

# Foreword<sup>1</sup>

*πόλλ' οἶδ' ἀλώπηξ, ἀλλ' ἐχῖνος ἐν μέγα.*<sup>2</sup>

Archilochus (flourished ca. 650 BCE)

Schuster, bleib' bei deinem Leisten!<sup>3</sup>

German proverb

Gegen Angriffe kann man sich wehren,  
gegen Lob ist man machtlos.<sup>4</sup>

Sigmund Freud (1856–1939)

Of all the engineers at the symposium for me in June 2005, I, perhaps, had the weakest credentials in Engineering. As an undergraduate in Physics, I took only a single Engineering course, which I failed the first time and was forced to repeat. As a graduate student in Physics, of course, I took no Engineering courses at all. I was 36 years old before I took my second Engineering course, and 39 before I acquired a slightly shaky non-thesis night-school master's degree in Electrical Engineering.

When I interviewed for my first job in Astronautics, I had learned only a few weeks before that “attitude” could be applied to something other than people. Now, nearly thirty years later, my knowledge of Astronautics, though much improved from those earliest days, remains very limited. I have published Engineering journal articles only in the micro-areas of Spacecraft Attitude Estimation and the Attitude Representations. These are, in fact, the only areas of Astronautics that I really know. Orbit Determination, Orbital Dynamics and Control, and Attitude Dynamics

<sup>1</sup>Adapted from the writer's opening remarks at the symposium.

<sup>2</sup>The fox knows many things, but the hedgehog one great thing.

<sup>3</sup>Cobbler, stick to your last!

<sup>4</sup>One can defend oneself against attacks, against praise one is powerless.

and Control remain for me almost *terra incognita*. At conferences I usually attend only the sessions on Attitude Determination, because they are the only ones that I can really follow.

Even in Attitude Estimation I have severe limitations. I engage only infrequently in Kalman-filter studies, because I am not completely comfortable with the dynamics component. When I do approach that topic, I avoid the many exotic and fashionable flavors of the Kalman filter (unscented, sigma-point, particle, quadratic, iterative, etc.), and stick without exception to the plain vanilla variety with which I have become comfortable. Even so, I much prefer batch least-square estimation to filtering when I wish to illustrate a point. I avoid less central topics like GPS attitude determination or star identification. With regard to modeling, most of my attitude estimation studies have taken place, at least in part, within the framework of one very simple measurement model, the QUEST measurement model, which appeared already in my very first Engineering journal article. I have seldom budged from this cozy corner of Astronautics. If I tend to write basic papers applying basic concepts to basic problems of Spacecraft Attitude Estimation, it is because my attainments do not permit me to venture far from the basics. If I have gained the reputation of having laid much of the groundwork for modern Spacecraft Attitude Estimation, it is because I am very much stuck on the ground.

But there I was at the symposium in 2005, surrounded by colleagues whose capabilities were so much broader than my own, whose knowledge of Astronautics was far greater than mine, and whose careers by many measures had been more successful than mine. As Governor Schwarzenegger of California, pondering the unlikely trajectory of his own career, averred: America is a wonderful place! I was not so dishonest as to deny that despite (or because of) my limitations I had made a worthwhile contribution to Astronautics, although, I still contend, not a contribution worthy of a three-day celebration. At the same time I could not, of course, insist that the attendees at the symposium, my friends and colleagues all, had gone to so much trouble and expense simply to gawk at the emperor's new clothes. To have done so, however justified, would have been ungrateful and showed bad manners.

I take pride in the fact that my contributions to Astronautics have been of a simple nature, created using simple means, and expressed in simple terms, powered less by intellect than by a lot of hard work. Given my limited education in Engineering in general and in Astronautics in particular, it could hardly have been otherwise. I take pride also that most of my work has had its origin in the practical support of real spacecraft and not in the expression of grandiose principles nor in the fulfillment of some imagined noble and glorious mission (well, maybe a very modest mission). I am not at all unhappy that the most useful of my papers have often been the least original. I am proud that my work has been as much a product of the heart as of the mind. I am most proud that some of my work has been helpful to my colleagues who do the real work of attitude estimation. For someone so uneasy about the value of his work, I seem to have a lot of pride.

In many ways I think I have been like the character portrayed so well by Buster Keaton in his films of the 1920s, the obstinate, clumsy dolt who through sheer persistence, good will and good luck manages to save the day and win the girl. Certainly, from the attention that has been given to my work by the symposium and this special issue, I have won much more than I could have imagined, let alone deserve.

## A Serious Complaint

Où sont les neiges d'antan?<sup>5</sup>

François Villon (ca. 1431–ca. 1474)

Despite my joy at the symposium and despite the enormous debt of gratitude I owe to the symposium organizers, who are also editors of this special issue, I have a very serious complaint about the organization of that and previous symposia.<sup>6</sup> I expressed this complaint at the Battin symposium in 2000 and would have expressed it again at the Junkins symposium three years later, had my health permitted me to attend. I expressed it in my opening remarks at my own symposium in 2005 and in the proceedings. I will express it here yet again: The organizers of those august events, however great their gifts in Astronautics, haven't the foggiest idea of what a symposium should be! There, I've said it a fourth time.

In classical Greece the symposium was a very different affair from what has been offered routinely by the AAS. No respectable woman or young child of the family was permitted to attend. The banquet guests wore laurel wreaths and reclined on divans. Food and drink were plentiful. Entertainment was provided by musicians and dancers, attired in the diaphanous fabric of Cos, by rhapsodists, who recited poetry, and of course, by the delightful *hetairai*. The guests caroused with abandon and ate and drank to excess and beyond. Certainly, they did not spend the majority of their time reading learned papers to one another. Socrates might ponder openly the merits of sensual and spiritual love at those events, as Plato has him do in his *Symposium*, but Aristophanes reclining nearby would brag that no one knew how to write obscenely as artfully as he and would offer choice examples of his art. The symposium festivities lasted frequently until dawn. Dreaming of the symposia of ancient Athens, I looked around me at the symposium in modern Buffalo, and I asked myself with longing and despair: where are the dancing girls? Where are the dancing girls?

## A Second Feature

La vie s'oppose aux deuxièmes spectacles.<sup>7</sup>

Maurice Cordonnier (b. 1943)

In addition to the journal version of my keynote address, titled here "In My Estimation," there is also a final article, "The Quest for Better Attitudes," which closes the special issue. This is a slightly abbreviated but updated version of my Brouwer lecture, presented in Santa Barbara in February 2001. At the time of its presentation, my health problems had made conference attendance difficult, and it seemed likely that the Brouwer lecture might be my last public presentation. By some happy providence, this has not been the case, although it would be more than four years before I would make my next presentation, at the symposium for me in

<sup>5</sup>Where are the snows of yesteryear?

<sup>6</sup>This complaint is treated in greater detail in the published Symposium proceedings, *Advances in the Astronautical Sciences*, Vol. 122, Univelt, San Diego, 2006.

<sup>7</sup>Life doesn't have second features.

June 2005. In my Brouwer lecture, I presented my personal history of the work for which I am best known, the QUEST algorithm, which was my very first effort in attitude estimation nearly thirty years ago, and which has reverberated through almost all my later work. Although my personal outlook in 2001 was grim, the lecture and the conference article<sup>8</sup> were very upbeat. It was, I believe, the very best presentation I have ever given. I wished very much for it to be in this special issue as well, and the editors have been generous in allowing it a place. Both the journal version of the keynote address and the revised Brouwer lecture are somewhat valedictory in outlook and sometimes overly pious in expression. Nonetheless, I hope they will not disappoint you.

### Acknowledgments

FORSAN ET HAEC OLIM MEMINISSE IUVA BIT.<sup>9</sup>

Publius Vergilius Maro (70–19 BCE), *Aeneid*, Book I

One of the joys of life is to have had many experiences for which one wishes to offer thanks. Another is to be able to offer those thanks. I have usurped the honor of writing the acknowledgments from the editors, so that I might offer them the thanks which they could not easily offer themselves. Certainly, of anyone at the symposium, I had the most to be thankful for. This special issue only adds to the long debts of gratitude which I already owe.

I wish very much to thank the editors, three of whom were the organizers of the symposium in my honor. I thank John Crassidis especially for having started it all and for being such a strong supporter of my work even while he was still a graduate student. I may question his judgment but not his sincerity. It is hard to imagine that I could possibly be worthy of the efforts and sacrifices he has made in order that the symposium take place. Landis Markley has been my friend since 1967, when we were still theoretical physicists. For almost thirty years he has been my guardian nemesis, the person who, more than everyone else together, finds errors or imprecision in my work (thankfully, *before* publication) and makes it much better. To my mind he is far more deserving than I of a symposium and special issue. I have known John Junkins, who has done so much to enrich our field, since 1982. He is the astrodynamacist I most admire, the noblest person I have ever known, and he has been my staunch ally in many ventures. His passionate Omega-Cross defense at the symposium will ever be my fondest memory of that event. Kathleen Howell was the AAS liaison of the symposium as well as an editor of its proceedings volume. As editor-in-chief of this journal for the past dozen years, she has published more than two dozen of my articles with generosity and tolerance. Her efforts as an editor of this special issue have been noteworthy. I have always been in the debt of these four people, and I have little to give them in return. I am proud, and not a little uneasy, that the symposium and this special issue were organized by some of the greatest contributors to Astronautics, but most of all, I have been proud to have them as my friends.

<sup>8</sup>“In Quest of Better Attitudes,” *Advances in the Astronautical Sciences*, Vol. 108, Univelt, San Diego, 2001, pp. 2089–2117.

<sup>9</sup>Someday, perhaps, we will remember these things fondly. This was Chippings’ parting phrase at his retirement celebration in the novel *Goodbye, Mr. Chips* by James Hilton and in the wonderful MGM film.

Jim Kirkpatrick, Executive Director of the American Astronautical Society, was very supportive of the symposium and the source of much good advice. Most of the pictures on the Shuster Symposium website and on the proceedings CD are by him.

Hank Pernicka, Managing Editor of *The Journal of the Astronautical Sciences*, has been very kind in responding to my typographic needs over the years and allowing me to gain a true appreciation of the workings of the Journal.

BeaconPMG has brought its considerable skill, effort, and patience to typesetting my articles for *The Journal of the Astronautical Sciences* for more than two decades.

Finally, I thank all of the contributors to this special issue, and once again the American Astronautical Society, the University at Buffalo, the contributors to the symposium, technically and otherwise, and everyone who contributed to my very happy and wondrous stay in Buffalo in June 2005. The friendships of all of these contributors and their collaborations with me did much to enrich the symposium, and have done much to enrich this special issue, my career and my life.

Thank you all.

Malcolm D. Shuster  
Germantown, Maryland  
December 2006