International Consortium for Telemetry Spectrum

The Potential for AMT in the Ku-, K- and Ka Bands

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Agenda

1. Review on the concluded study „AMT Spectrum above 15 GHz“ (2008)

2. AI for WRC-19 „Future Spectrum Requirements for IMT above 6 GHz“ with proposed candidate bands in the K- and Ka-band, for study !

3. General Trends and the Spectrum Problem: Need for AMT Bands > 15 GHz (horizon 2020 & beyond) ??

4. Preparing a Demonstration Project in Europe

Conclusions

First Initiative 15 G & up after WRC-15 Experience

- **Lessons learned from WRC´07: from identifying a specific need until a WRC decision one decade min. is required !**
- **Immediately after WRC-07 the "Telemetry over 15G" Study Group was chartered by the US DOD Test Resource Management Center (TRMC).**
- **Study was successfully concluded in 2008.**

„AMT over 15 G“:
TRL Assessment of Study Gp

- **Future TM Spectrum demand** cannot be accommodated in bands less than 15 GHz
- The **demand** for telemetry spectrum will **further grow** exponentially, reason to an increase of measured parameters and stringent requirements in resolution and time correlation**.**
- **Components** for designing an airborne transmitter, receiver and ground antenna technologies are **available**.
- Airborne **antennae** and both airborne and ground-based steering technologies remain to be investigated, as well as the **characteristics** of the **radio propagation medium**.

AMT over 15 GHz

A Feasability Study (Michael Rice, BYU, Dec.´14)

- Market-available components and systems for the Ku-, K- and Ka-Bands are capable of accommodating some of AMT needs.
- Biggest challenge to our community is the propagation issue, but methods to compensate for any loss of the link margin were identified.
- The considerable **regulatory challenge** in securing an allocation in these bands was addressed:

"***All of spectrum in these bands has been assigned by the USA's FCC and the NTIA, and the incumbents would try to enthusiastically protect their assignments.***"

WRC-15 Action Item 10:

New AIs proposed for WRC-19

- ***„Studies on frequency bands above 6 GHz (up to 100 GHz) for IMT applications“***

  „..to conduct & complete in time for WRC-19, the appropriate sharing and compatibility studies, taking into account the protection of exisitng services“.

- **That AI is presently number 1 on the priority list !**

  supported by APT, ATU, CEPT, CITEL

- **Ku-,K- and Ka bands are proposed for studies !**

  Supported by 6 CEPT countries !

Mobile Service Allocations

(*ITU Radio Rules 2012, Article 5*)

22,50 – 23,60 GHz: allocable in all 3 ITU-Regions

25,25 – 29,50 GHz: allocable in all 3 ITU-Regions

European IMT lobby favourising studies in that bands (supported by German Telekom, Intel et.al)

29,50 – 31,00 GHz: already allocated in some Arab and Asian countries on a secondary basis.

Need for AMT Bands >15 GHz ?

time horizon 2020 & beyond

Possible Reasons:

- ***Increase of missions*** to be supported
- ***More parameters*** per mission expected
- ***Higher time resolution*** and ***bandwidth***

*What **kind of missions** could live with **propagation restrictions**, expected in these bands ?*

Or** can **new technologies** (e.g. lossless encoding techniques, networked telemetry) help to **reduce future bandwidth needs,** **so available frequency allocations will do in far future, too ??

AMT Ka - Band Allocation

European Perspective

Highest chance seen in band **25,25–27,5 GHz:**

- **NATO** joint civil / military frequency agreement would not be in opposition (harmonised band, class B)
- **GEO satlinks** could be convinced live with AMT ops
- **Technology** of components and systems is highly developed due to the satneeds.
- ***Go ahead with demo projects to evaluate the possible use in future missions!***

Comparing S- to Ka - Band Telemetering

- **Link budget**

f_K = 27300 MHz, λ_K = 1,1 cm; f_S = 2320 MHz, λ_S = 13 cm

free space attenuation increase, $\Delta\alpha \sim (\lambda_K/\lambda_S)^2$ *-21dB*

gnd antenna gain* can compensate, $G_R \sim(\lambda_S/\lambda_K)^2$ *+21dB*

aperture angle of gnd antenna,* $\sim \lambda_K/\lambda_S$ $\beta_K = 0{,}085 \times \beta_S$

flight antenna, phased array beam control ~ +10*dB*

- **Influence weather & environment**

additional Atmospheric loss in wet regions (40° lat.) -10dB

less gnd reflections expected at low elevation angles:

higher "roughness" of terrain creating diffuse refraction patterns, instead of reflections.

Interference & noise floor ~ -10 dB compared to S-Band.

*** same effective antenna area for K-and S-Band assumed**

Wave Propagation & Flight Simulation *

- **Available information**

  Long-term collected K / Ka-band atmospheric propagation data (satellite, radiometer, dual polarization weather RADAR obs.) available, access to other data bases, too.

- **Challenges facing utilization in Flight Test**

  Characterize the telemetry channel and create a test bed to simulate & study propagation effects , ad hoc TRL 1..2

(Proposal Joanneum Research, Graz / Austria)

Recommended Approach

- ***Generate algorithms to derive relevant link budget figures***

  -starting on basis of ITU recommended algorithms,

  -improved with extracted useful data sets from DB´s.

- ***Application & generation of statistical analysis***

  - deterministic prediction allows insertion of TM link parameters, providing a CDF on link attenuation

  - statistic analysis providing gross estimates on atmospheric effects.

K- ,Ka Band Experimental Test System

- **Airbus Defence & Space** in Manching doing already comparison flight tests with S - vs. C – band telemetry.

- **EST** is in contact with the ***German BnetzA*** for getting an experimental frequency allocation in K-/Ka band

  (27,0 – 27,5 GHz is candidate).

- **Initial approach** is design with a comparable free-space link characteristic, as in S-and C-band.

  Advanced approach plans a controllable slotted array antenna onboard and a monopuls tracking antenna on gnd.

Conclusions

Future long-term TM spectrum needs must be identified **now**; WRC decision process can take more than one decade!

15 GHz & up TRL Study Group: Components for systems design available. Antennae steering /tracking and operational impacts of wave propagation effects to be investigated.

27 GHz band is most favourable to design & develop a demonstration system for pilot test flights.

ANNEX: TRL Assessment (2010)

On Board Transmitter

Available GaAs mHEMT & pHEMT technology:

10W (20 GHz)…..< 5 W (40 GHz), n = 0,13...< 0,1

Technology challenges:

SWAP limitations, high dissipation power level

ad hoc TRL 4…5

Recommended approach:

develop 2W package in one favourite band to meet TRL 6

**** Ref. Triquint, Agilent Technologies,and Wavestream Corp. data sheets & articles***

On Board Antenna & Accessories

Available technology:

slotted waveguide array antenna, 2D – steering

„patchwork“microstrip phased array antenna

Technology challenges

develop FTI compatible version (ad hoc TRL 1..2)

Difficulties / barriers

no basic approach available, that meets FTI requirements

Recommended approach

Design a steerable and a non steerable proto-version within FTI acceptable dimensions, qualifiy it up to TRL 6

Ref: ku & ka band phase array antenna for space based TM,
NASA Dryden, Harris Corp.

Gnd Antenna dish & TM Tracking

Available technology

state-of-the-art dish & pedestal, LNA & down converter can meet requirements, TRL7

Technology challenges

New TM tracking appoach (H/W & S/W) required, ad hoc TRL 1…2; phase noise and doppler shift in the receiving channel may restrict use of some modulation schemes

Recommended approach

feasibility study considering additional tracking information from other gnd target acquisition sources and up front evaluation of systems & algorithms, up to TRL 6.

Comparing S- to C & Ka- Band

at free space propagation conditions

Attenuation: $\alpha = 1 / (4\pi \times R)^2 \times \boldsymbol{\lambda}^2$;

$\underline{\Delta\alpha \sim \lambda_{C,K}^2 / \lambda_S^2}$

2320 MHz: 0dB; 5150 MHz: -7dB; 27300 MHz: -21dB

Antenna gain: $G_{t,r} = \eta \times \pi^2 \times D^2 / \boldsymbol{\lambda}^2$;

$\underline{\Delta G_{t,r} \sim \lambda_S^2 / \lambda_{C,K}^2}$

2320 MHz: 0DB; 5150 MHz:+7dB; 27300 MHz: +21dB

Antenna aperture: $\beta_{-3dB} = 70\,\boldsymbol{\lambda} / D$;

$\underline{\Delta\beta_{-3dB} \sim \lambda_{C,K} / \lambda_S}$

2320 MHz: 1β; 5150 MHz:0,45 β; 27200 MHz: 0,085 β

Rain Attenuation Prediction Model *

$\gamma(r,f) = K \times r^{a}$ $\gamma(r,f)$……rain absorption [dB/km]

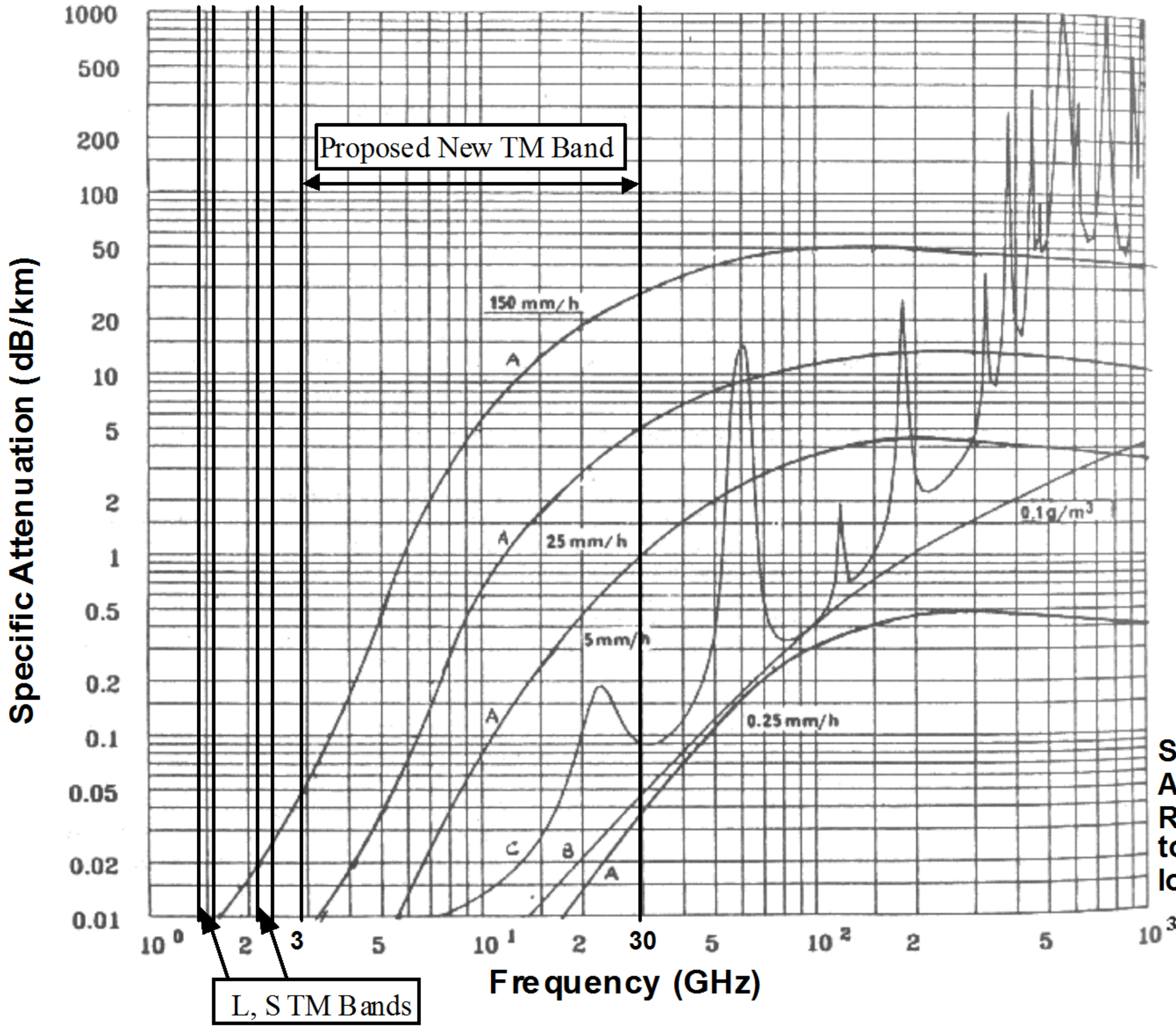
r……….rain rate [mm / h]

K,a(f)…coefficients

f [GHz]	**2,3**		**5,0**		**27**	
$\gamma(r,f)$ [dB/km]	**γ_H**	**γ_V**	**γ_H**	**γ_V**	**γ_H**	**γ_V**
r [mm/h]						
10	**<0,01**			**0,01**	**1,8**	**1,6**
50	**0,01**		**0,17**	**0,1**	**8,6**	**7,0**
150	**0,03**	**0,02**	**1,1**	**0,5**	**25,3**	**19,6**

* ***Recommendation ITU-R, P838-3 (2005)***

Atmospheric Attenuation vs. Frequency



A: Rain

Downpour (150 mm/hr)

Heavy (25 mm/hr)

Light (5 mm/hr)

Drizzle (0.25 mm/hr)

B: Fog (0.1g/m^3)

C: Gaseous (H_2O + O_2)

Source: Attenuation by Atmospheric Gases, Report 719-3, Reports of the CCIR, 19990, Annex to Vol. V: Propagation in Non-Ionized Media, Geneva, 1990, pg. 190.

Remember…..

Telemetry engineers
do it with frequency!

Are you getting enough?