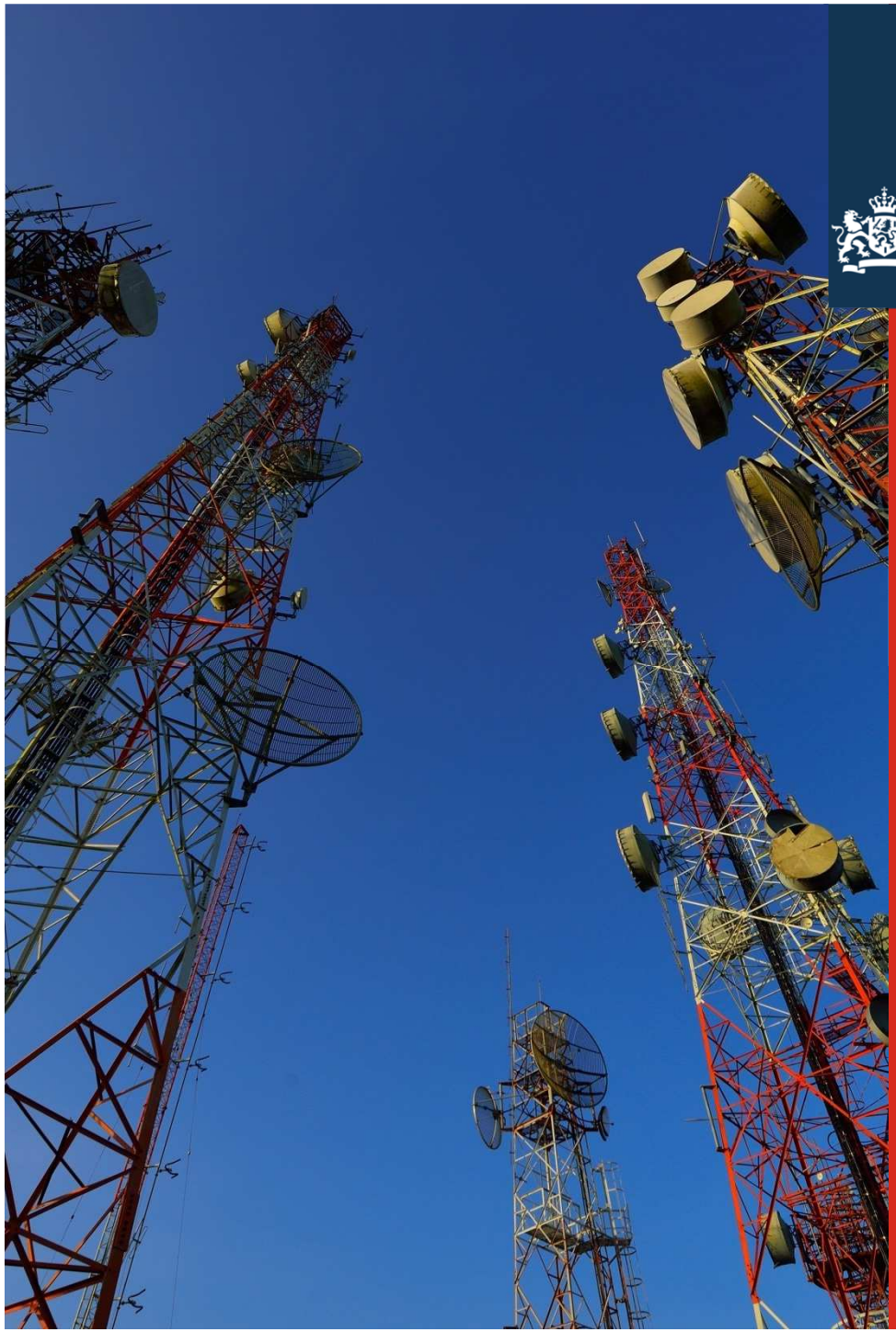

Radiocommunications Agency
Ministry of Economic Affairs

Spectrum demand for The Internet of Things

Research agenda of the Radio Communications Agency

LPRA meeting Groenlo 2017

Erik van Maanen

May 18 2017

Spectrum demand for the internet of things

- What is IoT from a spectrum regulators point of view
- How can spectrum demand be classified
- Guidelines and strategies of a spectrum regulator
- Research agenda
- Conclusions and actions taking into account the outcome of research

This presentation is based on a regulators view and is mainly the view of The Netherlands.
Conclusions in the research reports are the conclusions of the authors and researchers
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Spectrum demand for the internet of things

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What is IoT (from a spectrum regulators point of view)

- Applications

Before 1995 IoT was only RFID — identification
After 1995 IP addressing was added — addressability
After 2000 GPS-UWB became mainstream — localisation

Nowadays IoT is seen as a technology based on a large number of required properties such as able to autonomously communicate or send information to the internet in general

From a spectrum regulatory point of view IoT itself is not of great interest, the specific requirements are of interest and follow in the next slides.

What is IoT (from a spectrum regulators point of view)

- Applications
  - Industry view on particular application
  - Commonly accepted view
  - Regulatory view

What is IoT (from a spectrum regulators point of view)

- Applications (examples with a smile)

FM radio in the 70s

ITU rec BS.450

IoT in 201x

EN 300-220, EN 300-328

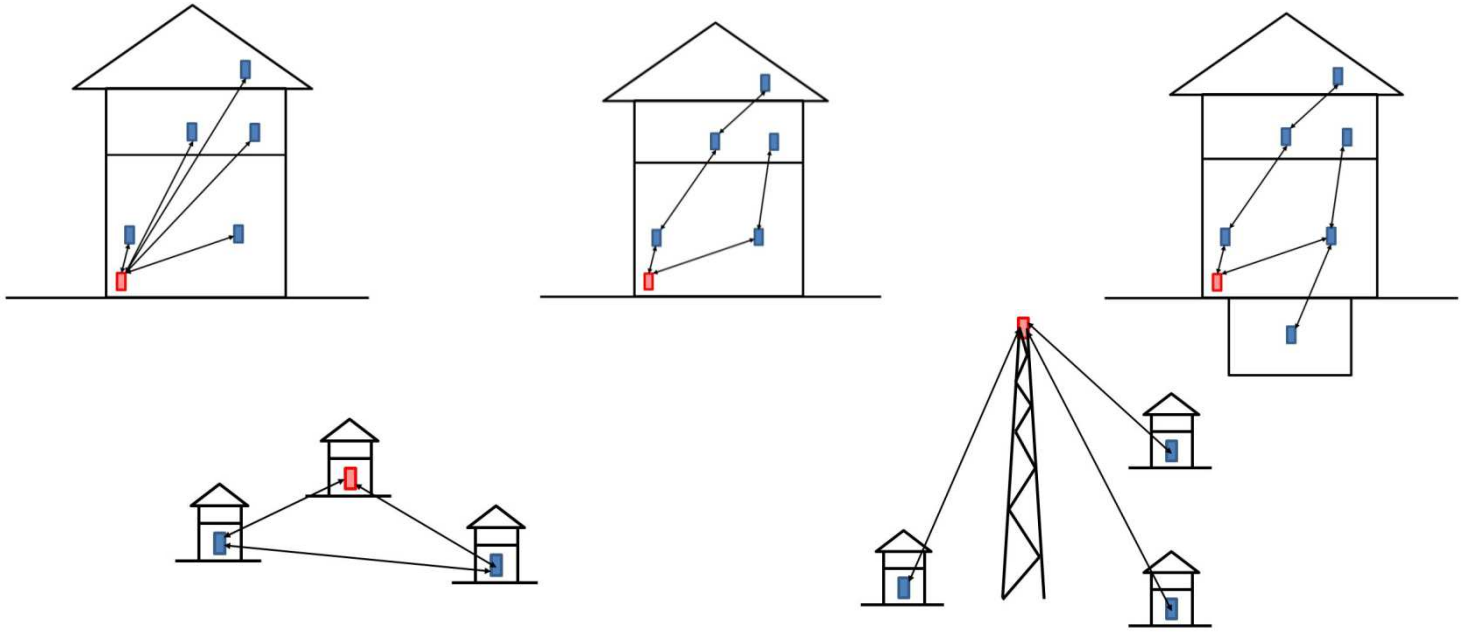
What is IoT (from a spectrum regulators point of view)

- Defined goal

- Work more efficient
- Live healthier
- Have more fun
- Have more comfort
- Political or economical goals like energy saving or green agenda

What is IoT (from a spectrum regulators point of view)

- Requirements (frequency choice based on topology)



What is IoT (from a spectrum regulators point of view)

- Requirements (based on the sharing environment)

Bandwidth
Duty cycle
Coverage (Power, type of application)

Technical

Expected deployment
Expected activity

Non technical

Environment (Sharing / operational)
Needs to be predictable

What is IoT (from a spectrum regulators point of view)

- Numbering (are IP based or numbered devices needed ?)

  – Is this really needed for the application or does it show good
    IP V.6
  – Is numbering in general needed
    E.164 numbering
    E.212 IMSI numbering

  – If you demand them, what are the spectrum costs
  – IoT can kill a business case

What is IoT (from a spectrum regulators point of view)

- Frequency bands
  - Soft relation with frequency bands but IoT bands are not defined
  - Choice of frequency band influenced by
    - replacement cost of devices
    - propagation properties
    - allowed technical parameters
    - worldwide or EU harmonisation

User usually doesn't care at all !

And we are not talking about people who buy this

What is IoT (from a spectrum regulators point of view)

- Overview most popular licence exempt and licenced Frequency bands

Band	Shared (pri/sec)	Type
164 - 169.8152 MHz	No	SRD
433.05 - 434.79 MHz	Yes	SRD
862-863 MHz	Yes	Networked (restricted) SRD
863-870 MHz	Yes	SRD
870-876 MHz	Yes	SRD
915-921 MHz	Yes	SRD
1880-1900	No	DECT
1900-1920	No	SRD, DECT
2400-2485,3 MHz	No	WLAN
2400-2485,3 MHz	No	SRD (10mW no restrictions)
5150-5350 MHz	Yes	WLAN
5470-5725 MHz	Yes	WLAN
5725-5875 MHz	Yes	SRD (25 mW no restrictions)
61-61.5	No	SRD (100 mW no restrictions)
57-66 GHz	Yes	WLAN
57-64 GHZ	Yes	SRD (100 mW no restrictions)

Band	Type
703-733/758-788 MHz	
791-821/832-862 MHz	
880-925/832-868 MHz	
1452-1492 MHz	
1710-1785/1805-1880 MHz	
1920-1980/2110-2170 MHz	
2300-2400 MHz	LSA
2500-2570/2620-2690 MHz	
2570-2620 MHz	
3400-3600 MHz	
3600-3800 MHz	

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How can spectrum demand be classified

- Industry demand
- Spectrum harmonisation demands
- Physical properties of, or linked to, available spectrum
- Bandwidth required by user
- Sharing environment suitable for user
- Reliability and long term availability required by user
- Users vendor lock-in

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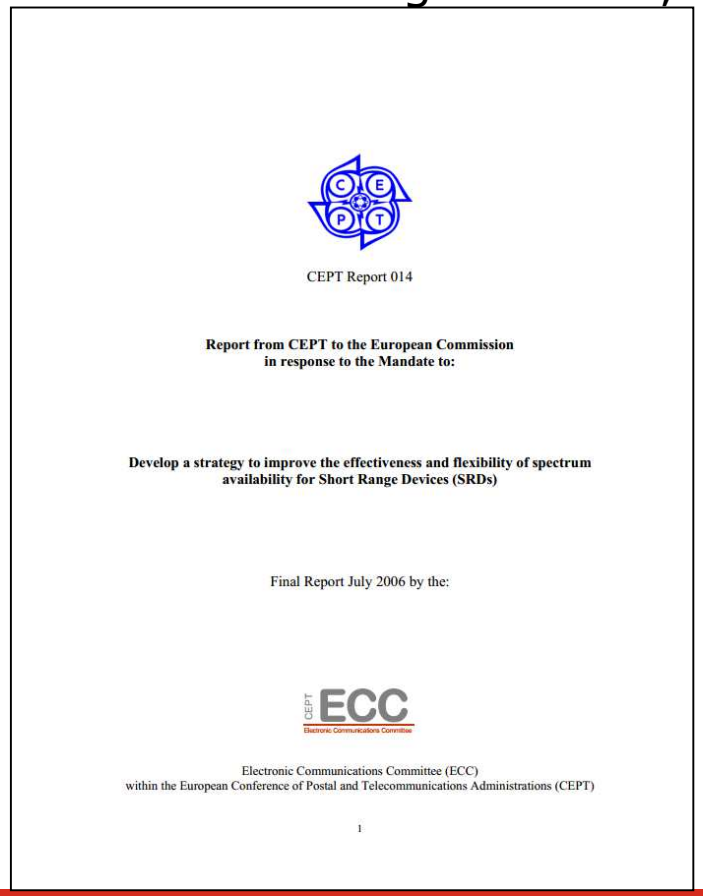
Guidelines and strategies of a spectrum regulator

- Is a frequency management solution durable ?
  This means no specific arrangements for one application but arrangements for specific technologies remain possible

- Is an application durable ?

Guidelines and strategies of a spectrum regulator

- International agreements, SRD Strategy



CEPT Report 014

Report from CEPT to the European Commission in response to the Mandate to:

Develop a strategy to improve the effectiveness and flexibility of spectrum availability for Short Range Devices (SRDs)

Final Report July 2006 by the:

ECC

Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

1

When developing new products, manufacturers should use existing frequency bands identified for SRDs before requesting new allocations of valuable spectrum

While the opportunities for applying market mechanisms to SRD are limited, it has to be recognised that spectrum has a value and its value to other possible future users may be affected by the presence of a SRD designation

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Research agenda

- Reasons
  - Gathering of specific information to be used for national strategy
  - Position in international consultation
  - Confirmation of current spectrum management practice

- Method
  - Independent
  - Preferably scientifically backed

- Results
  - Reports on different SRD and IoT related topics

Research agenda

- performed only in 2,4GHz and 5GHz spectrum mainly to check usage
- Based on mobile surveillance and limited spectrum investigation

  - Troughput test
  - RF scanning, limited setup
  - AP scanning (mobile, number of Aps)
  - Frame logging

Research agenda

- Report Research into the License Exempt Spectrum of the Netherlands

Conclusions observations and recommendations:

There are locations where available capacity on 2,4 GHz is severely limited. (City Centers, Residential Areas with houses in a row or high rises)

In locations with relative high usage, the Access Points are often evenly distributed over the channels 1, 6 and 11. However, this does not prevent interference and congestion. Public WiFi operators (UPC, Ziggo, KPN) cause excessive overhead.

Research agenda

- Report Research into the License Exempt Spectrum of the Netherlands

Conclusions observations and recommendations:

Overall capacity of WiFi is much less than advertised by the standard due to overhead in the shared environment.

Due to backwards compatibility and the high number of Access Points on 2,4 GHz up to 37% of the airtime was used for beacon signals of Access Points.

Research agenda

- Report Research into the License Exempt Spectrum of the Netherlands

Conclusions observations and recommendations:

In a number of locations high levels of interference were measured on 2,4 GHz with corresponding lower data throughput especially in Shopping malls

Spectrum measurements clearly show non-WiFi activity. This creates interruptions for WiFi traffic, but in the measurements it is not seen as problematic.

Research agenda

- Research on <1GHz IoT applications
- M2M, LPWAN, metering, smart cities

Based on the theoretical modelling of demand and supply and on data analysis of "the things network"

Research agenda

- Report Internet of Things spectrum utilisation and monitoring

Micro ecosystem may have a completely different deployment than a heat map of supposed users suggests.

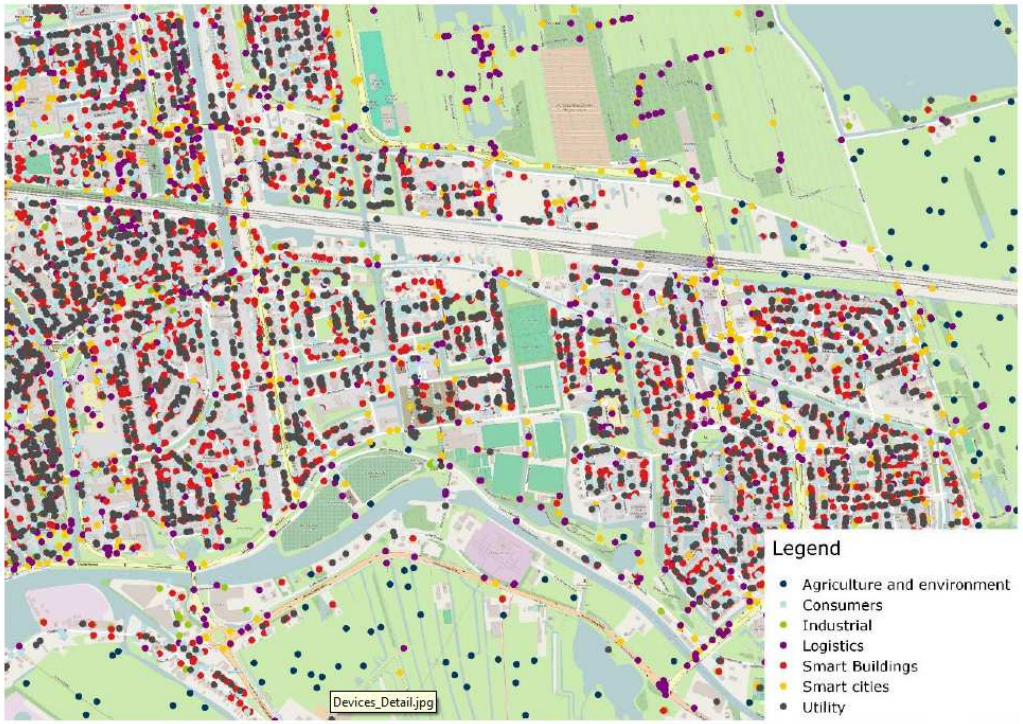


Figure 14 Example of modelled geographical dispersion of LPWA IoT devices (shown here for the city of Gouda)

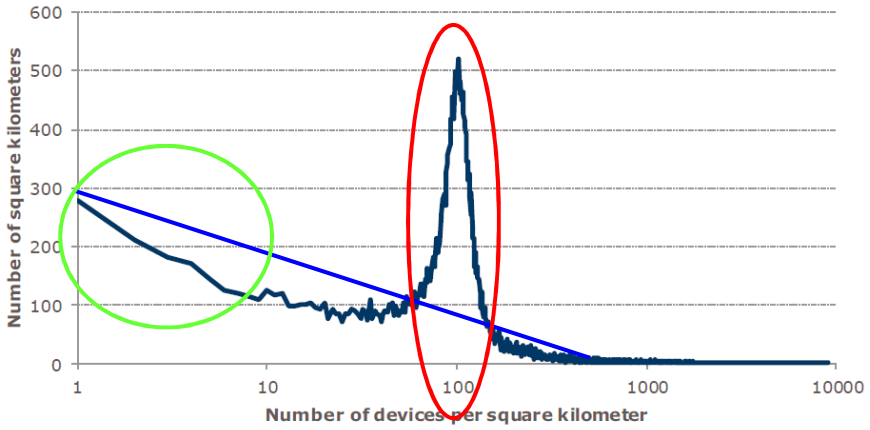
Research agenda

- Report Internet of Things spectrum utilisation and monitoring

Prediction of usage separated in type and devices / km^2 based on a micro ecosystem

Table 10 Number of LPWA devices per application

Type	Relative share	Devices
Smart buildings	24.90%	2,161,000
Agriculture and environment	23.60%	2,047,000
Utility	17.70%	1,532,000
Consumers	12.50%	1,080,000
Logistics	9.60%	831,000
Smart cities	8.60%	748,000
Industrial	3.00%	263,000
Total	**100%**	**8,661,000**



Research agenda

- Report Internet of Things spectrum utilisation and monitoring

For most IoT applications, it is expected that there will be more uplink (device-to-network) than downlink traffic (network-to-device)

- sensors will typically transmit data at (regular) intervals
- actuators will only be controlled irregularly

Note: Tools like SEAMCAT by default totally fail to analyse such scenarios

Research agenda

- Report Internet of Things spectrum utilisation and monitoring

Conclusions observations and recommendations:

Large IoT networks with long range have the maximum effect on spectrum usage. Commercialisation of public space question

Fierce competition between the licensed and unlicensed technology families is expected.

Based on the reports analysis we expect that there will be between 8.6 and 52.1 million LPWA devices in the Netherlands in 2024. Most of the devices are expected to be in the categories *agriculture and environment* and *smart buildings.*

Research agenda

- Report Internet of Things spectrum utilisation and monitoring

Conclusions observations and recommendations:

- Deployment of LPWA IoT networks in licensed spectrum is expected to be gradual and smooth.

LTE-M1 and LTE-M2: good power control, self management.

- SRD based: no self management between networks.

Impact limited but regulatory framework inadequate

limited in efficiency because current duty cycle regulations limit the downlink capacity

Different technologies lead to inefficiency

(RPMA/6LoWPAN/Sigfox/Weightless/DASH7/LoRa,LoRaWAN)

Research agenda

Not a technical report but an analysis of what to expect in the future with a focus on the areas to be important in the future 5-10 years.

Three different perspectives considered:

- Trends in applications and use

- Technology developments and trends

- Spectrum policy

Research agenda

- Report IoT Applications, trends and potential impact on radio spectrum

Based on the theoretical modelling of demand and supply and on data analysis of "the things network"

Considered adaptation areas:

Relatively fast adaptation

Domotica , Automotive, Personal care, Assisted living

Relatively slow adaptation

Medical, smart cities, industrial, manufacturing, agriculture

Research agenda

- Report IoT Applications, trends and potential impact on radio spectrum

Conclusions observations and recommendations:

Investigate the possibility to designate shared, license exempt spectrum for critical applications.

For non-critical or indoor applications the 5 and 60 GHz band are important alternatives

< 1 GHz spectrum is expected to be vital for the further growth of Internet of Things on a ‘smart city’ scale. Good option is the 915-921 MHz band.

Research agenda

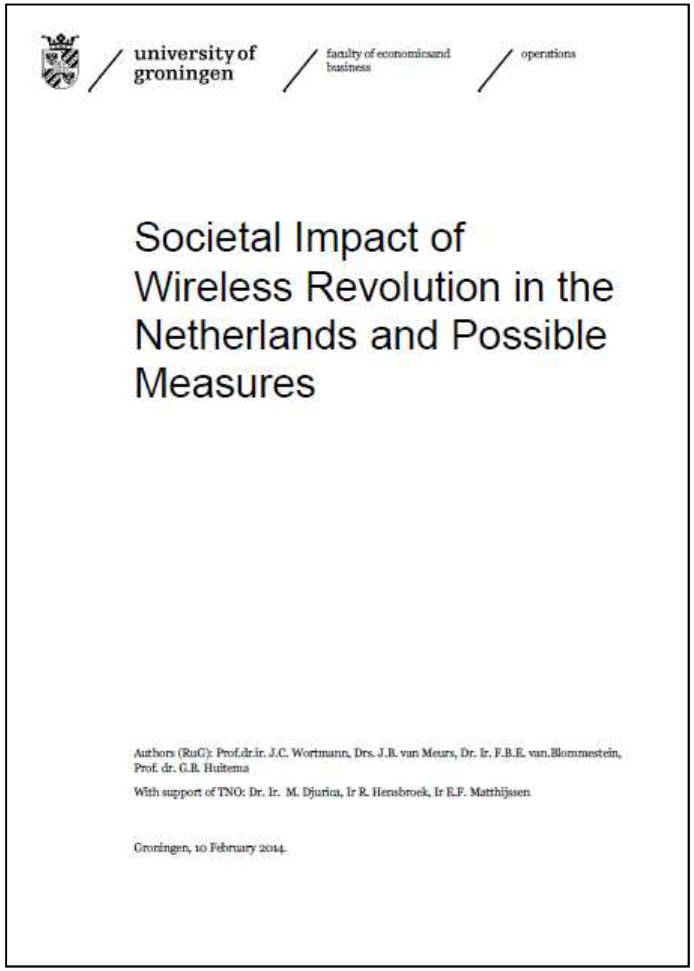
- Report IoT Applications, trends and potential impact on radio spectrum

Conclusions observations and recommendations:

Growth in the number of devices and the variety of protocols in shared spectrum will make monitoring and enforcement more difficult.

The role of the regulator and monitoring agency might (need to) shift towards earlier phases in the manufacturing process

Research agenda


university of groningen / faculty of economics and business / operations

Societal Impact of Wireless Revolution in the Netherlands and Possible Measures

Authors (RuG): Prof.dr.ir. J.C. Wortmann, Drs. J.B. van Meurs, Dr. Ir. F.B.E. van.Blommestein, Prof. dr. G.B. Huitema

With support of TNO: Dr. Ir. M. Djurica, Ir R. Hensbroek, Ir E.F. Matthijssen

Groningen, 10 February 2014.

Focus on healthcare and Industry

Again not a technical report but a report about the use of wireless in critical areas.

Research method, mainly interviews with users focussing on security and reliability.

Research agenda

- Report Societal Impact of Wireless Revolution in the Netherlands and Possible Measures

Conclusions observations and recommendations:

Raise awareness of risks
Prepare standards and regulations for steep growth
Mission critical usage requires back-up solutions
Implement spectrum management in organisations

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Conclusions and actions taking into account the outcome of research

- Participation in / observation of initiatives such as 5G Groningen
- Issuing cheap licences for experimentation
- Promotion of the usage of existing spectrum
- Promotion of sharing with existing services
- No application based regulation (there is no IoT specific spectrum)
- Make a case for frequency bands not directly requested such as DECT
- Informing users about the risk of licence exempt applications for mission critical applications and advise specific approach
- Investigate the possibility of a shared harmonised frequency space for critical applications (in general, not for IoT specific)

Conclusions and actions taking into account the outcome of research

- Actively steer in international committees such as ECC and ITU but also in early stages in for example ETSI
- If any new band is needed it should be 915-921 MHz
- Promote the use of 5 GHz and 60 GHz

References and further information

- research agenda and reports:

https://www.agentschaptelecom.nl/actueel/onderzoeksagenda-agentschap-telecom

- ECC reports: http://www.cept.org/ecc/

- Further contact: erik.vmaanen@agentschaptelecom.nl