

In this issue of *IEEE Control Systems Magazine (CSM)* we speak with William Garrard, professor of aerospace engineering at the University of Minnesota. Bill has worked extensively on modeling and control of aerospace vehicles, he is a Fellow of the AIAA, and he served as head of the Aerospace Engineering and Mechanics Department at the University of Minnesota for 15 years. We also speak with Asen Dontchev, associate editor for *Mathematical Reviews* of the American Mathematical Society and a former faculty member at the University of Florida and the Bulgarian Academy of Sciences. He has worked in the areas of optimization, control, and applied analysis.

WILLIAM GARRARD

Q. What brought you to aerospace engineering in general and dynamics and control in particular?

Bill: Even as a young child I was fascinated with machines that fly. Before I could read I could identify various types of airplanes, and as I got older one of my hobbies was building and flying model airplanes. I also read a lot of science fiction so that I was very familiar and comfortable with the idea of space flight long before it was actually accomplished. My ambition in those days was to be a military pilot, but I was not able to achieve that goal because I wore glasses (at that time 20/20 uncorrected vision was required). I was, however, a good student, particularly in math and science, so it was almost inevitable that I would end up as an aerospace engineer. My interest in control was a direct result of a required undergraduate course in electrical engineering, which briefly touched on feedback control. My interest in dynamics was primarily a result of a graduate course I took under Dr. Lyle Clark, the person who became my Ph.D. advisor at the University of Texas. Although I had made good grades in

my undergraduate dynamics courses, I did not really understand the subject until I took that first graduate course from Lyle. Another important influ-



William and Judy Garrard. Bill is a professor of aerospace engineering at the University of Minnesota.

ence on my career was consulting I did with Honeywell in the 1970s. Modern control theory was beginning to be applied to aerospace applications, and I had the good fortune to work with people like Gunter Stein, the young John Doyle, and others at Honeywell on a variety of fascinating airplane and spacecraft control problems. I learned a lot from those experiences, not all of which was technical.

Q. You've worked on parachute systems for re-entry. What are some of the challenges in that technology?

Bill: Most of the challenges are of a practical nature, for example, designing a parachute system that will operate reliably after months in space. The parachute systems for nonhuman entry into planetary atmospheres are not redundant, so they have to work. One problem I have worked on recently with my colleague Graham Candler and his CFD research group here at the University of Minnesota is the flow around an entry vehicle and the attached parachute in supersonic flight. Since the first Mars missions in the 1970s, it has been known that the wake of the entry capsule interacts with the trailing parachute to produce a violent and potentially destructive opening and closing of the parachute. The reason for this entry has remained the object of much informed speculation because it is not possible to simulate this type of flow in a wind tunnel. Graham and his students were able to simulate the unsteady, supersonic flow and show how the wake interacts with the parachute. My contributions were primarily to provide reality checks. The results of this work will be incorporated in the Mars Science Laboratory, which will be by far the largest and most sophisticated rover sent to Mars. The launch is scheduled for 2011, and I am thrilled that something I have worked on, even in a relatively small way, will actually go to Mars.

Q. What is the focus of your current research?

Bill: My current research is primarily focused on developing mathematical

models for control system design and optimization studies. Some recent projects have been precision payload pointing for high-altitude scientific balloons, optimal trajectory planning for airships in the presence of wind, and calculations of optimal planetary entry trajectories. I am also the director of the Minnesota Space Grant, which is a NASA-funded higher education program. In addition to my administrative duties as the director, I have been working with other faculty members on hands-on experiences for students in developing space hardware, such as high-altitude balloon payloads, small satellites, and sounding rocket payloads. These projects have provided tremendous educational experiences for the students who are engaged, and it has been rewarding to see them mature and develop into first-class engineers. Hands-on activities for students are vital, particularly today, when it is difficult for most students to acquire these experiences in their everyday life.

Q. What courses do you particularly enjoy teaching? Do you have any particular teaching style or philosophy?

Bill: I enjoy teaching courses that emphasize the use of physical principles to develop mathematical models for aerospace engineering systems. I like to teach anything involving dynamics, including the introductory sophomore course. I also like to teach courses that involve several disciplines, for example, aeroelasticity. We have such great simulation tools available now that students can easily implement their math models on their laptops and observe the responses to various inputs and the effects of parameter variations. I try to teach students that they can formulate and solve real engineering problems by knowing fundamental physical principles and some mathematics. I also try and get them to question their results to see if they make sense physically. With graduate students, I try to get them to be

generalists and learn some things outside of their specialized field. This is not always easy, but they can never predict the types of projects they may eventually end up working on.

Q. What do you see as positive and negative about changes in the teaching and learning environment over the past two decades?

Bill: On the positive side, I think the students that we see are in some ways better prepared than in the past. I rarely see an undergraduate anymore who is absolutely clueless in calculus. I know that this statement may be counter to conventional wisdom, and it may be due to the fact that we are more selective in our admissions than we used to be. Most of our students have done AP calculus in high school, for instance. When I started teaching it was rare to see a student who had calculus before entering the university. Our students also seem to be very serious about their education and realize that they are going to be in a competitive job market when they graduate. There are more opportunities for internships now, and a large fraction of our undergrads have had some type of technical job before they graduate. On the negative side, students do not seem to have the patience to read relatively complex technical material that may require numerous rereadings before understanding is achieved. Also, students want to be entertained in class, which is sometimes hard to do. But all in all, I am very optimistic about the students

Q. Do you have any advice for today's young faculty?

Bill: Young faculty members have a very tough job. They are expected to be good teachers, do good research, and generate significant research funding. If you don't thoroughly enjoy all of those endeavors, then you should probably find another line of

work. Young faculty members need to stay focused on their research and teaching and not get sidetracked on other peripheral activities. Let the more senior faculty members serve on all of those committees—very few faculty ever get tenure because they serve on lots of committees. Young faculty members need to network at the national and international level so that others know about their work. They will need letters of reference at some point, and they need to make sure that the leaders in the field are aware of their research. Since most research these days is collaborative, young faculty members need to forge productive collegial relationships with other researchers both at their own and other institutions. Young faculty members must be judicious in the choice of their graduate students. Good graduate students can make a research program, and poor students can break it. I have been fortunate myself to have had excellent students who taught me a lot. Most important, young faculty members must strive for quality—a long list of publications that report mediocre research is not particularly useful.

Q. What are your interests outside of aerospace and career?

Bill: I read a lot. Most of what I read for pleasure these days is history. I fly fish, catch and release only. I have a wonderful family—my wife Judy of 44 years is senior associate dean of the Department of Public Health at the university, two grown children, a son, Alexander, a partner in a software firm, and a daughter, Elizabeth, a physical chemist. Both of our children are married to great spouses. We have two grandsons and one on the way, and my wife and I have two wonderful English cocker spaniels. I also cook and am pretty good at it.

Q. Thank you for speaking with CSM!

Bill: You're most welcome.