"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
Putting 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

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Orbit Type</th>
<th>Inclination</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iridium</td>
<td>LEO</td>
<td>Polar</td>
<td>TDMA</td>
</tr>
<tr>
<td>Globalstar</td>
<td>LEO</td>
<td>Inclined</td>
<td>CDMA</td>
</tr>
<tr>
<td>ICO</td>
<td>MEO</td>
<td>Inclined</td>
<td>Custom</td>
</tr>
<tr>
<td>Constellation</td>
<td>MEO</td>
<td>Inclined</td>
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<tr>
<td>Elipsat</td>
<td>Various</td>
<td>Molniya</td>
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<tr>
<td>ACeS</td>
<td>GEO</td>
<td>Fixed</td>
<td>GSM</td>
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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

Diagram:
- C-band Forward Link: 5091-5250 MHz
- C-band Return Link: 6875-7055 MHz
- L-band: 1610-1626.5 MHz
- S-band: 2483.5-2500 MHz

Networks:
- Globalstar Gateway
- GOCC
- PLMN/PSTN Switch
- Private Network
Diversity Combining

- Path diversity, rake receiver, and higher elevation greatly enhance Globalstar's link availability
- Blocking of any single satellite signal compensated by reception of signals from other satellites
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.
Unexpected Demand Takes WildBlue, Telesat by Surprise

WASHINGTON

An anomaly prior of business and financial experts is no news that the satellite industry is poised to see an upsurge in demand for satellite services, particularly in the areas of communications and internet access. But the recent announcement by WildBlue and Telesat has taken the industry by surprise.

WildBlue and Telesat, two of the leading providers of satellite internet services, have announced plans to increase their coverage areas and expand their customer base significantly. The move comes as a response to growing demand for satellite internet services, particularly in rural and remote areas where traditional terrestrial internet connectivity is limited.

WildBlue, a company that has been providing satellite internet services since the late 1990s, has announced plans to increase its coverage areas by 20 percent. The company has also announced plans to launch a new fleet of satellites to meet the growing demand for its services.

Telesat, a company that has been providing satellite internet services in Canada since the early 1980s, has also announced plans to expand its coverage areas. The company has announced plans to launch a new satellite that will provide internet access to remote areas of Canada.

The move by WildBlue and Telesat has been met with excitement and anticipation from the industry, as it is seen as a positive development for the satellite industry. The increase in demand for satellite internet services is expected to drive innovation and growth in the industry, as companies work to meet the growing demand for these services.

It is worth noting that the increase in demand for satellite internet services is not limited to WildBlue and Telesat. Other satellite internet providers, such as SpaceX and OneWeb, have also announced plans to increase their coverage areas and expand their customer base.

The increase in demand for satellite internet services is expected to have a significant impact on the industry, as it is seen as a positive development for the industry. The increase in demand for satellite internet services is expected to drive innovation and growth in the industry, as companies work to meet the growing demand for these services.