"Globalstar, Iridium and other Satellite-Based Mobile Phone Systems: How Do they Work and Where Did They Go Wrong

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Talk Outline (all over the map)

1. How it all began
2. Many paths to the same summit
3. Complexity
   - Technical, political, regulatory, financial, cultural, business (e.g. roaming)
4. Globalstar as an example
5. Lessons learned
6. Could it have happened any other way?

Confluence of Two Parallel Evolutions

- In the 60's, [vacuum tubes], radio was
  - Primarily broadcast
  - Receivers were fixed locations or automobiles
- In the 70's [transistors], radio was
  - Primarily broadcast
  - Receivers were fixed, automobiles, or portable
- In the 80's [IC's], the cell phone radio was born
  - High spectral efficiency
  - Two-way communication
  - Sophisticated modulation types
  - Sophisticated state machines for control and handoff
  - *Mobile phones that switch between base stations*

Confluence of Two Parallel Evolutions (2)

- In the 60's satellites were
  - Low earth orbit or LEO
  - Useful only for intermittent surveillance and communication
- In the 70's, satellites were
  - Mostly geosynchronous earth orbit or GEO
  - Invaluable for relay and broadcast (big dishes)
- In the 80's, satellites were
  - Greatly increased in power
  - Telephone and communications relay
  - Direct broadcast, small dishes, competitor to cable

Puting Them Together: Return of the LEO

- Mobile phones have small, omni antenna
  - Could not reach existing GEO satellites
  - Could reach LEO, but intermittent availability
- What about a constellation of LEO satellites?
  - “Only” a few hundred miles away
  - An upside-down cellular system!
    - *Stationary phones that switch between moving base stations*

Who Would Want It

- Imagine if you could use a cellular phone ANYWHERE IN THE WORLD?
- Business executive, multinational company, or entrepreneur in underdeveloped county
- Made possible by constellation of LEO satellites
- And it could be done for only 5 billion dollars

Is That Worth It?

- Investment = $5B, lifetime = 7+ years, market = 5M users
- Operating expense $200M/year
- 2M users at $1/min for 100 min/month = $2.4B/year
- The investors will get RICH!
- Several market studies confirmed these numbers
- *Analysts wrote glowing predictions of success*

How Did It Develop?

- Several consortia formed in the early 90's
  - Iridium [LEO, intersatellite links]
  - Globalstar [LEO, satellite diversity]
  - ICO (from Inmarsat) [MEO works also!]
  - Odyssey from TRW (You can patent an orbit!)
  - Constellation (Mix and match!]
  - Elipsat [Circles aren't the only way!]
  - Two Russian system proposals (no funding)
  - ACeS and Thuraya [And even GEO!]

Design Issues

Altitude
Antenna size
Satellite relay?
Satellite diversity?
And many more…

Number of satellites
Modulation type
Bent pipe?
Soft handoff?

Heritage, performance, cost, risk, compatibility…
What is the optimal configuration?

The Magnificent Men in their Flying Machines

Iridium	LEO	Polar	TDMA
Globalstar	LEO	Inclined	CDMA
ICO	MEO	Inclined	Custom
Constellation	MEO	Inclined	
Elipsat	Various	Molniya	
ACeS	GEO	Fixed	GSM

Even the Consortia Were Not the Same (Star, Mesh, Etc.)

- Iridium dominated by Motorola, handled all aspects
- Globalstar had three legs: satellite, communications, and operations/marketing
- ICO was an Inmarsat spin-off, acted as a prime contractor
- Odyssey was a TRW “we wish we can”
- Constellation promoted by Brazil (equator)
- Elipsat was an orbital dream and a technical nightmare

So What Was the First Problem They Faced (Multiple Choice)?

A. Technology?
B. Organization?
C. Time-to-market?
D. Demonstrating that there was a market?
E. Raising money from sophisticated investors?
F. None of the above?

Spectrum and Regulatory Approval

- Can you think of any frequency that is used for the same thing everywhere in the world?
- Are the governments you know willing to let outside companies control their communications?
- How many countries do you think there are in the world?

In Pursuit of 16.5 MHz

- Benefited from radio location spectrum
- Led by Motorola with help from FCC
- Three year process, month of meetings
  - Eventually passed due to sleep depravation
- Was only the start of a techno-political process
  - In-country gateways
  - Domestic telecom support
  - State-run telephone monopoly

The Race to Market

- Once Iridium and Globalstar reached critical mass, became a race to market
- Iridium: 66 satellites, $7B, 2+6 gateways
- Globalstar: 48 satellites, $4B, 33+ gateways
- Exciting days
  - Coordination of worldwide partnership
  - Coordination of gateway uplink frequencies
  - No testing until almost complete

OK Already, What About the Technical Part?

- Three year design cycle
  - PDR, CDR, CSO (Council of Service Operator) meetings
  - 3 volumes, 1000 pp each for communication hardware
  - Similar for satellite
- Satellite innovations
  - Earth-facing panel for mass production
  - Circuit board" phased array antenna, GPS positioning, beryllium heat shield, variable power class A power amplifiers
- User terminal/gateway innovations
  - Extending helix antenna, IS-95 adaptations, GW beam switching
- Examine everything – no chance to "try it"
  - Implementation loss and Schindall's law

System Architecture

Globalstar is a worldwide, low-earth orbit satellite services system that provides access to existing terrestrial cellular telephone service as it extends, enhances, and operates with

- Public land mobile networks (PLMN)
- Public switched telephone network (PSTN)
- Government and private networks

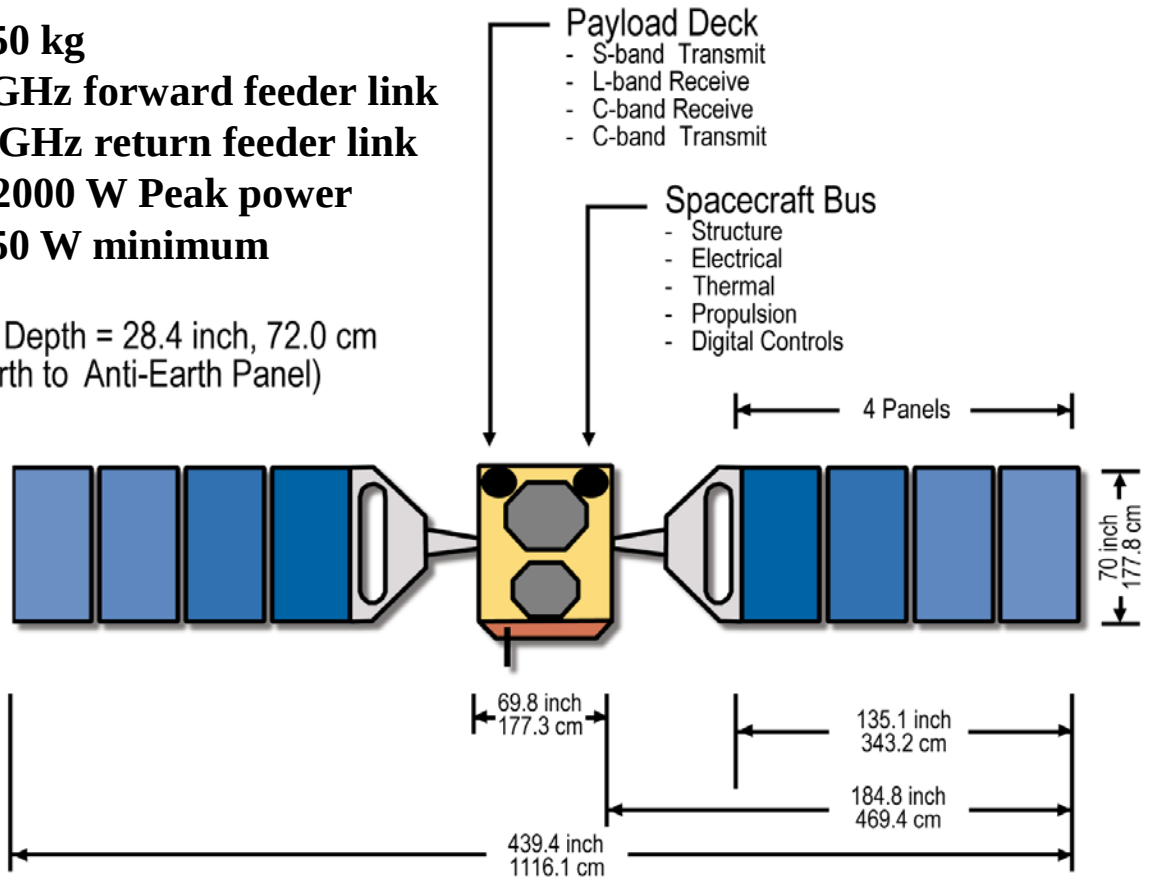
Globalstar meets the telecommunication needs of a changing world and benefit

- Cellular service providers seeking low-cost expansion technology
- Residents of rural or unserved areas seeking basic telephone service
- Telecom administrations seeking low-cost service expansion
- Businesses needing wireless telephone and data services among worldwide locations

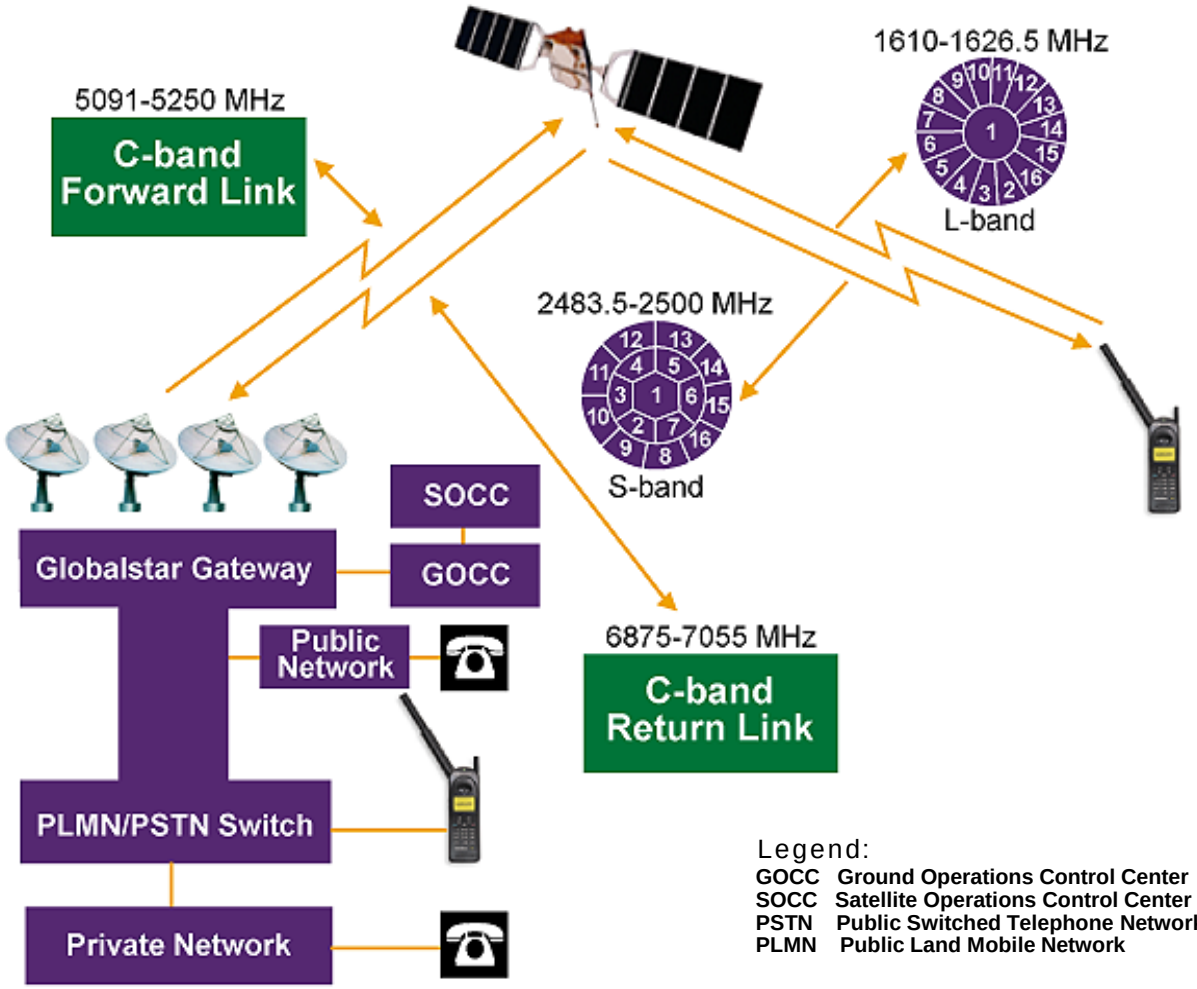
Globalstar Satellite
(Typical Configuration)

- **450 kg**
- **5GHz forward feeder link**
- **7 GHz return feeder link**
- **>2000 W Peak power**
- **650 W minimum**

Satellite Depth = 28.4 inch, 72.0 cm
(Earth to Anti-Earth Panel)



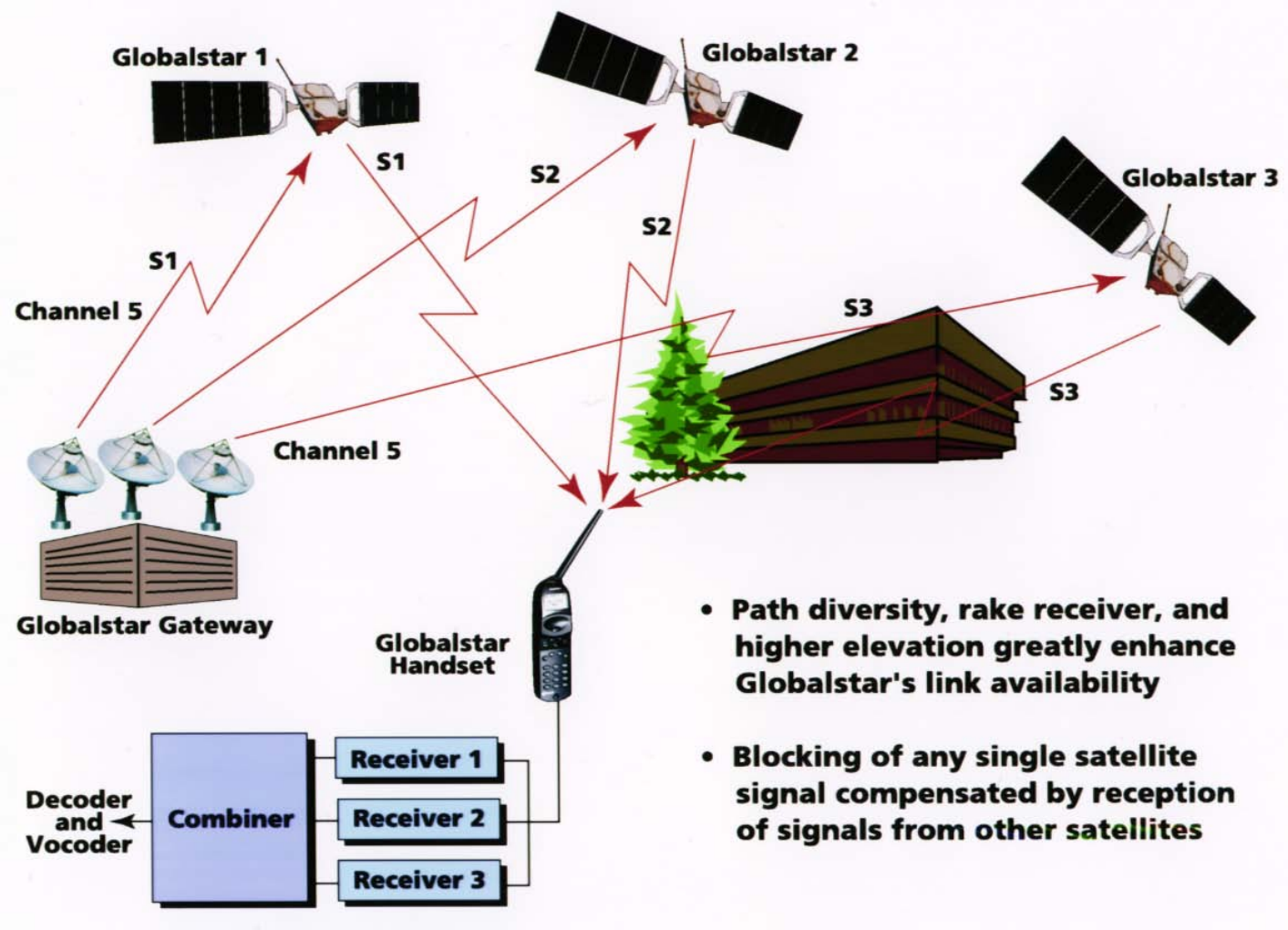
Frequency Summary



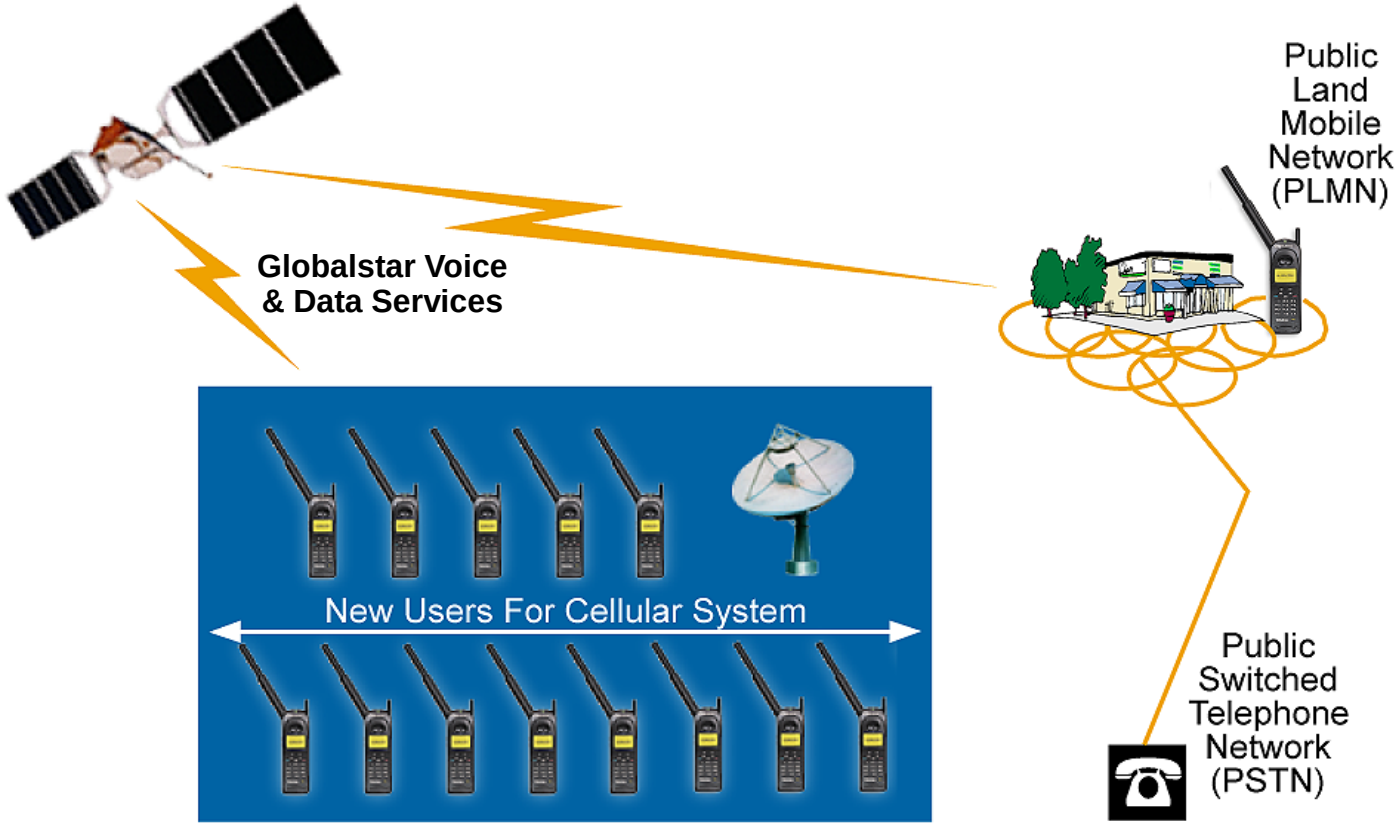
Legend:

GOCC Ground Operations Control Center
SOCC Satellite Operations Control Center
PSTN Public Switched Telephone Network
PLMN Public Land Mobile Network

Diversity Combining



Architecture Extends Cellular Telephone Services (How it works)



- Existing telecom infrastructure is not bypassed or duplicated
- Mobile calls are routed via satellite through gateway into PSTN/PLMN
- Low-cost introduction of satellite-based cellular services where cost and feasibility of terrestrial services is prohibitive

Success?

- Iridium rolled out service in 1999
  - Quality patchy, but it worked
- Globalstar rolled out service in 2000
  - Quality equivalent to terrestrial CDMA
- Both companies stockpiled handsets
- Some “early adapters”
- Mostly, the world yawned
- *And the analysts said “I told you so”*

Failure?

- Large investment -> large carrying costs
  - Perhaps 100K users instead of 500K-1M
  - Iridium in bankruptcy within a year
  - Globalstar lasted longer but also bankrupt
  - ICO failed before inception of service
- Iridium and Globalstar emerged for pennies on the dollar
  - Many people think they’re gone

Pheonix from the Ashes?

- Iridium seeing major use from DOD, positive earnings
- Globalstar up to 300K users, positive earnings, talking about major ISO
- ICO touting rebirth and new launch program
- ACeS and Thuraya seeing commercial success
- All participants expanding into digital services and low data rate sensors

Yes, Virginia, There Is a Market!

- Disaster usage in Indonesia, Iraq, Pakistan, New Orleans, etc
- Vertically-integrated companies in exploration, surveying, etc.
- Developing countries
- Marine industry in South Korea, Brazil
- Rural areas in Canada, Russia, Australia
- Poor villages in Ecuador

What Went Wrong?

- Time-to-market too long – dangerous
- Timing problem – end of dot com boom
- Adoption time-constant for new technology
- Just plain bad marketing
  - Motorola single market focus and arrogance
  - Globalstar tied to terrestrial cellular providers
- Not enough staying power
  - Extraordinarily high capital cost

Some Final Thoughts

- Was there another way?
  - Longer adaptation period in business plan?
  - For Globalstar, avoid cellular partnerships?
  - Better marketing approach?
- I don’t think so
  - Wouldn’t have reached critical mass to begin
- This is not a “new” story.
  - Telegraph, telephone, cell phone
- Does it have to be that way?
  - I don’t know.

SPACE NEWS

INTERNATIONAL

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DEBRA FACKTOR LEPORE

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NASA is revising its public affairs policies following allegations that political appointees tried to muzzle the agency's top climatologist. See story, page 4

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A U.S. company is studying the use of satellite and airborne remote-sensing technology in Romania to monitor the spread of environmental damage. See story, page 16

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Elliot Pulham says Apollo's a world success without some dire environmental ahead, the study of education in the United States, and now that we understand the problems, it is time for action. See commentary, page 19

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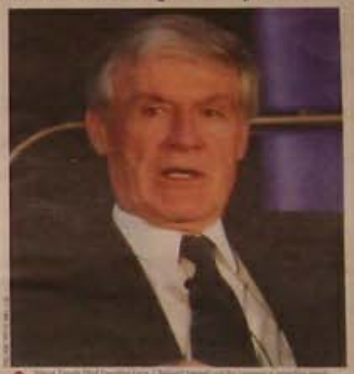
Unexpected Demand Takes WildBlue, Telesat by Surprise

PETER B. de SELDING
WASHINGTON



Telesat Canada Chief Executive Larry J. Boisvert (above) and his company is expecting more than 200,000 subscribers in Canada and the United States by year's end.

An unexpected demand surge in some parts of the United States has forced satellite broadband provider WildBlue Communications to close two of its satellite beams to new subscribers as it designs a software upload to accommodate the new capacity, WildBlue and industry officials said.

"We've been shocked at the level of demand in a region including parts of Ohio, Pennsylvania, Illinois and New York," said Evan K. Hudson, WildBlue's chief technology officer. "To preserve the quality of the service for our existing customers, we are no longer accepting new subscribers on those two beams. We are upgrading the software modification to permit increased capacity and expect to open those beams up again to new customers this spring."

Denver-based WildBlue, which started service from Telesat Canada's Anik F2 satellite in June, is rolling out a nationwide Ka-band consumer broadband service using 30 spot beams covering almost every region of the continental United States. Telesat is operating a similar Canadian service on the remaining 10 spot beams.

Unlike the Hughes Network Systems Spaceway 3 satellite set for launch in 2007, the Anik F2 spacecraft cannot be reconfigured easily to reassign onboard capacity to match peaks and valleys in customer demand.

As of Dec. 31, WildBlue had 25,000 subscribers for its high-speed Internet access service, a figure that company officials said is better than expected. But the demand has not been distributed evenly.

WildBlue plans to launch its own, dedicated Ka-band broadband satellite late this year aboard a European Ariane 5 rocket. In an interview here Feb. 9 at the SatMex 2006 conference organized by Access Intelligence, Hudson said the new satellite will be brought into service within three months of the launch.

Telesat Canada Chief Executive Larry J. Boisvert said around 50,000 two-way Ka-band satellite terminals have been sold in Canada. By the end of 2006, he said, subscribers in Canada and the United States combined is expected to reach 200,000.

Boisvert said Telesat has been surprised not only by the quick uptake in demand — especially since the service was slowed this summer by equipment-supply hiccups — but also by the type of service that customers want.

WildBlue and Telesat offer several classes of service, with prices corresponding to throughput. Boisvert said Telesat had expected that only 10 percent of customers would opt for the higher-priced, high-speed option. Instead, about one-third of them do.

Also like WildBlue, Telesat is planning its own dedicated Ka-band satellite, called Anik G1, to be able to accommodate new customers and to provide an in-orbit backup to the Anik F2 satellite. Telesat also has ordered eight Ka-band spot beams to be included on its yet-ordered Ninmi 4 direct-broadcast television satellite. The Ka-band payload will target those areas of Canada — mainly

SEE WILDBLUE PAGE 4

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