WIRELESS MACHINE-CENTRIC COMMUNICATIONS

INTERNET OF THINGS (IOT)
CONNECTED DEVICES
INDUSTRIAL APPLICATIONS

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WIDE RANGE OF REQUIREMENTS FOR MACHINE-TYPE COMMUNICATION

MASSIVE MTC

SMART BUILDING

LOGISTICS, TRACKING AND FLEET MANAGEMENT

SMART METER

SMART AGRICULTURE

CAPILLARY NETWORKS

CRITICAL MTC

REMOTE HEALTH CARE

TRAFFIC SAFETY & CONTROL

INDUSTRIAL APPLICATION & CONTROL

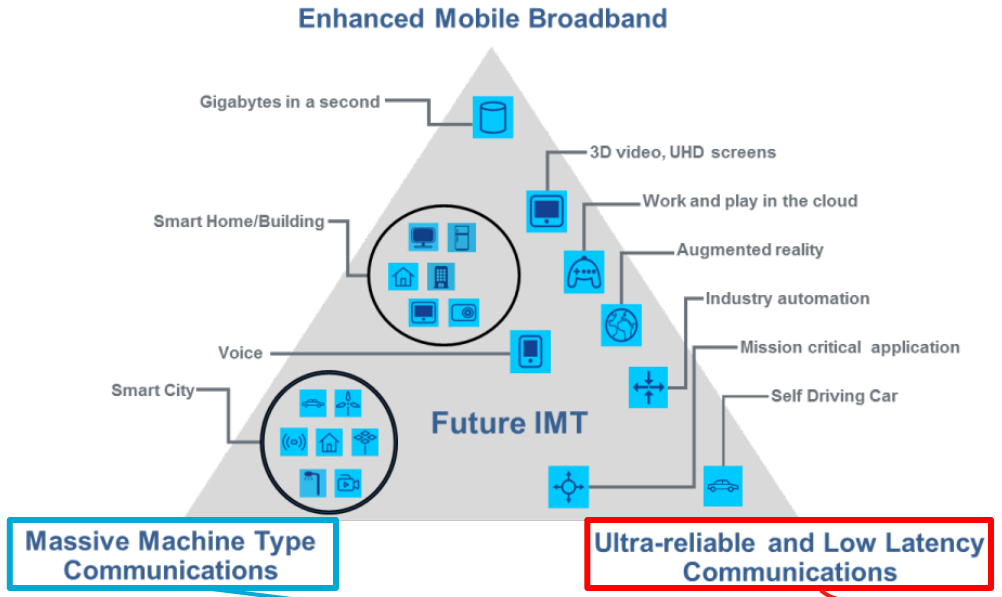
REMOTE MANUFACTURING, TRAINING, SURGERY

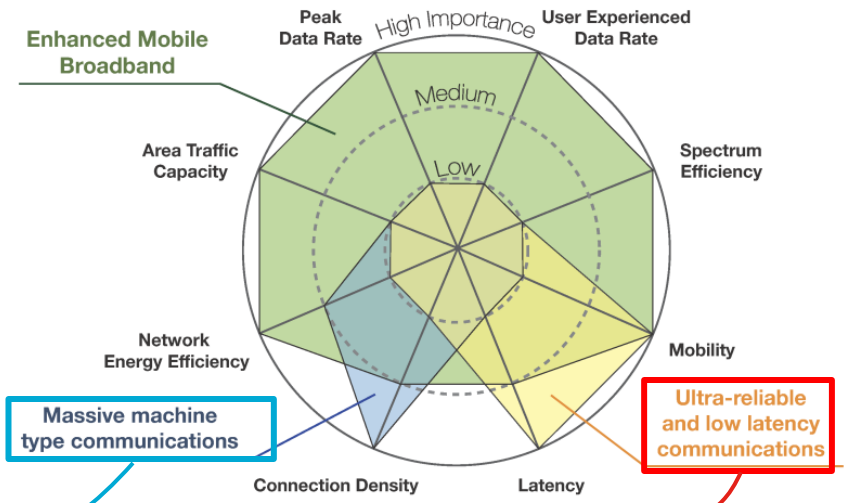
LOW COST, LOW ENERGY
SMALL DATA VOLUMES
MASSIVE NUMBERS

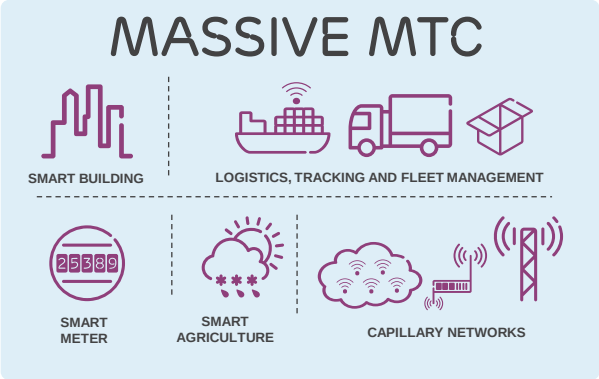
ULTRA RELIABLE
VERY LOW LATENCY
VERY HIGH AVAILABILITY

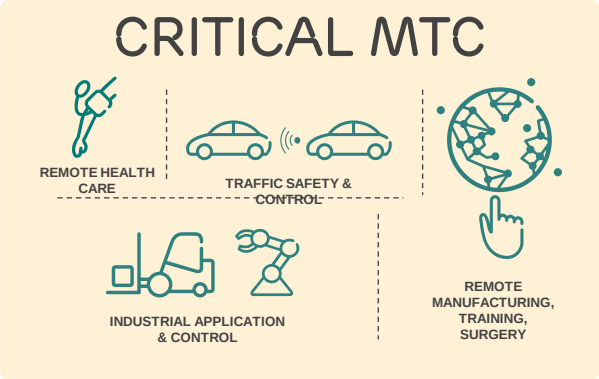
IMT-2020 - NEW MTC USE CASES

ITU-R Recommendation M.2083, Framework and objectives for IMT 2020







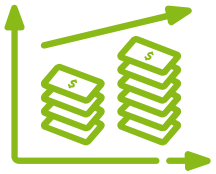


ENVIRONMENT AND POLICIES FOR SUCCESSFUL MARKET DEVELOPMENT

- Evolution of competitive wireless communication technologies
  - Enable technologies to address new requirements and drive new fields

- Enable economy of scale
  - International harmonization of regulation
  - Global standards

- Open market access
  - Enable market players to develop ecosystem and provide solutions
  - Market competition



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MASSIVE MTC
TECHNOLOGY CHOICES

Internet of Things

- Simple cheap devices
- Low energy consumption
- Can be massive numbers
- Coverage everywhere

Licensed spectrum

3GPP Releases 12/13
- LTE evolution for Massive MTC

3GPP Release 13
- New narrowband air interface (NB-IoT)
- Extended coverage GSM-IoT (EC-GSM-IoT)

License-exempt spectrum

Short Range
- Bluetooth Low Energy
- IEEE802.11ah
- IEEE802.15.4
- ZigBee
- Z-Wave
- …

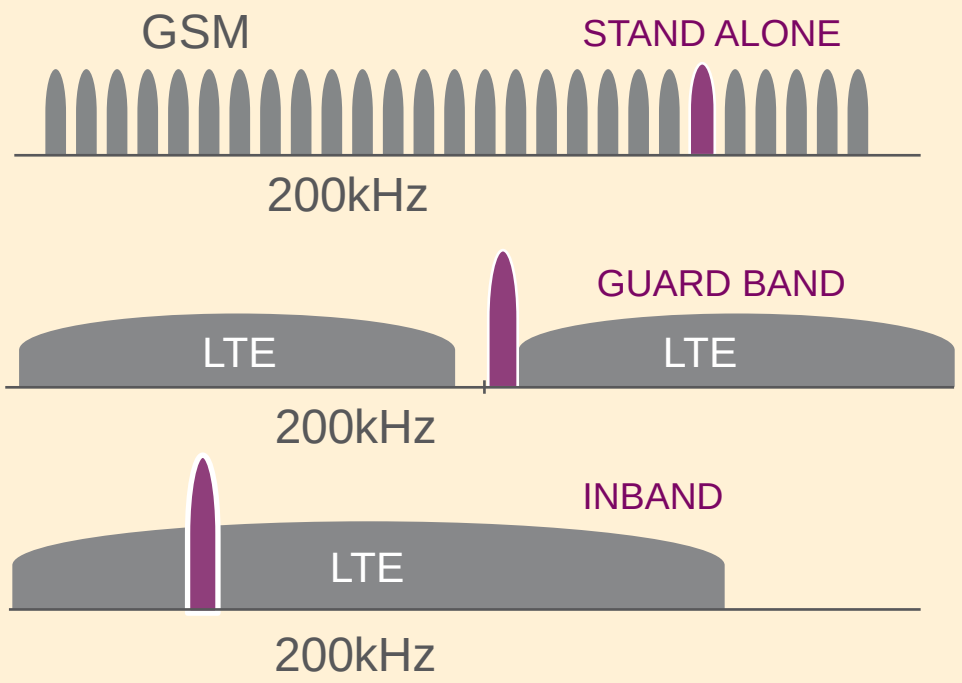
Long Range
- Sigfox
- Weightless
- Ingenu
- LoRaWAN
- …

CELLULAR IOT CONNECTIVITY

ADDRESSING DIVERSITY OF USE CASES

DEVICE COST | BATTERY LIFE | COVERAGE

EC-GSM-IoT	Global cellular IoT for all GSM markets
LTE-M	Wide range of applications
NB-IoT	Ultra low-bitrate applications Flexible deployments



MASSIVE -MTC MARKET STATUS QUO

- Competitive wireless communication technologies ? ☑
  - Many competitive solutions under deployment / trial

Licensed spectrum

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- Economy of scale ? ☑
  - Standardized solutions & installation on global basis
- Open market access ? ☑
  - Different market access options competing (operators, private networks, X-as-a-service)
- **No market barriers**

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CRITICAL MACHINE-TYPE COMMUNICATION: GUARANTEED IN-TIME DELIVERY

Industrie 4.0, Cyber-physical systems & networking, Industrial Internet of Things, Critical infrastructures

Factory Automation
≤ 1 ms, 10^{-8}

Motion Control
≤ 1 ms, 10^{-9}

Remote Control
5-100 ms, 10^{-6}

Smart Grid
3-5 ms, 10^{-6}

Tactile Internet
1 ms, 10^{-8}

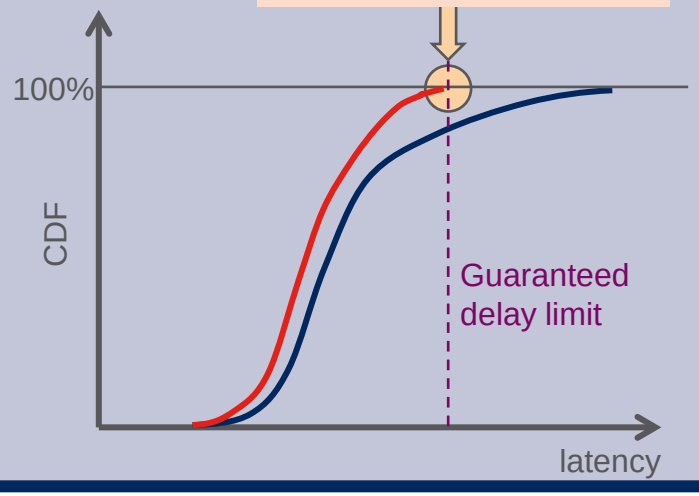
Process Automation
100 ms, 10^{-8}

Numbers are examples, requirements vary within one application area

Ultra-reliable low latency communication

Metric: 99.9999…-percentile

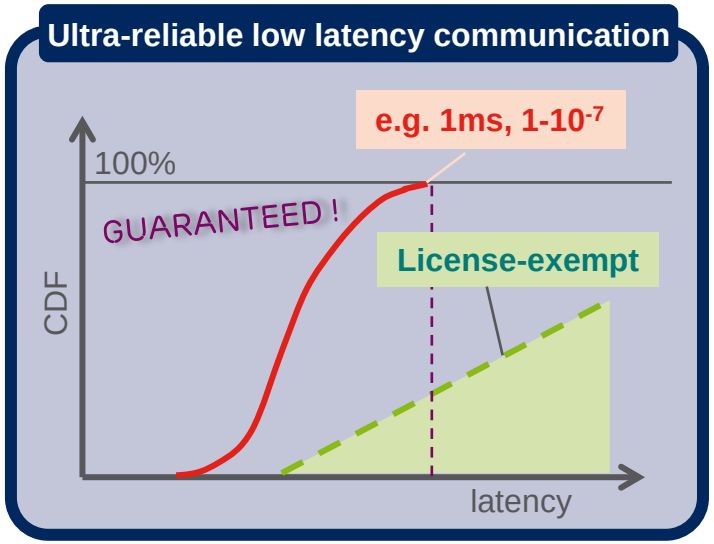
Focus on worst-case



- Limited possibility of license-exempt radio for reliable low latency services
  - Uncontrollable delay (listen-before-talk)
  - Uncontrollable interference

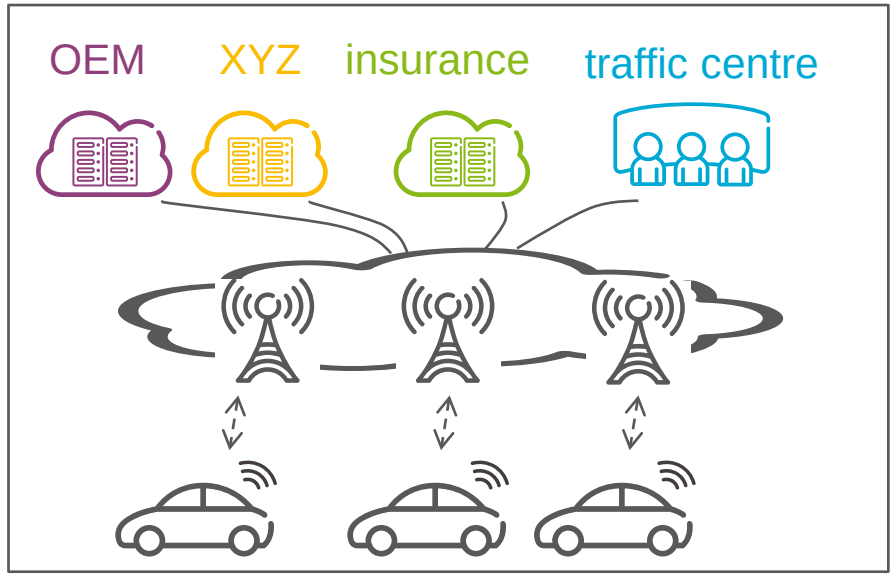
CRITICAL-MTC MARKET STATUS-QUO

- No wireless solution in place today
- Some 5G components for Critical-MTC
  - Physical layer design for low latency
  - Exclusive spectrum usage with
    - Controlled fast access to radio channel (MAC)
    - Controlling interference of simultaneous transmissions
- Requirements and market situation
  - Access to exclusive spectrum required (but often locally)
    - Potentially mobile operator driven business
    - Spectrum leases, light licensing, local licenses, licensed-shared access, …
  - Eco-system, business models still to be developed



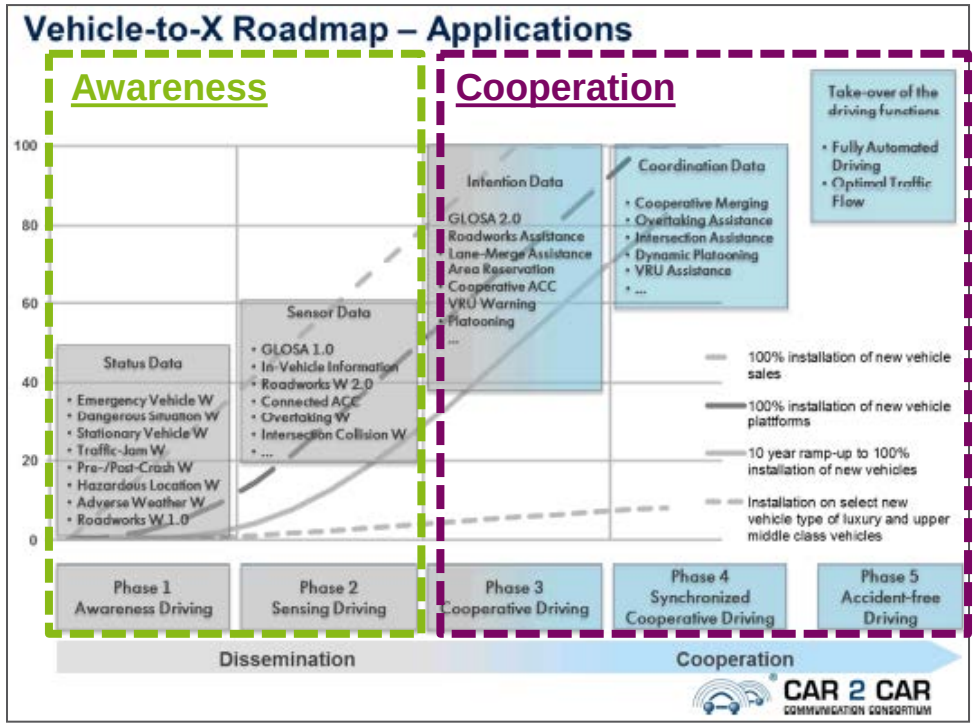
INTELLIGENT TRANSPORT SYSTEMS (ITS) & VEHICULAR NETWORKING (1)

- Growing market for commercial vehicular and ITS cloud services for connected cars
  - Pay-as-you-drive insurance
  - Remote diagnostics and maintenance
  - Dynamic traffic and map information (points-of-interest)
  - Fleet management
  - …
- Based on cellular networks (2G / 3G / 4G)
  - Often with embedded and global SIM



INTELLIGENT TRANSPORT SYSTEMS (ITS) & VEHICULAR NETWORKING (2)

- Cooperative ITS services (often vehicle-to-vehicle)
  - First wave of services: assisted driving <100ms latency
    - IEEE 802.11p as basis for ITS-G5 (Europe) / WAVE (US)
    - LTE-V2X currently standardized in 3GPP
  - 2nd wave services: self-driving, collective perception
    <5-10ms latency – safety critical, may incl. video exchange
    - Scalability of IEEE 802.11p unclertain
    - Envisioned in 5G-V2X and evolved LTE-V2X
  - ITS spectrum assigned in US, Europe, Australia (5.9 GHz)
    - Other allocation in Japan
    - China spectrum assignment ongoing in 5 GHz



V2X – vehicle-to-anything

ITS MARKET STATUS QUO

- Commercial vehicular & ITS cloud services growing based on mobile networks and specific vehicular service offerings

- Wireless communication technologies
  - 3GPP 2G, 3G, LTE for network based communication
  - IEEE 802.11p and upcoming 3GPP LTE-V2X for vehicle-to-vehicle (V2V) communication
  - Evolved LTE and 5G for future use cases (V2V and low-latency network based communication)

- Market access
  - ITS spectrum partly aligned, with some regional variations and allocations ongoing
  - Technology migration and technology coexistence to be considered
  - For non-commercial services: eco-system, business models still under development

SUMMARY

WIRELESS COMMUNICATIONS FOR M2M & INTERNET OF THINGS & INDUSTRIAL APPLICATIONS

- **Massive Machine-Type Communication**
  - Many solutions exist (licensed and license-exempt)
  - Larger scale uptake starting, market forces will determine winning solutions
- **Critical Machine-Type Communication**
  - Standardization objectives are being defined for 5G, first steps in LTE evolution
  - Exclusive spectrum access is pre-requisite for guaranteed low latencies
  - Market access options, business models and ecosystem not yet clear
- **Vehicular networking and Intelligent Transport Systems**
  - Solutions for first phase of cooperative ITS services (IEEE 802.11p and upcoming LTE-V2X)
  - Future-proof evolution needed for next phases of ITS services (evolved LTE-V2X and 5G-V2X)
  - Non-commercial services: market access, business models and ecosystem still in infancy
  - Commercial vehicular IoT services are successfully deployed based on cellular networks

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