U.S. Space Industry "Deep Dive" Assessment:

Employment in the U.S. Space Industrial Base

September 2014

U.S. SPACE INDUSTRY "DEEP DIVE" ASSESSMENT: EMPLOYMENT IN THE U.S. SPACE INDUSTRIAL BASE

September 2014

PREPARED BY
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EXECUTIVE SUMMARY

The United States Air Force, National Aeronautics and Space Administration (NASA), and the National Reconnaissance Office (NRO) requested that the U.S. Department of Commerce, Bureau of Industry and Security (BIS) lead a collaborative effort to study the U.S. space industrial base. The effort, called the U.S. Space Industry "Deep Dive" Assessment, sought to map the space industrial base supply chain in unprecedented detail. The project would provide all stakeholders with a single, consistent source of information, highlight interdependencies between agencies and programs, and reduce the survey reporting burden on industry.

BIS utilized its authority delegated under the Defense Production Act of 1950, as amended (50 U.S.C. app. Sec. 2155) to design, distribute, and collect surveys of commercial companies, universities, non-profit organizations, and U.S. Government agencies with equities in the space industrial base. In all, 3,780 organizations provided a completed survey response, which detailed the products and services they provided, their critical suppliers, their financial health and investment expenditures, and many other topics.

In addition to this report on employment in the space industrial base, BIS developed the following reports based on survey responses, independent research, and field interviews:

- Impact of U.S. Export Controls on the Space Industrial Base
- Small Businesses and the U.S. Space Industrial Base
- Challenges Facing the U.S. Space Industrial Base

This report seeks to provide a baseline of employment data and trends in the U.S. Space Industrial base. BIS developed this report because the space industrial base is dependent upon maintaining a highly skilled workforce in order to meet national security and civilian agency needs in space. The cancellation of the Space Shuttle, transition from the Constellation program, and other recent changes in U.S. Government space programs created concerns within the USG about the ability to retain a skilled workforce in the long-term. In addition, there are concerns about the ability to retain critical knowledge and capabilities with an aging workforce and difficulties recruiting young talent to the space industry.

To gather data on these issues, BIS developed a series of questions to better understand the workforce of organizations that are part of the U.S. space industrial base. Survey respondents identified the total number of full-time equivalent (FTE) employees in their U.S. operations (including space), from 2009 to 2012. Respondents also identified the percentage of FTEs that work in seven broad employment categories provided in the survey. BIS further analyzed data specific to the workforce engaged in space-related and Science, Technology, Engineering, and Mathematics (STEM-) related functions, a key element for a competitive space industrial base.

Overall, the report examines general employment statistics and trends of survey respondents including respondents that are dependent on current U.S. Government space programs for their continued viability. Employment trends for engineers, scientists, and R&D staff due to their vital role in the space industrial base are also detailed. An examination of unfilled vacancies and hiring issues for skilled workers affecting all levels of the space industry supply chain is also

included. Finally, there is a discussion of unique skills and competencies in the U.S. space industrial base.

BIS Key Report Findings:

- The organizations surveyed employed over 2.6 million workers in 2012.
- The total number of FTEs employed by respondents increased by eight percent from 2009 to 2012.
- Overall, 611 of the 3,780 total respondents indicated that they were dependent on current U.S. Government space programs for their continued viability. These 611 respondents employed approximately 350,000 workers in 2012, 5 percent less than in 2009.
- Fifty-eight percent (2,657) of total survey respondents indicated they had at least one FTE who performed STEM-related (Science, Technology, Engineering, and Mathematics) functions as well as worked on space-related products or services. On average, 41 percent of those respondent's employees performed STEM-related functions.
- In 2012, small businesses employed approximately 8 percent of total FTEs reported.
- Small businesses, on average, employed 88 FTE employees compared to 1,624 FTE employees by non-small business respondents.
- From 2009 to 2012, employment of engineers, scientists, and R&D staff increased 23 percent for non-dependent organizations. This is noticeably different than the 611 respondents dependent on current USG space programs, who experienced a decrease of approximately five percent in engineers, scientists, and R&D staff.
- Thirty-two percent of total respondents indicated that at least half of their engineers, scientists and R&D staff are over the age of 50.
- Over 43 percent of engineers, scientists, and R&D staff for dependent respondents are over the age of 50, compared to 33 percent of those working for non-dependent respondents.
- 1,234 of 3,780 respondents indicated that they had 24,836 vacancies nationwide for Engineers, Scientists, and R&D Staff; Production Line Workers; and Testing Operators, Quality Control & Support Technicians.

- The most common reasons for these unfilled vacancies were lack of proper skills/qualifications, geographic difficulties, variability of demand, and difficulty attracting workers to manufacturing.

For more detail on the key findings, refer to the Report Findings chapter of this report.

I. BACKGROUND ON THE U.S. SPACE INDUSTRY "DEEP DIVE" ASSESSMENT

The United States has continually recognized that "a resilient, flexible, and healthy space industrial base must underpin all of our space activities."[1] In recent years, the U.S. has grown increasingly reliant upon space-based technologies for its economic and national security. From communications to environmental monitoring, space-related technologies are vital to our everyday lives. As this reliance has grown, so has the interdependency between the civil, commercial, and national security space sectors. Programmatic decisions made by the National Aeronautics and Space Administration (NASA), for example, can have a significant impact on the U.S. Department of Defense's space interests, and vice versa.

In 2011, the U.S. Department of Commerce, Bureau of Industry and Security (BIS) completed an assessment of the U.S. space industry based on a review of 27 existing space-related studies covering the period 2006 to 2010.[2] Through this effort, BIS found that there have been many studies of different facets of the space industrial base in recent years, some very narrow in scope and others relying on anecdotal data. Individual government agencies, industry groups, and research organizations have all attempted to isolate key issues affecting the health and competitiveness of the space industrial base. In many cases, these efforts have been conducted independently, without collaboration or coordination between stakeholders. The end result has often been duplication of effort and an increased reporting burden on industry, while providing minimal benefit to U.S. Government (USG) strategic planners.

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[1] *National Security Space Strategy (Unclassified Summary)*, January 2011, p. 4, http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf.

[2] Presidential Policy Directive/PPD-4, National Space Policy.

These studies did, however, depict the many challenges that face the U.S. space industry. Some studies focused on the uncertain budgetary environment and the potential for adverse industrial base impacts resulting from modifications to (or cancellations of) to space programs. Other studies highlighted increasing international competition that has eroded the U.S. competitive advantage in the space sector. Several studies also mentioned the difficulties facing lower tier suppliers as they attempt to navigate a procurement environment with long lead times and inconsistent production rates. Finally, these studies touched on common issues, such as finding skilled workers, dealing with complex export control regulations, handling government purchasing requirements, and other challenges.

Based on previous studies of the space industrial base and experience with other sectors, BIS proposed that there be a single, collaborative effort to study the U.S. space industrial base. Such a study would provide all stakeholders with a single, consistent source of information, highlight interdependencies between agencies and programs, and reduce the survey reporting burden on industry.

In 2011, the U.S. Air Force (USAF), NASA, and the National Reconnaissance Office (NRO), partnered with BIS to initiate the U.S. Space Industry "Deep Dive" assessment. The principle goal of the assessment was to gain an understanding of the intricate supply chain network supporting the development, production, and sustainment of products and services across the defense, intelligence, civil, and commercial space sectors.

BIS and the partner agencies set the following objectives for the assessment:

a) Map the space industrial base supply chain in unprecedented detail;
b) Identify interdependencies between respondents, suppliers, customers, and USG agencies;
c) Benchmark trends in business practices, competitiveness issues, financial health, and other areas, across many tiers of the industrial base; and
d) Share data with USG stakeholders to better inform strategic planning, targeted outreach, and collaborative problem solving.

The assessment was also designed to be repeatable. BIS will be able to expand this approach to other sectors of the U.S. industrial base by incorporating lessons learned from this study.

This report will examine the workforce of the space industrial base in a variety of ways. First, there will be an examination of general employment statistics, including trends for respondents that are dependent on current U.S. Government space programs for their continued viability. Second, this report will analyze of trends in the employment of Engineers, Scientists, and R&D staff as well as an examination of unfilled vacancies and hiring issues for skilled workers. Finally, this report will identify and analyze unique skills and competencies in the space industrial base.

In February 2014, BIS published the first of a series of "Deep Dive" reports entitled *Impact of U.S. Export Controls on the Space Industrial Base*.

METHODOLOGY

BIS performed this data collection and assessment under authority delegated to the U.S. Department of Commerce under Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155), and Executive Order 13603. These authorities enable BIS to conduct mandatory surveys, study defense-related industries and technologies, and monitor economic and trade issues affecting the U.S. industrial base. For example, BIS recently completed the following assessments: NASA's Human Space Flight Industrial Base in the Post-Space Shuttle/Constellation Environment, National Security Assessment of the Cartridge and Propellant Actuated Device (CAD/PAD) Industry, and Consumers of Electro-Optical Satellite Imagery.[3]

Upon initiation of the assessment, BIS took a number of steps over several months to better understand the U.S. space industrial base. With the assistance of our USG agency partners, BIS collected information on relevant space programs and their known suppliers. BIS held discussions with other government agencies with an interest in space, including the U.S. Army, U.S. Navy, U.S. Air Force's Space and Missile Systems Center, National Oceanic and Atmospheric Administration (NOAA), and others. BIS also conducted outreach with space-related industry associations, such as the Aerospace Industries Association, Satellite Industry Association, and the American Institute of Aeronautics and Astronautics.

In addition, BIS conducted site visits with companies and universities across the country involved in different aspects of the space industrial base, from consortia of small machine shops,

[3] For these and other reports, see www.bis.doc.gov/DIB

such as the Southern California Manufacturing Group, to dedicated space-related companies. These discussions highlighted many of the diverse challenges in maintaining a healthy and competitive space industrial base.

With cooperation and feedback from our partner agencies, BIS developed a survey template that covered respondents' current space-related business operations. The core of the survey is a customized Product and Service List, which served to connect various sections of the survey together in a uniform manner. Based on experience, BIS noted that many respondents were unable to identify specific USG programs they participate in, particularly at the lower tiers of the supply chain. However, all organizations seemed to have an understanding of what products and services they provide. The Product and Service List was created to focus on what respondents were most accustomed to—what they buy and sell in the marketplace.

The Product and Service List consists of 16 general segments comprised of 360 individual products and services. The list was used to identify and categorize relevant respondents; organizations that did not provide a product or service on the list were exempted from the survey requirement. The 16 Product and Service List segments are:

A. Spacecraft & Launch Vehicles
B. Propulsion Systems & Fuels
C. Navigation & Control
D. Communications Systems
E. Space Survivability, Environmental Control/Monitoring, and Life Support
F. Payload Instruments & Measurement Tools

G. Ground Systems

H. Non-Earth Based Surface Systems

I. Power Sources & Energy Storage

J. Electronic Equipment

K. Computer Hardware & Robotics

L. Software

M. Materials, Structures, and Mechanical Systems

N. Manufacturing Tools & Specialty Equipment

O. Services

P. Research & Development

Respondents identified whether they manufactured, distributed, or provided any of the products and services on the list. They then identified their critical suppliers and customers for the selected products and services.

Additionally, if known, respondents identified their participation in any of over 205 USG space-related programs from 2009 to 2012. This program list, assembled with the assistance of our partner agencies, included programs from the U.S. Air Force, U.S. Army, U.S. Navy, Missile Defense Agency, NASA, and NOAA. Respondents were provided fields to identify any additional programs they participated in that were not on the list.[4] Respondents identified the level of participation in each program (prime contractor, sub-contractor, or other type of support) and selected the specific products and services provided based on the Product and Service List.

[4] Information on classified activities and programs was not collected in this assessment.

The use of the uniform Product and Service List and network analysis software allowed BIS and partner agencies to link together respondents' products and services, critical suppliers, customers, and USG space programs in order to map the space industrial base. Without such a list, it would have been exceedingly difficult to meet the objectives of this assessment and the individual needs of members of the USG space community.

BIS also developed a series of questions to better understand the workforce of organizations that are part of the U.S. space industrial base. Survey respondents identified the total number of full-time equivalent (FTE) employees in their U.S. operations (including space), from 2009 to 2012. Respondents also identified the percentage of FTEs that work in seven broad employment categories provided in the survey. BIS further analyzed data specific to the workforce engaged in space-related and Science, Technology, Engineering, and Mathematics (STEM-) related functions, a key element for a competitive space industrial base.

BIS distributed the survey in June 2012 to respondents identified by our partner agencies, previous BIS survey efforts, and independent research. The data collection period was divided into three, three-month long waypoints. At the end of each waypoint, the data was collected, compiled, and analyzed for preliminary results. The data was also disseminated to our partner agencies in order to facilitate their analysis and strategic planning. Aggregated results were made publically available and presented to the space industry.

In April 2013, the data collection period ended. In total, BIS received 3,780 completed survey responses from commercial companies, universities, non-profit organizations, and U.S. Government agencies (see Figure I-1).

Figure I-1: Respondents by Type of Organization	
Commercial Companies	3,585
Universities	125
Non-Profit Organizations	49
U.S. Government Agencies	21
Total	**3,780**

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

II. OVERVIEW OF EMPLOYMENT IN THE U.S. SPACE INDUSTRIAL BASE

To better understand the workforce of organizations that are part of the U.S. space industrial base, the BIS developed a series of questions related to employment. In reaching out to companies and working with partners to develop the survey template, BIS noted many issues related to the workforce in the space industry. To obtain a comprehensive picture of the workforce, employment data was collected from all tiers of the supply chain from 2009 to 2012, including primes as well as lower tier suppliers.

As the space industry is currently dominated by the United States Government, BIS also considered that many organizations face unique workforce requirements that are not found in other sectors. Based on interesting data results, BIS decided that it was warranted to conduct additional in depth analysis on the employment data. BIS chose to further examine employment in the space industrial base to provide a statistical underpinning for the U.S. Space industry supply chain and provide a distinct picture of the supply chain from an employment perspective.

This report seeks to provide a baseline of employment data and trends in the U.S. Space Industrial base. BIS developed this report because the space industrial base is dependent upon maintaining a highly skilled workforce in order to meet national security and civilian agency needs in space. The cancellation of the Space Shuttle, transition from the Constellation program, and other recent changes in U.S. Government space programs created concerns about the ability to retain a skilled workforce in the long-term. In addition, there are concerns about the ability to retain critical knowledge and capabilities with an aging workforce and difficulties recruiting young talent to the space industry.

The U.S. Space Industry "Deep Dive" assessment included a very diverse set of organizations, many of which have limited knowledge of the space-related applications of their products and services. Respondents provided employment data at the level they responded to the survey, either at the corporate/whole company or business unit/division-level. Organizations provided employment statistics that were broader in scope than their space-related operations. To mitigate the potential impact of this data, companies with over $200 million in annual sales were requested to provide employment data for only their space-related business units/divisions. For large respondents, this significantly narrowed the FTEs covered by these questions and kept non-space-related employment data to a practical minimum.

The workforce which supports the space industrial base is a vital component to the continued health and competitiveness of the sector. Changes to the USG space budget and programs, including the retirement of the Space Shuttle and the cancellation of the Constellation program, have impacted the workforce. The space industry is also struggling to attract young talented new workers as many of their employees move towards retirement. The educational and technical knowledge required for many jobs in the space industry results in a limited pool of applicants. This issue is further compounded by requirements that often dictate that all employees involved in a project must be U.S. citizens. In addition, there are many skills and competencies that are unique to the space industry and its workers.

Considering these and many other issues facing the space industry, BIS sought to better understand the workforce challenges organizations are encountering. BIS also looked at data from the current workforce and completed a four-year trend analysis.

Respondents identified the percentage of FTEs that work in each of the following seven categories:

- Administrative Staff
- Facility Operations/Maintenance
- Information Technology Professionals
- Marketing & Sales
- Engineers, Scientists and R&D Staff
- Production Line Workers
- Testing Operators, Quality Control, & Support Technicians

Respondents also identified the percentage of their current workforce that were engaged in space-related and Science, Technology, Engineering, and Mathematics (STEM-) related functions.

III. OVERALL EMPLOYMENT

To obtain a comprehensive picture of the workforce, BIS collected employment data from a diverse set of organizations including major prime contractors, small businesses, and universities. Many organizations provide products and services that have additional end uses outside the space industrial base, such as electronics, materials, chemicals, and engineering services. This chapter will identify overall changes in employment from 2009 to 2012 and detail employment trends by job category and by different types of organizations, including those dependent on USG space programs and small businesses.

In reviewing data, BIS analyzed employment trends by respondent size. Respondents were categorized by size based on their average annual net sales from 2009 to 2012 (see Figure III-1).

Figure III-1: Respondents by Average Annual Net Sales

Very Small	Less than $10 million
Small	$10 - $50 million
Medium	$50 - $250 million
Large	$250 million - $1 billion
Very Large	Greater than $1 billion
No Sales	0

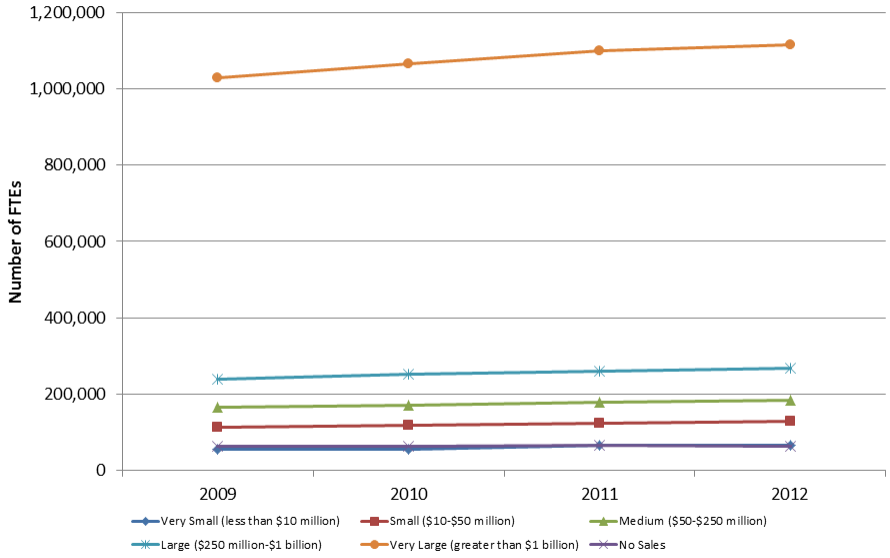
Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Overall, very large organizations (greater than $1 billion in sales) accounted for just over 60 percent of all FTEs in each year surveyed (see Figure III-2).[5] Large organizations accounted for about 15 percent of all FTEs each year surveyed. This was followed by medium organizations at

[5] Excluding universities.

10 percent and small organizations at seven percent of all FTEs. Very small organizations and organizations with no sales each employed approximately four percent of total FTEs.

Figure III-2: Full-Time Employees by Organization Size (Excluding Universities)



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Figure III-3 identifies the total number of FTEs per type of organization surveyed from 2009 to 2012. Overall, the total number of FTEs employed by respondents increased by eight percent over the four year survey period. Universities and non-profit organizations both saw employment increases of about four percent. Employment by commercial companies which constituted 95 percent of respondents, increased by 10 percent over the period - the largest growth of the four respondent types. USG organizations were the only category to show a decrease in their total employment from 2009 to 2012, declining 2.8 percent.

Figure III-3: Total Full Time Employees by Year and Organization Type					
	2009	2010	2011	2012	Percent Change (2009-2012)
Commercial Company	1,581,338	1,647,038	1,710,505	1,744,371	10.3%
Non-Profit Organization	51,010	51,566	52,726	52,823	3.6%
USG Organization	28,958	29,307	28,777	28,161	-2.8%
Universities	769,677	779,367	793,045	799,333	3.9%
Grand Total	2,430,983	2,507,280	2,585,054	2,624,689	7.9%

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Reviewing the employment data in more detail shows that organizations that are dependent on current USG space programs for their continued viability decreased their total number of FTEs over the survey period (see Figure III-4). Overall, 611 of 3,780 total respondents indicated that they were dependent on current U.S. Government space programs for their continued viability. BIS did not provide a specific definition of dependency due to the diverse makeup and characteristics of the respondents. Instead it was left up to respondents to determine their dependency on space-related programs. From 2009 to 2012, employment for these 611 organizations decreased by approximately five percent. The majority of this decrease was due to reductions in FTEs at commercial organizations, followed by smaller declines at USG organizations.

Figure III-4: Total Full Time Employees by Year and Organization Type for 611 Space Dependent Respondents*					
	2009	2010	2011	2012	Percent Change (2009-2012)
Commercial Company	272,964	276,531	264,848	254,179	-6.8%
Non-Profit Organization	18,179	18,775	19,864	19,630	8.0%
USG Organization	14,464	14,445	14,286	13,897	-3.9%
Universities	60,486	59.434	60,261	60,533	.1%
Grand Total	366,093	369,185	359,259	348,239	-4.9%

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

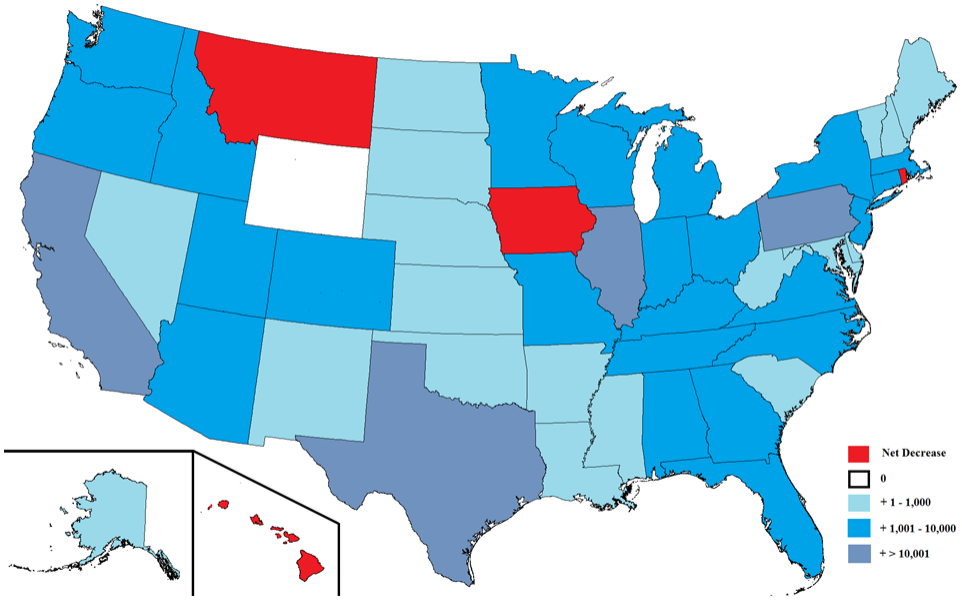
Forty-seven percent of total survey respondents indicated that they had at least one FTE who worked on space-related products or services in 2012. These 1,775 respondents had on average 33 percent of their employees classified as space-related. This rises to an average of 52 percent for respondents that are dependent on current USG space programs for their continued viability.

With regards to STEM-related functions, seventy-one percent of total survey respondents indicated that they had at least one FTE who performed STEM-related functions in 2012. Of these 2,697 respondents, on average 41 percent of their employees performed STEM-related functions. A smaller percentage, 58 percent of total survey respondents, indicated that they had at least one FTE who performed STEM-related functions as well as worked on space-related products or services. Respondents that are dependent on current USG space programs for their continued viability averaged 50 percent of FTEs working on STEM-related functions.

EMPLOYMENT BY LOCATION

From 2009 to 2012, survey respondents located in nearly all U.S. states had a net increase in FTE employment (see Figure III-5). During this period, respondents located in Illinois, California, Pennsylvania, and Texas had an aggregate increase of over 10,000 FTEs. Only Iowa, Rhode Island, Hawaii, and Montana had aggregate decreases in FTEs over the survey period.

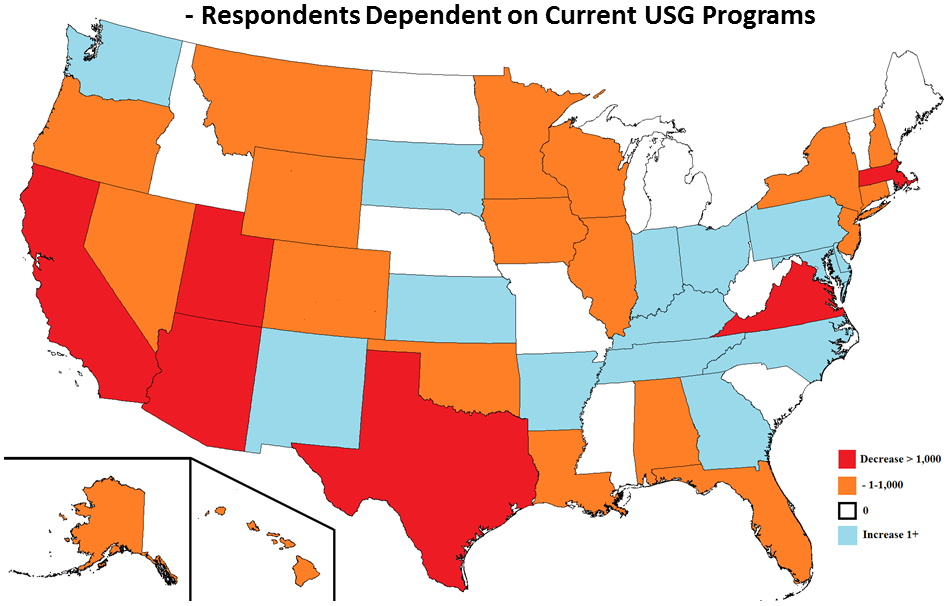
Figure III-5: Net Change in FTE Employment (2009-2012)



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

As mentioned earlier, employment decreased by approximately five percent for respondents dependent on current USG space programs. These respondents reported significantly worse net changes in FTE employment from 2009 to 2012. Taken alone, this group of respondents reported aggregate decreases in FTE employment in 25 states (see Figure III-6). The most prominent decreases were reported in Texas, California, Virginia, Utah, and Massachusetts. The contrast of Figure III-5 and III-6 shows that companies dependent on USG space programs performed more poorly in maintaining their workforce levels than more diversified organizations.

Figure III-6: Net Change in FTE Employment (2009-2012) - Respondents Dependent on Current USG Programs



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

EMPLOYMENT CATEGORIES

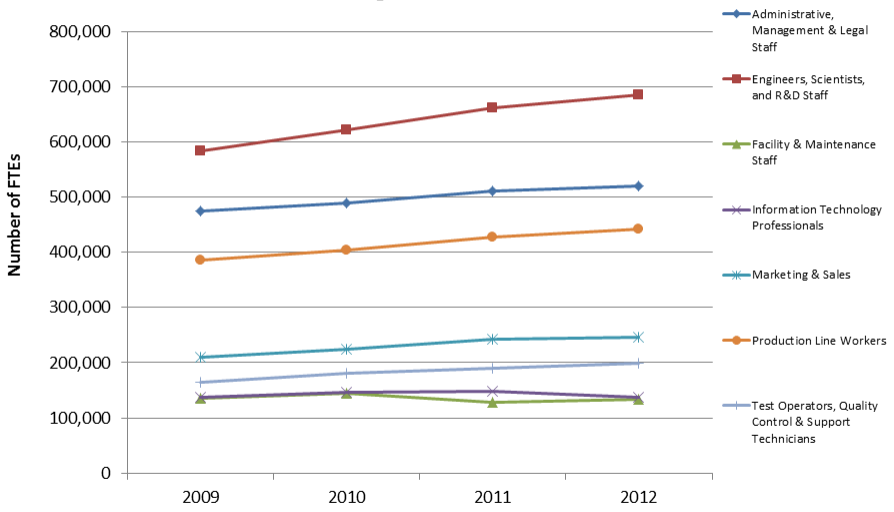
The FTE information was analyzed from 2009 to 2012 based on seven types of employees:

- Administrative, Management, & Legal Staff
- Engineers, Scientists, and R&D Staff
- Facility & Maintenance Staff
- Information Technology Professionals
- Marketing & Sales
- Production Line Workers
- Test Operators, Quality Control & Support Technicians

Commercial organization employment grew from 2009 to 2012 in each of these categories, except for the Facility & Maintenance Staff category, where employment decreased

approximately two percent from 2009 to 2012 (see Figure III-7). Employment in the Information Technology category grew less than half a percent from 2009 to 2012. Administrative, Management, & Legal Staff experienced a growth of nine percent in the number of FTEs. Four categories experienced a growth of 15 percent or more including Test Operators, Quality Control, & Support Technicians (21 percent), Engineers, Scientists, and R&D Staff (17 percent), Marketing & Sales (17 percent), and Production Line Workers (15 percent).

Figure III-7: Full Time Employees by Type – All Commercial Organizations

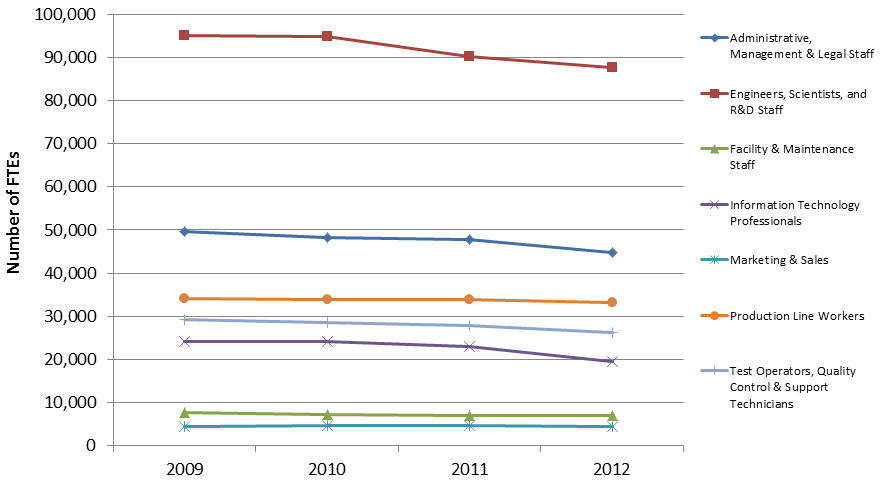


Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

WORKFORCE OF SPACE DEPENDENT COMMERCIAL RESPONDENTS

BIS also analyzed FTEs per employment category data for respondents dependent on current USG space programs. Of the 3,585 commercial organizations, 563 reported dependency on current USG Space Programs. BIS reviewed the FTE data for these companies and found that the data to be quite different than for all commercial organizations (see Figure III-8).

Figure III-8: Full Time Employees by Type*
- Respondents Dependent on Current USG Space Programs



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Among dependent commercial organizations, FTEs decreased for each employment category except Marketing & Sales, where FTEs grew approximately three percent from 2009 to 2012. The remaining categories decreased as follows:

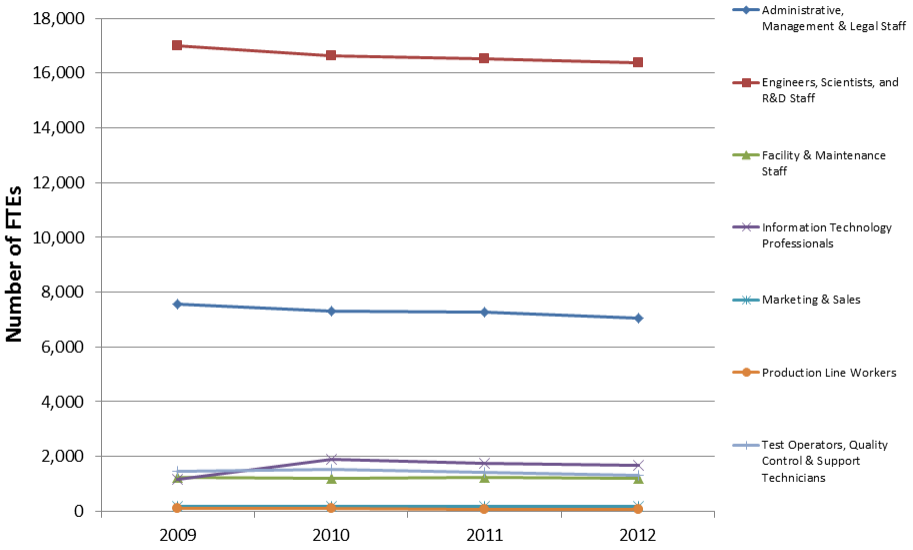
- Information Technology Professionals (-19 percent)
- Test Operators, Quality Control, & Support Technicians (-10 percent)
- Administrative, Management, & Legal Staff (-10 percent)
- Facility & Maintenance Staff (-9 percent)
- Engineers, Scientists, and R&D Staff (-8 percent)
- Production Line Workers (-2 percent)

BIS also looked at the employment data provided by USG organizations. Among USG organizations, employment increased in the Information Technology and Production Line categories from 2009 to 2012 (see Figure III-9). FTEs in the Information Technology category increased by 42 percent during the period while the Production Line category increased by 17

percent. The number of Marketing & Sales employees stayed stable from 2009 to 2012. The remaining categories decreased as follows:

- Test Operators, Quality Control, & Support Technicians (-10 percent)
- Administrative, Management, & Legal Staff (-6 percent)
- Engineers, Scientists, and R&D Staff (-3 percent)
- Facility & Maintenance Staff (-1 percent)

Figure III-9: Full Time Employees by Type – USG Organizations



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

SMALL BUSINESSES EMPLOYMENT

Small businesses, as defined by the Small Business Administration (SBA), represent 62 percent of respondents in this assessment. To be considered a small business by the SBA, an organization must:

- Be below a maximum size (either defined by average number of employees over the past year or average annual receipts over the past three years) as determined per NAICS codes
- Be for-profit
- Have a place of business in the U.S.
- Operate primarily within the U.S. or make a significant contribution to the U.S. economy
- Be independently owned and operated
- Not dominate its field of business on a national basis.

Generally, the maximum number of employees a manufacturer can have to qualify as a small business is between 500 and 1,500, although it varies by industry.

Despite consisting of 62 percent of total BIS survey respondents, small businesses represented only eight percent of total FTEs captured in this study. In 2012, small businesses had 219,519 of the total 2,624,689 FTEs reported (see Figure III-10). On average, small businesses employed 88 FTEs compared to an average of 1,624 FTEs by non-small business respondents.

The small business workforce did, however, increase at a higher rate than other types of organizations from 2009 to 2012. As a group, small businesses employed 16 percent more employees in 2012 than in 2009. Non-small business respondents increased their overall employment by seven percent during the same period.

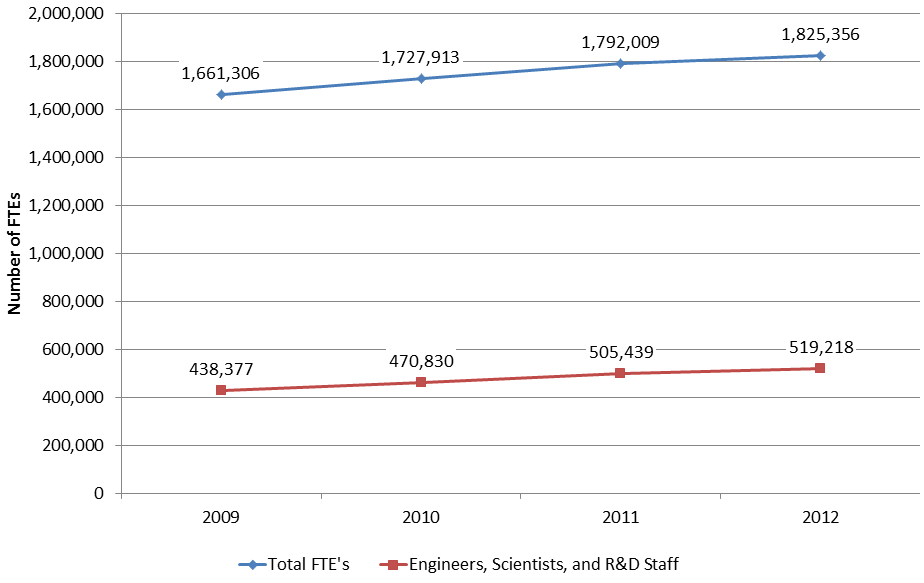
Figure III-10: Total Full Time Employees (2009-2012)					
	2009	2010	2011	2012	Percent Change (2009-2012)
Small Business	189,699	196,628	214,935	219,519	15.7%
Non-Small Business	2,241,283	2,310,652	2,370,119	2,405,170	7.3%

IV. ENGINEERS, SCIENTISTS AND R&D STAFF

Engineers, scientists, and R&D staff are the driving force for innovation in products, processes, and technologies and play an important role in ensuring long-term industrial base health and competitiveness. To gather information on these employees, BIS asked a series of questions related to the employment of engineers, scientists, and R&D staff including total employment over the four year survey period. BIS also collected information about hiring difficulties related to these employees as well as their citizenship and age.

Engineers, scientists, and R&D staff account for a significant portion of total respondent FTEs. In 2009 and 2012 respectively, these employees represented 26 and 28 percent of all FTEs. Based on BIS's analysis, changes in the number of engineers, scientists and R&D staff from 2009 to 2012 seem to be reflective of the trends of overall employment in the space industrial base, and tend to correspondingly increase when aggregate employment increases (see Figure IV-1).

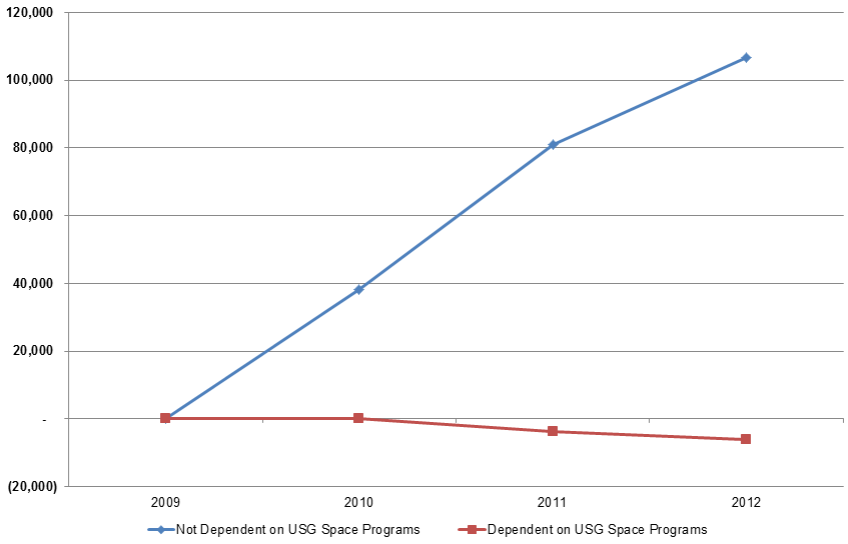
Figure IV-1: Full-Time Employees by Type (Excluding Universities)



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

From 2009 to 2012, employment of engineers, scientists, and R&D staff increased 23 percent for non-dependent organizations (see Figure IV-2). This is noticeably different than those respondents dependent on current USG space programs, who experienced a decrease of approximately five percent in engineers, scientists, and R&D staff.

Figure IV-2: Net Change in Engineers, Scientists, and R&D Staff – Dependency on USG Space Programs



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Fluctuations in engineers, scientist, and R&D staff varied among respondent types. For example, those who worked on the Space Shuttle/Constellation programs and those organizations with greater than 35 percent of their sales being space-related had a large decrease in employment for these types of staff. On the other hand, universities, small businesses, and respondents with no space-related sales increased employment in this category. Very large respondents constituted the majority of decreases in employment for those dependent on current USG space programs.

From 2009 to 2012 the following changes in engineers, scientists, and R&D staff occurred:

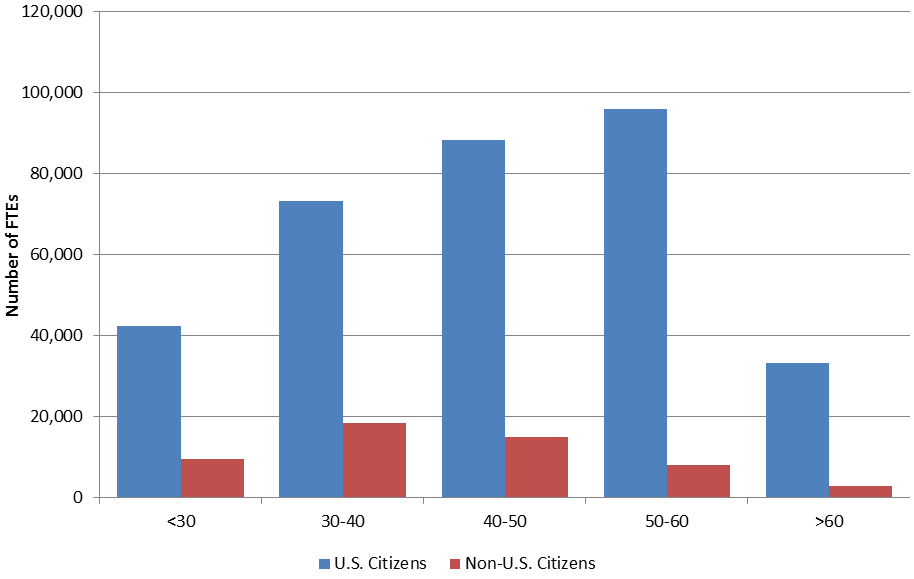
- Universities: Increase of 9,958
- Small businesses: Increase of 4,762
- Respondents that worked on Space Shuttle/Constellation: Decrease of 7,955
- Respondents with no space-related sales: Increase of 13,788

- Respondents with greater than 35 percent space-related sales: Decrease of 6,307

AGE AND CITIZENSHIP OF WORKFORCE – ENGINEERS, SCIENTISTS AND R&D STAFF

Analyzing the age of the workforce is an important factor when considering the long-term health and competitiveness of any sector. An older workforce of engineers, scientists, and R&D staff without a younger generation to replace them may stifle production, innovation, and the development of new technologies. Figure IV-3 shows the age range of engineers, scientists, and R&D staff for all survey respondents, excluding universities. Among U.S. citizens, the largest age bracket for this category of FTEs was the 50-60 year old age category, which accounted for 27 percent of all engineers, scientists and R&D staff reported. Experienced employees are important in this sector as it can take time to get new employees fully trained and up to speed. Respondents mentioned that a trained and experienced workforce is important for their long-term viability and it is difficult to find new workers to just "jump in". In addition, it is difficult to replace all the workers lost with the limited number of younger U.S. citizen workers available. Respondents indicated that the talent pool is limited.

Figure IV-3: Age Range of Engineers, Scientists, and R&D Staff (Excluding Universities), 2012



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

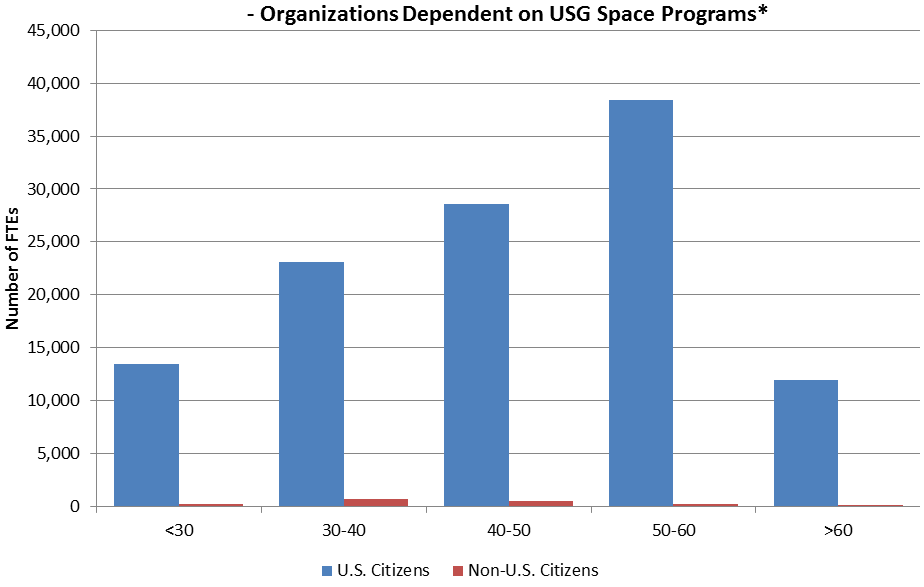
Citizenship issues are closely related with the age of the workforce for the space industrial base. Respondents are attempting to bridge the gap in the ageing workforce with qualified non-U.S. citizens. Fourteen percent of total engineers, scientists, and R&D staff reported are non-U.S. citizens and they comprise a greater proportion of the younger age categories. Non-U.S. citizens comprise 18 percent of FTEs under 30 and 20 percent of those between 30 and 40 years old. Of 3,780 respondents, 988 employ at least one non-U.S. citizen engineer, scientist, or R&D staff. For 129 respondents, non-U.S. citizens constitute at least 50 percent of their total engineers, scientists, and R&D staff.

However, the USG makes up a large percentage of overall space demand and due to the national security implications of many space programs only United States citizens can work on them. While this mainly impacts companies that support U.S. Department of Defense space programs,

it has more far reaching implications as well. Many of those companies support other space-related USG agencies including the civilian space programs of NASA and the National Oceanic and Atmospheric Administration (NOAA). The struggle to find a qualified workforce affects the overall health and competiveness of the company and their ability to provide the needed support to all USG agencies as well as to their commercial customers.

The concern with the age of the workforce is a greater issue for respondents that are dependent on current USG space programs for their continued viability (see Figure IV-4). Over 43 percent of engineers, scientists, and R&D staff for dependent respondents are over the age of 50, compared to 33 percent of those working for non-dependent respondents. For the most part, dependent respondents are also not being supplemented by younger non-U.S. citizens. Only two percent of engineers, scientists, and R&D staff at dependent organizations are non-U.S. citizens, compared to 19 percent of the workforce at non-dependent respondents. Based on BIS analysis, USG organizations experience many of the same problematic trends as dependent organizations.

Figure IV-4: Age Range of Engineers, Scientists, and R&D Staff - Organizations Dependent on USG Space Programs*

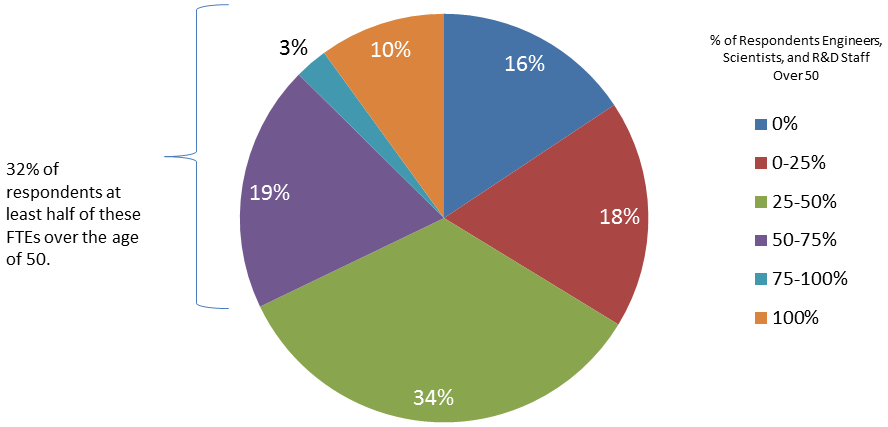


* Excluding universities.

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Thirty-two percent of total respondents indicated that at least half of their engineers, scientists and R&D staff are over the age of 50 (see Figure IV-5 and Figure IV-6). Generally, smaller respondents ($50 million in sales or less) are more likely to have an older workforce of engineers, scientists, and R&D staff. Forty-two percent of very small respondents (less than $10 million in sales) had at least half of these FTEs that were over the age of 50, compared with only 15 percent of large and 17 percent of very large respondents. Smaller organizations often struggle to compete with larger organizations that have better name recognition and the ability to offer more competitive salaries.

Figure IV-5: Percent of Engineers, Scientists, and R&D Staff Over the Age of 50*



* Based on 2,841 respondents that provided data, excluding universities.

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Figure IV-6: Aging Workforce	
Respondent Size	**% of Respondents with 50%+ of Engineers, Scientists, R&D Staff Over 50**
Very Small	42%
Small	28%
Medium	21%
Large	15%
Very Large	17%

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

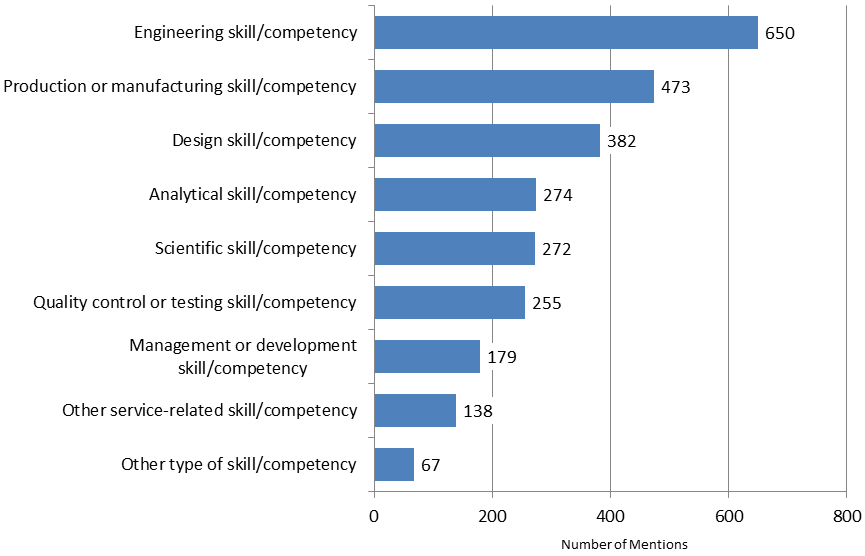
V. UNIQUE SPACE-RELATED SKILLS AND/OR COMPETENCIES

The space industrial base requires products and services that demand a skilled and specialized workforce. Respondents were asked to identify the unique space-related skills and competencies of their organization within the following skill and competency areas:

- Analytical
- Design
- Engineering
- Management or development
- Production or manufacturing
- Quality control or testing
- Scientific
- Other

BIS received 2,850 distinct responses from organizations regarding their space-related skills and competencies (see Figure V-1). Over 1,200 organizations provided information with over 700 identifying multiple skills and/or competencies areas.

Figure V-1: Unique Space-Related Skills/Competencies Identified by Respondents



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Engineering skills and competencies were the most common type of skills cited by respondents. Survey participants provided detailed descriptions of a diverse and expansive body of engineering knowledge that encompassed companies of all sizes and geographic locations. While in some instances companies claimed a unique competency due to the fact that they utilized advanced technology or research methods, others remarked that individuals within their operations made their products and services unique.

As an example, one very small company stated "four senior personnel with 20 to 25 years subject expertise in aerodynamics and guidance and control in support of space-related technologies" made their services unique when compared to other competitors in their field. Other respondents expressed their view that highly trained employees with advanced degrees and years of experience in various engineering fields gave them the ability to perform specialized engineering work.

The second most commonly cited unique skill was production or manufacturing followed by design skills. Here again, many respondents cited extensive years of experience and advanced degrees of individual employees as being responsible for their expertise in these areas.

A large number of organizations stressed the fact that they employ highly skilled and experienced machinists who are capable of producing precision products. These respondents also ranged from the very small to the very large, and they cited training certificates and "highly technical skills" among their staff as a reason for their ability to produce high quality materials and products. One small company cited their "highly skilled 5 axis machinists" while another cited their "highly skilled Precision Journeymen Machinists." A medium company with competencies in these fields reiterated the necessity of highly skilled workers by stating that "space development requires high horsepower engineering talent."

VI. UNFILLED VACANCIES FOR SKILLED POSITIONS

While conducting site visits to develop this survey, a number of space-related organizations of various sizes mentioned difficulties filling vacancies for skilled positions. These hiring difficulties persisted despite the high national unemployment rate during 2009 to 2012. To capture this issue, BIS asked respondents to identify the total number of unfilled vacancies they had for the following skilled employment categories:

- Engineers, Scientists, and R&D Staff
- Production Line Workers
- Testing Operators, Quality Control & Support Technicians[6]

Respondents were also asked to provide an explanation for why they were having difficulties hiring these skilled workers.

Overall, 1,234 of 3,780 respondents indicated that they had 24,836 vacancies for these skilled positions. These job vacancies were located in 48 states plus the District of Columbia. The needs for skilled workers were spread across all types and sizes of organizations (see Figures VI-1 and VI-2).

[6] Respondents provided a single number for unfilled vacancies. They did not provide a separate total for each employment category.

Figure VI-1: Vacancies by Organization Size (Excluding Universities)	
Very Small (Less than $10 million)	886
Small ($10 - $50 million)	1,413
Medium ($50 - $250 million)	3,594
Large ($250 million - $1 billion)	4,407
Very Large (Greater than $1 billion)	9,207
No Sales ($0)	949

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Figure VI-2: Vacancies by Organization Type	
Commercial Companies	19,127
Universities	4,560
Non-Profit Organizations	774
USG Organizations	375

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

Together, very large and large commercial companies accounted for 67 percent of unfilled vacancies. Commercial organizations had over 19,000 vacancies, however universities also had a relatively large percentage of unfilled vacancies. Despite representing only three percent of respondents, universities had over 18 percent of total unfilled vacancies for these skilled positions.

Based on respondents' explanations, the most common reasons for these unfilled vacancies included:

1. Lack of proper skills/qualifications
2. Geographic difficulties
3. Variability of demand
4. Difficulty attracting workers to manufacturing
5. Additional issues

BIS further examined these common reasons to gain a better understanding of the issues organizations in the space industrial base are facing when trying to staff their workforce.

LACK OF PROPER SKILLS/QUALIFICATIONS

Lack of proper skills/qualifications was the most cited reason for unfilled vacancies for skilled positions. In particular, organizations mentioned difficulty finding qualified engineers, machinists, computer programmers, and software developers. Of the 877 companies that mentioned hiring concerns, there were disproportionally more large companies that commented than smaller companies.

Many of the respondents, in commenting about hiring concerns, cited the quality of the degrees possessed by younger engineers, scientists and R&D staff, as well as their general lack of experience. One respondent explained "engineering degrees do not mean what they used to in [terms of] usable knowledge [and] good people are much harder to find now." Another respondent summarized the difficulty in finding the right balance of skills in new hires, stating the "difficulty is mostly in finding engineers/scientists/R&D staff with the right combination of aerospace skills, software development experience, security clearances, and have the ability to be 'customer-facing.'"

Those who cited a lack of applicants with proper skills/qualifications provided detailed explanations for their response. Many respondents could not find applicants with hands-on experience in specific subjects, technologies, and/or tasks. For example, one medium company stated that, "there are not too many experienced engineers for manufacturing and design of high temperature wire and cable for the aerospace industry in the area." One large company noted their shift to hiring inexperienced workers and developing extensive in-house skills training

programs to compensate for the lack of talent available. They stated that "we are resorting to hiring individuals with less than desired experience and developing training programs to make them productive. This delays our desired level of effective productivity by two to three years."

Many respondents also do not believe that American institutions of higher learning are capable of addressing the lack of training and experience that hinders many new graduates in these fields. One very small respondent said, "it is very difficult to find engineers and scientists with PhDs in Cryogenic Engineering, Electrical and Automation Engineering at U.S. schools." Another very small company expressed concern that students with "specialized material science and mechanical modeling experience" were difficult to locate at universities in the United States.

While some respondents cited a lack of specific types of university programs that are relevant to their work, others were concerned that academic programs are not providing enough hands-on experience. On this point, a very small respondent stated that "engineering degrees do not mean what they used to in [terms of] usable knowledge."

There were also respondents that required more basic skills, such as rudimentary mathematics, that cannot be found in the current pool of skilled/qualified workers. A medium company stated that the problem is "lack of sufficient skills…i.e., production line workers are commonly weak in factory math (taking measurements, converting measurements, calculating percentages)." This problem is particularly prevalent among machine shops and materials manufacturing survey respondents.

GEOGRAPHIC DIFFICULTIES

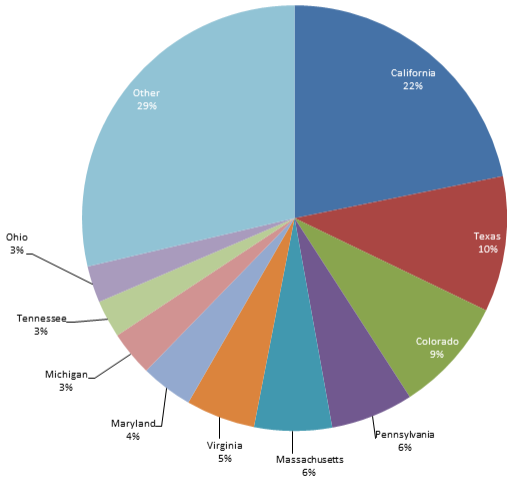
Respondents also cited their geographic location as a difficulty in finding skilled workers. Based on an analysis of comments, geographic difficulties were cited by respondents dispersed across 35 states, most prominently Tennessee, California, Pennsylvania, Texas, and Colorado. These geographic issues primarily relate to:

a) Difficulty finding qualified and/or experienced workers within a local area; and

b) Inability to find workers willing to re-locate to a specific area.

Figure VI-3 shows the number of unfilled vacancies per state.

Figure VI-3: Vacancies by State



Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

One small business said that their "small, rural town location" was a key obstacle in filling their vacancies, and this challenge does not seem to be unique only to smaller respondents. Another

medium size company said "many of our available skilled positions are located in production facilities that are in remote rural areas. It is difficult to find candidates that are qualified for these positions that are willing to relocate to these locations." Even very large respondents that may be capable of offering superior compensation and benefits are not exempt from difficulties in filling vacancies at their less accessible facilities. According to one very large company, the "availability of local candidates at our more remote locations" is a continuing obstacle for their operations.

VARIABILITY OF DEMAND

Other respondents also indicated that their inability to fill skilled vacancies was complicated by the "variability of demand," particularly with USG space-related contracts. Organizations have had to deal with numerous budget delays and policy changes, many of which they did not foresee or plan for. Complicating the issue, there are also various space agencies and budget cycles leading to peaks and valleys in the overall space-related budget.

Both large and small companies cited the USG contracting process as a hindrance to their hiring practices. A large company stated that "we hire to fill the needs for USG contracts. We do not know what service contracts we will have until the last second. Then it is a mad rush to hire the people needed to do the work." A small company indicated that "hiring is on hold due to cuts to DoD funded contracts."

DIFFICULTY ATTRACTING WORKERS TO MANUFACTURING

Respondents also commented that they found it difficult to attract workers to manufacturing jobs. One small respondent argued that a social stigma exists towards this type of employment, claiming that "schools/society tells kids that manufacturing is a dead end job, therefore there is a real shortage of younger people entering the skilled trade fields." Another very small company that was dependent upon USG space programs echoed this sentiment, claiming that "the culture in the U.S. is that it's not 'cool' to be in manufacturing. It isn't promoted in schools or in society."

ADDITIONAL DIFFICULTIES

Respondents also mentioned other assorted difficulties in filling vacancies for skilled workers. Among these are concerns over competition with other firms to attract the highest caliber of employees, citizenship issues, and difficulties in finding workers who are capable of obtaining security clearances.

Competition for qualified engineers and production line workers can be intense. Organizations are not only competing within their industry for talent but across other industries as well. A small company that is headquartered in Silicon Valley, CA, reported that they had to compete with popular organizations like Google, Apple and Facebook for highly skilled software engineers. Another respondent indicated that engineers with Electronic Design Automation knowledge are being recruited away by emerging industries such as social media. The oil and gas industry was also cited as competing for the same skill sets and offering competitive

compensation packages. As one respondent stated "competitive salaries in aerospace do not measure well against other fields." Even large companies in the space industry, who are generally able to offer superior compensation and benefits, are struggling to attract skilled workers. One large respondent reported that the demand for technical talent was very strong, which in turn "affected the number of available applicants."

Organizations also compete within the space industry to attract and maintain skilled workers. Small organizations said it is difficult to compete with the lucrative offers for skilled workers being offered by larger competitors. One very small respondent stated they have difficulty filling positions "since everyone wants to work for large companies." Another cited the challenges of "keeping up with rising compensation offered by competitors." The rising cost of employing skilled workers continues to increase. One respondent stated that the candidates with the right skill sets and appropriate clearance "often move around frequently because each move typically has a significant increase in their compensation causing these positions to open up often."

The limited pool of skilled workers has led many potential employers to look outside of the United States for such workers. Respondents offered several comments that explained why and how they recruit non-U.S. citizens to augment their work force. A medium sized company revealed that "due to the skill set required for our employees, there have been times it has been difficult to find" qualified workers, and as a result they often hire foreign nationals that require sponsorship. However, hiring non-U.S. citizens is not an option that is available to all respondents. Over fifty respondents cited citizenship issues as the reason for their difficulty

filling vacancies for skilled positions. One small organization stated that they "cannot use foreign nationals due to International Traffic in Arms Regulations (ITAR)."[7]

In addition, some respondents cited difficulties in attracting qualified candidates who were also able to obtain security clearances. A small respondent said "most of our contracts require Top Secret government security clearances so it is more difficult to find candidates who have the required skill set and the appropriate clearance."

One medium size respondent offered perhaps the best summary of the many obstacles the U.S. space industry faces in filling skilled employment vacancies:

> There is a myriad of difficulties in recruiting in our industry. Across each geographic market, there is a limited number of people with education and experience in the industry that match open positions. Big picture, the difficulty is that this country's youth is not focusing on math and science careers that would create products, technologies and jobs.

[7] The International Traffic in Arms Regulations (ITAR) are an export control regime for items identified on the United States Munitions List (USML). Control of select space-related commodities has shifted between the Export Administration Regulations (EAR) and ITAR over the past 20 years.

VII. ASSISTANCE PROGRAMS AND TRAINING

At the end of the BIS survey template, respondents were offered an opportunity to request more information on any of the 14 topics identified that may be able to assist them to better compete in the global marketplace. These topics included patents and trademarks, global export opportunities, business development, financing, and others. For each topic, BIS developed a resource guide to distribute to the respondents, which included an overview of existing USG programs and points of contact for each topic. One of the topics included in this outreach section was workforce training opportunities.

Overall, 416 respondents requested more information about training opportunities (see Figure VII-1). Of those, 76 percent were very small or small organizations. Approximately 20 percent of those companies were dependent on USG space programs. Since the conclusion of the survey assessment, BIS has reached out to all of these respondents to provide more information on training assistance and the other 13 areas of interest.

Figure VII-1: Respondents Interested in Available USG Assistance Programs and Services	
Program	# of Respondents
Business development	715
R&D programs	527
SBIR and STTR contracts	492
Global export opportunities	443
Training Opportunities	416
Export licensing (ITAR/EAR)	405
Manufacturing technology development	395
Financing	353
Government procurement guidelines and e-commerce	346
Marketing assessment skills	329
Product/service development	314
Energy and environmentally conscious manufacturing	213
Patents and trademarks	196
Country Commercial Guides	60

Source: U.S. Department of Commerce, Bureau of Industry and Security, *U.S. Space Industry Deep Dive*, September 2014.

BIS started to examine more ways to perform outreach on these important topics. In addition, BIS is working with the U.S. Department of Commerce, National Institute of Standards and Technology's Manufacturing Extension Partnership (MEP) to provide support to small manufacturers from this assessment. The MEP program maintains centers in every state to provide a "variety of services, from innovation strategies to process improvements to green manufacturing. MEP also works with partners at the state and federal levels on programs that put manufacturers in position to develop new customers, expand into new markets and create new products."[8]

[8] Manufacturing Extension Partnership. http://www.nist.gov/mep/about.cfm

BIS currently has two pilot programs with MEP centers in Southern California and Texas. A key part of this program is to provide these respondents with more information on how to export and the President's Export Control Reform Initiative, in addition to other business areas.

VIII: FINDINGS

Overall Employment

- The organizations surveyed employed over 2.6 million workers in 2012.
- The total number of full-time equivalents (FTE) employed by respondents increased by eight percent from 2009 to 2012.
- Employment by commercial companies, 95 percent of respondents, increased by 10 percent over the period, the largest gain of the four respondent types.
- United States Government (USG) organizations were the only respondent type to show a decrease in their total employment from 2009 to 2012, declining approximately 2.8 percent.

Overall Employment – Dependent Organizations

- Overall, 611 of the 3,780 total respondents indicated that they were dependent on current USG space programs for their continued viability. These 611 respondents employed approximately 350,000 workers in 2012, 5 percent less than in 2009.
- Among dependent commercial organizations, Information Technology Professionals decreased 19 percent from 2009 to 2012, the largest decrease of any employment category.

STEM

- Fifty-eight percent (2,657) of total survey respondents indicated that they had at least one FTE who performed STEM-related (Science, Technology, Engineering, and Mathematics) functions as well as worked on space-related products or services. On average, 41 percent of their employees performed STEM-related functions.
- Respondents that are dependent on current USG space programs for their continued viability (611) averaged 50 percent of FTEs working on STEM-related functions.

Small Business

- In 2012, small businesses employed approximately 8 percent of total FTEs reported.

- Small businesses, on average, employed 88 FTE employees compared to 1,624 FTE employees by non-small business respondents.
- As a group, small businesses employed 16 percent more employees in 2012 than in 2009. Non-small business respondents increased their overall employment by seven percent during the same period.

Engineers, Scientist and R&D Staff

- In 2012, engineers, scientists, and R&D staff accounted for 28 percent of all survey respondent FTEs.
- From 2009 to 2012, employment of engineers, scientists, and R&D staff increased 23 percent for non-dependent organizations. This is noticeably different than those respondents dependent on current USG space programs, who experienced a decrease of approximately five percent in engineers, scientists, and R&D staff.

Age of Workforce - Engineers, Scientist and R&D Staff

- The largest age range of engineers, scientists, and R&D staff for all survey respondents, excluding universities, was the 50 to 60 year old age category, which accounted for 27 percent of all U.S. citizen engineers, scientists and R&D staff reported.
- Over 43 percent of engineers, scientists, and R&D staff for dependent respondents are over the age of 50, compared to 33 percent of those working for non-dependent respondents.
- Thirty-two percent of total respondents indicated that at least half of their engineers, scientists and R&D staff are over the age of 50.
- Forty-two percent of very small respondents (less than $10 million in sales) had at least half of these FTEs over the age of 50, compared with only 17 percent of very large respondents (greater than $1 billion in sales).

Citizenship of Workforce - Engineers, Scientist and R&D Staff

- Of 3,780 respondents, 988 employ at least one non-U.S. citizen engineer, scientist, or R&D staff. For 129 respondents, non-U.S. citizens constitute at least 50 percent of their total engineers, scientists, and R&D staff.

- Only two percent of engineers, scientists, and R&D staff at dependent organizations are non-U.S. citizens, compared to 19 percent of the workforce at non-dependent respondents.

Unique Skills and Competencies

- BIS received 2,850 unique responses from organizations regarding their space-related skills and competencies. Over 1,200 organizations provided information with over 700 identifying multiple skills and/or competencies areas.
- Engineering skills and competencies were cited by respondents 650 times, the most commonly cited unique skill.

Unfilled Vacancies

- Overall, 1,234 of 3,780 respondents indicated that they had 24,836 vacancies nationwide for Engineers, Scientists, and R&D Staff; Production Line Workers; and Testing Operators, Quality Control & Support Technicians.
- Commercial organizations had over 19,000 unfilled vacancies nationwide. Very large and large commercial companies accounted for 67 percent of these unfilled vacancies.
- The most common reasons for these unfilled vacancies were lack of proper skills/qualifications, geographic difficulties, variability of demand, and difficulty attracting workers to manufacturing.

Requested Assistance

- Overall, 416 respondents requested more information about USG training opportunities. Approximately 20 percent of those companies were dependent on USG space programs.
- Of those organizations requesting information about training opportunities, 76 percent were very small (less than $10 million in sales) or small ($10 to $50 million in sales) organizations.

APPENDIX I: U.S. DEPARTMENT OF COMMERCE, BIS/OTE PUBLICATIONS LIST

OFFICE OF TECHNOLOGY EVALUATION (OTE)
PUBLICATIONS LIST

May 2014

The U.S. Department of Commerce's Office of Technology Evaluation is the focal point within the Department for conducting assessments of defense-related industries and technologies. The studies are based on detailed industry-specific surveys used to collect information from U.S. companies and are conducted on behalf of the U.S. Congress, the military services, industry associations, or other interested parties. *Bold indicate forthcoming studies.

Publications
Strategic and Critical Materials Supply Chain Assessment – Summer 2014
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages (Update) – Summer 2014
Defense Industrial Base Assessment of the U.S. Underwater Acoustics Transducer Industry – Spring 2014
Assessment of the U.S. Space Industrial Base Supply Chain – Spring 2014
Industrial Base Assessment of Consumers of U.S. Electro-Optical (EO) Satellite Imagery – August 2013
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Fourth Review – July 2013
Defense Industrial Base S2T2 Survey of C4ISR Sector – Spring 2013
Critical Technology Assessment: Night Vision Focal Plane Arrays, Sensors, and Cameras – October 2012
National Aeronautics and Space Administration (NASA) Industrial Base – Post-Space Shuttle – June 2012
Defense Industrial Base Assessment of the Telecommunications Industry Infrastructure – April 2012
Reliance on Foreign Sourcing in the Healthcare and Public Health (HPH) Sector – December 2011
Defense Industrial Base S2T2 Survey of Six Sectors –July 2011
Cost-Metric Assessment of Diminishing Manufacturing Sources and Material Shortages – August 2010
Critical Technology Assessment: Impact of U.S. Export Controls on Green Technology Items – August 2010
Technology Assessment of Fine Grain, High-Density Graphite – April 2010

Defense Industrial Base Assessment of Counterfeit Electronics – January 2010
Technology Assessment of 5-Axis Machine Tools – July 2009
Defense Industrial Base Assessment of U.S. Integrated Circuit Design and Fabrication Capability – March 2009
Defense Industrial Base Assessment of the U.S. Space Industry – August 2007
Technology Assessment of Certain Aromatic Polyimides – July 2007
Defense Industrial Base Assessment of U.S. Imaging and Sensors Industry – October 2006
National Security Assessment of the Cartridge and Propellant Actuated Device Industry: Third Review – August 2006
Economic Impact Assessment of the Air Force C-17 Program – December 2005
National Security Assessment of the Munitions Power Sources Industry – December 2004
National Security Assessment of the Air Delivery (Parachute) Industry – May 2004
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