October 13, 2021

HYPERION METALS COMMENTS ON THE DEPARTMENT OF DEFENSE'S ONE-YEAR RESPONSE TO EXECUTIVE ORDER 14017 "AMERICA'S SUPPLY CHAINS" OFFICE OF THE SECRETARY (DOCKET ID: DOD-2021-OS-0100)

Background

On February 24, 2021, President Biden issued Executive Order 14017 ''America's Supply Chains,'' which directs several Federal agency actions to secure and strengthen America's supply chains. One of these directions is for the U.S. Secretary of Defense, in consultation with the heads of appropriate agencies, to submit a report on supply chains for the defense industrial base, including key vulnerabilities and potential courses of action to strengthen the defense industrial base.

Executive Summary

Hyperion Metals, Ltd. ("Hyperion"), urges the U.S. Federal Government to support efforts to ensure U.S. control over its supply chains for titanium metal and other strategic minerals to both improve national security and increase economic growth, while doing so in a sustainable manner.

Titanium is a superstar metal and is utilized by the U.S. Department of Defense in many of the advanced systems it requires to defend the United States and its allies. In May 2018, the U.S. Department of Interior declared[i] titanium as one of the 35 mineral commodities considered critical to U.S. economic and national security. Unfortunately, the U.S. has virtually no titanium supply chain, from mining of titanium ores to the production of titanium metal. The U.S. is now 100% reliant on imported titanium primary metal, the production of which is dominated by political, military, and economic rivals. The solution to this significant challenge is to incentivize and develop a fully integrated, domestic titanium ore to metal supply chain in the U.S., combining domestic sources of titanium minerals with innovative and efficient processing methods to produce titanium metal for end users.

Hyperion Metals has set its mission to solve the end-to-end titanium supply chain in the U.S., and has secured mineral rights to over 6,000 acres of surface and mineral rights rich in titanium, and other critical minerals including rare earth elements, near Camden, Tennessee named the "Titan Project". The Titan Project's Mineral Resource Estimate ("MRE") has established it as the largest titanium, zircon, and rare earth minerals project in the United States, and confirms Tennessee as a major new American critical mineral province.

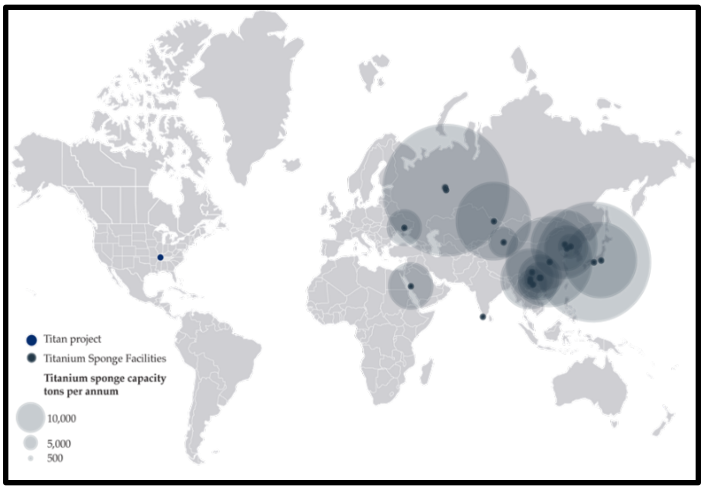
Further, Hyperion controls the breakthrough HAMR & GSD technologies to produce low carbon titanium metal and spherical powers, invented by the University of Utah with government funding from the DoE's ARPA-E program, re-shoring the production of titanium metal in the U.S.

Building a domestic supply chain for a metal as vital as titanium with targeted federal policies and investments makes national security sense. The U.S. is currently dangerously reliant on titanium suppliers in other countries that sometimes do not have America's best interests at heart. With Hyperion's world scale mineral deposit, ground-breaking titanium metal production technologies, and advances in 3D printing, the vision of a resilient, environmentally sustainable, domestic supply chain for critical minerals such as titanium can be realized while adding much needed new high-value production and manufacturing jobs across the country.

The Challenge

Titanium is a strong, lightweight metal with ideal properties for use in high value areas of the U.S. economy including space, aerospace, defense, automotive components, chemical processing equipment, and medical implants. Titanium bonds well with human bone, for example, making long-lasting joint replacements possible. Titanium has even found its way into consumer applications, from bicycles to laptops. Currently all domestic production of these value-add products, however, utilizes titanium metal sourced from overseas.

Titanium metal is desired by industry for its high strength to weight ratio, stiffness, fatigue strength and fracture toughness, excellent corrosion resistance, and the retention of mechanical properties at elevated temperatures. Due to these characteristics, titanium is not easily substituted, but is itself a threat to substitute steel and aluminum, with the cost of production being the largest barrier to substitution. Further, it is not possible to substitute titanium feedstocks for the production of titanium metal.



Global Titanium Production Facilities

Unfortunately, while the U.S. is the world's largest consumer of titanium metal, it has virtually no titanium supply chain, from mining of titanium ores to the production of titanium metal. The U.S. depends on imports for over 90% of its titanium ore consumption[ii]. As of 2021, the U.S. is 100% reliant on imported titanium metal. U.S. dependency on foreign sources of titanium ores and metals creates strategic vulnerabilities for both its economy and national security when adverse foreign government actions, natural disasters, and other events such as global pandemics can disrupt critical raw materials supply. Current global titanium sponge capacity is about 328 thousand tonnes per year (kt/y), centered in China (162kt/y), Japan (65kt/y), Russia (47kt/y), Kazakhstan (26ktp/y), and Ukraine (12kt/y).

The Solution

Hyperion and its subsidiary TN Exploration, LLC have secured mineral rights to over 6,000 acres rich in titanium, and other critical minerals including rare earth elements, near Camden, Tennessee. In addition, Hyperion has partnered with Blacksand Technology, LLC which has developed high efficiency, low carbon intensive, innovative technologies to manufacture titanium metal from titanium ores. Known as the HAMR & GSD processes, the technologies have been supported with funding from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E), with Boeing and Arconic (formerly Alcoa, Inc.) as industrial partners.

The HAMR process has the potential to simplify the metal manufacturing process through elimination of process stages, reduction in energy consumption, and elimination of manufacturing inputs. Combined with a commitment to reduce emissions in mining and mineral processing, the opportunity exists to create the lowest carbon titanium metal powder production business globally.

Request for Written Comments

The U.S. Department of Defense (DoD) has requested comments to help the Department respond to E.O. 14017 by providing information about key supply chain vulnerabilities and opportunities to address these vulnerabilities. Hyperion will focus its comments on the Castings and Forgings topic area along with Manufacturing as a critical systemic enabler.

i. Select kinetic capabilities: Includes Precision Guided Munitions (PGMs), Hypersonics, and Directed Energy (DE). Key components (*e.g.,* critical energetics, microelectronics) are almost exclusively produced by foreign entities, including adversarial nations.

ii. Energy storage/batteries: Energy storage is critical to all kinetic capabilities, and is an evolving requirement. Defense-unique requirements with low domestic production volumes create supply chain risk and high local costs.

iii. Microelectronics: Similar to energy storage, microelectronics are vital components used in nearly all defense systems. Defense-specific challenges arise from acquisition processes, obsolescence, and the need for secure suppliers. The one-year effort will focus on military-specific microelectronics requirements and the ongoing challenges between commercial and defense requirements.

iv. Castings and forgings: **Manufacturing is dependent on casting and forging capabilities and capacity. An overall decrease in domestic capability and capacity limits the industrial base's ability to develop, sustain, or expand production. Expanding our domestic capabilities will reinforce efforts to onshore commercial manufacturing.**

In addition to the topics listed above, the DoD requests input on the following five (5) systemic enablers, as they relate to the topics above. These enablers span all four (4) topic areas; they are critical to mission success, and gaps or fragility in each can create operational and strategic risk.

i. Workforce: Includes all persons needed for a focus area, from skilled trades to specialty engineering degrees;

ii. Cyber posture: Includes cybersecurity, industrial security, and counterintelligence;

iii. Interoperability: Requirements needed to support operations with our allies, as well as the requirements to further enhance our interoperability between and among DoD's systems and platforms;

iv. Small business: Focuses on addressing the barriers and challenges to small businesses to enter, and stay in, the defense ecosystem (both as primes and sub-contractors); and

v. Manufacturing: **Includes core/traditional manufacturing modes and new manufacturing technology, such as additive manufacturing.**

In regards to the four (4) topics and five (5) systemic enablers above, the DoD is particularly interested in soliciting information in response to the following questions:

Question 1. From your perspective, how has the globalization of the supply chain improved or complicated your ability to source DoD's requirements?

The DoD is highly exposed to a U.S. titanium supply chain that is currently 100% import reliant for titanium metals and 90% import reliant for titanium ores. The development of an end to end domestic U.S. titanium metal supply chain, from ore through to the production of titanium metal, will enable much greater transparency to the U.S. Federal Government regarding the sources and uses of key inputs along the supply chain.

Titanium Ores - A small amount of titanium ore is produced in the U.S., primarily as titanium dioxide in the form of the minerals ilmenite and rutile, produced by Chemours in Florida and Georgia. However, the country remains ~90% reliant on imports. Imported titanium ores are sourced from countries including Ukraine, South Africa, and Australia and are used primarily for pigment production. Imported titanium ores are not used to create titanium metal as the U.S. currently has no active domestic titanium metal production capacity as discussed below.

Titanium Metals - Over the last five-year period, the U.S. imported 50-90% of its titanium metal needs[iii], and now has no domestic titanium metal production capacity. The last U.S. domestic titanium sponge plant closed in 2020 in Henderson, Nevada, and as of 2021, the U.S. is 100% reliant on imported titanium metal, sourced almost exclusively from Japan. This represents a clear single point of failure, particularly in an event where the world's largest producer, China, attempts to curtail or undercut Japanese titanium metal production.

Given the dependence on imports, any increase in domestic capacity of both titanium ores and titanium metal will reduce exposure to price volatility and supply shocks. This is particularly important given the role of China and Russia as the largest producers of titanium metal, and this effort would limit their ability to influence global pricing.

Question 2. What are the one or two greatest challenges your firm/association/industry faces operating in a distributed environment?

U.S. dependency on foreign sources of titanium ores and titanium metal creates strategic vulnerabilities for both our economy and national security when adverse foreign government actions, natural disasters, and other events such as global pandemics can disrupt critical raw materials supply. Should a conflict arise among peer competitors in the world, the U.S. may find itself with an acute shortage of titanium metal. That shortage would be significant threat to the national security of the United States.

The largest global producers of titanium metal are China and Russia, countries where policies relating to the environment, health and safety, labor and fair trade are not well aligned with the U.S. China is the world's largest producer of titanium metal, with production capacity increasing by 22x since 2000. In the same timeframe U.S. production capacity had reduced to nil. The world's second largest producer is Russia. Japan, as the third leading producer, is the main supplier of titanium metal to the U.S.

Given that China and Russia are military and economic rivals, supply chain vulnerability for U.S. defense and aerospace applications present national security risks. Taking into account the human rights records of both China and Russia, the establishment of a U.S. titanium supply chain would draw demand away from countries which may be seen as high-risk regarding violations of human rights and forced labor.

In addition, China and/or Russia have significant ability to disrupt the global titanium supply chain, including the potential to render Japan, the primary U.S. supplier, uneconomic. Most of the titanium ores used by Japan come from China and Russia. If the current Japanese supply decreases, the U.S. would be dependent on and vulnerable to China and Russia for these needs. The White House 100-day supply chain report reiterates potential titanium supply chain vulnerabilities and the probability of a disruption event appears to be increasingly likely.

Question 3. Are there ways DoD can better support your efforts to mitigate such challenges?

The U.S. will most likely not see traditional large scale domestic titanium sponge capacity come back online due to the current standard technology, the Kroll process, being extremely capital, energy, and carbon intensive. However, there is an opportunity to re-establish titanium metal production in the U.S. utilizing high efficiency, low carbon intensive, innovative technologies to manufacture titanium metal from domestic titanium ores. The re-establishment of an end-to-end domestic titanium supply chain will enable the U.S. to influence the playing field in global markets and re-shore security of supply for our critical industries, including defense.

Environmental, Social and Governance supply chain policy recommendations should be focused upon incentivizing new technology to replace existing energy and carbon intensive processes in the titanium metal supply chain. The U.S. Department of Energy's Advanced Manufacturing Office conducted a "bandwidth" study that shows that further R&D in titanium refining can lead to up to 70% energy savings from today's typical process. A core principle of Hyperion's mission in developing the Titan Project and titanium metal powders for advanced manufacturing is to bring the highest levels of sustainability and decarbonization to all aspects of the titanium supply chain. In laboratory scale test work, Hyperion's innovative technology resulted in >50% less energy consumption and ~33% less carbon dioxide release than today's "Kroll" process for titanium metal production.

Titanium Ores - Work is rapidly progressing to bring the TitanProject into production. Activities include definition of the mineral resource, metallurgical test work, feasibility and engineering studies, permitting activities as well as discussion with potential customers for sales of mineral products. This development work has defined one of the largest critical mineral resources in the U.S., rich in titanium bearing minerals, with the potential to support a large amount of feedstock to an integrated U.S. titanium supply chain.

Titanium Metals - Further, Hyperion has teamed with Blacksand Technology which has developed high efficiency, low carbon intensive, innovative technologies to manufacture titanium metal from titanium ores, known as the HAMR & GSD processes. The new processes will significantly increase energy efficiency and reduce carbon emissions compared to today's processes, and can bring this down to net zero when renewable energy sources are utilized. The HAMR process can also employ an innovative "granulation, sintering and deoxygenation" that can reduce the cost of spherical titanium powder for 3D printing to $20-50/kg depending on feedstock quality. This represents a vast reduction in manufacturing costs for these metal powders, which are currently prohibitively expensive at $250-500/kg. These cost reductions will enable greater domestic and export markets for titanium and create an incentive for domestic production capacity to address supply chain vulnerabilities.

The hydrogen reduction technology has been proven at laboratory scale, and Hyperion will now commercially validate the process at significantly larger scale increments. Targeted Department of Defense support is needed for an intermediate high efficiency, low carbon pilot scale plant to reduce the technical and financial risk for follow-on private investment for a commercial-scale, net-zero carbon titanium metal plant by 2030. The intermediate pilot scale plant would validate product quality, energy consumption, emission generation, and cost targets prior to commercialization and commissioning of the commercial-scale plant.

Specifically, focused R&D and systems integration and scale-up are needed for de-risking the chemical processing and plant economics. The following **four key challenges** need to be addressed over the next five years:

1. <u>Materials Science</u> - Some carbon-free approaches require high-temperature, harsh environment (reducing atmosphere, abrasive particles, etc.) materials research to ensure

that furnace linings and other components maintain structural and mechanical properties under high, pure hydrogen concentrations and elevated temperatures required for ore reduction. This materials science potentially applies to reduction of titanium ore and other critical metal oxides/ores.

2. Manufacturing R&D – New process development such as titanium ore processing, unwanted competing chemical reactions, impurities, process yields and selectivity, process control and automation including AI, and other variables affecting product quality need to be optimized for decarbonized titanium production.
3. Digital Engineering and Simulation – Integrated energy systems modeling establishes the digital design basis for seamless integration of carbon-free electricity generation with hydrogen production, thermal management and other unit operations (condensers, etc.,) and ensures optimum heat and mass balances. Digital engineering will accelerate process design and enhance the experimental productivity. Detailed technical and economic modeling determines the optimum unit operations design and impact with respect to hydrogen stoichiometry, reaction temperatures, unsteady operations, and other variables. In addition, digital engineering/simulation software represents a digital twin of the laboratory hardware for theory validations, optimization and new AI-based digital process controls.
4. Scale-up and Testbed Validation – Operating experience at a larger scale verifies the materials performance/durability, process design and operations and techno-economic performance. This information and data under real operating conditions is critical prior to scale-up to the production plant with industry equipment manufacturers, sensor and controls developers, and others. Testbed plant validation would be needed before industry would invest in a first-of-a-kind production-scale plant. Given the large capital investment in titanium ore reduction, high confidence is required beforehand.

Question 4. How does the federal government effectively mitigate supply chain risks?

Secure supply chain policy recommendations should be focused upon mandating that materials within the titanium supply chain are domestically sourced. First, an assessment of the current state of the U.S. domestic titanium supply chain should be undertaken and include the following:

1. A review of U.S. domestic mining of titanium ores and the domestic production of titanium primary metal;
2. A comparison of how much titanium metal is utilized annually for U.S. national security requirements and how much titanium ore and titanium metal is currently available from the domestic supply chain;
3. An appraisal of the reliability of non-U.S. titanium producers during national defense emergency scenarios; and,
4. Recommendations on incentivizing new technologies to replace existing energy and carbon intensive processes in the titanium metal supply chain.

To more effectively mitigate titanium supply chain risks, Hyperion Metals recommends that "Buy American" clauses should be utilized for Department of Defense titanium requirements and suggests that mandates should be put in place for materials such as titanium to ensure they are domestically sourced. There is no reason why titanium used in the fabrication of military hardware cannot be sourced 100% from the United States. The Title III Defense Production Act is another viable option to support domestic titanium sourcing. Inclusion of critical minerals and their supply chains in the "American Jobs in Energy Manufacturing Act of 2021", introduced by Senator Manchin and Senator Stabenow, to reconstitute the IRS 48C tax credit is another policy option that would incentivize private investment in domestic titanium sourcing and manufacturing.

Question 5. What can the government do differently to better address supply chain risks and vulnerabilities in our major weapon systems/platforms (*e.g.,* PGMs) and critical components (*e.g.,* microelectronics)?

Federal support in securing long term research, development, and demonstration (RD&D) investments as outlined in these comments will enable and incentivize significant private investment in innovative solutions for domestic production capacity to address supply chain vulnerabilities. Funding would accelerate the timeline to obtain pilot plant experience and provide the technoeconomic information for investors to finance a production scale plant.

Question 6. What can the government do differently to successfully implement industrial base cybersecurity processes or protocols, attract skilled labor, implement standards, and incentivize the adoption of manufacturing technology?

The U.S. can economically and efficiently source critical titanium minerals from the homeland should the above recommendations be implemented. The U.S. has significant reserves of titanium ore that can be mined and used to produce titanium metal. The solution to this significant challenge is to incentivize and develop a fully integrated, domestic titanium ore to metal supply chain in the U.S., combining domestic sources of titanium minerals with innovative and efficient processing methods to produce titanium metal for end users.

The skill sets required to re-stablish and maintain a domestic industry are no more advanced than many other mining or metal / chemical production operations that currently exist in the U.S., and availability of skilled labor should not be an impediment to the development of the industry. The U.S. has a large pool of labor ideally suited to the mining of titanium ores and development of titanium metal manufacturing capacity, particularly in disadvantaged communities, including in the region surrounding Hyperion's Titan Project in west Tennessee.

Sincerely,

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[i] Department of Interior, Federal Register Notice of May 18, 2018, https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018
[ii] USGS 2021 Mineral Commodity Summaries for titanium mineral concentrates, see https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-titanium-minerals.pdf
[iii] USGS 2021 Mineral Commodity Summaries for titanium and titanium dioxide, see https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-titanium.pdf