

Ball Aerospace & Technologies Corp.

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Analytical Overview

Strategy: The aerospace segment owned by Ball Corporation is a well-established supplier of advanced space and technology-related solutions to the US Government. The company has developed a reputation for providing world class products and services, thereby garnering a highly satisfied customer base from which it can continue to grow its uniquely configured capabilities.

Few companies in defense and aerospace can boast Ball Aerospace's growth rate. Since 2015 sales have more than doubled and the backlog has consistently increased.

Ball Aerospace has achieved its goal of becoming a billion-dollar business, hitting that goal in 2018 and then continuing to grow strongly, reaching \$1.91 billion in net sales for all of 2021 (14% of the company's \$13.8 billion in total net sales across all segments).

The company's strategy is to provide larger value-added offerings to customers. It is taking its science work

and more into exploration and seeking to bring its data analytics work to more customers.

Ball's focus on bolstering its defense and intelligence business and a new management team installed several years ago have been keys to that success.

Ball Corp.'s management continues to assess whether Ball Aerospace is best within the company, given its primary focus on aluminum products for consumer goods, or whether greater value would be served by its divestiture. So far, no plans for divestiture.

Strengths: Ball is known for strong, conservative financial management, a factor that served it well in the space downturn and positioned it nicely for the subsequent renewed interest in space. It has a strong reputation for technologically.

The company's high concentration on intelligence work and growing commercial work help buffer it against government budget cuts.

Ball Corporation is a leading global supplier of aluminum packaging for the beverage, personal care and household products industries. It also provides aerospace and other technologies and services to governmental and commercial customers within its aerospace segment.

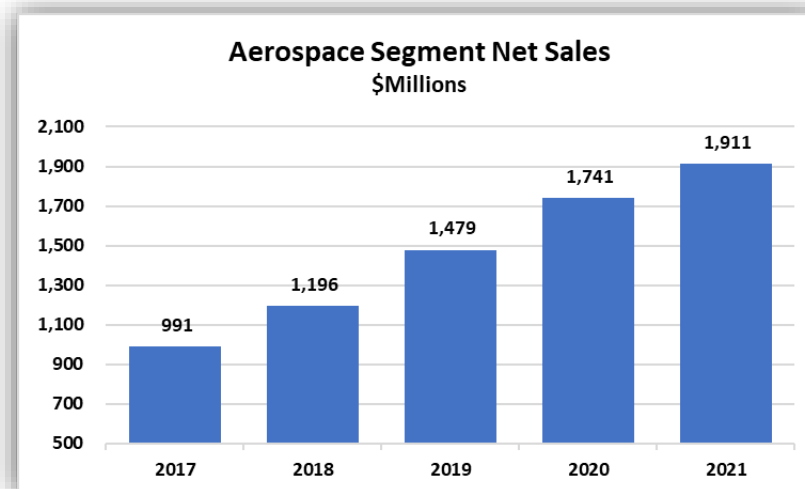
In 2021, Ball's total consolidated net sales were \$13.8 billion. The packaging businesses accounted for 86 percent of its net sales, while the aerospace segment accounted for the remaining 14%.

Ball's aerospace business offers components, systems and full mission support for intelligence surveillance and reconnaissance, civil, commercial, and national security aerospace markets. It produces spacecraft, instruments and sensors, radio frequency systems and components, data exploitation solutions and a variety of advanced technologies and products that enable weather prediction and climate change monitoring as well as deep space missions.

The company has demonstrated a strong ability to grow well beyond the market over the past five years.

Weaknesses: While the space market has grown recently, it had been flat for some time with NASA's budget stagnating between \$18-19 billion per year during the FY2009-2018 period. The FY2021 budget is up to \$25 billion, but overall government spending concerns could eventually put downward pressure on further increases.

The tendency, particularly in defense, to create larger systems and award a single contract means that Ball is unable to compete for many contracts except as a subcontractor to one of the prime contractors. Bid and



proposal costs for some of the large competitions would just be too costly. The pressure for consolidation in the industry is intense so there are fewer companies as small as Ball, despite its growth.

Ball Aerospace is part of a much larger company that may at any time decide that the business is not core to its overall packaging business.

Opportunities: The growth of Ball Aerospace's backlog to \$2.5 billion at the end of 2021, up from \$617 million in 2015, will continue to drive growth. However, more recently backlog growth has not kept up with annual sales growth.

Ball has been aggressively going after the growing defense market and has been successful in building up that business. The tendency of NASA and the Department of Defense to focus on building smaller satellites could also benefit Ball although that benefit could come as greater subcontracting work. As space companies have become larger, they are more willing to subcontract business that is less important to them.

The company also has focused on affordability in winning business. Ball's lower cost than major prime contractors is a key competitive advantage.

A shift in Ball's defense work towards more fixed-price contracts could add risk but also adds the potential for greater returns.

Ball also sees strong potential to increase its business with the National Reconnaissance Office, which has shown an interest in exploring innovative mission concepts and fixed-priced contracts that could benefit Ball Aerospace.

Following its victory on a Korean contract, Ball is planning to increase its efforts to win international earth observation satellite contracts.

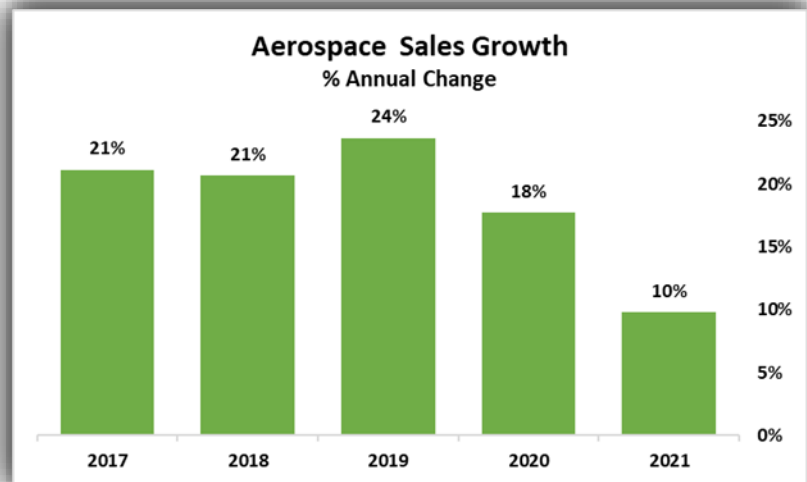
Threats: Despite its strong growth, profitability, as measured by operating earnings margin, has been in decline for the past four years.

Competition is intense as companies fight for fewer programs. Larger companies can spend lavishly on bid and proposal work and company-sponsored research and development to win programs.

Northrop Grumman is a serious competitor to Ball. It purchased Orbital Sciences which earlier purchased General Dynamics' space business. It competes in the same fixed-price, mid-tier, high-performance space segment as Ball. Orbital Sciences beat Ball for the Joint Polar Satellite System contract awarded in 2015. Now as part of Northrop Grumman, a major space company, it may be a more formidable competitor.

Moreover, pressure to consolidate is growing on the defense side as well with a growing tendency to create larger programs with a single prime contractor. That makes it more difficult for Ball Aerospace to go after smaller one-of-a-kind programs that it would be in a good position to win.

Business: Ball's aerospace business, which represents 14% of the company's business, specializes in space systems, systems engineering communications, electro-optics, and cryogenics. Ball makes space hardware (small and medium satellites), tactical products (cameras for the Predator UAV, antennas for Joint Strike Fighter), and information (data pro-



cessing and exploitation and technical services.) Ball's packaging

business represents the remaining 86% of the company's business.

Teal Group Analysis

Continuing to demonstrate exceptional growth. Ball Aerospace has grown at a compound annual rate of 18.5% over the past five years.

Its revenue of \$1.91 billion in 2021 was up almost 10% in the last year as the growth slowed from as high as 24% in 2019.

That growth came as the company surpassed its goal of becoming a billion-dollar business, when it reported \$1.196 billion in sales for 2018.

Ball Aerospace seems set to grow further as its backlog continues to be strong. Backlog totaled \$2.5 billion at the end of 2021. As recently as 2015 the company had a total backlog of \$617 million.

Keys to the businesses' success. Ball Aerospace's strategy is paying off. It seeks to provide larger value-added offerings to customers. It is taking its science work and more into exploration. It is bringing its data analytics work to more customers.

Yet Ball Aerospace's success has been largely due to a growth in its defense and intelligence business. The visibility into that growth is limited due to the company's work on classified programs.

Ball Aerospace highlighted the importance of that work with the May 2020 appointment of Deirdre M. Walsh, former chief operating officer of the Office of the Director of National Intelligence (ODNI), to serve as vice president, Washington Operations.

Ball Aerospace has been relatively successful in growing even in a difficult market. Before a sharp decline in 2015, the company managed to grow for five consecutive years. In 2014, the company achieved record aerospace profits and revenues. Even

with the decline, revenues in 2015 exceeded their level in 2011.

The recent environment has been different, with opportunities for sustained growth. The success is evident in the company's dramatic growth through 2021. Ball has won key contracts and is investing in facilities to continue its growth.

The company has been interested in increasing its fixed price work to improve its profitability. In fact, its contract work has gone the opposite direction.

In 2013, fully 40% of Ball Aerospace's work was done on a fixed price basis. By 2017, the mix had shifted to 32% fixed price and finished 2021 at 50% fixed price.

There has been a steady decline in the aerospace business' profit margins from 10.7% in 2016 to 9.9% in 2017 to 9.4% in 2018 and 9.5% in 2019. By 2020, it was down to 8.8% and held steady at 8.8% in 2021.

That decline appears to be a result of the phase of contract work. Early on work is likely to be less profitable

than later in the contract. With the rapid growth of the past several years, a decline in profit margin is not surprising.

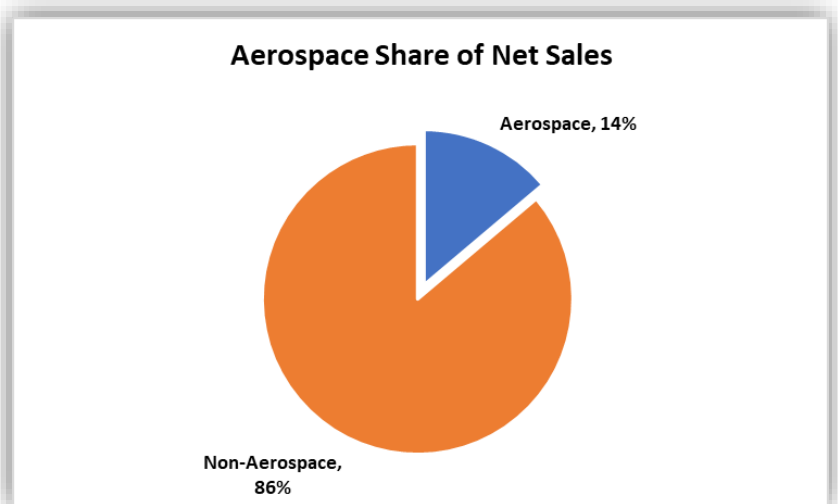
Possibility of divestiture. Rumors that Ball might divest its space business reemerge periodically, but Ball's management appears to be committed to retaining the business.

Ball's management's position is that it will do what is in the best interest of shareholder value, a position that John Hayes, Ball Corp.'s Chairman, and CEO, reiterated in comments to analysts in February 2021.

Although Ball Corp's basic business is packaging (86% of corporate sales), there are key reasons for wanting to retain the business, the company's management has said in the past.

Selling it would lose much of the value because of the low-cost basis of the business. Taxes would take much of the proceeds. Then if it is used for stock repurchases, it becomes a wash for shareholders.

Spinning it off does not make sense at this point. Aerospace is too small



to thrive on its own. It needs to creditworthiness of the entire corporation to be competitive.

Still, Ball may ultimately face pressure in its future strategic positioning in space. Despite its growth, it is small compared to most of its competitors.

The recent record of growth. In 2014, Ball Aerospace & Technologies achieved record revenue of \$934.89 million, up more than four percent from the previous year's \$897.1 million.

This was not a one-time event. Indeed, Ball's aerospace revenues had been growing since 2009, increasing from \$689.2 million that year.

Management attributed this growth to its ability to take market share from competitors.

Indeed, in May 2013, Ball Aerospace & Technologies Corp. won a contract to build a sensor for a South Korean geostationary environmental monitoring satellite under the GEO-KOMPSAT-2A program. Ball Aerospace will build the Geostationary Environment Monitoring Spectrometer which will measure air pollution for the Korean peninsula and the Asia-Pacific region.

In winning the contract, Ball Aerospace triumphed over competing offers by Astrium and Dutch Space.

In addition, Ball Aerospace has been on programs that are high priorities for customers whether in intelligence or civilian programs such as the Joint Polar Satellite System or the James Webb Space Telescope optics.

Underpinnings of recent growth. The backlog has grown because of a series of contract wins since April 2010, including:

- **Joint Polar Satellite System Satellite**—The National Aeronautics and Space Administration awarded Ball Aerospace & Technologies Corp. a contract for the first Joint Polar Satellite System

(JPSS-1) satellite. Ball Aerospace will be responsible for designing and building the JPSS-1 satellite bus, integrating all instruments, and performing satellite-level testing and launch support.

- **Ozone Mapping and Profiling Suite**—NASA awarded Ball Aerospace & Technologies Corp. a sole source contract for the Ozone Mapping and Profiling Suite (OMPS) instrument on the first Joint Polar Satellite System (JPSS). JPSS is scheduled to launch in 2014. Ball Aerospace will manufacture, test, and deliver OMPS, support instrument integration on the JPSS-1 spacecraft, and provide launch and post-launch support.
- **Digital Globe Next Generation Remote Sensing Satellite**—DigitalGlobe awarded Ball Aerospace & Technologies Corp. a contract to build their next-generation commercial remote-sensing satellite. Ball Aerospace previously built the trio of DigitalGlobe satellites currently in orbit including QuickBird launched in 2001, WorldView-1 launched in 2007, and WorldView-2 launched in 2009. WorldView-3, anticipated to launch in 2014, will expand DigitalGlobe's orbiting constellation to four remote-sensing satellites. Ball Aerospace

will provide the BCP 5000 spacecraft bus for WorldView-3, integrate the remote-sensing instrument onto the spacecraft bus, and perform all system testing.

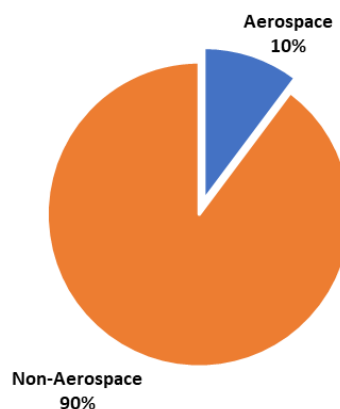
- **Geosat Follow-on 2**—The US Navy's Space and Naval Warfare Systems Command (SPAWAR), San Diego selected Ball Aerospace for Geosat Follow-on 2 (GFO-2), the next-generation ocean altimetry satellite. Ball Aerospace will deliver the Payloads Operation Centers hardware and software and provide the satellite platform. In addition, the company will perform payload/satellite integration, launch vehicle management and on-orbit commissioning. GFO-2 has a six-year operational mission life following its anticipated launch in 2014.

Ball's success in building up its defense and intelligence work. In 2016, fully 65% of Ball's revenue came from defense and intelligence contracts. Only 30% came from the NASA space science work that dominated it in the past. [Later figures are not available.]

Indeed, a decade earlier, 70% of Ball's work was space science.

This focus on intelligence work which has held up well even in a difficult budgetary environment has

Aerospace Share of Operating Earnings



paid off with growing sales and a relatively strong position compared to competitors.

Ball laid the groundwork for this success by creating a new strategic business unit dubbed the Defense Operations strategic business unit and appointing a new vice president and general manager to head the unit. The new grouping included businesses in sensors, remote sensing, components such as sensors and antennas, and systems engineering.

The unit was created to attempt to take advantage of likely growth in the defense and intelligence space budgets.

Ball needed to reverse some serious reverses in its defense work as ballistic missile defense programs for which it provided systems engineering or sensor work were canceled, or it lost key competitions to larger companies. It also wanted to take advantage of the potential for growth areas in defense such as Unmanned Aerial Vehicle sensor work, antennas for the Joint Strike Fighter, and new opportunities in missile defense.

Much of Ball's success in building up the intelligence business is invisible because of the classification levels of the work.

Efforts to improve on record aerospace profitability. Management has been working to improve its profit margins in recent years by cutting overhead and by increasing work volume. Aerospace's business has been shifting toward more fixed-price work rather than cost-plus contracts, giving the business greater upside in profitability.

With the turmoil affecting other space companies ranging from the Boeing Co. to Loral Corp., Ball has performed extremely well. Operating profit margins are respectable in the depressed space industry. That reflects a conservative management style that has served the company well in the current downturn. Unlike

some of its competitors, it will not invest in high-risk programs with uncertain payoffs.

This relatively strong performance of the space business has led Ball Corp. to give Ball Aerospace considerable autonomy to continue to deliver that financial performance. That approach dates from 1996 when Ball decided to retain the unit after considering its sale. There is no sign of any decision to reconsider the sale of the space unit, particularly at a time when it is not only performing well compared to competitors but also to the rest of the corporation.

The increased challenge from Northrop Grumman/Orbital Sciences. Orbital Sciences (now acquired by Northrop Grumman) is mounting a serious challenge to Ball with its purchase of General Dynamics' space business. It competes in the same fixed-price, mid-tier, high-performance space segment as Ball.

In April 2010, Orbital Sciences purchased General Dynamics' spacecraft development and manufacturing facility for \$55 million. As part of General Dynamics, the facility, formerly Spectrum Astro, was lost within a larger company.

Indeed, in the first sign that the competitive balance may be shifting Orbital Sciences Corp. beat Ball Aerospace in the competition to integrate and test the 81 Iridium Next mobile communications satellites. The contract awarded in January 2011 by manufacturer Thales Alenia Space is worth approximately \$150 million. Orbital won in part because of the manufacturing capabilities at its Gilbert, Arizona factory that could be used for integration and test of the platforms and communications payloads it receives from Thales Alenia Space.

Pressure receding somewhat from large, prime contractors. Poor performance on several large space pro-

grams is reducing the pressure to create large programs, with a single prime contractor.

In February 2010, the White House terminated the National Polar-orbiting Operational Environmental Satellite System (NPOESS) due to cost overruns and delays. The program, on which Northrop Grumman had been the prime contractor, was intended to merge polar-orbiting weather satellites that had been operated separately by the Air Force and NOAA.

Following the decision to split up the contract, NASA in Sept. 2010 awarded Ball Aerospace & Technologies a contract to build a second platform for a US civilian weather satellite system being managed by NASA. Ball Aerospace will be responsible for designing and building the JPSS-1 satellite bus, integrating all instruments, and performing satellite-level testing and launch support. Ball Aerospace is also under contract to deliver NPP, the precursor spacecraft to JPSS-1. JPSS is the restructured civilian portion of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). This includes the satellites and sensors that support civil weather and climate measurements, as well as a ground system that will be shared with the Department of Defense weather satellite system.

While Ball previously did its work through a major prime contractor, Northrop Grumman, it is now contracted directly through NASA.

This alleviates a serious concern for Ball's management, which had been worried that gradually prime contractors would squeeze out smaller, independent companies.

Ball sees the potential to build NASA work. Ball has been strengthening its relationship with NASA, broadening the types of work it does for the space agency. In the past, Ball has focused on systems integration for low earth orbit missions, but it is

broadening its work now to deep space missions.

While the company sees good prospects for long-term growth in commercial space, the difficult market now will take time to improve. The

company's main competitors in commercial work include Northrop Grumman/Orbital Sciences and Lockheed Martin Corp.

Financials

Below is a five-year selected financial summary of Ball Corporation and its Aerospace Segment. Ball Corp. operates under a calendar-year fiscal cycle.

Ball Corporation (All Segments)					
(\$ Millions)	2017	2018	2019	2020	2021
Net Sales	10,983	11,635	11,474	11,781	13,811
EBIT	802	935	932	1,003	1,291
EBIT Margin	7.3%	8.0%	8.1%	8.5%	9.3%
Long-term Debt	6,518	6,510	6,337	7,783	7,722
Shareholders' Equity	3,941	3,458	2,949	3,275	3,627
Long-term Debt/Equity	1.7	1.9	2.1	2.4	2.1
Total Assets	17,169	16,554	17,360	18,252	19,714

Aerospace Segment					
(\$ Millions)	2017	2018	2019	2020	2021
Net Sales	991	1,196	1,479	1,741	1,911
Operating Earnings	98	113	140	153	169
Operating Earnings Margin	9.9%	9.4%	9.5%	8.8%	8.8%
Backlog	1,750	2,200	2,500	2,400	2,500
Backlog/Revenue Ratio	2.0	1.7	1.4	1.2	1.1

US Government Sales

During 2021 Ball Aerospace's sales to various agencies of the US government approximated 97% of the sales of the aerospace and technologies unit. Below is a five-year summary of Ball Aerospace's US government sales. Figures are estimates based on the percentage of consolidated sales which they represent.

(\$ Millions)	2017	2018	2019	2020	2021
US Government Sales	971	1,184	1,449	1,689	1,854
% of Aerospace Revenue	98%	99%	98%	97%	97%

Competitions

The following is a selection of programs for which Ball has either won

or lost a competitive procurement. Only those competitions in which

Teal Group can readily identify the competitors are listed.

Wins

NOAA Ocean Color Instrument Study— On behalf of the National Oceanic and Atmospheric Administration (NOAA), NASA selected

two firms for the Geostationary Extended Observations (GeoXO) Ocean Color (OCX) instrument Phase A Study.

The firms selected were Ball Aerospace of Boulder, Colorado and Raytheon Intelligence & Space, El Segundo, California. The total value of each of these twenty-month firm-

fixed-price contracts is approximately \$5.2 million. The work will be performed at the contractors' facilities. [5/22]

NOAA Hyperspectral Infrared Sounder Instrument Study—Ball Aerospace was selected by NASA for a 20-month contract for the National Oceanic and Atmospheric Administration's (NOAA's) Geostationary Extended Observations (GeoXO) Phase A sounder (GXS) study within NOAA's GeoXO program.

Ball will study hyperspectral infrared (IR) sounder instrument design options. The instrument will also leverage Ball's proven cryogenic system to provide cooling power for a longer than 10-year mission life. [10/21]

TEMPEST RAMS—The Air Force Research Laboratory (AFRL), Wright-Patterson AFB, OH, awarded a \$91 million contract to Ball Aerospace & Technologies in Beavercreek, OH, to finance research efforts for Trusted and Elastic Military Platforms and Electronic Warfare (EW) System Technologies (TEMPEST) Resilient and Agile Mission Systems (RAMS). Work will be conducted in Beavercreek, OH; and Boulder CO, and is expected to be completed Apr. 5, 2026. [5/21]

South Korean Advanced Geostationary Weather Imager—Ball Aerospace & Technologies Corp. won a contract to build a sensor for a South Korean geostationary environmental monitoring satellite under the

GEO-KOMPSAT-2A program. Under the contract awarded by the Korean Aerospace Research Institute, Ball Aerospace will build the Geostationary Environment Monitoring Spectrometer that is scheduled for a 2018 launch. The spectrometer will monitor air pollution for the Korean peninsula and the Asia-Pacific region. Ball Aerospace beat out Dutch Space and Astrium. [5/13]

Operational Land Imager—NASA Goddard Space Flight Center awarded Ball Aerospace & Technologies Corp. a contract to build the Operational Land Imager (OLI) for the eighth Landsat Data Continuity Mission (LDCM). The OLI instrument provides 15-m (490-ft) panchromatic and 30-m multi-spectral Earth-imaging spatial-resolution capability. OLI instrument delivery is slated for Sept. 2010, with launch anticipated in 2011. ITT Industries, the losing bidder, unsuccessfully protested the award to the GAO. [7/07]

NGST—NASA awarded TRW an \$824.8 million contract to build the next-generation successor to the Hubble Space Telescope. The James Webb Space Telescope is scheduled for launch in 2010 aboard an expendable launch vehicle. Its destination is an orbit 1.5 million kilometers in space, where the spacecraft will be balanced between the gravity of the Sun and the Earth. Under the terms of the agreement announced in January 1999, Ball Aerospace will serve as the principal subcontractor for the ANGST payload. Ball will develop

the payload, with emphasis on the optical system and the program's science objectives. The TRW team beat Lockheed Martin Missiles & Space (Sunnyvale, CA) to win the contract. [9/02]

NGST—NASA Jet Propulsion Laboratory awarded two contracts, each valued at \$14 million, for the design of the Next Generation Space Telescope (NGST). Receiving contracts were Lockheed Missiles & Space (Sunnyvale, CA) and a team led by TRW Space & Electronics Group (Redondo Beach, CA). Ball Aerospace & Technologies Corp. (Broomfield, CO) is supporting TRW on this program. The Blue Dot Group was eliminated from the competition. [7/99]

NPOESS—The USAF Space and Missile Systems Center (Los Angeles, CA) awarded a \$65.2 million cost-plus-award-fee contract to Ball Aerospace Systems Div., & Technologies Corp., Civil Space System (Boulder, CO) to provide for Phase II algorithm and design development, investigation and analysis, and construction of two flight production units in support of the Ozone Mapping and Profiler Suite (OMPS) for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). It represents a defeat for Orbital Sciences which was developing a competing OMPS instrument. [5/99]

Losses

Joint Polar Satellite System—Ball Aerospace & Technologies Corp. (Ball) protested the National Aeronautics and Space Administration's (NASA) issuance of a contract worth up to \$470 million to Orbital Sciences Corporation (Orbital), of Dulles, Virginia, for three spacecraft buses to support the Joint Polar Satellite System (JPSS). Ball contended that Orbital's proposal violated the

terms of the solicitation and that the evaluation of proposals was unreasonable. The Government Accountability Office denied the protest. Ball built the first JPSS satellite, which is set to launch in 2017. [7/15]

NASA ICE Sat-2—NASA's Goddard Space Flight Center (GSFC) selected Orbital Sciences to design, build and test the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2)

Earth science satellite. Scheduled for launch in 2016, ICESat-2 is the next-generation successor to the original ICESat satellite, which operated from 2003 to 2010. The contract award is valued at \$135 million, including the spacecraft and associated options. Orbital will base the ICESat-2 satellite on its LEOStar-3 platform, the same technology that is being

used for NASA's Landsat Data Continuity Mission (LDCM) spacecraft, which is currently being assembled and tested at the company's Gilbert, Arizona satellite manufacturing facility. Ball Aerospace built the ICE Sat-1 platform. [8/11]

Iridium Next Integrator—Orbital Sciences Corp. beat Ball Aerospace in the competition to integrate and test the 81 Iridium Next mobile communications satellites. The contract awarded by manufacturer Thales Alenia Space is worth approximately \$150 million. Orbital won in part because of the manufacturing capabilities at its Gilbert, Arizona factory that could be used for integration and test of the platforms and communications payloads it receives from Thales Alenia Space. [1/11]

Landsat Data Continuity Mission—NASA awarded General Dy-

namics Advanced Information Systems, a business unit of General Dynamics, a \$116 million delivery order for the Landsat Data Continuity Mission (LDCM). General Dynamics will be responsible for the design and fabrication of the LDCM spacecraft bus, integration of the government-furnished instruments, satellite-level testing, on-orbit satellite check-out and continuing on-orbit engineering support. Other bidders were: Orbital Sciences Corp., Space Systems/Loral, and Ball Aerospace and Technologies Corp. [4/08]

Ares I Upper Stage Avionics Ring—The US Air Force awarded Boeing a \$265.5 million contract to build and outfit an avionics ring to control the rocket during spaceflight. Ball Aerospace and Technologies Corp. submitted a losing bid. Ball was hurt by past performance on con-

tracts and a higher bid during the development and early production under the contract. [12/07]

Lightning Mapper Instrument—NASA, acting on behalf of NOAA, awarded Lockheed Martin Space Systems Corp. a \$96.7 million contract to build an instrument that will monitor the quantity and intensity of lightning flashes. Ball was a bidder on the contract [12/07]

GLAST—NASA selected Spectrum Astro Inc. to build the spacecraft for the Gamma-ray Large Area Space Telescope (GLAST) Observatory. The \$107 million contract includes the design and manufacturer of the space vehicle as well as integration of the scientific instruments and of the Observatory with the launch vehicle. Ball also bid unsuccessfully on the contract. [8/02]

Contracting

Contracts In

B-2 AEU—The Air Force Sustainment Center (AFSC), Robins AFB, GA, awarded a contract to Ball Aerospace in Boulder, CO, to provide repair services for the B-2 Antenna Electronics Unit ((AEU).

AFSC-Robins AFB awarded Ball Aerospace a \$9.7 million requirements contract to fund depot level repair services for the B-2 AEU. Work will be conducted in Boulder, CO, and is expected to be completed by Sept. 16, 2026. [10/21]

NASA Landsat Next—Ball Aerospace was selected by NASA for two Landsat Next architecture studies: Landsat Next Instrument Study – Constellation Satellite Concept and Landsat Next Instrument – Single Satellite Concept. The two studies will look at instrument architectures and designs for the next generation of Landsat.

As part of the two studies, Ball will examine instrument architectures that extend Ball's Operational Land

Imager (OLI) and Reduced Envelope Multispectral Imager (REMI) instrument designs to address new spectral bands, improved spatial resolution and new orbit parameters. [8/21]

Solar Cruiser—Ball Aerospace was selected to support Solar Cruiser, a NASA small satellite technology demonstration on the use of solar photons for propulsion in space. Ball will perform several mission-critical functions, including the integration and test of the satellite bus with the solar sail system that will form the completed "Sailcraft." [2/21]

NASA GLIDE Spacecraft—Ball Aerospace was selected to build the spacecraft for NASA's Global Lyman-alpha Imager of the Dynamic Exosphere (GLIDE) heliophysics science Mission of Opportunity. GLIDE will study variability in Earth's exosphere, the upper reaches of Earth's atmosphere where it

touches space, by tracking far-ultraviolet light emitted from hydrogen. [2/21]

SpRCO Ground Command, Control and Communications (GC3) System—Ball Aerospace, teamed with Booz Allen Hamilton, was awarded a contract by the Space Rapid Capabilities Office (SpRCO) to serve as the prime system integrator for the SpRCO Ground Command, Control and Communications (GC3) system. GC3 will integrate into and help enable the larger tactical command and control enterprise for the United States Space Force. [8/20]

Military Satellite Communications Antenna—Ball Aerospace was selected by the Defense Innovation Unit (DIU) to develop a prototype of a new multi-band, low-observable satellite communications antenna to be installed on the U.S. Navy's newest stealth ships, the DDG 1000 Zumwalt-class destroyers. [7/20]

NOAA Study—Ball Aerospace was selected by the National Oceanic and Atmospheric Administration (NOAA) for four, six-month study contracts that will inform mission, spacecraft and instrument concepts for future operational weather architectures and Earth observation capabilities. Ball Aerospace is also collaborating on a fifth study contract awarded to L3Harris Technologies. [6/20]

Agile Cloud Processing—Ball Aerospace and Microsoft were selected to demonstrate agile cloud processing capabilities in support of the US Air Force's Space and Missile Systems Center's Commercially Augmented Space Inter Networked Operations (CASINO) project. The demonstration will show how simultaneous, worldwide data streams from large, distributed constellations of small satellites can be processed quickly using Microsoft's Azure cloud and Ball Aerospace algorithms. The demonstration also will include a single downlink directly into a Microsoft data center using a Ball Aerospace phased array antenna.

The prototype effort, facilitated by the Defense Innovation Unit, will evaluate Ball Aerospace's use of Azure as the cloud platform for CASINO to leverage Microsoft's deep expertise in data protection, security, and privacy. [9/19]

NASA SPHEREx Spacecraft—NASA selected Ball Aerospace to build the spacecraft for the Spectro Photometer for the History of the Universe, Epoch of Re-ionization and Ices Explorer (SPHEREx), a Medium-class Explorer mission. Ball is also responsible for the system integration and test, support for integration of the spacecraft onto a launch vehicle, and commissioning of the spacecraft after launch. The SPHEREx mission will study the nature of physics that drove cosmic inflation in the early universe; determine the properties of interstellar

ices, a key reservoir for water and biogenic material in the early phases of star and planet formation; and probe the cosmic history of galaxy formation. The SPHEREx bus will be based on the Ball Aerospace customizable and proven line of Ball Configurable Platform spacecraft. [2/19]

US Navy Network Tactical Common Data Link System—Ball Aerospace will deliver multi-beam phased array antenna systems as part of a contract win by BAE Systems for the US Navy. The NTCDL system enables multiple simultaneous, high-bandwidth communications links, which greatly enhance current mission capability and ship protection, allowing for a future sensor network across the Navy. Ball is building the Ku-band phased array antenna suite for BAE Systems. This contract represents the first phase of the program which will result in a low rate of initial production for the hardware with corresponding engineering support. [2/18]

Weather System Follow-on – Microwave—The US Air Force's Space and Missile Systems Center (SMC) selected Ball Aerospace to deliver the next-generation operational environmental satellite system, Weather System Follow-on – Microwave (WSF-M), for the Department of Defense (DoD). WSF-M is a predominantly fixed price contract that will provide for system design and risk reduction of a Low Earth Orbit (LEO) satellite with a passive microwave imaging radiometer instrument and hosted Government furnished energetic charged particle sensor. The contract will include options for the development and fabrication of two LEO satellites as well as options for launch vehicle integration, launch and early orbit test, and operational test and evaluation support. This mission will improve weather forecasting over maritime regions by taking global measurements of the atmosphere and ocean surface. This new environmental satellite system lever-

ages the Ball-built Global Precipitation Measurement (GPM) Microwave Imager (GMI) instrument, which is the on-orbit reference standard for calibrating precipitation measurements in NASA's GPM constellation. The WSF-M bus will be based on the Ball Configurable Platform. [11/17]

Ozone Mapping and Profiler Suite—Ball Aerospace will build the Ozone Mapping and Profiler Suite (OMPS) instruments for National Oceanic and Atmospheric Administration's (NOAA) Joint Polar Satellite System (JPSS) Polar Follow-On/JPSS-3 and JPSS-4 missions, under a sole source contract modification award from NASA. The value of this contract is approximately \$214 million for a total contract value of approximately \$421 million, with the contracted work to be performed over a 10-year period. OMPS tracks the health of the ozone layer and measures the concentration of ozone in the Earth's atmosphere. Under the contract, Ball will manufacture, test, and deliver the high-fidelity OMPS JPSS-3 and JPSS-4 instruments – which are composed of a nadir sensor and electronics module – and provide launch and post-launch support for both. [4/16]

Wide-Field Infrared Survey Telescope Wide Field Instrument—Ball Aerospace & Technologies Corp. has been selected by NASA to deliver a concept study for the Wide-Field Infrared Survey Telescope (WFIRST) Wide Field Instrument, the agency's next major astrophysics project to follow the 2018 launch of the James Webb Space Telescope. NASA's initial concept study for WFIRST will evolve the Wide Field Instrument design for optimal manufacturing, modularity, testing, and schedule efficiency. [3/16]

Land Imager-2 Payload—NASA awarded a sole source letter contract to Ball Aerospace & Technologies Corp. to build the Operational Land Imager-2 instrument for the Landsat

9 project. The estimated value of this cost-plus award-fee letter contract is \$19.3 million with a period of performance from Dec. 31, 2015, through Mar 31, 2021. Ball Aerospace will build a second Operational Land Imager (OLI) for the Landsat 9 project. The OLI is a reflective, multi-channel, earth-imaging instrument that provides highly calibrated imagery to detect and quantify the effects of natural and human-induced activities on the Earth's surface. [12/15]

Satcom Antenna Systems—Ball Aerospace & Technologies Corp. will supply the Royal Australian Air Force with 13 SwiftBroadBand AIR-LINK SATCOM antenna systems through a \$4.1 million contract with Airbus (formerly AusAero). Ball's SwiftBroadBand model ensures that flight decks receive the high data rates needed for both military and commercial applications. [2/15]

Hyperspectral Sounders—Tempus Global Data reach a joint operating agreement with Ball Aerospace. Ball will act as the prime contractor to build a constellation of six STORM (hyperspectral atmospheric sounding) sensors that will fly as a hosted payload in GEO orbit. Two additional sensors may also be built and deployed as free-fliers. STORM (Sounding & Tracking Observatory for Regional Meteorology) is designed to take high-fidelity measurements of atmospheric conditions, providing data not currently available to weather forecasters, and allowing better prediction of hurricane landfalls, tornado formations, and weather forecasts. [1/15]

Prime Contractor for Global, All-Optical Commercial Satellite System—Ball Aerospace & Technologies Corp. was selected by Laser Light Communications, LLC. The Ball Aerospace contract will include a first phase design analysis that will lead to the completion of an eight-satellite constellation operating in Medium Earth Orbit (MEO). The complete constellation of up to 12

satellites is expected to deliver six terabits of data per second with service speeds of 200 gigabits per second, bi-directionally, or nearly 100 times faster than conventional radio downlinks. [9/14]

Ozone Mapping and Profiling Suite—NASA awarded a sole-source contract modification to Ball Aerospace & Technologies Corp. of Boulder, Colorado, for the Ozone Mapping and Profiling Suite (OMPS) for flight on the Joint Polar Satellite System-2 (JPSS-2) mission. The JPSS-2 mission is funded by the National Oceanic and Atmospheric Administration (NOAA) to provide global environmental data in low Earth polar orbit in support of NOAA's mission. NASA is the acquisition agent for the flight systems and components of the ground system. This is a cost-plus-award-fee modification in the amount of \$113 million. This action extends the period of performance of the contract from November 2013 through May 2021. Under this contract, Ball Aerospace will manufacture, test, and deliver the OMPS instrument, support instrument integration on the JPSS-2 spacecraft and provide launch and post-launch support. The OMPS instrument will be similar to the OMPS currently flying on the joint NASA-NOAA Suomi NPP mission and planned for the JPSS-1 mission. JPSS-1 is being planned for launch in 2016 and JPSS-2 is planned for launch in 2021. [9/14]

Korean Geostationary Environment Monitoring Spectrometer—Ball Aerospace & Technologies Corp. was awarded a contract from the Korea Aerospace Research Institute (KARI) to build the Geostationary Environment Monitoring Spectrometer (GEMS) for the National Institute of Environmental Research in the Ministry of Environment of South Korea. GEMS is a geostationary scanning ultraviolet-visible spectrometer designed to monitor transboundary pollution events for the Korean peninsula and Asia-Pacific

region. Ball Aerospace and KARI will design, fabricate and test GEMS which is manifested on KARI's GEO-KOMPSAT-2B geostationary satellite for a 2018 launch. [5/13]

US Air Force Risk Reduction—Ball Aerospace & Technologies Corp. was selected by the US Air Force to perform risk reduction work on the next generation of microwave sounding and imaging instruments for the Weather Satellite Follow-on program. Under a contract awarded by the Space and Missile Systems Center, El Segundo, California, Ball Aerospace will investigate how to best achieve Department of Defense requirements for measuring soil moisture and ocean surface vector winds with a microwave instrument designed to fit into smaller, lower-cost launch vehicles. [4/13]

NASA TEMPO Mission—Ball Aerospace & Technologies Corp. is part of a team selected to build the first space-based instrument to monitor major air pollutants across the North American continent for NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission. Led by the Smithsonian Astrophysical Observatory, Cambridge, Mass., the TEMPO team will build a geostationary ultraviolet-visible (UV-VIS) spectrometer to continuously measure ozone, aerosols, and other trace gases over greater North America. The TEMPO spectrometer will be the company's first geostationary instrument for NASA. NASA anticipates the TEMPO instrument will catch a ride on a commercial communications satellite as a hosted payload when it is completed in September 2017. Mission costs will be capped at \$90 million, excluding the launch vehicle and integration to the selected satellite platform. [11/12]

US Air Force Distributed Common Ground System—Ball Aerospace & Technologies Corp. was awarded four task order contracts worth more than \$17 million to develop and inte-

grate enhanced operational capabilities for the US Air Force Distributed Common Ground System (DCGS). Under the task orders, Ball Aerospace will spend 18 months integrating data streams from enhanced sensors on the Global Hawk and Predator Unmanned Aerial Vehicles (UAV) into the Air Force DCGS. [11/11]

National Air & Space Intelligence Center Support—Ball Aerospace & Technologies Corp. was awarded four task order contracts valued at more than \$21 million to support the National Air & Space Intelligence Center (NASIC) at Wright-Patterson Air Force Base in Dayton, Ohio as part of Ball's larger Advanced Technical Exploitation Program contract. The contracts continue Ball Aerospace's previous work supporting development of the Integrated Overhead Persistent Infrared (OPIR) Tasking, Processing, Exploitation and Dissemination System (IOTS), as well as the Palette OPIR processing and exploitation software suite. Ball Aerospace has been supporting the IOTS program at NASIC since May of 2005. [11/11]

Joint Polar Satellite System Satellite—The National Aeronautics and Space Administration awarded Ball Aerospace & Technologies Corp. a contract for the first Joint Polar Satellite System (JPSS-1) satellite. Ball Aerospace will be responsible for designing and building the JPSS-1 satellite bus, integrating all instruments, and performing satellite-level testing and launch support. Ball Aerospace is also under contract to deliver NPP, the precursor spacecraft to JPSS-1, as well as the Ozone Mapping and Profiler Suite (OMPS), one of the critical scientific instruments to fly aboard the JPSS-1 spacecraft. JPSS-1, a clone of the NPP satellite, employs the Ball Commercial Platform (BCP) 2000 spacecraft bus. JPSS is the restructured civilian portion of the National Polar-orbiting Operational Environmental Satellite System (NPOESS). This includes the satellites and

sensors that support civil weather and climate measurements, as well as a ground system that will be shared with the Department of Defense weather satellite system. NASA is acting as the acquisition agent to procure these assets. NASA's Goddard Space Flight Center in Greenbelt, Md., has the lead for the acquisition of the restructured program for NOAA. [9/10]

Ozone Mapping and Profiling Suite—NASA awarded Ball Aerospace & Technologies Corp. a sole source contract for the Ozone Mapping and Profiling Suite (OMPS) instrument on the first Joint Polar Satellite System (JPSS). JPSS is scheduled to launch in 2014. Ball Aerospace will manufacture, test, and deliver OMPS, support instrument integration on the JPSS-1 spacecraft, and provide launch and post-launch support. The instrument will be similar to the OMPS planned for flight on the NPOESS Preparatory Project (NPP) mission scheduled to launch in the fall of 2011. Like its NPP predecessor, OMPS will monitor ozone, collect total column and vertical profile ozone data, and continue the current daily global data provided by the Ball-built Solar Backscatter Ultraviolet Radiometer/2 and Total Ozone Mapping Spectrometer, but with higher accuracy and precision. [8/10]

Digital Globe Next Generation Remote Sensing Satellite—DigitalGlobe awarded Ball Aerospace & Technologies Corp. a contract to build their next-generation commercial remote-sensing satellite. Ball Aerospace previously built the trio of DigitalGlobe satellites currently in orbit including QuickBird launched in 2001, WorldView-1 launched in 2007, and WorldView-2 launched in 2009. WorldView-3, anticipated to launch in 2014, will expand DigitalGlobe's orbiting constellation to four remote-sensing satellites. Ball Aerospace will provide the BCP 5000 spacecraft bus for WorldView-3, in-

tegrate the remote-sensing instrument onto the spacecraft bus, and perform all system testing. [8/10]

Geosat Follow-on 2—The US Navy's Space and Naval Warfare Systems Command (SPAWAR), San Diego has selected Ball Aerospace & Technologies Corp. for Geosat Follow-on 2 (GFO-2), the next-generation ocean altimetry satellite. Under the GFO-2 contract, Ball Aerospace will upgrade the payloads, as compared to the original GFO satellite that was launched in 1998, with a dual-frequency radar altimeter, and provide enhanced radio frequency interference immunity with significantly reduced data latency. For GFO-2, Ball Aerospace directs the activities of several experienced altimeter mission partners including instrument suppliers Thales Alenia Space and ITT/EDO. Ball Aerospace will deliver the Payloads Operation Centers hardware and software and provide the satellite platform. In addition, the company will perform payload/satellite integration, launch vehicle management, and on-orbit commissioning. GFO-2 has a six-year operational mission life following its anticipated launch in 2014. Ball Aerospace was also contracted for the original GFO satellite. GFO was decommissioned in 2009 after a decade of successful operations, exceeding its mission life by five years and design life by two years. [4/10]

US Air Force National Air and Space Intelligence Center—Ball Aerospace & Technologies Corp. received a contract from the US Air Force National Air and Space Intelligence Center (NASIC) to continue providing Measurement and Signature Intelligence and Advanced Geospatial Intelligence (MASINT/AGI) to warfighters through the Advanced Technical Exploitation Program (ATEP). The five-year, indefinite-quantity contract has a ceiling value of \$600 million to be competed among three contractors. ATEP continues Ball's prime contractor role on MASINT/AGI with NASIC, located

at Wright-Patterson Air Force Base, Ohio. NASIC is the nation's premier source of air and space intelligence for DoD and national intelligence consumers. Ball's ATEP team will support ten key NASIC mission areas: overhead non-imaging; infrared; synthetic aperture radar; spectral; thermal infrared; ground moving target indication forensics; line of sight radar; over the horizon radar; airborne electro-optical; laser intelligence; and radiofrequency measurement and signature intelligence. [7/09]

NASA Earth Sensing Contracts—NASA awarded Ball Aerospace & Technologies Corp. two contracts that support the agency's Science Mission Directorate 2007 Instrument Incubator Program (IIP) in developing Earth science instrument subsystem technologies. Ball will also participate in a third contract as co-investigators on a study led by the Jet Propulsion Laboratory (JPL). [5/08]

Spectral Exploitation Center/Cell and Thermal Infrared Operational Support—The National Air and Space Intelligence Center (NASIC) awarded Ball Aerospace & Technologies Corp. two contracts worth more than \$21M to continue providing actionable intelligence to warfighters through service contracts that support the Department of Defense (DoD). NASIC, located at Wright-Patterson Air Force Base, Ohio, awarded Ball Aerospace and its teammates a \$10.8 million Spectral Exploitation Center/Cell and Thermal Infrared Operational Support contract to continue performing non-

literal Geospatial Intelligence analysis and operational support. These tasks include data processing, data analysis, software modification and maintenance, system and network administration, analytic support, and instruction and training on the use of software tools and techniques. Teammates include AAI Corporation, BAH, CACI International Inc., the Space Computer Corporation, and The Boeing Company. NASIC also awarded Ball an \$11 million contract to extend its current program that transforms sensor data into intelligence information, for the Integrated Overhead Non-Imaging Infrared (ONIR) Tasking, Processing, Exploitation, and Dissemination System (IOTS) program. Ball is supported on the contract by Booz Allen & Hamilton, Inc., Command Technologies, Inc. a subsidiary of MTC Technologies, Inc., Northrop Grumman's Electronic Systems sector, Oracle Federal Systems, Raytheon Company, Structural Computing LLC, and Science Applications International Corp. [4/08]

Laser Research Contract—The Air Force Research Laboratory (AFRL) awarded Ball Aerospace & Technologies Corp. a \$42 million indefinite-delivery/indefinite-quantity (ID/IQ) research and development contract to conduct laser effects research. The contract will support the AFRL's Directed Energy Directorate located at New Mexico's Kirtland Air Force Base. Under the five-year contract, Ball Aerospace will conduct analytical modeling and experimental studies to accurately predict the effects of

lasers on missiles. These studies provide signature information associated with materials, components and systems. [3/08]

ICESat—The Ice, Cloud and Land Satellite (ICESat) built by Ball Aerospace & Technologies Corp. will continue operations until at least 2010 following a NASA mission extension contract. ICESat, designed for a three-year lifetime with a five-year goal, was launched Jan. 12, 2003. The Ball Commercial Platform (BCP) 2000 employed for ICESat was built under contract to NASA's Rapid Space Development Office (RSDO). In addition to ICESat, the Ball Aerospace's QuikSCAT, and the NPOESS Preparatory Project (NPP) spacecraft, were also RSDO procurements. [2/08]

Warfighter Interface Research & Technology Operations Contract—Ball Aerospace & Technologies Corp. has been awarded a five-year \$49M contract to support the Warfighter Interface Division of the Air Force Research Laboratory's (AFRL) Human Effectiveness Directorate. The Human Effectiveness Directorate is one of five AFRL directorates headquartered at Wright-Patterson Air Force Base, Ohio. Approximately 50 employees at the Ball Aerospace Dayton, Ohio location will execute the contract, along with Ball's teammates: Aptima, Bevilacqua Research Corporation, Booz Allen Hamilton, JXT Applications, The Design Knowledge Company, and Wright State University. [2/08]

Research & Development

Company- and Customer-sponsored R&D

Ball Corp's company-funded research and development, most of which is spent in Aerospace, rose to \$56 million, in 2021, a record level for the business. Ball's aerospace business focuses its research and development activities on the design,

development and manufacture of innovative aerospace products and systems. This includes the production of spacecraft, instruments and sensors, radiofrequency and system components, data exploitation solutions and

a variety of advanced aerospace technologies and products that enable deep space missions.

Below is a five-year summary of Ball Corp.'s spending in this area.

(\$ Millions)	2017	2018	2019	2020	2021
R&D	27.0	32.0	44.0	47.0	56.0
% of Aerospace Revenue	2.7%	2.7%	3.0%	2.7%	2.9%

Acquisitions/Divestitures

(Includes those related to defense and aerospace only).

Wavefront Technologies

In January 2016, Ball Aerospace & Technologies Corp. acquired specialized engineering cyber firm Wavefront Technologies to further strengthen and diversify its business portfolio. The transaction price was not disclosed. Wavefront Technologies, located in Annapolis Junction,

Maryland, provides systems and network engineering, software development software and analytical services for cyber and mission-focused programs to the US government and commercial industry. Established in 2004, Wavefront Technologies is a strong small business with multiple

successfully performing contracts. The company's team of more than 100 highly skilled and cleared systems engineers, software engineers, and analysts have unique domain expertise that complements Ball's workforce.

Efratom

In October 1994 Ball agreed to sell its Efratom Division (Irvine, CA) to Datum Inc. for \$26.5 million in cash

and stock. Acquired by Ball in 1982, Efratom develops rubidium frequency standards, time standard and

low-frequency and very-low-frequency receivers, and digital atomic portable clocks.

Imaging Products

In May 1994 Ball sold the assets of its San Diego-based Imaging Products unit to Canada's SDI Virtual Reality Corp. for \$5.5 million. The Im-

aging Products unit designs and manufactures simulators for the military, commercial and automotive industries. The unit had sales of \$10 million at the time of its sale. The unit,

then known as the advanced image generation group of Megatek Corp. (San Diego, CA), had been acquired by Ball in April 1991.

VERAC

In 1987 Ball paid \$20 million to acquire VERAC, Inc.—a defense systems and software development company.

Divisions/Subsidiaries

Ball Corp.'s defense- and aerospace activities take place within its wholly-owned subsidiary, Ball Aerospace and Technologies Corp., headquartered in Boulder, Colo. Ball's Aerospace segment is divided into three strategic business units: Defense Operations, Commercial Space Operations, and Civil Space Systems., and Defense Operations. While the bulk of the aerospace personnel work in various Colorado sites, Ball Aerospace also has facilities throughout the United States and in Australia.

Ball Aerospace and Technologies Corp.

**1600 Commerce Street
P.O. Box 1062
Boulder, CO 80306
Tel: (303) 939-4000**

Aerospace and Technologies Corp. provides imaging and communications products and services for a wide range of customers, including NASA, the Department of Defense, and several prime contractors.

Civil Space Systems

**P.O. Box 1062
Boulder, CO 80306-1062
Tel: (303) 939-4000**

The Civil Space Systems strategic business unit performs space programs including complete missions, scientific and operational instruments, spacecraft buses, and major subsystems, principally in the domestic market. This strategic business unit pursues a prime contractor role to NASA, NOAA, universities, and other civil agencies, and a subcontractor role to other prime contractors. Civil Space Systems pursues principally Earth and space sciences.

Great Observatories

Ball Aerospace will have built seven instruments for the Hubble Space Telescope by the last servicing mission. They include the Goddard High-Resolution Spectrograph (GHRS), the Corrective Optics Space Telescope Axial Replacement (COS-TAR), the Near-infrared Camera and Multi-object Spectrometer (NICMOS), the Space Telescope Imaging Spectrograph (STIS), the Advanced Camera for Survey (ACS) and for the final servicing mission, the Cosmic Origins Spectrograph (COS) and the Wide Field Camera 3 (WFC3). The

company built the Oriented Scintillation Spectrometer Experiment (OSSE) for the Compton Gamma Ray Observatory, the Aspect Camera and the Science Instrument Module for Chandra, and the cryogenic telescope assembly and two of the three science instruments for the Space Infrared Telescope Facility (SIRTF): the Infrared Spectrograph and the Multiband Imaging Photometer.

Hubble Space Telescope

By the final servicing mission scheduled for 2004, all of the axial science instruments aboard the Hubble Space Telescope will have been built by Ball Aerospace. The Advanced Camera for Surveys was installed during the March 2002 3B servicing mission. The Cosmic Origins Spectrograph and the Wide Field Camera 3 are scheduled for 2004 installation. Each of these scientific instruments, a total of seven built by Ball Aerospace, incorporated technological advancements that provided the Hubble with new capabilities to help scientists peer into the heavens more deeply than before.

Sage III

Ball Aerospace built three multiple units of the 4th generation SAGE III spectrometer.

CloudSat

The company is building the spacecraft and providing mission operations.

PICASSO-CENA

Ball Aerospace is building a multi-channel lidar and a suite of passive instruments.

Deep Impact

Ball Aerospace is building two spacecraft and three science instruments.

StarLight

For this first flight of two spacecraft in tight formation, Ball Aerospace is building two spacecraft to demonstrate long-baseline interferometry.

Next Generation Space Telescope

Ball Aerospace and TRW are developing a large segmented mirror telescope design for the NGST mission.

Terrestrial Planet Finder

The company Ball Aerospace is leading a team to study design concepts for TPF.

Mars Missions

Ball Aerospace has been working on Mars missions since 1976 with the Visual Imaging Subsystem for the Viking orbiters. The company provided the highly successful primary communication antenna for Mars Pathfinder. Today, Ball Aerospace is working with JPL on Mars Exploration Rovers (MER), proposing as prime contractor for the Mars Reconnaissance Orbiter (MRO) and supporting a science team proposing the High-Resolution Imager for MRO. The company is also involved in a study for the Mars Sample Return and presenting a concept proposal for Mars Scouts as well as beginning a study on Gossamer Mars aerocapture technology.

Explorer Mission Studies

Ball Aerospace & Technologies Corp. is on two of four teams selected by NASA for future Explorer mission feasibility studies.

AIM

Ball Aerospace is responsible for designing and building the spacecraft

and performing integration and test of the instrument onto the spacecraft.

Pluto

Ball Aerospace is responsible for designing and building the multi-wavelength camera for the New Horizons mission to Pluto.

HiRISE

Ball Aerospace is responsible for designing and building a high-resolution camera for use on Mars.

Kepler

Ball Aerospace is the prime contractor responsible for designing and building the spacecraft, photometer, and instrument, as well as managing all systems operations.

Advanced Baseline Imager

Ball Aerospace will perform trade studies and develop a preliminary design under an 18-month Formulation Phase contract to NASA/GSFC as part of the Geostationary Operational Environmental Satellite system of satellites.

Hubble Space Telescope

Ball Aerospace will have built all of the axial science instruments aboard the Hubble by the final servicing mission slated for 2004.

Mars Exploration Rover

Ball Aerospace is a teammate on JPL's Mars Exploration Rover mission, providing subsystem components and ground support equipment.

Terrestrial Planet Finder

Ball Aerospace is leading a team to study design concepts for TPF.

Solar Backscatter Ultraviolet Radiometer 2

Ball Aerospace has built nine operational remote sensors since the 1980s for this program.

Stratospheric Aerosol and Gas Experiment (SAGE) III

This instrument is the first of three SAGE III instruments Ball Aerospace built for Langley Research Center as part of NASA's Earth Observing System (EOS).

CALIPSO

Ball Aerospace is responsible for designing and building the LIDAR instrument and for the mission's communications package.

Defense Operations**10 Longs Peak Drive****Broomfield, CO 80021-2510****Tel: (303) 939-4000**

The Defense Operations strategic business unit provides a range of products and services to the defense and government markets. Products and services offered are remote-sensing space segments; specialized satellites; advanced sensor systems for space, air, sea, and ground applications; antennas and RF subsystems; precision pointing and control components; laser communication terminals; thermal management; data processing and exploitation; knowledge and enterprise management; and en-

gineering services. The Defense Operations strategic business unit includes separate units for Advanced Technologies, Defense Space, and Remote Sensing and Systems Engineering Solutions.

Advanced Technologies

Advanced Technologies provides components and subsystems for space, air and ground environments. These technologies are further segregated into antennas, sensors, and precision pointing and controls. Ball

Aerospace antennas support functions in the RF domain including communications, navigation and global positioning (GPS), identification, telemetry, tracking, command, radar, seekers, and electronic warfare.

Ball Aerospace's advanced antenna systems for aerospace and land vehicles, ships, and personnel are critical for radio frequency (RF) devices such as radios and radar. Ball aerospace antennas support all functions

in the RF domain including communication; navigation and global positioning (GPS); identification; telemetry, tracking, and command destruct; radar; seekers and electronic warfare (transmitting and receiving). Ball antenna systems are part of the Army Tactical Missile System (ATACMS) Block 1A and 2, Joint Air-to-Surface Standoff Missile (JASSM), Guided Multiple Launch Rocket System (GMLRS), Patriot Advanced Capability (PAC-3), and Tactical Tomahawk.

Ball Aerospace's advanced antenna systems for aerospace and land vehicles, ships, and personnel are the eyes and ears of radio frequency (RF) devices such as radios and radar. Ball Aerospace antennas support all functions in the RF domain including communication; navigation and global positioning (GPS); identification; telemetry, tracking, and command (TT&C) destruct; radar; seekers; and electronic warfare (EW) (transmit and receive). Ball antenna systems are part of the Army Tactical Missile System (ATACMS) Block

1A and 2, Joint Air-to-Surface Standoff Missile (JASSM), Guided Multiple Launch Rocket System (GMLRS), Patriot Advanced Capability (PAC-3), and Tactical Tomahawk.

Ball Aerospace also produces spaceborne imaging radar antennas to provide images of the most remote areas of Earth. Ball Aerospace's Spaceborne Imaging Radar-C (SIR-C) and Shuttle Radar Topography Mission (SRTM) are helping examine Earth's environmental changes. Radar imaging provides the capability to penetrate vegetation, sand, ice, and the Earth's deepest rain forests.

Ball Aerospace sensors include high-resolution military cameras for target acquisition, surveillance, situational awareness, and fire control. Ball Aerospace star sensors are used to provide precision attitude measurements for platforms like the Space Shuttle and the Hubble Space Telescope. Ball Aerospace precision pointing and controls are used to accurately direct laser communication terminals, high-energy lasers and to align sensors on targets.

Defense Space and Remote Sensing Systems

Defense Space and Remote Sensing Systems provides remote-sensing sensors from optical to RF wavelengths in space, air, and ground environments. Cost-effective spacecraft and satellite buses are provided for specialty missions. Ball Aerospace space flight validated designs are used in a variety of missions, including global meteorological and oceanic monitoring.

Systems Engineering Solutions

Systems Engineering Solutions provides systems engineering and program management services to customers on-site or at Ball Aerospace facilities. It supports customer requirements in data processing and exploitation, modeling and simulation, knowledge management, operational supply support, remote-sensing analysis, advanced information technology, measurements, and signatures intelligence (MASINT) and weapons systems.