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Advances in Vehicular Antenna Solutions for Mobile Satellite Communication Systems

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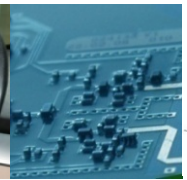
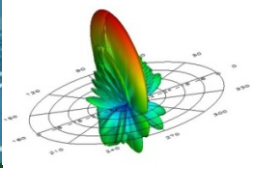

Presentation OUTLINE

- **Review of requirements**
- **Current solutions available and under development**
  - L/S-band
  - Ku-band
- **Conclusions**

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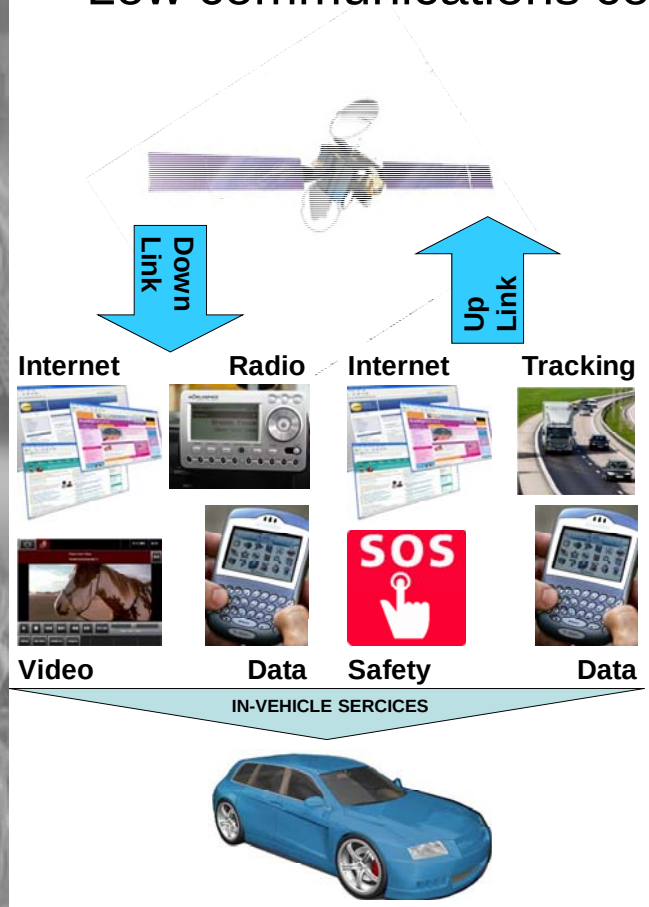
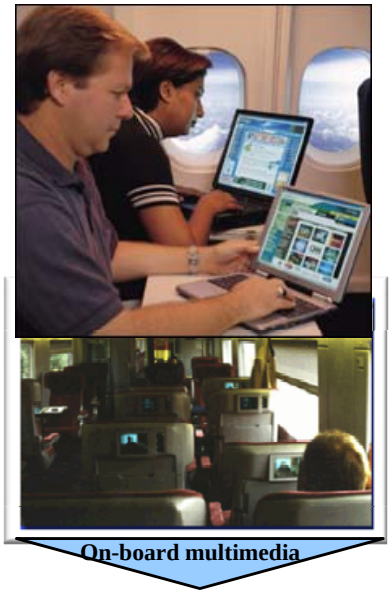
Market requests powerful Mobile Satellite Communication Systems

- Broadcast large amount of data for information and entertainment
- Effective broadband communication systems when terrestrial networks are unavailable or inadequate
- High capacity systems (Fwd & RC) to allow high number of users
- Low communications costs



IN-FLIGHT Communications



On-board multimedia

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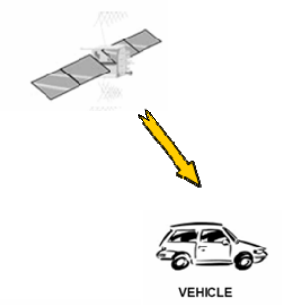
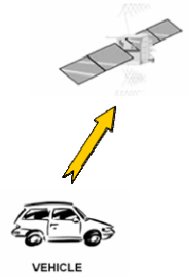
A wide set of System requirements

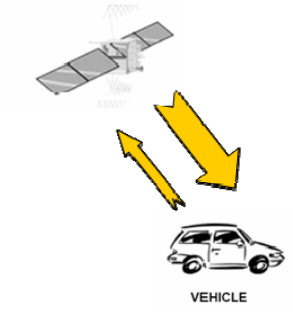
- **Unidirectional broadcast/multicast download to a vehicle**
  - ADAS (Advanced Driver Assistance System) applications
  - Speed Limits
  - Traffic Management and Control (TMC)
  - Digital Map Updates
  - Location Based Services (LBS)



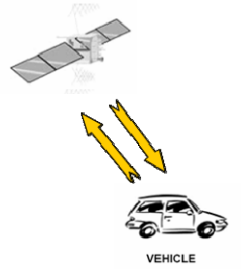
- **Unidirectional upload from a vehicle**
  - Map deviation
  - Digital Tachograph - static data
  - Pay per Use insurance
  - Vehicle Data
  - Road User Charging (RUC)



- **Bidirectional Fat – (asymmetrical: broadband download to the vehicle and a thin return channel)**
  - e-Call: RESCUE architecture
  - Dynamic Personal Navigation
  - Remote Vehicle Diagnostics - Data exchange
  - Fleet & Hazardous Goods Management - data direction to vehicle & Routing



- **Bidirectional thin – interactive (symmetrical narrow band data flo**
  - Hazardous Goods Management - Driver warning
  - Dynamic Personal Navigation On-Board navigation with real time info
  - ADAS - cooperative adas
  - Pay per Use insurance - fat client system



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Systems specifications

- L-band Satellite digital radio broadcasting:
  - Freq: 1.467-1492 GHz
  - Pol: dual circular switchable
- L-band bi-directional low data rate (GEO - Thuraya or Inmarsat BGAN)
  - Freq: Rx 1.525-1.560 GHz; Tx 1.625-1.660 GHz
  - Pol: LHCP or RHCP
- Positioning/Navigation
  - Freq: Rx 1.575 GHz
  - Pol: RHCP
- L-band bi-directional low data rate (LEO - Iridium)
  - Freq: Tx/Rx 1.610-1.626 GHz
  - Pol: RHCP
- S-band bi-directional medium data rate (GEO - Solaris)
  - Freq: Rx 2.170-2.200 GHz; Tx 1.980-2.010 GHz
  - Pol: dual circular switchable
- Ku-band bi-directional high data rate (GEO)
  - Freq: Rx 10.70-12.75 GHz; Tx 14.0-14.5 GHz
  - Pol: dual linear switchable with polarization tracking

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  - L/S-band: European Satellite Digital Radio Antennas (E-SDR)
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Dual CP antennas forf European Satellite Digital Radio (E-SDR)

Switchable Dual Circularly polarised antenna

- European Satellite Digital Radio uses L-band spectrum and polarisation diversity to offer up to 50 broadcasting channels with a capacity up to 128 Kb/s per channel
- JAST offers the only antenna products for mobile reception of Digital Satellite Radio.
  - Products are available for car and boat markets

WorldSpace Mobile
Car Antenna

WSMAC-1

WorldSpace Mobile
Boat Antenna

WSMAB-1

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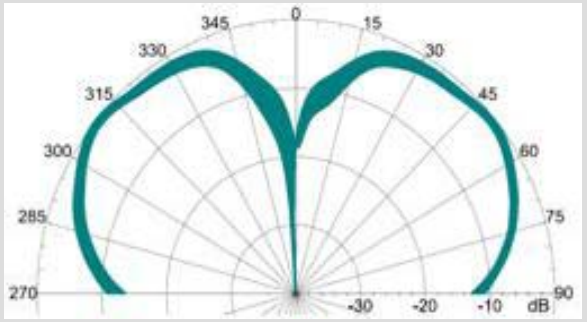
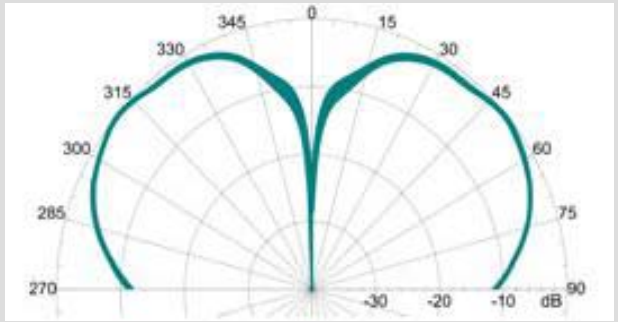
Dual-CP E-SDR antenna patterns and coverages

Antenna typical radiation patterns

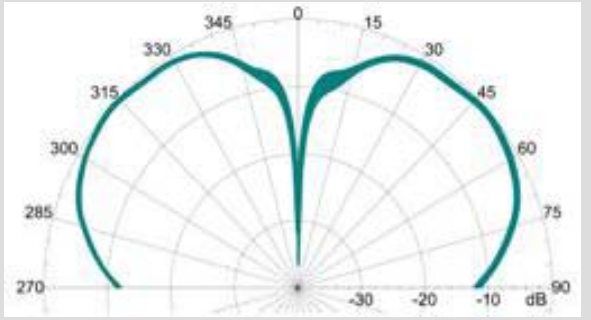
1462 MHz

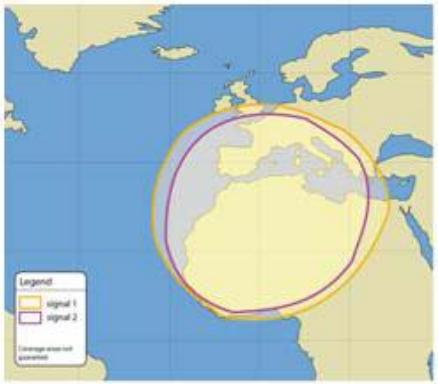


1472 MHz

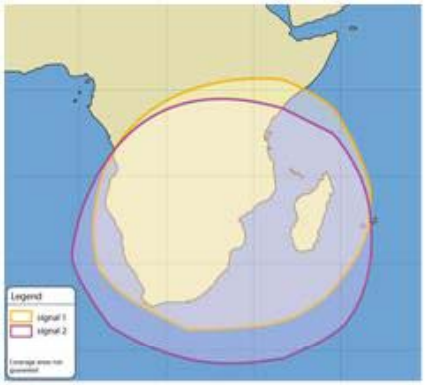


1492 MHz





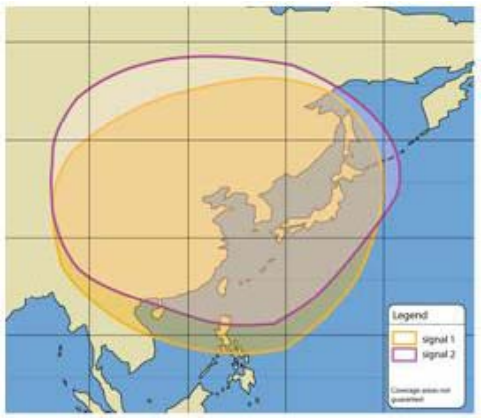
AfriStar North-West



AfriStar South

AfriStar North-East

AsiaStar North-East



AsiaStar North-West

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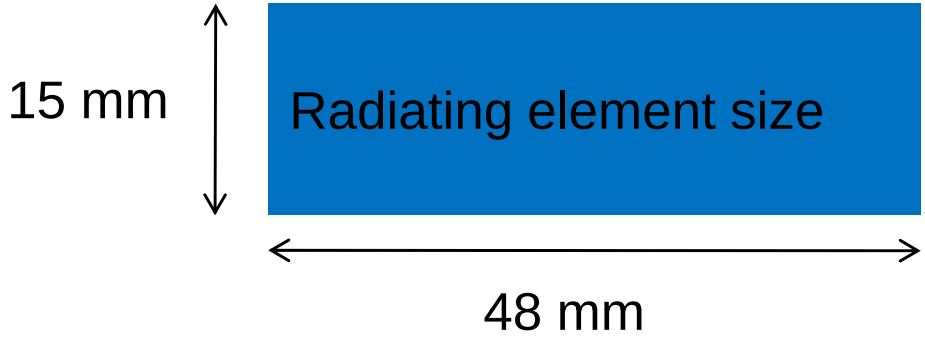
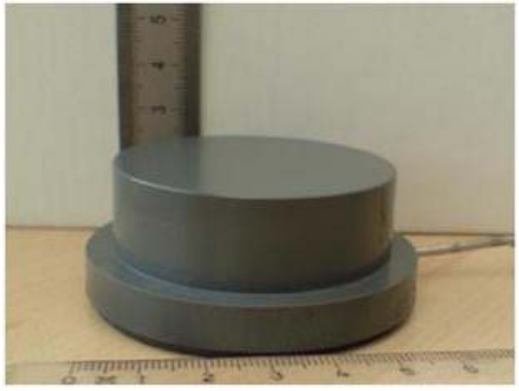
Linear polarized Antenna for E-SDR





Antenna on field trials

- Package size: Diameter = 52 mm, Height = 18 mm
- The diameter can be reduced of 5 to 10 mm with some additional design effort

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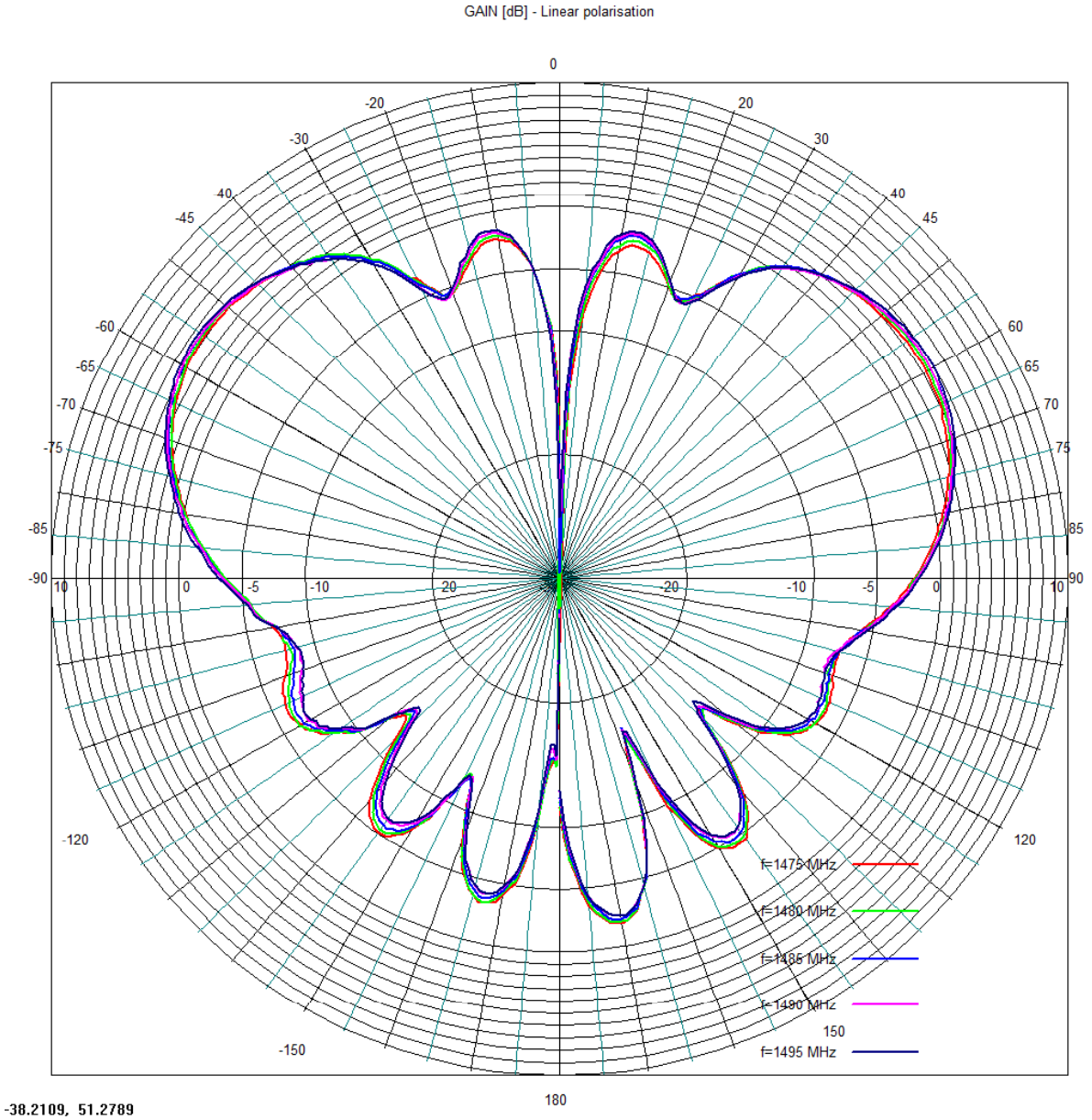
Lin-pol Thuraya Antenna - Radiation pattern and Gain

Gain pattern measured on a 70cm round ground plane



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E-SDR Antennas - field trials at FIAT Automobile

- Active antenna prototype for the European Satellite Digital Radio (E-SDR) field trials realised in Turin, Italy, in collaboration with Viatis, WorldSpace and Fiat.
- Size: footprint 6x4.5 cm height 3 cm (height can be reduced to less than 2 cm)

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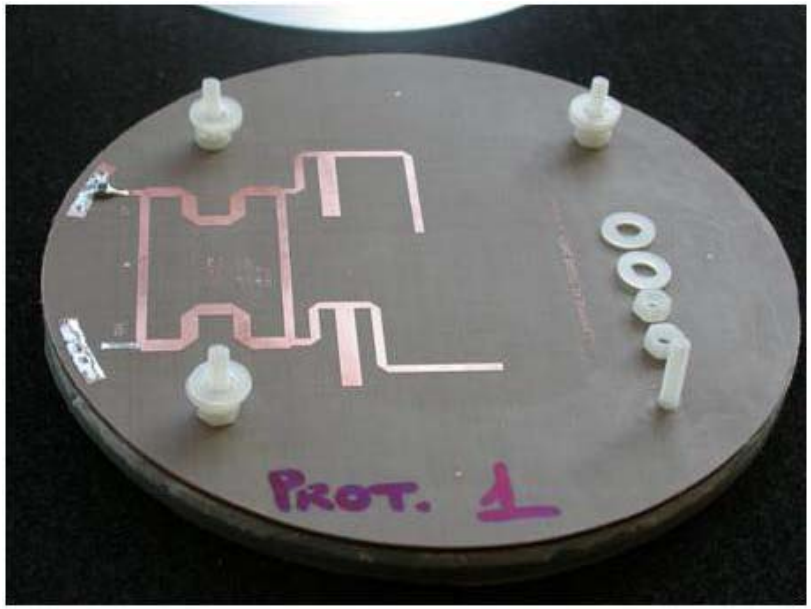
Dual CP Thuraya Antenna



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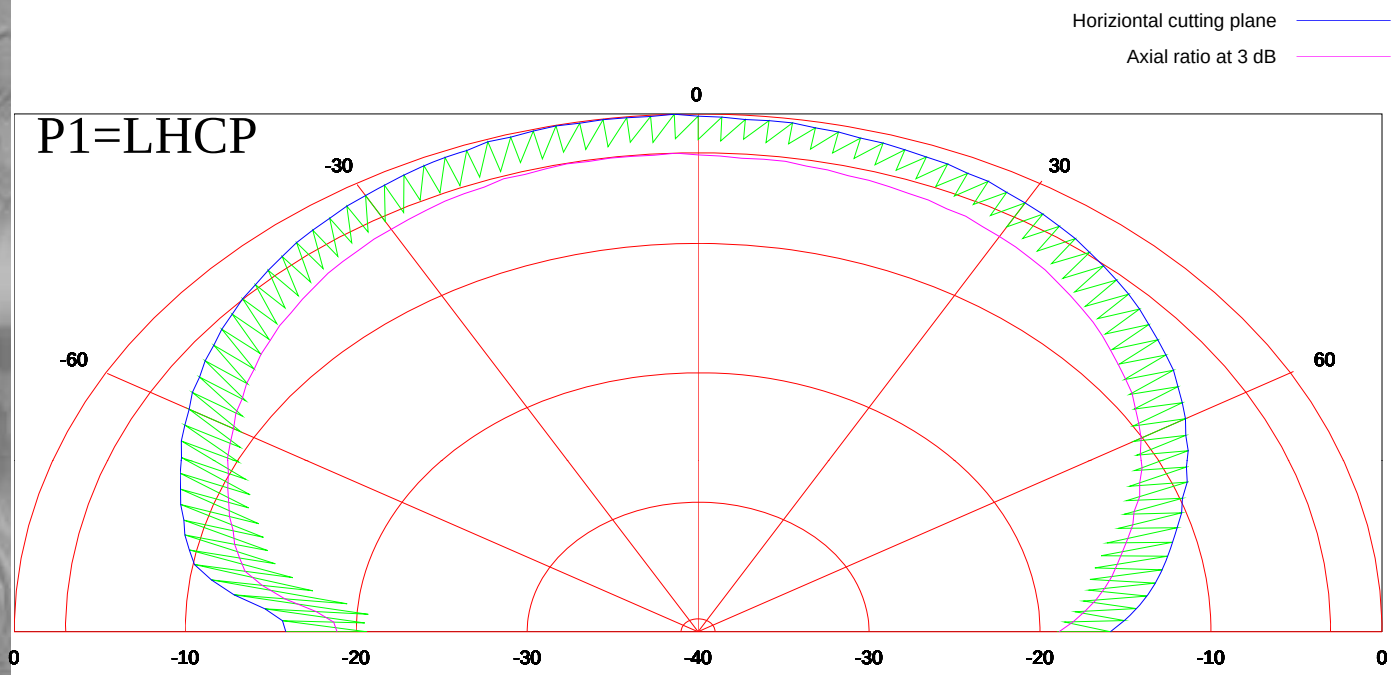
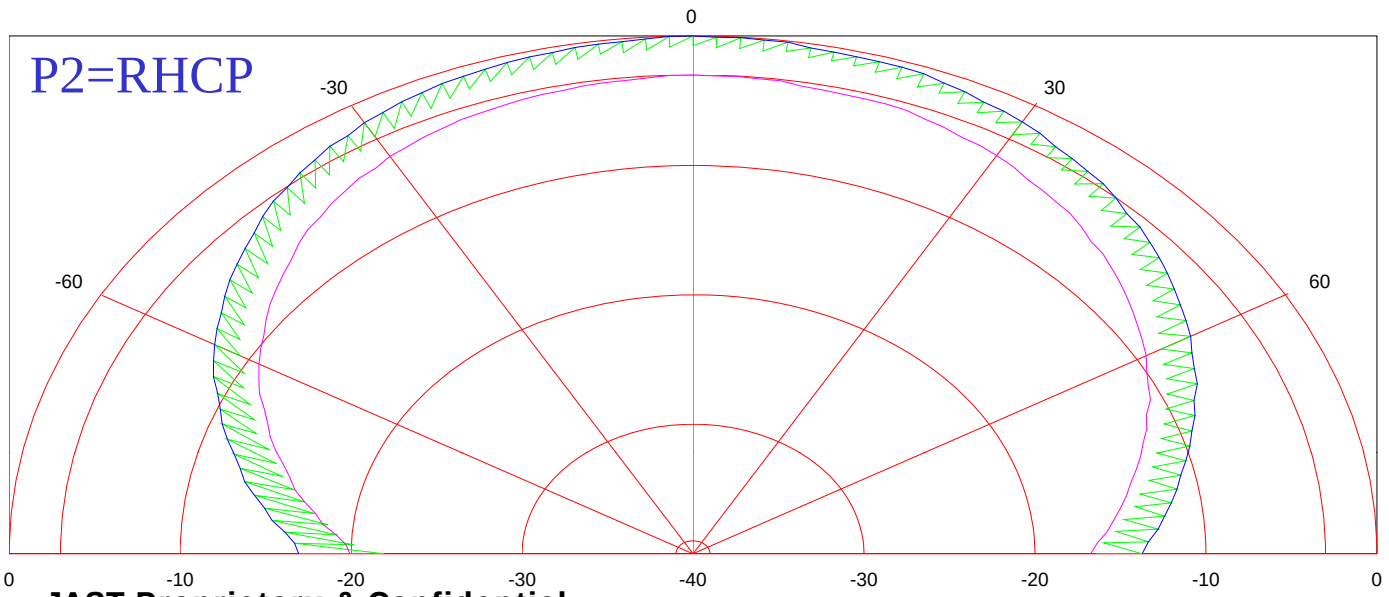
Thuraya-GPS Antenna – Radiation pattern



Thuraya = LHCP



GPS = RHCP

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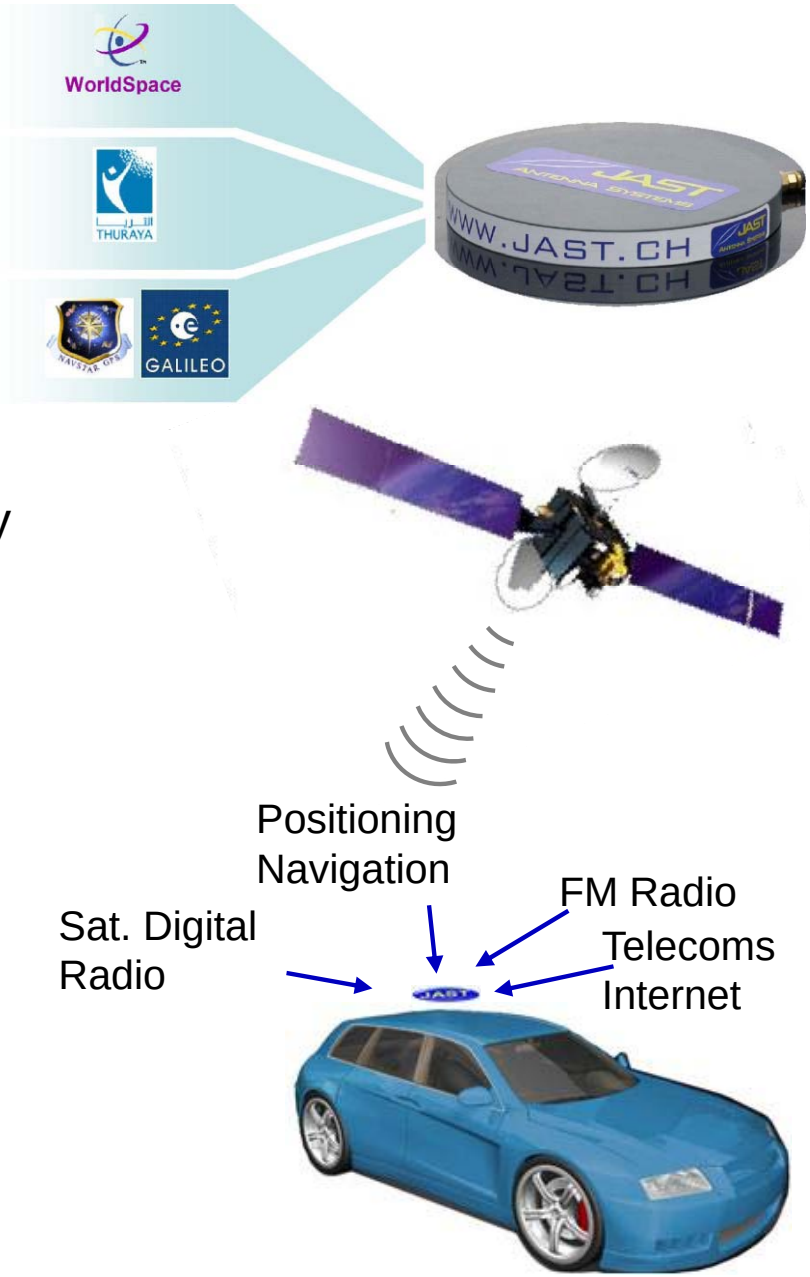
WGTI Multisystems antenna – WorldSpace, GPS, Thuraya, Iridium

- **Applications:**
  - S-DAB (Satell. Digital Audio Broadcasting, Rx)
  - Data Multicasting (Rx)
  - Positioning and Navigation
  - Voice+Data Communications/ Telemetry (Tx/Rx)
- **Market: automotive aftermarket and OEM.**
- **Systems: WorldSpace, GPS, Thuraya, Iridium (upgradeable with GSM/UMTS)**
- **Small size: diameter=15 cm; thickness=1.6 cm**
- **JAST Patented design**



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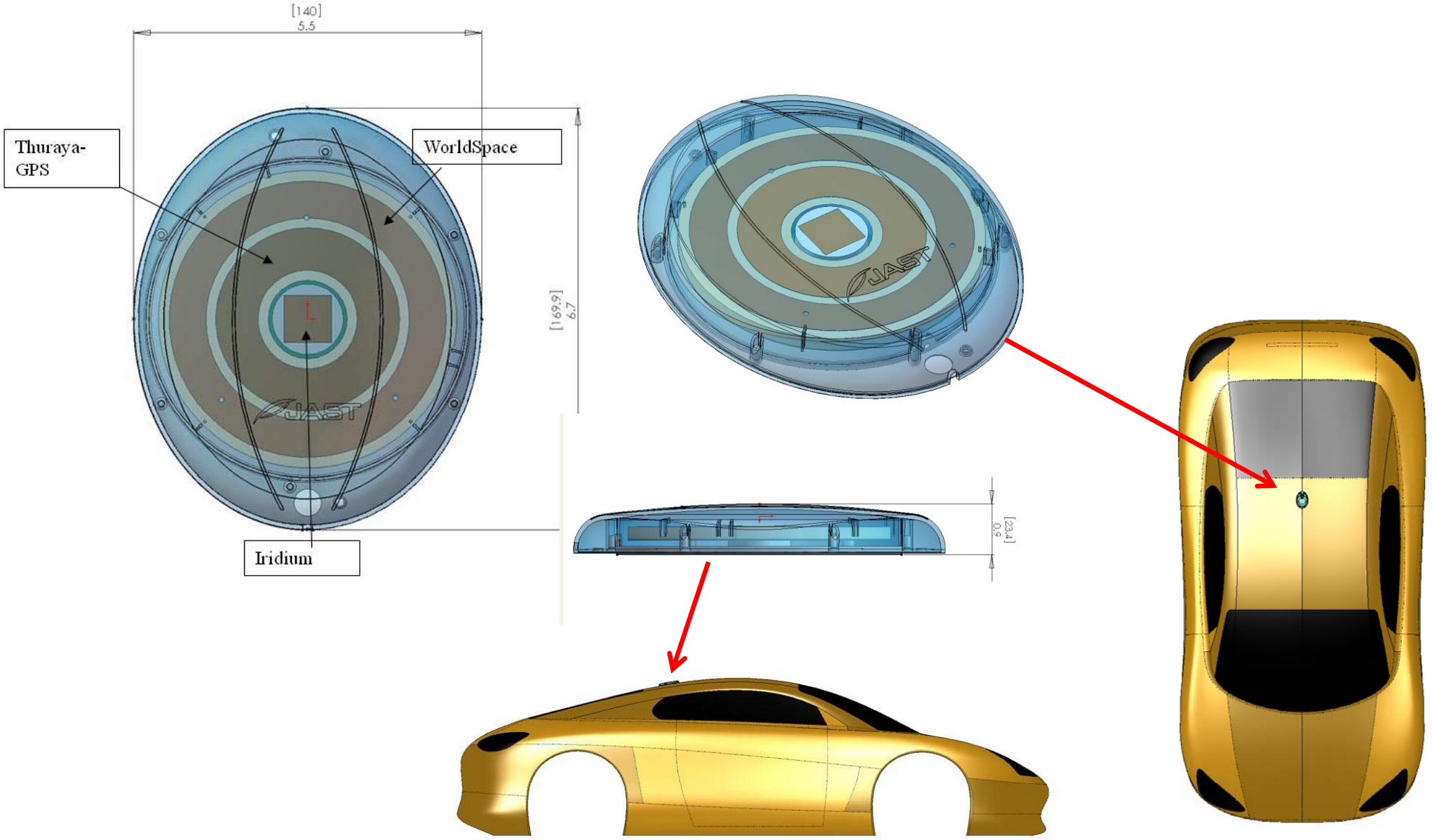
WGTI Multisystem antenna – WorldSpace, GPS, Thuraya, Iridium



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  - Ku-band: Hybrid steering Array Antenna
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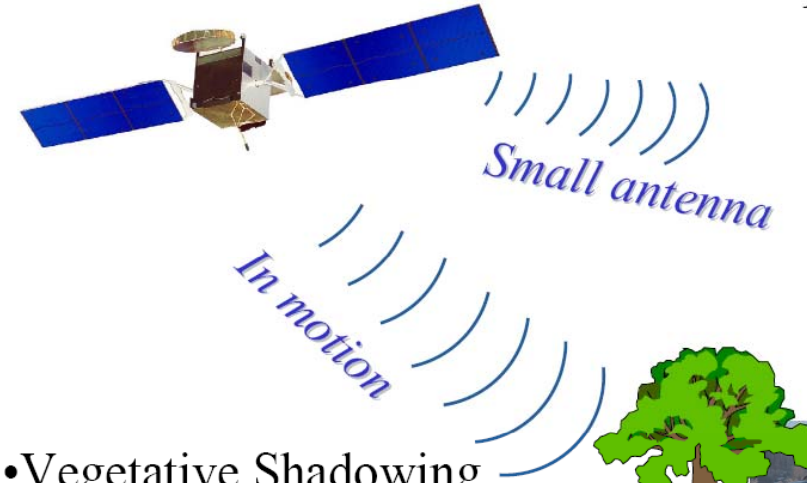
Ku-band Mobile broadcasting

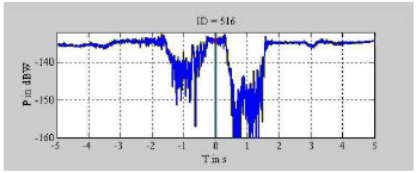
- Robust waveform and coding to reduce blockage effects
- Large capacity available at low-cost
- Simple user terminals with small antennas
- Possible use also outside Europe



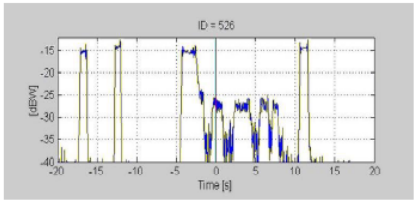
• Line-of-Sight (LOS)

Noise and interference

•Vegetative Shadowing



• Blockage



• *Environments: Urban, Sub-urban, Rural, Highway*

Fraunhofer IIS Institut Integrierte Schaltungen

SES GLOBAL

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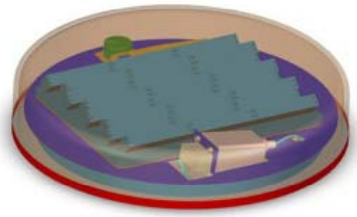
Ku-band solutions under development

Small hybrid steering Antenna

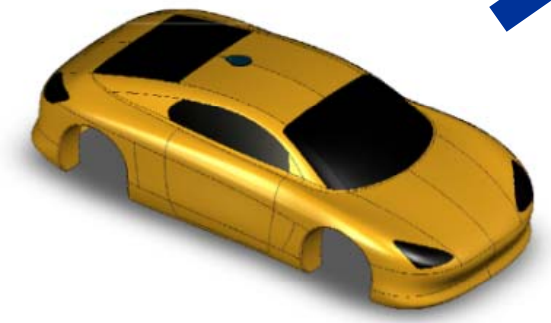
Hybrid array

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



Down Link

Small Electronic steering Antenna



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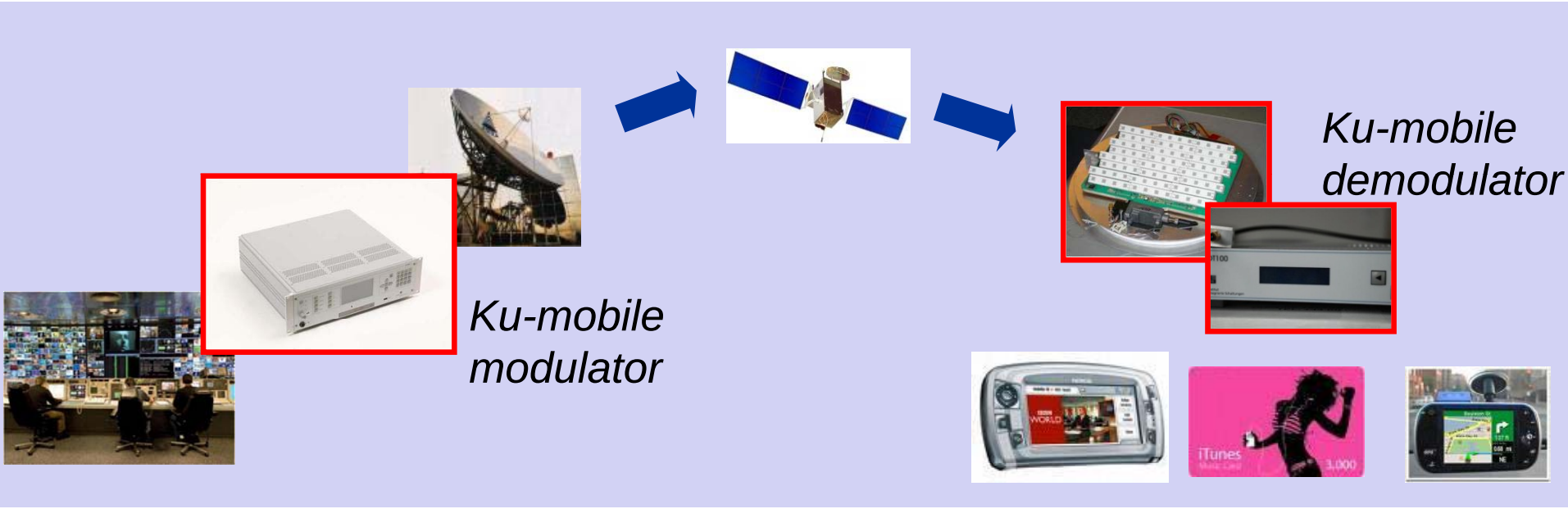
Fraunhofer Ku-mobile System Overview

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



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

- **APPLICATIONS**
  - Live Video and Audio streaming
  - Push to Store Applications (Podcasts, video-clips, …)
  - Information services
  - Support services to Navigation

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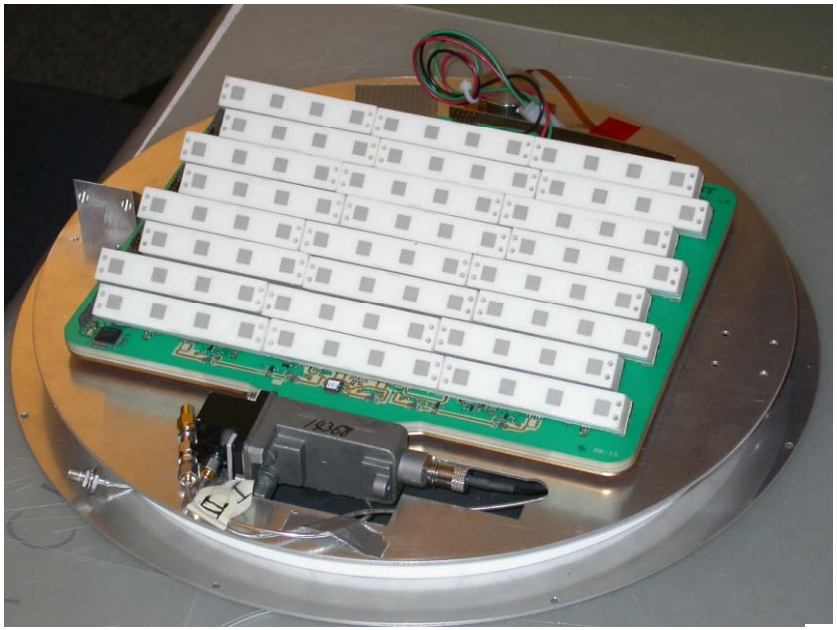
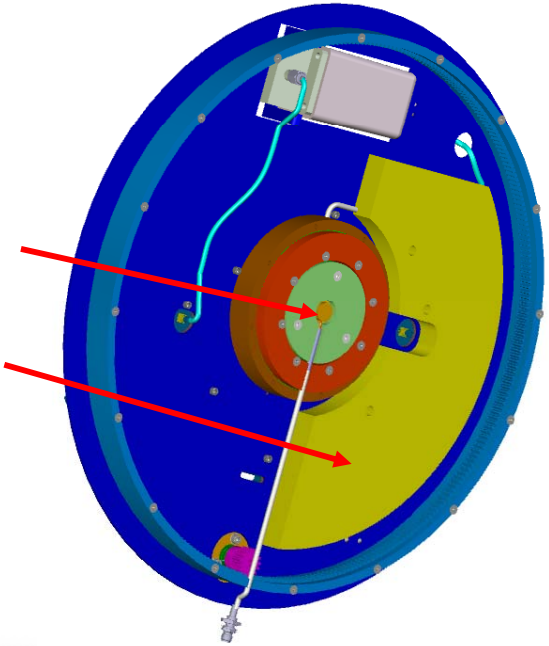
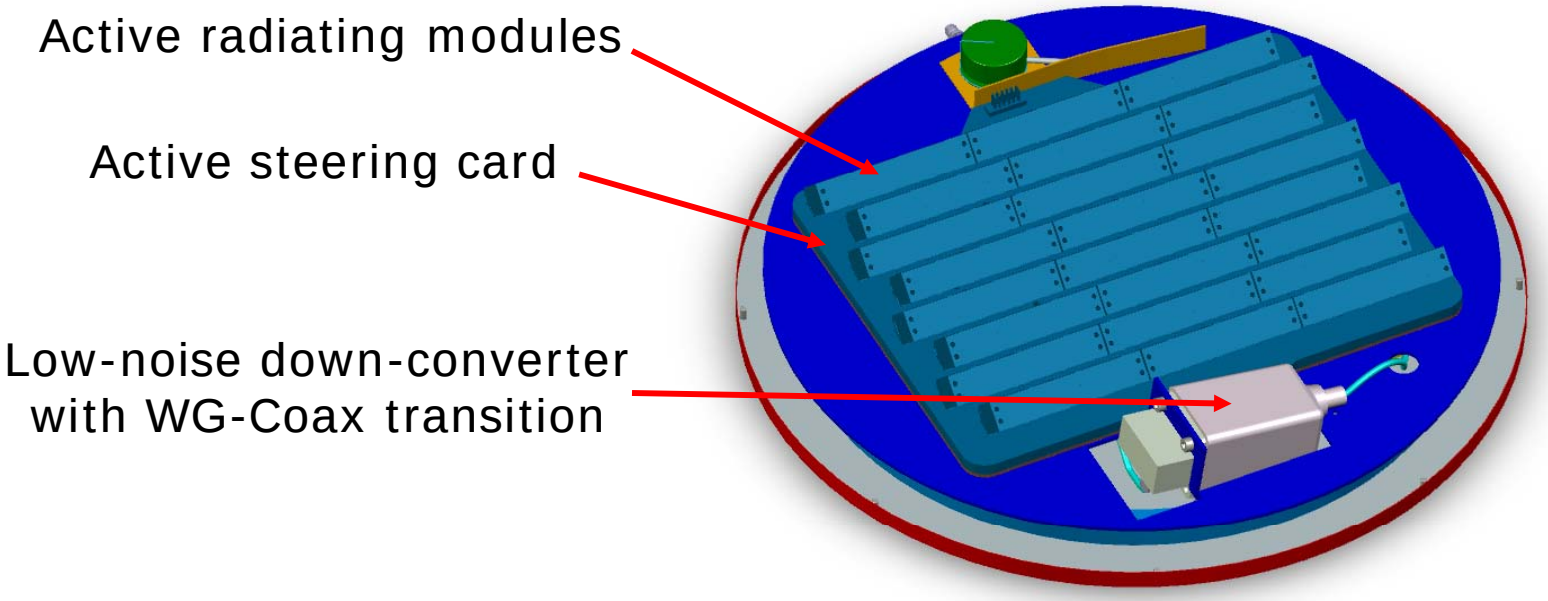
Ku-Hybrid Array Steering Mechanical Assembly







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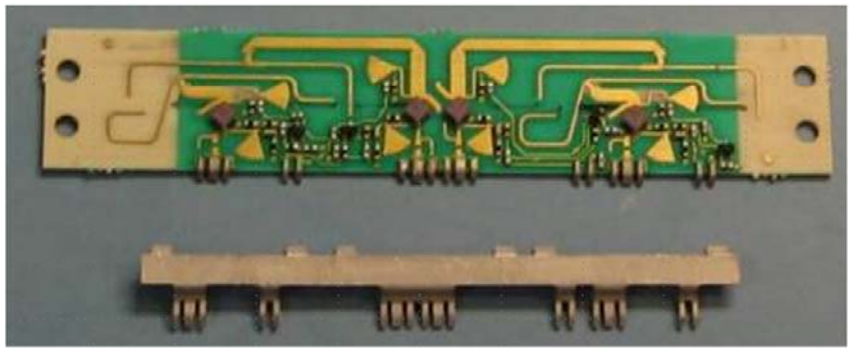
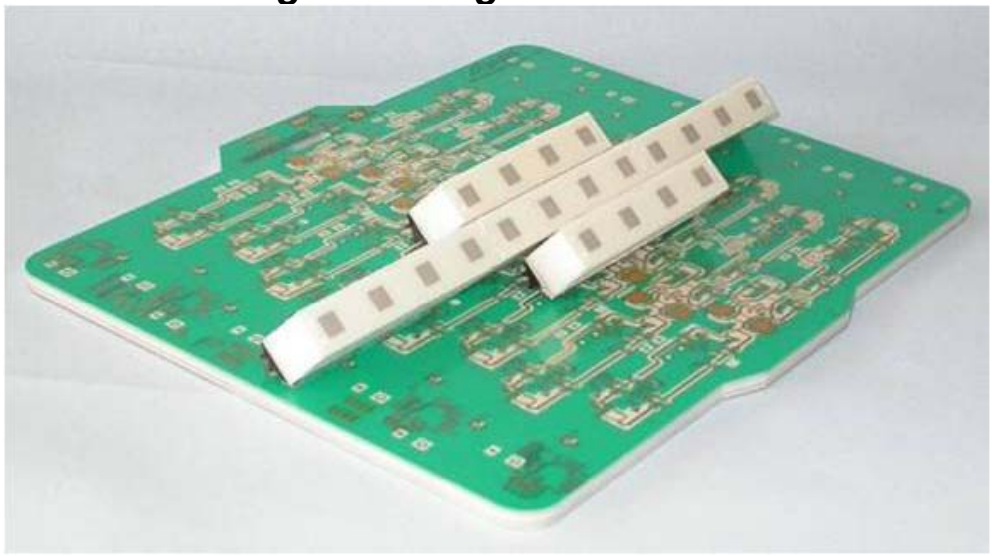
Ku-Hybrid Array - Detail of Antenna Parts



Active Radiating Cards & Lead-frame

Support & Inclined Radiating Cards

Mounting Radiating Modules on Rx Card



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Ku-Hybrid Array – Antenna results

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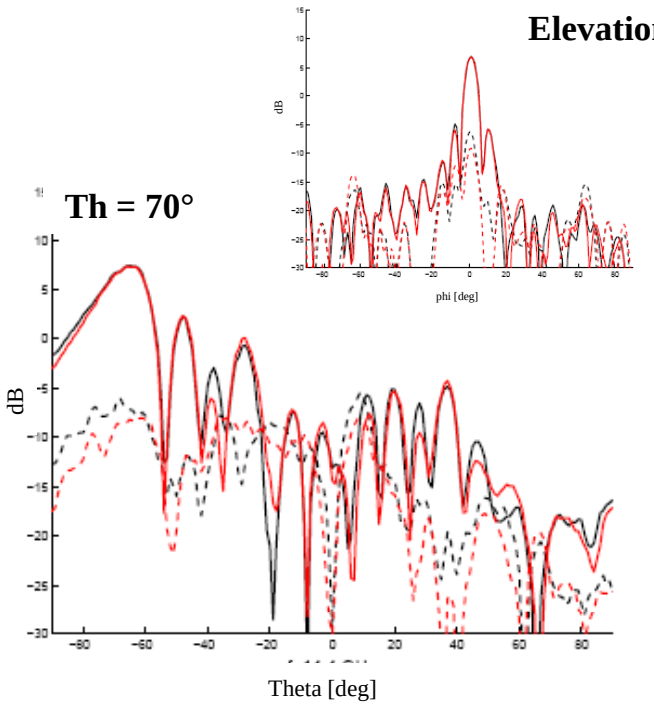
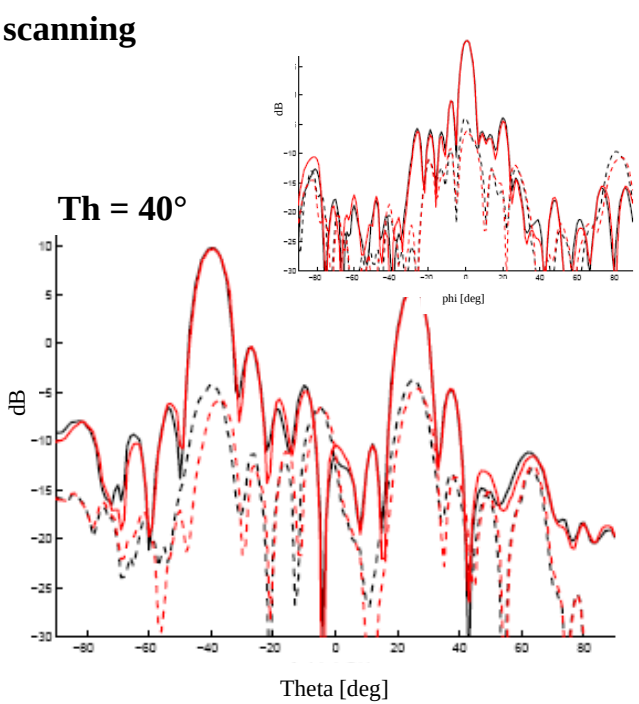
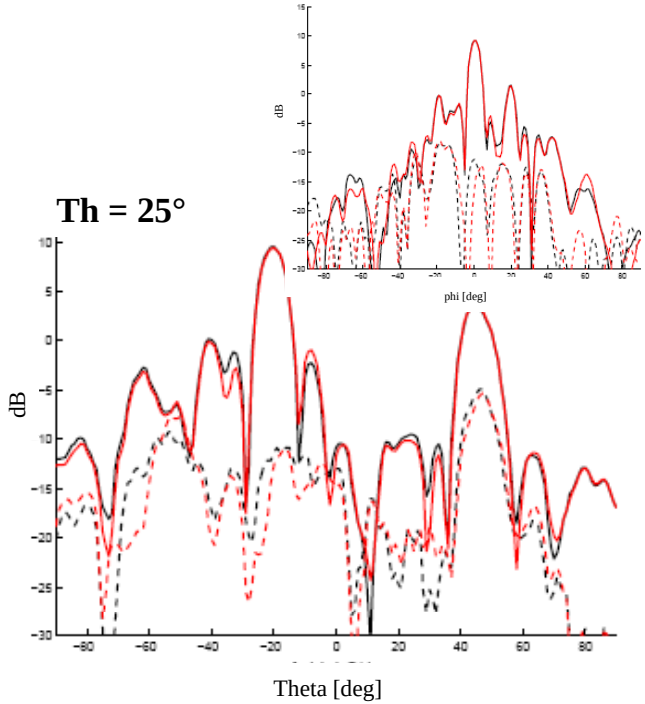
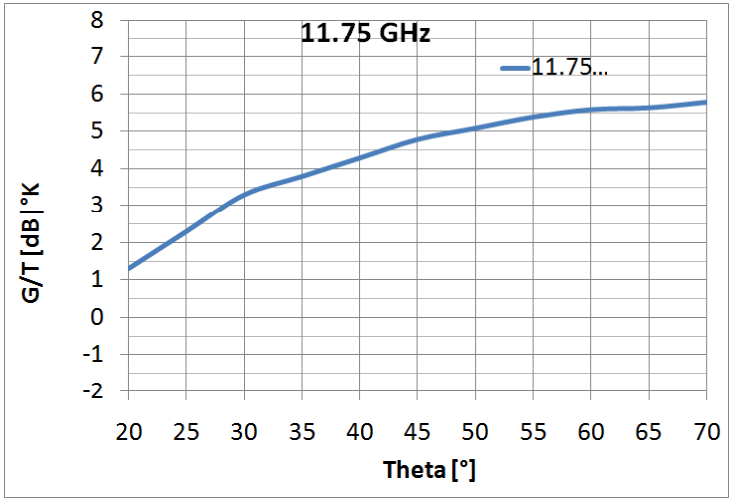
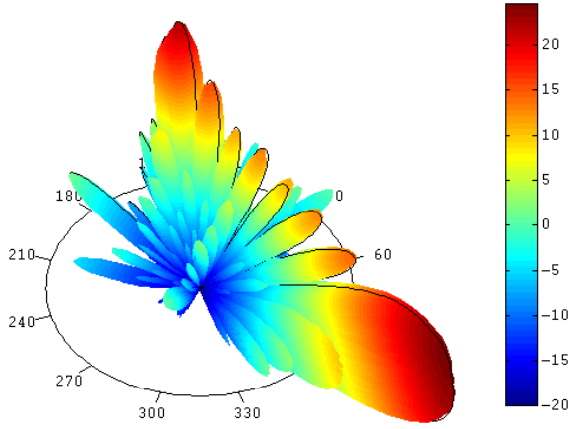
Elevation scanning











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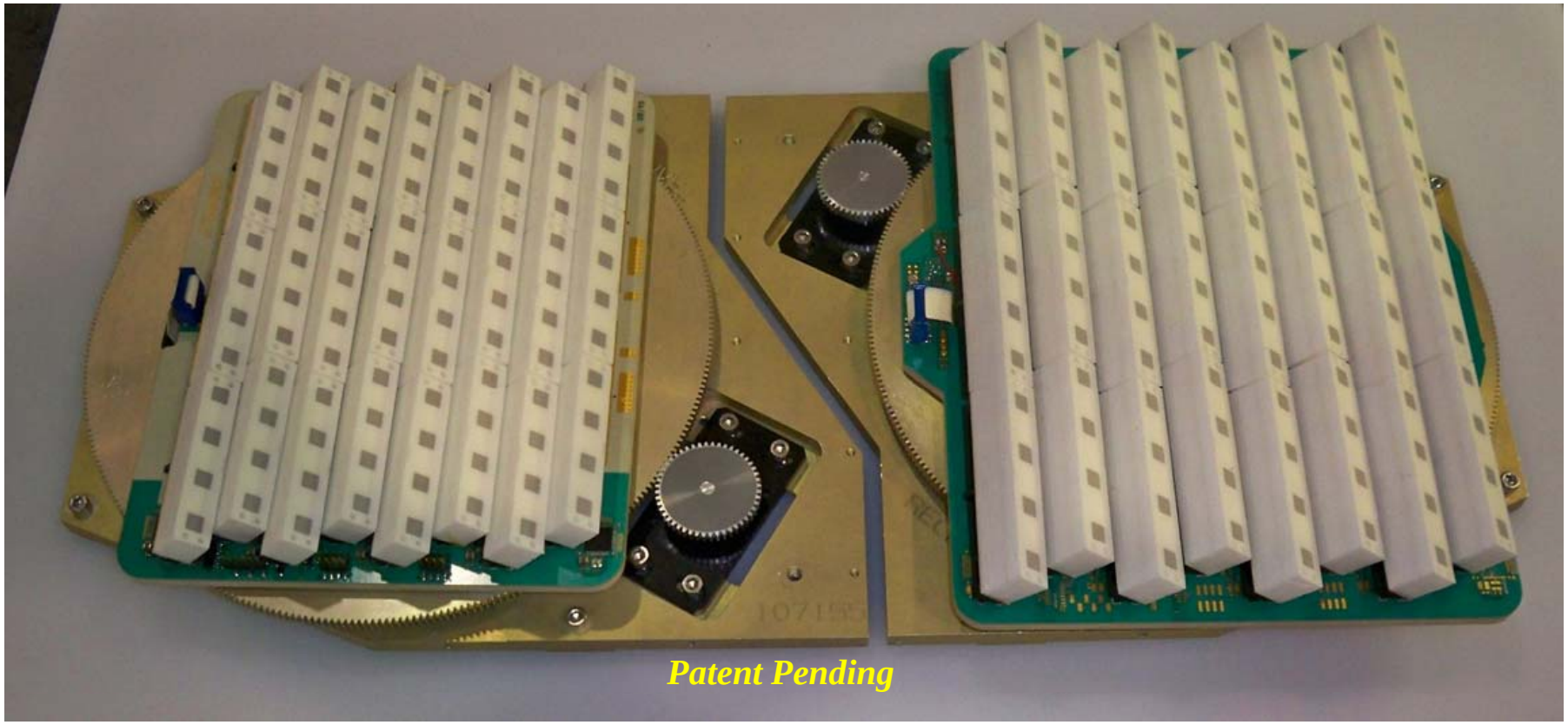
HiSat Ku-band Tx/Rx Antenna

- The vehicular Low-profile hybrid array antenna is currently extended to a dual aperture Transmit/Receive
- This solution will allow broadband communications to and from professional/fleet vehicles



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- **Conclusions**

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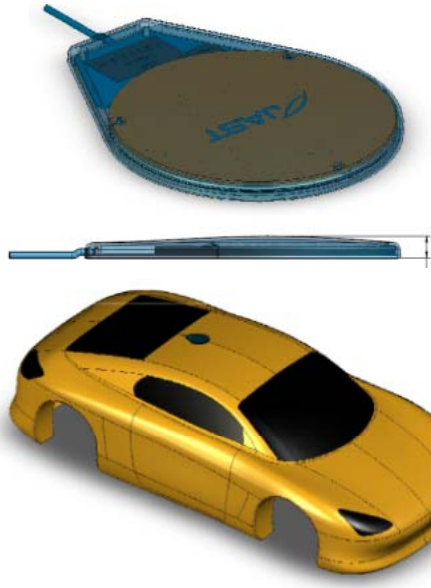
Natalia - Low-Cost Ku-Band terminal

- Small low-cost satellite terminal installed on cars
- Converged mobile TV + data casting services (maps, weather, traffic, POI)
- Low exploitation costs (€/bit) thanks to large available broadcasting capacity
- Personal Installation Kits & OEM directly integrated systems



- Development funded by esa
- Consortium:

IMST, JAST, SES GLOBAL, Lema Laboratoire d'Electromagnétisme et d'Acoustique, Fraunhofer IIS Institut Integrierte Schaltungen, BMW EUROSPACE

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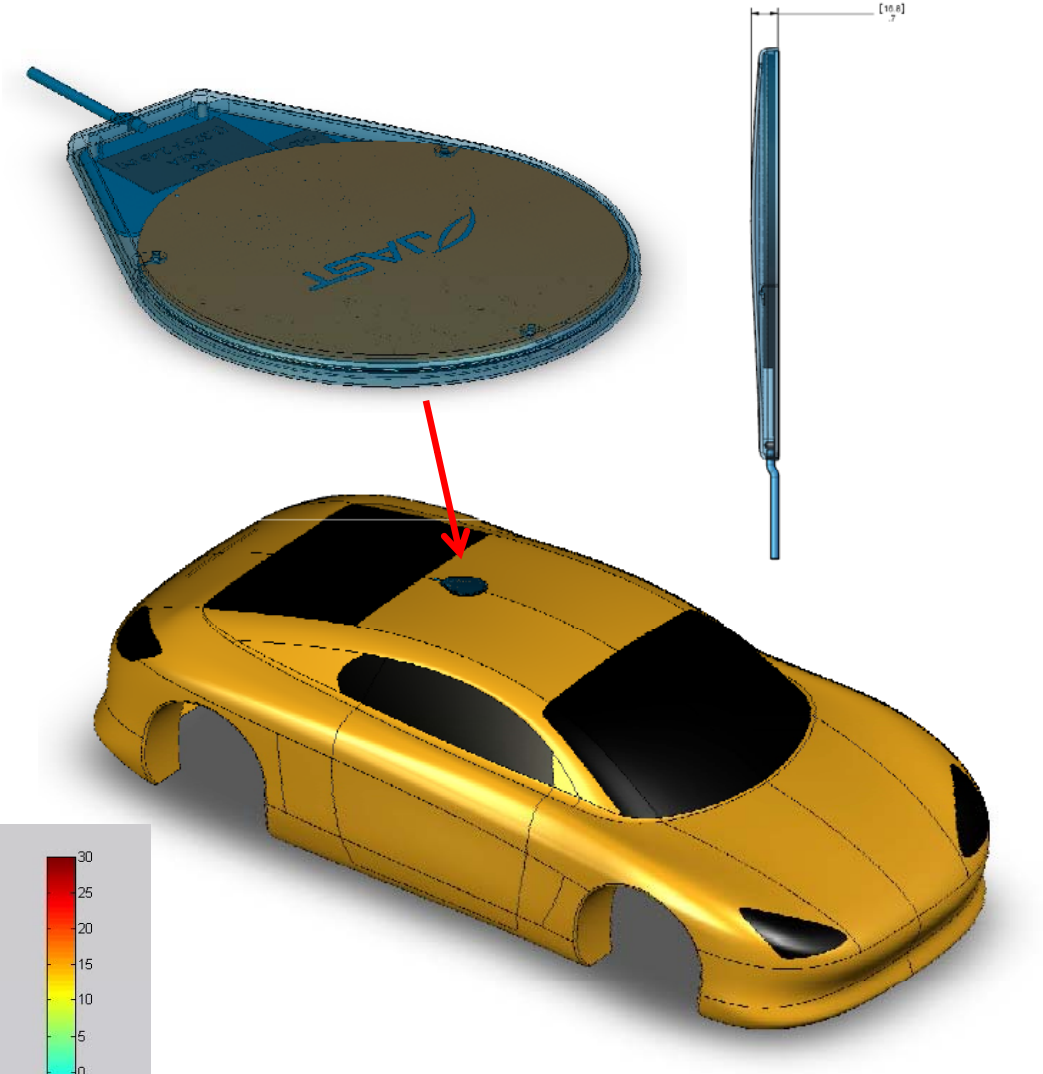
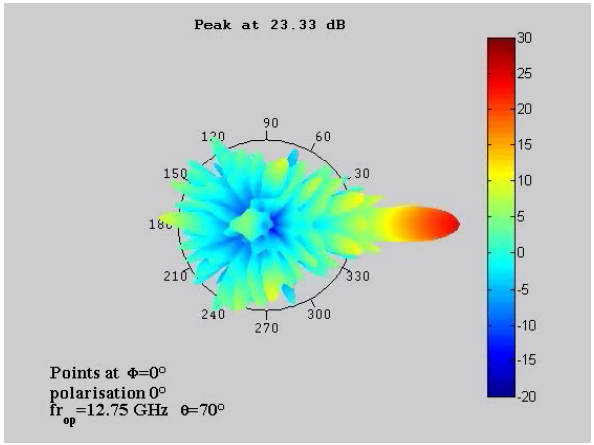
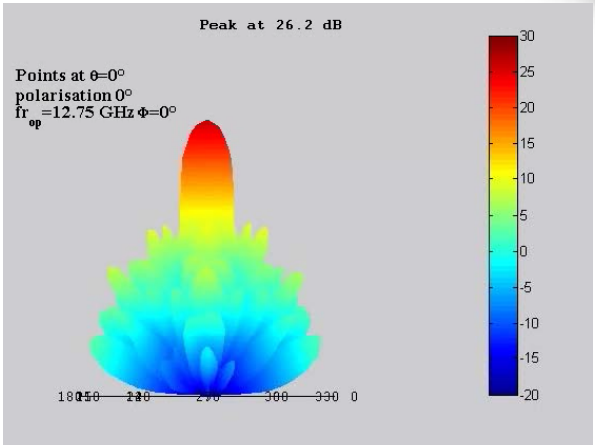
Fully active phase array for SES-GLOBAL Ku-Mobile

- Fully active phased array
- < 20 cm diameter
- < 17 mm thick
- Full scan capabilities
  - 360° Azimuth
  - 20°to 60° in elevation
- Full polarization tracking capabilities
  - Over 360°
- Customized MMIC design
- Monolithic structure
- Suitable for mass production in automotive market







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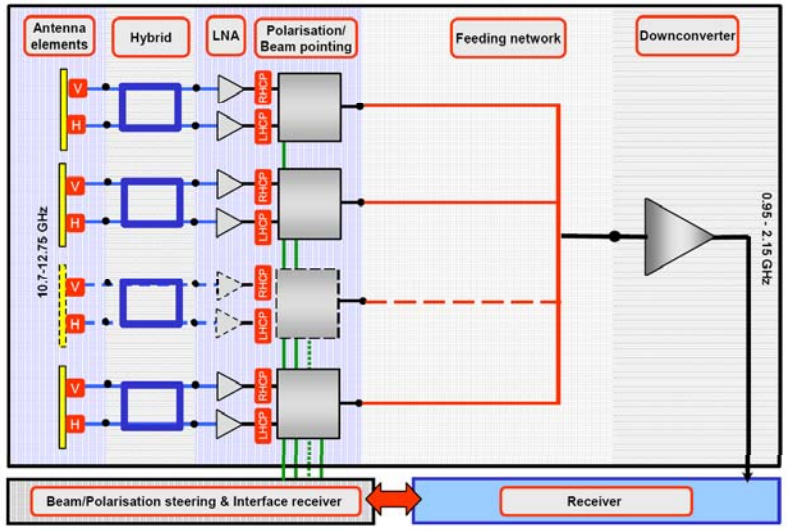
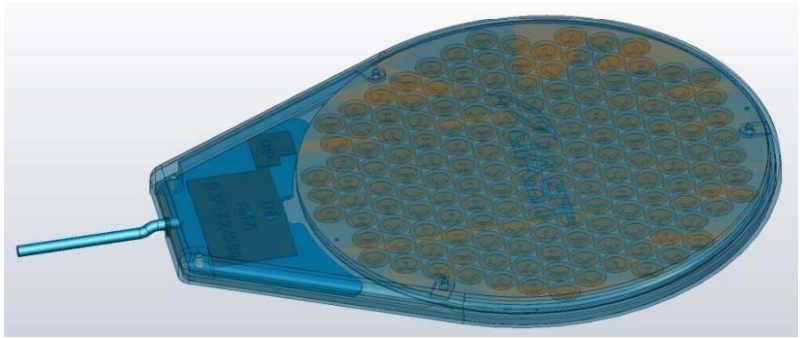
Low cost approach

- Major complexity factor in phased array are the control components for the polarization tracking and 2-axis scanning
- Reducing the complexity of the control components reduces the cost of the antenna
- The Natalia innovative architecture offers:
  - Reduction of the required number of phase shifters bits to achieve high precision scanning thanks to the traXpol concept (Patent filing in progress),
  - Beam steering and polarisation tracking are controlled by the same phase shifters
- The original design of the antenna allows to reduce the number of phase shifter bits (reduction of MMIC size) without decreasing the precision on beam and polarisation control





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Conclusions

- New on-vehicle telematics and entertainment services need large amount of data exchange to and from automobiles
- Satellite communications systems are required to make several application possible and cost effective (e.g. pan-European broadcasting)
- We have presented some of the available solutions suitable for different satellite system and combining communication and navigation services

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