NATIONAL RECONNAISSANCE

JOURNAL OF THE DISCIPLINE AND PRACTICE

JANUARY 2015

Analytical Article

(U) Solving Problems on the "Edge of What was Possible": Conceiving Solutions to the Most Difficult Intelligence Problems—The 2011 Pioneers of National Reconnaissance

By Patrick D. Widlake

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CENTER FOR THE STUDY OF
NATIONAL RECONNAISSANCE

Editorial Staff

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Solving Problems on the "Edge of What was Possible": *Conceiving Solutions to the Most Difficult Intelligence Challenges–the 2011 Pioneers of National Reconnaissance*

Patrick D. Widlake

Author's Note: On February 3, 2012, the Director of the National Reconnaissance Office (DNRO) Bruce Carlson honored Dr. Thomas A. Brackey, Dr. Michael N. Parker, Col. Joseph J. Eash, III, Dr. John W. Shipley, and, Mr. Richard C. Van Wagoner as the 2011 Pioneers of National Reconnaissance. In a ceremony held at NRO headquarters in Chantilly, VA, Carlson presented each of the Pioneers with an engraved plaque and Director of National Intelligence, the Honorable James Clapper, gave the keynote speech. At the ceremony's conclusion, the organization affixed medallions for each honoree in the NRO's Pioneer Hall, which now pays lasting tribute to 88 engineers, scientists, and program managers who have earned this highest honor in the field of national reconnaissance. "Pioneer Day" 2012 culminated the NRO's commemoration of its 50th anniversary since Deputy Secretary of Defense Roswell L. Gilpatric and Acting Director of Central Intelligence Charles P. Cabell co-signed a Memorandum of Agreement on 06 September 1961 that established a National Reconnaissance Program (NRP) and a covert NRO to manage it. Clapper saluted the 2011 Pioneers by observing that 1961 was the year when newly inaugurated President John F. Kennedy called on Americans to "ask not what your country can do for you, but what you can do for your country," words the Pioneers "clearly took to heart." The DNI called them "innovators" and "risk takers."

Established in 2000, the Pioneer of National Reconnaissance recognition event is an annually recurring ceremony for individuals who have made significant and lasting contributions to the discipline and practice of national reconnaissance–pioneering innovations that changed national reconnaissance's direction and scope. The selection process is rigorous, with a selection board of former senior leaders and subject matter experts winnowing as many as a dozen or more final nominations down to typically two or three recommended Pioneer candidates for the DNRO's consideration, ensuring that the DNRO selects only the best of the best. The Director of the Center of the Study of National Reconnaissance (D/CSNR) Robert A. McDonald–whose organization manages the NRO Pioneer Recognition Program–called the collective impact of the Pioneers "beyond measure," for their contributions enabled "spectacular mission success and made it possible for the U.S. government and military to obtain critical intelligence information not otherwise available."

In addition to a formal ceremony, Pioneer Day activities include interviews with the Pioneers and their attending family members. The 2011 Pioneers' interviews discussed their careers and specific programs they supported–the names and details of which remain classified–and the significance of their contributions to U.S. national security. They also reflected on lessons from their careers and experiences that helped shape them as individuals.

I based the following article on the Pioneers' recollections and insights expressed in their oral interviews and other written material they provided.

The 2011 Pioneers of National Reconnaissance—Dr. Thomas A. Brackey; Dr. Michael N. Parker; Colonel Joseph J. Eash, III; Dr. John W. Shipley; and, Mr. Richard C. Van Wagoner—conceived and developed innovative solutions to some of the most difficult intelligence collection challenges the U.S. faced from the Cold War era of the 1960s to the '80s, all the way through the post-9/11 years. Working alongside teams of space industry contractors and government program managers, these five individuals produced unique technological capabilities to answer some fundamental intelligence questions of senior United States leadership—e.g., What are the military capabilities and intentions of the adversary? Where are the adversary's forces located? The systems and applications the Pioneers produced dramatically improved U.S. national reconnaissance capability and bolstered the country's national security. Presented with a daunting challenge, but also given the rare opportunity, to create systems that were state-of-the-art and beyond—as Shipley observed, "to work on the edge of what was possible"—the 2011 Pioneers made groundbreaking contributions that forever changed the direction and scope of national reconnaissance as a discipline and had a lasting impact on the National Reconnaissance Office (NRO) overhead reconnaissance mission. Their accomplishments continue to influence NRO system development and capability in the second decade of the 21st century.

The 2011 Pioneer Contributions

As a newly minted Ph.D. engineer working for Hughes Aircraft Company in Los Angeles, California, Thomas Brackey pioneered critical breakthroughs in space-based communications technology, including first-of-its-kind hardware, to make possible the collection and dissemination of space-based intelligence in near real time. As chief of the NRO's "Special Staff," Joseph Eash pioneered the innovative application of special technologies and led the way in the development of new, highly sensitive NRO missions for aircraft and satellite systems. In the early-to-mid-1970s, while "moonlighting" on "interesting projects" (Parker, 2012) at the Electromagnetic Systems Laboratories (ESL, founded by former Secretary of Defense William Perry), Michael Parker pioneered tracking and geolocation techniques—demonstrating the first use of time difference of arrival/frequency difference of arrival geolocation from space, a technology at the center of 21st-century intelligence collection missions (Pioneer citations, 2012).

Long-time Harris Corporation engineer John Shipley pioneered the concept development, architectural approach, and initial system definition—applying his expertise in antenna design, adaptive signal processing, and structural dynamic modeling—for successful development of a revolutionary space-based NRO collection system. Finally, a manager of and subject matter expert for the NRO's space-based signals intelligence (sigint) collection systems, Richard Van Wagoner pioneered antenna and system design and the evaluation of system performance critical to the NRO sigint mission (Pioneer citations, 2012).

Models of Intellectual Curiosity and Creativity, with the Drive to Push Beyond Frontiers of Space Technology

Although a unique group of individuals who accomplished unique technical breakthroughs, the 2011 Pioneers possess some similar, significant personal characteristics and had related professional experiences that affected their technical approaches and contributed to their success. They all have had a life-long interest in engineering—which they chose to explore in the focused, specialized national security environment—and are expert problem solvers. They are highly educated and technically creative, which enabled them to conceptualize pioneering designs and to propose new applications. In making program decisions, they were unwaveringly focused on their technical goal and unafraid to take risks, for they possessed unshakeable faith in the ideas that no task was impossible, no technical challenge too difficult to overcome, and even seemingly impossible programs presented an opportunity to make a contribution. As team leaders and managers, they harnessed the talents of other dedicated individuals to accomplish a unified mission. The 2011 Pioneers are even connected by their similar ages and professional experiences. They were all born between 1935 and 1943—depression and war-era babies—and each began his national reconnaissance career within an 11-year span from 1969 to 1980, a decade or so after the beginnings of strategic national reconnaissance. They rightly belong not to the first-generation of national reconnaissance founders and pioneers, but to a successive generation of innovators who built upon the legacy of proven success left by their predecessors and the advances of formative national reconnaissance programs. By expanding upon well-honed engineering processes and following creative inspiration in their own programs, the 2011 Pioneers engineered revolutionary technological breakthroughs that re-defined space-based intelligence capabilities (McDonald, 2002).

Individuals Who are Expert Problem Solvers Capable of Conceptualizing Unique Solutions

Brackey, Eash, Parker, Shipley, and Van Wagoner were individuals who enjoyed tackling complex technical challenges. They were motivated by a thirst for knowledge and a relentless drive to find innovative technological solutions. All five were educated and trained as engineers, and they effectively led—and in some cases managed—teams of engineers and scientists, all of whom were tasked with transforming a set of intelligence requirements into a unique space or aerial payload capable of reliably delivering signals or imagery data, for example, for analysts' exploitation and ultimately decisionmakers' consumption. Brackey observed that his hardest challenge—"pushing the boundaries of the state-of-the-art" (CSNR Reference Collection)—also gave him his greatest satisfaction. Another NRO Pioneer Paul Mayhew (class of 2000) could have been speaking for the 2011 group when he wrote, "Like most engineers, my goals were to solve problems, to create and design systems, and to build something of use and significance" (2002, p. 117; CSNR Reference Collection).

Individuals with Higher Education and Specialized Knowledge—Supplemented by Fundamentals—Critical for National Reconnaissance Success

Three of the 2011 Pioneers hold Ph.D.s and all five have at least master's degrees in engineering fields. They all acknowledge that to even understand, let alone conceive and contribute to, complex national reconnaissance technologies, one must have a high degree of expertise in very specialized fields. In addition, the 2011 Pioneers credited their success to more basic developmental factors and influences, i.e., fundamental educational competencies and principles, and for some the benefit of having a career mentor. Shipley recalled he took many math and physics classes to immerse himself in fundamental skills and concepts that must be second nature to provide the analytic framework for solving the toughest engineering problems. Brackey advised young engineers contemplating an assignment with the NRO to acquire a "down-to-earth technical background." Eash stressed the importance of having a mentor who could manage one's career for him, freeing the individual to concentrate on the program's requirements rather than its impact on promotion (CSNR Reference Collection).

Individuals Who are Goal Oriented and Regard Every Job as an Opportunity

The 2011 Pioneers' fundamental natures are such that they are not daunted by uniquely difficult work. They refused to concede the possibility of failure on their programs—even when confronted by challenges for which there was little precedent, no parallel, and tremendous uncertainty over whether a solution was possible at all—and concentrated their entire efforts on accomplishing national reconnaissance mission goals. In *Beyond Expectations–Building an American National Reconnaissance Capability* (ASPRS, 2002), Robert A. McDonald cited the Pioneers' tendency to be goal oriented as one of their principal characteristics. The Pioneers, McDonald wrote, "consistently focused on the goal in a resolute way," (2002, p. xxv), and they believed absolutely in their ability to solve any problem they encountered. The 2011 Pioneers steadfastly believed in success for which, like their predecessors, they were willing to make risky decisions because the intelligence stakes were high and the reward was worth jeopardizing their professional reputations. The Pioneers' credo might best be described as "failure is not an option." They understood how critical their work was to U.S. national security. They believed that failed program initiatives put the country at greater risk. Despite being in a situation that would cause most people inordinate amounts of stress, the 2011 Pioneers—like many of their colleagues—instead felt privileged to have been given the opportunity. Brackey noted that the "psychic income [of his work] is extremely high"; Eash saw every job he had as "an opportunity to make a contribution"; and Shipley, in accepting his Pioneer honor, said "the opportunity…that, in itself, is honor enough" (MSC, 2012; McDonald, 2002; CSNR Reference Collection).

Individuals Who Leveraged Their Merit with Teamwork and Benefitted From Astute Management

Although the 2011 Pioneers were honored for individual discoveries and accomplishments, they could not have achieved complete success independently. All worked at some time or other with teams of other individuals—both government and contractor employees—and leveraged the strengths of individuals within the team. In *The 17 Indispensable Laws of Teamwork Workbook* (2003), *New York Times* bestselling author John C. Maxwell labels this approach "the law of the niche:" on the most successful teams, all team members have a place, and the manager or team leader places team members in positions where they have the most value. In addition to leading by their brilliant examples, the 2011 Pioneers benefitted from the astute direction of able Program Managers and accomplished senior leaders and scientific advisors.[1] Parker attributed his achievements to "the contribution over a number of years of brilliant people, both contractor and government". Eash said "...[I] could not have done what I did without the support of some really great leaders, like the DNRO, who backed me to the hilt" (MSC, 2012). Eash also noted the NRO gave him staffing flexibility to surround himself with "the smartest, most energetic, most wonderful people" with whom he believed he could not fail (CSNR Reference Collection).

Individuals Who Made Revolutionary Advances by Building on Past Organizational Successes

It has become cliché to quote Isaac Newton's observation "If I have seen further, it is by standing on the shoulders of giants," but having the first-generation Pioneers' models of success undoubtedly contributed to what successive generations of NRO Pioneers were able to accomplish. In national reconnaissance, like so many areas in life, success demonstrably breeds success. The 2011 Pioneers all came of age as space-based intelligence collection was born; each was between 18 and 26 years old in 1961 when the country established the NRO. These individuals gravitated toward nascent national security programs more than a decade after seminal events in the 1950s had spurred their predecessors to seek careers in space: e.g., the surprise outbreak of the Korean War in 1950; the U.S.S.R.'s development and testing of a hydrogen bomb in 1953, years ahead of Western predictions; the Soviet invasion of Hungary in 1956; the world's first ICBM launch in August 1957, which blasted off from Tyuratam, not from the Pacific Missile Test Range or Cape Canaveral;[2] and, finally, the satellite launches of Sputnik I and II in October 1957. Those events had galvanized a 1950s generation of U.S. engineers and scientists who would ultimately develop and operate American space programs, and make lasting national reconnaissance and intelligence contributions. That generation was the

1 The NRO programs for many years benefitted from the advice and guidance of very accomplished individuals in scientific and engineering disciplines, larger-than-life personalities like Edwin Land, Richard Garwin, Sidney Drell, and others, who met periodically as part of the National Reconnaissance Panel of the President's Science Advisory Committee (PSAC)—informally referred to as "the Land Panel"—to review the technical merits of proposed national reconnaissance programs (McDonald, 2002).

2 U.S. launch sites in California and Florida, respectively. The Air Force later renamed the Pacific Missile Test Range Vandenberg Air Force Base.

genius behind the earliest groundbreaking satellite programs: Corona, Grab (Galactic Radiation and Background), Poppy, and Gambit, to name a few.[3] The 2011 Pioneers built upon the capabilities and proven engineering processes established in those programs. Van Wagoner said he and the other 2011 Pioneers got there "on the backs of everybody we worked with" (MSC, 2012).

The 2011 Pioneers exemplify the NRO's historical ability to attract, recruit, and develop some of the country's best and brightest engineers and managers, but their intellectual curiosity and powers might not have been enough had they not also possessed an uncommon set of personal attributes that enabled them to succeed in the demanding, pressure-packed, high-risk, high-reward, national security environment. Unlike professional skills gained in maturity through training and on-the-job performance, there are more fundamental traits that individuals develop in their formative years: a strong work ethic; belief in the value of diligent study, meticulous preparation, and prudent time management; loyalty to people and institutions beyond one's self; and an optimism that manifests in the desire to fix things and solve problems. These five individuals, though they came from different walks of life, appear to have developed their unquenchable curiosity and desire to solve problems, and their tenacious ability to focus on a mission goal, while growing up as children of what some have labeled America's "greatest generation," the generation of parents who instilled in their children the belief that every opportunity was rare and special and not to be squandered.

The next section relates some of the Pioneers' life events and early lessons learned that set them on a path toward a career in national reconnaissance.

The Formative Years

Dr. Thomas A. Brackey—Values instilled through manual labor carried over into national security work.

Thomas A. Brackey was born 11 June 1938 on his family's farm near Nortonville, Kentucky, and raised in the surrounding, quiet farming community. The outbreak of World War II separated Brackey from his parents, who both supported the war effort—his father in the U.S. Army, and his mother as an administrative assistant in war materiel plants—and young Tom lived with his grandparents, seeing his mother only every couple of weeks during those years. Upon the war's conclusion, the family reunited and Brackey lived with his parents until he finished school. As a youth, he worked on the family farm, which though successful, was remarkably old fashioned in its setup and operation, and thus in diametric contrast to the high-tech world in which Brackey would eventually distinguish himself. He recalls milking cows and planting and harvesting vegetables in fields that on his family's farm they tended with a team of mules. The manual labor,

3 Corona was the unacknowledged program name of the world's first photoreconnaissance satellite—the scientific world knew it as Discoverer; Grab, which collected electronic intelligence (elint), was the first reconnaissance satellite and had an unclassified solar radiation mission, SolRad; Poppy was Grab's much more advanced follow-on elint satellite; and Gambit was the first high-resolution imagery satellite.

Brackey believes, instilled in him "an early understanding of the value of work and of meeting one's commitments," and the planting and harvesting schedule taught him "concepts of time management and the necessity of flexibility and prioritization" (Brackey, 06 August 2012 email communication with author).

After graduating high school, Brackey attended Ohio State University, where he earned a bachelor's, master's and Ph.D. degrees in Electrical Engineering, achieving distinguished graduate status along the way. "[I had] extraordinarily deep and broad training at Ohio State," Brackey recalled. "I could not have taken a better curriculum for coming to work in the space industry than [if] I had planned it, which I didn't" (CSNR Reference Collection). While at college, Brackey gained his first exposure to classified, national security work, first in a summer job as an engineering intern at the Pike County, Ohio uranium enrichment facility—directed by the Atomic Energy Commission and for which job Brackey was required to pass a complete background investigation—and later as a graduate student when he obtained a secret clearance to do research work. He wrote, "I learned a great deal…about the means necessary to protect sensitive elements of our national priority programs" (Brackey, email communication with author, 06 August 2012).

With his advanced degrees in hand, Brackey interviewed for engineering positions. One company, the Hughes Aircraft Corporation, impressed him with the professionalism of its employees that he met on his interview visit. Despite some misgivings about moving to Los Angeles—home to traffic, smog, and Hollywood, and a very different environment from his Midwestern upbringing—he eagerly accepted a job with Hughes. He did not know at the time how Hughes' work supported the national security of the country. Neither did he realize the career he was about to embark upon and the extraordinary opportunities to advance technology that awaited him (CSNR Reference Collection).

Col. Joseph J. Eash, III—Rigorous academic study a preparation for a future career.

Joseph J. Eash, III, was born 15 January 1938 in New Kensington, Pennsylvania. He recalled growing up in a heavily industrialized area that nevertheless featured open land with hills for climbing, and rivers and streams for swimming and playing in. It was an enjoyable place to spend one's childhood, and Eash lived there until he was 13, when his father accepted an engineering job in Beaver, Pennsylvania and moved the family there. Eash's father had overcome multiple challenges: Joseph J. Eash I, Eash's grandfather, had died when Joseph Jr. was just 14. At the time of his only child's birth, Joseph Jr. worked as a chauffeur while attending night school to study engineering, eventually earning his degree through Carnegie Tech. Eash later followed in his father's footsteps—"I probably picked engineering because he was an engineer and that was all I knew" (CSNR Reference Collection)—by studying Electrical Engineering at Grove City College, a small institution in western Pennsylvania with rigorous academic standards that prepared him well for his future career. Grove City had one other important component to Eash's career development: an Air Force Reserve Officer Training Course (ROTC), through which Eash joined the U.S. military (CSNR Reference Collection).

During Eash's years at Grove City College (1955-1959), an event happened that would affect not only his future career, but also would impact U.S. national security concerns and help shape the future direction of the American space program: the Soviet Union successfully launched the world's first satellite, Sputnik I, on 04 October 1957. Eash remembered "everyone was concerned with Sputnik and [that] the Russians were going to beat us" [in the space race]. With the formation of the National Aeronautics and Space Administration (NASA) in 1958, the country committed to a civil space program that President John F. Kennedy predicted in 1961 would land a man on the moon within the decade. By the time of the Apollo 11 mission in July 1969, there was another space sector that had already achieved success throughout the decade: the national security space sector, at the apex of which stood the National Reconnaissance Office (NRO). Even before Kennedy's inauguration, this American space program had successfully launched and operated four intelligence satellites—two sigint satellites in the Grab satellite program, and two imagery satellites in the Corona film-return, photoreconnaissance program. Like the public in the formative years of national reconnaissance, Grove City College student Joe Eash knew nothing about intelligence satellites, but that was soon to change. In his sophomore year, he obtained a job with the Westinghouse Corporation in one of its nuclear power-generating plants, for which he required a security clearance, giving him his first exposure to classified material and the national security environment in which he would work for much of the remainder of his career (CSNR Reference Collection).

Dr. Michael N. Parker—Small-town supportive community spurred accomplishment.

Michael N. Parker was born 10 January 1943 in St. Augustine, Florida. Like Brackey, Parker grew up in a small, farming community with "only one stop light in the entire [Flagler] county" (Parker, 2012). Having experienced the challenges of depression-era Alabama as children, Parker's parents had relocated to Florida as adults, and worked as rural letter carriers in a close-knit, conservative community.

Parker's parents encouraged and supported him in his education, and he read voraciously, developing an avid interest in science fiction, obtained a ham radio license,[4] and generally excelled in school. One summer during Michael's high school years, his parents sent him to study electronics at the Mary Karl vocational school, where he was a classmate with "Korean War vets on the G.I. bill" (Parker, 2012). His mother and father later funded his university education (and his brother's) at the Massachusetts Institute of Technology (M.I.T.), at a considerable cost burden for two public sector employees.

"I did not realize how lucky I was and how supportive this small farm community of modest means had been until later when my children were in school," Parker wrote. "The 1960 graduating class for the entire county was only 22 seniors. . .[but] when several of us requested a calculus class and were able to recruit 8 students, the school board authorized the class" (Parker, 2012). It was the first time the Flagler County school system had offered calculus as part of its curriculum, and it demonstrated the supportive nature of Parker's classmates and the school administrators. He would discover years later at a reunion that,

4 After Sputnik I launched, Parker tried for hours with his home equipment to hear the satellite's innocuous—yet earthshaking—20 MHz beeps.

of the 22 graduating seniors, nearly all had gone on to college, two had earned Ph.D.'s in science, one had earned a master's degree in electrical engineering, one had become a lawyer, and two others had become licensed nurses.

After Parker earned a bachelor's of science in Electrical Engineering (E.E.) at M.I.T., he furthered his education at Stanford University, earning an E.E. master's degree in 1966. His first foray into Intelligence Community (IC) work was as an analyst with the Central Intelligence Agency (CIA) in Langley, Virginia. After nearly two years, he realized his true calling was engineering, and he resigned from CIA to take a job with ESL in Sunnyvale, California, where he analyzed the Soviet antiballistic missile (ABM) radar systems (Parker, 2012).

Dr. John W. Shipley—A brother's advice helped establish a solid educational foundation.

John W. Shipley was born 23 December 1942 in Washington, D.C. His father was an instrument maker at the Department of Agriculture Experiment Station in Greenbelt, MD, and his mother was an elementary school teacher. John spent much of his youth analyzing and trying to fix the motley collection of boats, cars, and motorcycles that his two older brothers managed to acquire. These activities spawned his early interest in engineering that became his life-long passion. Shipley believes that, had he been forced to study any other discipline, he likely would not have gone to college at all (Shipley, 31 July 2012 email communication with author).

As it was, he enrolled at the Georgia Institute of Technology (now Georgia Tech University—known by alumni as "the M.I.T. of the South"), where he originally planned to study to be an aeronautical engineer. Shipley's older brother, Bill, who was a manager at Jet Propulsion Laboratory (JPL),[5] persuaded him that he would benefit more from studying a discipline with as much math and physics classes as he could handle. Bill Shipley reasoned that companies would pay to train their employees on how to design something, but would not pay educational assistance for additional classes in the "basics." John Shipley consequently changed his major to Engineering Science and Mechanics, which allowed him to take more math and physics classes than would be required of a standard engineering course of study (Shipley, 2012 email communication to author). "My education," Shipley said, "gave me a view of things that was much different from most people. As you synthesize, you can analyze" (CSNR Reference Collection).

5 The JPL is a major National Aeronautic and Space Administration (NASA) laboratory located in Pasadena, California, specializing in advanced sensor development for deep space research. The JPL began in the 1930s as a series of test launches in the Pasadena area by some rocket enthusiasts, including Frank Malina, a student at the California Institute of Technology's (CalTech's) Guggenheim Aeronautical Lab, who would one day direct JPL. A Caltech professor, Theodore Von Karman encouraged the group, and in 1943, the group obtained funding for the first JPL facility; Von Karman became its first director. Initially, the laboratory's biggest "customer" during World War II was the U.S. Army Air Corps. In 1957-58, JPL collaborated with the U.S. Army's Ballistic Missile Agency in Huntsville, Alabama to assemble a 4-stage rocket used to launch the first U.S. satellite, Explorer 1, on 31 January 1958. In December of that year, the Army formally transferred JPL to NASA, then the newly created civil space agency (JPL, 2012).

Shipley earned his Ph.D. at age 27, and in 1971 he began his professional career with the Martin Company in Orlando, Florida, where he did detailed analysis and simulation on the Patriot missile program. Although related to his future space work, Shipley found missile analysis to be different from his later satellite analysis because, with missiles, "your whole life is over in about a minute". Shipley stayed with Martin for nine years before joining the Harris Corporation where he launched—no pun intended—his still continuing career in national reconnaissance (CSNR Reference Collection).

Mr. Richard C. Van Wagoner—Engineering appeal proved stronger than interest in flight.

Richard C. Van Wagoner was born 18 June 1935 in Washington, D.C., and he and his brother grew up on a tobacco farm in Upper Marlboro, Maryland. His father was a naval veteran who worked multiple jobs to support the family, and who could design, build, or repair just about anything. He designed and installed a generator and wiring to bring electricity to their farm, which was more than a mile from the nearest power lines. "I got this desire to pursue engineering as a result of working with my father," Van Wagoner (Van Wagoner, 2012; 13 August 2012 meeting with author) recalls.

Van Wagoner's family moved to Northern Virginia, where he attended Fairfax High School, excelling in math and science courses. Although he originally enrolled at William and Mary College on a scholarship to major in physics, Van Wagoner decided he preferred engineering and consequently transferred to the University of Virginia (UVA), where he earned a B.S.E.E. in Electronics in 1958. Like Eash, Van Wagoner joined the Air Force ROTC while an undergraduate. The Air Force accepted him for pilot training, but Van Wagoner eventually declined, choosing instead to concentrate on engineering. Upon leaving UVA, he served a three-year tour as an Air Force Radar Maintenance Officer. In 1962, he went to work for Emerson Research Lab as a research engineer, but left to join a just-forming company, Radiation Systems, Incorporated (RSI). For the first few years, RSI flourished, growing from just 12 employees to 260, but a late 1960s slow-down in government-funded, contractor research and development convinced Van Wagoner it was time to move on, and he accepted a position as a Navy civilian employee at the Naval Research Lab (NRL), which could be assured of a more consistent funding stream. Although one of NRL's residents was NRO Program C, Van Wagoner did not work on national reconnaissance programs in his years there. His NRO work would ensue after another change in employer, this time to the CIA (Van Wagoner, 2012, CSNR Reference Collection).

Five Decades of National Reconnaissance Innovation

Brackey, Eash, Parker, Shipley, and Van Wagoner comprised the 12th class of Pioneers of National Reconnaissance since the NRO established the recognition in 2000. Since 2000 six different Directors of the NRO (DNROs) have selected nominated individuals to be Pioneers. Being named a Pioneer is the highest award in the discipline, comparable with the Charles Stark Draper Prize, which the National Academy of Engineering (NAE) annually bestows to individuals whose innovations have a beneficial impact in our daily lives.[6] As the NRO 50th Anniversary class, the 2011 Pioneers of National Reconnaissance constitute a special group even within the august company they now keep with 83 other NRO Pioneers. Rather than select two or three Pioneers, as is customary in most years, DNRO Bruce Carlson selected for the anniversary commemoration five Pioneers, one for each decade of the NRO's existence, and the largest class since the first one. Though their contributions were continuing at the time of their induction into Pioneer Hall—except for Colonel Eash, who already had retired—each of the 2011 class's pioneering accomplishments is loosely tied to the decade that he represents. Collectively, their stories provide a broad brushstroke view of NRO systems' evolution over time.

Of course, the still-sensitive nature of a majority of even historical or legacy NRO systems' breathtaking technological capabilities and programmatic details prevents a detailed discussion in open literature of what the Pioneers accomplished. The general technical challenges they confronted, and high-level goals of the NRO's leadership, which the NRO has publicly released, provide a means to place the 2011 Pioneers' accomplishments in the context of their representative decade.[7]

The Challenge of Evolving and Improving U.S. National Reconnaissance Capability

When they began work on their programs, the 2011 Pioneers sought to improve, extend, and enhance U.S. national reconnaissance capability to address a vital intelligence requirement; indeed, all 88 Pioneers of National Reconnaissance had similar goals on their respective programs. Throughout its history, the NRO, first through its program offices and later with its functional directorates, has conceived and developed technological solutions as a response to an intelligence requirement or need. In the formative years of "peacetime" strategic national reconnaissance—a concept credited to National Reconnaissance Pioneer Richard Leghorn, who first articulated it in 1946—the fundamental requirement was to obtain "reliable information of force levels and technological capabilities…to reduce temptations for surprise attacks, and to reduce the dangers of an arms race resulting from mistrust and potential misperceptions of capabilities and intentions" (Leghorn, 2002, p. 237). At first, the U.S. and its allies attempted aerial reconnaissance, the pinnacle of such capability being the U-2 high-altitude, photoreconnaissance aircraft, but because such missions violated target nations' internationally recognized airspace sovereignty, they put pilots' lives in grave danger and risked international incidents. The advent of space-borne intelligence collection removed the threat of both: satellites were "piloted" from the ground, and there were no international treaties or conventions forbidding satellite reconnaissance of denied areas.

6 National Reconnaissance Pioneers Sam Araki (2004) and Edward Miller (2005), in addition to former DNRO James W. Plummer were among five individuals to win the Draper Prize in 2005 for their work on the Corona Program, the CIA-U.S. Air Force program that became the world's first photoreconnaissance satellite.

7 For more detailed comments from former DNROs, see *Directors of the National Reconnaissance Office at 50 Years,* a booklet of reflections from the 17 individuals who had served as DNRO through 2010, published by the NRO Center for the Study of National Reconnaissance (CSNR) in July 2011.

Once satellite reconnaissance proved both viable and valuable, the NRO, through the diligent efforts of its pioneers and program managers, worked tirelessly to improve and expand the capability. The many NRO innovations and system enhancements are too numerous to list here, and many remain classified, but some areas where the NRO's pioneering programs advanced state-of-the-art include: computer simulations for design; digital signal processing; gallium arsenide technology; three-axis spacecraft; enhanced optical systems; thermal design; pointing and attitude control; design and analysis tools; and the development of solid state recorders that greatly increased time on orbit for satellites. The NRO also pioneered innovative program management techniques, creating the mechanisms to fund and manage these complex programs to keep them, as much as possible, on schedule and within cost (Mayhew, 2002).

The 2011 Pioneers' challenge, as then DNRO Carlson stated at the 2012 Pioneer ceremony, was to first conceptualize a unique, innovative solution—i.e., a space mission—to "the toughest problems on earth" (MSC, 2012), and then determine how to transport that solution into space. Often, it was a daunting proposition; working with teams of contractors and government managers, the Pioneers were trying to do things that had never been demonstrated even in a lab or testing environment. System conceptualization involved many hours of brainstorming, deliberations, and discussions, and after arriving at a proposed solution, the most difficult challenge yet remained: building the space payload, a spacecraft to house it, acquiring a launch vehicle to get it into orbit as an integrated space system, and then testing and refining that system to maximize performance, all while keeping to schedule and cost. Such was—and remains—the challenge that NRO pioneers confronted on their programs.

The 2011 Pioneers' Innovations

All of the 2011 Pioneers had lengthy careers and supported multiple programs and contributed to the success of multiple intelligence missions, but the accomplishments for which they were honored correspond to specific programs in a distinct time period. Acknowledging that their specific contributions—and names of and in-depth details on the programs they supported—remain beyond the scope of this article, I can discuss the generic achievements along with the goals of the NRO directors who served during the Pioneers' period of contribution, and provide context for the innovations of Brackey, Eash, Parker, Shipley, and Van Wagoner.

Dr. Thomas A. Brackey—Enabling Near-Real-Time Imagery From Space

Brackey was a relatively inexperienced engineer when he arrived at Hughes Aircraft in 1969. He had next to no exposure to the country's national security programs and absolutely no knowledge of the compartmented national reconnaissance programs. Although his education at Ohio State had been "extraordinarily deep and broad," Brackey still had much to learn on the job. In retrospect, he wonders at the amount of responsibility the company entrusted him with at that time, and he remains forever grateful that he was given an opportunity to "in a small way, personally contribute to some remarkable successes" (CSNR Reference Collection).

Dr. John McLucas was NRO director from March 1969 to December 1973. In his reflections in "Directors of the National Reconnaissance Office at 50 Years," McLucas recalls his tenure as the "golden age" (2011, p. 18), a period in which the NRO was developing the second generation of reconnaissance satellites and the infighting between NRO alphabetic programs A and B[8] had been quelled by a reworked NRO charter[9]and the decision by his predecessor, Alexander Flax, to divide program management responsibilities for the Hexagon program between the two program offices. The NRO's focus was on evolutionary improvements in its major systems, with one exception: a planned development of a revolutionary near-real-time system that promised to be not only more capable, but also more reliable than existing systems (CSNR, 2011).

The space-based communications technology that Brackey and Hughes developed was an essential element for near-real-time intelligence collection from space. The development of a more time-responsive imagery satellite system than Gambit and Hexagon film-return satellites was at the forefront of NRO Program B (CIA's Office of Special Projects at that time) activity, so much so that the program office transferred on 1 July 1973 most of its Hexagon program responsibility to NRO Program A (Office of the Secretary of the Air Force for Special Projects or SAFSP) to concentrate efforts on the follow-on system. Ironically, the concept for electronically down-linking image data had originated not with CIA, but with the Air Force, whose WS-117L program in the mid-to-late 1950s funded programs including the Samos family of satellites that included systems that electronically scanned film negatives and transmitted the data to the ground. Although Samos's "read-out" technological approach would have been a more time-responsive system than film-return, it also returned a lower-quality resolution, and so the program was cancelled in 1961.

Brackey led a team of engineers who were really pushing beyond technological boundaries: no one had ever launched and operated such a system before. Hughes personnel had to build first-of-a-kind hardware and develop new operational concepts. They had to overcome many challenges in getting the spacecraft ready and launched: the initialization procedures were behind schedule, and because they were building an entirely new system, they had to compile on-orbit test procedures "basically from scratch". In the months leading up to the first launch, the Hughes Corporation took the unprecedented step of transferring Brackey to full-time assignment at the ground station, a sign of how

8 For the first 32 years of its history, the NRO was organized as separate program offices, Programs A through C (there was also a Program D until the Air Force absorbed it in 1974), the "alphabetic program offices," each of which developed national reconnaissance assets primarily for the needs of the "parent" entities who staffed and resourced them. Program A was staffed by the Air Force and reported to the Office of the Secretary of the Air Force for Special Projects (SAFSP) and the Secretary of Defense; Program B was staffed by the Central Intelligence Agency's Office of Development and Engineering (OD&E, a sub-office within the Directorate of Science and Technology, DS&T) and reported to the Director of Central Intelligence (DCI); Program C was staffed by U.S. Navy civilians and military personnel who worked at the Naval Research Lab (NRL).

9 The 4th NRO charter, effective 11 August 1965, effectively served as the organization's principal authority document for five decades.

critical the system was to mission success. Brackey recalled that he had about 35 people on his team there, including software engineers, and a hardware and software person working shifts 24 hours a day, seven days a week. Brackey participated in training users in the nuances of the new system (CSNR Reference Collection).

Even after the NRO successfully launched the satellite and it settled into orbit, the ground station experienced problems receiving data because of faulty readings caused by a telemetry database error. Once major problems were resolved, the system became one of the NRO's most celebrated success stories. "Those were heady times," Brackey recalled. He said that his greatest satisfaction came from starting with little more than an idea, and having "the ability to look ahead. . .[and] understand what the possibilities were and figure out 'how could we do that'". Brackey's first-of-a-kind hardware made possible the collection and dissemination of data in near-real-time, a truly "game-changing" capability whose importance cannot be overstated. The new architecture eliminated the country's dependence on film-return systems and provided a persistent global information perspective that supported decisionmaking on emerging crises. It also moved the country's satellite intelligence capability closer to being able to support tactical military operations (CSNR Reference Collection).

Col. Joseph J. Eash, III—Innovative Applications for Overhead Systems

By the time he took an assignment with the NRO in 1979, Eash had already had "some very, very, interesting jobs in the Air Force," including being a nuclear weapons project officer, the director of contractor independent research and development technical evaluations, and director of engineering in the Air Force Satellite Data Systems (SDS) program office. "The most exciting thing in my career," Eash recalled, "was being able to go to Christmas Island and watch nuclear weapons go off over our head."[10] During this period when he was an Air Force captain or major, Eash received the legion of merit and consequently found himself being offered assignments typically given to colonels or generals. In one such "career-broadening" assignment, Eash worked for a supervisor who saw great potential in his mid-level officer and arranged the SDS job, in which Eash was responsible for the design, manufacture, testing, launching, and operation of multiple communication and relay satellites, work clearly similar to the NRO mission (CSNR Reference Collection).

From there, Eash became director of systems and technology at the NRO, where from 1979 to 1983 he managed a staff of about 30. Their major focus was spacecraft system design tradeoffs, cost analysis, and budget preparation. Not many specific details of what Eash and his staff did can be acknowledged, because the contribution for which he earned his Pioneer recognition remains sensitive and classified. What I can publicly acknowledge is that Eash became Chief of the NRO's "Special Staff," where he led the development of new NRO missions for reconnaissance systems. The focus was on accelerating development of technologies using unique materials.

10 The U.S. conducted thermonuclear testing around and above Christmas Island in 1962 as part of Operation Dominic.

The NRO Director during this period was Mr. Edward "Pete" Aldridge, the longest-tenured DNRO ever (he served from August 1981 until December 1988). For the NRO to be successful in its mission, Aldridge emphasized providing advanced collection technologies for intelligence and warfighter needs, and providing credible cost and performance estimates for its systems, so that the NRO could deliver on its promises. Aldridge had to confront two major issues: 1) a space launch policy that required all U.S. national security, civilian, and commercial launches to be on the Space Shuttle, which first flew in April 1981; 2) the competition between NRO program offices that with budget reductions in the mid-to-late 1980s was becoming counterproductive. To resolve the first issue, Aldridge, with others, successfully lobbied for a policy change to a "mixed fleet" strategy, and, for the second issue, he commissioned an internal study that recommended the collocation of NRO program offices (CSNR, 2011).

Eash and his staff assisted the DNRO in realizing his organizational goals. They allocated tasks, technologies, and missions to all three NRO "Alphabetic Program Offices"—NRO Programs A, B, and C—in pursuit of vital intelligence applications. In some cases, these programs had no precedent in either the NRO or the wider IC. It was the special staff's responsibility to efficiently allocate funding and then monitor its effective use. To protect these highly sensitive activities, Eash defined the requirements for a new security system that would cover all the activities being managed by the Special Staff; three decades later, this security system is still operating effectively. By encouraging innovation and creativity, balanced with accountability, Eash and his staff motivated and led three diverse program offices to deliver highly successful programs that advanced the role of space reconnaissance in intelligence gathering (Pioneer citations, 2012).

Dr. Michael N. Parker—Tracking and Geolocation From Space

Working as an intelligence analyst with the CIA for about two years, Parker began his career as a user of NRO-collected data, but when he left to join ESL in January 1968, he became a processor of signals data, and later served as project engineer for analyzing antiballistic missile (ABM) radars and telemetry in support of ABM treaty negotiations. He installed a Cesium clock system for precision timing at geographically divergent sites. The ESL made Parker director of a signal processing laboratory, "my ideal job" (Parker, 2012). The most important intelligence mission the lab supported was the tracking of Soviet missiles. Sometime around 1970, by his own recollection, Parker developed a system that used time difference of arrival (TDOA) for tracking Soviet vehicles, which provided useful experience for his later TDOA/Frequency Difference of Arrival (FDOA) measurements using NRO systems (Parker, 2012).

Although Parker began his seminal work a few years earlier, it was the priorities of the DNROs of the late 1970s and early 1980s, Drs. Hans Mark (August 1977–October 1979) and Robert Hermann (October 1979–August 1981), that were representative of the goals supported by the capability Parker would innovate. Mark's principal priority was developing space systems for monitoring and verifying compliance with the provisions of negotiated arms control treaties (in his time, the second major Strategic Nuclear Arms Limitation

Treaty or SALT II). Hermann, who had served for years in the National Security Agency, presided over a significant expansion in NRO signals intelligence capability and worked to establish concepts and mechanisms for NRO support to tactical military operations (CSNR, 2011).

A briefing from his Contracting Officer's Technical Representative (COTR) started Parker on the path that would eventually make him a Pioneer of National Reconnaissance. The COTR told several ESL employees about a new, very innovative NRO system: "It was far more ambitious than any unmanned spacecraft that NASA was doing at that time, and for many years later," Parker recalled. The COTR was concerned how to accurately analyze the data to know whether it was related to ABMs or other intelligence targets. On the spot, Parker suggested an approach by making signal externals measurements that could track missiles by reconstructing their altitude and answer multiple intelligence questions. Later, the head of ESL, William Perry, asked Parker for his analysis of a paper that had been presented to the government. The paper theorized that equipment signals could be located by measuring TDOA and FDOA. Parker reviewed the paper and pronounced the approach as sound. Extrapolating from his earlier experiences and system development, Parker later incorporated similar concepts to NRO systems, along the way inventing techniques for multipath echoes for tracking (Parker, 2012).

He recalled,

> The concept of TDOA/FDOA geolocation was suggested by several people over the years, often in the context of measurements from aircraft. Because of my background in radio astronomy, I was aware of work imaging cosmic emissions using Very Long Baseline Interferometry, tracking the lunar rover from earth, and proposals to make extremely precise measurements to track spacecraft with sufficient precision for aerodynamic re-entry at Mars.... I was fortunate to be performing experiments on these [NRO] spacecraft that gave me access to calibration sources and spacecraft data. Consequently, I was able to demonstrate the first TDOA/FDOA geolocation from space using spacecraft configurations and target signals that were considered impossible at the time. (Parker, 2012)

Interestingly, Parker found that his breakthroughs were not instantly exploited—"for about 5 years, nobody was interested," he said—but the combination of satellite enhancements and a series of global events that cost the U.S. some collection sites and capability made such measurements more accurate and more critical. In the 21st century, space-based geolocation techniques are at the forefront of a variety of intelligence applications.

Dr. John W. Shipley—System Definition for a Revolutionary Collection Asset

Shipley's first assignments with Harris were on NASA programs, i.e., open, unclassified programs, but after obtaining access to sensitive compartmented information (SCI), he began work on NRO antenna programs, including one very critical and long-lived sigint satellite program. He recalled the moment when he realized his job's significance to national security: in discussing one program, a colonel quipped, "When [Soviet Premier] Brezhnev farts [sic], we hear it," a colorful comment on both the capabilities of and the targets for such systems. Shipley participated on some signal processing and performance studies the NRO funded in the 1980s and later received tasking to do analysis aimed at overcoming the noise-like effects that impede intelligence collection. His work took him into technical areas in which he had little background in his education.

In considering the conceptual and analytical work he was performing in those years, Shipley recalled. "I took a course in communications theory…in random signals noise, but it wasn't until I started getting into that [analysis] that I started learning [that technology]" (CSNR Reference Collection).

Mr. Martin Faga (September 1989–March 1993) directed the NRO during its transition to being a publicly acknowledged and consolidated organization no longer functioning as three separate alphabetical program offices developing satellite reconnaissance capabilities primarily for parent organizations. His tenure immediately preceded the critical period of Shipley's pioneering work. Faga's vision for the NRO included incorporating the needs of the tactical military users into NRO system design and operation, an issue that became paramount after the first Gulf War (Operation Desert Storm in 1991), in which satellite assets assisted with targeting, earning the conflict the sobriquet of the "first space war." Faga's tenure saw the continuation of a trend of an enlarging NRO system user base in parallel with decreasing funding and increasing Congressional oversight. In an observation that indirectly salutes the Pioneers' accomplishments, Faga wrote, "The best intelligence is the intelligence the other side doesn't know you can get or, even better, doesn't even believe is possible by the laws of physics" (CSNR, 2011, p. 30).

The Gulf War had spotlighted the need for additional satellite reconnaissance capability, in particular the applicability to military operations of space-based, battlefield synoptic coverage. Shipley conceived a revolutionary idea and began work on a one-of-a-kind system using a groundbreaking new antenna design to address multiple intelligence needs. The subsequent antenna development progressed as a group effort in which Shipley's role was to write up analysis and specifications, and then give it to the team to work through the problem of producing a practical design. Unlike more contemporary developments, the specifications were not developed with dynamic, automated engineering allocation processes, but redrawn repeatedly from the project start date to the time of critical design review. There were budgetary challenges: the government management was encouraging the contractors to "design to zero margin", but there were too many elements to predict in advance what margin would be needed as the project progressed (CSNR Reference Collection).

The major challenge came from having to reduce complex technology into something the NRO could build relatively quickly. The antenna was an extraordinarily complex payload, the design for which needed to include the ability to place it into a stowed, launchable configuration, and have it deploy once on orbit to within very tight mechanical and surface tolerances, thermal control, and forming techniques. Shipley's contributions to the concept development, architectural approach, and system design were key to moving this unique capability from the drawing board to an on-orbit reality. The resulting system dramatically improved the nation's satellite reconnaissance capability.

Richard Van Wagoner—Pioneering Antenna and System Design for High-Quality Sigint Collection

While vacationing in Alaska in 1979, Van Wagoner received a call from a representative of NRO Program B. The program wanted him to work on an extraordinary new satellite program. The CIA recruited Van Wagoner after learning of his work on an antenna that he had designed and built while employed years earlier at RSI. He accepted and became the payload division chief responsible for the development of several hi-tech satellite collection subsystems, developing the concept for and managing the conduct of their deployment and verification. It would be the beginning of a distinguished 15-year career at the Agency, during which Van Wagoner was named as the very first CIA Federal Engineer of the Year in 1985 (CSNR Reference Collection).

Although he became payload manager, Van Wagoner maintained close, day-to-day involvement with the technical aspects of national reconnaissance satellite systems. He was instrumental in "bringing extremely broadband antennas, the first high-powered, solid-state downlink transmitter, and…monolithic microwave integrated circuits to the spacecraft program" (Van Wagoner, 2012). From Van Wagoner's perspective, the late 1970s into the 1980s represented the era of risk-taking in the NRO, when the organization had consistently large budgets, very little oversight, and the Office of Development and Engineering (OD&E—CIA's NRO Program B component) had the credo: don't let the possibility of failure interfere with progress. Executing the programs on schedule and within cost was of paramount concern, and consistent with that, Van Wagoner believed—and continues to believe—it was "better to ask for forgiveness later, but don't delay to ask for permission" (CSNR Reference Collection).

It is more difficult to pinpoint the DNRO whose priorities and vision are most related to Van Wagoner's accomplishments because of the nature of his contributions, although the other 2011 Pioneers also made multiple contributions over long careers. In keeping with the intent to have one 2011 Pioneer to represent each decade, however, Van Wagoner would have to be associated with the first decade of the 21st century, and DNROs like Mr. Peter Teets (December 2001—March 2005) and Dr. Donald Kerr (July 2005—October 2007). Teets, the first DNRO in the 9/11 aftermath, emphasized putting into orbit more capable and user-friendly systems that would support intelligence collection and the needs of the warfighter. Kerr strived to redefine the NRO not simply as an acquisition organization, but an intelligence agency. At a time when the IC was being restructured in response to the 2004 Intelligence Reform and Terrorism Prevention Act, Kerr sought to retain for the NRO its unique role in delivering integrated intelligence toward providing global situational awareness (CSNR, 2011).

In his career, which was continuing at the time of his recognition, Van Wagoner had pioneered antenna and system design across a range of NRO sigint capabilities, resulting in a number of patents—some classified and, by his estimation, three "that are worth talking about"—and setting a new standard for space antennae and power supplies. His development of groundbreaking technology contributed greatly to the high-quality sigint satellite collection capability available to the NRO and its mission partners. Moreover, as both a government manager and contractor consultant, Van Wagoner served as a systems engineering mentor to others, helping to build a cadre of experienced, knowledgeable, sigint workforce (Pioneer citations, 2012; CSNR Reference Collection).

Lessons from the 2011 Pioneers—Areas Critical to Their Success

In addition to recognizing individuals for innovative breakthroughs that made a lasting impact on the discipline of national reconnaissance, another objective for the NRO Pioneer Recognition Program is to capture the Pioneers' insights and record some of the lessons they learned--in Eash's words, "to see if there's some keys, something in the Pioneers [experiences] that maybe is not remembered or that needs to be emphasized." Through recognition of their accomplishments and documentation of their recollections, the Pioneers serve as models of excellence and recommend styles of leadership for the contemporary workforce. To that end, the NRO, through the CSNR, conducts interviews with the newly honored Pioneers before each Pioneer Day ceremony. In developing their innovative systems, this 2011 class of Pioneers—Brackey, Eash, Parker, Shipley, and Van Wagoner—overcame difficult technical challenges, encountered roadblocks, dealt with setbacks, and learned important lessons along the way (CSNR Reference Collection).

A few lessons that they noted in their interviews, some common almost to all of them, include the following: 1) Be honest with the customer; 2) Ensure NRO engineers can support programs "cradle-to-grave"; 3) Know when you're going down the wrong development path and then have the courage to change direction; and 4) Take risks, but also define all your risks.

Be honest with the customer. As a group, the 2011 Pioneers all stressed the importance of being completely honest with the program managers overseeing the development of any system. For the contractors, such as Brackey, Parker, and Shipley, this translated to "be honest with the customer." This was critical to maintaining trust between government and the contractors, which was essential to overcoming the many challenges during long, difficult developments. Brackey noted that his company, Hughes, "didn't know any better" than to tell the customer everything, good, bad, or indifferent. Parker advised would-be engineers to "never lie," and affirmed that "it is better to overachieve than to promise more than you can deliver" (Parker, 2012).

Ensure NRO engineers can support programs cradle-to-grave. The 2011 Pioneers were unanimous in decrying the modern-day practice at the NRO of "short tours," i.e., young engineers or acquisition officers assigned for two years and then rotated to another assignment elsewhere in their organization. Parker believed that assigning personnel to programs long term built and retained strong corporate memory that contributed to success. He said "the military model that rotates people through assignments every few years guarantees mediocre performance even from brilliant and dedicated people". Van Wagoner bemoaned what he sees as a decrease in experienced managers, saying that programs don't recruit and hire people with 20 years of experience any more, while emphasizing that "short tours are a problem," because it takes at least two years to even begin to make a contribution to a system, so on a short tour, "all anyone can focus on is process" (CSNR Reference Collection).

Know when you're going down the wrong path and have the courage to change direction. With the Pioneers, in many cases, trying to do things for which there was little to no precedent, it was inevitable that they would sometimes take the wrong path toward finding an innovative solution. They stressed that when that happens, one should not be afraid to change technical direction. "Indecision is the biggest enemy of progress." "Re-planning is probably more important than planning... We were a lot smarter about an issue or a problem after you had tried a few things that didn't work." Brackey saw another component to this issue. He noted that one has to be prepared, first to understand and recognize what is technically possible, but then also to recognize when development work is not going well and it is time to change direction. "You need to be flexible...use different people, another lab...but always keeping the objective in mind," Brackey said.

Take risks, but also define all your risks. Echoing many past Pioneers of National Reconnaissance, the 2011 class all praised taking risks. Without the ability to take risks an organization will be unlikely to produce groundbreaking innovations, they believe. Van Wagoner perceived the decades of the 1970s and 1980s as less risk averse, in part because of reduced oversight compared with the post-9/11 NRO. Parker recognized that the modern systems are very complicated, but advised that the NRO should not be afraid to take risks on its programs. Shipley agreed, but also recommended that program offices define all risks, "which you do through analysis." He noted that "as you define a new system, you'll find other things you don't know...so you better not have to spend time on things you could have identified first and gotten out of the way" (CSNR Reference Collection).

The Legacy of the 2011 Pioneers

> What was my impact on national reconnaissance? The spacecraft reflectors and my so-called structural brilliance were significant achievements, but they were not the things of which I am most proud....The thing I am proud of is my success with the process of taking a set of requirements and coming up with a spacecraft and associated launch components, as a system, and then trying to achieve maximum efficiency and performance.
>
> —John T. Bennett, TRW Engineer and 2000 Pioneer of National Reconnaissance in sigint spacecraft (Bennett, 2002, p. 53)

The noted California Institute of Technology professor Theodore Von Karman once tried to draw a distinction between scientists and engineers. "A scientist studies what is," Von Karman said. "An engineer creates what never was" (Petroski, 2010, p. 20). The 2011 Pioneers, all of whom were accomplished engineers, validated one half of Von Karman's definition. They conceived and innovated national reconnaissance capabilities that had not existed before, to solve some of the most difficult intelligence challenges, leaving to social scientists and historians the task of assessing the significance of their achievements. Their contributions enabled the NRO to provide the critical data that, during the Cold War, helped maintain the occasionally fragile balance of power—and kept the superpower rivalry between the U.S. and Union of Soviet Socialist Republics (U.S.S.R.) a non-shooting standoff. Some of the systems they produced continue in the 21st century to provide near-real-time information to keep senior decisionmakers well informed (and forewarned) and support U.S. warfighters and other military and IC professionals stationed around the globe. Much of the data collected by the systems the Pioneers helped to create and develop is unobtainable by any other means, particularly in the quality and quantity NRO systems consistently acquire. The 2011 Pioneers' outstanding examples of success serve as models of excellence for the modern IC and national security workforce (MSC, 2012).

The importance of recognizing and honoring pioneering individuals and remembering the examples they set should not be underestimated, particularly in a time of budgetary austerity. Through such efforts, organizations can capture and preserve lessons and best practices, so that they are not forgotten amidst an increasingly risk-averse management environment, and a leadership team challenged with greater scrutiny, increased transparency, and expanded oversight, and coping with budget reductions. The combination of such factors calls into question whether it will be possible again in the future to produce groundbreaking systems that change the direction and scope of national reconnaissance. In *Closing the Innovation Gap* (2009), celebrated entrepreneur Judy Estrin discussed "the five core values of innovation: questioning, risk taking, openness, patience, and trust" (p. 11). The 2011 Pioneers exemplified these values, as well as the spirit and dedication to work at a problem until a solution was found, never giving up. It is to be hoped that the next generation of NRO engineers embodies similar qualities, to continue the agency's specialized mission "to develop and operate unique and innovative overhead reconnaissance systems and conduct intelligence-related activities essential for U.S. national security" (NRO, 2012) for decades to come.

Brief Bios of the 2011 Pioneers

Dr. Thomas A. Brackey

Major Contribution to National Reconnaissance: Pioneered critical breakthroughs, including first-of-a-kind hardware, in space-based communications technology and operational concepts that enabled near-real-time collection and dissemination of data.

National Reconnaissance Career: 1969–Present (2014)

Career Highlights:

- Chief Technical Officer for Navigation and Communications System, Boeing Space and Intelligence Systems Division
- Major Program Manager
- Systems Engineering Laboratories Manager
- Chief Scientist
- Hughes Chief Technologist
- Technical Director
  All positions with Boeing and Hughes Space and Communications Company (formerly Hughes Aircraft Corporation)

Professional Credentials:

- Member, U.S. Air Force Scientific Advisory Board
- Member/Chairman, NASA National Advisory Committees
- Member, Institute of Electrical and Electronics Engineers/AFCEA Military Communications (MILCOM) Conference Board
- Founding Chair, Industrial Board of Advisors, The Ohio State University
- Distinguished Graduate, The Ohio State University

Education:

- Ph.D., Electrical Engineering, The Ohio State University
- M.S., Electrical Engineering, The Ohio State University
- B.S., Electrical Engineering, The Ohio State University

Colonel Joseph J. Eash, III

Major Contribution to National Reconnaissance: Pioneered the application of special innovative technologies to the NRO overhead mission. In his position as Chief of the NRO's "Special Staff," Col. Eash led the way in the development of new, highly sensitive NRO missions for both aircraft and satellite systems.

National Reconnaissance Career: 1979–1987

Career Highlights:

- Chief Scientist for computational social science modeling in the Center for Technology and National Security Policy, National Defense University
- Deputy Under Secretary of Defense (Advanced Systems & Concepts), Office of the Secretary of Defense
- Principal Research Engineer, Georgia Tech Research Institute
- Senior Vice President, GRC International
- President and CEO, SWL, Inc. (GRC International subsidiary)
- Senior Vice President, Engineering Research Group, SRI International
- Director of Systems and Technology, National Reconnaissance Office
- Air Force Office of Research

Professional Credentials:

- Member of the Defense Science Board Study on 21st Century Strategic Technology Vectors
- Member of Senior Advisory Board for the Air Force Center for Operational Analysis at the Air Force Institute of Technology
- Chairman of the Platforms Panel of the Defense Science Board Study of Global Surveillance
- Board Member of Grantham University
- Member of the Board of the David Sarnoff Research Center

Education:

- M.S., Nuclear Engineering, Air Force Institute of Technology
- B.S., Electrical Engineering, Grove City College

Dr. Michael N. Parker

Major Contribution to National Reconnaissance: Pioneered tracking and geolocation techniques based on precision signal externals measurements. In the 1970s, he developed missile tracking techniques that directly supported arms limitation treaty negotiations. He also demonstrated the first time-difference of arrival (TDOA)/frequency difference of arrival (FDOA) geolocation capability from space, a technology at the heart of satellite intelligence collection.

National Reconnaissance Career: 1968–Present (2014)

Career Highlights:

- Chief Technical Officer, Rincon Research Corporation
- Chief Executive Officer, Rincon Research Corporation
- Project Engineer and Department Manager, ESL, Inc.
- Independent Consultant (advised government and prime contractors on space and signal-processing topics)

Professional Credentials:

- Member of the Advisory Board of Arizona's NASA Space Grant Program
- Member of University of Arizona's Physics Advisory Board
- Member IEEE and AIAA
- Author or co-author of two dozen classified technical papers
- Founding Member of TAPR

Education:

- Ph.D., Electrical Engineering, Stanford University
- M.S., Electrical Engineering, Stanford University
- B.S., Electrical Engineering, Massachusetts Institute of Technology

Dr. John W. Shipley

Major Contribution to National Reconnaissance: Pioneered the concept development, architectural approach, and initial system definition that led to the successful development of a revolutionary NRO collection asset. His unique beam-forming design led to proven on-orbit performance and critical collections that have exceeded expectations.

National Reconnaissance Career: 1980–Present (2014)

Career Highlights: Nearly 30 years with Harris Corporation

- System Engineer for Space Deployable Antennas and Structures
- Radar Systems Engineering
- Advanced Signal Processing and ECCM
- Engineering Manager

Professional Credentials:

- Member of SENTINEL Joint Working Group
- Developed distributed Radar architecture used in SBR development study and DARPA Innovative SBR Antenna Technology (ISAT) program
- Conceived control of flexible structures (COFS) in space experiment for NASA
- Patents for inventions in COFS technology area include:
  – Inflatable antenna structure with a precision mesh control
  – Linear DC motor with accelerometer feedback for control of flexible structures
  – Linear DC motor incorporating active vibration control
  – Carbon-Carbon mirror technology

Education:

- Ph.D., Georgia Institute of Technology
- M.S., Engineering Mechanics, Georgia Institute of Technology
- B.S., Engineering Mechanics, Georgia Institute of Technology

Mr. Richard C. Van Wagoner

Major Contribution to National Reconnaissance: Pioneered antenna and system design and the evaluation of system performance critical to the successful execution of the NRO sigint mission. His ground-breaking development of innovative technology has resulted in the high quality sigint collection available to the IC and DoD.

National Reconnaissance Career: 1979–Present (2014)

Career Highlights:

- Payload Division Chief, NRO Program B (CIA)
- Deputy Director for Collection Systems (CIA)
- Independent Consultant to multiple NRO program offices
- Microwave Power Tube Section Head, Naval Research Laboratory

Professional Credentials:

- Federal Engineer of the Year, CIA
- CIA Career Intelligence Medal
- National Reconnaissance Office Superior Service Medal
- Technical Program Chairman of IEEE MTTS International Microwave Symposium
- Author of 19 technical papers presented at symposia or published in technical journals

Education:

- M.S., Electrical Engineering, George Washington University
- B.S., Electrical Engineering, University of Virginia

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