Air University Minerva Initiative 2010–11
Energy and Environmental Security

Report of Air University Minerva activities, which introduced strategic foresight methodologies through research, outreach, and professional military education curriculum development for the US Air Force and the Department of Defense

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Contents

1 What Is the Minerva Initiative?

The Minerva Initiative is a Department of Defense (DOD)–sponsored, university-based social science research program initiated by the secretary of defense. The research focuses on areas of strategic importance to US national security policy and seeks to increase the DOD's intellectual capital in the social sciences, improve its ability to address future challenges, and build bridges between the DOD and the larger science community.

In 2010 Air University (AU) was granted Minerva funding from the Office of the Secretary of Defense (OSD) to set up a program focusing on energy and environmental security (EES). Energy, energy resources, and environmental issues are key long-term concerns of the DOD. The US Air Force (USAF) Minerva funding has been used to explore the application of energy and environmental security to the DOD and the US Air Force related to policy, strategy, and operations. This funding is helping the DOD, the US Air Force, and AU establish mechanisms to emphasize these issues through research, outreach, and curriculum development. Activities to attain these objectives include

- development of strategic foresight training methodologies, war gaming, and scenario planning;
- risk assessment and mitigation tools; and
- other issues designed to assist with USAF operational and strategic preparedness in this increasingly complex and changing geopolitical world.

The owl was the companion of the Roman goddess Minerva (the namesake for this OSD program). Minerva was widely revered throughout the ages and heralded as the goddess of wisdom, war, art, schools, and commerce. The owl was her chosen sacred companion–the gift of wisdom is attributed to these birds because they can see what is not apparent to others in the dark. Similarly, foresight methodologies can be used as a tool to assist in the exploration of the dark outer reaches of collective knowledge. Developing foresight methodologies (or net assessments, as some commonly understand similar tools) is important because they can broaden perspectives beyond what is known and beyond conventional probabilistic future scenarios to peer

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into the darkness and illuminate institutional blind spots. Foresight methodologies are intended to develop the ability within and between interrelated expert groups to analyze potential risks and vulnerabilities that lie outside the comfort zone of relative certainty so as not to miss emerging complex security risks that affect the national and international security agenda.

The USAF Minerva Team

Air University and the Spaatz Center for Officer Education have been proud to participate in the Minerva Initiative this past year and look forward to continuing the relationship with colleagues across the DOD, among our allies, and in civilian academe. Energy and environmental security are and will remain significant facets of any national security framework, and it is through programs like Minerva that we can truly build the intellectual capital to address the challenges of the twenty-first century.

General Dynamics Information Technology (GDIT) (http://www.gdit.com/) was awarded the Minerva contract in November 2010 and serves as the prime contractor. Through GDIT, the consultancy firm Global Interconnections (www.globalint.org) accomplishes the primary responsibilities and deliverables set out in the contract. Global Interconnections' lead consultants for the AU Minerva EES Initiative are Dr. Chad Briggs and Mrs. Tracy Briggs, who bring years of interdisciplinary academic, policy-related, and diplomatic experience to the task. Ms. Katie Veazie serves as the senior analyst and program coordinator for all Minerva requirements between GDIT and AU, while Mr. Blair Ellis serves as the GDIT offsite program manager in Virginia.

Dr. Chad Briggs, *Chair of the Minerva Energy and Environmental Initiative, GlobalInt LLC*

Dr. Briggs is at the forefront of outreach efforts for the Minerva Initiative and partnership building across a broad range of national and international sources. His groundbreaking research on foresight strategic planning and risk assessments in areas of importance to national and international security is of particular value as is the work he has introduced to curricular development at AU.

Tracy Walstrom Briggs, *Associate Chair of the Minerva Energy and Environmental Initiative, GlobalInt LLC*

Ms. Briggs has assisted with the ambitious efforts that were built into the Minerva Initiative. She has been particularly focused on the promotional efforts, including the website, research and promotional publications, and workshop development. She has worked closely with Dr. Briggs throughout the evolution of the Minerva Initiative as it has shifted and adapted its focus to reflect the security needs of the USAF and the DOD.

Miss Katie Veazie, *Senior Analyst, Minerva Initiative, GDIT*

Ms. Veazie is employed by GDIT and provides direct support to Dr. Chad Briggs and Ms. Tracy Briggs. She provides customer interface with the Air Force Culture and Language Center for the Minerva Initiative, gives program management support, and navigates related program requirements between AU and GDIT for the Minerva Initiative.

Research

Minerva programs draw upon scientific research to aid DOD mission priorities. The AU Minerva Initiative has accessed cutting-edge contemporary research programs in the EES field to promote unique and innovative research. The primary goal has been to identify and guide USAF planning, strategy, and operations in energy and environmental fields and assist with partnership-building efforts.

This initiative's research builds upon work begun under the US Department of Energy's (DOE) global energy efficiency and sustainable energy (EESE) program. The EESE program creates a strategic energy and environmental intelligence capacity to foresee emerging risks and provide early warning of unrecognized threats. Tools and methods are being developed that identify critical uncertainties and vulnerabilities in energy and environmental security. The intention is to identify currently unmonitored EES risks that can disrupt USAF operational functions or spark instability in strategically important regions. In contrast to previous efforts that have applied summary climate change data to traditional threats, these foresight-driven early warning systems draw on leading-edge scientific research (continually updated) and integrate data into war-game or planning scenarios to identify second- and third-order effects from continuously shifting energy and environmental conditions.

Training exercises are being developed to introduce EES issues to officers and senior policy makers and to have groups of experts create clusters of new scenarios that can be more fully developed inside the DOD. The research draws upon the collective experience of military, intelligence, scientific, and risk experts. For example, initial scenarios in 2009 provided warning of potential problems such as

- instability in the west Indian monsoon systems, resulting in extreme drought and flood variance in regions such as Pakistan, creating a high probability of food insecurity and long-term socioeconomic and political instability risks;
- looming and acute water shortages across Peru and neighboring countries within 5 to 10 years, resulting in mass displacement, with an extremely high possibility for creating security and humanitarian pressures, and cascading risks to Columbia and Brazil; and
- disruption of food and energy exports from Australia to Japan or India resulting from shifting Indian Ocean wind patterns and associated drought, flood, or storm impacts that could overwhelm existing systems.

Many important questions may arise from this list of scenarios, such as, what do we do with this information?, what relevance does this have to US national security?, or why should we care or even consider these possible outcomes? These are questions the USAF Minerva Initiative is addressing and attempting to answer.

Outreach

Outreach is a crucial element of the USAF Minerva Initiative and has taken a number of forms: the development of foresight scenario workshops among key national and international security players, the evaluation and assessment of including complex environmental scenarios into war-gaming exercises, and the participation in relevant military and scientific events.

Participating in a variety of venues, lectures, national and international conferences, colloquia, symposia, workshops, and consultations concerned with energy and environmental security not only signals the interest and importance the US Air Force attaches to the issues of EES, but also expands and redefines the terms in a more comprehensive and meaningful way (see chapter 2 for further explanation). This outreach includes engagement with a broad range of DOD and other governmental agencies, corporate entities, scientists, policy makers, and relevant organizations from around the globe to establish strong working partnerships.

Curriculum Development

The final key objective for the EES initiative has been to develop an education plan that promotes the infusion of EES concepts into AU's professional military education (PME). PME development has been addressed in lectures, construction and delivery of the core curriculum, sponsorship of electives relating to EES, assistance with faculty development, and continuing consultations with AU faculty on ways to integrate EES themes into the existing curriculum.

Another example of how an EES curriculum can benefit AU is the development of EES-based scenarios that can be inserted into yearly war-gaming exercises. This insertion should give officers a greater appreciation and broader horizon for understanding the changing nature of USAF preparedness in the future.

AU Minerva Curriculum Development Activities, 2010–11

- Provided a standardized lecture for AU faculty on EES and integrated this material with course structures and background readings to provide PME instructional resources.
- Coordinated with AU faculty to provide EES curriculum materials for potential integration with PME courses and activities.
- Developed EES material for the School of Advanced Air and Space Studies (SAASS) war game held at Maxwell AFB, 26–28 April 2011. This cooperation included translation of volcanic and atmospheric data into air operations risks in coordination with the National Aeronautics and Space Administration (NASA) and Jet Propulsion Labs (JPL) in California.
- Held EES scenario-creation workshops in London (in cooperation with University College London and the Institute for International Strategic Studies) to refine instructional PME techniques for policy makers and senior military leaders on complex EES risks.
- Added *Parameters* article on EES to Air Command and Staff College (ACSC) online curriculum.

2 Net Assessment of Energy and Environmental Security

The 2011 Fukushima nuclear power plant disaster offers a useful lesson in how effective foresight planning could have mitigated the amount of damage caused and emphasizes the need for military intervention. Planners at Fukushima assumed a "most probable" scenario for earthquake and tsunami risk, while allowing key backup systems to remain highly vulnerable. In contrast to earthquake preparedness elsewhere in Japan, a lack of robust planning exposed low resiliency, resulting in significant and long-term radiological consequences. Yet the tsunami and nuclear responses also demonstrate the positive role played by US military forces and the unique capabilities they possess.

Airmen and the Japan Ground Defense Force. US Airmen, members of the Japan Ground Self-Defense Force, and members of various Japanese civilian agencies load water hoses onto a truck at Yokota Air Base, Japan, 26 March 2011, for a water pumping station to be employed at the Fukushima Daiichi Nuclear Power Plant during Operation Tomodachi. (US Air Force photo by MSgt Shane A. Cuomo)

Energy and Environmental Security Background

Energy security concerns emerged from the oil shocks of the 1970s and for many years remained fixed on political and economic access to fossil fuels. The concept of environmental security emerged post-1989 and throughout the 1990s remained concentrated on determining when and how natural resource degradation might lead to violent conflict. The two fields began to merge in the mid-2000s, with new definitions that emphasized the role of vulnerability and resilience and focused on less direct impacts on military interests.

The 2007 Center for Naval Analysis (CNA) report on climate security, the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, and the growing visibility of natural disasters such as Hurricane Katrina led to the formulation of new approaches to EES. New strategic intelligence efforts were established in 2007 under the DOE, which is important because of the DOE's emphasis on the early warning of potentially disruptive conditions to energy systems. The USAF Minerva Initiative has in part grown out of these DOE efforts.

Risk Assessments of Security

Definitions of security have often focused on factors that contribute to violent conflict, especially between states. Yet a more relevant definition should include recognition of disruptive and negative instability when underlying conditions are harmed in a society, political system, ecosystem, and/or energy infrastructure. Definitions of security have already shifted; the 2009 *Quadrennial Defense Review* identified key areas of concern that lay outside traditional "hard" security threats. Assessment of such risks requires adopting tools from areas traditionally considered outside defense planning and engagement with communities that normally would have little in common with the military and security community. But there is a growing recognition that security planning and risk assessment must take into account more than direct threats from kinetic operations if they are to be proactive and comprehensive.

This shift in the risk assessment community has evolved from the recognition that energy and environmental conditions can create strategic and operational surprises, potentially leading to mission decay or requiring intervention in locations or functions previously considered stable. Integration of early warning tools encompassing these factors can assist planners as they attempt to avoid or mitigate these disruptive conditions, providing space for greater focus on primary security threats.

Yet these risks are no less real for being difficult to understand. We must find ways to approach them, and we have many new questions to ask:

- How do changes in EES affect security?
- What risks are of most concern to societies and governments, and how do we identify them?
- If we face challenges that have not been experienced before, how do we know where to look and what to monitor?
- How do we trace risks from unintended consequences that cascade across complex systems?
- Where are the intervention points around such risks?
- How do we communicate risks in such a way that they do not overwhelm already burdened security concerns?

This is where foresight and complex systems analysis come into play.

Foresight and Complex Systems

EES risks are best approached in much the same manner as military planning, in the sense that exact predictions of events are less important than understanding categories of events and how best to respond. An aircraft engine may fail for any number of reasons, but all pilots are trained to recognize the possibility of failure and taught how to react given a certain set of circumstances. Likewise, the specific reasons for energy and environmental changes and the pathways those changes take may be less important than having the foresight to see that certain risks are possible and what responses can or should be taken.

Energy planners prior to the 1970s (and still too often today) assumed constant supplies of energy from existing sources and failed to consider sudden supply shocks caused by natural disasters or embargos from OPEC or Russia. New opportunities from emerging technologies were also discounted. Past environmental security work assumed that the world worked in a linear fashion, whereby decreasing amounts of natural resources would inevitably lead to violent conflict, and that such conditions could be predicted in advance.

Ecological and energy systems are better understood as complex emergent systems. EES units, however defined, are not nearly as important as the relationships and networks among a system's components. The whole is greater than the sum of its parts, and future changes cannot be predicted simply by looking at individual components. Changes can occur quite rapidly, from unexpected directions, shifting the entire landscape and potentially exposing areas with less resilience and greater vulnerabilities than were previously thought possible. In this light, the ability to identify these potential "tipping points" and possible drivers of change becomes more important than tracking changes themselves.

For example, understanding the exact combinations of events leading to the "Arab spring" in 2011 is less important than planning for the potential events themselves. One could hardly predict the specific chains of events, but revolts against governments in North Africa and the Middle East should have been recognized as a possibility. Likewise, with respect to environmental conditions, the kind of heat waves Europe experienced in the summers of 2003 and 2010 could not be predicted for any given year, but

Complex network. Solid rocket booster propellant is detonated. (US Army photo by Sgt April Johnson)

the possibilities of their occurrence and resulting risks could have been identified in advance. Instead, in 2003 heat tolerances for nuclear-power-plant coolant water were exceeded beyond design standards, resulting in 17 French plants being closed at a time of peak demand. In 2010 the heat wave and peat fires in Russia exposed critical vulnerabilities in firefighting response, resulting in the loss of over 200 aircraft at a naval air station near Kolomna and the near damage of a nuclear facility in Sarov. The risks were indirect but should have been foreseen as within the realm of possibility.

KC-130J Super Hercules. A KC-130J Super Hercules aircraft takes off on the newly repaired Sendai Airport runway at Sendai, Japan, 25 March 2011. US Marines and Sailors assisted the Japanese government in repairing the airfield destroyed by the devastating 9.0-magnitude earthquake and subsequent tsunami that struck northern Japan on 11 March. (US Marine Corps photo by GySgt J. L. Wright Jr.)

Such assessments rely upon identifying critical nodes in a system—weak points where resulting impacts can lead to a larger collapse. In such cases, the resulting impacts seem disproportionately severe compared to the initial event. It is possible, however, to analyze in advance how vulnerable systems are to particular events via complex network analysis, whether a resilient (scale-free) system or a more vulnerable (often hierarchical) system where the loss of one key component can disrupt the entire system. The DOE's work on the vulnerability of energy grids was applied to similar work on ecological and computer networks, as well as postconflict assessments on how to rebuild societies after protracted conflict. Risk foresight therefore involves translation of scientific data and other information into early warning for security planning.

With acute shifts in EES in recent years, can one assume business-as-usual background conditions when assessing security threats? Emerging conditions and latent security risks may affect strategic interests and operational planning, requiring identification of what risk categories might be faced in the future, what regions will be affected, and what resources might be needed to adapt.

Capabilities and Net Assessment

The AU Minerva Initiative is developing net assessment methods for EES that will allow capabilities assessments of extreme conditions, critical vulnerabilities in related systems, and necessary resources for responding effectively. These assessment methods will help answer questions such as the following:

- How bad might natural disasters become and in what areas?
- How might energy supply chains be disrupted?
- How will operating conditions in a given region change over time?
- Where and how is critical infrastructure at risk?

Integration of such questions with military planning may add realism and depth to future planning scenarios.

The intelligence community often uses capabilities assessments to determine what an adversary's military could conceivably do. Such assessments determine readiness factors, available equipment, basing location, and so forth. Environmental systems can also be assessed according to their capabilities (i.e., boundary conditions); however, environmental data are generally more reliable, more frequently updated, and need not rely on human factors of intention. Likewise, the DOE has examined energy systems for their critical vulnerabilities, but too often such capabilities and vulnerabilities have not been combined or linked to assessments of response capabilities. Bringing all of these elements together would create a workable net assessment of EES risk for the DOD and allied militaries, especially when conducted in cooperation with regional experts, combatant commands (COCOM), and contributing scientists.

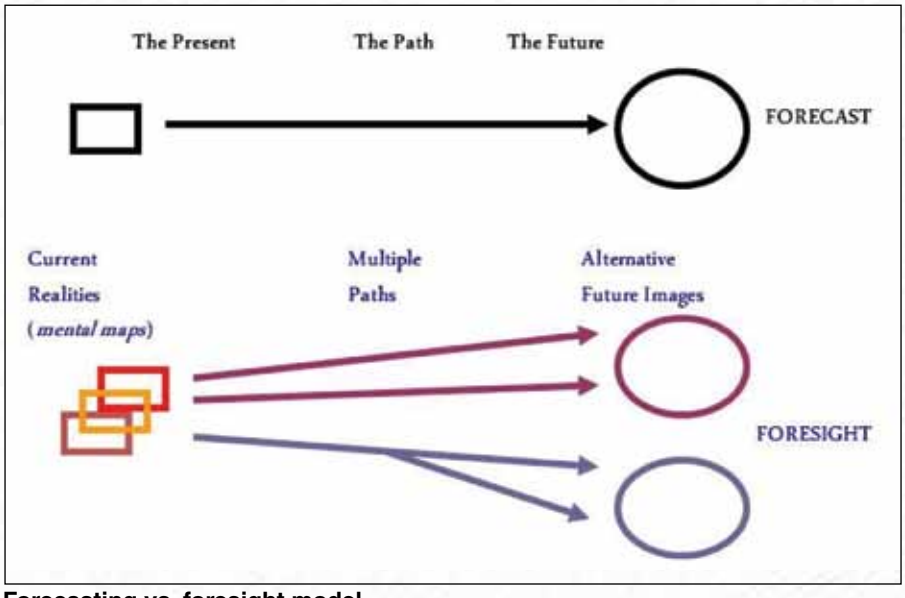
Jet contrails. An air-to-air view of contrails from five C-141B Starlifters. (DOD photo by Fred Jones)

The tools described below should help the DOD and the US Air Force provide actionable foresight for EES risks.

3 Tools and Applications

Part of the research conducted under the USAF Minerva Initiative focuses on the expansion of capabilities that address EES risks by harnessing existing expertise and building outside partnerships. Energy and environmental risks are difficult to address without proper advanced planning and warning (illustrated by the tsunami and nuclear emergency in Japan), so the Minerva program is developing ways for the US Air Force to use scientific communities and local experts to assist with its knowledge-base expansion.

This expansion of partnerships within the scientific community will assist in identifying EES risks that are currently not being considered but could disrupt USAF operational functionality or spark instability in strategically important regions. The figure below shows four avenues being developed to assess complex risks.



Forecasting vs. foresight model

Foresight Scenario Creation Workshops

Foresight scenario creation workshops represent the basic building blocks for illustrating the complexity and uncertainty inherent to EES. Through in-

tensive group work sessions, these workshops introduce USAF mission planners to complex EES risks and help identify potential scenarios of future instability as a result of structured team discussions. Previous USAF-sponsored workshops have helped draw attention to areas where further research and monitoring are needed and where DOD planning may lack appropriate responses or expertise.

To obtain the most value from these work sessions, each group should ideally comprise experts from a variety of different backgrounds and perspectives. This diversity is intended to give participants a deeper understanding of the complexity of the potential issues they should consider in an exceptionally complex horizon of risks linked by a cascading array of variables. It is also an important opportunity for participants not only to be exposed to different perspectives and observe a broader array of EES challenges they might face, but also to establish a cooperative network of experts who may serve as a powerful base for partnership building on a national and international scale.

These workshops were first used by the DOE and were more fully developed by the chair and associate chair for the USAF Minerva Initiative in the spring and early summer of 2011 in cooperation with University College London, the International Institute for Strategic Studies (IISS) in London, and NATO. These events have served not only as an opportunity to further develop the techniques of this tool in foresight planning, but also as a means to develop future partnerships from within the DOD and without. All participants of the USAF Minerva Symposium at Maxwell AFB on 27–28 September 2011 will also take part in this powerful scoping exercise.

War Gaming

War games are useful tools for exploring future security risks, both for planners and in PME. Military war games provide excellent platforms for exploring new or emerging security risks and draw upon existing expertise and institutions. The USAF Minerva program does not propose to change existing practices but rather augment current capabilities by adding data layers into scenarios. Minerva cooperates with others (for example, the Federal Emergency Management Agency and Yale University) in designing natural disaster and geoengineering war games, but too much focus on creating new war-game scenarios may distract from traditional threat responses.

Instead, the focus is on adding realism to war-game environments, for example, by illustrating how shifting environmental conditions may amplify existing operational challenges and the potential for mission decay. The combi-

nation of broad-based and interconnected environmental factors with existing strategic concerns poses new analytical challenges that may be better addressed through complex scenarios.

Environmental and energy conditions can create unique challenges to operations, either through vulnerability of supply or denial of operational environments. In 2011 Minerva cooperated with SAASS to include data on volcanic eruptions, providing additional challenges to air transport planning over polar routes.

Minerva developed EES material for the SAASS war game held at Maxwell AFB, 26–28 April 2011. This scenario included translation of volcanic and atmospheric data into air operations risks in coordination with NASA and the JPL in California, who assisted with the identification of up-to-date risk data on

- potential volcanic risks to arctic and continental US air operations,
- Arctic ash dispersal and residence patterns (parts per million concentrations),
- implications for turbofan engine safety, and
- implications for early warning radar disruption.

Volcano eruption. Lava flows down a slope following an eruption of Mount Etna. (US Navy photo by JO2 Laurie Beers)

What Are the Objectives of the Foresight Scenario Workshops?

The scenario workshops are a critical first step in a process designed to bring possible risks, as uncertain as they may seem, to the forefront of the participants' awareness. The scenarios created are designed to force participants to imagine a world that has not yet happened and may not be obvious. Though the awareness of such possible outlying risks may seem to offer no tangible quick or even long-term payoff, these scenarios signal real threats that reach beyond the comfort of the known and the certain.

These scenario creation exercises challenge what seems to be the presumed future by broadening one's thinking beyond what is probable to what is possible. The scenarios also encourage people to work in collaboration with others who have a diverse range of expertise and experience. These exercises are designed to allow people to ask questions such as these:

- What do we need to know?
- What is known in relation to what is unknown?
- How do we deal with the complex uncertainties inherent in energy and environmental change, and how might this change interact with the unpredictability of human dynamics?

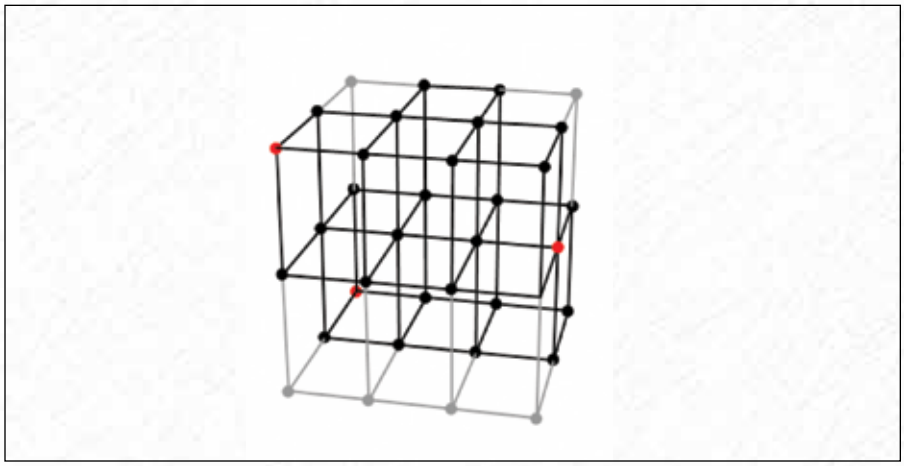
The key to these exercises is to learn how to prioritize risk and map uncertainty. When it comes to considering a topic as broad and yet as important as EES, how does it serve our purpose to broaden what is already an immensely complex and often ill-defined subject? This is where further research into developing better tools and techniques for evaluating uncertainty and risk in the form of complex scenario planning comes into play.

Complex Scenario Planning

A unique approach of particular interest to strategic planners is being developed in cooperation with the Swedish Defense Research Agency and other partners. USAF Minerva's complex scenarios provide a snapshot of possible futures in a given region in 5 to 10 years, with a focus on energy and environmental conditions that will pose strategic and/or operational security challenges. In contrast to previous efforts that have taken summarized environmental change data and applied it to traditional threats, these complex scenarios use leading-edge scientific research and integrate data into planning scenarios

to identify specific and potential impacts in a given geographical region. This approach employs a sophisticated modeling technique to identify a spectrum of extreme-case scenarios and then maps out a series of impacts and responses.

The two greatest challenges to EES scenarios in the past have been addressing high uncertainty and determining starting conditions. Earlier efforts indicated that environmental scientists tend to reject "black boxed" scenarios involving extreme conditions, resulting in overly conservative assumptions of the future. (This has been a recurring problem with climate scenarios in the IPCC.) The AU Minerva approach uses an N-dimensional modeling system to determine unique combinations of potential conditions, including both environmental and socioeconomic factors. For example, a 12-dimensional matrix with four potential variable states means we can conceive of 17 million starting points for scenarios. This provides traceability for assumptions and allows planners to choose starting conditions that focus on areas of greater uncertainty, extreme combinations, and lack of monitoring.



Simple multidimensional model. (Used with permission of Henrik Carlsen)

The complex scenarios largely focus on USAF-specific domains, but they can be tailored to accommodate other services and international partners. This perspective would allow the US Air Force to ask what combination of energy and environmental changes may affect a specific region of Pakistan in the near future and what the cascading impacts and responses would be on energy sources, food security, economic stability, migration pressures, and so forth. Would instability of the west Indian monsoon rain continue to put

pressure on food production? And how, for instance, would changes in air temperature affect power production, agriculture, urban health, and ecosystems?

The scenarios can give detailed resolution to potential EES risks or can be scaled to cover an entire region. Planners could then identify critical vulnerabilities in the system in advance of disasters and identify how those vulnerabilities may impact strategic priorities or operational missions. No assumption is made that EES conditions will spark violent conflict, but such assessments can provide essential backgrounds to larger planning and assessment efforts.

Combatant Command Risk Assessments

The DOD COCOMs have historically dealt with geographic regions and functional areas with unique approaches and capabilities. Likewise, environmental systems, energy resources, and related infrastructure vary greatly between geographic regions, as do attendant security risks and geopolitical backgrounds. The USAF Minerva program is tasked with providing COCOMs with tools and assessments for EES, whether at a macro scale that spans different commands (e.g., the Arctic) or at a regional or state level where particular needs exist. This approach helps to specify EES risks at both operational and strategic levels, while identifying networks of experts who can provide support for continuing assessment efforts. The AU Minerva effort supplements existing security assessments and gives direction to EES efforts that might otherwise remain at a global and generalized level. For 2011 the USAF Minerva team is focusing on the Arctic with applications to the European Command (EUCOM) and Northern Command (NORTHCOM)/North American Aerospace Defense Command (NORAD), with plans to expand into related Pacific/Asian assessments in 2012.

Formation of F-16 fighter jets. (USAF photo by MSgt Jason Wilkerson)

4 Case Studies

Where to apply EES risk assessments depends upon USAF and DOD needs and the availability of scientific data, since the Minerva project provides a supporting role for existing planning expertise. The program's goal is to provide tools that allow importing of energy and environmental data into ongoing efforts, add realism, and help identify potential blind spots and vulnerabilities in planning. In contrast to traditional scenario efforts that attempt comprehensive approaches to foresight, explaining all changes in a society, military, and economy in the coming years is not necessary. Importing EES risks into business-as-usual operations can expose key vulnerabilities and hidden assumptions, as the most crucial impacts may be indirect (second- or third-order risks). Inclusion of EES risks in more comprehensive efforts (such as the work by the US Coast Guard's Project Evergreen) can result in such risks being understated or overlooked instead of focusing on how underlying assumptions and conditions may change. EES risks can be addressed in different time and spatial frames to add extra dimensions to both operational and strategic risks.

Operational Environments

Operational planning often assumes steady-state environmental conditions, with variability relegated to "normal" hazards such as common weather events. Yet with shifting climatic and environmental conditions, and with such changes accelerating in coming years, it may be necessary to consider how these changes could affect operational planning. Even normal conditions can expose critical vulnerabilities if experienced in new environments or at unexpected times. The 2009 eruption of Iceland's Eyjafjallajökull volcano provides one example of how a normal event can pose unique environmental challenges. Although volcanoes are relatively common events in Southeast Asia or North America's Pacific Northwest, volcanic ash clouds grounded air operations across Europe, including NATO flights. Airlines could not make risk management decisions concerning loss of revenue versus damage to aircraft, and contingency plans were generally lacking.

Similar challenges were posed in the SAASS war games in the spring of 2011 with the scenario of a volcanic eruption in Alaska's Aleutian Islands. In cooperation with the JPL and NASA, war-game leaders introduced the eruption of Mount Spurr, including details about its direct ash impact (closing airfields at Elmendorf and Anchorage) and ash drift southeast over the continental United

States (CONUS). Thanks to NASA expertise, the ash drift, silicate composition, and subsequent risks to turbofan blades and windscreens could be described in detail. NASA provided data on the Mount Spurr ash cloud, which would drift as far south as the eastern CONUS within days and effectively block many polar flight routes from the Midwest and East Coast. Given the concurrent shifts in strategic risks (in this case involving the South China Seas and Central America), war-game participants were forced to consider how the ash clouds might complicate any effort to reposition air assets along polar routes.

Volcanic scenarios are a relatively easy and plausible way to introduce environmental conditions to operational risks, particularly given the vulnerabilities and sensitivities of military aircraft to ash clouds. Other environmental conditions can represent changing climatic conditions, including storm surge flooding of infrastructure (e.g., coastal flooding of air bases), extreme heat events (exemplified by the loss of a Russian naval air station to fires in 2010), more extreme winter storms (experienced across Europe in 2010–11), and appearances of tropical storms outside normal regions. Although such conditions cannot be avoided, proper contingency plans can mitigate risks and ensure a proper resource allocation for the response. Experiences in Europe throughout 2010 suggested that prepositioning fire suppression equipment in Russia and de-icing fluid in France could have prevented the worst impacts—instead authorities had only planned for "most probable" conditions and events.

Operational Energy

Advanced consideration of energy supplies and use can prevent or mitigate operational risks. Supply lines have historically been vulnerable to a variety of risks, and the DOD has initiated new programs to identify and reduce associated vulnerabilities. Using new equipment that provides energy on site, such as the solar panels recently adopted by the US Marine Corps in Afghanistan, can reduce costs and risks associated with extended supply lines.

Scenarios involving operational energy can explore the development and application of new technologies and can be tailored to different operational environments. Not all solutions will work in all theaters, and various services will need to cooperate to identify best practices and the most robust technologies.

Natural Disasters

Military resources are increasingly used to respond to natural disasters in the United States and abroad, with NORTHCOM shifting command struc-

tures to provide dual commanders (including federal and state assets) and remove legal barriers to Title 10. Many future climate scenarios suggest an increasing incidence of natural disasters, including greater severity of storms, droughts, and associated wildfires; increased flooding; and other natural disaster risks associated with demographic shifts. USAF Minerva has cooperated with the Federal Emergency Management Agency (FEMA) and the Department of Homeland Security (DHS) in scenario planning for disaster response, with an emphasis on contingency planning. In the case of natural disasters, one must identify "trigger points" for potential catastrophic risks, which involves asking

- at what point would it become necessary to involve military assets beyond the National Guard?,
- what resources would be necessary in the event of such a response?, and
- what planning is necessary in advance to avoid legal, political, and command and control barriers to action?

Future risk planning is already well developed in such agencies as FEMA and the DHS, and these agencies prefer to retain local and state control when possible. But if disasters fall outside of "normal" and historical experience and the resilience of emergency response is overwhelmed, contingencies for DOD involvement become even more necessary. The DOD experience with Operation Tomodachi in Japan in response to the March 2011 tsunami illustrates the positive role of dual-use resources in providing critical response. For example, the Sendai Airport was inundated by the tsunami, and yet it was restored to full operation within three weeks with assistance from the US Air Force, Marines, and Army. The Air Force's 353rd Special Operations Group builds combat-zone airbases, but their expertise proved invaluable in the Japanese disaster response. The USAF Minerva program hopes to identify when and in what capacity such response might be expected or warranted.

Strategic Energy and Environment

Energy and environmental conditions can combine in the long term to reshape underlying assumptions in both energy supply and environmental security. The most valuable contributions in scenario planning come from the ability to identify previously unforeseen directions and developments where no monitoring or regulation currently exists. Many such scenarios are first identified in scenario-creation workshops, where expert groups explore critical un-

certainties and vulnerabilities. To demonstrate the potential utility of such an approach, the following example was first identified during an April 2009 scenario-creation workshop run by the DOE:

> Marine deposits of methane clathrates, crystalline formations of methane (CH_4), exist in enormous quantities just under the sea floor, especially along the continental shelves. The total amount of carbon contained in such clathrates is difficult to measure, but estimates range from one to five million cubic kilometers (km^3), dwarfing the amount of carbon dioxide (CO_2) and CH_4 currently in the atmosphere. Any significant release of such deposits, by whatever means, would provide a powerful, positive feedback mechanism to global warming. Although it was long assumed that clathrate deposits would remain stable for many years, recent evidence suggests that changes in ocean temperatures might already be destabilizing deposits in areas such as the Barents Sea. Marginal changes in ocean temperature can release methane into the water and, if the changes are great enough, into the air as either CH_4 or CO_2.

The workshop produced a scenario involving methane clathrates and established three early warning signals that would indicate a potentially significant security situation requiring response and additional monitoring:

1. Scientific evidence of marine destabilization of clathrates (first reported in late 2008)* in the Barents Sea—The direct release of methane into the atmosphere suggested significant changes in ocean temperatures, sufficient to change the CH_4 from a clathrate to a gas.
2. State-led support for a commercial operation of CH_4 clathrate extraction—Given the enormous energy reserves contained in the marine deposits, a dedicated commercial harvesting program would produce great benefits for any successful operation. Pilot tests had been reported by oil companies in the past, but in September 2010 news reports emerged that Asian countries were sponsoring a program to ensure commercial support of harvesting, with imports to begin in 2018.
3. A sudden shock in energy markets, particularly in the same market as the commercial harvesting program, that greatly increased the need for natural gas imports—Following the Japanese tsunami and Fukushima disaster of March 2011, Japan required sudden import guarantees of gas from Russia. With Germany, Italy, and Switzerland deciding in May 2011 to end nuclear power programs in the future, Central and Eastern Europe likewise will see a significant rise in gas demand. Increased European

*Natalia Shakhova, Igor Semiletov, Anatoly Salyuk, Vladimir Yusupov, Denis Kosmach, and Orjan Gustafsson, "Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf," *Science* 327, no. 5970 (March 2010): 1246–50.

demand, coupled with growing Chinese and Indian markets, will place additional pressures on gas extraction in the future. The incentives for clathrate extraction have multiplied severalfold in the past few months.

Tracing this scenario's impacts is difficult. Further work will require cooperation with the US Navy, regional energy experts, and scientific experts in CH_4, climatology, and oceanography. However, even at this juncture, a few areas of potential impacts and critical uncertainties need to be explored more fully:

- The release of CH_4 from clathrate deposits, whether through ocean warming or harvesting byproducts, might discharge enormous amounts of carbon into the atmosphere. Even marginal releases might dwarf attempts to reduce greenhouse gas emissions, and very little monitoring of such releases is currently being done. Climate change might accelerate beyond reasonable hope of control. Much more work is needed on modeling such scenarios.
- Successful extraction of CH_4 from clathrate deposits would significantly shift global energy markets. Although positive in some respects, a successful commercial program would alter regulatory, financial, and other assumptions if not taken into account well in advance.

A high-impact, unknown probability risk comes from any destabilization of clathrate deposits. The deposits not only contain CH_4, but also help maintain the stability of sections of the continental shelves, much as permafrost provides stability to shorelines, roads, and pipelines. Degradation of the shelves would potentially disrupt local ecosystems, including fisheries, and historical evidence indicates that shelf collapse can result. In 6100 BC, a large undersea landslide occurred off the coast of Norway when melting clathrate deposits resulted in a 290-km sea shelf collapse. The resulting tsunami created 30-meter waves in Scotland, with deposits found up to 80 km inland. Although this Storrega Slide is an example of a catastrophic event, it indicates that some caution may be warranted when a combination of warming and harvesting disrupts existing deposits.

The above material represents brief summaries of the questions being asked by USAF Minerva concerning complex EES risks. Further elaboration on these issues will continue in cooperation with DOD and international partners, who will provide much of the detail in future scenarios. Much of the work in 2010–11 has been dedicated to outreach events and dissemination of research, with the intent of identifying other EES experts who can contribute to security scenarios beyond 2011.

5 AU Minerva Partnership-Building Activities, 2010–11

Collaboration with people and institutions from a broad spectrum of perspectives and expertise is the key to developing more integrated and reliable systems of analysis in this complex field of EES. Outreach to national and international conferences and other events represents a crucial opportunity to build partnerships and establish connections with people and organizations within the EES community.

The integration of knowledge through collaboration is not a simple task and must be based upon a sound system of trust, an understanding of common interests, and a willingness to share knowledge and information. Foresight scenario and complex systems planning concepts challenge common wisdom, notions of preexisting trends, and a future view of the world that is influenced by past experiences.

Foresight scenario and complex systems planning concepts require imagining a future by learning to think from the outside in. Most important, people need to trust that these scenarios signal real potential threats that are influenced by drivers in overlapping complex systems. The challenge is deciding what information is important and answering other questions, such as these:

- What do we *need* to know?
- What should be our focal questions?
- How is it possible to deal with the complex uncertainties inherent in environmental change and the many other factors that influence human dynamics?
- What problems can be mitigated, and what can possibly be avoided?

Within the realm of national and international security, if these planning tools and applications are to be advanced and used, collaboration on a large scale is required. Thus the US Air Force has deemed it of great importance that the research for the AU Minerva Initiative, undertaken by the lead consultants Dr. Briggs and Ms. Briggs, is not only well disseminated, but accompanied by a high measure of outreach to security players on a national and international scale.

The Minerva Energy and Environmental Security Symposium, scheduled for 27–28 September 2011 at Maxwell AFB, is intended to address the potential Minerva resources available to the DOD and allied militaries. The symposium will bring together selected experts to interact with one another, listen to

key speakers in the fields of EES, share their knowledge and expertise, and participate in a day-long foresight scenario workshop.

2010–11 Minerva EES Outreach Events

This list includes official functions attended or committed to prior to this publication and does not include the many informal meetings and other forms of outreach undertaken. The purpose of these engagements was to link the US Air Force to a broader network of people, institutions, and agencies already working on EES issues and foresight scenario planning.

ASEAN Regional Symposium—hosted by European Commission, Brussels, 19–20 November 2010

Environmental Security Assessment Workshop—hosted by Environmental and Security Initiative and Institute for Environmental Security, Brussels, 20–22 November 2010

American Geophysical Union Annual Meeting—San Francisco, 11–16 December 2010

A Roundtable on US and European Energy Security—hosted by International Institute for Strategic Studies (IISS), Washington, DC, 17 December 2010

National Defense University (NDU) Actionable Foresight Workshop II—hosted by the Global Futures Forum, Washington, DC, 19–20 January 2011

Launch of the IISS Transatlantic Dialogue on Climate Security Report—hosted at the IISS headquarters, London, 7 February 2011

Conference on Defence and Security—hosted by the Conference of Defence Associations, Ottawa, Canada, 23–28 February 2011

Trans-Atlantic Forum on Cooperation in the Arctic—hosted by Friedrich Ebert Stiftung Institute, Berlin, 15 March 2011

NDU Actionable Foresight Workshop III—hosted by the Global Futures Forum, Washington, DC, 16–17 March 2011

A Decade of Intelligence beyond 9/11: Security and Human Rights—hosted by the Centre for Intelligence and International Security Studies, Aberystwyth, UK, 12–14 May 2011

Human Security and Security Strategy: Institutions and Policies in a European Perspective—hosted by EU and Jean Monnet International Conference, Kiev, Ukraine, 26–29 May 2011

American Prosperity and Global Security: Ocean Solutions for the 21st Century—hosted by Capitol Hill Oceans Week 2011, Washington, DC, 7–9 June 2011

Chairmanship Workshop on Economic and Environmental Activities as Confidence Building Methods—hosted by Organization for Security and Cooperation in Europe, Vienna, 30 June 2011

Strategic Foresight Initiative Scenario Workshop—hosted by the Federal Emergency Management Agency Office of Policy and Program Analysis, Washington, DC, 11–14 July 2011

Scenario Analysis of Solar Radiation Management: Imagining Possible Futures—cosponsored by the Yale Climate and Energy Institute and the Yale Center for Environmental Law and Policy, New Haven, CT, 9–10 September 2011

Minerva Research-Related Activities and Publications

- The Minerva Initiative has undertaken research to examine how emerging risks related to EES will impact the US Air Force and to determine how best to tailor strategic foresight methodologies to Air Force–specific concerns.
- Dr. Chad Briggs and Ms. Tracy Briggs have conducted and published research that provides a framework for energy and environmental risk assessments in the DOD, with specific reference to USAF operations and strategic risks. They have described the need for human security approaches and for the leveraging of whole-of-government approaches at times, including cooperation with other services, the Department of State, and the US Agency for International Development. Their work was published in cooperation with the Army War College and Woodrow Wilson Center.
- The Briggs have applied risk and scenario methods to air operations and environmental risks, including emergency responses to disasters such as volcanic activity. In cooperation with NASA and the JPL, volcanic data was also applied to existing military scenarios and war games. A related paper will be published in cooperation with the HEC Paris business school.
- Continued research on the use of scientific data and its translations into security assessments for military and related services is underway. This has involved writing on new EES risk methods in preparation for conferences in Europe and extensive background reading on complex systems, historical precedents for military use of information, and outreach to other researchers with relevant regional and functional experience. Research has also included explanations of the nature of complex systems, nonlinear shifts, and specific environmental risks to arctic regions, including cascading risks to EES and their military significance.
- Research is ongoing for an article on complex scenario risk methods. The article will be completed in 2011. The research involves cooperation with physicist Henrik Carlsen and outreach to various experts with backgrounds in N-dimensional modeling, complex system modeling and tracing, risk assessment and uncertainty mapping, environmental sciences and ecology, and energy infrastructure. The research, which builds upon work presented at the American Geophysical Union conference in December 2010, requires integration of different methodologies and frameworks, to be condensed into an easily readable three-page analysis.

- Dr. Chad Briggs will present a guest lecture on EES to the ACSC class of 2012 on 26 September 2011. The lecture will take place in ACSC's Wood Auditorium at Maxwell AFB, Alabama.

USAF Minerva Team Publications
Submitted on or after 19 November 2010

Dr. Chad Briggs, "Abrupt Environmental Changes: Scenario Planning for Catastrophic Security Risks," in *The Challenge of Emergency Regulation: Beyond the European Volcanic Ash Crisis*, ed. Alberto Alemanno (London: Edward Elgar, 2011), forthcoming.

——. "Arctic Environmental Security and Abrupt Climate Change," in *Environmental Change and Human Security in the Arctic*, eds. Gunhild Hoogenson and Dawn Bazely (London: Earthscan, 2012), forthcoming.

——. "Climate Change and Human Security," in *Climate Change and Human Well Being: Global Challenges and Opportunities*, ed. Inka Weissbecker (London: Springer Publishing, 2011), forthcoming.

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Dr. Chad Briggs and Henrik Carlsen, "Environmental and Climate Security: Improving Scenario Methodologies for Science and Risk Assessment," *American Geophysical Union Research Abstract*, December 2010, http://adsabs.harvard.edu/abs/2010AGUFMNH12A..05B.

Dr. Chad Briggs and Inka Weissbecker, "Salting the Fields: Environmental Health Challenges in Post-Conflict Reconstruction," in *Water and Post-Conflict Peacebuilding*, eds. Erika Weinthal, Jessica Troell, and Mikiyasu Nakayama (London: Earthscan, 2011), forthcoming.

Dr. Chad Briggs and Stacy VanDeveer, "Europe, Climate Change, and International Security: Transatlantic and Global Dimensions," in *Climate Change & Regional Security*, ed. Dan Moran (Washington, DC: Georgetown University Press, 2011), 141–51.

Tracy Briggs, "Envisioning a Broader Context to Security with *The Ultimate Weapon Is No Weapon*," *New Security Beat*, Woodrow Wilson Center, 8 April 2011, http://newsecuritybeat.blogspot.com/2011/04/book-review-envisioning-broader-context.html.

Tracy Briggs and Dr. Chad Briggs, "Energy Security and Environmental Change in Eastern Europe: Assessing Future Risks" (paper presented at the Jean Monnet International Conference Human Security and Security Strategy, Kiev, Ukraine, 25–28 May 2011).

6 Proposed Plans for Future Development of EES through Minerva Funding with USAF, 2011–12

USAF/AU Minerva hopes to supplement existing work of the US Air Force and the DOD in the remainder of 2011 and 2012, providing critical tools and expertise in EES and related risks. By coordinating the Air Force and DOD expertise and drawing upon outside networks, the AU Minerva Initiative can provide added depth to current and future research needs of the Air Force. This can include continuation of COCOM assessments, with an expected expansion of focus into the Pacific Rim's energy futures.

- Increased attention will be given to regional assessments, including both COCOM-level and functional security needs as directed by the Air Force and the OSD. Additional resources may be marshaled for effective resolution of risk assessments and complex scenarios, including computer modeling, regional expertise, and background research.
- Outreach and cooperation will continue with key partners such as NATO, but a shift to include Asian/Eurasian/Australasian contacts is anticipated. We expect increased collaboration with the US Navy (and the US Coast Guard), NATO, the DOE, Pacific Command, and NORTHCOM in areas of critical expertise, including climate change, emerging technologies, disaster relief, strategic planning, and maritime patrols.

Appendix

Selected Readings

CNA Corporation. "National Security and the Threat of Climate Change." 2007. http://securityandclimate.cna.org/report/.

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Mabey, Nick, and Katherine Silverthorne. "Degrees of Risk: Defining a Risk Management Framework for Climate Security." 2011. http://www.e3g.org/programmes/climate-articles/degrees-of-risk-defining-a-risk-management-framework-for-climate/.

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Notes