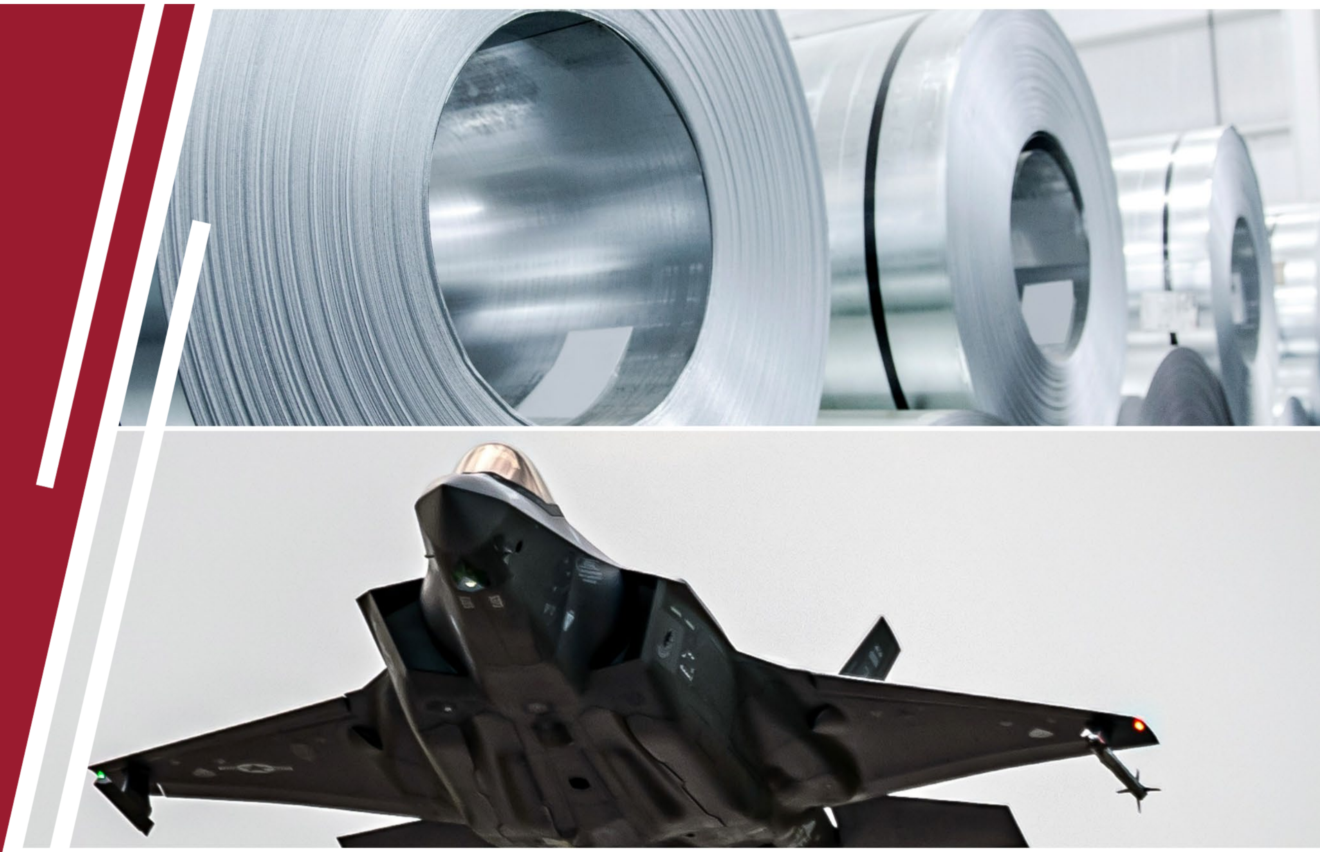

Defense Logistics Agency Aluminum Wargame

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Executive Summary

Aluminum is a strategic material that is a critical component to a wide range of Department of War (DoW) weapon systems. The domestic aluminum industry has declined dramatically in the last three decades; there currently are only four smelters in the United States, and only one producer of high purity aluminum (HPA). HPA is essential for many of DoW's most important systems. Imports of both primary aluminum and HPA—and many essential alloy materials—represent a high percentage of domestic consumption, both for defense and commercial needs. This reliance on foreign sources, as well as domestic single points of failure, raises important questions regarding the industry's ability to meet DoW requirements, particularly in the event of a future conflict scenario, in which DoW demand could increase dramatically. Such a contingency raises questions regarding what sources—domestic and foreign—will be able to meet demand; what risks are involved in relying upon those sources; and what alternatives DoW and the U.S. government should consider.

China is by far the world's largest producer of aluminum and alumina. This means China has significant influence over the world market and aluminum prices. While large amounts of Chinese production do find their way into intermediate and final goods that enter the U.S., very little of their primary production reaches the United States. Canada is by far the largest source of U.S. aluminum imports, and Brazil is the largest source of imported alumina. Furthermore, China is not a factor in satisfying U.S. demand for HPA, which is produced domestically or imported from the United Arab Emirates.

To explore the challenges facing the industry and DoW, and to develop recommended courses of action, the Defense Logistics Agency (DLA) tasked the Institute for Defense Analyses (IDA) to organize and conduct a government-industry Aluminum Wargame, which was held July 21–24, 2025. The wargame was attended by approximately 80 participants from the aluminum industry, aluminum associations, DLA and DoW, and non-DoW government agencies. This report documents: (a) the purpose of the wargame event; (b) its structure and content; and (c) the major themes, ideas, and recommendations that emerged from the wargame. Neither the wargame nor this report is intended to provide an in-depth analysis of the industry, nor did IDA independently assess the insights and recommendations from the wargame. DLA has already begun evaluating these insights and recommendations, and follow-on actions are being initiated, where appropriate.

The discussions and gameplay highlighted some of the challenges facing the domestic industry. These include high energy costs, unreliable access to power, aging infrastructure, and inadequate numbers of trained workers (in both trade and engineering occupations). These problems have been exacerbated by the subsidies and other support some countries have provided to nurture their own aluminum industries, which U.S. trade and industrial policies have not counteracted.

Wargame discussions and outputs explored current circumstances and highlighted strategies and recommendations that were seen as essential elements of a holistic approach—one that considers all aspects of the aluminum supply chain, from inputs to production of primary aluminum and HPA to advanced fabrication and recycling. Actions outside of the aluminum supply chain were not considered, and the objective of the game was to ensure adequate access to inputs throughout the aluminum supply chain under national emergency circumstances.

The IDA team observed wargame play and recorded the prioritized actions and investment decisions made by the players under different scenarios. Following gameplay, the IDA team translated player actions into sets of recommendations to be considered by DoW. These recommendations were discussed in detail by the group to refine and adjust actions where needed to yield a generally agreed-upon set of high-priority recommendations for leadership consideration. They are summarized below.

A key challenge for DoW leaders is to determine DoW's role in addressing problems in the aluminum industry. Many of the policy actions and mitigations proposed by wargame participants are directed towards improving overall aluminum industry outcomes: e.g., employing tariffs and addressing the need for reliable and affordable power. While there was widespread agreement that these actions would benefit the aluminum industry, there is still the question of when DoW should employ its resources to address industry challenges, and when it should rely upon U.S. industrial policy responsibilities that lie elsewhere in the government. This question was beyond the scope of the wargame.

1. *Stockpile as a near-term hedge*

HPA is alloyed in many different ways, depending upon the requirements of the final products. In addition, HPA is then cast, forged, and extruded into numerous intermediate products that are key inputs to final production. Thus, while wargame participants considered stockpiling HPA a good idea, they also noted that additional downstream products (e.g., particular alloys, forged and extruded parts) could be considered for stockpiling. Many alloy materials (e.g., copper, magnesium) are also critical and in short supply, and thus might be supplemental stockpile candidates. Stockpiling was viewed as an important near-term hedge to meet emergency needs while longer-term strategies come to fruition.

2. *Improve access to affordable, reliable non-interruptible power*

Access to power was perhaps the single most important issue that all wargame participants agreed needed to be improved. Recommendations included putting into place policies that better regulate access to and the price of electricity, reopening old (cold) coal-fired power plants, and opening new natural gas and nuclear power plants.

3. *Rebuild infrastructure/expand capacity*

The wargame developed numerous recommendations for supporting a more robust and resilient domestic industry. U.S. production facilities operate using outdated equipment that is in need of significant repair and replacement. Recommendations focused on investing in new equipment and other capital improvements, and reopening and investing in new smelters to increase overall domestic production capacity. Other recommendations included expanding the production capacity of HPA, building a domestic cathode production facility, and investing in R&D to help improve industry capabilities and efficiency.

4. *Build the workforce*

The shortage of workers in both trade and engineering occupations (especially metallurgical) is of great concern for the aluminum industry. Recommendations in this area focused on expanding and more aggressively promoting existing programs to build the workforce, particularly those that already exist in the U.S. government, and better coupling them with industry efforts.

5. *Support international access*

The importance of many hard-to-source alloys prompted a recommendation to work more closely with allies to ensure reliable access to these materials. Security of Supply Agreements (SOSAs) were seen as valuable tools for facilitating the flow of foreign materials to the United States during times of need. Another recommendation encouraged DLA to review, with the Office of the Secretary of War and the intelligence community, the assessments of international supply chain risk that influence how DoW addresses questions of foreign reliance.

6. *Incentivize recycling*

Recycled aluminum has much lower energy requirements compared to primary aluminum production. Thus, one recommendation centered on having the U.S. government promote recycling efforts. In addition, DoW could explore using acquisition policies to promote or require the defense industry, where it is cost effective, to recycle alloyed products that otherwise are sold off as scrap (and eliminate the flow of U.S. scrap to foreign competitors).

7. *Other policy levers*

Not unsurprisingly, industry participants, in particular, recommended employing higher tariffs on products that compete with the domestic aluminum industry, and lower tariffs on inputs the industry needs for the production of aluminum. One recommendation specifically for DoW is to more effectively employ the Defense Priorities and Allocations System (DPAS). Another recommendation is for DoW to develop "Contingency Playbooks" so as to be better prepared for likely challenges in the future. This could build on lessons learned from World War II, in particular, and would best be done in collaboration with other relevant government agencies.

Many of the recommendations from the wargame lie outside the authorities of DoW. In those cases—e.g., whether to promote investments in commercial nuclear power, or ways to improve the reliability of the electrical grid—DoW is encouraged to work with its interagency partners to explain the value of these actions for the military and national security.

Contents

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1. Introduction

A. Background

The Defense Logistics Agency (DLA) tasked the Institute for Defense Analyses (IDA) to organize and conduct a government-industry Aluminum Wargame. This event, which took place at IDA from July 21–24, 2025, was the third wargame in the DLA Industrial Base Campaign of Learning (DIBCoL) series. The first wargame in the series, held in October 2023, focused on a specific industry: clothing and textiles.[1] The second wargame, held in 2024, focused on an individual product: bromine water cartridges and associated items. For the third wargame, DLA chose to examine a strategic and critical material: aluminum.[2]

DLA's motivation for this wargame series comes from the observation that the Department of War (DoW) and the Joint Logistics Enterprise are continuously looking for better ways to evaluate sustainment requirements in contested environments. DLA leadership noted that few, if any, recent wargames have explored supply chain activity from raw materials sourcing and manufacturing through vendor distribution to DoW control. DLA felt it needed a more granular understanding of supply chains so as to better meet potential contingency requirements.[3]

Aluminum was chosen as the third wargame in the series because of its strategic importance as a critical component for U.S. military systems, and because of the poor health of the domestic aluminum industry, including its high dependence on foreign sources.

B. Wargame Objectives

The objectives for this wargame were to improve government and industry understanding of defense requirements for aluminum in peacetime and in crisis/conflict, to improve government's understanding of the challenges facing the aluminum industry and, with industry input, to improve government understanding of the costs, benefits, and

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1 See CNA Corporation, "CAMOLAND Clothing and Textile Industrial Base Wargame Report," Charles Cartier et al., 2024.

2 Strategic and critical materials are defined as those that "(A) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national emergency, and (B) are not found or produced in the United States in sufficient quantities to meet such need." Strategic and Critical Materials Stock Piling Act of 1939, Pub L. 76-117, 53 Stat. 811, 50 U.S.C. 98h–3.

3 DLA Aluminum Wargame "Calling Message" announcing the wargame May 30, 2024.

timelines associated with options for mitigating the risk to DoW end-items and parts that contain aluminum.[4]

As stated by the sponsor, the objective was to assess the resiliency of DLA's aluminum supply chain in support of a Globally Integrated Response that includes mobilization, and to identify:

- where there are gaps due to dependencies on China and other adversaries, and
- the potential for cascading impacts and the need for mitigation.[5]

An additional benefit of this wargame, as with the previous wargames in the DIBCoL, was building relationships and understanding among DLA, other U.S. government participants, and aluminum industry partners.

The purpose of this report is to document: (a) the purpose of the wargame event; (b) its structure and content; and (c) the major themes, ideas, and recommendations that emerged from the wargame. Neither the wargame nor this report intended to provide an in-depth analysis of the industry, nor did IDA independently assess the insights and recommendations from the wargame. DLA has already begun evaluating these insights and recommendations, and follow-on actions are being initiated, where appropriate.

C. DoW and Industry Challenges

A challenge facing DoW is that the domestic aluminum industry has been in decline for decades. This calls into question the ability of that industry to meet DoW requirements, not only in peacetime but also regarding potential demands posed in the future by a major contingency. These challenges, and numerous other details about the industry, were included in a primer supplied to all of participants prior to the wargame. The reader is referred to that document for references and sources on facts about the aluminum industry.[6]

Military systems—aircraft, ships, armored vehicles, communications equipment, and other DoW systems—require large amounts of aluminum, with strict requirements on the types of aluminum and aluminum alloys required for each system (i.e., purity and other properties) and the manner in which those products are fabricated (e.g., castings, forgings, extrusions). In the future, and particularly in the event of a crisis, how will military requirements be met? Although defense consumption of aluminum accounts for only about

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4 DLA Calling Message.

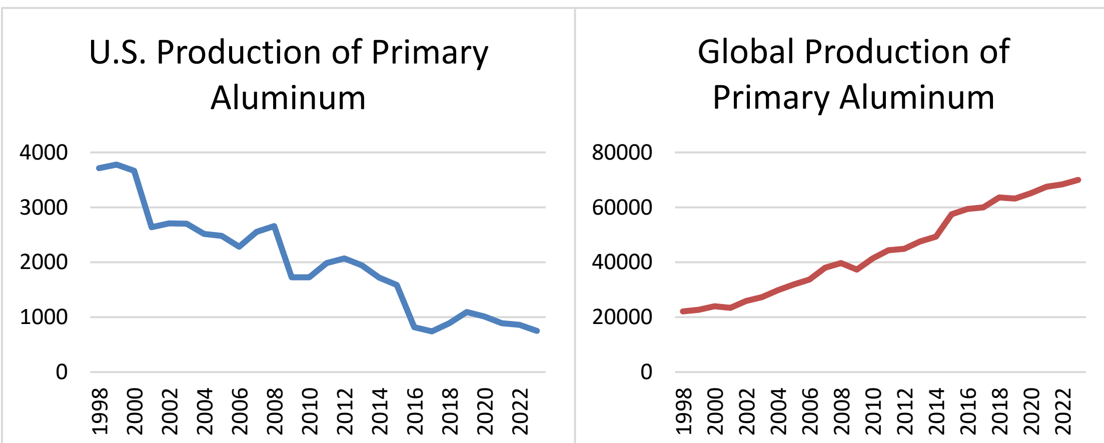
5 A direct quote from DLA briefings on the wargame, and the task order with IDA.

6 *Primer for Defense Logistics Agency Aluminum Wargame, July 21–25, 2025,* by Rowan W. Gast-Bray, Julie C. Kelly, Paul H. Richanbach, and Lander Turner, July 2025, IDA Product 3005118 (Alexandria, VA: Institute for Defense Analyses, 2025).

five percent of total domestic demand, aluminum is also required for essential civilian applications, such as in the transportation, electronics, and energy infrastructure sectors.[7]

That the domestic aluminum industry is in crisis is not debated. Neither are the basic facts surrounding its decline. Foreign aluminum manufacturers have come to dominate the market over the past 25 years.[8]

As recently as 2000, the United States was the world's largest producer of primary aluminum. There has since been a surge in global demand, which makes the current, diminished state of the U.S. industry all the more notable. The U.S. share of global production of primary aluminum is now eleventh worldwide, having fallen to less than one percent in 2024, down from 15 percent in 2000. The number of domestic smelters shrank from 23 in 2000 to four in 2024. The United States now imports nearly five million metric tons, over seven times the estimated primary aluminum produced in the United States in 2004.[9] This decline can be seen clearly in Figure 1.



Source: IDA-generated graphs based on data from U.S. Geological Survey, *Mineral Commodity Summaries*, 2000–2025.

Figure 1. U.S. Primary Aluminum Production as Compared with Global Production (thousands of metric tons, by year)

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7 Under Secretary of Defense for Acquisition and Sustainment, "Report to Congress: Aluminum Refining, Processing, and Manufacturing" (Department of Defense, October 2022), p. 3, https://delbene.house.gov/uploadedfiles/usa000204422_report_on_aluminum_refining_processing_and_manufacturing_redacted.pdf.

8 In preparation for the wargame, IDA prepared a primer with basic facts about the industry and DoW's reliance upon it. This section is drawn from that document, "Gast-Bray, *et al.*, "Primer for the Defense Logistics Agency Wargame," Institute for Defense Analyses Product 3005118, July 2025.

9 U.S. Geological Survey, "Mineral Commodity Summaries 2025: Aluminum," prepared by Adam M. Merrill (Reston, VA: U.S. Geological Survey, January 2025), https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-aluminum.pdf.

The reasons for this decline are well known and described in detail in the primer. Numerous other countries have nurtured—and in many cases subsidized—the growth of their own aluminum industries. China, in particular, has been very aggressive, and now accounts for 60 percent of worldwide production, as shown in Table 1. However, though China is an important global producer, most U.S. imports come from other countries, as shown in Figure 2. As can be seen in both Table 1 and Figure 2, reliance on imports is true not only at the aluminum production node, but at upstream nodes of production as well (i.e., bauxite and alumina).

Domestic aluminum producers must compete with advantaged foreign producers who enjoy lower labor costs, lower (often subsidized) energy costs, and more reliable energy sources. These challenges are exacerbated by other factors affecting the domestic aluminum industry (and shared by other domestic industries, such as steel) including a shortage of skilled workers, the impact of environmental and other regulations, and an aging infrastructure requiring higher maintenance costs and large capital investments. The role of U.S. trade policy over the past 25 years is also an important factor affecting the decline of the aluminum industry.[10]

Table 1. U.S. Geological Survey Material Commodity Summaries

Material Form	Top Producing Countries (2024)	Top U.S. Import Sources (2020–2023)
Aluminum	China (43 MMT)	Canada (2.75 MMT)
	India (4.2 MMT)	UAE (0.39 MMT)
	Russia (3.8 MMT)	Bahrain (0.20 MMT)
	Canada (3.3 MMT)	China (0.15 MMT)
	UAE (2.7 MMT)	Other (1.4 MMT)
Alumina	China (84 MMT)	Brazil (1.04 MMT)
	Australia (18 MMT)	Jamaica (0.15 MMT)
	Brazil (11 MMT)	Australia (0.11 MMT)
	India (7.6 MMT)	Canada (0.08 MMT)
	Russia (2.9 MMT)	Other (0.15 MMT)
Bauxite	Guinea (130 MMT)	Jamaica (2.41 MMT)
	Australia (100 MMT)	Turkey (0.32 MMT)
	China (93 MMT)	Guyana (0.29 MMT)
	Brazil (33 MMT)	Australia (0.21 MMT)
	Indonesia (32 MMT)	Other (0.36 MMT)

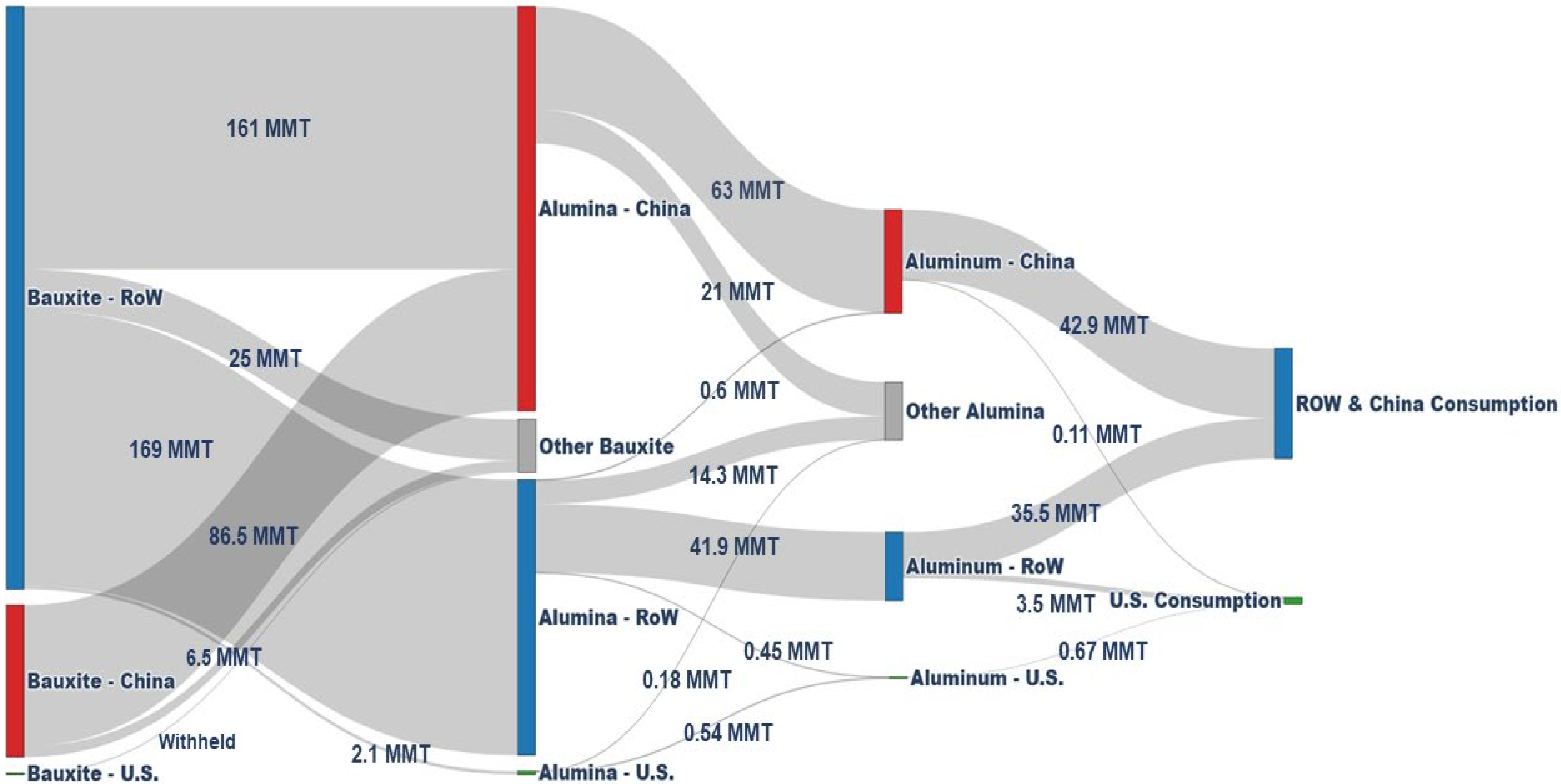
10 For more details and references, see, Institute for Defense Analyses, *Primer for Defense Logistics Agency Aluminum Wargame, July 21–25, 2025,* by Rowan W. Gast-Bray, Julie C. Kelly, Paul H. Richanbach, and Lander Turner, July 2025, IDA Product 3005118 (Alexandria, VA: Institute for Defense Analyses, 2025).

Note: Values are in Millions of Metric Tons (MMT). Aluminum import numbers include the import of aluminum scrap.

Sources:

U.S. Geological Survey, "Mineral Commodity Summaries 2025: Aluminum," prepared by Adam M. Merrill (Reston, VA: U.S. Geological Survey, January 2025), https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-aluminum.pdf.

U.S. Geological Survey, "Mineral Commodity Summaries 2025: Bauxite & Alumina," prepared by Adam M. Merrill (Reston, VA: U.S. Geological Survey, January 2025), https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-bauxite-alumina.pdf.



Source: IDA-generated graph based on data from U.S. Geological Survey, "Mineral Commodity Summaries 2025: Aluminum," prepared by Adam M. Merrill (Reston, VA: U.S. Geological Survey, January 2025), https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-aluminum.pdf.

Note: This chart shows the estimated flow of material (gray bands) through the aluminum supply chain from three different entities, the United States (green rectangles), China (red rectangles), and the rest of the world (ROW) (blue rectangles), in the year 2024. Material that is used in applications other than the creation of aluminum are labeled "Other Bauxite" and "Other Alumina" and denoted by gray rectangles. Flows were approximated using a combination of U.S. import data and global production data.

Figure 2. Sankey Diagram Showing Global Flows of Aluminum (in Various Forms) Supply and Demand

Almost every U.S. military platform requires primary aluminum and/or HPA. While defense demand for aluminum is only five percent of total U.S. domestic demand, the demand for high purity aluminum (HPA) represents a significantly higher percentage. In particular, special aluminum alloys that require HPA are necessary to build the nation's highest performing military systems (e.g., aircraft, ships, vehicles, and munitions). In the United States, HPA undergoes further refinement from primary aluminum. Currently, only one domestic smelter is producing HPA, and capacity at that plant is not sufficient to meet all defense and other domestic requirements. Thus, the United States, including the defense industry and military systems, currently relies upon foreign sources of HPA for a significant percentage of total HPA demand. The major foreign source of HPA is the United Arab Emirates (UAE).

While DoW's peacetime needs can today be met through a combination of domestic and foreign production, DoW planners must consider whether military and essential civilian demands could be met in the event of a major military contingency. Such a contingency would likely result in a significant increase in the demand for aluminum. From what sources, domestic and foreign, will that demand be met, what are the risks involved in relying upon those sources, and what alternatives should the DoW consider?

The challenge facing the DoW is to determine the risks it faces from its current dependence on a diminished domestic aluminum industry and dependence on foreign sources, and to better understand the options for the DoW, and the U.S. government, to manage those risks.

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2. The Wargame – Gameplay

A. Wargame Objective

Participants were reminded at the start that the objective of the wargame was to improve participants' understanding of the challenges to aluminum supply chains that may place defense requirements at risk during a protracted period of crisis and/or conflict, and to evaluate potential mitigations/options for meeting DoW needs for aluminum products before, during, and after a conflict.

B. Wargame Attributes

As with many wargames, any numbers, "precise" or otherwise, are artifacts of the game design and mechanics, and have no quantitative, analytic value. One can say that "most" participants placed a "high" priority on certain policy proposals. But it is not possible to say that because the average amount spent on Policy A at all six tables was 100 percent more than on Policy B, Policy A is therefore twice as important. All one can say is that the consensus of the people brought together for this wargame—who may or may not be a statistically representative sample of key government and industry decision-makers—was that one policy was a higher priority than another.

Participants in the wargame—many of whom had never attended a wargame before—were introduced to the following basic attributes of wargames and exercises such as this one.

- It is an analytic device used to uncover previously unknown insights based on interactions between players with different perspectives.
- In this wargame, your perspectives align with your affiliations (government or industry, and where you work within each of those sectors).
- We are not here to decide who wins and who loses. We are here to explore options and discover promising courses of action.
- In this event, unlike other DoW-sponsored wargames, there are no red, blue, or white cells that determine participant behavior.[11]

[11] "[W]argaming is a representation of military activities, using rules, data, and procedures, not involving actual military forces, and in which the flow of events is affected by, and in turn affects, decisions made during the course of those events by players…" (Peter Perla, The Art of Wargaming, 1990). Wargame

As discussed in Chapter 1, an unclassified primer was sent in advance to all attendees to help them prepare for the wargame. The primer provided background regarding the issues facing the aluminum industry, including potential impacts to national security and potential courses of action. The purpose of the primer was to help level set the discussions, which would include people with varying degrees of expertise on different aspects of the industry, DoW requirements, and public policy options.

C. Gameplay Preparations

Prior to actual gameplay, attendees participated in a series of presentations and facilitated discussions on important topics facing the aluminum industry and the potential national security implications. These sessions were invaluable in facilitating the exchange of information, perspectives, concerns, and opinions between the participants. The schedule for these discussions was as follows:

Day 1:

1330–1400	Civilian and Defense Demand for Aluminum
1400–1430	World Aluminum Industry and Supply Chains
1445–1545	National Defense Stockpile 101
1545–1700	Challenges Facing the Domestic Industry

Day 2:

0830–0930	National Emergency Demand for Aluminum
0930–1200	Potential Mitigation Options

D. Gameplay Part 1 – Scenario

The players were given the following scenario within which to operate:

- It is January 1, 2025. Players have a set of policy options and a budget to prepare the domestic aluminum industry to better meet DoW's needs for a future large-scale combat operation.
- There will be a major large-scale combat operation in 2027, plus a concurrent small-scale contingency. The operation is expected to last one year.
- The players' task is to increase the capacity of the aluminum industry prior to and after the conclusion of the large-scale combat operation.

roles often include red cell (opposition/adversary), blue cell (usually the United States), or white cell (responsible for game adjudication).

- The players need to evaluate the implications of potential cutoffs of aluminum imports.

The purpose of the January 1, 2025 start date was to simplify the instruction that the players have two years to prepare for a conflict. Players were instructed to treat as a certainty that a conflict would take place in 2027, and that there would be a considerable period of reconstruction after that. Players were further instructed not to differentiate between potential wartime losses and the subsequent demands during the rebuilding period. There would be a very large—a five times increase—in annual defense demand for defense products containing aluminum. This demand increase was purposely set high so that players would be unable to satisfy demand based on existing U.S. production capacity. They would be forced to explore other alternatives to mitigate the risk associated with insufficient supply availability in the scenario.

Finally, players were instructed to act as if they were an independent commission established by Congress to provide recommendations on policy and investments related to the aluminum industry that Congress can then enact into law and the executive branch agencies can execute. Players were instructed to set aside consideration of the political viability of the options they recommend (i.e., they should develop options as if they know their recommendations will be implemented).

Players then decided what improvements to make to help domestic industry better meet U.S. national security needs.

E. Gameplay Part 2 – Mechanics

The players, approximately 80 people from DoW, other government, and industry, were divided into six tables of 12–13 people each. Each table had a notetaker, provided by IDA.

1. Vignette Overview

The gameplay was scheduled for three hours on Day 2, during which time the players—industry and government—would work through three vignettes and prioritize government policy actions, including budget expenditures. Each vignette lasted six years, from 2025 until the end of calendar year 2030. Each table had the same budget for each of the three vignettes—$12 billion for the first vignette, then $3 billion, then $1 billion. The budget for each vignette was given as a total amount for the six-year period.

Each table was required to allocate funds and make decisions regarding the execution of policies that will shore up aluminum supply for the DoW. Players were reminded that some actions might not have monetary costs associated with them. The design for the vignettes was intended to force the players into continuing to focus their priorities as budget resources were reduced. This fundamental design feature proved highly successful.

With only government players present, a second game was played, this one with 25 people divided between two tables. In this game, players were given a $3 billion budget, but were presented with some important disruptions:

Table 1:

- A cyber-attack has led to the loss of power to the smelter Alcoa-Massena in Massena, New York.
- Labor Strikes in Canada have delayed all shipments of aluminum products by six months.

Table 2:

- Arconic's HPA production facility in Davenport, Iowa is brought offline for three years due to the effects of extreme weather (or any other reason; the point being that it is currently a single point of failure).
- Due to political unrest, all exports from Brazil have been cut in half.

2. Action Cards

Each team was provided with a set of action cards to help organize their discussion. The cards were divided into four categories: Stockpiling, Policy, Investment, and International Partnerships. An Action Card example is provided below in Figure 3. Each card had a space for noting the cost/budget allocated to that action by the team, and for other notes as needed.

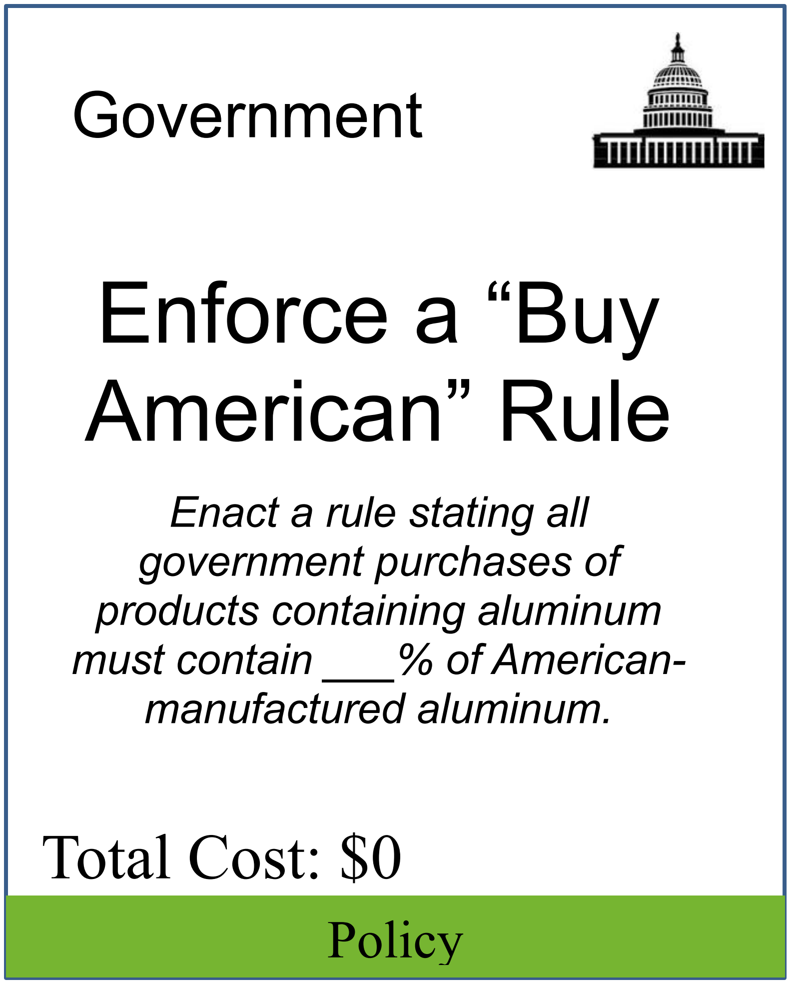
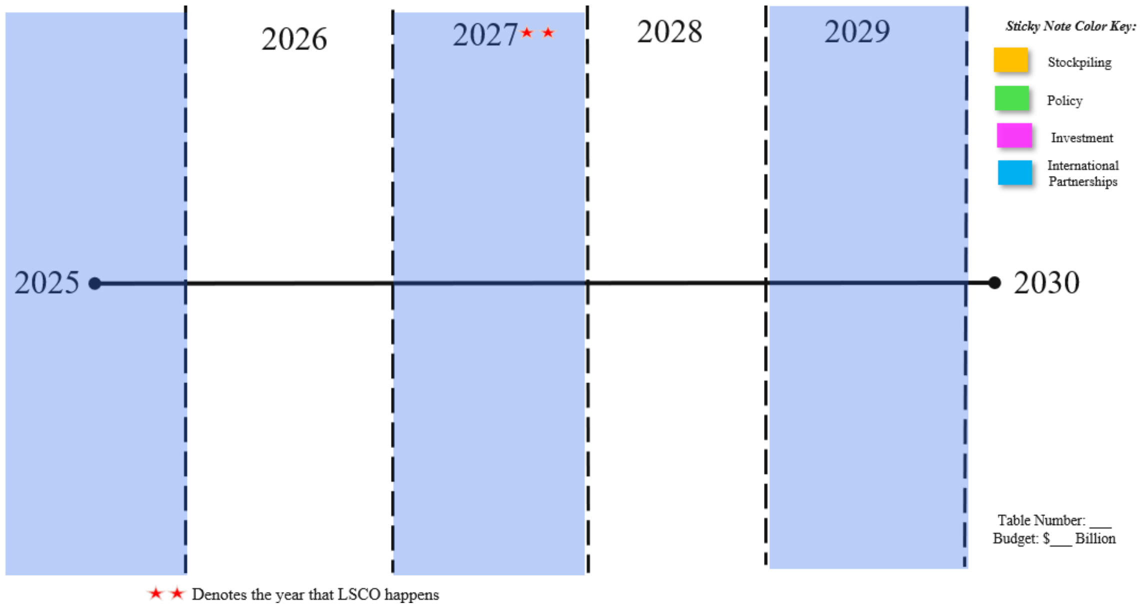


Figure 3. Example Action Card Given to Wargame Participants

Teams were not limited to using the action cards provided to them. They had additional "wild cards" that could be used to propose any action. In the end, while the action cards covered a significant portion of the actions that teams wanted to take, wild cards were also used liberally.

Each table had three wall charts, one for each vignette, where they posted their actions on a timeline. A blank wall chart is shown in Figure 4.



Note: LSCO: Large Scale Contingency Operation

Figure 4. Timeline/Wall Chart Used to Allow Wargame Participants to Place Actions

To officially play an action, the team posted the sticky note on the wall chart, corresponding to the action card completed at their table. The sticky note was placed on the chart at the time in which the effect of the action would be realized/completed (rather than when the action was initiated). See Figure 5 for an example of a completed wall chart.

Figure 5. Example of a Completed Wall Chart with Actions

3. Observations

Following each gameplay session, each table designated a spokesperson to describe their priority actions, by vignette, to the entire group. As each spokesperson presented, attendees had the opportunity to ask questions and dialogue with the team about their decisions. These facilitated discussions allowed members of various teams to engage with each other, debate the pros and cons of various actions, ask for clarifications, and explore other aspects of both the challenges presented by the scenario and the ability to mitigate risk via the action cards.

The use of the three vignettes with various budget levels in the first game generated some unexpected outcomes. Generally, members of all tables felt that the $12 billion allocation was sufficient for them to enact all of the action cards they desired. Some, though not all, participants also felt that the $3 billion allocation allowed them to effectively address the most important actions. The $1 billion vignette constrained player actions and was a small subset of the actions displayed on the $12 billion and $3 billion wall charts.

As mentioned previously, players were free to use wild cards in addition to the action cards developed for gameplay. Table 2 includes a listing of the unique action cards played by attendees.

a. Areas of Commonality

There was broad agreement on many actions, with most teams consistently choosing the same actions across multiple vignettes. This may be attributed to the extensive pre-game discussions on days one and two, which likely highlighted the most salient options before gameplay began. Also, due to budget constraints, the most popular actions tended to be those requiring lower levels of investment.

Teams generally perceived challenges across the supply chain, and consequently tended to apply smaller actions in multiple stages as the budgets became smaller. This occurred during the $3B and $1B vignettes, where the $12B featured large investments in the most critical areas.

In discussion and gameplay, actions to expand industrial capacity to meet increased demands were accompanied by actions intended to support the long-term viability of the aluminum industry. Most teams were not solely concerned about meeting the demand surge during the scenario, given the underlying longer-term needs of the aluminum industry. Rather, teams took action to both address defense needs based on the scenario, and invest in the long-term health of the industry.

b. Frequently Played Action Cards

Across all tables, and across all vignettes, several action cards were played. The most a particular action card could be played was 18 times (six tables, three vignettes). Table 2 lists all action cards next to their frequency of play; cards not played are not listed. All action cards provided to players were used at least once, with one exception: the card titled Exchange Best Practices. It may be that this action was interpreted as vague, or not relevant to player priorities.

As can be seen in Table 2 the most played card was the action to lower energy costs. This action could be achieved either through direct investment or by mandating price controls. This action was seen as critical for the long-term viability of the industry, and some players suggested that it was necessary to warrant expanding production capacity.

Reopening a closed primary smelter was also seen as an important way to increase domestic capacity, and more cost-effective than building a new smelter. For example, action to invest in building a new smelter was only taken in during the $12B vignette. Other important investment options highlighted through frequency of play included expanding capacity at advanced fabrication (AdFab) facilities, primary aluminum smelters, and the domestic alumina producer.

Table 2. Action Cards (including Wild Cards) Ordered by Frequency of Play

Action Card	Total Count
Lower Energy Costs	16
Reopen Closed Primary Smelter	12
National Recycling Initiative	12
Stockpile Alloy Material Inputs	12
Expand Existing AdFab	12
Relax Environmental Regulations	12
Invest in R&D	11
Expand Existing Primary Smelters	11
Expand Existing Alumina Capacity	11
Stockpile HPA	10
Accelerate Permitting Process	9
Workforce Training	9
Pursue SOSA	9
Build New Smelter	7
Invest In Low Cost Non-Interruptible Energy	7
Keep Tariffs	7
Limit Scrap Exports	6
Qualify Foreign Source	5
Lower Tariffs	5
Expand Existing HPA Production	5
Increase Tariffs	5
Stockpile Inputs For Primary	5

Action Card	Total Count
Stockpile Bauxite	5
Issue Demand Guarantee	4
Prepare Defense Critical Priorities	3
Expand Recycling Capacity	3
Cybersecurity Protections	3
Stockpile HPA Alloys	4
Demand Planning	3
Buy America Rule	3
Build New Cathode Facility	3
Stockpile Fabricated Parts	3
Build Alumina Silos	3
Stockpile Alumina	3
Protect U.S. Interests In Aluminum Inputs From Foreign Sources	3
Portion of 232 Tariff Revenue Given To Primary Aluminum Industry	3
Clear Rules On Tariffs To Reduce Uncertainty	3
Build New AdFab Facility	2
Build New Alumina Refinery	2
Subsidize Users of Domestic Aluminum	2
Relax Design Requirements of DoW Systems	2
Keep Reservists In Industry	2
Incentivize Co-investment	2
Exemption of Jones Act	2
Change OSHA Rules	2
USG Backed Price Ceiling	1
Stockpile Aluminum Refining Ingot	1
Tariff Protection	1
Relax USG Design Requirements	1
Industry Exemption on Jones Act	1
Expand Alumina Refinery	1
Stockpile Primary Aluminum	1
Stockpile Aluminum Refining inputs	1
Stockpile AdFab	1
Restrict Other Exports	1
Recycling Incentives	1
Prepare Emergency Playbook	1
Invest In Automation	1
Exempt Federal Tax For Qualified Sector Workers	1
Decrease Tariffs	1
Consider Canada And Australia Domestic	1

Recycling initiatives were embraced by participants as a low-cost way to increase the availability of primary aluminum for essential applications. Players envisioned this action as achieved through a multi-pronged approach: introducing national incentive programs, limiting the exports of scrap, funding R&D opportunities, and mandating recycling procedures for highly desirable alloys.

Of the stockpiling action cards, the most played cards were focused on stockpiling materials used for aluminum alloys. Players recognized that many of the alloying agents have at-risk supply chains of their own. The next most frequent stockpiling priority was HPA.

With respect to policy actions, relaxing environmental regulations, accelerating permitting, building the workforce, and pursing Security of Supply Agreements (SOSAs) were all frequently played action cards. Regarding tariffs, there were different strategies at play, while all teams favored some sort of tariff, each created a tailored strategy to lower tariffs on some items (e.g., inputs) and raise them on others (e.g., similar foreign products). Sometimes tariffs were lowered early on and increased in later years of the scenario. The general consensus was to use tariffs to help the industry compete in world markets.

4. Leadership Panel

A leadership panel of government officials was convened on the third day of the wargame to review and discuss with the government participants the initial results of the wargame. This was an opportunity to explore and discuss with senior officials the most serious challenges facing the industry, the risks to DoW and national security, and the relative importance of potential policy (mitigation) options.

The following officials participated in the panel (listed in alphabetical order):

- Dr. Rian Bahram (Department of Energy)
- Ms. Laura Beasley (National Nuclear Security Agency)
- Mr. Matthew Beebe (DLA)
- Mr. Adam Burstein (OUSW for Acquisition and Sustainment)
- Dr. Matt Draper (OUSD for Acquisition and Sustainment)
- Ms. Sonya Ebright (DCMA)
- Brigadier General Stephanie Howard (OUSD for Acquisition and Sustainment)
- Mr. Ryan Peay (Department of Energy)
- Ms. Katie Reid (Department of Commerce)
- Mr. Reggie Singh (State Department)
- Mr. Leland Smith (National Security Council)

The benefit of the panel to the wargame attendees, particularly those from industry, was to see how government officials weigh arguments when considering the need, or request, for government action. The benefit of the wargame attendees to the panel was to hear first-hand, from experts, about the most important challenges facing a critical industry.

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3. Mitigation Options

A. Introduction

The DLA Aluminum Wargame included approximately 80 participants from industry and government. During extensive discussions and gameplay—the wargame itself is described in detail in the next chapter—the participants reviewed and debated numerous options for addressing the risks faced by the DoW that result from the aluminum industry's challenges. There was widespread agreement developed during the wargame on most of the actions that the U.S. government could take to improve industry capabilities and responsiveness to DoW requirements. Some actions might be appropriate for the DoW to undertake, while others might be led elsewhere in the executive branch, with potential DoW input and involvement.

Some differences of opinion emerged regarding how to prioritize those potential government actions, and these will be highlighted here. These differences, and the reasoning behind them, represent some of the main decision-making challenges that DLA and DoW leadership will face as they seek to address the potential risks posed by aluminum supply chains.

A related challenge for DoW leaders is to determine what role the DoW must take to address industry challenges that affect the military. Many of the policy actions and mitigations proposed by wargame participants were directed towards improving overall aluminum industry outcomes (rather than being narrowly focused on DoW interests). Two examples popular among the participants included implementing higher tariffs on primary aluminum imports (although this was not supported by those representing the views of aluminum consumers), and taking action to address the domestic industry's need for reliable and affordable power. While there was widespread agreement that these actions would benefit the aluminum industry, the question of DoW's role relative to the rest of the government was beyond the scope of this wargame. Further questions remain regarding when DoW should employ its resources to address industry challenges, and when DoW should rely upon U.S. industrial policy responsibilities that lie elsewhere in the government.

Finally, one of the biggest challenges for DoW and other government leaders is considering the impact of particular measures across a time horizon. In the scenario used for this wargame, participants were directed to prepare for a major conflict in two years' time. That is to say, they were given a forecast of a conflict in 2027, to be followed by a period of large-scale reconstitution (2028–2030). The sooner the conflict, the less time to benefit from major investments in expanding industry capacity. The long-term fix may be to build a new smelter (4–6 years), or reopen closed production facilities (2–3 years), but what about meeting DoW's shorter-term requirements for aluminum and HPA in two years or less? The recommendations from the wargame must be considered in light of this timing issue. A comprehensive risk mitigation strategy will, ideally, incorporate measures to address immediate needs while also investing in building sufficient, secure supply in the longer term.

B. Seven Broad Areas for Mitigation

The options and ideas developed during the wargame for potentially mitigating DoW's challenges with respect to the aluminum industry fell into the following seven broad categories, and are discussed in detail in the remainder of this chapter.

1. Stockpile as a Near-Term Hedge
2. Improve Access to Affordable, Reliable, Non-Interruptible Power
3. Rebuild Infrastructure
4. Build the Workforce
5. Support International Access
6. Incentivize Recycling
7. Create/Leverage Policy

Responsibility for many of these potential mitigations falls to departments and agencies outside DoW. In those cases, DoW will need to engage with its interagency partners to determine what its own role should be.

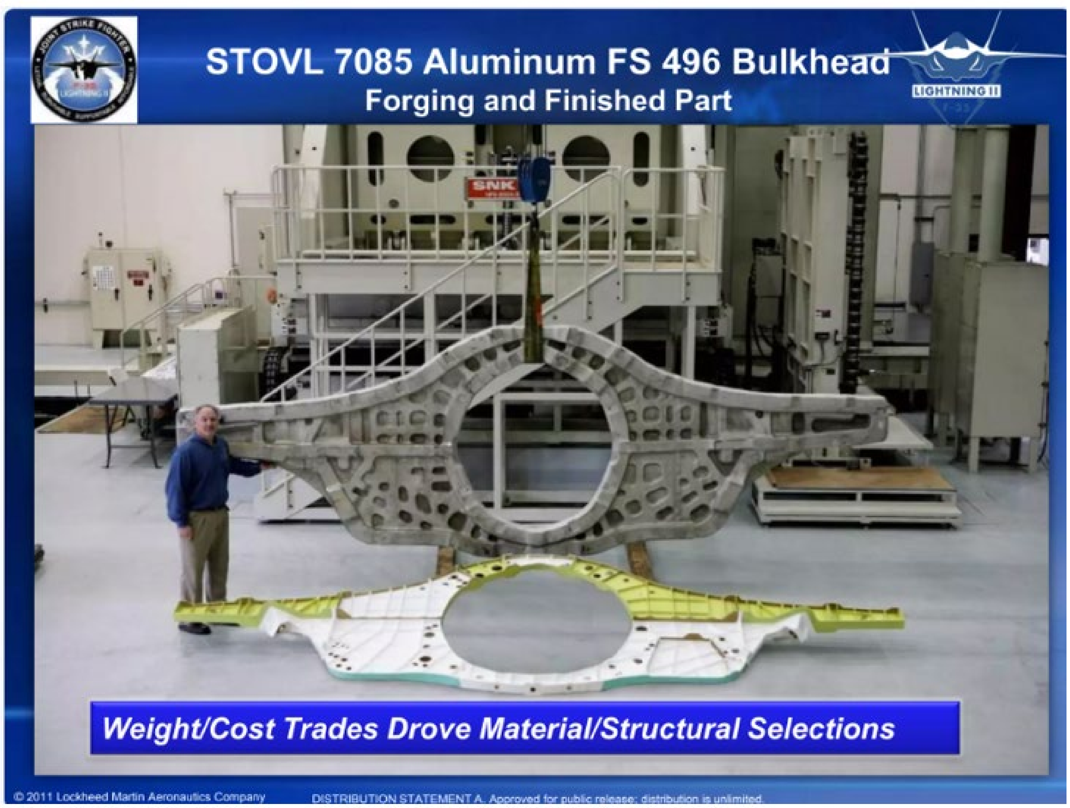
1. Stockpile as a Near-Term Hedge

The complexities in addressing DoW requirements and industry challenges were seen immediately and repeatedly in discussions about the potential value of stockpiling HPA. The DoW needs significant amounts of HPA for military systems, and there currently is only one U.S. producer—so stockpiling is seemingly an obvious choice. However, while there was support among wargame participants for stockpiling some HPA, most participants emphasized (a) immediately expanding industry capacity to produce both primary aluminum and HPA, and then (b) stockpiling alloy materials required for specialized HPA products. In other words, they chose to solve the underlying problem of domestic production capacity rather than the near-term solution that does not reduce a longer-term dependency on imported HPA.

As one participant noted, "Production and stockpiling of high purity aluminum was a major focus of the Wargame. We agree that this is critically important...However, we believe that funding and policies to address energy costs and energy availability, and investing in existing, aging infrastructure, should be primary areas of focus in the final report you develop."[12]

Participants also chose to address the potential risk of disruptions to alloy supply chains critical to HPA. The challenges posed by the U.S. dependence on and risks to strategic material and mineral supply chains were emphasized throughout the wargame.

AdFab production capacity—the capacity to roll, extrude, press, or forge HPA—was a source of considerable concern to most participants, and highlighted as a critical bottleneck in the production of DoW end-items. Figure 6 displays a forged and finished part for the bulkhead of the F-35. The ability to produce such a part only exists at a few AdFab facilities.



Source: Lockheed Martin Aeronautics Company

Figure 6. Forged Part for the F-35 Made with HPA

In fact, more attention was given to stockpiling these intermediate products, and some of the equipment required to make these products, than to stockpiling HPA. But again,

[12] Post-game communication received from Participant D04.

stockpiling is an effective near-term fix while longer-term solutions such as bolstering AdFab redundancy and resiliency are undertaken.

There was widespread agreement on the need to stockpile alloying materials. However, since the amount and type of alloys to stockpile depend upon detailed knowledge of current demand profiles, supply sources, and supply chain risk assessments, specific and quantitative recommendations were beyond the scope of this wargame. Nonetheless, the stockpiling of alloys, and key inputs to alloy production—such as lithium, manganese, magnesium, zinc, and nickel, among many others—remains a strong recommendation.

Finally, some participants proposed stockpiling bauxite as a relatively inexpensive means of ensuring against supply disruptions during a national emergency. This suggestion met with considerable debate, as the proposed action rests on non-expert concerns about the risk of supply disruptions from Jamaica, the major source of bauxite to the domestic industry, as well as from other countries and regions, such as Brazil, West Africa, and Australia. DoW leaders are best positioned to evaluate country-specific risks.[13]

2. Improve Access to Affordable, Reliable, Non-Interruptible Power

One of the strongest concerns raised by industry participants in the wargame relates to U.S. government policy and the competitive disadvantage faced by the domestic industry due to the lack of affordable, reliable, and non-interruptible power. This is a challenge faced by many U.S. industries, but it has had a devastating impact on the aluminum industry, where power costs can account for as much as 40 percent of total production costs.[14] This is a problem that is independent of the subsidized power available to many foreign competitors, including Canada and Australia.

One industry participant reported:

> [With foreign production] at 40% of the cost and 80% of emissions, the fundamental challenge of the domestic primary aluminum industry is the availability and affordability of electricity. A clean, competitive, reliable source of electricity is required for the U.S. industry to compete globally.[15]

Another industry participant emphasized the same point:

> Over the past 30 years, primary aluminum production in the U.S. has declined significantly, largely due to two factors: The deregulation of electricity, which increased the market rate for electricity; and oversupply of aluminum imports from China and Russia that undercut the

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13 DoW leaders and intelligence community representatives may wish to further explore the potential for the disruption of U.S. imports during a major conflict.

14 Source: Christopher Watson, "U.S. Aluminum Manufacturing: Industry Trends and Sustainability," (Congressional Research Service, October 26, 2022), https://www.congress.gov/crs-product/R47294.

15 Post-game communication received from Participant D01.

> competitiveness of U.S.-manufactured aluminum. Electricity availability and pricing remain significant headwinds to investment and expansion of primary aluminum production…The deregulation of U.S. electricity prices starting in 1977 led to a drastic increase in industrial electricity rates and was the single most important factor leading to the near total demise of the primary aluminum industry.[16, 17]

Aside from affordability, wargame participants expressed great concern over power reliability. An example discussed repeatedly is the potential for a catastrophic loss of power at a smelter. Reportedly, if power is lost for as little as three hours, the damage to the facility (from frozen pots) would require a shutdown and refurbishment period that according to industry representatives, could, last one to three years.

Considerable attention during the wargame was devoted to promoting options for reopening old coal power plants and opening new natural gas and/or nuclear power plants. Industry representatives also recommended regulations that would stabilize pricing in the face of the fractured nature of the U.S. power generation industry and transmission systems. An example of this problem is the current demand for power by the proliferation of data centers. Well-financed tech firms are out-bidding aluminum facilities, and other industries, in local markets for electricity, according to both industry and outside observers.[18]

If this is one of the biggest problems facing the domestic industry, it also provides the clearest example of the potential limits of DoW's role and ability to take action, as leadership on these issues lies with other government agencies, including the Departments of Energy and Commerce. DoW can impress upon other government policymakers the importance of addressing the aluminum industry's challenges, but are DoW leaders willing to use DoW resources as part of a combined government action on power access and reliability? The overwhelming consensus was that DoW should work closely with other executive branch agencies in a whole-of-government effort to address the power needs of U.S. industries important to national security, but there was less of a consensus on the specific role that the DoW should play.

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16 Post-game communication received from Participant D03.

17 Today there are only four smelters remaining.

18 Wargame participants were generally unaware of the Department of Energy Priorities and Allocations System, which can, depending on the precise circumstances, be leveraged to help address these concerns.

3. Rebuild Infrastructure

Wargame participants placed a high priority on reopening old and opening new facilities. This would not only aid the production of primary aluminum, but also enable the expansion of domestic HPA production.

As one participant explained:

> The infrastructure from refining to smelting, to advanced fabrication (AdFab) is all ancient. The newest infrastructure is early seventies, most is 40s and 50s, and some is early 1930s. We need about $3B in infrastructure to revitalize the sector…Reopening two closed warm smelters and reopening lines on open smelters [is another high] priority. [This] will double U.S. true capacity and output for primary aluminum in the US…[at a] cost of about $500M compared to $10B to open two new smelters.[19]

A related policy measure would be to increase government-supported R&D into new production technologies that could help the industry catch up to, if not surpass, foreign competitors.

Again, the question for DoW decision-makers is whether it is desirable or appropriate to devote DoW resources to rebuilding the industry, or whether DoW actions should be limited to support for action by other government agencies.

4. Build the Workforce

Another obstacle to increasing industry production capacity is the insufficient number of qualified workers, both in the (blue collar) trades and among engineers (especially metallurgical engineers). While wargame participants identified numerous actions that need to be taken to rebuild infrastructure—e.g., investing in new smelters, upgrading and expanding existing facilities—they also recognized that finding enough qualified employees for current industry requirements, not to mention an expanded industry, would be a major challenge.

There are numerous workforce training and incentive programs throughout the U.S. government. This includes the DoW, which has its own suite of programs to attract workers into technical specialties that support the defense industrial base. DoW's Innovation Capability and Modernization office (through their Industrial Base Analysis and Sustainment program) invests in bolstering the flow of skilled industrial workers needed for the production of complex defense weapon systems. There was some discussion of such programs during the wargame, and government and industry participants agreed that such efforts should be better promulgated within industry to be sure that existing programs are leveraged to their maximum potential, with particular benefit to the aluminum industry.

[19] Post-game communication received from Participant G01.

An important question for DoW leaders to consider, once again, is what role DoW should take beyond existing workforce efforts and programs, and what additional DoW resources should be expended, to address a major problem facing the entire economy.

5. Support International Access

Wargame participants expressed widespread concern over U.S. access to key inputs necessary for aluminum production in the event of a major military conflict and smaller-scale contingency. There was, not surprisingly, the most agreement on the need to secure access to critical alloy materials. Access to sources of alumina production was also given a high priority, unless and until U.S. production capacity increases. Numerous single points of failure were of concern to wargame participants, who expressed a strong desire to build redundancy and reduce foreign reliance.

The concern over access to bauxite was mixed among players, as many recognized that the risks during a major conflict where the ability to access foreign sources of supply are difficult to anticipate. Which, if any, key foreign suppliers will refuse to export material to the United States during a major conflict? (Participants focused on bauxite because the U.S. imports 100% of bauxite needed for alumina production.) This is not the case for downstream production nodes (alumina production, primary aluminum production, HPA production). What delays in first-party or third-party shipping might ensue? Might material coming from overseas be subject to shipping losses? In what quantities might overall imports be affected, and for how long? What if the United States or DoW is willing to pay more for these imports on world markets? These topics, while of critical importance, were beyond the expertise of most participants, and beyond the scope of an unclassified wargame.

One mechanism for reducing risk associated with foreign reliance is to maintain strong partnerships with friendly international suppliers. One example of this, which received considerable discussion, is strengthening supply arrangements through the use of SOSAs, which were viewed as potentially effective, even given their non-binding nature. SOSAs allow DoW to request priority delivery of defense goods and services from companies that reside in SOSA countries.[20] Canada has a special arrangement with the United States based on a Memorandum of Understanding negotiated by the Department of Commerce, which provides support for prioritization of U.S. defense purchases in Canada.

[20] SOSA countries include Australia, Denmark, Estonia, Finland, Germany, India, Israel, Italy, Japan, Latvia, Lithuania, the Netherlands, Norway, Republic of Korea, Singapore, Spain, Sweden, and the United Kingdom. See https://www.businessdefense.gov/security-of-supply.html.

Expanding such arrangements to countries from which the United States imports significant amounts of materials used to produce aluminum, as well as aluminum and HPA producers themselves, could help facilitate the flow of material during times of crisis.

6. Incentivize Recycling

Although secondary aluminum cannot be used in most defense applications, scrap can play an important role in defense readiness. Several industry experts at the wargame stressed the importance of recycling, especially as a means to increase the supply of secondary aluminum, thereby reducing some of the demand for domestic primary aluminum, which might also help to alleviate supply constraints experienced by the defense sector. In this (post-consumer) scrap form, the energy requirements are dramatically lower, allowing for relatively less costly increases in domestic production. A significant amount of recyclable aluminum is either lost (to landfills) or sent overseas, where U.S. competitors use it to their advantage (although recycled aluminum cannot currently be used in primary and HPA applications). Improving and developing automated sorting and other recycling technologies would drastically improve the ability to use post-consumer aluminum scrap. An additional goal would be to improve technical capabilities for the recycling of HPA alloyed scrap, in particular, which could then be reintroduced into the production process.

Government action to incentivize recycling could range from return deposits on containers to contractual obligations, regulatory changes, and investments in R&D for recycling. Recycling campaigns could be targeted to defense contractors, and/or oriented to a nationwide campaign.

7. Create/Leverage Policy

Four additional and potential policy actions—actions with no budgetary impact to the government—are important to mention here.

The first is tariffs and trade policy. The view of industry participants is that "The U.S. aluminum industry cannot effectively compete against unfairly traded products from China—nor defend itself against circumvention—without strong and sustained trade policy support."[21]

The second is government regulations. Industry participants, in particular, note the cost burden to domestic manufacturers of regulations that foreign competitors do not face. These include environmental regulations, state regulations that may be more stringent than federal regulations, and reporting requirements.

The third is the use of Defense Priorities and Allocations System (DPAS). The purpose of DPAS is to "assure the timely availability of industrial resources to meet current

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[21] Post-game communication received from Participant D02.

national defense and emergency preparedness program requirements and to provide an operating system to support rapid industrial response in a national emergency."[22] Administered by the Department of Commerce's Bureau of Industry and Security, DPAS implements the priorities for national defense and emergency preparedness as specified in DPAS regulations and DoW guidance.[23] Wargame discussions highlighted a general lack of knowledge about DPAS, and how it can be used to aid industry in prioritizing the delivery of particular DOW-required items via rated orders or other actions.

The fourth is a proposal for the development of "Contingency Playbooks," akin to contingency plans for potential military conflict. The idea is for DoW and its government partners to focus on the single points of failure and other high risks that are most likely to be encountered in a major contingency, and develop a set of "Plan B's" including alternate sources that can be called upon in a crisis. These playbooks might include emergency procedures for things such as faster qualification procedures, abbreviated mining permit processes, and other process aspects that will be needed during a time of crisis.

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[22] https://www.dcma.mil/DPAS/.

[23] See DPAS Regulation as written in 15 CFR 700, https://www.ecfr.gov/current/title-15/subtitle-B/chapter-VII/subchapter-A/part-700; and the DPAS Manual, DoD4400.1-M, https://www.bis.doc.gov/index.php/documents/sies/497-department-of-defense-s-priorities-and-allocations-manual-dod-4400-1-m/file.

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4. Next Steps

DLA could take several actions in response to the findings and recommendations of this wargame.

1. Interagency Engagement. Because many of the recommendations from the wargame lie outside the authorities of DoW, DLA will want to work with the Office of the Secretary of War (OSW) on engagement strategies for engaging with DoW's interagency partners on topics such as critical materials, energy access and affordability, support to (industrial policy for) the aluminum industry, and the impact of recycling. The goal is to be able to explain the value to DoW and national security of U.S. government actions that promote a healthier aluminum industry.
2. Warstopper. DLA is now better positioned to conduct industrial capability assessments on the Warstopper Program on topics such as alloys, inputs to alloy production, cathodes, and other equipment and parts. DLA will also want to determine the appropriate DLA program to lead acquisition efforts.
3. National Defense Stockpile. The outputs from the wargame provide valuable inputs to the National Defense Stockpile as it considers its own recommendations on stockpile strategies for specific materials.
4. Supply Chain Risk. The wargame provides some useful insights that DLA may employ in working with OSW and other partners on assessments of international supply chain risk, and the identification of risk-mitigating activities to build resiliency in the face of significant foreign reliance and single points of failure.
5. Contingency Playbooks/Resource Allocation Plans. DLA will want to engage with OSW in the development of Contingency Playbooks and resource allocation plans.
6. R&D. The Aluminum Wargame highlights the risks to DoW missions due to the fragility of this industry and the risks to important supply chains. DLA will want to consider these risks when evaluating or supporting emerging R&D efforts.

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Appendix B.
Abbreviations

AdFab	advanced fabrication
DCMA	Defense Contract Management Agency
DIBCoL	DLA Industrial Base Campaign of Learning
DLA	Defense Logistics Agency
DoW	Department of War
DPAS	Defense Priorities and Allocations System
HPA	high purity aluminum
IDA	Institute for Defense Analyses
OSW	Office of the Secretary of War
R&D	research & development
ROW	rest of the world
SOSA	Security of Supply Arrangement
UAE	United Arab Emirates

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