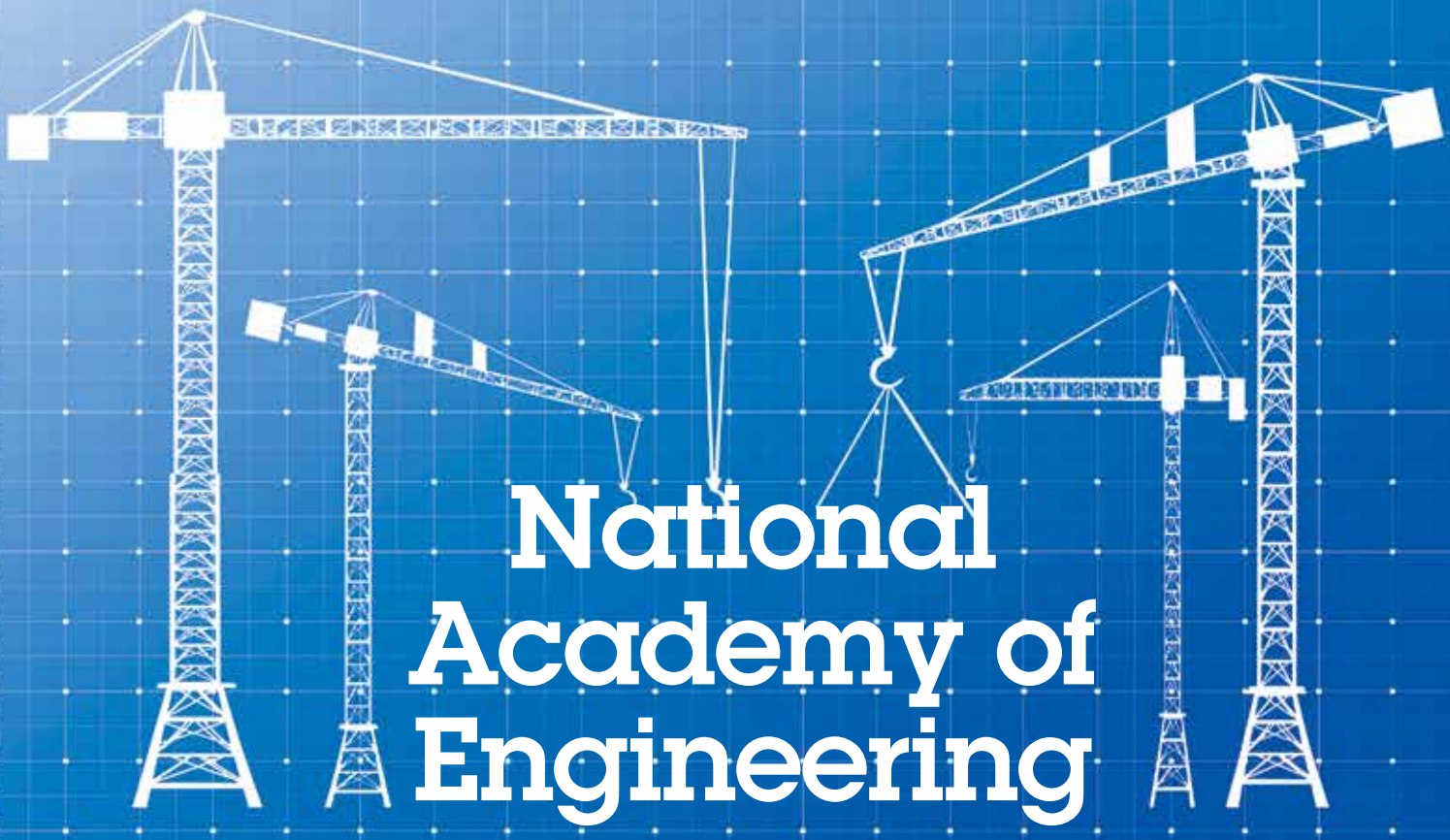


# National Academy of Engineering

**Dr Charles M Vest**, President of NAE, explains how innovation drives policy and education pertaining to engineering, building the discourse to spread awareness and deliver excellence

**To start, could you provide a brief history of the National Academy of Engineering (NAE)? What is your role within the Academy?**

NAE was established in 1964 through the leadership of an eminent group of engineers from industry and academia. Prior to this, Engineering had been a section of the National Academy of Sciences with which we still have a very strong relationship today. NAE has approximately 2,300 members. About 65 members are elected each year across all fields of engineering. The rigorous election process is designed to recognise some of the most accomplished US engineers, roughly half from universities and federal laboratories, and half from business and industry. We also have elected over 200 foreign associates who help keep us integrated into technology worldwide.

As president, I was elected by the membership to a six-year term to serve as the chief executive of NAE, reporting to an elected Council, our senior policy/governance body that currently is chaired by former DuPont CEO Chad Holliday.

**What are the overarching objectives of the Academy? How are you working together to improve research and knowledge within engineering?**

Our work in advising the federal government is done primarily through joint efforts with the National Academy of Sciences and the Institute of Medicine. We do, however, maintain a modest NAE Program Office. It focuses on engineering-specific issues such as education, public understanding, workforce diversity and ethics, and involves many of our members in its work.

Let me cite two examples. We run an exemplary programme, Frontiers of Engineering that each year brings together a carefully nominated and selected group of about 80 engineers who are engaged in leading research or practice. These men and women are in early to mid-career stages, and about half come from industry and half from academia or national laboratories. Each year, previous participants select a set of four topics and two speakers are selected to address each. The topics, and therefore the attendees, are quite varied. For example we might have a mix like Tissue Engineering, Bridge Design, Nanomaterial Design, and Cybersecurity. I have attended a large number of these programmes, and the animated discussion always has to be cut off when it is time to move on to the next topic. Through this programme we propagate the most recent leading-edge work, build understanding and synergy across traditional boundaries and disciplines, and create an amazing alumni network.

We also operate similar bilateral Frontiers of Engineering programmes with China, India, Germany, Japan, and the European Union and, in recent years, have established a Frontiers of Engineering Education programme focused entirely on innovation in engineering education.

In a very different vein, we recently worked with the Chinese Academy of Engineering to bring together high-level experts from both of our countries to discuss the issues and potential advances in global navigational satellite systems (GNSS). For example, they discussed potential advantages of making both US and Chinese systems (GPS in the case of the US) accessible to US and Chinese commercial receivers, thereby increasing redundancy and accuracy. Application of GNSS to precision agriculture, environmental studies, earthquake monitoring, dispatching in the marine fishery industry and many other fields were discussed, as were the increasing safety problems caused by other signals interfering with GNSS.

NAE was asked by the Secretary of the Interior in 2012 to lead what has become the definitive analysis of the probable causes of the Deepwater Horizon explosion, fire and oil spill in order to identify measures for

preventing similar harm in the future. This was conducted jointly by NAE and the National Research Council (NRC).

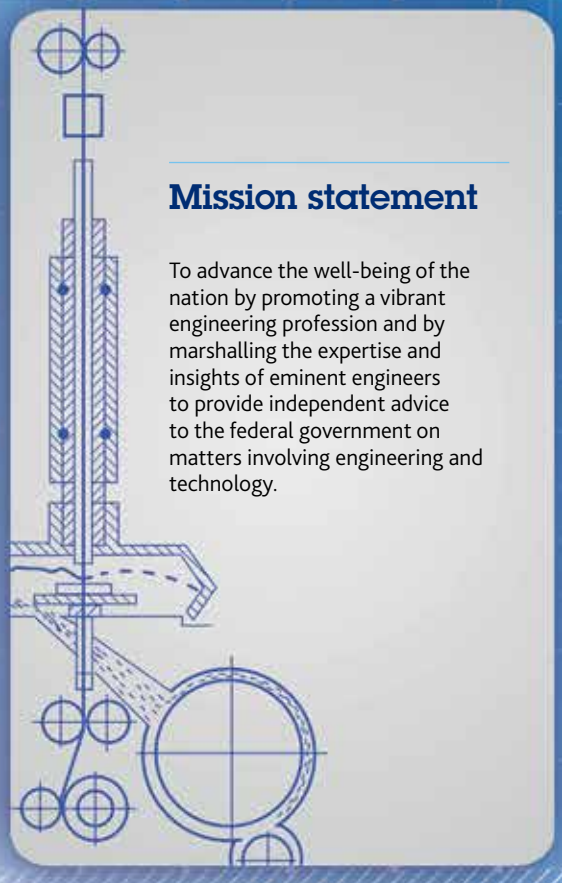
**How does your work relate to other National Academies?**

The National Academy of Sciences, NAE and the Institute of Medicine are private entities chartered by the US Congress to provide objective, expert advice to the government on matters of science, technology and health. Most of this advice is arrived at by consensus of well-balanced expert committees of volunteers convened to address a topic requested by Congress or an executive branch agency. Some of these volunteer experts are members of one of the academies, but most are not. The professional staffing and operations of these committees is provided by the National Academies' operating arm, NRC.

The National Academies produce 200 or so reports each year through this process. The vast majority of topics require input from two or three of the academies. Thus most of our work is well integrated and driven by the expertise required to analyse a given topic.

**How does NAE reward outstanding achievements of its members?**

Election to NAE is broadly considered to be the highest recognition of achievement in the engineering profession, so election itself is the primary recognition that we provide. In addition, we have two major annual awards that are given to NAE members. The Founder's Award honours an outstanding member or foreign associate who has upheld the ideals and principles of NAE through professional, educational, and personal achievement and accomplishment. The Arthur M Bueche Award, frequently presented to an NAE member, honours an engineer who has shown dedication in science and technology, as well as active involvement in determining US science and technology policy, promoting technological development, and contributing to the enhancement of the relationship between industries, government and universities.



## Mission statement

To advance the well-being of the nation by promoting a vibrant engineering profession and by marshalling the expertise and insights of eminent engineers to provide independent advice to the federal government on matters involving engineering and technology.

As an organisation, one of our key activities is to present three highly prestigious prizes for specific engineering accomplishments to reward extraordinary and impactful engineering achievements and to call them to public attention. Each prize has an honorarium of $500,000.

- Charles Stark Draper Prize – honours an engineer whose accomplishment has significantly impacted society by improving the quality of life, providing the ability to live freely and comfortably, and/or permitting access to information

- Bernard M Gordon Prize – recognises new modalities and experiments in education that develop effective engineering leaders

- Fritz J and Dolores H Russ Prize – acknowledging outstanding bioengineering achievement in widespread use that improves the human condition

**NAE applies the National Academies' rigorous research process. How has this allowed you to develop straightforward answers to questions of national importance?**

The findings and recommendations of our reports are derived from in-depth analysis conducted by volunteer expert committees. Committees are selected not only for relevant expertise, but also for balance and objectivity and professional staff from NRC support the committees. Most reports are book length with in-depth discussion and data supporting findings and recommendations.

Once a report has been drafted and adopted by the committee conducting the study, it undergoes a very rigorous peer-review process by several experts, followed by an iterative process to take reviewer comments into account. The reviewers are anonymous during the review process, but are listed in the final version of the report. Although 'straightforward' is a good objective, recommendations and especially findings reflect the complexity of the topic.

**Globally, women are underrepresented in science and engineering. In what capacity does the NAE try to promote equal opportunities and promote women in the field?**

This is a high priority issue for NAE. We have convened or engaged in several studies and workshops on the topic, some on our own, and some in conjunction with the other academies. We have a full-time professional staff member devoted to diversity and inclusion of women.

NAE places emphasis on helping young girls to understand the excitement of engineering and promote their consideration of engineering as an attractive carrier option. We have created and maintained two highly interactive websites to help meet this objective:

- EngineerGirl is designed to bring national attention to the exciting opportunities that engineering represents for girls and women. The site provides information, contests, vignettes of women engineers and is aimed at middle school girls. The site was launched in 2001 with input from a specially selected Girls Advisory Board – bright, energetic girls from all over the US and Canada

**www.engineergirl.org**

- Engineer Your Life is a guide to engineering for high school girls. It provides a more in-depth look at the careers and experiences of women engineers, and enables girls to ask questions about them. It also provides materials for parents and career counsellors

**www.engineeryourlife.org**

We believe that a sustained, high-quality web presence that is helpful and inspirational to middle school and high school girls is one of the

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best ways to scale and be effective in the long-term in attracting a larger percentage of women in our profession.

**The 'Climate Change and America's Infrastructure: Engineering, Social and Policy Challenges' event took place in January 2013. Could you outline some of the key outcomes of the conference in the wake of Hurricane Sandy?**

This conference was unique in the range of audiences that it incorporated and demonstrated a deep appreciation of the relationships between climate and society, and of the difficult infrastructure challenges that face our nation. Social and environmental conditions will change and planning needs to take that into account if infrastructure is to be resilient.

Many speakers and audience members agreed that all constituencies and stakeholders needed to be involved in decision making about climate and infrastructure, and that technical approaches needed to be inclusive. Engineering efforts need to emphasise robustness and adaptive management, and create institutions that can respond positively to crisis and change. They need to involve professionals and persons with pertinent local knowledge such as operators and managers.

Many agreed on the need to do 'backwards' analysis, not traditional risk assessment, to first focus on plans/scenarios and analysis of implications of their vulnerabilities, and then develop robust strategies that are good over a wide range of potential outcomes. Iterative analyses must be done because of the immense uncertainties.

Experts and local government officials in attendance agreed that building social capital requires all stakeholders, including media and business as well as multiple agencies and perhaps multiple jurisdictions. Knowledge is distributed in all these groups; governance should increase social sustainability and reduce long-term social risks. Many agreed that advance preparation is essential if moments and targets of opportunity are to be seized.

**How do you foresee the progression of engineering in the US over the coming decade?**

US engineering generally remains the best in the world, especially in terms of creativity and innovation. The danger is that just as technology is increasingly important in more and more dimensions of our economy, health, security and quality of life, its visibility and panache seems to have diminished. Federal support for engineering research has actually decreased during the last decade and public recognition and celebration of engineering is lacking. The public don't always grasp the excitement of engineering and all that it brings to their lives. If this leads boys and girls to bypass engineering as they think about their education and careers, we will be in trouble. In Asia and Europe, the profile and exciting image of engineering is generally higher.

Having said this, engineering actually has never been more exciting in any other period of history. The combined advances of science and technology will lead to extraordinary new developments. Information technology; 'Big Data'; synthetic biology; nanomaterials; quantum computing; new generations of robotics and artificial intelligence; systems engineering and informatics in healthcare; and new technologies for the generation, storage, and transmission of energy are among the areas ripe for research, innovation and entrepreneurship. As internet pioneer Vint Cerf states: "Engineers turn science fiction into reality".

Beyond the development of individual new technologies, engineering is absolutely key to facing most of the global grand challenges that must be met to sustain life and advance humanity as our planet's population approaches 10 billion: Sustainability, Security, Health, and Joy of Living. These four themes come from a committee of incredibly accomplished innovators established a few years ago by NAE. They suggested 14 specific challenges that fit within these themes. These challenges have formed the basis of numerous educational programmes at engineering schools and increasingly at the K-12 level as well.

Several NAE Grand Challenges summits have been held around the US bringing together cabinet officers, governors, business leaders, academics and students to discuss how to bring our intellectual and financial resources together to meet these challenges. We now are going global with this programme. In March, NAE, the Royal Academy of Engineering, UK and the Chinese Academy of Engineering joined forces to hold the first summit in London.

It is our hope that such activities will advance public recognition of the engineering profession, help set strategies to meet these challenges, and excite students, most assuredly US young people, to become engineers and apply their talents and skills to really important problems.

**www.engineeringchallenges.org**

**www.nae.edu**

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