



ETSI World Class Standards
ETSI Future Mobile Summit
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WHY 5G?

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PERCEIVED INFINITE CAPACITY
New communication paradigm
For 5G and Beyond



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WHY 5G?



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Impact of Broadband on GDP

- » US could increase its GDP by \$100 billion with an increase of 10 additional broadband lines per 100 individuals (30 million lines)
- » Similar figures are also reported by the EU Commission that 50 % of economic growth in the European Union is driven by ICT
- » Broadband Communications regarded as stimulus of economy (Source: OECD 2011 report)

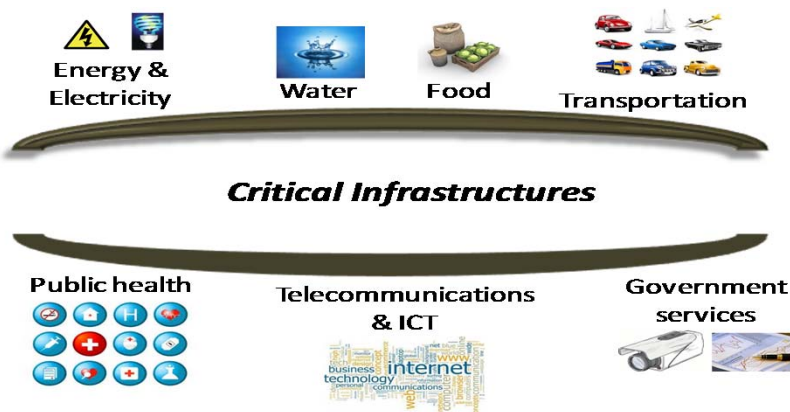
<http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/453&format=HTML&aged>.

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Super National Critical Infrastructure

Fully Connected Digital Economy and Society



- » **Transporting and Controlling** of all the other National Critical Infrastructures

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Broadband Mobile Internet

» Problems

- » Mobile data traffic 1000x by 2020 compared with 2010
- » Mobile Data traffic is doubling every year
- » If trend holds –1000,000x by 2030
- » Capacity doubles every 10 years
 - » Facing radio spectrum/Capacity crunch

» Current thinking

- » 1000x traffic \neq 1000 x capacity
- » 10 (more cells) x 10 (BW) x 10 (spectral efficiency)
- » Advance radio access technologies (new waveforms, massive MIMO, etc.), WiFi-offloading,
- » New Frequency bands –mm bands, 1000 MHz new spectrum

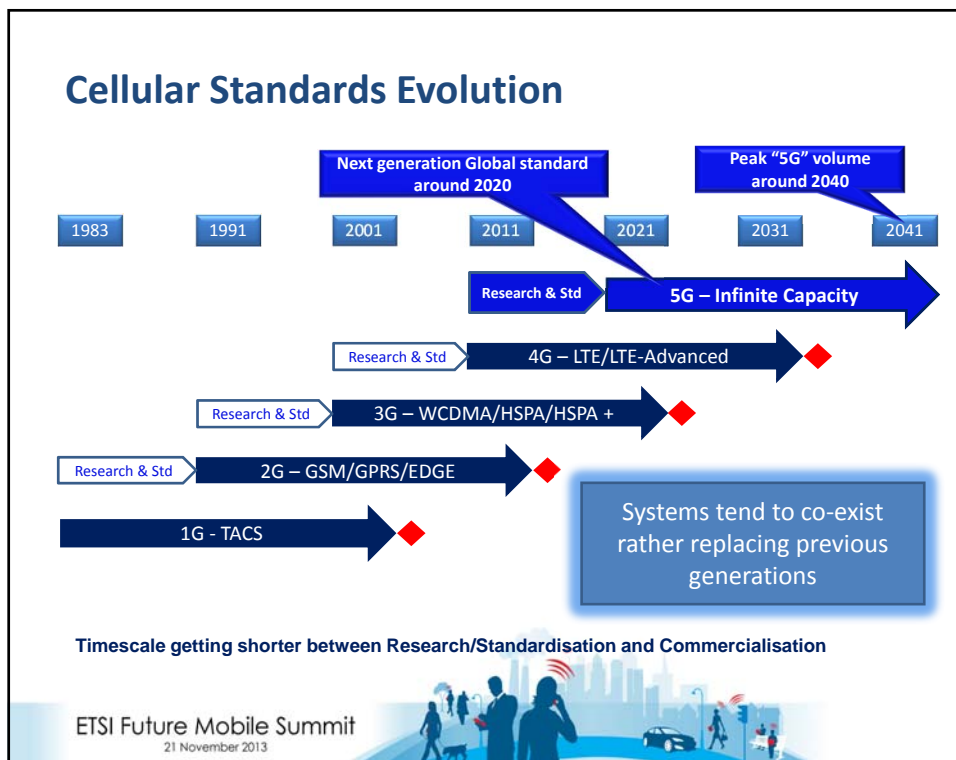


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TOTAL spectrum Requirement (MHz)					
Demand Scenario (UK)	2012	2014	2016	2018	2020
(Profile "A") - Working pop. Inner London					
TOTAL Demand (Gb/s/km ²)	2.10	6.89	14.88	31.55	67.72
ISD = 1000m; cell rad. = 333m	98-215	323-633	700-1520	1480-2900	3175-6225
ISD = 500m; cell rad. = 167m	26-56	88-180	190-395	400-840	860-1800
ISD = 200m; cell rad. = 100m	24-48	32-66	70-144	146-305	313-653
(Profile "D") - UK Peak					
TOTAL Demand (Gb/s/km ²)	0.47	1.54	3.33	7.06	4.68
ISD = 1000m; cell rad. = 333m	22-48	118-158	156-306	330-720	710-1546
ISD = 500m; cell rad. = 167m	6-12.2	20-41	42-88	90-188	192-403
ISD = 200m; cell rad. = 100m	2-4.5	7-15.2	15-32	32-68	70-146
(Profile "F") - UK Mean					
TOTAL Demand (Gb/s/km ²)	0.04	0.14	0.31	0.65	1.40
ISD = 1000m; cell rad. = 333m	2-4.4	6.7-14.5	14.4-31.4	31-67	65-143
ISD = 500m; cell rad. = 167m	0.5-1	1.6-3.3	4-8.2	13-17.3	17.8-37
ISD = 200m; cell rad. = 100m	0.2-0.4	0.6-1.4	1.4-3	3-6.3	6.5-13.5

- SU-MIMO 2 x 2
- SU-MIMO 4 x 2
- SU-MIMO 4 x 4
- SU-MIMO 8 x 2
- MU-MIMO 4 x 2
- MU-MIMO 8 x 2
- CS/CB-CoMP 4 x 2
- CS/CB-CoMP 8 x 2
- JP-CoMP 4 x 2



What is 5G?

“Always Sufficient Rate” to give users the perception of Infinite Capacity”

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Question

In a limited resources world can we achieve Infinite Capacity ?

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Infinite Capacity- is it possible?

- » Point to Point
 - » C_s = Shannon Capacity Limit

- » Point to Multi point –Cellular: 2G----4G
 - » $C_{\text{actual}} \propto C_s \times \text{Cell}_{\text{density}}$
 - » Limited to one degree of freedom – only spatial freq. re-use

- » Point to Multi-cells and multi-users: 5G , 6G,.....
 - » $C_{\text{perceived}} \propto C_s \times \text{Cell}_{\text{density}} \times 1/T_{\text{re-use}}$
 - » $T_{\text{re-use}}$: Time between resource re-use
 - » Two degrees of freedom: Spatial and temporal re-use
 - » $T_{\text{re-use}} \rightarrow \text{QoE}$, $C_{\text{perceived}} \rightarrow \infty$

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Infinite Capacity ... An example...

Infinite Capacity

In a limited resources world only possible by perception

Spatial and Temporal re-use of resources + QoE



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Actual £1 but Perceived £10



Happy bunch !

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5GIC approach

- » Research starts from end user QoE (H2H, H2D, D2D)
 - » Unlike 2G...4G , designed for end device
 - » Data rate is not the differentiation between 5G and previous generations
 - » Area spectral & energy efficiencies, Latency (radio and end to end) ..
 - » Spectrum packing

- » No difference between licenced and licenced-exempt bands
 - » Broadcast, Cellular, WiFi technologies
 - » Differences in Freq Bands
 - »while service offered the same or converging..
 - » Data, Video, Audio

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5GIC Research Approaches



Two complementary

- » Content, User and Network Context
 - » Dynamic user profiling
 - » Data Handling
 - » Intelligent Content (Storage, Search, Delivery) Networking

- » Efficient use of radio spectrum
 - » Area Spectral Efficiency
 - » Energy Efficiencies
 - » Spectrum Uniformity
 - » licensed (and exempt) bands

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Key Features of 5G

- » Capture and use the User context, Content context and Network context
- » QoE and resources efficiency based on user profile
- » Utilisation of telecom and IoT Big Data
- » In-network processing (storage, transmission) for content
- » Dense small cell
- » Device to device
- » Spectrum Sensing
- » Utilize the licensed and unlicensed band
- » New frequency bands: including mm-Wave
- » Split data and control radio network architecture
- » Multi cell cooperation
- » Massive MIMO
- » Full duplex

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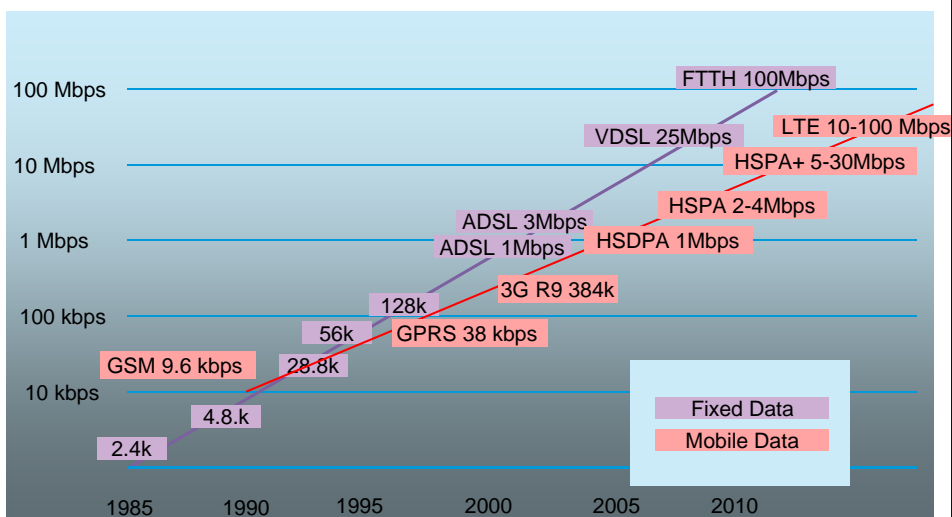
Why Higher Speed

- » 3 reasons
 - » Low latency: Full utilisation of advanced techniques potentials
 - » QoE: Fast network responses
 - » See next...

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Fixed & mobile data rate evolution



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Coverage and Capacity

- » One size does not fit all!
- » Low+ Medium+ High Dense cells
 - » Capacity limited
 - » Coverage limited

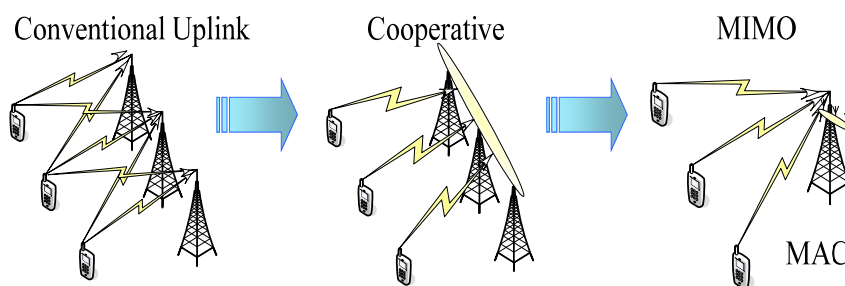
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Why New Air-Interface?

- » Low to medium density cells
 - » 4G (LTE-A,B,C) large cells
- » High Density Cells
 - » **Objectives is NOT link spectral efficiency**
 - » Very low control signalling overhead for management, relaxes the stringent time-frequency control inherent in OFDMA
 - » Flexible implementation of carrier aggregation across highly fragmented spectrum including license-exempt band
 - » Highly energy efficient
 - » Allow full-duplex operation
 - » Sub-millisecond Air-Interface latency
 - » Support fast and reliable spectrum sensing for opportunistic spectrum sharing with and without database support
 - » Support distributed MAC between network and mobile device
 - » Support of device to device communications
 - » Scalable for Machine type communications
 - »

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New Radio Access Architectures

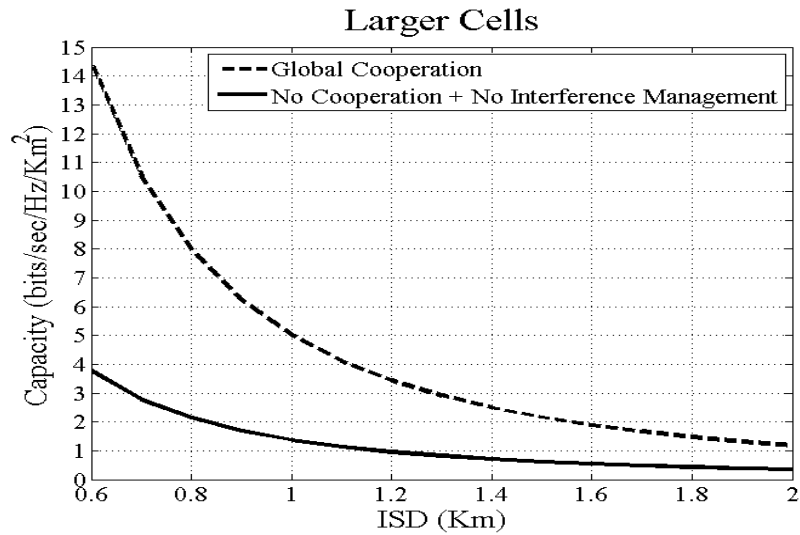


Cooperation converts the distributed cellular system into a MIMO system with distributed antennas

Interference is good

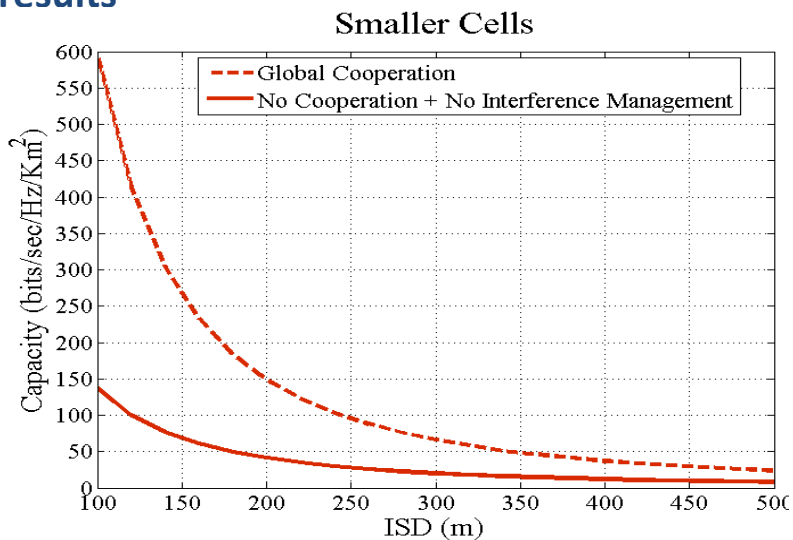
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Larger Cells – Fundamental capacity limits results



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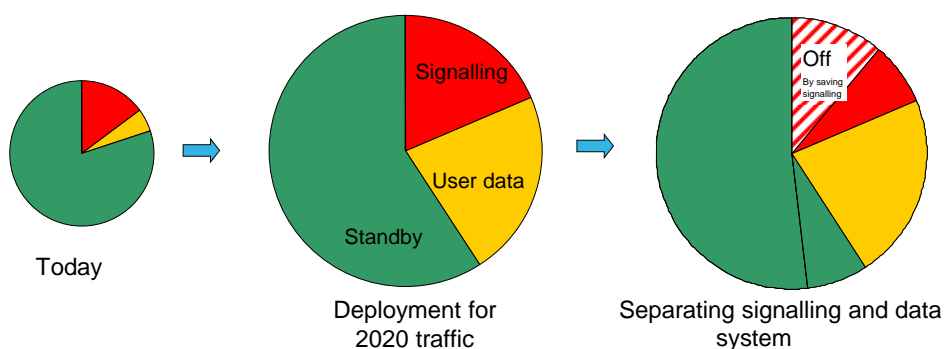
Smaller Cells – Fundamental capacity limits results



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New RA Architecture-SDN principles to Radio Access

- » Dynamic provisioning of resources
- » Data and Signalling resources separation
- » Reduce in signalling
- » Reduce in energy consumption
- » Cutting Energy, Cost and RF Emission



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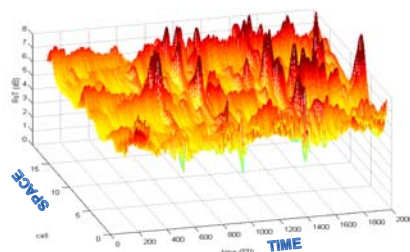
5G system approach - Summary

- » 5G includes: All other National Critical infrastructures including mobile broadband
- » New business models
- » Old approach to 2G, 3G and 4G not sustainable
- » Focus : Perceived infinite capacity
 - » Latency
 - » Energy Efficiency
 - » Scalability
 - » Reliability and Robustness
 - » Distribute control between Network and Devices
 - » Uniformity between licensed and license-exempt bands (including Broadcast)
 - » Dense cell technologies
 - » Explore and understand new frequency bands

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5G Targets

- » Maximum, Average or Percentile as cell rates not relevant



- » Targets:
 - » Area Spectral Efficiency...
 - » Energy Efficiency....
 - » Latencies: E2E and Over The Air...
 - » QoE....

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Let's make infinite capacity a reality

Thank you

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