ARTIC WorkShop

Overview of Automotive Antennas for Satellite Mobile Communications

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Presentation Outline

- Overview of developments roadmap for automotive applications
- L-band antennas
  - Satellite Radio Antenna
  - Wideband Antenna for bi-directional L-band systems (Thuraya, Iridium, Inmarsat)
- S-band antennas
  - Multi-systems antenna (DVB-SH-GPS-UMTS)
- Ku-band antennas
  - Hybrid Phased Array for Ku-mobile system
  - Electronic Phased Array for Ku-mobile system

SatCom Antenna developments considered in SISTER

Receiver Phase 1 → Receiver Phase 2

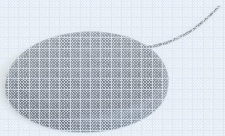
L-band

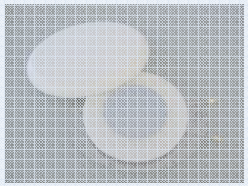
S-band

Ku-band

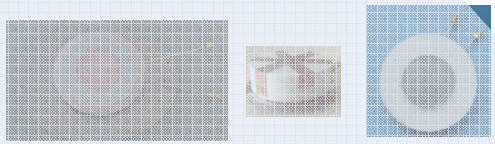
WorldSpace

Thuraya-GPS

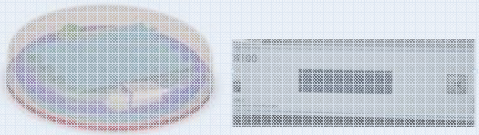




Solaris Rx-only Tx/Rx



Hybrid Mech-Elec Steering Integrated Rx



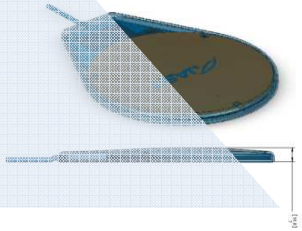
Antenna

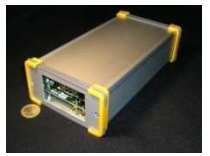
Receiver

Integrated L/S-band Tx/Rx

Solaris-GPS-Iridium-UMTS

Electronic Steering Integrated Ku-Tx/Rx





L-band antennas

WSMAx-1 - Omnidirectional Antennas for Mobile Satellite Digital Radio reception

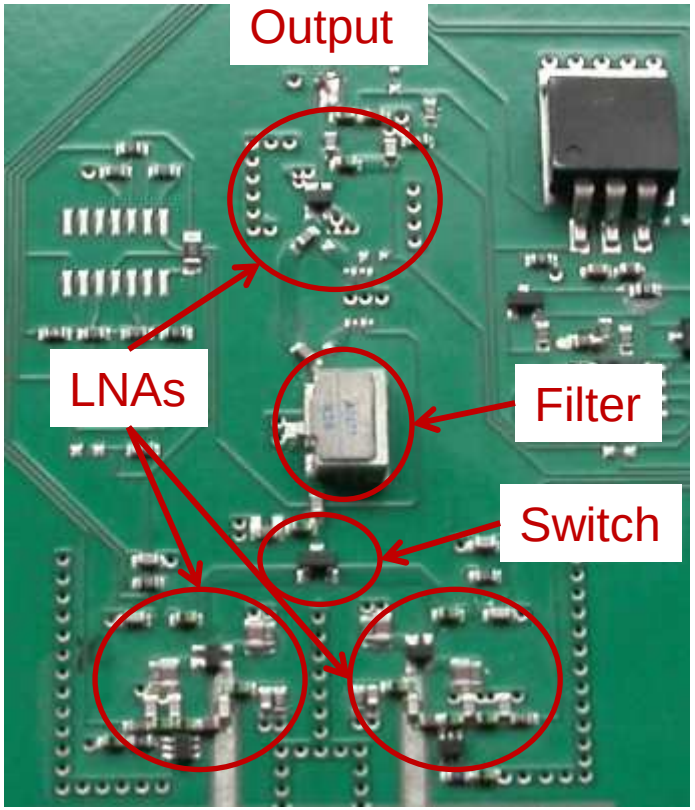
- Annular Ring with slot-coupled feed.
- Very homogeneuous pattern in Azimuth
- Switchable Dual Circularly polarised antenna
- Efficient signal reception maximizing the coverage for antenna applicability to low elevation angles of the satellite
- Very low-cost design
- Currently used worldwide in cars and boats(Europe, South-Africa, India, Indian Ocean…)

WSMAC-1 **WorldSpace Mobile Car Antenna**

WSMAB-1 **WorldSpace Mobile Boat Antenna**

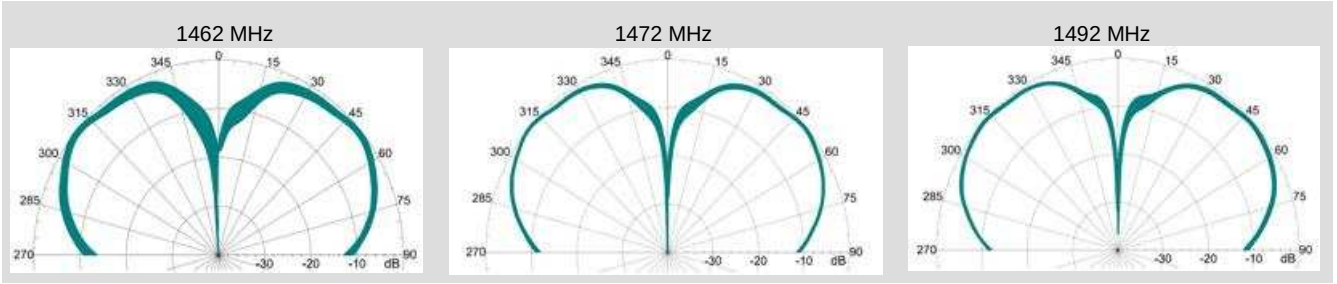
WSMAx-1 Active circuitry

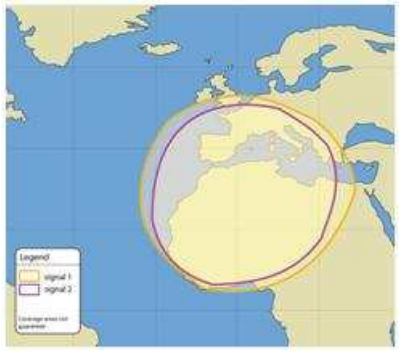
- Input for a dual circular polarisation antenna with dual independent channel or switched channel
- Include polarization switch to select desired polarization
- Include a pass-band filter to remove out-of-band noise and interferences
- Two stages amplification to allow for long cable connectivity
- Architecture portable to S-band DVB-SH



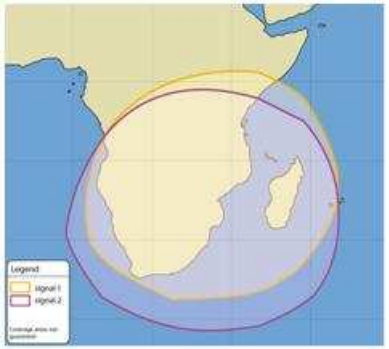
WSMAx-1 – Antenna patterns and associated satellite regional coverages

Antenna typical radiation patterns

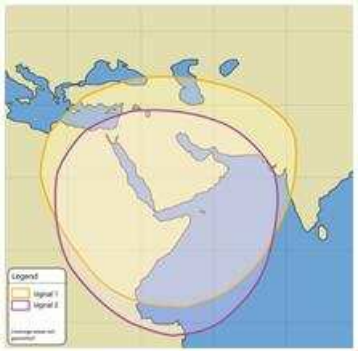




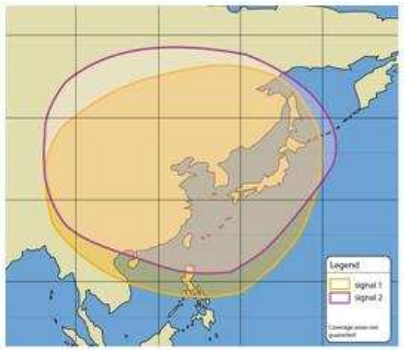
AfriStar North-West



AfriStar South



AfriStar North-East

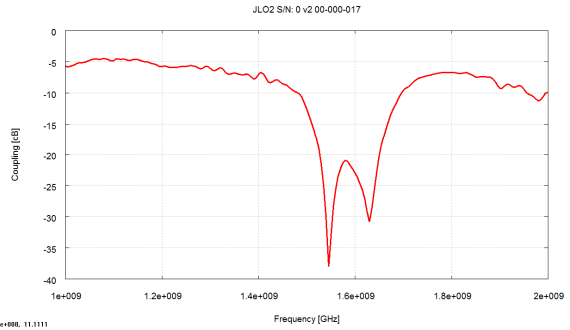


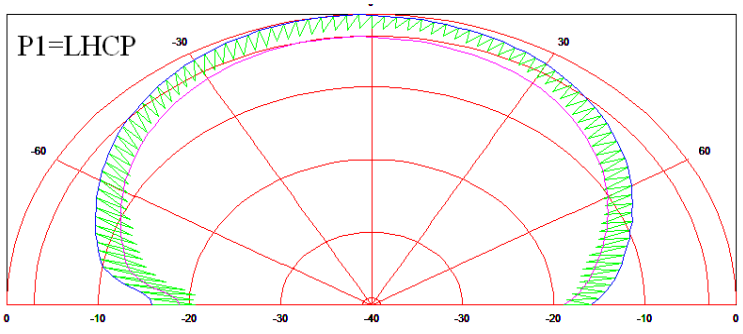
AsiaStar North-East

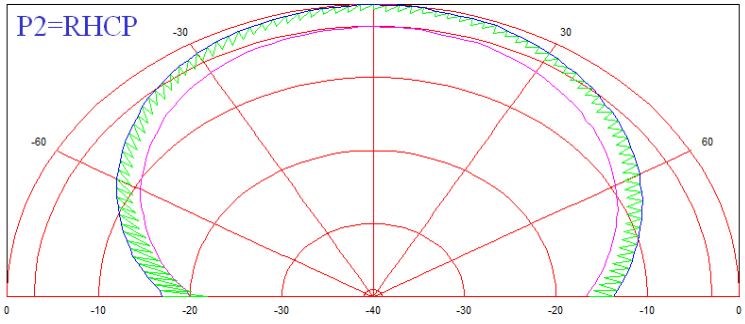
AsiaStar North-West

JLO - Dual Circular Polarisation Omnidirectional low-loss antenna

- L-Band omnidirectional antenna for MSS (Thuraya, Inmarsat Bgan, Skyterra, Iridium, GPS)
- Allows simultaneous or alternate reception of RHCP and LHCP
- The wide radiation pattern offers good reception level even at low elevation
- The low-loss and low-cost applied materials allow very high efficiency
- Reasonable size (Diameter=80mm, height=12mm) for integration in in car parts
- Omnidirectional radiation pattern allows for multi-element systems (spatial diversity)
- Suitable for Tx/Rx single element antenna

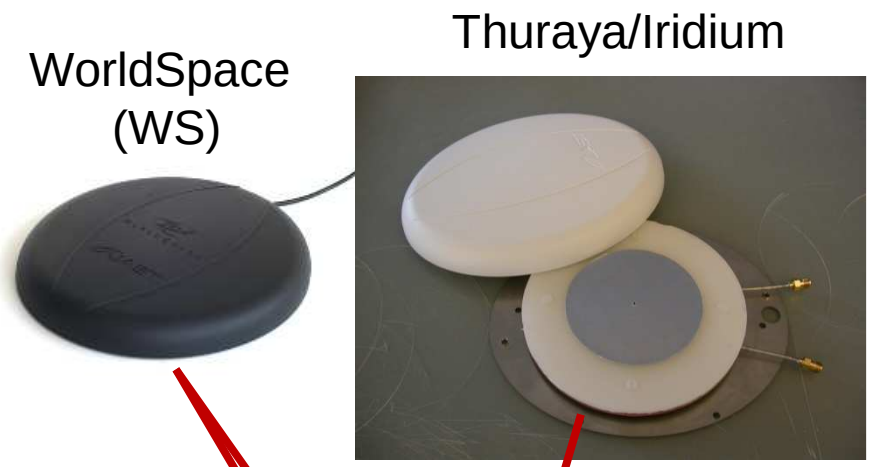






Application of L-band Antennas in SISTER

- WorldSpace and Thuraya antenna developed up to production level and provided to SISTER partners for demonstrations
- Successfully validated during Noordwijk field trials (2009)
- Both antennas are getting interest from Iridium system providers because of the high efficiency and wide patterns



JLO – Field trials

- An L-band version of this antenna have been designed for Thuraya system and tested in UK against competitors antenna
- Field trials show very good comparative results with respect to much bigger (helix) and more expensive antennas

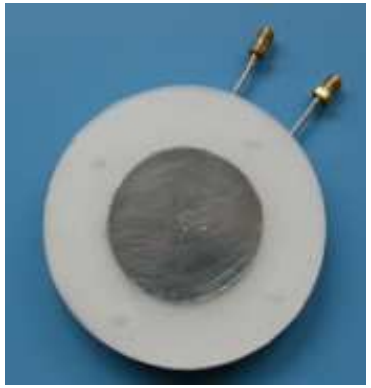
Trials performed by AVANTI-COMSINE

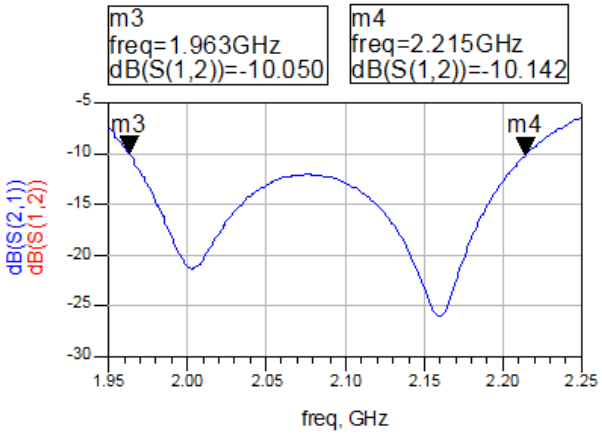
		European antennas HOA	JAST Dual-CP	JAST Lin-Pol	European antennas LPA7
					
Total driving time		00:21:16	00:22:13	00:22:20	N/A
% Lost packages		38%	44%	65%	N/A
Average latency (sec)		3.80	3.77	5.56	N/A
CSQ	North	35	38	37	20
	East	33	36	39	30
	South	34	37	36	33
	West	34	34	36	34
CSQ	Variance	2	4	3	14
Omnidirectional		yes	yes	yes	no
	Price	£300	tba	tba	£200

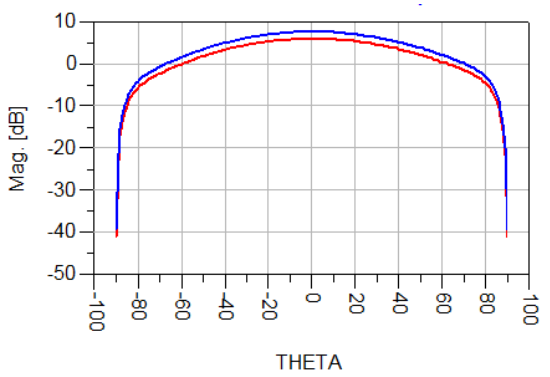
S-band antennas

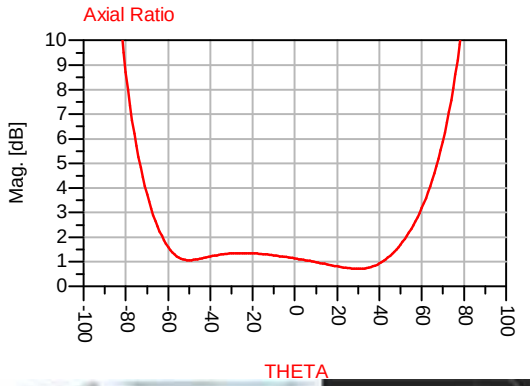
Broadband Antenna for Tx/Rx applications

- Broadband patch derived from Thuraya design
- Possibly applicable to Tx/Rx terminals
- Dual circular polarisation simultaneous or switchable



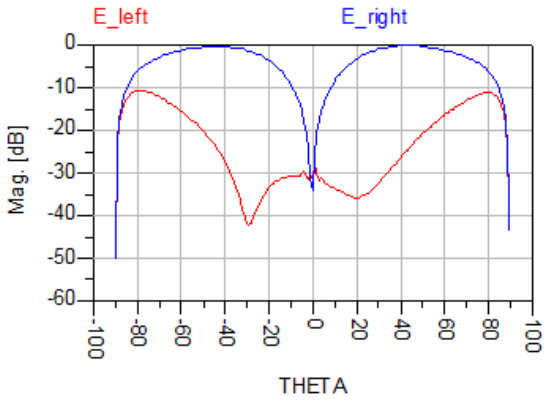


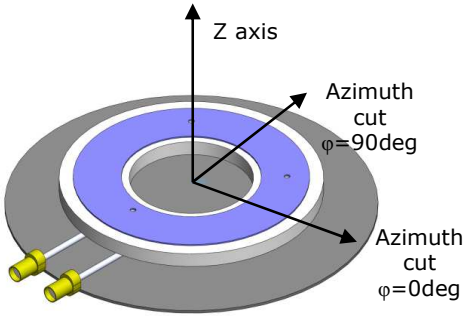


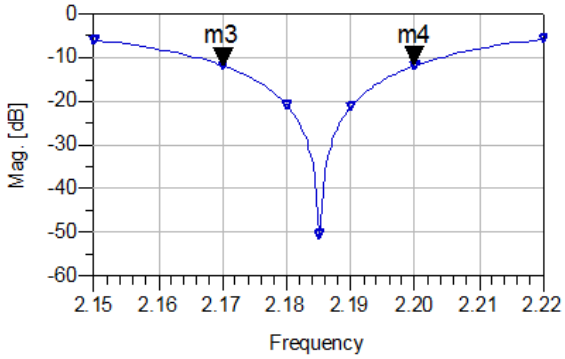


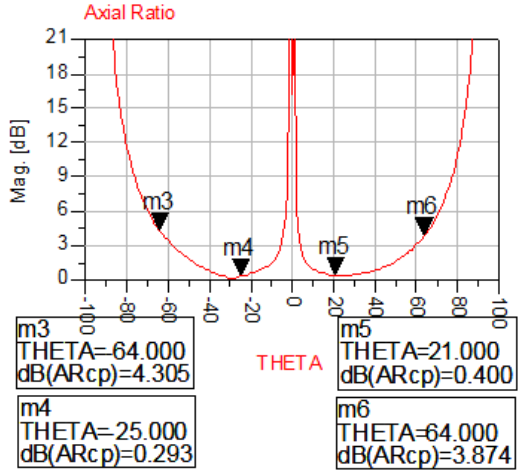
STREAM – Single band Conical beam antenna for DVB-SH

- Annular patch derived from our L-band satellite radio antenna
- Better coverage of low-elevation
- Limited to one band (require 2 elements for Rx and Tx)
- Dual circular polarisation simultaneous or switchable
- The available space in the center can be used to integrate another antenna



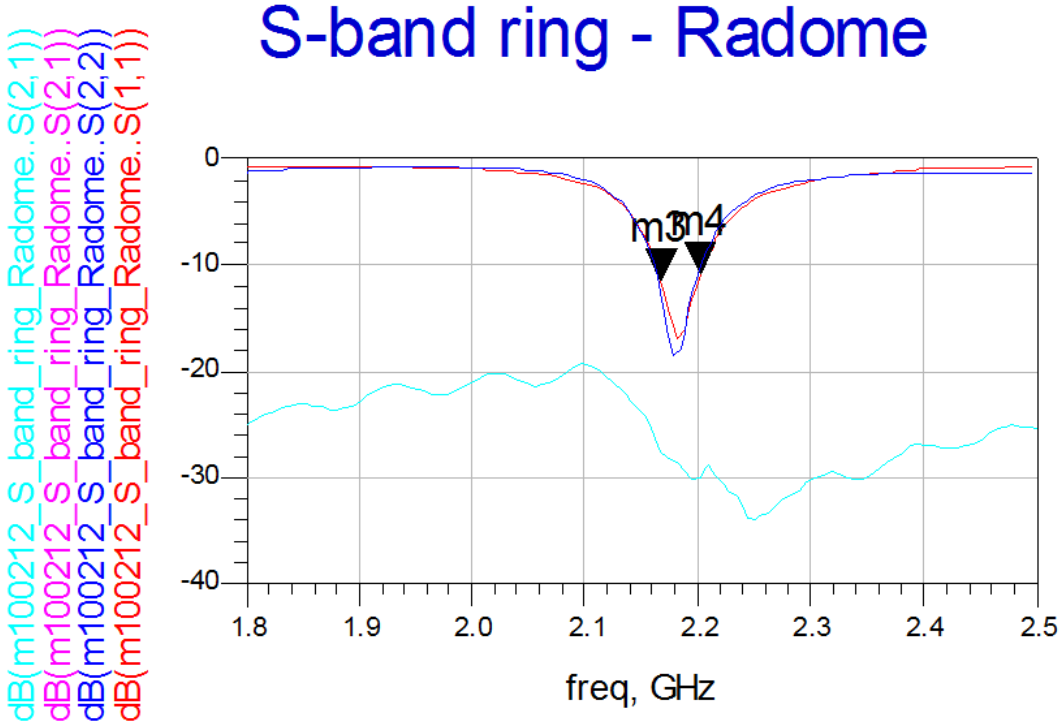






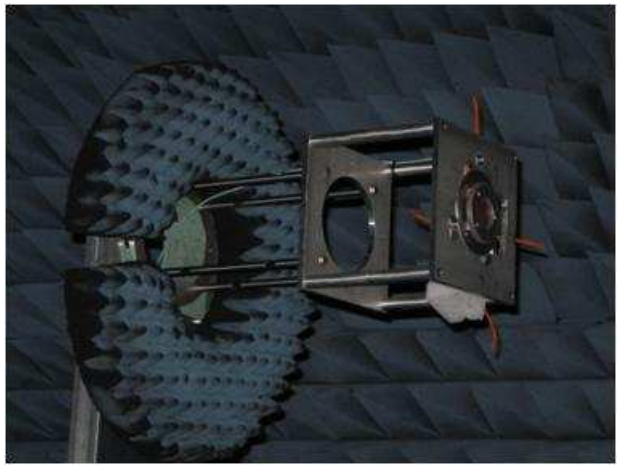
STREAM – Single band Conical beam antenna for DVB-SH

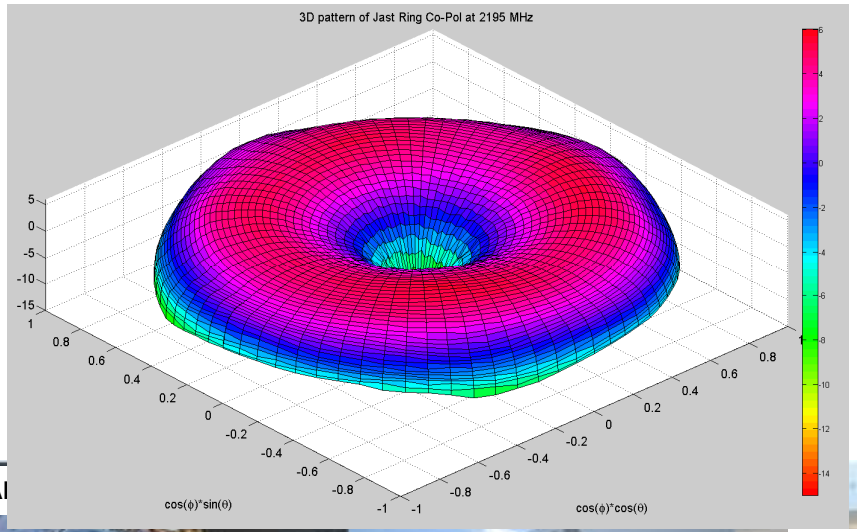
- Size: 80 x 10 mm

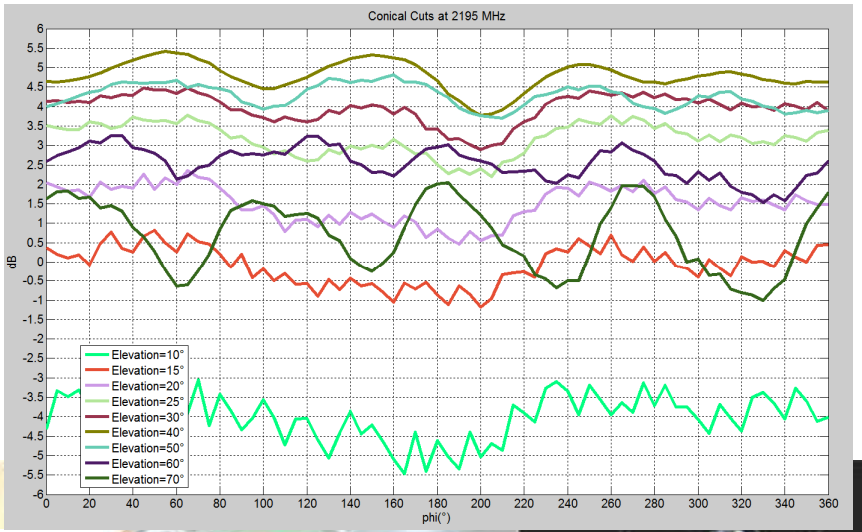


STREAM – Single band Conical beam antenna for DVB-SH

- Radiation pattern measurements:
  - Max Gain: 4.5 dBic
  - Gain @ 25° elev > 2.5 dBic
  - X-pol level < -15 dB (25° < elev < 70°)



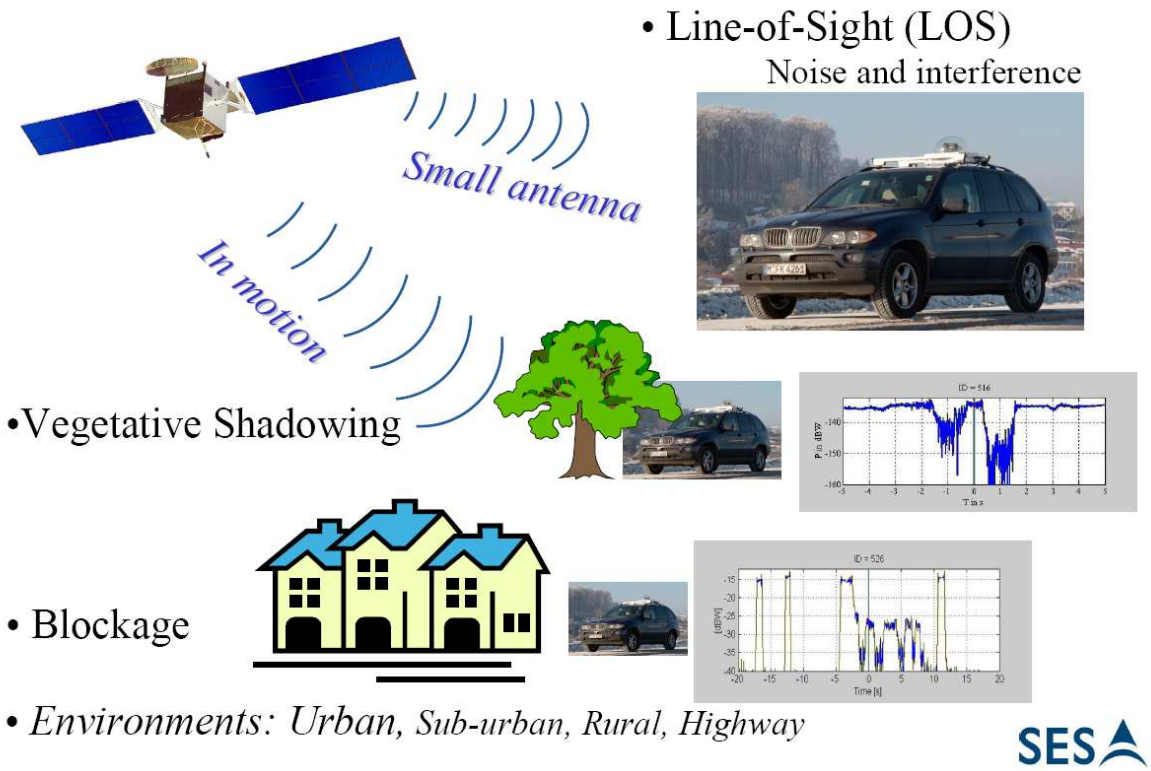




Ku-band terminal

Ku-band Mobile broadcasting

- Robust waveform and coding to reduce blockage effects
- Large capacity available at low-cost
- Simple user terminals with small antennas
- Possible use also outside Europe

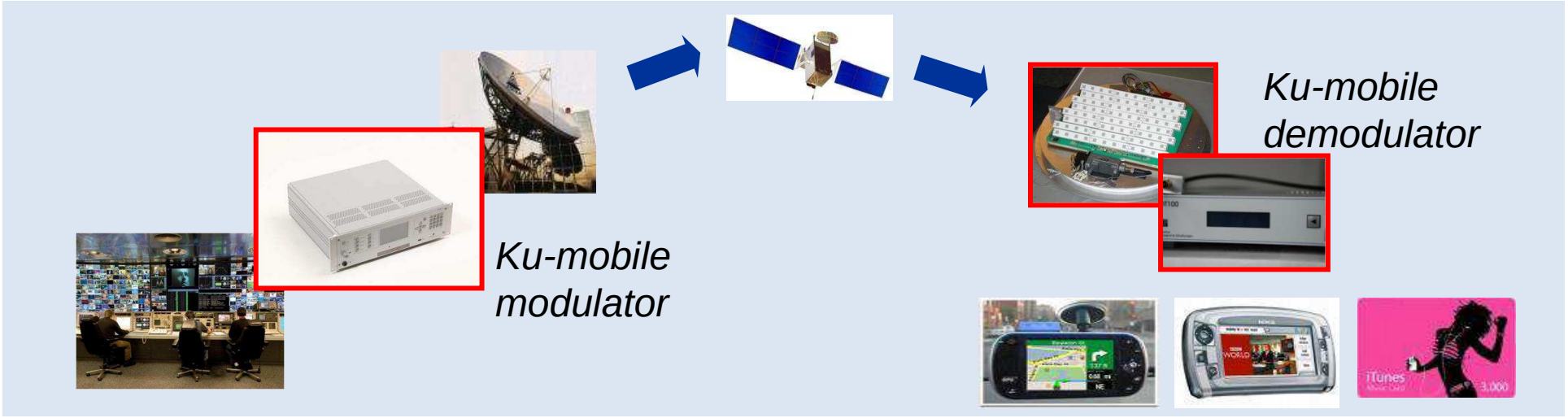


Courtesy of:

Fraunhofer Institut Integrierte Schaltungen

Ku-mobile System Overview

- New waveform with Forward Error Correction allowing:
  - Mobile reception in variable environment
  - Use of small low directivity antenna
  - Signal blockages management



- **STATUS**
  - Modulator and demodulator available
  - Reception possible with small antennas
  - System tested with small hybrid array antenna

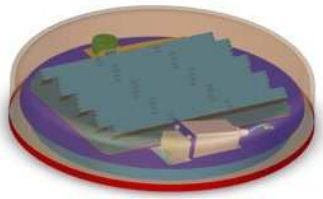
- **APPLICATIONS**
  - Download of large files (e.g. map updates)
  - Video and Audio streaming
  - Push to Store Applications
  - Information services

Ku-band solutions under development

Small hybrid steering Antenna

Hybrid array

Mechanically steered in azimuth and electronically scanned in elevation and polarization.

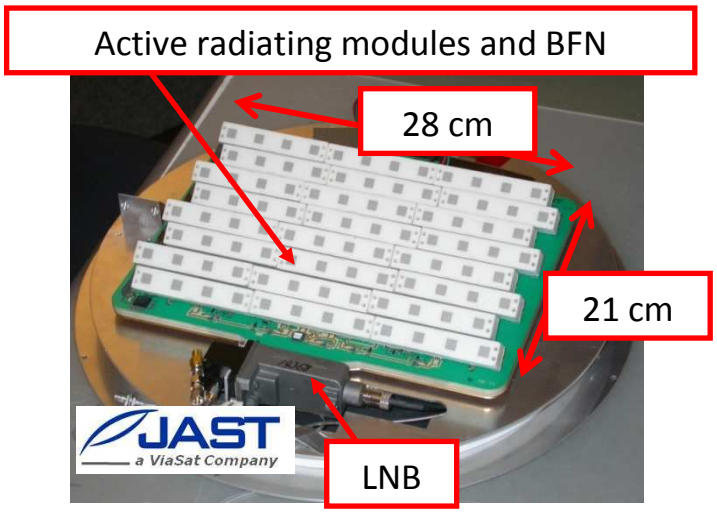


Down Link

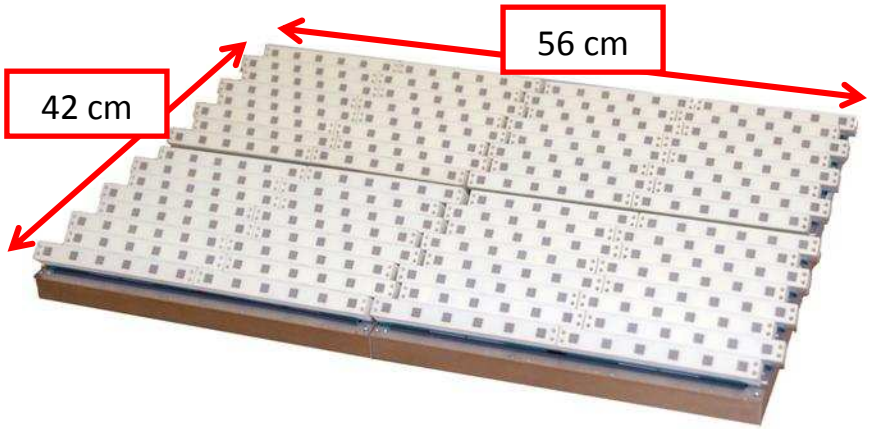
Small Electronic steering Antenna

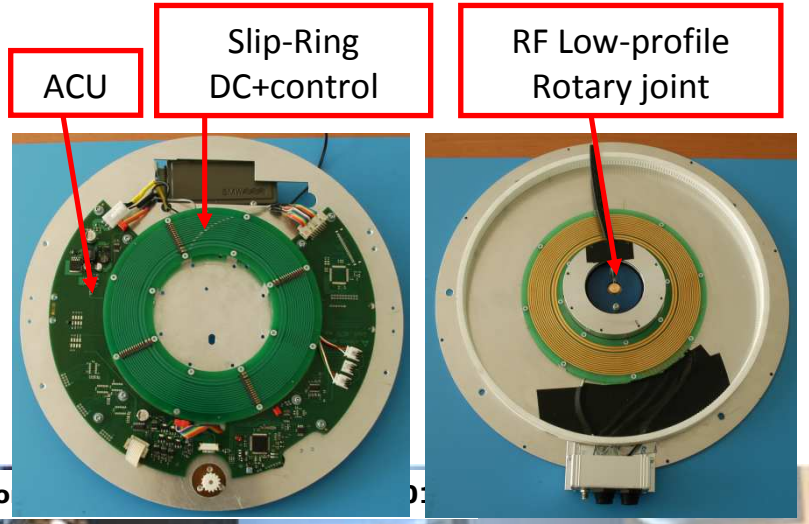
HiSat-KuRx prototypes

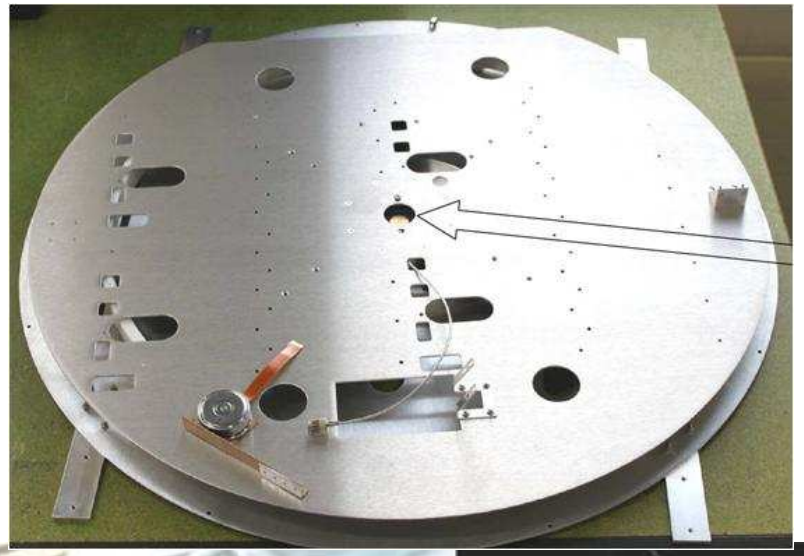
1 Module



4 Modules (2x2)







Ku-Mobile system OTA test with HiSat-3000RX Hybrid-Array Rx Antenna

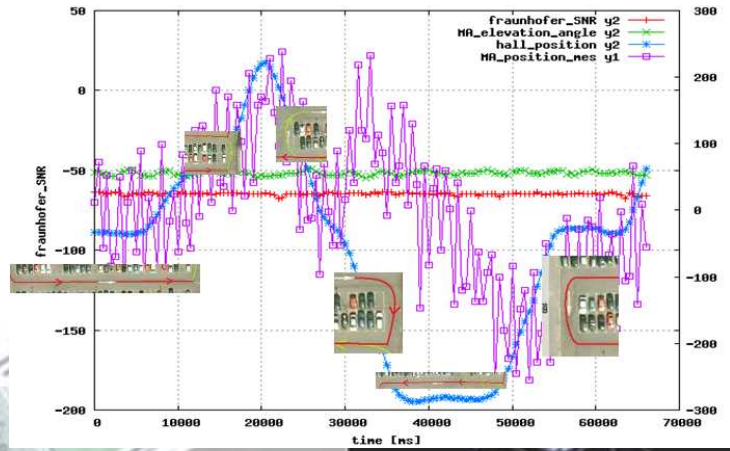
- Over The Air testing of the antenna with Fraunhofer Ku-Mobile demodulator

- Test Setup
  - Satellite: SES-Astra 28.3E
  - Sat EIRP: 50 dBw
  - External Temp: 0-5℃
  - Meteo Condition: Cloudy with some snow

- Antenna elevation beam setting:
  - ~30 deg

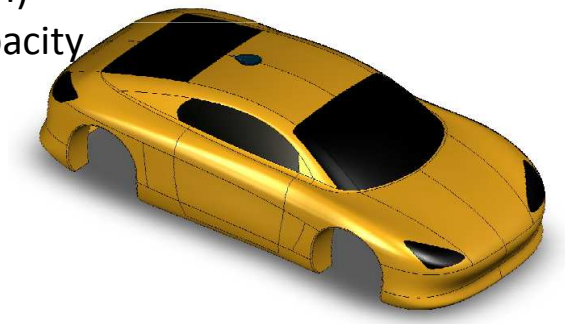
- Measured received Bitrates (forward link):
  - Raw: 8.00 Mb/s
  - Pipe 5: 4.00 Mb/s (Factor 1/2)
  - Pipe 4: 2.66 Mb/s (Factor 1/3)
  - Pipe 3: 2.00 Mb/s (Factor 1/4)
  - Pipe 2: 1.00 Mb/s (Factor 1/8)
  - Pipe 1: 660 Kb/s (Factor 1/12)

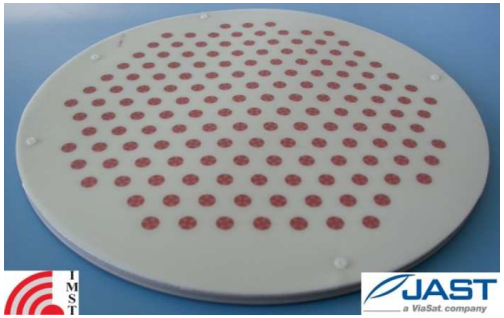
Antenna on vehicle



Natalia - Phased array antenna terminal for Ku-Mobile

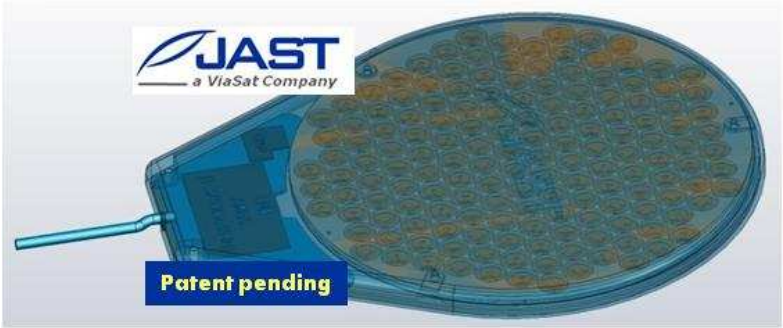
- Small low-cost satellite terminal for automotive market
- Converged mobile TV + data casting services (maps, weather, traffic, POI)
- Low exploitation costs (€/bit) thanks to large available broadcasting capacity
- System Based on Ku-Mobile terminal and waveform Antenna
  - Fully active phased array
  - < 20 cm diameter
  - < 1.7 cm thick
  - Full scan capabilities
    - 360° Azimuth
    - 20°to 90° in elevation
  - Full polarization tracking capabilities
    - Over 360°
  - Customized MMIC design
  - Monolithic structure
  - Suitable for mass production in automotive market

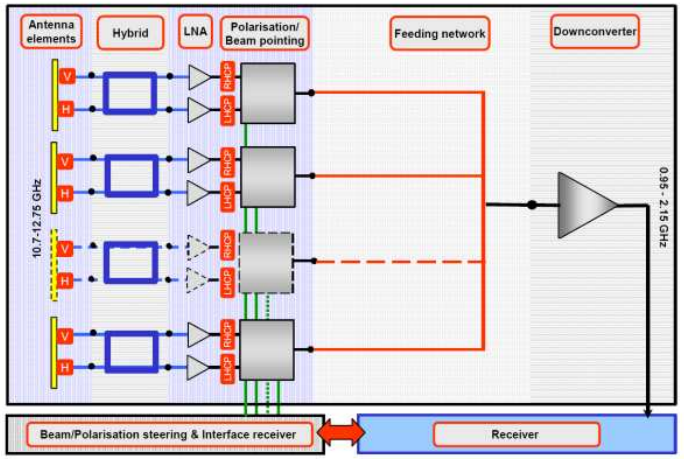




Natalia - Antenna core components

- **Single monolithic multilayer board realised in a single press (low-cost)**
- **Element+Corechip design allowing arbitrary element rotations**
  - Increase polarisation purity
  - Improve beam forming
- **Exagonal "tiles" can be assembled to build larger antennas**
- **First sub-array under assembling**





NATALIA- Ku-band Rx Low-cost Phased array Antenna Specifications

Ku-Phased Array Antenna	
RF Specifications	
Frequency band	Rx band: 10.70 – 12.75
Polarization	Linear
Polarization tracking	YES
Cross polarization discrimination	> 15 dB
Scanning range	Elevation: 20 - 90 degrees (from horizon) Azimuth: 0 – 360 degrees
3dB beamwidth	< 14 degrees in azimuth < 20 degrees in elevation
Off-axis lobes level	< -13 dB
Gain	> 20 dBi min @ 20° elevation
G/T	Peak -1.5 dB/°K @ 90° elevation Minimum -6.0 dB/°K @ 20° elevation
Thickness	< 70 mm
Weight	< 300 g
Size	< Ø200 mm
Price (estimated)	< 1000 Euro

Conclusions

- SISTER has contributed to the development of several antennas for the integration of SatCom to automotive systems
- The developments have covered antennas for several bands from L, S to Ku
- Multi-band antennas is an important feature for automotive market because allows to reduce the number of objects to integrate and the cost
- The advent of High Throughput satellites at Ka-band can allow the development of very small antennas and open new possibilities for the delivery of broadband communications to cars