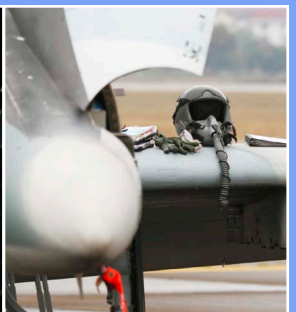
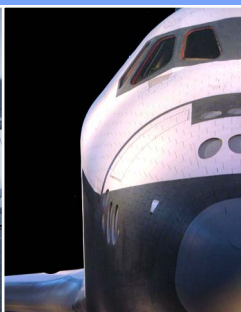




THE AEROSPACE INDUSTRY In Southern California



The LAEDC, the region's premier business leadership organization, is a private, non-profit 501(c)3 organization established in 1981.

About the LAEDC

The LAEDC, the region's premier economic development leadership organization, is a private, non-profit organization established in 1981 under section 501(c)(3). Its mission is to attract, retain, and grow business and jobs for the regions of Los Angeles County. Since 1996, the LAEDC has helped to retain or attract nearly 180,000 annual jobs in Los Angeles County with an estimated labor income, including wages and benefits, of nearly \$11 billion. Taken together with the supported indirect and induced economic activity, a total of more than 400,000 annual jobs with labor income of more than \$21 billion were impacted, accounting for an estimated \$850 million in property and sales tax revenues to the County of Los Angeles.

Regional Leadership

The members of the LAEDC are civic leaders and ranking executives of the region's leading public and private organizations. Through financial support and direct participation in the mission, programs, and public policy initiatives of the LAEDC, the members are committed to playing a decisive role in shaping the region's economic future.

Business Services

The LAEDC's Business Development and Assistance Program provides essential services to L.A. County businesses at no cost, including coordinating site searches, securing incentives and permits, and identifying traditional and nontraditional financing including industrial development bonds. The LAEDC also works with workforce training, transportation, and utility providers.

Economic Information

Through our public information and for-fee research, the LAEDC provides critical economic analysis to business decision makers, education, media, and government. We publish a wide variety of industry focused and regional analysis, and our Economic Forecast report, produced by the **Kyser Center for Economic Research**, has been ranked #1 by the Wall Street Journal.

Economic and Policy Analysis Group

The LAEDC Economic and Policy Analysis Group offers thoughtful, highly-regarded economic and policy expertise to private- and public-sector clients. The group focuses on economic impact studies, regional industry analyses and economic issue studies, particularly in water, transportation, infrastructure and workforce development policy.

Leveraging our Leadership

The LAEDC operates the World Trade Center Association Los Angeles-Long Beach (WTCA LA-LB), which facilitates trade expansion and foreign investment, and the LAEDC Center for Economic Development partners with the Southern California Leadership Council to help enable public sector officials, policy makers, and other civic leaders to address and solve public policy issues critical to the region's economic vitality and quality of life.

Global Connections

The World Trade Center Association Los Angeles-Long Beach works to support the development of international trade and business opportunities for Southern California companies as the leading international trade association, trade service organization and trade resource in Los Angeles County. It also promotes the Los Angeles region as a destination for foreign investment. The WTCA LA-LB is a subsidiary of the Los Angeles County Economic Development Corporation. For more information, please visit www.wtca-lalb.org

Table of Contents

I.	Introduction	1
	Defining the Aerospace Industry	2
II.	Overview of the U.S. Aerospace Industry.	3
III.	The Aerospace Industry in Southern California	10
IV.	What's Next for the Aerospace Industry in Southern California?	19
V.	Appendix.....	25
	History of the Aerospace Industry in Southern California.....	26
	Major Defense Contracts	30
	Sources.....	35

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Introduction

The aerospace industry in Southern California has a long and remarkably rich history that began not long after the Wright brothers accomplished the first powered flight at Kitty Hawk in 1903. As the twentieth century unfolded, the rise of the aerospace industry was instrumental in transforming Southern California into an industrial powerhouse. The aerospace industry altered both the physical and cultural landscape of the region. When floods threatened wartime production, flood control channels were built. As aeronautical technology advanced, test fields and research centers were constructed. As the demand for highly skilled workers grew, so did the ranks of the middle class. Following World War II, on a rising tide of prosperity, thousands of aerospace workers were able to buy homes, automobiles and consumer goods. Families were able to send their children to college. The regional economy boomed as money poured into the region from government and commercial production.

Over the last century, early aviation pioneers in the region transitioned from small workshops and hand-built aircraft to huge factories that produced bombers and fighters at an astonishing rate and employed tens of thousands of Southern California workers. In 1933, all the airplane factories in Southern California employed approximately 1,000 people combined. By November 1943, that number had risen to 280,300 workers.¹ Airplanes were rolling off production lines faster than the enemy could shoot them down. By the end of WWII, half of all industrial production in the world took place in the U.S., due in large part to the aerospace industry.

After the war, technological innovations pioneered by the region's aerospace firms made the industry an important driver of economic growth in Southern California. However, with the end of the Cold War in the late 1980s came defense budget cuts and military base closures. In response, the industry's largest firms contracted in a wave of consolidations and, as a result, many smaller, second and third tier contractors were forced to close their doors. The result was the loss of thousands of jobs.

The aerospace industry has undergone dramatic changes over the past twenty-five years in response to economic and political forces. Looking ahead, both of these forces will continue to shape the industry's role in Southern California's economy over the coming decades.

¹ Aerospace States' Incentives to Attract the Industry; Rosa Maria Moller, Ph.D. (2008)

Defining the Aerospace Industry

The aerospace industry is comprised of companies that manufacture aircraft (civil and military), missiles, satellites and other space vehicles and the companies that manufacture and distribute parts and components. Buyers of these products include private industry, the military and government space administrations.

Definitions of the aerospace industry vary widely and often include military applications such as land and naval vehicles as well as security and defense contracting software and services. For the purposes of this report, the aerospace industry is confined to two manufacturing sectors: aerospace product and parts manufacturing, and search, detection and navigation instruments manufacturing.²

Today, aerospace is a highly concentrated industry, dominated by a small number of large firms that are supported by a large number of smaller contractors. It is also characterized as a capital intensive and high-value added industry. Profitability depends a great deal on technical expertise, innovation and the ability to accurately price long-term contracts for programs that may take years to design, develop and build.

Demand for aerospace products is driven by both civil and military requirements. On the civil aviation side, demand for air travel, and thus aircraft, is derived from the strength of the domestic economy and from foreign economies, especially those of emerging nations with a rapidly expanding middle-class. The U.S. military budget, and to some extent, the budgets of foreign buyers of U.S. military aerospace products (both of which are based on the underlying threat of warfare), are also significant sources of demand.

The aerospace industry is essential to the national and Southern California economies because it provides a significant number of high-paying, high-skill jobs. It also makes a positive contribution to the U.S. trade balance. In fact, aerospace manufacturing is critical to President Obama's National Export Initiative (NEI) goal of creating jobs by doubling U.S. exports. Data published by the U.S. Department of Commerce demonstrate that U.S. aerospace manufacturers are internationally competitive, accounting for the highest trade surplus of all U.S. manufacturing industries.³

² North American Industry Classification (NAIC) codes 3364 and 334511, respectively.

³ The Department of Commerce definition of the aerospace industry includes aircraft conversion, and aircraft overhaul and rebuilding as well as manufacturers of products used by airports and airport security and does not include manufacturers of search, detection and navigation instruments.

Additionally, technological innovations developed by the aerospace industry have spilled over into the wider economy providing opportunities for growth in a number of other industry sectors.

This report will examine how the aerospace industry affects the economy of Southern California. It will explain why the aerospace industry is still an important driver of economic growth in the region and why it will continue play a prominent role in the years to come as it evolves to meet the challenges and opportunities rapidly unfolding before it.

Overview of the U.S. Aerospace Industry

Technological innovation is one of the defining characteristics of the U.S. aerospace industry. Beginning with World War II, aerospace and other major sectors in the U.S. were harnessed for the allies' war effort and played a major role in the economic growth of the nation. Billions of dollars in federal spending poured into Southern California. Technological innovations were primarily driven by the need to fight the war through improvements in armaments, communications and surveillance. This led to numerous advances in airframe construction, avionics, materials (e.g. synthetic rubber), electronics, radar, and meteorology.

As World War II gave way to the Cold War, other technological developments grew from the aerospace industry and related sectors including supersonic flight, communications satellites, microwaves and GPS navigation. As these examples illustrate, several innovations that initially come about because of a military need ultimately resulted in private, commercialized applications that are taken for granted today. Innovations in aerospace-related industries have also led to safe and efficient air travel for millions of people. Increased communications through the use of satellites and other technologies have augmented the spread of knowledge and the process of globalization.

Facilitating the creation of these new technologies is the close relationship that has grown up between aerospace (and defense) manufacturers and the U.S. government, which has the resources and capacity to fund research and development (R&D) budgets for large multi-year projects. The Office of Management and Budget publishes data on federal research and development outlays dating back to 1949. From 1949 to 1961, federal outlays for defense-related research accounted for 80% of all federally funded R&D. During the following years up until 1981, funds for defense- and nondefense-related⁴ R&D were more evenly matched, with defense outlays averaging 53% of the total. During defense build up

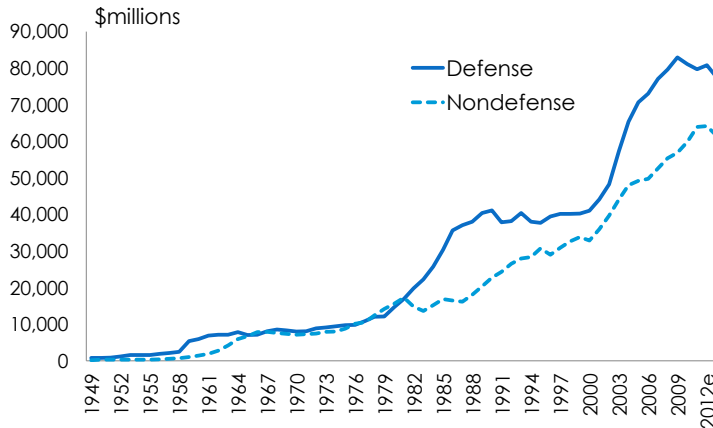
Innovations Originating in Aerospace Research

Automobile GPS Systems
Weather Forecasting
Invisible Braces
Scratch Resistant Lenses
Long Distance
Telecommunications
Cordless Tools
Water Filters
The Artificial Heart
Computer Joysticks
Golf Ball Aerodynamics
Robotic Arms & Hands
Whale Tracking Technology
Wireless Communications
Quartz Clock
Machine Tool Software
The Electric Car
Athletic Shoes

⁴ Nondefense-related R&D includes general science, space (NASA), technology, energy, transportation (DOT), health (NIH), agriculture, natural resources and the environment.

of the Reagan years through 1990, funding for defense R&D once again took center stage, averaging about 65% of total outlays. Over the last 20 years, defense's share has edged down to an average of 57%.

Composition of U.S. Federal Outlays for Research & Development



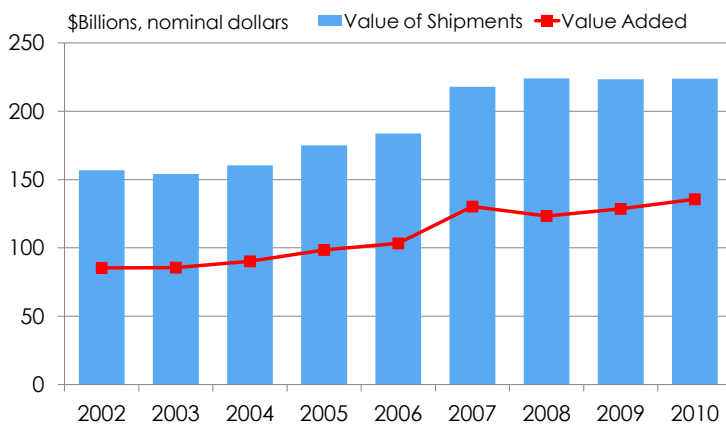
Source: Office of Management and Budget

Aerospace and related industries were also instrumental in the rise of the middle class during the second half of the twentieth century. Aerospace workers enjoyed higher average annual wages compared with other manufacturing industries and continue to do so today. However, after the end of the Cold War, Pentagon budget cuts and commercial airline consolidation resulted in drastic declines in aerospace industry employment. Nevertheless, even as the industry was reducing its workforce, revenues swelled on a tide of rising productivity.

The value-added⁵ component of aerospace and defense activities has increased, especially over the last decade, and continues to make a significant contribution to U.S. gross domestic product (GDP). Indeed, the value-added component of aerospace manufacturing has been growing at a faster rate than the total value of shipments. Between 2002 and 2010, the value of aerospace shipments increased by 42.6% while the value-added component shot up by 59.0%. In 2010, the two industry sectors examined in this report alone contributed nearly one percent to total GDP.

⁵ The value-added component of an industry's output, also referred to as gross domestic product-by-industry, is the contribution of a private industry or government sector to overall GDP. Value-added equals the difference between an industry's gross output (consisting of sales or receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semi-finished goods, and services that are purchased from all sources).

Value of Aerospace Shipments



Source: BEA, Census Bureau Annual Survey of Manufacturers

The aerospace industry also makes a significant positive contribution to the nation's trade balance. In 2011, the industry exported \$81.9 billion in goods (the bulk of which were civil aerospace products) and imported \$35.5 billion for a positive net trade balance of \$46.4 billion. Although the aerospace industry (as defined in this report versus the Department of Commerce as cited earlier) ranked sixth in terms of gross exports in 2011, it had the second highest net trade surplus, just behind chemicals. The top five U.S. export markets for aerospace products are France, China, Japan, the United Kingdom and Germany. The top five foreign aerospace suppliers to the United States are France, Canada, the United Kingdom, Japan and Germany.

Table 1: 2011 Comparative Trade Balances by Manufacturing Sector (\$millions)

End Use Description	Exports	Imports	Trade Balance
Industrial machinery	142,277	134,333	7,944
Computers & electronic products	140,262	219,817	(79,555)
Petroleum & coal products	135,909	457,351	(321,442)
Chemicals (excluding medicinals)	122,925	75,069	47,856
Agriculture, food & feed products	117,291	83,858	33,433
Aerospace & defense	81,946	35,526	46,420

Source: Bureau of Economic Analysis

Table 2: 2011 Aerospace Trade Balance (\$millions)⁶

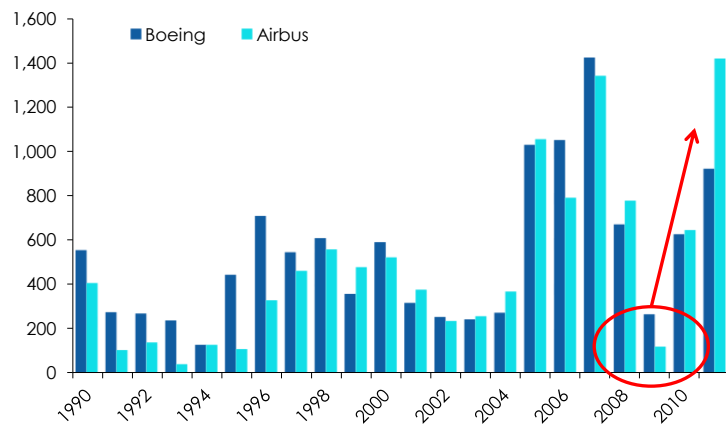
End Use Description	Exports	Imports	Trade Balance
Civilian aircraft, engines	80,175	35,360	44,815
Spacecraft, engines & parts	32	166	(134)
Military aircraft & parts	1,739	0	1,739
Total	81,946	35,526	46,420

Source: Bureau of Economic Analysis

The civilian aerospace industry was hit hard by the recession, with a plunge in orders for new aircraft, both from domestic and international customers. In 2009, combined Boeing and Airbus orders fell by 74% compared with 2008. By 2010, sales and production in the large commercial aircraft segment had turned around. Orders surged by 234% in 2010 and in 2011 were up by 84%.

In 2011, commercial aircraft manufacturers in the United States produced a record 1,011 airplanes. Additionally, the number of orders booked reached their second highest level ever.⁷ While this is great news for the industry, aircraft manufacturers could be facing supply chain disruptions in the short-term. The rapid increase in aircraft orders and requirements for faster production times has sent subcontractors scrambling to ramp up their own production lines in order to meet projected increases in demand.

Boeing & Airbus Orders



Source: Boeing & Airbus Company Websites

⁶ Totals do not directly correspond to NAICS based trade statistics due to broader coverage used by the Department of Commerce, International Trade Administration

⁷ Aerospace Industries Association

Commercial aerospace companies clearly see opportunities around the globe. China will become the second largest national aviation market in the near future. By 2020, China plans to add more than 80 civil airports to its national transportation network. Brazil will host the 2014 FIFA World Cup and the 2016 Olympics, both of which will require upgrades and expansion of their air travel infrastructure. India has plans to increase the number of its commercial airports from 80 today to more than 500 over the next decade.⁸

All three of these countries have an expanding middle-class that increasingly will be able to afford air travel, creating opportunities for U.S. aircraft manufacturers. At the same time, foreign competitors (many of which receive government support) are pushing ahead determined to challenge the market dominance currently enjoyed by Boeing and Airbus. These include China's Commercial Aircraft Corporation and Canada's Bombardier. Other countries with emerging aerospace industries include Japan, Brazil, India, Israel and Russia.

This is an especially exciting time for U.S. manufacturers of space vehicles. With the retirement of the Space Shuttle last year, new opportunities are evolving for the private sector. A number of aerospace companies, many of which are located in Southern California, are developing new systems for transporting personnel and supplies to the International Space Station. In June 2010, President Obama signed a new National Space Policy, which places less focus on national security space concerns and more emphasis on developing commercial space capabilities by promoting U.S. exports, minimizing the regulatory burden on the industry, and fostering fair and open international trade in space-related products and systems.

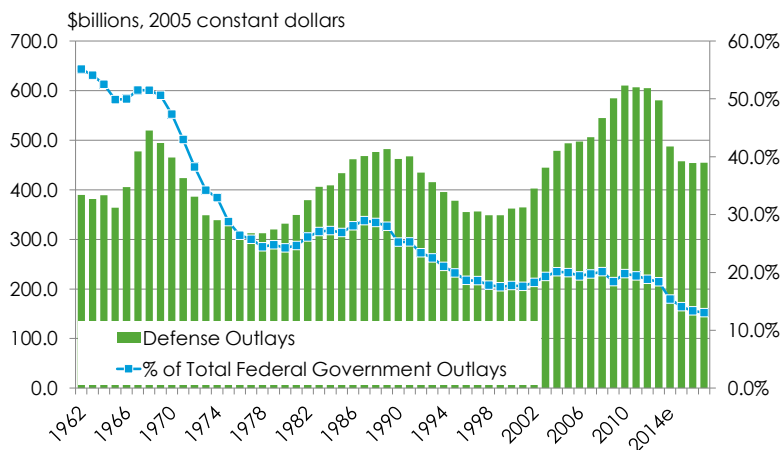
Acting on last year's Budget Control Act, the industry is planning for an estimated \$500 billion reduction in defense outlays over the next decade. The failure of the special congressional panel (aka "The Super Committee") last year to work out a deficit-reduction deal triggers a provision in the law that calls for the defense budget to be cut by over \$50 billion a year, or about 10% of the Department of Defense's (DOD) \$531 billion annual budget over the next 10 years (a process called sequestration). Not knowing exactly how the Pentagon will impose cuts makes for an uncertain environment that slows investment and hiring. This follows on top of \$489 billion in Pentagon-related budget cuts already called for in the 2013 budget proposed by the U.S. Senate. While members of Congress have proposed alternatives, if cuts are applied across the board to all programs, the DOD will have less discretion to spare higher-priority programs. As things stand now, jobs losses, cost

⁸ Flight Plan 2011 Summary, Department of Commerce, International Trade Administration

cutting and a pullback in investment are a near certainty in the coming years.

In addition to cuts in procurement spending, DOD budgets for research and development will also decline. The challenge over the next decade will be how to maintain the aerospace industry's base of skilled workers and investment in R&D, the concern being that when the defense budget pendulum swings the other way, the U.S. may find itself years behind in the research and development of new technologies. Additionally, domestic aerospace contractors with a defense component are experiencing greater competition from emerging economies that are developing their own domestic aerospace and defense industries.

U.S. Defense Outlays



Source: Office of Management and Budget

Given the expected slowdown in U.S. defense spending, it makes sense that domestic aerospace firms are looking for opportunities in adjacent markets in the form of military sales to foreign governments and in the transfer of military technology to civil applications. Growth in foreign military sales may replace some revenue, but this is by no means assured. A more likely way forward is to move into areas that will continue to grow even as defense budgets decline: cyber security, intelligence surveillance and reconnaissance, defense electronics and energy security.

The aerospace industry has long been a leading catalyst for technological innovation in the United States, with Southern California's aerospace firms taking the lead for much of the industry's history. The aerospace industry remains a vital sector for both the national and Southern California economies. Since the first powered flight at Kitty Hawk in 1903, advances in the aerospace industry have not only contributed to

national security, but have also brought the world low-cost and safe air travel, improved communications, new consumer products and advances in medical technology.

Viewed in this light, it is not an exaggeration to say that the aerospace industry has give rise to greater global integration between individuals, business and national economies.

Table 3: Leading U.S. Military Contractors

Contractor	% of Sales from U.S. Government	Employees
Northrop Grumman	90%	70,000
Lockheed Martin	82%	123,000
Raytheon	74%	71,000
General Dynamics	69%	93,000
Boeing	47%	170,000

Note: Boeing includes international military sales

Source: The Wall Street Journal

Table 4: Ranking of U.S. Aerospace & Defense Companies Among Forbes' World's 2,000 Largest Companies

Rank	Company	Sales (\$Bn)	Profits (\$Bn)	Assets (\$Bn)	Market Value (\$Bn)
120	Boeing	68.28	1.31	62.05	48.45
146	Lockheed Martin	45.19	3.02	35.11	29.61
181	General Dynamics	31.98	2.39	31.08	28.51
216	Northrop Grumman	33.76	1.69	30.25	19.08
246	Raytheon	24.88	1.94	23.61	21.53
463	L-3 Communications	15.62	0.90	14.81	10.62
716	Precision Castparts	5.65	0.94	7.46	16.46
806	Goodrich	6.69	0.60	8.74	8.42
878	SAIC	10.68	0.49	5.41	7.72
1048	Rockwell Collins	4.44	0.56	4.65	9.18

Source: Forbes.com

The Aerospace Industry in Southern California

At the height of the Cold War, 15 of the 25 largest aerospace companies in the United States were based in Southern California. Today, all but a handful of the largest of those original firms have closed their doors, have moved elsewhere, or have been absorbed through a wave of mergers and consolidations that swept through the industry in the 1990s. The industry is considerably more concentrated today than in past decades, especially for companies whose primary customer is the U.S. Government.

In 1987, California accounted for one in four aerospace jobs nationally, and in Los Angeles County, the share was one in ten. Following the collapse of the Soviet Union and the end of the Cold War, the Department of Defense (DOD) sharply curtailed procurement spending. In 1995, DOD spending fell below \$50 billion for the first time since 1982. Nowhere in the country were the changes in Pentagon outlays more apparent than in Southern California.

With the end of the Cold War came defense budget cuts and military base closures. Aerospace companies in the region met the challenge by merging with one another and consolidating operations. Many smaller contractors were forced to close their doors or look for business outside the industry. Already in a recession,⁹ Southern California's economy went into a tailspin. The severe contraction of the aerospace industry added a structural component to the downturn. As the business cycle turned up again elsewhere in the country, the permanent loss of thousands of aerospace jobs in the region led to a longer and deeper recession in Southern California. During this time, many skilled former aerospace workers scattered to other industries or other parts of the country.

Today, while Southern California may no longer be *the* focal point of the aerospace industry in the United States, aerospace is still an extremely vital component of the regional economy. Southern California's aerospace firms continue to provide a significant number of high-paying jobs and are an important incubator for technological innovation. Although complete airplanes are no longer built from the ground up in the area, final assembly of some aircraft still takes place in Southern California, notably the Boeing C-17 and the Northrop Grumman Global Hawk unmanned vehicle.

Modern aircraft have become amazingly complex and require millions of individual parts as well as support systems to operate and maintain these



Southern California Aerospace Test and Research Facilities

Dryden Flight Research
Center

Jet Propulsion
Laboratory

Los Angeles Air Force
Base

Vandenberg AFB



⁹ This was a national recession that lasted from July 1990 to March 1991; see NBER.org

vehicles. The industry has evolved during the past two decades to consist primarily of a large base of subcontractors who manufacture parts and assemblies for a variety of aircraft, ranging from fasteners to aircraft seating and in-flight entertainment systems to 747 fuselage panels.

Furthermore, a significant proportion of aerospace electronic components are produced in Southern California. Southern California is also a beneficiary of the growing importance of information in modern warfare systems (i.e. the rapid transfer of information between military units in the air, on the ground and at sea). The region's strong information technology base is attracting new opportunities for this growing segment of the industry.

Aerospace Employment Trends

Region	Employment, thousands		1990-2000 % Change	2000-2011 % Change	1990-2011 % change
	1990	2011			
U.S.	1,105.8	663.3	-40%	-6%	-44%
California	321.5	139.0	-57%	-23%	-67%
Southern California	271.7	88.4	-57%	-24%	-68%
Los Angeles County	189.0	59.2	-56%	-29%	-69%
Orange County	42.1	15.0	-53%	-25%	-65%
San Diego County	28.7	11.5	-70%	33%	-60%

Source: California EDD, QCEW Data

Employment in the Southern California Aerospace Industry

Southern California lost a significant number of aerospace and defense-related jobs in the 1990s. The region's aerospace industry employed nearly 272,000 workers in 1990, but had shed nearly 142,000 jobs -- over half of its workforce -- by 2000. The sharp decline in employment strongly affected the overall regional economy, causing a protracted downturn in Southern California that lasted several years after the national economy recovered from the 1990-91 recession.

The job losses continued but at a much slower pace throughout the opening decade of the twenty-first century. Following the attacks of September 11, military spending soared and aerospace firms with a defense component booked record profits. By 2010, DOD procurement

spending had risen to more than \$147 billion, nearly three times the amount in 1995.

Unfortunately, this did not translate into large gains in employment for Southern California's aerospace firms. Productivity gains achieved through technological innovation reduced the number of workers needed to meet production goals. Firms were able to increase output with fewer workers, a trend that has been reshaping the nation's entire manufacturing sector over the last three decades. For example, parts that once required a skilled worker to assemble or shape can now be built by a robot. Outsourcing of component parts and subassemblies to foreign manufacturers also contributed to the decline in the region's aerospace workforce.

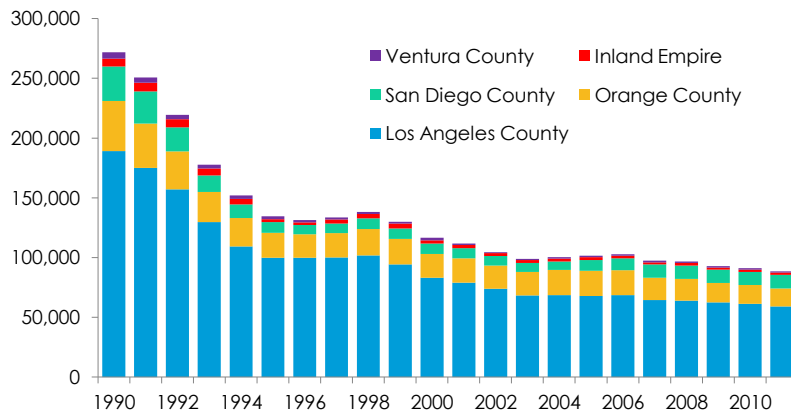
Aerospace employment has declined across the nation since 1990, but California has suffered disproportionately. While total U.S. aerospace employment declined by 40% between 1990 and 2000, California experienced an even steeper decline, losing 57% of its aerospace workforce. Job losses were similar throughout much of Southern California with the exception of San Diego County, which experienced a drop of 70%.

The industry continued to shed jobs over the following twelve years (2000 to 2011), but at a much slower rate. The decline over the past decade for the nation as a whole was only 6% (which was rather better than the experience of most other manufacturing sectors in the U.S.), but that still equated to the elimination of nearly 443,000 high-quality jobs. Things were worse in California where aerospace employment shrank by 23% over the same time period, while employment in Los Angeles County fell by 29%. Over the last 20 years, Los Angeles County has seen its aerospace manufacturing workforce shrink by nearly two-thirds or by almost 130,000 jobs.

San Diego County was the only region in Southern California that made up some of the ground lost during the 1990s, posting a gain in jobs of 33% between 2000 and 2011. All of the new jobs were in the search, detection and navigation (SDN) instruments sector – employment more than doubled during this period from 2,340 jobs to 5,200 jobs.

Moreover, in addition to the declines in employment in absolute terms, Southern California's share of aerospace related employment declined as well. As a percentage of the nation's total aerospace employment, Southern California's share fell from nearly 25% to just 14.4% in 2011. California as a whole continues to employ the largest number of aerospace workers, but has lost share to Washington, Texas, Arizona, Georgia, Ohio and Illinois.

Southern California Aerospace Employment



Source: California EDD, QCEW Data, 2011

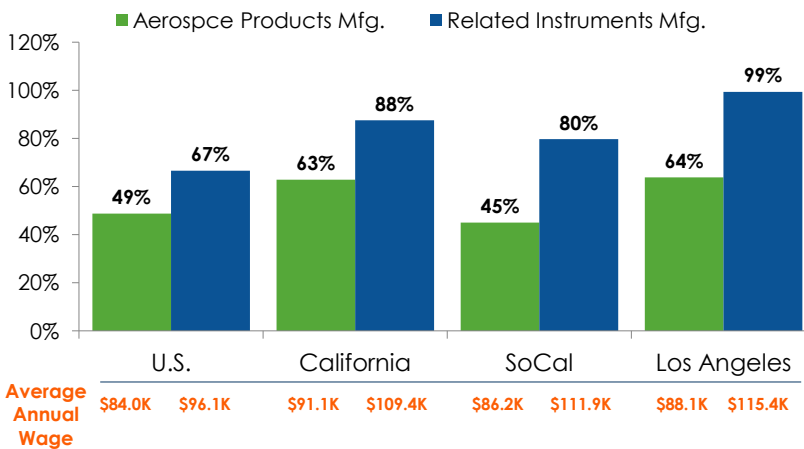
Southern California Wages in the Aerospace Industry

Nationwide, aerospace manufacturing wages are significantly higher than the average wage in the manufacturing sector as a whole. Wages in the aerospace products and parts manufacturing sector in 2011 were 49% higher, and wages in the SDN instruments sector were 67% higher.

In 2011, the average annual wage in Southern California in the aerospace products and parts manufacturing sector was \$86,200, while the average for the SDN instruments industry was \$111,900. This compares to the national average of \$84,000 for aerospace products and parts manufacturing and \$96,100 for SDN instruments. Wages in the aerospace industry are even higher in Los Angeles County. The average annual wage for aerospace products and parts manufacturing in Los Angeles County in 2011 was \$88,100 and for workers in the SDN instruments sector, the average annual wage was \$115,400.

In Southern California, wages in the aerospace products and parts manufacturing sector were 45% higher than the average manufacturing wage, while wages in the SDN instruments sector were 80% higher than the average manufacturing wage. In Los Angeles County, the gap was even wider. Workers making aerospace products and parts earned 64% more on average than their counterparts in other manufacturing sectors, while persons employed in the SDN instruments sector, earned nearly double.

Aerospace Mfg. Wage Premiums



Source: California EDD, ES202, 2011

Snapshot of Aerospace Firms in Southern California

When analyzing an industry in a particular region, it is useful to have an understanding of how it is organized. That is, are firms clustered in a particular geographic region? Is the industry made up mainly of small firms? Are they importing or exporting? How many people are employed and what kinds of revenues are these firms generating? In order to answer these questions, the LAEDC conducted a Dunn & Bradstreet search of aerospace firms in Southern California based on the two NAICS codes (3364 and 334511) described in this report. There are some limitations to this data because it is less inclusive than the data collected by the government agencies used in this report to source employment and wage data, but some interesting patterns do emerge.

The results of the search returned 384 firms that listed either of the two NAICS codes (#3364 and #334511) as a primary or secondary description of their business. In some cases, a firm may list its primary industry as “hardware and fastener” manufacturing, but also indicates it produces products for the aerospace industry. It should be noted that because this discussion is confined to a narrow definition of the aerospace industry, it does not capture the full extent and size of the industry and its influence on the regional economy. For example, Northrop Grumman has 2,000 suppliers located in Southern California, but this analysis focuses on just 384 companies.

Unsurprisingly, Los Angeles County captured the majority of employees, firms and revenues. Of the surveyed firms, 42% of the workers were employed by Los Angeles County firms. San Diego County was next with

26%, followed by Orange County with 19%, the Inland Empire with 8% and Ventura County with 4%.

The largest number of establishments was also located in Los Angeles County. Los Angeles County is home to 47% of these establishments, followed by Orange County (26%), San Diego County (26%), the Inland Empire (11%) and Ventura County (4%). Across the six-county region, smaller firms dominate. Establishments with 1-99 employees comprised 79% of listed firms. Those with 100-499 employees made up 17% of the total, and firms with more than 500 employees were just 4%.

The distribution of revenues departed from the pattern established above. Based on the firms included in this data, revenues earned by Los Angeles County firms comprised 29% of the total, whereas San Diego County, with considerably fewer employees and establishments, was nearly even, earning 28% of total revenues. One reason for this is that San Diego County has a disproportionately higher number of large firms. Less “nuts and bolts” manufacturing goes on in San Diego County as well. Aerospace manufacturing in San Diego County leans toward the higher value search, detection and navigation instruments manufacturing sector. Looking at the most recent five year period, 30.5% of firms in San Diego County were engaged in related instruments manufacturing versus 16.4% in Los Angeles County during that same period.

Finally, how open are the region’s aerospace firms to international trade? Of the 384 firms included in the data set, 74 (25.8%) report importing parts or materials, and 47 (12.1%) reported exporting at least a portion of their products.

Value of Aerospace Shipments in Southern California

Data for the value of aerospace shipments is harder to come by at the local level than it is at the national level. The U.S. Census Bureau’s Annual Survey of Manufacturers does publish data at the state level, but only for one of the two NAICS codes used in this report: aerospace products and parts manufacturing (#3364). Based on just this one industry sector, the value of California’s aerospace shipments in 2010 was \$27.5 billion with a value-added component of \$19.4 billion or 9.8% of California’s total gross product of \$1.9 trillion.

Data at the county level is not available, but if the statewide value of shipments is allocated based on employment, a rough estimate for the value of Southern California’s aerospace products can be derived. In 2010, Southern California employed 80% of the state’s workers in aerospace products and parts manufacturing. Applying that same ratio to the total value of aerospace shipments in California, the LAEDC

estimates Southern California's share was approximately \$22.1 billion. The value-added component equated to approximately \$15.6 billion or 8.8% of the state's total gross product in 2010.

Table 8: Value of Aerospace Products Shipments in Southern California

Year	California		Southern California	
	Value of Shipments (\$bns)	Value Added (\$bns)	Value of Shipments (\$bns)	Value Added (\$bns)
2004	19.1	11.2	15.5	9.1
2005	27.1	13.8	22.0	11.2
2006	21.9	13.5	18.1	11.2
2007	22.1	14.4	17.7	11.5
2008	23.8	16.8	19.2	13.5
2009	28.6	20.9	22.9	16.7
2010	27.5	19.4	22.1	15.6

Sources: BEA, U.S. Census Bureau Annual Survey of Manufacturers
 Southern California estimates by LAEDC; Value of aerospace products and parts manufacturing only (NAICS #3364)

Industry Outlook in Southern California

Commercial Aviation

According to the Aerospace Industries Association (AIA), the U.S. aerospace industry pulled out a relatively strong performance in 2011 and remains one of the most significant industrial sectors in the United States. Strong aircraft orders and the rollout of major new products contributed to industry gains in 2011. Boeing and Airbus reportedly have enough orders on their books to keep production lines humming through the next six to seven years. This is good news for the large number of subcontractors in Southern California who produce parts for these two giants of commercial aviation, especially as Boeing ramps up production of the 787 and 747-8 aircraft.

Global air traffic is expected to increase at an annual rate of 4.9% over the next 20 years, a considerably faster pace than global GDP growth projections. In order to keep up with the growing demand for air travel, the AIA estimates that the world's airlines will take delivery of 29,000 aircraft (to replace aging airplanes and expand fleets), valued at \$3.2 trillion by the end of 2029.

The forces driving commercial aircraft demand revolve around fuel prices and the rise of the emerging economies of Asia, Latin America and the Middle East. Persistently higher and variable fuel costs are prompting U.S. regional carriers to replace aging fleets with more fuel-efficient, and often larger, aircraft. This situation is also pushing the development of alternative aviation fuels. The U.S. is currently the leader in aviation fuel research. U.S. firms in this area of research are already conducting test flights using alternative fuels with the goal of achieving commercial production in the near future.

Military Aircraft

The U.S. military aircraft sector expanded by nearly 6.7% in 2011 with sales estimated at \$66.5 billion. Domestic purchases are expected to decline in the coming years, but it is not yet clear how far defense spending will fall. The uncertainty is putting enormous pressure on Southern California's defense-related aerospace companies. Foreign buyers of military aircraft provide one avenue for mitigating budget cuts at home, but the U.S. is facing growing competition from foreign manufacturers who are targeting the same opportunities.

Further industry consolidation will probably not provide the same relief as it did during the 1990s. The largest defense contractors may have grown too large to try to merge without conflicting with government regulators.

Space

Last year was a challenging time for the U.S. space industry. The retirement of the Space Shuttle caused the loss of thousands of high-tech jobs. There were also reductions in funding for NOAA weather satellites and national security space programs. Nonetheless, there are a number of bright spots going forward that include the NASA Exploration Initiative and the Space Launch System program, which is working to develop a new launch system to carry humans beyond Earth orbit. Although exploration and research are important, the market for space vehicles will continue to be driven by demand for satellites and launch services in the near- to mid-term.

Federal budget cuts will be the main challenge facing the region's space vehicle manufacturers. Competition from India, China and Russia is also on the rise. Perhaps strengthening the competitive stance of the U.S. is the government's increasing dependence on commercial systems to augment NASA space programs and launch capabilities. This has the potential to foster numerous new opportunities for the private sector.

Summary

The aerospace industry will continue to make significant contributions to Southern California's economy in the coming decades, but the industry is

once again at a crossroads. In defense, many of the region's firms will be forced to evaluate moves into adjacent markets. More worrisome is what will happen to the region's industrial base if it is forced by lack of funds to shift from investment in R&D and production of new capabilities to services and support for older, existing systems. Underinvestment in R&D could leave Southern California's aerospace and defense firms with limited capabilities to develop innovative technologies.

California's advantages to attract and maintain high-tech aerospace activities include an abundance of skilled labor, a rich infrastructure of test fields, universities and other educational and research centers, and the existence of a strong electronics industry. New market opportunities and improved industry efficiency are enhancing California's ability to compete in the commercial space arena and commercial applications of defense products. California could strengthen the competitiveness of its aerospace industry and its ability to retain and attract aerospace jobs by creating more favorable business conditions for the industry. The state can help by developing regulatory processes, tax policies and industrial development policies that nurture Southern California's aerospace industry and provide a strong platform on which to grow.



The Los Angeles Air Force Base

Located in El Segundo, the Los Angeles Air Force Base is the home of the Space and Missile Systems Center (SMC). The SMC is the Air Force's center for the development and acquisition of space and missile systems. Established in 1954, the SMC has been a leader in managing space systems since the beginning of the space program.

The SMC is an important part of Southern California's aerospace and defense industry. Although the existence of this facility is largely unknown to most people living in the region, the base employs approximately 4,500 workers including military personnel, civil service employees, the Aerospace Corporation (a dedicated federally funded research and development center) and technical support contractors. The SMC pursues partnerships with the broader space community to ensure an adequate technology base for space and missile programs. The SMC works with industry to develop standards and best practices by sharing information and benchmarking with individual companies.

The SMC is responsible for managing space systems from initial concept to development to maintaining post launch capabilities. Mission areas include satellites, payloads, launch vehicles, missiles, ground control systems, communications, navigation, space lift, missile warning, missile defense, and weather monitoring.

What's Next for the Aerospace Industry in Southern California?

The aerospace industry in Southern California is very much alive, but it is evolving. California's role as an innovation pioneer will continue, but the region's business leaders, educational institutions and policy makers cannot sit back and expect its role to remain unchallenged. California (and the U.S. for that matter) will need to become more competitive if aerospace is to remain in the ranks of its most important industries. The aging of the U.S. workforce also presents serious challenge. The Baby Boomer generation began retiring in 2011 and very few organizations have dedicated significant resources or implemented plans to close the skills gap that will open up as a result of older workers leaving the workforce. Particular attention needs to be focused on graduating more engineers and other STEM¹⁰ proficient workers.

There is no getting around the fact that the defense sector is an integral part the aerospace industry. Small swings in defense spending have huge impacts on the factory floors of aerospace companies. When there is a pull-back in defense spending, layoffs ensue, affecting not only aerospace workers, but rippling out into the wider community. Because aerospace is such a large industry, the direct and indirect effects of military spending cuts can be widespread and devastating.

Some of the larger programs in Southern California include:

- The Boeing C-17 aircraft – this program is set to terminate in 2014 unless additional orders are placed by foreign buyers.
- The F-35 Joint Strike Fighter – this is a Lockheed program but the fuselage is built by Northrop Grumman at their facility in Palmdale with composite work also provided by Northrop at their El Segundo facility. Many other smaller local contractors supply components. Final assembly takes place in Texas.
- The F-18 – this is a Boeing program, with Northrop Grumman participating as a major subcontractor. Approximately 40% of the F-18 is built in Southern California.

Further consolidation among both large and small companies in the industry is likely. As budgetary pressures from the Pentagon mount, there will be fewer opportunities to increase revenue through growth.

¹⁰ STEM: science, technology, engineering and mathematics

Aerospace firms will attempt to increase revenue by acquisitions instead. The largest will remain intact (Lockheed Martin, Northrop Grumman, General Dynamics, Boeing and Raytheon) so as not to conflict with U.S. anti-trust laws, but contractors in the next tier, those with revenues less than \$20-25 billion, are probable targets.

The aerospace industry will face significant challenges in the coming years. Defense markets are the most problematic given the current atmosphere in Washington DC. Defense contractors are facing 10 years of reduced demand from the Pentagon. Obviously, the defense industry is not about to come to a grinding halt, but contractors will be forced to focus on affordability when developing new weapons systems for the Pentagon. Additionally, less spending on research and development may result in shrinking a large part of the industry's innovation base, shifting focus from the development of new technologies, products and systems to service and support for older platforms and systems.

Policy makers need to be cognizant of how defense cutbacks may affect the nation's science and technology capabilities. Currently, the amount of federal science and technology R&D funding that goes toward defense is greater than total R&D funding across all other non-defense activities. Moreover, a significant percentage of U.S. scientists and engineers are employed by the defense industry. Given that reductions in the defense budget are a certainty, defense and related R&D cuts might be offset with increases in funding for civilian science and technology to avoid diluting the nation's science and technology capabilities. With its infrastructure of world-leading universities, research facilities and test fields, Southern California could greatly benefit from a shift in how the federal government allocates research and development dollars.

Still, in spite of impending defense cuts, opportunities for growth exist for both defense and civil aerospace activities. On the defense side, there are opportunities for the development of communications systems, unmanned aircraft systems (UAS) and satellites for military use.

On the civil aviation side, Southern California has a sizable pool of experienced subcontractors that will benefit from the global increase in demand for air travel and the need for domestic carriers to replace aging aircraft with new, quieter and more fuel efficient airplanes. Global demand is also on the rise for spacecraft, primarily to launch satellites, helicopters and business aircraft.

Drones or unmanned aircraft systems are being tested as tools for police and firefighters, as well as numerous other civilian applications. The FAA estimates 15,000 drones will be operated by civilian entities by 2020, with that number doubling by 2030. Potential uses are numerous and wide

ranging. For example, Northrop Grumman's Global Hawk was used in the aftermath of the Haiti earthquake to assess damage before aid teams were sent in. The Global Hawk has also been used to fight forest fires – they can fly at night and collect data to help firefighters predict fire behavior.

Currently, civilian drone use is restricted because of safety restrictions imposed by the FAA. Safety and privacy concerns are still being hammered out, but in 2012, Congress passed a law requiring the FAA to ease restrictions on commercial drone use in U.S. airspace by 2015. Next year, the FAA is expected to issue a rule allowing law enforcement and first responders to fly small drones. Questions regarding privacy remain an issue, but the Department of Homeland Security is drafting recommendations on how to protect people's privacy. AeroVironment, another Southern California (Monrovia) drone manufacturer, provides drones to the National Oceanic and Atmospheric Administration to aid in coastal mapping, surveys and wildlife monitoring.

There are estimates that global spending on unmanned aerial systems could reach \$89 billion over the next decade.¹¹ Given the high level of demand for these vehicles, several nations are ramping up their own research and development for drone programs hoping to capture some of this market.

Space-related activities are another sector where Southern California's aerospace firms are leading the way. In addition to established entities like Boeing's satellite division in El Segundo, a number of innovative aerospace firms have clustered at the Mojave Spaceport.

One of the latest developments in the space sector is the growing interest in small satellites. Until recently, the problem has been how to launch small payloads affordably. The cost of launching a small satellite using conventional launch platforms is three to ten times greater than that of larger payloads. The development of reusable vehicles with a high utility rate (i.e. capable of flying 100 to 150 times per year) is needed to bring costs down to a more affordable rate of \$300,000 for example, or less per launch.

Boeing has unveiled a Small Launch Vehicle (SLV) concept that could be in service by 2020. The SLV, which is a vehicle designed to carry payloads of up to 100 pounds is comprised of elements that are already flying or are at a high-technology readiness level. Virgin Galactic has also announced their own small satellite launch platform, LauncherOne.



Satellites have been in use for more than 50 years. The first U.S. satellite was launched in 1957, and the first commercial satellite was launched in 1962. There are over 500 satellites in use today.

¹¹ Teal Group Corporation 2012 UAV Market Profile and Forecast

Small inexpensive satellites are appealing both to firms looking to undertake their first space missions and to current satellite users adjusting to the reality of fixed or declining budgets. There are commercial and military applications for small launch vehicles. The downward trend in satellite size, the emergence of fractionated satellites¹² and affordable launch platforms will encourage market growth in the years to come. Drivers of small satellite demand include delivery of small payloads to orbital outposts (e.g. the International Space Station), military reconnaissance, weather monitoring, satellite servicing and space debris de-orbiting.

Another major trend in which Southern California firms are taking the lead is the “privatization” of space. Space Exploration Technologies (SpaceX) recently won a \$440 million contract with NASA to develop a successor to the Space Shuttle to transport astronauts into space as early as 2015. SpaceX made history earlier this year when its Dragon Capsule became the first privately built spacecraft to dock successfully with the International Space Station, a feat previously claimed by only four national governments (U.S., Russia, Japan and the European Union).

In addition to providing launch capabilities for NASA, other innovative companies are looking to expand opportunities for space travel to private citizens and researchers. Virgin Galactic expects to launch commercial services with SpaceShipTwo, a six-passenger aircraft (designed by Scaled Composites) by December 2012. SpaceShipTwo will air launch from WhiteKnightTwo to the edge of space, giving its passengers a few thrilling moments of weightlessness before gliding back to Earth. At this early stage, it is hard to estimate the value of the suborbital space flight market, but Virgin Galactic competitor Xcore (also located at the Mojave Spaceport) estimates a potential value of \$3 billion over the next few years.

Further opportunities for the privatization of space exist with the NASA Flight Opportunities Program. The focus of the Flight Opportunities Program is on research and development of new technologies. These flights provide researchers with three to four minutes of microgravity to test new technologies.

A **sub-orbital space flight** is one in which the spacecraft reaches space, but does not achieve orbital revolution. An object launched from Earth that reaches 62 miles above sea level and then returns to Earth is considered a sub-orbital space flight. Some sub-orbital flights are used to test spacecraft and launch vehicles later intended for orbital space flight. Other vehicles, such as Virgin Galactic's **SpaceShipTwo** and ICBMs, are specifically designed only for sub-orbital space flight.

¹² Fractionated satellites were developed by the Defense Advanced Research Projects Agency in 2006. A fractionated satellite involves the decomposition of a traditional satellite into a constellation of several smaller modules, each with a specific set of tasks to perform. For example, one module could be tasked with providing power to all the other satellites in the constellation or to provide a high speed data link to the ground for payload data. The sharing of resources is achieved through the use of a wireless connection between satellites.

Currently, NASA uses parabolic aircraft and suborbital launch vehicles that are capable of flying to altitudes above 62 miles, but one of the goals of the program is to foster the development of commercial reusable sub-orbital vehicles – an industry currently in its infancy. NASA's long-term vision for the industry is to develop reusable *orbital* vehicles that will provide lower-cost, more frequent and more reliable access to space, and allow scientists to ride into space with their experiments. According to NASA, the success of the program will be measured by the extent to which it can “infuse new technologies into NASA missions, while encouraging the development of commercial space services by enlarging the customer base for this emerging industry.”

Virgin Galactic has already announced plans to provide researchers with routine access to space either by giving them the opportunity to fly into space to conduct their research or by sending up unaccompanied payloads of up to 1300 pounds.

Conclusion

Going forward, the region's aerospace firms will need to work with educational institutions and policy makers to ensure an adequate supply of skilled workers. The imminent retirement of thousands of baby-boomers from the industry in the coming years is a serious concern. Training scientists, engineers and technicians should be a priority. The aerospace industry is facing stiff competition with other technology based industries and Internet companies for skilled engineers. Attention is usually focused on Silicon Valley as a technology center, but that ignores the larger center of high-tech activities that is Southern California's aerospace industry. It is also imperative that more Federal research and development dollars that are currently flowing into defense programs be directed to development of new technologies in the civilian sector.

The aerospace industry in Southern California is smaller (relative to the economy as a whole) than it was during the days of the Cold War, but it is no less innovative. The regional economy has become more diverse, but the aerospace industry continues to be an important economic driver employing highly skilled workers, providing high-paying jobs and driving innovation.

The usual answer to the question of why Los Angeles became the nation's aerospace capital is the local climate. In the beginning, before the development of electronic instrumentation, that was true. However, in the decades that followed, other factors came into play. The region's leaders actively supported the industry. There was a tradition of “boosterism” from local government, newspaper publishers and real estate developers. Additionally, local universities supplied research,

engineers and scientists. A synergy grew up between R&D labs, test fields, institutes of higher learning and the industry.

The history of Southern California and its economy are inextricably tied to the aerospace industry. While the industry has undergone many changes over the last 30 years, there are solid reasons why corporate relocations have not ended the aerospace presence in the region. Opportunities still abound for aerospace firms in Southern California – the industry's infrastructure, built over the course of 100 years would be hard to replicate elsewhere; there is an entrenched supplier base producing everything from fasteners to aircraft structural components and satellites. The region's talented workforce would also be difficult to recreate in other parts of the country. And, the weather is as nice as it was back in 1908 when the California Aero Club of Los Angeles organized the nation's first international air show in Rancho Dominguez. Still, we cannot overlook the threats posed by the changing aerospace landscape, the challenge of finding workers with the right skills and the new defense budgetary landscape.

Appendix

History of the Aerospace Industry in Southern California

The U.S. aerospace industry dates from 1903 when Wilbur and Orville Wright demonstrated their flying machine was capable of powered, sustained flight. The Wright brothers made the first sale of a military aircraft in 1908 to the Signal Corps of the U.S. Army (Model-A Flyer).

California's enthusiasm for flying began shortly thereafter and intensified during the 1920s. In the days before electronic instrumentation, California's weather attracted early aviation pioneers – airplane builders and pilots as well as military aviation activities to California.

- 1908:** The **Aero Club of California** was established in Los Angeles. The Aero Club organized the first aviation show in the United States that same year in Rancho Dominguez.
- 1910:** **Glenn Curtiss** (father of American Naval Aviation) began work to develop an airplane that could take off and land in water. **E.J. Hall** developed the first production engine designed to power aircraft.
- 1916:** The Loughead¹³ brothers established the **Loughead Aircraft Manufacturing Company**. The Loughead brothers produced the F-1, a ten-passenger airplane with a 74-foot wingspan that first flew in 1918. The Loughead Company went bankrupt in 1921.
- 1917:** Throop Polytechnic Institute in Pasadena (renamed **Caltech** in 1920) built its first wind tunnel.
- 1919:** Waldo Waterman started **Waterman Aircraft Manufacturing** in Venice to develop and produce the Mercury Gosling for the Mercury Aviation company.
- 1920:** David Davis and Donald Douglas created **Davis-Douglas Aircraft Company**. In 1921, Davis sold his interest in the business to the Douglas family.
- 1922:** T. Claude Ryan opened the **Ryan Flying Company** and later started the company that produced Charles Lindbergh's Spirit of St. Louis in San Diego. Ryan built the first production monoplane in the country. It was used by the Los Angeles-Seattle airmail service, which was managed by Pacific Air Transport the precursor of United Airlines.
- 1924:** Douglas became the largest provider of aircraft to America's military forces. It also entered the international market with the Douglas World Cruiser aircraft, which made the first around-the-world flight.

¹³ The spelling of the Loughead name was changed to Lockheed in 1926

- 1926:** The **Lockheed Aircraft Company** was formed. The first airplane produced by the company (Lockheed Vega) was the first airplane to fly over both polar regions. In 1929, Detroit Aircraft Corp. bought control of Lockheed but went bankrupt during the stock market crash later that year. A consortium bought the Lockheed Aircraft Corporation and re-launched the company as **Lockheed Corporation**.
- 1928:** Jack Northrop left Lockheed to establish the **Avion Corporation** in Burbank. Avion produced planes for TWA, the Department of Commerce and the Army Air Corps. Avion was purchased by United Aircraft and Transport Corp. in 1929 and operated as Northrop Aircraft Corp. until 1927.
- 1932:** Northrop and Donald Douglas formed the **Northrop Corporation** in El Segundo as part of Douglas Aircraft. The new subsidiary concentrated on military aircraft development. In 1929, Northrop formed **Northrop Aircraft Inc.** in Hawthorne, which concentrated on development work as opposed to production.
- 1932:** Howard Hughes Jr. formed the **Hughes Aircraft Company**. The company built planes that utilized retractable landing gear, a fully enclosed cockpit and the first use of flush rivets. The Hughes H-1 set a number of speed records including a transcontinental speed record in 1937.
- 1935:** **Douglas Aircraft Company** developed the DC-1, a prototype for the DC-3, one of the most successful airplanes in history. Only one DC-1 was built but it established 19 world records for speed, payload and range of flight.

Consolidated Aircraft Corporation moved to San Diego Harbor (it was previously located in Buffalo, New York and then Rhode Island). The company's most famous aircraft was the B-24 Liberator (1939), critical to the USAF's air campaign during WWII.

North American Aviation relocated from Maryland to Inglewood. A contract received by the Army Air Corps established the company as a producer of advanced tactical military aircraft.

- 1938:** **Lockheed** moves into the international military market after receiving an order from the British to provide military aircraft to the United Kingdom.

WWII to Present: **Douglas** began construction of a Long Beach manufacturing facility where a variety of aircraft were later produced. At peak wartime production, Douglas had 160,000 employees and produced more than 300 aircraft every month.

Northrop Corporation built the XP-61 Black Widow, a night fighter and radar equipped interceptor. **Lockheed's** employment expanded to 93,000 workers during the period July 1940 to September 1945. The company built 19,000 airplanes (primarily in Burbank), including the P-80, the first U.S. production jet fighter.

Vultee acquires **Consolidated Aircraft** in 1942. The new company name became **Convair**. Convair's primary products included delta-wing aircraft and the massive B-36 bomber, which was the only aircraft in production at that time capable of carrying nuclear weapons (72,000 lbs).

North American Aviation produced nearly 43,000 military aircraft during the period 1939 to 1945 (including the superior P-51 Mustang fighter) outstripping its closest competitor (Convair) by 10,000 airplanes.

Hughes Company designed and built the H-4 Hercules (Spruce Goose). At the onset of the war, Hughes had only four employees. By the end of the conflict, the company employed 80,000 workers manufacturing mainly subassemblies for other aircraft companies.

In 1942 the first jet-propelled airplane, the Bell XP-59A flew from Muroc Field (today Edward Air Force Base). In 1947, Lt. Chuck Yeager broke the sound barrier for the first time in level flight with the Bell X-1 (aka the "Glamorous Glennis" as a tribute to Yeager's wife) above the Mojave Desert.

After 1945 The **Douglas Aircraft Company** merged with the **McDonnell Company** in 1967 to become the McDonnell Douglas Corporation, the fourth largest U.S. aircraft manufacturer after Boeing, North American and Lockheed. The merged company produced military and commercial aircraft, spacecraft, rockets, missiles, electronics products and data processing services. Production of the DC-10 began in 1970. The company also produced many successful military aircraft (including the F-15 Eagle and the F/A-18 Hornet). The company was acquired by Boeing in 1996.

In 1952, **Northrop** acquired Radioplane Company, a company that produced target drone systems. By the 1980s, Northrop had become a leading producer of pilotless aero vehicles (drones). In the 1960s, Northrop Corporation (renamed in 1959) developed advanced jet trainers. In 1960, the first intercontinental cruise missile came into service. During this period, Northrop also became a subassembly vendor for **Boeing's** 747 aircraft.

In 1954, **Lockheed** produced the world's first Mach 2 fighter. During the Korean War, Lockheed opened a new facility at Palmdale Airport. Lockheed also produced the L1011, which competed with the Douglas DC-10 and the Boeing 747, as well as spacecraft for the military, NASA and the commercial sector. In 1995, Lockheed merged with Martin Marietta Corporation to become Lockheed Martin, the largest defense company in the world.

General Dynamics bought a majority interest in **Convair** in 1953. Convair developed space launch vehicles, fighter jets and bombers. In 1994, Convair was sold to McDonnell Douglas, but was closed after two years of operation.

During the years following the war, **North American Aviation** produced the F-100 Super Sabre, the first American production fighter to fly at supersonic speeds. North American also developed rockets, guidance systems, atomic energy and the Little Joe Launch Vehicle which was instrumental in the development of the launch escape system of the Mercury program. North American's Rocketdyne division became a leading producer of liquid-fueled rockets.

In 1967, North American merged with Rockwell Standard Corporation to form North American Rockwell and later, in 1973 **American Rockwell International Corporation**. In the 1960s and 1970s, the company developed the Saturn V rocket's second stage and the final assembly of the launcher. The company also designed and built the Apollo command and service modules. In 1972, Rockwell started development of the Space Shuttle for NASA. Rockwell International sold its aerospace and defense units to Boeing in 1996.

In the early 1950s, **Hughes Aircraft** became a major supplier of weapons systems to the U.S. Air Force and Navy through its Hughes Electronics division. In 1955, Hughes Aircraft formed the Toolco Aircraft Division and began developing light military helicopters. Later, in 1984, McDonnell Douglas purchased Hughes' helicopter business. In 1961, Hughes formed the Hughes Space and Communications Company and became a leader in the satellite market, building the world's first synchronous communications satellite. Following Howard Hugh's death in 1976, the Hughes Aircraft Company operated until 1985. After that portions of the company were sold or merged with other companies. Hughes Space and Communications was purchased by **Boeing** 2000 and renamed Boeing Satellite systems.

Table 9: A Sample of Defense Contracts Award to Southern California Aerospace Firms, 2012

Contract Award Date	Military Branch	Prime Contractor	Location	County	Project	Contract Amount (\$millions)
01/06/12	Airforce	Raytheon Co.	El Segundo	Los Angeles	Anti-jam Global Positioning System development	11.0
01/12/12	Defense Logistics Agency	Vinyl Technology	Monrovia	Los Angeles	Advanced technology anti-G suit for the Airforce	9.0
01/13/12	Airforce	Boeing Satellite Systems, Inc.	El Segundo	Los Angeles	Wideband Global SATCOM (WGS) Block II follow-on contract	376.5
01/17/12	Army	Hamilton Sundstrand Corp.	Pomona	Los Angeles	Chemical Biological Mass Spectrometer II Systems	14.6
01/23/12	Airforce	The Boeing Co.	Long Beach	Los Angeles	Five additional C-17 Air Force aircraft	693.4
01/31/12	Navy	Northrop Grumman Guidance and Electronics Co.	Woodland Hills	Los Angeles	To repair components of aircraft navigation systems	18.9
02/02/12	Airforce	Raytheon Co.	El Segundo	Los Angeles	Dismount detection radar	76.6
02/02/12	Airforce	The Boeing Co.	Long Beach	Los Angeles	Ten C-17 aircraft for the IAF	1781.4
02/06/12	Defense Award Research Projects Agency	Northrop Grumman Space & Mission Systems	Redondo Beach	Los Angeles	Research award for defense technology	9.0
02/29/12	Navy	Raytheon Co., Space and Airborne Systems	El Segundo	Los Angeles	16 radars for F/A-18E/F aircraft	45.3
02/29/12	Navy	ITT Corp., Electronic Systems, Radar, Reconnaissance, and Acoustic Systems	Van Nuys	Los Angeles	AN/SPS-48G(V) radar modification kits	13.3
03/07/12	Airforce	Northrop Grumman Corp., Aerospace Systems	El Segundo	Los Angeles	Radar Technology for Global Hawk Block 40	24.5
03/13/12	Army	Aero Vironment Inc.	Monrovia	Los Angeles	Logistics support for a small unmanned aircraft system	11.1

Source: U.S. Department of Defense

Table 9: A Sample of Defense Contracts Award to Southern California Aerospace Firms, 2012 (cont...)

Contract Award Date	Military Branch	Prime Contractor	Location	County	Project	Contract Amount (\$millions)
03/28/12	Airforce	Spectrolab, Inc.	Sylmar	Los Angeles	Improvements in performance and production of solar cells	8.3
03/30/12	Navy	Raytheon Co.	El Segundo	Los Angeles	13 retrofit kits for F/A-18 E/F and EA-18G aircraft	7.0
03/30/12	Airforce	LinQuest Corp.	Los Angeles	Los Angeles	Military Satellite Communications development and services	20.1
04/04/12	Navy	Alliant Techsystems Operations, L.L.C., Defense Electronic Systems	Woodland Hills	Los Angeles	Advanced Anti-Radiation Guided Missile (AARGM) Block I upgrade	10.6
05/01/12	Navy	Alliant Tech Systems	Woodland Hills	Los Angeles	Services and supplies in support of the Multi-Stage Supersonic Target Program	8.8
05/10/12	Airforce	Boeing Satellite Systems, Inc.	El Segundo	Los Angeles	Wideband Global SATCOM 7 & Beyond	21.0
05/11/12	Defense Advanced Research Projects Agency	Lockheed Martin Aeronautics Co.	Palmdale	Los Angeles	To increase efficiency in all steps of the production process	7.2
05/18/12	Airforce	Northrop Grumman Systems Corp.	El Segundo	Los Angeles	Radar Technology for Global Hawk Block 40	51.3
05/18/12	Defense Logistics Agency	Moog, Inc.	Torrance	Los Angeles	Vibration controls for the Army	11.0
05/29/12	Army	Aerovironment	Monrovia	Los Angeles	Raven Digital Data Link Gimball Systems and initial spares packages	15.8
05/30/12	Defense Logistics Agency	Northrop Grumman Systems Corp.	El Segundo	Los Angeles	Procurement of F-18 aircraft rudders	14.0
03/02/12	Army	Aero Vironment Inc.	Monrovia	Los Angeles	for the modification of an existing contract to supply logistics services for the Small	8.9
04/27/12	Navy	Pacific West Builders	National City	Orange	for design and construction of the Red Horse cantonment operations facility at Andersen	9.5
01/05/12	Army	Raytheon Co.	Fullerton	Orange	Support services and spares for satellite communications	18.1

Source: U.S. Department of Defense

Table 9: A Sample of Defense Contracts Award to Southern California Aerospace Firms, 2012 (cont...)

Contract Award Date	Military Branch	Prime Contractor	Location	County	Project	Contract Amount (\$millions)
01/05/12	Navy	EADS North America	Irvine	Orange	203 spare and repair parts for radio frequency program	9.8
02/13/12	Airforce	The Boeing Co.	Huntington Beach	Orange	17,873-507 very high and ultra high frequency modules	20.7
03/09/12	Airforce	The Boeing Co.	Seal Beach	Orange	Global Position System	14.5
03/12/12	Airforce	Parker-Hannifin Corp.	Irvine	Orange	Services for the C-5 hydraulic kneeling motor at Hill Air Force Base	7.5
04/04/12	Navy	The Boeing Co., Integrated Defense Systems, Phantom Works	Huntington Beach	Orange	Software support	20.0
05/10/12	Airforce	The Boeing Co.	Seal Beach	Orange	Launch operations and on-orbit operations for seven space vehicles	14.3
05/11/12	Defense Logistics Agency	Parker-Hannifin Corp.	Irvine	Orange	Engine starters for the Army	7.4
05/16/12	Army	Thales Raytheon Systems	Fullerton	Orange	Purchase of improved sentinel radar kits	22.5
05/16/12	Army	Parker Hannifin	Irvine	Orange	UH-60 helicopter valves	9.5
01/05/12	Army	General Atomics Aeronautical Systems, Inc.	Poway	San Diego	Operational test and evaluation	20.5
01/17/12	Army	General Atomics Aeronautical Systems, Inc.	Poway	San Diego	Improvements on the MQ-1C Gray Eagle unmanned aircraft system	30.3
02/08/12	Navy	Northrop Grumman Systems Corp.	San Diego	San Diego	Emerging surveillance technologies, sensors and systems	52.3
02/09/12	Airforce	General Atomics Aeronautical Systems, Inc.	Poway	San Diego	MQ-1 digital video integration	8.1
02/21/12	Navy	Raytheon Co., Integrated Defense Systems	San Diego	San Diego	Ship Self Defense System (SSDS) platform systems	21.2

Source: U.S. Department of Defense

Table 9: A Sample of Defense Contracts Award to Southern California Aerospace Firms, 2012 (cont...)

Contract Award Date	Military Branch	Prime Contractor	Location	County	Project	Contract Amount (\$millions)
02/27/12	Defense Logistics Agency	Care Fusion Solutions, L.L.C.	San Diego	San Diego	Infusion pump devices and related accessories	44.7
03/02/12	Airforce	General Atomics Aeronautical Systems	Poway	San Diego	Two modified Block 1 MQ-9 Aircraft and two Aircraft Containers	38.4
03/22/12	Airforce	General Atomics Aeronautical Systems, Inc.	Poway	San Diego	Counter improvised explosive device capability	9.6
03/30/12	Airforce	Northrop Grumman Space and Missions Systems, Northrop Grumman Information Systems	San Diego	San Diego	To operate and support aircraft E-11A communications system	26.8
04/10/12	Navy	ViaSat	Carlsbad	San Diego	Information Distribution System Joint Tactical Radio Systems	31.5
04/23/12	Navy	Northrop Grumman Systems Corp.	San Diego	San Diego	Finalization of unmanned airvehicles and acquiring six airvehicles	262.3
04/25/12	Army	Intelligent Automation Corp./Honeywell	Poway	San Diego	To provide aviation diagnostics support services	9.9
04/27/12	Navy	Intelsis Technologies Corp.	San Diego	San Diego	Software engineering support	22.1
04/27/12	Navy	Forward Slope, Inc.	San Diego	San Diego	Software engineering support	21.2
04/27/12	Navy	Kratos Defense Engineering Solutions, Inc.	San Diego	San Diego	Software engineering support	19.0
05/08/12	Navy	Northrop Grumman Systems Corp., Integrated Systems Sector	San Diego	San Diego	Three unmanned aerial vehicles and one ground control station	25.7
05/10/12	Army	General Atomics Aeronautical Systems, Inc.	Poway	San Diego	Services in support of the MQ-1C Gray Eagle unmanned aircraft systems	141.8
05/11/12	Navy	Booz Allen Hamilton	San Diego	San Diego	Engineering support for various communications systems	20.8

Source: U.S. Department of Defense

Table 9: A Sample of Defense Contracts Award to Southern California Aerospace Firms, 2012 (cont...)

Contract Award Date	Military Branch	Prime Contractor	Location	County	Project	Contract Amount (\$millions)
05/17/12	Airforce	Northrop Grumman Systems Corp.	San Diego	San Diego	Development of counter-improvised explosive device capability	33.3
05/17/12	Airforce	Science Applications International Corp.	San Diego	San Diego	Advisory and assistance services for the Weather Sustainment Division	7.0
05/24/12	Airforce	Zeecor	Oceanside	San Diego	Special runway repair kits and support hardware kits	15.6
05/31/12	Navy	Systems Applications & Technologies, Inc.	Oxnard	Ventura	Maintenance and operations of aerial and seaborne target assets	8.8

Source: U.S. Department of Defense

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