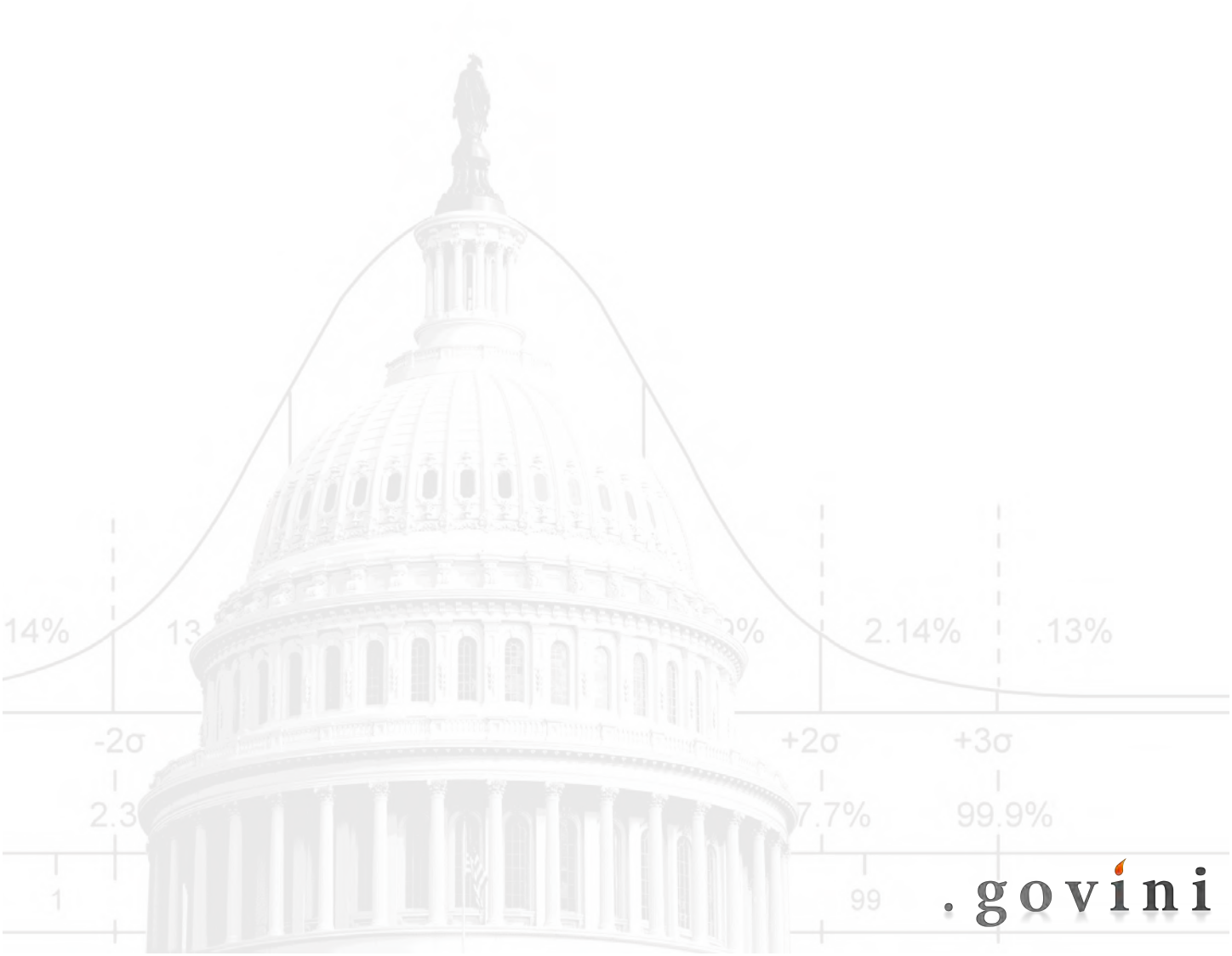
THE NATIONAL SECURITY INNOVATION BASE:

INVESTMENTS IN THE FOURTH INDUSTRIAL REVOLUTION

Foreword by
Chris Taylor, CEO



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FOREWORD

Chris Taylor, CEO

Klaus Schwab, founder of the Word Economic Forum (WEF), published his book The Fourth Industrial Revolution in 2016 to coincide with the annual WEF meeting in Davos. The First Industrial Revolution occurred when the world began to use steam and water as power sources, forsaking the mule and the horse. The Second Industrial Revolution was brought about by the discovery and use of electricity, enabling mass production in factories. The Third Industrial Revolution used electronics, computers and information technology to automate production. The Fourth Industrial Revolution fuses together technologies from the Physical, Digital and Biological spheres, where the impacts of near-instant changes in technology immediately reverberate across government, business and social ecosystems.

In the 20th century, the United States achieved economic and National Security supremacy by solving seemingly intractable problems with advancements in technology. Those successes, the cornerstone of America's global providence, also lulled the nation into misinterpreting how quickly the "rise of the rest" would occur. Over the last ten years great power competitors have leapt up the innovation value chain at a pace no one predicted. America assumed it would always stay safely ahead of the rest of the world in science, defense, economics and culture and never be disrupted.

That assumption was wrong.

The discovery and rapid commoditization of new technologies is disrupting the way we live at an inconceivable pace. The human application of one, two or many emerging and converging technologies, and their subsequent intended and unintended outcomes, are shaping our collective future. For every positive use case for the fusion of new technological discoveries, there are equal, often multiple, negative use cases employed by our great power competitors.

This is what keeps American National Security professionals up at night. The United States' ability to innovate, as well as create and sustain the necessary momentum to keep the country ahead of our rivals is paramount. It requires the complete alignment of what President Trump's National Security Strategy references as the National Security Innovation Base - the whole of American entrepreneurs, companies, industries, universities, research laboratories, and government agencies - to act as a network of people, knowledge, and capabilities to keep America safe.

The United States must shape the new future that the Fourth Industrial Revolution brings, or it will be shaped by others who do not share American values. To achieve this alignment, three critical actions must be taken.

First, the National Security Innovation Base must realign to shape, harness and accelerate moving from ideas to solutions in order to create the momentum necessary to increase readiness and keep America ahead of great power competitors. To do this, National Security leaders must reimagine their organizations with innovation as a core pillar. Having deep visibility into innovations within their organizations from a spending perspective will lead to more sustainable reform efforts. Rethinking private-sector engagements dismantles the status quo that has become the "Tar Pit" on the other side of President Trump's "Swamp." Reorganizing for speed, agility, and collaboration is required to support a talent and idea-centric approach that reveals the very best solutions Americans have to offer. Current DoD innovation efforts like the Strategic Capabilities Office, DIUx, SOFWERX, AFWERX, iLab, NEXTLOG and MD-5 and its Hacking for Defense program are scalable across the National Security Innovation Base because they put problems and people at the center, and use inclusive frameworks that help develop the next generation of National Security innovators.

Second, the National Security Innovation Base must have a clear and unbiased view of its current investments in Fourth Industrial Revolution technologies to determine how fast America's waning National Security advantage can accelerate. For instance, Science and Technology (S&T) portfolios across the National Security Innovation Base are collectively inefficient because no one portfolio leader knows what all of his or her counterparts are doing in S&T. National Security leaders need access to on-demand data science tools that can create a complete taxonomy of S&T spending to help eliminate redundancy and understand what technologies have matured to deployable solutions and what investments continue to languish in the "Valley of Death".

Third, as noted by Secretary of Defense Jim Mattis in his National Defense Strategy summary, the National Security Innovation Base must greatly improve its procurement practices to optimize for speed over burdensome processes in order to deliver scalable solutions to warfighters. Using a data science approach to acquisitions analysis, inefficiencies can be aggressively discovered and dismantled. Uncertain budgets and Continuing Resolutions create confusion in an already fluid National Security environment. Achieving a clear view of how money flows from intent to budget, procurement and execution is now possible using unique, purpose-built at-scale data analysis capabilities. Using the taxonomies in this analytic paper to create decision-grade information, the National Security Innovation base can make smart investments in the Fourth Industrial Revolution, increasing buying power, the velocity from idea to implementation and the distance between America and its rivals.

This Govini Analytic Report, created with our Strategic Intelligence Platform, is a detailed view of the investments that the National Security Innovation Base is making in the Fourth Industrial Revolution. It seeks to put decision-grade information in the hands of National Security leaders responsible for aligning strategy, people, and resources to keep America safe.

THE FOURTH INDUSTRIAL REVOLUTION MARKET TAXONOMY

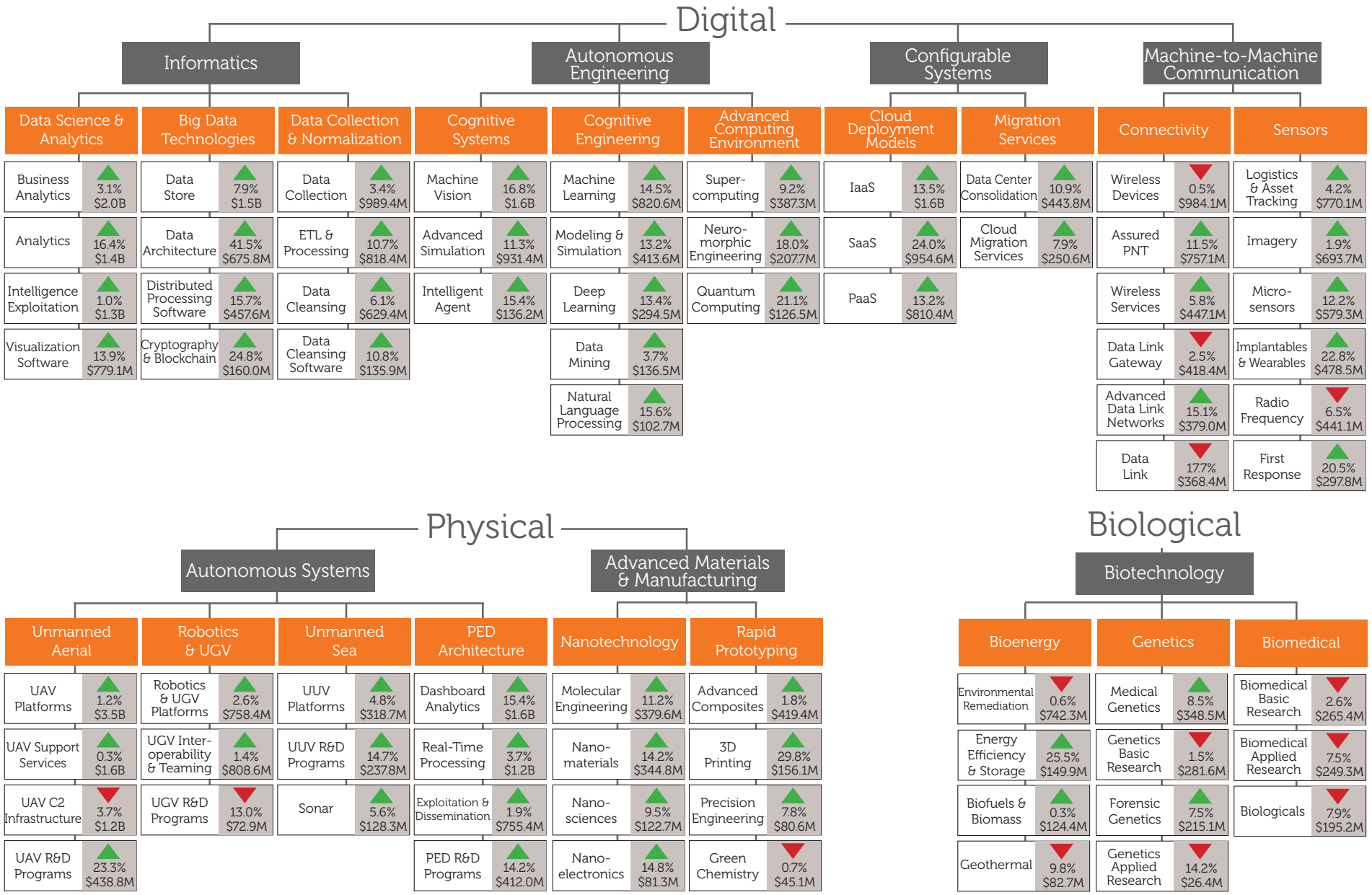


Exhibit 1: Govini's *Fourth Industrial Revolution Taxonomy* consists of three broad groupings (Digital, Physical and Biological) that represent spheres of material state; seven super-nodes (gray boxes) that relate to mission, 19 segments (orange boxes) that define capabilities and 73 sub-segments (white boxes) that constitute technological approach. The hierarchical organizational structure is designed to deliver insight ranging from high-level spending trends to granular details on specific programs and technical solutions. Current year spending and the five-year compound annual growth rate (CAGR) from FY12 through FY17 are noted for each sub-segment.

THE FOURTH INDUSTRIAL REVOLUTION: BLURRING THE LINES BETWEEN THE PHYSICAL, DIGITAL AND BIOLOGICAL

This analytic report leverages data science to present Govini's *Fourth Industrial Revolution Taxonomy*, a roadmap for tracking major drivers that will determine the responses of stakeholders ranging from the global polity and the public and private sectors to academia and civil society. The report presents unclassified Federal Government activity from FY12 through FY17 as a means for predicting priorities in FY18 and beyond.

Key Findings

- Federal spending on Fourth Industrial Revolution technologies and related services reached $43.9 billion in FY17. The Digital sphere accounted for the greatest share of overall spending with 59.2 percent, followed by the Physical sphere with 32.5 percent and Biological with 8.2 percent.
- Digital not only accounted for the greatest share of spending by a large margin, it also grew the most from FY12 through FY17 by a CAGR of 8.2 percent. The spending growth was driven mostly by increased investment in Configurable Systems and integrating autonomous capabilities with those systems.
- Within Configurable Systems, spending on Cloud Deployment Models increased by 15.9 percent to $3.3 billion in FY17. It also prompted spending increases in Migration Services of 9.7 percent.
- All aspects of Autonomous Engineering had significant growth. Spending on Cognitive Systems increased the most by 14.6 percent to $2.7 billion in FY17. Advancement Computing Environment followed with a spending increase of 13.2 percent and Cognitive Engineering with a 13 percent rise in spending.
- Advanced Materials & Manufacturing and a portion of Autonomous Systems drove a 3.7 percent spending increase in the Physical sphere. Advanced Materials & Manufacturing spending increased by a CAGR of 9.2 percent to $1.6 billion in FY17 and Autonomous System spending increased by 3.1 percent to $12.9 billion.
- Nanotechnology sub-segments such as Nanoelectronics, Nanomaterials and Molecular Engineering fueled growth for Advanced Materials & Manufacturing as did 3D Printing. Investment in 3D Printing grew by 29.8 percent from a low level of $42 million in FY12 to $158.2 million in FY17. Spending on Nanoelectronics grew by a CAGR of 14.8 percent; Nanomaterials grew by 14.2 percent and Molecular Engineering grew by 11.2 percent.
- Within Autonomous Systems, less mature platforms such as Unmanned Sea attracted investment compared to its system peers, with spending growing by a CAGR of 7.8 percent. PED Architecture, the mechanism for making sense of data, had an 8.1 percent increase in spending, reaching $3.9 billion in FY17.
- Spending in the Biological sphere decreased by 0.7 percent between FY12 and FY17, with most of the spending cuts coming in the last two years from less support for Biomedical and Genetics.
- Within Biomedical and Genetics, sub-segments related to basic and applied research had some of the largest decreases in spending. Biomedical Applied Research declined by 7.5 percent to $249.3 million in FY17 and Genetics Applied Research declined by 14.2 percent to $26.4 million. Biomedical Basic Research spending declined by 2.6 percent to $265.4 million in FY17 and Genetics Basic Research spending declined by 1.5 percent to $281.6 million.
- Bioenergy, the largest segment of Biotechnology, had a slight spending increase of 0.5 percent to $1.1 billion in FY17.
- Within Bioenergy, the Energy Efficiency & Storage sub-segment had the largest CAGR of 25.5 percent. Biofuels & Biomass spending grew by 0.3 percent to $124.4 million in FY17 and Environmental Remediation spending declined by 0.6 percent to $742.3 million.

Executive Summary

Industrial Revolutions have fundamentally altered the way we live, work and relate to one another, and we are on the brink of another Revolution. The Fourth Industrial Revolution holds great promise for how we live and govern. It is fueled by data and characterized by a fusion of technologies that will blur the lines between the Physical, Digital and Biological spheres. Fulfillment of that promise depends on how Governments adapt to the coming wave of technology.

The Federal Government is showing signs of adaptation, as it spent $43.9 billion in FY17 on technologies and services related to the Fourth Industrial Revolution. Agencies, however, must make better use of those investments by improving integration of emerging technologies with mature ones for solutions that address pressing challenges like cybersecurity, law enforcement, drug interdiction, first response and moving people and cargo safely.

Within the Digital sphere, agencies are prioritizing spending on Configurable Systems or Cloud. They are also allocating an increasing amount of capital to Autonomous Systems and Machine-to-Machine (M2M) Communication. Advancements in these emerging technologies will need to be aligned with existing capabilities of mature technologies such as Informatics.

Technological advancements in the Physical sphere are also helping to fuel the Revolution. Advanced Materials & Manufacturing is being used to produce the next-generation of Autonomous Systems that readily connect to the Digital sphere. Similarly, advancements in the Biological sphere, specifically Biomedical and Genetics, are reshaping the way machines interact with our bodies and can be used to create new life.

This analytic report explores the technological advancements of Fourth Industrial Revolution technologies that have resulted from Federal investment. The method for quantifying such investment leverages data science to create a proprietary data set of unclassified Federal contract obligations from FY12 through FY17 that is organized in a taxonomical structure. The structure is determined by two guiding factors. The first is how the spending data clusters and relates to broader concepts associated with the Fourth Industrial Revolution. The second factor is the selection of key technologies compiled by the World Economic Forum (WEF) that are most associated with the Fourth Industrial Revolution.

The Taxonomy has four levels that define the Fourth Industrial Revolution by varying degrees of specificity. The three material spheres (Digital, Physical and Biological) represent key technologies at an aggregated level. The seven super-nodes (gray boxes) relate to mission, 19 segments (orange boxes) define capabilities and 73 sub-segments (white boxes) constitute technological approach. The hierarchical organizational structure is designed to deliver insight ranging from high-level spending trends to granular details on specific programs and technical solutions.

Transforming Government Through Merging the Digital, Physical and Biological Spheres

The Digital, Physical and Biological spheres are becoming inextricably linked and the progression of technology is making them more so. Technologies developed for one benefit the others and ultimately heighten the intrinsic value of advancement.

Realizing the benefits of merging the three spheres can be challenging because of the associated disruption and change. Fourth Industrial Revolution technologies transform business, including products and how consumers interact with them, which in turn affects the global economy, particularly growth, employment and the nature of work.

Governments are not isolated from the disruption; in fact, they are most susceptible to it. Their internal operating processes will be altered, having profound impacts on authority structures, including how governments relate to each other, the private sector and broader society.

The Federal Government is transforming most through the Digital sphere. More vendors than any other sphere are collaborating to digitize workflow and deliver Informatics for efficiency gains. The number of vendors competing for Digital contracts is roughly double the amount of the other two spheres combined. Segments of the Physical sphere, such as Unmanned Aerial and PED Architecture, rank among the top by overall obligations. These segments along with their Autonomous System peers are closest to merging with the Digital Sphere.

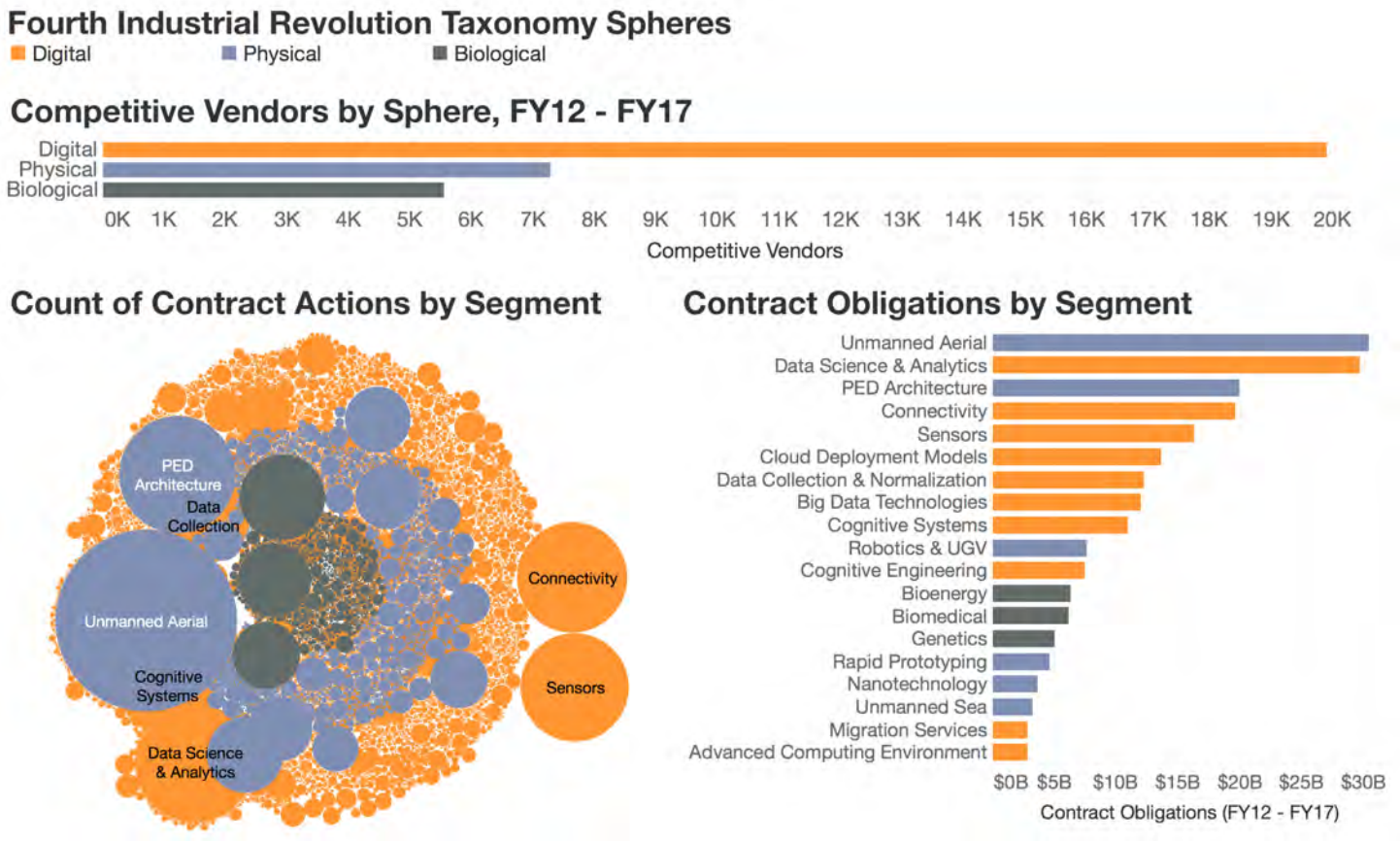
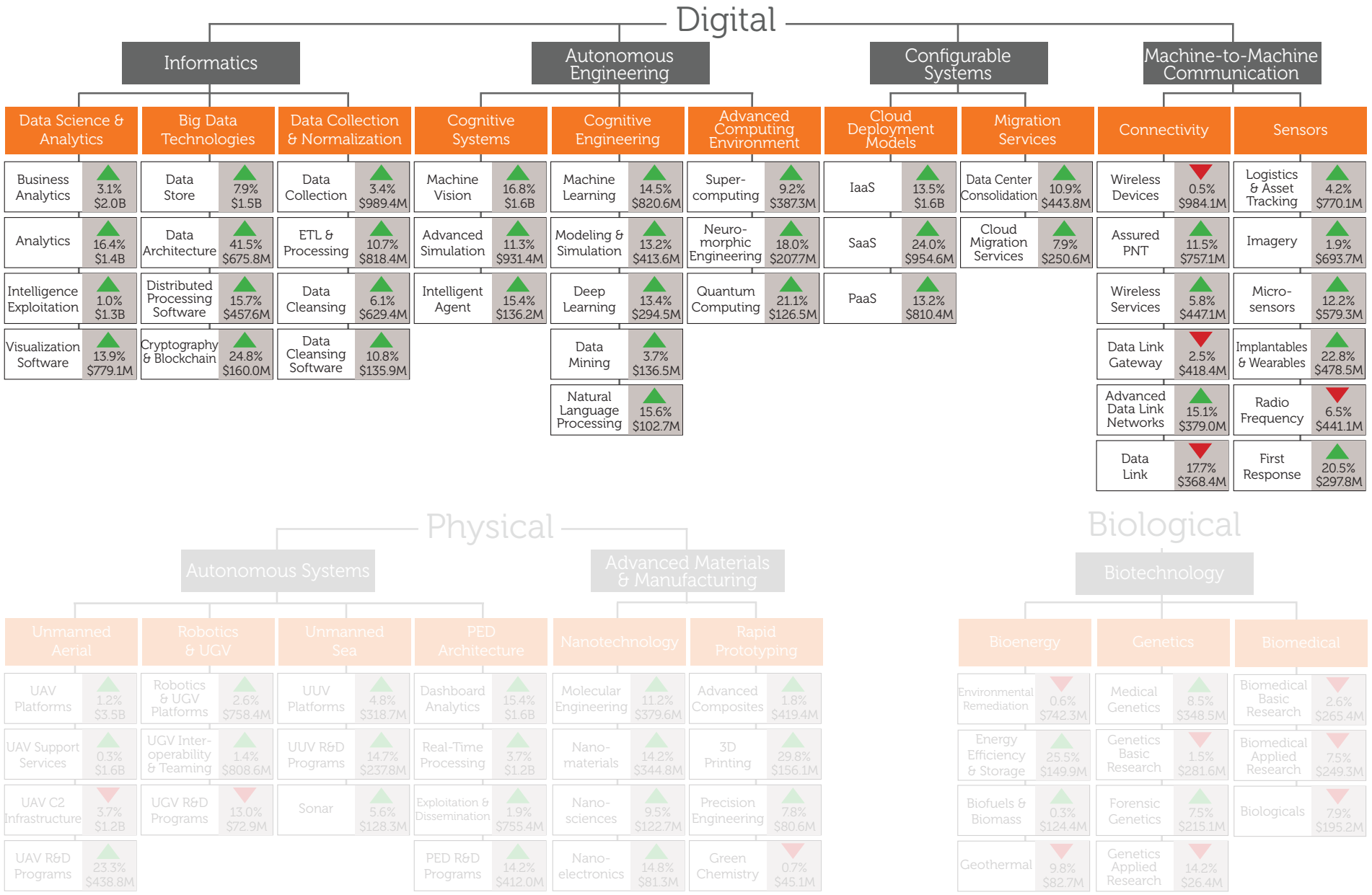


Exhibit 2: The Digital sphere is the largest among the three by a large margin in several measures. Roughly twice as many vendors compete for work related to the Digital sphere than the Physical and Biological combined. Digital accounted for 59.2 percent of overall spending with large portions coming from Data Science & Analytics, Connectivity, Sensors, Cloud Deployment Models and Data Collection & Normalization.

THE FOURTH INDUSTRIAL REVOLUTION MARKET TAXONOMY: DIGITAL SPHERE



THE DIGITAL SPHERE

Emerging Digital Technologies to be Integrated with Existing Mature Technologies

Digital technologies based on computer hardware, software and networks are not new. However, the ways in which they are being integrated with the Physical and Biological spheres for real-time decision making and automation is new. Further integration of the three spheres is dependent on advancement of emerging technologies and integrating them with existing mature technologies to create next-generation operational concepts.

The Federal Government has begun doing this in the Digital sphere. Progress is most visible where high opportunity costs and risk exist. For example, the U.S. military is using advanced sensors aboard unmanned vehicles operating across domains, air, land, sea and space as a means for taking humans out of harm's way. Similarly, sensors and M2M Communication is being adopted in tracking capital-intensive cargo throughout supply chains; monitoring individuals with critical health conditions; and optimizing first response and law enforcement capabilities.

Such M2M Communication can be augmented by advancing related emerging Digital technologies, including Autonomous Engineering and Advanced Computing Environments. Greater adoption of mature technologies like Configurable Systems is also critical for making more efficient and effective use of data for real-time decision making within the Digital sphere.

Exhibit 3 provides insight into how the Federal Government is investing to integrate emerging technologies with mature ones in the Digital sphere. Informatics and Configurable Systems are mature relative to peer digital technologies, M2M Communication and Autonomous Engineering. Without M2M Communication and Autonomy, Informatics is stuck delivering decision-grade information based on outdated data, rather than real-time or prospective data.

Emerging technologies are the most competitive, despite attracting less investment through a fewer number of contracts relative to their peers that are more mature. Deep Learning was the most competitive Digital sphere sub-segment, attracting an average of 11.6 competitive bids. Other sub-segments within the Cognitive Engineering segment were also highly competitive. Data Mining had an average of 7.3 competitive bids and Natural Language Processing had 6.8. Supercomputing was the most competitive among Advanced Computing Environment sub-segments and Implantables & Wearables was the most competitive among Sensor sub-segments.

Despite being mostly mature segments, Big Data Technologies and Connectivity contain some emerging technologies. Within Big Data Technologies, Data Architecture, Distributed Processing Software and Cryptography & Blockchain are considered emerging and attracted much more competition than their peer technologies. Similarly, within Connectivity, Assured PNT and Advanced Data Link Networks are emerging and highly competitive.

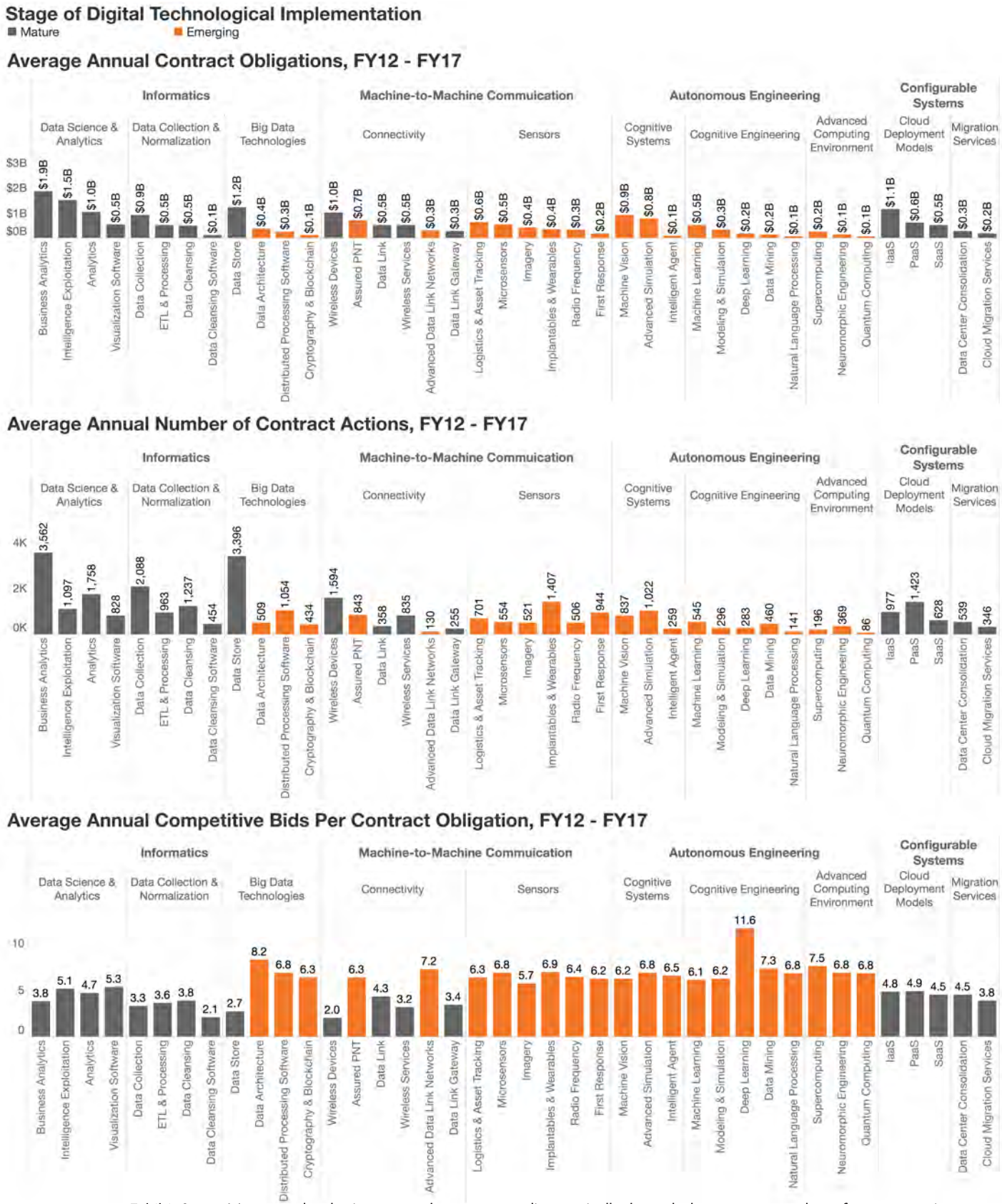


Exhibit 3: Mature technologies attract the most spending, typically through the greatest number of contract actions and the least competition. Emerging technologies such as M2M Communication and Autonomous Engineering are highly competitive relative to peer digital technologies such as Informatics and Cloud. Deep Learning was the most competitive, attracting an average of 11.6 bids per contract action.

Informatics to Serve as Cornerstone of Data-Driven Technology Revolution

Informatics, a branch of information engineering, is focused on interaction between humans and information alongside interfaces, technologies and systems. It will serve as the cornerstone of further integration of the three material spheres. Govini has categorized Informatics into the following three segments and twelve sub-segments:

Data Science & Analytics

- Business Analytics - data skills, technologies and practices used to gain insight
- Intelligence Exploitation - methods of translating, evaluating and transforming raw intelligence data into useful information
- Analytics - examining large datasets, increasingly with specialized systems and software
- Visualization Software - software that schematically abstracts data for visual representation

Data Collection & Normalization

- Data Collection - the process of gathering information in a systematic fashion
- Extraction Transformation and Loading (ETL) & Processing - three functions used to transition data from staging databases into production databases
- Data Cleansing - process to ensure data is free from error and in a usable format
- Data Cleansing Software - software that corrects corrupt or inaccurate records

Big Data Technologies

- Data Store - repository of integrated data that are routinely manipulated and processed
- Data Architecture - policies, models, rules and standards that govern how data is collected, stored and integrated with architectures
- Distributed Processing Software - software used to manage shared resources for processing, standardizing and normalizing
- Cryptography & Blockchain - cryptography methods inherently resistant to modification

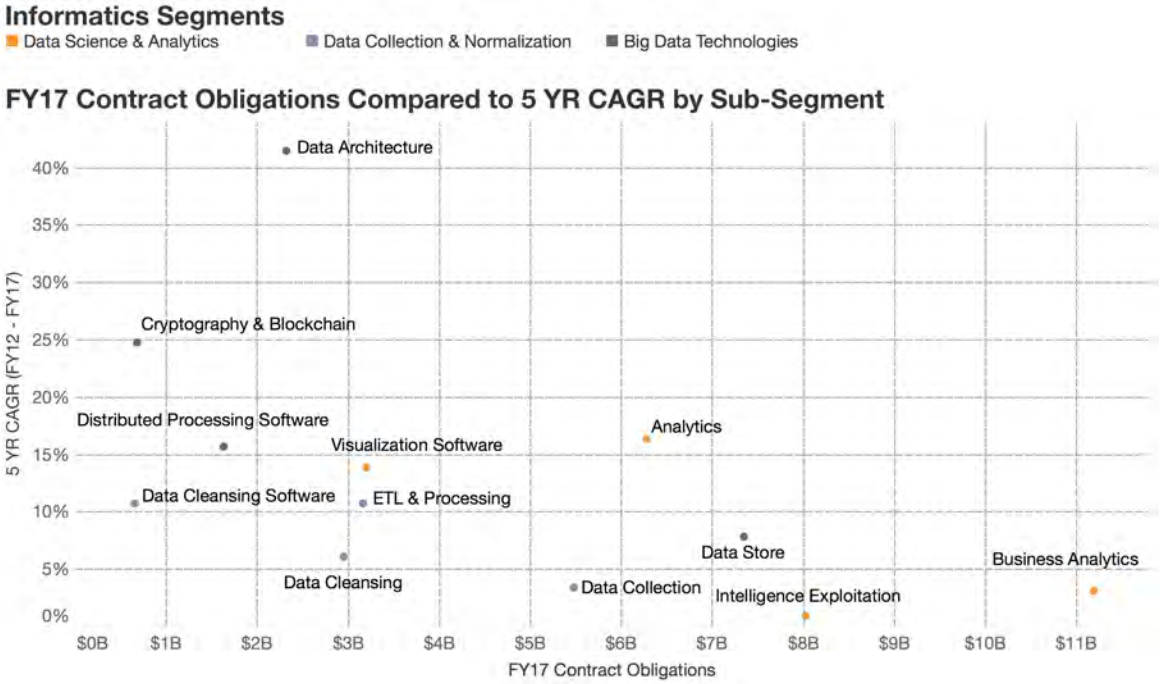


Exhibit 4: Data Architecture and Blockchain stand out among strong spending growth in Informatics. Other emerging technologies also attracting increasing investment, including Distributed Processing Software with a CAGR of 15.7 percent.

Data Science & Analytics to Gain Cognitive Capabilities from Emerging Technologies

Federal spending on Data Science & Analytics has grown steadily since FY12. Overall segment spending increased by a CAGR of 6.4 percent to $5.5 billion in FY17 from $4 billion in FY12. The growth is being fueled by new technologies that leverage science and analytics to automatically transform and make better use data. These technologies are configured for M2M Communication and Cognitive Systems. Contractors that deliver on the highly technical requirement stand to benefit from the coming wave of technical change.

Intelligence Exploitation is serving as a testbed for integrating emerging technologies with mature ones. Department of Defense (DoD) strategy calls for much of its mission analytics work to be automated with algorithms and artificial intelligence (AI). Project Maven, one of several efforts to help a workforce increasingly overwhelmed by incoming data, demonstrates how DoD is integrating AI and machine learning effectively with existing data science & analytics tools.

BAE Systems stands out among providers of Intelligence Exploitation for its ability to deliver automated technology coupled with services. It captured 9.2 percent of overall spending mostly from support of its Digital Electronic Warfare System (DEWS). Other leading providers of Intelligence Exploitation including AASKI Technology, Leidos and Booz Allen Hamilton rely mostly on services rather than the combination of an automated product coupled with services that transform data into useful information. The approach is poised to disrupt other sub-segments like Business Analytics where pure-play service firms also currently lead.

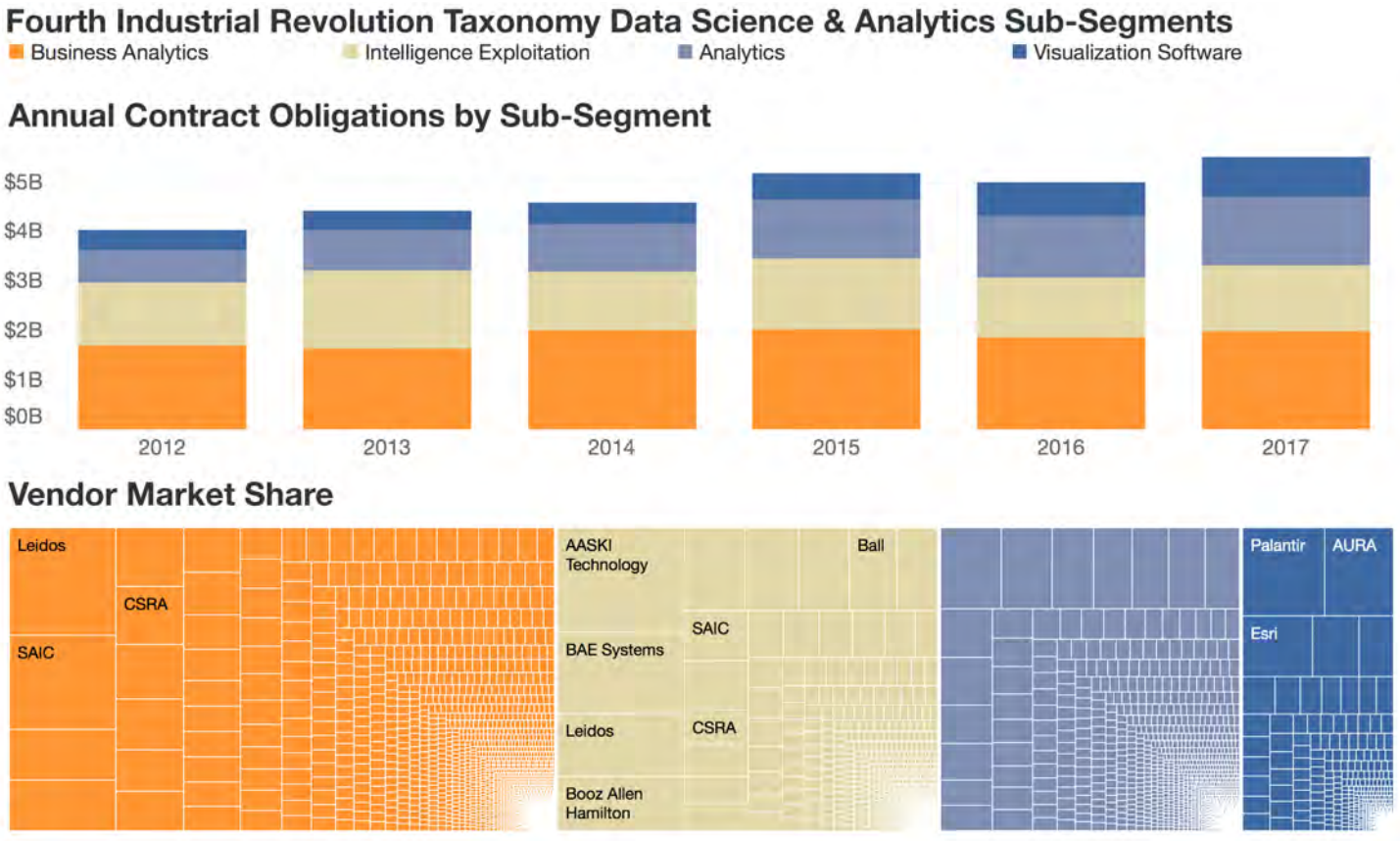


Exhibit 5: System Engineering and Technical Assistance (SETA) contractors including Leidos, SAIC and Booz Allen Hamilton captured the largest shares of Informatics spending of 6.2 percent, 3.4 percent and 3.7 percent respectively. AASKI Technology led capture of Intelligence Exploitation through contracts with Army that surged between FY13 and FY15. Palantir Technologies captured 16 percent of Visualization Software spending.

Data Collection & Normalization Surges in FY17 as it is Transformed by Emerging Technology

Data Collection & Normalization in the Big Data era is complex. Associated technologies harness structured and unstructured data in ways most conducive to a normalization workflow. Spending on Data & Normalization increased by a CAGR of 6.5 percent to $2.6 billion in FY17.

The growth is being fueled by software that cleanses and processes data at scale. The two smallest sub-segments had the most spending growth. Data Cleansing Software investment increased by 10.8 percent and ETL & Processing increased by 10.7 percent.

Advancement in such capabilities is paving the way for greater use of M2M Communication and AI. The two emerging technologies will not only collect more data, but will make better use of it. M2M Communication can be programmed to collect highly structured data related to specific events or conditions, while AI can be trained to sift through unstructured data and recognize patterns that trigger automatic decisions.

Data Collection & Normalization is critical to the advancement of emerging Fourth Industrial Revolution technologies and the current methods are not suitable and require transformation. This means that the market leaders today may not be the ones that pose disruption in the future. Such leaders include LexisNexis, which captured 5.6 percent of segment spend mostly from processing patent data, and Westat, which captured 3.8 percent from processing education statistics. System integrators, including General Dynamics, Northrop Grumman and Raytheon have large market shares at defense and civilian agencies.

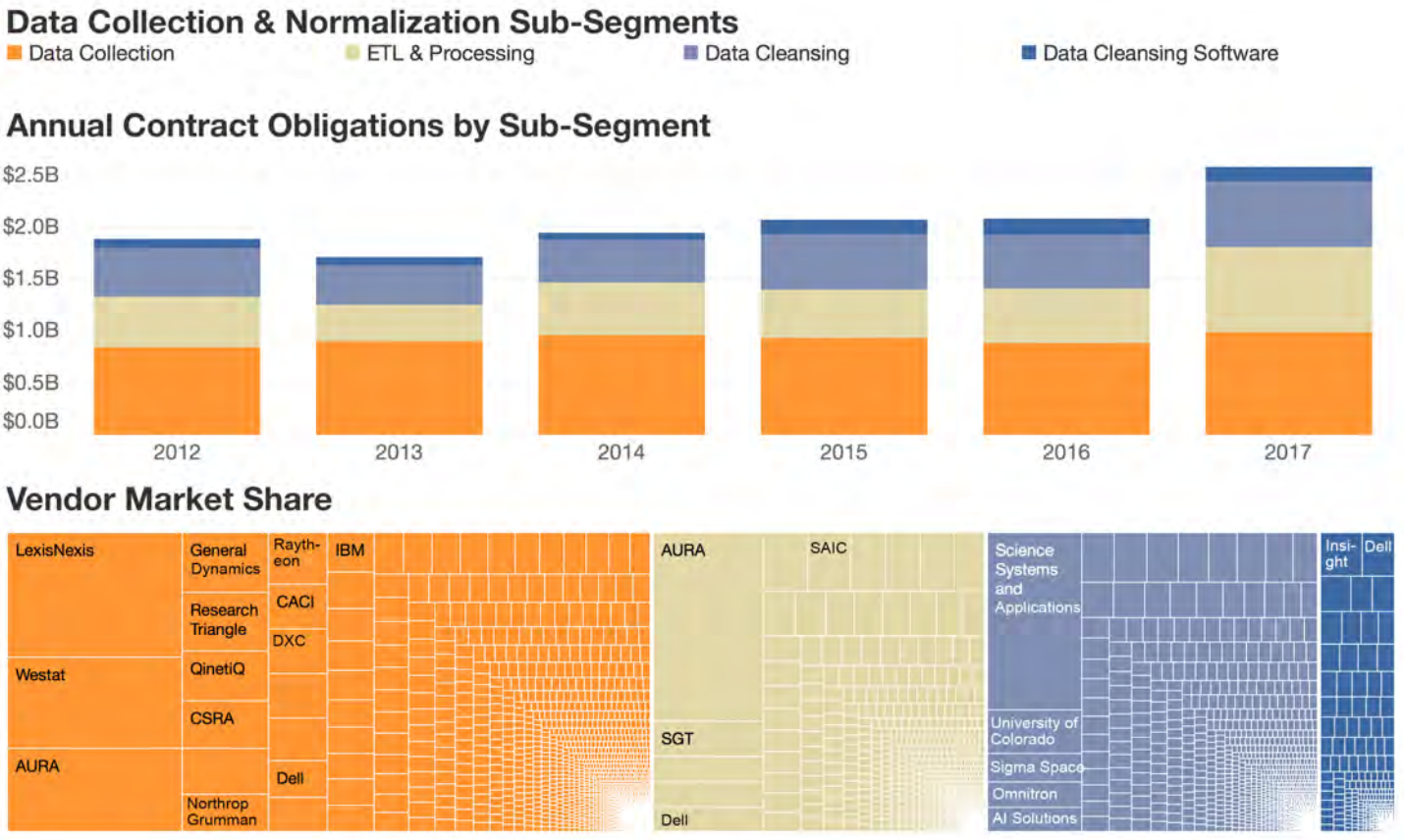


Exhibit 6: ETL & Processing and Data Cleansing fueled a FY17 spending increase. Much of the increases came from NASA and was captured by various Universities and technical engineers, including Science Systems and Applications, Sigma Space, Omnitron, AI Solutions and the Aerospace Corp.

Big Data Spend Surge Sets Stage for Integration with Emerging Cognitive Technologies

Data creation is progressing faster than ever and the Federal Government is investing to make use of the data it generates and collects. The technologies include hardware and software used to store, process, analyze and secure data. Overall spending on these technologies surged by 14.4 percent to $2.8 billion in FY17, the third most out of all Taxonomy segments.

The growth was fueled by all sub-segments, but spending on Data Architecture, Cryptography & Blockchain and Distributed Processing Software grew the most by 41.5 percent, 24.8 percent and 15.7 percent respectively.

Prioritization of the emerging technologies is an indication of the Government's growing sophistication in data processes and securing networks and systems. System integrators including Harris, Northrop Grumman and CSRA captured large Data Architecture contracts. Raytheon, Galois, Lockheed Martin and Centurum captured Cryptology & Blockchain contracts.

Integrators, also compete for Data Store spending, but they face-off against hardware OEMs, value-added resellers (VARs) and data providers. Vendors performing work for many agencies across sub-segments of Big Data Technologies have a distinct competitive advantage.

Leidos is one of those vendors with a competitive advantage. It performs large amounts of work across sub-segments for many agencies, including SSA, HHS, DoD, DHS, USDA, VA and Treasury. IBM performs similar work at some of the same agencies as Leidos. Harris, Northrop Grumman, CSRA and Raytheon also compete for work across sub-segments and agencies.

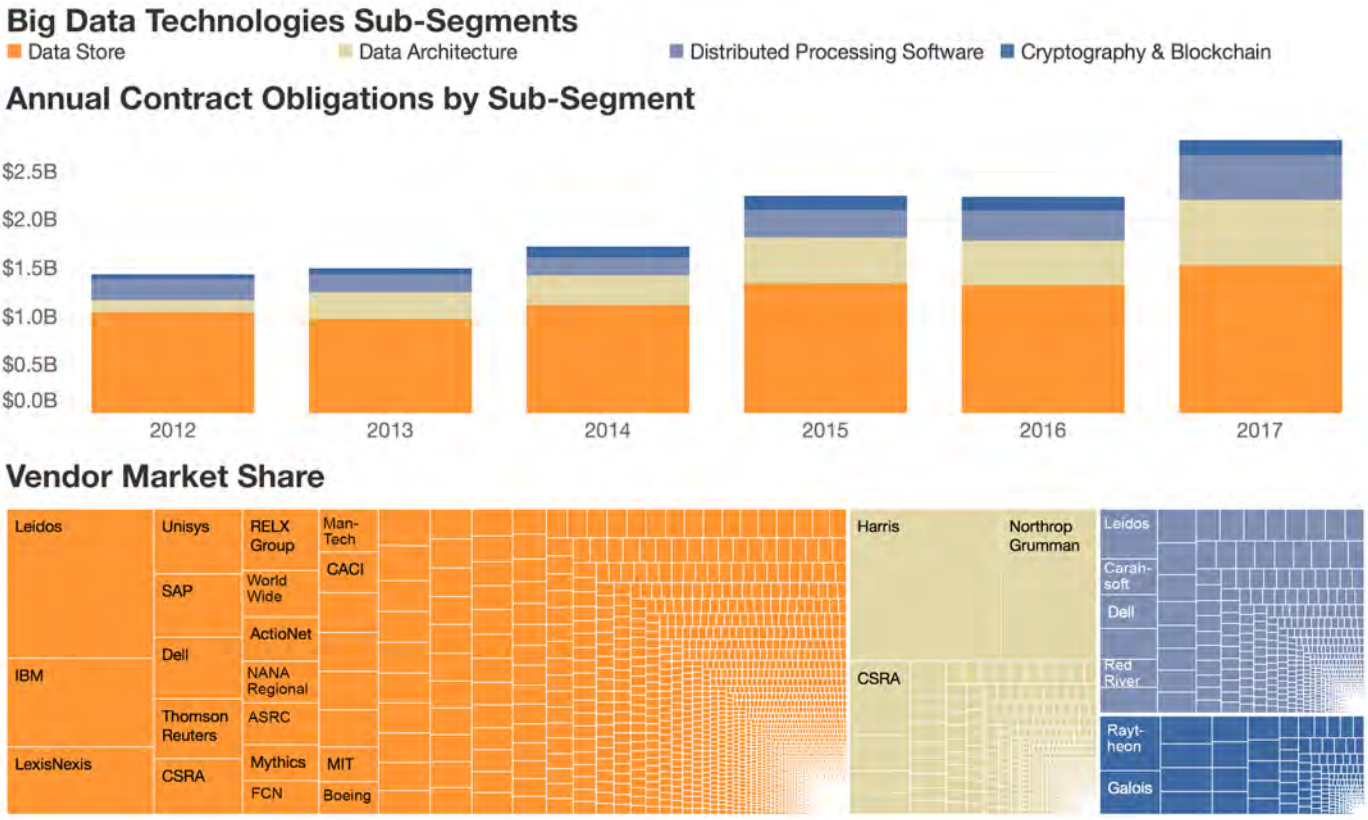


Exhibit 7: Data Store, the largest sub-segment by a large margin, had the least spending growth of 7.9 percent. Data Architecture, a sub-segment dominated by integrators, Harris, Northrop Grumman, CSRA, Leidos and Raytheon, grew by 41.5 percent to $675.8 million in FY17. Blockchain spending grew by 24.8 percent with large obligations to Raytheon, Galois, Lockheed Martin, Centurum and Boeing.

M2M Communication Bridges the Physical and Biological Spheres with the Digital

One of the main bridges among the spheres enabled by the Fourth Industrial Revolution is M2M Communication, which forms the basis of the Internet of Things (IoT). Govini has categorized M2M Communication into the following two segments and twelve sub-segments:

Connectivity

- Wireless Devices - any device with one- or two-way wireless communication
- Assured PNT - conveyance of positioning, navigation and timing for weapon systems
- Data Link - standardized and secure links for communication via radio waves or cable
- Wireless Services - services for device management, security and connectivity
- Data Link Gateway - legacy hardware that interfaces with other networks using protocols
- Advanced Data Link Networks - fast switching narrow directional communications links

Sensors

- Imagery - sensors that detect and convey information that constitutes an image
- Logistics & Asset Tracking - sensors that track changes to supply chain assets
- Microsensors - sensors of the micro or nano scale with high sensitivity and selectivity
- Radio Frequency - transmitters that send and receive radio signals between two devices
- Implantables & Wearables - detectors capable of being warn on or implanted in the body
- First Response - collectors used to report data valuable for emergency first responders

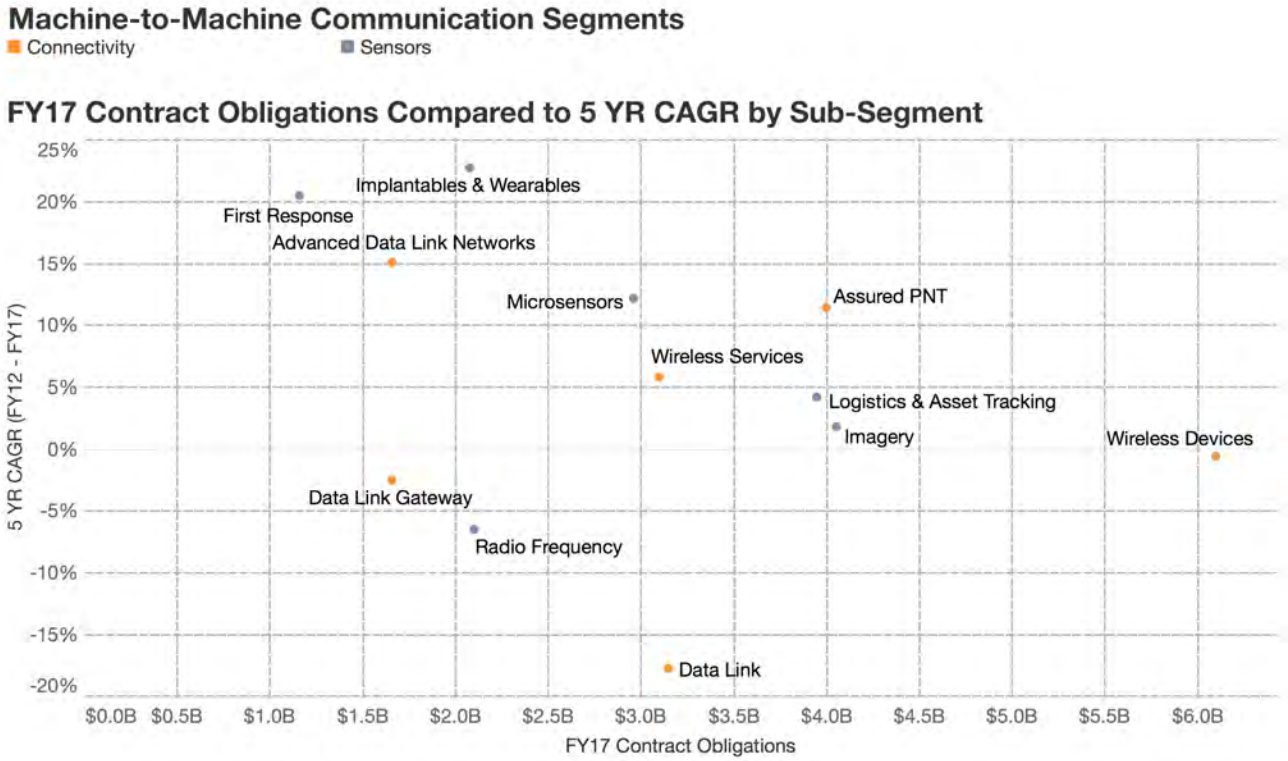


Exhibit 8: M2M Communication is being deployed where high opportunity costs exist, including military, health and lifesaving applications. Spending across all Sensor sub-segments grew by 5.5 percent while spending across all Connectivity sub-segments decreased by 0.4 percent. Spending on emerging technologies increased the most; Implantables & Wearables increased by 22.8 percent, First Response increased by 20.5 percent and Advanced Data Link Networks increased by 15.1 percent.

Spending on Next-Gen Connectivity Ramps Up Amidst Decline in Overall Segment Spend

Connectivity technologies range from data links to wireless and resemble any means of transmitting and receiving digital information. Investment in Connectivity decreased by a CAGR of 0.4 percent to $3.4 billion in FY17 from $3.4 billion in FY12. The decrease was driven primarily from less spending on legacy Data Links and Data Link Gateways and Wireless Devices.

The top-line trends cover up more interesting data points worth emphasizing, spending on Advanced Data Link Networks grew by a CAGR of 15.1 percent to $379 million in FY17 and spending on Assured PNT grew by a CAGR of 11.5 percent to $757.1 million in FY17. Advanced Data Link Networks allow aircraft to operate in highly contested environments and Assured PNT allow soldiers to operate in conditions with limited or denied GPS. Both are critical to maintaining high operational tempo for manned and unmanned assets that connect to the Digital Sphere. Harris, Northrop Grumman, BAE Systems, L-3 Technologies and Rockwell Collins compete for Advanced Data Link Network contracts while Harris, Data Link Solutions, ViaSat, General Dynamics, L-3 Technologies and Northrop Grumman compete for Assured PNT contracts.

Federal spending on Wireless Services also increased by a CAGR of 5.8 percent to $447.1 million in FY17. While Verizon led capture by a large margin, others carriers including AT&T and Sprint are gaining competitive advantages. AT&T has the First Responder Network Authority (FirstNet) of which Congress allotted $7 billion and 20 MHz of valuable radio spectrum to build the network. Fifth generation mobile networks also create opportunity for repositioning. 5G allows for a higher density of broadband users, and supports M2M Communication.

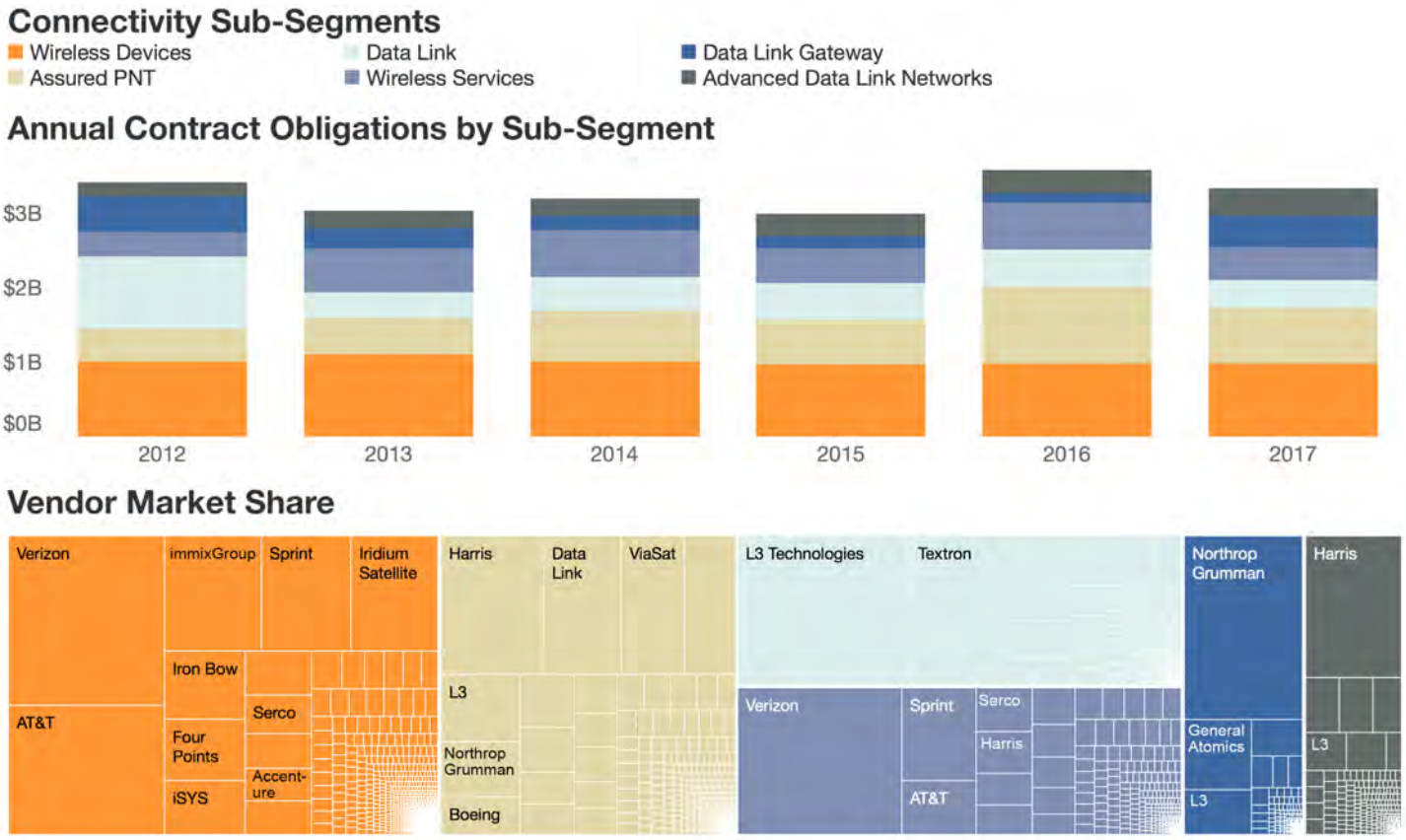


Exhibit 9: Spending on next-generation connectivity to support M2M Communication is ramping up amidst an overall decline in segment spending. Spending on Advanced Data Link Networks increased by a CAGR of 15.1 percent; Assured PNT increased by 11.5 percent and Wireless Services by 5.8 percent.

Emerging Technology of the Physical Sphere Prompts Sharp Rise in FY17 Sensor Spend

Sensors consist of any device that collects and transmits data. Recent advancements allow sensors to automatically communicate with each other, making M2M Communication possible. Advancements in miniaturization, fabrication and power usage have created an aperture for sensors, especially where opportunity costs and risk are high.

FY17 marked a shift in Sensor segment spending, rising by 21.7 percent to $3.3 billion. Much of the growth came from sub-segments that are just beginning to emerge. Implantables & Wearables, the second smallest sub-segment by total spending, had the most growth of 22.8 percent, reaching $297.8 million in FY17. First Response, the smallest sub-segment, had a spending increase of 20.5 percent and Microsensors, the third largest by contract obligations, increased by 12.2 percent.

Next-generation sensors that leverage technological breakthroughs in nanotechnology, precision engineering and additive manufacturing are gradually replacing previous generation sensors. This means that defense contractors that currently lead the market, including General Dynamics, BAE Systems, Raytheon, Northrop Grumman, Lockheed Martin and Boeing, will face competition enabled by Fourth Industrial Revolution technologies. In order to maintain market share, the market-leading vendors will likely seek partnerships or acquisitions of the firms that possess such technology.

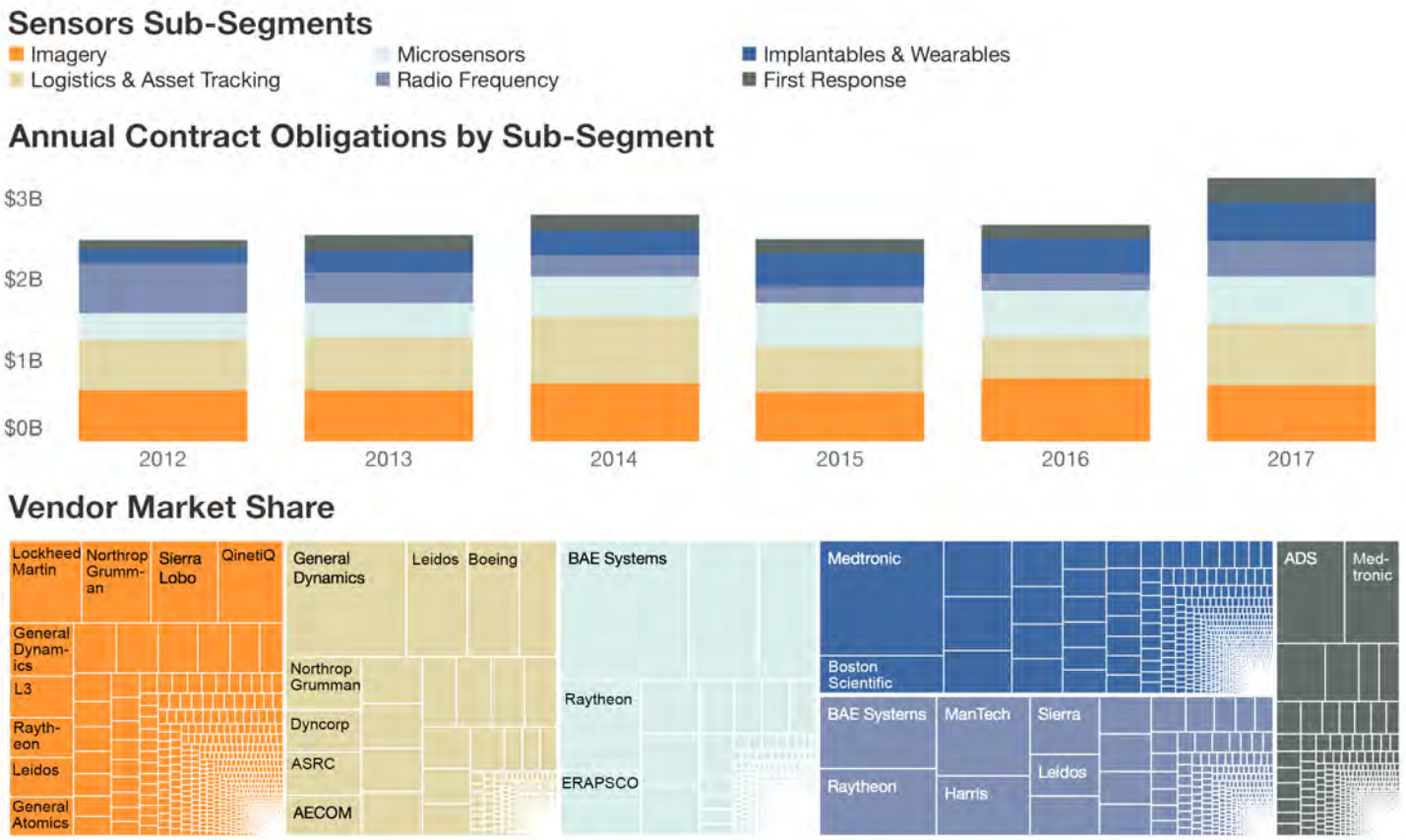


Exhibit 10: Emerging sub-segments, including Implantables & Wearables, First Response and Microsensors grew the most by 22.8 percent, 20.5 percent and 12.2 percent respectively. Medtronic captured the largest share of Implantables & Wearables with 20.6 percent and ADS Tactical captured the largest share of First Response with 19.4 percent of total sub-segment spending since FY12. BAE Systems, Raytheon, ManTech and Harris led capture of Radio Frequency sub-segment spend.

Annual Investment in Autonomous Engineering Nearly Doubles in FY17 from FY12

Autonomy is the core component of the Fourth Industrial Revolution. Without it real-time decision making is not possible, undercutting the value of other technologies including M2M Communication, connected homes, smart cities, driverless cars, robotics and other autonomous systems. Govini has categorized Autonomous Engineering into the following three segments and eleven sub-segments:

Cognitive Systems

- Machine Vision - systems that automate human vision tasks
- Advanced Simulation - environments which provide virtual presence and artificial affects
- Intelligent Agent - abstract functional systems that respond to a wide array of questions

Cognitive Engineering

- Machine Learning - the ability for computers to learn without being explicitly programmed
- Modeling & Simulation - facilitating understanding of system behavior without testing
- Deep Learning - mimicking cognitive functions, such as learning or problem solving
- Data Mining - discovering patterns in data sets and transforming for further analysis
- Natural Language Processing - programming to process large natural language corpa

Advanced Computing Environment

- Supercomputing - compute performance measured in floating-point operations per second (FLOPS)
- Neuromorphic Engineering - use of very-large-scale integration (VLSI) systems containing electronic analog circuits to mimic neuro-biological architectures
- Quantum Computing - use of quantum bits (qbits), which can be in superpositions of states instead of binary bits, which is always in one or two definite states (0 or 1)

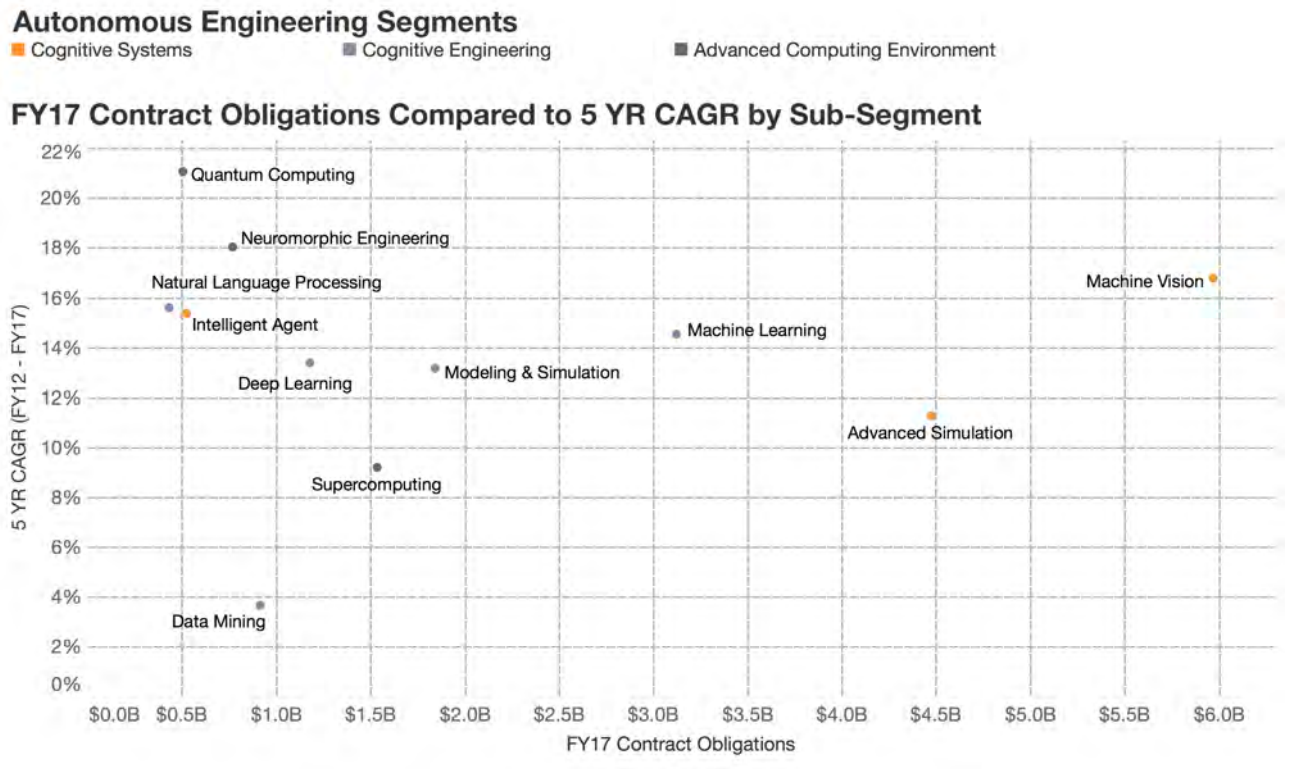


Exhibit 11: Autonomous Engineering is attracting investment with nearly all sub-segments having double-digit growth. Overall spending grew by 13.8 percent, the second most behind Configurable Systems.

Cognitive Systems Spending Spikes Through Support of Military and Space Missions

Systems that operate autonomously, known as Cognitive Systems, have great potential, particularly for creating asymmetric advantages in warfare. Their speed and accuracy in reacting, adapting and predicting scenarios makes them critical components of warfighting in contested environments. Segment spending increased by a CAGR of 14.6 percent to $2.7 billion in FY17 from $1.3 billion in FY12.

The spending growth is being fueled by Machine Vision, the largest sub-segment of Cognitive Systems. Annual spending in the sub-segment increased by a CAGR of 16.8 percent to $1.6 billion in FY17. Spending on Intelligent Agents and Advanced Simulation also contribute to growth with spending increases of 15.4 percent and 11.3 percent respectively.

While there are several constraints to widespread adoption of Cognitive Systems, DoD and NASA have begun to invest in applications where computer cognition can match that of a human. Advanced Simulation is an example of one of these applications and leading providers of virtualized simulation and training including Raytheon, Lockheed Martin, SRI International and JF Taylor are seeking to integrate cognitive capabilities with their solutions.

Machine Vision, the largest Cognitive System sub-segment, is being applied in missions critical to warfighting and weather forecasting. Lockheed Martin's market-leading position comes from work funded by NOAA and NASA, the Geostationary Operational Environmental Satellite (GOES) R Series, which provides atmospheric and surface measurements. Leidos supports Army's Geospatial Center's High Resolution 3-D Geospatial Information Program and Raytheon delivers multi-spectral targeting systems among other Machine Vision related technologies.

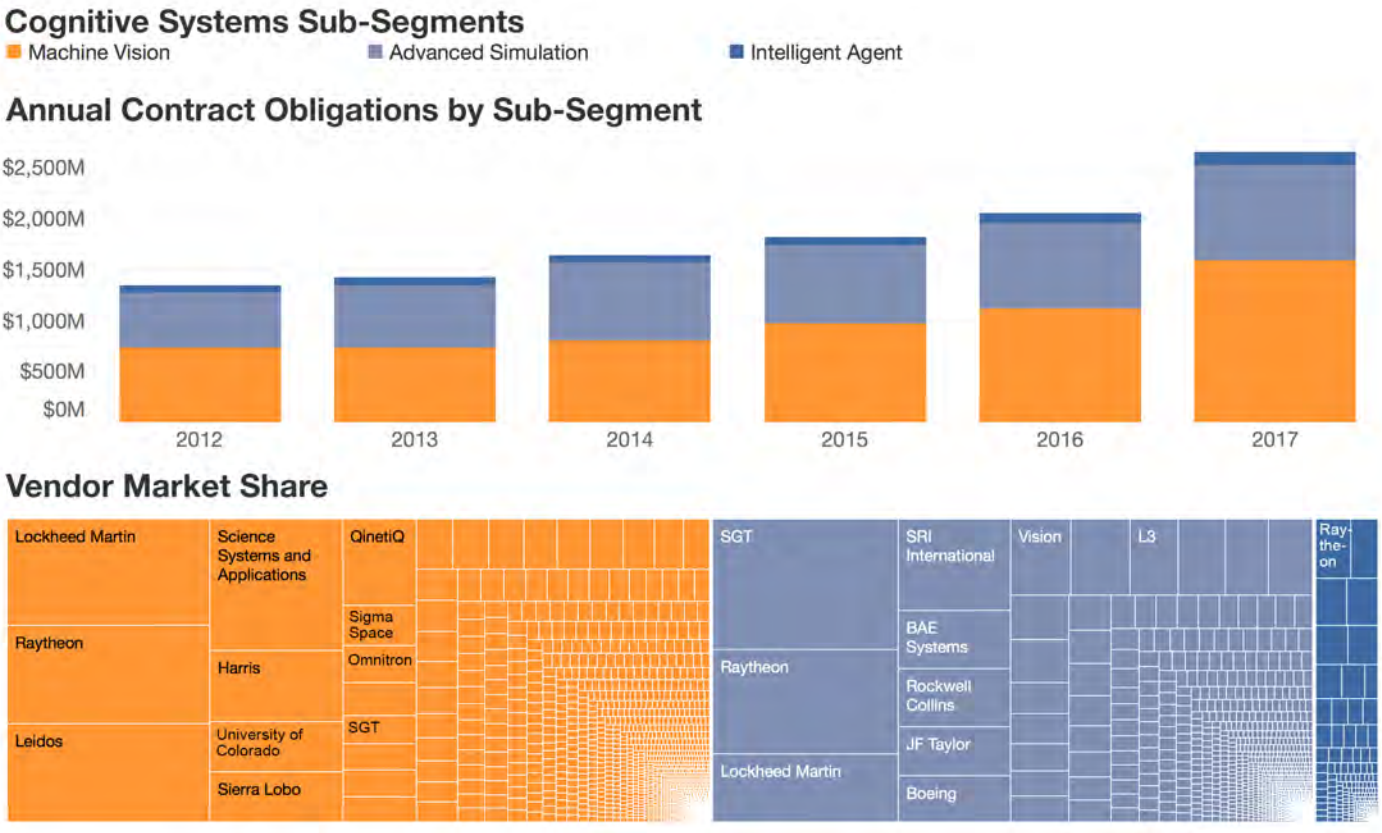


Exhibit 12: Machine Vision and Advanced Simulation are the most mature sub-segments, accounting for 95.3 percent of total segment spending. Leading providers of Cognitive Systems, Raytheon, Lockheed Martin, Leidos, SRI International, Harris and BAE Systems capture contracts across all sub-segments.

Diverse Set of Contractors Compete for Increasing Cognitive Engineering Spend

Cognitive Engineering consists of development methods to advanced Autonomous Systems. It is attracting investment from agencies and interest from the contracting community. FY16 marked the beginning of a rapid rise in both measures. Since then, overall segment spending increased by 67.3 percent to $1.8 billion in FY17 and the number of competitive contractors increased by 25 percent to 1,587.

All sub-segments of Cognitive Engineering are attracting investment, particularly by DoD and NASA. The two agencies accounted for 82.2 percent of total segment spending. NASA led funding of Machine Learning contracts, while DoD led funding of contracts in all other sub-segments.

The Johns Hopkins Applied Physics Laboratory captured the largest share of Machine Learning spending with 15.9 percent of total mostly from the Solar Probe Plus (SPP), a spacecraft built to observe the sun. Science Systems and Applications captured 11.5 percent of sub-segment spending. It performs on several NASA contracts including environmental research in Korea and hydrospheric and biospheric research that leverages sensors and machine learning algorithms.

Spending in the second largest sub-segment, Modeling & Simulation, is funded mostly by DoD and is spread across the services with Navy and Army taking the lead through their warfare analyses and sensor simulation programs. Leidos, SAIC, AECOM and Orbital ATK led capture of Navy program spending and SAIC, CACI, Torch Technologies and Millennium Engineering led capture of Army spending. Northrop Grumman captured the most spending by MDA through its ballistic missile defense system threat software modeling work.

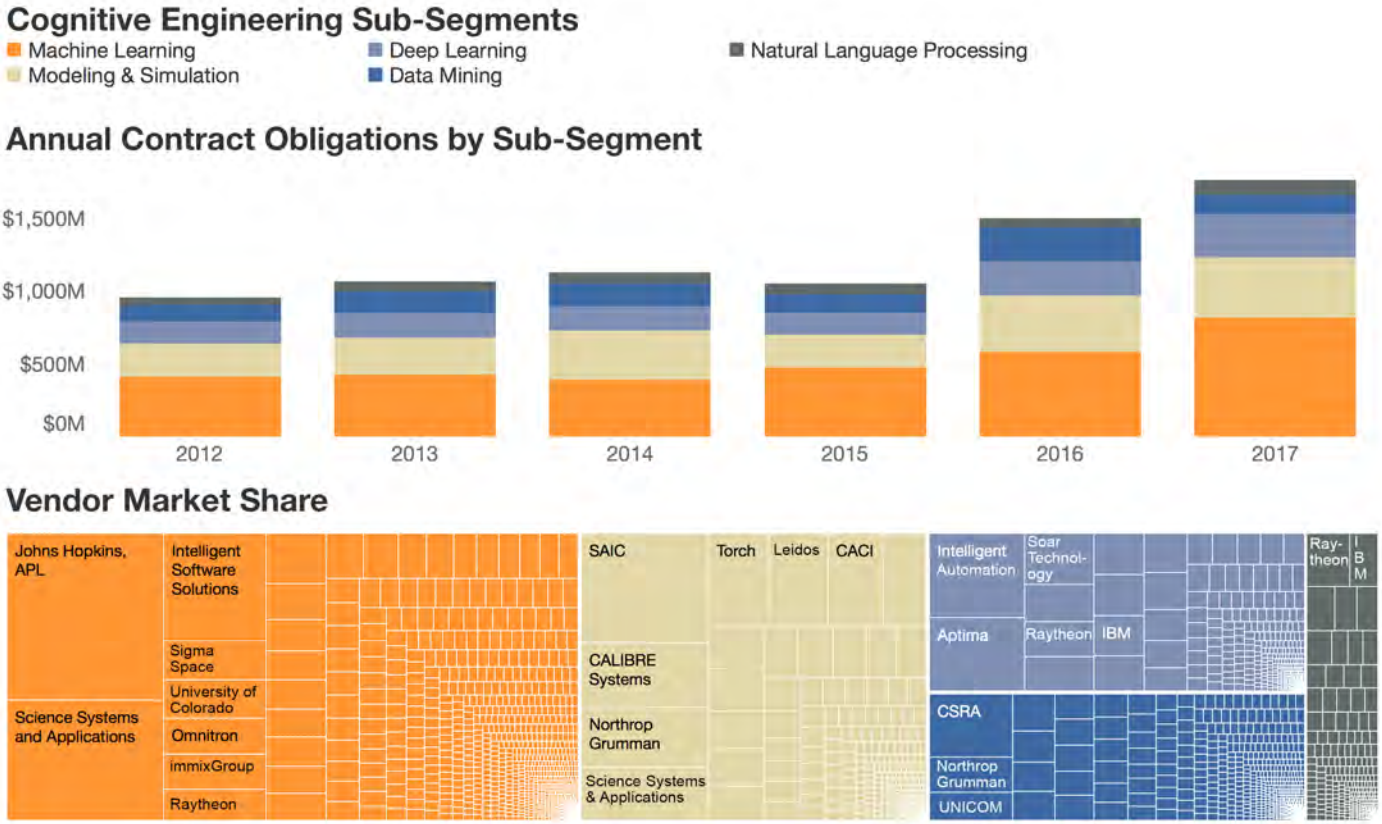


Exhibit 13: All Cognitive Engineering sub-segments had strong spending growth from FY12 through FY17. The smallest sub-segment, Natural Language Processing, had the largest CAGR of 15.6 percent, followed by Machine Learning with 14.5 percent, Deep Learning with 13.4 percent and Modeling & Simulation with 13.2 percent.

FY17 Advanced Computing Spend Spike Fuels Growth in Cognitive Capabilities

Like other Fourth Industrial Revolution technologies, Advanced Computing is an enabler. The segment consists of Supercomputing, Neuromorphic Engineering and Quantum Computing. Without these technologies, Cognitive Systems cannot be applied beyond narrow applications.

Spending on Advanced Computing surged in FY17 by 56.7 percent to $721.5 million, the largest single-year increase of any segment. Supercomputing, the largest sub-segment, led the charge with a 108.2 percent increase in FY17 spending. Neuromorphic Engineering, the second largest sub-segment, followed with a 34.2 percent increase in FY17 spending, reaching $207.7 million.

Most Advanced Computing contracts were funded by DoD, but NASA chipped in, too. NASA accounted for 31.9 percent of Supercomputing spending, 32.8 percent of Neuromorphic Engineering and 20.1 percent of Quantum Computing.

General Dynamics led capture of Supercomputing spending mostly from installations on Virginia Class submarines. CSRA, the next largest by capture, supports supercomputing initiatives by NASA's Ames and Goddard Research Centers. Lockheed Martin performs guided missile work for Army at Redstone Arsenal. University of Maryland also support NASA supercomputing initiatives through Goddard Space Flight Center.

A large portion of Neuromorphic Engineering spending goes to Universities, including University of California, University of Southern California, Massachusetts Institute of Technology, Carnegie Mellon, University of Pennsylvania and Penn State.

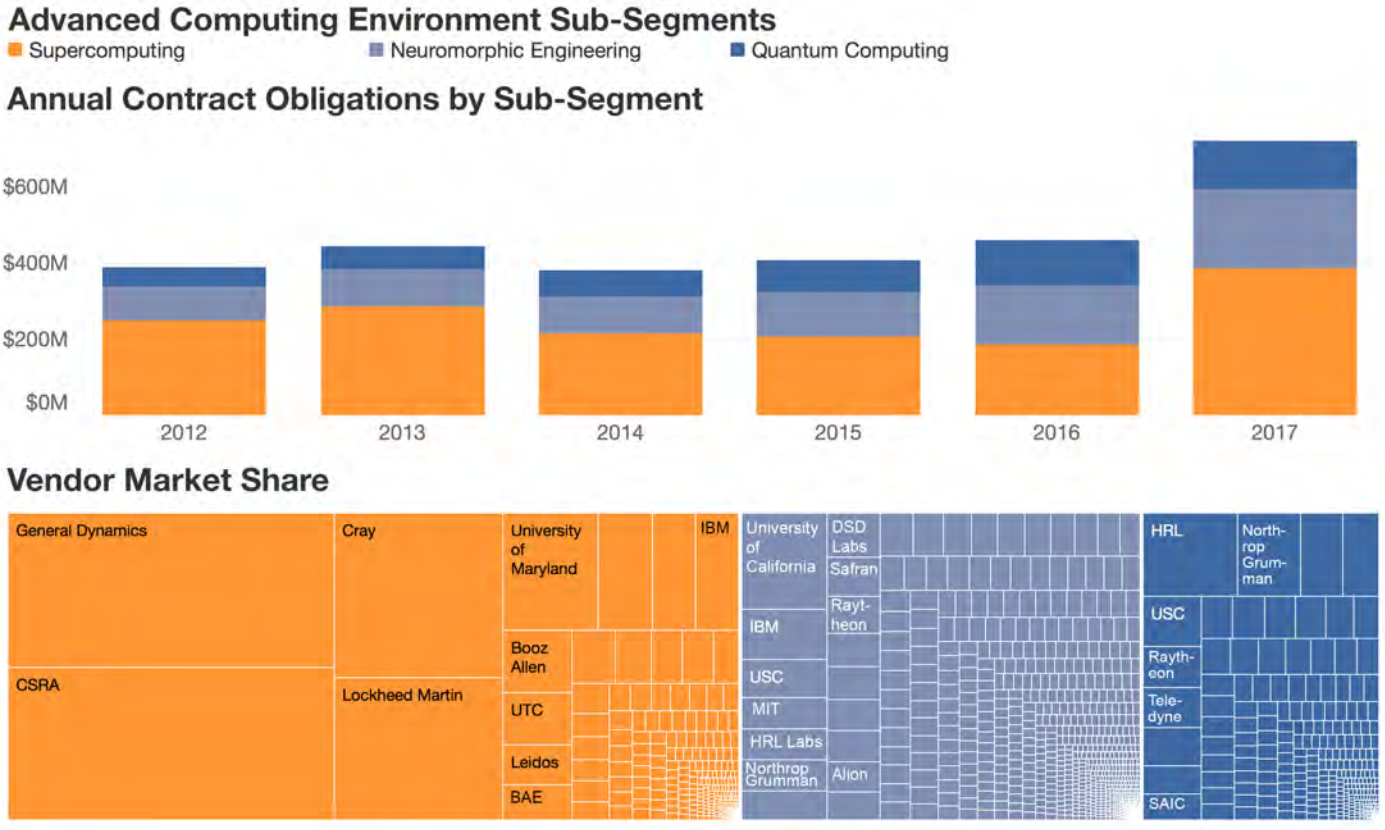


Exhibit 14: Advanced Computing spending increased sharply in FY17 by 56.7 percent to $721.5 million. Such capabilities are part of DoD weapons that plug into the effects grid, including submarines made by General Dynamics and land-based missile systems maintained by Lockheed Martin. University of California led capture of Neuromorphic Engineering and HRL Laboratories led Quantum Computing.

Government's Recent Embrace of Configurable Systems Leaves Much Work to be Done

The Federal Government has been slow to embrace Cloud and other Configurable Systems as a solution to their data challenges, but that is beginning to change. While spending has risen gradually over the last five years, FY17 marked a sharp increase, with spending rising by 34.9 percent to $4 billion. Federal agencies, particularly DoD, have established policies and guidance for computing systems to transition to the Cloud. Govini has categorized Configurable Systems into the following two segments and five sub-segments:

Cloud Deployment Models

- Infrastructure-as-a-Service - hosted infrastructure components traditionally present in on-premise data centers, including servers, storage and virtualization layer
- Platform-as-a-Service - resilient and optimized environment on which users can install applications and data sets
- Software-as-a-Service - hosted applications made available over the internet

Migration Services

- Data Center Consolidation - service work associated with assessing, planning and implementing consolidation of Federal data centers
- Cloud Migration Services - service work associated with transitioning computing systems

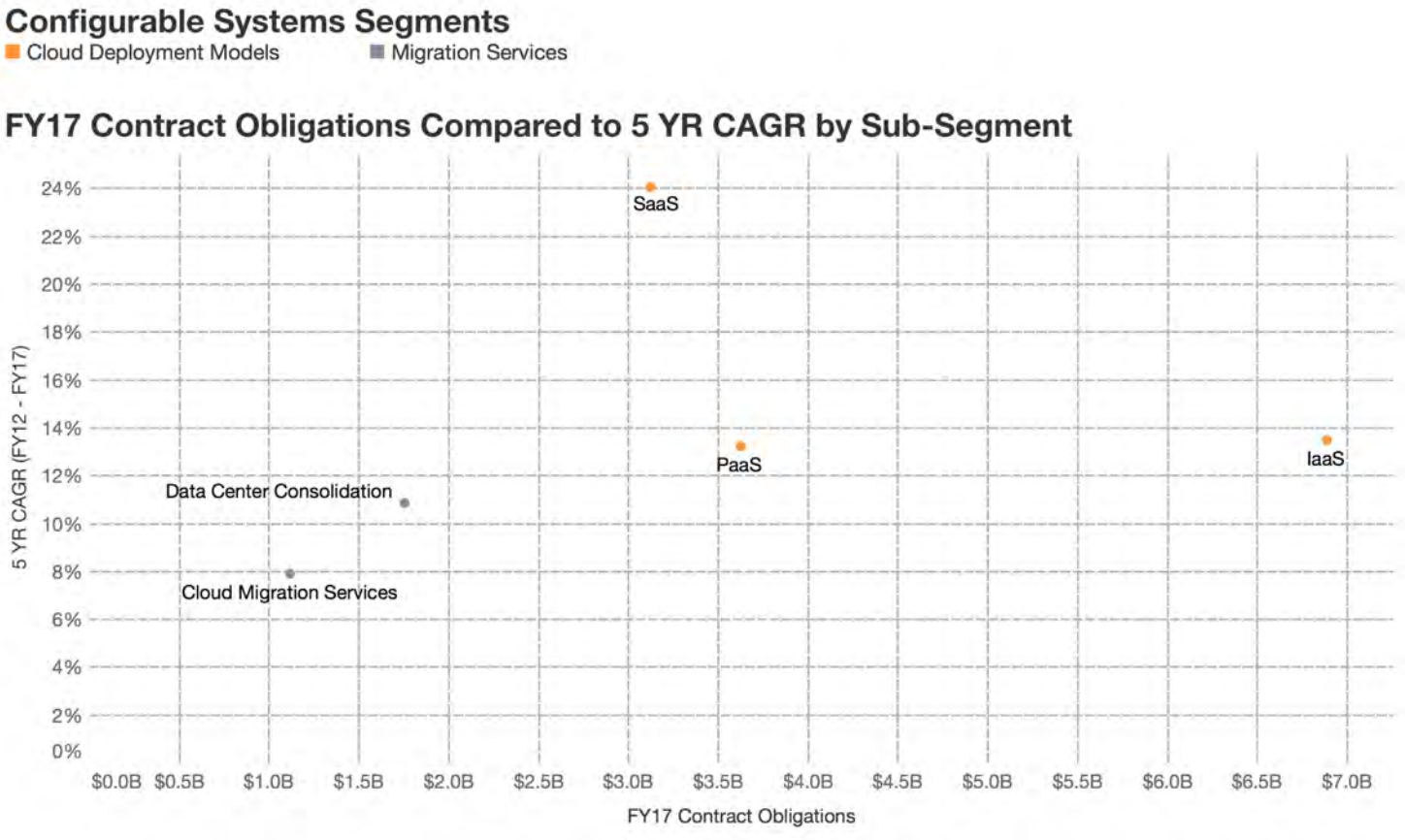


Exhibit 15: With an overall CAGR of 14.7 percent, Configurable Systems are being prioritized by Federal agencies. SaaS had the largest spending increase of 24 percent, followed by IaaS with 13.5 percent and PaaS with 13.2 percent.

FY17 Marked a Tipping Point for Federal Adoption of Configurable Systems

Up until recently, Federal agencies have been slow to embrace Configurable Systems like Cloud. Two primary areas of concern, cybersecurity and consensus on deployment models, have created barriers to moving forward. Even without a firm commitment and comprehensive strategy, Federal spending on Cloud increased significantly by 34.9 percent in FY17 to $4 billion.

The two largest sub-segments, IaaS and PaaS, accounted for 77.4 percent of overall spending from FY12 through FY17 and grew by 13.5 percent and 13.2 percent respectively. The two sub-segments are most critical to enabling Fourth Industrial Revolution technologies as they store, process and manipulate data for better use.

Federal agencies embracing IaaS and PaaS as solutions to their data challenges include Navy, DISA, HHS, NASA, DHS and DOJ. Other agencies with citizen service missions like Treasury, SSA and USDA have also allocated funding to the Deployment Models. Other agencies, most notably DoD, are planning to award billion dollar Cloud contracts by the end of 2018.

What makes Cloud providers uniquely positioned in the market is how they will leverage emerging technologies to make optimal use of data in an open environment, while keeping the data secure. This fact has prompted industry to make big bets in the form of mergers and acquisitions. DXC Technology, CSRA, Leidos and Booz Allen Hamilton have doubled down on their market position, while others like Lockheed Martin and Harris strategically chose to exit.

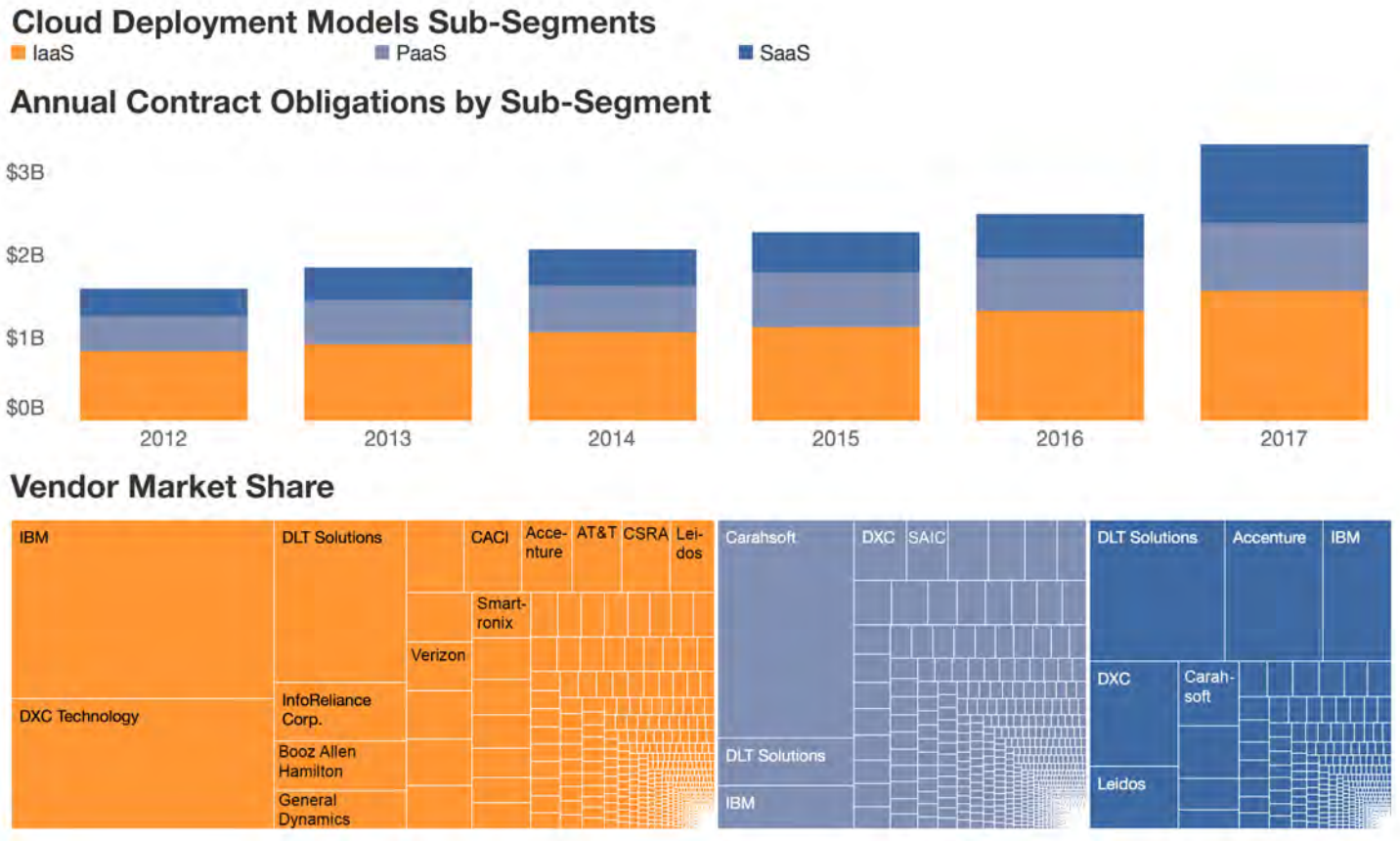


Exhibit 16: Spending across Configurable System sub-segments increased sharply in FY17 reaching $4 billion creating opportunity for market leaders. IBM captured 14.7 percent of segment spending from strong positions in IaaS and SaaS. DLT Solutions captured 11.2 percent of total segment spending mostly from SaaS. Other contractors such as DXC Technology, Accenture, Leidos and Booz Allen captured contracts across all three sub-segments.

Migration Services Spend Surge Signals Reversal of Tepid, Fragmented Cloud Adoption

Federal preparations for widespread Cloud deployments are underway. Spending on services to migrate Cloud increased by 41.9 percent in FY17 to $694.3 million. The single-year spending increase is the second largest out of all Taxonomy sub-segments.

Fully transitioning to a configurable architecture requires a commitment to abandon legacy systems and use those savings to help fund the transition. It will also require a comprehensive strategy that addresses Cybersecurity and close coordination among the agencies, each of which have unique needs tied to existing legacy assets.

The Modernizing Government Technology Act, which creates a $500 million central modernization, fund over two years through which agencies can borrow against to update aging, unsecure items will help fuel the transition. The law also requires the creation of working IT capital funds that agencies can stash savings from other modernization projects, including migrating to Cloud.

Dell, IBM and DXC Technology rank among top vendors by capture of Data Center Consolidation spending. Their competitive advantage comes from their familiarity with the equipment, systems and IT missions that require consolidating. Dell's top customer agencies include Department of Education, VA and SSA. IBM is focused on consolidating data centers for Army, DHS, USAID and FCC.

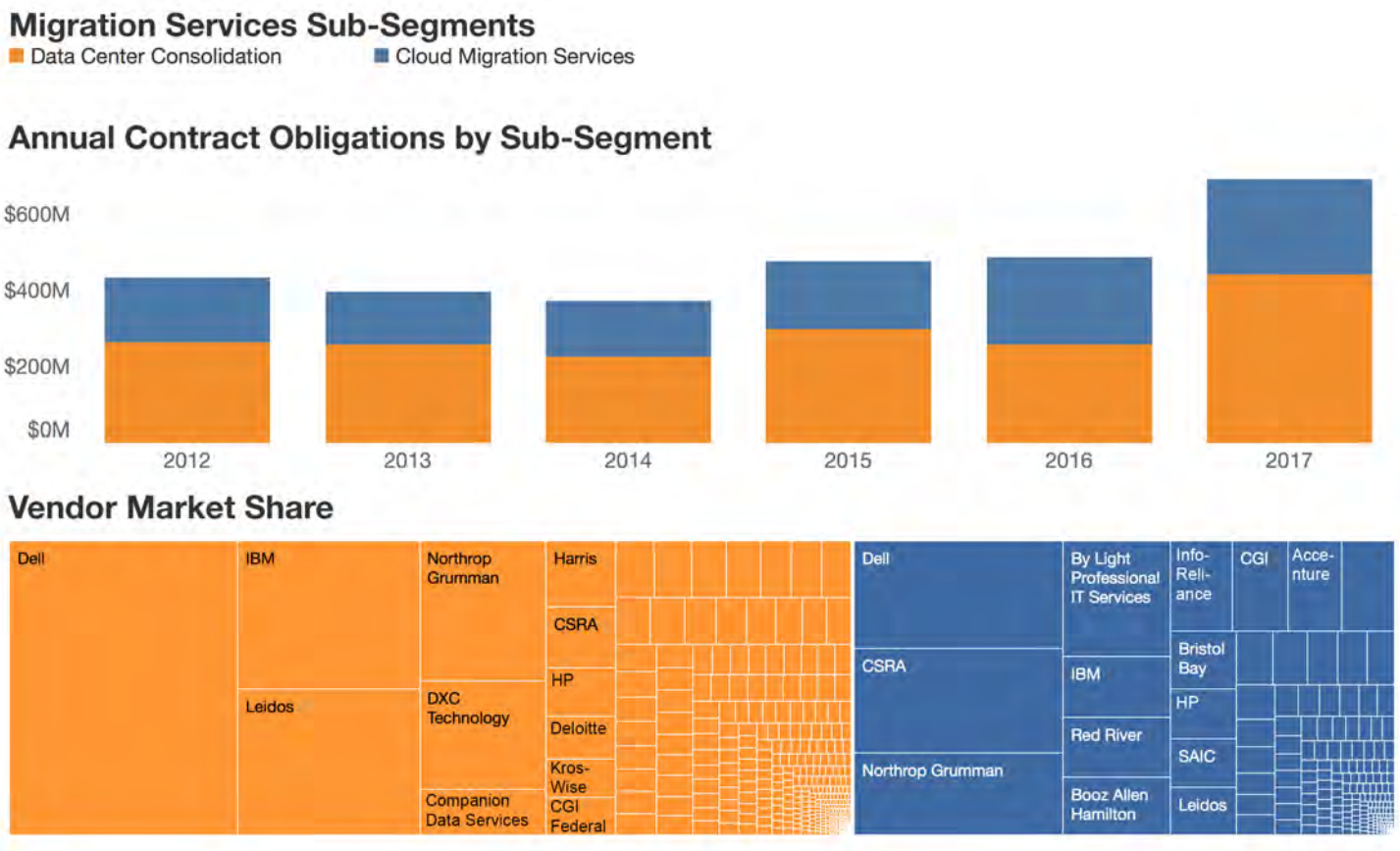
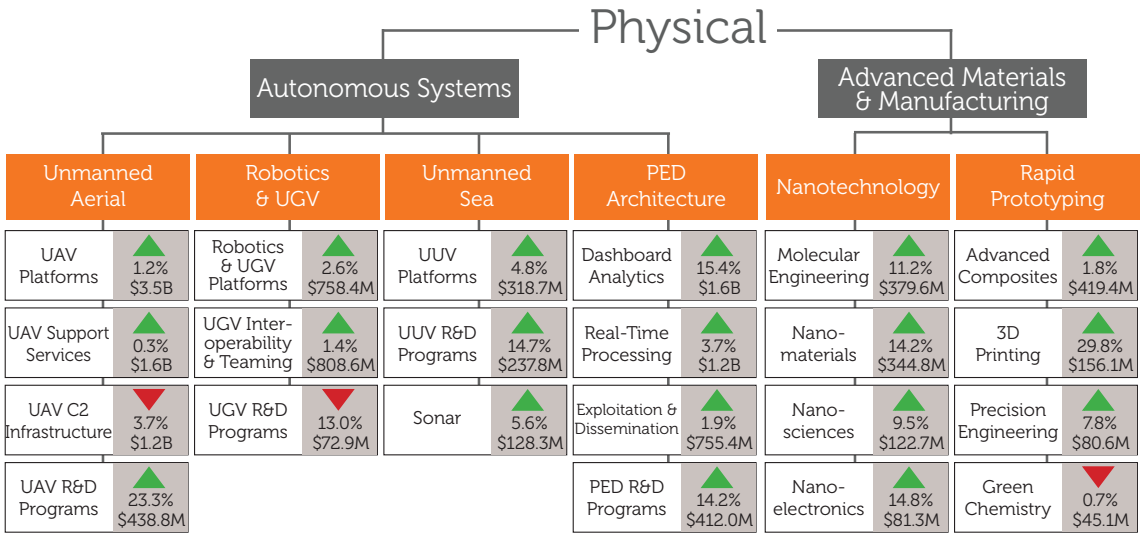


Exhibit 17: Spending on Migration Services increased significantly in FY17 by 41.9 percent to $694.3 million. Dell captured the largest share of segment spending with 22.1 percent, followed by Northrop Grumman with 8.6 percent, IBM with 8.3 percent, Leidos with 7.4 percent and CSRA with 6.4 percent.

THE FOURTH INDUSTRIAL REVOLUTION MARKET TAXONOMY: PHYSICAL SPHERE



THE PHYSICAL SPHERE

Emerging Technologies Help to Merge Spheres Beginning with Autonomous System

Fourth Industrial Revolution technologies make the physical world more useful by adding digital components that collect and transmit data. The harmonious convergence of the spheres enhance each other; physical things are augmented by digital insights and data-driven analytics are more meaningful when they represent an asset or something of value.

Autonomous Systems is one physical manifestation that easily relates to the digital world because of its nature. The integration is progressing faster than it otherwise would with the help of Advanced Materials & Manufacturing. Advanced Composites and Nanomaterials are being used to ruggedize platforms, and Nanoelectronics and other Nanotechnologies are being used to miniaturize sensor and power components. 3D Printing and Precision Engineering are also being used to fabricate highly customized parts of platforms and related subsystems.

While each Autonomous System exists at various stages of development, each one needs to be merged with the Digital sphere. The most advanced Unmanned System, Unmanned Aerial, is furthest along as it has attracted the largest share of investment, primarily to develop military surveillance and strike capabilities. Whereas other types of Autonomous Systems like robots, submersibles and boats still require more development ranging from enhanced power usage, sensing and endurance to operate according to mission requirements.

Exhibit 18 provides insight on how the Federal Government is investing to integrate emerging technologies with mature ones in the Physical sphere. Unmanned Aerial and its supporting Processing Exploitation and Dissemination (PED) Architecture consist of mostly mature sub-segments relative to other segments. Advancement and integration of emerging technologies including Advanced Materials & Manufacturing and other Autonomous Systems such as Unmanned Sea and Robotics & UGV will heighten the intrinsic value Autonomous Systems operating across domains.

Emerging technologies, such as Advanced Materials & Manufacturing and some sub-segments of Autonomous Systems are highly competitive. Rapid Prototyping stands out as being the most competitive with all of its sub-segments attracting more than an average of 8 competitive bids per contract action. Nanotechnology is also highly competitive. Nanosciences and Nanoelectronics both had an average of 8.2 bids and Nanomaterials had 7.1 bids.

Within Autonomous Systems, Unmanned Sea and Robotics & UGV are most competitive. One reason is because much of the spending is for research and development. Another is that platform OEMs have yet to establish dominant positions. UUV R&D Programs attracted the most competition within Unmanned Sea with an average of 8.3 bids. Sonar, another sub-segment that consists mostly of research contracts, attracted an average of 7.3 bids. Robotics & UGV reflected similar data trends. The two sub-segments closely associated with R&D were the most competitive. UGV R&D Programs attracted an average of 7 bids and UGV Interoperability & Teaming attracted an average of 4.8 bids.

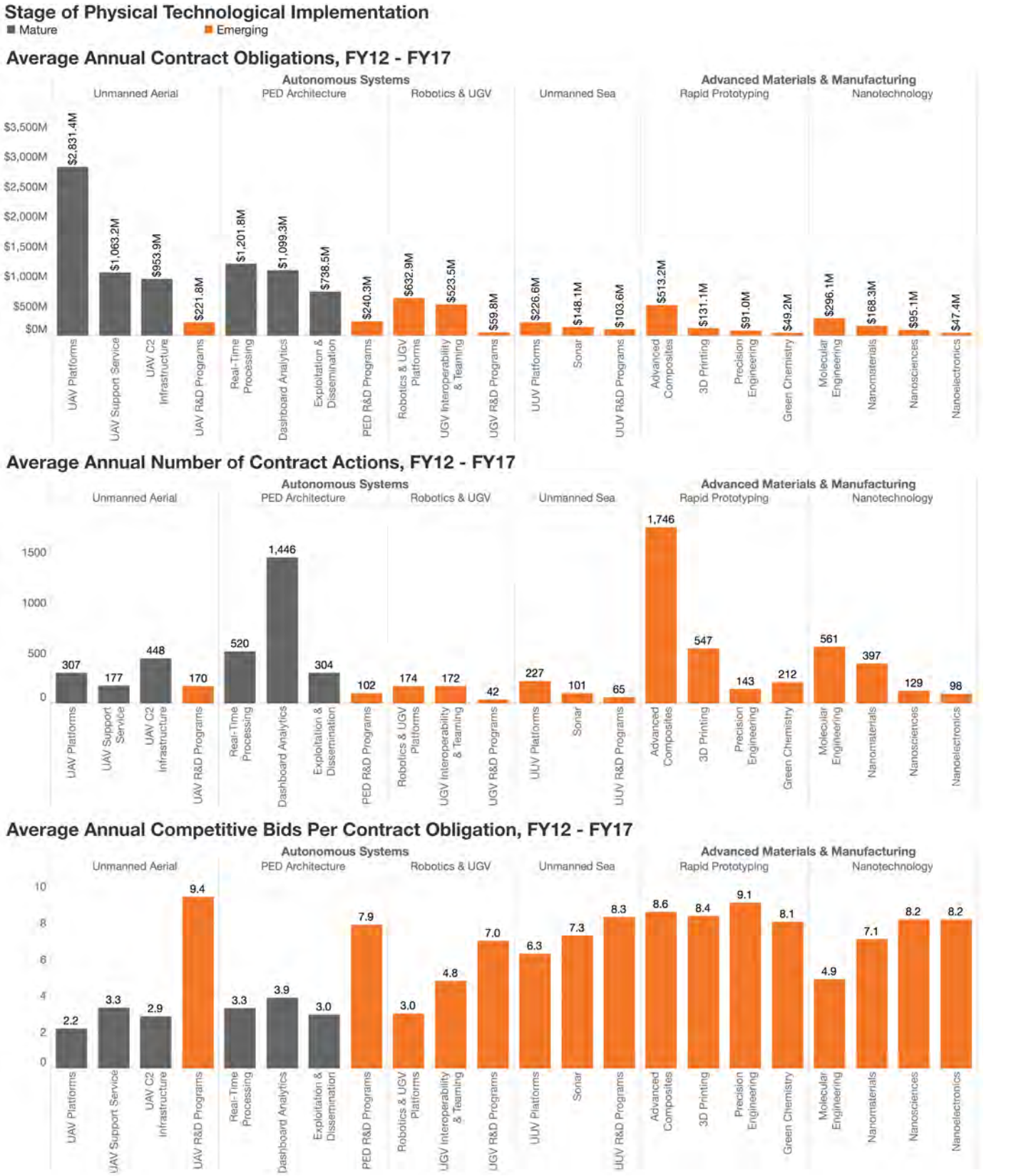


Exhibit 18: Physical manifestations that are being merged with the Digital sphere, include Autonomous Systems. Advancement in Additive Materials & Manufacturing is helping to facilitate the transition and competition for contracts are among the most competitive. Precision Engineering attracted the greatest level of competition among emerging technologies with an average of 9.1 bids per contract action, followed by Advanced Composites with 8.6 and 3D Printing with 8.4. R&D sub-segments within mature segments, such as UAV R&D Programs and PED R&D Programs, are also highly competitive.

Federal Agencies are Investing to Develop Next-Generation Autonomous Systems

Autonomous Systems are uniquely positioned to solve intractable problems that exceed current manual capabilities for reasons of technical limitation and human safety, among others. Govini has categorized Autonomous Systems into the following four segments and fourteen sub-segments:

Unmanned Aerial

- UAV Platforms - unmanned aerial platforms that perform ISR and strike missions
- UAV Support Service - depot-level maintenance and contract logistic support of UAV assets
- UAV C2 Infrastructure - command and control including ground stations that guide UAVs
- UAV R&D Programs - basic and applied research to support advancement of UAVs

Robotics & UGV

- Robotics & UGV Platforms - robotic and unmanned ground vehicles for security operations
- UGV Interoperability & Teaming - programs to develop M2M Communication
- UGV R&D Programs - basic and applied research to advance robotics and UGV application

Unmanned Sea

- UUV Platforms - surface and undersea vehicles supporting surveillance and strike missions
- Sonar - technologies that navigate and detect objects on or under the surface of the sea
- UUV R&D Programs - basic and applied research to support advancement of UUVs

PED Architecture

- Real-Time Processing - conveyance of ISR data in real-time for operational decision
- Dashboard Analytics - suite of indicator analytics that monitor priority assets and networks
- Exploitation & Dissemination - concepts of operations that follow from useful ISR data
- PED R&D Programs - basic and applied research to support advancement of PED

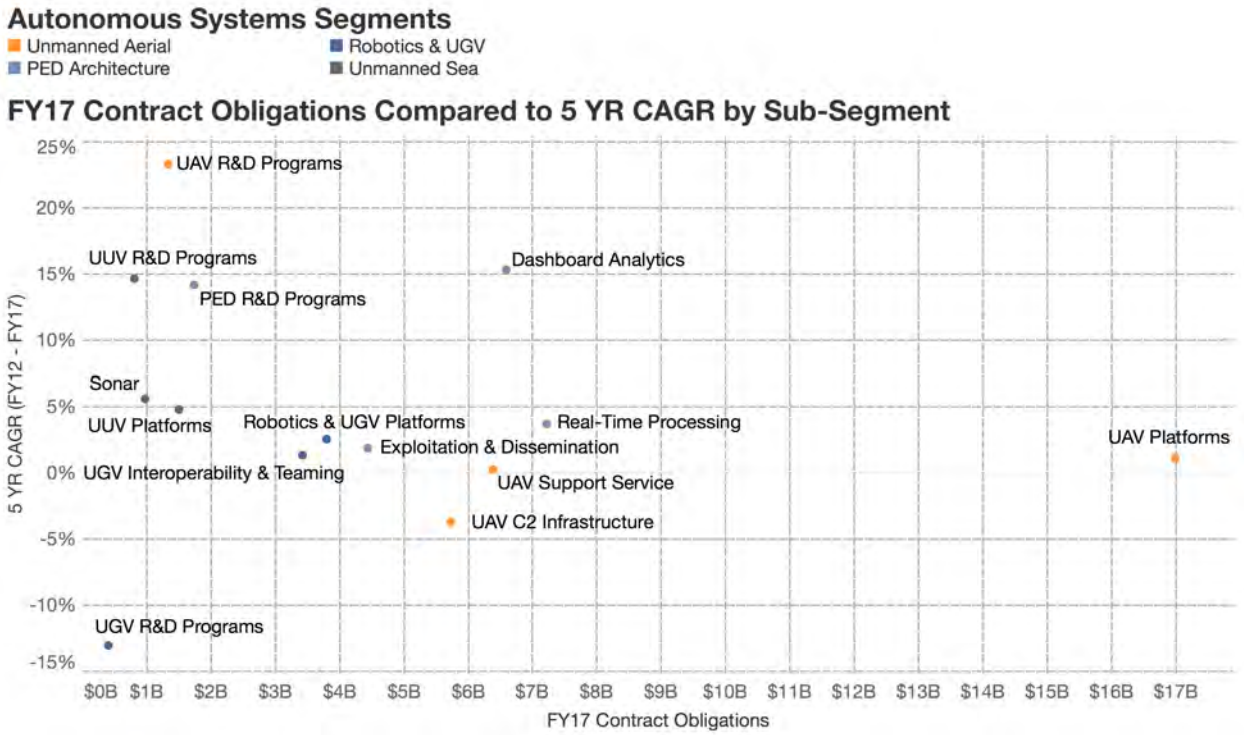


Exhibit 19: R&D sub-segments standout as having the largest spending increases as Federal agencies invest to develop next-generation autonomous systems. UAV R&D Programs spending increased the most by 23.3 percent, followed by Dashboard Analytics with an increase of 15.4 percent.

DoD Seeks Greater Autonomy and Human-to-Machine Teaming in Next-Generation UAVs

Unmanned Aerial is by far the largest component of Autonomous Systems, accounting for 49.9 percent of overall Autonomous Systems spending. Its maturity presents challenges and opportunities. Among the challenges is intrenchment of few established players and among the opportunities is introducing emerging technology that has great potential for market disruption.

While FY17 segment spending is only slightly higher than it was in FY12, spending priorities have shifted. DoD spending on Support Services increased by 41.7 percent to $1.6 billion in FY17 and spending on R&D Programs increased by 67.8 percent to $438.8 million.

The shift in spending creates a slight opening for new competitors as DoD is seeking to develop the next-generation Unmanned Aerial Systems that have greater autonomous and human-to-machine teaming capabilities. Unlike UAV systems of the past, the next-generation platforms will be capable of operating in contested environments and possess the ability to communicate with other manned and unmanned platforms connected to the effects grid.

These new requirements present opportunities for contractors with specialties in cognitive engineering and behavior models to help gain greater situational awareness that autonomous systems can share with human operators for improved teaming.

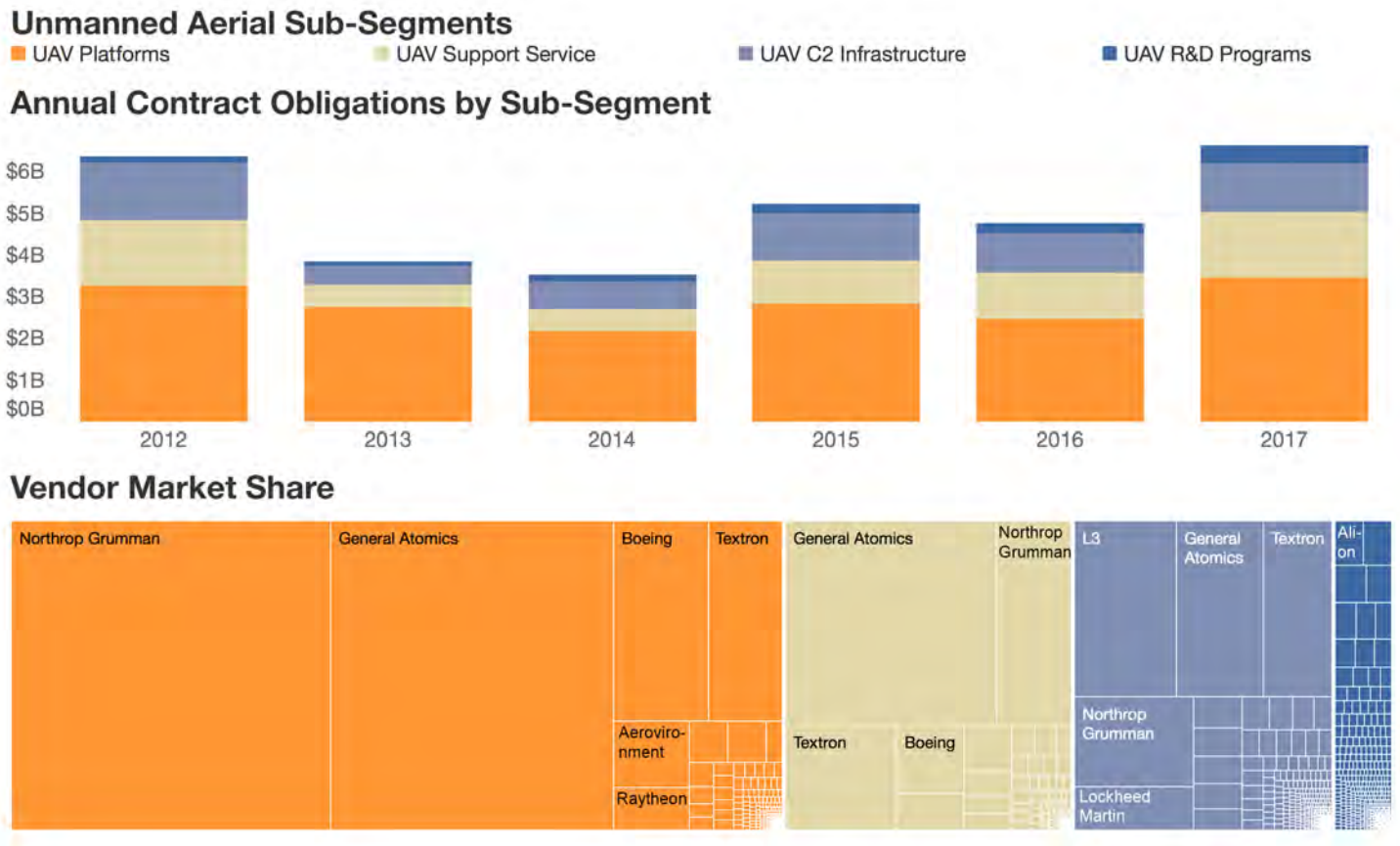


Exhibit 20: Platform manufacturers dominate the UAV market, but this may not be the case in the future as autonomy becomes the core component of Unmanned Aerial. Spending in the smallest sub-segment, UAV R&D Programs, increased the most by 23.3 percent to $438.8 million in FY17. Alion Science and Technology led UAV R&D capture, followed by Johns Hopkins, APL, General Atomics, Northrop Grumman, Raytheon, Textron, Navmar Applied Sciences and the University of Arizona.

Investment in Robotics & Unmanned Ground Vehicles Rises Rapidly From FY14 Low

Like many areas of Defense spending, Robotics and Unmanned Ground Vehicles (UGV) was hit hard by reshuffling priorities brought on by sequestration and changing defense priorities. However, segment spending has rebounded, strongly increasing by 140.5 percent to $1.6 billion in FY17 from the FY14 low of $681.8 million.

Advancements in cognitive engineering is one of several factors allowing robotics to rapidly advance. Specifically, robots are now able to figure out more things on their own and share that knowledge with other robots. The advancement is monumental, mostly because it lessens the load for programmers and transforms the development process from linear to exponential.

A large portion of development work is occurring at University Affiliated Research Centers (UARCs), Federally Funded Research and Development Centers (FFRDCs), commercial laboratories and niche engineering firms. Platform manufacturers also capture a lot of work.

Looking ahead to future year budgets, investment in UGV Platforms will grow by a compound average growth rate of 10.2 percent through FY21. Army's Common Robotic System-Individual CRS(I) and Brigade Combat Team UGV are the largest initiatives alongside Navy's Advanced Explosive Ordnance Disposal Robotic System (AEODRS) and several DARPA initiatives.

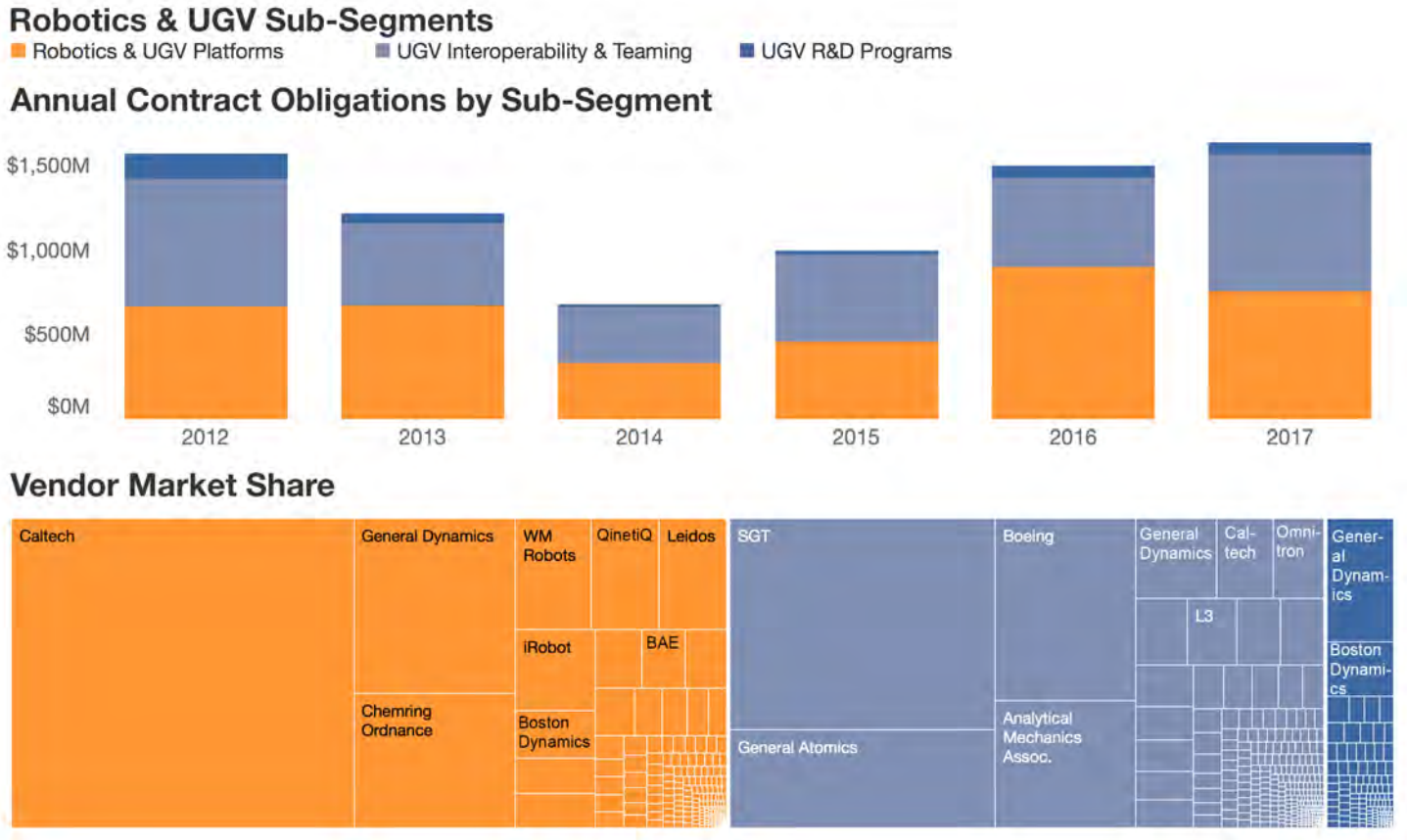


Exhibit 21: UGV Interoperability & Teaming had the most spending growth in recent years, increasing by 54.3 percent in FY17. SGT led capture mostly from NASA's Lunar Precursor Robotic Program. General Atomics performed contracts for modifications to its predator platform. Leading robotic OEMs, including General Dynamics, Boston Dynamics, QinetiQ and iRobot led capture of R&D contracts. Caltech manages NASA's Jet Propulsion Laboratory, the site of the Mars Rover & Robotics Program.

Unmanned Sea Emerges as Top Priority Amidst A2/AD Challenges in South China Sea

Overall market spending for Unmanned Sea is less than half the size of Robotics & UGV and less than one-tenth the size of Unmanned Aerial. That is because unmanned sea vehicles have not been widely deployed and have a substantially smaller share of R&D funds compared to the others. The dynamic is in the process of changing as UUV R&D led segment spending higher, increasing by a CAGR of 14.7 percent to $237.8 million in FY17.

A primary factor prompting spending increases is China's anti-access /area denial (A2/AD) strategy. To implement the A2/AD strategy, China is investing in long-range air and anti-ship defenses. U.S. guided missile destroyers such as the Tomahawk Land Attack Missiles (TLAM)-equipped Arleigh Burke-class presents significant threat to China's defenses. To protect the destroyers, the Navy is deploying unmanned buoyancy gliders as well as other UUV assets to expand its anti-submarine warfare edge.

Critical to the deployment of UUVs with advanced ISR capabilities are advancements in sonar, thermal and electric propulsion, energy use and payload capacity. Extended battery power is especially important for acoustic sensors used to detect enemy submarines. Acoustic sensors and sonar is another area attracting investment. The University of Texas has performed UUV sonar contracts for NAVSEA through Seaport-e. Top primes looking to integrate sonar advancements include Raytheon, Northrop Grumman, SAIC and Lockheed Martin.

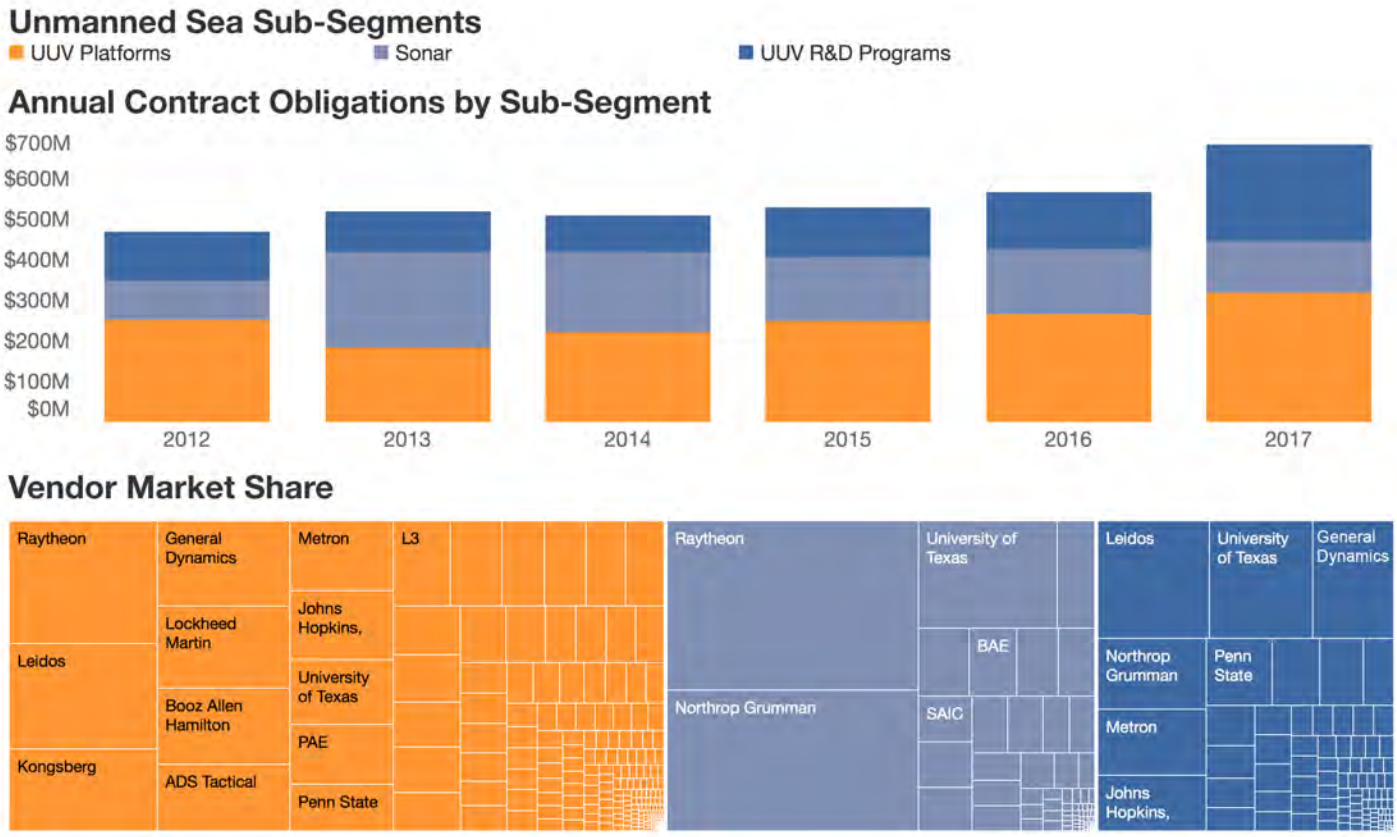


Exhibit 22: R&D Programs fueled a segment spending increase 7.8 percent to $684.9 million in FY17 and a large portion of those funds were obligated to universities. University of Texas, Johns Hopkins, Penn State, Woods Hole, University of Washington, Carnegie Mellon, Stanford and the University of Arizona rank among the top by capture. The technologies they develop with eventually be acquired by leading platform OEMs including Raytheon, Leidos, Kongsberg, General Dynamics and Lockheed Martin.

Greater Automation of PED Drives Investment and is Critical for Integration of Domains

In the Age of Information, Processing Exploitation and Dissemination (PED) Architecture is gaining importance. It is the hub-and-spoke network that receives data and turns it into insight. As cognitive capabilities mature, a fully-automated PED architecture will be allocated to a decision authority on problems deemed intractable or beyond human cognition.

PED is attracting investment as segment spending increased by 8.1 percent to $3.9 billion in FY17, the most of any Autonomous Systems segments. Among PED sub-segments, spending on Dashboard Analytics increased the most by 15.4 percent to $1.6 billion in FY17, followed by PED R&D Programs with a 14.2 percent increase in spending to $412 million in FY17.

PED Architecture spending can be expected to increase in future years with funding allocations coming primarily from Army and Air Force. Army is most focused on data migration and integration, while Air Force is investing heavily in advancing machine learning, AI and other cognitive capabilities to solve for challenges in three primary missions lifecycle management, sigint/geoint intelligence and cybersecurity. Incumbent contractors at Army include: Leidos, AASKI Technology, Lockheed Martin, Booz Allen Hamilton and ManTech. Raytheon, Lockheed Martin, Leidos, Northrop Grumman and L-3 Technologies perform the most work for Air Force.

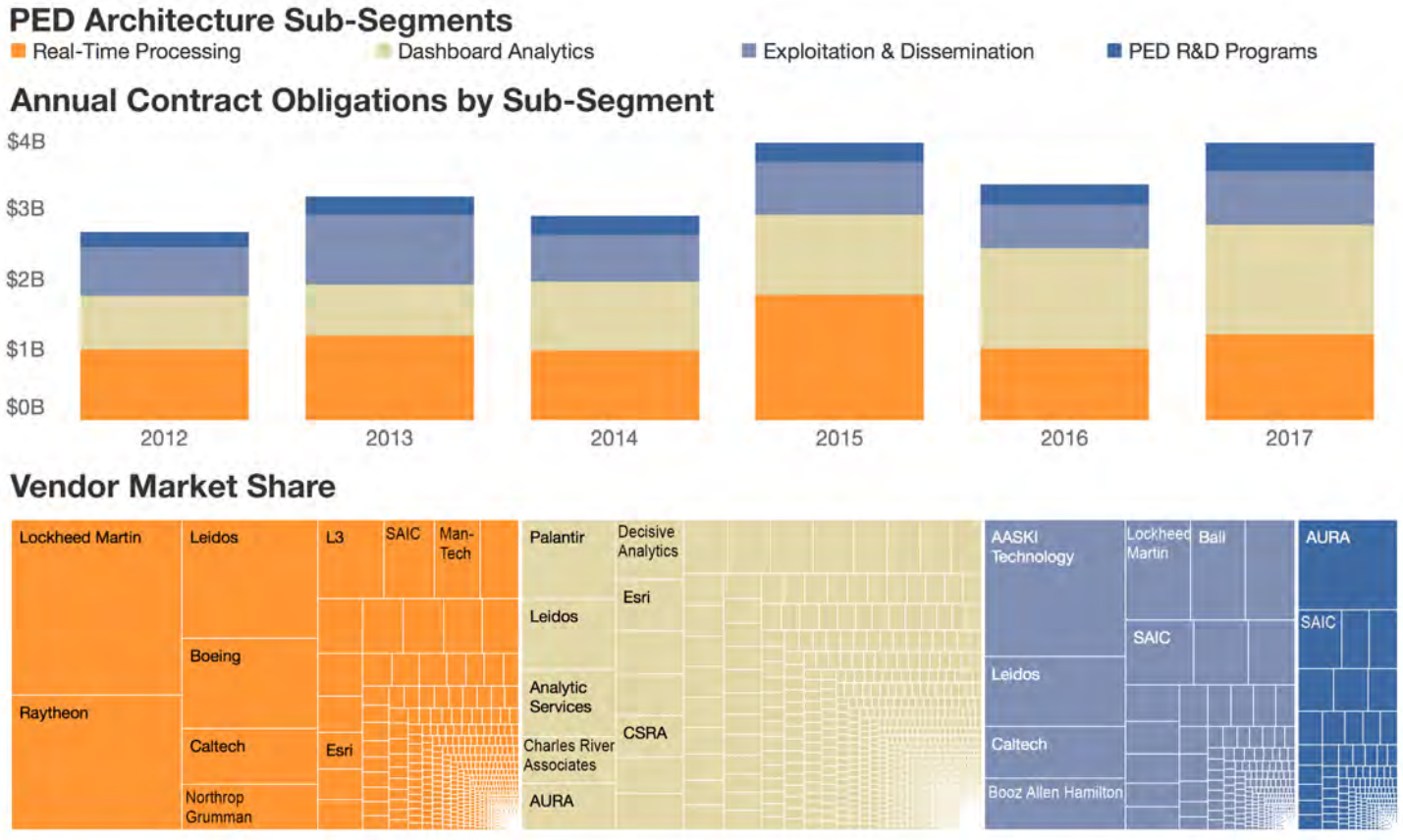


Exhibit 23: Dashboard Analytics and R&D Programs fueled segment spending growth of 8.1 percent to $3.9 billion in FY17. Palantir Technologies led capture of Dashboard Analytics with 5.2 percent of total sub-segment spending, followed by Leidos with 4.7 percent. The Association of Universities for Research in Astronomy (AURA) led capture of PED R&D Program obligations. Other top vendors include Sigma Space, Raytheon, University of Colorado, Johns Hopkins, APL, Lockheed Martin and BAE Systems.

Breakthroughs in Advanced Materials & Manufacturing Transform Autonomous Systems

With attributes that seemed unimaginable a few years ago, new materials are coming to market. On the whole, they are lighter, stronger, recyclable and adaptive and serve as a bridge to the Digital sphere through applications that are self-healing or self-cleaning, metals with memory that revert to their original shapes. Govini has categorized Advanced Materials & Manufacturing into the following two segments and eight sub-segments:

Rapid Prototyping

- Advanced Composites - materials constructed with unusually high strength fibers
- 3D Printing - computer controlled process of adding materials together to create objects
- Precision Engineering - designing machines or structures having high tolerance and stability
- Green Chemistry - chemical engineering that minimizes hazardous substances

Nanotechnology

- Molecular Engineering - design of molecular properties for assemblance of better materials
- Nanomaterials - materials constructed on the nanoscale between 1 to 100 nanometres
- Nanosciences - study of structures and materials on the scale of nanometers
- Nanoelectronics - inter-atomic interactions and quantum mechanical properties

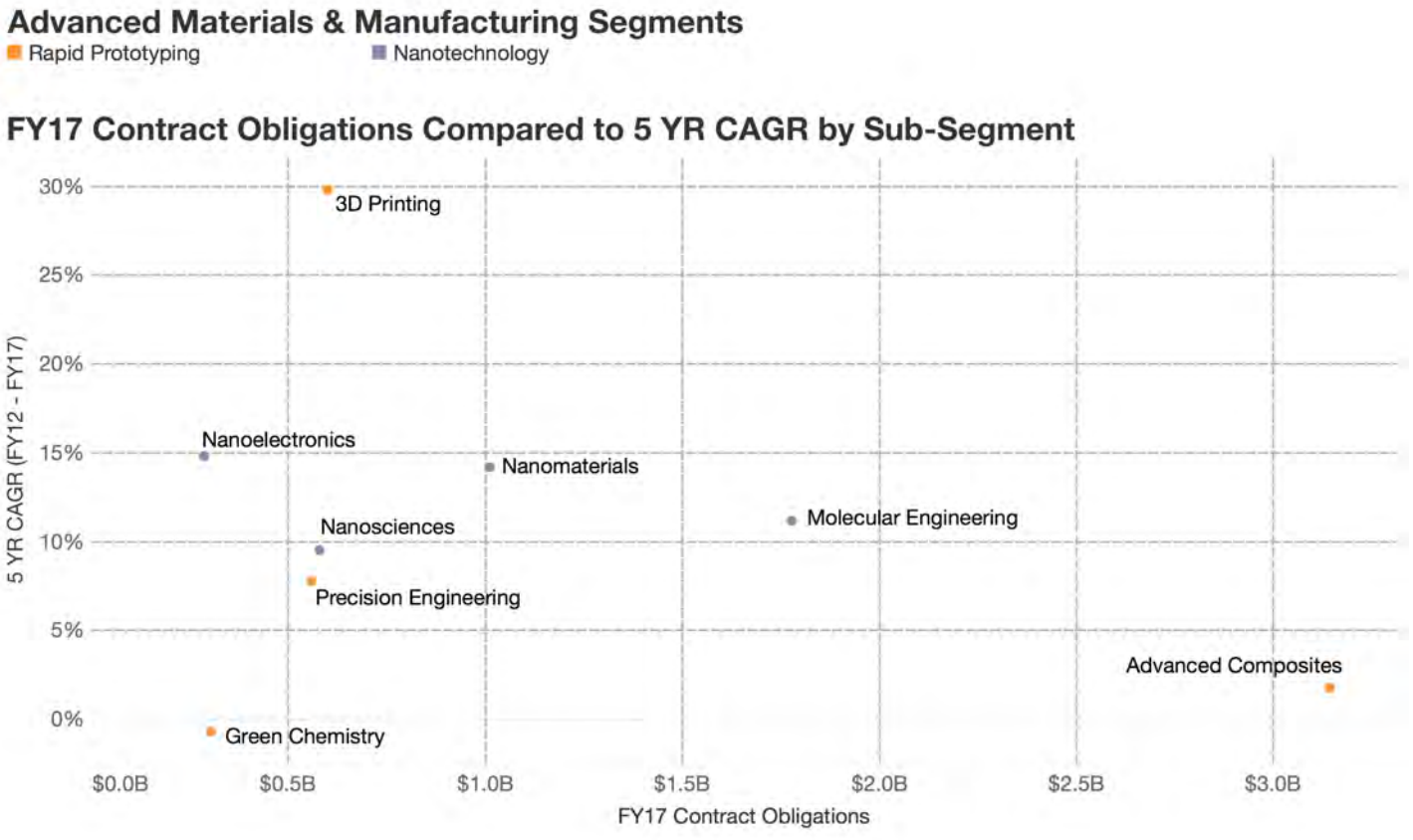


Exhibit 24: Overall spending on Advanced Materials & Manufacturing increased by 9.2 percent to $1.6 billion in FY17. Nanotechnology sub-segments, Nanoelectronics, Nanomaterials and Molecular Engineering, drove the growth along with 3D Printing increasing by 14.8 percent, 14.2 percent, 11.2 percent and 29.8 percent respectively.

3D Printing is a Bright Spot Amidst Rapid Prototyping Market with Irregular Buying

One prominent challenge that product designers or equipment sustainers face is not having the ability to rapidly produce prototypes or customized replacement parts. Additive manufacturing, also known as rapid prototyping technology, is beginning to be embraced as a solution as segment spending increased by 5.8 percent to $701.1 million in FY17.

While additive manufacturing technologies are far from being implemented at scale, they have the potential to help relieve a major excess inventory supply challenge for the Defense Industrial Base. Currently, the Defense Logistics Agency (DLA) purchases inventory irregularly. Sometimes the purchases align to depot maintenance schedules, but often times they simply don't and parts go unused. Typically, the average annual value of inventory held for three years is about $13.7 billion and of this amount $7.1 billion or 52 percent is estimated to be more than is needed to meet specific depot requirements and about $5.1 billion or 37 percent is deem excess of two years future demand. Estimated amount for reutilization or disposal is $1 billion.

3D Printing is the most common form of additive manufacturing and spending increased the most of all by a CAGR of 29.8 percent. Northrop Grumman captured the largest share of sub-segment spending through four contracts with NAVAIR; two with DARPA and two with AFRL. Other vendors performing on 3D Printing contracts include Leonardo S.p.A., United Technologies Corp., University of Dayton and Penn State University.

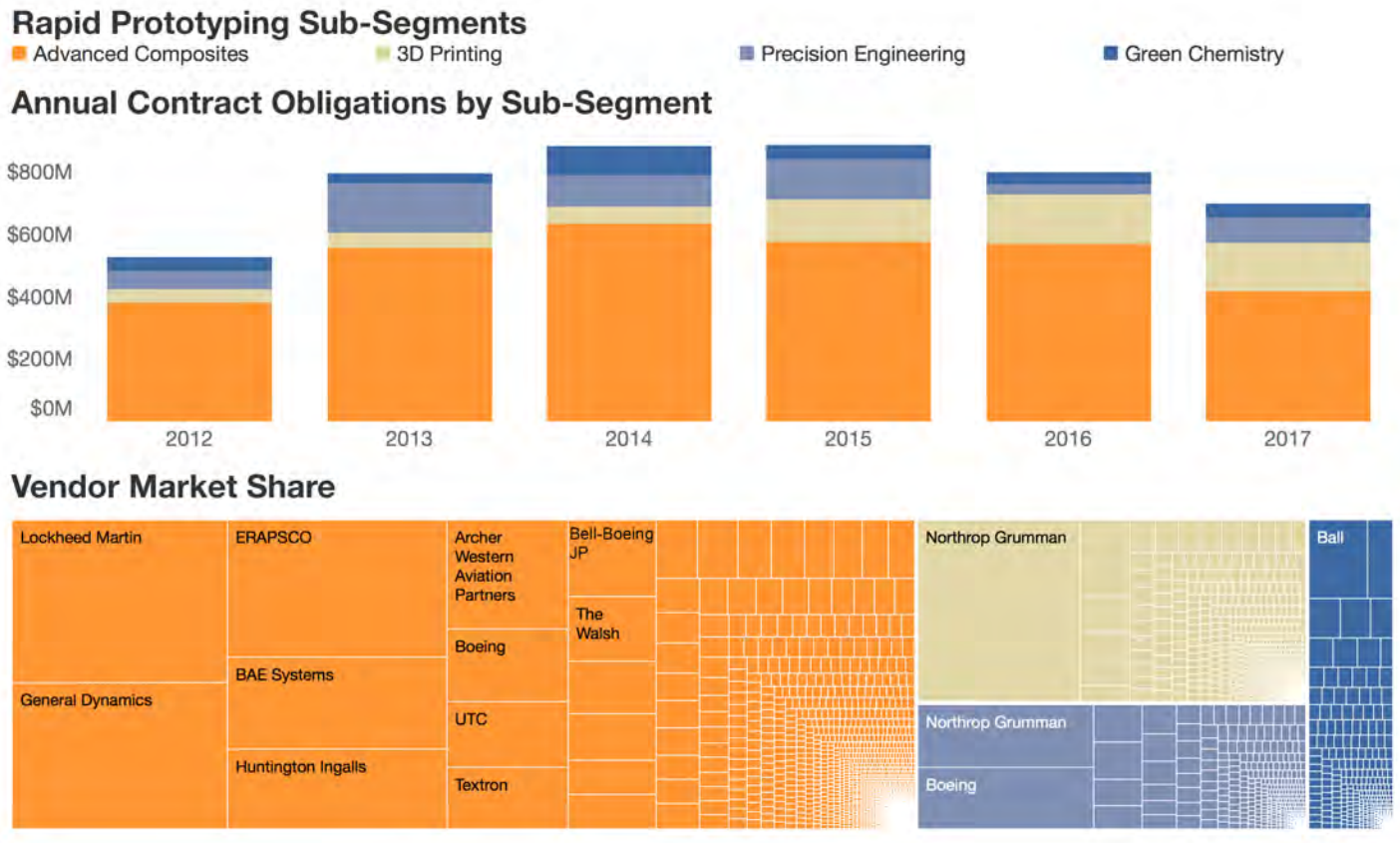


Exhibit 25: Spending on Advanced Composites, the largest sub-segment by contract obligations, surged between FY12 and FY14 reaching a high of $635.1 million. Investments include various structures, such as corrosion-resistant fuel cell hangers constructed by Archer Western Aviation Partners and ground components of anti-ballistic missile defense systems maintained by Lockheed Martin to Areleigh Burke-class destroyers made by Huntington Ingalls and thermoplastic composite beams made by Boeing.

Nanotechnology FY17 Spend Surge Fueled by Greater Investment in Nanomaterials

Much like Advanced Computing Environment, Nanotechnology is uniquely positioned within Fourth Industrial Revolution technologies as an enabler. By manipulating individual atoms and molecules, nanotechnology can be used to access intermediary states of matter where nature's physical properties have changed; this is unlocking commercial opportunities from health to manufacturing, energy and farming. As a result, annual spending increased by a CAGR of 12.3 percent, reaching $928.3 million in FY17 from $520 million in FY12.

Nanotechnology's promise is being realized through Nanomaterials, which have unique optical, electronic or mechanical properties. Such materials are being used to make the physical world smarter, more resilient, adaptable and durable. Platform OEMs including Lockheed Martin, General Dynamics, Huntington Ingalls and Raytheon lead capture. Lockheed won most of its work through delivering spares for guided missile platforms, while General Dynamics delivered nanomaterials for Virginia-class submarines and Huntington Ingalls for Navy's amphibious warfare ships.

Molecular Engineering, the largest sub-segment of Nanotechnology, also had significant spending growth in recent years. Medical Science & Computing captured all its revenue from the National Library of Medicine (NLM) and the National Institute of Health (NIH). Center for the Advancement of Sciences in Space supports NASA by managing International Space Station National Laboratories overseeing a broad portfolio of advanced sciences including Molecular Engineering. University of Alabama also supports NASA in material sciences research.

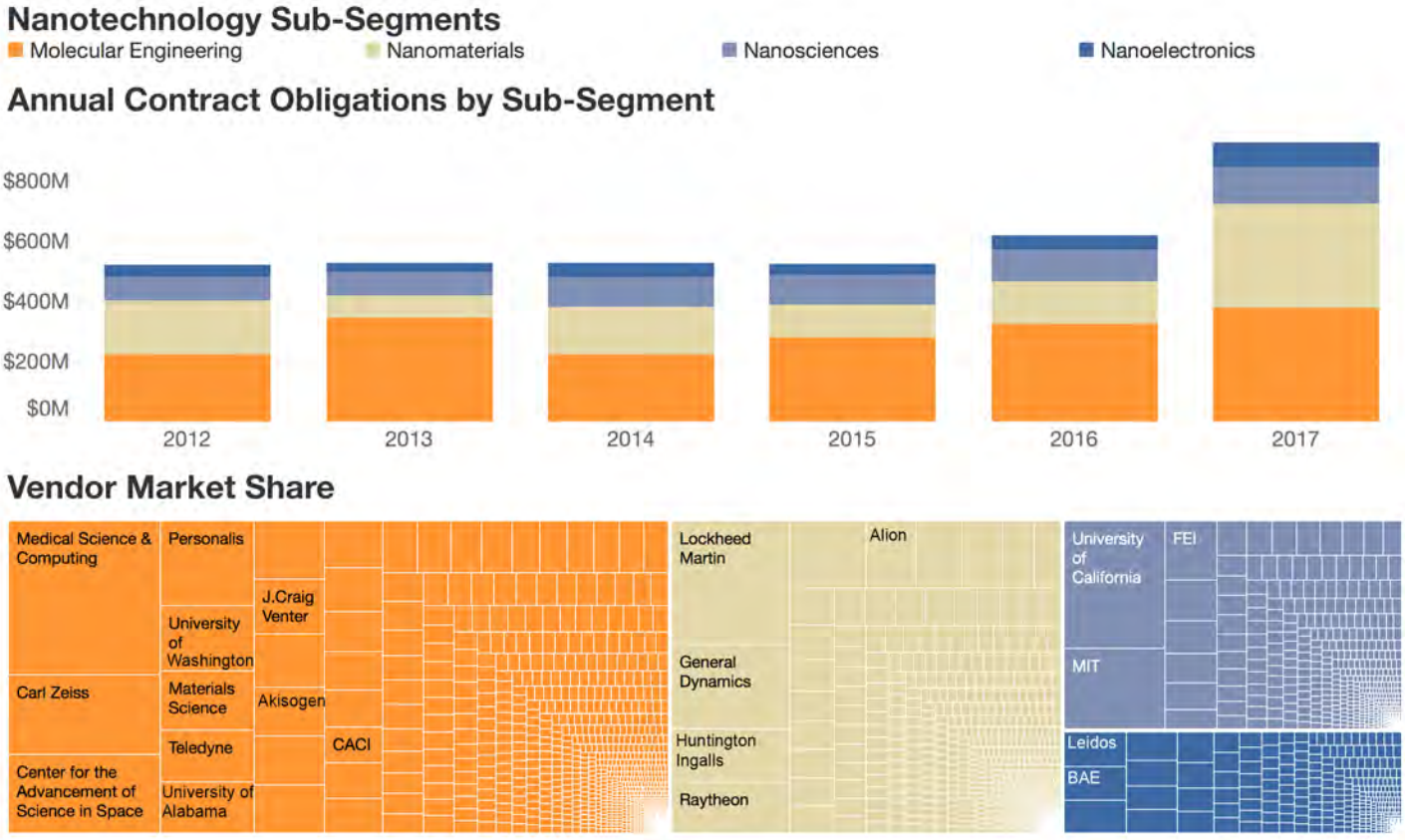
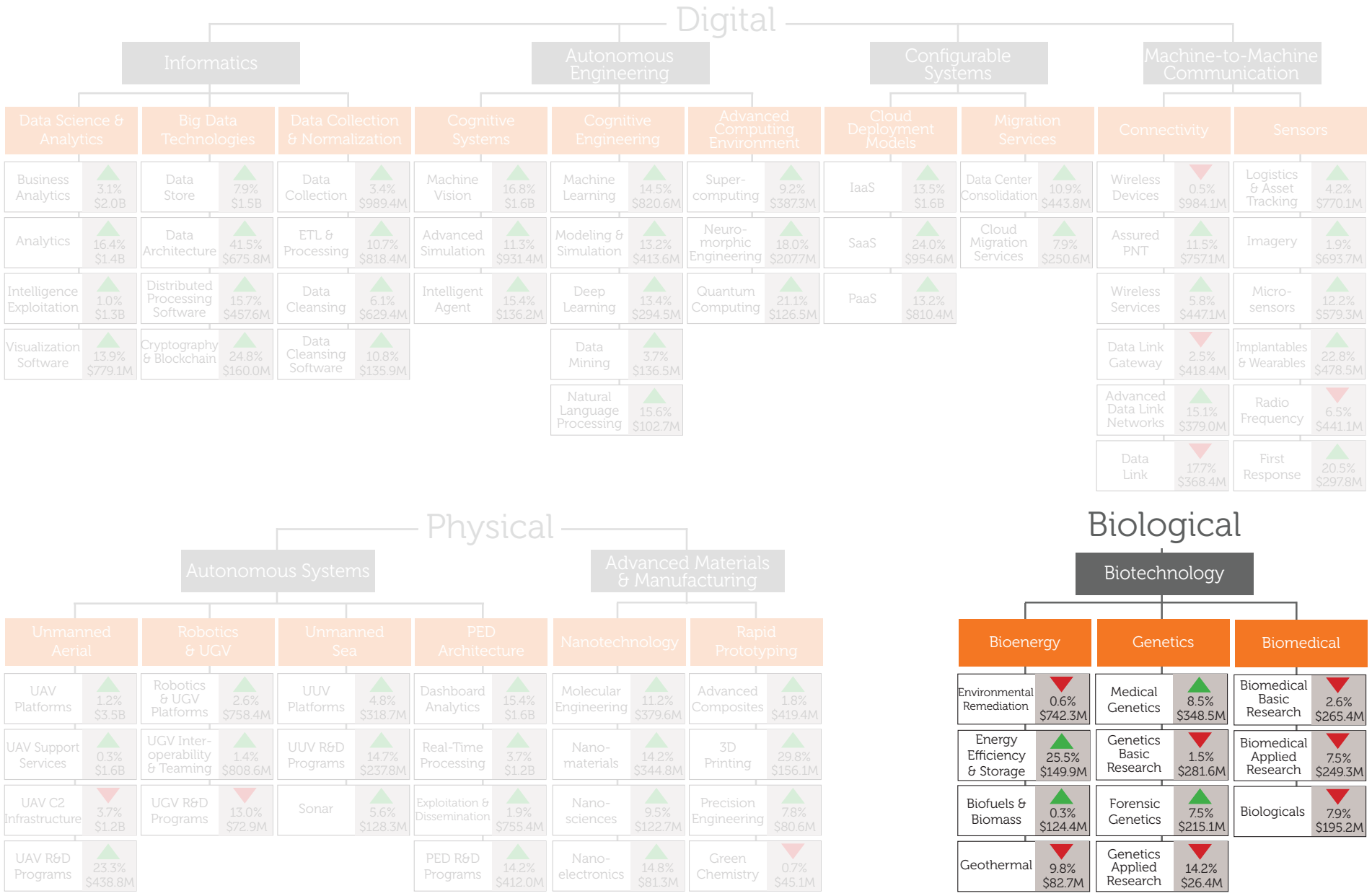


Exhibit 26: FY17 spending on Nanomaterials increased by 142.7 percent to $344.8 million, the most of any sub-segment. Spending on Nanoelectronics followed with a 72.1 percent increase in FY17; Molecular Engineering spending increased by 16.5 percent and Nanosciences by 16.3 percent.

THE FOURTH INDUSTRIAL REVOLUTION MARKET TAXONOMY: BIOLOGICAL SPHERE



THE BIOLOGICAL SPHERE

Government's Role in Biological Technologies Rely Mostly on Funding Research

Technological breakthroughs in the biological sphere, genetics in particular, are happening at a rapid pace. In recent years, the cost and ease of genetic sequencing have decreased dramatically. The breakthrough was enabled by advancement in computing power, which now enables a genome to be sequenced in a few hours and for less than one thousand dollars.

Activating and editing genes have also advanced considerably with the next step being synthetic biology, which will provide the ability to customize organisms by writing DNA. Setting aside the intricate ethical issues this raises, these advances will not only have a profound and immediate impact on drugs and biologicals but also on agriculture, biofuels, energy storage and environmental remediation and practically any cell type.

The science is progressing so fast that the limitations are proving to be less technical than they are about ethical applications. Like other material spheres, Government must lead by fusing emerging technologies with mature ones for solutions that transcend agency operations. Exhibit 27 provides insight on how the Federal Government is beginning to do so. Bioenergy is the stand-alone mature segment. It consists of Environmental Remediation, Biofuels & Biomass, Geothermal and Energy Efficiency & Storage, all of which are less competitive than their peer emerging technologies.

Geothermal attracted the lowest average competitive bids per contract action of 4.2. A primary reason is that high barriers to entry exist for Geothermal market. Another is that Federal Government does not consistently obligate funds for Geothermal. Spending in the sub-segment declined by a CAGR of 9.8 percent to $82.7 million in FY17 from $138.9 million in FY12. The Biofuels and Biomass sub-segment is similar in that the Government has not expressed great demand for them. Environmental Remediation is the opposite as consistent demand for clean-up services exist and only a few contractors are capable of delivering. The most competitive Bioenergy sub-segment is Energy Efficiency & Storage and part of the reason for it is because DOE and other agencies established multi-year programs of records that were consistently funded.

Research sub-segments were the most competitive within the Biomedical segment. Basic Research attracted the most competitive bids of 12 and Applied Research had an average of 9.6 bids. Competition for Genetics research contracts was similar. Basic Research attracted the most competition with an average of 13.2 bids and Applied Research had an average of 10.2. Even though the Government has not been able to allocate additional funds to Biotechnology in recent years, advancement hopefully will continue, particularly in Genetics as it is the foundational technology of the Biological sphere.

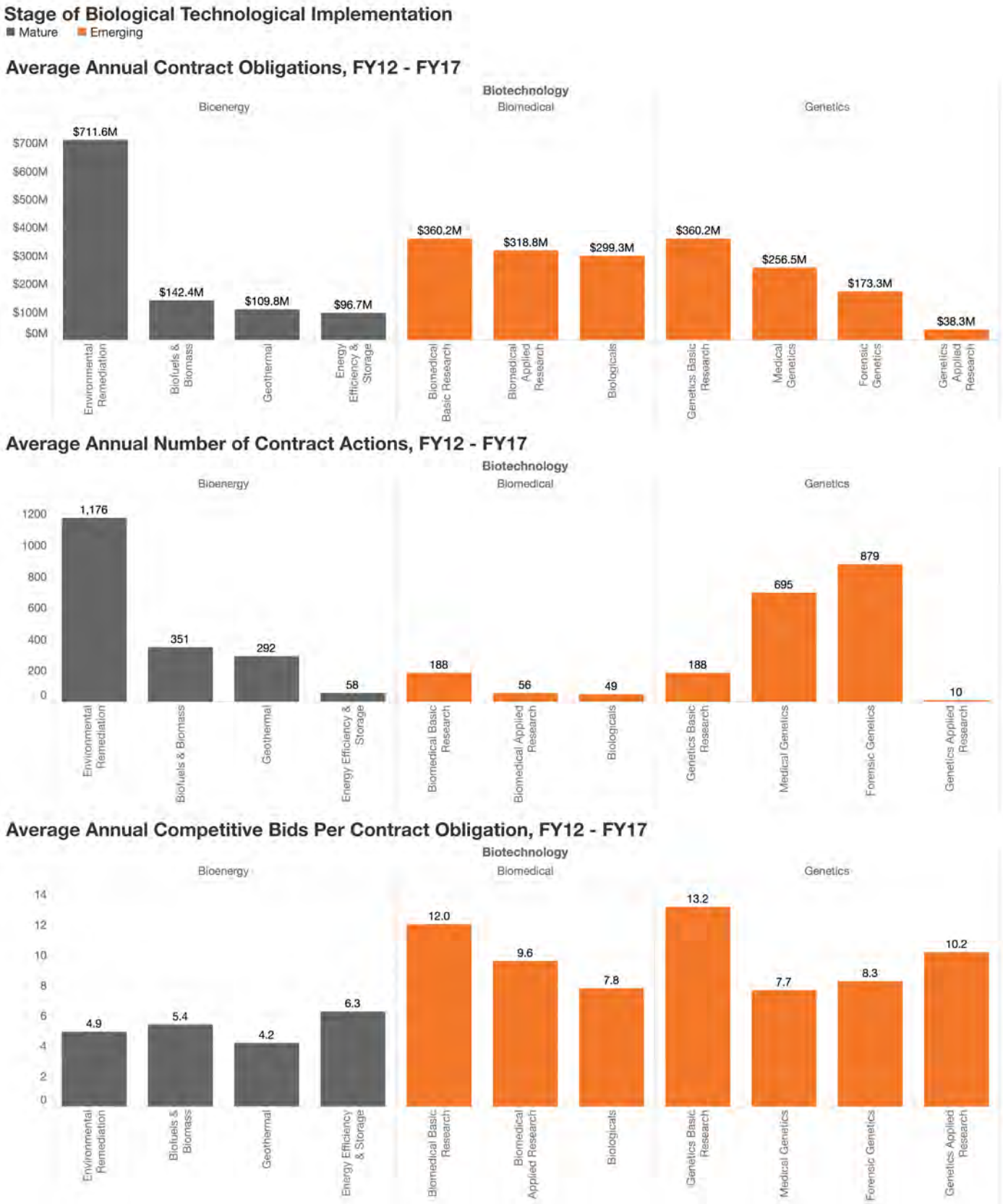


Exhibit 27: Bioenergy constitutes mature technologies relative to its peers, Biotechnology and Genetics which are classified as emerging. Environmental Remediation is the largest sub-segment by average annual contract obligations, followed Biomedical Basic Research and Genetics Basic Research. Basic Research and Applied Research sub-segment are the most competitive by a large margin.

Biotechnology Struggles to Attract Investment in Constrained Budget Environment

The rate at which new biotechnologies are coming to market has increased significantly in recent years. Part of the reason is increased support from the private sector, but the main reason is the incredible opportunity to digitally transform health monitoring devices. Govini has categorized Biotechnology into the following three segments and eleven sub-segments:

Bioenergy

- Environmental Remediation - removal of pollution and contaminants from the environment
- Biofuels & Biomass - fuels produced through advanced biological processes
- Geothermal - heat energy generated and stored in the earth
- Energy Storage - services and technologies that capture energy for use later in time

Biomedical

- Biomedical Basic Research - basic research to support advancements in biomedical
- Biomedical Applied Research - applied research to support advancements in biomedical
- Biologicals - treatments produced in living systems such as microorganism, plant cells or animal cells

Genetics

- Genetics Basic Research - basic research to support advancements in genetics
- Medical Genetics - diagnosis and management of hereditary disorders
- Forensic Genetics - DNA profiling of individuals to help clarify unknown outcomes
- Genetics Applied Research - applied research to support advancements in genetics

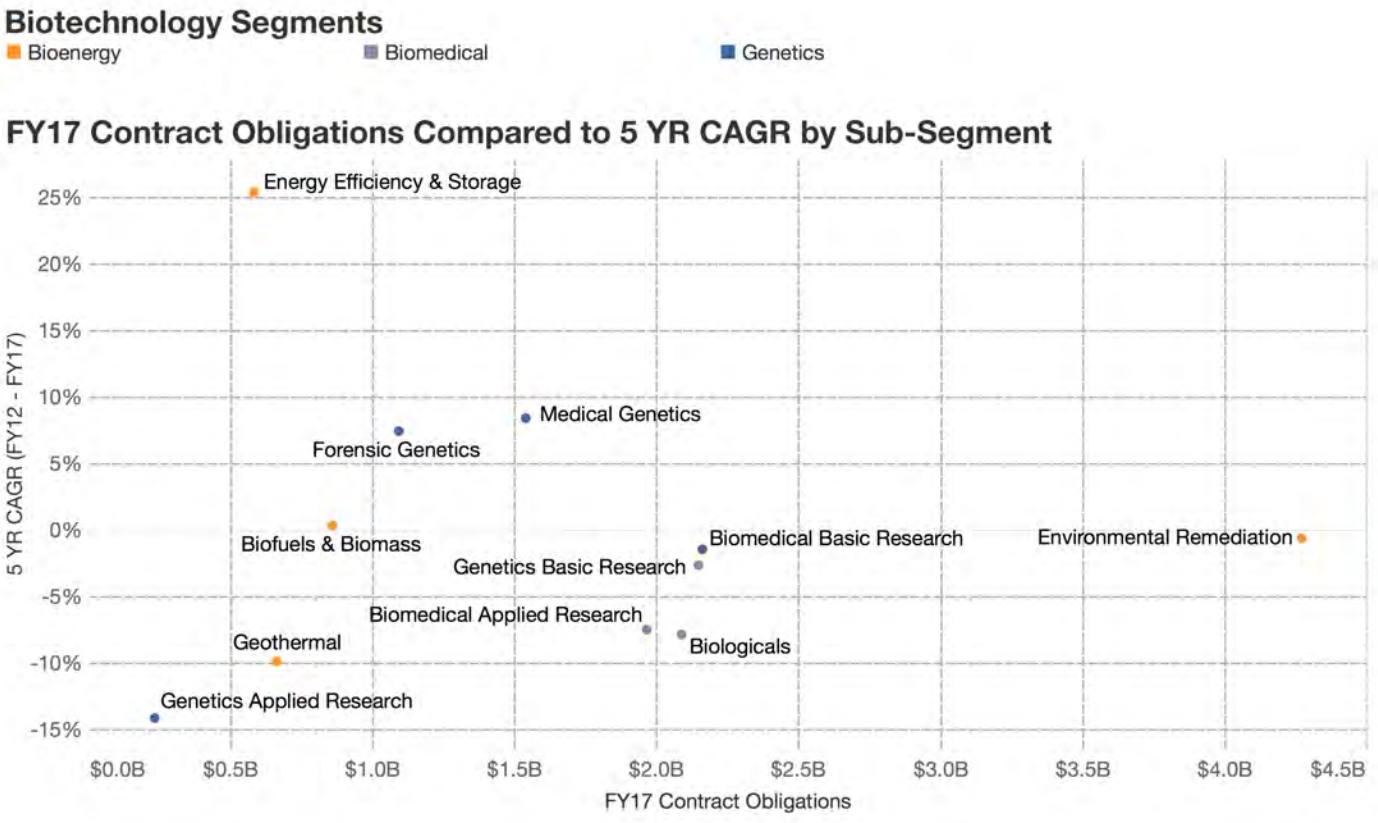


Exhibit 28: Most sub-segments experienced negative spending growth from FY12 through FY17. Energy Efficiency & Storage stands out as the only sub-segment with double-digit growth of 25.5 percent, however it likely will not continue to attract investment under the Trump Administration.

Bioenergy Investments Focused on Efficiency and Enabling Constant Collection of Data

While the first two Industrial Revolutions were themselves driven by energy technologies, the fourth is not. It is driven by technologies that enable the constant collection of data. While energy has a prominent role centered around efficiency, advancements in the area along with greater use of biosources prompted spending to rise by 25.5 percent to $149.9 million in FY17.

Environmental Remediation, the largest Bioenergy sub-segment, has great potential to be reshaped by Bioenergy technologies. For example, Rice University has developed sponges made of carbon nanotubes that can be used to soak up oil spills. Micro-algae and other living organisms can be developed to do the same. Few competitors currently dominate Federal Remediation including CH2M HILL, AECOM, Savannah River, Tetra Tech and Fluor.

Biofuels & Biomass, the second largest sub-segment, had a spending surge in FY13 reaching $301.4 million mostly from DLA Energy purchases of biodiesel from Petroleum Traders Corp., Mansfield Oil of Gainesville, Troy Company and Darden Putman Energy and Logistics.

Geothermal and Energy Efficiency & Storage, the two smallest sub-segments, also had irregular buying behavior. Energy Efficiency surged in FY16 reaching $329.4 million as the Obama Administration sought to deliver on renewable energy targets through energy savings performance s contracts (ESPCs) administered by Department of Energy (DOE). Most of the spending was captured by Honeywell, United Technologies Corp. (UTC), Ameresco, Siemens and Schneider Electric.

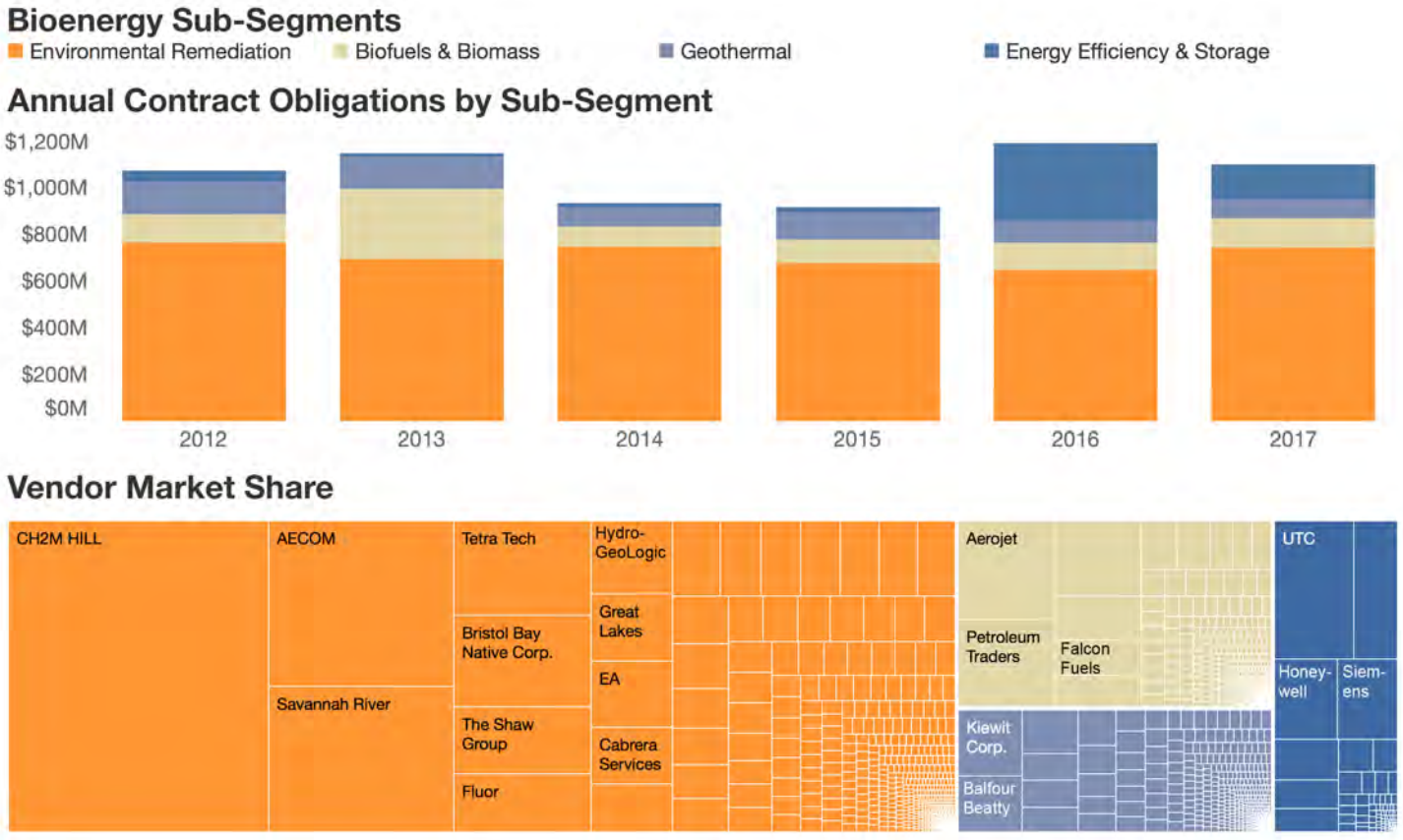


Exhibit 29: Environmental Remediation, the largest sub-segment by spending, predictably obligates an annual average of $711.6 million to few competitors. Aerojet Rocketdyne led capture of Biofuels & Biomass capture through a biodiesel contract funded by Navy. UTC led capture of Energy Efficiency & Storage with 28.9 percent.

Deep Spending Cuts Present Challenges for Advancement in Biomedical Technologies

Advancement in biomedical technologies is making medical practice easier for doctors, more effective for patients and cheaper for the entire healthcare system. Segment spending, however, decreased sharply by 21.2 percent to $721.2 million in FY17 from $1.4 billion in FY15.

Lower spending on Biologicals accounted for most of the decline as did fewer funds for basic and applied biomedical research. Spending on Biologicals decreased by 62.8 percent to $195.2 million in FY17 from $524.7 million in FY15 and spending on basic research decreased by 42 percent and spending on applied research decreased by 36 percent during the same period.

The deep cuts look like they may persist as President Trump's most recent budget request proposed to cut biomedical research by 18 percent. While several members of the House Appropriations subcommittee responsible for funding the National Institutes of Health (NIH) disagree with Trump's proposal, consensus on biomedical spending levels has yet to be reached.

Basic Research, the largest Biomedical sub-segment, accounted for 34.8 percent of overall segment spending from FY12 through FY17 and Applied Research accounted for 31.6 percent. HHS accounted for 74.5 percent of Basic Research and 45.5 percent of Applied Research. DoD accounted for 20.4 percent of Basic Research and 53.8 percent of Applied Research.

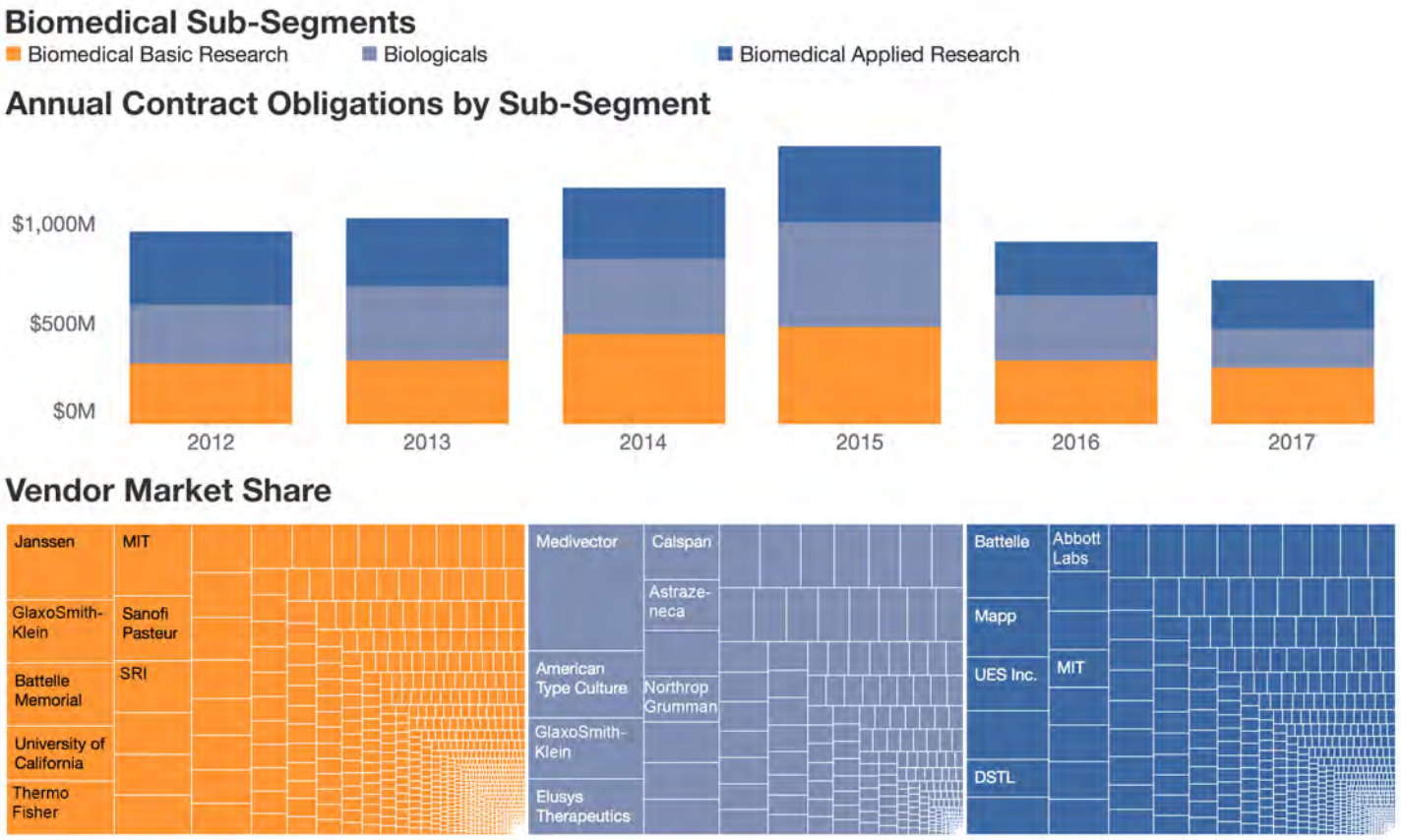


Exhibit 30: Basic Research was spread across the vendor landscape with Janssen Pharmaceuticals leading capture with 5.1 percent of sub-segment spending, followed by GlaxoSmithKline with 4.3 percent. Battelle Memorial captured large shares of Basic and Applied Research of 4.2 percent and 4.3 percent respectively.

Technology Fusion Fuels Advancement in Genetics While Funding Falls Sharply

Genetics, much like other Taxonomy segments, is an example of how different Fourth Industrial Revolution technologies in various stages of maturity fuse together to enrich each other. Despite the promise it holds, annual spending on Genetics declined sharply by 17.5 percent to $871.6 million in FY17 from $1.1 billion in FY15.

The segment spending decrease was driven by lower funding for Basic and Applied Research. Both were cut by more than 40 percent from their FY15 highs of $485.1 million and $45.9 million respectively. Despite lower spending on Genetics, support from other Fourth Industrial Revolution technologies have produced mind-blowing advancements. 3D manufacturing is being combined with gene editing to produce living tissues for tissue repair and regeneration.

The largest sub-segment, Genetics Basic Research, accounted for 43.1 percent of overall segment spending with 74.5 percent funded by HHS and the rest funded by DoD. Janssen Pharmaceuticals captured the largest share of sub-segment spending with 5.1 percent of the total, followed by GlaxoSmithKline with 4.3 percent. Medical Sciences & Computing led capture of the second largest sub-segment Medical Genetics with 12.2 percent of total spending, followed by Fred Hutchinson Cancer Research Center with 9.3 percent. Forensic Genetics, the third largest sub-segment had a spending increase of 7.5 percent reaching $215.1 million in FY17. CACI, Engility, Leidos, Booz Allen Hamilton and Abbott Laboratories rank among top vendors.

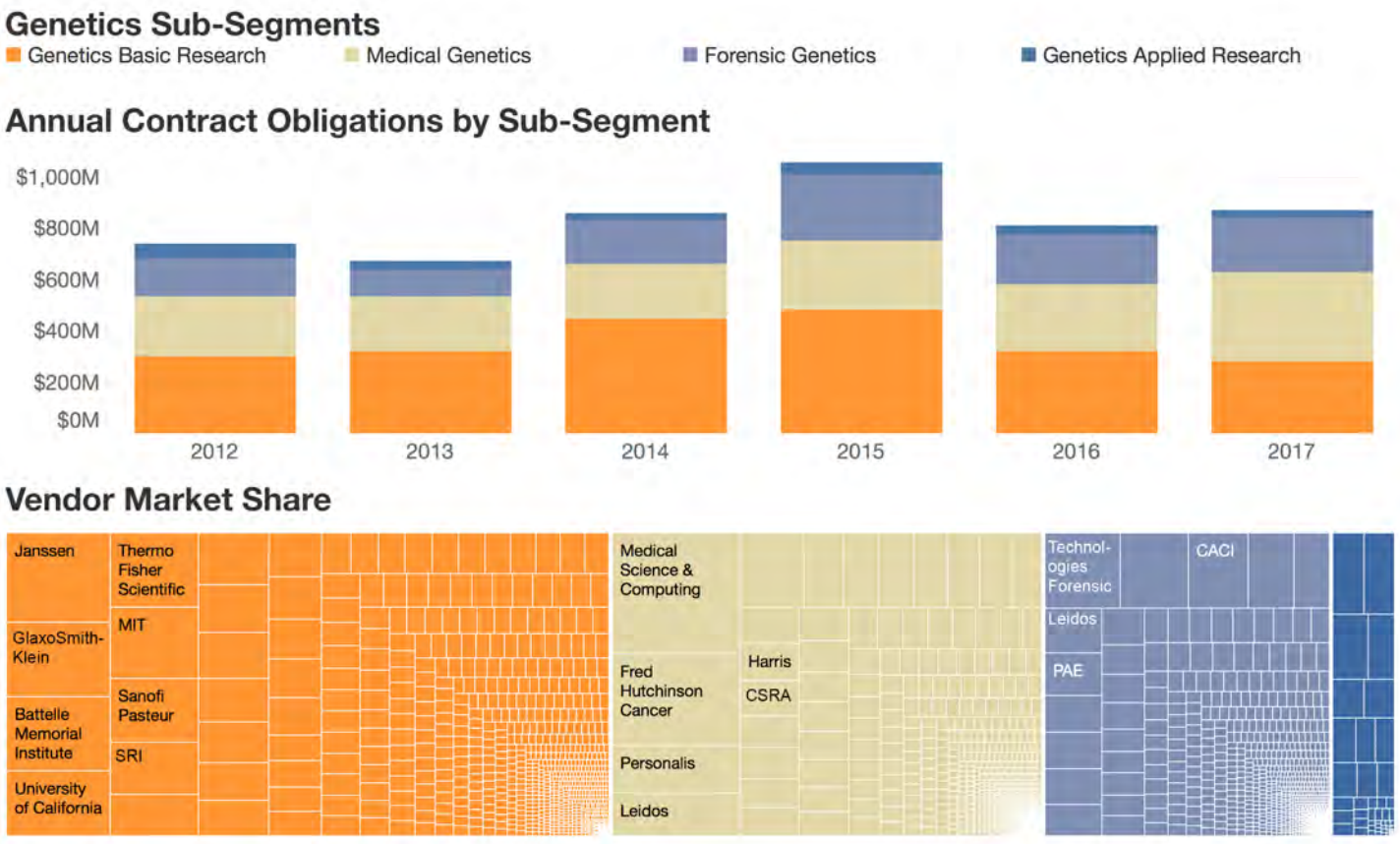


Exhibit 31: A large portion of Basic and Applied Research goes to Universities, including Northwestern University, Massachusetts Institute of Technology, University of Maryland, University of California, University of Washington, Johns Hopkins and University of North Carolina.

Conclusion

The Fourth Industrial Revolution is unlike any of the other three previously experienced. This revolution is fueled by data and new technologies that blur the divide between the Digital, Physical and Biological spheres.

Governments are most impacted by this Revolution. They must invest to fill capability gaps so that new technologies can reach their full potential. Governments must also find ways to better leverage the investments they make by successfully integrating emerging technologies with ones that are more mature as a means of transforming themselves.

The U.S. Federal Government is just beginning to do some of these things. It is investing heavily to integrate emerging Digital technologies, such as M2M Communication and Autonomous Engineering, with mature ones, such as Informatics and Configurable Systems. Components of each attracted increasing investment. Annual spending on Configurable Systems increased the most by a CAGR of 14.7 percent totaling $4 billion in FY17 and spending on Autonomous Engineering increased the second most by a CAGR of 13.8 percent, totaling 5.2 billion in FY17.

Investment in digitizing the Physical sphere is also growing and the Federal Government is prioritizing Advanced Materials & Manufacturing to do it. Annual spending in the area increased by a CAGR of 9.2 percent totaling $1.6 billion in FY17. Another area attracting investment is Autonomous Systems as it is one physical manifestation that easily relates to the digital world because of its nature. Spending on Autonomous Systems increased by a CAGR of 3.1 percent to $12.9 billion in FY17.

The biological sphere has not been able to attract increasing Federal investment. Part of the reason is because of greater private sector involvement. Regardless, the Federal Government has historically funded much of the basic and applied research and those funding streams are in jeopardy of drying up under the Trump Administration. Annual spending on Biotechnology decreased by a CAGR of 0.7 percent totaling $2.7 billion in FY17, with most of the declines coming in the last two fiscal years.

Investing in technology is one thing, but implementing it to transform agency operating concepts is much different. The later requires trial and error and a tolerance for change and high risk. This is where the Federal Government struggles and where the greatest risk to Fourth Industrial Revolution technologies exist. Existing procurement mechanisms play a role in the challenge and so does a pervasive risk-averse culture and reluctance to change.

Governments are in uncharted territory when it comes to embracing and adapting to the coming wave of technological change. Previous revolutions entailed mechanical advancements related to energy and digital advancements related to creating data. This one is all about making better use of data through autonomous machines. Such advancement changes the role of the human operator more than any previous industrial revolution. For this reason alone, Governments must rethink their roles, specifically how they structure their workforce and develop skill sets. This will change how they interact with the private sector, the public and nation states in order maintain the progression of world order.

Methodology

Govini creates decision-grade information that allows clients to tackle their most difficult problems. Govini takes a unique taxonomic approach to breaking apart the market and its players, and provide insights only available through its Strategic Intelligence Platform. These analytic reports are designed to categorize Federal Government contract obligations and budgets into segments and sub-segments. Due to some contracts being broad in scope, they may be included under multiple categories within a taxonomy to ensure an accurate, granular and evidence-based reflection of the market.

Govini is a big data and analytics firm committed to transforming the business of government through data science. Govini's insights and analyses are utilized by Federal Agencies, Federal Contractors, Private Equity Firms and Hedge Funds to guide their strategies and uncover opportunities. Govini was founded in 2011 and has offices in Arlington, Virginia and San Francisco, California.