Antennas

for

automotive applications

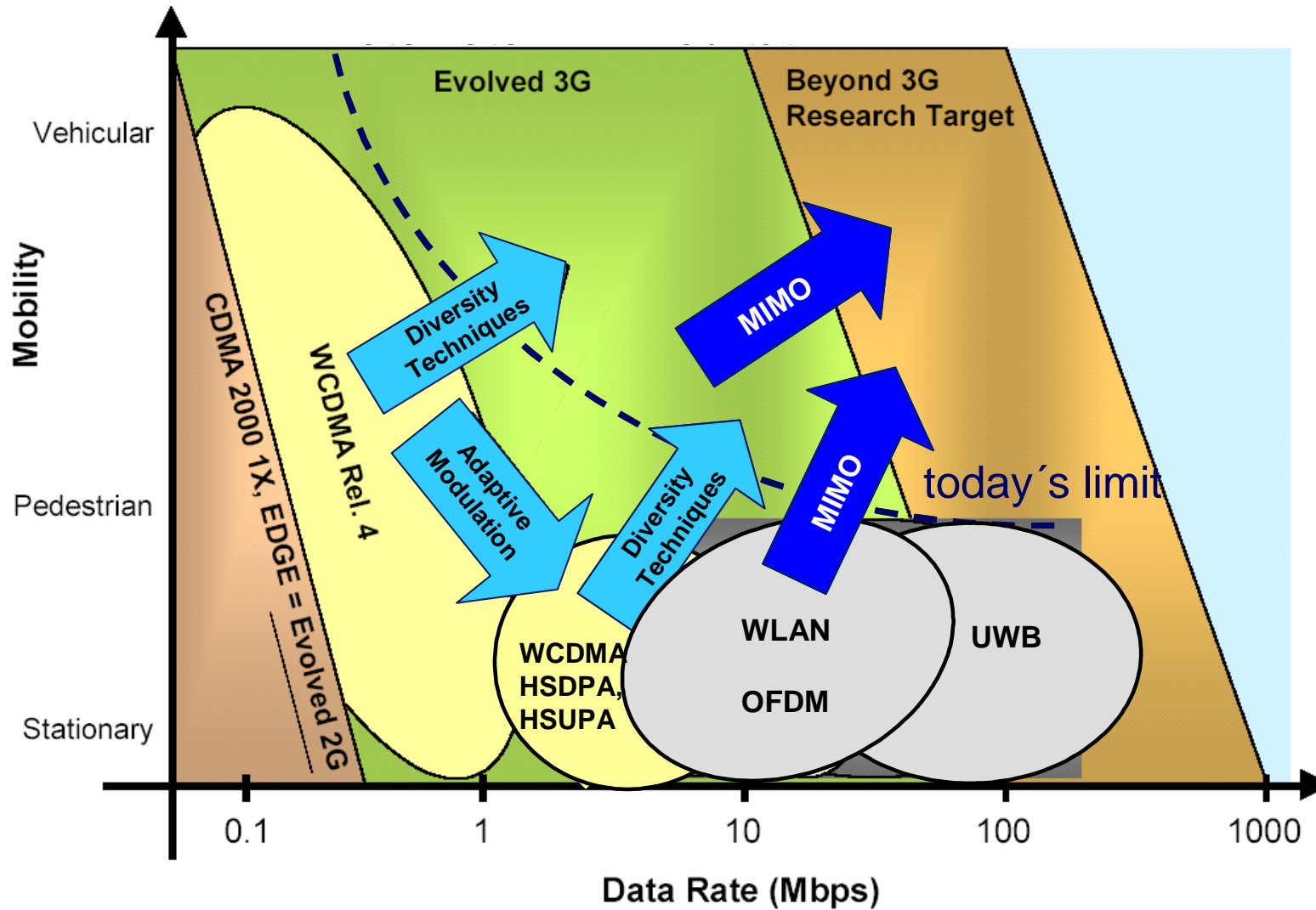*M. Martinez, A. Winkelmann, R. Baggen*

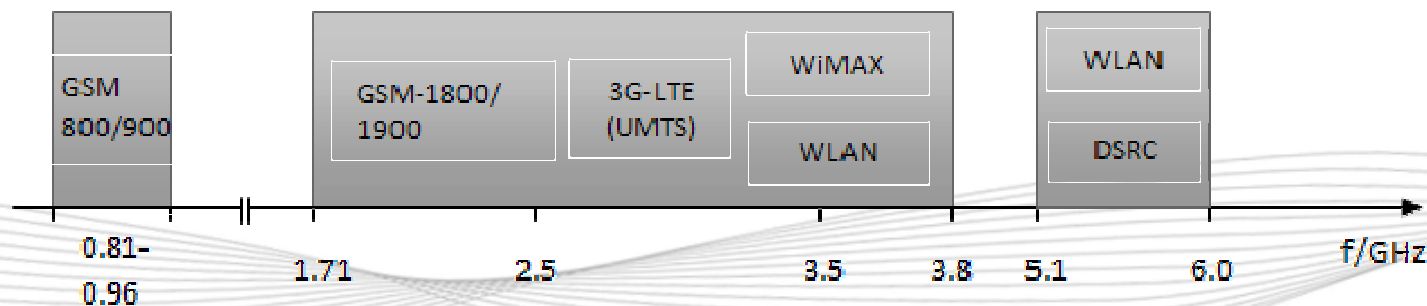15 April 2010, Artic, Barcelona

Overview

→ Today & Future services

→ New developments

→ Requirement profile

→ Car integration

→ Today's solutions

→ Future trends

→ Conclusions

Data rates only increase …
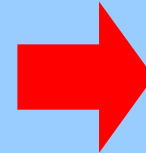
Services of Today

- GSM/UMTS services

- WLAN (3.5 GHz)

- Satellite radio

- DVB-S (Ku-band)

- Navigation

Services of Tomorrow

WiMax/LTE (3.4-3.6 GHz/ Band1 or 7):

- High data rates, hence:
  - ❖ Large absolute bandwidth
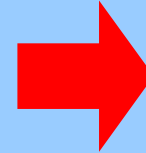 - ❖ MiMo capability

→

- MiMo capable antenna concepts
- Diversity capability required

DSRC/ITS (5.8 GHz): (Dedicated Short Range Communication, C2I)
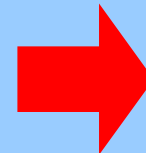(Intelligent Transport System, C2C)

- Originates from the RFID-area
- Medium data rates

→

- Pseudo omni-directional radiators

UWB (3-10 GHz), **60 GHz**:

- High-to-extremely high data rates with multimedia content
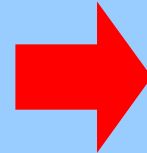- Dedicated for in-car communication

→

- Pseudo omni-directional radiators
- Directive radiators
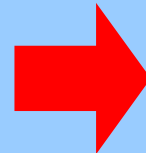
Upcoming Satellite services

Astra (Ku-band):

• Possible bi-directional links in future, extension services into the Ka-band

➜ • Steerable antenna frontends

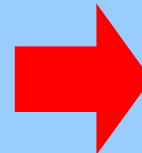• Tracking capability

• Line-of-Sight

INMARSAT/Thuraya (L-band):

• Bi-directional links

➜ • Steerable antenna frontends

• Tracking capability

• Line-of-Sight
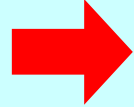
SDARS/Ondas/World Space Radio:

• Satellite radio

➜ • Pseudo omni-directional radiators

• partially diversity capability

„New" developments
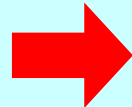
- **High data rates** ➡ MiMo/Diversity

  ⬇

  ❖ Distributed antennas

  ❖ Global coverage replacing pseudo omni-directional coverage of a single antenna

- **Digitalisation/One chip solutions**

  ⬇

  ❖ New antenna positions possible through new more cost-effective connections within the car infrastructure
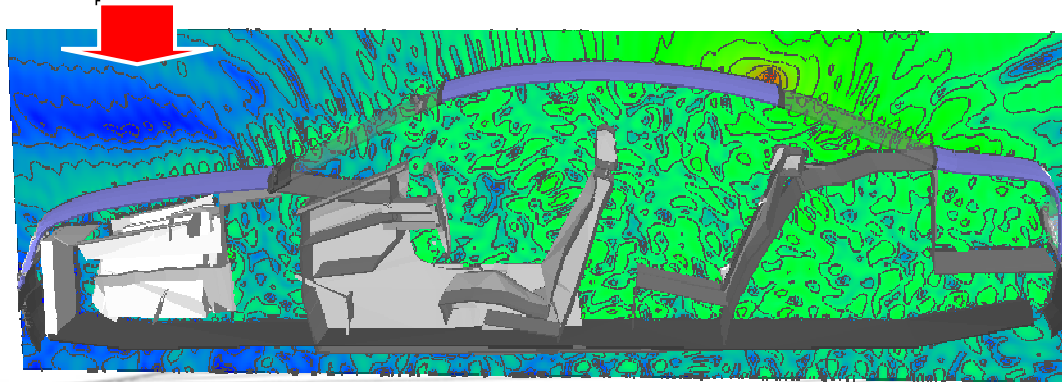
  ❖ Digital signal processing ➡ Digital Beam Forming (DBF)

- **Standarised technologies** ➡ Compact cost-effective steerable antenna frontends for satellite reception

Requirement profile

→ Multi-band capability

→ Compact design

→ Fits into the overall picture of the car body

→ Good spatial coverage

→ High flexibility with a minimum number of antenna modules

→ Diversity- and MIMO-capability

→ Extremely cost effective
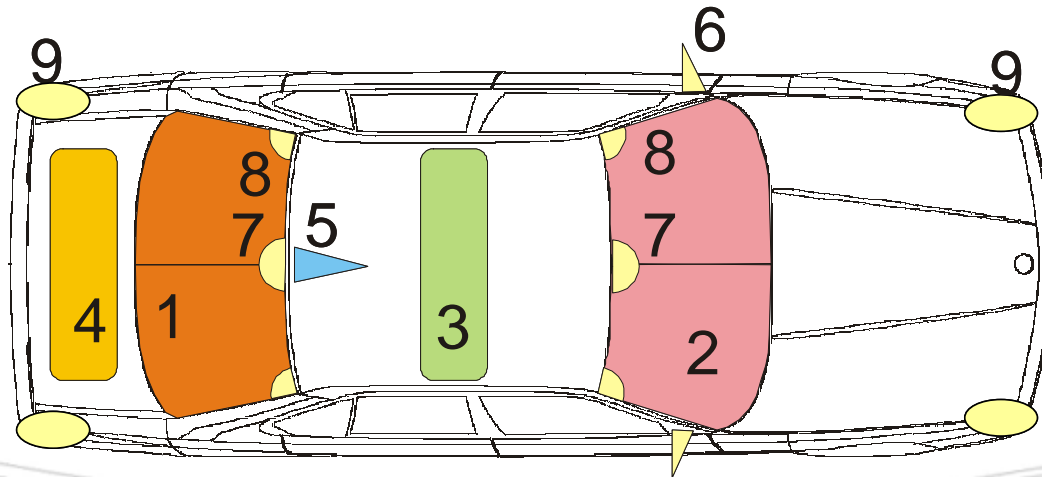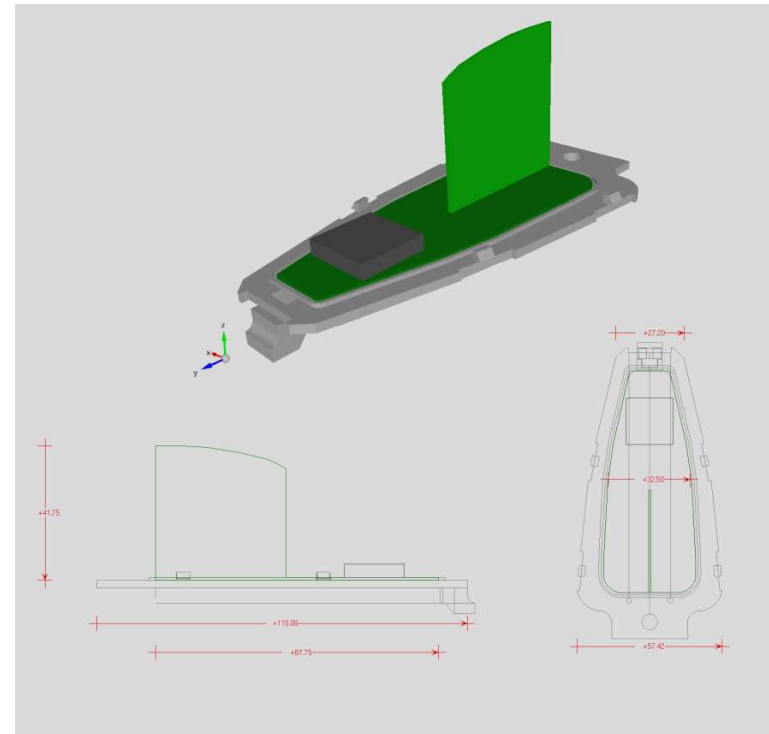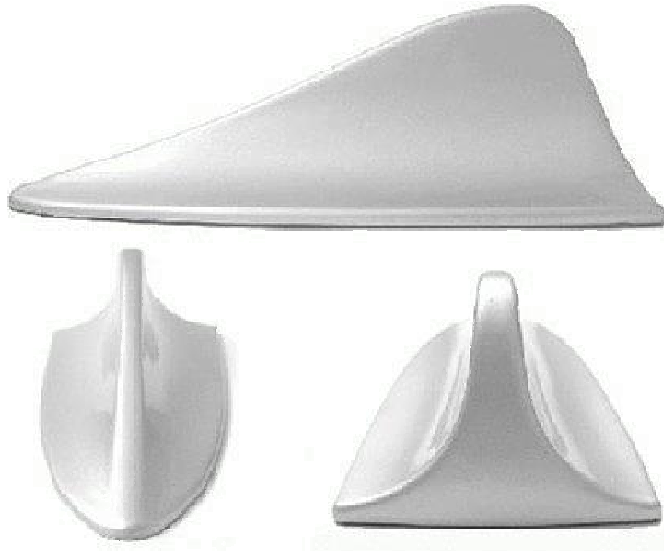
→ Low in-Car SAR exposure

Integration into car

→ **Only little space available despite the size of the car!**

1. FM-radio & terrestrial television
2. FM-radio & terrestrial television
3. Multiband modules & satellite terminals
4. Satellite terminals
5. Shark fin multiband antenna module
6. Multiband modules for diversity/MIMO
7. Supporting antennas for diversity/MIMO
8. Supporting antennas for diversity/MIMO
9. Supporting antennas for diversity/MIMO
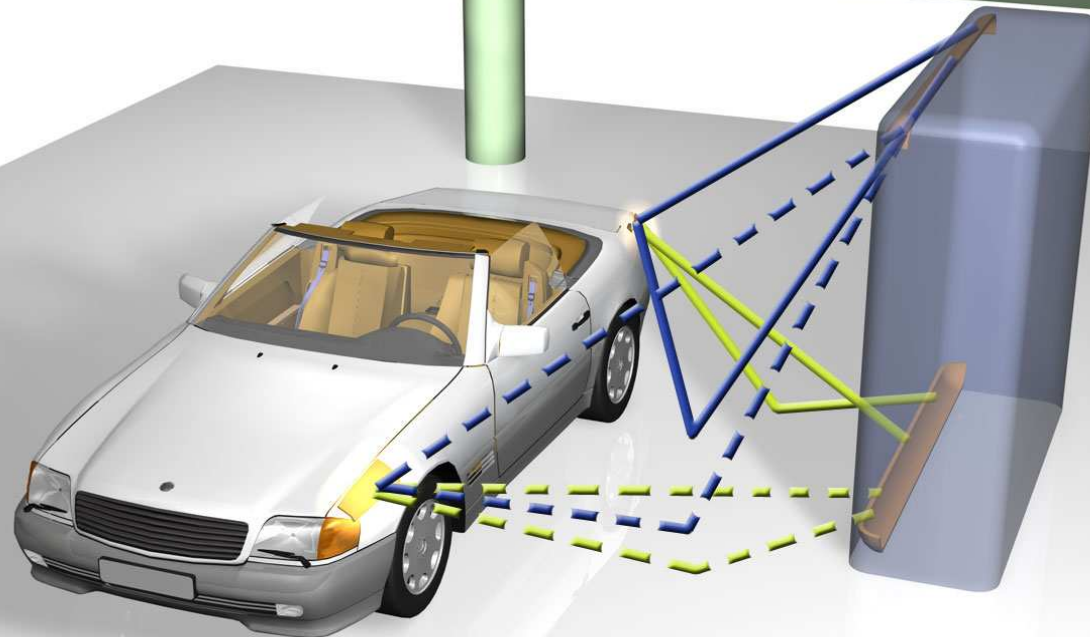
Today's solutions

- ❖ GPS–Patch antenna

- ❖ GSM 800/900/1800/1900

- ❖ Optional DAB antenna

- ❖ GSM- and DAB-antenna are mostly located on the vertical PCB

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Future trends

> **Multiband antenna systems**
>   **MIMO/Diversity**
> **Electronical beam forming**

- Trend goes towards reconfigurable antenna systems -

Reconfigurable antenna systems

Complete system is composed of connected multi-band antenna modules that are spatialy distributed through the car's infrastructure

Module 1: rooftop fin

Module 2: external back mirror

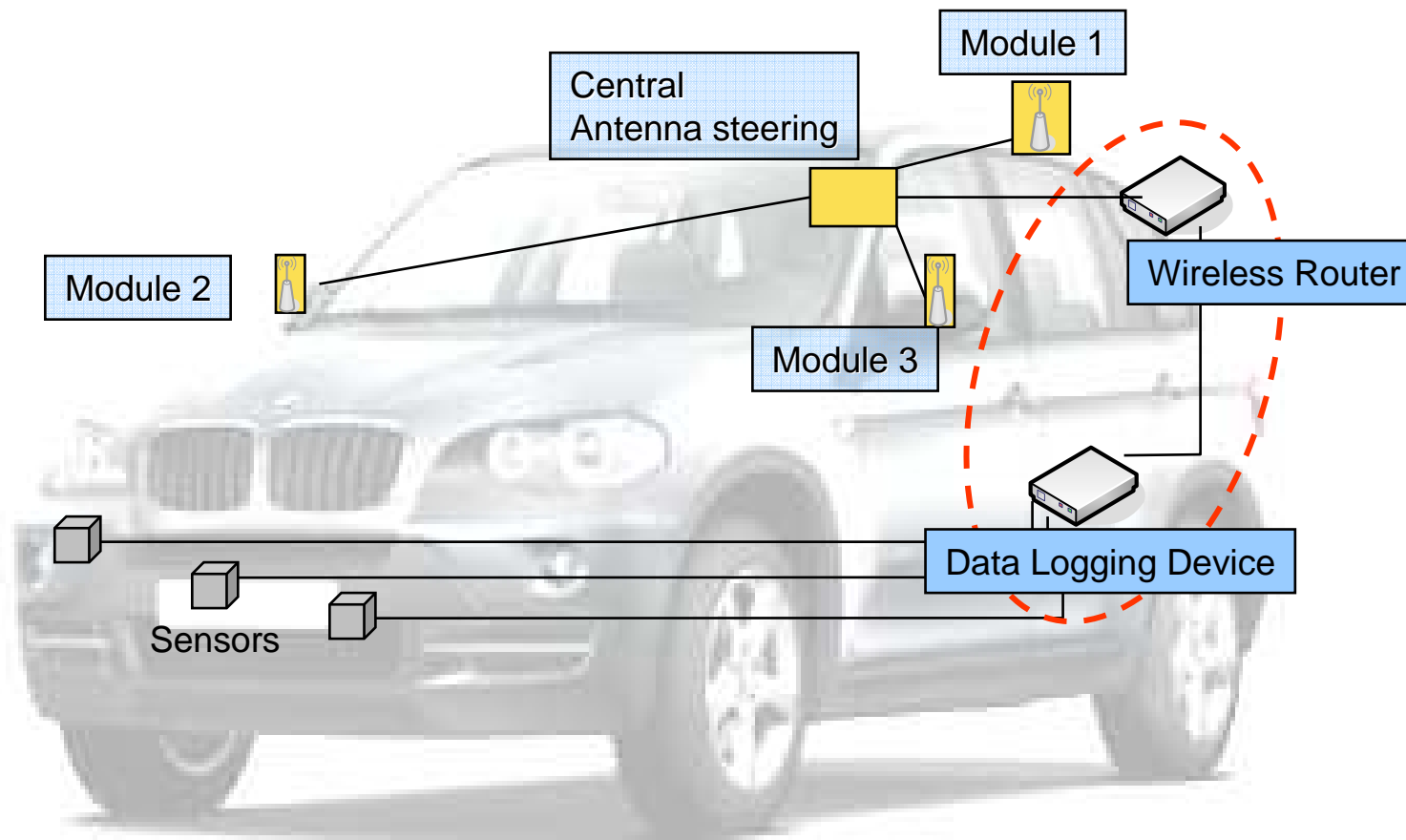*The Future*

Module 3: external back mirror

In cooperation with BMW Forschung und Technik, Munich - Germany

Concept: Connected Car

Diagram labels:
- Module 1
- Central Antenna steering
- Module 2
- Module 3
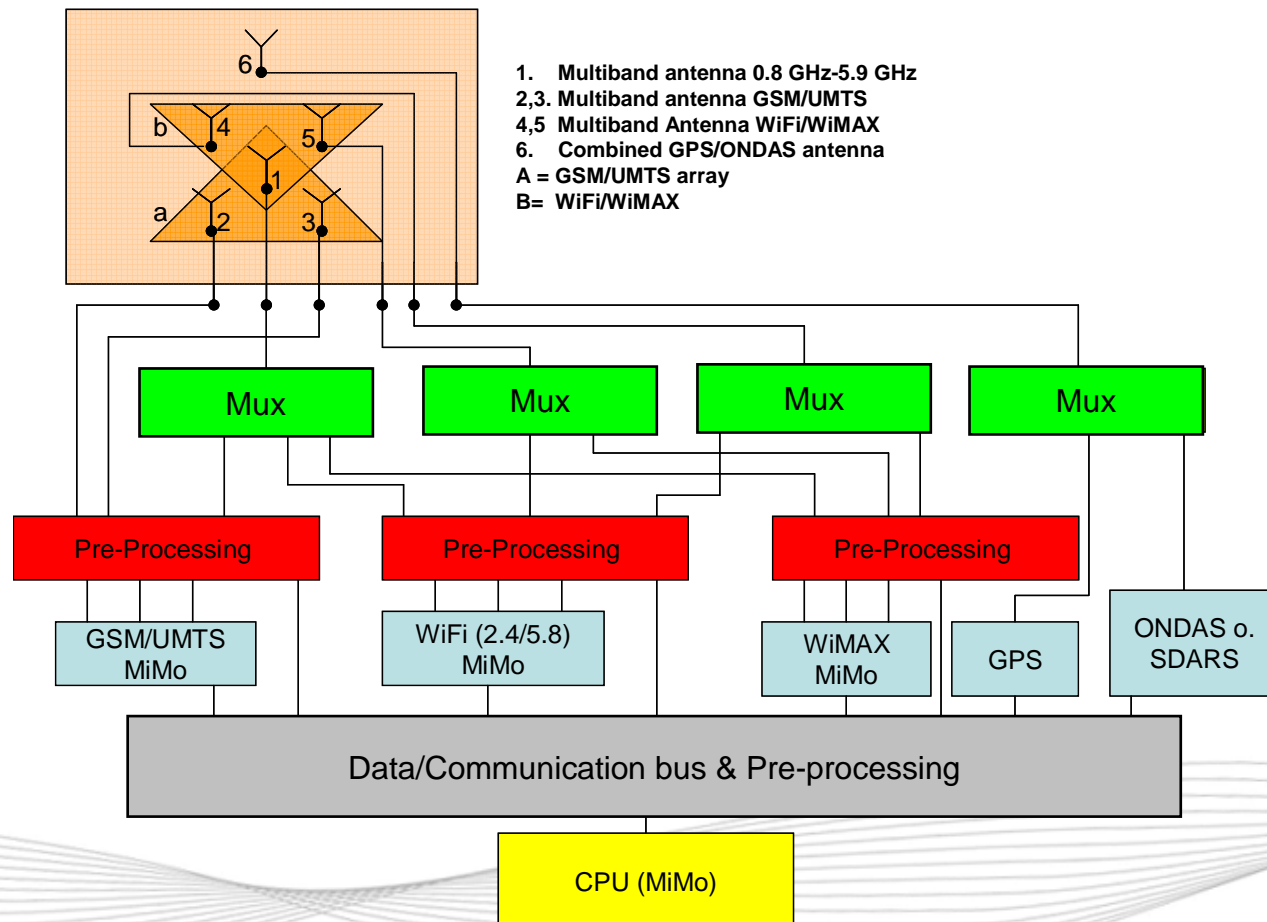- Wireless Router
- Data Logging Device
- Sensors

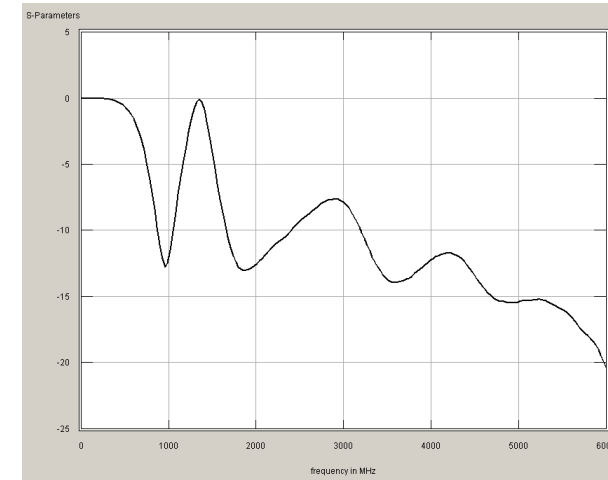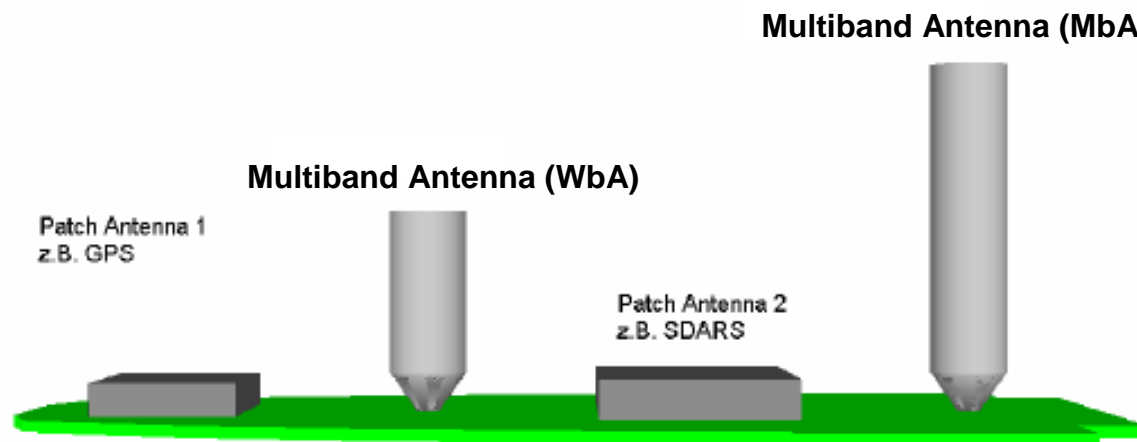**Requirements for combination of antenna modules 1,2 & 3**

- It should be possible to separate the frequency ranges of all services

- The isolation between the different services should be adequate

- It should be possible to realise the desired antenna characteristic for a single service

Example: interconnected multi-band modules

- 700 MHz (UMTS 700 for USA) till 2600 MHz (UMTS Japan)
- WiFi- und WiMax- 2400, 3600 and 5800 MHz
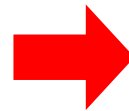- GPS
- Satellite radio (ONDARS, etc..)

1. Multiband antenna 0.8 GHz-5.9 GHz
2,3. Multiband antenna GSM/UMTS
4,5 Multiband Antenna WiFi/WiMAX
6. Combined GPS/ONDAS antenna
A = GSM/UMTS array
B= WiFi/WiMAX

Multiband module shark fin (add-on)

Multiband Antenna (MbA)

Multiband Antenna (WbA)

Patch Antenna 1
z.B. GPS

Patch Antenna 2
z.B. SDARS

Solution A (WiMax-MIMO)

WbA: 2.4 GHz - 6 GHz

MbA: 0.8 GHz - 6 GHz

Services	Frequencies/GHz
GSM	0.824 - 1.99
UMTS	1.71 - 2.36
WiFi (802.11b/g)	2.4 - 2.485
WiFi (802.11a)	5.18 - 5.835
WiMax	2.495 - 5.825
DSRC	5.850 - 5.925

MbA

WbA

Solution B (LTE-MIMO)

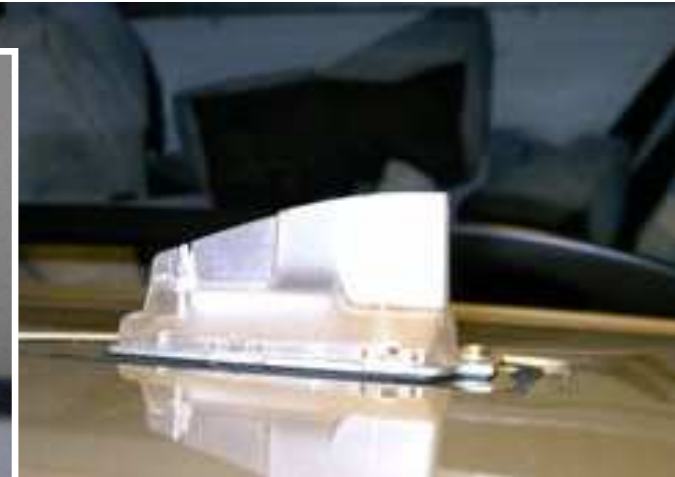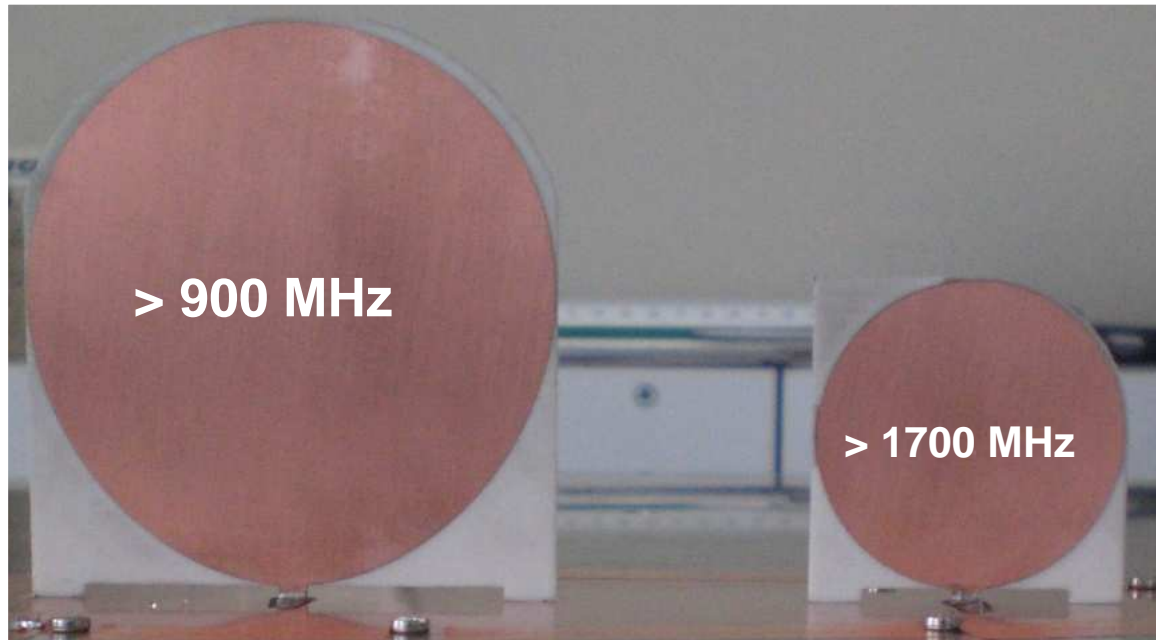WbA: 1.7 GHz - 6 GHz

MbA: 0.8 GHz - 6 GHz

Services	Frequencies/GHz
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MbA

WbA

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Shark fin prototype

> 900 MHz

> 1700 MHz

→ **Material**: Rogers 4003, d=813 µm, top/bottom copper layer d_{cu}=17 µm

→ **Dimensions**: 33x34x0.8 mm^3, small patch; 55x60x0.8 mm^3, large patch

→ **Good impedance matching**: -10 dB @ f = 1.7GHz-5.8GHz for the small patch; -10 dB @ f = 1.1GHz-6GHz) for the large patch

→ **High reproducibility**

→ **Easy** integration into the shark fin casing
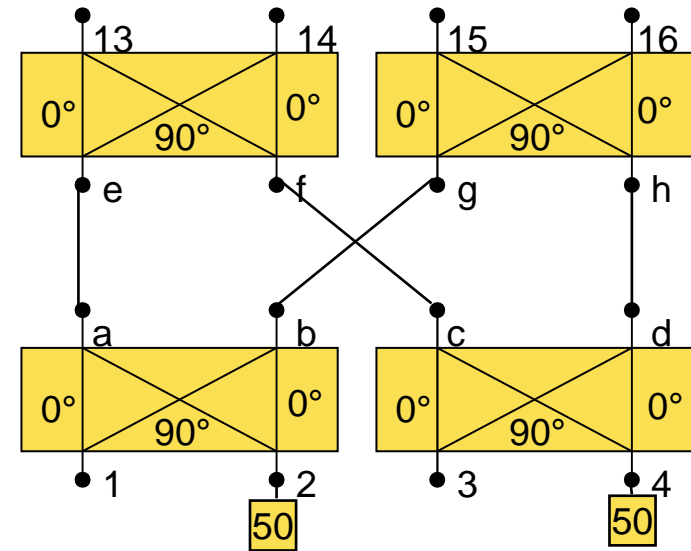
Integrated antenna in rear external mirror

Example interconnecting network

Problem

• WiMax Board has 2 antenna ports available, 4 antennas have however to be connected.

Solution

• Butlermatrix:

  ❖ effective distribution of all signals

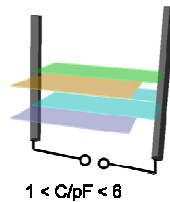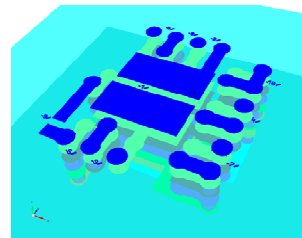 ❖ by using the phase differences in the Butler matrix, various antenna patterns can be generated
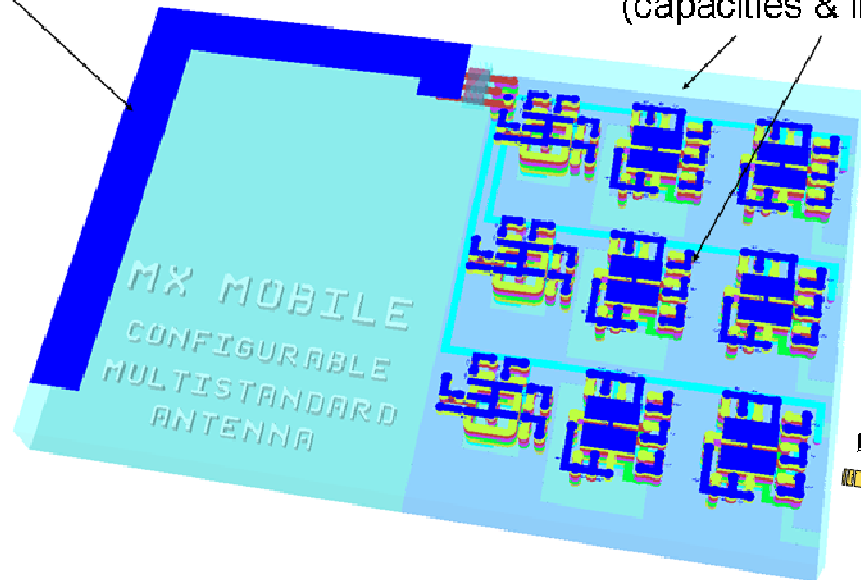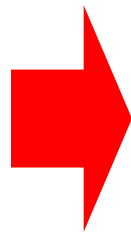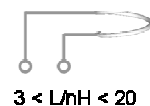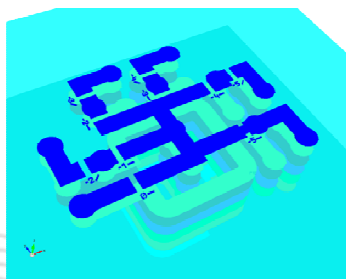
New tuning concepts

The car becomes more & more a **mobile phone** **on wheels**

Mobile phone technologies & concepts **transfered** to automotive antennas

Coupling to car chassis

Matching circuits (capacities & inductances)

$1 < C/pF < 6$

$3 < L/nH < 20$

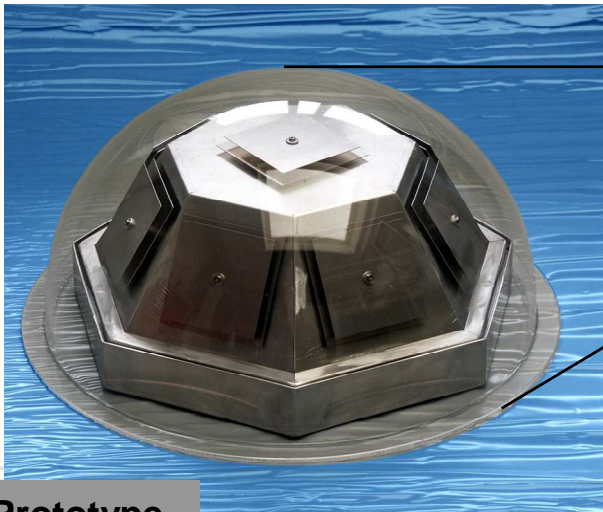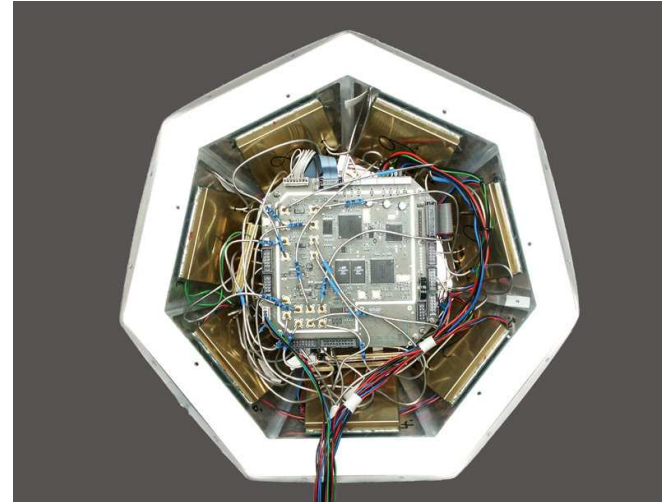MX MOBILE CONFIGURABLE MULTISTANDARD ANTENNA

LTE

GSM

DVB

Innovative satellite terminals in L-band

Requirements

- Transmit: EIRP=40dBm±2dB
- Receive: G/T=-17 dB/K
- Circular polarisation
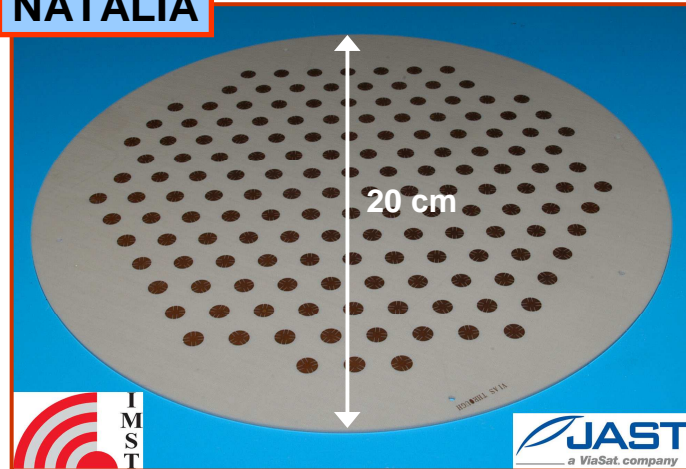- Low profile and low cost
- Full hemispherical coverage elevation ≥15°

Prototype

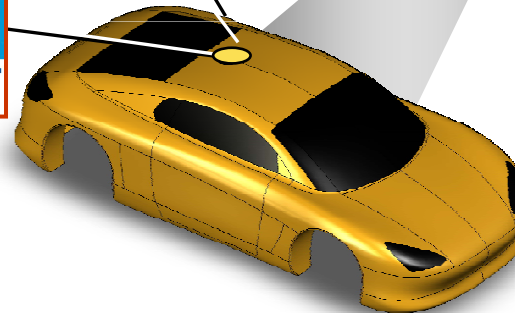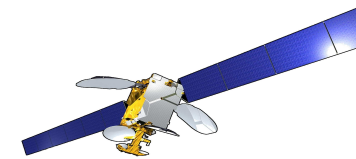Artist impression

Innovative satellite terminals in Ku-band

NATALIA

20 cm

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JAST
a ViaSat. company

GEO-satellite

Dedicated antenna with low gain

➡

Small size

➡

Attractive for the **automotive** industry

Dedicated receiver designed for **very low S/N** using **specialised** services

Dedicated satellite services based on **interference** scenarios

➡

➢ Memory caching
➢ Repeatability

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Conclusions

✓ Services & Requirements for automotive applications have been presented

✓ Nowadays solutions possess all **multiband** capability

✓ In near future **MIMO/diversity & beam forming** will become more & more important due to bandwidth hungry multimedia applications

✓ Solutions for this will not be found in designing only **one** multiband antenna but in creating a **complete** systems of connected antenna modules governed by a central processing module

✓ Technologies & Concepts used in the past for **mobile phone** applications can be **transferred** to the automotive platform