WHITE PAPER

ASP
American Security Project

Advanced Biofuels & National Security

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IN BRIEF

- America is dependent on oil. That undermines foreign policy, contributes to climate change, and is based on a source that ultimately will run out.
- New technology means that advanced biofuels - made from low-carbon, sustainable feedstocks - can provide a drop-in replacement for traditional fuels.
- Even with a 'boom' in production of oil in the United States, the global price of oil remains above $100 per barrel.
- Prices will fluctuate, but they are expected to remain high. By offering competition to petroleum-based fuels, alternative fuels can reduce the economic damage caused by high oil prices.
- The military is leading the way as a market for advanced biofuels, but the entire American economy will benefit from a new industry.

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Introduction: The National Security Need for Alternative Fuels

America is dependent upon oil for transportation. The United States uses about 18-19 million barrels of oil per day, depending on the time of year and global prices. This dependence on oil creates three problems for our economy and foreign policy:

1. **It undermines our leverage in foreign affairs**
2. **It contributes to climate change, and**
3. **Supplies of oil are finite and will run out**

Oil in the developed world is predominantly used to make transportation fuel (71% of the oil consumed in the U.S. is for transportation).[1]

For ground transportation, there are already low or zero carbon emission possibilities, like battery-operated vehicles and mass transit. In addition, increasing energy efficiency, especially in automobile fuel economy, has proven very effective at reducing oil use.

However, there is no alternative to liquid fuel for aviation (unlike batteries for autos) in the foreseeable future. The energy density and portability of liquid fuels are essential to modern flight.

There is some opportunity for an increase in efficiency, but if our military and our country want to continue flying, then alternative fuels are the only way to address these challenges.

Loading a 50/50 biofuel and petroleum blend aboard the oiler, USNS Henry J. Kaiser

The Strategic Threat of Dependence on Oil

For the United States, dependence on oil for transportation is a direct threat to national security.

The American economy relies on an uninterrupted supply of low-cost oil (which is dependent on the global market) - as such the U.S. military must defend shipping lanes around the world.

These missions are deemed important to national security because of the damage to our economy that a stoppage of the flow of oil, which causes spikes in oil prices (leading to a spike in gasoline prices).

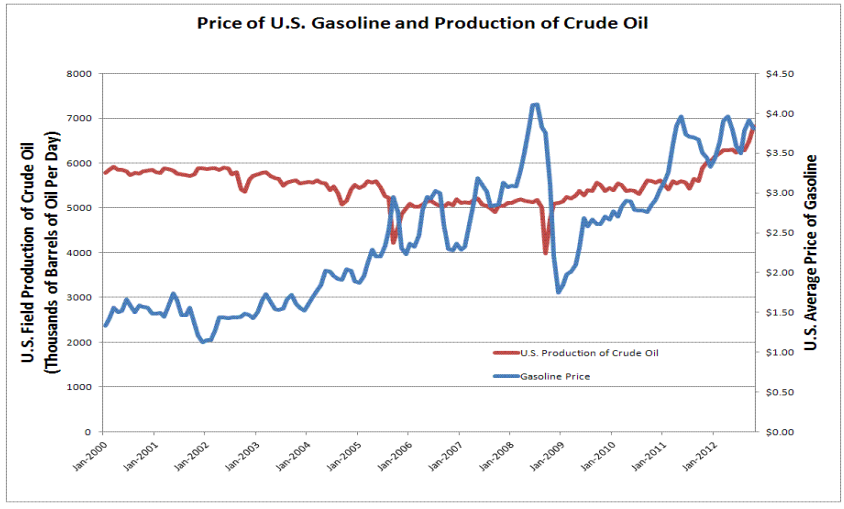
Oil price increases are similarly harmful to defense readiness because the dollars spent on oil are resources that cannot be devoted to training, operations, personnel, or equipment. A striking example of this is that the

military's fuel costs increased a staggering 381% from 2005 to 2011; from $4.5 billion to $17.3 billion. Over this period, fuel consumption actually declined by 4%, but that was overcome by a surge in oil prices.

There is no way to drill our way out of this dependence.

Even if the United States could produce 100% of the oil it used, American consumers would still be vulnerable to global price fluctuations based on supply disruptions in unstable regions. For example, the rise in oil prices due to the Spring 2011 revolution and civil war in Libya have impacted American consumers, even though Libyan oil exports to the U.S. compose less than 1% of all imports in 2010. Integrated global oil markets mean that producing more oil within the United States will not erase security threats.

Furthermore, major oil supplying countries hold leverage over the American economy; they hold the key to price stability.



There is no correlation between drilling at home and gasoline prices: we cannot drill our way to energy security

This affects American foreign policy because American policymakers have an incentive to prioritize stability in over American values like democracy, transparency and the rule of law. This is particularly evident when discussing policy in regions that are major suppliers of oil, like the Persian Gulf.

Climate Change

The Earth is warming at a faster rate than ever before and humans have played a major role in the change.

Over the past century, the average mean global temperature has risen about 1.4˚F (0.8˚C) and is projected to rise at least another 2-11˚F (1.1-6.4˚C) in the next century.[2] The emissions from the burning of fossil fuels accounts for 82% of the United States' greenhouse gas emissions, and 42% of those emissions come from the burning of oil.[3] This warming will cause significant threats to America's national security both at home and abroad (as shown in ASP's Climate Security Report).

In order to reduce emissions, then, any serious plan must include a way to reduce emissions from oil use not only in ground transportation but in air travel as well.

The Intergovernmental Panel on Climate Change estimates that aviation is responsible for about 2% of global emissions, but – because of the special nature of flying high in the atmosphere – aviation emissions are responsible for about 3.5% of warming.[4] Emissions from aviation are more harmful than ground-based greenhouse gas emissions because aviation emissions and aerosols are emitted directly into the stratosphere, whereas a portion of

ground-based emissions are absorbed by the earth and oceans, never making it into the high atmosphere where the greenhouse effect takes place.

Passenger aviation is expected to continue growing at rates of up to 5% per year.[5] Therefore, any credible government or private sector plan that seeks to reduce climate emissions will have to find ways to reduce aviation-related emissions. Already, new models of airlines like Boeing's 787 'Dreamliner' promise to reduce fuel use by up to 20% through use of lighter materials and more efficient engines.[6]

Future Scarcity of Energy Supplies

In the short or medium terms, there is no probable scenario in which the United States is unable to get the supplies of energy - and oil in particular - it needs to sustain our economy or for the American military to fight and win our wars.

A production boom of oil from shale in deposits like North Dakota's Bakken and Texas' Eagle Ford has allowed an increase in the production of oil within the United States. When combined with the reduction in demand for oil – fueled by the economic downturn and a move to more efficient automobiles – the United States is already producing 60% of the oil it uses, and there are credible scenarios in which the U.S. is able to provide up to 100% of its energy supply within the next two decades.[7]

However, America's infrastructure, military acquisitions, and business's durable goods orders are not made for the short or medium term, meaning we are making and buying things (like airplanes) that will last 50 or more years. While an absolute shortage of oil is not foreseeable within the next decade or two, there are credible scenarios in which domestic production falls in a period after the current boom, and that could be coupled with an international decrease in production.

When the military buys new airframes, ships, or vehicles, the expected lifetime of those of those vehicles lasts into decades. The B-52, first flown in 1952, is still in service. The largest military acquisition program in history, for the F-35 Joint Strike Fighter, is currently underway. The military expects to be flying the F-35 for the next five decades, and is planning to spend $1.45 trillion over that timeframe.[8]

The Navy's new petroleum-operated ships, similarly, are scheduled for a lifespan of 35-40 years.[9] Meanwhile, the lifespan of a commercial airliner has traditionally been between 25 and 30 years, and the newer models like Boeing's 787 have an expected lifespan of 50 years.

While policymakers may be confident that America's recent domestic boom in oil production will lead to energy security for our military and civilian aviation in over the next two decades, it is simply impossible to predict whether there will be enough oil in 2050 or 2060 to operate these systems. What this boom has given us, however, is a little breathing room to invest in alternative technologies.

Building the capacity for alternative fuel sources is an investment in the long lifespan of the infrastructure and acquisitions. Relying only on oil production – which has a history of wild fluctuations and defying predictions – would ensure that these acquisitions made for the long-term could end up as just expensive and wasted sunk costs.

Background: What are Advanced Biofuels?

For the purposes of this paper, this is how ASP defines Advanced Biofuels:

> *A fuel made from a low-carbon, sustainable feedstock that can be blended into a fuel supply to provide a drop-in replacement for traditional fuels.*

This sentence includes many qualifications, so it deserves some unpacking. When we say "sustainable feedstock" we mean a fuel that does not compete with food or animal feed and can be cultivated in a way that does not harm the environment or increase food prices. The fuel should be low-carbon, with significantly less lifecycle greenhouse gas emissions from seed to tailpipe - than the petroleum-based fuel it replaces. The term "drop-in replacement" means that the fuel produced can act as a direct replacement, without new equipment or infrastructure, for fuels like gasoline, diesel, marine bunker fuel, or jet fuel. That means that ethanol of all sorts is excluded (see box: What is Ethanol?) because it has a lower energy density than traditional fuels.

Importantly, there is a difference between ASP's definition and the legal definition for Advanced Biofuels, as defined in law to be virtually any biofuel other than corn-based ethanol.

Advanced Biofuels can come from many sources

Legal Definition

Advanced Biofuel is defined in American law in the Energy Independence and Security Act of 2007 as:

> *"Renewable fuel, other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions… that are at least 50 percent less than baseline lifecycle greenhouse gas emissions."*

The legislation then goes on to say that the fuels eligible to be called "advanced biofuels" may include:

i. Ethanol derived from cellulose, hemicellulose, or lignin.

ii. Ethanol derived from sugar or starch (other than corn starch).

iii. Ethanol derived from waste material, including crop residue, other vegetative waste material, animal waste, and food waste and yard waste.

iv. Biomass-based diesel.

v. Biogas (including landfill gas and sewage waste treatment gas) produced through the conversion of organic matter from renewable biomass.

vi. Butanol or other alcohols produced through the conversion of organic matter from renewable biomass.

vii. Other fuel derived from cellulosic biomass.

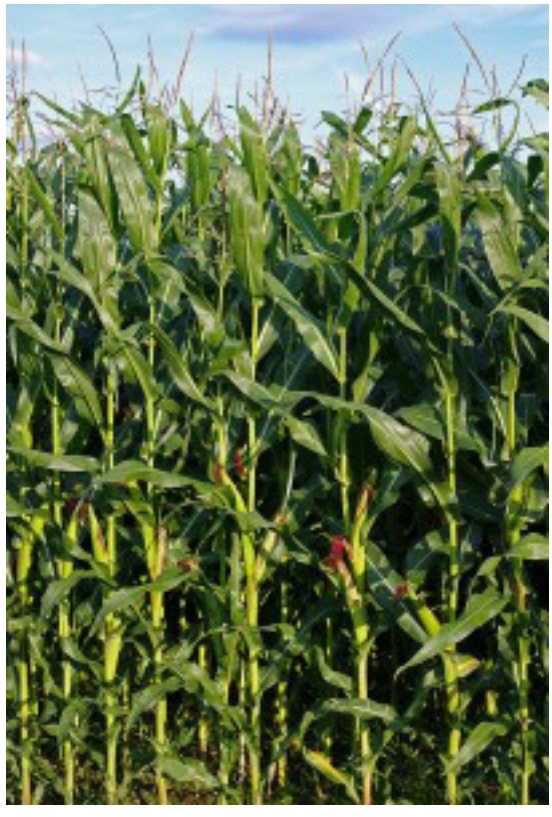
As discussed above, not all of these legally eligible types would meet ASP's definition of Advanced Biofuel – for example, ethanol from sugars or cellulose is not a drop-in replacement.

What is Ethanol?

Ethanol is pure alcohol, a volatile, flammable, colorless liquid. In its most basic form, it is the same as the alcohol that is wine, beer, or liquors that we drink. Production of ethanol fuel is very similar to the production of a spirit like vodka: the grain is first fermented, like beer, then the liquid is distilled to separate alcohol from water, and filtered to remove solids. If you were making vodka, the process would end here. For fuel, the distilled product must be dehydrated to remove any remaining water. After this process, the ethanol can be blended into fuel.

As an additive to fuel, ethanol increases a fuel's octane rating and helps the fuel to burn cleaner. In the United States, ethanol is predominantly fermented from corn crops, and accounts for about 10% of the fuel supply. In 2012, the U.S. produced over 13.2 billion gallons of fuel ethanol.[10]

Unfortunately, ethanol has some drawbacks. It does not have the energy density that traditional petroleum-based fuels have, meaning that more volume is needed for the same fuel economy. Modern engines are not equipped to run at the high octane that pure ethanol is. Finally, because of the way that it interacts with water, it cannot use existing pipelines.



Corn is the primary feedstock for U.S. ethanol production

Feedstocks for Advanced Biofuels

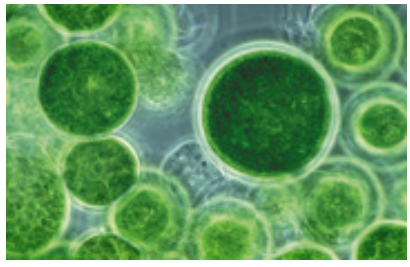
The most important, and usually the most expensive, portion of a refined fuel is the 'feedstock' which it is made from.

Crude oil is the feedstock for most of the liquid fuel used today, but that term hides a great variety of oils: from sour (high sulfur) to sweet (low sulfur) and from heavy (high carbon) to light (low carbon). There is an even greater variety of potential feedstocks for alternative fuels. In the end, with enough energy and time, almost anything, including water or air, can be refined into fuel.[11]

The feedstocks listed below are not an exhaustive list, then, but provide an example for what is used today.

Algae

Algae are single-celled plants, and are actually the original source of the earth's crude oil. Over millions of years, dead algae on seafloors were turned by a combination of heat, pressure, and time into crude oil. Producing algae biofuels recreates and speeds up this process. Algae's benefits are that it grows and replicates quickly, and can be grown in areas that do not compete with other crops or use drinkable water.



Algae are a type of single-celled plant

Animal Fats and Vegetable oils

Waste animal fats like beef tallow, chicken fat, greases, and even post-consumer oils provide excellent feedstocks for renewable diesel or biodiesel because they have a chemical composition that is fairly close to crude oils.

Grasses and Wood

"Woody biomass" is a widely available fuel source for a biofuels. Trees and grasses are a lignocellulose product that must be broken down via various processes before it is converted into ethanol via fermentation or into a liquid fuel via other processes.

Municipal Waste

Solid waste is garbage or refuse, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, food, agricultural operations, and everyday activities. This non-recyclable waste destined for landfills is full of carbon that can be chemically recycled into biofuels. Using a combination of heat, pressure, advanced chemistry, and special catalysts, municipal solid waste can create second generation ethanol, and other biofuels.

Sugars

The vast majority of the biofuel produced in the U.S. today is derived from sugar or starch-based feed stocks. For starch-based feedstocks like corn the starches are complex sugars that can be broken into simple sugars, and then fermented. Sugar feedstocks like sugar cane are easily fermented into ethanol, but other processes can turn them into other fuels.

Technology for Creating Advanced Biofuels

The technology for advanced biofuels is advancing rapidly, but much of the industry is still largely immature.

This means that there is not a dominant mode for producing fuels. The diversity of feedstocks and the many methods of production are a benefit: the variety will ensure that, over the long run, the United States does not replace its single-source dependence on oil with another single commodity.

Catalysis

Catalysis is the process by which a certain chemical compound, called a catalyst, jumpstarts a chemical reaction that changes molecules of a variety of feedstocks into fuel.

Fermentation

Fermentation is the process by which alcohol is created – fuel ethanol is a type of alcohol. This requires a feedstock of a type of sugar, whether from grains, sugar beets, or sugar canes. Fermentation of cellulosic biomass is possible, but it requires an earlier step that will break the cellulose down into sugars.

Synthetic Biology

One of the newest and most promising methods of creating advanced biofuels is a range of processes that can be called "Synthetic Biology." This refers to using cutting-edge biotechnology to design microorganisms that can replicate fuels. This is most active in algae.

Gasification

Gasification puts solid biomass under high temperature, high pressure conditions and converts it into smaller molecules. The resulting gas mixture, synthesis gas, or syngas, is a combustible fuel with a number of useful applications including the production of renewable biofuels.

Gasification has traditionally required high input costs to create the heat necessary for the process to work, harming its greenhouse gas profile. Newer gasification processes promise to use concentrated solar energy to achieve the high temperatures necessary for gasification.

Hydroprocessing

Hydroprocessing is a chemical engineering process that breaks heavy hydrocarbons like fats or oil into lighter fractions by the addition of hydrogen. This is common in traditional refining processes, for creating fuels out of crude oil. Hydroprocessing is useful in advanced biofuels for waste animal fats in producing fuels like bio-diesel, renewable diesel or jet fuels.

The Military and Alternative Fuels

The U.S. military has an aggressive program to develop and deploy advanced biofuels.

The goal is that, by the end of the decade, a significant portion of the U.S. military's transportation fuel will derive from feedstocks other than oil, and obtained at prices cost-competitive to traditional petroleum-based fuels, without operational disadvantages.

Both the Air Force and Navy have plans to acquire up to 50% of their fuel use from alternative sources. They are very clear that all fuel sources must be cost-competitive.

At this time, advanced biofuels are not cost-competitive with petroleum-based fuels. However, the national security need to reduce exposure to oil is clear, and the government is moving forward with plans to directly invest in a domestic biofuels industry.

The USS Princeton preparing to refuel with a 50/50 biofuel blend

The Military's Requirements

All fuels, whether alternative or traditional, must meet mission requirements and not hinder operations. The department intends to evaluate all fuels based on a series of requirements.

First, the fuel should have the potential for drop-in compatibility and interoperability with existing equipment and infrastructure across the Services. Second, there should be a large enough feedstock base to be able to provide "significant volumes of fuel to support an expeditionary, globally deployed force, including CONUS operations, at competitive cost."[12] The department also gives consideration to fuel that could be produced at or near forward operating locations.

The Defense Production Act

Over the next three years, the Department of Defense plans to invest $170 million to support advanced biofuels, with matching amounts from both the Department of Agriculture and the Department of Energy for a total of $510 million in government funding.[13] This investment will take place under the legal authority of the Defense Production Act, which allows the government to directly invest in an industry that is deemed to be important for national security. The funding will be matched with equal or more funding from private investment.

The Department of Defense has instituted a policy to ensure rigorous, merit-based oversight of these investments. The military is clear that beyond testing, certification, and demonstration activities, the Defense Logistics Agency, which buys fuel for operations, will not acquire drop-in alternative fuels unless they are cost competitive with petroleum products.[14]

Conclusion: An Industry that is Ready to Deploy

The Department of Defense intends to reduce its exposure to the national energy security and evaluate a range of alternative fuel sources. Advanced biofuels could be an important part of that mix.

Already, in 2011, the Defense Logistics Agency procured 450,000 gallons of advanced drop-in biofuels from Dynamic Fuels and Solazyme Corp., the largest government procurement of biofuels in history.

Biofuels were used by the Navy in 2012 RIMPAC exercise, an annual multinational military exercise near Hawaii. The RIMPAC exercise successfully demonstrated that an entire carrier battle group and its air wing can operate in an operational environment on a 50:50 blend of "drop-in" advanced biofuels.[15]

The military is an important first market for advanced biofuels. By 2020, if the services' goals are attained, there would have to be at least 770 million gallons per year of new advanced biofuels capacity added.[16]

Because of rapid advances in technology and the economies of scale that will come from these investments, the long-term potential for this industry means that it could become a key part of America's entire fuel supply. This would reduce America's dependence on oil and increase our national security over the long run.

Andrew Holland is a Senior Fellow for Energy and Climate at the American Security Project, a non-partisan think tank devoted to studying questions of America's long-term national security.

Further Reading

Fact Sheet: DoD's Biofuels Program

ASP Slides: Biofuels and National Security

Fact Sheet: Biofuels for National Security

ASP Event: "Biofuels for National Security"

LtGen John Castellaw, USMC (Ret.): "Investing in Biofuels: Strengthening Our Military's Energy Security"

LtGen Don Kerrick, USA (Ret.): "Time to Stop the Stranglehold of Oil on Our National Security"

BGen John Adams, USA (Ret.): "Support Biofuels Now or Pay the Price Later"

LtGen Norman Seip, USAF (Ret.): "Military's Dependence on Oil is Putting Our Forces at Risk"

ASP Blog: "Fueling the Future? Military's Biofuels Program at Risk

ASP Blog: "Budgeting for Biofuels: The Military's Dependence on Petroleum Must be Mitigated"

ASP Blog: "Algae Biofuel: A Promising Alternative Fuel"

Endnotes

1. Lawrence Livermore National Laboratory, "Estimate Energy Use in 2011" Available at: https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2011/LLNLUSEnergy2011.png (accessed January 25, 2013).

2. Foley, Catherine and Holland Andrew, "Climate Security Report" American Security Project. November, 2012.

3. Energy Information Agency, "Greenhouse Gases, Climate Change, and Energy." Available at:http://www.eia.gov/oiaf/1605/ggccebro/chapter1.html (accessed January 25, 2013).

4. Intergovernmental Panel on Climate Change, "Aviation and the Global Atmosphere." 1999. Available at:http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/aviation/index.htm (accessed January 25, 2013).

5. Boeing, "Current Market Outlook, 2012-2031."Available at: http://www.boeing.com/commercial/cmo/ (accessed January 25, 2013).

6. Boeing, "787 Dreamline Program Fact Sheet." Available at:http://www.boeing.com/commercial/787family/programfacts.html (accessed January 25, 2013).

7. Energy Information Agency, "Annual Energy Outlook 2013" Early Release Overview, December 5,2012. Available at:http://www.eia.gov/forecasts/aeo/er/index.cfm (accessed January 25, 2013).

8. Shalal-Esa, Andrea "Exclusive: U.S. sees lifetime cost of F-35 fighter at $1.45 trillion" Reuters, March 29, 2012. Available at: http://www.reuters.com/article/2012/03/29/us-lockheed-fighter-idUSBRE82S03L20120329

9. Cole, William, "Navy officials seek ways to extend lifespan of Pacific fleet " Honolulu Advertiser. Available at:http://the.honoluluadvertiser.com/article/2009/Dec/20/ln/hawaii912200388.html (accessed January 25, 2013).

10. Energy Information Agency, "Petroleum & Other Liquids"Available at: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPOOXE_YOP_NUS_MBBLD&f=4 (accessed January 25, 2013).

11. Connor, Steve "Exclusive: Pioneering scientists turn fresh air into petrol in massive boost in fight against energy crisis" The Independent, October 19,2012. Available at: http://www.newser.com/story/156102/scientists-turn-air-into-gas.html (accessed January 25, 2013).

12. Burke, Sharon. "Memorandum to Defense Operational Energy Board Members" July 5, 2012. Available at:http://energy.defense.gov/2012-7-5_DoD_Alternative_Fuels_Policy_for_Operational_Platforms.pdf (accessed January 25, 2013).

13. Memorandum of Understanding between the Department of the Navy, and The Department of Energy and The Department of Agriculture, March 30, 2011. Available at:http://www.rurdev.usda.gov/SupportDocuments/DPASignedMOUEnergyNavyUSDA.pdf (accessed January 25, 2013).

14. Blakeley, Katherine, "DOD Alternative Fuels: Policy, Initiatives and Legislative Activity" Congressional Research Service, December 14, 2012. Available at: http://www.fas.org/sgp/crs/natsec/R42859.pdf (accessed January 25, 2013).

15. Cunningham, Nick and Holland, Andrew, "DoD's Biofuels Program" American Security Project, January, 2013.

16. Yudken, Joel S. "The Economic Benefits of Military Biofuels" Environmental Entrepreneurs. November 10, 2012. Available at: http://www.e2.org/ext/doc/HRS-E2MiltaryBiofuelsReporNov2012.pdf (accessed January 25, 2013).

Building a New American Arsenal

The American Security Project (ASP) is a nonpartisan initiative to educate the American public about the changing nature of national security in the 21st century.

Gone are the days when a nation's strength could be measured by bombers and battleships. Security in this new era requires a New American Arsenal harnessing all of America's strengths: the force of our diplomacy; the might of our military; the vigor of our economy; and the power of our ideals.

We believe that America must lead other nations in the pursuit of our common goals and shared security. We must confront international challenges with all the tools at our disposal. We must address emerging problems before they become security crises. And to do this, we must forge a new bipartisan consensus at home.

ASP brings together prominent American leaders, current and former members of Congress, retired military officers, and former government officials. Staff direct research on a broad range of issues and engages and empowers the American public by taking its findings directly to them.

We live in a time when the threats to our security are as complex and diverse as terrorism, the spread of weapons of mass destruction, climate change, failed and failing states, disease, and pandemics. The same-old solutions and partisan bickering won't do. America needs an honest dialogue about security that is as robust as it is realistic.

ASP exists to promote that dialogue, to forge consensus, and to spur constructive action so that America meets the challenges to its security while seizing the opportunities the new century offers.

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