Satellite Mobile Broadcasting Systems

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The Satellite Digital Mobile Broadcasting Scenario

US SDARS Systems Overview

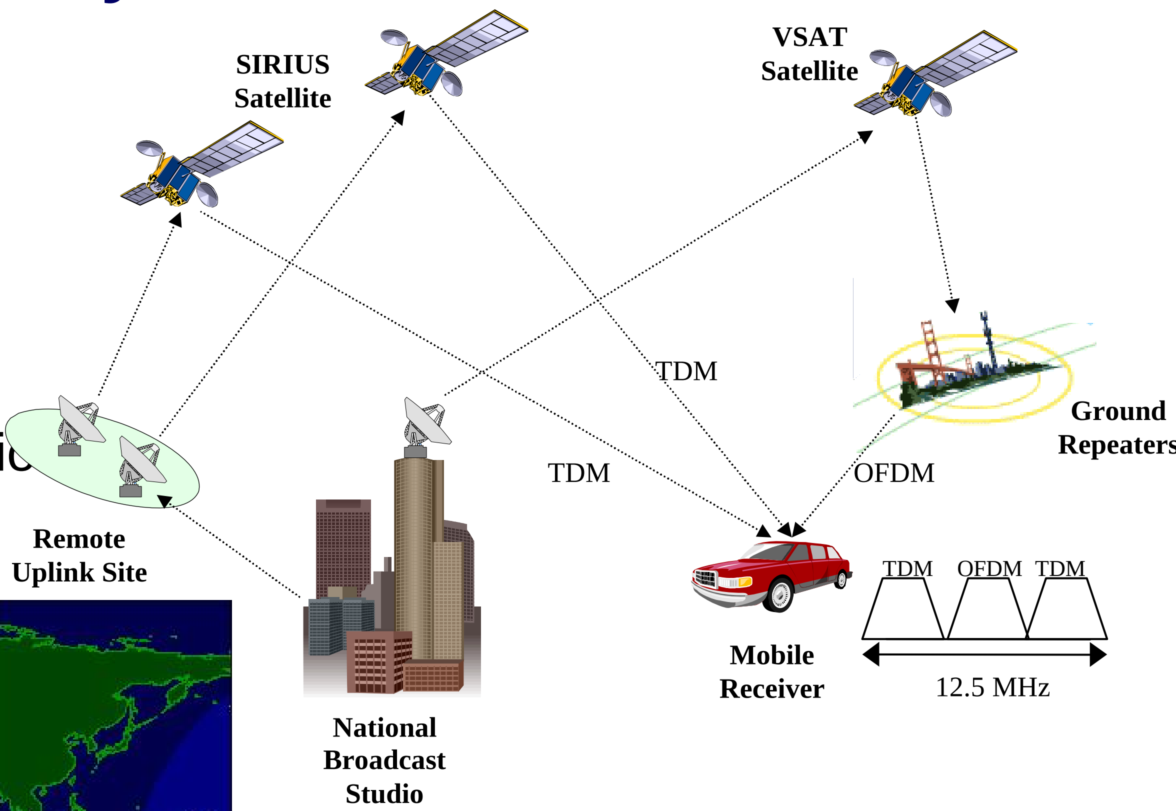
- In the United States, the FCC has approved in 1997 two competing SDARS (Satellite Digital Audio Radio Services) systems: Sirius Satellite Radio and XM Radio both operating in S-band (12.5 MHz bandwidth each)
- The 12.5 MHz band, is divided into three equal-sized bands: the middle band is used for the OFDM repeater signal while the two outer bands are allocated to the satellite signals
- XM uses two geostationary satellites in space diversity:
  - average elevation angle 45° or less ⇒ availability of terrestrial repeaters is critical, then it is based on the use of about 1000 repeaters, which significantly adds to its operation costs.
- Sirius Satellite Radio system is designed to limit the number of terrestrial repeaters by using three satellites in elliptical orbit: two satellites are active at the same time in space diversity, this requires a hand-over procedure (overall system more complex):
  - Minimum elevation angle ~60°: it is time-varying ⇒ for a given stationary reception point, coverage and reception quality can vary as a function of time.
  - It is based on the deployment of about 150 repeaters

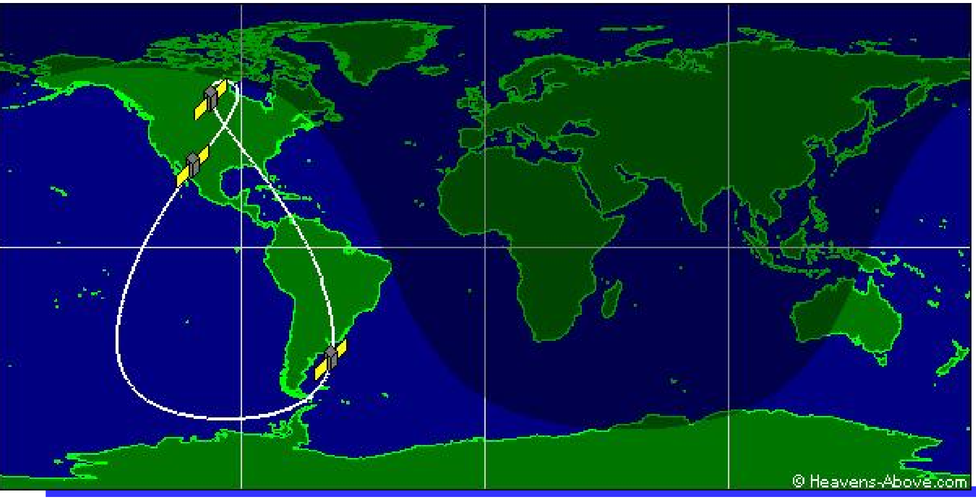
DARS systems: XM radio

- DARS = Digital Audio Radio Service
- XM Satellite Radio (CONUS)
  - started in 2001
  - 2 GEO satellites on East/West coast of USA
  - A $1,5 billions program targeting vehicular market
  - 100 Thematic radio channels, FM+ quality
  - $10/month subscription
  - Receivers price starting today from $120
  - XM has10 million customers in USA

DARS systems: Sirius

- Sirius (CONUS)
  - Started in 2002
  - 3 HEO satellites
  - 120 Thematic radio channels, FM+ quality
  - $12.25/month subscriptio
  - 9 million customers



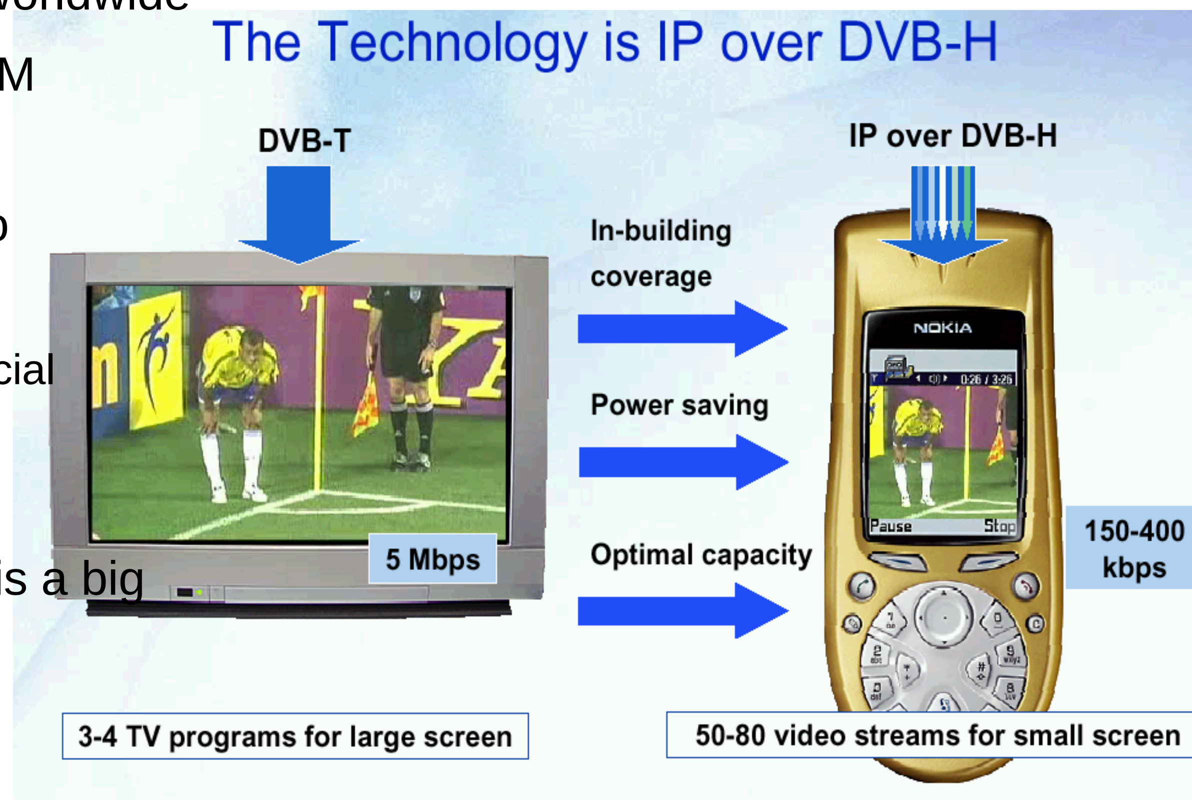


MBSAT

- MBSAT (Japan and Korea)
  - opening 2004
  - 1 GEO sat, 12 m antenna
  - CDM air interface with SFN Gap fillers
  - 25 MHz band at 2,6 GHz, 7 Mb/s capacity
  - Vehicular and pedestrian usage
  - 10 TV and 50 Radio broadcast programs
  - Target 20 Million customers in 2010
  - 400 to 600 $ receivers
  - 3 to 20$/month subscription
- System Cost ~800 M$
  - Tens of thousands of terrestrial repeaters
- Partnership: Toshiba, NTV, NTT, SKT, Toyota, Mitsubishi, Samsung,...
- Strong involvement of SKT in Korea to market the MBSAT system
  - Targeting video over cellular phone with Samsung products

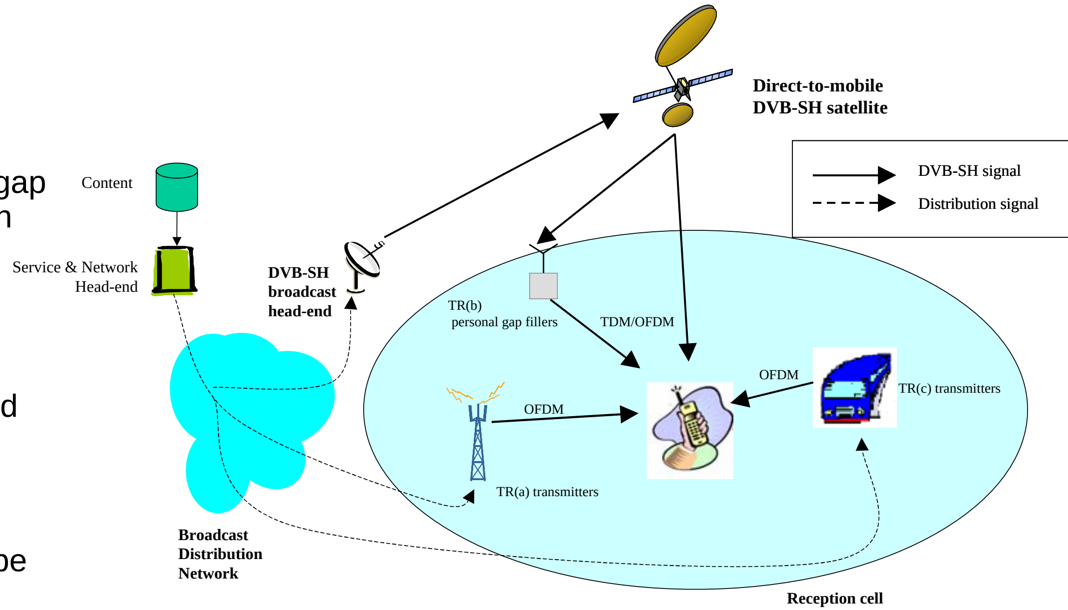
DVB standards: DVB-T/H

- DVB-T has been standardized in 1997 and now deployed worldwide
- DVB-T adopts QAM-OFDM
- DVB-H is the evolution of DVB-T for broadcasting to mobile handsets
  - Targeting 2005 commercial product availability
- Regulatory allocation for DVB-H Networks in UHF is a big concern
  - Will require tremendous lobbying effort to grant VHF/UHF before 2010



DVB standards: DVB-SH

- Background:
  - Recent US FCC and EC normative has been introducing the concept of mobile satellite/terrestrial hybrid systems
  - Satellite can be complemented by terrestrial gap fillers to extend the satellite coverage in urban areas (ATC in USA or CGC in Europe)
  - Hybrid networks frequencies have been allocated in USA and are being allocated in Europe
  - High commercial interest for this kind of hybrid networks
  - The new DVB-SH (satellite to hand-held) standard has been developed in 2007
  - First commercial customers are expected to be ICO (USA) and Eutelsat/ASTRA (Europe)
- Applications:
  - Broadcasting of classic Radio and TV content;
  - Broadcasting of audio or video content customized for Mobile TV (e.g. virtual TV channels, pod-casts,);
  - Data delivery (“push”), e.g. for ring tones, logos;
  - Video on demand services;
  - Informative services (e.g. news) including location-based services;
  - Interactive services, via an external communications channel (e.g. UMTS)



Enhancement of DVB-H to support satellite channels

Mobile Broadcasting Technical Challenges and Solutions

Key Technical Challenges

- Differently from terrestrial systems, satellite can not provide very high link margins:
  - The system shall be able to cope with link interruptions lasting up to seconds
  - High power efficiency is a must
- Solutions:
  - Powerful coding and long time interleaving
  - Space diversity
  - Terrestrial gap fillers to cope with urban environment
  - Satellite/terrestrial signals soft combining

Key Technical Challenges

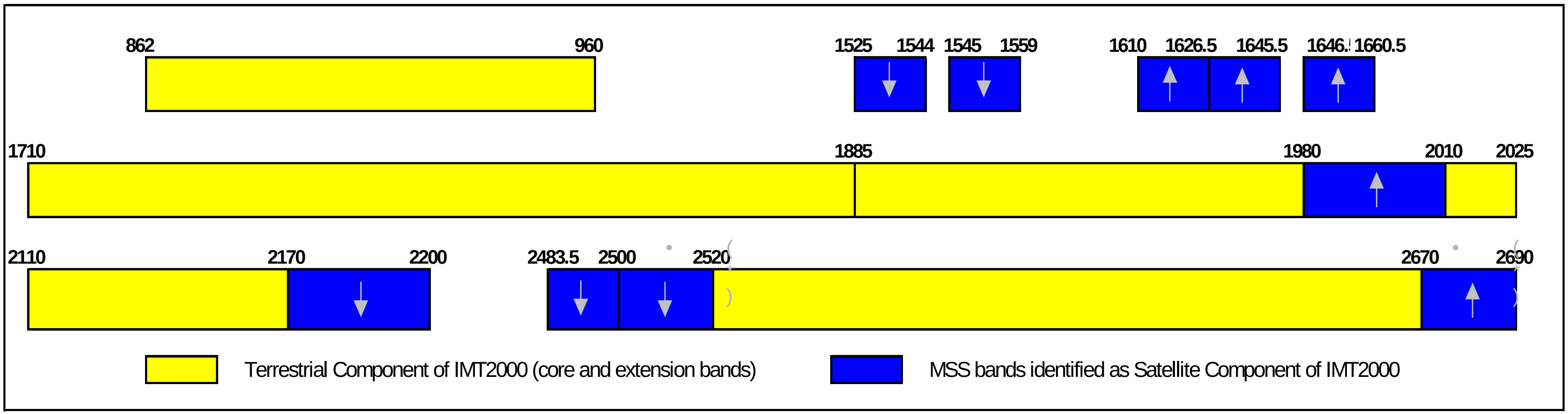
- Spectrum allocation is scarce:
  - Need to maximize the information broadcasted
  - Match the coverage to market requirements (e.g. linguistic regions)
- Solutions:
  - Spectral efficient transmission techniques
  - State-of-the art source encoding (e.g. MPEG4)
  - Satellite/terrestrial frequency reuse (OFDM)
  - Frequency reuse among satellite beams
  - Contoured (linguistic regions) satellite beams

Frequency Bands

– band identified for the satellite component of IMT-2000

– band immediately adjacent to the terrestrial band for simplification of the user terminal 2170-2200 MHz (+1980-2010 MHz if uplink)

IMT-2000 bands in Europe



(*) May be used in the longer term for terrestrial component of IMT2000

Space Segment

- Satellites
  - 1 or 2 GEO for a European coverage depending on:
    - Required QoS (Time/space diversity, redundancy)
    - Required capacity & in-space redundancy
    - 1 GEO satellite is sufficient for a pre-operational network

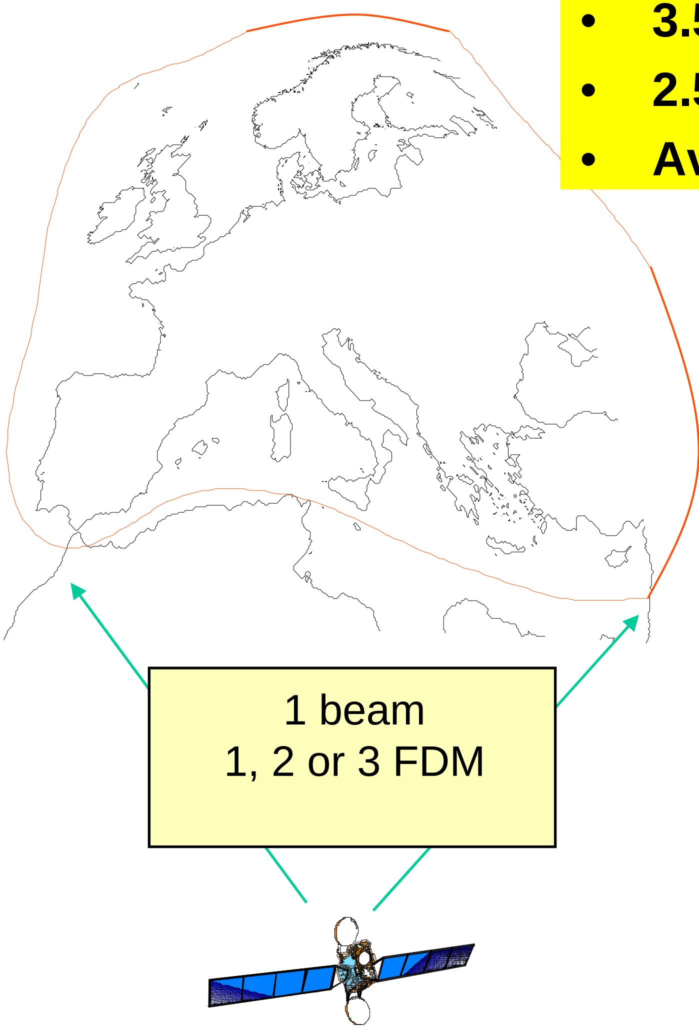
- Ground Control System (GCS)
  - Satellite control center
  - TCR stations
  - IOT-simulator and facilities

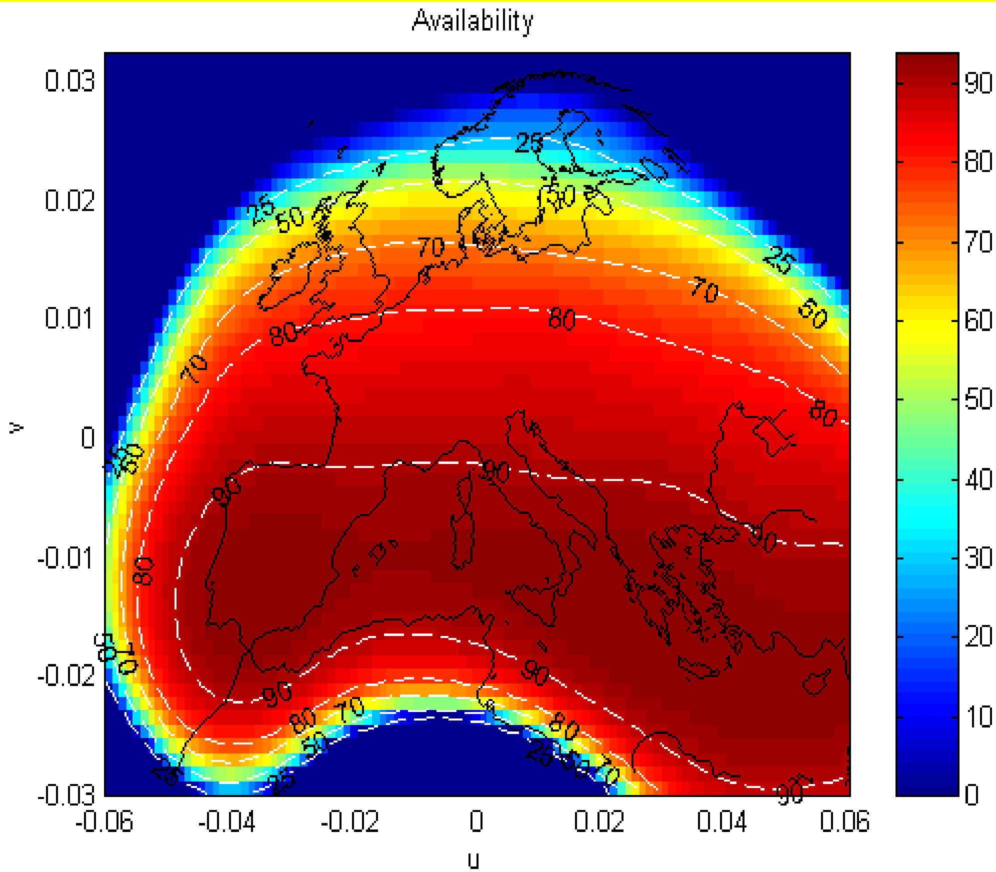
Space Segment Possible Architectures

- Global beam
  - About 3-4 meter shaped reflector
    - Pros:
      - » Simplicity and large heritage from XM-radio
    - Cons:
      - » No linguistic beams
      - » No frequency reuse possible
      - » Low availability at high latitudes
- Multibeam
  - About 7-12m Antenna Fed Reflector – 5-8 beams
    - Pros:
      - » Linguistic beams
      - » Frequency reuse possible
      - » Power-to-beam allocation flexibility
    - Cons:
      - » Large reflector
      - » More complex payload

Coverage Global Beam

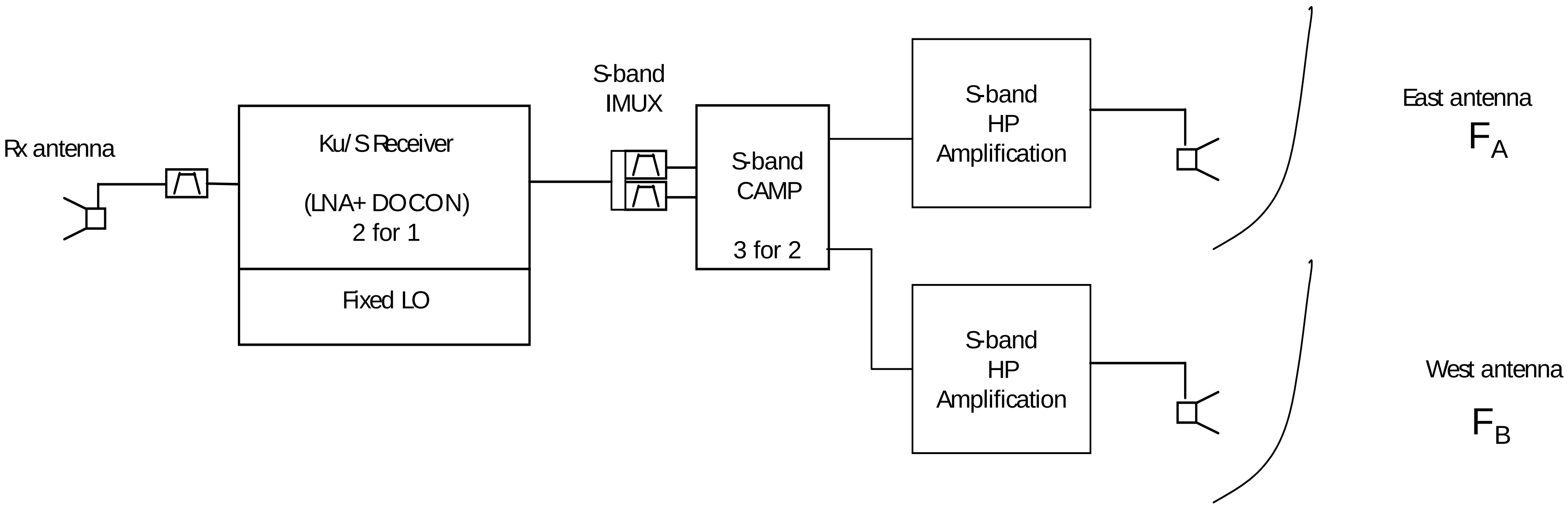
- 3.5 meter shaped reflector
- 2.5 kW RF per FDM
- Availability simulation based on ITU ERS model





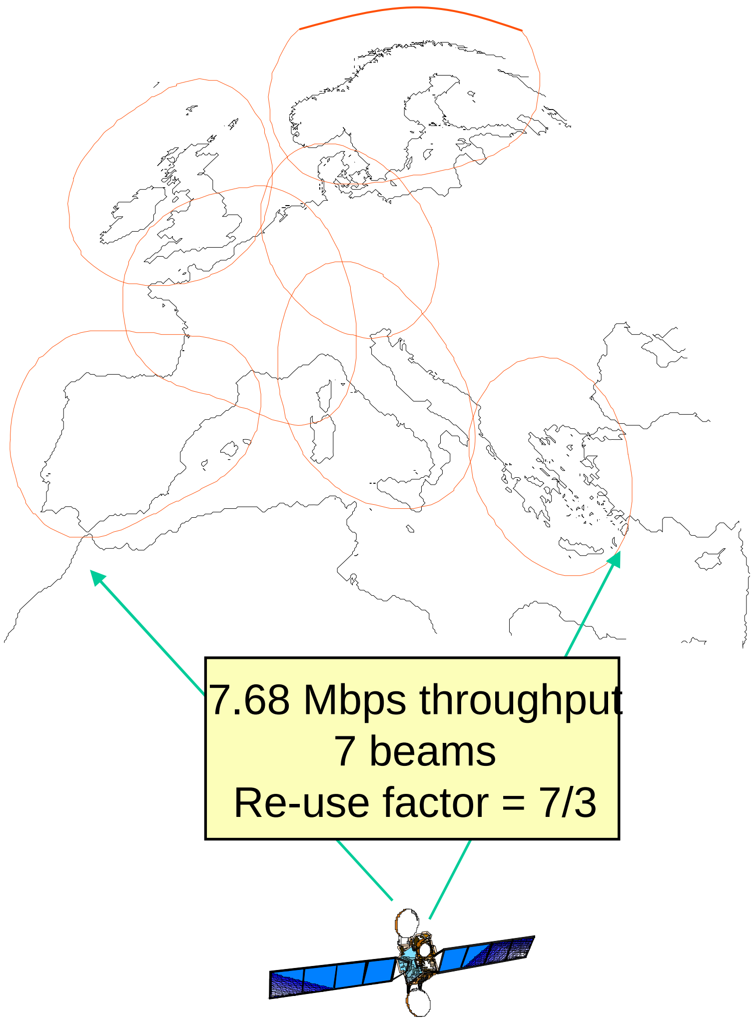
Payload Architecture Global Beam

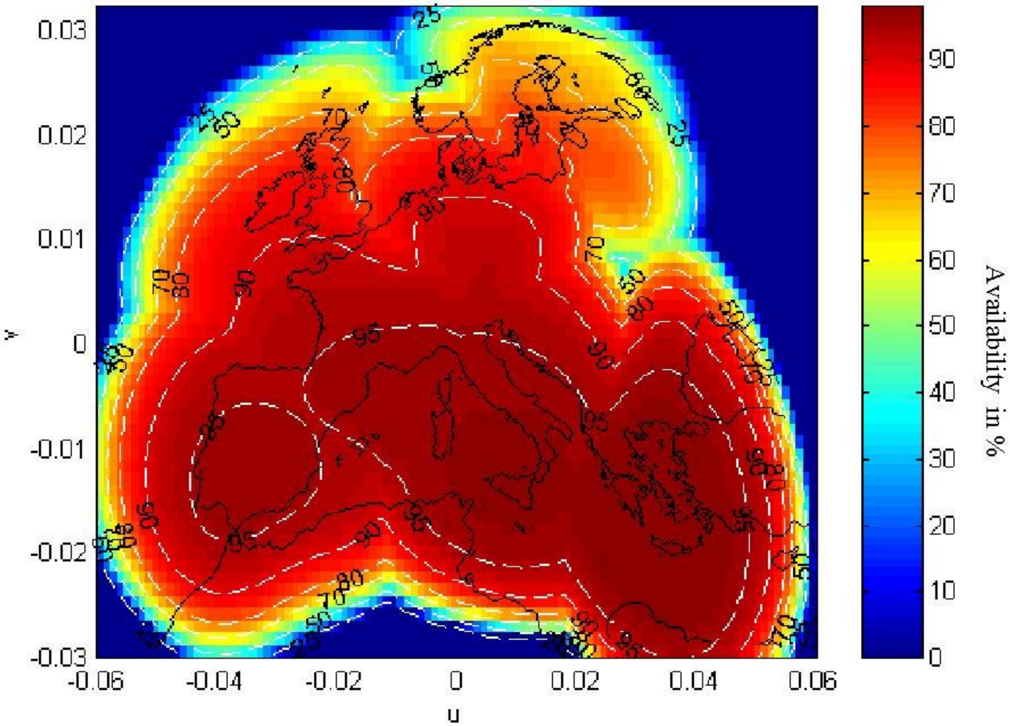
- Example Characteristics
  - 64 dBW per carrier
    - 32 active HPA in parallel
  - 18-20 kW payload power consumption (compatible with @BUS)
- Payload architecture



Coverage Multibeam

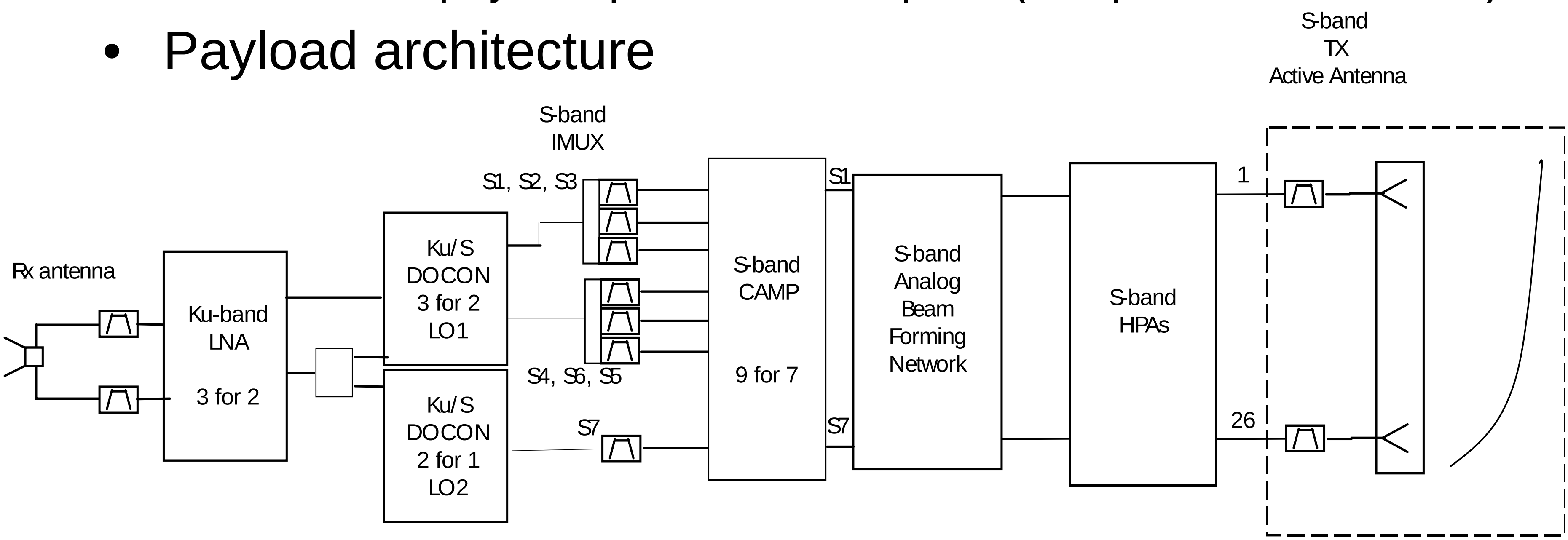
- 7.4 meter FAFR reflector
- Frequency reuse factor = 7/3
- 5 kW RF per FDM
- Simulation based on ITU ERS model





Payload Architecture Multibeam

- Characteristics
  - 64-68 dBW per beam
    - 8x8 or 16x16 High Power MPA
  - 18-20 kW payload power consumption (compatible with @BUS)
- Payload architecture

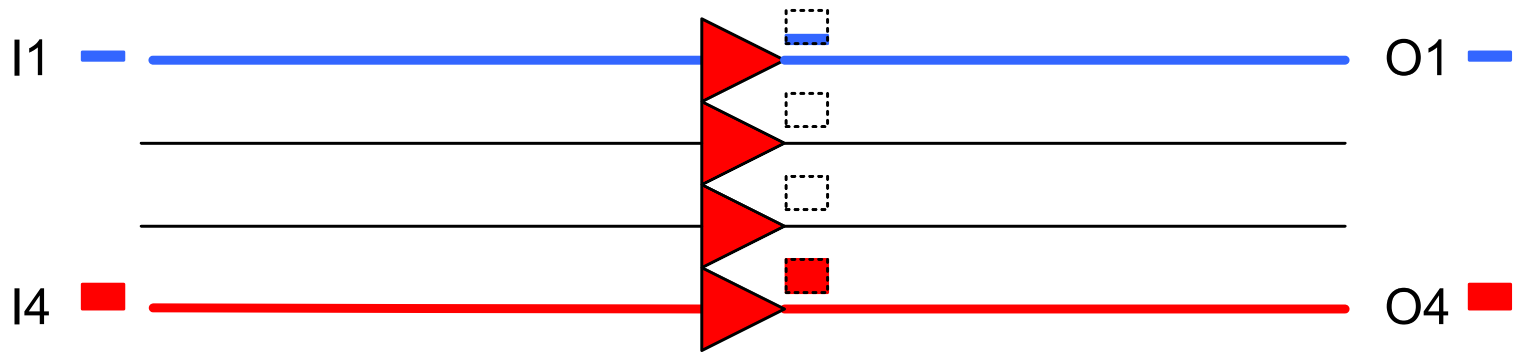


Payload Design Aspects

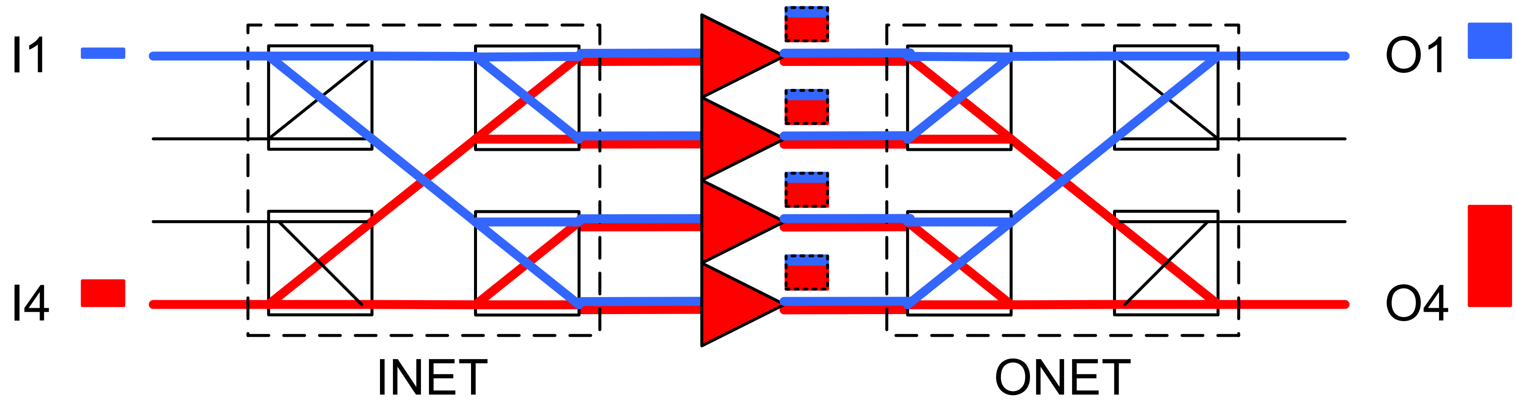
- Ka-band Y-polar is converted to the 19 GHz gap-filler donwlink frequency and amplified
- Ka-band X-polar converted to IF frequency channelized and then upconverted to S-band
- S-band multi-beam flexible payload:
  - A low signal level phase-only BFN
  - A fully shared stack of 32 TWT amplifiers in a power pooling configuration (in groups of 4:5 phase tracked redundancy blocks)
  - A stack of 4x4 Butler-like matrices
  - An array of 32 feeds appropriately connected to the hybrid matrices
  - An S-band Large Deployable Reflector of 12 meters projected aperture

Basics of Power Pooling

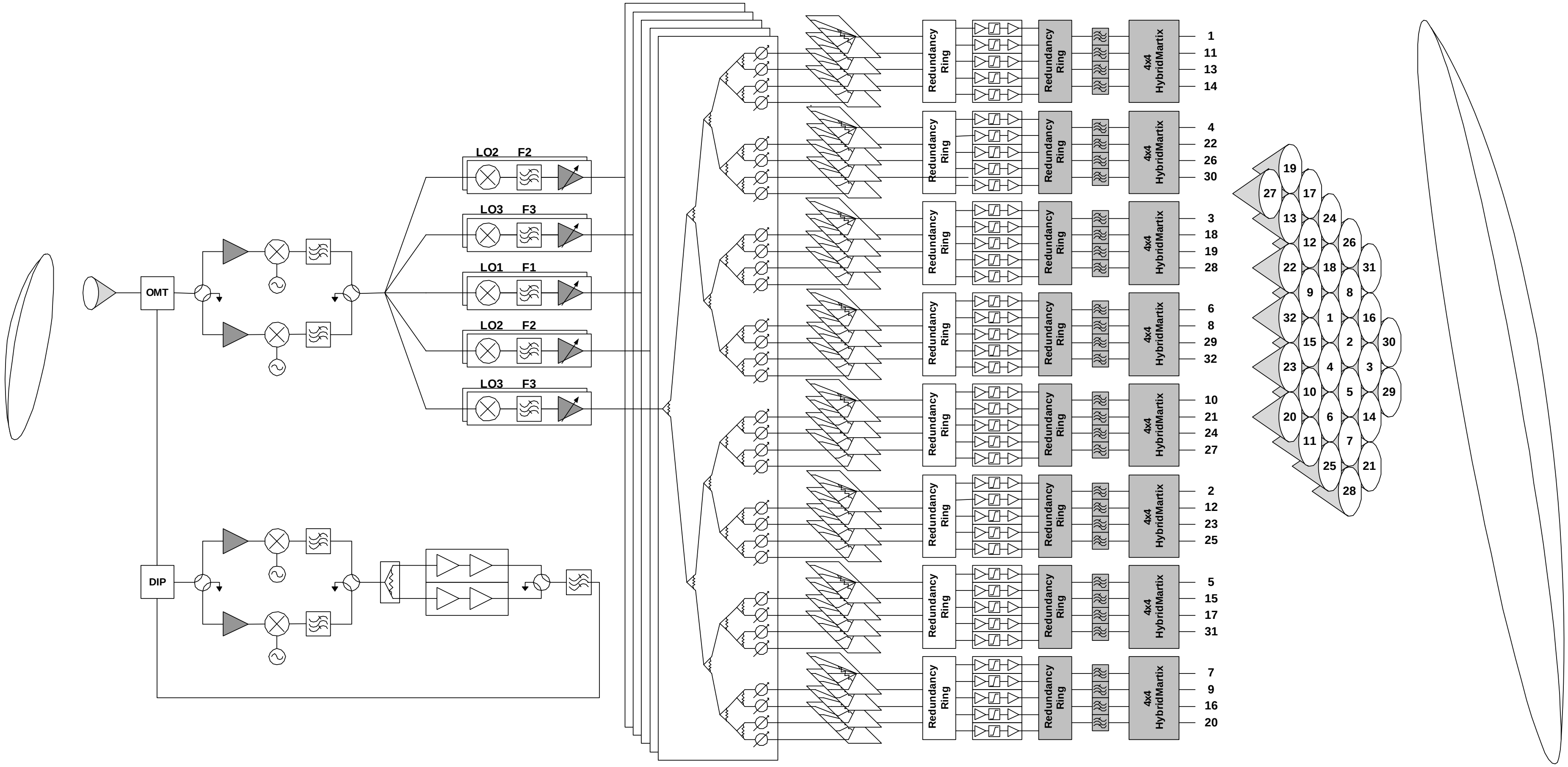
Conventional Power Amplification (No Power Pooling)



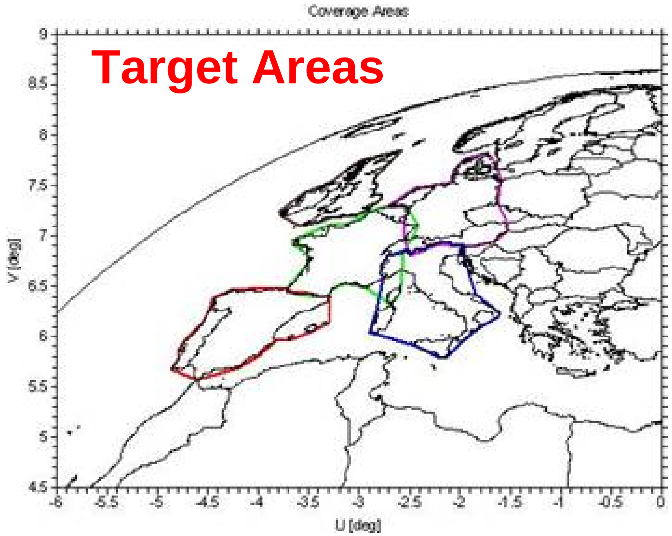
Multi-Port Amplifier (RF Power Pooling)

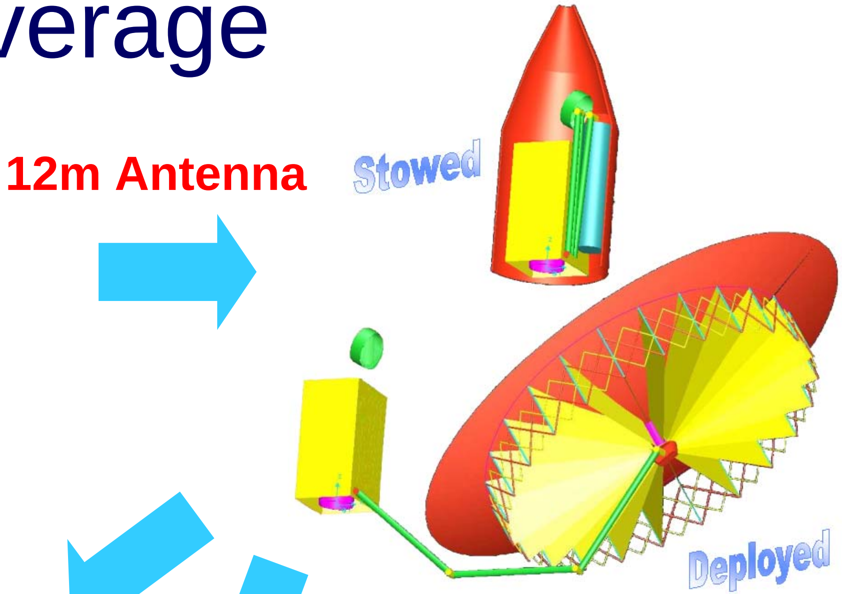


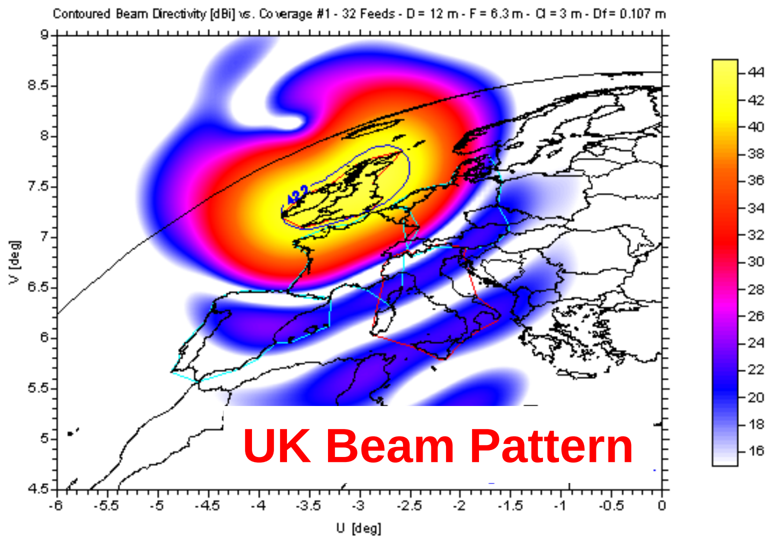
Payload Block Diagram

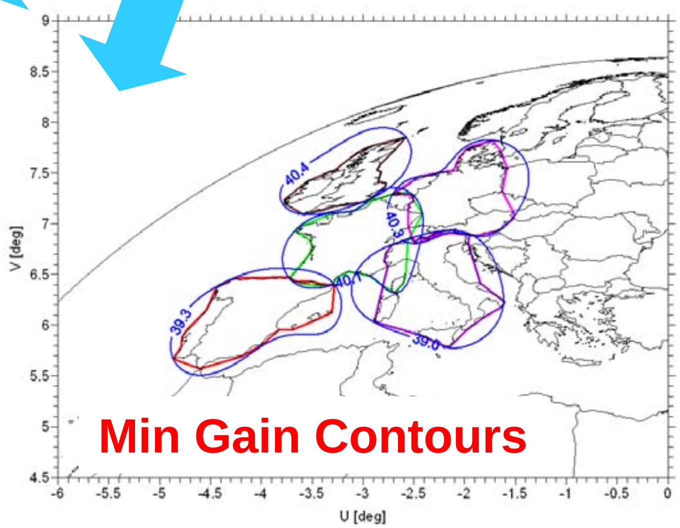


Coverage


Coverage Areas
Target Areas
V [deg]
U [deg]


12m Antenna
Stowed
Deployed


Contoured Beam Directivity [dBi] vs. Coverage #1 - 32 Feeds - D = 12 m - F = 6.3 m - Cl = 3 m - Df = 0.107 m
UK Beam Pattern
V [deg]
U [deg]


Min Gain Contours
V [deg]
U [deg]