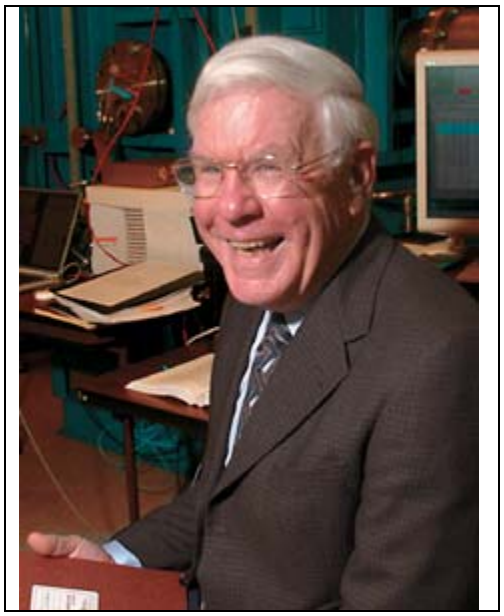
THE AEROSPACE CORPORATION

Interview with Dr. George Paulikas
The Aerospace Corporation
El Segundo, California
March 26, 2003



During his long and distinguished career at The Aerospace Corporation, George A. Paulikas became widely respected for his work in space science and physics and received many awards in recognition of his contributions to the U.S. Air Force space and missile program. In 1981, he received The Aerospace Corporation's Trustees' Distinguished Achievement Award for his research that resulted in "a new understanding of the dynamics of space radiation." Additional honors include the Air Force's Meritorious Civilian Service Award, awarded in both 1981 and 1995, and the National Reconnaissance Office's Gold Medal, which Paulikas received in 1998.

Dr. Paulikas began working for The Aerospace Corporation in June 1961 as a member of the technical staff in the Space Physics Laboratory. Prior to coming to Aerospace, Paulikas earned a B.S. in engineering physics and an M.S. in physics from the University of Illinois. He served as a National Science Foundation Fellow from 1958 to 1961 and received his Ph.D. in physics from UC Berkeley in 1961.

Paulikas was promoted to research scientist in 1964 and to senior scientist in 1967. From 1968 to 1981, he served as director of the Space Sciences Laboratory. Paulikas became vice president of Laboratory Operations in 1981, senior vice president of Development Group in 1985, and senior vice president of the Programs Group in 1989. In 1993, Paulikas was named executive vice president, a post he held until his retirement in 1998. In 1997, Paulikas published Thirteen Years: 1936–1949, an autobiographical account of his childhood years in Europe.

Steven R. Strom interviewed George A. Paulikas on March 26, 2003, at The Aerospace Corporation in El Segundo, California.

Strom: *Dr. Paulikas could you start by telling me about your educational background?*

Paulikas: I began my technical training at the University of Illinois in the mid-1950s. I attended a branch of the University of Illinois, which in the 1970s became the Chicago campus of the University of Illinois. When I attended, it was called the Navy Pier Branch of the University of Illinois, which you might think odd, but in fact it was a school that was located on a pier that stuck out into Lake Michigan. It was a two-year branch of the University of Illinois and, for reasons that will be obvious, because it was housed on a pier made of rocks, it was called "Harvard on the Rocks." It was a very excellent school, a commuter school, and I thought, in terms of the quality of the teaching that I saw there,

was substantially better than some of the other institutions that I've attended. In any case, I started there in engineering, initially in aeronautical engineering and then later switched to physics. I completed my work for the bachelor's degree from the University of Illinois at Urbana-Champaign and stayed there for a master's degree, which I received in 1958. About that time, I was old enough to know better about Midwestern winters and left for California, arriving in Berkeley in the fall of 1958 and receiving a Ph.D. in physics there in 1961.

My work at that time dealt with plasma physics and controlled thermonuclear reactions, which in retrospect was excellent training for the work that I did in later years in space physics because space physics in the main is an environment dominated by space plasmas. Although the number densities and energies are very different from those you encounter in the laboratory, that early work was a good beginning. At that point it was time to look for a job, and it turned out there was a company called Aerospace that was just beginning to be established. This would have been sometime in the fall of 1960. One of the professors that I had known at the University of Illinois by the name of Bob Becker recruited me. He was just starting the laboratory called the Space Physics Laboratory at Aerospace. So I got in almost on the ground floor in the spring of 1961 with my old professor and started work here.

That was a very exciting time because the company was just beginning. Everything had to be built up from scratch, both the technical as well as the administrative side of Aerospace. We (Aerospace), the Air Force, and Space Technology Laboratories, the historical antecedent to Aerospace, were all quartered in the buildings across the street called Area A now, plus trailer upon trailer upon trailer, which filled all the parking lots. So my initial office was in a trailer, which was good because it was quiet and isolated; it was bad because there were mice, and rats, and ants, and all manner of wildlife. The laboratories were established in Building 120—at that time called Building F. My first roommate was John Stevens, who recently retired from Aerospace.

It was truly an exciting time because it was a new organization; it was an opportunity to start an organization from scratch, to start research programs from scratch. The problems of the space environment were basically unknown, so Aerospace and Bob Becker's Space Physics Laboratory had a very important role in establishing some of the initial research programs that led to substantial contributions by Aerospace in various fields of space physics.

Strom: *Can you give me a rough outline of your work at Aerospace prior to becoming director of the Space Physics Laboratory in 1968?*

Paulikas: My initial work dealt with developing experiments to fly aboard satellites to study space radiation. Initially that work was governed by interest in just establishing what was the actual space environment because, except for a very few measurements, prior to that time it was basically unknown. Then in the summer of 1962, first the United

States and then later the Soviet Union exploded nuclear weapons in space, several of them, which totally changed the Earth's radiation environment and therefore posed an additional set of challenges. You now had to disentangle the effects from the space radiation that occurs naturally around the Earth from those radiation effects that were contributed by the artificial radiation belts created both by the Soviet Union and the United States. It was a very exciting time in that we had a number of launches of our experiments aboard spacecraft in the fall of 1962, and subsequent experiments in 1964 and 1965 enabled us to both develop data regarding the natural radiation environment as well as the decay of the artificial radiation belts that were created in 1962.

About that time it became clear that the synchronous orbit was going to have great practical value, and the radiation environment there was not being measured in any comprehensive way. So my colleagues and I developed several measurements programs that flew on both Air Force and NASA's spacecraft to look at the radiation environment in the synchronous orbit. And the totality of the work that we did between 1962 and 1970 resulted in a dramatic improvement of our knowledge of space radiation to the point that the models of the radiation belts that engineers and scientists used, and still use, were built on data that were developed by Aerospace. And in fact, some of that data turn out to have been unique and still are cited in the literature even 40 years after the fact.

Then I changed from a scientist to a bureaucrat [laughs] and became laboratory director, although my interest in space radiation continued, and the group that I worked with has made major, major contributions in later years. The award in 1981 [Aerospace Corporation Trustees' Distinguished Achievement Award] was really based on the work that I had done in the 1960s and early 1970s that I just mentioned, namely the study of space radiation, the discovery of some new phenomena of the way radiation in space behaves, the input of these data into radiation belt models, and then of course work with a large number of program offices. That work made data immediately available so that spacecraft and sensors aboard the spacecraft could be designed to account for space radiation. I must tell you that it was an incredibly exciting time. Here I was a kid almost fresh out of school and able to put our experiments aboard the Agena spacecraft at Vandenberg. The Agenas, the size of a large RV, were launched aboard Thor rockets from Vandenberg. Inevitably all the checkouts would occur about 3 o'clock in the morning, and the only place that one could stay in those days was at Santa Maria, so you were always driving up to Vandenberg in the middle of the night, through the fog and the wind, which always blows there, freezing your buns [laughs], but it was just very thrilling to me to be able to climb all over these rockets and work with the technicians and engineers from Lockheed, the principal contractor for the rockets. In fact it turns out I was providing my experiments to fly on the Corona Program, which was the first U.S. reconnaissance satellite.

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Strom: *How did Aerospace originally become involved with studying the effects of the space environment?*

Paulikas: It became clear that the thrust of the National Security Space Program was going to be in orbits that were within Earth's radiation belts, which had been discovered in 1958 by Professor [James] Van Allen. The measurements by Professor Van Allen [made by a cosmic-ray instrument onboard the Explorer I satellite] were not particularly quantitative in terms of the information they returned, although they were very useful in outlining the general areas of radiation. It became clear that Aerospace needed to get a better handle on the extent and the characteristics of the radiation, both protons and electrons and their energy spectra so that the proper design issues could be made. Aerospace was in a unique position because of our close association with the satellite programs to allow experiments to fly on these satellites, which in turn returned the kind of data that were needed for future development. So that was the motivation initially, to understand space radiation as nature provided. After the high-altitude nuclear tests, which dramatically increased the level of radiation to the point that several satellites, not Air Force satellites, were destroyed by the effects of radiation, it became important to understand the characteristics of radiation in space created by nuclear detonations, how long the radiation would last, how long it would evolve over time. So for several years, in fact almost many years thereafter, an important ingredient of our work dealt with the affects of artificial radiation belts.

Strom: *Could you relate some of your favorite programs or experiences during your tenure here at Aerospace?*

Paulikas: Well there are many, of course, but these are some in more or less chronological order. I think it has always been a point of pride with me that I was able to participate in a small way with the Corona Program, which was the first U.S. reconnaissance satellite. I was actually asked to help write the request for proposal for DSP [Defense Support Program], which has been serving the nation now for more than 40 years. My contribution was minor; nevertheless I still fondly remember that. The other one that I fondly remember is the early days of GPS [Global Positioning System] when Ed Lassiter was the Aerospace program director. He would be up at Vandenberg and I would be looking at my radiation belt data, and he would wonder what the state of the radiation belt was that day so that the launch could take place. So I would be talking to him on the telephone telling him that it did not look like there would be any disturbances caused by the sun as they were getting ready to launch. It was a very intimate, real-time involvement that I still remember today. And that would have been in the early 1970s, I think.

Strom: *Ed Lassiter became the program director in 1974. I just interviewed him.*

Dr. **Paulikas:** Yeah, that would have been about right, because I remember he was at Vandenberg and I was in my office and there was a concern about the effects of solar

particle events. In addition to working with the Earth's radiation belt we were also concerned about the effects of solar radiation, electrons and protons coming from the sun and striking the Earth, mainly the polar regions. And that was the concern at that time that we were working with GPS. So that would have been 1974, that's about right.

Strom: *Could you describe of the period of your career at Aerospace when you were in management?*

Paulikas: There were really two phases to my management. When I was the laboratory director and then later vice president. My principal concern was ensuring the quality of the scientific and technical work of the people in my laboratory or laboratories, and assuring that technical work bore a close and intimate relationship with the basic mission of Aerospace, which was namely the success of the national security space programs. As I became a senior vice president and later an executive vice president, my viewpoint naturally broadened to make sure that the entire technical resources of Aerospace were brought to bear on the technical issues that the various space and launch programs faced, and that Aerospace was always in a position to render credible technical judgments on difficult matters and appropriately advise the Air Force.

The great pleasure that I derived in those responsibilities was seeing the incredible dedication and maturity and mission orientation of the people at Aerospace, at all levels I might add, who never, never hesitated to throw themselves fully into whatever challenge was presented to them. Working the long hours under difficult circumstances away from friends and family in classified environments where they couldn't talk about what they were doing, they brought a kind of a pride and dedication to the task that made the management easy and a pleasure. I always got an enormous amount of pleasure out of working at Aerospace. My job satisfaction was always very high despite the fact that some fraction of my time was necessarily consumed in bureaucracy.

Strom: *What do you see as Aerospace's role in scientific and technical innovations for space systems?*

Paulikas: Well Aerospace is in a unique role, we have a central position, a locus of centrality in all national security space systems, and I might add that our involvement here in recent years has broadened substantially to encompass additional government agencies that ask for our help, additional involvement with NASA. So Aerospace as an organization has an overview of the entire national space program, both DOD as well as, to a large extent, NASA. In that way we have an insight and a viewpoint, which is really unique in our research programs in the laboratories and our engineering development programs. We have an opportunity to excel; we have an opportunity to provide solutions that affect not only the Air Force programs but also the national space programs. Witness our involvement in recent times, for example, by Bill Ailor in the Columbia investigation, which came out of his involvement with Space Command and tracking reentering objects of interest to Space Command. So it's that kind of thing that leads to

continuing excitement, continuing technical challenges, a continuing ability to attract excellent people because of the excitement of the work, and continuing development of our tools and capabilities based on our unique and broad overview of the national space program "from soup to nuts," to coin a phrase.

Strom: *Do you see any particular challenges for the corporation in the immediate years ahead?*

Paulikas: The challenges are that we are being asked to do more with a very slight increase in the corporate workforce. If I look at the number of programs that we support, both the legacy programs that are still flying, such as DSP, 40 years later and the new programs coming along such as SBIRS [Space-Based Infrared System] and STSS [Space Tracking and Surveillance System], the challenge is to take our limited workforce and apply it across the board. The other challenge, which is really a focus of The Aerospace Institute, is to make sure that the lessons learned of the past, some of which exist only in anecdotal form, are coherently combined into educational and training programs, which while not fully replacing the kind of experiences that I was lucky to have, nevertheless giving people "a leg up."

You see I learned space systems engineering by sitting at the feet of great men and going to program reviews. People like Pete Leonard and Wally Leverton who would run the program reviews here every week. Kids like me would just watch them in action and learn and pick up pointers from them. And now we have a much better formalized structure that to some degree circumvents the inefficiencies of on-the-job training, and that is really a challenge because we are rapidly losing and probably have lost a very large fraction of the people that were here during the 1970s and maybe even the 1980s so that the demographics of Aerospace are indeed changing. And it's important to transfer the wisdom, knowledge, and craftiness of the past to the people that we're hiring.

Strom: *Can you tell me some of the ways that you continue to remain involved with the corporation?*

Paulikas: I was pleased to note that my abilities as a technical manager and space systems engineer and expertise in some elements of space science have not decayed over the years. So I've been asked to serve over the years, for example, on the independent review team that oversees GPS. This is something that the Institute of Defense Analysis has asked me to work on. The National Research Council has asked me to serve on the Space Studies Board, which is really a NASA-focused, space-science-directed advisory committee. Various program offices at Aerospace have asked me to help out on various reviews, which may last for only a couple of weeks but they're a lot of fun; they're very intense. I hope that I've been able to make contributions to addressing some of the current issues in some of the programs that are here at Aerospace. So it's a lot of fun is the answer.

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Strom: *Are there any areas besides space physics, in terms of scientific research, that you're currently interested in?*

Paulikas: Well, I know a lot about the various aspects of space science, enough to make me dangerous. In fact, I wouldn't characterize myself as an expert anymore in space physics, but I know some of the general issues and general problems. I think I can converse intelligently with people that are on the frontiers of this research, such as the people in the current Space Science Applications Laboratory, I think it's called. So, that I continue to be able to read the technical literature without gagging [laughs].

Strom: *Do you have any plans to update your autobiography [*Thirteen Years: 1936–1949*] starting with the period after your family's arrival in the United States?*

Paulikas: No, I was not going to do that. That biography really started out as a very modest endeavor to try and just capture some of the memories of my mother before she passed on. And then as I started writing I discovered that I remembered more and more of the events of those times. And lo and behold from what was going to be about a 10-page outline, it turned into a 100-page book. It's actually hard work to write a book. It's very hard work. Word processors make it somewhat easier, and the events of my childhood and youth were so different from the current environment that, in retrospect, these were worth recording. My arrival into the United States and subsequent events were just simply those of a typical American teenager, nothing of particular interest.

Strom: *It might be of interest to more people than you think. You worked in an exciting period.*

Paulikas: Yeah, you know, the thought that crossed my mind, and I haven't formulated it, was to write down some of the experiences of the early days of the space age, which would have various anecdotes associated with them. But that would be fairly brief, and really my hands-on involvement there lasted from 1961 until the mid-1970s, when the early exciting period was sort of over. In a peculiar way all the programs and all the things that we're doing now at Aerospace were thought of in one way or another during those first 15 formative years. And while we've gotten incredibly better at doing it, the kernels and the roots of today's Aerospace are traceable to those early days. So you know, what you see in the typical curve of development is a very, very steep rise and then sort of a slower increase in capability. And it's those first 15 years that made me work. But I'm too busy doing other things [laughs].

Strom: *I would like to ask you a question that I asked Joe Wambolt up at Vandenberg. When you were working in areas related to the space program, were you aware that there was such a steep rise in the advance of technology and this was really a historic period? Were you aware of that at all?*

Paulikas: Yeah, you know it was sort of in retrospect that I was aware of it. At the time I didn't think about it, but for example, the detectors that we flew in 1962 and later years were really, really novel and unusual. And we would go up to a manufacturer, up the road here to West LA and Santa Monica. The contractor would make the detectors to order while we watched. Then we'd grab them, mate the detectors to our electronics, and run them up to Vandenberg, you know. So you were aware that you were really at the cutting edge, but it's much more of a retrospective awareness than it was at that time. At that time you were just trying to get the job done, and trying to grab the best of whatever you had. And if it was better next year, that was great. You know it is like being inside a forest. You see the trees; you don't see the forest. That's an excellent question, and I never thought about it at that time. It was very exciting, but I didn't think of it as the curve and slope and development….

Well I take that back, there was one incident that sticks in my mind. We were launching something from Florida, from the Cape, and at that time the Apollo Program was just being developed. There was only minimal security, and you could freely wander over the Saturn V launch pads. If you weren't called on to go do something you could go wandering around the launch pads. So I did drive my car literally up to the launch pad, because it was just under construction, and I saw these hold-down bolts, which were the bolts that held down the launch tower, and they're bolts about this big in diameter [holds out hands to indicate about a foot across]. I said, "My God these people are really serious about going to the moon!" You know the reality doesn't strike you despite reading all the stuff in the newspapers until you see the physical hardware. And I just remembered these bolts, about this big in diameter, steel bolts you know buried in about 20 or 30 feet of concrete.

Strom: *How many inches in diameter across would you say?*

Paulikas: Oh, I would say about 10 inches across in diameter, steel bolts. Just seeing the physical reality struck you as real. And in a way, you know, my first time I went up to Vandenberg to put my experiments on a rocket, you'd drive through this fog and mist and through two or three guard gates and then all of a sudden you'd come to this big long shed, because the Thors were assembled horizontally and then erected and launched vertically. Then all of a sudden you go through a door and there is this gigantic rocket, you know, a hundred feet of rocket, with a satellite up in front. And people climbing all over drinking coffee and eating junk food, it's three in the morning [laughs]. And you try and find the guy who is in charge of your checkout procedures and say, "Okay I'm here to check my experiments." And then he says, "All right, I don't really want to do this, but let me show you what you have to do" [laughs]. So it's that kind of stuff that you remember.

Strom: *It's interesting because in many ways Mr. Wambolt gave much the same answer—that only in hindsight did he realize the history. He said that at the time he was just too busy trying to do a good job, which is essentially what you're saying.*

Paulikas: Yeah, and you know after I would get my radiation data back, guys from program offices would come into my office and say "Now tell me what you see because the next satellite is carrying film," or words to that effect. So I'd do my calculations on those to see if the film would be blackened or not, and my visitor would say, "We'll fly." I mean it was incredibly informal, here I am a 26-year-old kid, telling these guys to launch the next reconnaissance satellite.

Strom: *It must have really been something.*

Paulikas: It's only clear in retrospect. At the time, it's just a guy coming into your office and wondering how many rads per day that particular film is going to get in that particular orbit.

Strom: *And you were just doing your job.*

Paulikas: Yeah, punching the calculator. Punching a mechanical calculator I might add [laughs].

Strom: *Over the course of your career you received many awards and honors, and I wondered if there are any that you are particularly proud of or that stand out in your mind?*

Paulikas: Oh, gee. I guess the Trustees' Award is probably number one, the NRO [National Reconnaissance Office] gold medal is number two. I think I would put them in that context in that the Trustees' Award is recognition by your colleagues and the company, and the NRO medal is the recognition by the customer.

Strom: *Do you have any final thoughts in what role that you see Aerospace playing in the future of space systems in this country?*

Paulikas: Well I think that the Aerospace way of doing business, despite the various attempts to change it or reinvent it, is key to the success to the National Security Space Program. In fact, our record, and the way we do business working with the Air Force and the NRO is very efficient, and I would like to think that Aerospace is one of those corporations that, while it changes and transforms as the times demand, will be here a hundred years from now. I once read an article about the survival of corporations. Turns out that the oldest corporation is a Swedish company about 700 years old. There are some others that are quite old, like Shell bordering on 150. So on the timescale of long-existing corporations, we're still babies. On the other hand, we're going to celebrate our 50th anniversary in a mere seven years, which about puts us into the class of people, who in terms of organizations and methods of doing business, are past their early childhood and the infant mortality associated with new starts. And I would like to think that as long as we keep learning and adapting, and as long as the nation's space

endeavors are robust, we will be in a central position to continue the very important work that we do.