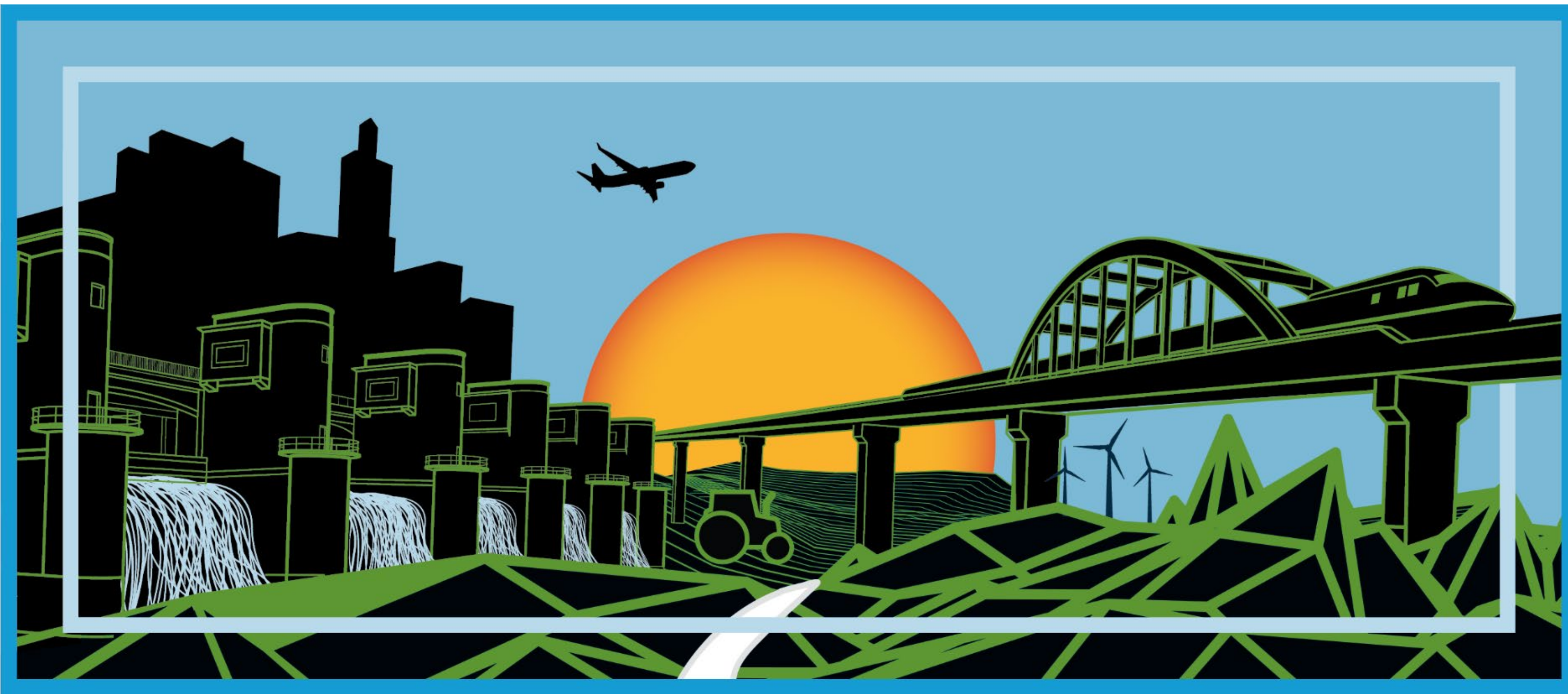

# Secure Tomorrow Series

# Alternate Futures: Advanced Manufacturing Player Guide

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## BACKGROUND

**How prepared are critical infrastructure sectors in light of potential advances in the advanced manufacturing ecosystem?** *Alternative Futures: Advanced Manufacturing* presents you with scenarios that could plausibly occur within the next three to seven years. During each round, you and your opponents will take turns proposing initiatives and debating strategies that will shape critical infrastructure resilience and security in light of potential advancements in advanced manufacturing processes and technologies. How successfully you manage to present your arguments for (or against) these initiatives determines their chances of success. Depending on your role for the round, you can score points for either successfully implementing or countering initiatives.

The Cybersecurity and Infrastructure Security Agency's (CISA) National Risk Management Center has developed this game to assist stakeholders across the critical infrastructure community to self-facilitate and conduct foresight activities that will enable them to derive actionable insights about the future, identify emerging risks, and proactively develop corresponding risk management strategies to implement now. One goal of the Secure Tomorrow Series is to develop a repeatable and defensible process that (1) identifies emerging and evolving risks to critical infrastructure systems, and (2) identifies and analyzes the key indicators, trends, accelerators, and derailers associated with those risks to help critical infrastructure stakeholders direct their risk management activities.

For players, the game hopefully represents a fun and interactive way for you to think broadly about future threats and opportunities, learn from your peers, and identify strategies to inform preparedness activities.

The game takes about three hours to complete. This includes an introduction and description of the current state, three rounds of gameplay (each about 45 minutes long), and a final 20-minute open-discussion period to collect any final feedback from players and wrap up the game.

## PLAYER ROLES AND ASSIGNMENTS

At the start of the game, each player will be assigned one of three roles. Players will rotate roles in subsequent rounds, so that they fill different roles through the course of the game. The three roles are as follows:

- The Innovator(s): Responsible for developing initiatives and arguments in support of those initiatives.
- The Devil's Advocate: Responsible for developing counterarguments to the initiatives proposed by the Innovator.
- The Judge: Responsible for adjudicating the validity of the Innovator's arguments versus the counterarguments made by the Devil's Advocate for a particular initiative and determining the initiative's likelihood of success.

Players will bring their personal knowledge, experience, and perspectives to debate strategies that will shape critical infrastructure resilience and security in light of potential advancements in the advanced manufacturing ecosystem. Players should consider policies, programs, investments, public-private partnerships, research and development, or other actions that, if successfully put into motion today, they believe will better position and prepare one or more critical infrastructure sectors for the future. In preparing for the game, players may want to think about the following questions:

- What risks and opportunities are associated with current trends in advanced manufacturing processes and technologies?

- What are the implications for future critical infrastructure resilience and security?
- Are there specific ramifications for one or more critical infrastructure sectors?
- Are there other trends that may influence potential advancements in the advanced manufacturing ecosystem?

## PRESENT STATE

Advanced manufacturing describes the use of innovative technologies and processes—such as artificial intelligence, automation, robotics, 3D printing, sensors, and big data analytics—to make existing products and create new ones. Advanced manufacturing technologies have led to increased efficiency, safety, productivity, and other benefits in various industries, including the aerospace, automotive, chemical, and electronics industries. Some examples include the following:

- A manufacturer of high-precision parts for the aerospace industry implemented a manufacturing execution system to help automate assembly and ensure quality control. Sensors on the factory floor capture processes down to the number of times a screw has been turned; a software system then uses this data to adjust assembly functions.
- A medical-device manufacturer uses 3D printing to create components that are recyclable, replacing plastic parts with organic materials that break down upon disposal. The company also employs sensors and automation to monitor and track production in real time, allowing for more efficient energy and water usage.

Current drivers affecting future developments in advanced manufacturing include the following:

- Rapid prototyping methods that combine 3D printing, printed electronics, and fabrication capabilities will enable products that are tailored to individual needs and shorten design-to-production lifecycles.
- Digitalization of production (e.g., use of digital representations) will allow manufacturers to capture data throughout the product lifecycle, allowing for digital traceability.
- Advances in algorithms for smart machines will increase use of autonomous systems and will necessitate new approaches for human-machine interactions.
- Growing emphasis on supply chain innovation will facilitate sustainable sourcing of raw materials and product recycling.

## PLAYING THE GAME

*Alternative Futures: Advanced Manufacturing* has three rounds, each of which will present the players with a scenario that could plausibly occur within the next three to seven years. In Round 1, the Innovator(s) will have 15 minutes to identify up to three initiatives that will support critical infrastructure resilience and security in response to the specified scenario disruptor. For each initiative, the Innovator(s) will then describe up to three supporting arguments for why the initiative will succeed. The Devil's Advocate will then have 10 minutes to describe up to three counterarguments for each initiative. Each counterargument can be directed at one or more of the arguments presented in favor of the initiative's success or underscore a new concern that may cause the initiative to fail. The Innovator(s) will then have 5 minutes to rebut any or all of the counterarguments. The Judge will listen to both sides of the debate and ultimately determine if each initiative has a high, medium, or low likelihood of success. The Judge will have 5 minutes to present the rationale for his or her determinations and roll a 20-sided die to see if each initiative succeeds or fails.

The die simulates the unpredictability of the supporting environment for initiatives, and the game's inability to account for all positive and negative factors that might influence success.

- An initiative with a **high** likelihood of success will be implemented with a roll of 6 or higher (75 percent chance).
- An initiative with a **medium** likelihood of success will be implemented with a roll of 11 or higher (50 percent chance).
- An initiative with a **low** likelihood of success will be implemented with a roll of 16 or higher (25 percent chance).

An open-discussion period may occur after resolving the success or failure of the initiatives to continue any discussions cut short by previous time constraints.

In Rounds Two and Three, the participants will rotate roles.

## DISRUPTORS

Social, technological, environmental, economic, and political (STEEP) influences have the potential to alter the trajectory of future trends or disrupt them altogether. For example, urbanization is a social disruptor that has the potential to significantly affect the resilience of lifeline sectors and cyberattacks are a technological disruptor with a wide range of cascading implications for all critical infrastructure sectors.

To account for a changing future environment, each round features a STEEP disruptor scenario that may limit player actions, alter the trajectory of current trends in the advanced manufacturing ecosystem, or require players to consider the implications of an event. The possible scenarios to choose from during the game are described in Appendices I–V. As an added incentive for players to craft compelling arguments and counterarguments, the winning player of each round is awarded the ability to select the STEEP disruptor category for the next round.

## WINNING THE GAME

If the Innovator(s) successfully implement(s) a majority of the initiatives, the Innovator(s) win(s) the round. Alternatively, if the Devil's Advocate counters a majority of the initiatives, he or she wins the round. While the game is designed to encourage competition between the players, its main purpose is to generate discussions that develop well-conceived and thought-provoking initiatives. Your collective subject matter expertise is what matters, regardless of the outcomes of each round.

## GAME SCHEDULE

Table 1: Schedule for Conducting the Matrix Game

| MATRIX GAME STAGES (~3 HOURS) | | | | |
|---|---|---|---|---|
| Introduction | - | Welcome participants and discuss game purpose (Controller) | 3 Min | 18 Min Total |
| | - | Explain game rules (Controller) | 5 Min | |
| | - | Practice round | 7 Min | |
| | - | Introduce current state and potential implications (Controller) | 3 Min | |
| Round 1 | - | Introduce future scenario based on STEEP disruption (Controller) | 5 Min | 41–51 Min Total |
| | - | Craft initiatives and present arguments (Innovator(s)) | 15 Min | |
| | - | Present counterarguments (Devil's Advocate) | 10 Min | |
| | - | Rebuttal (Innovator(s)) | 5 Min | |
| | - | Adjudicate arguments and roll die (Judge) | 5 Min | |
| | - | (Optional) Open-discussion period | < 10 Min | |
| | - | Select STEEP disruptor | 1 Min | |
| Round 2 | - | Introduce future scenario based on STEEP disruption (Controller) | 5 Min | 41–51 Min Total |
| | - | Craft initiatives and present arguments (Innovator(s)) | 15 Min | |
| | - | Present counterarguments (Devil's Advocate) | 10 Min | |
| | - | Rebuttal (Innovator(s)) | 5 Min | |
| | - | Adjudicate arguments and roll die (Judge) | 5 Min | |
| | - | (Optional) Open-discussion period | < 10 Min | |
| | - | Select STEEP disruptor | 1 Min | |
| Round 3 | - | Introduce future scenario based on STEEP disruption (Controller) | 5 Min | 40–50 Min Total |
| | - | Craft initiatives and present arguments (Innovator(s)) | 15 Min | |
| | - | Present counterarguments (Devil's Advocate) | 10 Min | |
| | - | Rebuttal (Innovator(s)) | 5 Min | |
| | - | Adjudicate arguments and roll die (Judge) | 5 Min | |
| | - | (Optional) Open-discussion period | < 10 Min | |
| Wrap Up | - | Determine final game status of critical infrastructure security and resilience (Controller) | 5 Min | 20 Min Total |
| | - | Open-discussion period (Players) | 15 Min | |

The Cybersecurity and Infrastructure Security Agency (CISA) has produced these scenarios to initiate and facilitate discussion. The situations described here are hypothetical and speculative and should not be considered the position of the U.S. government. All names, characters, organizations, and incidents portrayed in these scenarios are fictitious. Any positions expressed by fictional characters herein regarding any particular issues or technologies do not represent the positions of CISA or the federal government

# APPENDIX I: SOCIAL DISRUPTOR

## MACHINE-HUMAN INTERACTIONS

*March 3, 2030. One person is killed, and six others injured when an autonomous forklift veers off course at a Dutton & Co. facility. The incident is the latest in a series of near-misses and accidents plaguing the company's new, state-of-the-art metal fabrication facility, which has experts debating whether the company paid sufficient attention to occupational safety when updating the facility.*

*A Dutton & Co. spokesperson attributes Thursday's incident to a failure in systems software. To deliver parts throughout the facility, the company uses several autonomous material-handling vehicles that are guided by sensors using guidance beacons that map the production floor. The spokesperson acknowledges previous incidents in which vehicles veered off course and struck warehouse racks. In the wake of the latest incident, however, the company places further use of these autonomous vehicles on hold.*

*Although this incident seems at first blush to be one of robotic error, plant employees have expressed broader concerns about inadequate training and confusing operational interfaces that they had repeatedly asked management to change—to no avail. A new stamping press in one production line, for example, was connected to sensors to help synchronize the placement of raw metal into the press. Three key devices involved in the production line were each made by different manufacturers, and the safety software and devices were not fully understood by the system integrator, who unknowingly made the system less safe when designing the central control panel. As a result, workers who believed the machinery to be fully deenergized were struck by a robotic arm that activated suddenly. One advanced manufacturing expert notes that the use of autonomous systems does not absolve companies of the responsibility of addressing new machine-human interactions that occur in the workplace.*

***What initiatives can help ensure workforce readiness and safety?***

# APPENDIX II: TECHNOLOGICAL DISRUPTOR

## ADVANCED MANUFACTURING INTRODUCED NEW CYBER VULNERABILITIES

*On March 1, 2030, defense officials order an indefinite halt to a $750 million-dollar small satellite project. The stoppage is announced following reports that Zacrexus Satellite Enterprises, the prominent U.S. satellite manufacturer, was the target of a devastating cyberattack several months back. An investigation of the company's headquarters facility reveals numerous exploitable vulnerabilities, including compromised smart sensor devices, hidden public-facing networks, and upstream supply chain cybersecurity issues.*

*According to the investigation report, the cybercriminals likely sought lucrative intellectual property. Sensitive proprietary digital threads of Zacrexus' satellite blueprints and prototypes have recently been traced to friendly and adversarial countries, raising concerns about illegal component manufacturing of the patented satellite technologies. The availability of this technical data represents a blow to U.S. leadership in satellite manufacturing.*

*In the decision to halt the satellite project, a defense spokesperson cites concerns about potential sabotage associated with the cyberattack. Investigators, alongside Zacrexus engineers, are still working to confirm that the criminal hackers did not alter the digital design files of several satellite components. Moreover, the criminal hackers appear to have gained access to Zacrexus' operational technology systems and may have covertly compromised or even controlled SCADA devices that support Zacrexus' manufacturing processes.*

***What initiatives could ensure that cybersecurity protocols and assessments are implemented within manufacturing facilities? What initiatives could help in the post-event recovery from a cyberattack?***

# APPENDIX III: ECONOMIC DISRUPTOR

## FOREIGN MARKET DOMINANCE IN 3D PRINTING FOR AVIATION

*By 2027, steady advances in aviation 3D-printing technology have resulted in foreign 3D- printing companies becoming the major supplier for Eurocoach Air, Europe's largest aircraft manufacturer. These companies are able to produce 3D-printed parts for aviation at scale, including critical components such as wing control surfaces and landing gear parts. By leveraging 3D-printed parts, the airline industry is able to save approximately 50 percent on the cost of new aircraft and parts replacements and save on fuel costs because of performance improvements that reduce aircraft weight.*

*U.S. aircraft manufacturer XYZ which is prohibited by U.S. regulations from contracting with certain foreign 3D-printing suppliers—faces a degraded market position relative to Eurocoach Air. By 2030, XYZ is suffering steep losses in revenue. In addition, U.S. 3D-printing companies, which are restricted in their suppliers for machinery, feedstocks, and designs, are facing higher production costs and losing market share outside the United States. As a result, by the end of 2030, several of XYZ's parts suppliers go out of business, and major air carriers begin reporting concerns about future parts shortages. Concurrently, U.S. officials implement additional restrictions on the purchase of Eurocoach Air aircraft that contain 3D-printed parts made with designs, equipment, or feedstocks from certain countries, citing concerns over reliability and the risk of sabotage.*

***What initiatives can you think of to address the economic and security impacts to the United States of foreign-market dominance of 3D printing for aviation?***

# APPENDIX IV: ENVIRONMENTAL DISRUPTOR

## NEW OPPORTUNITIES FOR SUSTAINABLE ENERGY

*Throughout 2030, senior energy officials embark on a "Net-Zero Heroes" roadshow, holding a series of press conferences nationwide to highlight transformative advancements in energy-sector capabilities. Policymakers, industry leaders, and researchers alike agree that a revolution is underway in America's energy sector, led by the U.S. advanced manufacturing industry.*

*Press conferences tout the following examples of how advanced manufacturing is accelerating progress in solar, geothermal, and wind technologies:*

- *Atomic-layer printing techniques have led to new solar technologies, such as more efficient eco-friendly semiconductors and the mass production of transparent panels for windows. Solar usage has tripled nationwide, and 10 states have attributed decarbonization gains to solar manufacturing advancements.*
- *Gulf Coast states are leading the country in wind-turbine technologies as they race toward renewable electricity commitments. New coastal hubs for wind energy now have onsite 3D-printing capabilities for blades, turbines, and other structural parts.*
- *3D-printing capabilities have also helped the United States exceed federal wind power development goals, as 22–25 GW wind turbines have progressed from an aspiration to the standard.*
- *In the Midwest, geothermal advancements have played a central role in several state decarbonization initiatives. Advanced automation technologies now allow for remote drilling operations in harsh environments without endangering field crews. In addition, digital twin technologies have led to zero waste in the production of geothermal equipment.*

*Some scholars and leaders, however, are challenging advanced manufacturing's sustainability within traditional energy providers, noting that past advanced manufacturing efforts within petrochemical and oil and gas industries have faltered.*

***What are other ways in which advanced manufacturing can contribute to advancements in the energy sector? What actions can federal and state governments take to ensure that advanced manufacturing's potential is realized in energy transition efforts?***

# APPENDIX V: POLITICAL DISRUPTOR

## REGULATORY OVERSIGHT FOR ADVANCED MANUFACTURING TECHNOLOGIES

*May 31, 2030. Graryx Industries, a growing parts supplier for the aerospace industry, is under fire for the 2029 crash of Patriot Airways Flight 121. The lead federal investigator for the crash, Theodore Lawson, confirms that key components that failed prior to the crash were designed and produced using advanced manufacturing processes. Unconfirmed reports link these components to Graryx Industries, with investigators citing a rushed prototyping process as one contributing factor, noting that the company deliberately ignored structural concerns voiced during multiple inspections. They also note the variability among domestic and foreign sources for the company's raw feedstocks; v Industries mixed these sources.*

*A congressional investigation is imminent as legislators lambaste the lack of regulatory oversight for advanced manufacturing technologies. U.S. House Speaker Paula Thornberry vows to hold hearings soon, demanding to know why Graryx's much-heralded quality and safety measures, such as real-time tracking and artificial intelligence–powered preventive maintenance, failed. She calls for urgency in issuing new federal legislation, noting the absence of binding standards, oversight, or regulatory frameworks for these technologies in numerous states.*

***What initiatives can help ensure the formation of appropriate domestic and/or international advanced manufacturing standards and regulations within critical industries like aerospace?***