Advanced Technologies for Multimedia Broadband Satellites Systems

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Advanced Technologies for Multimedia Broadband Satellites Systems

- 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

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

- 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

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

Workshop on Satellites in IP and Multimedia - Geneva, 9-11 December 2002

25.11.2002
Enabling Satellites Technologies

- **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

1970

Defense Systems Communications Satellite II

1980

Milstar Payloads

INTELSAT III

Fleet Satellite Communications

Landsat 4 Downlink

1990

Tracking and Data Relay Satellites

Advanced EHF

Astrolink (type) Ka Broadband

2002

Over three decades of providing increasing SATCOM capabilities

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TRW Technology Enables Cost Effective Architectures

- 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

Advanced Antennas

Highly Integrated RF Components

Wideband Datalinks

Flexible Digital Processors & Software

Lasercom

Mega Gate ASICs

Single Chip Computers

480-Msps, 10-bit ADC

Dense Memory

TRW
Multimedia Satellites System Requirements

- 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)

- 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)

- More than ten times capacity
- Higher effective system bandwidth

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

Example: 50-beam system using dual polarization

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

Equivalent number of 36 MHz transponders ≈ 12.5 GHz/40 MHz = 310
Satellite Mesh Reflector Antenna Coverage Performance (Example)

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)

Mesh Shaped antenna
Satellite Channel Plan (7.5 m)

Solid antenna
Satellite Channel Plan (2.2 m)
Satellite System Capacity Comparison
(Example)

Satellite Capacity
Solid Pan European Vs
Mesh Shaped Regional

Regional Satellite
Beam Capacity
(204 Channels)
Digital Transponder Concept Block Diagram

- Divides complex baseband input signal (which contains user channels) into 250 overlapping 0.5 MHz sub-channels
- ALC function levels the power between user channels
- Sub-channels are reconstructed into their respective user channels with minimal signal distortion (perfect Filter reconstruction design constraint)
- Recomposes user channels into a single signal with a 125 MHz bandwidth

- Digitizer
- Channelizer
- Switch
- Recombiner
- Analog Reconstruction

- Analog to digital conversion of 125 MHz signal centered at 640 MHz
- Sampling rate 512 Msp
- 40 dB SNR (6.5 bits)
- Routes sub-channel data to the appropriate port
- Sub-channel remapping
- Broadcast/multicast
- Converts digital samples to 125 MHz bandwidth analog signal
Digital Transponder Discriminating Advantages

- 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

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

36 MHz Bandpass filter
Multimedia Satellite Drivers

- 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
Backup Slides
References

- Various paper on this subject are available at TRW WEB site URL: http://www.trw.com/innovations/main

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- 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)

Antenna Integration Simulator (AIS)  Design Verification Model (DVM) Antenna Upgrade

Antenna Integration Simulator and Design Verification Model
Mesh Reflector Shaped Antenna
Multi Shaped Beam Satellite Concept
(Example)

- 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

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