



Space & Electronics Group  
Telecommunication Programs Division

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**19th International Communications Satellite System Conference  
American Institute of Aeronautics & Astronautics**

**Plenary Session A:  
Advanced Communication Satellites:  
Technological Challenges**

Martin Melnick  
Vice President & General Manager  
Telecommunication Programs Division

April 17, 2001

# TRW Inc.

## TRW Inc.

- Global Leader in Integrated Vehicle Safety Systems
- Premier Company in Space, Defense and Information Engineering

\$17 Billion 2000 Sales

### Automotive



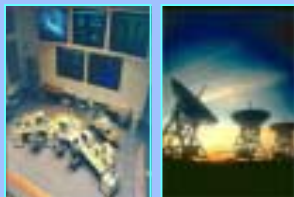
\$11 Billion 2000 Sales

### Aerospace & Information Systems



\$6.2 Billion 2000 Sales

**Systems & Information Tech Group**  
D.C. Winter  
Exec VP & GM



\$3.2 Billion

**Space & Electronics Group**  
T. W. Hannemann  
Exec VP & GM



\$1.9 Billion

**Aeronautical Systems Group**  
W. K. Maciver  
Exec VP & GM



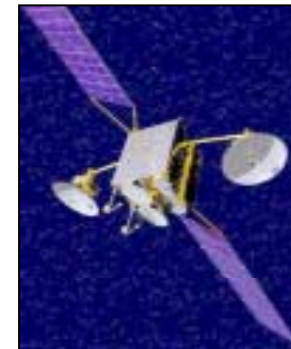
\$1.1 Billion

# TRW Has a Long History of Satcom Systems



**Defense Systems  
Communications  
Satellite II**

**Milstar  
Payloads**



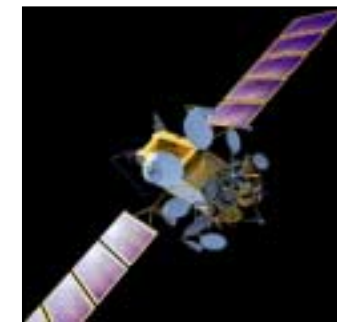
**Advanced EHF**



**Fleet Satellite  
Communications**



**Tracking and Data  
Relay Satellites**



**Astrolink**



**INTELSAT III**

**Landsat 4  
Downlink**



**1970**

**1980**

**1990**

**2000**

**Over Three Decades of Providing Increasingly Capable Satcom Systems**

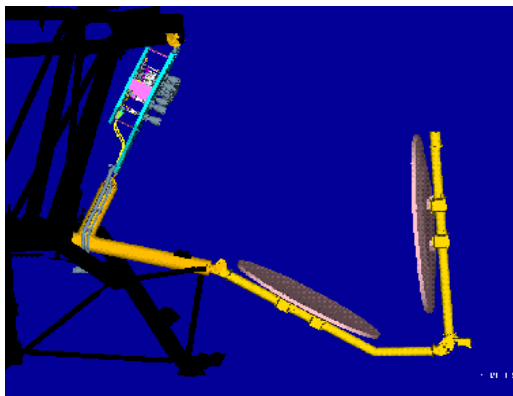
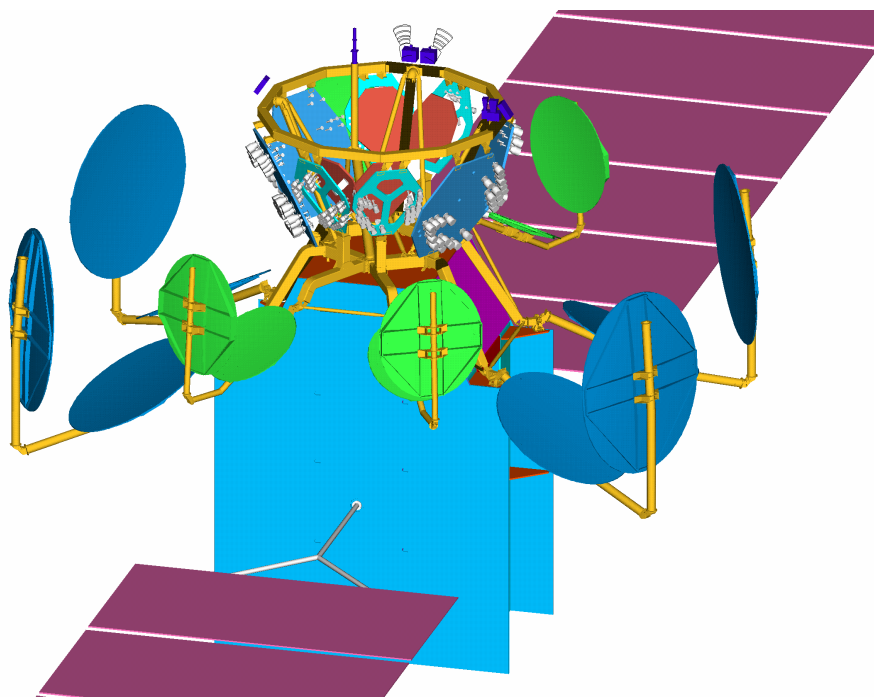
# TRW's KaBand Payload - Met the Challenge, Reduced the Risk



- **KaBand Regulatory 1995 filings created “leap ahead” product opportunity**
- **TRW's systems engineering studies identified market opportunities revenue potential**
  - TRW's Gen\*Star architecture created candidate processed and transponder payloads
  - Identification of high leverage technology
- **High leverage technology items developed and qualified**
  - Multibeam antenna emphasizing low sidelobe performance
  - MMIC frequency devices to reduce cost
  - On board processor to maximize throughput
  - End-to-end payload breadboard completed in June 1999
- **Complete engineering model payload finished integration in December 2000**
  - End-to-End verification testing will be finished by 2nd Q2001
- **First flight payload (Astrolink) is in production**
  - To be delivered in 4th Q2001

**Challenged Identified - Technology Risk Addressed - Design and Production Risk Eliminated**

# Gen\*Star Antenna System Overview



## Full Earth FOV

- Cells located anywhere

## Provides

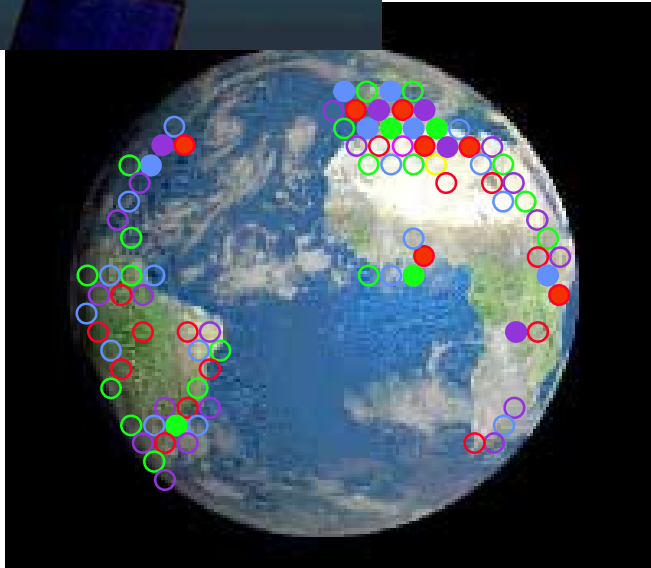
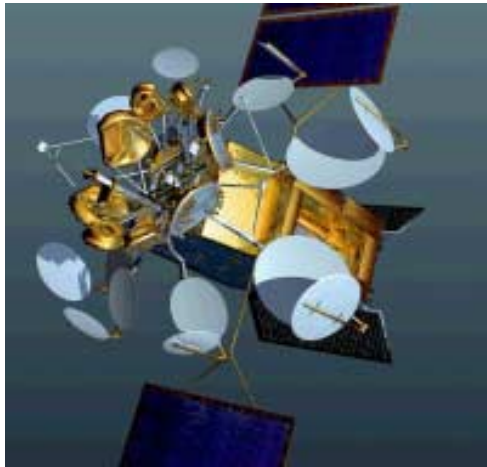
- Excellent C/I across FOV
- High Gain across FOV
- Low Xpol ( $< -30$  dB, linear pol)
- Wide bandwidth (18.3 - 20.2)

## Design Features

- 4 Uplink reflector assemblies with integral electronics
- 4 Downlink reflector assemblies with custom low-loss waveguide
- Baseline fits in 4.3 m fairing

**In Production => Astrolink**

# Antennas Enable Worldwide Coverage with Focused Capacity

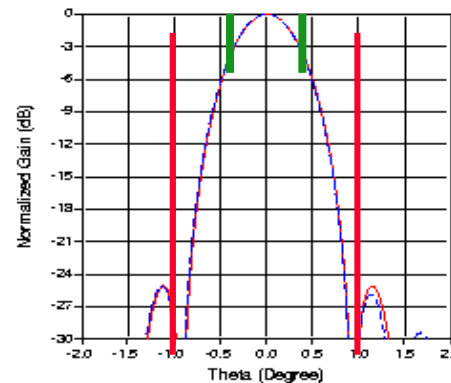


**Atlantic Coverage  
21.5°W**

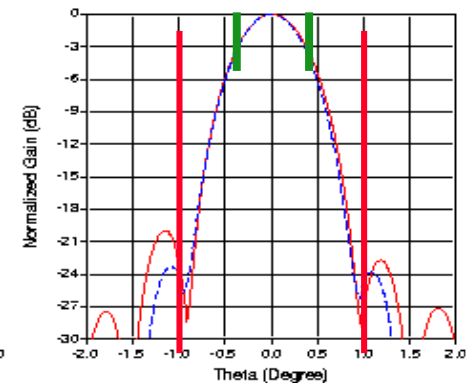
- Integral antenna assembly provides precise alignment of beams to cells
- Excellent C/I performance in the entire earth field of view

**TRW  
Gen\*Star  
Antenna**

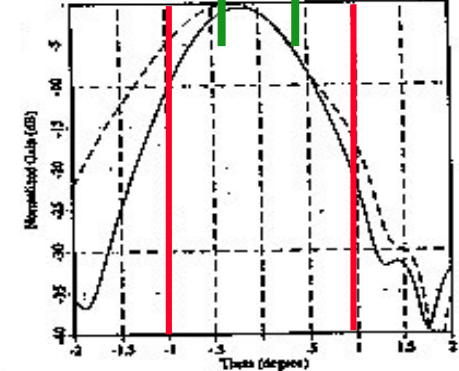
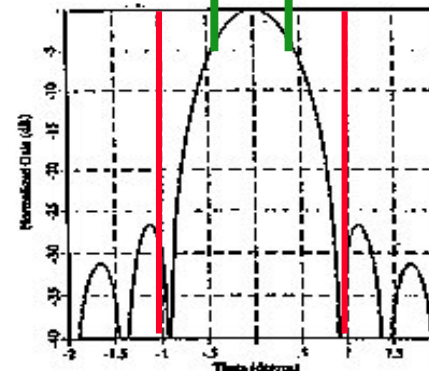
**NADIR**



**Edge of Earth**

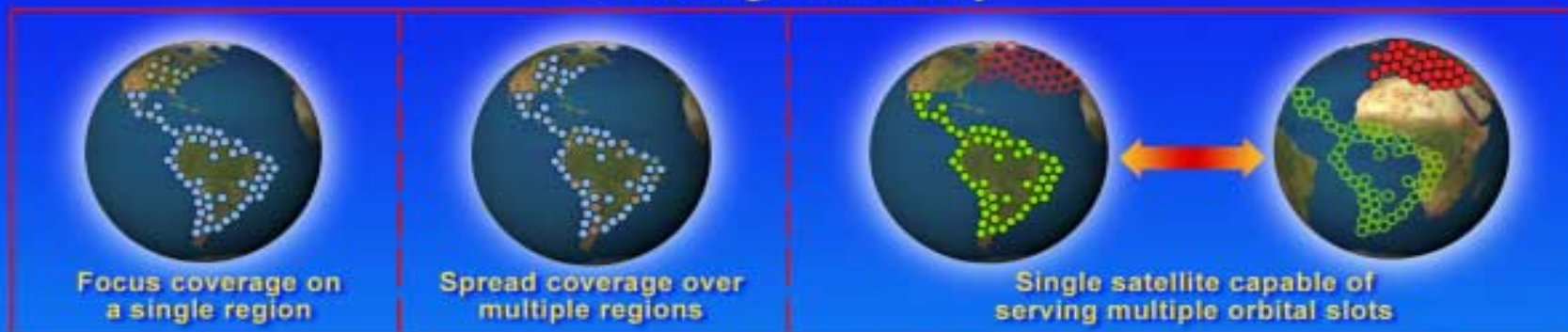


**High  
Performance  
Cassegrain  
Design**

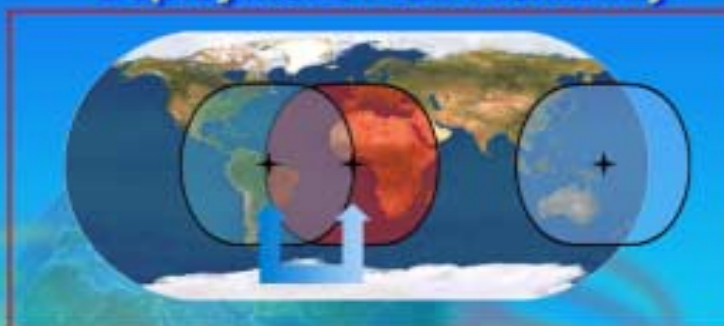


# Antennas Enable Flexibility

## Coverage Flexibility



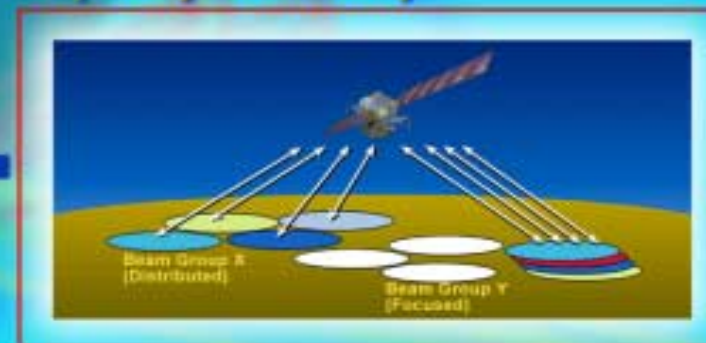
## Deployment Plan Flexibility



## Service Restoration Flexibility

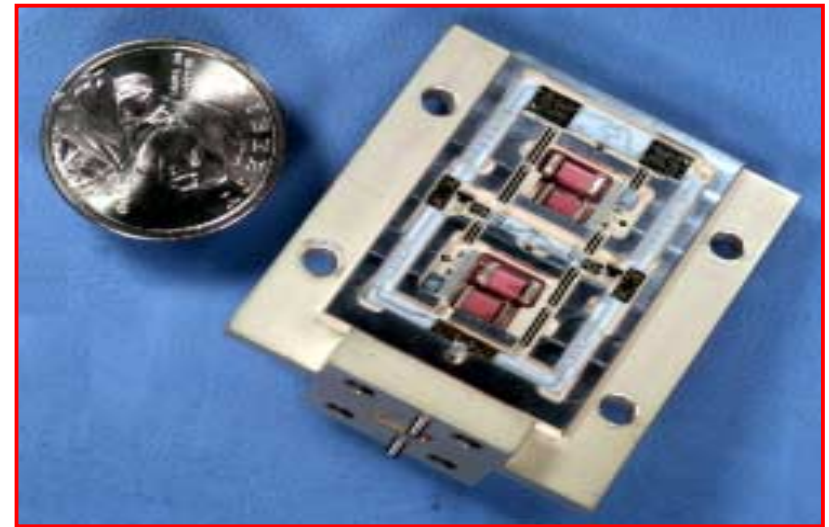
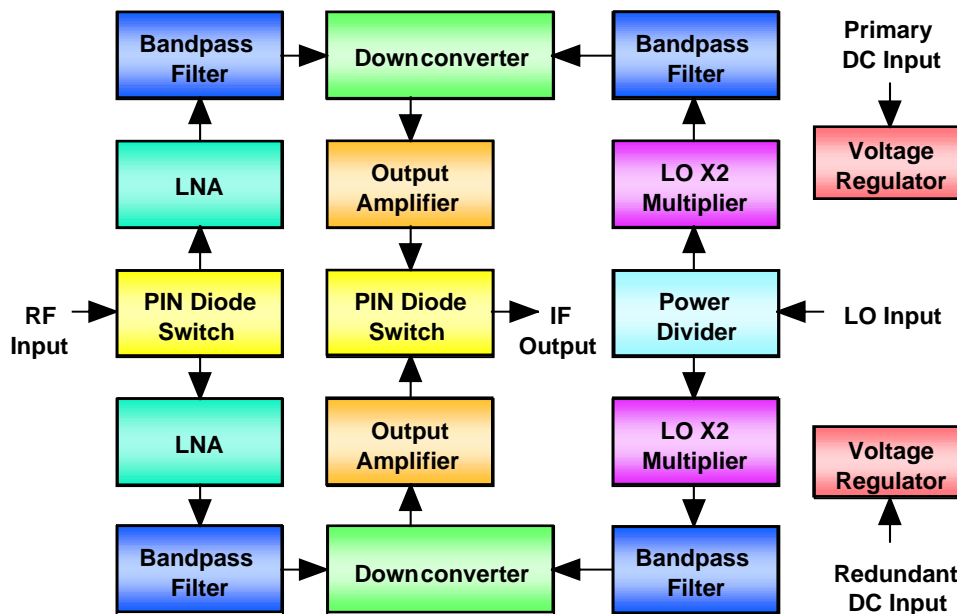


## Capacity Flexibility



# KaBand Internally Redundant LNA/Downconverter IMA

- Ultra low noise MMIC LNA
- HBT MMIC input PIN diode switch
  - DC power application automatically selects RF path
- X2 LO frequency multiplier
- Low overhead secondary regulator
  - +6.8 Volts supplied by payload mounted AEU



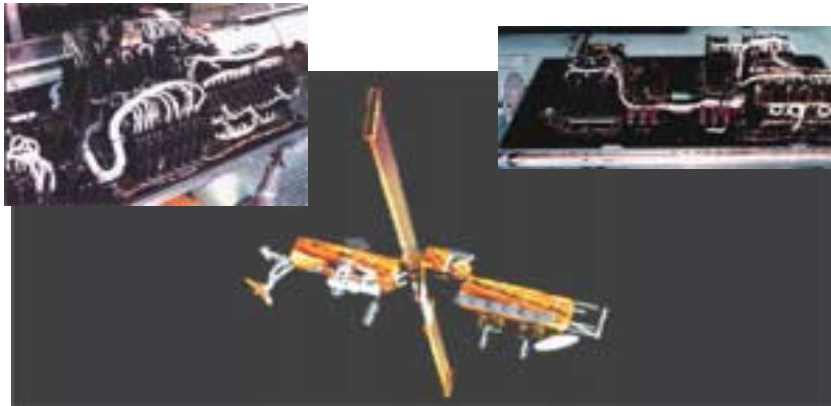
- Efficient flight proven TRW GaAs MMIC technology throughout
  - 0.10 and 0.15  $\mu\text{m}$  HEMT and 1  $\mu\text{m}$  HBT
- Silicon monolithic voltage regulator
- Hermetic housing
  - Monolithic Waveguide/housing
- 0.010" alumina substrates
- GPO connectors for LO, IF, and DC

# Fourth Generation Broadband Satcom Flight Processor Designs



## 1st Generation

1983  
Milstar I  
Digital Payload



- Circuit switched
- Capacity - 1 Mbps
- Maximum data rate - 30 Kbps

## 2nd Generation

1993  
Milstar II  
Digital Processors



- Circuit switched
- Capacity - 40 Mbps
- Maximum data rate - 1.54 Mbps

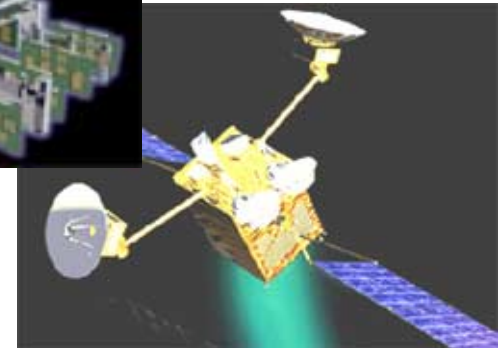
## 3rd and 4th Generation

1999  
Commercial KaBand  
Digital Processor



- Circuit or packet switched
- Capacity - 5-10 Gbps
- Maximum data rate - 10 Mbps

2001  
Military Advanced EHF  
Digital Processor



**TRW Digital Processor Technology has Contributed to Dramatic Advances in Satcom Capability**

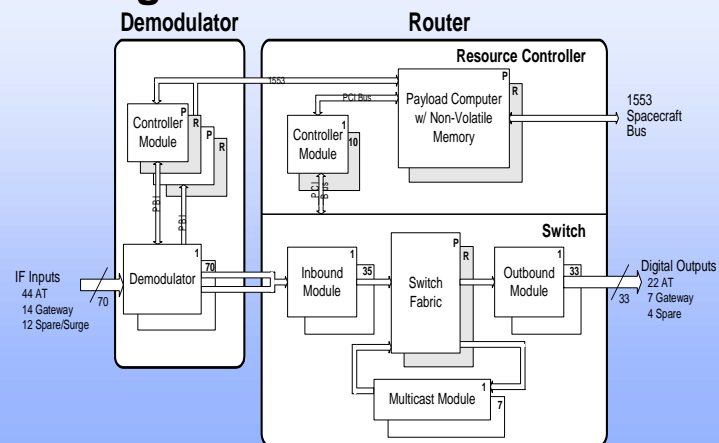
# Gen\*Star On-Board Processing Enables Maximum Throughput and User to User Networking



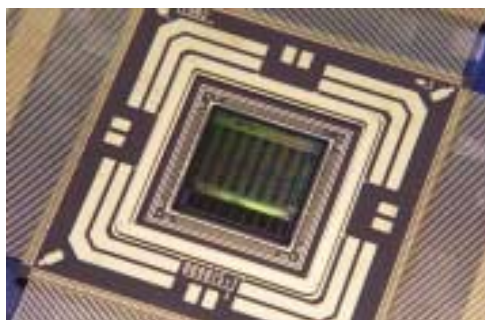
## Features / Production Readiness

- Digital Demodulator
- High Speed ATM Switch
- Fault tolerant computer
- Engineering Models completed and working in end-to-end payload
- Flight production underway for Astrolink
- Software code 90% complete

## Block Diagram



Proven design verification methodology with FPGA's



Multi-million gate ASICs minimize size, weight, power



Line replaceable units enabled by plugin backplane architecture

**Commercial Processor Products & Processes Directly Applicable to Military Needs**

# What's in the Future?

- **Systems Engineering**
  - Constellation efficiency (coverage, capacity, restorability)
  - Advanced Waveforms
- **Antennas**
  - Large active arrays for flexible coverage
  - Large C/Ku band multibeam deployables for increased spectrum reuse in legacy bands
- **Processors**
  - Digital transponder for routing Flexibility
  - Advanced OBP for increased capacity and service flexibility
- **RF - Indium Phosphide Devices**
  - Improved Receive Sensitivity
  - High efficiency power amplifiers
- **V-Band Systems**
  - Gateway links frees up spectrum for more user capacity
  - Two-way services for applications requiring smaller terminals

**Copies of this Presentation available on TRW's Broadband WebSite:  
<http://www.trw.com/broadband>**