Distinguished speakers set the tone for the proceedings at TITANIUM USA 2018, the 34th annual international conference and exhibition, which was held Oct. 7-10, 2018 at the Bellagio Resort in Las Vegas, organized and sponsored by the International Titanium Association (ITA). The conference gathered 960 professionals from 30 different countries and proved to be one of the highest attended ITA events in recent years.

Keynote speaker Tom Captain, retired vice chairman, global aerospace and defense leader, Deloitte LLP, the London-based international industry consultant and financial advisory firm, along with distinguished speakers Laurent Jara, vice president, metallic material procurement, Airbus S.A.S., Jeffrey Carpenter, director, aerospace materials and standards, Boeing Commercial Airplanes, and Thierry Viguier, vice president, Safran Materials Purchasing, all provided insights for the titanium industry as it navigates through business conditions and trends in the global aerospace market.

Annual Award Winners
The Las Vegas gathering also served as the venue to honor recipients of the ITA’s lifetime achievement and application development awards. Russell Gordon
Sherman, who developed alloys and heat treating protocols for the titanium industry and pioneered the high-volume production of titanium aerospace fasteners, received the 2018 Lifetime Achievement Award. Sherman was involved in developing titanium alloys and heat treating protocols to raise the mechanical properties and usability of the “wonder metal” during the formative years of the titanium industry, according to Hogue.

![Russ Sherman accepting the Lifetime Achievement Award from Henry Seiner, ITA President](image)

Sherman presented the initial findings from his research at Titanium Metals Corporation of America (Timet), Henderson, NV, at the ASM’s convention in Philadelphia in October 1955, a paper titled “The Heat Treatability of Ti-6Al-4V.” The backdrop to his research work came during the Cold War years of the 1950s, when the United States and the Soviet Union were vying for supremacy in aerospace.

Norsk Titanium, the world’s first FAA-approved supplier of aerospace-grade, additive manufactured, structural titanium components, garnered the 2018 Titanium Application Development Award. Norsk Titanium, in 2017 began delivering the structural, additive manufactured aerospace parts to industry giant Boeing. These first (original equipment manufacturer) OEM-qualified components are now flying on the Boeing 787. Norsk utilizes its Rapid Plasma Deposition™ (RPD™) wire-fed process to produce near-net-shape titanium parts at its production facilities in Hønefoss, Norway, and Plattsburgh, NY.
Norsk’s Plattsburgh Development and Qualification Center (PDQC) houses nine of Norsk’s proprietary RPD™ titanium printing machines. Norsk’s Norwegian facility, known as the Engineering and Technology Center, continues to operate qualified and approved RPD™ machines. The RPD™ process uses titanium wire with plasma torches to print titanium structural components on an industrial scale. According to Norsk officials, this additive manufacturing technology has demonstrated it can be used to produce parts weighing over 100 lbs. They said that RPD™ is also 50-100 times faster than powder-based additive manufacturing systems and uses 25-50 percent less titanium than incumbent forging processes.

**Featured Speakers**

Captain, the keynote speaker, who has accumulated four decades of experience in commercial aircraft program launches, defense industry technology innovation, and manufacturing and engineering process improvement, shared his wisdom during his presentation titled “Aerospace and Defense Sector – Need for Innovation.” He delivered an assessment of medium-range trends and unfolding aerospace industry dynamics, all of which will have an impact on the global titanium industry.

He reassured the conference audience that the commercial aerospace sector remains a growth business. However, he also took note of “disruptive innovations”
and pointed out that the aerospace industry “is becoming commoditized, with pricing the main differentiator. Process technology advances will supplant production labor content almost entirely; from aero structures, electronics, systems to final assembly. Winners will be those companies that design and produce parts that are more innovative – better before cheaper.”

**Global Commercial Aerospace**

- 43,000 new aircraft in next 20 years
- Value is $6.3 trillion
- 44% will replace older aircraft in service
- Only 5,800 aircraft in today’s fleet will remain

**Disruptive Innovation**

*Could this happen to the Titanium industry?*

- Are basic titanium products at risk of obsolescence and further commoditization; i.e. aluminum, sand, gravel, steel?
- What disruptive technologies could make titanium obsolete?
- What titanium innovations under development could be a disruption opportunity?

According to Captain, disruptive innovation, which spans all industries in these early years of the 21st century, is an industrial convergence driven by technology
and caused by the inevitable march of commoditization. “New technology becomes old quickly and at risk of exponential change.”

For executives from aerospace OEMs, titanium supply chain issues have been the main topic of discussion in recent years at the ITA’s annual titanium forums – and the Las Vegas confab was no exception. Jara of Airbus reviewed plans for titanium sourcing during the next 10 years. Jana oversees the Airbus IM3 (Integrated Metallic Material Management) transformation program. According to information posted last April in the newsroom section of the Airbus website (www.airbus.com), the company explained that IM3 is an Airbus-driven approach “that will see us challenging every part throughout our entire supply chain. We’ll be working alongside suppliers to check that we’re making the best possible decisions on materials and processes at every stage. Testing to check that a material has the properties we require is absolutely a key. Even though we choose reliable suppliers and trust them, we still regularly push materials to their limits in testing to be sure that they’re safe and that we meet our responsibilities.”

As for Airbus’ interaction with the global supply chain for titanium, Jara said Airbus “will re-source its full titanium demand over the next 10 years. The massive introduction of titanium over the last decade is calling for cost optimization. The long term attractiveness of the aerospace industry is creating an environment with increasing competition at each layer of the value chain. The competition among materials is calling for an E2E (end-to-end) transformation of the fragmented metal value chain. The metal industry needs to innovate all along its industrial value chain to remove the current waste (buy-to-fly ratio) and to develop the metallic products of tomorrow for Airbus’ incremental developments and future aircrafts.
The titanium value chain shall significantly improve its buy-to-fly ratio to remain the material of choice on Airbus incremental developments and future new products.”

Much like Jara, Carpenter of Boeing focused his remarks on the commercial aerospace market outlook and its links with the global titanium supply chain. He said single-aisle jets will account for 73 percent of a projected 42,700 commercial airplane deliveries through 2037. Boeing, by way of Carpenter’s remarks, continues to see supply chain strategies as the key to success for the aerospace and titanium industries. “Materials must ‘buy their way’ onto an airplane and earn the privilege to stay.” The “keys to success” for the supply chain include a commitment to quality, delivery and rate readiness, increase competition, research and development, and innovation, according to Carpenter.

He took note of a “large, competitive titanium landscape,” displaying a slide with an assortment of company logos from around the world. Regarding this competitive landscape, Carpenter asked the question: “where are you in the journey? Future business opportunities are tied to best value, working together, and PFS (Partnering for Success).”

Carpenter reaffirmed titanium’s benefits in aerospace manufacturing – lightweight, corrosion resistance, the ability with withstand high temperatures, and compatibility with composites. However, he also said that, while titanium remains a material of choice in aerospace, “cost is limiting the additional use on airplanes.”
He presented a slide that illustrated a “cost-reduction toolbox;” suggestions for companies that do business in the aerospace supply chain. Points listed in this graphic included embracing: new technology development, such as linear friction welding and additive manufacturing; the use of alternative materials, such as new titanium alloys; process improvements through supply chain efficiency and big-data analytics; and “future” technologies such as robotics and artificial intelligence.

Viguier shared Safran’s expectations regarding the global titanium supply chain as he analyzed titanium’s evolving role in modern jet engines. He said Safran “expects support” for the supply chain for two critical points: weight savings and cost savings. Viguier said the “challenge for the future on rotating parts is to have a titanium-based alloy that can replace the 6.2.4.2 without the problems of relaxation at “low temperature” (dwell effect) or replace Inconel 718.” He said Safran uses in excess of 2,000 metric tons of high strength titanium for its landing gears, seeking a good compromise between mechanical properties (ultimate tensile stress, fatigue), density and easier maintenance (corrosion). He said “composite materials are catching a bigger share on the engine,” providing a 500-pound weight savings on LEAP engines. “Aluminum materials are much cheaper than titanium by 10 times on plate.

“‘Aerospace is still a growing market (6-percent revenue passenger kilometers growth) and Safran has a major share on this story,’” he said. For the next decades, every working day, Safran will use 20 metric tons of titanium. Titanium-based alloys have a great future in this industry. Lighter parts help reduce fuel consumption and emissions and the resistance to high temperatures means thermal...
efficiency of turbomachines can be improved. Titanium powders could be extensively used by additive manufacturing new technologies, if they reach the market price.”

**World Titanium Industry Demand Trends**

Henry Seiner, vice president, business strategy, Titanium Metals Corp. (Timet), examined trends for commercial aerospace engines during his presentation. For the global commercial jet engine build forecast, the combined next-generation and legacy engines are expected to reach over 5,000 units in 2030, compared with an estimated 3,500 engines in 2018. Seiner said next-generation engines will be used to power the A320 Neo, the 737 Max, the A330 Neo and the 777X. He noted that next-generation engines will have up to three times more titanium compared with legacy engines.

![Engine Build Forecast](image-url)
By 2030, it’s projected that total titanium demand for commercial jet engines will reach in excess of 25,000 metric tons, with more titanium needed to meet performance specifications. For 2018, the total engine titanium demand is estimated at just over 15,000 metric tons. These figures are based on studies by Airline Monitor and internal Timet estimates.

Seiner mentioned concerns regarding the current climate of geopolitical uncertainty, particularly the recent trade disputes between the United States and China. He acknowledged the interest in additive manufacturing for engine production. He described it as being attractive for its potential cost savings, compared with traditional manufacturing methods, but noted that there are regulatory hurdles and a relatively “long-time horizon.”

Jeremy Halford, president, Arconic Engineered Structures, reported on global titanium demand for aerospace structures. Halford began his talk by declaring that “the large commercial aircraft market has never been this good.” Using 2017 figures, he said there were 1,500 aircraft deliveries, an “absolute backlog” of 13,000 units based on Boeing and Airbus estimates, and a relative backlog of nine years of production at 2017 levels. The projected unit production of commercial jets will reach 2,000 units by the year 2020. Among major aerospace metals, titanium demand is slated to grow at the fastest pace—a CAGR (compound annual growth rate) of 4.3 percent, through 2020.
Factors behind the buoyant outlook include forecasts for strong air traffic demand growth, fuel prices that are rising but still within the “sweet spot,” and the profitability of airlines, giving them the ability to pay for new aircraft, according to Halford. He also identified challenges in the face of the soaring numbers. “The supply-side challenge is how to profitably deliver the backlog.” He said an “industry shift” has emerged: an era of design to an era of delivery. Aerospace suppliers face a “squeeze,” with pressure to reduce costs and improve efficiency.
Industry restructuring from merger and acquisition activity across the global aerospace sector “is picking up speed and insourcing decisions are becoming the norm.”

Albert Bruneau, president of Neotiss, addressed “Global Trends in Industrial Markets.” Global titanium consumption for the industrial sector, which includes power, desalination, process, automotive and shipbuilding, is expected will register 28,112 metric tons this year and will top 30,000 metric tons by 2021.

Regarding titanium’s competitiveness in industrial markets compared with alternative metals, Bruneau observed that the market has been shaken with recent protectionist measures impacting negatively global aluminum, copper and nickel. “It’s difficult to predict the trend over the medium to long term. Titanium’s existing indicators remaining less reliable compared to other metals as nickel or copper.” Bruneau suggested that, for titanium, there is a need to “rebuild a strong supply chain around non-military and non-aeronautics industrial markets.” He said there are few specifications from end users, no care of origin or traceability, no specified process requested, and less innovation resources.”

Bruneau said that, in the global desalination market, the trend currently doesn’t favor titanium, as membrane reverse osmosis (RO) has emerged as the technology of choice, while thermal multi-stage flash distillation (MSF) is declining. For chemical processing, titanium remains strong, with consumption expected to reach around 17,000 metric tons by 2021.
He also assessed titanium’s prospects in power generation. China is the largest market for nuclear power generation, with 19 units under construction and 28 units waiting for approval. For fossil fuels, natural gas-fired plants are “the cleanest and most efficient way of producing electricity.” There are several projects in the final stages in the U.K, Malaysia, Thailand, Pakistan and Turkmenistan.

Marty Pike, Vice President – Commercial for ATI Specialty Materials, outlined “Titanium Demands and Trends in the Defense Market.” The United States is expected to have a defense spending budget of around $700 billion in 2019, outpacing rivals such as China and Russia.

Geopolitical uncertainty continues to influence defense spending. As a result, titanium demand is picking up based on strong defense budgeting around the globe, Pike said. “Concerns over tariffs and sanctions continue to effect defense buying decisions. New defense platforms such as the new bomber, trainer and continued demand for fighters are driving year-over-year growth.” He pointed out that there is only “limited growth” expected from renewed naval construction. “Acquisition cost outweighs life cycle cost savings. Initial acquisition cost and reliance on mature ship designs are barriers to titanium adoption.

In addition to his presentation, Pike was installed as the newest member of the executive board of directors for the ITA.

Michael Metz, president, VSMPO Tirus US, outlined trends in Russian titanium markets, saying that demand for titanium products in the Russian market is
expected to reach 12,000 tons by 2022, compared with just over 10,000 metric tons in 2018. “The total demand of the Russian market for titanium products is characterized by a restrained growth in accordance with the forecasts of aircraft manufacturers, and stable demand for titanium products from the industrial sector, which development is governed mainly by the state projects.”

VSMPO is the largest Russian producer of ingots, with an estimated capacity of 67,000 metric tons, while Avisma is the largest producer of sponge, with a capacity of 44,000 metric tons.

Metz said that, within the Russian market, electron beam technology for melting titanium ingots has been successfully developed over the last years. New high-strength titanium alloys, alloyed with aluminum, zirconium, niobium, iron, and designs of industrial electron beam installations with intermediate capacity, also have been developed.

The major consumers of titanium in the industrial sector of the Russian market are nuclear industry and shipbuilding. “Similar to the global industrial market, the Russian industrial sector is characterized by titanium consumption, which depends on the implementation of various industrial projects,” he said. “The main demand-forming projects in shipbuilding are construction of drilling and production platforms, offshore equipment, ships, specialized ice-class vessels for the development of the Arctic region, ships for inland waterways, patrol vessels.”
Metz said the Russian nuclear engineering has internal projects launched to develop and commission new nuclear power plants. “Rosatom backlog includes foreign nuclear orders for more than 10 years. The program of restoration of nuclear icebreaking fleet is being implemented as planned: the icebreaker Arktika was put into operation, construction of the icebreaker Siberia is being finalized, the keel of the next vessel, Ural, was laid.”

The dynamics of the development of the Russian aerospace sector is mainly controlled by the state program known as “Development of the Aviation Industry for 2013-2025,” which includes sub-projects for the development of both aircraft and helicopter construction and aircraft engine building. It is also controlled by the State Program “Development of the Defense Industrial Complex,” State Armament Plan 2027, and the Transport Strategy of the Russian Federation until 2030. Metz said the “Development of the Aviation Industry for 2013-2025” program is aimed at creating a highly competitive aviation industry and securing its position in the global market as the third manufacturer in terms of the output for aircraft engineering.

Mohamed Bouzidi, vice president for aerospace, energy and the defense strategic business unit of AUBERT ET DUVAL, outlined “Demand Trends from a European Perspective.” He began with a chart that tracked and projected world titanium ingot production. According to his company’s estimates, in 2017, the level for ingot production registered around 225,000 metric tons; that level will go up to a projected 250,000 metric tons by the year 2020.
Ingot exports from the United States totaled 9,000 metric tons in 2017. About 95 percent of that amount was exported to the European Union, including 65 percent to the United Kingdom. Scrap exports from the European Union in 2017 surpassed 20,000 metric tons, of which 71 percent was exported to the United States.

Yasuaki Sugizaki, chairman of the Japan Titanium Society, and the president and board member of OSAKA Titanium Technologies Co., Ltd., offered an “Outlook on Current Titanium Trends in Japan.” He began his talk by noting that Japan accounts for about 25 percent of global titanium sponge production. “Japan supports stable supply of titanium sponge against volatile demand,” Sugizaki said, adding that shipments in the near term will see stable growth due to the demand for titanium from the aerospace and industrial sectors. He said Japan also provides about 10 percent of global titanium mill product shipments.

Given the widespread expectations for the growth of titanium additive manufacturing and metal injection molding, and the related demand for titanium alloy powder to support those processes, Sugizaki said Japan has embarked on a “Strategic Innovation Promotion Program” (SIP) that’s based on industry, government and university cooperative efforts. According to Sugizaki, the program is targeting the development of high-quality titanium and nickel-based powders to be used for the production of aerospace engine components. He added that the demand for titanium powder used in additive manufacturing is expected to rise sharply, reaching nearly 3,000 metric tons by the year 2026.
World Titanium Industry Supply Trends
A talk by David McCoy of TZMI examined “High-Grade Titanium Feedstocks Supply Under Pressure.” Spurred by the aerospace and auto markets, which have had upward trends beginning in 2016, feedstock demand for titanium sponge reached 449,000 metric tons in 2018 and is expected to rise at 5.3 percent CAGR through 2022, according to McCoy. “TZMI believes that the strong demand from aerospace and new-energy automobiles will support demand growth for titanium sponge in the foreseeable few years.”
McCoy displayed a chart for an outlook on rutile feedstock supply/demand to the year 2022. His bullet points indicated that the global rutile market is experiencing extremely tight market conditions, with a deficit position of 104,000 TiO2 units forecasted for 2018. He also listed “likely new rutile projects” such as two rutile-rich mineral sand deposits in New South Wales, Australia; Iluka Resources Sembehun deposits in Sierra Leone; and the Engebø rutile deposits in Norway.

Terry Perles, president of MoTiV Metals LLC, reviewed “Master Alloy Market Trends and Analysis.” Perles underlined several overview points, saying that quality is an absolutely critical attribute for master alloys given their use in critical applications. “A critical and highly variable cost component in master alloy production is the market price of raw materials, primarily vanadium and molybdenum. Assurance of supply of the broad range of master alloys is an important issue. The ability of the master alloy supplier to design solutions for titanium alloy producers is a critical value-added factor in the relationship.”

He pointed out that master alloys in the titanium industry are binary, ternary or multi-component alloys used to efficiently and effectively allow the melting of titanium alloys. Vanadium and molybdenum master alloys account for approximately 90 percent of the total annual demand volume, and that more than 40 master alloys are regularly used by the titanium industry.

Demand for vanadium is expected to surpass 130,000 metric tons by 2025, compared with projected capacity of 90,000 metric tons during the same period. “It appears excess inventory is depleted and the supply base will struggle to meet demand in the next few years,” he said. “There is a need for new sources of vanadium to meet the growing market demand, particularly from 2022 onward.”
Perles said molybdenum demand was “very strong” during the first half of 2018, but there has been volatility for demand and consumption in recent years: a decline in 2015/16; followed by a strong bounce-back in 2017/18; followed by a possible reversion to trend or even weaker in 2019/20. “China has the potential to surprise on upside given its low per-capita use in 316 stainless (there was surprising stainless strength in 2017, especially in 300 series). Large supply shortfalls (for molybdenum), projected in 2018/19, which will have to be met by destocking.”

Peter Baumeister, director, business unit alloys, GfE Metalle und Materialien GmbH, addressed “Master Alloys: Production Applications and Influences on Future Supply.” Baumeister said the influences on future demand for master alloys for aerospace applications will increase, mainly driven by the Asian/Pacific region expansion, along with new civil aircraft designs that require much more titanium alloys per aircraft than past models. Aerospace master alloys require high purity raw materials, a class of alloys that includes vanadium, molybdenum, niobium and chromium. Another influence on the future supply of master alloys involves the trend towards increased use of titanium scrap.
Master alloys are used for the production of titanium ingots, improving the mechanical properties, heat and corrosion resistance of the base titanium. He said raw material suppliers should provide clear strategic commitments supporting the titanium industry with sustained supply of consistent quality materials. In addition, there should be flexibility regarding pricing while balancing the expectations of customers and the capabilities while taking into consideration their own constraints.

“Raw material suppliers should be willing to share commercial risk,” he said. “A master alloy is not a commodity. Master alloys are essential for the titanium industry, and the titanium industry requires a healthy master alloy supplier base.” Sylvain Gehler, chairman of UKTMP analyzed “World Titanium Sponge Supply Trends.” According to Gehler, 2017 world titanium sponge capacity was rated at 255,300 metric tons, with China identified as the country with the largest sponge production capacity at 93,000 metric tons. By way of comparison, the sponge production capacity in United States is estimated at 12,600 metric tons, while Japan has a production capacity of 65,200 metric tons.
Gehler forecasted that the supply of titanium sponge will continue growing in 2019, but at a lower rate. “The main issue for sponge producers will be the sourcing of feedstock at a reasonable price level,” he said. “Titanium sponge producers, except China, still have an operational production capacity reserve of 26,550 metric tons. The aerospace industry is not the only driver of this increased demand due to emergence of regional markets. Melters outside the United States are more dependent on sponge than on scrap, which will encourage sponge producers to increase production.”

As for developments affecting the global titanium sponge market, low inventories have triggered an additional demand for sponge and increased sponge production, according to Gehler. Titanium sponge producers in the Commonwealth of Independent States (CIS) “were first to react to the additional demand for sponge; production in the CIS countries increased by 22 percent over the last two years.” Other factors include increased demand for titanium products in China and Southeast Asia for chemical, oil and gas, energy and defense industries. “A strong demand for titanium mill products has lifted Russian sponge production close to a full capacity. Titanium sponge inventory has decreased worldwide; the biggest decrease is in the United States.”

Ed Newman, senior vice president, United Alloys and Metals Inc., during his presentation, wondered whether there were “More Questions than Answers” when it comes to pondering future trends in the titanium scrap market. Scrap is a low-cost alternative to virgin materials, fills the void when raw materials are in tight supply, saves energy, and is good for the environment.
Newman said industrial demand for titanium scrap, estimated to be just over 30,000 metric tons in 2018, is expected to rise and then level off over the next three years to an annual level of around 35,000 metric tons.

Considering the effect of titanium sponge on the scrap market, Newman said sponge capacity remains available, but sponge inventories have dropped and prices have firmed. “There is some concern about adequate supply of feedstock to the sponge producers,” he said.

He said a major advantage in utilizing scrap in the titanium market is that the material is “an above-ground mine.” Titanium and vanadium alloying units are readily available in scrap. “New mining operations are extremely expensive and require long lead times. Scrap comes to the market quickly and without the cost and risk of new mining operations. Scrap processors running at very high utilization rates. Current generation will require some increase in processing capacity.”

Weighing the impact of recent tariffs on Chinese scrap titanium, he said a 10-percent tariff on all titanium scrap went into effect on September 24, 2018. “Tariffs will increase to 25 percent on January 1, 2019 without a new trade agreement.”

Summarizing his presentation, Newman said the increase in scrap usage continues to be driven by availability and cost benefits, while trade disputes put a question mark on scrap imports to the United States. “Aircraft build rates continue at high
rates increasing both supply and demand for scrap. Vanadium supply and pricing issues will put pressure on scrap. New scrap demand in Europe will change the flow of scrap. Low cost 30-percent ferro titanium should prevent major upward movement of ferro titanium prices from pressuring aerospace scrap prices.”

Jessica Roberts, a manager with of Roskill, pondered the question: “What Will the Next Decade Bring” for titanium metal. Based on Roskill research, Roberts said that while there are challenges for the sector, next decade is projected to see reasonable growth.

Roberts said that titanium mill product demand is projected to grow at 2 percent per year out to 2028, with industrial uses expected to perform strongly. Aerospace demand for titanium is expected to be impacted by growth of additive manufacturing and a larger share of models with lower titanium content. Aerospace is estimated to account for 30 percent of the metal additive manufacturing market, focused on the production of complex parts. She said commercial air framers have order backlogs representing around nine years of production, while jet engine deliveries forecast to grow 3 percent per year between 2018-2028. More than 5,000 military fighter aircraft are expected to be delivered between 2018-2028, led by the F-35 in the United States.

The availability of scrap for remelting is projected to decline, and more premium-grade sponge may be required. Premium-grade melted product capacity could require investments under “business as usual” aerospace titanium scenario. National policies present some risks to the sector. Russian sanctions and “no deal” Brexit are the main risks to titanium supply chains, while U.S./China tariffs are a
risk to end-use markets such as aerospace.

**Global Industrial Markets**

Dr. Louis Pignotti, chief chemist, Kolene Corp., discussed “Molten Salt Cleaning of Titanium and Its Alloys: From Primary Metal Manufacturing to Finished Products.” According to Pignotti, titanium and its alloys possess unique properties that present challenges for manufacturing. Molten salt is well suited to help with the surface preparation and cleaning (such as scale removal, paint stripping and dry lubricant removal) for many manufacturing processes associated with titanium.

Cleaning salts are composed of inorganic compounds that become liquid due to operating temperature (400-1200°F). They produce repeatable, consistent results even when supersaturated with reaction by-products and allow for the removal of by-products and addition of fresh chemicals allow for perpetual bath life.

Pignotti said molten salt bath systems should be custom engineered to meet production throughput, with robust, rugged designs provides a long service life. The systems should be fully hooded and ventilated and be energy efficient to compare favorably with conventional hot soak processes. Integrated handling systems can be manual or automated. The systems may require waste water treatment depending on alloys processed and local water discharge requirements.

The systems can be used for thermal coating and lubricant removal, paint stripping, and descaling of parts. “Salt bath cleaning can be used to remove a variety of surface contaminants,” Pignotti said. “Salt bath cleaning provides efficient and economical processing of titanium parts.”

Dr. Sungwook Kim, principal researcher at the Research Institute of the Industrial Science and Technology (RIST), provided insights on “Friction Stir Welding (FSW) of Ultra Fine Grained Titanium Plate.” Kim said studies have been conducted to improve the strength of titanium by refinement of the grain size as means for further enhancing the physical properties. He presented information on FSW as a technology to consider for maintaining the metal’s fine grain size.

According to findings from RIST, FSW welds of ultra-fine grained (UFG) titanium plate maintain the initial grain size of the base metal, and the FSW shielding box effectively shields oxygen more than local shielding. Regarding the mechanical properties of UFG titanium plate by FSW, there’s uniform distribution of weld hardness (as indicated by a micro-hardness test), and the weld shows the tensile strength and elongation of over 90 percent of the base metal.
Dmytro Lazorkin, general director, Lazorkin Engineering LLC, presented a technical paper titled “High-Performance Technology and Equipment for Forging the Ingots and Blanks Made of Titanium Alloys and Specialty Steels, and Alloys Using Four Dies in Forging Presses.” Lazorkin said a four-die forging device (FDFD) is a unique tool, which combines the advantages both of radial forging in radial forging machines (RFM) and conventional two-die forging method using a forging press.

Lazorkin said a FDFD consists of the lower and the upper cases, sliders, dies, and side guides. The lower case is rigidly secured to the press table. Prior to the start of the forging operation, the upper case is usually fixed to the movable cross-beam of the press. One die is fixed to the lower case, and remains stationary during the forging, while the other die is attached to the upper case, and always travels along with the press as it operates.

FDFD is used for the forging of ingots and the blanks made of all ferrous materials, as well as for the forgings of non-ferrous materials, such as titanium, aluminum, titanium, nickel and copper based alloys. He said FDFD is a cost-effective alternative to RFM to ensure the production of forgings by four-die forging in the conventional forging presses, but with better metal quality and lower costs compared to RFMs.

**Research and Analysis on Current Tariffs**
Jeffrey Orenstein, a representative from the international law firm Reed Smith LLP, shared his thoughts on “Current Tariffs and Their Impact.” Specifically, he analyzed the current situation of tariff battles between China and the United States.

Regarding the origin and overview of U.S. tariffs on Chinese imports, the authority for the tariffs falls under Section 301 of the Trade Act of 1974. The President ordered the office of the United States Trade Representative (USTR) to investigate whether China’s practices related to technology were unreasonable or restricted U.S. commerce. The USTR team found that China’s policies harmed the U.S. economy by at least $50 billion per year. In response to this, President Trump ordered 25-percent ad-valorem duties on certain Chinese-origin goods; initiated a World Trade Organization (WTO) case on China’s licensing practices; and placed restrictions on Chinese investment aimed at obtaining key U.S. technologies.

The analysis for the “pro” side of these measures by the United States suggested that, because China engages in unfair trade practices, these tariffs may pressure China to make concessions. Domestic producers of covered products will benefit from a cost advantage. However, on the “con” side, Orenstein said that a tax or tariff on Chinese imports is effectively a tax on U.S. manufacturers that will, at a
minimum, increase costs and likely cause job losses and other disruptions to U.S. industries. In addition, there is retaliation by China covering U.S. agricultural products, cars, aircraft, and high-tech industries, all of which hurts the ability of U.S. companies to compete both in the domestic market and abroad.

The likely impact of the tariffs would mean inevitably lead to higher prices for products that use titanium—a range that spans jet planes to medical implants, according to Orenstein. As a result, capital investments may decline and U.S. titanium producers may need to expand their operations. Orenstein suggested strategies for coping with the current situation involving U.S. and Chinese tariffs:

- Confirm Applicability by making sure you have the right Harmonized Tariff Schedule (HTS) classification and country of origin
- Shifting Supply: In many cases, importers will shift to non-Chinese suppliers
- Passing On the Costs: If Chinese origin goods are the only option, the cost increase will typically get passed on to customers
- Absorbing the Costs: Companies that cannot pass-on the full 10 percent due to price competition may have to absorb some or all of the cost increase
- Stockpiling in a Bonded Warehouse: Delay payment of duties by keeping imported goods in a bonded warehouse. This has its own costs, but it is an option if: (1) payment at the time of entry is not practical: or (2) if you want to see if the tariff will be repealed (e.g., due to a trade deal or political change)
- Drawback: Goods manufactured with imported components subject to tariff may be eligible for “drawback” if the finished products are exported
- Product Exclusions: Product exclusion requests can be submitted by “interested persons,” which would include various parties impacted by the tariffs, such as U.S. importers, U.S. manufacturers, consumers, brokers, and trade associations representing parties impacted by the tariffs.

**Titanium in Medical Technology**

Gene Kulesha of Onkos Surgical presented information on “a true industrial revolution” in the 3D printing of medical devices. Customized implants using titanium 3D printing have improved and the technology can support patient-specific printing, according to Kulesha. Titanium 3D printing for medical applications “has gone mainstream, but is still an untapped market. Regulatory agencies understand and embrace the technology.”

He estimated that 3D printing of titanium medical devices registered $1 billion in 2017. “Demand is outpacing supply,” he said. “There are few qualified contact
manufacturers. Mass customization (of this market) is a maybe; clinical benefits must outweigh costs.”

The global orthopedic device market was $52 billion in 2017, and the United States accounts for 50 percent of that market. Titanium accounts for up to 70 percent of hip, spine and trauma implants. He described 3D printed titanium knee implants as a “success story in the making;” a potential $4-billion market opportunity. Knee surgery, which requires numerous bone cuts and soft tissue manipulation, is more complex than hip surgery, he said.

Prabhu Gubbi, Ph.D., a technical specialist and scheme manager with BSI Group America reported on “Medical Device Regulatory Changes in Europe.” BSI, a global company, with 81,000 clients in 180 countries, is involved in certification, consulting, and standards-related products and services. Gubbi said regulatory changes include classification rules (Annex VIII), conformity assessment (Annex IX to XI), general safety and performance (Annex I), technical file documentation (Annex II), risk management and clinical evidence.

Gubbi said that, for dealing with medical device regulatory changes, BSI helps customers bring their medical device products to market. “We ensure patient safety while supporting timely access to medical device technology globally. “We provide our customers with conformity assessments, evaluations and certifications that are recognized and accepted worldwide. We provide added value to customers through information, training, knowledge and management systems solutions to anticipate, maintain and exceed compliance with internal and external requirements.”

Mathew Thoppil, Ph.D., associate professor, Cedric W. Blazer endowed professors in biomedical science, addressed “Tribocorrosion Aspects of Titanium-Based Biomedical Implants: Current Concerns and New Directions.” Thoppil said that the U.S. Center for Disease Control has estimated 78 million people will suffer from arthritis by the year 2040. “Titanium is widely used in hip and other joint replacement surgeries such as shoulder, elbow or knee or spinal fixation devices and in dentistry applications.”

Thoppil defined tribocorrosion as an irreversible transformation of material in tribological contact caused by simultaneous physicochemical and mechanicals surface interactions. “Upon implantation, electrochemical interactions are induced by corrosion between the implant materials. As a result, complications like pitting, fretting, galvanic corrosion, and stress corrosion occur. Implant failure has been also associated with several other causes, such as infections in the implanted area,
mechanical loosening, bone resorption, and an increase in time taken for osseointegration to occur apart from the fibrous tissue formation.”

Thoppil’s study also examined micro-arc oxidation and plasma electrolytic oxidation for titanium implants, as well as titanium nanotube corrosion resistance. He concluded that further research is needed to develop new surface coatings and modification methods to minimize tribocorrosion.

**Powder Metallurgy**

Art Kracke, the president of AAK Consulting LLC, presented “Titanium Alloy Powder: Accelerating Demand for Years to Come,” reviewing the differing processes for producing titanium alloy powder metals and the size and growth rate of the titanium alloy powder market. Key end-use markets include biomedical, aerospace, automotive, industrial and consumer.

Kracke said that additive manufacturing, enabled by titanium powder metals, is developing innovations that lower cost while improving part performance and shortening development and production cycle-times. Lower cost and improved performance will drive growth titanium alloy powder and advanced manufacturing, according to Kracke. This will be accomplished by: melt-free continuously produced powder alloys; continued developments in additive manufacturing; and interest for metal injection molding and compaction technology applications.

He mentioned two recent titanium alloy powder development facilities in Australia. The first, a 16,000 sq. ft. research and development pilot plant in
Melbourne, is engaged in new alloy development, such as TiAl, and titanium 6/4 customer evaluations and qualifications. Meanwhile, a 16,000 sq. ft. production plant in Perth, with a production capacity of 200 metric tons per year, is slated to be commissioned by mid-2019, and will focus on titanium 6/4 and extra low interstitials 6/4.

A presentation by Dr. Sergey Prikhodko, a professor at the University of California, Los Angeles, explored the “Structure and Mechanical Behavior of Titanium Based Multi-Layered Materials Fabricated by Blended Elemental Powder Metallurgy for Anti-Ballistic Applications.”

Prikhodko explained that anti-ballistic protection of the land systems mobility and protection of the fighting vehicles and military personnel is paramount in the success of defense and anti-terrorist operations. “The two most important anti-ballistic properties of the armor are penetration and fragmentation. Those require high hardness and strength from armor to eliminate sharpening effect of projectile as well as sufficient ductility in order to stop armor fragmentation. Traditional armor material is rolled homogeneous steel. However, steel armor can increase the overall weight of combat vehicle on about 15-20 percent. That causes reduction in mobility, maneuverability, fuel efficiency, and requires stronger suspension, brakes, and more powerful engines.”

He said the Army is in search of alternative lightweight materials for armor “and titanium is very attractive material in this list. Titanium alloys have a high mass efficiency compared to steel and aluminum. They have an excellent corrosion resistance. Titanium alloys are readily fabricated in existing production facilities and are easily recycled. The only disadvantage of titanium-based armor is its high cost compare to steel and aluminum when produced using traditional ingot technology.” Due to the high specific strength of titanium, materials on its base are considered viable alternatives for low-weight armor. However, the feasibility of implementation is questionable when the armor parts are fabricated using traditional and pricy ingot and wrought technology.

Prikhodko suggested a more cost-efficient process of producing armor parts, using blended elemental powder metallurgy (BEPM) of titanium-base materials and multi-layered structures. He said that test results indicated that large, layered structures of titanium 6/4 alloy and metal matrix composites (MMCs) were successfully fabricated using the BEPM die-pressing protocol. “Sintered materials were characterized with uniform structure and composition within each layer and complete integration between the layers. During BEPM processing the shrinkage levels of the base alloy and MMC are similar, enabling the successful fabrication of multi-layered structures without need for optimization of the sintering
processing parameters for relatively large plates. Multi-layered plates fabricated in the course of this study using BEPM were successfully tested for anti-ballistic application.”

S.J. Oosthuizen of CSIR Titanium Centre of Competence offered an update on the “Development of a Continuous Titanium Powder Production Process.” Oosthuizen said CSIR (South Africa’s Council for Scientific and Industrial Research) was tasked to develop a novel process for non-melt powder with cost advantages. In 2007 CSIR began research and development into: primary processes for metal production; powder metallurgy; titanium investment casting; and additive manufacturing with Aeroswift, one of the world’s largest titanium powder 3D printers.

CSIR’s goal was to develop a novel process that offered competitive advantages as a continuous process with non-melt powder, water leach vs. vacuum distillation (with no entrapped/adhered chloride), and direct alloy production. A continuous powder process, conceived in 2012, was demonstrated in a plant commissioned in 2014 as the “Continuous Stirred Tank Reactor” system with molten salt pumps, according to Oosthuizen. The CSIR process for continuous titanium powder encompassed powder produced in a stoichiometric ratio of TiCl4 to reducing metal; powder was suspended in molten salt by-product. Product slurry is pumped from reactor and cools under argon. Frozen salt with powder water leached and dried for packaging. Depending on process parameters, the powder can be “spongy” or crystalline.

Oosthuizen listed the perceived process benefits of the technology: continuous process vs. industry standard batch process; independent techno-economics studies, with the potential to match Kroll sponge production; the potential for heat recovery/energy generation from exothermic reaction; and the potential to tailor particle size, produce alloys or coat particles/powders with titanium.

Benedikt Blitz, managing director, SMR Premium GmbH, provided an “Update on Forged Special Steels, Remelting and Powder Metallurgy.” Blitz’s presentation highlighted recent developments in the world of forged special steels and remelted steels (nickel alloys, stainless steel, alloy tool steel and alloy steel) and gave an overview about end-user demand and structures of these special steels and also summarize the actual status of installations (forging presses and remelting units) on a global scale. He also focused on the production of metal powders and powder metallurgical steels and associated production technologies like metal injection molding.
Nobuhiro Arimoto, general manager, High-Performance Materials Department of OSAKA Titanium Technologies Co., Ltd., discussed “The Superiority of Our Integrated Production from Titanium Sponge to Titanium Powder for Additive Manufacturing.” Arimoto said his company’s approach involves full control of “integrated production from material to titanium powder,” adding that oxygen content is an important variable to manage.

OSAKA is building a new $10-million plant dedicated to titanium alloy powder, Arimoto stated. The facility will have a production capacity of 100 metric tons per year and is slated to go online by the year 2020. He said that, unlike conventional methods, the OSAKA titanium powder production method will go from sponge to alloy powder, bypassing the typical intermediate steps of producing an ingot and bars, which is expected to reduce the overall cost of the titanium powder.

In summary, Arimoto said that as a titanium sponge manufacturer, OSAKA tackles “varied issues to supply products stably to the growing market and to meet customer needs by utilizing the new plant as well as the superiority of our integrated production processes for titanium powder.”

**Global Titanium Market Economic Drivers**
Bank of America Merrill Lynch (BAML) research analyst Ronald J. Epstein provided an outlook on economic trends in the aerospace industry, examining the evolving titanium global supply chain, the Airbus and Boeing duopoly, and plans to ramp up single-aisle aircraft deliveries. Epstein said BAML forecasts that combined deliveries for civilian aircraft, which includes large planes from Boeing and Airbus and regional jets from Bombardier and Embraer, will reach 2,095 aircraft in 2022, up from an estimated total of 1,736 in 2018.
Quoted in a separate press release, Epstein said global air traffic growth has remained strong between 6.5-7 percent so far in 2018. This falls within similar rates to the last 10 years but beats previous long-term estimates of 4.8 percent. As a result, airlines are expected to maintain strong order books to meet the sustained demand growth. He also noted that aircraft retirement peaked in 2013 at 3.5 percent of the total fleet. High oil prices and low interest rates drove airlines to retire more aircraft during that year, according to Epstein. This in turn injected serviceable use spare parts into the market, competing with new parts for aftermarket sales. Lower oil prices brought the retirement rate below 2 percent in 2017.

Thomas Hohne-Sparborth, director, economics and analytics, Roskill Information Services, analyzed “The Socio-Economic Impact of Metal Industries and Implications for Titanium.” In his opening remarks, Hohne-Sparborth said the main purpose of his presentation was to “identify the socio-economic benefits created throughout the value chain and product lifecycle” of the metals industry. He began by citing four bullet-point questions:

- Production: How many jobs depend directly on the mining and processing of cobalt, nickel or titanium?
- Usage: To what extend do downstream sectors depend on the use of these metals?
- Indirect: How much further activity is created among suppliers of energy, inputs, transport and services?
- Economic growth: How do such metals and their usage contribute to research, investment, revenue and tax income?

Hohne-Sparborth said that the socio-economic effects include direct effects from the titanium value chain (mineral mining, metal production, first use and end use, and recycling), as well as indirect effects from supporting industries (energy, transport, legal/financial, and chemical processing) and consumer spending.

“Mineral and metal processing industries contribute to local economies in a variety of ways, from generating employment, to research and development, and tax income,” he said. He added that indirect effects take into consideration the requirements of metal industries for inputs from supporting industries, as well as income effects. Metal producers and suppliers will themselves trigger further demand for energy, chemical and transportation. “A metal processing plant is relatively capital intensive, but its dependence on goods and services from other industries will often generate many more jobs in other sectors.”
“Attributing socio-economic effects among downstream industries depends on the calculation of allocation factors for metals such as titanium,” he said. He used a chart to illustrate the allocation factors of titanium in American aerospace manufacturing. He estimated that 30,000 metric tons of titanium is used for aerospace in the United States. It has a “back-of-the-envelope” value of $1 billion (in 2018, based on titanium 6/4 prices). The total value of aerospace manufacturing in the United States in 2018 is about $227 billion.

For his summary, Hohne-Sparborth noted that, for capital-intensive business sectors such as mining, metal processing and aerospace, “indirect effects often dramatically outweigh the ‘on-site’ effects on employment and other socio-economic indicators.”

Bill Bihlman, president, Aerolytics LLC, discussed “Manufacturing’s Evolution and Its Impact on Titanium for Aerospace.” Bihlman said that, during past two decades, aerospace has experienced a shift in materials and associated manufacturing methods. Aircraft material evolution has shifted to carbon composites in the fuselage, engine and wing, with titanium being used for landing gear.

He said advances in CNC machining have changed traditional approaches to manufacturing components, with a “key enabler” being five-axis CNC machining. In aerostructures, there has been a movement towards larger “monolithic” structures to reduce part count and weight. For engines, the trend is towards increased machined tolerances for components for greater operational efficiency.
In both categories, there is a move toward near-net-shape technology for hard alloys that are difficult to machine.

Bihlman said automation has three basic subcategories, the most prominent of which is carbon fiber placement. Automated tape laying or fiber placement is the most prominent area of automation. The second most significant is robotic drilling and fastening for metallic structures. The third area is small scale with automated pallet systems and robotic CNC tool exchange.

Among his other observations, Bihlman said most constraints in titanium supply chain appear downstream, particularly involving special processes, both for aerospace structures and engines, while digital connectivity is impacting most areas of manufacturing, with varying degrees of success. In addition, he noted that laser fabrication (drilling, welding and cutting) is becoming increasingly more common in aerospace due to its high precision.

Christopher Olin, vice president, senior research analyst, Longbow Research, presented a titanium market update and a demand forecast, wondering if there is “real turbulence or just noise” in the industry. Longbow Research provides quarterly updates on various metal and aerospace markets (including specialty materials) through proprietary survey work and industry analysis.

According to Olin, the titanium market “is still strong. Titanium is within the ‘sweet spot’ of global demand, driving restored distributor/mill confidence and pricing leverage. Industry growth is back to the healthiest level we have seen since
2011—up 6-7 percent globally and 8-9 percent for the Western World. Our industry model is showing 5-6 percent global demand growth potential in 2019, supported by steady aerospace demand and favorable industrial and energy activity. Aero inventory could be too long heading into next year’s 737/A320 production ramp. Titanium sponge and melt operating rates should start moving higher.”

Along with the upbeat forecast, Olin did acknowledge that there is “quite a bit of noise in the titanium market,” and listed these five factors as the source of the noise:

1) Rolls-Royce and Pratt & Whitney seeing another round of engine performance challenges
2) We believe there is too much inventory in the aerospace channel (parked fuselages)
3) China growth is likely to slow due to trade uncertainties with the United States
4) Rising interest rates
5) GE still having problems with its gas turbine business.

Overall, the Longbow 2018 forecast for Western World titanium demand is 260 million to 265 million pounds, with global demand seen at 435 million to 440 million pounds. He pointed out that Longbow lowered its 2019 outlook by one point (globally) to 5-6 percent. “This is the first time we lowered expectations (the one-point drop for the 2019 outlook) in two to three years,” Olin said. “Still it’s a good year, but we are looking for a bumpy one to two quarters.”

Glenn McDonald, senior associate, AeroDynamic Advisory, examined “Aerospace Supply Chain Trends: Implications for Titanium.” McDonald said three key factors
that will shape aerospace demand for titanium during the next 10 years will be: Boeing’s proposed New Middle of the Market (NMA) jet; supply chain bottlenecks; and geopolitics.

He said AeroDynamic expects the Boeing program to be launched in 2019, with a potential EIS (entry into service) by 2026. According to a June 20, 2018 online report by ainonline.com, Boeing is now in talks with more than 60 airlines to develop the right configuration for the NMA jet. The report said the NMA “is envisioned to carry 220 to 270 passengers and have a range of 5,000 nautical miles.” The report also quoted a Boeing executive, who said the aerospace giant is “working on several aspects (of the NMA jet), like the life-cycle cost of the airplane and the supply chain, not just range or capacity. We want to make a revolutionary airplane.”

McDonald said the NMA fuselage design could have implications for titanium demand, and that several engine suppliers already have submitted bids for the NMA platform. As for supply-chain bottlenecks, he said investment casting shortages, especially for turbine blades, have “hit engine OEMs hard.” Forgings also are experiencing a host of issues. Geopolitical issues, such as trade sanctions, also may disrupt the global titanium supply chain. McDonald noted that, following the recent U.S. sanctions on Russian aluminum, aluminum prices spiked. In response, Russia threatened to cut off titanium supplies to the United States.
Aerospace
Ernie Crist of Arconic explored the “Improvements in Oxidation Resistance; A New Titanium Alloy for Aerospace Applications.” Crist said the alloy known as ARCONIC-THOR™ provides superior oxidation resistance up to 1200 F and is lighter than alternatives to nickel superalloys.

Crist explained that fuel efficient jet engines provide enabling capabilities, with higher efficiency and reduced fuel burn. However, hotter engines also present structural challenge to adjacent systems such as pylons, nacelles, heat shields, plugs, and nozzles. As a result, temperature requirements exceed the current capabilities of titanium.

To meet the requirements, Arconic has introduced ARCONIC-THOR™; a 50-percent lighter conventional titanium alternative to nickel superalloys for next-generation aerospace systems, providing significant cost savings and fuel efficiency. Crist said superior oxidation resistant properties enable ARCONIC-THOR™ to operate at service temperatures 200°F higher than the current state-of-the-art titanium alloys. Arconic has completed successful development projects with commercial aerospace and defense customers, including the U.S. Air Force, Boeing and Honeywell.

Keith Fleming of investment casting system supplier Feinguss Blank reviewed “The Difference Between Know-How and Know-Why on a TiAl (Titanium Aluminide) Application.” He listed the advantages of TiAl (lightweight, heat resistant, good strength) versus the disadvantages (expensive, difficult to cast and machine, and not weldable). In order to achieve successful results, TiAl
applications require clean, proper wax, proofed dry time, exact casting parameters and non-reactive ceramics.

Daniel Finkeldei, scientific assistant, TUWien (Technische Universitat Wien), discussed the “Analysis of Chip Formation in Machining Nickel Based and Gamma Titanium Alloys.” Chip formation is a primary indicator to analyze the surface quality of machined workpieces, according to Finkeldei. He said that while chip formation and surface quality are discussed in several studies in machining nickel based alloys, only a few investigations have been made in machining brittle/hard gamma TiAl. He provided results of an examination of TiAl chip formation through the use of a high-speed camera.

Mark Tomlinson, managing director, Metalysis Ltd., in a presentation titled “Metalysis: the Lab to Factory Journey,” recapped the process to develop a promising laboratory experiment into a commercial reality. Since Metalysis was established in 2005, the technology has been developed from a promising proof-of-concept to a true industrial process, according to Tomlinson. Plans in 2019 call for a Metalysis facility capable of delivering up to 1,000 metric tons of “distributed production” of titanium alloys suitable for aerospace, automotive and biomedical applications.

The Metalysis process involves electrochemical engineering, where electrons are used to remove oxygen from a range of metal oxides to create metals, alloys or intermetallics, all of which are suitable for a wide range of end-user applications in aerospace, automotive and advanced manufacturing.

Charles Young, metallurgist and business development manager for Tricor Metals, reviewed his company’s role in the development and construction of NASA’s Parker Solar Probe. The probe’s titanium truss structure assembly (TSA) was built at Tricor’s Wooster, OH, facility. The Applied Physics Lab of Johns Hopkins University designed, built and managed the overall solar probe project.

Young said Tricor’s original design for truss structure used titanium Grade 9 tubes and titanium Grade 5 bars, but during 12-month design discussions Tricor decided to change the design to all titanium Grade 5. The titanium truss structure assembly weighed 55 pounds, with a height of nearly 48 inches, a top diameter of 70 inches and a bottom diameter of 40.7 inches. Tricor’s fabrication process included five-axis CNC machining, drilling and tapping; chemical milling for tubes; hand TIG welding with an argon shield; and a FARO® 3D coordinate measuring machine.
NASA’s Parker Solar Probe is named in honor of Eugene N. Parker, Ph.D., a former professor at the University of Chicago, who predicted the existence of solar winds in 1958. NASA launched the probe on Aug. 12, 2018, from Cape Canaveral Air Force Station, FL. It will travel through the Sun’s atmosphere, providing the closest-ever observations of a star, according to NASA officials. Flying into the outermost part of the Sun’s atmosphere, known as the corona, the probe will gather information to determine the origin and evolution of the solar wind.

**Poster Sessions**

TITANIUM USA 2018 featured five poster sessions from university research students. The list of poster-session scholars included Dinh Nguyen, Phi-Ho Lee, Kyunghee Park, Yang Guo, and Patrick Kwon, from the Department of Mechanical Engineering at Michigan State University and the Korean Institute of Industry Technology; Sharoo Shrestha from Oregon State University’s School of Civil and Construction Engineering; and Yang Xia, Ying Zhang, Pei Sun, James Paramore, Matthew Dustan and Mark Koopman of the University of Utah’s Department of Metallurgical Engineering. The poster sessions focused on research to enhance titanium powder metallurgy, lubricants for cutting tools, and seismic retrofits of concrete bridge columns using titanium alloy bars.

Copies of the published posters along with video proceedings and slides from TITANIUM presenters are all available in the Events section of the ITA Website https://titanium.org/page/TiUSA18Proceedings
Save the Dates  
**TITANIUM EUROPE 2019**  
13-15th May 2019  
Austria Trend Hotel Savoyen Vienna  
[Exhibition Reservations](#)  

**Call for Abstracts**  
Delegate Registration with industry related tours offered November 1, 2018. A limited number of corporate Sponsorships are also now available.

A stay at the Hotel Savoyen Vienna is bound to be unforgettable – just like its namesake, Prince Eugene of Savoy. The hotel effortlessly combines old and new, occupying a revitalized building that was once home to the imperial Austrian state and court print works.

Organized industry tours include:  
Borealis AG Europe's second and world’s eighth largest producer of polyethylene (PE) and with the acquisition of Agrolinz Melamine International (AMI), the company is expanding its product portfolio to include melamine and fertilizer. The tour will be hosted through a bus excursion and includes a general overview of Chemiepark Linz and Borealis Linz.

Rolling Mill Tour of BÖHLER, voestalpine BÖHLER Bleche GmbH & Co KG is a producer of single cross rolled sheets and plates of steel and special alloys. The product range varies from tool and high speed steel to special materials for the energy, oil & gas and aerospace industry. Within the special material segment super austenitic and super duplex steels with high demands on corrosion and heat resistance, nickel and nickel base alloys for even higher demands and titanium and titanium alloys are manufactured. voestalpine BÖHLER Bleche manufactures according the latest technological standards and has recently invested in state of the art rolling, heat treatment and flattening equipment, including a vacuum creep flattening machine. The tour will include both mill sites, the rolling and the finishing mill, where all manufacturing steps from heat treatment, cutting, quality control, flattening and surface finishing are performed.

**TITANIUM USA 2019**  
September 22-25th, 2019  
Mobile Convention Center, Alabama USA  
[Exhibition Reservations](#)  
[Call for Abstracts](#)  
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[Download Conference Brochure here](#)
ITA's 35th anniversary meeting, hosted and organized by the International Titanium Association (ITA). TITANIUM USA 2019 will be held at the SMG Mobile Convention Center in Alabama. Presentations will host a variety of topics including world titanium supply & demand trends; powder metallurgy / additive manufacturing; commercial aerospace; medical; and the 2nd anTi Corrosion day will be dedicated to topics serving the global industrial markets.

**Industry Related Tours:**

Just minutes from the Convention Center is Airbus Mobile, an **assembly site for Airbus's Commercial Airplanes** division. The site is the major assembly and delivery site for Airbus commercial aircraft in the United States and will be one of the largest employment centers in the state.

The site will serve as one of four final assembly and delivery points for the Airbus A320 family. Aircraft will be delivered as a whole from the Mobile Aeroplex at Brookley surrounding the Airbus facility. Special Thanks to Airbus SAS for making this tour possible.

Tuesday Evening Tour & Dinner will be offered at the USS Alabama Memorial Park.

USS Alabama (BB-60), a South Dakota-class battleship, was the sixth ship of the United States Navy named after the US state of Alabama.

Alabama was commissioned in 1942 and served in World War II in the Atlantic and Pacific theaters. Alabama was decommissioned on 9 January 1947 and placed in the reserve fleet in Puget Sound Naval Shipyards Bremerton, Washington. Visitors are allowed to view the inside of the main gun turrets and anti-aircraft guns. The powder magazine was opened to the public through some holes that were cut, and stairs put in.

**TITANIUM ASIA 2020**
February 9-11, 2020
In conjunction with the Singapore Air Show Singapore
ITA is pleased to host the 2nd TITANIUM ASIA conference in Singapore at the Grand Hyatt Singapore hotel. Exhibition Reservations, Call for Abstracts & Conference Registration all available January, 2019.

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TITANIUM ASIA 2018 Conference Video Proceedings

Based just outside of Denver, Colorado, the ITA (Titanium.org), is a membership-based international trade association dedicated to the titanium metal industry. Current ITA membership is comprised of more than 200 organizations and over 1,500 individual members worldwide. Established in 1984, the ITA’s main mission is to connect the public interested in using titanium with specialists from across the globe who may offer sales and technical assistance.

ITA educates engineers, designers and business executives on titanium’s superior properties and explains how those properties may be developed to enhance products and services. The organization also strives to advance ideas in research, design, metallurgy and engineering, and serve as the leading forum to cultivate the exchange of ideas and support a diverse, dynamic, global industry.

This report was developed by Michael Gabriele, an independent freelance writer on behalf of the International Titanium Association (ITA) and is intended to provide a broad overview of the event. The summary provided is based on the information interpreted, but is not intended to be either exhaustive or inclusive of all announcements or information provided at the event.