

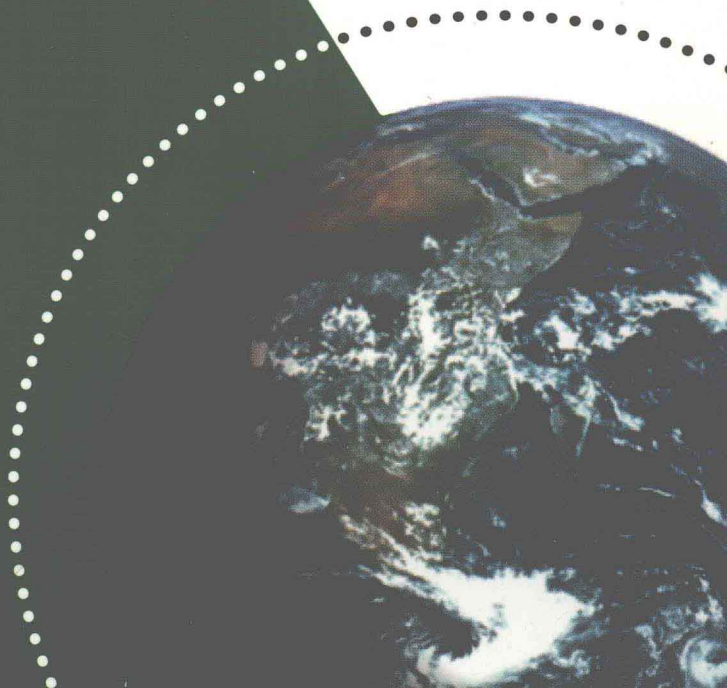
THE LOGIC OF MICROSPACE

Technology and Management
of Minimum-Cost
Space Missions

Rick Fleeter



Space
Technology
Library



The Logic of Microspace

by

Rick Fleeter

AeroAstro Inc.



Space Technology Library

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Preface

Welcome to *The Logic of Microspace*

I'd like to say welcome to a brand new book, but in the interest of keeping my closet skeleton-free, I'll admit it's not entirely new. But neither are small satellites. While microspace practitioners might build a satellite in a year or even six months, it still takes a year or more of brainstorming to really get the bugs out of the mission concept, bureaucracies need years to get them under contract, and the launching process is a bit more than a matter of stepping up to the turnstile with the appropriate number of quarters to drop into the slot. Or maybe that's a pretty good model, since it would take a few years (four is my estimate) to drop ten million quarters into a slot. Books are not that different — writing them takes forever minus epsilon, and the production process is long. Plus, in another assault on “new,” *The Logic of Microspace* includes, as one of its three major sections, an updated version of the wildly popular (ok, the popular) *Micro Space Craft*.

What one million dollars still buys

What noble motivations spurred me to write a second book on microspace, stripped of the excuse of naivete and ignorance I enjoyed when I wrote *Micro Space Craft*? None that I can think of, but plenty of baser ones. For instance, we sold all the existing copies of *Micro Space Craft*. The business side of my brain could not bear the thought of turning away a customer, even for a product with no profit margin (thank the humanistic brain hemisphere for that pricing decision). In almost four years, a few things had changed. Like Dr. Evil, the uncharred members of the publishing machine that brings out these great works were forced to break the news to me that a 64kbyte chip was no longer considered an example of breathtaking density and brash newness. Stuff like that. Unlike Dr. Evil, I'm pleased to say that nowadays in the microspace world, one million dollars is, even more so than in 1996, a lot of money.

Engineering is not alone — there is management

Speaking of hemispheres, I also realized that very little of my own time was being spent on deploying automobile antennas out of trunks, putting golf balls into orbit and building rocket powered Mustangs, some of the subjects treated in *Micro Space Craft* along that merry road to understanding how microspace works. Very

much of my time is in fact consumed trying to make microspace programs happen, which is really the philosophy of microspace (the answer to the question “Why do we want to talk to Rick Fleeter” often posed by the leaders of AeroAstro’s erstwhile clients). And having done that, the rest of my time is absorbed in trying to get microspacecraft to emerge from the end of a program, also known as management of microspace projects. A second book was my answer to those questions, and that second book, merged with the updated version of the first, is *The Logic of Microspace*. Almost.

Aesop did not sleep here

Too much logic can seriously erode readership. Know any best sellers on inductive reasoning or Boolean logic? And the ultimate reason we go to space is quite different from the ultimate reason we grow corn. Without corn, microwave ovens in offices lie fallow, and animals go hungry. Without corn to feed animals, the price of Egg McMuffins goes up, and people on the margin starve, while people not on the margin grouse about getting poorer, farmers’ livelihoods are destroyed, inflation rises, and the President does not get reelected, and neither does his VP. Oh, that already happened too? You can see how tough it is to be Dr. Evil.

Sure, some spacecraft have enormous utility, but space is motivated by more than commercial imperative alone. We shape our future according to what we want to get from space. Do we want to discover extraterrestrial intelligence? Or visit comets and asteroids and think about the beginning, and possibly the end, of Earth? Or entertain ourselves with telerobots on the moon, or neat pictures from the surface of planets or of astronauts floating around inside a space station? Motivation is key — it’s why trees get tall, birds fly, and people get out of bed, gridlock the Beltway, and eventually boot their office computers.

A Wrinkle In Microspace is the third part of this book. It is a novella about some motivations for doing small, low cost space. It is also the first adventure drama ever written about small satellites and the people who build and use them. And if, like me, the only reason you pick up the copy of the *New Yorker* in your dentist’s office is to read the cartoons, you’ll be pleased that my editors describe *Wrinkle* as “richly illustrated.” Actually, if you spend most of your workday reading the Federal Acquisition Regulations or the Unified Tax Code, and possibly even if you don’t, you’ll find that all three parts of the book are richly illustrated, each in its own way.

Going the twofer one better

Three really fun books including lots of pictures for the price of one uninteresting one filled with small print and possibly depreciation schedules. You can’t go wrong. Plus you get this free bulleted list of what’s in here:

- All the technology you need to know to know why you can't just fire all the engineers on day one;
- Enough philosophy of small space to understand why it's the fastest growing sector of the space business and most important in creating the space applications of tomorrow, combined with some management insight on how to succeed in breeding this new species of space program; and
- A fable to provide a few new reasons to get out of frozen storage and design, manage, pay for, study about, or otherwise help make happen, lots of new microspace projects.

Introduction to MicroSpaceCraft: (The Original Edition)

The way we (like to think we) were

Sizzling in the hot Virginia summer sun and humidity, I try to imagine January. Let's see: snow piled up over the gas grill; icicles hanging from the gutters; driveway is a mixture of ice, snow and largely ineffective sand; the non FWD (TWD?) car cowers in the garage; ducks face windward standing on sheets of ice on the pond out back. All the images are there, but without the bite. The twain, even in imagination, don't fully meet.

Can we remember when space was mission, rather than budget, driven? In the late '80s Air Force generals pronounced small, low cost spacecraft "worthless" and a "distraction." Today, excepting some special cases, if a program can't lay a claim to smallness, low cost, and rapid schedule, it is either dying or already dead.

Aerospace's fall from grace with the sea of humanity

Why? Shrinking budgets is the obvious and partially true answer. Aerospace's springtime of raw attractiveness for its own sake is over. Society has been there, done that and won't spend large sums on an infatuation with the siren song of space. The dollars are smaller now, and relevance to more people means moving projects away from the exclusive purview of a few industrial giants. Relevance in part forces lower cost, more rapid schedule and a more diverse community of developers including students and young professionals - people who don't have decades in one job to nurse along stone by stone construction of a modern pyramid. Immediacy and relevance are attributes of low cost programs of more limited scope.

The world has changed in other ways than economic. The rate of change, in science and particularly in technology, is increasing. Classical aerospace programs require decades from concept to flight. In that time they are typically obsoleted by several generations and often uninteresting beyond an initial "turn it on and see if it works." It has become more important to fly a new technology immediately, learn and progress forward, than to wait long years to create and fly the most capable possible facility.

Savoir Faire — Can't leave home without it

These are societal imperatives. But in our technology-based society, change happens only when there is a confluence of our desires and our technical abilities. What created the mass markets for answering and fax machines in the '80s? The desire to stay in touch coupled with the technical ability to improve our connectedness. In the '90s the cellular phone is booming because our ability to provide mobile telephone service compliments our increasing mobility. Small satellite technology is now so important both because we want it (all those societal factors) and we can do it - a highly capable spacecraft which a few years ago weighed tons and was built by thousands can now be built, thanks to revolutionary progress in electronics and the ingenuity of small satellite designers, by 10 people on a tabletop.

No Fear, No Limits, No Grades

Except for occasional (ok, frequent) philosophical interludes this book is an introduction to the core technologies behind small satellites. It is not a textbook, it does not profess great rigor and it is far from exhaustive - where necessary I may have shortchanged Fourier in favor of Fun and taken a few scenic but definitely off road shortcuts to get from Anabru to Zurbranchburg without straining any attention spans. But it covers the entire field of low cost space activity in a way that is meant to be accessible - as are the satellites themselves - to a wide audience. This is satellite engineering for the rest of us - not just for people who've spent 5 or 10 years studying the subject in college and in engineering jobs.

We have an 800 number

Some of the topics covered were serialized in The ISSO (International Small Satellite Organization) and *New Space Newsletters*, though all of them have been updated and improved for this book. The book chapters stand alone, and the bitesize morsels of education they contain include no prerequisites and no grades — pick it up wherever you'd like and browse.

I wasn't born this way

Thanks to Professor Dan DeBra, whose classes at Stanford were a delight and an inspiration, and who encouraged the articles which lead to this book. The only thing Dan showed me I ever found incomprehensible is his stamina on a bicycle. Professor J. Kestin taught me the discipline to write and to continue to learn. I am grateful to have been allocated a small part of his time while he was alive among us, time which could have been spent on serious, talented students. Another inveterate biker, Richard Warner, encouraged and cofounded our company, AeroAstro. Richard suggested many of the book's topics, created several illustrations, and coauthored with me sev-

eral sections. This plus his predictably unpredictable advise has been invaluable. I thank Josh Cohen who composes, out of the ASCII mess I create and email to him from long distance and noisy phone lines, readable, interesting and attractive articles. Professor Rudy Panholzer of the Naval Postgraduate School first suggested my writing this book — a suggestion I found easily dismissed at the time, but which ultimately seeded the entire effort. Fran and Terry Ponick have somehow managed to maintain their cheery demeanor and professionalism, even after years of working with me to take the messes I create and turn them into something quite amazingly resembling a book. Their skills and their continuing encouragement have been wonderful. My wife Nancy has learned to tolerate loss of a husband in exchange for an icon, sitting at the kitchen table, staring at a computer screen and tapping a keyboard. And my mother, who says my writing is great, even when I know it's lousy, who said my piano playing was great even when it was truly unbearable (the good things never change, right mom?), and who has kept AeroAstro together single handedly, by providing us an unending supply of the worlds greatest bread, aka Hannah's Bananas.

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Part 1

MICROSPACECRAFT