International Telecommunication Union

Advanced Technologies for Multimedia Broadband Satellites Systems

Dr Satchandi Verma

TRW Space & Electronics

Communication Satellite Business Development

One Space Park, Redondo Beach, CA 90278

310-812-1742

satchandi.verma@trw.com

Workshop on Satellites in IP and Multimedia

Geneva, 9-11 December 2002

Advanced Technologies for Multimedia Broadband Satellites Systems

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- Broadband Satellite Market
  - Satellite Industry Trend
  - TRW's Systems Engineering Process
- Multimedia Satellite Systems Capabilities
- Satellite System Enabling Technologies
  - Advanced Antenna Systems
    - High gain Multi Beam Antenna (MBA)
    - Mesh Reflector Satellite System
    - Shaped and Spot Beam Coverage
  - Efficient satellite link frequency utilization
    - Higher operating link frequencies
    - Multi color frequency reuse
  - Digital Transponders
    - Applications and Advantages
- Satellite Performance/Capacity
- Multimedia Satellite Key Drivers

Broadband Satellite Industry Market

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Today's Market

- Current system architectures successfully serving Broadcasting Market
- Inability to capture network based broadband service market
- Inability to attract financial capital
- Commodity Services
- Evolutionary Vs Value added satellite technology
- Excess capacity in some markets

Near Future

- Satellite Industry consolidation
- Expansion of Global Coverage
- Data Transport systems with Broadband Interconnectivity
- Government need for broadband packet switched networks

Within a Decade

- New networked satellites with value added services
- New Service Offerings
- Expandable Content-Based Networks
- Ubiquitous Information on Demand

Broadband Satellite Industry in Transformation stage

Broadband Satellite Industry Trend

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- In US Government sponsored efforts may lead to the Multimedia satellite architecture
  - National Rural Telecommunication Cooperative (NRTC)
  - Transformational Communication Study (TCS)
  - Office of the Secretary of Defense (OSD)
- Service provider Strategies
  - Initiate network based satellite fleets which increase the value of service offerings to information intensive markets
  - Team with suppliers for developing business based satellite solution
  - Develop long range transformational architectures satisfying Global trends and emerging customer markets
  - Develop regulatory strategies for satellite network operation
- Pull satellite technology from proven manufacturers
  - For application to information intensive satellite designs
  - Providing economical cost effective solution for broadband multimedia satellite systems

TRW's Systems Engineering Process

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Broadband Satellite Services Needs (Government, Commercial)

Marketing Plan (Network Opportunities, Service Provider Strategy)

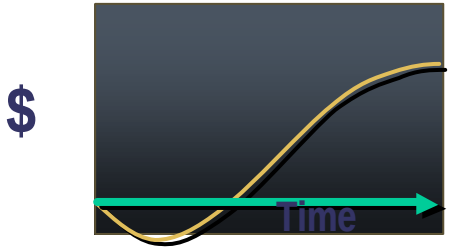
Satellite System Trades (Network Access, Management, Inter-working, Communication Links)

Marketing
- Addressable Market
- Market Penetration
- Service Definition
- Traffic Model

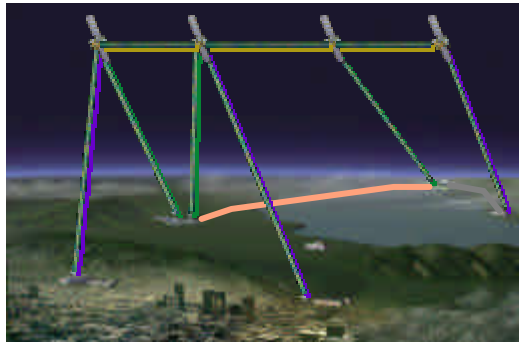
Design
- System Architecture
- Capability Analysis
- Service Capabilities
- System Cost

Finance
- Revenue Projections
- Cost of Capital
- Negative Cash Flow Break-even Point

Cash Flow



Network Architecture



Bringing Marketing, Engineering, & Financial disciplines together to achieve a successful business plan

Enabling Satellites Technologies

TRW

- Expert Systems Engineering Support
  - System definition, analyses and trades for optimum Network
  - End-to-end communication system simulation capability
  - Rigorous requirements definition to include all system needs
  - Expert advice on international standards implementation
- Satellite Antenna
  - Deployable Large Mesh Reflector Antenna (Shaped/Spot beams)
  - High Gain Solid Reflector Antenna (Multi Beam Spot Coverage)
- Satellite link frequencies
  - Higher up and down link frequencies
  - Frequency Reuse with Multi color schemes
- On Board Processors (Analog/Digital)
  - Full Digital Processor
  - Partial Processor – Digital Transponders
- Larger satellite antenna gain reduces payload power requirement and size (RF power, solar cells, thermal dissipation)

TRW Has a Long History of Satellite Communications Systems

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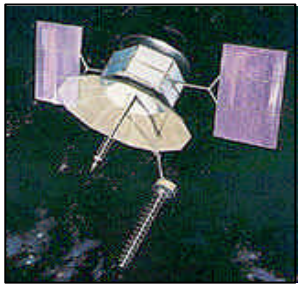
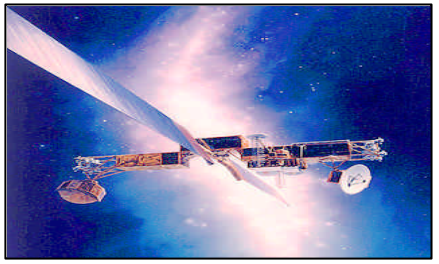
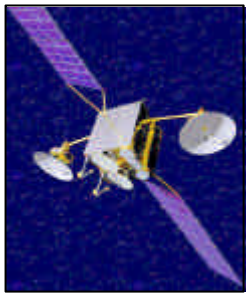
Defense Systems Communications Satellite II



Milstar Payloads





Advanced EHF

Fleet Satellite Communications

Tracking and Data Relay Satellites

Astrolink (type) Ka Broadband

INTELSAT III

Landsat 4 Downlink

1970 1980 1990 2002

Over three decades of providing increasing SATCOM capabilities

TRW Technology Enables Cost Effective Architectures

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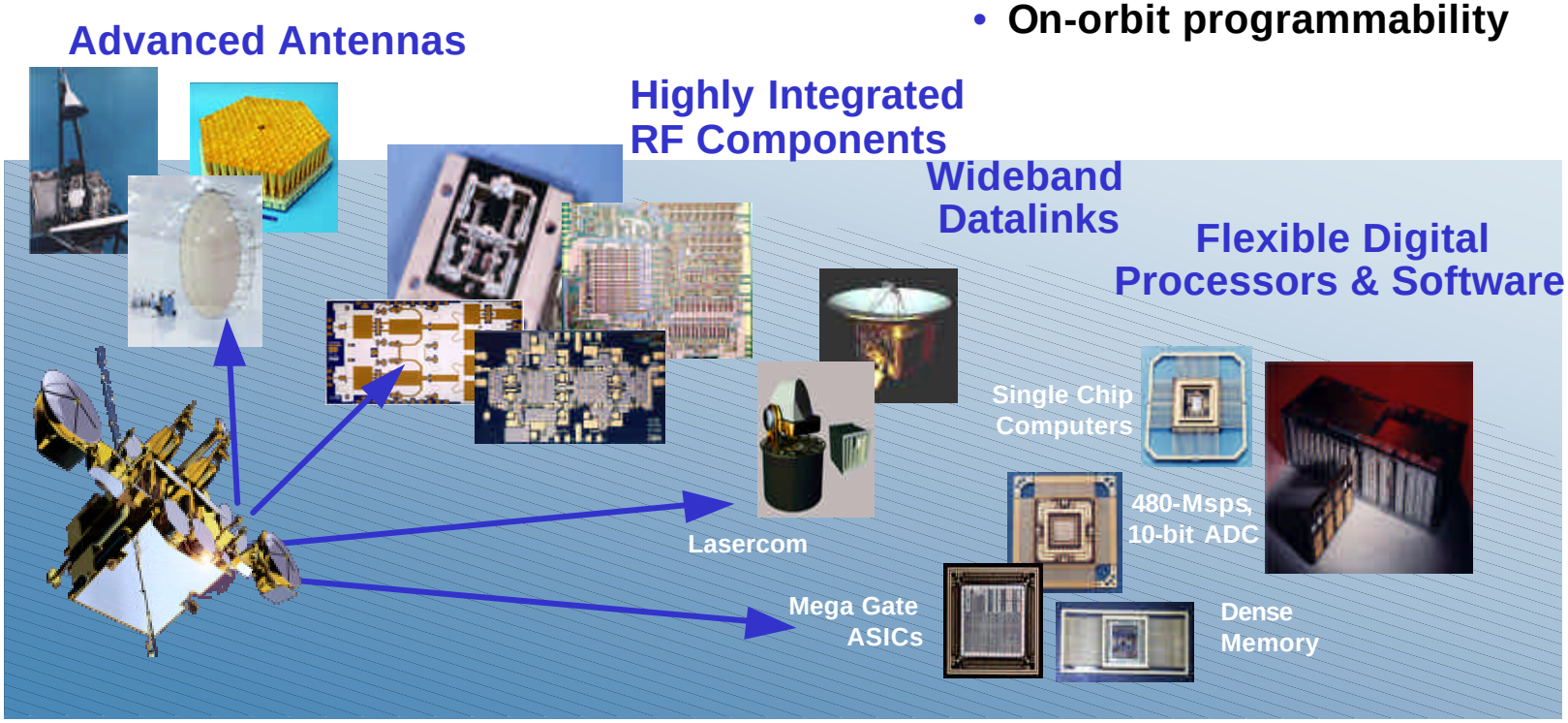
- Flexible coverage
- Frequency re-use
- Comm-on-the-move

- More capacity in same size and mass envelope

- More capacity per kg or W
- Flexible Services
- On-orbit programmability



Multimedia Satellites System Requirements

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- Larger System Capacity
- Higher Network Connectivity
- Better Service Performance and QoS
- On orbit satellite coverage area flexibility
  - Meet dynamic traffic demands of customer
  - Meet specific regional and local service needs
- Backward compatibility with Legacy systems
  - Applications and Advantages
- Overcoming legacy satellite limitations

Satellites Multi Beam Antenna Coverage Flexibility (Example)

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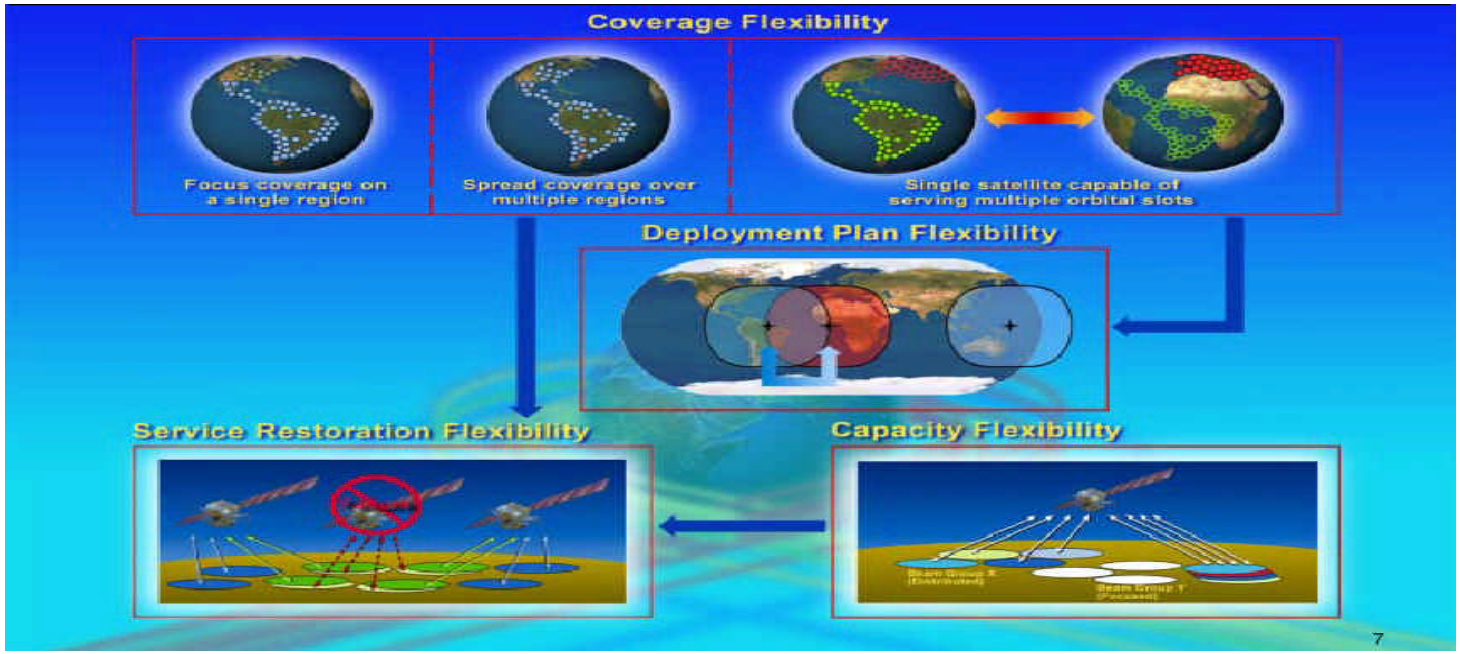

- Satellite Spot Beam with Frequency reuse
  - Available bandwidth is divided into 4 sub-bands
  - Larger capacity by using same sub-band in multiple spot beams
- Satellite coverage flexibility
  - On-orbit coverage changes for Tailored landmass coverage
  - Larger downlink EIRP for smaller user terminals

Higher System Capacity Through Frequency Reuse (Example)

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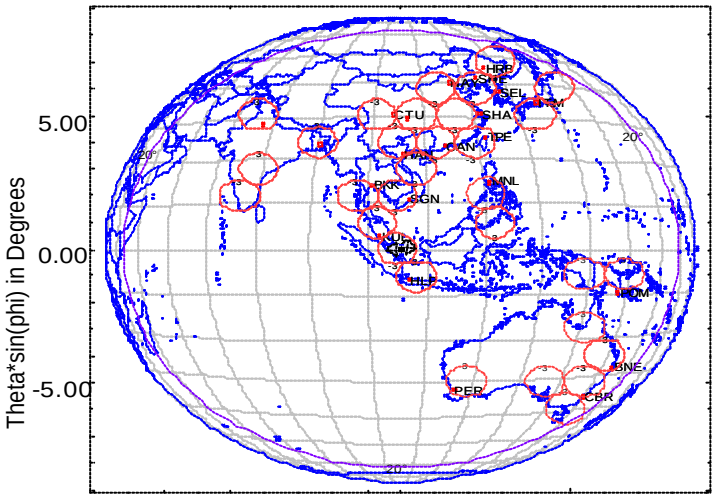
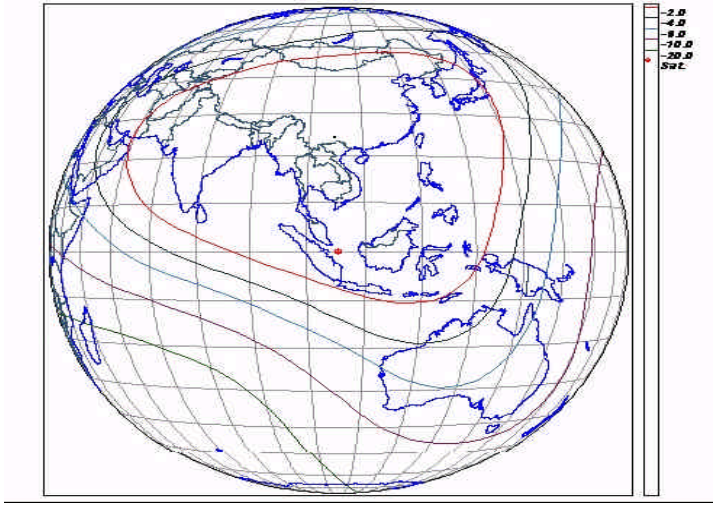


Multi-Beam Coverage



Single Wide Area Coverage Beam

- More than ten times capacity
- Higher effective system bandwidth

$$\text{Effective bandwidth} = \frac{(\text{number of cells}) \times (\text{allocated bandwidth})}{\text{Frequency reuse factor}}$$

Example: 50-beam system using dual polarization

$$\text{Effective bandwidth} = \frac{(50 \times 2)\,(500\ \text{MHz})}{4} = 12.5\ \text{GHz}$$

Equivalent number of 36 MHz transponders $\approx$ 12.5 GHz/40 MHz = 310

Satellite Mesh Reflector Antenna Coverage Performance (Example)

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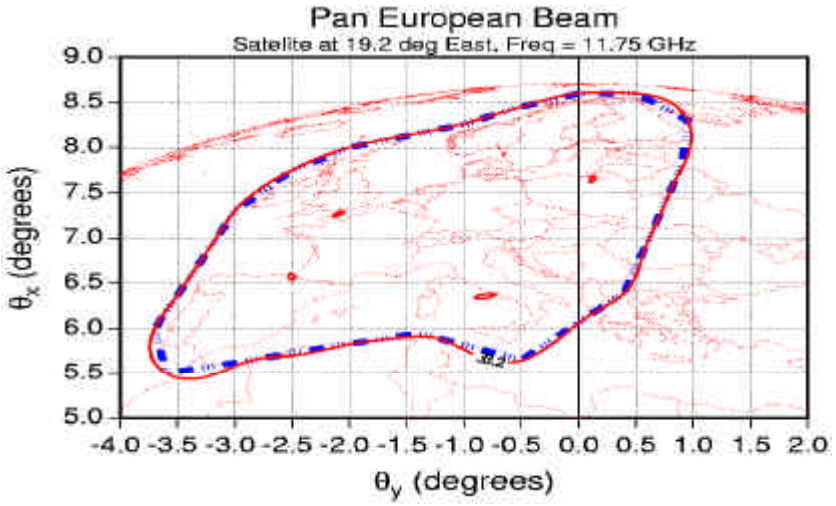
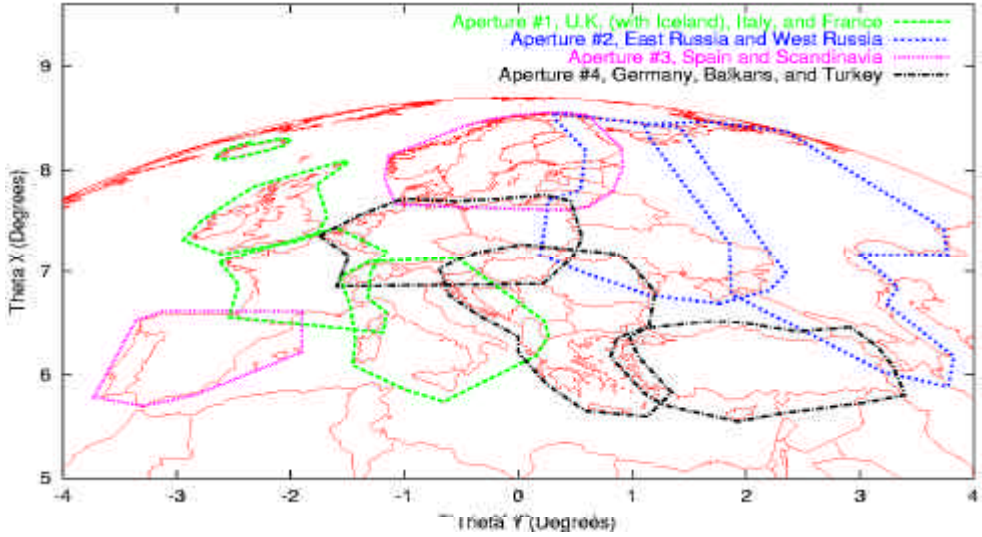


Edge of coverage performance

- **Solid Reflector Pan European Beam: 33 dBi**
- **Shaped Reflector European Shaped Beams: 34-38 dBi**
- **1 – 5 dB improved performance over solid reflector**

2.2 m Solid antenna Satellite Coverage

7.5 m Mesh Shaped antenna Satellite Coverage



Satellite Channel Frequency Reuse Plan (Example)

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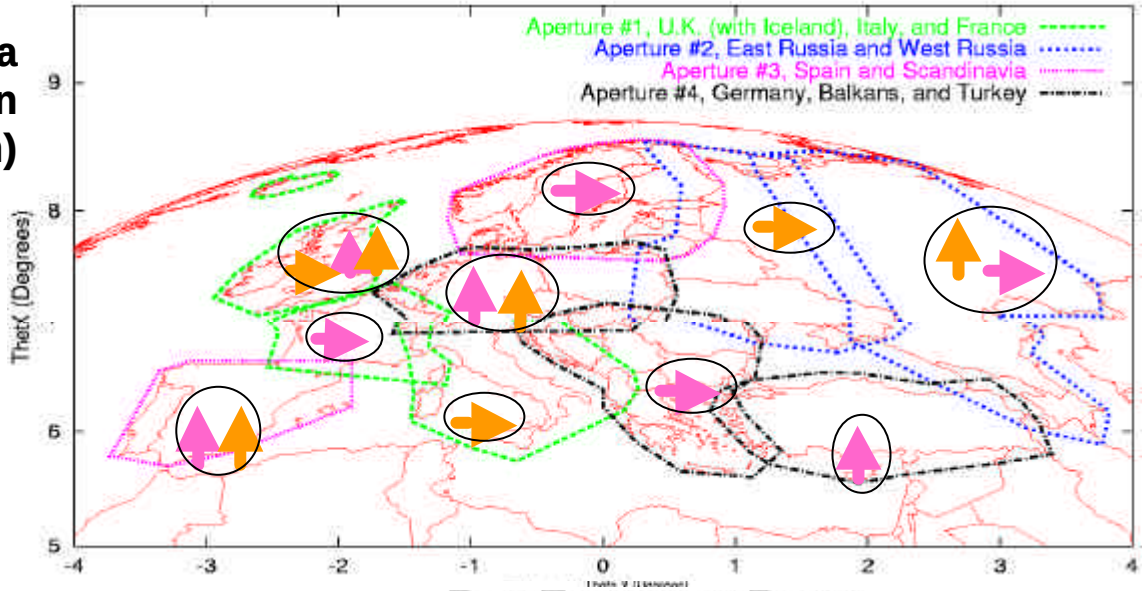
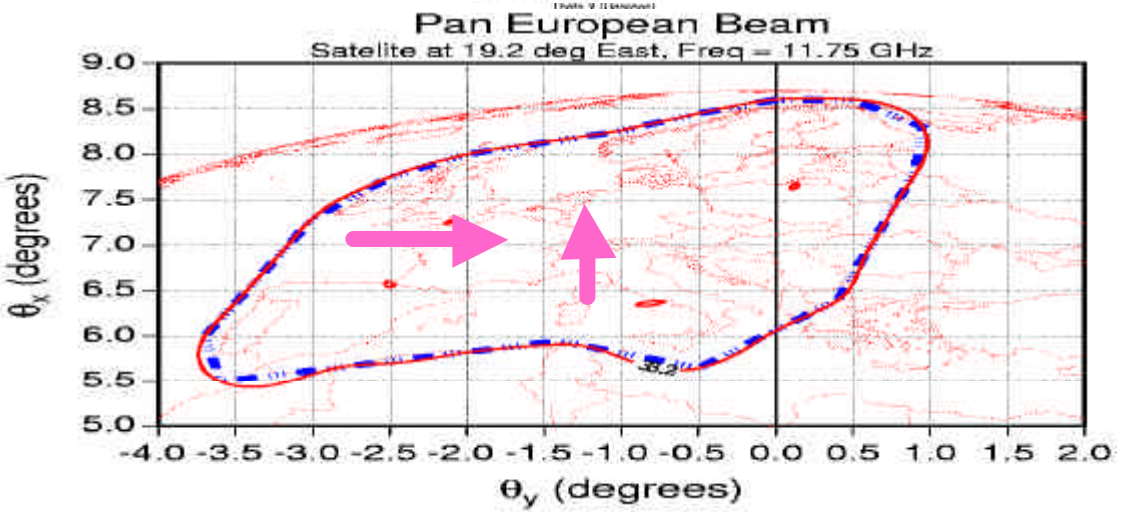
Mesh Shaped antenna Satellite Channel Plan (7.5 m)

14AH
13BH
14AV
11BV



Solid antenna Satellite Channel Plan (2.2 m)

32 H
32 V



Satellite System Capacity Comparison (Example)

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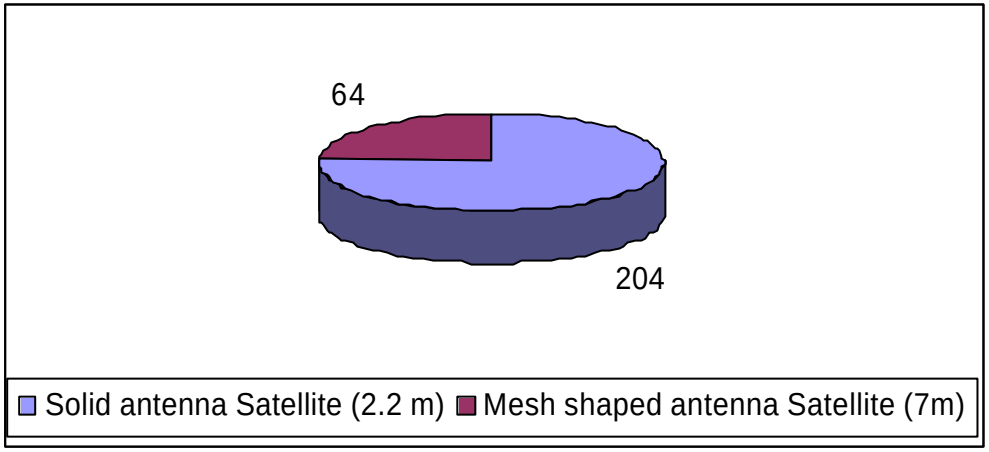
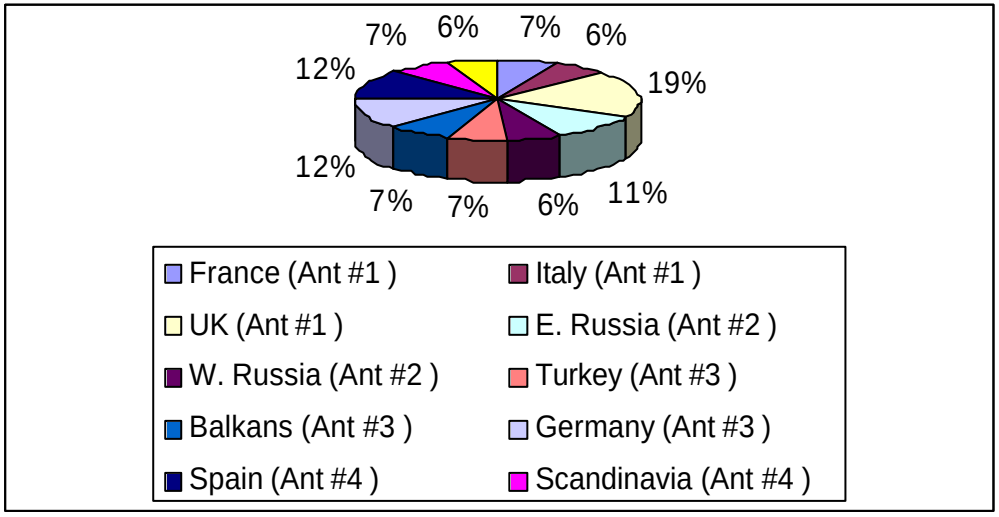


Satellite Capacity Solid Pan European Vs Mesh Shaped Regional



Regional Satellite Beam Capacity (204 Channels)

Digital Transponder Concept Block Diagram

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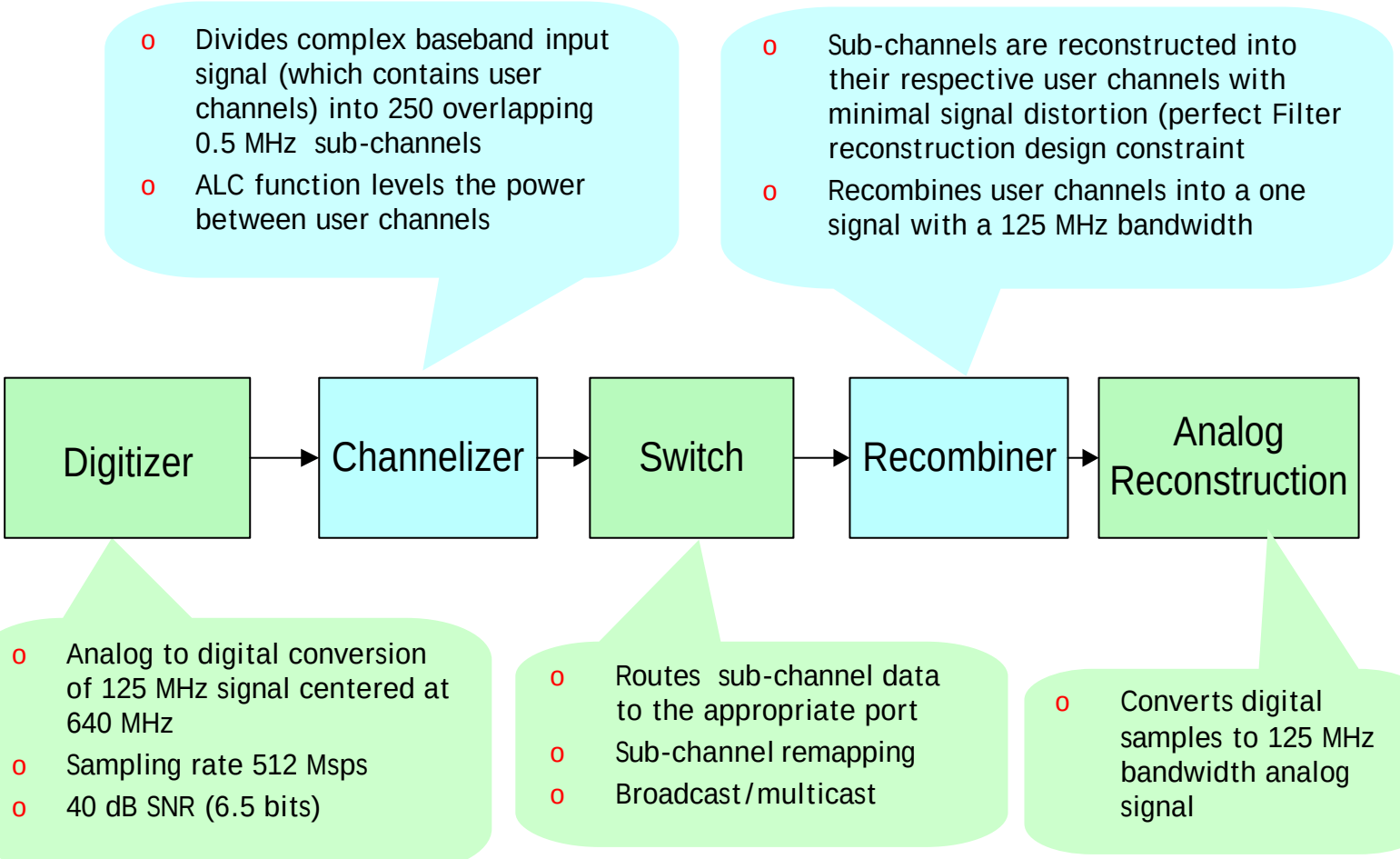

Digital Transponder Discriminating Advantages

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- On-board aggregation from multiple sources
  - Can combine multiple uplink channels from widespread locations into a single downlink
  - Frequency translation and time slot (TDM) switching
- Improved amplitude and phase linearity
  - Digital pre-distortion of HPA
- Increased capacity
  - More efficient modulation, Reduced channel guard band
- Ability to respond to changing markets and traffic patterns
  - Reconfigure connectivity at sub-transponder level
  - Allows selling fractional bandwidth (2.5, 7, 36, 72 MHz)
  - Provides circuit switching between different spot beams
- Backward compatibility with analog transponders
- Lower SI&T costs for complex switching architectures

Frequency Response Comparison Digital Vs SAW Filters

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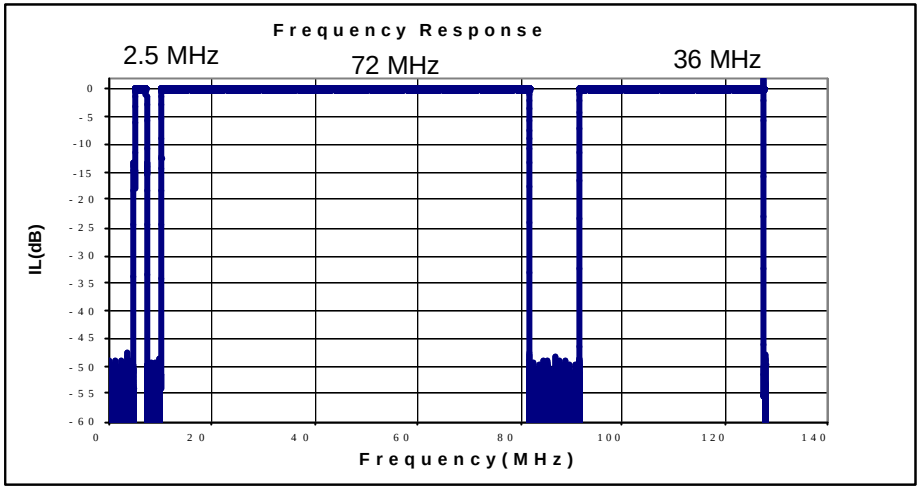
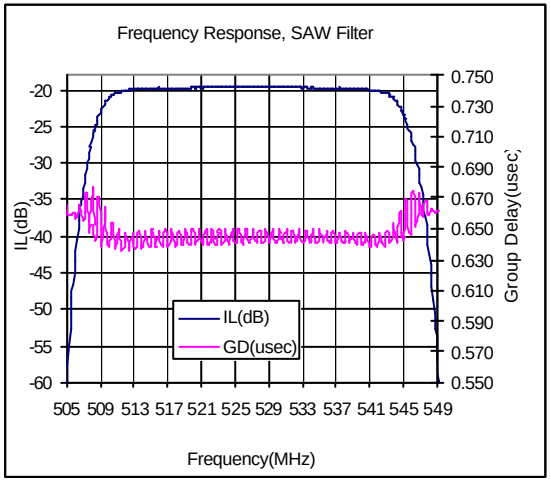
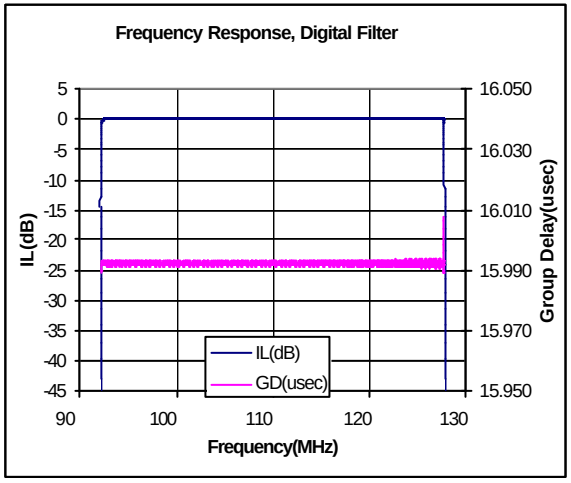


2.5 MHz, 7 MHz, MHz channels in 125 MHz band





36 MHz Bandpass filter

Multimedia Satellite Drivers

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- Broadband Multimedia Satellite Industry is going through Transformation and consolidation
- Service providers
  - Initiate network based satellite fleets for value added service offerings for information intensive markets
  - Team with suppliers for developing business based satellite solution
  - Develop long range transformational architectures to meet Global trends and emerging customer needs
  - Develop regulatory strategies for satellite network operation
- Pull satellite technology from proven manufacturers
  - For application to information intensive multimedia satellites
  - Providing cost effective broadband multimedia satellite system solutions with high performance
  - Expert Systems Engineering Support
    - System definition,analyses and trades for optimum Network
    - Expert advice on standards in network implementation

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Backup Slides

References

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- Various paper on this subject are available at TRW WEB site URL: http://www.trw.com/innovations/main
- Broadband payloads for the emerging Ka band markets, 7thKa band conference, M Bever, S Willoughby, E Wiswell, K Ho, and S Linsky, 52nd International Astronautical Federation Congress, Toulouse, France, October 1 - 5, 2001
- Next generation broadband satellite communication systems" S Verma, E Wiswell, AIAA 20th Conference on Satellite Systems, Montreal, Canada, May 12 – 15, 2002
- Venture Development Planning for Broadband Satellite Networks, J Freitag, P Stenzel, J Myers, P Varend, E Wiswell , 5th Ka-Band Utilization Conference, Taromina, Italy, October 18- 20, 1999,

Multi Beam High Gain Antenna (Example)

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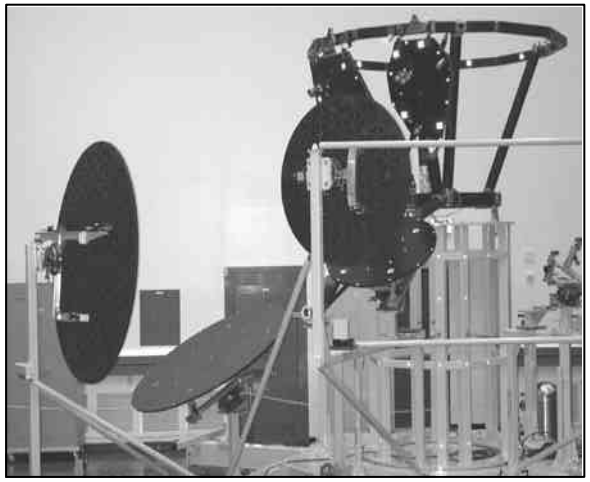

Antenna Integration Simulator (AIS)

Design Verification Model (DVM) Antenna Upgrade

Antenna Integration Simulator and Design Verification Model

Mesh Reflector Shaped Antenna

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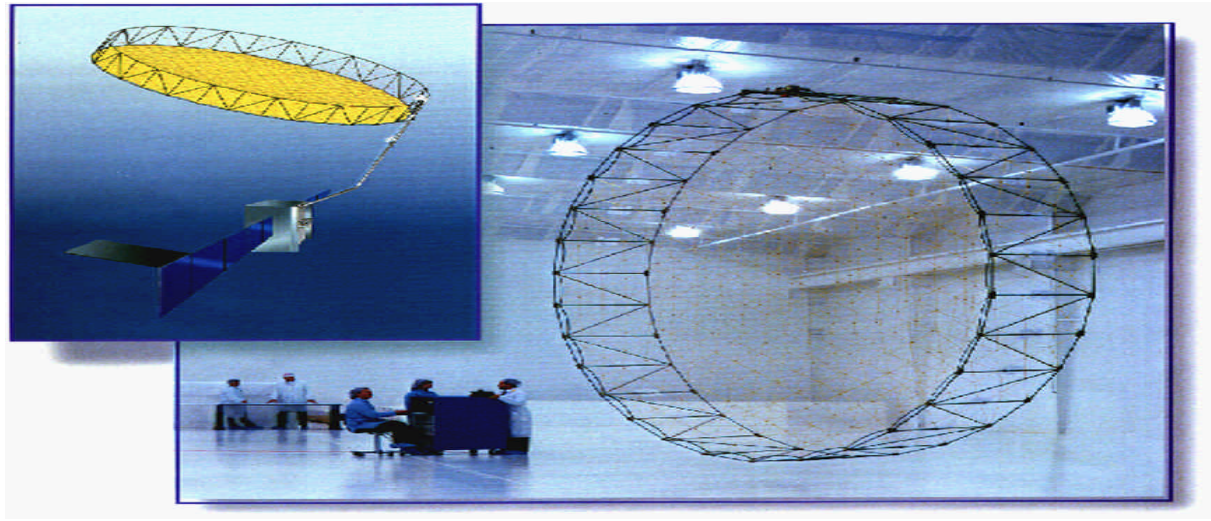

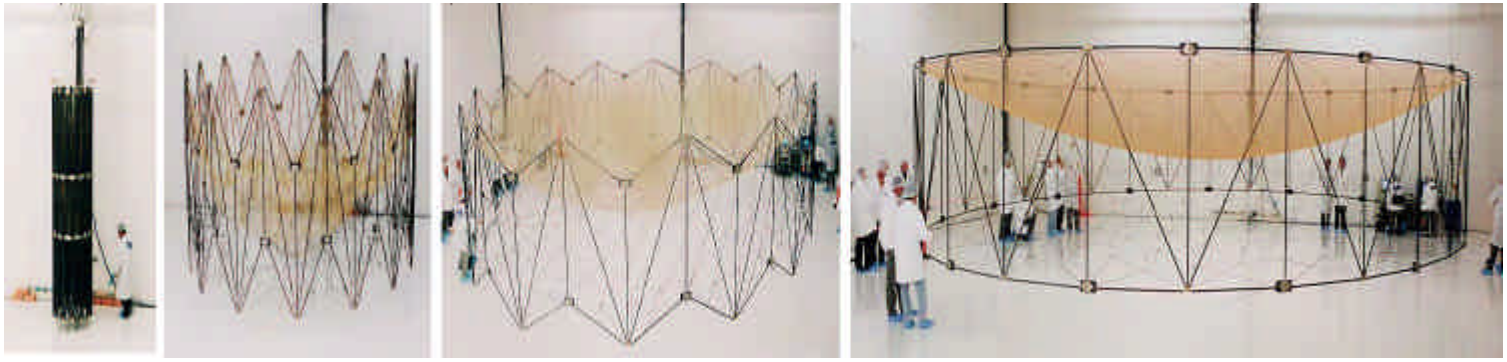

Multi Shaped Beam Satellite Concept (Example)

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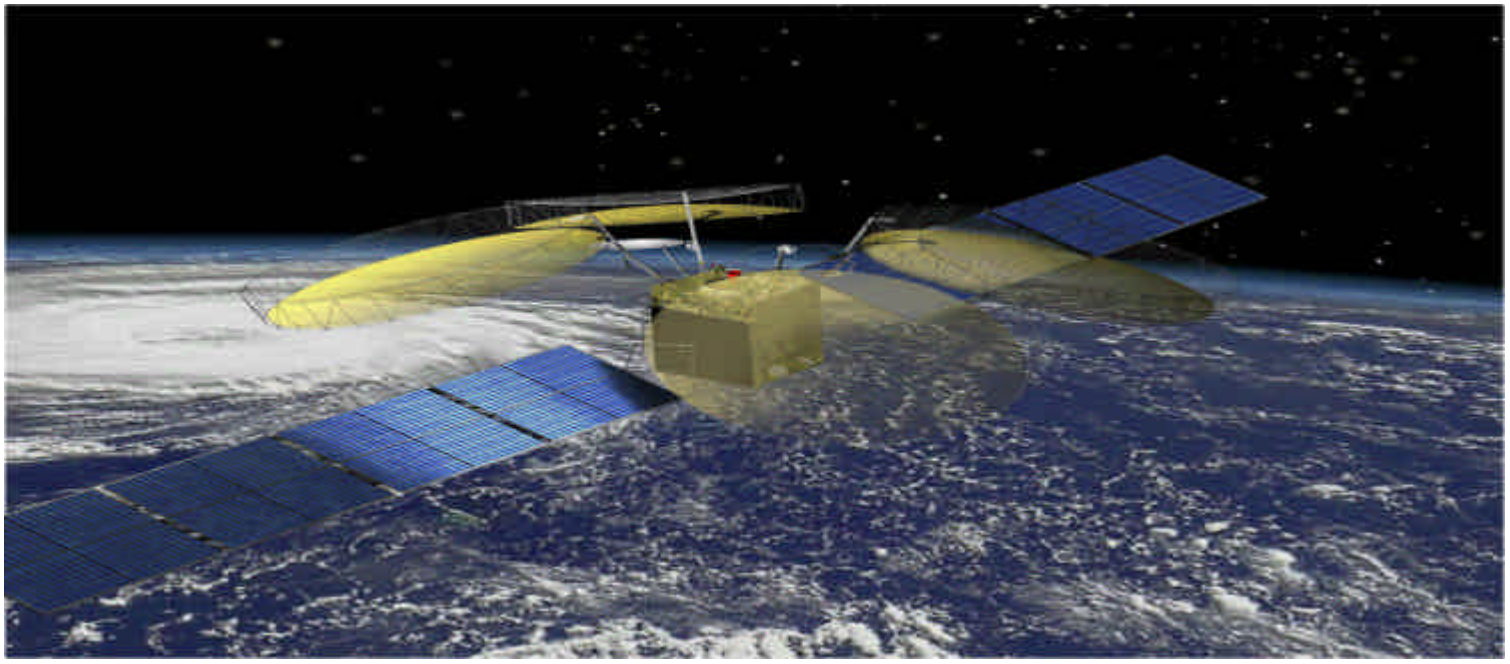

- One Satellite @ 19.2 E with five Satellite Communication Antenna
- Four antennas to generate ten beams for ten European coverage regions
- One solid antenna to provide Pan European region beam coverage
- Higher satellite system channel capacity (204 Vs 64)
- System coverage meeting customer linguistic needs

TRW Broadband Satellite Payload Heritage

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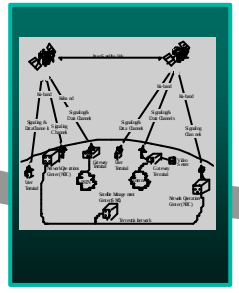
Early 1980s to Present

19 years Processed Payload Experience

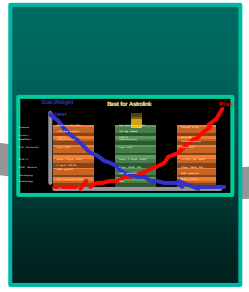
1995 to 1996

Early Ka-Band Architecture Studies



1996

Identified Enabling Technologies



1996 to 1998

Early Development of Enabling Technologies

1998 to 1999

Functional Validation in Hardware Functional Prototype (HFP)

1999 to 2002

Payload Design Verification Model Development and First Flight Payload Delivery