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# Preliminary Estimates of the U.S. Space Economy, 2012–2018

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## Background

Economic activity related to space exploration in the United States dates to the early 1800s with the construction of America's first observatories (MacDonald 2017). Despite the long history of space economic activity in the United States and dominance of U.S. space spending relative to the rest of the world (Organisation for Economic Co-operation and Development (OECD) 2012), there is a lack of consistent and comprehensive economic data about the U.S. space economy. To address this, the Bureau of Economic Analysis (BEA) developed preliminary estimates of the U.S. space economy as part of a Space Economy Satellite Account (SESA). The SESA represents a collaborative effort to measure space activity within the U.S. economy. These experimental estimates shed light on the contribution of space-related goods and services to the U.S. economy using a framework consistent with how the overall U.S. economy is measured. Specifically, the SESA provides an estimate of the space economy's contribution to current-dollar gross domestic product (GDP) and illustrates the contributions of individual industries to the space economy. In addition to GDP, the SESA also provides gross output estimates and private sector compensation and employment estimates for the space economy.

The newly released statistics show in 2018, the U.S. space economy accounted for $177.5 billion of gross output, 0.5 percent ($108.9 billion) of current-dollar GDP, $41.2 billion of private industry compensation, and supported more than 356,000 private sector jobs (tables 1–4). Relative to the overall U.S. economy over the 2012–2018 study period, the space economy experienced slower growth in all four sets of statistics (table 5). Relatively slow growth over the period was driven mainly by the information and manufacturing sectors (chart 1). Strong growth in the wholesale trade sector over the period partially offset declines in information and manufacturing output. The following section highlights additional significant findings from the preliminary set of space economy estimates. The rest of the article provides an overview of satellite accounts, including an explanation of the data and methodology used to develop the SESA statistics, and concludes with a description of next steps of the project.

## Table 1. U.S. Space Economy Gross Output by Industry

**[Millions of current dollars]**

| Line | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 1 | Space Economy[1] | 162,746 | 169,742 | 171,655 | 177,299 | 177,944 | 179,222 | 177,535 |
| 2 | Agriculture, forestry, fishing, hunting, mining, and utilities | 12 | 10 | 9 | 24 | 23 | 18 | 10 |
| 3 | Construction | 364 | 329 | 509 | 606 | 643 | 938 | 576 |
| 4 | Manufacturing | 52,975 | 54,435 | 52,253 | 50,757 | 49,951 | 49,602 | 48,093 |
| | Of which: | | | | | | | |
| 5 | Computer and electronic products[2] | 31,689 | 31,860 | 28,912 | 28,878 | 28,377 | 29,338 | 28,308 |
| 6 | Other transportation equipment[3] | 17,522 | 18,233 | 19,274 | 19,447 | 18,938 | 17,711 | 17,355 |
| 7 | Wholesale trade | 23,171 | 24,866 | 26,293 | 29,139 | 30,578 | 31,707 | 33,163 |
| 8 | Retail trade | 293 | 477 | 627 | 806 | 1,368 | 1,901 | 2,562 |
| 9 | Transportation and warehousing | 1,660 | 1,508 | 1,350 | 1,295 | 1,282 | 1,305 | 1,577 |
| 10 | Information | 56,842 | 60,463 | 63,135 | 65,921 | 64,731 | 64,650 | 61,446 |
| | Of which: | | | | | | | |
| 11 | Wired telecommunications carriers[4] | 40,123 | 42,982 | 45,167 | 46,681 | 44,588 | 43,894 | 39,762 |
| 12 | Satellite telecommunications | 6,661 | 6,763 | 6,569 | 6,817 | 7,076 | 6,842 | 6,975 |
| 13 | Finance, insurance, real estate, rental, and leasing | 37 | 72 | 92 | 124 | 135 | 248 | 199 |
| 14 | Professional and business services | 6,774 | 6,987 | 6,396 | 6,804 | 6,711 | 6,647 | 6,671 |
| 15 | Educational services | 2,058 | 2,046 | 2,047 | 2,133 | 2,112 | 2,065 | 2,427 |
| 16 | Health care and social assistance | 94 | 100 | 88 | 101 | 113 | 110 | 142 |
| 17 | Arts, entertainment, recreation, accommodation, food services and other services | 117 | 124 | 129 | 124 | 127 | 141 | 142 |
| 18 | Government[5] | 18,350 | 18,327 | 18,727 | 19,469 | 20,172 | 19,890 | 20,525 |
| 19 | Federal | 15,792 | 15,903 | 16,338 | 17,014 | 17,746 | 17,550 | 17,809 |
| 20 | State and local | 2,559 | 2,424 | 2,389 | 2,454 | 2,427 | 2,340 | 2,717 |
| | **Addenda:** | | | | | | | |
| 21 | Private industries | 144,395 | 151,415 | 152,928 | 157,831 | 157,773 | 159,332 | 157,009 |
| 22 | Space Economy excluding satellite television, satellite radio, and educational services[6] | 117,958 | 121,945 | 121,432 | 125,183 | 127,253 | 128,416 | 130,362 |

1. The space economy consists of space-related goods and services, both public and private. This includes goods and services that:
   - Are used in space, or directly support those used in space
   - Require direct input from space to function, or directly support those that do
   - Are associated with studying space
2. Includes manufacturing of satellites; ground equipment; search, detection, navigation, and guidance systems (GPS/PNT equipment)
3. Includes manufacturing of space vehicles and space weapons systems (intercontinental ballistic missiles)
4. Includes direct-to-home satellite television services
5. Includes spending on personnel, operations, and maintenance. Government spending on private sector investment (structures, equipment, intellectual property) is included within the individual industries
6. This value represents a narrower interpretation of the “Space Economy” definition. These commodities are primarily produced by the Information (line 10) and Educational services (line 15) industries

## Table 2. U.S. Space Economy Value Added by Industry

**[Millions of current dollars]**

| Line | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 1 | Space Economy[1] | 96,689 | 104,486 | 102,909 | 109,010 | 110,571 | 111,404 | 108,901 |
| 2 | Agriculture, forestry, fishing, hunting, mining, and utilities | 9 | 8 | 7 | 17 | 16 | 13 | 7 |
| 3 | Construction | 239 | 228 | 350 | 423 | 449 | 655 | 400 |
| 4 | Manufacturing | 34,236 | 37,347 | 35,865 | 35,514 | 36,979 | 37,399 | 36,446 |
| | Of which: | | | | | | | |
| 5 | Computer and electronic products[2] | 22,909 | 24,633 | 23,020 | 23,172 | 24,458 | 26,843 | 26,264 |
| 6 | Other transportation equipment[3] | 8,649 | 9,593 | 9,899 | 10,460 | 10,541 | 8,657 | 8,342 |
| 7 | Wholesale trade | 12,594 | 13,477 | 14,185 | 16,405 | 17,292 | 17,833 | 18,004 |
| 8 | Retail trade | 208 | 336 | 433 | 555 | 937 | 1,292 | 1,701 |
| 9 | Transportation and warehousing | 810 | 752 | 683 | 712 | 745 | 727 | 852 |
| 10 | Information | 29,909 | 33,457 | 32,467 | 35,338 | 33,961 | 33,654 | 30,993 |
| | Of which: | | | | | | | |
| 11 | Wired telecommunications carriers[4] | 22,362 | 25,645 | 24,897 | 27,075 | 25,426 | 24,817 | 22,424 |
| 12 | Satellite telecommunications | 2,837 | 2,963 | 2,766 | 2,862 | 2,823 | 2,897 | 2,651 |
| 13 | Finance, insurance, real estate, rental, and leasing | 34 | 48 | 59 | 90 | 107 | 155 | 128 |
| 14 | Professional and business services | 3,904 | 4,036 | 3,724 | 4,099 | 3,917 | 3,762 | 3,777 |
| 15 | Educational services | 1,595 | 1,551 | 1,548 | 1,646 | 1,584 | 1,511 | 1,800 |
| 16 | Health care and social assistance | 75 | 78 | 68 | 79 | 86 | 82 | 106 |
| 17 | Arts, entertainment, recreation, accommodation, food services and other services | 72 | 74 | 78 | 67 | 76 | 83 | 85 |
| 18 | Government[5] | 13,006 | 13,097 | 13,441 | 14,064 | 14,422 | 14,239 | 14,601 |
| 19 | Federal | 10,993 | 11,236 | 11,611 | 12,142 | 12,583 | 12,502 | 12,566 |
| 20 | State and local | 2,013 | 1,861 | 1,830 | 1,922 | 1,839 | 1,737 | 2,035 |
| | **Addenda:** | | | | | | | |
| 21 | Private industries | 83,684 | 91,390 | 89,468 | 94,946 | 96,150 | 97,165 | 94,300 |
| 22 | Space Economy excluding satellite television, satellite radio, and educational services[6] | 72,104 | 76,702 | 75,929 | 79,817 | 82,582 | 83,842 | 83,807 |

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2. Includes manufacturing of satellites; ground equipment; search, detection, navigation, and guidance systems (GPS/PNT equipment)
3. Includes manufacturing of space vehicles and space weapons systems (intercontinental ballistic missiles)
4. Includes direct-to-home satellite television services
5. Includes spending on personnel, operations, and maintenance. Government spending on private sector investment (structures, equipment, intellectual property) is included within the individual industries
6. This value represents a narrower interpretation of the “Space Economy” definition. These commodities are primarily produced by the Information (line 10) and Educational services (line 15) industries

## Table 3. U.S. Space Economy Employment by Industry

**[Thousands of full and part-time employees]**

| Line | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 1 | Space Economy,[1a]Private[1b] | 351 | 359 | 351 | 355 | 357 | 362 | 356 |
| 2 | Manufacturing | 124 | 124 | 116 | 112 | 113 | 112 | 112 |
| 3 | Wholesale trade | 56 | 57 | 58 | 64 | 69 | 71 | 70 |
| 4 | Information | 116 | 121 | 123 | 121 | 112 | 114 | 105 |
| 5 | Professional and business services | 27 | 28 | 25 | 26 | 26 | 23 | 23 |
| 6 | Educational services | 17 | 16 | 16 | 16 | 16 | 15 | 17 |
| 7 | All other private industries | 12 | 13 | 14 | 16 | 22 | 27 | 31 |

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   - Are associated with studying space
2. Excludes government employees

## Table 4. U.S. Space Economy Compensation by Industry

**[Millions of current dollars]**

| Line | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 1 | Space Economy,[1a]Private[1b] | 39,966 | 41,032 | 41,235 | 42,638 | 43,033 | 42,625 | 41,193 |
| 2 | Manufacturing | 18,419 | 18,664 | 18,324 | 18,368 | 18,902 | 17,769 | 16,748 |
| 3 | Wholesale trade | 5,949 | 6,208 | 6,488 | 7,301 | 7,841 | 8,429 | 8,444 |
| 4 | Information | 10,623 | 11,025 | 11,418 | 11,477 | 10,722 | 10,745 | 9,982 |
| 5 | Professional and business services | 3,140 | 3,272 | 3,036 | 3,369 | 3,206 | 3,030 | 3,010 |
| 6 | Educational services | 1,114 | 1,109 | 1,132 | 1,172 | 1,184 | 1,129 | 1,357 |
| 7 | All other private industries | 721 | 754 | 836 | 952 | 1,178 | 1,524 | 1,651 |

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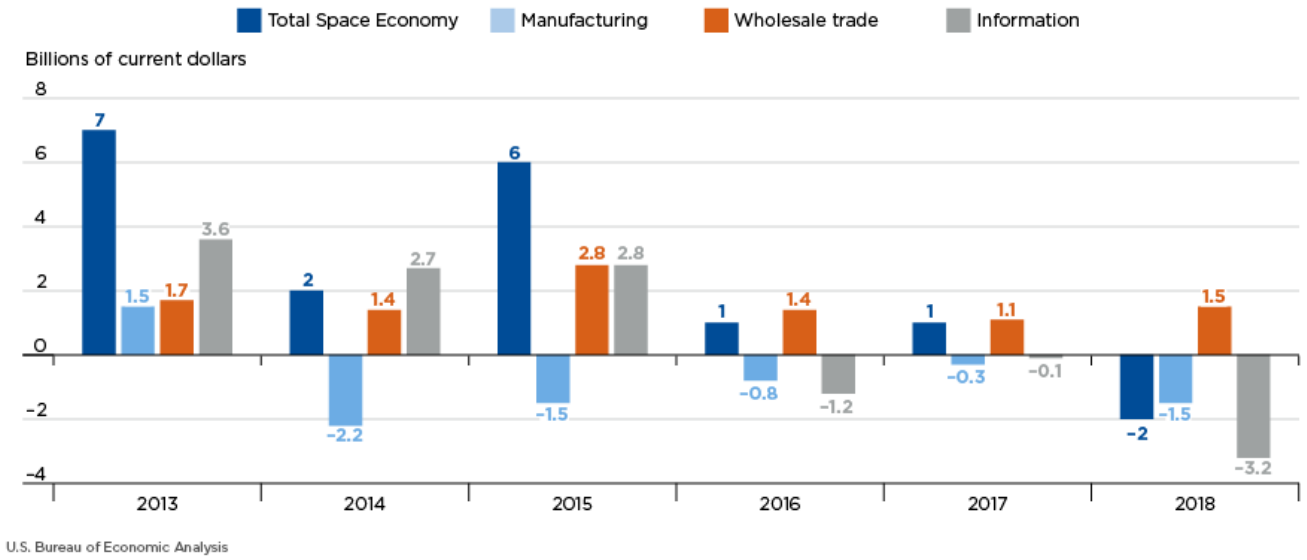
   - Are associated with studying space
2. Excludes government employee compensation

## Table 5. Comparing the U.S. Space Economy to the Overall U.S. Economy, 2012–2018

| Series | Space economy, 2018 (billons of dollars; thousands of jobs for private employment) | Space economy as a percent of U.S. economy, 2018 | Space economy average annual growth rate, 2012–2018 (percent) | U.S. economy average annual growth rate, 2012–2018 (percent) |
|---|---|---|---|---|
| Gross output | 178 | 0.5 | 1.5 | 3.9 |
| Value added | 109 | 0.5 | 2.1 | 4.1 |
| Private employment | 356 | 0.3 | 0.3 | 2.0 |
| Private compensation | 41 | 0.5 | 0.3 | 4.5 |

Chart 1. Space Economy Gross Output, Changes in Levels from Largest Contributors




U.S. Bureau of Economic Analysis

# Preliminary Estimates of the U.S. Space Economy, 2012–2018

Gross output by industry and GDP (value added) by industry are both published as part of BEA's Space Economy Satellite Account, along with compensation and employment. The gross output of an industry is the market value of the goods and services produced by an industry. The primary component of gross output is revenue or receipts, but it also includes commodity taxes, other operating income, and inventory change. Since most existing reports related to the space economy use revenue to describe and quantify space activities (for example, Space Foundation 2019; Satellite Industry Association 2019), we focus in this section mainly on our gross output by industry results. However, caution is urged when comparing BEA's space economy estimates to existing economic impact reports due to differing definitions and measurement concepts (see the box "Comparison to Industry Economic Impact Reports").

## Industry distribution of gross output

The space economy accounted for $177.5 billion (0.5 percent) of U.S. gross output in 2018 (table 1). Two sectors dominated the space economy, information and manufacturing, and represented 61.7 percent of total space economy gross output in 2018. The information sector was the largest contributor to space economy gross output for all 7 years in the study (2012–2018). In 2018, the information sector contributed $61.4 billion to the space economy, or 34.6 percent of the total gross output estimate. The largest component of the information sector is the wired telecommunications carriers industry, which includes direct-to-home satellite television services.

Manufacturing was the second largest sector in terms of gross output, accounting for $48.1 billion of gross output in 2018. The share of gross output attributable to manufacturing decreased from 32.6 percent ($53 billion) in 2012 to 27.1 percent in 2018, mostly reflecting a decline in the computer and electronic products industry. This industry includes many space-related products, notably manufacturing of satellites; ground equipment; and search, detection,

navigation, and guidance systems (GPS/PNT equipment). Almost 8 percent of the total U.S. gross output in 2018 for the computer and electronic products industry is attributable to the space economy. The second largest industry within manufacturing is other transportation equipment, which includes space vehicles and space weapons systems, including intercontinental ballistic missiles. This industry contributed 9.8 percent, or $17.4 billion, to 2018 space economy gross output.

Although space economy gross output is concentrated in a couple of sectors, space activity can be seen in essentially every major sector of the U.S. economy. Many of the relatively small sectors in the space economy, such as agriculture, forestry, fishing, hunting, mining, and utilities, reflect production related to research and development (R&D) and remote sensing software and services.

## Industry contributions to gross output growth

Gross output for the space economy grew 1.5 percent, on average, from 2012–2018 (table 5). Since these estimates are in current dollars, caution should be used when interpreting growth rates. Current-dollar estimates are not adjusted for inflation, so growth rates incorporate both changes in prices and changes in quantities. Growth throughout the period ranged from a high of 4.3 percent from 2012–2013 to a low of −0.9 percent from 2017–2018. Chart 1 shows the major contributors to growth for each year. In general, three sectors were driving growth: information, manufacturing, and wholesale trade. From 2012–2015, the information sector was the main source of growth in the space economy. Conversely, it was a major negative contributor for 2016–2018. This contraction corresponds to the decline in satellite television subscribers and revenue that began in 2016 (Satellite Industry Association 2019).

Manufacturing gross output declined for almost the entire period (2013–2018). Both the computer and electronic products industry and the other transportation equipment industry showed volatility over the time series. These growth rates can reflect many factors, such as fluctuations in R&D spending or changes in inventories over the period. Additionally, because these growth rates are not adjusted for inflation, they capture both price and quantity changes for the period. From 2012–2018, the U.S. computer and electronic products industry saw current-dollar gross output increase by an average of 1.1 percent, whereas real gross output increased by 2.4 percent. This suggests price effects influenced real growth for this industry over the period, and estimates of real manufacturing output for the space economy may follow the same pattern. The value-added estimates provide additional insights into these trends, described below.

Wholesale trade showed positive growth for every year, 6.2 percent on average, offsetting some of the declines in information and manufacturing. Wholesale trade margins, or markups, reflect the value added by wholesalers in the distribution of a product from producers to purchasers. Wholesale trade output is margin based (sales less the costs of goods sold) instead of purely sales based, meaning this growth reflects an increase in the margins received and not necessarily an increase in sales. In other words, the 6.2 percent annual average growth rate reflects strong growth in the margins earned on the use of space-related products as intermediate inputs, such as GPS receivers.

## Value added, employment, and compensation by industry

Tables 2–4 show value added (GDP), employment, and compensation by industry for the 2012–2018 space economy. An industry's value added is the market value it adds in production, or the difference between an industry's gross output and the cost of its intermediate inputs. Employment includes both full- and part-time employees, and compensation consists of wages and salaries and employer contributions to pensions and insurance. In 2018, the space economy accounted for $108.9 billion of current-dollar GDP (0.5 percent of total U.S. current-dollar GDP), $41.2 billion of private industry compensation, and supported more than 356,000 private sector jobs. Many of the trends in the gross output statistics are also true for these statistics. Specifically, the manufacturing and information sectors dominated GDP, private employment, and private compensation.

One notable difference between space economy gross output and GDP was within manufacturing. While manufacturing gross output mostly declined over the period, manufacturing GDP often increased. Since the value of manufacturing intermediate inputs (gross output minus value added) fell steadily over the period, this could suggest declines in gross output were related to lower production costs or increased returns to capital. This finding aligns with recent innovations in manufacturing that have shown to lower marginal costs of space-related production, such as reusable rockets and 3D printing (SpaceX 2020; Relativity 2020). As previously mentioned, it is also unclear what role inflation plays in these growth rates.

# Methodology

## Satellite accounting

A "satellite account" refers to statistics that complement BEA's official U.S. economic statistics. These satellite accounts provide additional detail and allow for a more indepth analysis of key sectors of the U.S. economy, such as health care. Satellite accounts are also useful to understand economic activity that is not easily identifiable under the standard industry classification used for official economic statistics (North American Industry Classification System (NAICS)). BEA produces many of these satellite accounts, including travel and tourism; arts and culture; outdoor recreation; ocean economy; and digital economy. These satellite account statistics reflect economic activity that is spread across multiple industries under the NAICS.

As with BEA's other satellite accounts, the SESA is built using BEA's comprehensive supply-use tables. The supply-use tables provide insight into the internal workings of the U.S. economy and detail the contribution of specific industries and commodities (goods and services) to GDP. The supply-use tables detail the flows of commodities purchased by each industry, the incomes earned from production in each industry, and the distribution of sales for each commodity. The Economic Census from the U.S. Census Bureau is the primary data source for the supply-use tables. The Economic Census collects data from U.S. establishments that provide the foundation for the supply-use tables, including receipts and expenses of business establishments and of government, sales by detailed industry and product line, final industry and product shipments, input costs by general category, inventories, and trade margins.[1]

The goal of the SESA is to highlight space production and spending that is already present in the supply-use tables. In practice, the SESA is a rearrangement of BEA's supply-use tables to isolate space spending and production. For example, the SESA shows the production of educational services specific to space, such as astrophysics and astronautical engineering, while the supply-use tables show the production of all educational services, regardless of the subject. Likewise, construction spending on space activities, such as construction of space ports and observatories, is already embedded in the supply-use tables, and the SESA simply isolates such spending. There are three main steps to developing satellite account estimates:

- Step 1: Identify relevant commodities (goods and services) within BEA supply-use tables.
- Step 2: Separate economic activity within commodities, when necessary.
- Step 3: Use BEA supply-use tables to determine total economic activity by industry.

An important aspect of identifying relevant commodities in step 1 is deciding on a definition of the "space economy." Determining definitions is significant because it provides the overall framework for the new satellite account and influences the data and methods used to develop the new statistics. The OECD (2012, 20) has done extensive research related to measuring the space economy and provides the following definition: "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space." We used the OECD definition as the foundation of our research but determined more specific language was necessary to provide the framework for the SESA statistics. Therefore, the approach we took was to first identify the commodities that comprise the space economy and then develop a definition that characterizes these commodities.

Commodities were chosen based on industries identified by the OECD, products identified in a Bureau of Industry and Security report describing the U.S. space industry supply chain (2013), various reports from the private sector (for example, Satellite Industry Association 2019; Space Foundation 2019), input from U.S. and international space agencies (for example, the National Aeronautics and Space Administration (NASA), the Canadian Space Agency, and the Australian Space Agency), BEA industry analyst input, and industry expert feedback. We also considered future commodities when developing this definition. A description of the included commodities is found in table 6, along with the industry sectors that primarily produce these commodities. Our definition of the space economy is as follows:

The space economy consists of space-related goods and services, both public and private. This includes goods and services that:

- Are used in space, or directly support those used in space
- Require direct input from space to function, or directly support those that do
- Are associated with studying space

As shown in table 6, space-related commodities range from telecommunications and space vehicle manufacturing to R&D and construction of observatories, plus many others. Space-related commodities are produced by most sectors of the U.S. economy, including information, manufacturing, retail trade, wholesale trade, government, professional and business services, and construction.

**Table 6. Industries and Commodities Included in the U.S. Space Economy Estimates with Principal Data Sources**

| Primary industries | Brief description of commodities | Principal data sources |
|---|---|---|
| Information | Telecommunications, broadcasting, software | Bureau of Labor Statistics (BLS) Occupational Employment Survey (OES); Federal Communications Commission "Internet Access Services" reports; Securities and Exchange Commission 10-K filings; Bureau of Economic Analysis supply-use tables |
| Manufacturing, retail trade, and wholesale trade | Space vehicles; space weapon systems; satellites; ground equipment; search, detection, navigation, and guidance systems (GPS/PNT equipment) | Economic Census product line data; BEA supply-use tables |
| Government | Military, civilian, federally funded research and development centers | Public budget documents; National Science Foundation (NSF) Survey of Federal Funds for Research and Development; BEA supply-use tables |
| Professional and business services | Research and development; engineering and technical services; computer systems design; geophysical surveying and mapping services | BLS OES; NSF Survey of Federal Funds for Research and Development; NSF Business Enterprise Research and Development Survey; BEA supply-use tables |
| Construction | Space facilities, observatories, planetariums | Census Value of Construction Put in Place; BEA supply-use tables |
| Other various service industries | Launch services, insurance, education, observatories, planetariums | Federal Aviation Administration "Annual Compendium of Commercial Space Transportation"; MITRE launch demand model; National Center for Education Statistics Integrated Postsecondary Education Data System; Public documents; BEA supply-use tables |

Commodities can be split into two categories: intermediate inputs and final demand. Intermediate input commodities are goods and services used up in the production of other commodities. Final demand commodities are goods and services purchased or consumed for "final use" and comprise GDP. Final use consists of personal consumption expenditures, gross private fixed investment, change in private inventories, exports of goods and services, imports of goods and services, and government consumption expenditures and gross investment. For BEA's satellite accounts, we only need to identify final demand commodities. The intermediate input commodities do not need to be separately identified, because they will be accounted for using our supply-use tables. For example, when we include the commodity "space vehicles," the intermediate inputs used in the production of the space vehicle, such as electronic equipment and metal body, will be captured by default in the SESA gross output estimates. The rare exception is if we think the value of an intermediate input commodity should be included in the SESA estimates, but not the value of the corresponding final demand commodity. For example, GPS receivers are intermediate inputs to final demand commodities like cell phones and cars—we do not include the entire value of cell phones and cars in the space economy, but we do include the value of the GPS receivers in these products.

## Estimating space activity by commodity

Most of our chosen commodities include both space and non-space economic activity, so we use external data sources in combination with our internal supply-use table data to isolate space activity. In practice, we must estimate the percentage of each commodity's output that is specific to space activities. A list of the primary data sources used to estimate space activity within commodities is found in table 6. In most cases, the external datasets we used as an indicator for

output included information about space-related revenue or spending. When revenue or spending data were not available, space-related employment and wage information were sometimes used to identify space activity within commodities.

Information is the largest sector in the space economy driven by telecommunications services. Telecommunications includes satellite telecommunications (forwarding and receiving of satellite signals and resale of satellite telecommunications), satellite television services, satellite phone services, satellite internet services, and related support services such as tracking stations and telemetry services. Satellite radio services are primarily within the broadcasting industry, and certain remote-sensing software is within the software publishing industry. A variety of data sources were used to isolate space activity for these commodities. Securities and Exchange Commission data were used for satellite television and radio estimates. Federal Communications Commission reports were used for satellite internet estimates. Bureau of Labor Statistics (BLS) Occupational Employment Survey (OES) data were used for the remote-sensing software estimates. Internal BEA supply-use table data were used for satellite telecommunications, satellite phone, and the support services estimates.

Manufacturing products includes space vehicles; space weapons systems (for example, intercontinental ballistic missiles); satellites; ground equipment; and search, detection, navigation, and guidance systems (GPS/PNT equipment). In many cases, output for these commodities is available directly through the supply-use tables. Otherwise, U.S. Census Bureau detailed product line data were used to estimate space activity for commodities that include non-space activity.

Wholesale trade and retail trade margins (that is, markups) on manufactured products are determined directly from the supply-use tables. Wholesale trade is a significant contributor to the space economy (chart 1). The following vignette describes the role of wholesale trade in the space economy. When cell phone manufacturers purchase GPS receivers to install in their phones, the GPS receivers can be supplied in a couple of ways. Cell phone manufacturers can purchase GPS receivers from standalone wholesale distributors or directly from GPS receiver manufacturers via their manufacturing sales branches. Both the output of standalone wholesale distributors and the manufacturer sales branches for GPS receivers are accounted for in the supply-use tables within wholesale trade.

Government represents spending on federal, state, and local government employee personnel, operations, and maintenance. Table 7 shows the federal agencies that provide government space services. This list was determined from space activity identifiable in public budget documents. In practice, government space services mostly involve space exploration, satellite communications/navigation/observation, and weapons that go into space. Government spending paid to private companies for equipment (for example, space vehicles and satellites), structures (for example, space facilities), and intellectual property (for example, software and R&D) is considered government investment and is separate from the government estimate. For example, purchases of GPS units by the U.S. Coast Guard will show up in our SESA manufacturing values, even though U.S. Coast Guard is not listed in table 7. Therefore, the agencies in table 7 do not represent the entirety of government spending in the SESA estimates, only the federal agencies we identified with direct space activity. Publicly available government budget documents were the primary data source for the government estimate. National Science Foundation (NSF) Survey of Federal Funds for Research and Development were used to estimate most nondefense R&D performed by government employees. Classified government services performed by national intelligence personnel are excluded because these data are not publicly available.

**Table 7. Federal Government Agencies and Federally Funded Research and Development Centers with Direct Space Activity**

| | |
|---|---|
| **Nondefense** | |
| Department of Energy | National Institute of Standards and Technology |
| Department of the Interior | National Oceanic and Atmospheric Administration |
| Federal Aviation Administration | National Science Foundation |
| National Aeronautics and Space Administration | Smithsonian |
| **Defense** | |
| Air Force | Defense Logistics Agency |
| Army | Missile Defense Agency |
| Defense Advanced Research Projects Agency | Navy |
| Defense Information Systems Agency | Office of the Secretary of Defense |
| **Federally funded research and development centers** | |
| Aerospace FFRDC | Los Alamos National Laboratory |
| Brookhaven National Laboratory | National Center for Atmospheric Research |
| Jet Propulsion Laboratory | National Optical Astronomy Observatory |
| Lawrence Livermore National Laboratory | National Radio Astronomy Observatory |
| Lincoln Laboratory | National Solar Observatory |

Note. These federal agencies show space-related activity within their annual unclassified budgets for 2012–2018, therefore Space Force and other space-related agencies funded after 2018 are not included in this list.

Professional and business services includes R&D, engineering and technical services, computer systems design, and geophysical surveying and mapping services. NSF surveys were used to determine R&D estimates. Space activities within engineering and technical services were identified using BLS OES occupational data. The BLS OES data were also used to estimate space activity within computer systems design services and geophysical surveying and mapping services, specifically remote sensing production.

Construction estimates for space facilities, planetariums, and observatories are derived from special tabulations of U.S. Census Bureau Value of Construction Put in Place (VIP) data. Census VIP data reflect construction work on new structures, plus improvements to existing structures.

Additional commodities within the space economy include launch services, insurance, educational services, observatories, and planetariums. Launch services appears within two industries: other transportation equipment manufacturing and air transportation. In both cases, these data are available directly from the supply-use tables. Estimates of insurance purchased for satellites and launches come from The Mitre Corporation launch demand model and Federal Aviation Administration Annual Compendium of Commercial Space Transportation reports. Educational services estimates include tuition and fees for college courses related to space, such as astrophysics, and are based on data from the National Center for Education Statistics Integrated Postsecondary Education Data System. Estimates for observatories and planetariums were determined using data from individual websites.

Due to insufficient source data, a couple of commodities are excluded from our estimates that definitionally should be included. This includes construction of laboratories or manufacturing facilities related to space (astrophysics laboratories) and professional organizations or nonprofits that study space. We believe these values are relatively small and would not significantly impact the SESA estimates. Additionally, it could be argued that terrestrial solar power should be included because it represents use of an input from space. However, due to lack

of precedent in past research, commodities related to terrestrial solar power are excluded from these preliminary estimates. Finally, we do not include employment and compensation estimates for government employees in these preliminary estimates. Although certain agencies like NASA publish their employment data online (NASA's website shows its employment to be over 17,000 in 2018[2]), many of the budget documents used to identify space-related government spending do not have corresponding employment and compensation values, especially space activity within the Department of Defense. More research is necessary to develop accurate estimates of space-related government employment and compensation.

## Calculating space economy gross output, value added, employment, and compensation by industry

Space economy gross output by industry represents the share of each commodity's gross output specific to space for every industry that produces the commodity. Although commodities can be produced by multiple NAICS industries, most commodities are made by a primary industry. For example, most guided missile and space vehicle equipment is made by the guided missile and space vehicle manufacturing industry (NAICS 336414), but guided missile and space vehicle equipment can also be made by the aircraft manufacturing industry (NAICS 336411). By choosing individual commodities, we capture production from all relevant industries.

Value added is the gross output of an industry less its intermediate inputs. Intermediate inputs are goods and services that are used in the production process of other goods and services and are not sold in final-demand markets. Value added summed across all industries is equal to GDP. Value added for the space economy is derived from the relationship between the industry output for space activities and total industry output. This means the ratio of intermediate consumption associated with the industry output for space activities is assumed to be the same as the ratio of total industry intermediate consumption to total industry output. Employment and compensation are derived through the same procedure as value added. Specifically, the ratio of an industry's space economy output to total output is applied to total employment and compensation for the industry. Compensation consists of wages and salaries (primarily the monetary remuneration of employees) and supplements (employer contributions for employee pension and insurance funds and employer contributions for government social insurance). Employees include both full- and part-time employees. Estimates of employment and compensation by industry are presented at a higher level of aggregation to avoid potential disclosure issues.

# Conclusion and Future Work

These statistics are the first to shed light on the contribution of space-related goods and services to the U.S. economy using a framework consistent with how the overall U.S. economy is measured. However, additional research and resources are needed to develop an official time series of the entire U.S. space economy. Foremost, government employment and compensation estimates are needed for a comprehensive estimate of space economy employment and compensation. Also, inflation-adjusted statistics would allow for a better understanding of the effect of price increases on growth in the space economy. Finally, the commodities currently excluded from these preliminary estimates, such as professional organizations or nonprofits that study space, would provide a more holistic representation of the U.S. space economy, even if those values are relatively minor.

BEA will endeavor to implement these changes and other extensions to this satellite account subject to time, data, resources, and funding constraints. We ask for feedback from data users and other stakeholders regarding the definitions and commodities included in the SESA and any other comments users think may be relevant to the development of this satellite account. Please send comments to SpaceEconomy@bea.gov.

## Comparison to Industry Economic Impact Reports

How do BEA's estimates of the space economy compare to industry economic impact reports?

BEA's estimates of the space economy are prepared within an economic accounting framework that is fully consistent with the framework used to produce U.S. GDP. This framework also underpins the estimates of BEA's other "satellite accounts," such as that for arts and cultural production and for travel and tourism. Industry economic impact reports related to the space economy use different economic measurement concepts from the SESA and use different definitions of the "space economy," so their estimates are expected to differ from those presented here. For example, industry economic reports often reflect revenue values for space-related companies or space-related products. Although revenue relates closely to BEA's gross output measure, there are significant differences between the two concepts. In addition to revenue, gross output also includes commodity taxes, other operating income, and inventory change. The different measures and differing definitions make it difficult to make direct comparisons between the various industry economic impact reports and the SESA estimates.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