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Military Applications of Commercial SATCOM Systems
Robert R. Rankine, Jr.

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Military Applications of Commercial SATCOM Systems

Robert R. Rankine, Jr.

Dr. Robert R. Rankine, Jr., is vice president for government business at Hughes Space and Communications Company, and director of the Washington Space Office for parent company Hughes Electronics Corporation. He represents Hughes Electronics to the federal government space community, both civil and national security, and represents government perspectives within Hughes Space and Communications Company. He is also a member of the U.S. Air Force Scientific Advisory Board, the State Department's Defense Trade Advisory Group, and the Commerce Department's Transportation and Related Equipment Technical Advisory Committee. Before joining Hughes in April 1995, Dr. Rankine was a program director at TASC, Inc., where he led the development of a technology program plan for the Defense Airborne Reconnaissance Office and directed a TASC contract providing scientific, engineering, and technical assistance to the Ballistic Missile Defense Organization. Dr. Rankine began his career in the U.S. Air Force, where he rose to the rank of major general. At the time of his retirement from the USAF in 1992, he managed the USAF's $1.7 billion science and technology program. His prior Air Force assignments included the acquisition of space systems, initiation of the Strategic Defense Initiative program, management of all DOD directed energy weapons programs, and command of the Air Force's largest laboratory complex. Dr. Rankine received a B.S. in electrical engineering from the University of Illinois, an M.S. in electrical engineering from the Air Force Institute of Technology, and a Ph.D. in engineering from the University of California, Los Angeles.

Oettinger: Today's speaker will either confirm or contradict all you've heard about the use of direct broadcast satellite technology to support requests for and dissemination of military intelligence and other information. He assures me that he will be talking about roughly that sort of thing. He welcomes interruptions and questions right from the start, so please feel free to ask for clarification or engage him in questions that may be of interest to you, even if they are not right on that particular topic. So saying, I turn this over to you. Welcome, Bob; it's all yours.

Rankine: Thank you very much. I'm pleased that you invited me and, as Doctor Oettinger said, please feel free to interrupt me as we go along if you have any questions or comments or would like some more information.

The world of satellite communications right now is in the midst of a real explosion. More and more applications of satellite communications that will benefit the consumer, around the world, are emerging. Whereas in the past governments—and particularly the U.S. Department of Defense—were the largest investors in technology for new communications satellites, and not only led investment, but also had the most advanced satellites in orbit for communications, that's all changing now. As I'll show you in a few minutes, the commercial market investments for satellite communications are now an order of magnitude greater than those of the U.S. government. As a result, that's what's driving the train nowadays. Whereas 15 or 20 years ago Hughes Electronics would develop technology for satellite communications for the military, and then we would apply that technology on our commercial satellites, what's happening now is just the reverse. We're developing the technology for commercial satellites, and then we're applying it to the military. This reversal of fortune is sort of interesting, and that's what I wanted to talk to you about today. The messages of my briefing are that there's been a lot of success in applying commercial SATCOM to military needs, and the DOD can take more advantage of it (figure 1).

Key messages of this briefing

- There has been considerable success in applying commercial SATCOM to military needs.
- DOD can further leverage the billions and billions of dollars now being spent on commercial satellite infrastructure and services.

Briefing outline

- Introduction to Hughes Electronics
- The world of commercial satellite communications
- Recent successes in meeting military needs
- Some approaches to further leveraging commercial SATCOM services
- Summary

Figure 1
Overview

First I'd like to talk to you just a little bit about Hughes. Hughes is involved in defense consolidations, just like all of the other companies now in the defense business within the United States. I want to explain a little bit about what businesses Hughes is in and how things are going to be changing here toward the end of the year.

Probably the meat of the presentation, which I think most people find the most interesting, is: Where are commercial satellite communications going? What are the different kinds of services that are going to be available, and when?

There's nothing in here that's proprietary. What I'm going to cover here is where the world of satellite communications is going. I will use some Hughes examples, but they're really just examples. I'm not here to sell you a satellite today, although if you would like one, I'd be glad to talk to you afterwards. But I'm going to use a Hughes example of each of the different classes of service, just because I know more about those and I can give you some details on them and answer your questions. Then I'll talk to you about how the military has begun to use some of those commercial capabilities. But in order really to take advantage of what's coming, we think that the military maybe has to change the way that it goes about defining what it wants to buy, and how it goes about buying or leasing or renting or whatever, and so we'll talk a little bit about those matters of acquisition policy and so forth.

Let me start off with Hughes. This chart, you'll notice, is Hughes 1997 (figure 2). This is the way we exist today. There are five major companies that report to Hughes Electronics, and Hughes Electronics is a wholly owned subsidiary of General Motors.

Hughes Electronics was created a number of years ago when General Motors purchased Hughes Aircraft and merged it with Delco. Delco is automotive electronics. Hughes Aircraft doesn't build aircraft. They're a defense electronics firm. It goes all the way back to where Howard Hughes did build aircraft, however. The idea of bringing Hughes Aircraft and Delco together was a recognition on the part of General Motors that automobiles of the future were going to have higher and higher content of electronics, and that the defense electronics industry was ahead of the rest of the industries in the United States with the application of electronics technology. So the thought was that if they put their automotive electronics company and their defense electronics company under the same corporation, the technology would flow and General Motors would then benefit by getting that technology transitioned into new automobiles.

For example, as a result of this, the new General Motors cars, such as the Cadillacs, now have a voice-activated cellular phone. It actually does voice recognition. You can say, "Name," and it will say, "Name, please?" You say, "Home," and it'll say, "360-0874." You say, "Call." It says, "Dialing." It's all hands free, so you don't have to take your hands off the wheel. That's just one example of how some of the applications of defense technology get applied to automobiles. Also, there's a GPS (Global Positioning System) receiver in Cadillacs called "Onstar." You've probably seen some of the advertisements for that.

That was all well and good, and another thing that happened since the merger was that

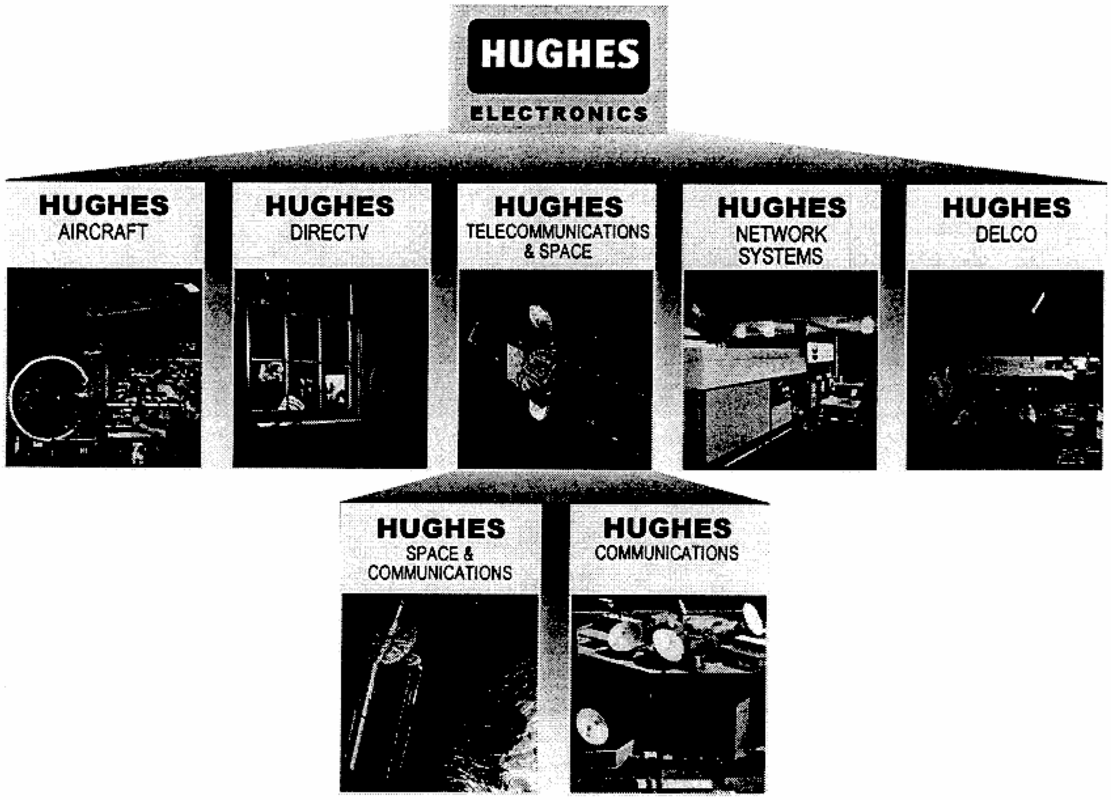


Figure 2

Hughes Electronics Family of Companies—1997

the Hughes Space & Communications group sort of spun off and began to become a business area of its own. All this expansion that you see here in the middle is in the telecommunications and space area. The company that builds satellites is called Hughes Space & Communications. It sells those satellites around the world. That's the company of which I'm a part. Hughes Communications Incorporated buys some of those satellites and operates them; it leases transponders to the news media, the cable companies, and so forth. Those are both parts of the company called Hughes Telecommunications & Space.

DirecTV also bought some satellites from Hughes Space & Communications, and that's now become the most promising introduction of a new consumer product ever. There were 1 million subscribers in the first year—1 million purchases of set-top boxes and 18-inch dishes. It took three years for CD players and VCRs to sell their first million. It took 10 years for color televisions to sell their first million. We'll say more about DirecTV in a little bit.

Hughes Network Systems is the world's largest supplier of very small aperture terminal (VSAT) business networks. I'll say a little bit more about that, but this is satellite communications for businesses, and they do the ground stations. What you see here is a little satellite dish on the roof of a Chevron gas station, and I'll say more about that in a few minutes. So that's the Hughes family of companies today.

The next slide I'm going to show you is Hughes 1998 (figure 3). What's happening is that back in January [1997] it was announced that the Hughes Aircraft defense electronics business was going to be spun off from this family and be merged with Raytheon, and in the last week of September that was approved

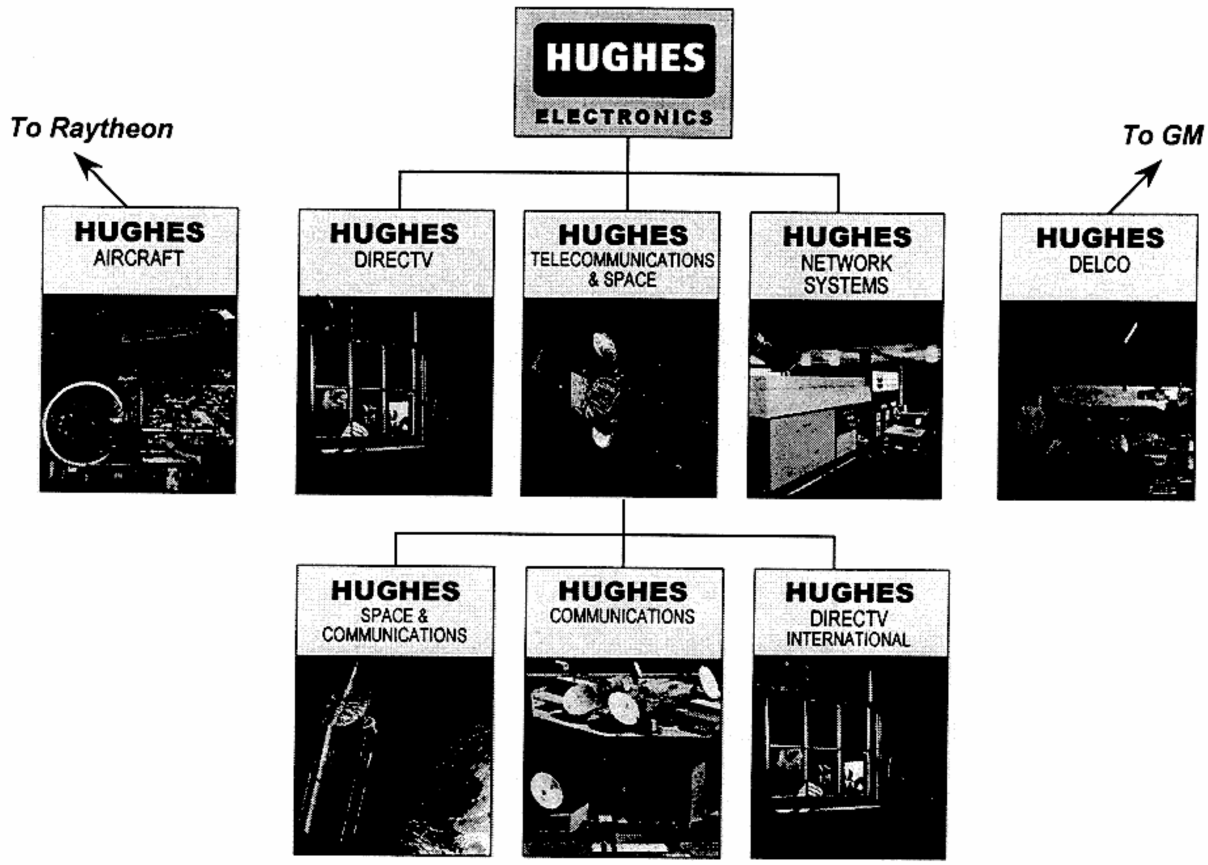


Figure 3

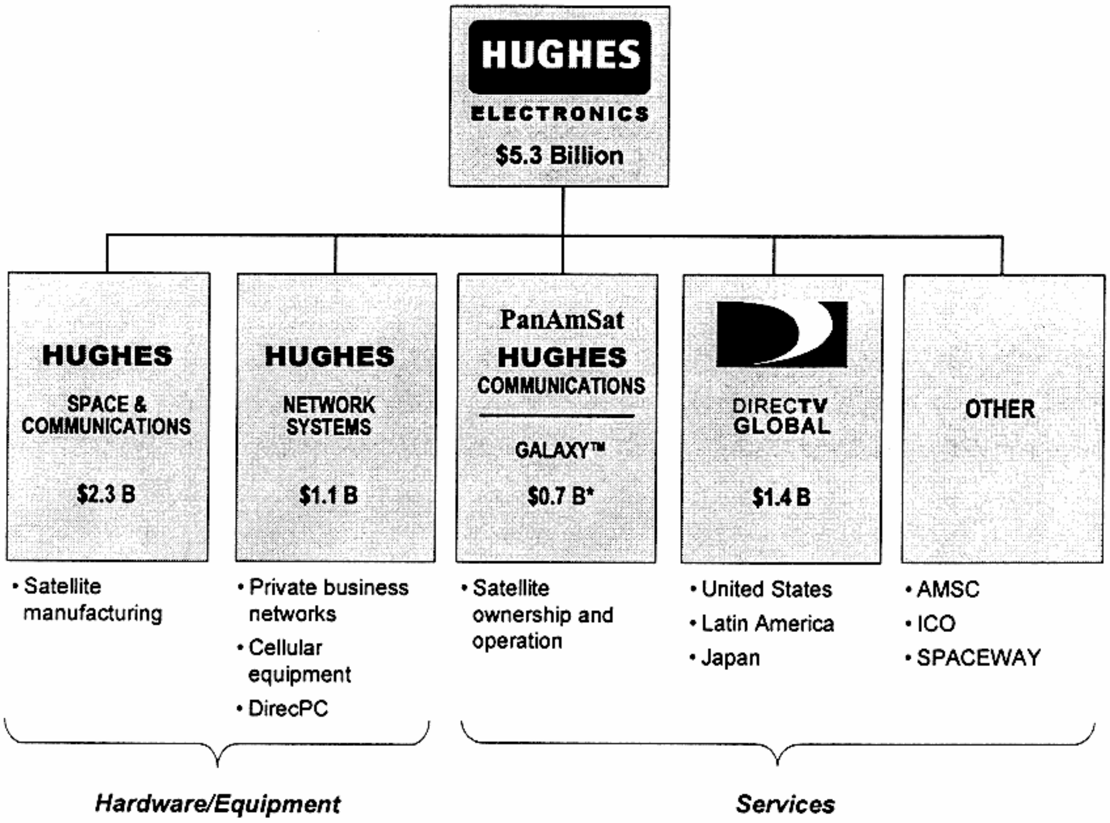
The New Hughes Electronic—1998

by the Department of Justice. In the first week of October, it was approved by the board of directors of General Motors, and now it goes out for a vote among the stockholders.

At the same time, Delco now has absorbed all this technology, and so there's no need for it to be housed in a company that deals with telecommunications and space. So it's being spun off and it's going to report back directly to General Motors, not through Hughes Electronics. So, the new Hughes Electronics, still owned by General Motors, is going to be solely a telecommunications and space company.

Here I've taken the organization for 1998, with the revenues from those various pieces from 1997, just to give you a feel for what that company will look like, structurally or from the standpoint of revenues: the sizes of the companies, and what businesses they're in (figure 4). For the satellite manufacturing business, the company that I'm involved with, the 1997 revenues were $2.3 billion. Hughes Network Systems—the very small aperture terminal business networks, cellular phones for General Motors automobiles, DirecPC, which I'll talk about a little bit more in a minute—those are all hardware and equipment businesses. As you'll see, that's the majority of the revenue.

I mentioned Hughes Communications Incorporated, HCI. They operated a fleet of 10 satellites across the United States that provide transponders for television, for the news media, for cable companies, and what have you. They were merged with PanAmSat, and Hughes now owns 71 percent of PanAmSat. PanAmSat had four satellites around the rest of the Earth, not in the United States. So, now there's a network of 14 satellites—to grow to 20 by the year 2000—circling the



*Pro-forma combined PAS/HCG

Figure 4

Organization and 1997 Revenues*

globe, and that becomes the largest privately owned satellite services company, second only to Intelsat and Inmarsat, the two that are state subsidized.

We call DirecTV "DirecTV Global" now, because it's not only DirecTV for the United States. We formed a company with three Latin America partners called Galaxy Latin America, which is now taking DirecTV into Central and South America, with programming in Spanish and Portuguese. We've also just joined with a couple of companies in Japan to form DirecTV Japan, and we will be providing digital television to Japan in Japanese.

Other businesses are on the horizon, and I'll talk a little bit about these. These are some of the emerging businesses: American Mobile Satellite Company (AMSC); ICO, which is a global mobile phone system; and SPACEWAY, which is bandwidth on demand, the Teledesic kind of thing that maybe you've already heard about. So, that's Hughes as it will become shortly.

Just to give you a feel of where Hughes is positioned in the market, this is a count of all of the commercial communication satellites ever launched (figure 5). Nearly 45 percent of those were built by Hughes. Today, we're still capturing the majority of the business—50 percent of the business over the last couple of years—so we're maintaining that. You see that Hughes's position in the market is more than twice as large as that of our next competitor, Lockheed Martin, even though they've tried to buy all the other companies.

Student: Is that the world market, or just the U.S. market?

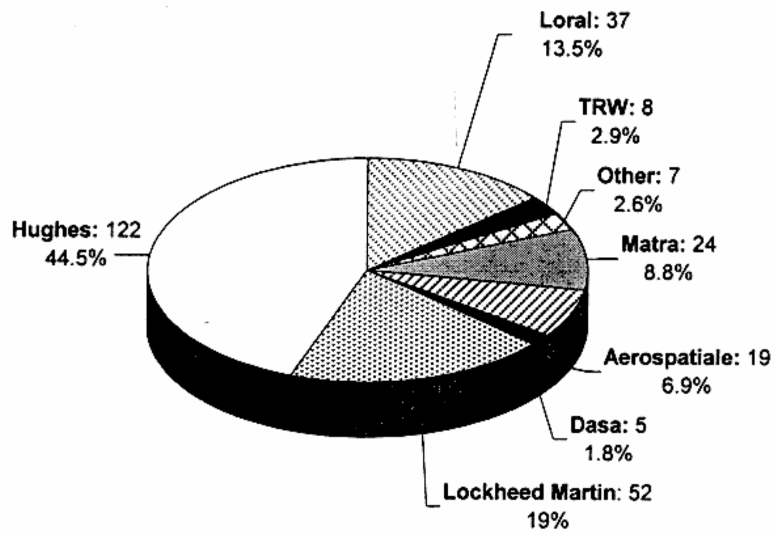


Figure 5
Commercial Communications Satellites Launched

Rankine: It's the world communications satellite market.

Let's talk just a little bit about trends in the world of commercial satellite communications (figure 6). We've already been kicking this around a little bit during lunch, for those of you who were here. As I mentioned, there's a tremendous growth in investment in satellite communications. Entrepreneurs around the world are saying, "Gee whiz, I'd like to put in my own satellite phone system. I'm going to go buy a satellite. I'll get some investors." All the investors are finding that this is a very lucrative market, because you put your money in up front and then you get a continuous revenue stream for a decade or more.

- Tremendous growth in investment
- Revolution in information technology
- New and emerging services
- Global service providers
- Total end-to-end systems designed with focus on affordable consumer products
- Rapid growth in commercial support to DOD operations

Figure 6
Trends in Commercial SATCOM

That's created a revolution in technology, because now the consumer is the person whom you're trying to serve, and the consumer wants hand-held phones and small products, such as DirecTV. It's an 18-inch dish, so it doesn't violate any of the covenants on apartment buildings and homes. These emerging services are coming as a result of the investment and the consumer demand, and they're tending to be global in nature. This is creating all sorts of strange fellowships, I guess I would say. To be successful in a global mobile phone system, like Iridium[1] or ICO or Odyssey or Globalstar, you actually need to have partners around the world because you want to be able to use your phone in that country, and in order to have landing rights they have to be a partner. So what's happening is that global companies, global consortia, are being created.

The way that we approach the commercial market is total end-to-end systems. DirecTV is a good example. It was designed as a total end-to-end system, starting from the con-

[1] Iridium is Motorola's configuration of 66 communications satellites.

sumer. What's the product? You won't pay more than a thousand bucks for this. You need about 150 channels. You've got to have a dish that's only about as big as a pizza because of the covenants in the neighborhood and so forth. Those starting positions, then, drove the design of the satellite. It wasn't, "Design the satellite and then see what you could do on Earth." It was, "Design the Earth system, put limits on the Earth terminal, the consumer terminal, and then that makes the satellite be what it has to be."

Technology has made that approach possible. One of the things we're going to get to later on is that the government needs to start thinking that way also, and start thinking about buying an end-to-end information system, instead of buying an SHF (super-high-frequency) satellite and then terminals separately and so forth.

Oettinger: Stop me if you're going to get to this later on, but before you leave this slide that mentions "new and emerging services" and "affordable consumer products," one of the strikes against satellite voice communications has been the delays in going back and forth to geostationary orbit. As a consequence, on heavily traveled routes, fiber, let's say, without these delays is competitive. Can you say something about either the marketplace or technology that is changing that, and where the business is and where it is going?

Rankine: Yes. We'll actually get to that in quite a bit of detail, but let me just give you a little bit of up-front information. As you'll see in a moment, it is true that most of the geosynchronous satellites in use today are used for video, so it doesn't matter if there's a couple of seconds' delay. It is also true that the satellites for global voice, the mobile satellite-based phone systems that are coming along (we call them the big LEOs—the big low-Earth orbits), are at low-Earth orbit for that reason, so that you don't have this annoying four-tenths of a second delay that it takes to go all the way up to geosynchronous and back at the speed of light. However, I'll also talk to you about some systems called regional mobiles that we're now selling. Those are in parts of the world that haven't had phones. If you haven't had a phone, then you don't find a four-tenths of a second delay all that annoying. So, it really depends upon where you are in the world. We'll get into each those in some detail.

Anyway, DOD has recognized that there's a tremendous advantage, perhaps, to capitalizing on this reversal of fortune. DOD has invested all this money in technology to push it and now, maybe, the DOD can step back and buy and adapt commercial products to the DOD's needs. But that's a lot easier said than done, and so we'll talk about that a little bit as well.

To talk about the commercial world—this is kind of an outline of this section of the briefing—the idea is that from the 1980s, through the 1990s, through the year 2000, investments have been growing (figure 7). I'm going to talk in terms of four kinds of services. The first is fixed satellite service (FSS), which is the traditional form. It started with Intelsat and the Hughes Galaxy, and that's the stuff that, as I say, is primarily big Earth terminals and a satellite across the ocean to carry video traffic and things like that. That's the way it's used today. That's growing, but it's not growing as fast as the other areas.

Mobile services include Inmarsat (International Maritime Satellite) with a suitcase-sized terminal, which is government supported. Its primary motivation was communication with ships at sea, and that satellite system has been around since the late 1980s. But what's happening now is that we're going from suitcase-sized to briefcase-sized to hand-held satellite telephones that you can use everywhere in the world. That's why this is growing so. The most popular term you've heard is probably Iridium. By the way, Hughes builds the ones shown in boldface, and those are probably the ones I'll use as a point of reference. But Hughes isn't the only one in this business, and there are lots of systems coming along, so when I'm talking about this as a business, I'm talking about lots of suppliers in this regard.

We've had direct-to-home broadcast for some time, and you've seen these great big 6-, 8-, or 10-foot dishes sitting in the back yards of the farms around here. It's analog television, and not too many channels. The big breakthroughs here, with DirecTV, were

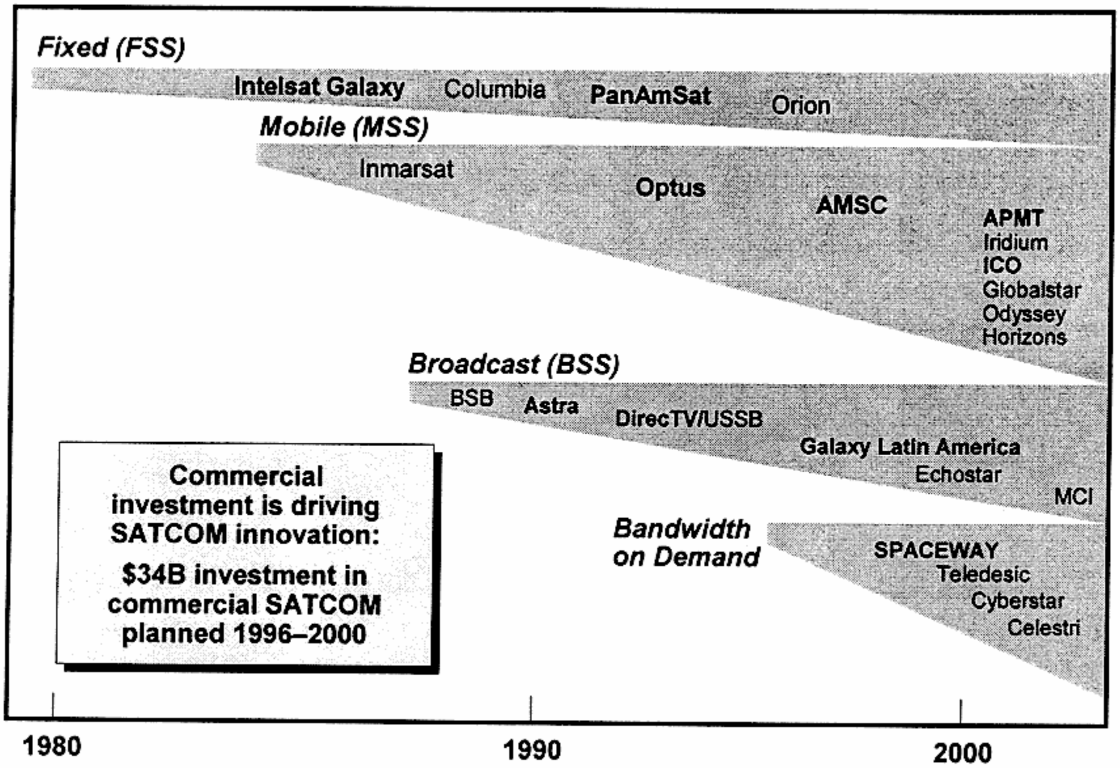


Figure 7

Investment Trends

digital transmission, digital compression, and very high-powered satellites, which have enabled the broadcast of very-high-resolution television to homes, directly into an 18-inch dish. That's the technology that's now spreading around here.

Student: Will they be compatible with the format change for television?

Rankine: HDTV. Yes, they'll be compatible with high-definition television.

The latest entry into this category is called bandwidth on demand. This is up at EHF, extremely high frequency. This was the area pioneered by the MILSTAR satellite, and now it's going commercial. The advantages of very high frequencies are that you get by with smaller terminal equipment. This is where Bill Gates is with Teledesic: put up a network of satellites at low-Earth orbit and ...

Oettinger: It's more Craig McCaw. It's a little bit of Gates's money and a lot of McCaw money.

Rankine: Yes. The idea here is bandwidth on demand. Imagine a computer network phone system, a global area network, where, just as you dial up your phone today, and your phone bill depends upon how long you use the phone, in the future, you will pay for not only the time, but also the bandwidth. So you'll say, "I want T1 for six minutes," or "I want 128 kilobits for 30 seconds," and you'll actually have a global network provider that will sell you, as a business or as an individual, access to a global internet that will allow you to pay for bandwidth on demand. There have been 14 filings for those kinds of services in the United States alone. Hughes is only one of those. Hughes' system is called

SPACEWAY, and I'll talk to you about that in a little bit, by way of example.

What we're going to do now is go through each of these, and I'll give you some specific examples of where that business is going. But the important point here is that as you collect all that together, just in the five-year period from 1996 to 2000 inclusive, we had estimated that there was $34 billion in very sound investment. This is turning out to be a very conservative estimate (it was done back in 1996, and I'm still using the chart), because it's actually been a lot more than that. DOD, for example, typically spends about $1 billion a year, so this is seven times greater, very conservatively, than DOD. Who's driving the market now? Of course, this a global number as opposed to just DOD, which is a U.S. government number. But a big change is coming about.

Let's talk about fixed service, which is where most of the stuff at geosynchronous is today. Everybody is familiar with what I mean when I say geosynchronous orbit, right? Geosynchronous means synchronous with the Earth. In low-Earth orbit, you have to be going faster so you'll circle the Earth more frequently. The Shuttle comes around every one-and-one-half to two hours, I guess. As you go higher and higher, you eventually get to an altitude where you can stay in orbit and circle the Earth once in 24 hours, and so, if you were at the equator, you'd stay over the same place on the equator. The altitude for geosynchronous orbit is at 23,000 miles above the Earth, and that's where most of the communications satellites are today.

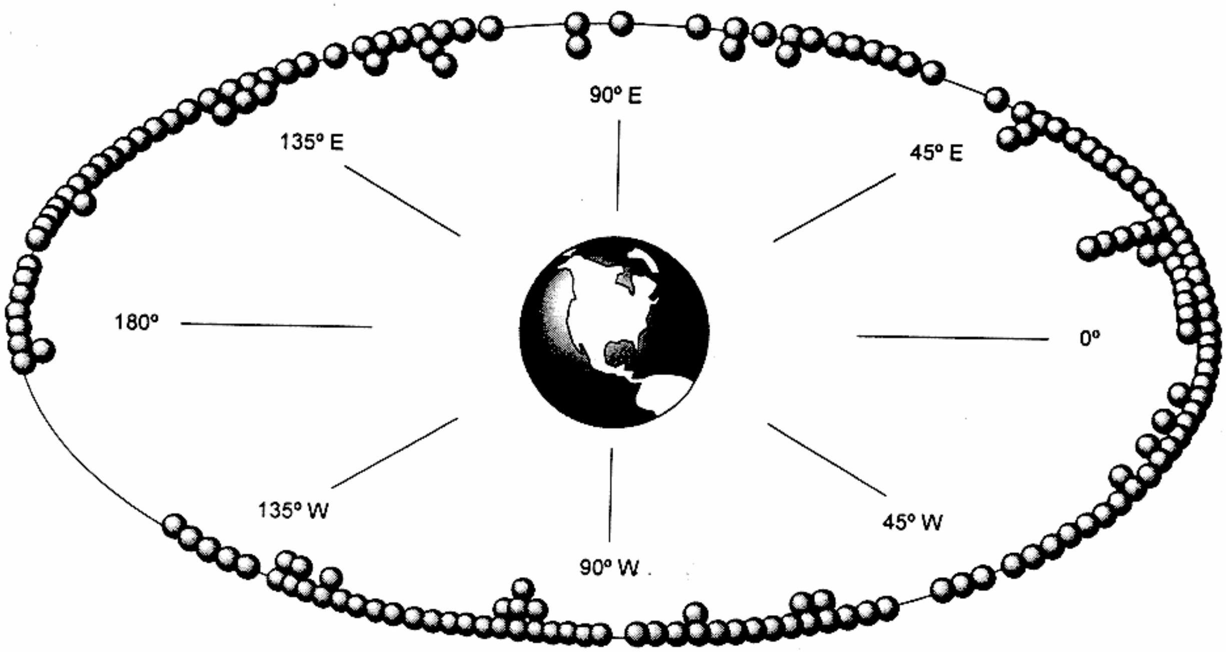
This shows the satellites that are in orbit today (figure 8). I think there are 167 of them, with 70 of them built by Hughes. The PanAmSat fleet consists of 15 satellites, and the rest are owned or operated by other service providers. The slide gives you a feel for what's up there. The ones that Hughes built are shown in blue. The PanAmSat fleet is shown red, and then those that are owned or operated by others are shown in yellow. It gives you a feel for what's up there. This is, primarily, fixed service, and the number of fixed satellite service transponders over the United States (there are several transponders on a satellite) is 567. Since 1991, worldwide, the number of on-orbit C- and Ku-band transponders grew from 1,800 to nearly 2,800. So, it's a growing area, but, even at that level, it's not growing as fast as some of the other areas.

How are those satellites used? As I said, most of the traffic being carried by the satellites is video. The reason is that video takes a lot of bandwidth, and so it tends to use up a lot. If I use the Galaxy fleet—the 10 satellites over the United States that Hughes owns and operates, which we just transferred to PanAmSat—as an example, you see 38 percent cable (figure 9). This is servicing the cable heads: we bring the video to the cable heads and then they distribute it through the metropolitan area. Broadcast/video is where we're supporting the networks, and then there is the area of occasional video/brokers. When you have an unplanned event in the world—like Princess Diana's funeral, where all the news media converged into London and they all wanted to get satellite access—there are brokers who buy transponder time and then resell it at a premium for these surge kind of requirements. They take about 23 percent of the market.

Only 10 percent of this satellite traffic is used for data and voice. But video, a TV channel, is about four to six megabits—five-and-a-half megabits, something like that—so it takes a lot of throughput to do video. Ten percent of this throughput for data and voice is an awful lot of data and voice, and that's where the growth is today, as it turns out. It's in the data and voice part, but because it's a small part of the total, the total growth is smaller.

One of the big uses for fixed satellite service, data, is in the area of very small aperture terminals, VSATs (figure 10). To qualify as "very small," they have to be on the order of a meter or less. Satellite dishes on the order of two to three feet are generally considered very small. The DirecTV dish, which is only 18 inches, is considered an ultra small terminal (USAT). So, if you hear that terminology, that's what it refers to.

The idea here is that many businesses have a hub/spoke sort of an arrangement, like the Chevron gas stations that are spread out all over the country. You want to use your credit card from Chevron to pump gas, and so you swipe the card through the pump and the satellite dish on the roof transmits that



- Total number of fixed satellite service transponders over the U.S.: 567
- Since 1991, worldwide, the number of on-orbit C- and Ku-band transponders grew from 1,800 to nearly 2,800.

Figure 8

Satellite Services Are Experiencing Tremendous Growth

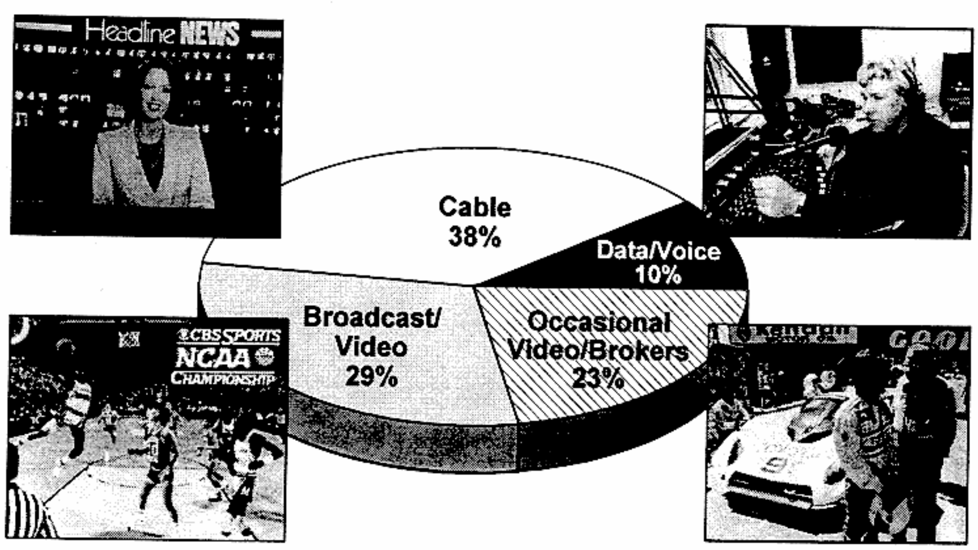


Figure 9
Galaxy Transponder Use

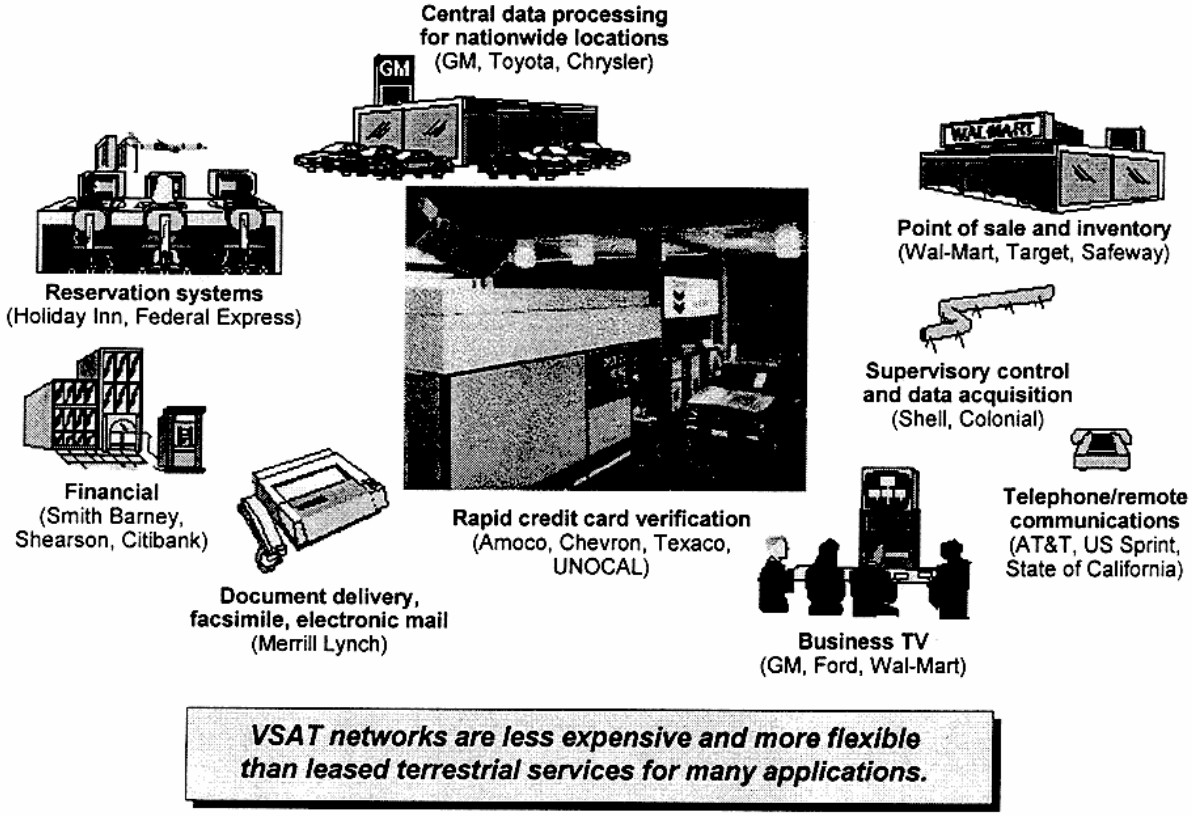


Figure 10

Very Small Aperture Terminals (VSATs)

through a satellite to the central hub, where they look you up in the computer and see that you've paid your bill and that you're authorized to pump gas, and they send the authorization, and the sign on the pump says, "Begin pumping gas." It turns out that this sort of a hub/spoke arrangement can end up being a very inexpensive way of providing communications for such businesses. They don't need the line on a continuous basis. It's a burst transmission, and that transponder on the satellite is handling lots of those bursts with lots of those businesses, so you're only paying for the time, and the time is very short and so the bills are small.

If you go to Wal-Mart, as you check out, they run the light pen across the barcode, and that automatically decrements the inventory for that store. Then, that evening, a burst communication goes out and notifies the warehouse of all the sales in that store. The truck is loaded overnight and comes to replenish all the products that were sold the day before. There again, it allows Wal-Mart to do just-in-time delivery and that, of course, makes them much more competitive because it reduces their overhead. These are the kinds of business networks, and in a moment I'll talk to you about where the Department of Defense is taking advantage of some of this capability as well. So that's where the growth area is in fixed satellite services.

Let's go now to broadcast. Does anybody in here have DirecTV? No? Too bad.

Student: Not one of the million.

Rankine: DirecTV provides more than 150 channels of high-resolution entertainment television and CD-quality audio throughout the United States (figure 11). Three satellites are positioned at the same location: 100 degrees west, and from that location, they have an antenna pattern: literally, this line you see around the United States. If you could see the contours of power for that, what you'd find is that there's more power projected into those regions of the country where the rain rate is higher than into the very arid desert area, where the penetration is easier. The whole system is built to generate enough power to provide a 99-point-whatever percent probability of closing the link from the satellite to your 18-inch dish on your home. Of course, exceedingly high rain rates can interfere with that, but, generally speaking, that has not turned out to be a problem. There's an uplink in Castle Rock, Colorado, where all of the programming is put together, broadcast up to the three satellites and then rebroadcast down in this pattern so that you in your home, with an 18-inch dish facing to the south or southwest, can get 150 channels of programming.

As it turns out, we have also leased five of the transponders on those three satellites to USSB, which you'll find is one of our competitors, but they're actually using five transponders on the same satellites to provide that service, and their uplink is in Minnesota.

Student: Sir, how do you get local television access into DirecTV, or do you have to get that somewhere else?

Rankine: You have to get that separately. I think DirecTV is now selling a product where the set-top box has a connection and you can now put rabbit ears on top of your set, and/or an attic or roof antenna, for the local programming, and then use the satellite dish for the DirecTV programming. Of course, the DirecTV is providing the same service as ... well, I wouldn't say the same service as cable, but it's providing networks: ABC, NBC, CBS, CNN, and so forth. So, if that network program is on your local channel, you can get it over DirecTV. But that's right: it isn't practical to try to provide local programming, because you would have to dedicate channels to that. As I pointed out, this is the antenna pattern, so you'd have to use up all of your 150 channels providing the local stations for Boston, Chicago, Indianapolis, Los Angeles, and what have you.

When we started out in DirecTV, the whole marketing analysis was based upon people who couldn't get cable. As it turns out, though, half of our subscribers are people who had cable and weren't satisfied with it. They like our higher-quality picture, and they like the CD sound, and so forth. So, at any rate, that's been a very successful venture. I guess another thing that I should mention is that with the deregulation that now permits cable companies to handle phones and phone companies to handle cable and what have you, what we see probably coming in the future is a sort of convergence of

DirecTV™	DirecPC™
• Provides over 150 channels of high-resolution entertainment television and CD-quality audio • Current subscriber base is over 2 million since June 1994 • Expected to grow to 10 million subscribers by 2000 • Other satellite broadcast companies: Primestar, USSB, Echostar • Pricing competitive with existing cable	• Provides high-rate data delivery and internet access from 400 kbps to 3 Mbps (significantly better than terrestrial modems) • Current subscriber base is over 20,000 since August 1996 • Expected to grow to 2 million subscribers by 2000 • Competitors expected to emerge in the near future • Competitive with other high-speed delivery choices

Figure 11

Satellites Are the Ideal Solution for Broadcasting Data, Video, or Audio

your home computer, your home television set, and your home telephone. Evidence of that is that AT&T has bought a small percentage of DirecTV, and now they market DirecTV through their 90 million subscribers. DirecTV has signed an agreement with Microsoft to make the DirecTV connection compatible with the PC.

So that ties in with another product that Hughes has called DirecPC. If you've tried to download files off the Internet into your home computer—maybe some sort of an image—you can start loading it and then go have a cup of coffee, go have dinner, and come back later, because it may take several minutes. The idea here is that by using a satellite dish, you can request the file over the phone lines. The order wire, if you will, can be at a low data rate. A click on the mouse, and the file is sent to an uplink in Germantown, Maryland, to a Hughes satellite and then broadcast down with the same sort of pattern as on this slide, and your (in this case) 22-inch dish can collect that signal and feed it in at 400 kilobits per second. The system is actually capable of up to three megabits per second, but most of the PCs that you have at home are limited to 400 kilobits. That's had about 20,000 subscribers since it went into business in 1996, and we expect to have that up to about 2 million by the year 2000.

What Hughes is now offering is called DirecDuo, which is a set-top box for DirecTV that incorporates DirecPC. The kit for DirecPC alone costs $1,200, and with that you get this 22-inch dish, the cable to your desktop computer, and a card that plugs into a 486 computer that provides the interface and the software, and that will enable you then to have these kinds of data services.

At any rate, that's the broadcast area. We see this as a growing area, and for the future, as I pointed out, Hughes is now taking broadcast television around the world. It started in the United States with digital compressed television, and now we're spreading that to South America and to Japan.

Student: How much redundancy do those uplinks have? You've only mentioned one location for each of those. What would happen if you had either a physical or a malicious disruptive event to those uplinks?

Rankine: There are multiple antennas at Castle Rock, but there's not a second backup site. I don't know; maybe we could work a deal with USSB to use their site in that event. That's probably what we'd have to do. Castle Rock is a fairly stable area of the world; it doesn't experience many extreme events.

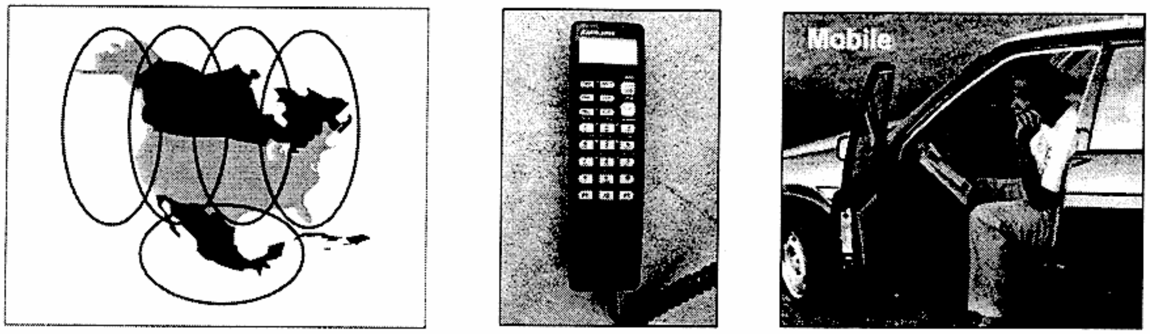
Student: Actually, I used to live there.

Rankine: You didn't experience a lot of earthquakes or anything like that, and it's really out in the boondocks.

Student: You do get a lot of thunderstorms there.

Rankine: Yes. On the uplink it's not a problem because you can pump plenty of power up. The main challenge was the power on the satellite to get the power down to the small dish. Digital systems can take more noise. It's the digital compression technology and the high-power amplifiers onboard a satellite with very large antennas that allow us to close the link to an 18-inch dish, and that's the challenging part. That's the technology that's changed. It kind of opens up a whole new world, because now you've got small terminals with a big satellite. It used to be the other way around. You had a small satellite and you had to have big terminals.

Let's go to mobile services next (figure 12). In 1995, about two years ago, we launched a satellite for American Mobile Satellite Corporation here in the United States. They are in Reston, Virginia. It puts down five beams that look like the ones in the slide, covering the United States, Canada, Mexico, and the Caribbean region. Unlike Inmarsat, which is a suitcase-sized terminal, generally speaking, this is more like a briefcase-sized terminal. The main use of this, the main customer base, is for the transportation industry—buses, trucks, trains, automobiles—and people in the oil fields who have to be out and mobile. So, if you have a business that requires a great deal of mobility, this



AMSC offers the following services nationwide:

- **Satellite telephony**
- **Interconnection to public telecommunications networks**
- **Digital broadcast dispatch**
- **Fax**
- **Data services**
- **Secure communications**

Figure 12

American Mobile Satellite Corporation Providing Satellite Telephony Today in the U.S.

particular phone turns out to be about a third of the price of Inmarsat for service. I think it's on the order of $3 a minute instead of $9 a minute.

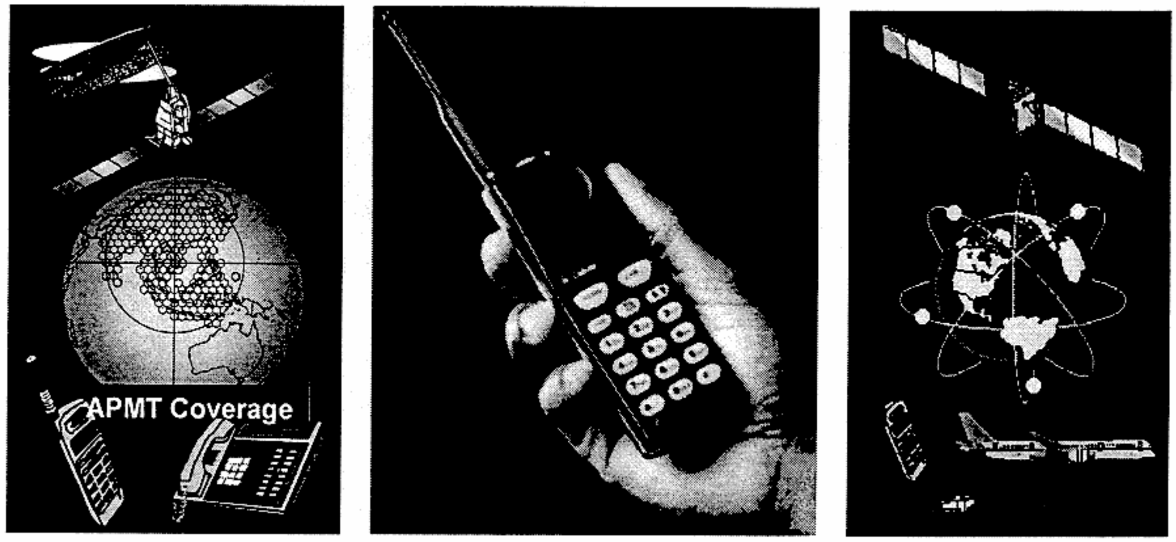
That's where mobile phone capability is today: on orbit. Where we're going shortly is shown in the next slide (figure 13). There are two kinds of mobile phone systems. What we're trying to get to is a hand-held phone, just like your cellular in town here, only now you'd be able to use that cellular phone to talk all the way to a satellite in orbit. Two types of systems are emerging: those that are at geosynchronous altitude, which provide mobile phone service over a fixed region, and what we call "global mobiles," like Iridium and ICO, that have satellites in low-Earth orbit that can provide phone service anywhere on the globe. The idea there is one phone, one phone number, one phone bill, no matter where you place the call anywhere in the world. That would be down there in the same price range that I just talked about with AMSC, but now on a global basis—about $3 a minute, again compared to maybe $8 or $9 a minute for Inmarsat.

This is an interesting satellite. Asia Pacific Mobile Telecomm (APMT) has purchased one, and we just sold one about a month ago to the United Arab Emirates, to a company called Thuraya Satellite Telecommunications Company. As Tony mentioned before, the time delay to a geosynchronous satellite is annoying to people who have had phone service for most of their lives, and so, most of the global mobiles are in low-Earth orbit. But regional mobile addresses a different problem. In the Asia-Pacific region, the Middle East, North Africa, and other parts of the world, there is not a lot of existing fiber and wire structure today. And so, as those countries accumulate wealth and begin to move into the 21st century with the other countries of the world that are more economically advanced, the first thing they need is communications. What they found is that by putting up a single satellite, like these regional mobiles, they can connect their country or they can connect their region, and they can do that overnight with the launch of the satellite, as opposed to several years of stringing fiber and wire.

The left-hand part of the slide (figure 13) kind of shows you the region covered by APMT, which is a consortium of companies from China and Singapore. It covers the

Regional Mobile

Global Mobile



In two to three years, global hand-held telephony will be available for less than $3/minute provided by one or more service providers

Figure 13
Global Satellite Telephony and Data Services

whole Indonesian and Malaysian region—everything from India all the way across China to Japan. Thuraya is going to cover the Middle East, North Africa, and Eastern Europe, all the way across to India. It will kind of join up with this system. The Thuraya sale is a turnkey operation. Hughes provides not only the satellite, but also the ground infrastructure: the satellite telemetry, tracking and commanding, and the handsets, in a deal that's estimated to be about $1 billion, so these are big deals.

Oettinger: Can I ask you about the architecture of these things? Would a system like that be self redundant or would they rely on arrangements, let's say with Intelsat and so on, for backup? How's that industry developing with respect to the worry about outages?

Rankine: In the case of Thuraya, they are buying a ground spare. However, the sale to Thuraya and the sale to Asia Pacific Mobile Telecomm does provide a degree of redundancy, and that actually facilitates sales elsewhere. So, what we're finding is that the companies are working out ways to provide redundancy. A good example is AMSC, which I talked about on a previous chart. There's a Canadian company that's doing the same thing, and they've agreed with American Mobile Satellite Corporation that they will back one another up.

Oettinger: So these are more business arrangements?

Rankine: Right. Remember, we just sell the satellites. But if I were a regional operator adjacent to Thuraya, I could make a business arrangement with Thuraya to back me up if I have a problem, and they will do the same. So, we back one another up. It's a win-win situation.

Oettinger: If I might just break in again for a moment: term paper suggestions. One of the issues, when you've got multiple ownership and multiple countries, is the question of what happens in an emergency and who takes precedence and who screws whom, but can you rely on it, et cetera? I would love for somebody to look at the history of the Postal Union and the Telecommunications Union and the question of interruptions or continuation of flow, especially in the Postal Union during two World Wars. There is a history of both continuity and horsing around, which would be valuable to understand. So if anybody has any inclinations to deal with that, it's a topic that I'd be very interested in.

Rankine: We also have a new satellite series that's coming along, a new model that will offer a great deal more power and capacity. From the standpoint of redundancy, what we're offering to some of our customers is that maybe two of them will want to join up and be on the same satellite. Let's say there are six transponders for customer A, and six transponders for customer B, and three transponders in backup that go to whichever one needs them. Then both customers are allowed to sort of decay by agreement, on a mutual basis, so you can actually provide redundancy on the satellite itself as well. Now, all these satellites have a great deal of redundancy in order to achieve reliability. We're not unusual in the marketplace, but we've got about 98 or 99 percent availability of the channel, which is what's typically required. It used to be that satellites had 5 to 7 years of life; nowadays they are at 8 to 10. That new model that I just talked about will be a 15-year-life satellite.

Oettinger: Can you comment on another question, or rephrase the question if it's not adequately phrased? Switching on the satellite versus switching somewhere on the ground: what is the current state of thinking, state of the art, state of what's being bought?

Rankine: You're talking about routing the messages.

Oettinger: Yes.

Rankine: There are two kinds of service. Most of those fixed services that I was talking about are just that. We call it a bent pipe. They just relay what has been received back down again, so there's not much switching.

Let me go to the next chart (figure 14). We'll talk about switching in the context of ICO, which is the global mobile that Hughes is building right now. Let me explain a little bit about the constellation, and then you'll see why there's a need for some on-board switching and routing.

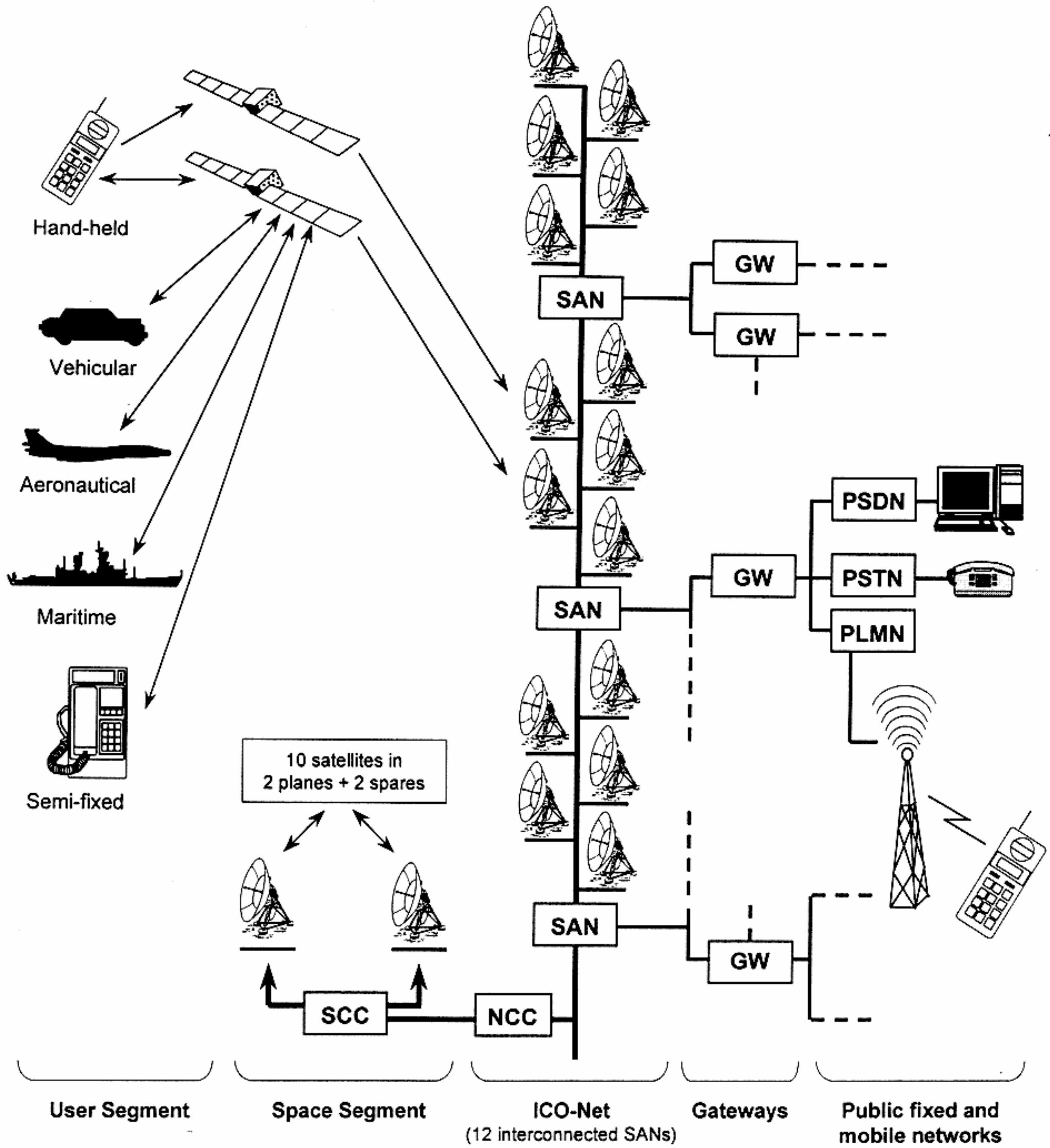
There are going to be 10 satellites, 5 each in two inclined orbits at 45 degrees to the equator. So you've got 5 satellites going around in one direction and 5 going around in the other; a total of 10 satellites. Then there will be a spare in each orbit as well. So your redundancy is provided by putting in an on-orbit spare right from start. Each satellite can handle 4,500 telephone calls, so the whole network of 10 handles 45,000 simultaneous telephone calls.

I should mention the orbit. The orbit is a six-hour orbit. That means it's about 6,000 miles, 10,000 kilometers, above the Earth, so that we get away from the delay going all the way to geosynchronous.

You'll see the antennas are just flat. These are phased-array antennas with electronically steered beams. Having electronically steered beams is important from a business standpoint because these satellites spend a lot of time over the water, where there aren't a lot of customers. What you would like them to be able to do while they're over the water is look to the side, over the land mass. The electronically steered beams on these satellites actually track the customer. In other words, we're going to point to land, where the volume of customers is, with the beams. There are 167 individually pointed spots from this electronically steered array on each satellite. That way we actually manage the customer base and can put the beams where the customers are.

Let's say you're in a vehicle or on an airplane, or you've got a hand-held phone. When you place a call, it goes up to the satellite and then the satellite has to route that call from the header on that call, the phone number, so it will actually route it to the nearest satellite access node on the Earth. This routing, and the antenna steering, requires on-board processing, which makes this different from just a simple bent pipe.

Also, this call comes up in one beam on the receive side, and now it's got to go out on another beam on the downside. It might be



GW = gateway
NCC = network control center
PLMN = public local area mobile telephone network
PSDN = public switched digital network
PSTN = public switched telephone network
SAN = satellite access node
SCC = satellite control center

Figure 14

ICO—the System

going to another mobile, and the satellite knows where that mobile is because it's been in communication, and so we have to route the call into the correct beam for the downlink. That causes a need for on-board routing and on-board processing, which is not typical of a fixed satellite service, where you've got a larger terminal in the U.S., a larger terminal in Europe, and they're just talking to one another, so it's just a simple relay.

Oettinger: There's something I don't quite comprehend. Whenever I'm initiating a call, what guarantees that I'm in the path of one of your beams?

Rankine: The orbits and the number of satellites that I've described make it so that at least two satellites are always in view no matter where you are. As I say, the beam patterns will be controlled to cover the areas where customers are, by and large. I imagine some beams will be left to cover the ocean for ocean traffic, but, by and large, what you want to do is be able to put more throughput where the greater concentration of population is going to be. That's what this ability to squint from side to side allows you to do.

This is different from Iridium. Iridium is crosslinked. These satellites are not crosslinked. Think of a fiber backbone going all around the Earth, connecting 12 satellite access nodes around the Earth. The call goes up to the satellite. If it's going to another mobile in that same region, it'll go directly there. But for the most part, it will go to a satellite access node and then around the earth to another satellite, back to a mobile, or into a gateway and into the public switched telephone network.

This is probably a good point to start talking about the global nature of these systems. ICO is a spin-off of Inmarsat, and its ownership is spread among something on the order of 60 companies in 40 countries. In the United States, the owners are Comsat and Hughes, but we only own a small percentage of it. That becomes very important, because if you want to establish a global phone system, and you want to have the right to operate in all of these countries, you need partners in those countries who are in the phone business so that you can get into their gateway and can make the connections: so you can get into their public switched networks. Therefore, you've got to have partners who are from all of the countries that you want to participate in your phone system. So, I guess you'd say it's sort of a precondition that you must have many international partners—companies in countries around the world—so that you can create a global phone system. That's the only way you'll get the proper landing rights.

Now, when we talk about military applications, this causes a problem for the military, because the phone system's liable to be owned in whole or in part by someone who objects to what we may be wanting to do in some part of the world. That may or may not cause some problems for military operations by the United States or any other nation that happens to be participating in the phone system. It's sort of like the good news/bad news about global participation when you consider applications for the military.

Oettinger: If I might just make another interjection here, I think he's raising an extremely important and generic kind of an issue. There are some Cold War precedents there: for example, in warfighting versus war termination capabilities, which set up different dynamics for, on the one hand, destroying the other guy's resources and, on the other hand, collaborating to maintain them. The outcomes are surprising. There's been more cooperation, even at the height of the Cold War, than one might suspect, and it's a topic that someone might well be interested in.

The other element is that there's an awful lot of loose talk about globalization, which seems to suggest (and often says explicitly) that somehow national boundaries and so on don't matter, locale doesn't matter; it's all sort of global. Claire Boothe Luce used to call that "globaloney." Tip O'Neill, when he was speaker of the U.S. House of Representatives, used to say, "All politics is ultimately local." The manifestations of that continue.

I will make a note to myself, and next week I'll bring in a thing on global-local balances and so forth, which I'll hand out. It's an extremely important topic, especially given the prevalent view that somehow global is overwhelming local. What Bob said underscores the importance of the local, and I think it's a point that you guys will find well worth pursuing as an antidote to some of the prevalent globaloney.

Rankine: ICO, which is headquartered in London, is a spin-off of Inmarsat. Iridium, which Motorola partially owns and started up, also has global partners, as do Odyssey and Globalstar. A number of these phone companies are starting up, and Iridium will be the first to market, with service beginning by the end of 1998 or early 1999. ICO will begin limited service at the end of 1999. The first satellite is being launched at the end of 1998; six satellites, three in each orbit by the end of 1999, will allow ICO to open service.

The reason I mention this is that we're talking about stuff that's fairly near term. We believe that the market is out there at $3 a minute to fill these phone systems up. What that means is that probably more than one will survive. So it isn't just a matter of: "Oh, well, Iridium's up there and it's successful, so nobody else can do it." All of these systems are limited in the number of calls that they can take in a particular region at any moment in time, and so if a market really does grow the way all the analysts are predicting, there's probably room for three or four of these systems in the stew.

So that's the global mobile, which is primarily voice and low data rate stuff. If you want to get to high data rate, then we go up to the new Ka-band. As I said, the technology here comes from MILSTAR, a military satellite that developed a lot of the EHF devices, transmitters, receivers, phase shifters, and what have you. That technology is now being applied to the commercial world. When the Ka-band opened up, there were 14 filings in the United States. Hughes was one of those. The idea here is to have a network of satellites around the globe that permit everything from voice and data communications all the way up to data rates generally around T1, although higher data rates would be possible. It's a matter of what the market requires. It's not particularly limited by what can be provided technically.

The idea is to be able to connect any computer anywhere on Earth to any other computer anywhere on Earth via satellite links (figure 15). It could be for business purposes; it could be for personal purposes. Also, this is a technology that could, honest to goodness, enable videophones, because now you can have a small video camera, as perhaps you do now over your PC. By linking it into this, you're getting up to bandwidths of 384 kilobits and higher where you can get a reasonably good video picture. So we talk about having teleconferencing and telemedicine. Today, it takes 21 minutes to send a medical X-ray over the phone lines. Here we're talking about a matter of a few seconds to send a medical X-ray. So, the medical community, for collaboration, sees this as quite a definite advantage for interactive training, interactive distance learning and so forth between student and teacher, worldwide.

Again, there are two kinds of terminals. The very small one, the ultra (now you know what a USAT is, right?) is a small-aperture terminal, about two feet, which would be able to handle a 384-kilobit per second burst. A larger terminal, about four feet, can handle 384 continuous or a T1 on a burst basis. We're looking to put the cost of the ultra-small terminal under $1,000, which is the magic consumer entry level if you're going to get these things into households. If you recall, DirecTV started off at $700, and that's kind of where the consumer products have to be. They can only have three digits of dollars, I think; they can't have four. So that's, generally speaking, where you have to start. You're also looking at less than $3 a minute for a 384-kilobit connection, which is good enough for a videophone.

Teledesic is the Gates/McCaw entry in this. They've gone to Boeing to build their satellites. It's not publicly announced yet, but it's not a secret that Hughes is talking to Boeing about the payloads for those satellites. We haven't signed a contract yet, but we're the only ones they are talking to right now. Teledesic is a large number of satellites, 288 satellites, in low-Earth orbit.

Contrast that with the Hughes entry into the same market called SPACEWAY, which is eight satellites at geosynchronous (figure 16). Here's a case where geosynchronous doesn't matter, because this is primarily viewed as being a data network connecting computers

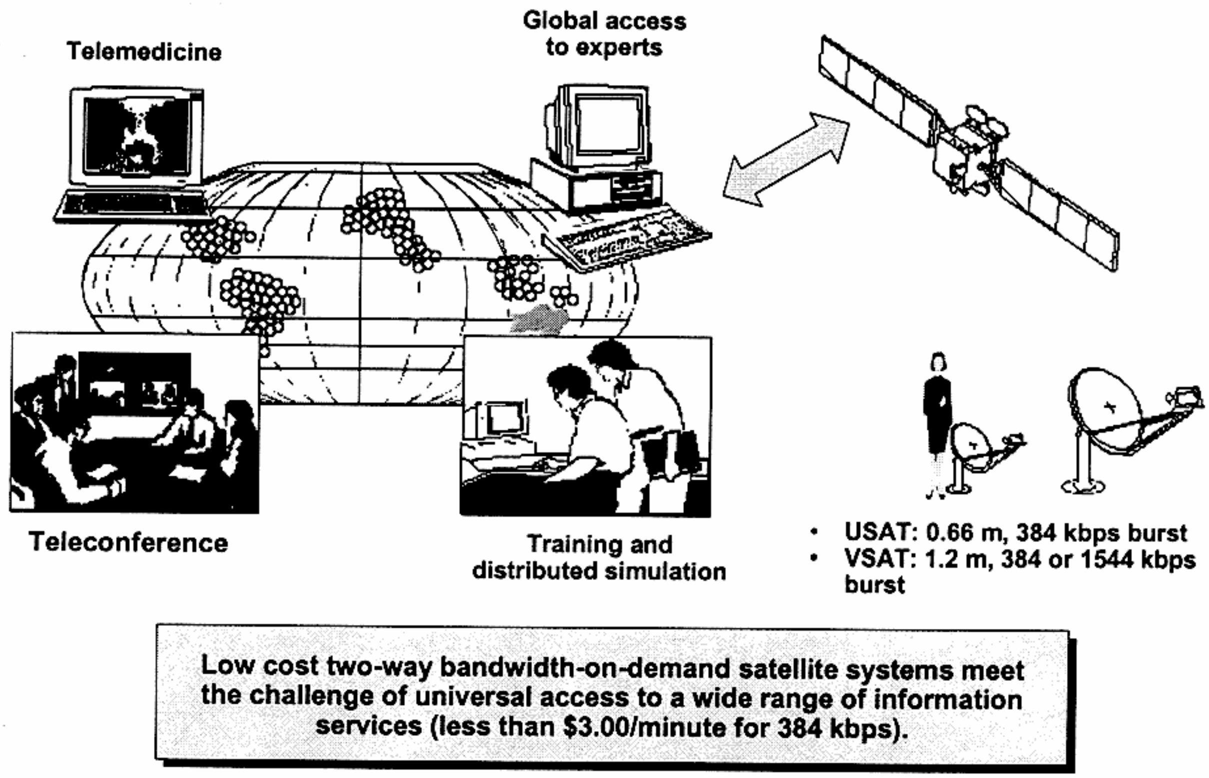


Figure 15

Bandwidth-on-Demand SPACEWAY™ Space-Based Information Exchange

around the world. Therefore, a little latency of four-tenths of a second doesn't matter all that much. As I mentioned to you previously, these would be crosslinked in order to provide a ring around the earth. The services that you are looking for here are teleconferencing, telemedicine, interactive distance learning, distributed simulation, all of those things that require two-way broadband connectivity, as opposed to things like DirecTV, which is one-way broadband.

Oettinger: Can you comment for a moment? The voice and the low data rate things are proven markets with huge growth rates, and so, in a sense, it's not that big a gamble to figure that there'll be a market. You're talking about stuff here that strikes me as much more speculative. Am I wrong?

Rankine: No, you're not wrong. If you remember that chart where I showed you the different businesses (figure 3), you saw there that bandwidth on demand was further to the right. It's less developed. Teledesic, Motorola's Celestri, Hughes' SPACEWAY: the business case is still being built right now. Nobody is building satellites yet. They are building business cases and doing satellite designs that will come up with terminals and charge rates for the service that the consumer can afford. That will constrain, then, how many satellites you can build and what they're going to have to cost.

Oettinger: May I pursue that just a little bit further? It seemed to me that one indicator that this scheme is about to take off would be if large companies, or militaries, or whatever, that have fiber linkages and are in fact using those linkages for that kind of application, are aching for broader coverage, ad hoc coverage, et cetera. What's your sense of what's visible out there as opposed to speculative?

Provides worldwide "bandwidth on demand"

- interactive, digital, low-cost, Ka-band communications services: voice, data, images, video
- affordable teleconferencing, telemedicine, interactive distance learning, distributed simulation

Communications at rates from 16 Kbps to 6 Mps— compatible with terrestrial services

Eight-satellite constellation serving four interconnected regions

- North America, Asia Pacific, Central/South America, and Europe/Africa

Capacity per satellite:

- 230,400 simplex 16 Kbs circuits
- or 2,880 simplex 1.5 Mbs circuits

Low cost (<$1,000), easily installable, mass market, ultra-small aperture terminals (26")

Figure 16

Spaceway™ Switched Bandwidth

Rankine: The issue of fiber competition is an important one. I think the way that the entrepreneurs who wish to enter this market see it (we talked about this a little bit at lunch) is as what is called "the last mile." The fiber that you run to your home, to your business, is an expensive addition. It's not just a matter of running the fiber from New York to Chicago, but it's a matter of running a tail of that fiber to every home and business in Chicago and every home and business in New York. That's a whole infrastructure issue that takes time and a great deal of money.

Now you're saying, "I want to do the whole United States and I want to do the whole world," and that begins to look a lot more difficult than giving everybody a hand-held phone (because we see people running around with hand-held phones already), or giving them a small, 22- or 24-inch, dish with their PC.

Oettinger: So you're saying that part of this is speculation on things that might leapfrog the last mile.

Rankine: The problem is the last mile. The other problem that it overcomes is mobility. If you want to do this in an airplane, a car, or a train; if the military wants to do it on the move; if you want to be able to pick it up and take it with you no matter where you go; if you want it either portable or mobile, then it may be a lot more convenient to do that with a satellite connection than with fiber, provided the rates are competitive.

Oettinger: I'm not thinking only of rates. I'm thinking of the fact that in some of these areas, although there's been a lot of talk, there is on whole less practice. I sort of wonder whether there are enough people around with the know-how and the interest and the ability, in fact, to use enough of it to pay for it over a reasonable payback period.

Rankine: Just think about the airlines. You could have DirecTV in the seat back in front of you, like you have the phones now, and you could also plug in your computer and collect your e-mail, carry on phone conversations, or carry on videophone conversations from your seat in the airplane. That all is possible within the next five years. That's what you're looking for, and it's hard to imagine how that's going to be perceived. There is a certain degree of skepticism, even with the global mobile, because who's really going to use that one phone/one phone number anywhere in the world? We think that business people will use it. I'm not sure that consumers might not find it cost prohibitive initially. Three dollars a minute may be too much for consumers. I don't know.

Student: I haven't seen a motor home on the road that doesn't have a DirecTV dish on top. I've seen ads now in the magazines for DirecPC setups for motor homes and that sort of thing. There are 2 or 3 million of those things on the road right now, and that number is growing with all the retiring yuppies. That's a pretty good subscriber base right there.

Rankine: Right. I think the people who have seen the success of DirecTV and cellular phones say, "Cellular phones work, DirecTV works, that was a good marketplace; so why not a global Internet for computer networks and why not global phone systems and so forth?"

Oettinger: His point is well taken. It's this question of indicators: real indicators of real people, either in businesses or in mobile homes, who are, in fact, shelling out real money to do something, as opposed to somebody doing a business plan in a corporate entity or trying to milk the taxpayers in some government entity, both of which are less real than some mobile home person shelling out their own hard-earned money. To my mind, this evidence for a base on which something can really take off is a critical thing to focus on to test the reality of ideas that have been around for a long time, but where the issue is not whether something is technically feasible or whatever, but whether there is anybody out there who really wants it.

Rankine: This part of the briefing was intentionally longer than the rest, so you shouldn't worry that I only got through this first area, because to me this is where the real meat is. You have to understand where the commercial business is going, and then you can talk about how that could be applied to the DOD. You first have to realize what you've got, and then some of the applications, I think, become a bit more obvious.

What does it mean when I say "military use of commercial?" There are really four elements of that (figure 17). Military use of commercial means that when we buy DOD satellites, we use commercial practices in the manufacturing. We allow the use of commercial parts, those sorts of things. That's commercial, and that's being done.

Technology insertion could mean here that, because we've gone ahead and created DirecTV, the military can now take that

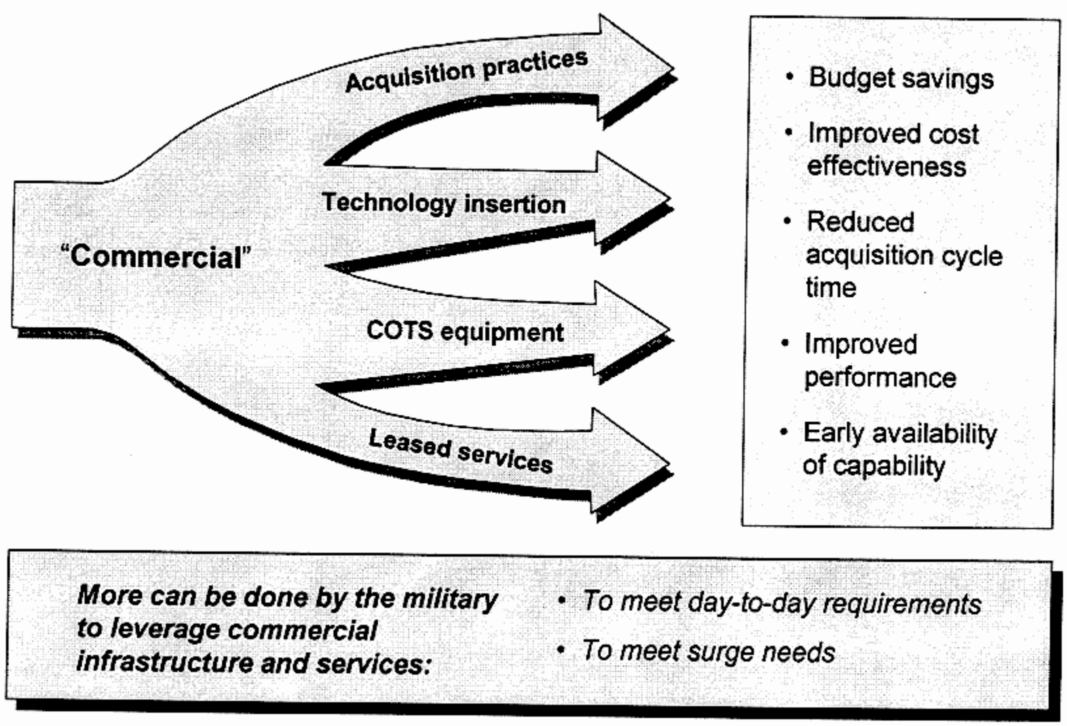


Figure 17

Military Use of Commercial Has Multiple Meanings

DirecTV technology and put it on a military satellite and call it the Global Broadcast System (GBS). I'll say more about that in a moment, because that's exactly what happened.

I'm going to show you an example where the military goes out and buys a VSAT network based on COTS (commercial off-the-shelf) equipment, and pays for the time.

Finally, there are leased services. This is something that DISA, the Defense Information Systems Agency, has been doing for some time: leasing commercial satellite communication services. More recently, under the Commercial Satellite Communications Initiative, DISA went out and purchased some transponders on satellites. DISA had been leasing circuits for the military for a number of years. The idea was that if DISA could bundle those circuits, they could lease a whole transponder. Of course, now they're a bulk buyer, and they ought to be able to get wholesale rates instead of retail rates, and they ought to be able to reduce the cost of commercial satellite communications to the military. So there's an example of leased services. It turns out all these things listed on the slide are true, and there are opportunities to take advantage of this explosion in commercial satellite communications in all of those ways.

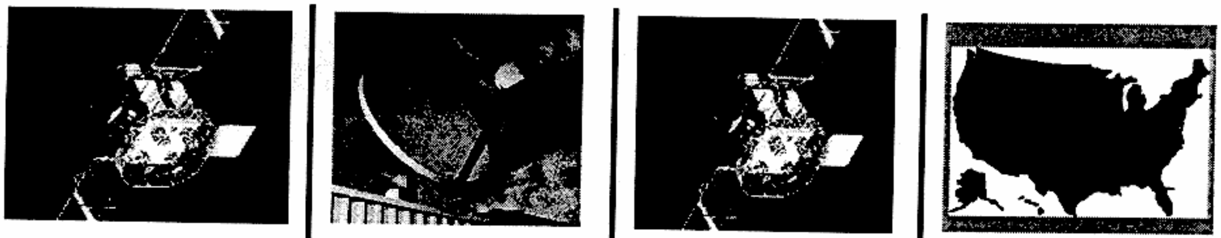
The military has begun to do this. Let me give you a few examples here (figure 18). First of all, I'm using Hughes examples, but other companies could come in and give you their own examples. The U.S. Navy buys the UHF follow-on satellite from Hughes. Ten satellites in all are being manufactured, and this is a firm fixed-price contract, which is sort of unheard of in the military. DOD typically buys a product, such as a satellite, on a cost-plus-fixed-fee basis. So firm fixed-price is beginning to get commercial like.

They take delivery on orbit. Again, that's kind of unheard of in the U.S. government. But, believe it or not, now NASA is doing that. Hughes is building the TDRS, the Tracking and Data Relay Satellite, for NASA. We won it away from TRW, and we offered a firm fixed-price deal. And so, NASA is buying their very first satellite on a firm fixed-price basis, which is the way we do all of our commercial satellites. The UHF follow-on and TDRS programs are examples of the U.S. government beginning more and more to use commercial-like practices in buying communications satellites.

The second thing is that the federal government, the Department of Defense, is leasing commercial circuits. The LOCE, Linked Operational Centers Europe, is for the distribution of intelligence information. It's got a wire from Molesworth to the VSAT hub at Hughes-Olivetti in London, and then it's distributed to 160 fixed receive sites around Europe, including Bosnia, so it's supporting the operations in Bosnia. It's a leased service from Hughes-Olivetti: a VSAT network every bit the same as the one I just described for Wal-Mart and for Chevron.

The Joint Broadcast Service is the forerunner to GBS, which I'll talk about in a moment. DISA, cooperating with some other agencies, went out and bought, I think it's up to 206 now, DirecTV set-top boxes, and took them to Bosnia, and they're using that DirecTV commercial capability off a commercial satellite in Europe to distribute Predator data. The Predator unmanned aeronautical vehicle is a surveillance vehicle. It goes out, looks, and keeps track of who is doing what to whom in Bosnia among the factions. It's continuously watching them on TV, with an infrared picture. That data is taken from the ground station and sent back to the United States, believe it or not, and then rebroadcast, over a satellite, back into Europe. But the warfighters don't really know the difference, because they're seeing it in near-real time and now everybody throughout the theater, and in all the support regions in the surrounding country, is able to watch the same video that's coming down from Predator.

Oettinger: To put that in context, if you start reading, for example, a couple of those books on which I gave you reviews about the Gulf War and so on, one of the major complaints was the inability to do that. So we're saying that in the period since the Gulf War, we've put in place an ability to deliver at least some tactical stuff that's gotten on site, processed in the U.S., and brought back, essentially, in real time. So it's a significant change from just four, five, six, or seven years ago.



UHF follow-on program

- Firm fixed price
- Full government specifications
- Agreement to use some Hughes practices and standardized processes
- Delivery on orbit
- New requirements accommodated

Commercial SATCOM support to Joint Endeavor

- LOCE network
  – 100+ site VSAT shared hub network
  – Information sharing between U.S., allies
- Joint Broadcast Service
  – Commercial DBS-based broadcast service
  – Modified commercial DSS™ boxes

Interim GBS on UHF follow-on

- Total commercial pricing
- Using commercial specifications on hardware
- Primarily commercial test requirements
- Leveraged commercial investment in DBS system concepts and technology

Air Weather Service VSAT Network

- 160 site commercial VSAT network
- Hub installed at AFGWC in Omaha, NE
- 2 Mbps weather dissemination
- Full operational capability 1998

AFGWC = Air Force Global Weather Central
LOCE = Linked Operational Centers Europe

Figure 18
Recent Successes in Meeting Military Needs

Rankine: This Joint Broadcast Service is phase one of a three-phase DOD program to permit the use of this kind of a DirecTV-like broadcast service for the secondary dissemination of intelligence information primarily, but also for any wide-bandwidth product the military uses. The military has found out that a lot their needs can be met by a broadcast system. In other words, I'm at an airbase, and I want targeting information. The request for the targeting information is a small message; the actual targeting information, which may be images, is a big message. It's very asymmetric, and so this fulfills a very dire need.

In the Gulf War, one of the things that was recognized was that although we were able to get intelligence information to the headquarters, the ability to get it out to the warfighters who really needed it was significantly hampered. That's called the secondary distribution of intelligence information.

Oettinger: Ken Allard's presentation in the spring [of 1997] describes how he was sent to Bosnia to investigate why this stuff was not possible, so it's an interesting note.[2]

Rankine: Joint Broadcast Service is an experiment using a setup just like DirecTV; in fact, using the same set-top boxes as we use here in the United States. To provide a military system, though, for more permanent use, the Navy contracted with Hughes to put DirecTV ...

Student: Which satellite do they use? I am certain that DirecTV has their own satellite over in Europe.

Rankine: DirecTV, in concept, can use any satellite. It depends upon what the beam

[2] C. Kenneth Allard, "Information Warfare: Hierarchies or Networks?" in seminar proceedings, 1997.

coverage is. Remember, we have high-powered satellites, but the beam coverage is the whole United States. It turns out that in Europe the satellite has lower power, but the beam pattern is smaller, so the equivalent radiated power can still be quite high, and you're able to close the link with perhaps a little bit larger dish. It's still digitally compressed data that you're getting, so you get essentially the same sort of product. It's a commercial product.

What's being done now is that the Navy contracted with Hughes to modify the last 3 of these 10 satellites to put DirecTV-like transponders on the UHF follow-on satellite. I'll go into some detail on that in the next chart, because that was an area of specific interest.

One last example I wanted to give you before I go back to GBS is the Air Weather Service. It gathers information from the civil and the military weather satellites, collects it at the Global Weather Central in Omaha, Nebraska, and then it needs to disseminate that data to all of the airbases in the United States and, indeed, around the world. They have procured a VSAT network to do that, and that allows them to send weather data out, actual cloud imagery and so forth, at 2 megabits per second. Because there's a low data rate reply, each airbase can respond, "Yes, I got the new weather information." That becomes very important from a safety of flight standpoint. The base needs to confirm that it got the current weather information because that could have an impact on flying operations. So that's another example of military use.

Let me talk about GBS just a moment. Begin with this chart, which shows what GBS is all about (figure 19). The idea of GBS is that you've got a lot of mobile military units in the theater that require broadband information and have no way to get it today without having headquarters send them a glossy black and white picture of something, and that means they've got to fly it to them or mail it to them or something like that.

How can we get them into the loop? A Navy admiral pointed out a couple of years ago that his uncle in Nebraska was able to get more megabits through his DirecTV into his home—700 megabits, from which you select which 4.5 to 5.5 you want to watch—than the whole carrier task force could get. So, the idea was that maybe we could adapt DirecTV technology to fulfill this military need, which was recognized in the Gulf War.

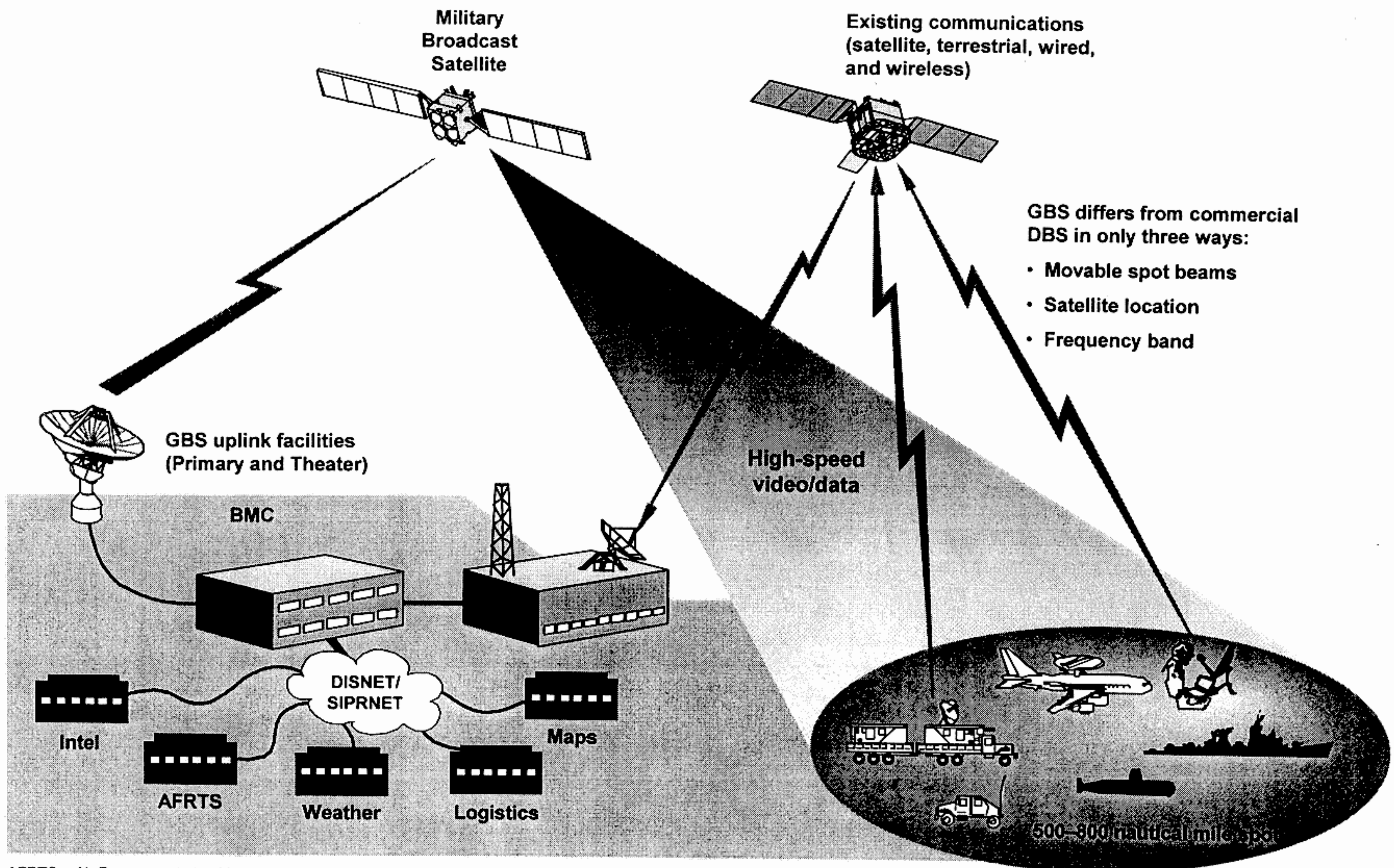
There are lots of ways to request data. If I've just received my air tasking order and I've got to go fly a mission, and I've been assigned a target at a certain time, I can request that targeting information. As I said, that message to request the targeting information is a small, narrowband, short message, but the targeting information itself is broadband. It's an image, and it's other intelligence information. I can use many of my mobile comms capabilities to make the request. I can use the UHF satellite. I can use MILSTAR. I can use line-of-sight wireless radio. I can use all sorts of capabilities and capacities that already exist in the theater for narrowband mobile comms. But now I can receive wideband if I can put DirecTV-like transponders on a military satellite, and put them at a military frequency so that I can address the landing rights problems. Then, on the broadcast band, the weather information, intelligence information, map information—all of those things that are large files—can be assembled and broadcast over an uplink to the satellite and then back down to the warfighters. That's kind of the idea of GBS.

Specifically, then, here's what we are going to have on the last three UHF follow-on satellites (figure 20). The first of these is going to be launched in February, and it will go up in the Pacific.

Oettinger: Could you just make sure, so that UFO is not misinterpreted, what that stands for?

Rankine: UHF follow-on. It's not an unidentified flying object.

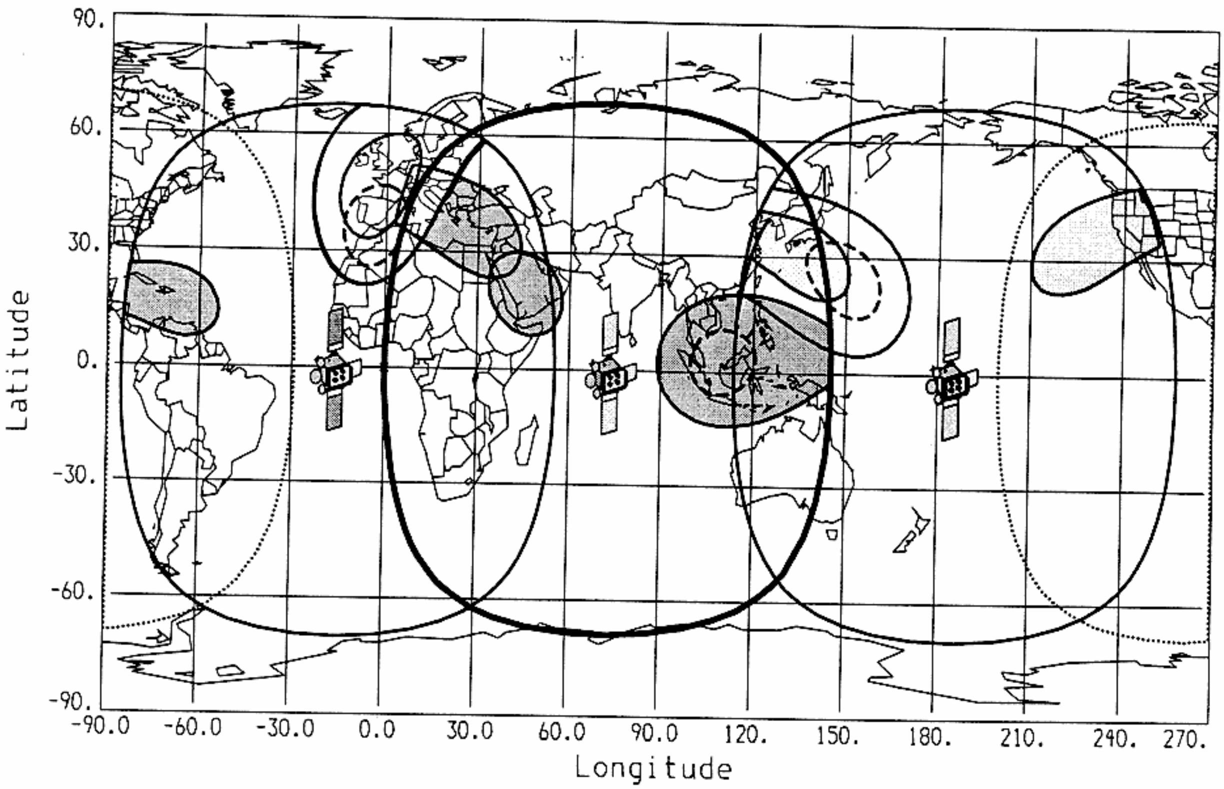
The Navy provides the UHF SATCOM. The Air Force provides SHF and EHF SATCOM on two other satellites that I'll tell you about in a little bit. But UHF provides mobile comms for all of the services. In other words, although it's owned and operated by the Navy, it provides mobile capability for all the services. Up to this point it's been two way, fairly narrowband. Now this gives the U.S. forces the ability to receive broadband at military Ka-band.



AFRTS = Air Force remote tracking system
BMC = Ballistic Missile Command
DISNET = Defense Information Services Network
SIPRNET = Secret Internet Protocol Router Network

Figure 19

A Global Broadcast Service Architecture



All three GBS payloads on UFO provide:

- three very high throughput (24 Mbps) + one high throughput (1.544 Mbps) communications channels,
- data injected from one uplink broadcast management center terminal plus (1–4) direct theater injection terminal(s),
- downlink into two steerable 500-nmi regional coverage beams plus one wide area 2,000-nm coverage area,
- and received by a large population of very small (22-inch) user terminals.

Legend

24 Mbps 500-nmi Spot Beams

1.5 Mbps 2000-nmi Wide Area Beam

500-nmi Sweet Spot

Figure 20

Interim GBS on UFO—2-Spot + 1-Wide Area Coverage

Just to give you a picture, here's the Earth with the three satellites up, one over the Pacific, one over the Atlantic, and one over the Indian Ocean. The one at the right is the first satellite, over the Pacific. The satellite is equipped with four transponders, each of which has 23.7 megabits capacity, so on the order of about 100 megabits throughput is available from each satellite. A video channel, as I told you, is about four, five-and-a-half for continuous video, and, obviously, that's not all going to be used for continuous video. But it just shows you the number of video channels, if you wanted to use it that way, that would be possible.

You noticed that in the case of DirecTV, the antenna was fixed over the United States, because that's where the population is that we want to serve. In the case of the military, in order to broadcast down to the warfighters, we don't know where the next crisis is going to occur. If I try to make it a global coverage antenna, now I don't have enough power to close the loop, to close the link, so I've got to have spot beams. Then the answer is, okay, then I've got to go to movable spots.

What you see here is that anywhere in the viewing region of this satellite I can put down two 500-mile spots—in fact, I could overlap them—and I can put down one 2,000-mile spot. I can use three of those transponders to drive those 500-mile spots. Therefore, I could have one 500-mile spot, and everybody who's in that spot could receive 23.7 megabits (I'll say 25 to round off). I could put two transponders in the other spot, and they're getting 50 megabits. In the 2,000-mile spot, because that's spreading the energy over a larger area, I can't close the link at 25 megabits, so that's a T1 spot, and everybody in there gets one-and-a-half megabits. I'd have to use one of my transponders and run it down to only one-and-a-half megabits.

The point is, now, that's probably for the ships and airplanes in transit, and so forth. In that 2,000 mile-spot, they'll be able to get information about maps, intelligence information, and what have you, and the 500-mile spots can be placed down over the AOR, the area of responsibility in the theater, where the activities are actually being exercised. Now, everybody in that theater with ... in the case of the military, I think a 22-inch dish, could receive 75 megabits per second if both spots were put there. In fact, all four transponders could drive all the spots in one region and they'd get 100 megabits per second.

So, we've got a global system now with three satellites, with the ability to distribute 300 megabits per second. You see the overlap regions in Europe and in the Asia-Pacific region, where there's perhaps the area of greatest concern. It takes four satellites to cover the whole Earth, and so the slot where there's no coverage is over the United States and the Pacific off the coast of South America. But the areas where most of the warfighting activities or crises or humanitarian activities are likely to occur around the world are covered by a three-satellite constellation.

The reason that there are only three, as I said, is that these are the last three in production and they were the last three that we're able to catch in time, in production, in manufacturing, in order to make the modification to add the GBS transponders.

That's kind of a quick tutorial on the GBS. Are there any questions about that?

Oettinger: I have a quick comment on the revolution of rising expectations and why this paradox of on the one hand, progress, and on the other hand, dissatisfaction. If you go back to seminar proceedings around the time of the Gulf War, you'll see a lot of our Navy friends complaining that while they're at dock they have this wonderful communication capability, but a quarter mile out, they might as well be in the middle of the ocean with their eyes and ears cut off.[3] From that point of view, this is miraculous stuff. From the point of view, though, of what you get used to on the farm in Nebraska, it isn't adequate. And so, on the one hand, you get this sense of wonderful progress, on the other hand not. We've only begun the revolution, so it's fascinating.

Rankine: Let me close this off in more rapid fashion, since we're running out of time here. But, the next question is, "Okay, well, what can we do to further leverage commercial for the military?" I think the first thing to note is that if you look in various military documents about the requirements for communications in the future—the Joint Warfare Capability Assessment, C4I for the Warrior, OSD Requirements Summaries—they are at the generic "300,000-foot level" (i.e., the "big picture").

Here's one way of putting the requirements (figure 21): fully integrated mix of high/low bandwidth services, direct user connectivity at the workstation/telephone

[3] Richard J. Kerr, "The Evolution of the U.S. Intelligence System in the Post-Soviet Era," in seminar proceedings, 1992; Barry M. Horowitz, "The Emergence of Data Systems: Cost and Technical Change in Military Systems," in seminar proceedings, 1993.

- Fully integrated mix of high/low bandwidth services
- Direct user connectivity at workstation/telephone level
- Rapid deployment of theater infrastructure independent of existing assets in place
- Significant improvements in access by introducing more affordable services earlier in architecture

Source: Joint Warfare Capability Assessment; C4I for the Warrior; OSD Requirements Summaries.

Figure 21

Emerging Requirements— Digital Battlefield Communications

level. There I could say the same thing for the commercial consumer. In the area of rapid deployment of theater infrastructure independent of existing assets in place, consumers want something light and small, not too expensive, because of using it in their homes. The military wants it so they can deploy it easily without taking a whole 10-meter DSCS (Defense Satellite Communication System) dish to the theater. Now they can take a 22-inch dish to the theater. Then they want significant improvements in access by introducing more affordable services earlier in the architecture.

So that's what the military says they want. If you look at what the military has today, and we've already talked about this to some great extent, wideband only exists between major fixed installations. Everything else, even some of the tail circuits out to the smaller bases that are wired in, is still not necessarily wideband. The slide shows some of the connectivity and systems that are available today: long-haul fiber, microwave, trunk SATCOM, MILSTAR, mobile SATCOM, line-of-sight, and terrestrial telephony. I'll talk about the DSCS satellite in a minute.

If the military can harness this bandwidth on demand and global mobile technology that I've just described to you, actually there's no reason that everything on this map cannot receive wideband connectivity. That's why the military is interested in trying to harness this growing capability that's appearing in the commercial world.

Just one small point of reference. I know that some of this is old hat to some of you, but some of you may not be familiar with it. These (figure 22) are the military satellite communications systems in existence today. Although the slide says Hughes Electronics, it's a military slide. It was borrowed from the Senior Warfighters Conference that was held about a month ago. These are not my words. This is what the military is saying. We talked about the UHF follow-on satellite, and that's what provides the mobile communications for the military today. The Navy has purchased 10 satellites. They've got eight slots to fill with those 10 satellites. There were, of course, forerunners to that.

As those satellites are launched, and they begin to age, you start playing probability games. You say, "I'm going to have to buy the next system in the 2003–2007 time period." MILSTAR provides what was called protected service. It has nulling antennas. It's got protection against nuclear scintillation. It will also need replacement at about the same time period, 2003–2006. DSCS, which is used for wideband service today, similar to commercial fixed service, starts degrading in the same time period. So you notice that the military has to start replacing all these systems at about the same time, in the mid-decade 2000 time period. Commercial is coming along and many of these systems are emerging. So the question is, how can the military take advantage of this emerging commercial stuff and apply it?

We think that there are at least two things that the government needs to do (figure 23). There are a couple of things that they could do that would facilitate harnessing some of this commercial technology and some of this commercial capability for military use.

The first thing is that when you designed a system the way it was done in the past—with the UHF satellite, the MILSTAR satellite and the DSCS satellite—you started with the satellite. Technology was very challenging. You tried to do as much on the satellite as you possibly could, and then you did the rest on the Earth. So we ended up with big Earth terminals.

In the commercial world, what we had to do is turn that upside down. We had to figure out what the consumer would buy, and what kind of product the consumer needs, and then

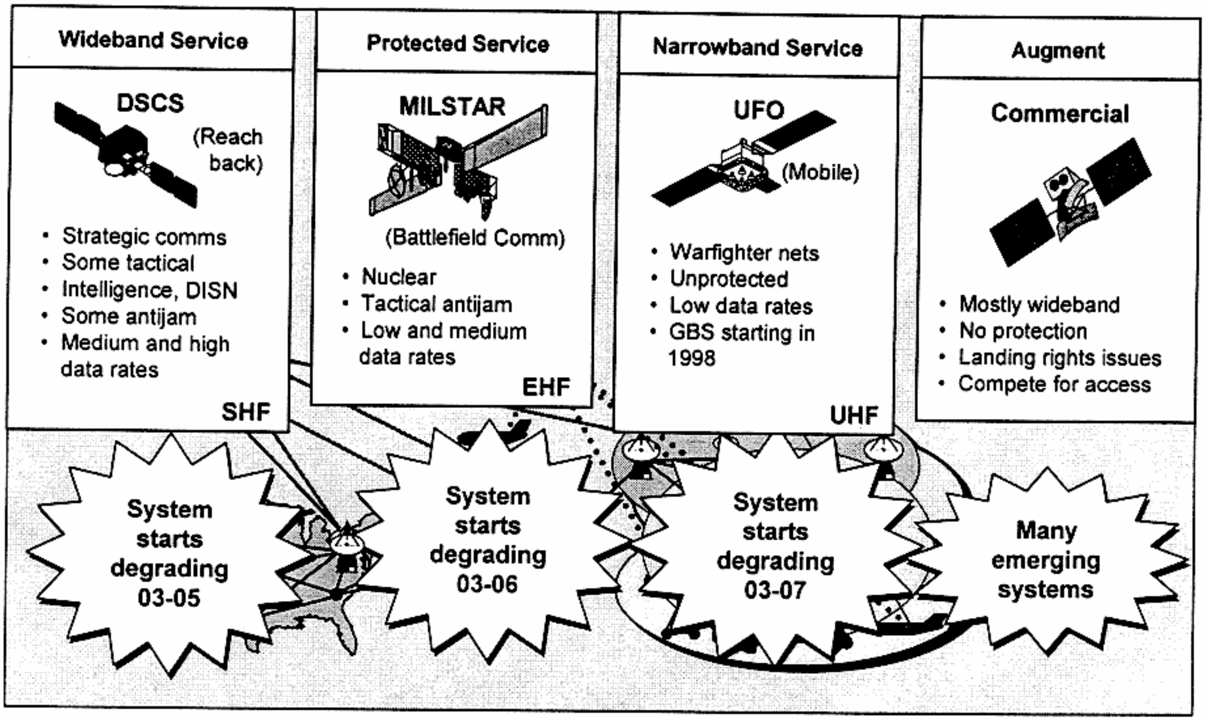


Figure 22

Starting Point—Today's SATCOM

use that to drive the satellite design. Our suggestion is that that's the way the military needs to think now, because the technology has come along so that the satellite is no longer the constraining item. That requires a paradigm shift: to start thinking now about, "What kind of service do I want my military consumer to have, and, therefore, what does that push into the satellite?"

The second thing is a functional allocation of requirements (figure 24). Here's the MILSATCOM road map. Here are the EHF, SHF, UHF—that's MILSTAR, DSCS, and UHF follow-on— satellites, all running out of steam in about the mid-2000s, and having to be replaced. Here's the new stuff coming along. The other thing we tell the Department of Defense is that you really need to start thinking about what services you want to get in terms of the functions you want to buy, rather than in terms of the frequency. So it isn't that you want a replacement EHF, SHF, and UHF; it's that you want a replacement trunk service, broadcast service, switched bandwidth service, or whatever. If you think that way, then you'll be keeping up with what's coming out of the commercial world and you'll have a much higher probability that commercial technology can be applied to the problem.

We believe, and the military has now decided, that they will continue using EHF for the protected service. That's really military unique. It has significant jam resistance, hardening, and assured military communications capabilities in it, and because that is unique, it's not likely that's going to be terribly commercial like. At the other end, as we mentioned before, the military is already leasing commercial circuits. But for all these other services, largely provided by the DSCS and UHF follow-on satellites, there is a match between commercial service and the government's needs, the Department of Defense's needs: mobile service—Iridium, ICO; switched bandwidth—SPACEWAY, Celestri, Teledesic; broadcast—DirecTV; and trunked service is the fixed satellites—the Galaxy, PanAmSat capability.

So this is, again, just another paradigm shift. If the government will look at purchasing their products this way, they can increase the likelihood that they'll be able to

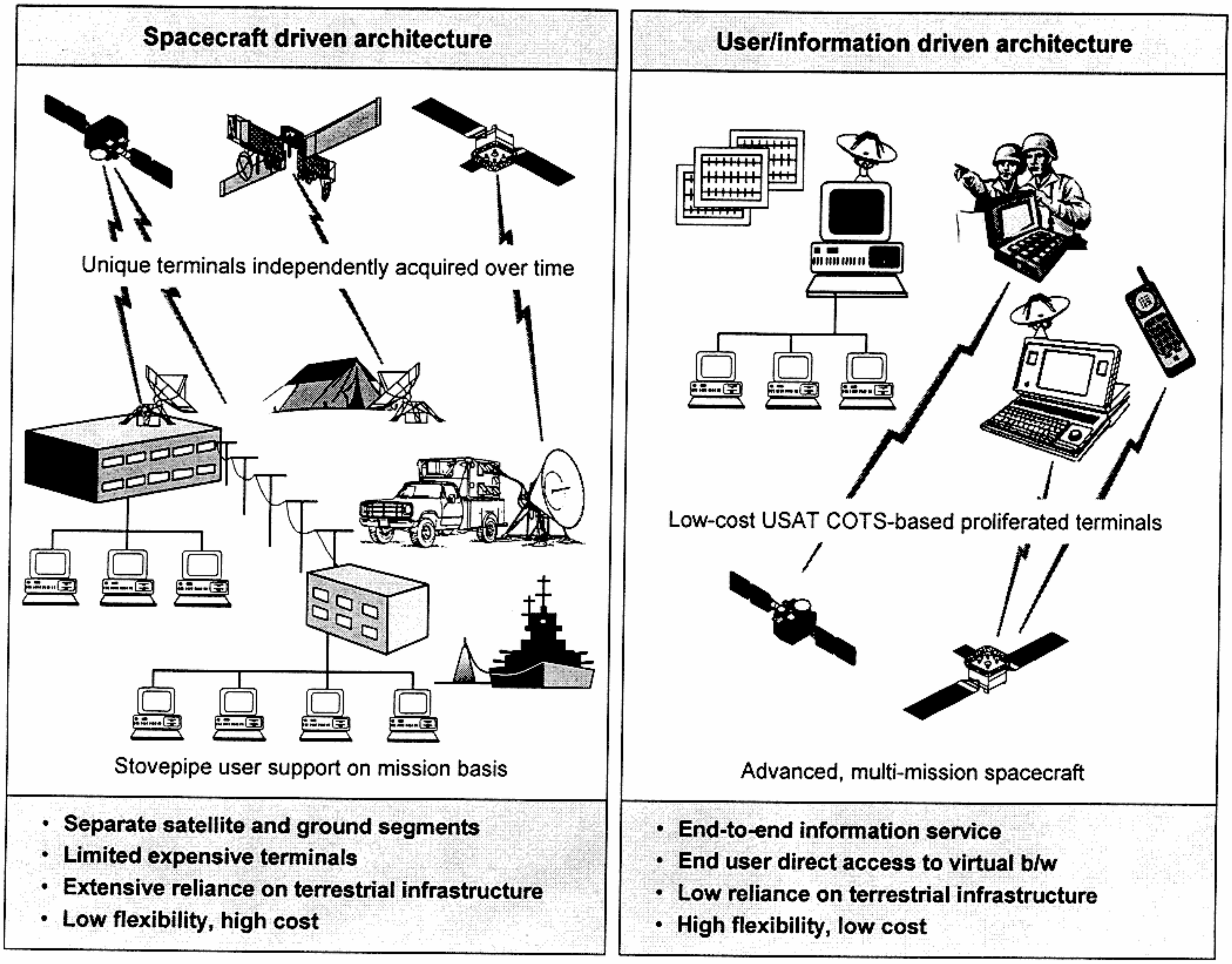


Figure 23

Facilitating Military Applications of Commercial SATCOM Systems: (1) User/Information Driven Architecture

match up with commercial technology, and be able to leverage it.

Student: One of the things in the past was that Congress really liked using military satellites as a way to help shuffle money and balance budgets by delaying launches, and if the satellite lasted longer, we could save a few million dollars and put it someplace else. Once you buy services and go on contracting, you lose that flexibility.

Rankine: Right, I didn't necessarily mean to imply that this was sort of all or nothing. Rather, it could be: The government can own the satellite, but use commercial technology. A good example is that DirecTV became Global Broadcast on the UHF follow-on satellite. This is true, I think, whether the government leases a transponder, pays fee for service, or buys and owns the satellite. They still need to approach the problem this way.

Student: Is it applicable to all military needs around the world, not just in America?

Rankine: Yes, of course. For example, in Europe, right now, there's a program called TRIMILSAT, which is Germany, France, and the U.K., and they want to buy services

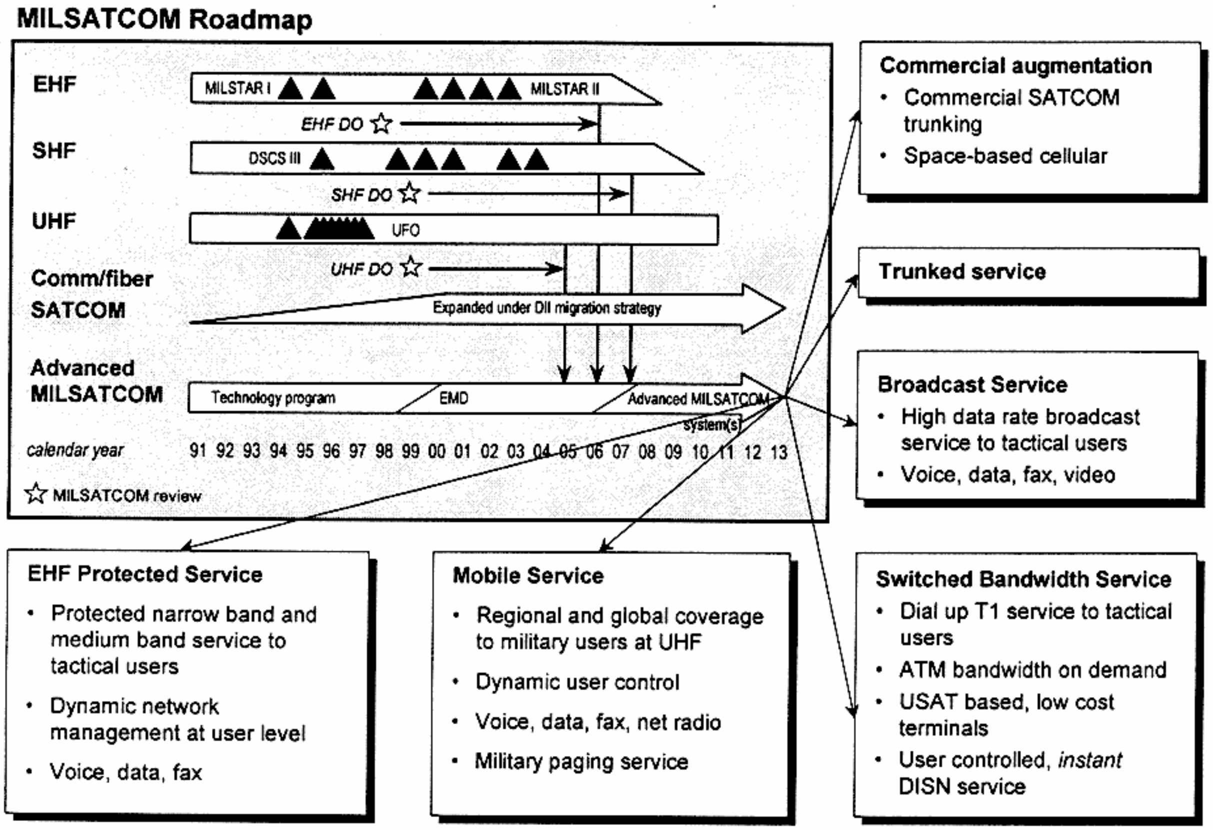


Figure 24

Facilitating Military Applications of Commercial SATCOM Systems: (2) Functional Allocation of Requirements

similar to this for the future follow-on to their military capabilities. So, certainly, that's true.

The other advantage of the military emulating commercial services is that if you can leverage the production lines for military terminals, you can reduce the cost of the terminals by two or three orders of magnitude (figure 25). It's really incredible. This is a logarithmic scale, and look at what we're paying today for military terminals and what the consumer demands in the way of cost for the same throughput. Now, these aren't hardened, but okay, instead of three orders of magnitude, it's only two, and you use one order of magnitude—a factor of 10—scale up in the price just to harden it, to ruggedize it, and put in encryption. The point is that the more that you can make the military satellite communications like commercial, the more likely you can leverage the production line for the commercial terminals. That could offer huge savings, because about half of the government's money is in the terminals, and the other half in the satellites.

As I said, one of the reasons why the government is often reluctant to use commercial is that it's not hard enough, it's not military enough. I just wanted to point out a few of the features of modern commercial satellites that are coming along (figure 26). They're becoming a little bit more military like. They're not wimps. If fact, it's a kind of Catch-22. We have difficulty getting export licenses because this stuff is too military like and, yet, the military doesn't want to use it because it's too commercial like and it's not hardened.

We already talked about small spot beams. We use those for frequency reuse. We get this huge antenna to give us a 200-mile spot, and it's got low sidelobes so it doesn't interfere with the spot next to it.

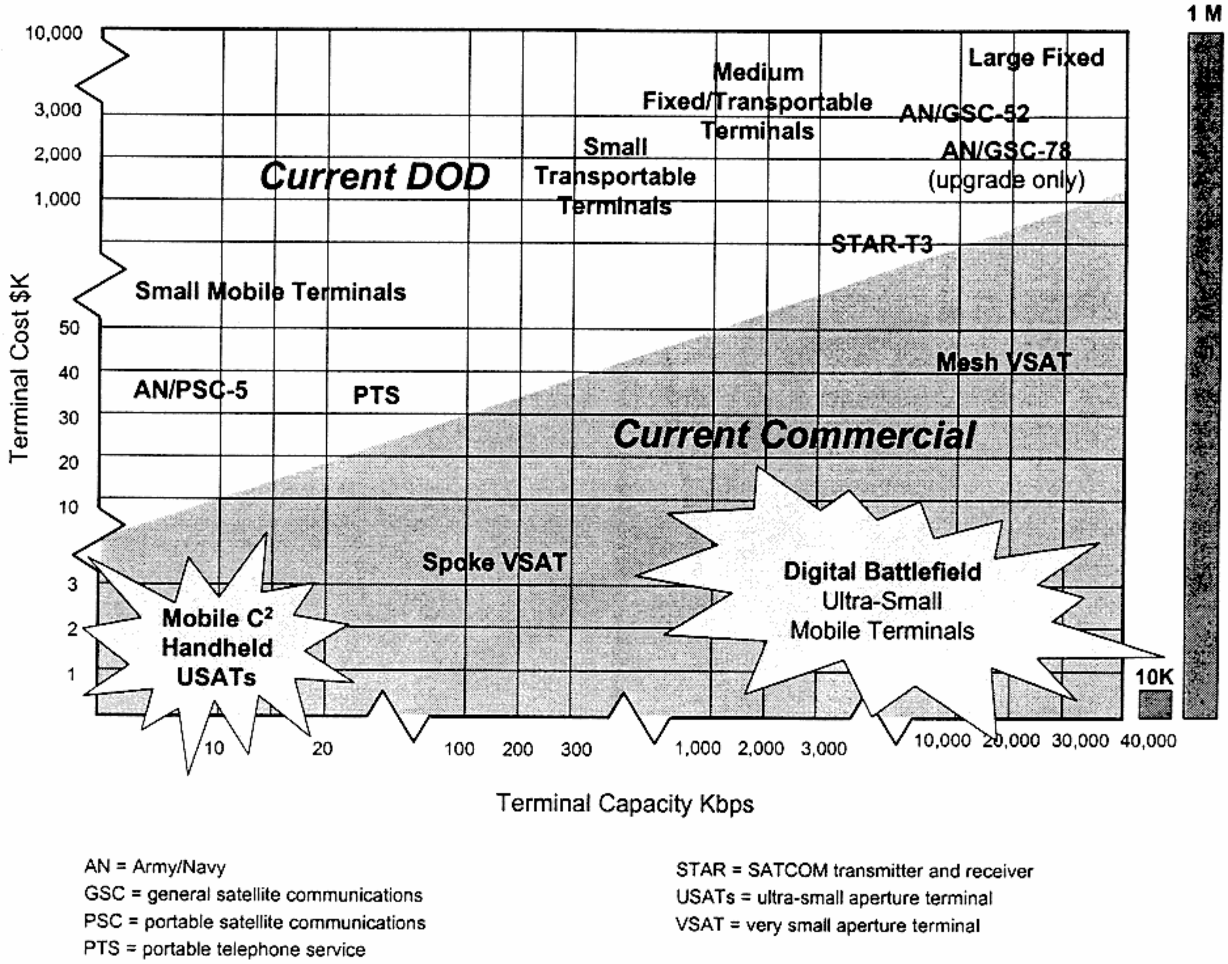


Figure 25

Impact of Bandwidth-on-Demand Satellite Systems

What that means is that you could jam one spot with your fixed-point jammers, but you can't necessarily jam the spot next to it. So there are some advantages there.

We already talked about encrypted telemetry, tracking and control (TT&C) and on-board processing. We're already radiation hardened to the natural environment, and so you're already a step toward nuclear hardening.

Then there are intersatellite links, which we call crosslinks. Eight out of the 14 new Ka-band filings, which include Teledesic and SPACEWAY and so forth, filed for 60-gigahertz crosslinks. Those are secure links, because 60 gigahertz won't penetrate the atmosphere. It's absorbed. So that means that on Earth you can't intercept those links. The fact that these are digital communications means end-to-end encryption is a piece of cake. We've already demonstrated encryption on DirecTV. It uses just zeros and ones, and so it doesn't matter if they're encrypted or not.

I already talked about steerable antennas. On ICO I can steer the antenna away from the jammer. I can put the small spots on the regions where I want to communicate.

These are global companies, so landing rights are already prenegotiated. That doesn't mean that there may not be some objection from one of the owners, and that's something that we need to wrestle with from a policy standpoint, but landing rights, using commercial, can be viewed as either an advantage or a disadvantage depending on how you want to look at it. That's the only point I want to make. The coverage is worldwide, so

- Small spot beams (APMT: 40' antenna; ICO: <200-nm spot)
- Low sidelobes (reduces interference between beams)
- Encrypted TT&C (some owners require encrypted command link)
- On-board processing (global mobiles have on-board routing)
- Radiation hardening (natural environment)
- Intersatellite links (8/14 new Ka filings include 60-GHz crosslinks)

Figure 26

Features of Modern Communications Satellites of Importance to the Military

no matter where you go you already have capability there.

We talked about lease versus buy (figure 27). Let's get into that just for a second. I cannot refute the fact that if the military is going to use the capacity of an entire satellite continuously, for the satellite's entire life, it's cheaper to buy it than to lease it. That's just a fact of life in any product.

However, if you look at the military's demand, it tends to go up and down through peace and crisis. So, if you're not using some throughput in some region all the time (this slide could be showing a region of the Earth), you may want to look at whether or not you'd like to lease to augment your services in that region. Today, that's difficult to do because there's limited throughput. But in the future that I'm talking about here, with Celestri and Teledesic and SPACEWAY and Iridium and ICO and Globalstar, and all these systems out there, a U.S. confrontation in Somalia may—in a civilian, commercial sense—be just a small increment. Today, it's a big piece, and you may have to bump somebody off. That's a preemption, and that's frowned upon because there are commercial customers out there. But in the future, when you have bandwidth on demand, it's quite possible that this kind of fee for service may be possible with these attendant benefits.

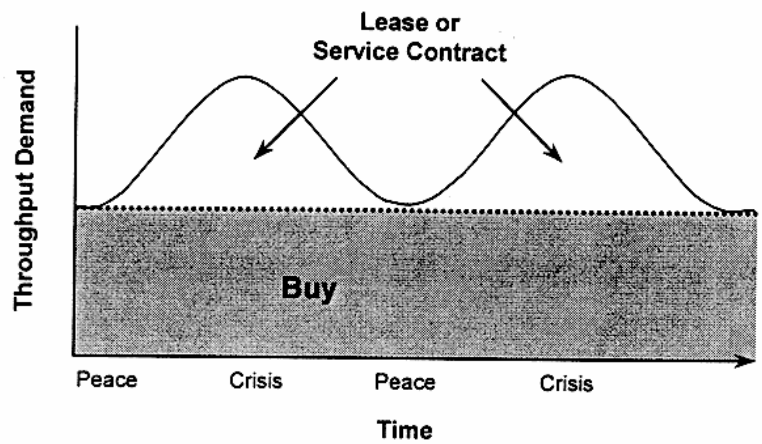
Oettinger: Bob, I hate to do it ...

Rankine: And I'm finished!

Oettinger: It's been an absolutely marvelous, marvelous presentation! We'll give you a big hand for that talk, and a small in size but large in spirit token of our appreciation. Thank you very much.

Rankine: Well, thank you very much.

If the military is going to use the capacity of an entire communications satellite continuously, it is cheaper for the military to buy and own the satellite than to lease the satellite or pay a fee for communications services.



Advantage of lease and service contract:

- Avoid up-front costs; achieve level payments
- Satisfy short-term need
- Avoid premature commitment; increase flexibility; reduce risk
- Reduce need for own expertise (training cost); reduce infrastructure cost
- Benefit from price reductions over time due to increased commercial competition

Figure 27

Buy vs Lease vs Fee-for-Service

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