather than publicly.

- Undergo continuous improvement to meet competitive market needs

Today's airways, airports, and enterprise hubs were largely created for market-driven products and services conceived in the 1930's. Lockheed, Douglas, Sikorsky, Beech, Pratt & Whitney, and Boeing developed from this marketplace.

Thankfully, hard-won historical insights, knowledge, and aerospace experiences are becoming available from NASA-DoD laboratories--which are national treasures! This knowledge base, and many assets of experience and best-practices tools from private industry are increasingly available to New Space enterprise. Examples include electronic control systems, network protocols, servo-mechanisms, CFE, FEA, fuels, propulsion systems, direct digital fabrication, GPS, etc. These assets enable privately funded New Space enterprises to prosper, providing cost-effective space services, products, capabilities, and support businesses.

Cost-effective private-commercial space businesses are becoming vital services to DoD-NASA ventures in technology development and education. DoD-NASA are both resources to, and customers of, many New Space enterprises.

Like space itself, New Space opportunities will exceed our imagination! Many of the enterprises we foresee today, will come true. Some will not. History teaches us the most fruitful inventions and enterprises have not yet been imagined. But, I'm certain and thankful that minds like Steve Jobs, Einstein, Burt Rutan, Kelly Johnson, Thomas Edison, and Walt Disney will come along again to make us think, all over again--"Huh! Why didn't I think of that?!"

Space Tourism is the definitive, high value, gateway opening private-commercial space industry. Like Lindbergh's 1927 flight across the Atlantic, space tourism kindles imagination, and encourages the public to become comfortable and excited about rocket powered space flight. Space tourism will inspire tales of pioneering, exploration, adventure, and insights like Anne Morrow Lindbergh's "North to the Orient", except these are gained from the High Frontier of space. Each person who has viewed the earth from space has discovered a valuable new perspective on life. Everything we are and know comes from this single, beautiful, blue planet. Then, when the tourist turns around to look outward, the universe seems to ask, "Are you ready, yet, to come out and play, on my terms?"

Space tourism will be a growing, bright sector of the next Golden Age of Flight. For example, Bigelow Aerospace will provide the next step for those who answer "Yes." In a few years, Bigelow will offer the equivalent of hotel accommodations in orbit. Of course, this opens new employment and entrepreneurial opportunities for infrastructure and support services. Space business entrepreneurs will certainly offer imaginative recreation activities for weightless space tourists.

The cost of space travel will grow cheaper as space tourism pays down capital investments, and operational experience climbs the learning curve. Like early airline history, space travel will follow the pattern of decreasing price and exponentially increasing business volume. At this time, the price of suborbital space tourism is about \$1,000/lb, That is 1/2 to 1/10 the cost of previous space access with life support. Independent projections suggest the price will eventually drop to around \$250/lb. Payloads not requiring life support will fly for even less.

At this time, space tourism finances SpacePorts, defines licensing requirements, identifies best practices standards and procedures, and stands up spaceflight support business. In short, space tourism is creating the early spaceport network and infrastructure for the crown jewel of

private-commercial space industry--point-to-point transportation. Comparison of this initial spaceport network to Pan Am's worldwide service depots is startling and valid.

Point-to-Point transportation will become the economic base of private-commercial space industry. Transportation is on the critical path of human history. From foot travel with sledges, to horse and stagecoach, through airways mapped from Golden Age Lockheeds, and via today's international jetliners and airports, each advance in transportation has changed the structure of commerce and industry. Transportation between spaceports on earth, or to space itself, requires less than 3 hours via suborbital spaceplane. As early as 1985, FedEx expressed serious interest in providing services from the continental US to Europe and the Pacific Rim via suborbital, vertical launch rocket service. That, is a game changer!

When airlines opened for business, only a few well-heeled travelers, wealthy adventurers, and high-value/time-critical shipments considered flying. Thanks to those users of air transport before and after WWII, flying today is generally quicker, less expensive, and more convenient than ground transport. Unlike the Lindberghs' China flood relief work, human expertise and relief services can now be delivered anywhere within days or hours.

The most significant element of air transport is air freight. I recently discovered that Concorde SST air freight service was profitable. Fast, affordable, and reliable air freight reduced the cost of warehousing and inventory management dramatically. Each day, massive shipments of products, documents, machinery, replacement parts, tools, and manufacturing subcomponents are shipped air-freight/just-in-time between worldwide hubs of commerce.

Fast space transportation, with delivery in hours or even minutes, will again slash the costs of warehousing, manufacturing, logistics, critical response, and inventory management, just as dramatically as air freight did.

Businesses that use Point-to-Point effectively to transport high-value/time-critical cargo and people will improve their bottom line. Similarly, early, well managed Point-to-Point providers will have better margins than airlines and air freight businesses. These margins will attract investment capital to Point-to-Point providers, businesses that use Point-to-Point effectively, and related ventures including spaceports, that service the industry.

Investment capital will find private-commercial space enterprises a compelling new sector as Point-to-Point transport proves itself. Naturally, not all New Space ventures will succeed. However, there will be some well-crafted plans, savvy management, and appropriate technologies brought to market. Some of them will reward retirement accounts, insurance portfolios, and maybe even Berkshire-Hathaway, handsomely. It WILL be fun to watch!

NASA and DoD are encouraged to contract for Commercial The Shelf [COTS] technology and services for research missions and access to space. This policy saves the government substantial capital development costs, through using available vehicles and flight services. NASA's Commercial ReUsable Suborbital Research [CRUSR] program is one implementation of the policy.

Among the many capabilities of WhiteKnight2, it can launch a rocket with up to 200 Kg payload to low earth orbit. Other horizontal launch spaceplanes will carry similar orbital launch capability. Where fast access to space, at low cost, with smallish payload is the primary market priority, these vehicles will service both public and private needs from airports upgraded to SpacePort runway and traffic control standards. The needs of ORS might be met by this service.

Other examples of private-commercial services for government missions include:

- * WhiteKnight1 has been contracted for unspecified missions from Edwards - Muroc.
- * NASA has contracted SNC and Virgin Galactic to modify Dream Chaser for attachment to WhiteKnight2. WhiteKnight2 will carry an unpowered Dream Chaser up to 50,000 ft for release and dynamic glide testing.
- * NASA has contracted Virgin Galactic for up to 3 flights of SpaceShip2. Price is between \$2.5 million and \$4.5 million. Missions will be educational and research.
- * Jerry Larson's UP Aerospace SpaceLoft XL rocket has been qualified for CRUSR missions. UP Aerospace is a privately developed vertical launch sounding rocket. The New Mexico Space Grant Consortium (Student Launches), Celestis, AFRL, and several aerospace contractors use SpaceLoft rockets several times each year.

Education needs will expand a great deal, and will benefit most from the economic success of private-commercial space industry. In 2003, I learned that there is a 20 to 30 year gap in fabrication skills, as well as STEM skills, needed in aerospace manufacturing. Unlike stem skills, we humans learn fabrication skills best between ages 8 and 12! Increased skills demand and funding from an expanding private-commercial space industry will help meet these challenges.

Student imaginations are being kindled with ideas and opportunities from New Space. IMAGINATION + STEM + FABRICATION = INNOVATION ! When STEM becomes the tool turning imagination into achievement, rather than the end in itself!, education becomes an inspirational joy, enterprise flourishes, and prosperity grows.

Following are just a few of the foreseeable skill assets and education needs for New Space enterprises:

- * Financial planning and market analysis
- * SpacePlane and rocket turnaround services: including propellants, vehicle safety inspections, maintenance, and repair.
- * Planning, design, construction, and testing of payloads. Hooray for New Mexico's Student Launch program, now being extended and expanded from middle school to grade school projects.

- * Electronics design, construction, and testing
- * Proper uses of exotic metals, materials, and processes in manufacturing
- * Systems integration, with design for reliability - durability in the total system.
- * Direct digital fabrication methods, materials, and machinery
- * High speed navigation, spaceplane flight, and astronavigation
- * SpacePort traffic management and control. Happily, the Cameron organization is moving to provide the tools and training for this field, using the SpacePort America paradigm plus standards and procedures from the FAA Center for Excellence - Commercial Space Transportation.

In conclusion, like the last Golden Age pioneers, adventurers, and entrepreneurs, we are privileged to be standing up an entire industry. Together, using our best skills, knowledge, technology, and market insights, we will create new enterprises of prosperity, here on Earth, and beyond the Earth! One of our challenges is to identify and fill the many new and valuable market niches in this industry.

Dad's Golden Age was about exploration and adventure--pioneering new enterprises and markets. Aviation entrepreneurs of the 1930's imagined, discovered, and implemented new opportunities through the sky, enhancing prosperity for both providers and consumers. Replace the phrase "through the sky" with "in space" and it pretty well covers New Space private-commercial opportunities.

Circa 1965, Dad illustrated to me his respect for other's achievements. We went to a vintage aircraft fly-in in Tucson, where I saw a Howard DGA for the first time. Benny Howard was the designer and pilot of very successful air race planes, including "Mike" and "Ike", and "Mr. Mulligan". The DGA was a high wing, four place tail dragger. Like most Vega's, it had a 450 HP radial Pratt engine, a snug NACA cowl, sleek wheel pants, and an overall sleek, muscular look, similar to a late model 7 place Vega, but smaller. I asked Dad if it was a copy or derivative of the Vega design. He told me it was not derivative, and was a Howard DGA. For some reason, I asked what DGA stood for. Dad told the classic Benny Howard story... When the first of these planes flew, someone asked Benny what the airplane was. Benny replied, "Well, I guess it's a Damn Good Airplane!". Thus, the DGA identification came about. Then Dad added, "and it was!" Dad never thought to mention that DGA's ended Lockheed domination in cross-country air races and executive transport business aircraft. His thought was only that Howard had identified a viable market niche and filled it better than earlier Lockheed products. He never told me the rest of that story.

Only a few years ago, I discovered the successes of DGA's and the Lockheed aircraft they outperformed. Dad never mentioned it, because it was not important to him! When he was building aircraft, they were exploring opportunities in a blossoming industry, not focussed on maintaining total control of a niche.

There will be opportunities for best success in New Space industry through applying that intention again.