MIDWEST RELIABILITY MATTERS

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FROM THE PRESIDENT

MRO President, Daniel Skaar

For this newsletter, I want to introduce a respected colleague who has worked in our industry for years – Dr. Massoud Amin from the University of Minnesota. Recently, Dr. Amin addressed our Board of Directors to discuss system resiliency. Resiliency is the ability to recover from adversity. For example, the speed and ability to restore the regional electric grid from an unplanned event. Dr. Amin was very well received by the board and other meeting attendees.

As our infrastructure and those that operate the system become ever increasingly networked, we have growing interdependencies which makes risk more complicated to manage. As a result, our focus needs to be on managing overall system risk which involves a variety of operators, planners, and facilities owners. In a networked system, it truly takes a village to manage risk. And, I think this is where MRO would like to evolve – bringing Registered Entities together to manage overall system risk and, in turn, improve reliability.

As we think about managing risk, we need to focus on potential vulnerabilities while at the same time increasing our ability to respond to failures as a result of system events (ex. resiliency). Creating adaptive systems which can predict and self correct is a key component for the reliability of the networked electric grid.

Evolution has taught us an important lesson - ***it's not the strongest or the smartest that survive – it's those who adapt that survive and thrive in the future.*** Dr. Amin studies, teaches and ably applies this to airplanes, battlefields, enterprises and power grids.

We are not in Kansas anymore...

The next "stimulus"... filling potholes is necessary but insufficient

Toward a 21st century human-centered education and tech-intensive innovation, discovery and entrepreneurial economy

S. Massoud Amin, D.Sc.

We are ending a month during which our nation observed the 8th anniversary of the August 2003 Blackout (over 50 million consumers affected and more than $6 billion in losses), the 6th anniversary of Hurricane Katrina (more than 1800 deaths and over $150 billion in economic losses), and the August 1, 2007 collapse of the I-35W bridge in Minneapolis (killing 13 and disrupting traffic and the local economy for a year), in addition to the hundreds of black-outs, water main breaks and daily traffic gridlocks. These events have stimulated growing public awareness of the necessity for accelerated programs of replacement, rehabilitation and new investment in the U.S. infrastructure.

More of the Same is Not an Option if long-term relevance matters for us to become more competitive globally. The key is to choose a few pivotal areas of growth and to innovate to achieve sustained competitive advantage. This needs a fresh outlook on what we expect our 21st century economy to be, what is the condition and quality of underpinning lifeline infrastructures. These include the "invisible" infrastructures such as the electric power grid and IT and communication systems which we mainly notice during service disruptions. What is needed is not only filling the "potholes" in roads and fixing bridges, but also to judiciously retrofit and build 21st century infrastructures pivotal to support our quality of life, power the economy, and serve as ***our fastest model(s) to success.***

Quite a different focus is needed to rebuild the foundations of our economies. Deeper,

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more patient and longer-term investments in education, discovery and innovation are needed to build a bridge to the 21st century economy supported by smarter, more secure and high-quality infrastructure. Also, investments in research, development and the human capital to build, manage, maintain and upgrade them must be made.

The traditional approach has been to 1) discover, 2) scale up, 3) commit a sales force -- it's all about being competitive in a fast-paced global environment. **To gain speed we need to renew public/private partnerships** for high throughput discovery and commercialization. In doing so we must cut red tape and reduce the cloud of uncertainty on the ROI of infrastructure modernization and upgrades. It will require an extensive, prolonged commitment by the federal government and the industry to provide targeted research funding, and on the part of industry to modernize and invest in new technology. This eco-system is under stress as corporations have de-emphasized discovery and reduced R&D expenditures during the last 3 years. Venture Capitalists (VCs) were the Mercenaries of Innovation during the growth of the 1990s; however VC investments have also diminished during the past few years**.**

What to do? Pathways forward

Updating the American Model: We've wasted 10 years arguing the roles of the public and private sectors while our competition adapts and innovates. **An 'About FACE' is required to align innovation and policy: Focus, Alignment, Collaboration, and Execution** to revitalize leadership in education, R&D, innovation and entrepreneurship.

Align and Conquer: In the critical few areas of focus, develop a new 'value delivery system' from concepts in university and R&D laboratories to the marketplace, to bridge the so-called "Valley of Death" (the chasm between research and development which hinders the transfer of *basic research and ideas in "laboratories"* to development of services and technologies in the marketplace) by forging strategic public/private alliances with key stakeholders.

Speed up discovery (e.g., industry/university skunk works, government's successful model of DARPA - the Defense Advanced Research Projects Agency) to enable mechanisms for institutional transformation: The same structure and modes of funding, produce the same incremental results, thus new approaches and models are needed for novel outputs.

Focus and create National Infrastructure Banks: Focused on addressing both the much-needed repairs today (to modernize existing aging infrastructure) AND also to bridge to more advanced, smarter, more secure and sustainable lifeline infrastructures envisioned for the next 10-20 years. Created as public/private partnership enterprises that lend money on a sustainable basis and has clear cost/benefit, performance metrics and include fees for quality of services provided by the modernized infrastructures.

Retool and re-train our best and brightest for this call to action. Some of the best talents to help rebuild our critical infrastructure are our veterans of the Armed Forces. Our student veterans emerge from service with maturity and years of advanced technical training, and the majority cope well with adversity. As an example, several of the students and alumni of the *Master of Science in Security Technologies/MSST in Minnesota (est. 2010)* are veterans. They enroll in a 14-month program designed to shape analytical and risk management policymakers and innovators. These veteran alumni help create, develop, and implement the next generation of critical security measures, including cyber, bio, food, and critical infrastructures. They flourish in this learning environment tying theory and concepts to practical, real-world applications.

Examples of Smarter and More Secure Lifeline Critical Infrastructures:

1) A smarter and more secure I-35W bridge

Within less than a year after the August 2007 collapse of the I-35W bridge, a city of sorts on the south side of the former bridge took shape, complete with a host of heavy-duty equipment, temporary on-site areas for casting and other tasks, and crews constantly at work. The days and months that followed required extraordinary efforts from many, including alumni of the Infrastructure Systems Engineering program in Minnesota. They incorporated a sensor network built into the I-35W bridge (at less than 0.5% of total cost) which provides full situational awareness of stressors, fatigue, material and chemical changes, to measure and understand precursors to failures and to enable proactive and *apriori* corrective actions.

2) More Secure, Resilient and Smarter Grid

From a historical perspective, the electric power system in the U.S. evolved in the first half of the 20th century without a clear awareness and analysis of the system-wide implications of its evolution. In 1940, 10% of the energy consumption in America was used to produce electricity. By 1970, this had risen to 25%, and by 2002 it had risen to 40%. (Worldwide, current electricity production is near 15,000 billion Kilowatt-hours per year, with The United States, Canada, and Mexico responsible for about 30% of this consumption.) This grid now underlies every aspect of our economy and society, and it has been hailed by the National Academy of Engineering as the 20th century's engineering innovation most beneficial to our civilization. The role

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of electric power has grown steadily in both scope and importance during this time and electricity is increasingly recognized as a key to societal progress throughout the world, driving economic prosperity and security and improving the quality of life. Still it is noteworthy that at the time of this writing there are about 1.4 billion people in the world with no access to electricity, and another 1.2 billion people have inadequate access to electricity (meaning that they experience outages of 4 hours or longer per day).

Once "loosely" interconnected networks of largely local systems, electric power grids increasingly host large-scale, long-distance wheeling (movement of wholesale power) from one region or company to another. Likewise, the connection of distributed resources, primarily small generators at the moment, is growing rapidly. The extent of interconnectedness, like the number of sources, controls, and loads, has grown with time. In terms of the sheer number of nodes, as well as the variety of sources, controls, and loads, electric power grids are among the most complex networks made.

"Power outages and power quality disturbances cost the US economy over $80 billion, possibly up to $188 billion, per year."

The power outages and power quality disturbances cost the U.S. economy over $80 billion, possibly up to $188 billion, per year. For the past 25 years we have been in a mode of operation of the system that is analogous to harvesting more rapidly than planting replacement seeds. As a result of diminished shock absorbers, the electric grid is becoming increasingly stressed. In an average year, outages total 92 minutes per year in the Midwest and 214 minutes in the Northeast. Japan, by contrast, averages only 4 minutes of interrupted service each year. The outage data excludes interruptions caused by extraordinary events such as fires or extreme weather.

I cannot imagine how anyone could believe that in the United States we should learn to "cope" with these increasing blackouts, and that we don't have the technical know-how, the political will, or the money to bring our power grid up to 21st century standards. Coping as a primary strategy is ultimately defeatist. We absolutely can meet the needs of a pervasively digital society that relies on microprocessor-based devices in vehicles, homes, offices, and industrial facilities. And it is not just a matter of "can." *We must* - if the United States is to continue to be an economic power. However, it will not be easy or cheap.

Customized and cost-effective advancements are both possible and essential to enable smarter and more secure electric power infrastructures. For example, advanced technology now under development or under consideration holds the promise of meeting the electricity needs of a robust digital economy. The potential exists to create an electricity system that provides the same efficiency, precision, and interconnectivity as the billions of microprocessors that it will power.

"Smart Grid" is a concept and a range of functionalities: It is designed to be inherently flexible, accommodating a variety of energy production sources and adapting to and incorporating new technologies as they are developed. It allows for charging variable rates for energy, based upon supply and demand at the time. In theory, this will incentivize consumers to shift their heavy uses of electricity (such as for heavy-duty appliances or processes that are less time-sensitive) to times of the day when demand is low (called peak shaving or load leveling).

There are many definitions of the smart grid, but there is but one vision: a highly instrumented overlaid system with advanced sensors and computing with the use of enabling platforms and technologies for secure sensing, communications, automation and controls as keys to: 1) engage consumers, 2) enhance efficiency, 3) ensure reliability, and 4) enable integration of renewables and electric transportation.

R&D spending for the electric power sector dropped 74 percent, from a high in 1993 of US $741 million to $193 million in 2000. R&D represented a meager 0.3 percent of revenue in the six-year period from 1995 to 2000, before declining even further to 0.17 percent from 2001 to 2006. Even the hotel industry put more into R&D.

Our first strategy for greater reliability should be to expand and strengthen the transmission backbone (at a total cost of about $82 billion), augmented with highly efficient local microgrids that combine heat, power, and storage systems. In the long run, we need a smart grid with self-healing capabilities (total cost, $17-24 billion annually for 20 years). The costs cover a wide variety of enhancements to bring the power delivery system to the performance levels required for a smart grid. They include the infrastructure to integrate distributed energy resources and achieve full customer connectivity, but exclude the cost of generation, the cost of transmission expansion to add renewables and to meet load growth, and a category of customer costs for smart-grid-ready appliances and devices.

Investing in the grid would pay for itself, to a great extent. You'd save stupendous outage costs - about $49 billion per year (and get 12 to 18 percent annual reductions in emissions). Improvement in efficiency would cut energy usage, saving an additional $20.4 billion annually.

The benefit-to-cost ratios are found to range from 2.8 to 6.0. Thus, the smart grid definition used as the basis for the study could have been even wider, and yet benefits of building a smart grid still would exceed costs by a healthy margin. By enhancing efficiency, for example, the smart grid could reduce 2030 overall CO2 emissions from the electric sector by 58 percent, relative to 2005 emissions.

A key challenge before us is whether the electricity infrastructure which underpins our economy, society, and quality-of-life, will evolve to become the primary support for the 21st century's digital society - a smart grid with self-healing capabilities - that powers our innovation and economy or will it be left behind as a 20th century industrial relic?

We must modernize the electric power infrastructure, and evolve it into a smarter, stronger, more secure and more resilient system. Electricity is the lynchpin and enabling infrastructure for all knowledge and innovation-based economies. Our $14 trillion economy--all aspects of it--depends on reliable, disturbance-free access to electricity. From a national security viewpoint,

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in the aftermath of the tragic events of September 11th and recent natural disasters and major power outages, there are increased national and international concerns about the security, resilience and robustness of critical infrastructures in response to the evolving spectra of threats. Secure and reliable operation of these networks is fundamental to national and international economy, security and quality of life.

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Pathways forward: *From a broader perspective, when America has judiciously and strategically made investments, the payoffs have been huge: In the 1960s we had as a goal going to the moon and beyond (when President Kennedy pointed to the moon did we even fathom or know what talents/ resources would converge on that one singular goal and innovations that resulted--both tangible and intangibles, like National pride); the Interstate Highway system (commerce, trade, tourism); national park system; the moon challenge (inertial guidance systems, LSI and then VLSI circuits). Now is the time for judiciously-selected large strategic investments.*

It does seem clear that the "infrastructure" investment should be in people - and "the big ideas." The challenge politically is that filling potholes demonstrates a direct return on investment. Education and "risky" investments are redeemed in the mid- and long-term. Nothing new there. Then, there's the challenge of what level - in terms of grade level - to invest in education. Again, the immediate political "redeemable" is at the elementary school level: it's local, and is aligned with a clear political constituency. Same with the smart grid investments to date, mostly on smart meters as they are needed and are visible to the customers.

We need some judiciously and strategically planned aspirational goals (such as a maglev high speed system) for the United States to improve the transportation of goods (a 21st Century version of Alexander Hamilton's networks of commerce), to help position a globally competitive work force that is trained/ focused on a few key area that matter.

I believe the best of America and our greatest generation is yet to come--many of them will be the veterans of the Armed Forces who can be the new "greatest generation," fully engaged and focused on these few big hairy audacious goals. For example, find real ways to reduce the electrical cost by say 20-30%, substantially improve batteries for cars and trucks so they can go 200-250 miles on a single charge and be light weight, reliable, and safe...or improved solar panels with a cost per watt by 50%.

Time is not on our side. We all work under compounded interest … time is critical. Many of us also work under Moore's law (the prediction by Gordon Moore-cofounder of the Intel Corporation-that the number of transistors incorporated in a chip will nearly double every 24 months) and its resultant innovations… time is critical and making wise strategic choices essential. Job creation, economic growth, and stability for our nation and throughout the world are basic needs. Meeting these goals calls for a systematic effort to reduce the clouds of uncertainty and to meet judiciously selected strategic targets. Enabling factors and accelerators include more reliable, smarter and robust national infrastructures stimulating economic growth. The time for this leadership is now.

About the Author

Dr. Massoud Amin witnessed the 1977 NYC blackout, the 9/11 tragedies in DC/VA, and the collapse of the I-35W bridge in Minneapolis. He works on enabling smarter, more secure and resilient infrastructures. He is leading extensive R&D efforts in smart grids and infrastructure security and is a leading expert on the U.S. electricity grid. Before becoming the Honeywell/H.W. Sweatt Chair in Technological Leadership, a professor of Electrical and Computer Engineering, and a University Distinguished Teaching Professor at the University of Minnesota, he directed all Infrastructure Security, Grid Operations/Planning, Energy Markets, Risk and Policy Assessment at the Electric Power Research Institute (EPRI) in Palo Alto, California. Prior to 9/11 he led mathematics and information sciences at EPRI, worked on self-repairing energy infrastructures, pioneered R&D in "smart grid" and coined the term in 1998, and led the development of over 24 technologies transferred to industry.

Dr. Amin is the author or co-author of more than 190 research papers and the editor of seven collections of manuscripts, and serves on the editorial boards of six academic journals. At Washington University, students voted him three times Professor of the Year (voted annually by seniors in the School of Engineering and Applied Science at Washington University, 1992-1995), Mentor-of-The-Year (Assoc. of Graduate Engineering Students, Feb. 1996), and the Leadership Award (voted by the senior engineering class, May 1995). Dr. Amin received Best Session Paper Presentation Awards (American Control Conference, 1997) and an AIAA Young Professional Award (St. Louis section, 1991). At EPRI he received several awards including the 2002 President's Award for the Infrastructure Security Initiative, 2000 and 2002 Chauncey Awards (the highest annual EPRI Award, in March 2001 and 2003), and six EPRI Performance Recognition Awards during 1999-2002 for leadership in three areas.

He served as a member of the Board on Infrastructure and the Constructed Environment (BICE) at the U.S. National Academy of Engineering during 2001-2007, and is a member of the Board on Mathematical Sciences and Applications (BMSA) at the National Academy of Sciences during 2006-2009, Sigma Xi (serving as President of the MN Chapter for 2011-2013), Tau Beta Pi, Eta Kappa Nu, a Fellow of the ASME, a senior member of IEEE, AAAS, AIAA, NY Academy of Sciences, SIAM, and Informs. He served as a founding member of the IEEE Computer Society's Task Force on Security and Privacy (post 9/11 during March 2002- Dec. 2006) and on the Board of the Center for Security Technologies (CST) at Washington University (2002-2006). Dr. Amin holds B.S. (cum laude) and M.S. degrees in electrical and computer engineering from the University of Massachusetts-Amherst, and M.S. and D.Sc. degrees in systems science and mathematics from Washington University in St. Louis, Missouri.