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SPACECAST 2020 was a Chief of Staff of the Air Force (CSAF)-directed space study, challenged to identify and conceptually develop high-leverage space technologies and systems that will best support the warfighter in the twenty-first century. This is the second of four monographs: Executive Summary, the SPACECAST 2020 Process, The World of 2020 and Alternate Futures, and Operational Analysis. This monograph gives a description of how military officers used creative techniques and an innovative process to envision the space systems that would provide the capabilities required to support US national security objectives in the middle of the twenty-first century, the years 2020 to 2050.

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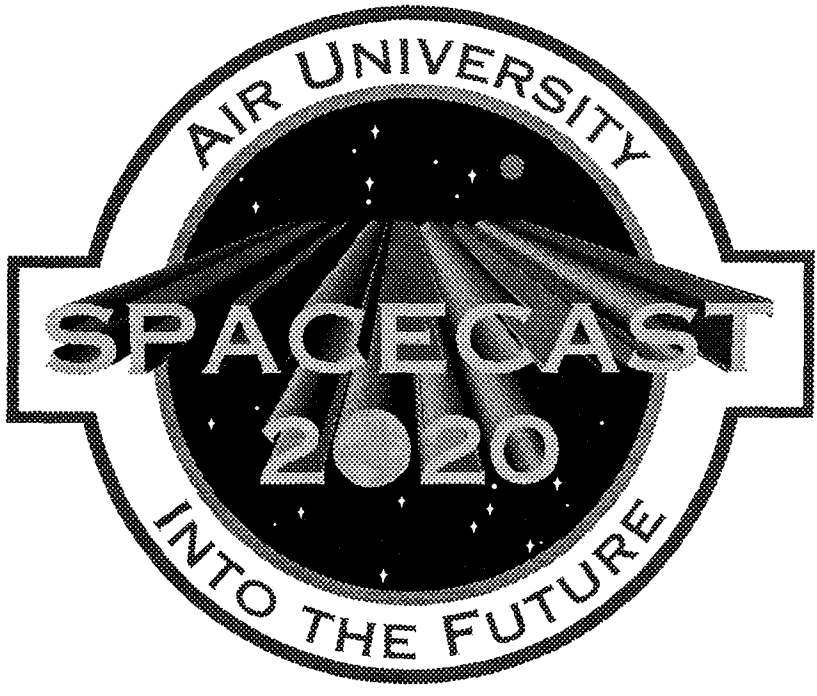
SPACECAST 2020 was a chief of staff of the Air Force-directed space study, challenged to identify and conceptually develop high-leverage space technologies and systems that will best support the war fighter in the twenty-first century. The study was composed of officers, airmen, and civilians from institutions within Air University and assisted by outside advisory groups made up of the Air Force major command vice commanders, senior retired military officers and distinguished civilians, and technical experts throughout the Department of Defense and civil/commercial laboratories. This is the second of four monographs: *Executive Summary, The SPACECAST 2020 Process, The World of 2020 and Alternative Futures,* and *Operational Analysis.*



THE SPACECAST 2020 PROCESS

Air University • Air Education and Training Command • United States Air Force
Maxwell Air Force Base, Alabama

The SPACECAST 2020 Process

Introduction

When I do a tradeoff study, I have absolutely no idea where it's going or what I'm going to learn. If I knew what I was going to learn, that means I already knew the answer, so why am I doing a study? Everything's got to be rubber, nothing's hard, when you do tradeoffs. Don't get worried. When people asked me where I was headed or what I was concluding, I'd tell them that I didn't have a clue ***where*** *I was headed or* ***how*** *I was going to get there, but I knew I'd* ***get there****.*

Col John R. Boyd (USAF, Retired)

Given the right conditions and using the right process, it is possible to harness the creativity of individuals in small group settings. What follows is a description of how military officers used creative techniques and an innovative process to envision the space systems that would provide the capabilities required to support US national security objectives in the middle of the twenty-first century, the years 2020 to 2050.

"SPACECAST 2020" was the name given to the study. It centered on 114 officers and civilians attending the Air Command and Staff College (ACSC) and the Air War College (AWC) at Maxwell Air Force Base, Alabama, during the 1993–1994 academic year. Gen Merrill A. McPeak, the chief of staff of the Air Force, requested the study. The study chair was the commander of the Air University, Lt Gen Jay W. Kelley. Under General Kelley's supervision, Air University personnel had to devise the process that would produce new ideas. They also had to execute the study both to produce and validate those new ideas. All this had to be accomplished within the confines of the Air University academic year. The guidance issued required that the study: (1) be characterized by unconstrained creativity, (2) remain detached from redefining service organ-

izational structures or redefining the assigned roles and missions of the armed forces, (3) be centered on generating a vision of the military space capabilities our country would require in the far future, and (4) not interfere with the core curricula of any of the Air University colleges. This last requirement mandated that the study be completed by the end of June 1994. Additionally, and although not part of the study's original mandate, General Kelley created two oversight groups apart from the Air University to advise the study participants and evaluate their progress and findings. General Kelley defined a key requirement of his role as study chair as "being the only person involved in the study with the power to say 'no'."

The Process

The Right Conditions

The essential prerequisite for success in any creative effort is an architecture that affirms the creative activity of the people stretching to create. The architecture has to organize people in collegial, creative-peer relationships that are relatively free of a rigid hierarchical structure. Initially the process has to aim more for idea generation than for idea assessment. Study participants must be bright and committed males and females. As a group, participants should be cross-generational and come from many different backgrounds. Moreover, and at least initially, having fewer "experts" in the area of inquiry or idea-generation is better than having many experts. Experts possess as many unconscious prejudices as they possess elements of certain knowledge. Experts usually are less open. Experts normally prejudge new ideas more often than nonexperts or those who are inexpert. All the attributes necessary for a successful creative study, including a shortage of space experts, existed within the student body and faculty of Air University. The SPACECAST 2020 study process was devised to take advantage of the best features of the Air Command and Staff College and the Air War College.

All the study participants were volunteers. Each participant consciously rejected the time-honored tenet: "Do not volunteer." A revolutionary 1993 and 1994 core curriculum change affected the more than 70 study participants from the Air Command and Staff College. The new curriculum was designed to demand superior scholarship and to place a premium on individual accountability for learning and group research. Air Command and Staff College students, for example, had to read approximately one full book every three days to complete their core curriculum requirements. The Air Command and Staff College also had introduced dramatic changes in the school and curriculum structure. These included: (1) the elimination of "departments" and their replacement with interlocking "teaching teams," (2) reduction in lecture hall mass meetings, (3) shifting the accountability for learning from the teacher to the learner, and (4) the introduction of multimedia courseware, requiring each student to have a laptop computer. As a consequence of these and other changes aimed at empowering the learner, the Air Command and Staff College intended to produce a number of the most intellectually agile and well-educated officers in the history of military education. These officers helped form the creative core of the SPACECAST 2020 study teams.

The 30 study participants from the Air War College had a much different core curriculum. While Air Command and Staff College students studied the "science" of warfare at the operational level, the more senior Air War College students studied the "art" of warfare at the strategic level. The Air War College curriculum highlighted "themes" and "principles, processes, and application" to educate senior leaders on the complex interactions between the armed forces and society. Understanding the process of national security decision making and the role of the political process in crisis resolution were important features of the Air War College curriculum. Unlike the students in the Air Command and Staff College, the class members of the Air War College routinely confronted questions that were unanswerable. Like Air Command and Staff College, there were no "school solutions" to the more complex issues raised in Air War College.

A-1

The students at Air Command and Staff College are majors (and Navy lieutenant commanders) or major-selects, with about 12 years of military service, and an average age of 32 years. Air War College class members are lieutenant colonels (or Navy commanders) or colonels (or Navy and Coast Guard captains) averaging 42 years of age, with around 17 years of service. Because "air" officers dominate Air University, Air Force officers and air crew members comprised the bulk of the students and the majority of the study participants. Nearly 80 percent of the study participants were from the operational "line" of their service. Less than 5 percent had either space or scientific backgrounds. The distribution of participants by military specialty is indicated in Table 1.

Table 1

Student Backgrounds

Pilots, Navigators/Weapons System Officer & Missile Operations	34	29.8%
Human Resources	15	13.2%
Acquisition	15	13.2%
Communications & Computers	12	10.2%
Engineering & Research and Development	7	6.1%
Navy & Marines	5	4.4%
Space Operations	5	4.4%
Logistics	4	3.5%
Intelligence	4	3.5%
Civilian	4	3.5%
Security Police & Office of Special Investigations	3	2.6%
Weather	2	1.8%
Army	2	1.8%
Finance	1	.9%
Chaplain	1	.9%
	114	100%

Thus, the volunteers formed a team that was both cross-generational and multidisciplinary. Relatively conservative, staid, and sedate senior officers became the colleagues of less conservative, more enthusiastic, and sometimes ardent junior officers. What the more senior officers (long experienced in surviving in a hierarchical system) lacked, the more junior officers provided. Whatever experience of

the "real world" the junior participants lacked, the senior officers provided. Included in the study group were a member of the clergy, personnel officers, accountants, intelligence officers, communications officers, Army helicopter pilots, naval antisubmarine warfare pilots, logistics specialists, computer experts, and a very large number of Air Force aviators. The study participants cut across service boundaries, spanned a significant portion of the military grade structure, and represented nearly every "product division" of the corporate armed forces. Moreover, the students represented the very top percentage of their commissioning year groups. They were the best and the brightest, competitively selected to complete the mind-expanding, career-enhancing professional military education schools in residence.

The commandants of the Air War College and Air Command and Staff College were both supportive of the study effort and their commander, who was the study chair. Study participation counted as the required group research for Air Command and Staff College and fulfilled the elective and advanced study course requirement in the Air War College. Both schools generously contributed space, faculty advisors, and equipment to the effort.

The SPACECAST study aimed for the creation of "new products" related to military space operations. Consequently, the participants needed to be armed to fight in the new product development arena. Few of the participants thought of themselves as creative. Few participated in studies searching for new products in the past. None previously participated in studies unaffected by service advocacy for equipment, roles, missions, or functions. The conditions at AU made it possible to craft the right process.

The Right Process

The process of producing new ideas is always an iterative one. Because executing the study **process** was more important than producing a product initially, the research methodology took the form mandated by the study's primary function. That is, it focused initially on the process of generating creative thinking. This process intended to pre-

pare the participants to think creatively within the possible operating environments of the far future.

Air University, like most colleges and universities, has a superb library containing hundreds of books and thousands of journal articles on the subjects of innovation, creativity, and creative thinking. Air University also hosts the Air Force Quality Institute, an additional source of information on innovation. The challenge was to research the subjects of creativity and innovation and devise a system that unavoidably resulted in the creation of new things. The study process had to (1) capitalize on individual creativity, (2) link idea-generators in small and interactive teams, (3) somehow compensate for a shortage of technologists and scientists, and (4) produce an abundance of new product ideas that could be winnowed to select the best ideas. Moreover, it had to overcome some of the perceived barriers inherent in military organizations. These included hierarchical organizational structures, specialization, and what others have called the pecking order and associated dominance-submission behaviors sometimes imposed by military grade. The tendencies to support conservatism and eschew maverick thinking were consequences of these barriers.

The study participants had each spent years "coloring inside the boxes." The participants had built their successful military careers on being good followers, on executing the ideas of others. The study process had to capitalize on the participants' abilities as followers, but it also needed to take advantage of their potential as innovative leaders. The study process had to be regimented enough to expand the participants' comfort zones ever so slowly, but not so regimented that it stifled creativity. To do this, the study process had to be continuously iterative, with built-in due dates for deliverables and their evaluation. The evaluations or assessments had to begin as "hidden" so as not to stifle creativity, but become increasingly "open" to refine the ideas.

The study customer, General McPeak, and the study chair, General Kelley, made it easy initially. Both saw the heuristic value of the effort as sufficient justification to undertake the study. Although General McPeak wanted

new product ideas, he appreciated that this might not be possible from a group of nonscientific officers grappling with "space," the domain of scientists and engineers. Thus, even with the motivation provided by serving the most senior military customer in the Air Force, the study was nonthreatening to the participants. General Kelley, echoing General McPeak, also knew that the study outcome would be unpredictable. He too wanted new products and new ideas. "One or two" were the numbers he most often used, but the study participants were under no compulsion by General McPeak to produce any new ideas or products. Thus, from the beginning, the whole effort had the characteristics of a win-win arrangement. Even so, all involved knew that a 10-month effort resulting in no new ideas would have been less valuable than it might have been and should have been.

Volunteer study participants were organized initially into three teams under the general supervision of a research director: (1) creative activity teams (CAT), (2) realistic assessment teams (RAT), and (3) a Technology Team made up of engineers and scientists at Air University's Air Force Institute of Technology (AFIT). The CATs comprised about 80 percent of the study team. The CATs initially organized in small group "seminars." The seminars later became "teams." The RATs were the assessors or evaluators responsible for assuring that new product ideas made sense. The RATs also ensured that ideas did not unintentionally violate any laws (including the laws of physics) or treaties. The ideas also had to be scientifically sound. Finally, the RATs guaranteed enough understanding of the ideas for later rank-ordering in tradeoff analyses. Initially and by design, the CATs were separated from the RATs. Later both groups would work closely together to bring the descriptions of the new products to completion. The role of the Technology Team was to provide the necessary scientific and technical linkages requisite for the study's credibility.

Phase One: Preparation

Graham Wallas and others describe creative thinking as a serial process that progresses through several stages. The four stages are: (1) preparation, (2) incubation, (3) illu-

mination or insight, and (4) verification. The stages or phases of the SPACECAST study process corresponded with the stages necessary for creative thinking. The first stage, preparation, began with an introduction to the art of creative thinking.

Although military officers actually are quite creative, they usually do not associate their own problem-solving abilities with creativity. They view problem-solving as the science of getting things done in the face of resistance. Creativity, on the other hand, is the art of envisioning things that might never be done. Problem-solving is a necessity for military officers, but military officers often see creative thinking as a luxury. By not viewing themselves as creative, most military officers lack confidence in their creativity. The first challenge was to structure a study process that guaranteed a creative output. The Center for Creative Leadership suggested that the study architects make contact with Rolf Smith at the Office of Strategic Innovation in Houston, Texas. Smith, who retired from the Air Force as a colonel, was familiar with the challenge in general and with innovative studies in particular. Smith was one of the first of many *pro bono* contributors to the SPACECAST study. He remained among the best contributors. He described the SPACECAST charter as one that required "doing things that **had not** been done" as prerequisite to "doing things that **cannot** be done." It was impossible to fulfill this charter without participants confident in their creative ability.

Thus, the immediate challenge was to devise a way to convince the study participants that they **were** creative and competent for the task. That task fell to Dr Roger von Oech and Bob King. Two of the more readable and popular books on creative thinking are by Roger von Oech, *A Kick in the Seat of the Pants* and *A Whack on the Side of the Head.* SPACECAST invited Dr von Oech to Air University to conduct a half-day workshop, filled with idea-generation exercises, for the study participants. Dr von Oech, using his books as a benchmark, described the four facets of creativity as roles. Creative thinkers had to embrace the role of Explorer, Artist, Judge, and Warrior. Explorers sought new ideas or fundamental truths, even to the point of

"slaying sacred cows." Artists recombined old ideas or envisioned new things. Judges accurately assessed the new constructs to determine whether or not the new ideas or products were valuable and useful. Warriors, convinced that a new idea was meritorious, worked and fought to see it implemented. All these facets or faces of creativity must be present to make important new discoveries.

With the study participants encouraged and vitalized by the workshop, Bob King of QPC (Quality, Performance, Competitiveness) Gold reinforced von Oech's insights into creative thinking and added techniques for critical thinking. Mr King was a consultant under contract to the Air Force Quality Institute. Small group idea-generation exercises and small-group idea evaluation exercises exposed the team to exciting new methods for unlocking their creative faculties. A key point was that analysis, or what another consultant, John Boyd, called "destructive deduction" had to precede synthesis, or "creative induction." Thus, one element of creativity was the process of fragmenting "wholes" into their component parts and reorganizing these parts into new combinations or wholes. Those creative and critical thinking skills learned, if not mastered, it was next necessary to immerse the study participants in a study of the future. Figure 1 roughly approximates the blueprint for the study process.

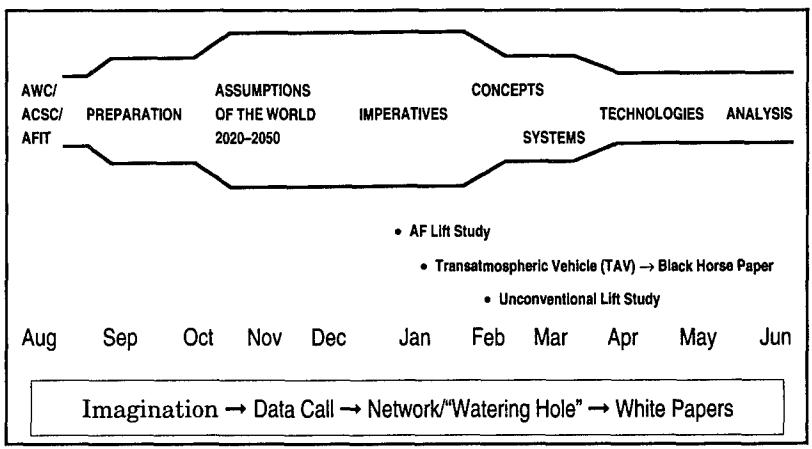


Figure 1. Year in Review

The focus of SPACECAST 2020 was on devising ways—including the introduction of hardware—that space systems could provide the capabilities necessary to support national security in the far future. Hence the next part of the preparation effort aimed at looking into the future. Neither the Air War College nor the Air Command and Staff College curriculum specifically focused on the far future. The objective of this portion of the preparation period was to better understand the unknown and the unknowable. This required answers to such questions as: What will "national security" mean in the next century? What forces will likely affect it? and How can space and operations in space help us provide for it? To answer these and other equally difficult questions, SPACECAST created what amounted to a separate and virtual university within the Air University, specifically structured to focus on the future. This, in turn, required a slate of lecturers capable of focusing the study participants on specific aspects of the future. The SPACECAST project director stepped up to the monumental task of inviting the selected guest lecturers to Air University, arranging their transportation, and serving as host when they arrived.

The study's unequaled extended and global "faculty" interacted with the study participants in person or over two-way, interactive video telephone piped directly into the lecture hall and classroom. Table 2 identifies some of the members of the SPACECAST "faculty." This faculty included—but was not limited to—Alvin and Dr Heidi Toffler (*Future Shock, Powershift, The Third Wave, War and Anti-War*); Dr Edward Teller (one of the world's leading physicists and "the father of the hydrogen bomb"); Professor Martin van Creveld (*Command in War, The Transformation of War,* and many other works); Sir Arthur C. Clarke—addressing study participants via satellite-linked video telephone from Sri Lanka—(*2001: A Space Odyssey, How the World Was One,* and many other works); John Boyd ("Creation and Destruction," *A Discourse on Winning and Losing,* and "The Conceptual Spiral"); Dr John Arquilla ("Cyberwar is Coming!"); science fiction writers Dr Jerry Pournelle and Joe Haldeman; Col John Warden, the commandant of Air University's Air Command and Staff

College and author of *The Air Campaign* and the one who envisioned "The Five Rings: Strategic Centers of Gravity"; Dr Lowell Wood (a senior scientist from Lawrence Livermore labs and the creator of "Brilliant Pebbles" for the Strategic Defense Initiative); Col Simon ("Pete") Worden, Air Force Ballistic Missile Defense Office (AFBMDO) Tech Chief; Dr David Webb; Dr Wendel Mendell; Carl Builder (*The Masks of War* and *The Icarus Syndrome*); and others. Dr George Stein and Dr Armin Ludwig of the Air War College presented forecasts of the future. Representatives from the Central Intelligence Agency, the National Security Agency, the Defense Intelligence Agency, and the United States Command gave highly classified presentations. Dr Carl Sagan (*Cosmos,* and many, many other works), addressing the study participants by video telephone from Cornell University, was the final speaker. Participants also read Paul Kennedy's *Preparing for the Twenty-First Century,* and Samuel Huntington's "The Clash of Civilizations."

Table 2

Guest Lecturers

CREATIVE THINKING	FUTURE WORLD ENVIRONMENT/CONFLICT	FUTURE TECHNOLOGY AND SPACE
DR ROGER VON OECH *(AUTHOR)*	DR CARL SAGAN *(SCIENTIST)*	COL TED WIERZBANOWSKI *(NASP)*
MR BOB KING *(CONSULTANT)*	DRS STEIN & LUDWIG *(AWC)*	COL PETE WORDEN *(AFBMDO TECH CHIEF)*
COL JOHN BOYD, RET *(MAVERICK THINKER)*	DRS ALVIN & HEIDI TOFFLER *(AUTHORS)*	DR EDWARD TELLER *(SCHOLAR)*
DR JOE HALDEMANN *(SCI-FI AUTHOR)*	MR CARL BUILDER *(RAND)*	DR LOWELL WOOD *(SCIENTIST)*
DR JERRY POURNELLE *(SCI-FI AUTHOR)*	DR JOHN ARQUILLA *(CYBERWAR)*	DR F. X. ("DUKE") KANE *(SPACE STRATEGIST)*
SIR ARTHUR C. CLARKE *(SCI-FI AUTHOR)*	DR MARTIN VAN CREVELD *(FUTURE WAR)*	DR DAVID WEBB *(SPACE POLICY)*
MR BOB JUSTMAN *(MOVIE PRODUCER)*	COL JOHN WARDEN *(FUTURE CONFLICT)*	DR WENDELL MENDELL *(SCIENTIST)*

By the time the preparation period ended, the participants had interacted with over 40 different lecturers and spent over 100 hours focusing on space, technology, and conflict in the future. This investment of time was in addition to the time devoted to completing the requirements of the Air War College and Air Command and Staff College core curricula. Even so, SPACECAST participants were out-performing their classmates in the rated areas of the core curriculum. Those on the colleges' faculty who thought of the core curriculum as valuable attributed this exceptional performance to the fact that the best minds had volunteered to participate in the study. Others ascribed the anomalous performance to the unique SPACECAST preparation curriculum, the relative lack of a rigid structure within the SPACECAST seminars, the multidisciplinary fusion of information that the nondirective and open-ended process encouraged, or the empowerment of the adult learner treated as an adult and colleague. Which of these explanations was actually the case was less important than the fact that SPACECAST participants became totally immersed in their studies of the potential operating environment of the far future. Moreover, the SPACECAST participants were able to articulate the forces that could or would affect US security and military operations in the far future.

While the strategic purpose of the preparation period was to introduce creative thinking and provide insights into the challenges anticipated in the far future, it also provided an essential tactical advantage. The tactical advantage was that it bought time. Even as the preparation phase was underway, the SPACECAST support staff, under the general supervision of a project director, was very busy. Administrative support tasks included ordering supplies, buying and leasing office equipment (copier, facsimile machine, an answering machine, laptop and desk computers and printers, and software), ordering books, establishing security and document control procedures, and building a network connecting the Air Force Institute of Technology at Wright-Patterson Air Force Base to science and technology nodes nationwide.

The Air Force Institute of Technology, a subordinate unit of the Air University, is the accredited postgraduate, degree-granting science and technology school for the Air Force. Staffed with civilian faculty and military PhDs, the Institute fulfilled the Air Force's critical need for in-house scientists, engineers, and analysts. Since both the CATs and the RATs lacked scientists and technologists among their numbers, one value that Institute participation added was that it possessed and was able to make available scientists and engineers in abundance. Two, then three, and eventually four Institute personnel worked on the study full time. Their roles included: (1) superintending a call for papers, (2) condensing or abstracting information in the papers received, and (3) putting the condensed information into an electronic filing system. A unique feature of the electronic filing system was that all information in it was accessible by subject area and key word. The Technology Team also (4) evaluated the abstracts (using criteria including feasibility, time to fruition, and a gross estimate of technological challenge). The team (5) created a network encompassing labs and university research centers nationwide. Lastly, (6) Technology Team members sat on RAT assessment panels whenever these met.

The call for papers went out over multiple computer information networks and bulletin boards, through announcements to over 150 military organizations, through press releases, and through advertisements in *Aviation Week and Space Technology.* The call for papers and persistence yielded over 400 technology and technology application papers, nearly 70 technology studies, and sparked the curiosity of a great number of people. Technology abstracts came from as far away as Moscow in the Russian Federation, from Norway, and from the Czech Republic. Many came from concerned private citizens (including students, a real estate agent, and other unexpected contributors). Most of the ideas and technology abstracts were valuable and some were extremely valuable.

As the preparation period approached its culminating point, the participants became increasingly eager to put their ideas on paper. The participants were encouraged to **incubate** and pursue **insight** during this phase, but they

were not encouraged to develop concepts or ideas prematurely. There were two reasons for this. First, the intention was that the ideas would percolate in their heads, allowing the left and right brains to interact and sort out things until **illumination** arrived. Second, the SPACECAST team was not yet ready to receive the ideas in an organized way.

As the end of the preparation period for CATs and RATs approached, CATs worked in brainstorming seminars to transform all the information presented into assumptions about the operating environment of the far future. Brainstorming seminars were small groups with about six students and three faculty members interacting collegially. Each of the 14 CAT groups presented its assumptions to a review panel of faculty, drawn from the RATs. These assumptions, some remarkable, some extrapolations of the present, approximated the operating environment of the period from around 2005 to 2050. The assumptions about the operating environment were designed to focus the attention of study participants on how and why the challenge of providing for the national (or perhaps by then international) security would change. The assumptions also served as benchmarks to help understand the novel space capabilities, applications, and systems that would emerge as the study progressed.

The descriptive characteristics of the operating environment differed from CAT seminar to CAT seminar. To provide a consensus view of the future, only those characteristics that all seminars agreed upon constituted the consensus view of the future operating environment. As a consequence, SPACECAST temporarily set aside alternative futures and a very fertile rogue set of possible and plausible future characteristics. The consensus view became known as the SPACECAST future. The study participants would return to the rogue set to exploit it later.

Student participants organized the assumptions regarding the operating environment of the far future into six major areas: people, geopolitics, the environment, economics, technology, and future sources of conflict. The oversight group called the Executive Board reviewed the

consensus assumptions about the operating environment of the far future and commented on them. The Executive endorsed the process and did not disagree with any of the characterizations of the future operating environment. The Executive encouraged participants to look for creative ways to transform all military air activities into military space activities.

Enthusiasm for the project and its process was high among the senior military officers who constituted the Executive. Executive Board members are listed in Table 3. After the initial meeting, several commands represented in the Executive Board created their own idea generation teams to support and harmonize with the Air University team. As a consequence of creating their own idea generation teams, the Air Combat Command, the Pacific Air Force, and the Air Force Special Operations Command submitted hundreds of additional ideas to the SPACECAST team at Maxwell.

Table 3

Executive Board

Lt Gen John S. Fairchild PACAF/CV	Lt Gen Thad A. Wolfe ACC/CV
Lt Gen Eugene E. Habiger AETC/CV	Lt Gen John G. Lorber USAFE/CV
Lt Gen John E. Jackson, Jr. AMC/CV	Lt Gen Dale W. Thompson, Jr. AFMC/CV
Lt Gen Thomas S. Moorman, Jr. SPACECOM/CV	BGen James L. Higham AFSOC/CV

As word of the study spread throughout the Department of Defense, other organizations became interested in hearing more about what SPACECAST was learning. Through a growing network, SPACECAST became aware of similar studies. These included studies underway in the Secretary of Defense's Office of Net Assessment, the Defense Intelligence Agency, the Office of the Joint Chiefs of Staff Plans and Policy directorate, and the United States Air Force

Academy. Since by this time SPACECAST offered an already-available vision of the operating environment of 2020, each of these other organizations joined the SPACECAST network. General Kelley greatly facilitated interaction with these and other organizations when he authorized these outside agencies full access to what Air University was learning in return for participation and help in the effort. As a consequence, Air University was able to greatly expand the talent and capability of the RATs by creating an expanded realistic assessment team (ExRAT). The expanded team had participants from all the services, all the intelligence agencies, all the military space commands, and many of the government-owned and funded research and development centers. It eventually included over 40 additional participants.

While the CATs were envisioning the operating environment of the far future, the RATs were building the assessment criteria they would use to evaluate CAT-created concepts. These criteria required asking 45 very specific questions about each concept. Among them were such things as: What are the political consequences of employing this concept? What does this concept contribute to US commerce and industry? and What maintenance and sustainment requirements does the concept impose? That work done, two other items were required before the study could move into the next phase. First, there needed to be a vision of the format for the final product. Second, and more importantly, there needed to be concepts to manipulate to form the basis of the final report.

Bob King had exposed study participants to "brain writing" and the Crawford slip technique for small group creative thinking. Both techniques were proven ways of capturing new ideas, but neither technique had the traceability necessary for SPACECAST. New ideas often come in bursts, so it was necessary to devise a method of capturing these bursts for SPACECAST. SPACECAST developed a one-page concept paper format as a variant of existing brain writing techniques. The concept paper format required the originator to: (1) describe the new idea, (2) identify how the idea differed from present practice or equipment, (3) postulate countermeasures to the idea, and

(4) specify a civilian or commercial application for the idea. Thus every concept paper included three ideas: the basic new idea, the countermeasure an adversary might use to defeat the idea, and a commercial or nonmilitary application of the idea.

The mental agility and discipline required to generate new ideas and simultaneously generate a way to defeat the new idea resulted in more robust ideas than would have resulted otherwise. Moreover, this process fostered a uniquely valuable way of thinking for military officers. They quickly learned that some of their best work was evidenced not in the new idea, but in their own countermeasure to the idea. Likewise, the search for commercial applications for each idea required that thought be given to the needs and desires of the average, nonmilitary citizen at every point in the process. Where commercial applications were easily forthcoming, obvious opportunities for partnerships were readily apparent. The concept papers were the foundation for everything that followed and became the building blocks of the final report. Individuals and small teams produced concept papers.

Because the one-page papers might contain classified information and needed to be standardized, laptop computers were provided for each team. Each laptop had a concept paper template loaded into it. The study participants treated the laptops as classified materials and treated the papers the same way until qualified security personnel adjudicated them to the unclassified level. At the end of the study, security personnel degaussed and sanitized the laptops to remove all the information from them. The one-page papers were easy to manage. The one-page papers were easy to evaluate, combine, and amplify into a more comprehensive and robust product as the study progressed.

After harvesting the initial ideas, and over the December 1993 holiday break, impaneled RATs evaluated them. RATs categorized, catalogued, and numbered each concept paper. Each was cross-linked to other similar ideas and to categories of technology in the technology abstracts. RATs commented on each idea. These comments deliberately were affirming and supportive, and general in nature.

While the comment, Violates the Outer Space Treaty of 1976, might have been appropriate for a particular concept paper, the RATs instead asked a question: Is this idea in compliance with current treaties? This nondirective approach was a planned feature of the creative SPACECAST process. The approach required the originator of the idea to think about the question, its implications, and the possible effects of one answer or another on the new idea. Thus, the originator bore responsibility for any modification of the idea. No one could direct the originator to amend the idea. Although most study participants understood and affirmed this approach, a few others found it discomforting. Those who found the approach discomforting wanted very clear and specific guidance.

The RATs also aggregated the concept papers by general subject area. The selection of general subject areas was less analytical than it was creative. This categorization included a number of ideas that logically could reside in more than one category. Duplicate, or very close to duplicate ideas were not eliminated. Some ideas could not be linked easily or naturally to an assigned category. Those cases challenged the study participants to stretch to find a creative connection. When the study participants returned from the holiday break, SPACECAST was ready to enter the second phase of the study.

Phase Two: Concept Development and Refinement for Illumination

Considering their interests in pursuing a particular area, the participants in the 14 Phase One seminars were reorganized into 15 Phase Two teams. The teams and their associated area of inquiry are depicted in Table 4. Each team had a team coordinator, selected randomly and without regard for military grade. This too was intentional. It was intended to preserve the peer-creator architecture characteristic of the study process. As a consequence, colonels were on teams headed by or coordinated by a more junior officer. Each team also had a faculty member attached as a team player and colleague. The RATs joined the CATs so that each team had the assured equivalent of left- and right-brain skills. (Left-brain skills include logical

and linear evaluative thinking. Right-brain skills include more artistic and imagistic thinking.) Each team pursued a particular area of inquiry. The areas corresponded to a chapter or section of the final product, described internally and at this point as "the Book." Only two teams explored the same area. At this point, SPACECAST assigned only one team the chore of inventing creative solutions for our nation's most pressing space challenge: the lack of inexpensive spacelift.

Table 4

The 15 Teams

- TEAM 1 = SPACELIFT
- TEAM 2 = COMBAT SUPPORT
- TEAM 3 = COMMAND & CONTROL
- TEAM 4 = COMMAND & CONTROL
- TEAM 5 = COUNTER SPACE/WEAPONS
- TEAM 6 = WEAPONS
- TEAM 7 = STRATEGIC ATTACK
- TEAM 8 = SPECIAL OPERATIONS
- TEAM 9 = FORCE APPLICATION
- TEAM 10 = SURVEILLANCE/RECON
- TEAM 11 = FORCE ENHANCEMENT
- TEAM 12 = HUMANS IN SPACE
- TEAM 13 = PLANETARY DEFENSE
- TEAM 14 = EDUCATION/TRAINING
- TEAM 15 = CIVIL/COMMERCIAL

The demarcations between areas were neither hard nor fast at this point. All participants had electronic access to and paper copies of all the concept papers generated by the study group at large and all the technology abstracts. Each group set about refining their ideas by combining, amplifying, and improving the concepts generated in the first phase. A new template, a White Paper Template, became the outline for writing and reporting.

Although the research director provided some guidance as SPACECAST Bulletins, the guidance deliberately was restricted to minimum essential information. This information included process tips, due dates, the format of deliverables, and announcements of some coming events. Some participants were anxious because of the intentional lack of very

specific instructions. The objective was to create a study environment that gave maximum latitude to study participants by providing a minimum amount of specific instructions. Military officers found themselves empowered to do their own thinking and schedule their own workload. While uncomfortable for some, this empowerment and lack of rigid structure was a deliberate part of the process. The result was approximately 50 candidate white papers, each briefly developing a single idea from the combination of ideas available.

In addition to the team-authorship of white papers, each writing team had to begin putting the substance of their white paper into a 10-minute briefing. The purpose of these briefings, to be given in the latter phase of the study, was to quickly communicate the essence of an idea to those who had not taken the time to read the paper that amplified the idea. At this point in the study the papers were so numerous and detailed that a cover-to-cover reading of the entire evolving report required a minimum of 15 hours for a speed-reader. The briefings also placed the writers into the position of having to defend their ideas to critics. This type of oral defense, usually found only in doctoral programs, required SPACECAST participants to master additional skills. These skills included thinking on their feet and selecting support data and graphics that quickly communicated their ideas. The briefing preparation requirement also sharpened the skills that Dr von Oech warned that creativity required: the ability to assume the role of both Judge and Warrior.

The ExRATs reviewed the initial drafts of these products while the Senior Advisory Group met. The scientists and engineers in the ExRATs evaluated each of the 50 candidate white papers. They also studied each of the 200 concept papers fused to create the white papers. Finally, the ExRATs reviewed each of the 237 technology abstracts available at that time. (The number of technology abstracts later grew to over 400.) A universal observation was that, while highly creative, many of the candidate white papers lacked evidence of close linkage to emerging technologies. Moreover, the rate of technological change in our country—especially in information technology—was much more rapid than the study participants had expected. Many of the things SPACECAST envisioned for

2020 were "already on the street" or would be operational well before 2020. The SPACECAST support staff and RAT captured the comments of the ExRATs in writing over a weekend. They presented the comments to the teams on a diskette the following Monday. The next deliverable was due in two weeks. The expectation was that the candidate white papers would respond to the guidance of the ExRATs and the advice of the Senior Advisory Group, Table 5.

Table 5

Advisory Group

MR EDWARD C. ALDRIDGE
President & Chief Executive Officer, Aerospace Corp

MR ALF L. ANDREASSEN
Information Systems Vice Presdient, AT&T

MR BRUNO W. AUGENSTEIN
Senior Scientist, Defense & Technology Planning Department RAND

MR NORMAN R. AUGUSTINE
Chief Executive Officer, Marin Marietta

DR ANTHONY K. HYDER
Associate Vice Pres for Graduate Studies and Research, University of Notre Dame

DR JOAN JOHNSON-FREESE
Associate Professor, Dept of Natioal Security Studies Air War College

VADM WILLIAM RAMSEY
USN (Ret)
Vice Pres of Corp Business Development, CTA Inc

GEN ROBERT W. RISCASSI
USA (Ret)
Vice Pres, Land Systems for Loral Corp

COL JOHN R. BOYD
USAF (Ret)
Consultant

BG ELMER T. BROOKS
USAF (Ret)
Deputy Assoc Administrator Mgmt Sys & Fac, HQ NASA

MR DONALD FUQUA
Presidet, Aerospace Industries Association, Inc

GEN ALFRED M. GRAY
USMC (Ret)
Senior Associate, GIA Inc

GEN BENNIE SCHRIEVER
USAF (Ret)
Consultant

MR JAMES R. THOMPSON, JR
Exec Vice Pres & Gen Mgr, Launch Systems Group Orbital Sciences Corp

GEN LARRY D. WELCH
USAF (Ret)
President, Institute for Defense Analysis

DR JOHN P. WHITE
Dir of the Ctr of Business & Gov't, JFK School of Gov't Harvard University

The academic requirements of the core curriculum after the new year frustrated the process somewhat. Air Command and Staff College students had a four-day long take-home test to complete, followed a week later by an intensive two-day war game. Air War College participants had a two-week-long regional study trip abroad. Even so, the available SPACECAST participants filled the gaps as best as possible and produced the next deliverable by the due date.

Unfortunately, the second drafts of white papers evidenced little more science than the first drafts did. Admonishment joined encouragement. All knew that when the full team assembled once again, more brains would get more and better work done. Everyone understood that the months of February and March—with their remaining iterations of white papers—would be the most critical months in the entire study. If ideas did not join technology, and if things did not grow into integrated "systems of things," the final product would join the ranks of 25 previous space studies done elsewhere. These previous studies were, in the words of one critic, "Interesting, but not compelling."

The RATs met for three days to evaluate the 50 draft white papers submitted in the second round of drafts. They made recommendations on each one. In many cases the recommendation was to make the paper a subset of another paper. In some cases the recommendation was that no further effort be expended on the paper. The result of the review was the recommendation that the 50 narrow papers evolve into 17 broader ones. The review also resulted in the recommendation that more effort be expended to examine emerging technologies that might provide the technological solutions that the proposed future capabilities required. Further, it became the right time to transition to a standard essay-like format for each paper. This would require citing references for the ideas or technologies in the paper. An essay-like format also facilitated cross-referencing among the papers. Cross-referencing helped the SPACECAST team to jointly understand and assess the future space force structure SPACECAST postulated. By the third draft the papers had to have more

granularity and a much higher degree of specificity. This included important details omitted to this point: for example, such things as the number of spacecraft comprising a particular system, orbital assignment and analysis, command and control, and near-term technology requirements or opportunities.

Just as he had at the end of the first phase, General Kelley addressed all study participants at the culminating point of the second phase. He shared the update briefing he provided to the Secretary of the Air Force, the Air Force Chief of Staff, and his senior Air Force colleagues at the CORONA Conference. He told the study participants that the next several weeks were critical to the study effort. He said that if they could not devote the effort to the study required to produce a satisfactory third draft, he would work with the commandants of the colleges to provide relief from some core curriculum requirements. Finally, he announced that, save for one exception, "The time for creativity is over. Now is the time for hard work." The exception was a special study he commissioned at the Air Force Institute of Technology.

Without a doubt, the most serious and obvious shortcoming in the United States' space program was the lack of affordable and reliable transportation to space. By 2020, the problem would either have been solved or the nation would be a marginal space power. For the purposes of our study, it was necessary to assume that it would have been solved by 2020, and that we would be looking at follow-on systems to those systems that provided the pre-2020 solution. Of 15 study teams, a solitary SPACECAST team explored far future lift systems. Committed to the SPACECAST creative thinking methodology and reinforced by NASA's and Dr John L. Anderson's "Horizon Mission Methodology," General Kelley intended to exhaust all possible avenues in exploring far future space lift technologies. He directed the Air Force Institute of Technology virtually to "shut down for one or two days" and enlist the creativity of their entire faculty and student body to come up with far future solutions to the lift problem. He made the challenge immense by requiring that they examine propulsion technologies that were not dependent on chemical

combustion or hypergolics. The question he posed was "How do you get to space without going on a tail of fire?" They could, he advised them, assume whatever they chose to assume, as long as their assumptions were explicit and reasonable. Excited by the project, the Institute commander promised to provide their findings within a month. Their remarkable conclusions, including the finding that there was no silver bullet, joined the SPACECAST final report as a paper entitled Unconventional Lift.

At the same time, three other initiatives were underway: (1) building alternative futures to give more discernment of the view of the future posited by SPACECAST, (2) expanding and formalizing the electronic network that glued key partners to Air University and the SPACECAST effort, and (3) devising the theory of space power that seemed to be emerging through the SPACECAST effort. SPACECAST levied this last requirement in an attempt to avoid what Carl Builder described in *The Icarus Syndrome.* The syndrome is an affection for technology and hardware divorced from their contributions to military power and national security.

One of the decisions made at the beginning of our study of the future was that SPACECAST would use a consensus view and not build scenarios or alternative views of the future. One of the SPACECAST partners and contributors proposed expanding the utility of the study effort by taking the wealth of research already done by the study participants and using it to create other plausible futures. The group proposing the idea backed its belief with funding. They hired an organization called the Futures Group to help the SPACECAST team build the alternative futures. Eight plausible futures emerged from three dominant driving forces of the future. The forces were the will to operate in space, the "technomic" capability—the combination of technical development and economic capacity—of potential actors, and the number of future space actors. The four most fertile comparative futures, in addition to the most likely future postulated by the SPACECAST team, were: the Space Barons, the Rogue States, MadMax, Inc., and the Spacefaring World. A person who was an Air War College faculty member, RAT member, Air Force colonel, and

PhD spearheaded the analytic and creative effort. The findings were included in the SPACECAST report. Both military and academic communities will continue to examine and discuss these findings.

The SPACECAST effort gave the Air University a growing network of partners. These included the distinguished members of the SPACECAST senior advisory group, the scientists and technologists in the Expanded RAT, military organizations worldwide, members of the intelligence community, the Office of the Secretary of Defense, and scholars and intellectuals. Electronic mail and the information superhighway allowed SPACECAST to communicate routinely with all of SPACECAST's partners, including such scholars as Alvin and Heidi Toffler and Carl Builder. The SPACECAST "knowledge network" grew to incorporate scores of powerful contributing nodes. Although the SPACECAST study was the genesis of this network, the network itself would endure long after the initial SPACECAST effort was complete. General Kelley encouraged these linkages and described the emerging network as "a watering hole." The watering hole was a place where diverse constituencies could come to drink in a safe, protective, and nonthreatening academic environment.

General Kelley also expanded the network to include over 150 colleges and universities. He encouraged the commandant of the Air Force Reserve Officer Training Corps (ROTC) in a letter to bring each college and university ROTC detachment on line with SPACECAST. This incidental accomplishment, originating because of SPACECAST—but clearly bigger than SPACECAST—has continuing utility for Air University and its network of partners. One of the key partners in the network proved to be Carl Builder of the RAND Corporation.

SPACECAST enlisted Builder, the author of *The Masks of War* and *The Icarus Syndrome,* to help the SPACECAST team consider what might be the theory of space power in the 2020 time frame. After postulating the theory, military space missions, a vision of the role of military space forces, and strategies for employing space power would follow from it naturally. Postulating a theory of space power was

no easy chore. Builder agreed with General Kelley that our studies were finding that space was "more than a place." The "more" emerging from awareness that it was only from the vantage of space that the terrestrial limitations imposed by time and position could be overcome. Builder asserted that the theory of space power must explain how space power worked and why that was important. He suggested that the key to the theory was that space allowed simultaneous access or proximity to large portions of the globe and the means to rapidly change the vantage to encompass other areas. In 2020 space power could provide unparalleled and simultaneous proximity or access to the earth and the cislunar region for observation, orientation, force application, and the timely reduction of uncertainty. We should care because **without** spacepower we will lose the opportunity for nearly simultaneous proximity to the earth, thereby impeding observation (limiting surveillance and weather observation), causing disorientation (degrading communications, command and control, intelligence, navigation), limiting force application (reducing the threat engagement envelope) and increasing uncertainty.

If that were the theory, what would be the mission statement, the internal compass, of military space forces in 2020? The team seemed to think it might be, *"To operate in the transatmosphere and space in order to promote stability and enhance the security and interests of the United States and our partners."* What then would be the missions or categories of activity that enabled the exercise of space power in 2020? Although other categories were used at the beginning and midpoint of the study, the final categories appeared to all be encompassed within three major areas of activity. These were Global Presence, or global view; Global Reach; and Global Power. With these working categories, SPACECAST was able to better organize the final product.

The third drafts evidenced considerably more research and technology inclusion than the previous deliverables. The iterative process appeared to be working. The white paper format was again amended to require attribution of specific technology abstracts used to create it or make it more robust. Beyond the effects of moving from encouragement to admonishment, the process of linking technology

to ideas was greatly facilitated by the Technical Team from the Air Force Institute of Technology. The team graded each of the technology abstracts and suggested linkages between each of them. The grades were: existing technology (one that could be applied now), emerging technology (one that, if developed, would be useful by 2020), innovative emerging technology (unproved, but apparently scientifically sound, even though it lacked some bridging technology prior to development), and theoretical or conceptual (possible, but beyond 2020). Linkages between one technology or application and another, and linkages between each abstract and the ideas in evolving white papers, produced an automated cross-referencing system of immense value to the operationally oriented study participants. Selection of a single word—such as "weapon"—from a key word list of more than 300 words identified all the technology abstracts in which the selected key word appeared. Moreover, by using more than one key word at a time, the document search could be more and more specific. Thus, a search using several key words connected by "and" would identify only the technology abstracts in which all the selected key words appeared. This cross-referenced electronic filing system, finally fully operational in March 1994, was so valuable that many of the organizations participating in the study as assessors or advisors coveted it.

General Kelley suggested earlier that SPACECAST take advantage of the creative goal of the study and consult with screenwriters and movie producers who turned science fiction into successful and profitable films. The Los Angeles office of Air Force Public Affairs made contact with four successful and creative screenwriters and producers who agreed to serve as informal consultants. The screenwriters were: William Wisher, *Terminator II;* Louis Abernathy, *Deep Star Six;* Eddie Niemeier, *RoboCop II;* and producer-screenwriter Bob Justman, *Star Trek.* These Hollywood screenwriters, serving *pro bono,* found the evolving SPACECAST ideas intriguing, but found the lack of visual images unsatisfying. They suggested that pictures, illustrations, and artists' conceptions be included with each white paper. Each screenwriter asserted, "An idea cannot grab you until you can grab an idea." Words,

they said, are more difficult to grab than pictures. "People want to **see** how things *work,*" they admonished. Illustrators joined the team part-time during the final phase of the study. Each team added illustrations to each paper.

The screenwriters also advised that films were becoming increasingly environmental. That is, successful films "created an environment where people want to be." The task for SPACECAST, they alleged, was to show through the product ideas that we had created a good and valuable environment. The screenwriters and others also objected to the charter SPACECAST had given itself: "Envision the capabilities and hardware that would be required to control and exploit space for national security in the far future." SPACECAST took this advice to heart and knew that creating the vision of an environment where people wanted to be would be a goal of the final phase and a test of the final product.

The Air Command and Staff College's School of Advanced Airpower Studies voluntarily provided a military analysis of the emerging ideas. Thirty scholars in this specialized course focusing specifically on the attributes of air and space power studied the candidate white papers with an eye toward improving them. They produced hundreds of useful comments on the papers. Their valuable suggestions included organizing the concepts into a hierarchy of value and linking each task to whatever SPACECAST believed would be the national security strategy and national military strategy of the far future. Moreover, the school identified numerous small internal inconsistencies in and among the evolving papers. This review expanded the SPACECAST network of partners, increased the educational value of the SPACECAST study, and enhanced the curriculum of the School of Advanced Airpower Studies.

Phase Three: Verification and Finishing

Inventing or creating is hard work. It is even more difficult when one does not know what it is one is inventing or creating until it's invented. The last step in the creative process—**verification**—would determine the value of

SPACECAST's creative insights or illuminations. External assessors and the study participants bore the burden of a creative process that moved so quickly it was always dysynchronous. That is, depending on the next scheduled deliverable—a briefing or a draft of the white paper—the white papers and briefings were never synchronized. One was always more current than the other. Reviewers understood and were sympathetic. As the 50 candidate white papers became 26 papers, then 18 papers, illumination arrived. The ExRAT, the Executive Board, the Advisory Group, and later Air University's Air Force Institute of Technology (AFIT) facilitated illumination and provided verification. AFIT's operational analysis of the SPACECAST discoveries provided the final element of verification. A joint meeting of the Advisory Group and the Executive Board provided what General Kelley called "the end-of-runway check" immediately prior to his briefing to General McPeak. The specific white papers produced are listed in Figure 2.

- An Information Demand System for the Joint Warfighter of Tomorrow
- Leveraging the Infosphere: Surveillance & Reconnaissance in 2020
- Navigation & Data Fusion for the 21st Century
- Space Traffic Control
- 21st Century Weather Support Architecture
- Space-Based Solar Monitoring & Alert System
- Space Weather Support for Communications
- Spacelift: Suborbital, Earth to Orbit, and On Orbit
- Unconventional Spacelift
- Rapid Space Force Reconstitution
- Space Modular Systems
- Professional Military Education in 2020
- Defensive Counterspace
- Offensive Counterspace
- Force Application
- Projecting Information Power in War and Peace
- Counterforce Weather Control
- Preparing for Planetary Defense

Figure 2. White Paper Titles

The ExRAT met to review the pre-final drafts of the white papers and to receive all the 10-minute briefings that described their contents. The participants found this to be a very grueling two-day process. The ExRAT members were scientists and technologists, experts in all the areas of space science and space operations. Their pointed questions and comments illustrated the kinds of tests that new ideas could expect to face in the space community. Although exhausting for the participants, the ExRAT review resulted in numerous refinements to the white papers.

When the Executive Board next met, SPACECAST took a different approach. Time did not allow the Executive to receive all of the 10-minute briefings. Instead, each Executive Board member examined the ideas in one or two white papers in great detail. While the prior review by the ExRAT was discouraging for many of the teams, this review encouraged each team. The Executive, senior military officers, praised the work of the teams, focused on the positive aspects of each idea, and provided useful suggestions on ways to improve the ideas or their explanation.

Like the ExRAT, the Advisory Group met to hear and evaluate each briefing. The Advisory Group took the middle ground. That is, they affirmed and encouraged the study participants but warned that some ideas or some technologies may prove to be faulty. The Advisory Group admonished the participants to make their assumptions about technological development more explicit, to give better evidence of analysis, and to anticipate and address shortcomings in each idea. These reviews completed, the ideas were ready for final evaluation. AFIT's department of operational research was challenged to find an analytic model that could rank-order the value of SPACECAST systems. This was a five-step process.

The AFIT Technology Team completed the first step. The team read each of the classified and unclassified papers produced by the SPACECAST team. Faculty editors and advisors had already reviewed the final drafts of each paper. The papers were revised, as required, to communi-

cate as logically and effectively as possible. The purpose of the Technology Team review was to identify and describe coherent systems communicated in the compilation of papers.

Contained within the SPACECAST white papers were 19 identifiable systems. These systems formed the SPACECAST force structure of the far future and are shown in Table 6. Some papers contained technologies that did not form a separate system. When the Technology Team review was complete, the SPACECAST team was confident that all the enabling systems had been captured and described.

Table 6
Enabling Systems

• Space-Based Solar Monitoring and Alert Satellite System (SMASS)	• Global Surveillance, Reconnaissance & Targeting System (GSRT)	• Weather C3 System
		• Weather Forecast System
• Space Traffic Control System (SPATRACS)	• Orbit Transfer Vehicle (OTV)	• Space-Based High Energy Laser (HEL) System
• Kinetic Energy Weapon (KEW) System	• Orbit Manuevering Vehicle (OMV)	• Super Global Positioning System (S-GPS)
• High Powered Microwave System	• Particle Beam Weapon System	• Spacelift Transatmospheric Vehicle (TAV)
• Holographic Projector	• Space Modular System(s)	• Solar Mirror System
• Ionospheric Forecasting System	• Asteroid Detection	• Asteroid Negation

The Technology Team proceeded to the second step: identifying the technologies that enabled the described system to operate or function as envisioned. The definitions in the Department of Defense *Military Critical Technology List* provided the standard for describing the enabling technologies. When this step was complete, all the essential enabling technologies supporting the 19 enabling systems had been identified. There were 25 of these, identified in Table 7.

Table 7
Enabling Technologies

• Advance Materials	• Micro-Mechanical Devices
• Data Fusion	• Navigation, Guidance, and Vehicle Control
• Electromagnetic Communications	• Neutral Partical Beam (NPB) Systems
• Energetic Materials	• Nonchemical High Specific Impulse Propulsion
• Hard Real-Time Systems	• Optics
• High Energy Laser Systems	• Power Systems and Energy Conversion
• High Performance Computing	• Pulsed Power Systems
• High Power Microwave Systems	• Robotics, Controllers, and End-Effectors
• Image Processing	• Sensors
• Information Security	• Spacecraft Structures
• Kinetic Energy Systems	• Vehicle Survivability
• Lasers	• Virtual Reality
• Liquid Rocket Propulsion	

The third step was the most difficult one. The Technology Team, supported by the experts from the AFIT department of operational research had to select an evaluation scheme that could differentiate the comparative value of each of the systems. Since none of the 19 systems were extant, traditional evaluation schemes—such as strategy to task—could not be used. AFIT selected the "Value-Focused Thinking" scheme as the most appropriate evaluative tool. This tool required the quantification of qualities that enabled a system to contribute to some goal. In the case of SPACECAST, the goal was the contribution that a system made to the missions or force activities described in the February 1994 draft Joint Chiefs of Staff Publication (JCS PUB) 3-14, *Military Space Operations: Tactics, Techniques, and Procedures.* This document, agreed upon by all the

armed forces, described four space missions or areas of activity and 15 tasks associated with the four missions.

The fourth step in analysis required that the SPACECAST team describe, quantify, and weigh the force qualities or attributes that enabled the 15 space tasks to contribute to or accomplish the four space missions or activities. This effort had never been attempted before. SPACECAST identified over 90 force qualities. These 90 force qualities would eventually require over 1,800 separate decisions to evaluate all the SPACECAST systems.

The fifth and final step required that each SPACECAST system be pushed through the analytical model to determine its weight or contribution to all military space operations. The weight of a system logically lent itself to identification of the weights that different technologies carried. After completing the operational analysis, the 19 systems and the 25 enabling technologies were rank-ordered. Rank-ordering identified the higher leverage systems and technologies in the universe of SPACECAST. Excursions, using different values for SPACECAST's alternative futures illuminated changes in value as the characteristics of the future changed.

At around the same time, interest in the SPACECAST study increased. The secretary of the Air Force requested and received an update briefing from General Kelley. In series, a number of visitors came to Maxwell Air Force Base to study SPACECAST's initial findings. These visitors came from the Office of the Secretary of Defense for Net Assessment, the Central Intelligence Agency, the National Reconnaissance Office, the Defense Intelligence Agency, the United States Space Command, the Air Force's Phillips Laboratory, and the Headquarters Air Force Directorate of Studies and Analysis. Each was eager to have a copy of the final report and the materials used to create it.

Once the internal analysis was complete, and except for preparing the report for delivery to General McPeak, the SPACECAST creative effort was finished. A small team from among the Advisory Group met in mid-June to assess the results in preparation for a final, joint meeting of the Advisory Group and Executive Board. The combined over-

sight groups endorsed the final product and advised General Kelley as to how he might present the findings to the chief of staff of the Air Force.

General Kelley presented the three volumes of the final report to General McPeak on 22 June 1994, approximately one year after the initial tasking. General Kelley briefed General McPeak that SPACECAST had fulfilled its mandate for creativity. In the most flattering word in the lexicon of military aviation, General McPeak called the results of SPACECAST a "Shack," or a perfect score. He expressed delight with the process and its findings and announced his intention to "wring every last drop out of the report" by translating its best ideas into operational requirements.

Conclusion

The SPACECAST team had expected to create satellites that did a few new or different things. The team anticipated some new proposals for space lift. The team also had envisioned the possibility that there were new ways to do business. What SPACECAST had not envisioned, however, was that the sum of its ideas would result in a vision that could change the way in which military forces operated and the equipment used to operate in the future.

The SPACECAST vision of military space operations in 2020 and beyond was one where many military systems were largely indistinguishable from commercial or civil ones. Many military space systems, like private and scientific ones, had the collection and transmission of information as their objective. Global surveillance or global view fulfilled the requirement for global information. Global view was not possible without Global Presence. General McPeak provided the insight into the importance of Global Presence.

SPACECAST also concluded that the military had a need for more granular data more often, but nonmilitary needs did not always require separate spacecraft. Different software and different data handling protocols were all that distinguished some military space systems from oth-

ers. The objective of the envisioned SPACECAST force structure was not so much to control space; terrestrial, transatmospheric, and subspace vehicles could, in a crisis, provide the space equivalent of control or air superiority. Nor was the objective of military systems to exploit space *per se.* Space in the SPACECAST view was more than a place. Space was more because it represented the uppermost set of nodes in a vertical network that was cross-linked and down-linked throughout the full vertical dimension. Space itself was not exploited. The advantages provided by Global Presence were exploited by operating in space and integrating the full vertical dimension.

The on-orbit force structure envisioned in SPACECAST was the space analog of, or was equivalent to, the movement from mainframe computer systems to PCs and the smaller distributed systems that occurred in the 1980s. Moreover, SPACECAST envisioned a space force structure that was a vertically integrated network spanning from the earth all the way up to space. That is, earth portals were linked to space portals both directly and indirectly. Small and proliferated interconnected satellite constellations made the direct linkages. Medium- and high-altitude remotely piloted vehicles, long loiter time subspace relay and collection vehicles, and transatmospheric vehicles made the indirect linkages. Space became the air writ large, the last exit, and the most important entryway to the planet's information highway.

Space also became the place from which humankind could be protected against the next generation of threats. SPACECAST postulated defending the planet from asteroid impacts as an important future military-civil-commercial mission. As the US capitalized on earth-looking systems, the SPACECAST team saw the need to simultaneously look outward and defend our common home against the kinds of errant rocks that could damage it or destroy it. Earth became more borderless, the "little blue pixel" that Carl Sagan reported seeing through *Voyager's* aperture. As the study team thought about it, SPACECAST came to understand what the astronauts understood: the planet is, or could be, looked upon as a whole.

SPACECAST, a military study, did not neglect its responsibilities to create new combat applications for, from, and in space. These were all in the study findings. Yet even these evidenced a mature awareness that space was a place that allowed greater speed, certainty, and greater potential for dominance of position and information than other places. Combat applications joined the other ideas as part of a larger offering of ideas, insights, and applications. The final product became a compendium of final products, each individually tailored to the needs and interests of its intended audience. What will become of these final products is now in the hands of others.

Was it worth the time, money, and effort? Participants gave their time voluntarily. Many of the student participants graduated from the Air Command and Staff College with distinction. One won the United States Space Command Military Space Strategy Essay Competition. One of the Air War College participants won the Orville and Wilbur Wright Officership Award. The cost of the study, less than $300 thousand, was marginal when compared to any other military space study. The educational benefits and the leadership development opportunities alone were worth the investment in psychic capital and resources. The value of the ideas and architecture generated may prove to be of incalculable value. The effects of one canny hardware investment, one breakaway technology, or one breakthrough vision can be worth millions. This is especially true if the discovery or investment saves national treasure or national blood. SPACECAST did its job.

Lessons Learned

Few organizations are as adept as the armed forces of the United States in rapidly transforming vision into venture. From a standing start, from a university's summer posture of quiet repose, SPACECAST built a plan, acquired an infrastructure, enrolled volunteers, and commenced the process of idea-generation directed toward a very specific goal. All this began within very few weeks. The great strengths of our troops are discipline, an in-being

organizational structure that can quickly get things moving, and the ability to improvise and adapt within the requirements of a mission, even if the mission changes. It may be that nonmilitary organizations are incapable of executing the SPACECAST process, but that is very likely not the case.

To do something similar to SPACECAST with only internal resources would be exceedingly difficult. It would require an already-established innovation office, connectivity with experts worldwide, an electronic filing system for handling volumes of data, an issue-specific resource library, and the creative minds to do the idea-generation and assessment. Where these attributes do not exist already, however, SPACECAST participants know that it is possible to create them. Consultants can help create them temporarily. If others attempt to duplicate these conditions elsewhere, and if creative individuals are already part of the organization, the following guidelines may be useful.

1. **Begin with a very specific purpose and a clear vision of the desired end state.** If the purpose is "create new products," that purpose mandates an approach that is considerably different from the ones tailored to meet the purpose "educate people about the operating environment of the future," or "generate ideas for new products." Similarly, after beginning, the introduction of even small changes in intended function could require much larger changes in methodology or structural form. In all cases, headwork must come before the footwork. One of the strengths of the SPACECAST process was the clear vision provided by the study chair and the obvious confidence that, one way or another, SPACECAST would fulfill that vision. There were no predetermined correct answers, and there cannot be if creative new ideas are the goal.

2. **Designate only one individual as the critical node in the study network.** If the study is being done within a hierarchical organization, the study group must remain apart from the firm's existing hierarchy. The commodity being transacted in a study is knowledge, or ideas, or information. When the commodity is any one of those, networks are superior to hierarchies. The commodity

transacted in hierarchies is power or authority. A knowledge network cannot function as a power hierarchy. A power hierarchy is often unable to generate knowledge. General Kelley's insight that he was the only person in the study team who had the power to say no proved to be extraordinarily helpful to the study's creative process. Operating outside the established hierarchy facilitates creativity. Top cover nurtures creativity. Absent empowerment to work outside the system, the creative process may only endorse what the system already holds to be true.

3. **Build and publish all milestones in advance.** Knowing the objectives of the study in advance and possessing a clear vision of the end state, it is not a difficult chore to determine each major and interim milestone in advance. In advance means before the study commences. For SPACECAST, in advance sometimes meant days or even hours in advance. If the study requires specialized equipment to meet a specific milestone, the arrival and operational checkout of the equipment is itself a milestone. Knowing who is responsible for creating or meeting each milestone is also valuable.

4. **Do not pass up opportunities, but do not deviate from the schedule unless a deviation provides extraordinary advantages.** There is already considerable adaptive behavior required when participating in a novel enterprise. If even milestones are in flux, the participants can become frustrated quickly. An exception, of course, is when the participants themselves sense an opportunity and want to seize it. Using the right-brain is exhausting work for most people. Its intensive use must be scheduled to allow periods of rest interspersed in a production schedule that requires intense periods of creative activity. SPACECAST could not have succeeded by locking 114 people in a room for a one-, two-, or three-month study. Incubation takes time.

5. **Be open to discovery.** This is the creative part and it gives the lie to all the previous guidelines. An organization committed to and involved in a creative study will metamorphose and discover new things. Science is a self-correcting process. Art is the process of concretizing and

refining a vision into a rendering. Slavish commitment to anything discovered to be less good than once thought defeats the purpose of a creative study. This is especially true if the old thing or way proves to be counterproductive to some larger purpose or greater awareness. Said another way and by way of example, if the network is not producing on time or to the level of quality expected, revert to more hierarchical forms of behavior or organization. Likewise, if broad guidance creates confusion, narrow it. If specific guidance is confining or creates seams, expand it.

6. **Remain aware that history is being made.** Depending on the scope of the effort, detail one person or several people to chronicle the study. For example, it might be useful to videotape guest lecturer presentations and any briefings or progress reports made to oversight groups by the study participants. Record the problems and setbacks with the same fidelity used to memorialize successes. In the case of SPACECAST, the record of guest speaker presentation became an invaluable educational library. With the permission of each of the speakers, the use of the videotapes within the Department of Defense continues to expand. In 2020, they will make a wonderful reflection on what occurred when people in 1993 and 1994 looked into the future. Each of the participants also must remain aware that history is being made.

7. **Continue.** Once a knowledge network exists, and as SPACECAST quickly learned, dismantling it is not easy. Helpers, advisors, consultants, collaborators, and lecturers all want to know both what happened and what happens next. Like it or not, the knowledge network endures long after formally concluding the study. Be aware of this and plan uses for the network when the initial effort is complete. In the case of SPACECAST, the commandant of the Air War College directed the college faculty to study the SPACECAST process and incorporate leverage elements into the core curriculum. The associate dean of the Air War College faculty, even before the study concluded, restructured the next year's academic curriculum to begin with a week of creative thinking training and forward-looking lectures by Alvin and Heidi Toffler and Carl Builder. The chair of the Air War College department of leadership and

strategy studies requested a presentation to the department faculty on future war and the future operating environment. Key faculty in the Air War College throughout the SPACECAST process are continuing to examine the implications of information power and the changing paradoxes of warfare that study of the future suggested. The SPACECAST study is finished, but the process continues.

SPACECAST set out to understand the operating environment of 2020, space power, and the space capabilities and hardware required for national security in the first half of the twenty-first century. SPACECAST met those objectives. In the process of meeting them, SPACECAST created a large knowledge network. SPACECAST gave hundreds of people new awareness of the perils and promise of the future. Scores had leadership opportunities they had never expected. All received insights into their own creativity and the creativity of others.

Even before SPACECAST had completed its middle phase, an Expanded RAT from one of the Air Force's most important scientific laboratories wrote the laboratory director that the lab needed to prepare to assess and develop five to seven new ideas. Even before SPACECAST had completed its middle phase, the institutional Air Force was preparing to add project research money to its budget in anticipation of SPACECAST's findings. By standing in the far future and looking backward to the present, SPACECAST helped plot the course into the future. How that future turns out, of course, cannot be known until 2020. One thing is certain: the SPACECAST process worked.