NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY REBECCA WRIGHT
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The Early Years

WRIGHT: Today is October 4, 2006. This oral history is being conducted with James R. "Jim" Jaax in Houston, Texas, as part of the NASA Johnson Space Center (JSC) Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson.

Thanks again for coming in to visit with us today for this project. We learned that when you were enrolled in graduate school at Kansas State University [Manhattan, Kansas] in 1966, you opted to participate in the Aerospace Summer Internship Program for college graduates at NASA's Manned Spacecraft Center in Houston. Tell us why you took part in this program and give us some impressions of what you thought about Texas when you moved here for your internship.

The Making of an Engineer

JAAX: Thank you for inviting me to participate in this project. First I will provide some background information. I was born in Kansas and raised on a dairy farm that my grandfather passed on to my father. We also farmed wheat, corn, sorghum (milo), and alfalfa and had pasture land that still had the prairie sod the Indians and buffalo walked on. I am the oldest of four children of second generation German parents. During the 1940s and 1950s our farm was 4 miles west of Wichita, Kansas and 5 miles south of the small town of Maize. Today that farm and the adjoining land I knew are fully populated with houses, an urban subdivision of Wichita.

I attended and graduated from Maize's grade school and high school; was valedictorian of my 8th grade and 20 member high school classes. I and two other graduating seniors attended Maize schools all 12 years. Year to year size of my class ranged between 11 and 28 with an average of 3 not returning and 5 new students every year. Only 4 graduates lived on a farm. Much of the yearly changeover was of those that had a parent working in Wichita where the job market and housing availability varied widely year to year.

I greatly enjoyed each of my school years, thus by my freshman year I knew that I wanted to attend a university, something neither of my parents had done. I had minimal desire to stay on the farm like my father and grandparents. I did not dislike farm life. I was accustomed to early and long hours, hard work, ever present daily chores and the twice a day milking schedule. But, becoming and being a successful farmer too often was the result of chance and sometimes just plain "luck," especially when you dealt with weather, pests and the marketplace on a daily basis. Growing up on a dairy farm provided many great life experiences. But I knew that I wanted a different career. What it would be, I did not know.

Early in my senior year my math teacher, Mrs. Mary Koewing, the only math teacher in our high school, encouraged me to consider majoring in engineering. I knew nothing about "engineering" as a profession. At that time my only knowledge of an engineer at work was someone who drove a locomotive, a "train engineer."

Fall of my sophomore year *Sputnik* was launched. It aroused some curiosity within me about rockets and space travel. That soon faded. None of my teachers or other students in my high school expressed interest in rocketry or space travel beyond what was contained in science fiction and comic books. And, I certainly had not met any "rocket scientists or engineers," those fellows that design and test rocket ships. I enjoyed the basic math and science classes offered

but translating my success in them into becoming a part of America's space program was well beyond my youthful ambitions and dreams as a Kansas farm boy. Years later, I was truly amazed when I discovered the number of engineers of my generation working at JSC that like me had grown up on a farm or ranch.

Undergraduate School

I wanted to attend Kansas State University (KSU) because I had enjoyed my visits to the campus during my 10 years of membership in 4-H. Manhattan, Kansas, was 2 ¼ hours from our farm. Commuting from home was not practical. Besides, I wanted to live on-campus and housing was available. But, the more important selection factor was that Kansas State (K-State) offered me a better scholarship than the $100 for the first semester only offered by nearby Wichita University. September 1960, I began study of Industrial Engineering (I.E.). I chose I.E. because with my farming background, the courses' content in the curriculum guide were easier to understand. Freshman year, I quickly learned that college class-work for an engineering degree required much more focused study than I had done in high school. Upon seeing my grades on that first semester's report cards I recognized that I needed to immediately make some life style adjustments or I would lose my scholarship. So I chose to go cold turkey ("stopped dating" and significantly reduced my "campus socializing") during the second semester. "Boring", but it worked. More importantly, I also learned "how to focus and multi-task my studies" while in the middle of all the distractions available in a university environment.

"Conducting time and motion studies and designing factory floor layouts," described as one of the opportunities for an I.E. during the Freshman Engineering seminar, did not appeal to me. As I learned more about "the different fields of engineering" I decided that having a Mechanical Engineering (M.E.) degree would provide the type of career opportunities I would

like to pursue. Near the end of the first semester of my sophomore year and without consulting with anyone I entered the office of the College of Engineering and transferred into the Mechanical Engineering degree program.

During my undergraduate years I lived in Straube Scholarship House, one of the University's two academic scholarship houses for men. The 45 men in the house performed all of the day-to-day chores (meal preparation, cooking, dishwashing, house cleaning, bathroom cleaning, etc.). "Parenting guidance" which was often "needed" was provided by the house mother and "assignment and scheduling of house chores for each semester and daily follow-up" was provided by the student house manager. Our scholarship was based on each semester performing 3 hours of "house services" per week in exchange for a 50 percent reduction of that semester's university residence hall housing bill. During my 5 years living in the house, my accumulated experience from performing assigned "house services" tasks included food preparation, meal servicing, cleanup and dishwashing for 50 people; housecleaning common living and recreation areas weekly; and cleaning one of the common bathroom daily.

After my freshman year, I became very involved in campus activities. As the result of campus wide elections I served in Student Government as a Student Senator (representing the College of Engineering for 2 years), member of the Engineering Council (undergraduate representative for 2 years) and chairman of the 1964 Engineering Open House Committee (College of Engineering's weekend on-campus recruitment of high school seniors). I also served as President, Social Chairman (three semesters) and Alumni Secretary for my residence, Straube Scholarship House. During my senior year the student body president and I as a student senator represented the University at two national student government organizational weekends, one in St. Louis, Missouri, and the other in Norman, Oklahoma. This was the '60s and the leadership of

university level student government organizations was becoming political activists. We were tasked with determining if and how Kansas State would participate in the changing times. On our recommendation K-State joined a newly formed "non-political" national organization. These "leadership" experiences helped bring me out of the shy, quiet, nerd-like personality I had grown up with and helped me develop self confidence in expressing my ideas and working effectively with people and organizations.

Kansas State, a land grant university required all male students take two years of ROTC (Reserve Officer Training Corps) classes. As I approached completion of my sophomore year I signed up for "Advanced ROTC." Upon graduation I would receive a Reserve Officers' commission as a second Lieutenant. I chose the Army for my branch of service because it had the shortest active duty obligation (two years). Additionally, (and more importantly at the time) during the 2 school years of advanced ROTC, I was paid 90 cents per day (my primary source for spending money). Money for non-essentials including dates, and socializing with the guys was extremely limited. During my first two summers of college I worked on my dad's farm and for a few weeks during wheat harvest time on relatives' farms in Kansas and Colorado. My third summer I worked the wheat harvest for my father again then spent six weeks in ROTC summer camp at Fort Riley, Kansas. The fourth summer provided the only significant engineering job experience and income ($500/month) working as a "junior engineer" on guidance system hardware for The Bendix Corporation in Kansas City, Missouri. By this time my parents had three children attending Kansas State. Keeping my scholarship throughout my undergraduate study was very important to me and my parents. I completed my undergraduate degree and one-half of a year graduate school while holding the scholarship and living in the Scholarship House.

Because the 12 credit hours of advanced R.O.T.C. courses did not count toward an engineering degree, I needed a third semester my senior year to complete the 142 engineering credit hours required for my bachelor's degree. The additional semester with a "light" undergraduate academic load allowed me to include a graduate credit course in mechanical engineering to test my interest in graduate school and provided some "free" time to see if I could find a fellow student to marry. I really wanted to find someone who had experienced college life and would understand why I would have a life-long passion for participation in the many academic, cultural, and sporting events that are available at universities. Early fall, not knowing if I could find the "right" one before graduating at the end of that semester, I responded to several graduate schools that had invited me to apply for admission to their Mechanical Engineering Master's Degree program. That would provide additional time and opportunities to find my life partner.

But for this plan to work I recognized that to obtain a master's degree before going on active duty I needed a graduate student deferment. On October 6, 1964, I submitted my application and on January 25, 1965, I was approved by the U.S. Army for a postgraduate educational delay of my reporting for active duty while obtaining a master's degree in Mechanical Engineering, as long as I made passing grades.

Curious about opportunities in the "real world" I also interviewed for full-time employment through K-State's Placement Center. Fall of 1964, I interviewed with 28 companies, had 10 on-site company paid visits and received 8 job offers with salaries ranging from $635 to $660 per month. Don't laugh, these salaries were good for the mid-'60s. During this process I was "rejected" by Langley Research Center [Hampton, Virginia], the only NASA Center that sent a recruiter to Kansas State. Realizing that none of the eight offers seemed right

for a life-long career, especially with a commitment of two years Army active duty on the horizon, I focused on graduate school opportunities.

Fortuitously that October, I met a fellow senior, Suzanne Behrens in the lunch line of K-State's Student Union cafeteria. I quickly decided that this was the one, but…. Suzanne had a near perfect 4.0 GPA (grade point average) and was also applying to graduate schools. Unfortunately, none of the schools where she was accepted were interested in me. Although academically I was 9th out of 64 mechanical engineering seniors my GPA of 2.83 was significantly lower than Suzanne's. At the time I "rationalized" that my involvement in all of those college activities, carousing with the men in the scholarship house and the significant amount of socializing and dating had held my grades down. This, I believe, was "proven" true during graduate school where being married, working a part-time job and taking academic classes of interest to me resulted in my graduate school GPA being nearly equal to Suzanne's.

Graduate School

As fall turned to winter, our romance became more serious, but only one graduate school had accepted me that was common with Suzanne's list. It was Kansas State University whose graduate school for mechanical engineering was highly respected. And, I had a close relationship with the Head of the Department of the Mechanical Engineering, Dr. Ralph Nevins. The previous summer I had worked on a special project for him during my "after hours free time" while working for Bendix. I was the newly elected President of the Mechanical Engineering undergraduate academic honorary, Pi Tau Sigma; Dr. Nevins was the advisor. Before leaving for my summer job Dr. Nevins asked me to help refocus the purpose of the organization by rewriting the organization's Constitution during that summer, which I completed and was approved by the membership that fall. When I asked if I might be accepted in the M.E.

department's master's degree program for Environmental Engineering, Dr. Nevins immediately said yes. He offered and I accepted a graduate research assistantship at $230/month.

My "research work" would be in the recently opened, on-campus Environmental Research Institute. The Institute and its Environmental Test Chamber had been moved to Kansas State in 1962 by its sponsor ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) primarily through the efforts of Dr. Nevins, who was appointed its Director. The Institute's purposes included: performing research on human response to thermal environments that affect health, comfort, learning and productivity; conducting biomedical engineering research on primates and humans; conducting air pollution and fine particle research relating to human health and comfort; providing research and service for the air-conditioning industry; and providing graduate education in environmental engineering at the M. S. and Ph. D. level. The Institute also developed and assessed requirements for designs for heating and air-conditioning systems, ventilation systems, and humidification systems for buildings, homes and etc. My major professor would be Dr. Preston McNall, one of the Institute's two associate-directors. I also hoped that by Suzanne knowing I was committed to seeking my master's degree at Kansas State, she would give serious consideration to staying at Kansas State for her master's degree.

My association with the Institute had actually begun a year earlier when I often assisted a friend and classmate, R. D. Caughron with his student job of feeding and cleaning the cages of several chimpanzees and rhesus monkeys housed in the Institute. He worked for Dr. Fredrick H. Rohles, a psychologist and engineering researcher, the other associate director of the Institute. While in the Air Force Dr. Rohles had conducted simulated spaceflight research studies with some of these animals. Their need by NASA and the Air Force for studies including serving as

subjects during Project Mercury's ballistic suborbital and orbital spaceflight tests had been completed years earlier. When Dr. Rohles left the Air Force for Kansas State he arranged for these animals to be sent to the Institute. Cleaning chimpanzee and monkey cages was my first association with NASA.

I was one of the two graduate student candidates selected by the Mechanical Engineering Department for the "Environmental Engineering" Masters Degree program's inaugural class. Early January Eugene Smith and I were ready to sign up for classes. We met with Dr. Nevins, who said, "We don't have an established curriculum. The two of you will need to create a master's degree curriculum for us." I was so "creative" that I "overachieved," identifying for myself and completing a 50 credit hour curriculum that included a thesis instead of the standard 36 credit hour master's degree curriculum and report. A major feature of my program was integrating the physiological and psychological needs of human beings with engineering practices for home and office environments. My thesis would be an evaluation using human test subjects of temperature effects on human comfort while working at several metabolic rates in an environmental test chamber. None of my undergraduate engineering courses had included the study of human physiology or behavior. Lacking the prerequisite courses I would need to attend summer school to take undergraduate courses in zoology, human physiology and psychology before starting the graduate level "human" engineering curriculum I had created for myself. I also knew that the additional "graduate" courses would also slow down my academic pace, allowing Suzanne and I to graduate from graduate school within a semester of each other.

As part of my undergraduate school graduation activities on February 3, 1965, I received my appointment as a second Lieutenant, a reserve commissioned officer in the U.S. Army with

both Suzanne and my mother pinning my bars on my uniform. It was another sign that Suzanne and I may have a future.

March 1965 while kneeling in the University's Formal Gardens Suzanne accepted my proposal of marriage. Until then Suzanne had fully expected to attend graduate school at another university that fall. She quickly applied to K-State's College of Home Economics and was accepted for graduate work in Foods & Nutrition, but was too late for consideration of financial assistance. With full knowledge that we would start our lives together as truly "poor graduate students;" we were married September 4, 1965, and have been happily so for over 45 years.

A pleasant surprise occurred as I approached completion of my first semester of graduate school. Dr. Nevins, knowing I would soon marry Suzanne, offered me a National Institute of Health (NIH) Public Health Traineeship that was associated with the Institute and my degree program. It paid better ($275/month) and the next spring semester included an allowance ($41.67/month) for a spouse.

Unknowingly, beginning with my first semester in graduate school (Spring 1965), I had began a path that led to my career with NASA in Houston. My instructor for the Applied Mechanics course "Intermediate Dynamics" wanted us to solve "real-world" space dynamics (trajectory) problems; therefore, he included several homework and test questions based on published objectives and data for the launches of NASA's Gemini 3 and 4 missions occurring that spring. The next semester (Fall 1965) I enrolled in "Environmental Engineering I" a graduate level Mechanical Engineering course being offered for the first time. The course content was focused on developing a conceptual design for an integrated system based on understanding the requirements, technologies available, design considerations, analytical tools and techniques available and system integration concepts for ECLSS (Environmental Control

and Life Support Systems) in human spacecraft. My instructor was Wayne Springer, a former assistant project engineer, who had worked on Environmental Control Systems for Hamilton Standard Division of United Aircraft Corporation. Hamilton Standard was the provider of the Apollo Lunar Module's environmental control system. Wayne started his career in 1959 as a Research Engineer in Environment Control and Bioastronautics for the Boeing Company. From 1961 to 1964, Wayne worked on several Hamilton Standard teams designing the ECLSS for several space station concepts studied for NASA and the Air Force (including the Manned Orbiting Laboratory). Taking this course at this time would be one of the biggest and best decisions in my life.

Summer Interns at NASA's Manned Spacecraft Center

Reality was that Suzanne and I were full-time graduate students; had very little money; owned a '57 Chevy, some household items, and a brick and board bookcase. To have sufficient money for our second and final year of graduate school at least one of us needed to work during the summer of 1966. In March 1966 posted on the Mechanical Engineering Department's bulletin board was a blue, four-page flyer, which I still have. The flyer announced an opportunity for 30 graduate students to work for NASA's Manned Spacecraft Center in Houston, Texas, as summer aerospace interns and be paid $500/month. Looking through the requirements I found nothing that would eliminate either of us from consideration. My graduate class in design and operation of environmental control and life support systems for human spacecraft and Suzanne's graduate work in foods and nutrition (which I believed would be appreciated by those responsible for developing "space food" for the astronauts) should make us attractive candidates. We quickly prepared and sent to NASA separate applications. If one of us was selected, that would be great, or if both of us were selected, that would be even better.

In mid April we received letters from NASA that both of us were selected and requested to report the Crew Systems Division (CSD) at the Manned Spacecraft Center (Manned Spacecraft Center, Houston, Texas), on the 9th of June. We sublet our apartment, bundled our few possessions in the smallest trailer U-Haul made and headed for Texas. As we drove through Houston we were impressed with the size of the city and its tall buildings, but the "interstate highway" within the city left a lot to be desired. I-45 through downtown Houston was under construction. We followed the highway signs on regular streets through town until we were on the Gulf Freeway (also under construction) headed to Galveston. We discovered that the Manned Space Center was on a flat, almost treeless plain near a few small, rustic, rural towns. The flatness was very similar to Kansas. Clear Lake City was a new community that consisted of a small shopping center anchored by a Piggly Wiggly grocery store and TG&Y [variety store].

Across the street were a Lum's casual restaurant and a small single screen movie theater. North of the shopping center on El Camino Real were some duplexes, two apartment complexes, a few houses, large areas of empty space between drainage ditches and fenced pastures with grazing cattle and lots of cattle egrets. Looking toward Houston you could easily see the buildings at Ellington Air Force Base and skyscrapers in Houston.

Finding an apartment that would give us a three-month lease proved to be difficult. Nothing was available in Clear Lake City. We finally found one on Main Street in League City near Clear Creek high school. But, within an hour after renting it (while sitting on the floor of an empty bedroom looking out a window into an empty field) I decided that we needed to find something closer to Houston; where the "action" was. That evening we moved into a first floor apartment in the St. Patrick Field complex on the Gulf Freeway outside of Loop 610 near the Harmony Wedding Chapel. Unfortunately, we were not aware of how close we were to

Pasadena's chemical plants. Mornings, when there was little or no wind, there was an awful chemical plant smell that just hung in the air outside our apartment. The smell really dampened our interest in swimming in the apartment pool on weekends.

Daytime temperatures were much like Kansas but we never quite acclimated to the continuous high humidity and nighttime temperatures being in the high 70s and low 80s. During that summer it seemed to rain a lot (especially, if you grew up in Kansas), mostly at noon time and again around the time we would leave work. It seemed like we were always sweating or in a sauna caused by the afternoon sun evaporating the rainwater. We were always looking for places with air conditioning like Gulfgate shopping center or in the Weingarten's grocery store next to Gulfgate. The warmth of Galveston's surf was appreciated but the dirty brown color and seaweed washed up on the beach were a real disappointment. What we expected were white beaches, clear blue water and large waves. The water of the Gulf [of Mexico] and Clear Lake reminded me of the ponds without the dairy cows and Cowskin Creek on my parent's farm where I had pole fished and gone noodling (hand fishing) for catfish and whatever else we could scoop out during my teenage years.

We became friends with the other married couple in the Intern Program, from the University of Colorado. They told us that when they applied, they stapled their applications together and wrote in big, bold letters on both applications that neither would accept the internship unless both were selected. He was a business major and she majored in astrophysics. He was on the University's golf team. I was a willing golf partner but I had never swung a golf club except on miniature golf courses. Several times after work he and I played on Houston public courses and on a few Saturday mornings at Ellington Air Force Base with the jackrabbits and egrets. I did not play well. Each time we played it seemed to be stifling hot and muggy and

in still Houston air. And I remember sweating profusely while carrying my bag and too often searching through the rough for my ball while he patiently waited at the edge of the fairway.

Other entertainment included on August 5 attending my first major league baseball game during the Astrodome's second season with Sandy Koufax pitching for the Los Angeles Dodgers. As part of a record setting crowd that night we sat in the upper stands of right field. Almost everyone around us spoke Spanish. Loop 610 was under construction so we took Old Spanish Trail (Highway 90) from Interstate 45. It proved to be a moving parking lot to and from the Astrodome. As a result we arrived at our seats well into the second inning and did not get home until midnight. It was a great ballpark to see the game; unfortunately the Dodgers won.

Like newly-hired NASA full-time employees, summer employees signed in at Ellington Air Field. I was assigned to the Environmental Control Section of the Environmental Control System Branch in Crew Systems Division of the Engineering and Development Directorate. I worked under the supervision of Wil [Wilbert E.] Ellis and Walt [Walter W.] Guy. My work group of civil servants and Lockheed support contractors were co-located in a "bullpen" on the second floor, northeast corner of Building 29. The discolored tinted windows behind my desk were still in place on the building when I retired in 2002. My group's primary responsibility was to provide analytical analyses of ECS and Space Suit design issues and flight problems in support of the Gemini flights. But during my stay much of the analytical talent was being redirected to Apollo, which was in its development phase. One of our projects was the development of a transient computer simulation of a "metabolic man" based on thermodynamic and heat transfer principals. This analytical model was a key part of our in-house studies of a crew person's thermal and heat transfer response in space vehicle cabins and space suits as worn for launch/entry and during EVA. The model simulated the real time generation, transfer and

storage of heat within and between major body parts and the resultant gain or release of heat by the human body as affected by metabolic rate, clothing worn and the surrounding environment. Since I had taken courses on the physiology of the human body at Kansas State and was somewhat familiar with computer coding, the tasks I performed were mostly to improve the correlation of the metabolic man subroutine with the biophysics data provided by a consultant, Jan Stolwijk of the John B. Pierce Laboratory at Yale University. The simulation was later identified as the 41-Node Man; although significantly improved it continues to be used by the Division.

One of my memories of that summer occurred with my section head, Walt Guy. Walt possessed extraordinary engineering capabilities, vision and memory; was an exceptional systems engineer; and was highly regarded for the mentorship and leadership he provided and products produced during his long service as a Division Chief in the Engineering Directorate. I have always respected and considered him a mentor. For 20 years after I became a full-time employee at JSC I was in Crew and Thermal Systems Division with Walt as my supervisor much of the time.

Back to 1966—one day he requested that I sum the columns of annual budget estimates for a project and prepare a graphical profile that he wanted to show to our division chief. Simple enough, I added up the numbers for each year and hand drew the plot. The resulting profile contained several big sawtooths in the middle of the profile. Upon seeing the graph he told me that he did not want to show a profile that contained sawtooths. He explained that I needed to smooth the profile so that it rose, smoothly peaked, and gracefully tailed off over the life of the project. That's because, in this business, what you plan to have happen a year or more from now, often doesn't quite happen. For example, requirements may change, hardware can

encounter fabrication issues, or tests may be expanded, delayed or need to be repeated. So when you're planning your budget at the beginning of a project, you should protect yourself by smoothing over the data, especially the valleys. I redrew the plot. A few years later some of those budget busting events occurred to other vehicle systems within Projects and a Flight Program that I supported. I observed the major negative impact it had. And, confirmed he was correct. That's one lesson that I remembered through my thirty-five years working for NASA.

Suzanne worked on the third floor of building 7A in the Biomedical Specialties Section of the Biomedical Research Office of the Biomedical Research and Operations Directorate. Her supervisor was [Robert A.] Bob Nanz. She maintains that they were not expecting a summer intern. She quickly convinced them that she was not there to perform "secretarial" duties. She spent much of her time conducting "taste panels" of dehydrated food squares and drinks that were being evaluated for space food menu items. Her panels were usually composed of engineers in her building and nearby buildings. I "eagerly" participated on several taste panels. The cubes of food, such as tuna and noodles were in plastic bags that you rehydrated by adding a prescribed quantity of water and "squished" the contents until they appeared ready to eat. Drink mixes were rehydrated similarly, then "drank" through a tube in the bag. None of the food samples I ate were "tasty or delicious" items. Well, maybe the "peaches." I do not know if any of the food candidates I tasted made the Apollo flight manifests. Suzanne was allowed to bring home some "nearly expired" space food items. Shrimp cocktail was my favorite. Nine years later, I attended a special luncheon for the U.S. and U.S.S.R. participants in the Apollo-Soyuz Test Project. The meal was served on a ship on the Moscow River near Moscow, Russia. The menu was Russian space food out of tubes and cans like they flew for their Soyuz crews. Most of it was very bland with the consistency and taste of paste. Our space food tasted much better,

probably because I at least had some idea of what I was eating. The other activity Suzanne and I participated in together was an excellent 30 part series of orientation classes for new employees and the summer interns. The classes were about MSC and the design and operation of Human Spacecraft and its individual systems, held after lunch twice each week in the Building 30 Auditorium.

A terrifying, life threatening event occurred as our internship was ending. Suzanne and I made our only road-trip of the summer, a visit to New Orleans during Labor Day weekend to celebrate our first anniversary. The hotel and local environment was much better than in East St. Louis, Missouri, where I had mistakenly booked us for our honeymoon. After enjoying the sights and sounds of the Big Easy, we arrived at our apartment complex about 8 pm on Labor Day. After parking our car under a carport and taking our suitcases out of the car trunk I began crossing to other side of the carport. A clean cut, college age white male stepped out of the darkness into the roadway. A bright light was above and directly behind him. I could not see his face but I did see his right hand was holding something. He said, "Give me your billfold or I will kill you." I stopped in my tracks, asked him to repeat his statement, which he did. Foolishly believing I was not in real danger and that it was imperative that I retain my billfold (our daylong drive back to Manhattan, Kansas, would be in five days), I sat the suitcases on the ground and proceeded to "negotiate" by offering all my money but not my billfold. He did not accept that suggestion. I repeated my offer. We went back and forth at least four more times. Each time he repeated that he would kill me if I did not do as he asked. I was stalling, believing that any second a car would enter the parking area and the robber would run away. That did not happen. He finally convinced me that I was in real danger when he waved his gun and told me he would also kill the woman, my wife. At the beginning of our confrontation Suzanne had been under the

carport on the passenger side of the car. I turned to see where she was but did not see her. Now I was worried; he and I were alone. I quickly proceeded to begin removing my billfold from my pants pocket. He stopped me. I explained that I was removing my billfold and would give him all of my money. I then placed the billfold in front of me and slowly removed and dropped all of my money on the ground, three $1 bills, a $10 bill and a $20 traveler's check. I then started dropping credit cards (I believed he would still end up with the billfold). He told me to stop and step back which I did, while still holding my billfold. He came forward, gathered up only the money and ran back through the carport, past our ground floor, corner apartment that was next to the carport. He quickly disappeared into the shadows of the complex. I picked up the credit cards then stood there for a few seconds, waiting to see if he was coming back, while calling out and scanning down the rows of cars for Suzanne. Not hearing or seeing Suzanne I quickly carried our suitcases into our apartment and returned to search for Suzanne.

Standing in the middle of the carport roadway I saw at the far end, a distance of about 50 yards, three people running toward me, one I recognized as Suzanne, with a man and woman. As they came closer I could see the man was holding a handgun. They explained that they were the apartment manager and his wife. While I was "negotiating," Suzanne had quietly run up to the manager's apartment and now they were coming to my "rescue." I am very thankful that the robber had left the scene before the manager began his run. I could have been standing between these "cowboys" during a real shootout.

They had called the Houston police. After waiting for 45 minutes for the Houston police to arrive and answering a few questions that easily could have been done over the telephone, the manager mentioned that the robber might be in the Apollo Bar that was in a corner location of the strip center in front of the complex. The four of us entered the bar and sure enough the

robber was sitting at a table in the back. I'm sure he recognized me because of the "colorful" '60s shirt and shorts I was wearing. The manager, still carrying his gun, immediately wanted to make a citizen's arrest. I reminded him that we were in a crowded room and I had seen enough guns already. We sat down and ordered a round of beer while Suzanne went outside to find a pay telephone to call the Houston police. Over a three-minute period the robber went to the men's room twice, then out the back door. The manager and his wife followed him while Suzanne, who had returned, and I went out the front door, in case the robber came around the front. We never saw him again. It was another 45 minutes before the Houston police arrived. This time they searched the front area of the complex with no success. I now believed the robber knew I could recognize him.

Neither Suzanne, nor I slept much during any of the remaining five nights in our apartment. Later that week my work unit held a going-away luncheon celebration for Suzanne and me at a seafood restaurant on Clear Lake. I ordered flounder. I had never tasted fried flounder. I determined with my first bite that nothing should taste this horrible; it had to be "spoiled/rotten" fish. I told no one, pretended to take a couple bites, all through the meal believing that one of the cooks in the kitchen was the robber and was trying to poison me. That Saturday we quickly loaded our stuff back into a small U-Haul trailer and headed to Kansas. I was thrilled to have worked at the Manned Space Center in a job that seemed a perfect fit with my academic interests, but due to the shock of the events occurring during our final week, we never dreamed that we would be returning to Houston or MSC within three years for a permanent job.

Military Service Options

For my final semester I enrolled in three courses, but was primarily focused on analyzing and interpreting my thesis project's test data, writing my master's thesis and passing my orals exam. While I was at MSC I had observed that there were a number of employees they called "blue suits," military personnel, who were fulfilling their active duty military commitment, by working as a "military detail" at the Manned Spacecraft Center. Before returning to school I asked my Division management if I could be one of those. Early that fall my former supervisor began the process. In November he received approval from MSC's Center management through NASA Headquarters to petition the Pentagon on my behalf. NASA's request was sent to the U.S. Army in mid January of 1967.

Earlier that fall I had initiated another action. South Vietnam had changed from a rest and recreation area into a war zone. Back in February 1965 I had received a reserve officer's commission as a second Lieutenant in the Intelligence and Security Branch of the U.S. Army. When I applied for Army Intelligence in 1963, my ideal assignment was to go to San Diego, learn a language and be assigned overseas, preferably in Europe eaves-dropping on the Russians or East Germans. But, as an intelligence officer you could also be imbedded in an infantry squad or platoon, go on patrols in the jungle, and "interrogate" prisoners as they're captured. I had seen films of field interrogation during my ROTC training. It was not something I wanted to do, whatsoever. My reasoning was that while on that same patrol I could be captured and if found to be an "intelligence" officer, my life expectancy would be extremely short and I would suffer a horribly painful end.

I researched all of the information I could find in the ROTC building at Kansas State on engineering positions within the U.S. Army. The only opportunities for using my particular

engineering training were within the Quartermaster Corps, performed at the Natick Research Labs [Natick, Massachusetts]. A plus was that during the previous summer at MSC I had reviewed several technical papers on work being performed at Natick that was applicable to the development of Crew Systems Division's metabolic man simulation. On November 21, 1966, I applied for a transfer from Intelligence to Quartermaster. The branch transfer was approved January 18, 1967. I fully believed that, "Either I'm going to NASA, or I'm going to Natick for my active duty assignment."

On April 10, 1967 I received the package containing my military orders. The Orders were "you are assigned to the General Equipment Test Agency (GETA) at Ft. Lee, Virginia as the Officer-In-Charge (OIC) of the Combat Effectiveness Test Facility at Camp Pickett, Virginia. And, your **ultimate assignment is Vietnam**." Needless to say, I was shocked and dismayed! The only good news was that the reporting date for active duty service was 11 May. That would be and was enough time for Suzanne to complete her master's coursework, thesis, and orals. I was unsure if NASA's request had been considered.

On April 12 NASA received word that their assignment request for me was denied. Walt Guy immediately called asking, "What happened? NASA MSC has had few requests turned down by any branch of the military. MSC management does not want to make that mistake again. Can you find out why they refused to allow you to work your military commitment here?" I went to the Military Science building and asked, but no one in the University's ROTC Detachment, not even the Commander could answer that question. I was advised that I would need to talk with someone in the Quartermaster Corps' Personnel Office in Washington, DC.

On April 15, 1967, I sent a letter of appeal with supporting letters to the Adjutant General, Department of the Army in Washington for change in my assignment to serving my full

tour of active duty at NASA's Manned Spacecraft Center. I also included that enroute to Ft. Lee for reporting for active duty I planned to visit the officer assignment branch of the Quartermaster Corps in Washington, DC, to further discuss my request.

That same fall of 1966, I again tested the water for possible permanent employment opportunities besides NASA MSC. I would have a master's degree but I also had a two-year military obligation that required me to begin my active duty service within months of graduation. I interviewed with 9 companies and received 2 offers with salaries of $800 and $875 per month, even with the pending military obligation. I did not accept either offer because I knew then that I really wanted to work for NASA's MSC. At that time I only had a promise from Walt and Wil that my employment application would be considered by MSC and that they would not be allowed to proceed until shortly before I completed my active duty military obligation.

My first experience with technical writing was my master's thesis. Reviewing, assessing and transforming ideas and technical data into words came fairly easily but assembling them to tell a clear, concise, simple story was much more difficult. Fortunately, I had two technical writing opportunities. One was my thesis and the other was a technical paper on the same subject titled, "Thermal Comfort Conditions for Three Levels of Activity" that my major professor presented at the first technical session of the January 1967 ASRAE conference in Detroit, Michigan. As "compensation" I did get to attend the conference. The paper was published in the ASHRAE Transactions, Volume 73, Part 1 in August 1967. The writing skills and discipline developed during this period were a major part of the foundation that enabled me to author and publish 17 technical papers during my first 15 years at NASA. Late September like most other graduate school candidates, I hired an experienced "thesis" typist (a fellow graduate student's wife) known for her skills with a standard Royal typewriter. I provided the

"thesis paper," carbon paper, and handwritten drafts. There were strict rules for thesis preparation and presentation. Fortunately, my review committee accepted with few required changes my draft of each section of the thesis. I quickly gained a sincere appreciation for technical writers and anyone skilled at typing, especially if they were fast and took pride in their work. Defending and passing the oral examination of a master's degree candidate's thesis and coursework was anything but routine in KSU's College of Engineering. In fact they were eerily similar to the technical studies and projects reviews I participated in with NASA's Center and Agency senior managers. Preceding mine were two nuclear engineering master degree candidates, both failed their exam. Yes, I was concerned; the date for my orals was December 21 and the consequences of not graduating on-time would dramatically affect my future and any plans of working for NASA. I passed my oral exam, made the rewrites requested, obtained the final approval of the document by my orals committee and major professor, delivered my thesis "An Investigation of Thermal Comfort (Thermally Neutral) Conditions for Three Activity Levels" to the bookbinder in Topeka, Kansas and graduated on January 27, 1967.

Shortly after I received my military orders I again went to Dr. Nevins to see if an employment opportunity existed for me until May. He immediately asked me to become an Instructor for the Department of Mechanical Engineering and staff member in the Environmental Research Institute. One of his instructors, Wayne Springer, had just resigned to return to work in industry. The department had nine graduate students enrolled in the "Life Support Systems Design" course starting in a couple weeks with no one prepared to teach them. Because I had taken the course (formerly titled Environmental Engineering I), worked for NASA in Houston the previous summer on the subject matter to be taught and had my master's degree, Dr. Nevins

believed I was the best qualified person available. What could I do but agree, ecstatically. I had a paying job for the three months before entering active duty.

What I did not know was that all of the graduate students taking my class were foreign students, mostly Asian, from Taiwan, at least that is what I was told. In early April five of my students did not show up for class. I was told by the ME Department that the Central Intelligence Agency had informed the university that these individuals were being deported because they were from Red China. And, here I was explaining, probably not very well, the requirements and design options for providing environmental control and life support in human spacecraft in Earth orbit. Much of the subject matter was also applicable to submarines because they stayed below the ocean surface for months at a time. I never saw or heard from those students again.

The most difficult task was developing lesson plans for the course, a graduate level course. Mr. Springer had not left any documents. I had my notes and tests from when I took the class and some technical documents I was given during my summer job at NASA. I quickly contacted members of Walt Guy's section at MSC. They provided published technical papers, documents received as deliverables from ECS related research and development contracts and numerous document references that I researched, studied and used in my lectures. Today, in my home in 12 notebook binders is a copy of the lesson plans I prepared. I was required to report to my active duty post at Ft. Lee, Virginia, on May 11, three weeks before the end of the semester. My thesis advisor, Dr. Preston McNall agreed to finish the course for me. I gave him the 6 lesson plans for the last 2 weeks of classes, final paper requirements and final quiz. I also gave him a full set of lesson plans and quizzes that I had already used. When I wasn't working on lectures I worked for the Institute reviewing experimental designs, supporting tests, performing

data analysis and background research, conducting literature reviews for staff members on technical papers being prepared (two papers were published) and developing proposal ideas for obtaining research funding from ASHRAE.

Junior Officer in U.S. Army Quartermaster Corps

Early May my wife and I bundled everything we owned, barely filling the floor of the smallest U-Haul trailer, and drove to Virginia for my nine weeks of schooling to learn the duties and responsibilities of an officer in the Quartermaster Corps. Tuesday May 9, two days before reporting for active duty and determined to find the answer to NASA Houston's question we arrived at the Pentagon [Washington, D.C.] at approximately 9 am; literally, parking our car and U-Haul in front of the main entrance. Assuming that the personnel offices for each of the Army branches were inside I left Suzanne on the front steps. I was going to find the person who had approved the Orders that I now had to abide by. I walked in and went down the hallway on the outer ring passing the office doors for the Secretary of Defense, Army, Navy and Air Force. I was unescorted, in civilian clothes and the U.S. was at war in Vietnam. Just before I retired in 2002 I was again in the Pentagon, this time as a badged representative of NASA JSC for discussions of joint technology interests. What a change in building security. You could neither park close to the building, nor enter the Pentagon without an escort, proper badges and passing several metal protectors.

After a lengthy walk in the outer ring and several inner rings of the building I found the U.S. Army's suite of command offices only to discover that the person I wanted to see did not have an office in the building. The Quartermaster Corps' Office of Personnel was at another location in the Washington [DC] area. I was directed to take a military bus from under the Pentagon to Fort Myer in Virginia, a ride of less than 10 minutes. The bus station was on a

lower level of the Pentagon, a level which looked to be like a small city. There were shops for all the facilities and services that you needed for food, clothing, literally for everything, and a bus station with city buses, military buses, and taxis running all over the place. I boarded the military bus going to Ft. Myer, Virginia.

I had no difficulty finding the Quartermaster Corps' Office of Personnel. The title was posted on a sign outside a building near the bus stop. It turned out the senior person in the office, a full Colonel, was the very person I wanted to see. Two days before reporting for active duty; in civilian clothes and I really did not know if I should salute or not. I walked up to his desk and to be safe, saluted. He appeared to be drafting a letter and had two stacks of personnel folders (201 files) on his desk. I told him who I was and described my situation. He thought a minute and then said, "Lieutenant, I remember your case."

I said, "Then would you explain to me what happened? NASA and I would like to know?"

He said, "I remember NASA's request and that was okay. But at the same time a colonel from Ft. Lee, Virginia, came through here. He went through the resume of every captain and lieutenant coming on active duty for the next three years. He picked your resume out of all those people for a critical position at Ft Lee. I do not know what the special job is at Ft. Lee. But, NASA's request was denied because the needs of the U.S. Army come first."

I replied, "Okay, I understand why I am assigned to the General Equipment Test Activity at Ft. Lee. But, why is my ultimate assignment, Vietnam? My active duty commitment is for two years. In 2 days I will be in Quartermaster Officers School for 9 weeks. I will then go to this Test Activity Unit to perform a job that I was handpicked to perform but only for maybe six months, followed by a year in Vietnam, and then I will be complete my last four months at a

place yet to be determined. This sequence, especially the Vietnam assignment, I do not understand. I should serve my two years either at the Test Activity in Virginia or with NASA."

He said, "The folders in front of you are for the 44 Officers that entered active duty 6 months ago. I am now informing them of their next assignment. Forty are done and they are going to Vietnam. I have four more to go. Each of them is going to Vietnam. And when your time comes up, lieutenant, I'm sure that's where you and your classmates will be going."

I again asked if sending me to Vietnam after denying NASA's request and serving no longer than six months at the Ft. Lee assignment before being deployed to Vietnam seemed reasonable.

He told me "**Lieutenant, that's the way of the Army**." Stunned, but realizing that his decision was not going to change, I thanked him for his explanation, saluted, turned around and walked back outside. I took a military bus back to the Pentagon; rejoined Suzanne who had been patiently waiting for over 3 hours on the front steps of the Pentagon and started losing my hair, which as you can see I've lost a great deal of it [laughter].

The next day we drove to Ft. Lee, Virginia. Our experiences during my two years of active duty, starting that first week, would make an interesting if not entertaining "book." I will summarize the "highlights" and offer an explanation of how these "experiences" were beneficial in developing my management and leaderships skills for the positions and responsibilities I was assigned at NASA.

After arriving at Ft. Lee and the two of us spending a couple sleepless nights in a very small room with paper thin walls in the very noisy Non-Commissioned Officers' guest barracks, we were approved for off-base housing. We quickly found an apartment close to Ft. Lee in Colonial Heights, Virginia. First priority was to get a "real Army "haircut." I found a local

barber that was an "old-timer" and pro at military haircuts. During my first visit he informed me that Petersburg, Virginia, had "Negro's" but not Colonial Heights. It was a "white" town. He then told me his version of the history of white and Negro race relations in that part of Virginia. He also mentioned that he was "sort of" recruiting for the local KKK. I did not take him up on his offer. I listened to his many stories; one was of a local race riot many years earlier, possibly in 1919 that resulted (using his words) "in many Negro bodies being stacked like cordwood on flat cars and being hauled away by train." He implied he had seen, possibly participated in the riot. He was a true racist. I have been unable to verify this "story." Very early in my Test Activity assignment I was "tested" for racial bias by the black enlisted members of my work team and "passed." I am also very thankful that racism was never an issue during my work experience with NASA.

Officer's school started and I immediately told my classmates about my discussion with our duty assignment officer in Washington, DC. Because no other class member had visited or corresponded with the Quartermaster Corps' Office of Personnel, I jokingly urged that sometime spring of 1968 we meet in a bar of an Officer's Club in Saigon [Vietnam]. We would be in-country by that time and one of us may be able to "host" because one of the possible assignments for Quartermaster Officers is managing the Army's Officer Clubs.

Officer in Charge at Camp Pickett, Virginia

My class of 45 graduated on July 14. I was the only class member that stayed at Ft. Lee, where I reported to the General Equipment Test Activity (GETA) unit for my first and it turned out to be my only assignment. My duty station was Ft. Lee but I quickly discovered the Combat Effectiveness Test Facility (CETF) was located at Camp Pickett, Virginia, about 40 miles west, southwest on U.S. 460 near Blackstone, Virginia. Daily, at 6:30 a.m. Suzanne drove me onto Ft.

Lee and I then rode in a Ford carryall van with up to 8 of my men to Camp Pickett and at 4:15 p.m. we drove back. As the OIC I was expected to sit in the "shotgun" seat. I quickly discovered that the other riders in the van were asleep within minutes if not seconds of our leaving, leaving only me to watch the driver and road for the 50 to 60 minute trip. Believe me; I never slept during the drive. Many times I wished I was driving instead of one of my sleepy, heavy footed Army Specialists. There were too many near misses with on-coming cars and logging trucks. The two-lane blacktop, winding road through Central Virginia's pine forests was often wet resulting in slick pavement often covered with multiple large chunks of mud that had been thrown from the dual wheels of the logging trucks after entering the highway from the dirt logging roads. One afternoon we observed a civilian car following us rapidly blinking its headlights. We slowed to allow him to pass. He didn't pass but started honking his horn, so we stopped. When I exited the van to "help" the driver I was "shocked and then embarrassed" as I was "duly" chewed out next to the highway by the driver, an Army major, for allowing the van to be speeding, a message I clearly passed on to my drivers. That would not and did not happen again.

The CETF was under construction and development to be a permanent Army field test facility, on 340 acres in the Virginia pine forest. The technical planning and monitoring of site activities was led by senior Department of Defense civil servant, James C. "Jim" Perkins in GETA's Methods Engineering Directorate at Ft. Lee. He was my supervisor. The methodological research, design, development, scheduling, and integration of day-to-day implementation and construction work on the courses and data center were provided by Dunlap Associates, Incorporated, a civilian contractor selected by GETA through competitive competition. On-site, Dunlap provided a project manager and 2 to 5 engineers and technicians

with technical skills that were not readily available through normal Army enlistments. Under my command were 18 to 50 enlisted men including 2 NCOs [non-commissioned officers] that provided the day-to-day manual labor pool needed to construct, maintain, secure and later operate the facility.

The test site was designed to provide a field test environment for determining the effects of experimental clothing and equipment on the combat effectiveness of individual army soldiers. Providing appropriate clothing and equipment for battlefield use is one of the core functions of the Quartermaster Corps. The facility's seven test courses were designed to evaluate the ten most important tasks essential to combat success and likely to be affected by clothing and equipment as identified by veterans of World War II and the Korean and Vietnam conflicts.

Each of the 12 combat infantrymen test subjects would traverse each course once during a 6 to 8 hour day under simulated combat conditions. This test protocol with the sequence of courses randomized was repeated for 4 consecutive days, then a rest period of 2 days followed by another 4 days of testing. The test subject groups were chosen and provided by Army military units within the Continental U.S. Each group stayed two weeks, housed in our post-WWI barracks at Camp Pickett.

The individual tasks included loading, reloading, and firing a M14 rifle (replaced by M16 rifle just before I left) using several physical positions and a sequence of locations at a number of pop-up targets, performing reconnaissance tasks, maneuvering through obstacles, climbing up and down a cargo net, throwing hand grenades at multiple targets, digging hasty fighting positions (foxholes), and performing extended marches on a flat course and hilly terrain course. Precise measurements while completing these tasks were made under highly controlled conditions using photo cells, pressure sensitive pads, micro-switches, stopwatches, and

acoustical transducers to measure each soldier-participant's performance. All hand collected data and the electronically monitored data were entered into a $600,000 data acquisition and analysis computer system (Hewlett Packard paper tape machine) housed in a house trailer that also served as an office for the contractor team. The computer trailer later became our control/data center. Across the small parking lot was the "command/office" house trailer I shared with my two NCO staff sergeants and a clerk/typist.

As OIC I served as project officer and manager of project funds and supervised up to 50 Army enlisted men, a crew of "construction workers, ditch diggers and cable installers" that later became my test team. I assisted the on-site contractor's senior technologists in developing and critiquing their physical layout of courses and mechanical testing methods, and led the planning and execution of field verification trials that provided the final acceptance by the U.S. Army of the courses and testing methods. I wrote the facility's standard operating procedures for test conduct including the procedures to be followed by the test team and test subjects at each test station of each course and requirements for data collection and processing and logistical support.

When I arrived at the test site in mid-July 1967, all of the courses had been laid out (brush and trees cleared), about one-half of the courses were fully constructed and the stations in those courses were in the process of being instrumented. The design of one course was still "on the drawing board." None of the "hand labor" construction work of excavating, laying, and installing underground power and data cables to connect each station and each course to the data center had begun.

During the 15 month construction phase work typically was from 8 to 12 and 1 to 4 pm. The enlisted men ate lunch at the Camp Pickett mess hall. I would eat a sack lunch with my sergeants and the project manager on-site in my office trailer. Once a week we would go out for

hot food at a café in Blackstone and on a few "memorable" occasions I ate at Camp Pickett's Officer's Club. During the last 6 months as we transitioned into the operational testing phase, I, my military team and the test subjects almost always ate at the test site. We knew it was approaching lunch time when the World War II C-ration cans containing "meat" were dumped into a 55 gallon drum of boiling water. A perk for me was being offered first choice of the "meat" most days. C-rations were what the Army had decided would be fed to our test subjects and I had many crates with cases full of boxes stored on-site. I quickly discovered that they were always a high demand barter item for "necessary supplies and services" from Camp Pickett's facility operation's civilian workers who were avid deer and turkey hunters.

Housing for eight of my enlisted men was a modern brick barracks at Ft. Lee while the others including my NCOs stayed at Camp Pickett, calling the second floor of a World War I era wooden barracks' home. The WWI structure had a coal fired furnace that spewed soot throughout the building, making my inspections and maintaining morale a challenge. But I heard few complaints because the Camp Pickett men had discovered an all-girl college was nearby. And, that our supply tent which was locked during non-work hours had all the necessary equipment and supplies for weekend campouts.

None of the enlisted men assigned to my unit when I arrived had attended more than a year of college. Many had not graduated from high school. The few who attended college had either dropped out or were drafted because of poor grades. Many were physically fit because their previous assignment in the Quartermaster Corps was in Special Services which operated and maintained the physical training facilities at Army bases. Some had completed a year in Vietnam and had been randomly assigned to our test facility for their last few months of active duty. All were expected to be "day laborers" for the construction work needed. To a man they

showed little interest in being there. Much of the original group's work assignments required significant amounts of manual labor, mostly using picks and shovels to dig literally miles of narrow trenches in the woods from the instrumentation on the courses to the house trailer that contained the data computer. This was not an easy task with the heavily forested, rocky soil, and countless tree roots. Then, they strung out power and multiple data lines beside the trenches before threading them through ½ inch and 1 inch diameter PVC piping. The pipes were laid in the trenches, and covered with dirt. My men found more ways for breaking the handle of a pick and shovel than I ever believed existed. An increased frequency of occurrence was an easy way to determine that "all was not right" between my men and "management."

During the first year as members of the original enlisted group were transferred or discharged (having completed their two-year military commitment) their replacements had the same background. But by mid 1968 through the foresight and persistence of my supervisor Jim Perkins the replacements changed to draftees that were college graduates with technical degrees serving their first year of active duty. Several were engineers and technicians drafted while working for companies like Ford Motor Company and IBM. Talk about unhappy campers. Two, like me, had advanced degrees. It was a challenging contrast, but necessary for transition from construction to an operational test facility. I needed their skills to maintain, operate and improve the individual courses and its instrumentation, operate the computer system, assist with the collection and evaluation of the test data and prepare the technical reports.

July 1968 an Army private first class (E-3) with less than two years of service was paid $137.70 per month. This was not a problem with the first year men but in the second year's replacements I had two PF's receiving much more, the same monthly income as when they were civilians. Their civilian employer/company (e.g. IBM) paid them the difference between their

civilian salary and their military pay as an incentive to go back to work for the company. In fact, both were paid far more than I, which was $379.80 per month as a second Lieutenant and $569.70 after being promoted to 1st Lieutenant in May 1968. The result was an enlisted group with a couple men having plenty of spending money available living in the same barracks with others that had literally no money. Fortunately, those paid the compensated income were married with family responsibilities chose to maintain a lifestyle compatible with the rest of the draftees and sent the remainder back to their spouse.

Several of the drafted engineers were really angry at being drafted for Army service during the Vietnam Conflict. Their mind set was to do only what was asked, and when asked, to do it at the minimum level that would "get by" until they were discharged. It took some innovative thinking to discover tasks that would motivate them to provide their expertise and work at the level that I believed they were capable of performing. This was a real management challenge that taught me a lot about leading, managing, motivating and working with people.

WRIGHT: You were in Virginia the whole time you were on active military duty?

JAAX: Yes, the whole time. I never received orders to go to Vietnam.

Late fall and winter of 1967 - 1968 was a stressful time for Suzanne and I because of the Vietnam statement in my original Orders. We flew back to Kansas in December for Christmas with our parents and family, fully believing that when we returned I would have Orders to go to Vietnam. Several weeks before we left Virginia I had begun receiving calls from my Quartermaster School classmates, who were scattered in various parts of the world, that they had received their Orders. When I responded to their question by saying, "I haven't received

anything yet," there would be a long, pregnant period of silence. I quickly assured them that I expected to receive my Orders any day.

We flew back to a frigid Baltimore [Maryland]; the parking lot had a thick blanket of snow. After a long, cold, windy, walking search of the airport parking lot we located our '65 Ford. It was covered with two inches of snow, had ice in the door key locks and the battery was dead, all bad, bad signs. Finally, we arrived at our Colonial Heights apartment. There was no letter from the U.S. Army in our mail box. I had not received Orders for re-assignment to Viet Nam. Throughout the remainder of that winter and early spring we waited anxiously and fearfully for each day's mail. As an additional precaution, I purposely avoided contact with my unit's personnel officer. But I also knew if he had seen or knew of anything, he would have already told me. The last thing I wanted was for him to "ask questions" about my status that involved people in Washington, DC. Time passed and I did not receive "the" letter with new Orders. And, the calls from my classmates stopped.

I continued to work at Camp Pickett. We successfully completed construction and in February 1969 began a lengthy period of field testing with human test subjects. Spring 1969 the Combat Effectiveness Test Facility was officially a "show-and-tell" site. Mid-level to senior Army officers (majors, colonels and generals), who, as best as I could tell had "time on their hands" in the Washington area, would make a "day trip" to Camp Pickett to "tour" our facility. Hosting these visitors meant we spent a lot of time "spit-shining and grooming" our administrative and course areas in addition to testing and maintaining the test courses' equipment. My replacement arrived in April. We were now "operational" and our first "tests for the record" of new clothing and equipment began a month before my discharge date of May 6, 1969.

The most perplexing personnel problems I encountered were dealing with the issues presented by the test subjects as we conducted the 2 1/2 months of field checkout, verification, and acceptance testing. The subjects were detailed for two weeks at Camp Pickett from Army units across the Nation. If you, as a company commander of an Army unit in say, Dugway, Utah, were ordered to send 15 enlisted men to Camp Pickett for two weeks, which individuals would you select? We did not get their best and brightest. They usually detailed their near-worst problem makers. The worst were serving time behind bars somewhere. Too often, 1 or 2 of the test subjects from the sending unit would arrive visibly drunk or "spaced out" on marijuana or some "drug" and almost none of the others showed any interest or demonstrated any motivation supporting what we were doing. We rejected (sent home) several upon arrival. Most subjects were draftees that had recently returned from Vietnam and were only interested in crossing off the days until they would be discharged. Some were in reasonable physical shape, many weren't, and of course, the courses we ran them through were demanding physical exercises. My NCOs and I have many stories of how we dealt with these individuals; some required really inventive solutions. Lacking motivation and commitment the test subject's performance on the individual courses was not establishing a representative baseline for the intended purpose of this facility. I repeatedly asked my civilian supervisor to request the Army "provide better test subjects."

One motivational tool I used was a Course Records Board located in the Administrative Area. It identified for each course the individual(s) and their unit that had the fastest time, best score, etc., for the week and "all-time" records. It was of interest to some test subjects, but proved to be of more interest (for bragging rights, I believe) to our "distinguished visitors from Washington DC." For our final field checkout and acceptance test the Army Command at Fort

Benning [Georgia] did us a real favor. They sent a squad from their honor guard company, men from the unit they showcased at base parade ceremonies, their best and finest. These young men arrived in great shape, highly motivated and expressly competitive. They obliterated every course record that had been previously set. For us they provided our best evaluations of the individual tasks for each course. We used their data to produce the baseline standard for performance at each course while wearing the standard issue combat clothing and equipment. Their performance became the benchmark for comparison with future test groups. Maybe the observations I had made to my civilian boss about the "poor quality" of the test subjects being provided had made a difference. That reminds me: throughout my stay my only supervisor was the same civilian, Jim Perkins. I was never requested to report my activities through the military chain-of-command.

When I was discharged, the facility was "operational" and we had successfully completed field testing of three new personal equipment items, a helmet with a lip in the back, a triangular shaped folding entrenching tool, and a light-weight flak jacket. The facility had cost the U.S. tax payers a little over a million dollars by May 1969. Two years later, I received a letter from Jim Perkins, who was still the civilian leader for the facility that the Army with its infinite wisdom had decided the CETF was a good thing but in the wrong location. Construction of an identical facility was already underway at Fort Benning, Georgia, and would be operational within a year. The Virginia facility was to be razed and sold as scrap metal. I was shocked and thought what a waste of effort and money. Then I rationalized that we had built an operational "proof of concept" facility that the U.S. Army believed had definite value. And, at least by relocating the facility at Fort Benning, the test team would be provided immediate access to top quality test subjects.

During my two years of military service, my observation was that the DOD [Department of Defense] civil servants were the backbone of GETA's test and evaluation activities and technical projects. Years of sustained effort were required to complete the cycle of conceiving, planning, obtaining funding, implementing, and verifying as operational many of the Quartermaster Corps complex technical projects. It was a rewarding experience to observe and interface with a few of those dedicated civil servants who provided that leadership, maintained and nourished the continuity and truly "owned" their projects.

Another observation was that military leadership assignments of junior officers with GETA typically were six months or less, especially for the lieutenants and captains. This was too short in duration for most junior officers to feel a real commitment or ownership of an assigned job especially when one believed his next assignment would be in Vietnam. My stay of 21 months was an extremely rare case, especially during the Vietnam Conflict and was more than 2½ years short of spanning the 4+ years from CETF project's conception to full operational maturity. The officers in GETA with ranks above captain had longer tours but I did not see or hear of anyone initiating and staying for the full life of a complex field project that was under their command.

I was made aware by fellow officers of instances where more harm than good was done by the frequent change-out of military leadership primarily because an individual never stayed long enough to "live with the results of his decisions." Often the military officer's interest seemed to be more in "check marking" another of their experience squares and "making cosmetic splash changes" to a project rather than taking ownership by leading and managing projects or activities through their full life cycle. This proved to not be a situation unique to the DOD. During my career at NASA, especially while in senior management, I often dealt with the

"fallout and unintended products" produced by changes made by "management change agents" that did not stay long enough to experience or have to "live with" the results of their decisions."

The following are some of my experiences in the military and lessons learned that helped prepare me for my career with NASA:

Fortunately, when I arrived at Camp Pickett, neither my NCOs, nor enlisted men knew me or my abilities as an engineer. They did know that I was a "freshly minted" Lieutenant. Under the direction of the previous OIC my crew had started constructing a 4 bay overhead cover structure to provide on-site protected parking for our jeep, ¾ ton truck and dump truck. The flat roof had a 15 degree slant and was supported by telephone poles buried in the ground that were originally about 16 feet tall. He and the work crew knew very little about construction techniques. After the poles had been set and cut to the correct height, the men had placed across the bays 2x4's that were nailed to both sides of the poles to serve as joists. When I arrived, only the joists were attached to the poles. They were severely misaligned; nails were backing out. Each bay of the structure had the look of a swayback mare. The men were openly "embarrassed" of the results of their efforts.

I had never seen or built a pole barn. The next morning before going to Camp Pickett, I went to the woodworking shop on Ft. Lee. Their carpenters should know how to construct a pole barn. I asked them, "What should I do?" They proved to be a great resource. First, I had my crew remove the 2 x 4s from the poles. Each pole was then notched; 2" x 8"s were placed across the bays, set upon the notches and nailed to each pole to serve as roof joists. Then 2" x 4" rafters were placed across the joists; followed by layers of plywood, felt and roofing shingles for the roof top. The day after completion of the roof's construction one of my enlisted men, PFC [Private First Class] Tobias, inadvertently tested the quality of our construction. He was backing

the dump truck into the second bay when he nudged and unseated the center pole's joist from its notch. The roof held; locally, it sagged less than an inch. We removed the dislodged nails from the joist, placed a jack on the bed of the dump truck and slowly lifted the joist and attached roof. When the joist cleared the bottom of the notch, the pole sprang back under the joist. The men were so pleased with the roof's sturdy construction that my NCOs hosted a "beer" party with all of us on top of the roof the next afternoon. From then on for each "engineering" design challenge we faced, if I said, "Do this," they went out and did what I asked without question. They and I needed a test like that to prove that we could really construct this test facility. I experienced "tests" of a similar nature during my career working human spaceflight for NASA. I believe that "tests" of this nature are a necessary part in the development of a leader's technical and management skills, and in building trust and teamwork within organizations.

During my second week at Camp Pickett while traveling in our van to the test site, the leader of the four black enlisted men under my command asked several probing questions seeking my views on the black-white race issue, a hot topic in 1967 and 1968. Growing up in Kansas, I had very little interaction with any persons of color. I immediately established my position that we were all created equal and that I would use performance and behavior regardless of color, faith, or sex in my decision-making. That was acceptable to him and the rest of my men. But I experienced some nuances.

Going to a small rural high school I had been a member of all of our varsity sport teams. Entering college I had visions of being a walk-on basketball player. After going to the first open practice and seeing how big, quick, and talented the scholarship athletes were, I quickly decided not to "suit up" and embarrass myself and walked back to the chemistry lab class I had cut. Each year in school, I continued to participate in many sports through the university's intramural

programs. In October of that first year at Ft. Lee I attended the tryout for GETA's basketball team that would compete in Ft. Lee's intramural league. I discovered that the men trying out for the team were almost all African-American players. Two starters were from my work crew; one was the team captain, Specialist T. Shields, who claimed to be a former small college All-American and had been asked to try-out for the Atlanta Hawks following his discharge. He was the same man that questioned me in the van about my racial views. I must have proven true to my earlier statement because another Lieutenant and I were the only white players selected for the team. The Army's Quartermaster Corps' Special Services was where many drafted professional athletes were assigned to work in the late 1960s. Their duties usually involved the operation and maintenance of the base or post's recreational facilities and participating in the inter-military sports programs. So if you had played basketball for the Atlanta Hawks or Houston Rockets there was a high probability you would be assigned to Ft. Lee, if so, I saw you play. None of the "professionals" were on my team. A "team rule" that the other Lieutenant and I did not know until the first game was being played, was that the two of us would play only after our team scored one hundred points. Fortunately, scoring was not a problem. True to their word we had the opportunity to play when one hundred was reached **and** as we also learned, if we were sufficiently ahead. Until then, we watched a lot of "great" basketball players running and gunning. [Laughter] Defense was not important in this league.

My passion was men's volleyball but very few in GETA were familiar with the game. I "volunteered" to coach and entered our unit's team in the Post's intramural league for the spring 1968 competition. I recruited many on the basketball team. During rainy days at Camp Pickett we often held physical training sessions in the Camp's indoor gymnasium. That is where I taught my two basketball players the basic skills and rules of volleyball, well sort of. Neither

individual really ever transitioned from catching and throwing the volleyball to being able to routinely spike the ball over the net with it landing inside the playing area. Our team was reasonably competitive. That was until new arc-lamps were installed in Ft. Lee's main gymnasium. Staring up into the new lamps during a Saturday tournament resulted in several of my players including myself suffering significant eye fatigue/soreness that felt like a sunburn. We had radiation burns from the lamps. One of my players was in the Post hospital for several days. The season was terminated and new lamps ordered. During my first 10 years at JSC I continued to play on intramural volleyball, basketball and slow pitch softball teams, many of which I organized and was the "team manager."

I was told while in Officer's school that some commanding officers were extremely serious about "all officers under their command" supporting an activity such as the United Fund campaign. One hundred per cent participation was expected or more correctly stated "demanded." The monetary amount of the contribution did not matter. You must contribute. A dollar would do. The officer that replaced me arrived at United Fund time. I told him that our unit commander, Colonel Church, "expected" all of his officers to participate. The Lieutenant said he would not. Two days after his refusal got back to Ft. Lee, the Colonel, who had never visited the CETF during my tour, made a quick visit to our facility, had a short face-to-face meeting with the Lieutenant and left without even a token "tour" of our facility. I discretely disappeared during the "discussion." The Lieutenant stayed his course. He did not intend to make the Army a career. During my early years with NASA, I heard similar rumors about "participation" but did not have any personal exposure to such pressure.

Early April of 1968 while the riots in Washington, DC, were on-going, I was notified that the Company at Ft. Lee that our unit was in had been placed on alert for performing riot control

in DC. My men and I had had zero training in riot control. We were told that we were the third level of support which meant I could continue construction work. We sequenced our men for their required riot training at Ft. Lee. Fortunately, we were never called up.

Additionally, I was told to beef up the physical security for the CETF by imposing a two-man on-site CQ (charge of quarters) duty during all off-duty hours. GETA management and I were concerned about protecting the supply tent at our work-site. That tent housed all of our supplies and combat equipment used during our tests including 15 M-14 rifles. Fortunately, the live rounds of rifle ammunition were not stored in our compound; they were stored in one of Camp Pickett's ammunition bunkers. Our test site had always had a perimeter fence made using three rolls of concertina wire and lockable gates. In addition, we kept in the administrative area an admittedly very timid German Shepard guard dog, acquired from a local dog pound. That combination was determined to be insufficient for security. Round-the-clock human presence was now required.

Camp Pickett included sufficient land area to provide a firing range that supported artillery and tank firing training. The Virginia National Guard maintained a year-around tank maintenance facility on-site that housed, maintained and repaired, tanks, armor support vehicles and artillery pieces used by National Guard and Army Reserve units. During training exercises these vehicles often were used to supplement the visitor's vehicles provided from their home station. The CETF was located next to the tank firing range. It was mainly during summer camp season that we would hear the "boom" of the guns firing followed by the whine of shells as they flew over us and the concussion sounds as they exploded upon hitting the ground in the impact zone. Believe me; you were always listening to verify the shell was not falling "short." Unfortunately, that was the least of our issues with the "reservist and national guard campers."

National Guard units from the Mid-Atlantic States and Army Reserve units on the East Coast came to Camp Pickett for their "two weeks of specialized summer training." Throughout the summer of 1968 "riot control" was a major part of their training plans. Unfortunately, these units appeared to invent their "riot control" training as they went. One consistency was that the reservists were instructed that anyone, especially a group they did not know could be "rioters." They may be dressed like civilians or in military uniforms; performing "regular" tasks. And, to **trust no one** you did not know.

Platoon size groups of "summer campers" would often march on the roads near our worksite, "looking" for rioters and often were harassed by "pretend rioters from aggressor forces" provided by Camp Pickett. Throughout that summer I had several "work parties" working at various locations on-site every weekday. We used a two-way radio network to communicate between myself, my office staff, the civilian contractor supervisor and the many work parties. Because of the summer heat I often allowed my enlisted men to remove their shirts while digging the trenches. Our contractor's civilian workers wore shorts and maybe a T-shirt. This combination provided many suspicious individuals for the Reservist and Guards being trained near our test facility. Too often I would receive a call that an individual or work party had not called in and search parties had not located them. My missing men would reappear late in the day with "wild" tales about being captured and interrogated by the Reservists. I protested this treatment of my men to the Post Commander but that had little effect because the offending Unit would soon leave and a new Reserve Unit would arrive for their summer training. The final straw that caused the Camp Commander to change the Reservists training protocol was when I had a work party of enlisted and civilians cutting a trench using a small tractor driven "ditch witch" across a major roadway between our rifle firing course and the test site's control/data

center. The NCO with the small work party radioed that a large group of Reservists that had been marching toward them on the roadway were now stopped in front of the trenching location. The work party was being accused of being "rioters." The NCO requested that I talk to their leader. Before I could answer, in the background I heard the leader of the Reservists say "Don your gas masks." This was not a good sign. The NCO quickly repeated what I heard and added, "They're tossing tear gas grenades at us." That was followed by a lot of yelling and coughing by my men as tear gas filled the air and they ran for cover. Needless to say I was in the Post Commander's office within the hour and we had no further problems with the summer training units.

Another major complaint about the summer campers was their bi-weekly major buying sprees that routinely emptied the shelves in the Camp's PX (Post Exchange). The PX's prices were significantly lower and only available for those on active duty and retired from the military. The reservists knew that compared to their hometown stores, there were real bargains in the PX. Throughout the summer months they virtually cleared the shelves of clothing and staple goods that we needed for our families. Many purchased a year's worth of non-perishable items and mailed them home.

The movie M.A.S.H was released a year after I was discharged. I could hardly contain myself as I watched. There were so many similarities with my military experiences. I often said that my unit at the CETF had done or been a part of equivalent "experiences" representing about 80 per cent of the "events" portrayed in the movie. My list included the following:

Upon arriving at Camp Pickett for my first day, my NCO, whom I had just met, advised me that one of my men was AWOL (away without leave). He had hitchhiked to his parent's home near Boston, Massachusetts, far beyond the approved distance from Camp Pickett for a

three-day pass. And, the NCO assured me it was OK; the corporal had telephoned and was hitchhiking back. He added "this happens with him all the time." It was hard but I "listened and responded" as my NCO recommended that time. But, I made sure it was understood that there would be no "next time." Lesson learned: Seek and listen to those who have "been there and done that." The wisdom in their advice has been honed by "meaningful" experience. It is almost never productive to repeat the same errors and mistakes of others that preceded you.

I received a call from Ft. Lee's Military Police on the Sunday evening of my second week at Camp Pickett. They had located my "stolen" jeep (which I did not know was missing). It had rolled over, was in a highway ditch halfway between Ft. Lee and Virginia Beach, Virginia, and the two men apprehended were from my parent unit, GETA, but not under my command, "whew." That was not my last incident with a jeep being taken for an unauthorized "drive." A few months before I was discharged I received a call at 6 am on a Sunday morning from the Camp Pickett military police. Our jeep had just been found rolled over in a ditch on an on-site road. They had not found the driver yet. Eight hours later the "missing" driver showed up with no visible injuries. There were no witnesses. The road was nowhere near our barracks or test site facilities. We suspected he had been drinking and went on a "joy-ride" to celebrate his up-coming discharge from the Army. He said he was alone, had swerved to miss a deer, was thrown out of the jeep, became disoriented and slept in the woods. He maintained that he had not been drinking and that he had been on his way to fill the jeep with fuel. His punishment was swift and decisive: demotion to the lowest rank and reimburse the government for the cost of the jeep before being discharged. Lessons learned: Sometimes, things just happen even though the proper safeguards are in place. Learn from the situation, share your expectations with your employees and make the consequences of not complying significant.

About four months after arriving at Camp Pickett, I was informed by my NCO that one of our enlisted men had revealed he had fathered the unborn child of three currently pregnant women, which included a member of Ft. Lee's military police. No marriage was planned. And his family was in the process of "compensating" the women. Fortunately for me, our unit's Company Commander dealt with the situation and the "father" did not return to our work group. Lesson learned: Never be surprised by what an employee may have done or be doing. Do not try to resolve the situation by yourself. Quickly seek and consult with other "interested" parties, professional and institutional services that may be able to help address and resolve the situation. It is a certainty that they are better trained to help.

Once in a while one of my enlisted men would remain at Ft. Lee for the day because of appointments, medical services, or sickness. When he returned to our Company's barracks or if a "recovery" had occurred an officer and/or NCO often assigned him a "task" for the rest of the day. One snowy afternoon that first winter my NCO received a call from Ft. Lee that one of our "sick" men earlier that day been directed by the Company Commander to "sweep the snow off the sidewalks" in front of the barracks. Unfortunately, no specific directions about what to sweep with had been given. Instead of using a broom and snow shovel the specialist obtained a jeep from the motor pool and had driven it up and down the sidewalks at sufficient speed to "remove the snow." This also resulted in severe trenching of the wet ground next to the sidewalks. Punishment for this incident had yet to be determined. Lesson learned: Before issuing always consider how "instructions and directions" may be interpreted. Are they rational, clear and complete? And, always mentally review at least twice before speaking, or with today's computer electronics gadgets hitting the "send" key.

Midmorning on a sunny, hot June day as we were about to leave for Camp Pickett one of my Ft. Lee men arrived at the van wearing a uniform that included 1930s khaki shorts, something I had only seen in old black and white movies. His unorthodox appearance caused a lot of "cat-calling" by my other riders. Firmly gripping the U.S. Army regulations manual he proudly told me that his diligent research had verified that the clothing he wore, which he had found in a local Army surplus store was still regulation. I looked at his manual, agreed, and we proceeded to Camp Pickett. My NCOs believed that that uniform was last worn "publically" in the 1950s. The serious sunburns he received that day put a stop to his "fun." Lesson learned: There will always be an employee trying to "use or beat the system;" therefore, try to understand where he is coming from, assess the objective of the rule(s) he is challenging, offer options and then make your decision.

Unfortunately for me, it was not until I had been there five months that I was assigned someone that had grown up on a farm, like me, or worked in the construction industry, a basic skill set that was really needed. Often I provided the hands-on training. We learned and grew together. We had obtained a small farm tractor with a ditch digging chain attachment but I was the only person in my work unit that had experience operating a tractor with hydraulic equipment. I had some success in my attempts at training operators. But, I did not "trust" them to be safe operators or have the best "interests" of the tractor in mind. In addition, we were behind on our ditch digging schedule. My prayers were answered when our next replacement, the young man that grew up on a farm, arrived. His paperwork indicated he had the tractor experience I was looking for. He had served a year in Vietnam and was returning from a 30 day leave. Imagine my shock when he immediately asked me to approve another 30 day leave request because it was "sheep time on his dad's Oregon farm." After some internal turmoil

about priorities I approved the leave and when he returned his performance including being the tractor operator was outstanding. Lesson learned: Listen to your employees and look for the greater good when making decisions.

Early July 1968 an enlisted man who was performing all of our administrative functions requested a 10 day pass so he could compete in the mixed pair's competition at the National Roller Skating Championship in Cleveland, Ohio. Many thoughts came to mind. I had no idea he roller-skated. It was a competition I had never heard of, and I had no idea how and when he had trained with his female partner. Plus, his backup for the task at the facility was really "green." It was an event he desperately wanted to attend. I reluctantly approved his request. Again when he returned, he was a model worker for the remainder of his tour. Lesson learned: Employees do have outside interests, some may be quite unusual. Find ways to openly become aware of their major outside interests. Trust, but verify and find ways to support their interests that are mutually compatible with their duties and your organizations needs. And, always have a backup trained to perform critical jobs.

One morning upon a late arrival to the worksite I was informed that earlier that morning at the work-site my recently assigned new on-site NCO had with one punch knocked unconscious one of our enlisted men. I was assured that the PFC was physically OK and resting in his bunk at the barracks. The PFC for weeks had been badgering the staff sergeant, challenging his story about formerly being the Army's middle weight boxing champion while serving in Europe. The PFC wanted to box with the NCO. I had heard some of the PFC's pestering but never expected this to happen. After talking with the combatants and observers and verifying the PFC did not need medical attention, I had a short, factual discussion about behavior expectations and consequences with my NCOs and test team, then dropped the matter. The

altercation had occurred during off-duty hours, was a "family" matter and no further badgering or retaliatory events occurred. Internally, I felt the PFC deserved what he received. Lesson learned: Obtain as much information as possible in the time available before taking actions. How to obtain and when to trust the information provided was learned later in my career. My rule of thumb was that the first story about an incident must be provided to the work unit leader immediately and that leader share a heads-up advisory with technical and facility management as soon as possible and recognize that the story will almost always provide just one "view" of the event (first story facts are usually 50 percent correct). As more "investigators" are involved and information is verified the work unit leader will receive the second story about the incident. It will include basic information from the participants and direct observers (facts will be improved usually to be 70 percent correct). Again provide a status to management of the current situation. Wait before taking final action, if possible for the third story which will have supporting details (facts in the third story are usually 90 percent correct). Early actions may be required to "safe" the situation but always keep management aware of what is happening. When possible, let the involved parties sort "things" out themselves.

On a Monday morning in late March 1969, I received a telephone call from the Deputy Commander of Quantico Marine Base in Quantico, Virginia. He asked: Where his daughter was and identified her as a student at a girl's college near Camp Pickett? I was stunned and flabbergasted by the question. He told me she was last seen with one of my men on Friday evening. Saying he was not happy is a total understatement and he let me know as only a Marine can what he thought of the situation and what I should immediately do about it. After I hung up one of my NCOs informed me that one of our Specialists was late reporting for duty that morning. I immediately called the College and they told me the girl had just returned to school.

I strongly recommended they have the girl immediately call her father. We questioned or I should say interrogated the Specialist and discovered that he had borrowed some "camping equipment" (sleeping bags, blankets, tent, etc.) from our storage hut and the two of them had spent the weekend in the "woods" and Sunday night in his barracks room. I discovered this was not his first time and that on prior occasions others in the work group had "borrowed" items from the hut for weekend camping and "adventures." I immediately imposed security changes for the hut containing our "camping" equipment and administered "appropriate" punishment. We also suggested the specialist not see this girl again unless he wanted to meet a "mad Marine." Lesson learned: Safeguarding government property is not easy especially when "the foxes are in charge of the henhouse." Published policies and posted procedures are not sufficient. Employees must feel and believe they are personally responsible for the safekeeping and appropriate use of government property.

Camp Pickett's civilian staff and the many closed, boarded up pre-WWII constructed wooden structures were our best "alternate" resource for obtaining hard to find supplies and timely services. Many times we bartered one or more cases of C-rations for roadwork, specialized shop-work, construction or removal of small wood bridges, concertina wire, etc. The NCOs made sure we never ran low on our supply of C-rations cases.

First of three bartering stories: Early one morning my tractor driver as he began a turn failed to hydraulically lift the ditch digging device out of the ground. The I-beam holding the digging chain bent and now had a banana shape. We removed the I-beam. It would take a week or more to obtain a replacement beam. In desperation I asked a member of the Camp maintenance shop's civilian staff to drive a military tank being serviced over the beam to straighten the beam. Using the concrete floor to support the beam I guided him up onto the

beam. Unfortunately, the first pass overachieved. We had reversed the beam's banana shape. I turned the beam over for the second pass. This time we were successful. They received their case of C-rations and we had lost only a morning of work.

Second bartering story: I was aware but never asked my NCOs about their "bartering" activities. I also did not pry into their infrequent use of "mid-night requisition" for "parts" to repair and maintain our barracks which I suspected were obtained from remote, empty barracks that had been unused for decades. An especially vivid memory was the action by one of our test subjects that required replacement of our barrack's six outer doors. This individual arrived from Dugway Proving Grounds [Dugway, Utah] with strong indications of drug usage. My senior NCO did not believe this solder could safely perform the actions required on our test courses and told him stay at our barracks for the day. His only task was to insure there was hot water for showers late that afternoon. For some reason he decided he needed "more" kindling wood to heat up the coal in the hot water heater. Using a fire axe he "chopped up" and burned parts of each of our barrack's doors. When we returned to the barracks at 4 pm we did not recognize our barracks because of the gaping holes in the doors. Needless to say, he was immediately disciplined and sent back to Utah. As my van left for Ft. Lee, my NCOs told me not to worry about the doors. "Midnight requisition" would take care of it. When I arrived the next morning there was a full set of "new" white doors on the barracks. And I did not ask how this was achieved.

Third bartering story: As I was preparing to transfer hand receipts for the equipment at the work-site to my replacement 2 of our 6 stop watches were discovered to be missing. The NCOs quickly replaced them "with anything that looked like stop watches" to pass an internal audit being performed later that week. The following week we found the missing watches.

Again, I did not question them about how the substitutes were obtained or missing watches returned.

Lessons learned: Look for the "simple" and sometimes "innovative" solutions. Go ahead and ask about availability of existing and "non-conventional" resources. Having "clever" people working for you can be good and bad, be ever watchful and maintain awareness. Bartering can be an effective means for problem resolution. An employee on drugs is bad news, address the situation quickly.

The following are a couple safety related events that really shook me:

One evening at home I received a telephone call that one of my men had been admitted to the hospital at Ft. Lee. He had parked our van next to our Company's mess hall at Ft. Lee and locked it with the keys still in the van. In an attempt to recover the keys he used his fist to break a side window, cutting several of the tendons attached to his right thumb. He was my basketball player, who upon being discharged in 2 weeks was set to attend training camp for the Atlanta Hawks. It was a life-changing decision for him.

A rare day was my going to lunch at the Camp Pickett Officer's Club. A couple months before I was discharged I decided to treat myself to a real lunch in the Officer's Club dining hall. As I was about to take my first bite, my senior NCO approached my table. He told me that one of our specialists had been run over by our small tractor while attempting to attach to a farm disk. The Specialist had volunteered to drive the tractor and disk to "cut down the weeds in the administrative area" during the noon break. As he mounted the tractor his foot slipped, he inadvertently engaged the clutch as he fell to the ground. As the tractor moved slowly forward, a rear tire crushed his right collarbone and arm socket. Fortunately, he had not completed the connection to the disk. After a lengthy period of physical therapy he was determined to have a

40 percent disability. He had had the appropriate training and was an experienced operator of the tractor. I never ate lunch at that Officer's Club again.

Needless to say, I was truly amazed at some of the enlisted men's lack good judgment in dealing with life's day-to-day decisions. Because of my rank and position I controlled much of their lives (e.g. when the got up; what they wore; when, where and what they ate; when they got time off; and what they did while they were at the work place). However, dispensing punishment in most cases was the responsibility of our Company Commander. For many individuals the Army was their "parent." And growing up in the Army with all the distractions available to 18 year olds was a challenge. Some required a full-time babysitter because they displayed little or no feeling of responsibility or accountability for their decisions. Too often the Army ignored or condoned the misbehavior or overreacted making the individual's life truly miserable. I am truly pleased to say that during my 33 years at JSC I saw very little behavior of a similar nature or displays of immaturity by the men and women of NASA and its support contractors.

My active duty service in the Army was truly eye-opening, a real growth and maturing experience. Unfortunately, it was a very difficult two years for my wife. She basically vegetated because no company in the local area would hire her for technical work. They assumed that she would be at best a temporary employee because when I received Orders to Vietnam that she like other spouses would not stay in the Ft. Lee area, which was probably true. And she was considered over qualified for the few other jobs being advertised. While for me, I would have much preferred to have been assigned to NASA's MSC during those two years, but that did not happen. I do not know of any other work environment where I would have seen or learned more about what influences the behavior of people, how to motivate people, and how dependent some

people can be on others to make decisions for them. I believe that having this experience made me a better leader and manager during my career at JSC.

Hired by NASA's Manned Spacecraft Center

Summer of 1968, I began my third search for a full-time job in the "real world." I would be available immediately upon being discharged May 1969. My preferred career plan was to work for NASA MSC on environmental control and life support systems associated with human space vehicles. Being cautious I first contacted Dr. Nevins about pursuing a Doctorate in Mechanical Engineering and working for the ERI. He was now the Dean of Engineering at Kansas State University. This was my "backup plan" if I received no job offers that I liked. Dr. Nevins again immediately offered to help. In the academic world it is considered better to have obtained your second graduate degree from an academic institution other than where you received your prior degree(s). He strongly encouraged me to consider Yale University because of the John B. Pierce Laboratory, a research institute that had a strong association with ASHRAE's research. He contacted their graduate school and the Pierce Laboratory and invited us to visit the university during an ASHRAE committee meeting that he would be attending that August in New Haven, CT. Combining the visit with a short New England vacation, Suzanne and I toured the Yale campus and close-by residential areas. Great campus, but we were not impressed with the surrounding urban environment. Later, I received an offer for admission to the Yale Graduate School for full-time study in the Department of Epidemiology and Public Health on March 28, 1969. I liked the thought of having a Doctorate degree. But living on Yale's offer of a U.S. Public Health Service Traineeship that provided a tax free stipend of $2,900 a year and covered tuition meant we would continue to be "dirt" poor for at least five more years unless Suzanne was able to find a suitable job. And, we were ready to start our

family. I decided I would decline Yale's offer if I received an acceptable offer from NASA or industry. But would I receive such an offer?

Early February 1969 I received the standard letter and one-on-one recruitment talk from the commanding officer of GETA about making military service my career. I knew that if I re-upped it would be the Army's choice as to when I could return to civilian life, not a good deal for me. I would be on the next list for reassignment, probably to Vietnam which was a place where I did not want to be. I was not excited about continuing to be a First Lieutenant earning $588.60 per month. Plus the Defense Department had just extended the time-in-grade requirement for promotion eligibility of all officer ranks which meant I would not be eligible for rank of Captain for another six months. Because of graduate school I was already one of the older 1st Lieutenants on active duty. I had zero interest in staying in the military, but was much more diplomatic with my written response to the GETA commander, Colonel Church.

In November (6 months before my discharge), I sent letters of interest in full time employment to 34 companies that were either in aerospace or involved in engineering activities that appealed to me. Many were companies I had contacted during my previous job hunts. Almost all immediately responded requesting I submit an application. But it was unsettling that many requested I delay mailing until 30 to 45 days before my military separation date. I did not want to wait.

I had maintained contact with NASA's Wil Ellis and Walt Guy by letter and telephone throughout my two years on active military duty. On December 18, 1968, I submitted my Standard Form 171 application for NASA employment. At that time Wil told me their Branch had an open position requiring the skills that I possessed. The division would soon submit

paperwork for securing approval to make me an offer but currently MSC was not hiring. Walt and he hoped to hear good news soon. But I should have a backup plan, just in case.

I began to have a real concern about having employment options to choose between. In late December 1968, I decided to enlist the aid of a professional recruiting organization, Lendman Associates, that specialized in placement of junior military officers. They coordinated and facilitated career weekend interviews. I attended one career weekend, held late February in a Washington DC hotel. None of the 20 companies participating were in the aerospace or space business and very few were looking for engineers. I had four uninteresting interviews. My more focused interests were not a good fit with the placement services of Lendman.

Between February 18 and April 14, I received five employment offers, but not from NASA's Manned Spacecraft Center, the one I wanted most. Two (Westinghouse Electric and Whirlpool) were non-aerospace positions while the other three (LTV Aerospace, McDonnell Douglas Astronautics and Boeing Aerospace) were for an aerospace/life support position. The salary offers ranged between $11,100 and $13,000 per year, quite a jump from my graduate student and Army pay.

Early January Walt and Wil submitted their request for my appointment to a position in Crew Systems Division. As the months and weeks drew closer to my separation date they continued to assure me of their interest. Early April I was told that although NASA's MSC was "not hiring at that moment" and "billets were hard to come by" within the Engineering and Development organization, I had been selected through a competitive process to be the Division's next hire. I should be receiving a verbal followed by a written offer "soon."

On April 15 I sent letters declining offers to all but McDonnell Douglas whom I called for a two week extension and explained that I was waiting to hear from NASA.

Finally on April 20, two weeks before my discharge, I received the verbal offer from Mona Kazmierski, staffing specialist in NASA MSC's Personnel Office. I immediately accepted. If I had not received NASA's offer I would have accepted McDonnell-Douglas Astronautics offer to work on the Air Force's MOL (Manned Orbiting Laboratory) Program. What a disaster that would have been. Because less than four months later, on August 9, 1969, the Department of Defense cancelled the MOL Program. I would have again been on the street looking for a job, any job. What really sealed the deal was that NASA's offer was for a GS-11 position with an annual salary of $11,563 that was expected to increase soon and did to $12,729 on July 27, 1969, making it fully competitive with industry.

Walt and Wil had used my graduate degree, my college graduate level teaching and MSC work experiences in a critically needed technical skill area and their personal knowledge of my abilities and potential seen during the Summer Intern Program to qualify me for the GS-11 position. According to Wil, my soon to be supervisor, I was being hired to work on space station design and analysis activities for the Thermal Systems Section of the Environmental Control Systems Branch. The position called for an engineering specialist responsible for performing configuration analyses and conceptual design of environmental/thermal control and life support systems. In addition, I would perform independent studies and monitor various contractors' designs of regenerative systems for environmental control and life support systems on various space station designs. And that is the work I did during my early years at JSC.

WRIGHT: This was in May of '69 when you came back?

JAAX: Yes, I reported in at Ellington Field and signed an excepted appointment form for the period of May 26 to June 30, 1969. And, as assured by Wil and Walt I was converted to a career conditional appointment on July 1, 1969, which made me eligible for government employee benefits.

Early NASA Work Assignments

One of my first assignments was to design a regenerative environmental thermal control and life support system (ETC/LSS) for an in-house study led by Engineering and Development's Spacecraft Design Office. The study's objective was to provide a conceptual design for a 60 to 90 man Space Base orbiting in low Earth orbit. The Base had 100 kW of nuclear power and artificial gravity requirements that seemed to be out of a science fiction novel. The design team had already chosen to use the Saturn V as the launch booster; on top was a Saturn IV derived twenty two foot diameter living module that would be assembled in space with five other twenty two foot diameter modules to form the Space Base.

Wil told me: "This is an in-house, conceptual design study, expected to be completed in early September. You will prepare and present your requirements and the resulting design for the regenerative ETC/LSS as part of the study team's final briefing." You will be briefing [Maxime A.] Max Faget, Director of Engineering and Development and his senior managers in the Building 30 auditorium. I then learned that the study had been underway for 9 months; I had 2 months to create and flesh out a design and produce a technical briefing. Fortunately, ETC/LSS technology had not changed much during the two years I was in the service. The biggest challenges were acquiring "tip of the tongue" familiarity with ETC/LSS "jargon" and an in-depth understanding of ongoing analytical studies, research and development activities and their test results. The Center's study team met several times each week. Those meeting

provided me frequent insight into the design options, performance capabilities and integration opportunities available with other spacecraft systems for long duration missions in a space base and space station.

My solution was a modular 12-man regenerative ETC/LSS system housed in each of the Base's habitable structural modules. I completed my design using much of the component design information available in documentation from an on-going study contract titled "Basic Subsystem Module Environmental Control/Life Support System" that the Division had awarded in 1967 to Hamilton Standard and was later completed in 1971.

Three months later the big day arrived and I was on stage in front of the world's foremost experts on human space vehicle design. That was the only time I rehearsed at home, out-loud, in front of my wife a full technical presentation, trying desperately not to just read the words on the charts. I rehearsed the presentation many times. Wil Ellis had really helped to make sure the appropriate content was on the charts. But I would still be saying a lot of technical words that I felt I could not fully explain. Also, this was back when you delivered your material to the Center's graphics folks several weeks ahead of the presentation date to allow them time to prepare the final charts from your handwritten "one-liner bullets," notes and sketches; there were no computers or word processors to cut and paste graphics or build an integrated presentation.

During the briefing I was able to describe the driving design requirements and processes selected for recovering drinking water from urine and sweat, recycling wash and shower water, and recovering breathable oxygen from the CO_2 the crew would breathe out. The briefing went fine and I was able to answer all the questions, with a little help from Wil. One of the study's recommendations, obvious from the beginning was that a vehicle (space station) with a much smaller crew size such as 12 men should be our focus for our next step toward achieving

permanent presence in space. A product of this activity was a 1/10th scale model of a 22 foot diameter living module outfitted with "doll house furniture" for "show and tell," constructed by North American-Rockwell, that is still at JSC in Building 7A. I know this because in 1974 I took the module home to prevent destruction of the model as planned by one of our division managers. I returned it to Building 7A in 1987.

Apollo Lunar Landing Missions

Few opportunities for directly supporting the Apollo Program's lunar missions were made available to me. Much of my involvement was in short term support working special analysis problems or being an extra "body" for real-time mission support in Building 45 where Engineering's Mission Evaluation Room was located. On July 20th two months after I joined NASA Apollo 11 landed on the Moon. I watched the landing and EVA [Extravehicular Activity] at home with my wife on our black and white television. Like many others I took black and white photographs of the television screen. None of my photographs were very good. One of my work section's responsibilities was preflight predictions and real-time consumable and thermal analyses of the Space Suit Extravehicular Mobility Units providing life support and cooling for the suited crewman. On later Apollo missions I was sometimes assigned a shift in the Mission Evaluation Room as backup support for my section's tasks during the Lunar EVAs. Our assigned area was a small room next to the MER bullpen area that had a black and white television on a table against one wall and several television monitors for monitoring flight data from Apollo. The seats were filled with my co-workers. As a "relief worker" I hand copied real-time down-link data from a monitor screen onto a form and ran data sheets back and forth to the guys in the EVA Analysis Group. Being a "data runner" was a great experience but because I had been with NASA only a short period of time, I shared, but more as an observer, the

overwhelming sense of accomplishment felt by my co-workers. I believed that landing on the Moon was what NASA did and was proud to be a part of it. But it was not until I gained hands-on experience I fully appreciated the uniqueness and inspiring work performed by NASA.

In-House Modular Space Station Studies

While I was working on the Space Base, another in-house team had been studying reusable launch and landing vehicle concepts (ala Space Shuttle). Momentum was building for NASA's next human spacecraft to be a reusable vehicle that would serve as a "truck" carrying "large payloads" to and from low Earth orbit. MSC managers had coordinated the two in-house studies so that the Space Base study's concept for a modular design would be based on the 15 foot diameter, 60 foot long cargo capability of the Space Shuttle concept. Following the September 1969 status review the Space Base study team conducted a two month conceptual design assessment of modular space station concepts. The result was the 12 man modular space station design, which some of us affectionately described as the Tinker Toy design. The reduction in total crew size requirement to the building block crew size of our ECLSS made my job relatively easy. By the way some of the features and processes in the 1969 design have been included or are being evaluated on the International Space Station (ISS).

The recommended configuration for the Modular Space Station was a long central core with 4 sets of opposing modules in 2 parallel rows docked to 2 sections of core modules. Each of the 10 modules was sized to take full advantage of the cargo bay's 15 foot diameter and 60 foot length. Our quick look at this configuration verified that there would be sufficient habitable volume for the permanent residence of a crew of 12 and the other systems a station required. I prepared a 12 man and a 6 man ETC/LSS conceptual design. As we developed cost, power, weight, volume, and number of assembly flights estimates the beauty of a six crew Modular

Space Station came into focus. This was the stopping point for our study team. Phase B study contracts for two prime contractors to provide preliminary designs for both a re-useable Shuttle and a 12-man space station had already been released. NASA MSC would provide technical management oversight of one of the two Shuttle studies and one of the two Space Station studies. October 14, 1969, CSD informed E&D that I was the division contact for ETC/LSS for Space Station/Base studies. November 12, 1969, the Manned Spacecraft Center released the "Key Personnel in Support of the NASA In-house and MSC Contractual Space Station Program Definition (Phase B) and Supporting Effort." In this document I was identified as being the member of Crew Systems Division assigned Division Representative/Manager for Environmental Control/Atmospheric Generation for both Space Station/Base and Space Shuttle. And, at this same time a joint mission with the Russians was being considered which would also draw on Engineering's talent not committed to the Apollo Program or the Phase B studies.

This was the beginning of a number of "additional duties" assignments for me.

NASA Technology Plans for EC/LSS

November 1969, just five months into my NASA career I was assigned the task of creating the ETC/LSS section of NASA Headquarters first advanced technology plan, the Space Station/Space Base Technology/Requirements Planning Document. Quickly added to the task was preparation for NASA Headquarters of the ETC/LSS section for the "Space Station Technology Program Plan," the roadmap for developing technologies needed for Space Stations. Crew Systems Division was the Agency's lead for almost all aspects of environmental control systems for human spacecraft; therefore, they were assigned document preparation responsibility which included providing a fair and unbiased assessment and integration of each NASA Center's input. Being the latest hired I was "available" and "willing volunteered" to take on this

responsibility. This opportunity enabled me to see, familiarize and evaluate each NASA Center's ongoing advanced ETC/LSS technology projects, assess progress being made and identify critical areas for funding based on the needs identified by the current (late 1960s) long duration human mission studies. I enjoyed the "education" opportunity but if I had had today's computer capabilities this task would have been a lot easier.

Phase B Space Station Studies

July 1969 NASA awarded two independent Phase B study contracts, one to North American Rockwell and the other to McDonnell Douglas. The 9 months studies were for the preliminary design of a 12-man Earth orbital space station that would begin on-orbit assembly by 1975 for a 10 year mission. It would replace the 3-man Skylab I vehicle launched in 1973. JSC's engineering staff was directed to monitor North America Rockwell, and Marshall Space Flight Center [Huntsville, Alabama] monitored McDonnell Douglas. Independent meant that there would be no exchange or sharing of any contractor design information between the two contractor/NASA monitor teams for the duration of the studies. MSC's in-house pre-Phase A study of a six man Shuttle Launched Space Station that I had supported was presented that fall to NASA Headquarters management and both space station contractor's teams. It included the six man advanced ETC/LSS configuration with regenerative life support technologies I had formulated. Both prime contractors had reviewed and evaluated our in-house ETC/LSS conceptual design during their Phase A study. The functions, selected systems and preliminary schematics described in both Phase B contractor proposals were very similar to the ETC/LSS configuration described in our in-house study. We were all on the same page.

October 1969 I was assigned division representative for ECLSS on MSC's technical team monitoring and evaluating NAR's (North American Rockwell) Phase B Space Station Definition

contract. My responsibility was to ensure the requirements for the ETC/LSS design imposed and that evolved during the contractor's preliminary design activity were consistent with and integrated into CSD's requirements for long duration human occupation of space vehicles. As the Agency's ETC/LSS lead the Division wanted to ensure that the many on-going research and technology contracts and the integrated system hardware contract were as compatible as possible with the requirements being derived by the Phase B contractor's Space Station studies. If an inconsistency existed or was being considered, I was to assess the information available (technical and "political"), inform the Division (including providing a recommendation) and provide "feedback" to my contractor interface. That sometimes included finding ways to help my contractor interface be successful with his design, development, and testing recommendations to his management as the vehicle's preliminary design matured. I also had to ensure that no design information was exchanged between the two prime contractors.

Working with the Prime Contractor

I have always felt fortunate that George Laubach, lead for NAR's ECLSS team, was my first prime contractor interface. He was an Apollo CSM ECS veteran, who worked primarily on the Active Thermal Control System. I quickly found that he had limited technical knowledge of the regenerative life support system technologies that would enable Station to be continuously crewed in Earth orbit for 10 years. Fortunately, NAR had teamed with Hamilton Standard to be the prime subcontractor for the ETC/LSS portion of the station preliminary design activity. The baseline they established for the Phase B study was essentially our MSC ETC/LSS design with minor modifications. From the beginning George accepted my role, listened to my questions and suggestions and openly shared his opinions with me. He could have made our relationship difficult by adopting an, "I'm busy, I'll talk with you later," attitude; thankfully, he almost

always immediately took my telephone calls, was quick to respond, listened attentively, viewed my representation of "NASA's concerns" positively and believed that we (NASA) were actually there to help him. George did not adopt a dog from the dog pound and name it "NASA" so he could kick something in the evenings as another contractor we worked with often jokingly said he did. We quickly developed a mutual respect and friendship.

For my part I tried to respect his time by establishing and maintaining a set telephone contact plan, keeping our conversations relevant to the design activities and ensuring he was aware of our issues and concerns before his management was aware. It was a pleasure to work with a person willing to find good, compatible technical solutions and positions that often required compromises by both of us. I assumed he had the same respect and good working relationship with his subordinates and subcontractors, but I also was aware that he had a tougher persona too. He and I would work together again during the Space Shuttle Program (SSP) where he was Orbiter's Active Thermal Control System lead during the design, development, test, and early flights.

Some Observations of Phase B Study Processes

This was my first experience with Phase B definition studies. I quickly learned that the contractor's engineering design team had a hi-fidelity conceptual design that provided a reasonably mature definition of the vehicle and its major features; but to produce a preliminary design required a significant amount of additional engineering design and analysis effort. My contractor technical interface and I reviewed the ETC/LSS design requirements, major design products to be produced, relevant technical issues to be addressed and resources planned to be used during the conduct of the study. For some tasks I found that EC had better analytical tools available. I developed and used the available analytical resources and capabilities within my

branch to perform quick assessments as a "check" of the contractor's study results. As designs of the systems in the vehicle were maturing an equally difficult task was integrating them together and packaging them within the constraints of the vehicle's structural design envelope. The resulting integrated design had to also comply with increasingly challenging weight, cost and schedule constraints and limits in an "ever changing" requirements environment. An observation was that new and revised requirements often appeared "out of the blue" and were frequently sponsored by someone within NASA wanting to make something good, better. And that some change(s) had not been fully vetted at the review boards before being approved resulting in conflicting requirements that compromised the integrity and required rework of the ECLSS design. I also learned that from the design engineer's point-of-view there were never enough analyses or breadboard/concept development testing conducted prior to or during the preliminary design phase. My observation was that the Phase B study produced a reasonably mature paper design when derived from analytical studies supported by limited testing. What enhanced the credibility of the contractor's design was providing evidence of completed work on critical design features and key technologies especially having proof of concept or breadboard hardware produced and tested. Through use of whatever resources were available the contractor was expected to have sufficient design maturity to have approximately 10 per cent of the final design's drawings completed at the time they entered the Phase C/D (Final Design/Production).

Space Station Prototype ETC/LSS

December 1969, NASA through MSC's Crew Systems Division (CSD) awarded a contract to Hamilton Standard Division of United Technologies titled, "Space Station Prototype (SSP) Environmental and Thermal Control/Life Support System." This contract called for the design, fabrication, and testing of a fully integrated ETC/LSS systems technology base

comprised of prototype hardware capable of being operational for a two-year to ten-year Earth orbital mission. The SSP ETC/LSS would be housed and maintainable within one of the 15 ft diameter by 45 ft long modules for an early 1970's concept of a Shuttle launched modular space station.

We were really pushing for use of regenerative life support technology back then. We didn't know it but we were more than thirty years ahead of NASA's flying and testing these technologies on ISS. Today, hardware based on the SSP technologies for recovering potable water from urine and wash water and recovering breathing oxygen from human exhaled carbon dioxide are operating on the International Space Station. I truly believe that if we had been given the opportunity we could have had most, if not all of the SSP ETC/LSS subsystems up and operating in low Earth orbit by the late 1970s. The final report for SSP's contract was submitted to NASA in October 1973.

The SSP design integrated together the best of NASA and CSD's regenerative ETC/LSS technologies. Operational hardware for almost all of the subsystems in the baselined system were built, installed in racks for demonstrating station volume packaging, accessibility of replaceable hardware, maintainability of the subsystems and tested at the subsystem level in CSD's ECLSS development laboratories. Unfortunately, funding was not provided to complete the integrated system test program. Completion of the buildup and planned integrated systems unmanned and manned testing in JSC's 20 foot diameter vacuum chamber would have demonstrated that regenerative ETC/LSS technologies had achieved the maturity needed to be competitively considered by NASA's Program Managers as the baseline for Space Station Program studies after the mid 1970s.

Mobile Quarantine Facility as Crew Quarters for SSP Manned Testing

Mid summer of 1972 I participated in a quick look study of an alternative to using Building 7's 20 foot chamber for SSP manned testing. We assessed the heating, air conditioning, ventilation, and plumbing reconfiguration required for using the Apollo Program's Mobile Quarantine Facility (MQF) as the crew quarters during a proposed 6 man, 60 day test of the closed cycle SSP in the high bay area of Building 32 at MSC. This study was my only opportunity to be in the MQF and allowed me to become familiar with the heating, air conditioning, and ventilation design selected by the providers of the MQF for quarantine of Apollo lunar crewmen returning to Earth. The study determined that the schedule and cost impact for modifying a MQF exceeded the SSP's resource limits.

My SSP project assignments included being the ECLSS design requirements provider/monitor and integrated ETC/LSS system analysis manager. The products of these activities were also provided to all related on-going CSD technology projects. Specific responsibilities included monitoring and assessing the on-going Phase B Space Station study managed by MSC for vehicle level ETC/LSS design drivers, converting those drivers into measureable ETC/LSS requirements, and being the advocate for their acceptance by SSP; and providing system engineering and analysis of the SSP's integrated system. I made available to the prime contractor ETC/LSS team the "design and sizing" products as they were produced by the SSP Program. The prime's team assessed then tweaked the Phase B study's ETC/LSS design to reflect critical SSP findings.

The two independent Phase B Space Station studies were completed in May 1970. A NASA-only team composed of MSC and MSFC [Marshall Space Flight Center, Huntsville, Alabama] members was immediately established to conduct a comparative assessment of the

technical designs produced by the two contractors. I was co-chairman of the team's ECLSS sub-panel. We reported our findings on July 31, 1970.

Identifying and Communicating Requirements

As part of my monitoring responsibility I observed the prime contractor's treatment of guidelines and requirements, then identified which issues and compromises were driving ETC/LSS and vehicle design decisions including the latest NASA approved changes to flight program requirements. I reviewed and assessed my findings for appropriateness as requirements and constraints for ETC/LSS and then prepared the documentation that provided technical direction to ensure the candidate requirements were integrated with the ongoing SSP and prime contractor design activities. This was done so that SSP, Phase B space station and CSD's technologies were all maturing at the same time under the "same" requirements and constraints. One of the ways I achieved this was by writing and distributing within CSD a weekly "Phase B Space Station ETC/LSS Status Report." In addition, monthly I presented a 15 to 30-minute status with Q & A (Question and Answer) of the Phase B Space Station Activity (focused on ETC/LSS). This was held at noontime in CSD's Building 7A Auditorium and was open to "cleared" members of CSD. It was like today's "brown bag" discussions. I was pleasantly surprised at the continued large attendance and interest shown by CSD and the few other organizations at MSC allowed to attend based on "need to know" and confidentiality requirements.

Additionally, throughout this five year period I collected and maintained in a file every requirement that I believed may affect the design and operation of ECLSS on long-duration space missions. When I could not find documented requirements for an issue or design feature I created a requirement based on the best information available to me. I used this collected

information to author a "living" internal document (CSD-SS-009, MSC 01484) titled "Preliminary Space Station Design Requirements for Environmental Thermal Control and Life Support System Equipment." It was my personal reference document used to keep CSD's internal studies, ETC/LSS subsystems technology developers and prototype system development activity with Hamilton Standard and MSC's Phase B Station contractor on the same requirements pages.

Summer 1970 with the Phase B station studies completed I provided an assessment to MSC's E&D management of the NAR ECLSS design that included concerns with the selections for nitrogen makeup, ECLSS/RCS integration, and waste management system. This assessment and my contributions to the contractor ETC/LSS comparison assessment led to my authoring and presenting in August 1972 an ASME paper (72-ENAv-25) titled, "Design Criteria for the Modular Space Station Environmental Control and Life Support System Selection." Described in the paper were the ECLSS guidelines and requirements given to both contractors and a side by side comparison of the hardware or process for ECLSS functions selected for their preliminary designs.

Writing technical papers was becoming a habit. I believe it (writing in my own words in a logical sequence what I had learned about a technical subject) was my way of formulating and building up areas of expertise. I enjoyed the investigative activity required and it allowed me to scratch the ought-to-publish itch I caught in graduate school. I used this activity to help fill "guidelines and requirements" voids for Space Station functions that interfaced and were supported by ECLSS and EVA hardware. For example, I knew very little about "airlocks" and found little help in the public sector literature. So, I scavenged from whatever resources I could find any pertinent information that could be developed into "common" requirements for multiple

vehicles. I sorted and synthesized them and then authored an internal document (CSD-SS-010, JSC 04634) titled, "Preliminary Requirements for Airlocks on Space Stations," that was approved by CSD for release on February 8, 1972. This document identified the provisions required at the airlock to support: 1) EVA and IVA with suited crew having either portable or umbilical life support capability, and 2) experiment operations performed from an airlock. The document also identified habitability guidelines and hardware interfaces for the airlock to be compatible with Shuttle Orbiter and Russian human spaceflight vehicles known at that time.

Systems Engineering Branch

June 1970 Crew Systems Division reorganized, establishing the Systems Engineering Branch (EC2), led by Walt Guy to provide system engineering support and coordinate program requirements across all of the division's technical products. My section was reassigned to the new Branch and renamed the Environmental and Thermal Systems Section with Wil Ellis as Section Head. That was the first time "Thermal" showed up on a Crew Systems Division organization chart. This was part of our branch chief's strategy to ensure that ownership of the technical discipline, "active thermal control" would not be transferred to Structures and Mechanics Division by the Directorate's Director. It worked. And, I later I became an "expert" on Active Thermal Control Systems. For the next 10 years, I was a member of the Systems Engineering Branch.

Very quickly after I was hired my branch management convinced Division management I was more of an "up-and-out" type person, than "down-and-in." "Up and out" meant you were a spokesperson or a representative to organizations outside the division of what your division does. My interpretation was that division management was comfortable with you representing the technical, schedule, and budgetary aspects of specific Division products; you were trusted to

keep from over committing the Division's resources, and you were capable of producing quality products and information that both the Division and customers felt comfortable about. "Down and in" meant you were more detail-oriented and prefer working within the organization's boundaries. I liked detailed work, some would say I was somewhat anal about it, but I also really enjoyed interacting with engineers in other organizations and seeing the "big picture."

WRIGHT: Well, what an interesting time to come aboard, right at the landmark time period.

JAAX: Oh, it really was, and—well, that first year even included a "job reality check," more commonly known as NASA MSC's first RIF (Reduction in Force) that really shook up my world. I will discuss it later. During the short period in 1966, when I worked for NASA everything was "good." Then late January 1967 the Apollo 1 fire occurred. I was in graduate school, not here to see or feel the shock, sadness, and depression that must have swept over the Center. Nor, was I aware of the personal resolve, work commitment, and family life sacrifices that NASA's civil servants and contractors made to enable the Apollo lunar landing to occur in 1969. So to be employed at JSC in 1969, and see the Eagle (Apollo Lunar Module) land on the Moon was an energizing and breathtaking historical moment. And I had the privilege of witnessing the day-to-day activities and working side-by-side with the people who made it happen. The many NASA teams resolve and perseverance had overcome all obstacles. The people at MSC were very proud, happy, and everything was going very well. We were going to be landing on the Moon about every 6 months for another 3 years.

NASA's First Reduction-in-Force

But, there was a war on-going in Vietnam and a significant anti-war movement. We had beaten the Russians at putting a human on the Moon, but we had not found a compelling reason to immediately explore beyond the Moon. Skylab, which was the follow-on Manned Program, was assigned to NASA Marshall Space Flight Center. Skylab missions would require a staff much smaller than NASA and MSC then had onboard to develop, operate, and support Apollo. Space station and a reuseable Shuttle vehicle had paper designs but there was no commitment by the President or Congress to build either. Therefore, downsizing of the civil servant and contractor staff was expected. Many rumors floated through MSC's halls and offices during the spring and summer of 1970 about a big RIF being announced soon, NASA's first.

No one knew how the RIF process was "really" going to be implemented, what the selection criteria was, how many would be affected, or who was most threatened by this "event." I knew that I was one of the last hired by MSC due to the on-going hiring freeze. And that the seniority criteria of "last in, first out" would be a driver in the RIF selections. To their credit my supervisors "reassured" me they were certain that by being hired for NASA's future programs (ala Space Station), having my unique set of skills and being a military veteran I would not be affected.

What totally blind-sided us were the ramifications of "bumping rights." Bumping allows the person in a position that is being abolished to be moved to a position he formerly held, if he has more days of government service than the current occupant. This trickle-down of bumping rights continues until there is no lower position or person with less service time available to be bumped. Thus a GS-15 could be bumped to a GS-7 position, but it is unlikely that person would accept the "much" lower paid position.

MSC's personnel office did not have the "sophisticated" computer capabilities that we have today. Thus their attempts to use "paper" exercises to see where and who would be impacted were extremely limited. I was told that they were virtually clueless about the possible results of that first RIF.

Late in the morning of August 8, 1970, I received a call to be in CSD's division conference room at 12:30 pm for a meeting with our division chief. I was stunned, felt very insecure, and really did not want to attend this meeting. Everyone at the Center knew that the notification of employees affected by the RIF was imminent and would most likely be done by the division chiefs. And, I had been called. I and approximately 12 other members of the division gathered at the appointed time. I had never been in the division conference room before. And, I must admit, knew less than 5 of the people attending. It was eerily quiet, except for a couple jokes about the gathering of the "condemned." Most had downcast eyes and there was very little eye contact between each other. All expected they were going to be RIFed. The division secretary entered, did a "roll-call," and gave each a letter. Mine was a Letter of Separation informing me that I would be separated from NASA MSC effective September 30, 1970. Some had letters that they had been bumped to a different position. Our Division Chief, [Robert E.] Ed Smylie, briefly talked to us about the process used, our rights, and that the division would be protesting the letters of separation. I walked out and briefly talked with Wil and Walt who reassured me that they would do everything in their power to overturn this decision. I immediately drove home, walked into our apartment to a very surprised Suzanne because I never came home early. She still remembers my dazed and shocked appearance as I entered our apartment. I shared with her what I had been told. Our first child, Bryan, was only 5 months old and in 7 weeks I would not have a job. We did not panic, primarily because Walt

and Wil had given me hope. I do not recall when we shared this news with our parents; it was at least a week later. I continued to go to work and perform my duties but I also looked for every opportunity to bring this situation to a closure that would be "good" for me and my family. It was a very unsettling time.

Being RIFed caused me to again think very seriously about going back to graduate school and changing my career path. I immediately contacted my "safety net," Dr. McNall, my former advisor and Dr. Nevins who was now Dean of the College of Engineering at Kansas State. We discussed several options. Both again encouraged me to get the PhD and if at K-State work in the ERI laboratory. I volunteered to outline a plan that would lead to returning to the ERI. I also advised both that my preference was to ride out the appeal process at MSC. Comforted that I had their support I mentally began preparing myself for being separated from NASA.

The next day my Branch Chief, Walt Guy, took me aside and told me to: "Just hang in there. Don't worry about it. We'll take care of this." He recently shared with me that the Division had that day identified to Center management that the result of this RIF action was unacceptable. At the time I had no idea what magic could be done by CSD with Center management. Each day I waited for something positive. A long, long 2 weeks later on August 24, I was informed that a letter had been submitted by Max Faget (Director of Engineering and Development) to the Center's Associate Director requesting review of personnel classification within the competitive level used to determine RIF action on the four CSD personnel grouped within my competitive level. Again, it was a long, wrenching 2 ½ weeks of waiting when on September 10, I received from Walt Guy a handwritten note containing the following message: "Smylie said that the 'good news' should be official by the end of this week. Hold tight. Secret." I began feeling a lot better. But I was only three weeks from being laid off and my

"eggs were all in one basket." I had not made any inquiries about opportunities for another job in aerospace. I do recall my supervisors telling me that if the appeal was not approved that I should consider working for E&D's Engineering Support Contractor, Lockheed Aircraft Corporation. On September 14, I received the letter "canceling the RIF action for myself and stating that I will remain in my current position" from Jack Lister, MSC Personnel Division Chief. I was a very happy person and greatly appreciative of the many efforts put forth to make my case.

Later I learned that the position eliminated was a technician's position in our division's chemistry laboratory. On the incumbent technician's resume of position descriptions was a job classification that included degreed chemists and engineers. That job classification was an umbrella classification assigned to many of my division's engineers. I was the last hired in; thus, I was the first bumped out. Division and Center management quickly determined that grouping ECS skills into a single job classification was inappropriate and needed to be redone. Center management stopped my RIF action by rescinding the action that eliminated the original position. I know several other engineers who received separation reprieves at the last minute of the first RIF and went on to have significant technical and management careers at JSC, including a former Center Deputy Director, [Brock] Randy Stone.

During the weeks of waiting for NASA to decide my fate, I outlined a plan for Dr. McNall and Dr. Nevins that over a six year period had me leaving MSC, obtaining my Ph D at Yale University, working for a year at the Technical University of Denmark in Copenhagen, and concluded with me becoming a member of the ERI Staff at Kansas State. The Denmark opportunity was due to an invitation by a visiting professor, Dr. Ole Fanger, who during his one year sabbatical worked with me in the ERI while I was in graduate school. When I received the

RIF cancellation letter I informed K-State. I continued corresponding with K-State about specific options in my plan for a couple more months. During that time I again became comfortable that I could have a long career at NASA as new opportunities became available for me. I put my backup plan on the shelf and never opened it again.

For the next several years I exchanged correspondence with Dr. Nevins about my NASA work. At Dean Nevins invitation, on March 31, 1973, I spoke about my work at MSC and experiences working with the Russians on the ASTP (Apollo-Soyuz Test Project) at the KSU Engineering Alumni Symposium held on campus during Engineering Open House. I was on a panel with several "recent" graduates of the College of Engineering that were asked to speak to undergraduates and high school students about our work since graduation. The panel also included mid career and senior career speakers. It was after the presentations during face-to-face discussions with my fellow speakers and audience members that I realized how fortunate and special it was to work and be a part of human spaceflight at NASA. Literally everyone I spoke with began the conversation with "I wish I had your job." This was from men whose working careers ranged from 3 to 40 years that were very successful in their field of work. That feedback reinforced my determination to continue working for MSC. Interestingly, in July 1973 Dr. Nevins left Kansas State to become a fellow at the John B. Pierce Foundation at Yale University, a path I never took. Unfortunately, Dr. Nevins died unexpectedly June 1974.

Rumors began to circulate that there would be another RIF, soon. I continued to feel vulnerable, because of my experience with the first RIF. The second RIF was announced in March 1972, 19 months after the first RIF was announced. This time E&D's work units were better prepared. MSC's Personnel Division had more computer tools with better capability and was much better at "dry running" the impact on each organization's staff based on positions

abolished. At the time of the first RIF, most of CSD's engineers were in two large groups having the same specialty classification, AST [Aerospace Technology] Environmental Control engineers. Within that classification we had a small number of smaller groups comprised of 1 to 10 engineers who were working on different aspects of ECS, e.g. portable life support systems for space suits, atmosphere revitalization subsystems, water and waste management subsystems etc. With Personnel Office's encouragement, CSD's branches and sections further redefined their technical positions placing their technical staffs in much smaller specialized skill groups which shortened the bumping sequence and made the end results much more logical. Because of my "experience" and strong interest in the results I was one of the three member division team that worked this issue with Personnel and developed job description revisions for members of my Section of the Systems Engineering Branch.

There also existed some extra credit protections. For example if you received an Outstanding Performance Rating (OPR) for the previous rating period two additional years of service credit was temporarily assigned to you for purposes of a RIF. Both of the next two years I received an OPR which was for my work performance but to me the significance was that I would be further protected in the next RIF. Another extra credit was in case of a tie, military veterans bump non-veterans and I had certainly served in the military. Thankfully, I was never again personally involved in a RIF.

When there was a threat of a RIF the Personnel Office would conduct many RIF simulation runs. The cases for the runs were based on many scenarios such as a elimination of x, y, and z specific non-technical or technical skill(s), technical area(s), project(s) or program(s). Reasons for the reduction could range from out-sourcing of function(s), elimination of activity to loss of funding and cancellation of a project or program. Each case was run to find out what

skills would be separated from JSC at the end of the process. If they suspected that that the results were not what the directorate, division or organization wanted, they would consult with the affected organization (but not always), change the makeup or number of position eliminations, and run the simulation again. This was developed like a surgical process to provide insight into the resulting bounce-down effect that had caught everyone by surprise during the first RIF. I worked a number of scenarios with Personnel in the l970s and 1980s as they prepared for RIFs that never materialized.

Spacecraft Design Study Teams

I joined NASA MSC just before the first lunar landing. During the remainder of the Apollo lunar program, CSD's staff working on Apollo was stable and sufficient to accommodate the sustaining and "new" tasks for the later Apollo lunar vehicles and missions with minimal support by me. Because I was hired to work on ECLSS for future vehicles including space stations and was familiar with the regenerative ECLSS technologies, one of my "additional" duties was being the Division's ETC/LSS technical domain expert for the Spacecraft Design Office study teams. I was to and did carry the message supported by analytical data that we wanted regenerative ETC/LSS systems on the vehicles with mission durations beyond two weeks.

During the 1970s, E&D's Spacecraft Design Office included a small team of technical managers staffed through matrix support by technical domain experts within E&D's Divisions. The technical managers led in-house pre-Phase A studies that prepared conceptual designs, identified major attributes and technical challenges and provided weight, power, volume, and cost assessments of proposed new space vehicles or design, operational capability, or cost reduction improvements for vehicles and their support systems that were currently being

developed or flown. Technical managers I worked with included Clarke Covington, Ralph Hodge, and James "Jim" Jones. Studies conducted in 1969 and the early 1970s included the 100-man Space Base and 12-Man Modular Space Station (both of which I discussed earlier) and Reusable Space Shuttle; precursors of the International Space Station and Space Shuttle vehicles we are flying today. My participation in the early Space Shuttle studies including the Reusable Shuttle study which was conducted at the same time as the Modular Space Station study was limited and sporadic. It and several studies were of U.S. vehicles for missions that involved docking with Russian vehicles will be described later.

At the start of a study only top-level guidelines and requirements were provided to team members. As system lead I provided an initial conceptual design and identified the key design drivers and requirements. After performing an analysis of candidate alternate technologies and concepts, I developed a baseline system schematic for the ETC/LSS and worked with other team members to produce a solution that integrated reasonably with the rest of the vehicle's systems. My primary data source was the internal document CSD-SS-009 I maintained in which I had a parametric database of ETC/LSS subsystems and components performance and physical characteristics derived from documentation available on vehicles studied and those built for the manned Programs and the component level databases in documentation provided by our technology developers. For each study I produced a system schematic and subsystem level weight, power, and volume estimates, and technical attributes. Sometimes I was asked and reluctantly provided ROM (rough order of magnitude) cost estimates. At this early stage of my career, I felt my cost estimates had very little credibility because we (at least I) did not have experience in developing a "basis of estimate" for tasks. I leaned heavily on MSC Procurement's Cost Estimators for guidance and the rule-of-thumb parametric data that I used

during our cost estimating exercises. Our products would typically be mid-term and final viewgraph briefings by team members to E&D and Center management and a summary report based on the final briefing. Occasionally, the final briefing would be presented by the team lead to NASA managers at NASA HQs.

I continued to be the Division's lead representative for this activity until 1981. The number and variety of studies supported helped me develop "big picture" awareness, sensitivity for "good and bad requirements," and insight for "system engineering and integration" opportunities with interfacing vehicle systems as part of the design and operation of a human spacecraft. The processes we used during these studies had a significant influence in my development of an understanding, appreciation and expertise in systems engineering.

Apollo Soyuz Test Project

Late October of 1970 a four man team from MSC flew to Moscow, U.S.S.R. It was the first technical interface meeting with the Russians for a possible joint flight, the International Rendezvous and Docking Mission (IRDM), which later was named the Apollo-Soyuz Test Project (ASTP). I was primarily working SSP ETC/LSS analysis tasks and supporting the in-house studies led by the Spacecraft Design Office's technical managers. It was becoming apparent that America's next manned space effort would be development of the Space Shuttle Transportation System (announced by President Richard M. Nixon early January 1972). The Phase B Space Station studies had been completed and "put on the shelf." This lull in Space Station work opened a new opportunity for my career. I was extremely fortunate to literally be at the right place at the right time with the needed technical skills to participate in a once-in-a-lifetime opportunity. The concerns about job security that lingered after my experience with MSC's first RIF were completely removed during ASTP.

Early November 1970, several Spacecraft Design study team members and I attended the initial debrief meeting held by the MSC team after they returned to Houston. After describing their meetings in Moscow and first impressions, we were told we were going to work with the Russians. And that several options involving future U.S. vehicles (with and without involving crew transfers) needed to be defined and sent to the Russians by February 1971. We, the study team members, were to prepare white papers describing a conceptual design or designs of the systems that would be part of a new U.S. built vehicle called the Docking Module that would dock with a Russian spacecraft. The initial mission would be called the International Rendezvous and Docking Mission and would involve the Apollo CSM and a Russian scientific space station of the Salyut type. Later this activity became the Apollo-Soyuz Test Project and the Russian vehicle was changed to the Soyuz. Obviously, for me the most intriguing requirement being considered was providing capability for multiple transfers of shirtsleeve crews between the Russian and U.S. vehicles. Our initial thoughts for the transfers would have the crew of one vehicle transferring to the other vehicle, the visiting crew would stay a night, then both crews would transfer back to the first vehicle, stay a night, and then the visiting crew would return to the second vehicle, thus demonstrating how our docking hardware and vehicle systems for future vehicles can be designed to support crew rescue of either Nation's spacecraft. This conceptual scenario was significantly altered later.

I immediately recognized I had a major challenge to overcome. I had never seen a technical description of any portion of the Soyuz's environmental control system, thermal control system or life support system. No one at the Center and to my Division's knowledge no one in the U.S. had a "technical awareness or detailed knowledge" of the Soyuz ECS. Whereas,

the Apollo ECS was described in "fair" detail in technical papers presented during the preceding years at technical society's meetings and were available to the general public for a small fee.

Literature Searches

WRIGHT: How did you find those materials? What were some of the places that you looked to get them?

JAAX: I started with literature searches in the MSC technical library. Only vague descriptions were contained in the articles found in the aerospace technical magazines. No textbooks on this subject were found. The most likely place to find this information was in the conference papers presented and published at least annually by the technical societies for aerospace disciplines. At that time papers on topics involving ETC/LSS for space vehicles were accepted by the SAE (Society of Automotive Engineers), ASME (American Society of Mechanical Engineers), and AIAA (American Institute of Aeronautics and Astronautics). Anyone in the world may submit a paper, but a "technical" review by "subject matter peers" of the proposed paper may result in a rejection for publication. Frequently, conference agendas included a few international papers. But one must remember that in the early1970s we were in the middle of the Cold War and the Soviet Union's Manned Space Program was under military control. It would be extremely unlikely that they would openly publish "technical" information about the Soyuz or Salyut vehicles.

I did not find any significant "useful" information about the Salyut or Soyuz in the literature. Inquiries into other parts of our government that required a higher security level than my "secret" clearance were also unfruitful. It was not until we met our Russian ECS counterparts, set up and had the exchanges of "questions" by the technical experts prior to the

joint working group meetings, and conducted a face-to-face joint review of the prepared technical documents and responses at the meetings that both sides were provided the required level of technical understanding. In the beginning the question and response sequence was like a fishing expedition. We threw a lot of "fishing lines" out, hoping that one would provide "useful" information. Once we established some mutual trust identifying and obtaining the necessary information was much easier.

During this literature search (remember that this was before computers) I did find brief "descriptive" information about the Salyut and Almaz space stations and several articles describing "next" generation U.S.S.R. space stations. As was their practice the Salyut and Almaz ECS descriptions were very vague.

One concern I had with literature searches was that based on my experience a technical paper takes about a year to go through the preparation, review, approval, and publishing cycle. Thus, at conference presentations you viewed data and results that were at least a year old. Because of the fast pace of research and development and introduction of new technologies during the 1970s, year old information could be quite misleading. For me, the real value-added of publishing technical papers was that it documented the progress of a technology's development at that point in time and even better provided a resource list of authors and where they worked that you could contact for the "latest" information on a particular technical discipline and related technologies.

The white paper I prepared provided a conceptive description of ECLSS, crew transfer and airlock operations capabilities projected to be on future U.S. vehicles that would support transfer of crews between U.S. and Russian vehicles. Major projected changes from Apollo included: cabin pressure be 14.7 psia with a sea level composition of oxygen and nitrogen versus

the Apollo's 5 psia almost pure oxygen composition; larger hatch size to accommodate shirtsleeve crew and equipment transfers; airlock capable of supporting both space-suited intra-vehicular and extravehicular crew transfers; and ECLSS sized to accommodate larger numbers of crew, longer duration on-orbit and extended overlap times by visiting crew.

The resulting derived ECLSS requirements described in the paper included cabin pressure limits, trace gas concentrations, oxygen pressure limits, carbon dioxide pressure limits, portable pre-breathing systems, drinking water quality, augmented with some proposed human factors guidelines such as color coding of equipment. Contents of the ECLSS paper were integrated with descriptions of other systems into a "collector" document that provided a vehicle level overview of NASA MSC's technical approach for its next generation of human spacecraft (Modular Space Station and Reusable Space Shuttle). The document was delivered to the Russians in February 1971. Most of the information I provided was taken from the space station design requirements that we were using in CSD (documented in CSD-SS-009) and the products of the 1969-1970 Phase B Space Station Study of North American Rockwell. This product was submitted to the Russians before learning that we would be using the Apollo CM for the first joint mission.

Documenting and Publishing Technical Papers

I am a firm believer that "a study or test is not done until you have completed documentation of your work." This came from my graduate school experiences in a "publish or perish" environment where documentation by writing reports and books and preparing papers that were peer reviewed and published in technical journals were really important for career advancement. Therefore, I captured all of the information that supported that initial conceptual design in Internal Note MSC-EC-R-71-14 (MSC 04646) titled "A Description of Cabin,

Atmosphere, Environmental Control and Life Support, Crew Transfer, and Airlocks for Future Space Vehicles" approved for release by CSD on June 2, 1971. This document and all of the documents I published is in the JSC library.

Surprisingly, at least to me was that preparing and publishing technical papers was not the norm for most engineers within my Division or at the Center. I voluntarily prepared, often on my own time and published technical reports and papers for each major design activity and test that I led. I was fortunate to have very tolerant and professional secretaries including Donna Mays and Joan Sallis who politely and successfully read my small handwriting, tolerated my many edits, and skillfully integrated within the pages of text the numerous bulky pages containing "cut and tape" cartoons, graphs and tables. All of my published technical papers and documents were hand written and typed using a standard typewriter before word processors and computers became available. Thank goodness we had black and white copy machines with image size adjustment capability. These papers and documents have been a valued record of what was "actually" done and are a permanent record of my interpretation of the results of the analytical studies and hardware tests. During several human spaceflight missions in-flight anomalies occurred where I was asked to be in Mission Control as a "technical expert" and depended on these documents to "assist" my memory as we addressed the resolution options.

Fall of 1971 the study team specialists were asked to provide a conceptual design supporting an early demonstration mission of joint docking capability using the Apollo CM instead of a generic U.S. future vehicle with the Salyut type vehicles. In January 1972 the U.S. proposed to the Russians that a mission be conducted using our existing vehicles, Apollo CSM and Soyuz. The Russians needed time to consider our proposal. Therefore, we specialists were instructed by the Spacecraft Design manager "to continue working technical requirements and

general concepts for docking an Apollo CM with Russia's proposed future vehicles as a continuing show of good faith." A decision on which Russian vehicle would be selected for our joint flight should be made at our next joint meeting later that spring. To me that meant wrap up our input into the paper study involving Apollo CM and Salyut type vehicles as soon as possible. Thus, with the help of Gary Mills, a support contractor from Hamilton Standard, I quickly put the final touches on our conceptual design of an ECLSS for an International Rendezvous and Docking Mission (IRDM).

Using the Apollo CM for the IRDM with a generic Russian vehicle required the U.S. to design and provide a Docking Module (DM) with provisions for isolating (using closed hatches), pressurizing and depressurizing its volume while occupied. This was needed to enable crew transfers between Apollo CM's cabin pressure of 1/3 atmosphere almost pure oxygen composition and a generic Russian vehicle with an atmosphere at sea level pressure and composition. I led the development of a conceptual design of the DM ECLSS for an IRDM. The design features included: pressurizing the cabin with O2 or N2, depressurizing the cabin through controlled venting; providing and maintaining a near 100% oxygen atmosphere in the DM cabin for the 4 hour crew prebreathe protocol to prevent "bends" symptoms required prior to transferring into the CM; and providing CO2, temperature and humidity control that would maintain a habitable DM environment during the prebreathe period. Analytical trade studies and breadboard tests supporting the design were conducted and a failure modes and effects analysis of the selection design was prepared.

Again, I documented our work, providing a much more detailed conceptual design description of the DM ECLSS than described in my previous document. This document also included the known ECLSS characteristics of the U.S.S.R.'s Salyut type vehicle. My document

titled, "Docking Module Environmental, Pressure, and Thermal Control System Conceptual Design," was approved by CSD for release on March 22, 1972, as MSC Internal Note MSC-EC-R-71-15 (MSC 04647). This document was not provided to the Russians because by the time it was released MSC management believed the Russians would accept our proposal for the docking mission to be with the Soyuz.

After the April 1972 meetings in Moscow we refocused our design on a real mission using the CM and Soyuz that would be flown in 1975. This U.S.–U.S.S.R. joint space activity would not be officially named the Apollo-Soyuz Test Project until June 30, 1972. In June 1972 Glynn S. Lunney was given the responsibility for leading the ASTP team negotiating with the Russians and directing the development of the mission and spacecraft hardware. Glynn, a former Apollo flight director, proved to be a very competent, likeable, tactful, and respected leader. In 1973 Leonard S. Nicholson was assigned Glynn's technical assistant for ASTP. I enjoyed a very pleasant working relationship with both men during ASTP. I had no idea this relationship would be lead to something much bigger.

Over the next decade I provided and represented the ECLSS, ATCS, and EVA portion of Engineering's technical team that supported many cargo, payload and mission integration reviews chaired by Leonard for the Space Shuttle Program. Then in 1993 Leonard was appointed JSC's Director of Engineering. In 1994 to my surprise he selected me to be Manager of the Engineering Business Management Office (a brand new organization), and in 1995 it was an even bigger surprise when he selected me to be Deputy Director of Engineering, a position I remained in until my retirement in 2002.

Selection of the Docking Module ECS Design

Soyuz was designed to launch with and maintain a sea level like cabin atmosphere. The crew cabin had a total pressure of 14.7 psia [pounds per square inch absolute] composed of an air like mixture ratio of 21 percent oxygen and 79 percent nitrogen. Apollo's CM cabin atmosphere was maintained at 5.0 psia and composed of near pure oxygen. Unfortunately, once the vehicles were docked we could not just open a valve to equalize cabin pressures. The result would be a combined cabin volume with a total pressure of 9.4 psia exceeding the Apollo CM's allowable structural limit for cabin pressure of 6.3 psia. In reality this could only occur if the relief valves in the Apollo vehicles were inhibited from opening to dump cabin gas overboard to maintain 5 psia. The resulting mixed volume would have a 45 percent oxygen content exceeding the Soyuz cabin's oxygen content fire safety limit of 40 percent.

Believing the crew had at least a four hour stay time requirement to pre-breathe in the DM, and assisted by Gary Mills I drafted a schematic based on the Apollo CM design and the addition of a few advanced life support system technologies. This "solution" would support crew transfer and stay times of many hours to days. We needed a reality check and a concession by the Russians. Walt Guy, my supervisor and coordinating CSD's support for the Russian venture, looked at the schematic, and said: "This is way too complicated, simplify the ETC/LSS. Make the crew transfers as simple as possible. Assume a shirtsleeve two-person crew and that the transfers will go really well. No crew prebreathing requirement. No contingency EVA capability. And the crew stay time in the DM will be for no more than thirty minutes during any transfer between vehicles." I did some "back of the envelope" calculations on CO2 buildup, oxygen consumption, condensate generation, and cabin temperature buildup for various crew stay times. I whacked our Cadillac design down to a very austere Volkswagen design. The

"simple design" provided only the bare essentials: a fan for cabin air ventilation to keep the gases in the DM's atmosphere well mixed while hatches were closed; no CO_2 removal or humidity control; two tanks each of high pressure gaseous oxygen and nitrogen to raise the cabin pressure for Apollo to Soyuz transfers and purge the cabin of nitrogen for Soyuz to Apollo transfers; overboard depressurization valves; and cabin equalization valves for the transfers. Fortunately, at the October 1972 joint meetings, the Russians volunteered to lower the Soyuz cabin pressure to 9.75 psia during the docked phase of the flight to eliminate the need for the transfer crew prebreathing oxygen for an extended period of time to remove nitrogen from within their bodies prior to their return to the Apollo CM. This change greatly reduced the ECLSS flight hardware required, simplified the crew transfer procedures, and significantly reduced the time needed for the crew transfers. At the same joint meeting it was agreed that there was no requirement for external crew transfers, thus eliminating the need to provide special equipment related to operation of space suits and conducting EVA from the CM or DM.

My simplified DM ETC/LSS design and crew transfer scenario was presented to the Russians at the next joint meeting. After adding some redundant valves it was accepted by the Russians, built by North American Rockwell, tested at JSC, and flown. I co-authored with Walt Guy an ASME technical paper (73-ENAs-21) titled, "Description of the Docking Module ECS for the Apollo-Soyuz Test Project," that was presented at the SAE (Society of Automotive Engineers) conference held in July 1973. The paper included the philosophy and rationale used in evaluating and selecting the capabilities required to satisfy the DM's airlock and ECS functions and the planned interdependencies and interactions with the Soyuz ECS and Apollo CM ECS.

Crew Transfer Procedures Overview

Operationally, a crew transfer was the sequence of going from the Apollo CM to the Soyuz and returning back to the Apollo CM. At the start of a transfer to Soyuz the DM was at 5 psia composed of near 100 percent oxygen. After the CM and DM hatches were closed nitrogen was added to the circulating air raising the DM's cabin pressure to closely match the Soyuz's cabin pressure. Prior to starting the first transfer Soyuz's pressure had been lowered to 9.75 psia and was maintained by the Soyuz at that pressure until all transfers had been completed. Actual stay time in the DM with the hatches closed for transfer to the Soyuz was less than 33 minutes. Return to the Apollo required that after the DM and Soyuz hatches were closed, purging the DM with oxygen until nearly all of the nitrogen in the cabin was gone, then venting the atmosphere overboard until the cabin pressure closely matched the Apollo cabin pressure. Actual stay time in the DM with the hatches closed for transfer to the CM was less than 20 minutes. This sequence was repeated for each of the four over and back transfers.

Formation of Working Group 5

Technical interfacing between the U.S. and Russian experts was through five Working Groups. I was one of the original U.S. members of Working Group 5, "Life Support and Crew Transfer" which was responsible for the equipment and conditions affecting crew transfer. My primary responsibility was "ECS Design and Analysis." The other original members were: [Raymond G.] Ray Zedekar, responsible for development of the "Flight Procedures for Crew Transfer (initially called "Operations and Procedures"), Dr. [W.] Royce Hawkins, our Medical and Life sciences representative and Ed Smylie and Walt Guy, Working Group chairmen.

Ilya Lavrov

In June 1972 Working Group 5 splintered from Working Group 1 with Ed Smylie and Dr. Ilya V. Lavrov, who had been the Russian's sole negotiator in earlier discussions on ETC/LSS, named co-chairman. Dr. Lavrov was the designer of the Soyuz environmental control system. He did not attend the July 1972 meeting in Houston; Lavrov was soon replaced by Yuri Dolgopolov who was the Russian co-chairman for the remainder of the Project. Walt Guy replaced Ed Smylie as the U.S. co-chairman in 1974.

I had the pleasure of meeting Dr. Lavrov a year earlier, an "interesting" experience. It was June 1971 during the first joint U.S. and U.S.S.R. meeting in Houston. This was before Working Group 5 was formed. I was invited to Working Group 1's first splinter session for the ECLSS technical experts. A small group was assembled for the "get acquainted" session on a Saturday morning. Walt Guy, Dr. Royce Hawkins (a flight surgeon), and myself had assembled at the table in Building 7A's small conference room next to Division Chief Ed Smylie's Office. In walked Smylie with an interpreter and a short, graying, extremely thin man, Dr. Lavrov; all sat down. Lavrov looked us over. Of course, he only knew Smylie. Admittedly, probably each of us shared a suspicion about KGB [Soviet Political Police] and CIA [Central Intelligence Agency] involvement especially as we studied each other's interpreters. After Smylie briefly identified the U.S. attendees, Lavrov stood up and through the interpreter proceeded to ask: "I want someone to write the equations for heat transfer." (I assumed he meant derive the 3 basic heat transfer equations describing convection, conduction, and radiation heat transfer.) He looked at the blackboard which was behind him and then again at us. My mind immediately jumped to the conclusion that I was about to participate in an activity similar to a orals defense of a doctorial thesis.

I was stunned. I suspect that the others were at least a little shocked. Smylie asked the interpreter to repeat his question. Since Smylie and Lavrov had met before I sensed that the questions were directed to the rest of us. My guess was that this was an "engineering credentials check;" were these real ECLSS engineers in the room or were these "government agents" who were trying to get sensitive Soyuz design information from him? I was more than a little concerned about who was going to answer. I was the youngest in the room. I do engineering analysis on a daily basis. Did he want us to derive or just write down each of the equations? Would each of us be asked a similar question? There was a pregnant pause…

Then, Walt looked at him and said, "Okay", moved to the blackboard and proceeded to write the basic equation for radiation heat transfer: Q = (epsilon) times (sigma) times (Area) times [(Temperature) to 4^{th} power] also known as Stefan-Boltzmann's law. As Walt started to explain what he was writing, Lavrov stopped him and said that was enough, he was satisfied. OK. We then proceeded to discuss some thoughts about the ECLSS requirements for transfer of crews. Never again was I in a joint meeting with a Russian "expert" where any participant was questioned about their purpose for attending the meeting.

Lavroff was an interesting individual. There was no doubt about whom was in charge when he entered the room. He spoke only Russian, loud Russian. I was later informed that he had been a "tanker," an armored tank commander, during World War II and had lost one side of his hearing. He was a chain smoker. In fact almost all of the Russian ECLSS experts were "chain smokers" while very few of the U.S. experts smoked. He was highly respected by his fellow engineers. His engineering knowledge was fundamentally sound. And he was always interested in the safety of the crew.

Working Group Processes and Protocol

On the final day of that first meeting and all future joint meetings, we drafted and agreed upon the minutes or "protocol" for the meeting. In the protocol were the decisions and actions with assigned actionees and due dates agreed upon during the joint meeting. To be official the protocol was signed by the participants. Several months prior to a joint meeting we established and jointly agreed on the agenda topics and exchanged lists of questions. Several weeks before each meeting we exchanged responses to the previously submitted questions, responses to actions still open from prior joint meetings, and drafts of working documents to be discussed and hopefully approved during the next meeting. All exchanged documentation were translated by the receiving side into Russian (or English by the Russians) prior to the joint meeting. I participated in 8 joint meetings (3 were in Moscow). Meetings I attended in the U.S. ranged from 9 to 25 days and in Moscow from 12 to 13 days. We started the joint sessions with preliminary meetings between the technical experts reviewing the exchanged documentation. Both sides freely asked questions until we obtained the depth of penetration needed for technical understanding of each other's design and operational descriptions as provided in the documentation. Misunderstandings, usually misinterpretations and descriptive differences were usually quickly ironed out. Technical concerns and issues required significant deliberation and study to resolve.

Our goal was to have a mutually acceptable translation for each document by the end of each joint meeting. Agreement was not reached until the document's language was acceptable to the author and his technical counterpart. If something was beyond the author's authority to change or there was insufficient information, time, or resources to resolve the issue at that joint session, we would identify an action and due date in the protocol. Technical description

documents required approval signatures by the appropriate U.S. and Russian technical experts, interpreters, working group co-chairmen, and the project technical directors. Discussions and arrival at an agreed upon translation of the technical description documents I worked on usually took one to three days. A summary status of progress was given daily by the Working Group co-chairmen to the Project Technical Directors. I had the "opportunity" to write and negotiate major portions of the protocols for each of the joint sessions that I was a participant. From my "knot-hole," I really liked this process. It was both efficient and effective.

Slide Rules to Calculators

At the start of ASTP, I was still using my slide rule and the Russians were using abacus. Mid 1971, I obtained a small electronic four-function calculator which replaced a few of the slide rule's functions. During one of the early visits to Houston our Russian colleagues asked where they could obtain these calculators. We told them they were available at some of our retail stores, but a compatibility problem would need to be resolved. Powering a calculator required replacement batteries, which were not available in Russia or accessing power directly through a Russian electrical outlet at 240 volt, 50 cycles per second, a definite incompatibility with a device designed for the U.S.'s 120 volt, 60 cycles per second. Within a year their electrical engineers had figured out how to solve the power source problem. But the western world's electronic calculator technology had greatly advanced so that by 1973 I was using a Hewlett-Packard-45 scientific calculator.

Eugenia Zaytsev

During the March 1973 joint meeting at MSC I met another of the Russian ECLSS experts, Eugenia Zaytsev, who quickly put me in my place least I believe that he was impressed with my experience in the U.S. manned space program. He had dark, thick eyebrows and a burly

appearance that reminded me of Russian bear, although his last name's English translation was "rabbit." Another chain smoker, I can still remember the smell of those Turkish cigarettes. He was the designer of the atmosphere control subsystem portion of the Soyuz's environmental control system. How did I know? Because he said so and showed me the handwritten notebook he carried in his briefcase containing requirements, notes, sketches, drawings, and test data for each of the components in his system. He said "these are the originals and only design data for this system" (admittedly, this is my very limited interpretation of spoken Russian with lots of hand-waving).

I asked if blueprints or copies had been made of his notebook and were they in Moscow.

He replied: "No, (They did not have Xerox capability). I am the designer."

I asked: "Isn't that a big risk to your Program? You could be run over by a truck."

He responded, "It's job security."

He had personally directed all activities from conceiving the initial ideas through design, development, testing, flight production, and monitoring its performance during Soyuz flights in their Mission Control. Needless to say I was astonished. Only he had access to the cradle to grave knowledge and experience he used to develop the technical expertise he had in his technical domain; he was a true single point failure; the classic example for a "what do we do if you are run over by a truck" situation.

It was then I realized a major difference in the engineering approach that had been taken by our two space programs. Our conceptual, preliminary and final designs, production drawings and data packages, test plans and reports, certification documentation, and operational procedures and performance data are stored in multiple paper types and electronic media, accessible to all with a "need to know." We have people that are specialist's in design, test or

operation of subsystems like ECLSS ranging from the vendor, subcontractor, and prime contractor to NASA JSC's engineering subsystem managers, technical and safety experts, and flight controllers. Depth of each individual's knowledge of the component, system, or subsystem beyond his primary job responsibility varies but the intent is to never have a situation where one person's knowledge or experience is a single point failure for critical functions, systems and hardware.

That wasn't the way of the Russians designers I spoke with in the early 1970s. What was described and implied was: "I'm the expert. I am given a requirement, create the design, lead the development and production, plan and conduct the tests and monitor the flight performance of the product. I want to continue to be the expert. I will keep the knowledge that makes me the expert to myself. I do not want or need to have a backup." I have wondered if that's the way it is with the current Russian designers supporting the International Space Station.

That philosophy also meant before each joint meeting of the Working Group in Houston we would carefully scan the list of names on the visa request received by the U.S. State Department. If I didn't see a name of one of the "designers," I knew that discussions related to his expertise would be "later." The best I could then hope for was receiving written input prepared by the expert before or at the joint session.

Another eye opener was the construction of Zaytsev's personal "notebook or data book." It was neither a three-ring binder, nor expandable folder with metal clasps like we used. It was bound on one side by a string drawn through a brown cardboard-like cover and many sheets of European size paper, slightly larger than our 8 ½ x 11 inch paper, and tied in a knot. To add a page he used a small awl to make two holes in the new sheet(s), inserted the sheet(s) in his "data book," drew the awl with the binding string attached through the holes of the existing and new

sheet(s), and then tightly tied the string. Everything was legibly handwritten, of course, in Russian.

Our first meeting was in a third floor office in Building 45 with a partial view of a grassy area and one of the MSC duck ponds. We both had arrived early and were alone. Zaytsev asked me in broken English: "How experienced are you, how long have you worked for your space program?"

I told him, "Three years."

He immediately turned toward the window, pointed at the grass, and said in Russian: "*Vy zelyony*" which in English is: "You green." [Laughter]

I replied, "*Da, Ya znayu,*" which in English is: "Yes, I know." I fully understood and accepted his feedback. Being a member of the U.S.S.R. human space program since its beginning he had lived and worked all of it. Whereas, I being three years younger had watched and read about the Mercury, Gemini, and early Apollo Programs while in school and serving in the U.S. Army, but I was trying to catch up as fast as I could.

Russian Language Training

I understand and speak a little Russian. My study of Russian began in spring 1972 when for several months I attended a weekly Basic Conversational Russian language class that MSC made available to the U.S. ASTP team members. I also attended some of the on-site classes in 1973 and 1974. We were instructed on speaking, reading, and writing in Russian. In 1976 through a NASA JSC program to maintain and improve the proficiency in Russian language achieved in connection with the ASTP, I attended a class that met twice weekly for two semesters (Russian I and Russian II) at the University of Houston–Clear Lake (UHCL). It really helped to be able to understand, speak, read, and write some Russian. Much of our training

focused on technical words relevant to spaceflight and our technical specialty. I never felt very proficient, but it felt good to help the interpreters find the best English word for a translation and occasionally be able to talk directly with my counterpart. And, it enabled my working relationships with my Russian counterparts to be much more "interesting." I believe I still have a 400+ word vocabulary.

During our technical discussions I could sometimes understand the question or response being spoken in Russian and therefore, I would be formulating my answer while the interpreter was still translating into English. On a few occasions, I would recognize that the "translation" provided by the interpreter was not quite what had been spoken in Russian and ask for the translation to be repeated. I believe I was the only person from my Division that received more than introductory Russian language training during ASTP. I never found someone to help me outside of the classroom with conversational Russian. I did attempt to teach our two children how to count and speak a few words in Russian but had no takers; they were more interested in learning Spanish.

Valeriy Novikov

During that same October 1973 joint meeting I met the Russian "expert" who became my counterpart and good friend, Valeriy Novikov. He, like I was "green" relative to past spaceflight experience, a near perfect match for me. I was the expert for ECLSS design and crew transfer matters related to the Docking Module. He was their expert that "looked" over my shoulder at the "details" of the Docking Module ECLSS. He also produced a flight item which caught us by surprise.

A concern we identified early in our joint meeting discussions was the Russians apparent lack of concern about flammability and the lack of a fire extinguisher in the Soyuz. We had

viewed newsreel films of their crews entering into the Soyuz for launch. It appeared they wore woolen and cotton clothing and fur hats. The Russian position was that they were not concerned about a cabin fire because they had a sea level composition of oxygen and nitrogen and had never had a problem. We countered that the Apollo 1 fire had made us very sensitive about materials flammability and exposing our crew to a spacecraft cabin environment that had minimal fire safety considerations and provisions.

Finally the Russians agreed to use the U.S. flammability test procedures to determine the safety of their equipment. They also developed a flameproof material of their own called Lola, for their crew's clothing that was superior in its self-extinguishing characteristics to cloth used for the U.S. crew's shirtsleeve clothing. We volunteered to give them one of our fire extinguishers to launch in the Soyuz. They "refused" our offer, insisting that in the Soyuz they did not need a fire extinguisher. We continued to press the issue at the next joint meeting and received the same response. About nine months later we met again; this time the Russian co-chairman, Yuri Dolgopolov, announced that they have a fire extinguisher thanks to "designer" Novikov. Our review of the technical design, test, and certification data found that its performance was as good and in some respects even "better than ours." Of course, they had the advantage of knowing at a cartoon drawing level our design and required performance capabilities. Valeriy told me their testing included zero-gravity flights on their aircraft equivalent to our KC-135. He was the designer and test engineer. This is the only case I am aware of where we shared some requirements and design information that was later used to help the Russians design and produce a flight hardware product for ASTP.

I believe they recognized the significance of our concern about flammability. But they were not going to be dependent upon our technology and hardware to perform a crew safety

function in their spacecraft. I was impressed with their ability to rapidly produce a quality piece of flight hardware. Because of the openness and frankness of discussions during our joint meetings, I often wondered why they did not reveal they were working on this new hardware until it was completely certified for flight.

I developed a great respect for Valeriy. It continues to amaze me that our earlier lives had so much in common. He was three years older with a similar tall slender build and a pleasant personality. He had experienced military service, serving in their Air Force. I had served in our Army. He had recently joined their space program, just like I had. Both of us had advanced engineering degrees and were married to college graduates. He was a father, one child; I had two children. He had studied English (about 900 word vocabulary); my Russian abilities at that time included a 600 word vocabulary. Unfortunately, the only phrases and words we really understood in the others native language were the technical stuff. Although opportunities were there, we were unable to converse with any substance or depth about personal interests, social activities, political events, or even talk about the weather beyond a few very basic words. And, I never used interpreters for discussions of a personal nature. I was afraid it would raise unneeded concerns, suspicions, and questions for Valeriy. I do not know if he shared the same concern but I do know that he never discussed "non-work" subjects in the presence of an interpreter. The inability to fully communicate frustrated both of us, but we continued to try.

By late 1974 Valeriy and I had developed enough language skills that we could begin negotiating as we looked at a sketch, drawing, schematic, list of technical data, and even some text. The engineering physics concepts and equations, physical units, plots of test data and schematics were easy to grasp, but the words were not so easy. Most of the time we had to rely

on our interpreters to provide the words needed for us to understand, agree, and accept each other's document's wording. There were occasions when we would not have an interpreter available. I would "attempt" to describe my understanding of what we were reviewing and he would "attempt" to describe his understanding of what it meant to him. If the item being reviewed was relatively straight-forward we then edited the sketch or text until we "agreed in concept." Then we would have an interpreter verify that we had a good mutual understanding and clean up the English and Russian wording. This made each other's interpreter's work during our documentation reviews a little easier and quicker.

At the time and even now it was truly amazing to me that there was this person literally living on the other side of our planet who was having life experiences so similar to what I was living. And even more amazing was the fact that I had actually met and was working with him.

There was one thing he really desired, a second child. Our daughter, Kristen, was born in April 1972. He had met my wife and children on several occasions and had been a guest in our home in Clear Lake City in 1974 and 1975. July 1975 while sharing a little vodka during an evening social get-together at his hotel near JSC, he talked about missing his wife and nine year old daughter. She was a civil engineer, worked on river dam projects. He really, really wanted a second child. I suggested that he knew how to do that. He replied that his wife only wants the one child. I suggested a vacation. He told me that for vacations, he flew way north to hunt geese, while his wife and daughter went to a resort on the Black Sea. He expressed no interest in changing that arrangement. I do not know if he ever got his wish for a second child.

I have a photo taken in Houston in February 1975 of Valeriy and me sitting at the Technical Directors conference table under the U.S. and Russian flags appearing to be "signing

official looking papers." It was our attempt to "look important" and perhaps be an indication of where our careers may meet again in the future. I consider him a good friend.

Meeting Participation Protocol

Normally each day during our Working Group's joint meetings a "group" meeting with all team members of both countries present. This time was used to "fine tune" the agenda, review progress being made on the agenda items, discuss significant concerns and issues, obtain final agreement on documents and establish agenda topics for the next joint meeting. During the "group" meetings there was a noticeable contrast in how the members within the two teams interacted and arrived at a real-time position. For the "group" meetings the working group experts, typically 2 to 4 U.S. and 2 to 4 Russian, would sit across from their counterpart with the two chairmen at the center of the table and an interpreter next to one or both co-chairman. Prior to the "formal" meeting they like, we briefly caucused in private with our chairman on the topics expected to be discussed. The Russian's protocol was for the co-chairman to do all of the speaking for his team, no matter what the issue was. He rarely if ever caucused with his team at the table; the "experts" would remain silent. Whereas, the U.S. co-chairman always presented our opening position and stated our final position, but in between the U.S. experts could and would openly engage in discussion with the two leaders often at the request of the U.S. chairman to clarify, seek, or provide more information. On a few occasions the U.S. team members would request a closed door caucus with the U.S. chairman to clarify wording, provide, or seek more information or achieve consensus on a possible U.S. position adjustment, if needed.

There were several occasions while the Russian co-chairman was speaking, I'd look across at Valeriy, obtain eye contact and slightly shake my head, indicating that what was being

said was not correct or what he and I had agreed upon. I may have even mumbled in Russian "*Ne pravda,*" not true.

His feedback was usually a slight nod which I believed meant he agreed with me. But never did he interrupt, caucus, or correct his co-chairman while at the table. That was not their custom. Any "fixing" that was needed, waited and was done at the next group meeting. Another tactic was to defer discussion of a topic until "later" if either side believed "additional" information or input from other "experts" were needed. "Later" usually meant at the next joint meeting.

After witnessing the difference in meeting protocol, I have often wondered if our "openness and consensus building" approach had any influence or changed even a little bit how our Russian counterparts conducted meetings and negotiations later in their careers. Collectively, we both achieved the results we sought. But, the autocratic leadership style did not allow real-time input or challenges by the Russian team's experts when in a "formal negotiation session." This style can result in real-time disagreements especially on complex technical issues that require "timeout" for "backroom" interpretation of the position being taken; re-work of the preliminary negotiations by the experts and a re-visit of the subject the next day or a longer delay until the next joint meeting. Whereas the participative leadership style allowed open expression and discussion of ideas and options for resolution of concerns that often enabled us to quickly obtain group consensus or at least insure our chairman was "fully informed" before he made and presented our "final" position on a contested issue.

Many years later when I was Deputy Director of Engineering many of our engineering management decisions were made using the participative management style. When the technical expert(s) or group informed us that they were ready to present a recommendation or position on

an issue or concern, we invited the appropriate and the affected parties to participate in the meeting. We strongly encouraged open discussion and debate to get everything expressed and out on the table. We strived to arrive at a consensus, if not achievable, the leader would then make the decision based on the best information available. Occasionally, there was a time and place when the autocratic leadership style was the best fit for a situation; overall it was used sparingly and judiciously.

Highly Competent Engineers

The Russian engineers I interacted with were well schooled in engineering fundamentals and highly technically competent. The laws of physics and chemistry are universal. Therefore, the equations used by us and our Russians counterparts for solving physics and chemistry problems are the same. It was a matter of observing which equations they were using and recognizing and equating their Cyrillic alphabet symbols to the English symbols we used in those equations. One additional complexity was the needed application of the appropriate conversion factors between metric and English units. Once these familiarizations were achieved, I could look at the equations used and quickly become comfortable with the analytical information being presented. I believe a similar process was used by my Russian counterparts to develop trust and acceptance of our analyses.

It was my observation that both space powers included the appropriate competent and experienced technical experts to support the negotiations that were done and that the engineers on both sides strongly believed that there was more at stake than just personal pride to "do it right." This mission would be a showcase for how the U.S. and U.S.S.R. can work together to successfully achieve a common objective.

The one time I questioned the technical make-up of the Russian Life Support team was in July 1972. Ilya Lavrov was noticeably missing from this joint meeting in Houston. And, their only representative was Yuri Dolgopolov who specialized in water, food, and waste management aspects of life support systems. Yuri did not have a fundamental knowledge of the Soyuz systems that provided oxygen and eliminated carbon dioxide and other waste products for the spacecraft atmosphere. We had many questions about the recently received Russian schematics of the Soyuz cabin atmosphere support systems and especially what, if any changes had been made to the atmosphere support system design and hardware to prevent a repeat of the Soyuz 11 accident. Yuri could not answer these questions. This frustration was expressed to the U.S. Technical Director, Glynn Lunney. From then on the Russian participants for our Working Group 5 joint meetings were augmented with appropriate and sufficient technical experts to support the topics on the meeting agenda.

Soyuz ECS Design

The Soyuz ECS design was simple, highly functional, and uncluttered with extra "bells and whistles." Their "simple and rugged" hardware, structurally stout and heavy when compared to the U.S. designs, had to work the first time and every time. To achieve confidence in the reliability and operability of their hardware, they must have conducted many tests of their ECS before they committed to their first manned Soyuz flight. Our Apollo and Docking Module ECS designs were equally functional, but in addition "options" were provided for the crew and flight controllers through either like or dissimilar hardware to improve reliability for critical functions. Their approach works under their rules for flight safety. For us, having backup options available in-flight for a function or multiple functions have proven their worth many times.

Interpreters

NASA recognized at the start of the Project the need for people that were proficient in simultaneous Russian – English interpreting. In the early 1970s there were very few people in the "free" world known to have this language capability and fewer available due to the needs of the United Nations and possibly our military services. And, the availability of skilled interpreters within Russia was a complete unknown to us. Somehow, someway highly skilled and experienced individuals were located and agreed to be interpreters for ASTP. Our Working Group was very fortunate to be assigned excellent interpreters by both sides. I particularly enjoyed working with Americans Tamara Holmes (1972 – 1974) and Alex Lasareff-Mironoff (1974) and Russia's Olga Yavorskaya [phonetic] (1974 – 1975). Many of the interpreters provided by the U.S. during ASTP had experience at the United Nations. Much earlier in the century some with their parents had lived in Russia and still had relatives living there. A few expressed concerns about traveling to Russia with us and possibly not being allowed to return to the U.S. because of circumstances associated with their parents and relatives leaving Russia.

Typically, only one interpreter was assigned (usually by the host country) to a Working Group. We were especially pleased to see the same interpreter at the next joint meeting because of the "learning curve" needed to become familiar with the Russian and English translations of our technical jargon. Prior to each meeting we would check the interpreter assignments. Several times we "traded" with another working group so that we would be using the "ECLSS experienced" interpreter. Each of the interpreters diligently maintained a notebook of words and phrases with the technical translation that we technical experts jointly agreed were equivalent.

Tamara was a fun person whose personality made everyone comfortable with the "process." Alex had an additional talent (former member of the Yale University glee club) that

was really helpful during a long bus ride in Russia that I'll talk about later. Olga was assigned by the Russians. She was extremely knowledgeable, sociable, and "well connected." Her interpreter skills were highly regarded by the Russian management team. A number of times she was asked to interpret for the Project Directors. In Moscow she could obtain anything, theatre and ballet tickets, restaurant reservations, you name it. And they would be choice, center seating for that evening's performance. She was so amazing that I often wondered if she had Intourist state travel agency or possibly "other" connections.

Technology Transfer

July 1972 during the first joint meeting of Working Group 5, we discussed the exchange of ECS technical descriptions for the Apollo CM and Soyuz. There were concerns within our technical team and probably within the Russian ECS team about exchanging any "technical" information. We were already hearing that there were concerns in the public sector about possible "technology transfer." I can assure you that no proprietary, classified (secret), or new technology design information about the U.S. ECS hardware was knowingly made available or provided to the Russians. Our discussions were of the Apollo vehicles as they related to the Earth orbit mission with the Soyuz. Besides, NASA was a civilian space agency; Apollo's ECS design was already described to varying degrees in technical papers published and available in the open literature. Whereas the Russian space program was under the Soviet Union's military control, whose information was classified, therefore, we knew very little about the Soyuz design. It is my belief that we learned much more about their ECS than they did about ours that was not already published.

At the time I did recognize that space stations and submarines have similar requirements for sustaining humans for long periods of time without resupply (i.e. 6 months to a year). This

was not a concern during the ASTP discussions because Apollo and Soyuz both used "open loop" life support systems whose expendables were exhausted within a couple weeks. Neither Valeriy or I identified or entered into any substantial discussions on the different technologies we were pursing for space stations that were not already described in the open literature. Another area of interest was learning if their designs contained new or exotic materials that significantly improved performance and reliability or presented any significant off-gassing concerns. I am not aware of any surprises in the materials selection and applications used in the Soyuz cabin or of any sensitivity being expressed about identifying and sharing with the Russians the list of materials used in the Apollo CM or Docking Module.

Classified Project or not

ASTP started and ended as an unclassified project. I handled my design documents and analyses like I had protected my Apollo work. During the work day I could and did temporarily place everything I wrote in the open, on my desk. Civil servants and contractors with a NASA approved security badge could and a few did enter my office while ASTP related documents were in the open. At the end of the day I cleared my desk of ASTP material and placed it in a drawer of a lockable file cabinet. Many times I placed unclassified "paperwork" in my briefcase which I took home and worked on later that evening. For several relatively short time periods before 1973, we were told that the "Project" was "classified as secret." All "sensitive" design documentation was required to be placed in a safe location under lock and key, whenever we left the room. No explanation was provided. We complied, but I never understood why the shifts between classified and unclassified occurred. We were and are a civilian agency. Each time the Project was "classified" within weeks to a few months the Project was "declassified" and we returned to our normal work habits. During one classified period, I attended a couple

"classified" meetings in a "secure" room at JSC. Before and after ASTP the only "classified" information I encountered were large blank spaces within the volumetric envelopes for Department of Defense payloads flown in the Orbiter cargo bay during the early to mid 1980s.

Sharing Information about Soyuz 11's Pressure Equalization Valve

On June 30, 1971, Soyuz 11's three man crew died as the spacecraft was performing its re-entry procedures. This was a stunning blow to the Russian space program and presented a significant cause for concern about any future joint flights. There were many theories offered with most focusing on the failure of a component in the Soyuz ECS. On July 12 the Soviet Union's State Commission investigating the accident reported that a rapid drop of pressure within the descent vehicle occurred which led to the sudden deaths of the cosmonauts. The drop in cabin pressure resulted from a loss of the ship's sealing. There were no failures of the spacecraft structure.

We pushed to know the details. In December 1971, Dr. Lavrov shared with Ed Smylie some remarks that pointed to the pressure equalization valve being the "guilty" component. But, it was not until October 1973 that the Russian ASTP team shared with Working Group 5 the results of their investigation, experimental reenactment tests of the failure, and re-design of the effected hardware.

All 12 Soyuz pyro-cartridges had fired simultaneously instead of sequentially to separate the orbital module from the descent vehicle. Within the pressure equalization valve was a ring raceway with detents and a number of ball bearings. For the equalization valve to go from closed to open or back to the closed position a mechanical movement involving an internal spring would allow the two piece raceway housing to separate and rotate sufficiently for the ball bearings to be unseated and moved until fully filling the detents for the other position. On Soyuz

11 when the pyro-cartridges fired simultaneously the vibration frequency excited the spring in the pressure equalization valve sufficiently for the ball bearings to be unseated and moved from their closed to open position. They had verified this by test. They redesigned the valve and verified its operation by test. Throughout the investigative process they had been extremely reluctant to share any information until they had completed a successful redesign. Along the way as we developed mutual trust through person to person relationships, they began sharing the technical details about their hardware that we needed to know to develop the same trust they had in the Soyuz ECS.

Reluctant Exchange of ECS Designs

With the Soyuz 11 event in our minds at our second Working Group joint meeting, the Russians agreed to exchange technical descriptions of those ECS systems and components that directly supported the health and safety of the visiting crew during the transfers and while in the host vehicle. To reduce the technology transfer concerns on both sides a document was needed that illustrated the level of detail to be shared on the technical aspects of the Soyuz and Apollo ECS. The perfect candidate vehicle was the new Docking Module that interfaced with both the Apollo CM and Soyuz.

Thus, I conceived, prepared and authored the "Operational Description of the Docking Module's Systems and Hardware for ECLSS and Crew Transfer" (IED 50706) which was approved by the ASTP Technical Directors on April 26, 1974. The content included a short description of each subsystem and its components operation and performance capability. Subsystems and assemblies were illustrated with schematics. Represented on the schematic were the subsystem's hardware elements (components) and interconnecting fluid paths. Individual components were illustrated on a single page using perspective view, cut-away drawing (usually

a sectional view), and a brief listing of the overall characteristics. The perspective view provided a three dimensional shape as it would be viewed with the human eye. The sectional view provided insight into the structural layout and materials used in the housing and internal piece parts. The listing included type of component, function and operating characteristics (e.g. flow rates, temperatures, pressures, operating times, and location) on the vehicle. We insisted on the drawings for the hardware so that we could understand the overall design, operation, and capabilities of the component and assure ourselves that the materials used did not pose a crew health or fire concern.

A somewhat reluctant Zaytsev prepared the document "Functional Description of the Provisions for Transfer and Mixed Crew Presence in Soyuz Spacecraft" (IED 50723). An equally reluctant Don Hughes and I prepared the "General Operational Description of Command Module Environmental Control System" (IED 50725). Neither was in any hurry to share technical details on their systems. Thus, neither document was approved for release until the spring of 1975. During the interim, Don and I asked lots of questions about the Soyuz ECS and answered their verbal questions about the Apollo CM ECS.

As we obtained detailed descriptions of their flight hardware and relevant flight experience, we accepted their explanation of how devices that were new to us operated—like their gas flow regenerator. It was an absorber containing chemical cartridges of potassium super oxide (KO2) that absorbed carbon dioxide (CO2), water vapor and harmful contaminants and released oxygen (O2). As cabin air passed through the device the KO2 reacted with water (H2O) in the air to produce O2 and potassium hydroxide (KOH). The KOH reacted with the CO2 in the cabin air to produce H2O and potassium carbonate (K2CO3). The net result seen in the cabin atmosphere was removal by absorption of CO2 and addition of breathable O2. The rate of O2

release was dependant on the metabolic output of the crew, thus of very little help should an overboard leak of cabin air occur. Whereas our design of directly adding make-up O2 to the cabin based on cabin pressure from the electrical power system's supercritical cryogenic O2 tanks provided significant cabin leak protection. Following much discussion we jointly agreed the KO2 process was adequate for the Soyuz cabin needs during the crew transfers due to the relatively short crew stay time in the Soyuz and low probability of a cabin leak occurring during the stay time. Their design also included a lithium hydroxide (LiOH) absorber to supplement the regenerator's CO2 removal capability. This was a CO2 removal process we were fully familiar with since we used LiOH absorbers in the Apollo CM and Lunar Module.

Obtaining specific design, operating and performance information from the Russians was slow, sometimes requiring "encouragement" through telephone conference calls with our Russian counterparts. The needed information on the various components within the Soyuz ECS was identified, documented, and exchanged as part of the U.S. and U.S.S.R. Working Group 5's internal documentation. Total Working Group 5 internal documentation exchanged was 47 documents provided by the Russians and 60 provided by the U.S. Our telephone conference calls were either early in the morning or late in the afternoon because of the nine hour time difference. Obviously, when we initiated the call we would call at 7 or 8 am Houston time.

By May 1975 we had exchanged and reviewed sufficient design, operational, and performance information, witnessed enough system and vehicle tests in each other's test facilities, and conducted sufficient analyses that we felt confident about the integrated design, how the other's systems worked and what each systems' capabilities and limitations were. When there were questions, both sides were willing to discuss, although getting a response beyond, "We're still working on it," sometimes took weeks to months.

ASTP DM ECS Development Verification Test

During the development phase of the Docking Module two major tests of the ECS were conducted at JSC. The first for development verification of the DM's ECS design was conducted January 16–23, 1974, within the 8-foot vacuum chamber in building 7 at JSC. A complete breadboard test article was provided by North American Rockwell and placed inside the chamber. The chamber's gas volume had to be physically reduced to simulate the free volume in the Docking Module. CSD's test branch which led the test activity also provided the two test subjects. The manned test phase was of a simulated mission having three two-man crew transfers. This part of the test was the first opportunity I had to observe the ECS hardware perform using flight procedures.

My test team responsibilities included assisting preparation of the test plan by defining the test objectives; identifying the test points and defining the operating parameters for each test point; assisting transfer and conversion of test point objectives into detailed test procedures; and manning one of the data analysis consoles. As lead analyst for the DM ECS and the test activity, I was interested in demonstrating the ECS met all design specifications, the transfer procedures were adequate in both normal and emergency situations and in obtaining model correlation data for individual component and integrated system hardware performance that spanned the operating envelope of the ECS including a flight representative simulation of the crew transfers. To achieve this, the DM environment was adjusted before each transfer to reflect extreme but acceptable compositions that were not likely to occur during flight. By testing extreme cases, the suitability of the ECS was scrutinized and the acceptability of manned operation under low or high oxygen pressures was determined. The unmanned functional performance and manned

simulated mission testing successfully verified the capability and operability of our Docking Module's ECS design.

I also coordinated the participation and was the technical host for the five Russian observers from our working group that witnessed this test activity. This was an opportunity for the Russians to gain awareness and confidence in the capabilities of our space vacuum environment test facilities and observe the professionalism, rigor, and discipline maintained by our test team during testing. We wondered who the Russians would send to observe our testing. We expected the addition of test article and facility specialists that we had not seen before, but were pleasantly surprised when the visitation list included the Russian Army general who was in charge of the testing facilities that trained the cosmonauts. He returned to Houston in July for the DM thermal vacuum test in Chamber A which gave him an opportunity to observe some of our astronaut training,. My observation was that he was cordial and respected our Working Group protocols, but that he was his own boss, participating when and in what he wanted. He apparently had no restrictions on what he could do on his own time including a private visit to Galveston's beach. Later I will describe my experience at a social event arm wrestling and playing ping pong against him.

The only anomaly I recall occurred before our observers arrived in the U.S. It was during a manned pre-test checkout of the in-chamber fire suppression system while the chamber door was closed. One of the two test engineers located in the chamber inadvertently activated a water deluge system used for fire suppression resulting in a partial flooding of the chamber requiring a quick hatch opening and exit scramble by the test engineers followed by a short delay for chamber "dry-out" and test article checkout.

Russian Life Support System Testing

Two months later, mid March 1974 the only Russian life support system test observed by the U.S. working group members was successfully conducted on a modified Soyuz life support system at an Air Force Base outside of Moscow near Star City. Following the Russian's lead our five member team included individuals who were test facility "experts." I was not a member of U.S. team sent to witness their testing. Post-test I was one of the technical reviewers of the Russian prepared test report from which I obtained test performance data that I used to correlate and improve my math model predictions. It was not until later in my career that I realized how useful it would have been to have gained on-site awareness of their thermal vacuum test capabilities, facilities and facility operations, and observed the implementation of their processes and protocols for testing.

ASTP Docking Module Thermal Vacuum Test in Chamber A

The second of the two major U.S. ECS tests was the thermal vacuum test conducted on the flight Docking Module in JSC's Chamber A July 15–29, 1974. Building 32's Chamber A was a large vertical, man-rated, thermal vacuum test chamber. Beginning in 1968 (prior to the first Apollo lunar landing) Chamber A was used to test each of the Apollo Command Module and Service Module stacks. It easily accommodated the docking module and its test support equipment. The chamber was designed to provide environments that simulated the vacuum of space (up to 1 X 10 to the minus 6 Torr), coldness of space (down to minus 420 degrees F.), heat radiated by the Earth on the vehicle (simulated by arrays of infrared lamps surrounding the vehicle), and heat radiated by the sun using Solar Simulator lamps. The DM was installed in the chamber and connected to a man-lock that provided the capability for a shirtsleeve crew to enter

and leave the DM. During the manned test, the ASTP prime flight crew entered the docking module and performed the crew transfer procedures following a nominal mission profile.

For this test I was much less involved with the test preparation activities because the ECS was one of many systems performing in an integrated vehicle test. I reviewed the test plan, test points, and crew transfer procedures in the detailed test procedures and manned a test data console during the crew transfers portion of the test. I again served as a technical host for the five Russian members of Working Group 5 that witnessed the test. The Russian team included the General and had one new member. The test was successfully completed and the ECS performed well, providing flight representative data of the docking module ECS's operating characteristics, and performance that I correlated with my analytical models.

Moscow Trips - Stay Awake As Long As You Can

I was a participant in 3 of the 7 Working Group 5 joint meetings held in Russia, October 1973, September 1974 and May 1975. Our first trip in 1973, we flew first class on a Boeing 747, a great way to fly, but that was quickly changed to economy class for the other trips. Each trip had an overnight stay—London in 1973, Paris in '74 and London in '75 —to adjust our sleep time. Early the next morning we boarded Aeroflot and flew to Moscow. Unfortunately, I could only lightly doze during the long oversea flights, probably too excited. I chose to adjust my "clock" by staying up as long as I could. Others in our travel party could not wait to get to their hotel rooms and sleep.

In 1973 after checking in at our hotel in London a small group of us walked and rode the Tube (London Underground) to see the tourist sites. We started with Big Ben and Parliament Square, followed by the changing of the guard at Buckingham Palace, Trafalgar Square, and Piccadilly Circus, and then we called it a day.

During the 1975 stopover in London, I decided to "tour" the British Museum on my own. I enjoyed seeing the exhibits and relied heavily on the anticipation of what the next room held to keep from curling up on a bench and sleeping. It was quiet, dark, drier and much warmer than being out walking the streets. I still remember the looks the guards and docents gave me as I walked through the exhibits wearing my scarf and wrinkled raincoat. I must have looked like a homeless zombie walking or was it sleep-walking past the Rosetta Stone, Magna Carta, and through the Egyptian mummy displays.

In Paris I'm sure I presented a similar image as I passed the Mona Lisa during my "self-guided tour" through the Louvre Museum. Even better entertainment was the methods I used to stay awake while I ate my "evening" meal at a restaurant near the hotels as the local time approached 4 pm. No, they did not include using toothpicks or splashing water on my face.

The "stay awake until you drop" approach worked for me, because I was able to have an extended sleep before our morning flight and I was young. Each trip we arrived in Moscow in mid afternoon checked in our hotel (a lengthy process) and went to bed early. The next day I truly felt rested and ready to work.

Flying on Aeroflot

Flying on Aeroflot was always "interesting." There was good reason the stewardess gave us hard candy before takeoff and as we started final descent. Like some of my flights on Houston Metro Airlines (a small commuter airline of the '70s that flew 20 passenger Twin Otter aircraft between Houston's Intercontinental Airport and Clear Lake City), the Aeroflot pilots flew much steeper angles of climb and approach during descent than the major U.S. airplanes. It alarmed some passengers but we always landed safely at our destination. It was just different from what we were expecting. Another observation was the noticeable difference in the

appearance of their stewardesses. Some were beautiful; others however, were…. very sturdy with a rough, ruddy appearance. And the food served was edible but always a mystery.

Flying into Moscow

As we flew into Moscow for my first trip I was in a window seat in the back of the plane casually taking photographs out the window. The plane dipped and dived as it followed the Moscow River, finally touching down at Sheremetyevo airport. As the plane approached the terminal I saw uniformed men standing on the tarmac with rifles at their side that appeared to be military troops (Russian mulitia). And I become a little worried. Someone then announced in a Russian accent that "no photographs are allowed." What had I just done? I quickly placed the camera and lens in my camera case. I wondered if my camera or just the film in the camera would be confiscated or worse yet all of rolls of blank film in my carry-on would be zapped by X-rays. And what about the Playboy magazine that somehow had been placed in with the stack of magazines in the seat pocket in front of my seat. I had not brought it on the airplane and I definitely was not going to place a Playboy in my briefcase. Would I be allowed to enter the Country?

I quietly exited the plane, quickly joined our group, walked up to passport control and waited, all the while not looking back and trying not to appear worried. It was obvious that everything was very tightly controlled. Uniformed and armed personnel seemed to be everywhere. The guard at the control booth peered at my passport, appeared to compare my name with a list of names he had in front of him, made a telephone call and again compared it to a list of names. I waited for a seemingly long time. I started breathing again when he stamped my visa and passport and motioned me through the gate. On the following two flights into Moscow I kept the camera in its case (for the most part) and because I was part of the American

delegation for the Apollo-Soyuz joint meeting, I was able to rapidly go through passport control. One observation never changed. At the airport each of the three visits into and out of Moscow, Russian militia troops were visibly present on the tarmac.

Why are we in Warsaw?

This trip was my second visit in 1974. About 1¾ hours into our scheduled 3 hour flight from Paris to Moscow our plane made an early, unannounced and unscheduled landing. It sure did not look like Moscow's airport. I saw very little activity on the airfield. We had landed at an "unknown" airport and were taxiing to some "out buildings." Then a building with large Cyrillic letters above it came into view. The signage indicated we were at an airport serving the capital of Poland, Warsaw. But, how could we be sure? There were some worried looks and murmurings about why we would be in Warsaw. All 80 plus passengers were quickly evacuated from the plane without our carry-ons. We walked across the tarmac, then were herded into a second floor "cattle like" holding pen in an "out building" constructed like an airplane hangar. We were held there for about an hour before being allowed to re-board the plane. Below us on the first floor we saw a "holding pen" containing about 30 people and heard voices from other locations in our building. Too many languages were being spoken to understand the nationality of any of the other groups. No explanation was provided. We speculated that while we were on the ground they searched the plane for "something" or maybe we had a "mechanical" problem that was quickly fixed. None of us wanted to hear anything implying the plane's safety had been threaten by someone on the ground. We re-boarded the plane and flew on to Moscow without receiving an explanation.

Driving into Moscow from the Airport

It was an impressive, eye-opening ride from the airport to the city, especially seeing complex after complex of new large apartment buildings along the road and the World War II memorial of Soviet tank traps indicating how close the Germans came to the center of the city. Buses provided by the Russians transported our group to our hotel in Moscow. There were a few exceptions for some members in our traveling party who rode with their Russian counterparts in cars.

In 1974 our Working Group was met at the airport by Yuri Dolgopolov, the Russian co-chairman of our working group. He graciously drove four of us from the airport to our hotel in his new recently delivered Russian car, a Lada Zhiguli. This was his first car and he was very excited because at that time very few people owned a car. Also, at that time Moscow had very little traffic; its major streets or boulevards were at least 10 lanes wide (we were told to support military vehicle needs). In the center of the major intersections standing, often on a stool, was a policeman or militiaman who controlled the lights and used hand signals to direct traffic.

Yuri was "cruising" along in the center lane of the boulevard. As we entered the outskirts of the city Yuri suddenly stopped the car, literally in the middle lane of a major boulevard. He jumped out, walked behind the car, then began running away from our car down the middle of the street. Fortunately, vehicular traffic was very light. Off in the distance we saw blue lights flashing on top of an approaching small white car. Yuri, now about 100 yards from us and standing in the middle of the highway stopped the militia (traffic police) car, talked for several minutes with the occupants, then the police car drove away and he walked back to our car. I must admit visions of scenes involving people trapped in a car from James Bond movies and thoughts of possible personal danger entered my mind. We did not know what was

happening. My guess was, Yuri had been speeding and he did not want to be pulled over and questioned with his American guests in his car. What was discussed and possibly "exchanged" between Yuri and the police, I do not know, nor did I ask. But, I did not see a traffic ticket. Later I read what could be an alternate explanation. On major Moscow boulevards the central lanes were reserved for vehicles, typically limousines carrying top-level leaders, a security measure. Militiamen had an intricate system of whistles and lights to ensure that the leaders' vehicles moved without impediment. Perhaps Yuri was "reassuring" the policemen that his passengers were important enough to justify his using the center lanes. Who knows? We continued to drive in the center lane to our hotel.

My next trip to Moscow was in 1975. Yuri again met our working group at the airport and drove us to our hotel. It was a nice, warm spring day and the ride was pleasant and uneventful.

Hotel Ukrania

On my third trip we stayed in the Hotel Ukrania, one of Stalin's seven grand design skyscraper structures and the tallest hotel in Europe at that time. The hotel was constructed between 1949 and 1955. During our stay the following occurred on one of the elevators. Walt Guy and I had entered the elevator on an upper floor. As we descended at each floor more people got on until we were packed in like sardines. Both of us were backed up against the back wall. Next stop was the ground floor. Expecting to be at the ground floor when the doors opened the elevator car had actually stopped about 2 feet below the floor. It immediately began to rise, but overachieved; it was now about 2 feet above the floor. It recognized that this was not where it should be, closed the doors and started back down. It stuttered, stopped, stuttered down some more then up and the doors opened. By now we were hearing at least four different

languages; none were speaking English. All were probably pleading for a way to get off this elevator. Walt and I, taller than the others, looked at each other, and then continued to wait as the elevator car continued to adjust its position. Finally, it stopped, doors opened still at least six inches above the ground floor. The people in front hesitated, but only momentarily as the doors were held open and all of us jumped off as quickly as we could. The group waiting to enter the elevator had watched this event unfold, waited for the empty elevator to readjust itself to floor level, and then calmly entered. They must have had nerves of steel. I never used that elevator again.

Rossiya Hotel

The first two trips we stayed at the Rossiya Hotel near Red Square, largest hotel in Europe. The 21-story hotel had 3200 rooms capable of sheltering 4000 guests. It was registered in the Guinness Book of Records as the "World's Largest Hotel." Construction was completed in 1967. The hotel was built using the existing foundations of a cancelled structure that would have been the eighth of what has been referred to as the Seven Sisters (Stalin's tall skyscrapers built in an elaborate collaboration of Russian baroque and Gothic styles).

Hotel Rooms

In both hotels my room was very small, but adequate for my stays. Each had a single bed, a little short in length for me. I could find only one bed sheet. Rolled up on top of the bed was what appeared to be a comforter that had a closed sack like cover with a large opening in the center of one side. Inside were several blankets that after experiencing several very warm nights I decided could be removed and used individually. Next to one of the room's walls was a chair, a TV stand holding a small black and white television, and a small writing desk with a desk lamp, telephone, and radio on top. Television programming of course was all Russian language.

Different country, different customs: news anchors read from papers you could see being held in their hands; photos shown were often far more "graphic" than on U.S. TV; and I could always find a soccer or ice hockey game during the evening. A small round table with two chairs was in the middle of the room. A small wardrobe was provided for hanging clothes. Bathroom provisions included a sink, Russian toilet, and small bathtub with a hand held wand for showering. Central steam heating via a small radiator was provided but cooling the room had to be done by opening and closing the window. It was highly recommended that valuables be stored in the hotel safe.

Key Ladies

On each hotel floor located close to the elevators was the desk where the key lady sat. They were the keeper of your room key. When you left your room you gave your room key to the key lady who would return it to you when you wanted back in your room. Some were friendly and some were not. They were ever watchful about who entered your room. On one trip some papers and documents I had worked on with one of our women secretaries were placed in my baggage for the flights to Moscow. During hotel check-in she said that she wanted to retrieve the papers for typing the changes before our first joint meeting the next morning. Before checking into her room on her floor she came with me, suitcases and all, directly to my floor. I asked the key lady for my key and told the key lady that the secretary and I would be in the room for a short while. I believe she told me in Russian that was "forbidden." I insisted that the secretary be allowed to enter my room to pick up some documents. I volunteered to leave the door open. Reluctantly, the key lady agreed to my request. We entered the room, retrieved the papers and documents, and briefly sat at the table to discuss which papers were needed first. We had not been in the room more than two minutes when my key lady knocked on the partially

open door and requested entry to "check the towels." The key lady entered, carefully looked around, fussed with the towels and left. I had never before had a visit to my room by a key lady. To this day I believe she was "checking up" to make sure we were doing what I said we would be doing.

The most enjoyable experience involving a key lady was the couple hours late one evening I sat with one at her desk and helped her read and understand a chapter in a school textbook written in English. She had obtained the book to help (home school) one of her grade school age children prepare for an English language exam. She was formerly employed as an Aeroflot hostess, where she learned some English but it was the British version. She apparently worked the late shift of 10 pm to 8 am because she was still at her desk the next morning. I enjoyed scanning through the school books that were being used by her children to learn English.

Breakfast at the Hotel and U.S. Embassy

Breakfast on the first and second trip was either in Rossiya's second floor restaurant or at the U.S. Embassy. The hotel offered a huge buffet with a wide variety of food that I considered breakfast and lunch items including cereals, soft boiled eggs, breads, cheeses, meats, vegetables, fruits, coffee, juices, hot tea, and many other items I did not recognize. You could really stuff yourself, if you knew what you were eating or drinking. I was adventuresome with their food but mineral water was not my favorite drink; therefore, I took every opportunity to hoard some "no-gas" bottled water. They did not serve and I did not drink tap water. I boiled the tap water before using it to brush my teeth. It was an amazing set of white mineral crystals that formed while I was boiling the water.

Most days I rode on our "charter" bus that went to the U.S. Embassy before it drove us to the Institute for our meetings. The Embassy's cafeteria which was available to us on weekdays

served typical American breakfast food (eggs, any style, bacon, ham, cereals, coffee, milk, etc). It was like being home.

The other reason for going to the U.S. Embassy was to read the latest news from the U.S. It was printed on teletype paper taped to the walls. Finding anywhere in Moscow any current news reports written in English about the U.S. was impossible. Being an avid sports fan I quickly discovered that reports and scores for U.S. sports were not to be found on local TV or in their newspapers. I accepted the reality of living in Moscow with a U.S. news "blackout." Besides, what can happen during a two week stay?

Yom Kippur War

Well, imagine my shock on the sixth day of our first visit, October 1973. During our breakfast ride to the Embassy our U.S. interpreters saw the headline and front page of *Pravda [Truth]*, the Russian daily newspaper at a street corner newsstand and started rapidly talking in Russian. They declined to tell us what had them all excited. After much prodding they told us that Egypt and Syria were at war with Israel. It was the start of the 16-day Yom Kippur War. The headline and story indicated Israel had initiated the attack. The U.S. had immediately sided with Israel. Russia was actively supporting Egypt, Syria, and other Middle East and North African Countries. And, there we were, in Moscow. Our two nations were on different sides of a "fighting war."

You can be sure that I literally devoured all of the news releases available at the Embassy. Interestingly, the U.S. reports, contrary to the Russian reports indicated that Egypt and Syria had launched a surprise attack on Israel. Would all of us be sent back to the U.S. immediately? We still had a week of work before our joint meeting finished. Would it be "safe" for "Americans" to be seen in Moscow during this period? We were reassured at the Embassy

that we would be fine. Fortunately, the "war situation" never became a subject of discussion with our hosts. I did ask Valeriy Novikov if he knew anything about the war situation; but he like the rest of the Russian engineers expressed no interest in discussing the subject, especially through an interpreter. Plus, our limited vocabulary greatly impeded our ability to converse on non ECS subjects. We continued our daily meetings as scheduled. And from then on, every weekday I ate breakfast at the Embassy. Daily our interpreters would give us a very sketchy summary of the Russian view of the war as described in *Pravda*. Deep down I had a concern that the interpreters for whatever reason were not fully sharing all that they read. But there was no need for concern, we completed our work, left on our scheduled flights and the war had not escalated.

Also during that visit I was just as surprised when I read that baseball's New York Mets had beaten the Cincinnati Reds (the powerhouse of baseball at that time) to win the National League pennant. The Mets had won their division and the opportunity to play the Reds with the lowest regular season winning percentage in major league history. And my Houston Astros had the same winning percentage as the Mets but were fourth in their division. Was I living in a parallel universe where "anything that can happen, will happen"?

Working in the Institute

All technical meetings I attended were held in the Moscow area. In 1973 we were bused (an approximately 30 minute drive from our hotel) to an Institute (possibly the Institute of Automatics and Telemechanics), a gated building, under construction.

Easily seen from the bus during the early morning and sometimes during the afternoon drive were the many babushkas (grandmothers), dedyshkyas (grandfathers), and old men and women pensioners sweeping their assigned section of the street's sidewalk and gutter with their

stick brooms. Most appeared to perform their job with obvious pride; they kept the streets of Moscow meticulously clean.

Our meeting rooms were on an upper floor of the Institute; a new building whose construction was nowhere near being completed. Many interior walls did not have dry wall installed yet; electrical wiring was being installed. The floor in most areas was bare concrete. The accommodations in place were primitively basic, mostly functional; and the rooms were **cold**. It was October and winter weather had set in. We adjusted the thermostats but never had heat. I do not believe the heating system had completed its installation. We wore many layers including jackets; and the secretaries were praised for maintaining a continuous supply of hot coffee and hot water for tea and successfully typing with their numb fingers.

The Russian construction workers inside and outside appeared by dress to be "military personnel." The whole structure looked like it was being built by Army conscripts who had no idea about how to build buildings. The walls weren't aligned to be straight or fully vertical. Mortar was missing or slopped over (not trimmed) on the brick outside walls. On our floor wind whistled through gaps of up to ½ inch between the windows and their frames. Not surprisingly the bathroom facilities (commodes, hot and cold water for the sinks) were hit and miss (sometimes they worked, often they didn't work).

Driving onto the building site, the approximately 1 ft x 1 ft x 10 ft square brick structure that held the hinges for the driveway entrance and exit gate was a classic example of how not to construct a brick and mortar structure and of someone who does not care about his workmanship. You can imagine the impression made as we viewed the site through our bus windows then set up shop on our assigned floor during our first trip to the Institute. A testament to the strength of

both teams mutual interest to make this Project successful was that neither team let the working conditions interfere with their daily work.

The meetings were informal starting at 8:30 am. You could depend on both sides being punctual and having full attendance. Activities started on time but you could never be assured when they may be completed. The first day started with everyone assembled in an auditorium that had more than enough seats for all to hear the technical co-leaders instructions including room assignments and processes that would be followed during our meetings. We separated and met as individual working groups, then separated into subgroup(s) in separate room(s), depending on the availability of interpreters. Both sides were usually fully prepared, if the appropriate "designers" were present. We observed the traditional Russian lunch time of 2:30 pm, three hours later than my stomach thought it should be, and usually dined at a small cafeteria or kiosk in or near the building. Our Russian colleagues followed their custom of drinking a couple bottles of warm "*pevo"* (beer) with their meal and sometimes drinking another during the afternoon. From what I observed their consumption had no effect on their abilities during the afternoon. Needless to say, we were not excited about warm beer no matter what time of day it was. Late in the afternoon we would agree to stop discussions at a "natural break" opportunity that allowed time for our group chairmen to give a brief report of our progress to the Project Technical Leaders. The entire ASTP team almost always stopped at 5:30 pm and was bused or they took the Metro (subway) to the hotel.

Office Supplies and Support

Each trip to Moscow included a new group of highly competent secretaries and an office support staff from JSC. They quickly established our office support protocol, organized and provided our office supplies while providing the typing support for any paperwork or documents

that the U.S. technical team and interpreters required to be typed in English. I really appreciated their help and willingness to stay until the job was done. To enable them to work efficiently we brought a wide variety of office supplies and equipment including electric typewriters with English type, an almost non-existent item in Moscow. The Russian's office support team was equally proficient and supportive of the Russian team's needs. But they did not have some of the office support equipment that had recently become available at JSC. One example occurred on my second trip with the arrival of our own copy machine, a big time saver for us. The Russians did not have copy machines at the Institute. At that time I believe the U.S. Embassy did not have a copy machine, certainly not one available for our temporary use. I believe before we returned to the U.S. we sent one or more machines over to the U.S. Embassy to use until NASA needed them for ASTP meetings.

Once we, at the working level, agreed on the technical wording it was important to be able to make copies so that others could review the text to make sure that it and the translations were okay, especially for the protocol we would be signing. In Houston we were able to step out of the room, find the copy machine on that or the next floor, make copies, and be right back. In Moscow until arrival of our copy machines, the document would be taken away and reappear, hopefully the next day.

Dinners in Moscow

During the first two trips we often ate in the two restaurants in the Rossiya hotel. Occasionally, when a planned excursion did not include dinner reservations, we would walk, passing Red Square to the area of the shopping streets. We did not have favorite place so we searched until we found a restaurant that had open seating.

The Rossiya's main restaurant was in a large room on the second floor. It provided standard seated service and included many large tables that would seat eight or more. Unless specifically objecting we would be seated with other customers (total strangers) at a table until it was full. This provided us a great opportunity to meet travelers from all over the world. If we could not find a common language, there would be a lot of pointing, nodding, and smiling. We had some truly enlightening and entertaining meals.

Bad Vodka

One meal at the main restaurant was particularly memorable. Three of us were seated with two businessmen from the Russian Republic of Georgia. The businessmen had already ordered dinner and were well along in drinking their wine and vodka. After we ordered our dinner we attempted to communicate. Only I knew a little Russian and one of them knew even less English. Using hand signals they indicated that they wanted to share their vodka and make a toast. As one of them was pouring vodka into five glasses, one in our party placed his hand over a glass and politely said, "nyet" (No). He would toast using wine. The Georgian looked quizzically at the American, attempted again to fill the glass. Again the response, more forcefully, was "nyet." This was repeated several more times.

Then the Georgian placed the vodka bottle on the table and the American removed his hand from over the glass. I again made attempts to communicate the preference of wine versus vodka. It was obvious that the Georgian was upset. He then grabbed the vodka bottle and filled the empty glass before it could be covered. Again the American said, "Nyet." That did it for the Georgian. He said "Bad vodka, bad vodka" while he quickly emptied each of the five vodka glasses onto the table. All of us scrambled to keep from getting our pants soaked. Our colleague then left for his room. My other colleague and I quickly concluded that we had not been a party

to this exchange, we were hungry and our food was now being served. The Georgians repeated their invitation for us to stay. A new bottle of vodka was ordered and we completed our toasting.

As we ate the Georgian that had offered the vodka quizzed me trying to determine why his offer had been rejected. He repeatedly asked if our colleague was a ship's captain, priest, religious or what, which I replied that he was none of those, he was an engineer and preferred wine. At the conclusion of our meal they invited the two of us to partake of a "feast table" they had in their hotel room. I must admit I had some concern about this request, especially after the scene that has just transpired. Hesitantly, we accepted. We entered their room and true to their word there was a long dining table in the center of the room stacked to overflowing with Georgian fresh fruits, vegetables, meats, cheeses, wines etc. My guess was that they were business representatives and this feast was prepared for hosting potential clients. We were honored to be their first and while there, only guests. To stay sober during our stay with all the Vodka toasting, I watched and did what the Georgians did. Before drinking they would quickly eat something (bread, cucumber, anything). This would dilute and absorb some of the alcohol. It worked for me. We ate our fill and politely left, never to see them again.

The 21st Floor Nightclub

The Rossiya's other restaurant we were frequent diners was in the nightclub on the top (21st) floor that had a full bar, served dinner, and had a live band and vocalists. The hotel's management gave us "privileges" at the nightclub in that we were able to bypass the long lines waiting to get a table by saying to the doorman, "Inter-cosmos." They were "magic" words that we really appreciated especially if we were dining late.

Menus were challenging. Apparently, a common menu of many, many pages was used in Russian hotel restaurants. A somewhat "rough" English translation was typed under each item.

We quickly discovered that only items that had prices were served at that restaurant, which were maybe 5 out of 20 listings on a page. But, only the waiter could tell you if that item was available that day. Most were not.

When we ate at the nightclub I often ordered "longet," which had the closest description I found for beefsteak. I have no idea what type of meat it was other than tough red meat, certainly not filet mignon. We gave up on ordering medium rare or medium because it made no difference. Each time the longet was served, it was raw on one side and a burned well done on the other side. And, the piece of meat would be floating in so much cooking "oil," that we joked that there must be a dispenser of Mazola vegetable oil on the kitchen exit door and the waiters were required to apply two squirts on the plate before they left the kitchen.

After dinning, a group of us would sometimes move to the bar area and listen to the American and European dance music that ranged from the '40s to the '70s. I liked to dance. One time during the 1973 visit a couple of our secretaries (there were no women engineers in our travel group) were also eating in the restaurant. They joined us and we danced to a couple songs with each. Feeling brave, I then asked a young woman that was standing alone and I had overheard speaking English. She appeared to also be from the West. When she revealed she was a local Russian woman and openly propositioned me while we were dancing, I stopped asking anyone to dance.

Late Night Calls

During that first trip, several of us received telephone calls after we had gone to sleep. The calls to my room were female voices speaking in Russian. When I demonstrated I could not understand, sometimes the voice switched to speaking German. That did not help. I was again clueless about what she said. Finally, obviously agitated that I was not responding the caller

would hang up. My assumption was that it was a solicitation for "who knows what" and "God knows where." Whatever it was it would only mean trouble that I did not want.

President Nixon was in Moscow during a week visit to Russian that began June 27, 1974. During preparations for the visit, his staff and the Nuclear Threshold Test Ban technical negotiations team, which stayed five weeks, lived in the Rossiya Hotel and worked in the U.S. Embassy. This was before my second trip in September 1974. Before leaving for Moscow we were told that the Secret Service or State Department had asked the Russians to get rid of the prostitutes operating in the Rossiya hotel. Based on my stay I would say they had totally cleaned the place up. I did not see any "unescorted women" in the hotel's nightclub or receive a "questionable" call during that stay in the Rossiya. I often wondered how long beyond our September stay the prostitutes stayed away.

I never entertained the thought of walking out of the hotel in the middle of the night to "meet" a complete stranger. Looking back, if you did "rendezvous" with someone and they drove you to another location, you would have no idea where you were and if "dumped" onto the street, how to get back. If foul play was involved how would one even communicate to anyone who you were or where you wanted to go? You had no proof of identity; the hotel had your passport. And that's if you survived. There were rumors of romances, even one resulting in marriage.

Calling Home

When I requested the Rossiya's front desk set up an overseas call to the U.S. from my room, they never promised a time for me to be ready for the call. Typically, it would be between midnight and 3 am. I was always fast asleep when awakened by a loud ring and told: "Your overseas telephone call is ready." To stall for time while I cleared my head I would ask, "What

time is it?" Then I would wait and wait as they patched me to the overseas operator. I called Suzanne twice every trip. With the 9 hour time difference, in Houston it would be between 3 pm and 6 pm. It was a real joy to hear her and our children's voices. The calls were quite expensive so we kept them brief. A major distraction existed during each of the calls. It started when connected with the overseas operator and lasted throughout the overseas call. The distraction was hearing an immediate echo of each syllable I spoke combined with a resonance sound like I was talking in a large auditorium. Others in our group described having the same experience. We figured it was just the KGB listening to our calls.

A question on the minds of some in our travel group while staying in Moscow was: Were the Institute meeting rooms, hotel rooms and hotel telephones bugged? Occasionally, late evening a group of us would gather in someone's hotel room with our technical director and group leaders for some social relaxation. Once in a while the discussion would turn serious about a technical issue or concern that was not being recognized as important or not achieving the progress we were seeking. Almost immediately, the jokes would begin about the existence and possible locations of bugs in the room. Almost always this would be followed with a request by one of our group for the speaker to: "Speak a little louder so that they can be sure to hear everything that we're saying and won't be confused about our position." I never saw evidence of a room or telephone having been bugged, but that does not mean they weren't. I just assumed they were and behaved accordingly.

On my second trip a colleague was concerned that someone would open his suitcase and take something while he was out of his room. Each morning he carefully affixed a human hair across the opening of his closed suitcase before leaving for breakfast. One day the hair was gone. He carefully checked; nothing was missing from the suitcase. I suggested that he had

dislodged the hair himself. He never believed me or trusted the hotel staff for the remainder of our stay.

Adventures on the Street

Several evenings during each visit a group of us would walk to the shopping street to look at the merchandise in the storefronts before a late dinner. Their sidewalks especially on major streets were much wider than ours and always crowded. I liked having underground passages at the intersections of their major boulevards for people to cross from one side to the other side of the street. It appeared that everyone who didn't ride the city buses or subway walked, probably for long distances. Thus, I do not know why I was so surprised to see such large calf muscles on the Russian women, young and old. An even bigger surprise was seeing long curly hair on their legs below the mini-skirts. The style of the day apparently was for women's legs to be unshaven in nylons with a seam in the back and wear brightly colored almost glowing plastic boots. The combination was truly "memorable."

For one walking adventure a member of our group, a tall, robust man with a neatly trimmed beard, chose to wear a black turtleneck knit shirt and accessorize it with a gold neck-chain that held a very noticeable Christen cross inlayed with small polished stones. It had a noticeable effect on some of the people passing us, especially the older women. Some stopped in front of us for a "better" look. Was he a Russian orthodox priest? As others approached, a few quickly made the sign of the cross gesture and dipped in a slight genuflection movement. One woman dropped to her knees and blessed herself as we passed. I must admit that I moved slightly away from my friend during this display. I began to feel as if I was walking beside the Messiah. We did not stop or say anything but the effect of his apparel was noticeable. That

wardrobe combination also significantly improved the service of our dinner at the restaurant that evening.

Will They Replace the Worn Stone Stair Steps?

The impact that the years of walkers and shoe nails had on the stone stair steps in the old department stores like GUM, the State Department Store, that faces Red Square was stunning, especially if you were concerned about public safety. GUM must have been a forerunner of their version of a shopping mall. It had three levels each with many small shops that together offered almost any conceivable item for sale. Our visits were years before OSHA's [Occupational Safety and Health Administration] equivalent was added to the Russian government.

Most of the stair steps appeared to be constructed with a standard 10 inch tread depth and 8 inch rise height but in the early to mid 1970s all steps were deeply worn into a scalloped shape. The center front of the tread was 1 to 5 inches instead of 8 inches higher than the back of the tread of the step below. The step sloped in a half moon shape both to the sides of the stairway and to the back of the step's tread. All of the steps between any two floors showed a similar wear pattern. The wear down of the rise height on the steps was much greater on the street level floors than at the top (third) floor in the building. The steps were difficult to adjust to and slippery when wet. My assumption was that the stone had been literally worn away by the nails in the shoes and boots. There were plenty of opportunities for slips and falls.

Dinner on Our Own

With a little help from our Russian interpreters and U.S. members of other working groups, we found during our discovery walks some acceptable eating establishments. However, we quickly discovered that the business model for these restaurants was not like American restaurants. Volume of business, number of table turnovers, and tipping were not important.

The state paid the employees a flat salary based on their job description. You didn't tip. Therefore, one seating at a table usually by 8 pm was the norm, and if the party stayed the whole evening (which they usually did) it was even better. The staff prepared and served food to that table once and refilled the drinks all evening. From the street you could see they really enjoyed their food and drinks (lots of loud talking, singing, and laughter). If we saw an empty table, we would enter and request to be seated. If it was close to 8 pm, it was "reserved." When we told the head waiter we would wait, he would give us an estimate of 2 to 4 hours before a table would be available. We left. We learned quickly to make the first seating.

As the Russian members of our working group learned of our restaurant adventures they gave us excellent recommendations and their support staff helped secure reservations at local restaurants. I enjoyed the food and dining experiences. I will admit there was occasions when I had no idea what I was eating. And on those occasions I would eat a "taste sample" before proceeding to "clean my plate or bowl."

Public Cafeteria

This was especially true when Valeriy took just the two of us to a public cafeteria. From the beginning to the end of the serving line I didn't recognize a thing. The food items were presented on small plates and heating trays much like in our cafeterias, but the labels were in Russian, nothing had an English translation. The line servers were no help especially when I could not understand their Russian. Most items appeared to be wrapped in pastry. I quickly gave up guessing and went with Valeriy's recommendations on what to eat or not to eat. His recommendations were good enough and quite tasty. Most foods were recognizable only by taste, if the seasoning did not overwhelm the taste buds. I thought I was safe ordering a soup with small bits of meat, carrots, and onions but I wasn't prepared for the large pieces of fat and

gristle in the bottom of my bowl. Edible, but I did not ask for a re-fill. Oh, and the pastry covered meats and vegetables were quite good, worthy of taking a chance whenever I go back to Russia.

Ice Will Give You a Cold

The beverage item I missed most was ice for ice tea. Hot tea was always available. No Russians used ice with soft drinks or tea. Each time I requested ice the waiter would give me either a blank or scornful stare. When I asked Valeriy why, he would jester by pinching his throat and saying "give you a cold." Not to be fully deterred we prevailed on our Russian hosts, when they assisted in making dinner reservations, to request the restaurant make ice for us. You can imagine our surprise at one restaurant when they brought us a large cooking bowl that was filled with frozen water and an ice pick. We chipped to our hearts content.

Borscht for Dinner

Our Working Group was in an up-scale restaurant preparing to order dinner. A comment was made that we had not tried the Russian soup, Borscht. Our waiter informed us, and then insisted that Borscht was only served for lunch. It took a while for our interpreter to convince the waiter that this was a group of Americans who really wanted to have bowl of Borscht with their meal. It was a much longer time that we waited as they prepared and finally served the quite tasty soup,

Wedding Dinner and Dance

At a Working Group 5 dinner celebration hosted by our Russian team members during the September 1974 visit, 14 of us were seated at a long table in the center of the main floor of a large restaurant. All of the many tables surrounding us were filled with diners obviously enjoying their "dining and drink." Service was excellent, vodka and toasting flowed freely, and

the food was great. All good, until I was told by a colleague after we were back at the hotel that the piece of meat I had eaten included a "large white worm." "Didn't I see it?" he asked. Yuk, No!! I asked why he had not warned me when he saw it. The reply was that he thought I knew and that he did not want to dampen my evening.

The reason I became so excited at the restaurant was that a wedding celebration feast was taking place in a large second floor room that had a window which looked down on our room. I heard the live band playing Russian folk music which I greatly enjoyed, and could see the participants dancing and having a great time. Curiosity got the better of me so during a toilet break I found the stairs up to the room and peered in. Observing me, they invited me in to join the celebration. They were extremely excited about my being an American and that our group was part of the Apollo-Soyuz spaceflight activity. I accepted their offer of some wine and wished them well. Upon my return to our group, members of the wedding group gathered at the window and toasted our group. The only down part besides the "worm" of this dining experience was the heavy layer of smoke in the dining room from the many smokers. And no, I did not have a reaction to the worm. It had been cooked but probably not anywhere near "well done."

Cottonwood Seeds with My Salad

Our May 1975 trip occurred while the female cottonwood trees had their branches loaded with millions of white cottony filaments (sails for dispersal of the seed), which when the wind blows, slowly drift to the ground. Working Group 5's Russian team hosted a dinner for us at a restaurant that specialized in Kazakhstan food. It was a beautiful, still air evening with late afternoon sunlight when we arrived at the restaurant but in the distance we also saw dark clouds building up. As our "social" hour of vodka and wine began the staff prepared a large banquet

table outside under several large majestic cottonwood trees. The trees appeared to have been dusted with snow. Glasses were refilled while the waiters filled the table with ethnic food. The huge centerpiece appeared to be shredded meat that looked like tuna or chicken salad, but I have no idea what it really was. Finally (there were a lot of toasts), we were ready to fill our plates for our family style meal. Suddenly there was a great gust of wind causing the trees to shed their coats of white cotton. For about five minutes we were in a "snowstorm" of cottonwood seeds and some large raindrops, which instantly coated the food, glasses, and table. The staff quickly covered the table with tablecloths while we retreated to cover. When the "storm" passed, we uncovered the table, brushed away the "snow," and ate our feast. The food was outstanding but occasionally a little "stringy and crunchy."

Moscow's Metro System

Moscow's subway system is the best I have ever ridden. It was fast and cheap (5 kopeks). Many stations in the central area were beautifully decorated and above all, all were clean (absolutely no graffiti, wall posters or trash anywhere). We visited most of the stations that were celebrated for their sumptuously decorated interiors, the people's palaces. They were really special. People we saw in the stations and on the trains were quiet, polite, courteous, and occasionally friendly. I did not see any shoving or pushing as the train doors closed. They must have the longest, deepest, and fastest escalators in the world. I could see why the tunnels served as air raid shelters during World War II. And if you did not walk while on the station escalators you were quickly and firmly reminded to stay to the right.

The hardest part of my Metro rides was trying to read the station name as the train pulled into a station. I never understood what the train conductors said. Most of the names were far too long, more than 12 Cyrillic characters, for me to phonetically read in the short time they were in

view. I was doing well if I could recognize five characters at a time. Before entering a train I always counted the number of stops I needed to pass before exiting and I made sure I was close to the subway map on the wall next to the door. I wish we had a mass transit system like their Metro in Houston.

Great Patriotic War

Our interpreters had told us that many Russian people were very emotional and continued to have lasting impressions about World War II (The Great Patriotic War). An estimated 20 million Soviet soldiers and civilians had perished during the conflict. Most families had been directly affected by the war including loss of home, livelihood, and human life. As I walked the streets there were always a number of older men dressed in black suits and women wearing small black jackets that proudly displayed their war ribbons, medals and lapel pins; some may have had 50 or more ribbons and medals pined on the left side of their coats. Some appeared to be doing well, but many appeared to be pensioners. I did not interact with them during the Apollo Soyuz visits, but I did meet and listen to the stories of three military participants in WWII during a visit to Moscow in 2008.

Collectable ASTP Lapel Pins

The official crew patch for ASTP showed the Apollo and Docking Module in Earth orbit about to dock with the Soyuz. Its image was used on many of our document covers. Both countries made lapel pins based on the crew patch design. I purchased some of the U.S. made ASTP pins to give and possibly trade with the Russian members of our Working Group for Russian pins. There was a niche market in Russia based on designing and providing collectable lapel pins for national events and celebrations. The Apollo-Soyuz mission was of such importance. I was told that more than 125 towns and villages had created their own unique

ASTP pin, but a very limited number of each was made. My observation here in the U.S. was that the ASTP lapel pins were a novelty prized mostly by collectors of space memorabilia and rarely worn or displayed. But in Moscow they had importance and if they could obtain the American pin that was a prized possession they proudly wore. While in Moscow I saw a number of vendor displays with as many as 500 different lapel pins for multiple activities for sale. The majority of the pin designs were associated with Space (launch vehicles, launch site, satellites, manned Soyuz and Salyut missions and the ASTP joint flight). I obtained through trade with some vendors and Russian ASTP members 8 different village ASTP pins which were nowhere near the more than 100 different pins that one of the Russian ASTP members had collected. And, I was told, he was continuing his quest until he had collected them all.

Shopping in Moscow

On my first trip I discovered that prices of goods were set by the State; there were no sales or bargains. I also heard that a "black market" existed and that there were places like our "farmer's market" where on certain days bargains could be found. But, I did not go to those places. We had been advised before leaving Houston not to participate in black market activities. The State set the price of all items. In the stores if you found something you liked and wanted to buy, you bought it. You would not find it at a cheaper price in another store and there was a strong possibility it was in short supply. Also the State set the salary for the clerks selling you merchandise; therefore, she (and it seemed to always be a she) had no incentive to ring up a lot of sales. More transactions just meant she had to work harder. At the precise moment the clock or closing bell sounded they would immediately stop the sales transaction, return the item back to the store shelf and leave. I know because it happened to me.

The process I experienced in the 1970s for making purchases in department stores was very time consuming, inefficient and archaic. I would search the displays and shelves behind counters for a desired item (often with no price shown on the shelf). Locating the item(s) I then had to find and ask a clerk to obtain the price from the label attached to that item; leave the item with the clerk; find a cash station and tell the cashier the price(s) on the item(s) I wanted to purchase. She then used an abacus to determine the total cost; I paid her in cash (rubles and kopeks); she gave me receipt(s) that I took back to the clerk behind the counter where I had priced the item(s); the clerk retrieved the item(s), wrapped the item(s) in brown paper and tied a string around the bundle; I collected the item and either carried it or placed it in my shopping bag (small mesh bag with a draw string) and departed.

Maybe Bags

Everyone appeared to have at least one small mesh bag in their pocket. We nicknamed these bags "maybe bags" for maybe I will buy something, maybe not. These were used like paper bags or plastic bags, but were better because they were reusable.

Lots of Lookers and Few Buyers

Groups of people would stand as many as 5 deep at the storefront windows and at display cases inside shops; they were the "lookers," showing great interest in the items and price, we observed very few "buyers." When I went souvenir shopping I often had to elbow my way to the front and discovered that I was the only customer buying.

Foreign Currency Only Stores

I was in several of the Berezeka (Russian for birch tree) chain of stores where only foreign currencies were accepted for purchasing Russian goods (clothing, hats, jewelry, art objects, etc). The prices were comparable with regular store prices if you accepted the Russian

government's rate of exchange of rubles for dollars. Better yet, the variety of selections was often better. For the tourist's and our convenience, a store was located in the Hotel Rossiya.

We were strongly warned to not purchase items for Russian citizens in the foreign currency stores. Sure enough, during my last visit I was approached by a man outside the Hotel Rossiya store requesting I purchase an umbrella using dollars he had in his hand. I declined; you never knew who was watching or what else would be requested. Later I was told that umbrellas had become very difficult to find in Moscow.

They must have had a similar shortage of rubber inserts for windshield wipers on their cars. In the street parking area in front of the Hotel Ukrania I watched each of the drivers remove the wipers and store them inside his car before locking and leaving the car. I was told that car owners that left their wipers on their car would have them stolen during the night.

Russian Souvenirs

During check-in at the hotel desk on the first day of each visit, we were provided a per diem in Russian rubles by the Russians. Similarly, when in the U.S., each of our Russian guests was provided a per diem in U.S. dollars. We were told to not take rubles out of the country; a ruble exchange check point to convert rubles to dollars was provided in the airport. And why would someone take them out; they were worthless currency in the western world. I used the rubles they provided to pay for food, Metro tickets, an evening's activity or entertainment and small souvenirs. My preferences for souvenirs were books in English about Moscow and Russian history; small wood inlay plaques of churches; nesting dolls; amber jewelry on necklace and earrings; enamel on copper paintings; Russian hats; a Russian world map; and folk shoes for my daughter. Something I really wanted but could not find was a wood carving of a standing bear. I was told that it was not a popular figure for woodcarvers at that time. I'm still looking

for a hand carved "Russian bear." I did not find one during our 2008 trip to Moscow and St. Petersburg.

Was I Followed During my "Free Time"?

During "free time" we were on our own. We were free to move about the city. No host or escort was assigned to "help" us. I would find someone or a small group that wanted to shop, sightsee or "explore a part of the city" and off we would go. Well, as much as one could by walking and riding the Metro. And, at times I went out by myself. If I was followed by "observers," I never saw them. I truly felt I was alone. However, there were a couple times "things occurred" that caused me to think that I was possibly being shadowed.

Buying a Political Map of the World

On my 3rd trip when I was shopping by myself I went into a Knechne Magazen (book store). I was looking for a wall map of the world in Russian to bring back as a souvenir. There was the usual crowd of lookers that I gently pushed my way through until I reached the counter. I asked the clerk in a combination of Russian and English if I could have a closer look at book containing maps that I pointed to on a high shelf. She obviously didn't understand me. I tried English, no success. I again tried using just Russian words, still no success. Then, a man standing behind me tapped on my shoulder and asked in very good English, "Can I help you?" Startled, but desperately needing help I replied, "Yes." He spoke with the clerk and she obtained and handed me the book. I turned to thank the stranger, but he was gone. Was he just a Good Samaritan or was he shadowing me, who knows.

I returned the book and instead purchased a large wall size "political map of the world." The unique feature on that map was that it provided a view of the world from the Russian perspective. Moscow was near the center of the map and the U.S. was at the edge on one side.

Of course, it was in Russian. It was also a political map. Each country was colored. Russia and many Communist run countries including Cuba were colored pink. If you are familiar with the political events of the early '70s the map already "projected" the existence of a combined North and South Vietnam and that other countries would be leaning or Communist such as Angola, Guatemala, Nicaragua and El Salvador. I had it mounted and displayed it in my office until I retired.

Late Night Walk from U.S. Embassy to Rossiya Hotel

Another time I may have encountered a "shadow" was during my only late night "adventure" walk from the U.S. Embassy back to the Rossiya. I had gone to the Embassy after dinner with a couple other Americans in our Working Group to relax in the Marine bar. When I was ready to leave the others wanted to stay for a longer time. It already was late at least for me; it was just after Moscow's buses stopped running. I knew generally where the hotel was, but was somewhat unsure about finding the "shortcut" which included walking through a small wooded area. I decided that walking the two miles to the hotel would be better than taking a taxi. We had been cautioned to not trust taxis.

I began what turned out to be a three mile journey on Novinsky Boulevard. As I was crossing New Arbat street, a wide major street with many new shops, I observed a woman walking toward me on the same side of the street that I was about to walk. She was a block away. We were the only people on the street, at least I thought so. Suddenly, a police car entered the street behind her, raced up to her and stopped. Two men exited the car and spoke briefly with the woman, then "forced" her into the car and raced quickly past me. I was now totally alone on the street. I immediately revised my route back to the hotel but I did not have a city map.

I continued walking south on Novinsky Boulevard toward where I believed the Moscow River to be. As I entered one of the back streets I realized how thick the stone walls and deeply inset the entrances to the buildings were. There were a few streetlamps but not near enough for me to feel comfortable being alone. I decided to walk on the edge of the sidewalk next to the street. My plan was when I reached the river I would turn to the left, walk along the river until I passed the Kremlin's wall and enter Red Square where I knew how to find the hotel. I was unaware that the river made a large loop near the Kremlin. After going several long blocks further than I expected and seeing no evidence of a river, I turned left on Old Arbat street walked a few blocks then fearing I was going too far north I turned onto Znamonka Street. I soon arrived at the end of the street. Across the street I saw a fenced wooded area which had the Kremlin walls in the background. I had not found the river but I was greatly relieved I had reached the west wall of the Kremlin.

I decided to turn left and walk on the side with streetlights next to the wooded area until I found an opening to Red Square. As I began to cross the street I stopped when heard loud popping sounds similar to gunfire. At least one long block in front of me I saw large sparks flying from the electrical lines that powered the city buses. Fortunately, it was next to a streetlamp where I saw a work truck and some workmen who appeared to be working on the electrical lines. I remained stopped, looked around, saw no one, but …. In the woods on a windless evening, some leaves and a "shadow" moved. I decided I would walk toward the workmen, continuing to stay next to the street gutter. Glancing to my right as I walked, I again saw "moving shadows." My impression was that the movement would continue for a while; stop, then a few yards ahead another shadow would start moving at my pace. I did not slow down. I passed the workmen, who were still making lots of large sparks fly and loud popping

sounds, and continued for another block before the woods ended. I continued to walk next to the wall, past Russia's Tomb of the Unknown Soldier with the external flame. I now knew where I was and soon found an opening onto Red Square.

Entering the square I observed that I was all alone, except for the two Russian soldiers walking guard duty in front of Lenin's Tomb. When I was a third of the way across the square, about even with Lenin's Tomb which I and most others in our Working Group never visited, I began hearing the roar of a car engine racing through the back streets to my left. Suddenly ahead of me, gate lights began flashing and a loud beeping sound came from the Kremlin's Spasskaya clock tower. This tower was built in 1491 and was housed near the top a 600 year old mechanical clock with 14 bells that produce a distinctive chime every ¼ hour. The same chime was used on Moscow's television stations to mark the hour for news broadcasts. I stopped and waited. The tower's vehicle gate opened. The sound of the vehicle grew louder and louder. Suddenly, 80 yards in front of me from a small street on the far side of the GUM department store and directly across from the open gate, a single large black car raced with noticeable bouncing across Red Square doing at least 60 miles per hour. It entered the Kremlin, gate closed, lights stopped flashing, beeping stopped and I was again all alone in the middle of Red Square. I did not move for at least 30 seconds, looked all around, saw nothing "moving" then immediately picked up the pace and walked to the hotel where I slept …. a little bit. I never walked alone late at night in Moscow again.

Russian Cultural Adventures in the Kremlin

Our Russian hosts always treated us with the greatest of respect and enabled us to see and do within reason whatever we wanted to do. I was in Moscow for 12 days each trip enabling me and members of our working group to attend many of their cultural entertainment venues. Our

half-day Kremlin tour included the grounds with the Tsar Cannon and Bell, Armory with its treasures, and the five Cathedrals surrounding Cathedral Square.

On later trips we were again in the Kremlin. We went to the State Kremlin Palace Theater to see the Moiseyev Dance Company's presentation of U.S.S.R. folk dances. The dances and costumes were beautiful representing many of the regions of the U.S.S.R. The individual and group display of their dancing and singing talents was truly amazing almost unbelievable. I enjoyed their show more than any other act I saw during my trips to Moscow.

We requested tickets to see a ballet in the Bolshoi Theatre but it was closed for remodeling during that visit; instead we saw "Swan Lake," my first and most memorable ballet experience, at the State Kremlin Palace Theater in the Kremlin.

A Russian Ed Sullivan Show

About 20 Americans were invited by our Russian counterparts to join them at a nightclub for a dinner show. The show closely resembled the format and content of the variety acts I had seen during the late 1950s and early1960s on the Ed Sullivan Show, a popular U.S. television program. Couples filled the club; except for our tables of stag men, most probably feeling somewhat guilty about being in a nightclub without their significant other. The food and refreshments were enjoyed by all. Unfortunately, the excellence of the master of ceremonies and comedians was wasted on us because they spoke only in Russia. The strikingly effective visual and audible capabilities of the singers, dancers, magicians, animal acts, and dance band were greatly enjoyed and appreciated, but the format seemed a little outdated. Our Ed Sullivan variety show had been off the air since 1971. When the audience began dancing we headed home.

Obraztsov Puppet Theatre

A story or joke can only be appreciated if you understand the language being spoken. During our third trip approximately, 40 of the Americans in our ASTP group attended an evening performance at the Obraztsov puppet theatre. The theatre was easily identified by the large clock with distinctive copper metallic figures of dancing puppet dolls representing the hours on the front façade. Built in 1970 the structure was home for the largest puppet theater and puppetry teaching center in Russia and housed the State Museum of Theatrical Puppets. We felt quite honored to be special guests and seated in one row about eight rows from the stage. The show included many large puppets like on Sesame Street with painted faces and colorful clothing, all maneuvered from below by puppeteers using hands, sticks, and wires.

As the show progressed a full house of over 600 people were continuously laughing to the point of rolling in the aisles at the jokes and personalities contained in the satirical adult comedy story. Well, almost everyone. Our row of Americans sat on their hands in stone silence. We did not understand a word being spoken, it was all in Russian. We must have really been a puzzle to the people seated near and behind us. Suddenly, about half way through the show one of puppet characters began speaking in English. Other puppeteers also began speaking in English. Their comedy routines and jokes had us doubled over laughing. And as you may have guessed, the rest of the audience was stone silent. This lasted for about three minutes, and then we were politely introduced to the audience as U.S. space experts working on the ASTP joint mission. To my disappointment the remainder of the show was in Russian.

Old Moscow Circus

It took two trips to Moscow to see performances by both Moscow's old circus and new circus. The old circus or Moscow State Circus was in a building originally built in the 1880s. It

had a single large show ring. The show started with a lengthy (maybe 20 minutes long), highly patriotic and dramatic reenactment of the major events during and after the 1917 Revolution including photos and video punctuated with loud marshal music. It was a spectacular pageant presentation. They had many animal acts; some with animals I had never seen perform in a circus. I really enjoyed the bear, double humped camel and clown acts. The big surprise was that all of the trapeze high wire artists wore safety harnesses. Their human balancing, tight rope, and gymnastics acts were truly amazing. What I did not like were the tiny, squared off bench seats that were butt-sore uncomfortable.

New Moscow Circus

The New Circus or Great Moscow State Circus was located in a new round building that seated 3,400 people. Again we sat on tiny, squared off wood bench seats that were just as uncomfortable as at the Old Circus. It was a beautiful facility with a single main ring composed of five interchangeable ring structures for the different acts. They had acrobats working at floor level and on the high wire, clowns, water acts with seals and walrus, ice skating acts and animal (double humped camels, horses, lions, dogs etc.) acts. Light and water fountain shows were a specialty. Again the aerial artists wore safety harnesses.

Hockey in the Sports Palace

One of the evening social highlights during my first trip to Moscow was a group outing with other sports enthusiasts from our Working Group to see my first hockey game. The contest was in Luzhniki Sports Palace's Small Sports Arena between two of Moscow's top teams, Spartak and Dynamo. The arena which provided a beautiful facility for viewing hockey was filled with 14,000 rabid fans. But, before entering the rink you had to pass through the concourse area where coats were checked, food and drinks were sold, and smoking was

permitted. When we arrived, the concourse air appeared to be stagnant and had a "hazy gray" look. At the end of the first period I ventured back into the concourse to purchase a snack. Looking around it appeared that everyone was smoking. And, the smoke was so thick that when I swung my arms I saw smoke swirls move through the air. Breathing was a real challenge. For many, handkerchiefs covering the mouth were a must. I made my stay in the concourse area as short as possible including cancelling my search for souvenirs. I gave strong consideration to forgoing a necessary visit to the toilet room at the end of the second period, but Mother Nature was calling. Back in the arena the air was crystal clear because smoking was not allowed and the rule was strictly adhered to by the fans. Magically the ventilation system did not allow the concourse air to enter the arena.

It also appeared to me that almost all of the Russians working on ASTP smoked. As I had observed at the hockey game, during our meetings in Houston and Moscow the smokers usually went outside the building to have their smoke. The "smoke break" provided them an opportunity to "caucus" among themselves.

The game itself was very exciting but most striking was the contrast of brightness of the light on the ice and the resulting view of the crowd. As I scanned the packed stadium, I was reminded of scenes in an old black and white movie of the legislative chamber of Russia's State Duma in session during the Russian Revolution. Like the movie the fans had pale white faces with most wearing a white long sleeve shirt and black trousers. There were very few colored shirts or coats to be seen in the crowd. The fans had brought their black overcoats but they were required to be checked at the coat check stand. In contrast we Americans showed lots of color, especially me because of the "light green and brown" tweed sports coat I wore. Remember, it was the early '70s. And, we were obviously American tourists.

Evenings at the English Speaking Embassies

We were told that three of the English speaking embassies in Moscow each had one night during the week designated as "open" club and bar. Open meant people with foreign passports were allowed access to the Embassy's club for that evening. At least once during each trip, some of us visited the U.S. and/or British Embassies on their open club nights, Monday and Thursday respectively, I believe. The music in the U.S. club, which was operated by the U.S. Marine Contingent, was much quieter, making it a great place to sit, relax, and visit. I met members of the embassy staff, travelers from the U.S., nannies, au pairs and teachers from Scandinavia, and students from all over the world studying at Moscow's universities. During a discussion with a male student from an African nation, I was asked if I would send a letter representing myself as a sponsor for him to travel to the U.S. He told me he could not return to his country because "the situation at home had changed;" it was too dangerous for him to return. He was "trapped" in Moscow. I politely declined his request.

If you wanted to drink or dance to extremely loud, early heavy metal music, in a large, smoke filled garage like room filled with people, many having way too much to drink, the British Embassy's "club" was the place to go. I was at the British club only once and it was a short visit.

Spaso House

During our May 1975 visit, the American ASTP members were guests at an early evening reception hosted by the U.S. Ambassador to Russia, Walter Stoessel, at the ambassador's residence in Moscow, the Spaso House. The house, located about one mile west of the Kremlin had been the residence of the U.S. Ambassador since 1933. It was a pleasant evening as we strolled through the large grounds before entering the house. The structure was

constructed in 1914, quite obviously during a period that favored ostentation in architecture. Most impressive in the interior was the long main hall crowned by an enormous crystal chandelier. If I remember correctly, the ambassador was unable to join us, so we raised a toast to him in absencia.

Weekend Russian Cultural Experiences

My stay in Moscow during each trip included a full weekend. Our Russian colleagues proved to be excellent hosts, keeping Saturdays full of Russian cultural and historical experiences. Usually all of the U.S. travelers and their Russian counterparts participated in these adventures. Sites toured in and near Moscow included the Kremlin and Red Square which I discussed earlier, several former Russian Orthodox churches and monasteries (we were told all churches had been turned into "museums"); Moscow University and its environs (as viewed in the rain); Arkhangelskoye state museum (a pre-revolution Russian nobleman's country estate started in 1703 that included tours of the house and its fine art collection and grounds); and a museum estate that claimed to have the "Little Boat of Peter the Great."

Twice the combined American and Russian groups boarded large buses and were driven for day trips to distant historical places.

Dinner Banquet at a Grand Duke's Fortress

The day trip during my first visit was a 2+ hour drive to a small city (Rostov) where we toured a 17th century grand duke's fortress. We were met by people in traditional folk costumes including a woman who presented us with bread and salt (an old tradition) as we entered the fortress. We walked on the walkway atop the rampart (outside defensive walls) that had been used by solders to defend the fortress, peered through the slots for archers and saw nothing but cleared, flat land for about a mile before entering heavily forested land. Being a cold, blustery

day, it was not hard to imagine how miserable you could be if you had sentry duty during a classic Russian winter night. A tall roofed room was at each of the four corners of the outside walls walkway; a couple appeared to have been small chapels. Painted on the plaster walls inside the two rooms were many very old appearing religious icons. But what stood out were the pocket marks all over the wall's surface including the icons. They looked like bullet marks. Our guide did not explain the marks. Maybe it was just the plaster flaking off, but I doubt that based on the randomness and depth of the "marks." In any case, something happened in those rooms that I would not have liked to have been a party of or to have witnessed.

Within the fortress was the duke's banquet hall, a long room with a semicircular cross section like a small Quonset hut. At its highest point the ceiling was about 20 feet. Waiters entered through the many doors along one side of the room. Unknown to visitors, the roof's design allowed a conversation, even a whisper, spoken next to the wall on one side of the table to be heard as clear as a bell by anyone seated or standing next to the wall directly opposite the speaker. We were warned that guests had to be very careful about what they said. The walls were listening. Our guide, of course, related stories of intrigue, treachery and murder especially as more and more vodka was consumed. The fortress hosts treated us like royalty, providing us with a feast for our meal, wine, and vodka for toasting. We tested the whisper cross-over legend a number of times. I was unable to prove the legend was true. Too crowded and noisy!!!

Hydrofoil Ride - Mushroom Hunt

The day trip during my third visit was 1+ hour hydrofoil ride on the Moscow River to a remote area that I believe was a park, perhaps Elk Island National Nature Park, to hunt mushrooms in the forest. Most of us Americans had never picked wild mushrooms and identifying the edible versus poisonous was not something I knew how to do. The only edible

mushrooms I knew were on pizzas, in mushroom soup, or sold in grocery stores. Most of the Russians were really excited about the hunt and planned to cook them as part of our lunch. It was a cool, damp but pleasant morning for our adventure. We split into small groups and began our search. Our hosts were very helpful and, of course, we trusted that they knew which were safe to pick. It was a little disheartening to be informed that each mushroom I found was either poisonous or non-edible. During our walk through the woods with our Russian counterparts we came across a village with children playing in the roadway. We did not enter the village fearing that this could be part of a "protected area." We had been warned to not go outside the boundary of the woods.

Playing "Football" with the Russians

As we gathered together in an open area about an hour before time to return to the boat, the Russians produced a soccer ball and began "warming up." We were immediately challenged to a "football" game. It did not take long to see that none of the Americans including myself had ever played soccer. That did not deter our Russian friends. Game started and ended quickly. We could not run with the ball, dribble, pass, or properly kick the ball. We did not know the rules or even how you scored. They made us look so embarrassingly bad, it was quickly agreed that we should stop.

Then the Russians split into 2 teams and played quite aggressively as they demonstrated their skills. I watched, while others drifted away. If only we had an American football or a baseball bat and softball to challenge them. As a side note several years later I volunteered to coach both my son's and daughter's youth soccer teams here in Clear Lake City. I coached both teams for nine years until the players entered high school. In 1986 our last year of youth play, competing at the highest competitive level available for youth soccer in Texas, the boys team

(Under-16 Clear Lake Sonics) was the South Texas State Champion for the fall season and the girls team (Under-14 Clear Lake Cougars) were the South Texas State Champions for the fall (Club) and spring (Regional) seasons. Following the 1986 spring season the girl's team represented South Texas in the Southern Regional of the U.S. National Youth Soccer tournament.

Dinner - Russian Space Food

Upon returning to the hydrofoil we were informed that dinner had a "surprise" menu and would be eaten during our cruise back to the Port of Moscow. The surprise was Russian space food! On the dining tables next to each of our plates they had placed five tubes, each a different space food. Each table had several large bowls containing packages of space food cubes still in their thick, plastic wrapper. Several scissors were next to the bowls. Space drinks were provided in their flight tubes and cans for all 120 of us. Our plates were served with a helping of large chunks of "meat and something, maybe fat" in a "gravy." We were told we were eating the same meals of space food that the cosmonauts ate in space. My first impression was that Apollo had a much larger variety of food and drink selections than what the Russians shared with us on the hydrofoil.

Sampling was "fun" but not tasty or filling. We had no idea what we were eating. I ate little more than a spoonful of each item; many items seemed to taste the same. Having tasted a variety of Apollo space food in 1966 as a member of Suzanne's taste panel, none of the Russian items were as good. Contents of some of the tubes had "globs" of fat and most were very "greasy." Some of the Americans were not adventuresome at all when it came to eating "strange looking" food. They opted to not open their tubes so I collected many samples and carried them back to Houston to share with Suzanne. We taste tested a few tubes. She was equally

unimpressed. The remainder I stored in a box in a closet. Years later an odor was detected coming from that closet; most of the tubes had begun leaking (metal corrosion from the food contents inside the tube). We threw the remaining tubes away.

Day Road Trips in Russia – Rules of the Road

During the day trips our two buses were always escorted by a small white militia or police car with a flashing blue light on the roof that stayed about 10 car lengths in front of us, and a second police car that stayed a similar distance behind us. Outside the city we drove on narrow, paved, two lane roads. One of the rules of the road was that militia cars with their flashing light and escorted buses drove down the exact center of the road. Any approaching vehicle had to move onto the dirt shoulder of their lane and remain stopped until we had passed. Rarely did I see a sanded shoulder. No vehicles passed us. We stopped only at the security check points between "regions" where "travel papers" and the "internal passports" of our Russian hosts were checked. The Center Federal District which included Moscow had 19 regions. We passed through 1 or 2 check points each trip. All occupants had to have an "approved passport" to go from one "region" to another. Where and how you obtained a "pass", I do not know. Our hosts always had the "right papers." Maybe the requirement to have a pass and the control over issue of passes were major reasons we saw very few personal vehicles on the roadway during our trips. There also was a law that if a Russian citizen stayed longer than three days in a region other than where his internal passport indicated he lived, he had to register with the local police.

There was a heavy rain the day before one weekend's trip. As we rode with our militia escort I was saddened to see many of the pulled over vehicles, mostly cars hubcap to axle deep in mud. In most cases the occupants were standing behind their vehicle, looking to see who was in

the bus. I didn't see any anger. I'm sure some were not happy, but whenever the police or militia was involved, nobody argued with them. I wondered what means they used to free their vehicles from the mud.

Dachas and Small Villages

For those riders that did not fall asleep during the bus rides there was a new world to see. I really appreciated the advantage of being in a bus with the seats and windows above the cars. That position allowed me to see over the wood and metal fences and overgrown shrubs in front of the many colorful and very old looking small homes and businesses on the outskirts of Moscow. Traveling further beyond Moscow's urban area we passed many heavily forested areas intermixed with large cleared open and agriculturally cultivated areas that usually included several small villages. Many villages were very small with 20 to 100 very old looking wood constructed small single level homes. Each Dacha or country cottage was surrounded by a small fenced yard that included small gardens and one or more out buildings. Most, if not all of the Dacha's had gingerbread trim along the roof edges, above the front door and surrounding the windows. Many were painted in bright colors: yellow, green, blue, red, etc; others had badly faded paint or no evidence of ever being painted or lived in for decades.

The highways we were driven on seemed to always pass beside the small villages, not run through them. I remember one village in particular that looked like it never left the 19th century. Our "caravan" had stopped for a rather lengthy red traffic light. The village's main road was a dirt road that started at the highway and was deeply rutted as it traced a crooked path through the village. There was absolutely no order or grid-like placement or orientation of the houses. Thus, the single road went whichever direction had been needed to pass the front of a house. There were townspeople and children walking on the muddy, pot-holed road. A few walked next to the

road; I could not see evidence of sidewalks. One man had the physical appearance and dress of a Rabbi from the 1800s. He and several other men and women wore wooden yokes on their shoulders that held two buckets. Everyone looked to be in good spirits. I saw oxen, horses, cows, geese, ducks, chickens, pigs, etc., scattered among the houses. The look of the village and dress of the people reminded me of scenes in the movie "Fiddler on the Roof." I was truly amazed to see that this way of life still existed in 1974. All of the villages I saw seemed to have crooked paths made into dirt roads that may have first been ox or cow paths. Also next to the paved road each village had a covered bus stop.

At another village I saw a large group of motorcyclists that had stopped to let us pass. Most likely it was a club ride. What made the scene memorable besides they and their bikes being totally mud brown colored or maybe mud covered was that the riders' bikes looked like they were from the 1930s or World War II. The clothing and leather helmets looked like our cyclists wore in the 1920s and 30s.

We also passed an airfield filled with vintage single engine propeller airplanes that also looked like they were built before the Great War (World War II). They may have been private planes on a private air field or a "boneyard" for old airplanes. As much as I wanted to I did not photograph the airfield or planes heeding the caution about photography we had been given prior to our trip.

Passing Time during the Bus Rides

During the Saturday excursion's long bus ride on my first visit, we discovered that many of our Russian hosts loved to group sing. Not "100 beers on the wall," not just Russian songs, their repertoire included foreign songs sung in the original language including American songs **in English**. Songs from movies like "Oklahoma," "Sound of Music," and "My Fair Lady;"

patriotic songs like "America the Beautiful," "Battle Hymn of the Republic," and "Dixie," and church hymns like "Silent Night" and "Amazing Grace." These were the engineers, secretaries and support staff who could not speak or understand English, but somehow they knew and correctly pronounced the words to "our" songs. Even more surprising was the fact that they knew the words to second and third verses.

And of course, we were challenged to join in by our identifying a song and having only Americans sing it. Quickly, we discovered that almost everyone knew the melody and the first few words. Unfortunately, most of us could not remember the remaining words of the first verse. But we could and did hum the melody quite nicely. No American attempted to harmonize. A few mumbled words and phrases could be heard as we hummed the second verse. We didn't attempt a third verse; we fell silent. Sometimes the Russians would then sing that same song and we would join in because they jogged our memory of the words. They knew our music better than we did. Of course, some really gloated about this situation.

Even before we returned to Houston I had decided that that "situation" was not going to happen again; we would do better at group singing. I'd enjoyed group singing in 4-H and high school and could tell that many in our group also enjoyed group singing. We needed music sheets, like were handed out for the banjo-strumming sing a-longs in many pizza parlors of the 1960s. The pizza parlor song sheets had the words to multiple verses of short "fun" songs that most of us had learned while growing up. I began my quest but did not limit the types of songs to be collected. When I finished I had a 34 page "book" of verses for 329 songs that included pizza parlor, beer garden, folk, Irish, religious and others. I made copies of a shortened 10 page 78 song version and of the full book that for the next two trips to Moscow I carried over in my luggage and waited, telling no one.

A year later I was on my second trip to Moscow. Again, during a Saturday outing we were on a long bus ride. This time as soon as the Russians started singing, I distributed songbooks among the Americans. With so many songs in the books, we joined with them on the American songs they chose to sing. All I had to do was call out the number of the song. Again we were asked to sing by ourselves. Our turns went unbelievably good. What made it even more special was the discovery that I was sitting next to someone who had a great trained singing voice. He was our interpreter, Alex, from the U.N., a Yale graduate and former member of the Yale Varsity Glee Club. He knew the tenor part for most of the songs in my collection; I knew some of the bass part; and a couple of other guys filled in the baritone and second tenor parts. We continued challenging back and forth for the other to sing another song. As we listened to ourselves our confidence began to soar. When the four of us began singing "Holy, Holy, Holy" in four part harmony, the Russians raised their hands and shouted, "No, no, no more, Stop." [Laughter]

It was a total turnaround. Admittedly it was only because we had the words in front of us, but the experience was a lesson for me. "Try, observe, adjust, prepare, and then try again." If you request me to participate in something I have not done before, I will try my best to do the task well and observe the other performers and their results. If I expect to be asked to do this or a similar task again, I will use my observations to adjust and further prepare (which may include adding a few aids to help me) before I try again. I do not want to repeat the same mistake(s). I will be prepared should a similar situation arise. This process sure worked when I was coaching soccer.

Where Are the Restrooms?

None of the buses provided had onboard restroom accommodations. That was not a problem for our short weekday rides. However, on the long weekend rides we also discovered there were "no planned potty breaks" while en-route. Again, it was not a problem going to our tour destination but for the return trip, not good planning, as we experienced during the lengthy drive to Moscow after the banquet at the fortress near Rostov. All of us had consumed lots of liquids, be it vodka, wine, mineral water, or de-gassed water. About 30 minutes into our ride a few people start saying: "We could really use a bathroom," or a potty break. It was translated and told to the Russian driver. He continued to drive, asked again he contacted the other bus and the two police cars.

As a result of that discussion our driver quickly stopped in the middle of the two lane road and turned the headlights off. It was dark in the bus and even darker outside. We appeared to be in a forest with many trees on both sides of the road. We could not see any evidence of civilization next to us or in the distance. There was very little moonlight. We used our camera flashes to obtain momentary glimpses of the roadside. We could see tree trunks and brush close to the road, but peering a couple feet into the forest, it was totally dark. There had not been and still were no cars coming or going. The police cars with their blinking blue lights were at least 200 yards away. No one had told us why we had stopped; we were expecting that when we stopped it would be at a Russian version of our roadside convenience stores, Stuckey's or Nickerson Farms. Fact is I do not remember seeing a roadside store on any stretch of open roads in Russia. The very few gasoline stations I recognized all had a large sign with the word "Benzene," and all were located within Moscow's suburbs. I admit that I had a little concern

about what was going to happen next. I had read too many stories about World War II and seen too many "adventure" movies.

Suddenly, we hear, "Girls on the right, boys on the left."

After a lot of quizzical looks and snickers most of the guys including myself left the bus to find a tree and do our business. The Russian women expressed no concerns and also exited, but none of the American women got off. Returning to the bus the men started teasing the women, even offering to have the bus driven further down the road to give them more privacy.

"No thanks, we can hold it," was the reply.

Everyone re-boarded and we proceeded down the road. I could hear mutterings between the women. We had gone less than five miles when one of the American women said, "Okay. If the guys can do this, we can do this." There was unanimous agreement among the American women. Again calls were made and the drivers all stopped their vehicles. We were still in a dense forest with trees on both sides of the road. Again, a few camera flashes went off to confirm there the presence of a small, dry ditch, and no fence. We promised and did not use our camera flashes while the women did their business. Once back onboard, everyone slept comfortably for the rest of the drive back to the hotel. This type of potty break while on the open road must have been our Russian colleagues' custom. Having grown up on a farm, this was not a new experience for me, but to do it next to a public highway with mixed company in a foreign country was a novel experience. After that I was curious if this was also the custom during daytime, but we never put ourselves in a situation where we could test that concern. I chalked it up to being part of the cultural learning experience.

Reasons for Cancelling Post-Trip Travel Plans

When the last day of each visit arrived I was ready to leave, but always felt that if a longer stay was necessary I could easily accept that decision. I really enjoyed developing and assessing the technical requirements and design, preparing and participating in the technical meetings and the experiences gained while seeing, hearing, and absorbing the culture and customs of Moscow. If further work needed to be done in Moscow, I would have willingly stayed until the work was completed. However, there were others in our travel party that could not get back on U.S. soil soon enough. The list of reasons included: some understandably missed their families or significant other or some disliked the food, often describing the entree as "mystery meat or mystery fish," being too greasy or not cooked to their taste. They wanted American food: steak, pizza, French fries, a Big Mac, or Mexican food. I will admit that I didn't particularly care for cold soft boiled eggs, a popular breakfast item or dried copper colored whole fish that some of our Russian colleagues carried in their coat pocket, their version of a beef jerky snack.

Some disliked the weather. It was too cold, wet, windy or hot. For example, the institute and hotels did not have air conditioning; in May that often meant sweating while at work and for comfort while sleeping cooling your room by opening and periodically during the night adjusting your hotel window and that assumed the street and bird noise during the night did not bother you. Some disliked the length of daylight. In summer the sun came up too early or stayed up too late. For example, in May the sun rose at 5:15 am and sundown was at 9:30 pm, but the sun's glow before rising and after setting would last for hours which resulted in the birds seeming to never quiet down.

These and other experiences were sufficient reasons for some to cancel whatever travel plans they had made pre-trip for a short rest and recreation period in Europe. They would find, re-ticket and board the plane that had the fastest route back to Houston. I did not change my post-Moscow travel plans for any of my three visits.

Flying out of Moscow after First Visit

My first trip's joint session was completed on October 19. The next day's weather turned to a gray overcast and much colder than we had experienced the previous 12 days. As we arrived at the airport Moscow was experiencing a light snow, its first snow of the winter. It was a good time to be leaving. Again, the airport was tightly controlled with uniformed military militia seemingly everywhere. Only passengers with a ticket could go past the airline check-in counters. In this waiting area were several "rubles exchange" windows where all your rubles were to be given to a not-so-friendly person who converted them to your preferred "hard currency" like dollars, marks, or pounds at a rate set by the Russian government.

Passengers could only leave the post check-in area to enter passport control when their flight number was called. The result was we spent a lot of time in many queues. Passage through Passport Control was slow but steady. Then we queued up again in one of several lines for a physical inspection of each traveler's luggage contents. Not all of the luggage was opened and hand searched, seemed to be random selection. They had the most interest in antique Russian made articles that were "souvenirs" about to leave the country. We had been forewarned that some articles such as old books, paintings, old award winning samovars, silver and gold pieces could be confiscated. And, it was rumored that some possibly questionable souvenirs did leave on our planes. After the inspection our luggage was taken to be loaded on the airplane. We entered a second floor holding area, again waited until our flight was called,

then walked down a flight of stairs to the tarmac and boarded a bus that took us to our plane. With the many checks they had in their process, I did not see how anyone could "miss their plane." They would hold the plane until they found you.

The Nervous Passenger

It was my second trip to Moscow while waiting in the airport terminal for my flight to Stockholm that I observed the militia in action. The second floor holding area had large windows that allowed a panoramic view of the airfield and bus boarding area. While in the holding area I observed a slender, chain smoking man nervously pacing back and forth. He was obviously sweating, frequently wiping his face with his handkerchief. Repeatedly, he approached a window and appeared to be searching for someone or something, then returned to pacing. This continued for a lengthy period. And, of course, mingling with us were several uniformed "airport militia guards." One guard with an officer's insignia showed a "casual" interest in the nervous man's behavior. The man's plane was called before ours. Standing near a window I watched the man descend the stairs and start to walk to his bus. The officer stood at the next window also watching the man descend until he reached the tarmac. The officer then nodded to another guard on the tarmac; immediately two guards walked up to the nervous guy and escorted him off in a different direction. I don't know why the guy was so nervous, but his behavior throughout this period was a blinking beacon of light that no security guard would ever miss. I have always wondered if that man boarded his flight that afternoon. I doubt it.

Entertaining our Colleagues in Houston

During the Russians stays in Houston they were provided several American cultural experiences that I was invited to attend.

Astrodome Visit

One of the large group events I attended was a bus trip to the Astrodome for an evening Astros baseball game. We were escorted and seated in team owner [Harris County] Judge Roy Hofheinz's private suite high above the right field seats and introduced to the crowd during the game's opening introductions. We enjoyed an excellent barbecue buffet dinner and had plenty of liquid refreshment, while watching the game either on television monitors or from the seats outside the suite. The suite was wonderfully, uniquely decorated. Unfortunately, the Judge's seats were so high and far away from home plate that it was really difficult to see the baseball and any finesse in the player's movements. The closed-circuit TV monitors provided a much better view of the game. I spent most of the evening trying to explain the game of "baseball" to a group of Russians that had no knowledge of the game and expressed limited interest. It was very confusing for them and frustrating for me, yet it was a truly enjoyable evening. My impression was that the Russians were much more interested in the construction of the Astrodome and the buffet offerings than whatever was happening on the field.

Frontier Village and Rodeo

Another large group event with our Russian visitors was a Saturday visit to the frontier village on former Texas Governor Bill Daniel's historic Plantation Ranch near Liberty, Texas. We enjoyed a Texas style barbecue lunch, toured his collection of more than two dozen restored East Texas historical buildings on an Old West style dirt street that included a town hall, saloon, livery stable, school house, mercantile store, grist mill, etc., and observed a small rodeo. After lunch while we sat on the storefront porches and others were kicking up dust in the street a parade formed up. The parade of horses and riders (some were our Russian colleagues) was followed a Wild West drama that included a couple shootouts in the middle of the street between

the good and bad cowboys. We were told that the good guys were the ones wearing white Stetson hats. Each of us was then offered a white cowboy hat. Then it was rodeo time. We walked to a corral where some watched from the stands, others peered through the fence. The performance included demonstrations of bronco riding, steer wrestling, calf roping, barrel racing, outing.

A Second Western Outing

A different location in northwest Houston was selected for another Western themed group outing held on a Saturday in January 1975. This occurred during the sixth and final visit by members of the Russian Working Group 5 before the July launch. The meetings were primarily focused on assessing results of tests involving the DM and Soyuz ECS and reviewing and approving documentation that was being exchanged. The outing invitation included all of the ASTP Working Group members and their spouses. Early action was at the stables for horse riding lessons greatly needed by our Russian colleagues. Acts included a sharp shooter gun demonstration and another staged gunfight in the street. Again an excellent barbecue buffet was served while country and western music was played and sung by two groups including the LaFrance Sisters.

Home Visit in Moscow

During each of Russia's Working Group 5's visits to Houston, at least one of us would host an evening party in his home for all group members and their spouses. We hoped that the home visits would be reciprocated by our Russian friends when we were in Moscow. We were told not to get our hopes up to high. Fortunately, we received one invitation. It was for a short visit by five of us during early evening to Yevgeniy Klimenko's apartment. His responsibility was spacecraft thermal control, a subgroup within our Working Group. His apartment was in

one of the large apartment buildings within a large group of older apartment buildings, probably constructed in the late 1950s. The building's one elevator did not work, which he explained was the normal situation, so we walked up to the fifth floor. In a very small three-room apartment, three generations were living: his mother, he, his wife and their son, who was a young teenager. The kitchen, which was part of the family room area, had a very small gas stove, sink and a refrigerator that was a little larger than a standard size igloo ice chest. In the family area were a small breakfast size table, several wood chairs, a small couch, and a black and white television, which while we were there was tuned to a soccer match. The other rooms, a bathroom and two bedrooms were much smaller. Family photos and other mementos were on the walls. We had a very pleasant visit with the family and greatly appreciated the opportunity he provided us. It obviously was a very cozy arrangement. Multigenerational living was the norm for housing accommodations in Moscow at that time. We had been told that most married couples waited years to get approved by the government for their own apartment. I did not see any single family houses or dachas inside the city of Moscow.

Home Visits in Houston

My wife and I hosted an after work social gathering in our home for the Russian and American members and their families of Working Group 5 and my NASA work group branch in CSD. It was a potluck buffet with lots of socialization. Walt Guy hosted very nice dinners and social parties in his home; usually his were our unofficial, official "group" party for Working Group 5 members where we exchanged small mementos before our colleagues returned to Russia.

Ping Pong and Arm Wrestling

During the gathering at Wil Ellis's home in January 1975, I discovered how competitive some of us can be. Ping pong and arm wrestling were the venues. The Russian General I described earlier who was an expert in astronaut training was challenging all comers. During my teenage years I had played socially and competed in an all-grades ping pong tournament in my high school; no, I did not win, but I also was not embarrassed.

I heard the General make comments about the "lack of quality play" by his American competition thus far. I accepted his request to play. He was very good. I was lucky, won the first game. He insisted we play best 2 of 3 games. We started the middle game. Never had I seen such focused determination on a person's face. Sweat was flowing, I guessed because of the hot, humid evening combined with the liquid refreshments he'd consumed. I never thought that winning or losing was that important especially at this social gathering. It was close but he won the second game. Now, the pressure really showed. As we are proceeding through the third game, I began rationalizing that winning may not be "good" for "international relations" with this particular individual. He won fairly and I needed some refreshments.

Later, it was arm wrestling and again the General was "easily" winning against all comers. I was 25 years younger than he, in pretty good shape, and had grown up on a farm where manual labor was part of growing up. We matched up, as we began he moved my arm back about 15 degrees and I held him in that position for "too long a time." We gritted our teeth, then his face became way too red and beads of sweat began rolling down his face. Observing this I continued to hold him in place. I began to understand that I had little chance to pin him, the best I could hope for was a draw. He adjusted his weight. He started muttering; now I just knew this would not end well if somehow I won. It was very important to him to "win." So,

slowly he pinned me. Neither of us wanted a re-match. That was the most competitive individual within the Russian and U.S. group members I observed during my participation in ASTP.

Novikov Visit

In Houston it was impossible to invite just one of our Russian colleagues to spend an evening with you. An "interpreter" would always be added to the group. Well, there was the exception if you were a General as told by one of our secretaries, which I will not go into any further. During their last visit to Houston, I invited Valeriy Novikov to have dinner in my home with my family. We discussed the desirability of only his coming to our home versus a rule that the Russians always travel in groups of two or more. We identified a way to achieve our goal and implemented our plan. He and his fellow travelers were to be driven to a local shopping center (Almeda Mall) for a couple hours of shopping. He would find a way to stay behind. I would pick him up 30 minutes before the shoppers expected to return to the King's Inn motel. Unfortunately, I was delayed by traffic about 10 minutes and as I'm driving into the motel lot the shopper's returned 20 minutes early. There was an instant change of plans. We had an additional guest, an "interpreter," join us for dinner.

Women in the Workforce

All of the Russian engineers my Working Group interfaced with were male and I believe that was the case for the other Working Groups. That surprised me. I had the impression that in Russia, women were fully integrated in the nation's workforce especially in the professional and technical positions of doctors, dentists, judges, lawyers, and probably engineers. With the newness of the space program, I fully expected to meet some working level women engineers and see at least one in a leadership position. After all, the first woman to fly in Space was a

Russian Cosmonaut. The only Russian women I interfaced with during ASTP were interpreters, or on the secretarial and support staff. It may be that if I had toured their mission control center in Star City or traveled to their launch site, Baikonur [U.S.S.R.], I would have seen some.

Like the Russians the U.S. engineers and management team for ASTP were nearly, if not, all male. In the early 1970s there were a few women in technical and engineering skills positions at JSC, but I did not observe them interfacing with the Russians. In the early 1970s NASA was actively seeking and hiring women and minority engineers, mostly as co-op students. Some hired during that period worked with and for me in Crew Systems Division.

I believe the small number of women engineers in NASA's workforce was because so few women in the '60s and early '70s were seeking engineering degrees. When I was an undergraduate at Kansas State, I recall only two women, both nuclear engineering students, being in any of my classes in the College of Engineering. In 1965 the student population at Kansas State was just under 10,000 with the men to women ratio of 2 to 1. The College of Engineering's undergraduate enrollment was slightly over 1600. The Department of Mechanical Engineering had an enrollment of about 300, all men, I believe.

There has been a huge change since then both in undergraduate study and in JSC's workforce. For example in 2009 Kansas State University had an undergraduate enrollment of 23,500 with a 1 to 1 ratio of males to females. The College of Engineering had 2960 undergraduates, 20 percent were women. The Dean of Engineering and his staff have spoken with me about their continuing efforts to increase the enrollment of women in Engineering.

June 1970, CSD had 165 employees, 17 were women, all either in administrative assistant or secretarial positions. Today, more than one-half of the approximately 100 members of Crew and Thermal Systems Division's technical staff are female. In the late 1970s NASA

increased its efforts to hire and promote more women and minorities in engineering positions. The early results were mixed, especially when some were promoted to positions of responsibility perhaps a little too soon. A period of time was needed for natural growth and maturing of technical and management skills to develop. That happened during the 1980s and 1990s.

Now, I see as many women as men in critical technical skill positions and in management positions at all levels within JSC. This is good!!! I wonder if a similar movement of women into the Russian space program has occurred. As a side note our son and daughter both have undergraduate degrees in mechanical engineering, from the University of California, Berkeley and Stanford University respectively. And both have advanced degrees, one a MBA and the other MD/PhD (Bioengineering) degrees.

In Mission Control with the Russians

As we approached the July 1975 launch, it was agreed that both nations would have technical experts from the Working Groups as observers in Mission Control at JSC and Star City in Russia. Walt Guy and I were Working Group 5 representatives located at JSC. My daily shift of observing with the Russian team, which my friend, Valeriy Novikov was also a member included the crew transfers. Our responsibility was to provide technical support, quick input, feedback, and insight to each other's technical team and flight controllers. Valeriy and I focused our attention on the options, actions, and procedure changes the Russian and U.S. technical and flight controller teams were assessing that involved crew transfer or either vehicle's ECS; in case something didn't work as planned.

We were located in a side room next to the Mission Control Room used for the ASTP mission. We had several consoles and monitors that allowed us to see the same data as the flight controllers in Houston's Mission Control. We time-shared who sat at the consoles and had

headsets plugged in based on criticality of events in the flight timeline. We were able to talk "real-time" to the flight directors and flight controllers in Houston and Star City and both ASTP support teams in Star City. The Russian and American technical teams staffed the room from the start of the Soyuz pre-launch timeline on July 15, 1975, through the Soyuz's Descent Module's landing or "dust-down" in Russia's Kazakh steppes on July 21, 1975.

My shift ranged from 4 hours to 16 hours a day. This allowed me to be in the room daily for systems status checks, during preparations and conduct of the four crew transfers on July 17 and 18 and for Soyuz's separation from the Docking Module, de-orbit and landing. Valeriy and I closely followed the execution of the crew activity plan and crew procedures observing and verifying that the real-time flight data for our areas of responsibility were within acceptable limits and consistent with our analytical predictions and test experience.

I listened as the Russians talked among themselves and with Star City, but I could only understand what was interpreted for me. I depended on Valeriy to tell me if a topic affected the Crew Transfer or ECS procedures or hardware. There were many discussions with Star City. Valeriy would just shake his head to indicate when the discussion did not affect us. Fortunately, only one of the major discussions was an ECS concern and it occurred during Walt's shift. As the mission proceeded I suspected there may have been a couple minor concerns worked and resolved involving the Soyuz ECS that were not shared with me, but certainly nothing of note occurred to gave me cause for concern.

The ECS concern occurred while the Docking Module was docked with the Soyuz. Sensor data indicated a possible cabin gas leak overboard had begun after the U.S. crew had transferred back to the Apollo following the first crew transfer to the Soyuz. A pressure integrity check of the seals between the Docking Module and Soyuz by the Soyuz's tunnel pressure

monitoring equipment indicated the pressure in the gap between the seals was increasing, indicating a possible extremely small (not serious) overboard cabin gas leak. The leak, if verified real, would probably result in cancellation of the remaining crew transfers. The volume for the gap between the seals was extremely small. Earlier as planned the crew had introduced a small amount of cabin gas into the gap volume. A specified time had been allowed for the gas in the gap to reach temperature equilibrium with the docking structures and seals. The Russians began monitoring the pressure for any changes. Only a small pressure change was predicted, if we had no leak. The detection of the possible leak and lengthy monitoring of the situation occurred during Walt's shift, while the flight crews were sleeping. By the time I arrived to replace Walt, the technical teams and flight controllers had most of the information needed to establish and verify that there was no leak. The pressure rise was most likely caused by the docking interface structure being heated up by the sun as the vehicles orbited the Earth.

I observed part of the interaction between members of the Russian observer team in Houston, members in Star City and flight controllers in both mission controls as they debated whether or not we have a good seal. The Russians demonstrated the same enthusiasm and carefully considered use of engineering judgment that I have seen and experienced real-time during flight anomaly interactions with our flight controllers, their back room people and JSC Engineering's subsystem manager teams in the MER (Mission Evaluation Room). The relatively quick resolution of the situation confirmed for me that the U.S. and Russian technical and flight controller teams can effectively and efficiently work together in analyzing and resolving an unforeseen problem.

Only during the actual crew transfers were Valeriy and I allowed to sit at one of the flight consoles and listen to the networks available to the U.S. flight controllers. The hardware and

procedures worked as planned. Everyone was very cooperative and professional. Shortly after the last crew transfer was completed, Valeriy and I moved to seats on the back row. Fully believing that the final crew transfers would be successful, I had that morning placed in a pants pocket two small airline size bottles of vodka. I covertly pulled them out of my pocket. Valeriy's face beamed with a big smile when I showed them to him. We discreetly moved to a corner where we lifted our bottles to "toast" the successful transfers and quickly drank our celebratory vodka. I knew I was probably breaking some rules but it sure felt good to be celebrating a great success with my Russian friend, and naturally with vodka.

Dobrynin Visit

July 17 [Anatoliy F.] Dobrynin, Soviet ambassador to the United States was in Houston's Mission Control Center as the guest of NASA Administrator James Fletcher; he witnessed the docking of Apollo and Soyuz (at 11:10 am Houston time) and first crew transfer activities. Shortly after completion of the crew transfer activities he made a surprise visit to our side control room to congratulate the Russian team for their successful efforts. I was at the console with Valeriy finalizing our review of flight data when we heard excited voices behind us. Hearing who it was, we immediately stood up. After a short "speech" in Russian by Dobrynin and response by their team leader, the Russian team, visibly excited about his visit, introduced themselves and the American team members. When I was introduced I could only think of one word of Russian. As we shook hands I said, "*Zdrastvuytye*," which is "hello."

He turned back to me, and in clear English, said, "You speak Russian very well."

I immediately responded, "*Spaseeba*," which is "thank you."

Mentally I thought, "If you only knew how few words I know and can pronounce correctly." That was the only recognition I received about my ability to speak Russian from the Russians. He was a very polite politician.

The most memorable and uplifting event of my early career occurred shortly after the Soyuz Descent Module landed (on July 21 at 5:48 am Houston time) or as we called it; "dusted-down." It was the Apollo era; we were accustomed to describing landing on Earth as "splash down." My 8-hour shift that day started at midnight. The docking module's systems were performing as planned. I watched the Russians busily prepare for the separation of the Soyuz modules. It was a tense time as many recalled it was an in-flight failure during re-entry preparations that cost the lives of three cosmonauts on June 30, 1971. All went well including the landing. Then we American team members shared lengthy heart-felt goodbyes with the Russian team, wondering if we would ever see each other again.

After the Russians left I collected my "stuff" and left the room. The door from the hallway outside our room to the Mission Control Room for the ASTP mission was open as it was during most of the mission. Nearest to the door was the EECOM [Electrical, Environmental, and Communications] flight controller's console. His responsibilities included ECS. I had worked with him and his flight control team during Docking Module procedures development and testing prior to the flight. As I approached the door to say goodbye to him, he saw me and waved his hand indicating he wanted me to sit next to him. That was the first time I was specifically requested to be on the floor in Mission Control during a mission. On previous days I had gone to the EECOM console and briefly provided the flight controller a "handover" status of what the Russian ECS engineers were working. These brief exposures immediately changed my perception of the noise level in the Mission Control room. It was quiet, like being in a library

even though almost everyone appeared to be talking. They were talking, but it was into microphones attached to their headsets and at a level that could barely be heard at the next console. It was eerily quiet, but reassuringly professional.

Going Beyond the Expected

Throughout the ASTP project I had, on my own, done parametric analyses of the Docking Module environmental control system's design; I wanted to be sure I understood what performance to expect and options were available for all possible failures and conditions that I believed may occur. In addition, I felt that during any "free" time at work I should be doing something "productive" and, I admit, I often identified and analyzed ASTP ECS anomalies and performance predictions at home.

From early 1972 until July 1975 I collected all of the ECS related requirements I could find. I created analytical design nomograms of ECS requirements. I developed analytical equations and time based prediction plots of performance for the nominal, minimum and maximum allowable operational characteristics of the ECS hardware components to be used during crew transfer and open hatch operations for the Apollo Command Module, Docking Module and Soyuz. I analyzed and plotted a time based prediction for those related failures that I believed the Docking Module ECS could credibly encounter during the mission. In most cases the plots were based on the flight instrumentation on the vehicles that would be downlinked and seen in the U.S. Mission Control Center. I collected and published the products of this effort in a 150 page JSC document titled, "Design Data and Performance Analysis Data for the ASTP Docking Module Environmental Control System," JSC 08701, CSD-AS-016.

The first release of the book was June 6, 1974. At that time I shared the book with the EECOM flight controller team for developing their flight procedures, malfunction procedures

and simulation runs. Two revisions each adding additional "anomaly cases" were released, May 8, 1975 (Revision A) and July 10, 1975 (Revision B).

Some of the analyses did not require much beyond an understanding and application of the laws for an ideal gas, thermodynamics, and fluid mechanics. I knew when and how the hardware was to be operated, but had little knowledge of how as a system it would perform or react to anomalies. Therefore, for me the major benefits of this activity were the confidence I gained in understanding the system's expected full range of performance; experience gained at identification, definition and analysis of credible anomaly situations affecting the system; and insight gained in understanding the appropriateness and techniques for identifying the system's operational limitations. In addition, I really enjoyed the systems engineering aspect of looking at the bigger picture (spacecraft level) and identifying and analyzing the options available to help flight controllers and engineering teams resolve real-time flight anomalies involving any of the three vehicle configurations the Docking Module ECS hardware would see.

This experience also helped me to more fully understand and appreciate the process subsystem managers and flight controllers go through in developing their system's operational and malfunction procedures. It was the "homework" preparation and problem-solving I imagined flight controllers and flight directors did in Mission Control. A part of me had a desire to briefly sit in the seat of a flight controller during a mission. I just did not know how fast that itch would be scratched.

My Co-Op Student Support

Before I go further I want to acknowledge the excellent analytical support provided from beginning to end of ASTP by Sharon LaFuse. She was the first female engineer assigned to CSD, beginning as a co-op student shortly after ASTP began. She was assigned to work with me

when she was not attending Purdue University. She recently retired from NASA JSC after 35 years of service in CSD. I was "old school" still using a slide rule and a four function calculator. I also used French Curves to produce a smooth curve that best fit a line of data points on a graph. In my briefcase were the three curves that I used for almost every set of data points my analyses produced. In 1971 my branch obtained a Wang calculator capable of producing x-y plots, but I had not learned how to program it. Sharon, being much more computer literate, quickly learned the necessary skills to program the Wang and produced all of the analytical plots in the ASTP design and performance data book.

I would identify a planned or anomaly event and identify possible scenarios and solution options. For example, if a solution involved adding and/or venting cabin and/or make-up gases through line(s) or orifice(s) into a given cabin volume, how long would it take to reach the desired cabin gas composition and total pressure?" I would then develop and write out the appropriate analytical equation(s) for the situation.

She converted my equation(s) into machine language, and plotted the profile.

We would look at the profile and many times I would say, "That isn't what I expected," or, "That does not look or feel right." I would re-verify the equations and re-assess the limits for the variables and the duration of the elapsed time being plotted.

Sharon would convert the changes and produce a new plot. As she became familiar with my objective she would also "fine tune" the equations and variables.

When comfortable with the plot profile, I would cut the plot to size and tape it to a blank formatted page for the book. Then I'd write the equation(s) and constants used on the same page and any assumptions needed to understand the plot profile. I did that for every conceivable combination of ECS operations and anomalies I believed could credibly happen. We produced

no more than two or three profiles a day, for one to three days a week. An equally time consuming job was performed by my branch secretary; who in addition to supporting as many as 10 other engineers' typing, telephone and office supply needs would type my text and "notes" on the same formatted page that I had placed the plot and then frequently was asked to re-type the page guided by the "red-lined" changes I had made.

One anomaly I analyzed dealt with having an unknown cabin gas composition (possibly due to inadvertently adding too much nitrogen to the cabin atmosphere) while the command module and docking module hatches were open. Both vehicles had total pressure sensors onboard, but neither the CM, nor DM had cabin gas sensors that detected nitrogen. Only the docking module had oxygen partial pressure sensors, but they would be unavailable to the crew after the docking module hatch was closed for DM jettisoning. An unknown failure requiring isolating and jettisoning the DM could occur at any time. Therefore, a rapid preventive response to this anomaly was required such as purging the atmospheric gas of the combined cabin volume overboard while adding oxygen gas and maintaining a well mixed cabin atmosphere until you achieved a near 90 percent oxygen environment.

Procedurally, a crewman verified the low pressure dump valve portion of the Docking Module's pressure vent valve switch was in the "automatic" position to expose a small vent hole for dumping cabin atmospheric gas to space. The dump valve was designed to open exposing the vent hole at 6.2 psia and as cabin pressure decayed to reseat by 5.6 psia. The flow through the vent hole orifice was sized to match the maximum flow from the DM oxygen purge valve at a cabin pressure of 6.2 psia. The crewman then opened the DM oxygen purge valve to add oxygen to the cabin from the DM's oxygen tanks increasing cabin pressure until the dump valve "automatically" opened. The crewman allowed oxygen to continue to flow into the cabin

volume until the DM oxygen sensors indicated the desired partial pressure level had been reached, then he would close the DM Oxygen purge valve. The duration of this "wash out" procedure depended on the starting composition, but the general rule was to vent three times the cabin volume of gas to achieve a near 100 percent oxygen environment in the cabin volume. My predicted maximum wash-out time for the combined cabin volumes was from 17 to 31 minutes.

EECOM Flight Controller's Request

Back to July 21, 1975, as requested I walked up to the EECOM controller and said, "I'm going back to my office. See you later."

He replied, "Please, sit down. We've got a problem here that we haven't really worked before. Have you by any chance looked at this situation?"

It was the unknown cabin atmosphere composition problem I just described.

He outlined their situation. "The crew reported the Docking Module's Nitrogen gas supply switches were in the wrong position (open, increase). They quickly placed them back in the 'Closed and Off' positions where they are supposed to be. But we don't know how long the switches were in the open position. We know nitrogen has been added to the cabin atmosphere. We know the cabin's gas composition, because we have the Docking Module's oxygen partial pressure sensors and it is lower than we wanted at this time. Have you analyzed a 'wash-out' procedure that would get us back to a near 90 percent oxygen cabin while the hatches are open?"

I was surprised by the unexpected request but quickly replied, "Yes, I have the plot of one that I've analyzed here in my book." It was one of the last "anomaly cases" I had analyzed and after a brief search I located it on page 147b in Revision B of my document, released five days before the mission started (too late for the EECOM flight controller's team to be trained by ASTP's flight simulation team). I briefly described what I assumed for combined cabin volume,

ECS configuration for the DM and CM, and crew procedures. Then I described the equation I used to predict the change in cabin oxygen partial pressure during the purge and explained how to interpret and use the resulting plot shown on the page. I had plotted the change (increase) in the combined cabin atmosphere's oxygen concentration (partial pressure) verses elapsed time. I recommended that real-time he should monitor DM oxygen tank pressure, DM cabin total pressure and DM oxygen partial pressure. If tank pressure is decreasing oxygen must be entering the docking module atmosphere. If cabin pressure is holding below 6.2 psia you must be venting, thereby, washing nitrogen out of the cabin atmosphere. To insure a good mix, the crew should verify the suit hoses are in place to mix the docking module with the command module atmosphere. To monitor the procedure's progress I recommended using the plot to compare the actual DM cabin O2 pressure reading with the predicted reading for the same elapsed time.

He thought about it for a few seconds then said, "Okay. It looks simple enough. We haven't simulated this, but you believe that it will work?"

I said, "Yes, it will work."

He asked me to plug my headset into the EECOM console so I could listen to his conversations on several of the networks in Mission Control and respond if needed. He then briefly discussed my recommendation with his backroom support team. He concluded with, "OK, let's do it."

He immediately called the Flight Director and as best I can remember said, "On our cabin atmosphere situation. I've got a guy here I trust. He has a procedure for washing out the nitrogen. We haven't sim'ed it, but my team and I went through it. It's simple; it seems to be straightforward. Here's what it is." EECOM then described the ECS configuration to be used and outlined the procedure.

The Flight Director asked EECOM a few more questions then he immediately requested CapCom [Capsule Communicator] to be prepared to pass the procedure steps to the flight crew. EECOM provided the procedures via paper, then described and confirmed the steps with CapCom. In a very short time I heard the procedures for "my recommendation" being called up to the crew onboard Apollo for immediate execution.

During Apollo we did not have TDRS [Tracking and Data Relay Satellite] providing 24 hours, 7 days per week communication coverage. Communication periods were limited by the distribution of ship and land communication sites around the Earth and orbit of the spacecraft while circling the Earth. During low Earth orbit Apollo often experienced LOS [Loss of Signal] for periods lasting well over 20 minutes. During LOS all data parameters were frozen; next to each data field on the controller's console screens was an "S" for static data.

Quickly, a crewman in the Docking Module began executing the procedure. We would lose spacecraft communication in two minutes. I had already observed that this LOS would be for 17 minutes. Completion of the procedure was expected to require a minimum of twenty minutes; because we wanted to be sure we had adequate wash-out of the nitrogen. We heard the crew confirm that wash-out had been initiated.

Using the plotted curve on the page from my book, I showed EECOM what the expected end points should be. EECOM ticked on the plot in my book the starting oxygen partial pressure reading, the predicted pressure in 17 minutes and the actual readings at one and two minutes after the procedure was started. Just before LOS, the Flight Director called EECOM and asked, "How does it look?" EECOM paused a little, then to my surprise he responded to Flight by saying, "We've got our fingers here on the edge of the cliff, and we're peering over. The first

two data points look good from here. We'll tell you in seventeen minutes what the result is." Flight acknowledged and pressed on with other activities.

It was a long, long wait for me. EECOM busied himself working with his team on other EECOM systems issues. I didn't second guess the actions taken but was overwhelmed with the speed that everything happened. My confidence that the procedure would work had been reinforced by the two data points indicating that oxygen was flowing into the cabin. As we neared the end of LOS, I again showed EECOM my prediction of what the instrumentation reading from the Docking Module would be at AOS [Acquisition of Signal].

At the predicted time for AOS the Flight Director asked EECOM, "Are you seeing anything yet?" EECOM responded: "No, we still have static data."

I continued to sit, watching the screen and listening. A few seconds later we had live data. Sure enough, the Docking Module's oxygen partial pressure reading was where the analytical model predicted it would be. EECOM called Flight. "Looks like it worked. Everything looks okay. Tell the crew to close the DM Oxygen purge valve." EECOM, grinning, turned to me, and said, "Thanks." I acknowledged by nodding; he quickly turned back to view his screen and began assessing the status of the rest of his systems with his backroom team.

Feeling relieved that it worked, a big grin spread across my face; but just as quickly I realized I was no longer needed. I quietly closed the black binder containing my ASTP document, disconnected my headset, collected my stuff and again observed a calm tranquil room full of people doing business as usual. It was like nothing significant had just happened. In the reality of their world it was a truly minor situation that they routinely dealt with every flight; yet I was cruising on Cloud 9. I walked out of the room, exited the building and that was it. [Laughter]

I will admit to a being a little confused as I walked out of Building 30. At that moment I did not understand the significance to me of what I had just participated in. I did know that I felt real good, in fact I felt great. It was nearing 8 am as I walked across the JSC campus to my office in Building 7A that my mind connected the dots. I felt truly appreciated. That probably was the most uplifting experience I had as a young engineer. I remember thinking how great it would be for every member of Engineering to have at least one experience like this during their career at JSC. It also reinforced some fundamental beliefs that characterized my attitude and approach to work. Those beliefs include: "Always put your best effort into what you work on; develop your solutions by walking in your customer's shoes; and take the time to document your findings especially if someone else will operate or use your product(s). You never know when you may be called, and given a chance to make a difference."

It was when I entered Building 7A that I realized no one in the building was aware of what just happened and that they may never know, that is until now. I enjoyed the moment silently and worked until noon.

Benefits of Investing Personal Time to Gain an Understanding

Occasionally, I describe this experience when I talk with members of JSC's Engineering organizations about the lessons I learned during my participation in the Apollo, Space Shuttle, Space Station Freedom, and International Space Station Programs. I tell them, "If you have the opportunity to participate in or manage the design, development and/or test of a system for a flight Program, take the time to do a little extra work, even if some is on your own time. Do collect and document in one place all requirements effecting your hardware's design, operation, safety and reliability. Do take the time to understand how the hardware parts and whole system work, and its limitations and constraints (that includes doing and documenting your own

analysis). Any test conducted is worth taking time to document the following: all of the test objectives including the "subtle" ones; hardware and operational configuration(s) actually tested; actual conditions established and results observed for each test point; conclusions derived from the hardware's performance during the test program; and specific recommendations for hardware and procedural changes, additions or deletions. This investment of personal time and resources proved to have a major positive influence on my career."

Know Your System's Instrumentation

In addition, I encouraged JSC Engineering's subsystem managers and engineers to know and understand their systems instrumentation. A method I recommend is to role play as a flight controller or a flight crew member that is observing, operating, and assessing your hardware and system's health and performance or identifying, understanding and resolving "anomalies" in your system. This will require you to: learn and understand the nominal and off-nominal situational decisions required for safe operation of your system; become fully familiar with the flight instrumentation and development flight instrumentation's purpose, operational ranges, physical locations, and limitations for your system; become fully familiar and comfortable with the list of data displayable real-time on the vehicle and ground versus data that is stored on-board and periodically down-linked and only seen in Mission Control for your system; become fully familiar and comfortable with the flight instrumentation of vehicle systems that interface with your system that are and can be indicators of your system's health; and, to identify and understand the dependencies of other systems on your system's instrumentation.

Had My Career Peaked?

For a brief time that July, I pondered if my career with NASA had already peaked? I knew opportunities like this were extremely rare. Fortunately, JSC Engineering had

responsibility for design and development of the Space Shuttle Program's Orbiter vehicle. My almost immediate transition to near full-time supporting the Space Shuttle ECLSS design, development, and test activities helped to quickly dismiss any further concerns about what could "top" my ASTP experiences. Fortunately, during the years ahead I participated in many equally rewarding activities.

Recognized for ASTP Work by NASA and U.S.S.R.

December 1974 I was recognized by JSC with a Superior Achievement Award presented by Center Director Dr. Christopher C. Kraft for my technical contribution to ASTP of providing essentially the entire analytical base for the ECS design, development, and confirmation of the ASTP Docking Module ECS and the establishment of the transfer operations.

September 1975 I received on behalf of ASTP's Working Group 5 Life Support and Crew Transfer team the NASA Group Achievement Award from NASA Administrator Dr. James Fletcher for our outstanding contributions to the success of ASTP through technical skill and diplomacy in planning and negotiating the life support and crew transfer activities of the joint mission with representatives of the Soviet Union.

January 1976 I was recognized by the U.S.S.R. Aeronautical Sporting Federation with the Sergei Pavlovich Korolev Award and medal for technical work performed during ASTP that was presented at JSC by Dr. Max Faget, Director of Engineering and Development. Korolev was the Soviet chief designer of the Vostok rocket and spacecraft that launched the first human, Yuri Gagarin into Earth orbit on April 12, 1961.

In Mission Control Room as Technical Expert

In addition to the ASTP mission I was in Mission Control during several Space Shuttle missions providing the flight director technical information, problem resolution options, and

answering related engineering design and support questions. These face-to-face situations were always very brief. They involved either the Orbiter's Flash Evaporator subsystem that had experienced an in-flight anomaly, or a thermal technology flight experiment developed and provided by Crew and Thermal Systems Division. In each situation I was representing a larger engineering team that I had spent many hours working with inside the customer support room or MER. On several other Shuttle missions I worked ATCS anomalies with the ECS flight controller's support team in the team's backroom where the course of action was finalized without my going into the Mission Control Room. The backroom activities are not included in the mission's real-time TV coverage.

On TV While in Mission Control

Yet, a few of my relatives have told me, "I think I saw you on TV in Mission Control." My response was, "It was possible, but highly unlikely because of the very few missions and the short duration during those missions that I was on the floor of the Mission Control Room. In fact I preferred not to be seen on TV. If I was on TV, the mission had an anomaly or problem that was beyond flight control's knowledge base and required engineering support in my area of expertise. In each situation the information I provided helped the flight director and effected flight controller team understand the situation, identify, and assess the options available and achieve a successful conclusion."

Long-Term Requirements for ECLSS on Future Vehicles

Personal benefits of participating in ASTP included the technical knowledge I gained of the Soyuz's ECS and the frequent face-to-face interactions with the Russia's ECS design engineers. The Soyuz's ECS design philosophy and hardware's capabilities were no longer a

mystery. And, I truly valued meeting their ECS design engineers, working together as technical colleagues and becoming personal friends.

After the Apollo-Soyuz flight there was renewed interest at JSC in developing jointly agreed requirements for compatibility between our future vehicles that as a minimum would support crew rescue by either nation. Preparatory activities were organized using the ASTP working group's structure. I prepared the U.S. recommendations draft for ECLSS. Design capabilities addressed included cabin atmosphere composition, conditioning and limitations; shirtsleeve intra-vehicular crew transfer accommodations, provisions and interface hardware; and space suited extravehicular crew transfer accommodations, provisions and interface hardware. My recommendations were based on Phase B Modular Space Station studies recommendations, ASTP lessons learned, and Space Shuttle Orbiter requirements.

Areas addressed in the draft for the cabin's pressurized environment included allowable ranges for the cabin atmosphere's total pressure, temperature and humidity; allowable major atmosphere constituents and range of their partial pressures; and a list of potential atmospheric trace contaminants in U.S. vehicles and their maximum allowable concentrations. For shirtsleeve intra-vehicular and space suited crew transfers, I included minimum allowable hatch opening size, provisions access enabling to be on the vehicle, umbilical interface provisions, and composition and rate gases would be vented by space suits Other areas addressed included human factors such as noise limits, color coding and labeling.

Unfortunately, this activity quickly withered on the vine. The Russian leadership did not express interest in exploring the subjects of crew rescue or joint missions with future generations of spacecraft until the mid 1990s when the International Space Station Program was conceived.

And, by 1975 our focus had turned to designing and developing the reusable Orbiter for the Space Shuttle Program.

I do not know if my draft of long-term compatibility recommendations was passed on for review by the Russians; I received neither feedback on my draft, nor an equivalent Russian compatibility recommendations proposal. Work on this subject stopped in early Fall 1975. I do not believe that the long term requirements for ECLSS compatibility between U.S. and Russian vehicles I prepared had any influence on the Mir's ECLSS design.

Regenerative Life Support

I was curious about the Russian human space program's progress in developing regenerative life support technologies. The subject had not been discussed in any depth with the Russian ECLSS specialists as we planned and executed the ASTP test flight. Post-flight while doing literature searches for developing the long term agreements, I found a few "summary" descriptions in technical society papers of vehicles having a closed loop, regenerative ECLSS authored by Russian "specialists" I did not know.

The papers outlined proposed plans and major features of vehicles including brief descriptions of systems including ECLSS that "will" be part of Russia's "next" generation of space stations. However, during an early technical interface meeting's discussion of technical descriptions of processes and systems available in the open literature with one of my Russian counterparts, he "suggested" that some of these conference papers describing new manned vehicles were "proposal ideas" that often did not represent what they were actually working on. Thus, you could never be sure that what was written was real.

As time passed I found that the technical descriptions of their "new" space station vehicles and systems were fairly accurate but the development schedule and projected first flight

dates were greatly underestimated. I also found Russian authored papers that described results of manned, long duration ground chamber tests involving regenerative life support technologies for oxygen generation and potable water recovery that appeared to be very similar to the technologies we were developing for use on our future space stations.

Salyut Vehicles

Salyut I was launched in April 1971, advertised as the first space station, designed for long-term flights of approximately one month. That June Salyut I was manned by the 3-man crew of Soyuz 11 for 23 days. During their stay in Salyut, a large Russian delegation arrived in Houston for the first joint discussion between specialists of requirements for rendezvousing and docking U.S. and Russian space vehicles. At the conclusion of the five days of meetings, it was decided to base planning on an experimental flight in which Apollo would dock with "a manned orbital scientific station of the Salyut-type." In addition it was suggested that a subsequent experimental flight might be conducted with Soyuz and Skylab. Tragically five days after the Russians left the U.S., the Soyuz 11 crew died during re-entry of the Descent Module. Of course those of us working ECS were saddened and very interested in the findings of the Russian experts which we reviewed closely in the summer of 1973 as I described earlier. During the remainder of the summer of 1971, the JSC study team focused on a single Apollo-Salyut flight. I was asked to gain a technical understanding of the Salyut ECS and provide an ECS design for an airlock module which became the Docking Module. The loss of the Soyuz crew in June did not change what I was requested to prepare. Earlier in this session I described the difficulty of finding technical descriptions of Salyut and Soyuz systems.

During the April 1972 meetings in Moscow, the Russians proposed changing from the Salyut-type vehicle to the Soyuz for the test flight in 1975. It was reported that the Russians had

concluded that it would not be technically or economically feasible to fly the mission using a Salyut-type vehicle. Salyut I's design had one docking port (needed for Soyuz); it would be difficult technically and very costly in time and money to add a second docking port to accommodate a U.S. vehicle. There was also speculation that because we were in the Cold War era, Salyut or as we later learned of a military version, Almaz may have had "special equipment" onboard for military purposes. I did not see or hear of any hardware or operations that supported this suspicion, but the military space station version, Almaz was real.

Following the April 1972 meetings, when told to focus on the Soyuz for our ASTP flight test, I no longer closely tracked the other Russian manned vehicles being flown. Two years after Salyut 1, the next Salyut was launched. Salyut 2, a prototype military space station (Almaz) launched in April 1973 but had an engine failure that caused it to crash before it was manned. Cosmos 557, launched in May 1973, was of the Salyut 1 design and reportedly was for taking spy photos of the ground also experienced an engine failure that caused it to crash before being manned. Salyut 3, launched in June 1974, was a military space station of the Almaz design and occupied by 2 crewmen for 15 days. Salyut 4, launched in December 1974, was of the Salyut I design and occupied by 2 crewmen for 92 days. These Salyut vehicles supported three man crews with an open loop ECLSS like on Salyut 1 and Soyuz. Additionally, during Salyut flight's 3 and 4, a humidity water recovery system was tested. During Salyut 4 they also conducted a closed cycle plant growth chamber experiment that cultivated peas and onions. By 1975 the descriptions in the open literature of Russia's future vehicles to be flown in the late 1970s and 1980s all included regenerative life support processes for water and oxygen recovery.

While having lunch in the JSC cafeteria during his last Houston visit in November 1975, I briefly approached Valeriy about the on-going and near-term regenerative life support

technologies described in the open literature as being pursued for their future space stations. I told him there were widely varying conceptual descriptions of the next space station ECLSS. And that I had pieced together the regenerative life support technologies that they appeared to be most seriously considering. I asked if they were collecting, distilling, and filtering water from urine and cabin air condensate and electrolyzing it to produce breathable oxygen? And were they collecting and sending hydrogen through a Sabatier process that combined hydrogen with CO_2 collected from the cabin using a molecular sieve process and passing the combined gas stream over a catalyst to produce potable water and methane? Were they using a filtration process for recovering water from "gray" water sources like showers, hand wash towels, clothes washers and dishwashers? Were they pyrolyzing fecal waste and trash to recover water and produce carbon?

My interest was piqued because each of these processors was part of the suite of technologies that JSC's Crew Systems Division and other NASA Centers were developing for future U.S. space stations. He "sort of" confirmed my interpretation of what the open literature indicated but in a very passive way. We did not have further discussion of the subject.

Use of regenerative processes for ECLSS on the Russian vehicles for long-term missions did become fact. On Salyut 6, launched in September 1977 and Salyut 7 launched in April 1982, potable water was routinely recovered from cabin air condensate. The Mir space station launched in February 1986 included closed loop regenerative systems for water and oxygen reuse that used processors based on the life support technologies I just described.

Post-ASTP Work with the Russians

During the remainder of my NASA career I did not interface or negotiate directly with the Russians again. The next opportunity would have been in 1993 while I was on a detail

assignment to NASA Headquarters in Washington, D.C., supporting the Space Station Transition Team in Crystal City.

I was one of three from JSC Engineering selected by the Director of Engineering, Henry Pohl to be a member of the Transition Team. Selection was based on JSC's view of the team's need for the systems engineering and integration skills and products I produced for JSC's Option C Space Station study that Spring. Our contribution supported the development of the technical rationale and conceptual design for a space station that became the International Space Station.

While at Crystal City discussions with the Russians about participating in ISS were initiated. I provided some quick look analytical data but was not asked to participate in the technical discussions. When the ISS activity moved back to JSC in October, I was asked to become a member of the ISS Program management team. This would have involved working with the Russians again. I declined the opportunity because I believed I could do more good for ISS as a part of CTSD in the Engineering Directorate at JSC. Nine months later the Director of Engineering moved me from hands-on technical management in CTSD to a senior management position within the Engineering Directorate. My staying with JSC Engineering proved to be a good decision.

Management Development Program

By 1975 I had begun seeking ways to enter the management ranks. In June 1975 I was selected to participate in JSC's fifth Management Development Program (MDP-V) for administrative and technical employees taught by the University of Houston's College of Business Administration. Class for each of the four courses (Human Behavior in Organizations, Government Science and Public Policy, Theory of Complex Organizations, and Theory and Management of Systems) were held on-site in Building 12. We met twice a week during work

hours and followed UH's fall and spring semester calendar schedule. The Program's curriculum design: assisted the participants in developing insight into the complexities of workplace organizational life; introduced variables that are important in organizational decision making; provided awareness of the forces, factors, and processes in the environment that surround complex technical organizations; and introduced development techniques for influencing and managing a complex organization within its environment. Our class of 16 completed the program on June 6, 1977 with 12 graduate credit hours from the University of Houston-Clear Lake.

Letters to Valeriy

Three times in the late 1970s I sent through the U.S. Mail short personal letters to Valeriy Novikov expressing interest in maintaining our personal friendship. Each letter's content was very benign and short. I expected them to be "screened" before delivery and did not want to cause Valeriy or myself "problems." I received no response. Maybe he had moved but I also suspected the Cold War suspicions and politics could be involved. In the late 1990s, Valeriy telephoned me at JSC while I was Deputy Director of Engineering. He was in Los Angeles on a business trip. He had not received my letters. He told me he was head of an aircraft company and doing very well. Photos he sent me showed he had aged like I have, but he had put on a little more weight than I. His English was better, much better than my Russian. Unfortunately, we could not meet during that trip and I have not had contact with him since. I am aware of a number of our Russian counterparts in Working Group 5 that, sadly, have passed on: Lavrov, Dolgopolov, Zaytsev. I am aware of the following U.S. members of Working Group 5 that have passed: Harris, Hughes and Taylor.

Docking Module for Mir

The definition of requirements and initial design activity for the Shuttle-Mir docking missions began in 1992. The Shuttle Orbiter ECLSS provided a sea-level atmosphere equivalent to Mir, thus for shirtsleeve crew transfer between vehicles no adjustment of cabin pressure or composition was required. Therefore, the technical requirements and challenges were focused on the interface between the Shuttle and Mir docking mechanisms. The Russian built Docking Module contained compatible docking interfaces that provided a permanent extension of the Mir's docking interface to afford better docking clearances for future Shuttle dockings to Mir. The Shuttle – Mir Docking Module launched on Shuttle Mission STS 74 supported eight docking missions from November 1995 to June 1998.

Personally, I was already quite busy. During the early 1990s I was simultaneously the Active Thermal Control System Architectural Control Agent for the Space Station Freedom Program and Deputy Division Chief of Crew and Thermal Systems Division.

WRIGHT: Did you work with the training of the crew?

JAAX: During ASTP I did not have direct involvement with training the flight crews. My only work related contact with the flight crew occurred during the final reviews of the detailed test procedures and conduct of the manned portion of the Docking Module thermal vacuum test in JSC's Chamber A which I described earlier in this session. Other than that event, I only saw the prime and backup flight crews when they participated in a project level joint working group session or ASTP social event.

The following are additional examples of working with the flight crews.

My opportunities to interface with astronauts and mission operations' flight controllers increased dramatically as I became a major participant in Mission Operations Directorate's Shuttle Orbiter flight techniques reviews. During many of the flight techniques review sessions of the late 1970s and early 1980s I provided and defended my integrated systems transient analyses of the Orbiter's ECLSS and ATCS subsystems hardware, consumable, and thermal performance. This was in support of the development and assessment of nominal and contingency flight procedures for the early Shuttle missions.

As Shuttle became operational in the early 1980s through late 1980s, I led and presented to Shuttle Program management and the flight and backup crews at each Mission's Integrated Hardware and Software Review (IHSR) a technical assessment describing the Orbiter ECLSS, ATCS and EVA supportability requested, agreed upon hardware and operational adjustments and resulting capability to be provided for that flight's payloads and flight experiments.

In the early 1990s, I served as Deputy Chief of CTSD whose responsibilities included design, development, production and test of flight hardware for new systems, tools and support equipment for EVA. As part of my duties in this position I chaired the test readiness boards (TRB) for the flight certification testing of this hardware in our thermal vacuum and vacuum test chambers which used astronauts, often the flight EVA crew as the test subjects.

Resolving Technical Opinion Differences

WRIGHT: When you had to actually negotiate a point with the Russians that you didn't agree on, or maybe you needed to have them adjust something, did they accept your critique and your evaluation well?

JAAX: During ASTP my participation in direct negotiations was primarily focused on the IED (Interfacing Equipment Documents) documents where we described the functions, technical characteristics, and operation of the interfacing equipment. The dialogue was usually one-on-one aided by an interpreter. It was sometimes highly technical, sometimes challenging, like "why do you need to know" or "I still do not understand" but always respectful. Both teams were seeking information of sufficient depth to understand and document the "need to know" capability and operation of the other's ECS. The information we exchanged included the functions, construction, and method of operation for any equipment the visiting crew may have a need to operate during the crew transfers and stays in the host spacecraft. Both teams were highly cautious that only jointly agreed "need-to-know" information or details were exchanged.

It was my observation that both sides respectfully accepted the critique and evaluations made by the other. My recollection of the process used during Working Group 5's negotiation discussions was that while one sides' chairman presented their position, the other side politely and attentively listened to the speaker's rationale. This was followed by an open discussion of any concerns about each others' stated position. If agreement was not obtained, the item would either be tabled until a later joint meeting with actions assigned to one or both sides, or in rare situations placed on the project's co-technical director's agenda for discussion and often a decision would be reached before adjourning that joint meeting. There were occasions when we quickly agreed to table further discussion of a concern to allow internal and group caucus by the "technical experts" on both teams. This usually occurred when the concern or issue was "new" (had not been identified prior to the joint meeting) and affected others; there would not be an agreement until the technical experts at home were consulted.

The following are examples of concerns that used this process: Working Group 5's U.S. members identified early in the Project several technical concerns about performing shirtsleeve crew transfers with the Soyuz. These concerns included lack of plans by the Russians to reduce Soyuz cabin pressure prior to the transfers would require the crew to prebreathe 100 percent oxygen and lengthy crew transfer times; lack of fire retardant clothing to be worn by the Russian crew while in Apollo CM; and lack of a fire extinguisher on the Soyuz. The Russian leader of our Working Group did not agree with our position on these issues, but since we were concerned he promised that a suitable solution would be provided by his team. And they did for each concern.

Prime Contractor Involvement with Working Group 5 Activities

Throughout ASTP civil servants from NASA JSC including myself represented the U.S. in all negotiations with the Russians concerning life support and crew transfer. For a few joint Working Group 5 sessions in Houston, a member of the prime contractor's ECS team was invited and did observe our negotiation activity but he did not actively participate in those discussions. This maintained the government to government working relationship that had been established for this project.

Early July 1972 North American Rockwell accepted a contract from NASA to modify an Apollo CSM to meet the requirements of ASTP and to develop, fabricate, assemble, and prepare for flight the ASTP DM. In 1973 the prime contractor's name was changed to Rockwell International. The conceptual design of the DM ECS was the product of NASA JSC's ASTP Working Group 5 and was provided by the Apollo Spacecraft Program Office's ASTP Working Group Technical Director to the prime contractor. Technical monitoring, coordination and management of the prime contractor's work on the ECS were provided by the NASA Apollo

CSM ECS subsystem management (SSM) team in CSD's ECLSS branch. Between joint meetings we in the ASTP working group informed and coordinated with our ECS SSM team on an almost daily basis. It was imperative that the SSM and contractor team understood our negotiation positions and decisions to insure that they were compatible with Apollo's maturing CSM and DM ECS designs.

Equally, we needed to understand the impacts of possible solutions to "open technical issues with our Russian colleagues" on the technical design and operability of the ECS in the Apollo vehicles. It was a priority to make sure we were fully coordinated, because the prime contractor provided the final design and fabricated the flight hardware. During each of the tests conducted at JSC that involved operation of DM ECS hardware the prime contractor's ECS representatives were present to monitor their hardware's performance. As I identified earlier several of these tests were also witnessed by Russian ECS experts, members of our Life Support Working Group. Those occasions enabled members of the contractor team to meet some of their Russian counterparts. The Rockwell International ECS design engineers and managers were very cooperative and supportive of my working group activities and needs throughout the life of the Project.

WRIGHT: Did you go out to Downey [California] as they were building the hardware?

JAAX: No. It was the Apollo ECS subsystem manager and his support group in Crew Systems Division who made the frequent trips to Downey and the various subcontractors's manufacturing facilities. They were the hardware managers, fully familiar with the Apollo CSM ECS hardware. They attended and actively participated in the various design reviews and monitored the design,

manufacturing, inspection and test processes and activities used to modify or build new flight hardware for the CM and DM ECS. Early in the Apollo development phase they had established and continued to maintain an excellent working relationship with the prime contractor and his subcontractor team.

Small Technical Team

My perception was that the ASTP activity was very lean organizationally involving a very small portion of JSC's technical team, and that it still stands as an excellent example of how to organize and manage a complex technical project involving international partners. My estimate of the number of JSC Engineering's 950 employees that worked half-time or more on ASTP tasks involving the Russians from 1973 through 1975 averaged no more than 30. Most of us were multi-tasking, with significant time spent supporting other Center managed activities including: Apollo CSM for Skylab and the Space Shuttle Orbiter flight Programs; in-house Space Station design activities; and various Research and Technologies Development Projects for Agency assigned technical disciplines associated with human space vehicles.

My estimate of the number of Crew Systems Division employees working more than one-half time on ASTP during those same years was no more than three, primarily within the Apollo ECS SSM group. There were 13 Working Group 5 meetings, 7 in Moscow and 6 in Houston. There were 14 different U.S. signers of at least one of Working Group 5's protocols (meeting minutes), 7 were members of CSD. The remainder included experts in flight medicine, passive thermal control, and crew procedures development. There were 15 different U.S.S.R. signers of the Working Group 5 protocols. At the completion of the ASTP activity 35 U.S. people were identified as participants in at least one Working Group 5 activity. Of these 12 were

CSD civil servants, 8 were CSD support contractors and 5 were interpreters. There were 143 different U.S. signers of all of the ASTP protocols. We were a lean, mean working machine.

Cover for Docking Module O2 and N2 Tanks

Rebecca, I see you have a copy of the artist's drawing of the Apollo-Soyuz vehicles [Robert T. McCall, 1975] on the wall. You probably know that our nickname for the two box-like protective covers mounted on the outside of the DM was doghouse. These covers provided the thermal insulation needed to protect the oxygen and nitrogen storage tanks mounted on the outside of the DM from the heating effect of the sun and cold of deep space while orbiting the Earth. Introducing the term "doghouse" to the Russian team was "amusing" but they fully understood this application.

The design was provided by the passive thermal engineers led by Tommy Taylor in Engineering and Development's Structure and Materials Division and their North American Rockwell team. Tommy was the lead of the Thermal subgroup in Working Group 5. The design worked well during the mission.

Technical Drawings and Schematics

WRIGHT: We had an opportunity to talk to Bob [Robert T.] McCall, and he described doing that painting, and—it's one of our favorites, because [of] his perspective. Speaking of drawings and things, and you had talked about the crew transfer cartoons, so did you use that same type of aspect as that when you were talking with the schematics?

JAAX: Yes.

WRIGHT: Did the Russians bring their own drawings or were you working from a set of drawings that you all were sharing?

JAAX: The Russians in Working Group 5 that I worked with did not provide "formal" drawings, only notebook sketches. They indicated their formal drawings were not necessary for our discussions. Likewise, we did not provide or use the Apollo Program D-size formal engineering drawings during any of our technical discussions with the Russians. Our practice was to use the detailed drawings to create and edit the simpler schematics and cutaway drawings of the hardware we did exchange via the ICD documents I described earlier. If changes were made to the schematics or cutaway drawings during discussions with the Russians at the joint meetings then post-meeting, we would work with the ECS SSM and follow Apollo's formal drawing control change process. I assume our Russian counterparts followed the similar practice.

NASA Report on Housing Development

WRIGHT: Well, before we close out for today, would you like to share with us about the totally unrelated project that you worked on, for the President's Domestic Council? It's very different.

JAAX: Yes. Summer of 1971 NASA Headquarters established a NASA team to participate in a study for the Department of Housing and Urban Development [HUD]. The study was to look at the needs of a new generation of homes that should not only be economical, livable, and durable as possible, but should be designed to improve fire safety, to minimize environmental pollution, and to conserve water, energy fuels, and electrical power. NASA Centers involved included the Ames Research Center [Moffett Field, California], Langley Research Center, the MSC, and MSFC. Late July 1971 MSC established an AD HOC sub-study team of 30 to 40 MSC civil

servants (my estimate based on design and report preparation activities I witnessed) who had been responsible for the development of all operational manned spacecraft and currently responsible for developing advanced spacecraft systems.

Most team members including myself were co-located in a bull-pen arrangement on the top floor of Building 36. Wil spent part of his time at NASA HQ as one of the team's liaisons with the HUD team which required daily late afternoon tag-ups with our group. MSC's "skunk-works" team's purpose was in four weeks to conduct a study and develop a technical proposal for President Nixon's Domestic Council illustrating the application of NASA technology and systems engineering approach to housing problems for enhancing Department of Housing and Urban Development activities.

This team drew heavily on NASA's in-house talents, experience, capabilities, systems engineering and integration approach and technologies for environmental control (heating and cooling systems), water and waste water reclamation, solid waste treatment, materials utilization for fire prevention, combustion sensing, structures, habitability, electrical power generation and distribution and remote Earth sensing.

To illustrate NASA's message an integrated design for a 500 unit apartment complex was conceived and evaluated. Key elements of the design were based on using NASA technologies being developed for closed ecological systems to decrease domestic use of electrical power and water, decrease domestic gaseous pollution, and reduce the burden on central sewage (waste water) treatment plants, thereby reducing HUD's projected required growth of community utilities and minimizing future housing's impact on the national ecology. The two volumes of the report were approved on September 16, 1971.

One may ask why we engaged in this activity. Remember, it was the early 1970s. NASA MSC had experienced its first RIF in 1970 and more were being forecasted. I believe that within MSC's senior management there was strong interest in demonstrating to the President and his advisors the technical versatility of our Engineering capabilities. This activity represented the type of technical challenge associated with a national need or priority that landing man on the Moon had just proven we can do. Producing additional similar studies involving national interests would engage many elements of our technical workforce and thereby allow MSC to retain much of its technical skill base as the Apollo Program downsized. In addition it would provide "meaningful, challenging work" as we waited for the President's announcement of the next human spaceflight program. The good news did not come until January 5, 1972, that the Space Shuttle would be our next major program.

Many of the housing study team members were selected from MSC's Engineering and Development organization because of their human spacecraft design experience, system disciplines expertise, and advanced technologies knowledge. This activity also needed people with a systems engineering mindset. CSD Systems Engineering Branch's Walt Guy, Wil Ellis, and I provided the system engineering, integration, and analytical models and analyses of the designs for environmental control; drinking water supply; waste water recovery; solid waste management; heating, ventilation, and air conditioning; and heat collection, transport and rejection. The three of us knew the current state of ETC/LSS technologies and their applications due to our participation in CSD's SSP ETC/LSS prototype development and integrated system testing project.

Vehicle level system engineering and design integration were a major part of our branch's skill set. My responsibilities included the conceptual design and analysis of the heating,

ventilation, air conditioning and cooling system; development of project manpower estimates; and preparation of the economic assessment of our integrated system.

We created schematics that represented ways we could integrate NASA developed technologies using regenerative and recycle processes into a ground-based subsystem for a single apartment's utility systems that would integrate into a system for all 500 apartments. I performed mass balance, energy balance, fluid flow and thermal analyses. As we approached the end, I provided a cost estimate comparison for the major installations of our integrated closed loop system versus a conventional system. There were times I did not have a good "feel" for where in the ballpark the answers should be and that "feel" is critical for an analyst to be successful. It wasn't until during the development of my ASTP design data book that I developed an instinctive "comfort" feeling about my analyst skills and results.

The study was led by Jim [James A.] Chamberlin. I do not know how much exposure the study products received at NASA HQs or within HUD. The exercise was useful to me, because it broadened my thinking about how ECLSS technologies can be applied to terrestrial problems. It also gave me my first exposure and an appreciation of the time, effort and intensity of the work that contractor proposal teams put into preparing a technical proposal. Our technology providers and vendors who were developing regenerative processors did not participate in this activity. As we neared completion of the report interest was expressed within the team to continue this outreach effort by working on similar Earth based opportunities. Shortly after both documents were completed and submitted we were reminded by senior management that the Center's business is "to put humans in space." So we stepped away and returned to designing vehicles and their systems for use in low Earth orbit and beyond.

Since we are talking about that early period, are there any other activities of interest?

WRIGHT: I had another question, going back to the beginning when you worked on the space base project. What happened to that study?

JAAX: As I described earlier, scaling up from a 3-man Skylab and Apollo CSM combination to a 60 to 90 person Space Base was too big of a leap, thus it was put on the shelf with a lot of other "space station conceptual design studies" of the 1960s and early 70s. During the summer of 1969 as this study was being conducted, it became apparent that a Reusable Shuttle, the delivery truck for the future, was highly likely to be the next human spaceflight program. And the space station that Shuttle would dock with would not be Skylab. Skylab, under study since 1965 and launched in May 1973, was a single launch space station with limited crew stay time capability. The Apollo CSM transported crew to Skylab and back to Earth. Shuttle would service a new space station assembled in space using modules sized to fit in Shuttle Orbiter's cargo bay, like we assembled the International Space Station we have today. The new space station would provide accommodations in low Earth orbit for "permanent human presence in Space." And as I described earlier a crew of six was considered a more reasonable maximum crew size.

WRIGHT: Okay. Want to check and see if there are some things you left out?

JAAX: This interview covers my career through 1975 pretty well. But is missing a couple activities that I will now add.

Skylab Repairs Expeditor

The other manned flight Program that occurred during this period was Skylab. I had minimal involvement in the design or flights because most of the ECLSS related work was led by NASA engineers at Marshall Spaceflight Center. *Unfortunately during the May 14, 1973 launch of Skylab 1 severe damage was sustained by the workshop, including loss of the\ micrometeoroid shield/sun shade and one of its two main solar panels. Immediately JSC sprang into action much like was done 3 years earlier for Apollo 13. CSD being the EVA suit and tools provider and maker of flight softgoods played a major role in this recovery activity. CSD management quickly organized a team to identify and assess technical problems within their technical domain responsibilities and provide fixes. A 9-day sprint ensued as various fix concepts and tools including parasol and umbrella thermal shields were conceived, mocked-up, analyzed, tested, evaluated, built for flight and delivered to KSC [Kennedy Space Center, Cape Canaveral, Florida]. I was assigned to provide day shift support as one of the "expediters" which meant hand-carrying hardware and paperwork wherever it needed to go. I delivered paper and hardware to test facilities on-site, senior managers in their offices and special vans outside Building 7 for transport to the T-38 airplanes waiting at Ellington Air Force Base.

Astronauts and test pilots then flew the hardware between KSC and JSC for fit checks and final stowage in the Apollo CM sitting on the launch pad for the first manned Skylab flight that launched on May 25, 1973. I remember the pressure I felt while waiting for the last hardware item to be certified and released by CSD. It was delivered at the last possible moment for stowage on the last T-38 flight to KSC before launch of Skylab 2. I have always believed there was a story worthy of a movie about how and the urgency, with which JSC pulled together, conceived, built, and certified solutions that saved the Skylab Program.

During Skylab's 3 manned missions launched in May, July, and November 1973 ten EVAs were conducted. CSD was responsible for the EVA systems and hardware. Systems Engineering Branch (my assigned branch) provided analytical support to the Extravehicular Equipment Branch including pre-flight analytical predictions of the EVA crewman's oxygen and water consumables usage, LiOH usage for carbon dioxide removal, crewman heat storage, etc. During the real-time preparation, execution and re-stowage phases of each EVA, members of my branch served as the EVA Analysis Team. We were located in a side room next to Engineering's Mission Evaluation Room (MER) in Building 45.

During the shifts I supported, I was occasionally an EVA data runner and infrequently a short term relief person for team members monitoring and recording real-time data from the Apollo CSM ECS and EVA astronaut's portable life support systems. Whenever we had air-to-ground communications we would, between data takes, observe the EVA on a black and white television. We hand-plotted flight data on graphs containing the pre-flight prediction plot and periodically provided an on-going assessment to the EVA support teams in the MER and Mission Control Center. I have a photo I took of the EVA Analysis Team at our station in Building 45 during the first EVA of Skylab 4. Shown on the photo are Walt Guy, Wil Ellis, Wayne Proctor, Charlie Seaman, and Keith Hudkins. We all looked much younger than today.

Early Work on Space Shuttle ECLSS

Crew Systems Division had actively supported the 1960s conceptual studies for space stations and reusable launch vehicles. My formal involvement in these activities began in June 1969 supporting the Spacecraft Design Study team's space base and space station projects I discussed earlier. My limited participation in reusable manned launch vehicles began with the August 1969 in-house reviews of the initial and subsequent drafts of the Space Shuttle System

Program Statement of Work sections describing ECLSS requirements. My involvement included being a member of the in-house team that assessed the resulting ECLSS designs for the Integral Launch and Reentry Vehicle (ILRV) or Space Shuttle under NASA contracted Phase A studies by North American Rockwell and McDonnell Douglas in November and December 1969. In 1970 and 1971 I provided "quick look" analytical assessments of ECLSS hardware weight, power, and volume characteristics for CSD's internal evaluations of alternate Shuttle ECLSS configurations based on my hardware characteristics data base for crew size and mission durations identified by the division Shuttle studies lead, D. W. (Bill) Morris.

The reusable Space Shuttle Program was formally announced by the President in January 1972. When North American Rockwell was selected in July 1972 to be the prime contractor for the Orbiter, CSD was assigned responsibility for Subsystem Manager monitoring of the design, development, test, evaluation, and operations activities of the ECLSS which was subdivided into five areas. Those areas were Atmospheric Revitalization, Active Thermal Control, Water and Waste Management, Airlock Support, and Crew Provisions. The Subsystem Managers' productivity was augmented by assignment of specific responsibilities to other engineers within the Division. As an additional duty, I was responsible for developing the analytical tools and conducting the analytical studies that tracked the contractor's progress on the Orbiter ECLSS and ATCS designs as an integrated system and the integrated system's ability to support payloads.

One of the products of my Shuttle work during 1973 was the ASME paper (74-ENAs-22) presented in July 1974 titled, "Orbiter ECLSS Support of Shuttle Payloads" that I co-authored with Bill Morris and R. Norman Prince, the Orbiter's ATCS and ARS subsystem managers. My contribution was describing and quantifying the baseline ECLSS services available for payloads including automated spacecraft, Spacelab, and Department of Defense missions. I also described

and quantified the payload chargeable penalties for increasing this support and identified the operational and consumable limits of Orbiter ECLSS support available for payloads. Much of the Orbiter ECLSS payload interface and support definition was based on the analyses of multiple Spacelab and Sortie Lab configurations that I provided to MSFC led study teams and in-house assessments of the prime contractor's design during 1973, 1974, and 1975. Early summer 1973 I was assigned as the Payload Accommodations team's functional area lead for ECLSS during Orbiter's Systems Requirements Review (SRR) later that summer.

During this period, I initiated and led a particularly difficult set of studies that assessed the capability of the Orbiter's ATCS heat rejection baseline design versus various hardware reconfiguration and augmentation options, and multiple operational techniques and constraints to reach a compatible integrated design for payload ATCS support. Significant changes to the Orbiter ATCS design that resulted from this effort included increased coolant (Freon 21) flow rate, positioned the payload heat exchanger to be in parallel with the cabin interchanger heat exchanger, added a two position flow proportioning valve that provides ATCS coolant flow to the heat exchangers, and changed the radiator coating material to silver Teflon.

During this time period, I also led analytical assessments of the baseline Orbiter ARS's maximum capability to support human activity in a Spacelab that had maximum dependence on Orbiter resources. Interfaces with an ARS circulation duct at the airlock hatch opening were added but no changes were made to the baseline Orbiter ARS.

1975 saw even more orbiter payload cooling assessments being performed as identification of payloads matured with periodic release of a list of Payload Models from NASA HQs containing higher fidelity definitions of each payload's requirements including payload viewing (e.g. Earth viewing, full sun, or deep space viewing, and expected heat rejection load).

To define the orbiter radiator systems heat rejection capability for various radiator configurations, mission definitions and orbital altitude, inclination and solar incidence angles, I initiated and led a parametric analysis activity that was published as a data book for engineering assessments and mission and experiment planners in the late 1970s. This was a time consuming activity that would have been much easier given today's computer and graphical presentation capabilities. For each of these assessments we looked at various candidate improvements of the Orbiter ATCS design that would enhance heat rejection capability and minimize or eliminate vehicle attitude constraints. Ideas considered included addition of supplemental water tanks, increased deployment angle of forward radiator panels, deployment all eight radiator panels, relocation and deployment of the four forward radiator panels to and from the outboard edge of the forward payload bay doors, dedication of aft radiator panels for fuel cell heat rejection and use hydraulic system as a heat sink. None of these candidates were implemented but none the less we assessed each of them.

In 1975 as I transitioned from the ASTP activities I had even more technical and management opportunities and great experiences ahead. Many of those opportunities occurred while I supported the Space Shuttle Program through the 1990s. I will discuss these in the next sessions.

[End of interview]