DEUTSCHE TELEKOM CAPITAL MARKETS DAY 2018

LIFE IS FOR SHARING.

TECHNOLOGY & INNOVATION

CLAUDIA NEMAT

KEY MESSAGES

01 SUPERIOR PRODUCTION MODEL
We are entering the final stages of our peer leading superior production model. While we have learned lessons on the way, we can broadly confirm financial and customer experience benefits.

02 LEAD IN 5G
We will leverage our superior fiber networks and modernized SRAN to lead in 5G. Within an overall stable CAPEX envelope, we will focus on:
1) smart capacity/speed upgrade
2) FWA
3) selected new products/solutions.

03 ACCELERATED DIGITALIZATION
Our agile approach to IT transformation will enable accelerated digitalization for better customer experience and lower cost in accordance with the superior production model.

04 LEAD IN CUSTOMER EXPERIENCE AND BUSINESS PRODUCTIVITY
To lead in customer experience and business productivity, we have market proven innovations and a compelling innovation pipeline going forward.

REVIEW 2014 – 2018

REVIEW 2014−2018

	Ambition level 2018	Achievements 2017	Delivered
ALL-IP TRANS-FORMATION	▪ All integrated countries 100% IP-based	▪ Slovakia, Croatia and Hungary 100%, Greece 45% (100% in 2019[1]) ▪ Germany 67% (consumer 100% in 2019, business finished in 2020)	🟡
PAN-EUROPEAN NETWORK	▪ Backend and frontend data centers set up ▪ Geo-redundant Network Operations Centers established ▪ Services fully migrated to Pan-Net	▪ Backend data centers in Hungary and Poland in 2017, Greece in 2018. Frontend according to roll-out plan ▪ Set up in Romania and Germany ▪ Selected services migrated	🟢 🟢 🔴
INTEGRATED NETWORK STRATEGY	▪ LTE pop-coverage Germany & Europe: 75%–95% ▪ Germany: ≈ 80% Fixed high speed internet HH coverage ≥ 50 Mbps[2] ▪ Europe: ≈ 50% Fixed high speed internet HH coverage ≥ 100 Mbps	▪ Germany 94% and Europe 94% ▪ ≈ 80% HH vectoring coverage in 2019 ▪ 32%	🟢 🟢 🔴

[1] Intentional postponement by one year in Greece to refocus invest on access   [2] Depending on regulatory adjustments

SUPERIOR PRODUCTION MODEL – SUCCESSES/LESSONS LEARNED

Digital Transformation

- Our shift towards an agile approach to IT transformation with upside on customer experience and lower cost in accordance with promised savings

Source: CMD 2015 commitment

DIGITAL TRANSFORMATION OF CUSTOMER FACING PROCESSES

COST EFFICIENCY & SIMPLICITY

ALL-IP TRANSFORMATION
PSTN migration in all NatCos

PAN-EUROPEAN NETWORK
Centralized, virtual architecture and production platforms
PAN NET

INTEGRATED NETWORK STRATEGY
1 LTE roll-out
2 Optical fiber
3 Vectoring
4 Hybrid access

We confirm CMD 15 gross cost savings of €1.2 bn for early 2020ies as well as customer experience benefits

ALL IP Migration

- Peer leading IP migration
  - Scope: Simplification across all (!) layers
  - Achievements: Complete or close to completion in all major markets
- We see clear customer experience benefits and network cost savings

PAN-European Network

- Modified approach: Focus on value creation through virtualization and cloudification
- We centralize services only when it accelerates time to market

Integrated Network Leadership

- Clear differentiation by integrated networks: We create the basis for FMC commercialization
- Superior fiber backhauling: We have a competitive advantage for 5G experience
- Mobile technology leadership in Germany and in 9 out of 12 European countries: We create a better customer experience and can monetize it

CUSTOMER BENEFITS OF ALL IP MIGRATION ARE PROVEN

Customer benefits

Precondition for plug & play
- Auto-provisioning (without filling in credentials)
- Improved customer satisfaction regarding provisioning

Fewer incidents
- 38% fewer tickets in provisioning

Massive speed uplift
- Simplification of aggregation network layer (BNG) as basis for product innovation
- Example: 250 Mbps Super Vectoring product

BNG migration as basis for (Super) Vectoring

of Super Vectoring homes passed/BNG migration quota

	2017	2018e	2019e
Super Vectoring homes passed		15 mn	28 mn
BNG migration quota	77%	95%	100%

Super Vectoring homes passed

% BNG migration quota
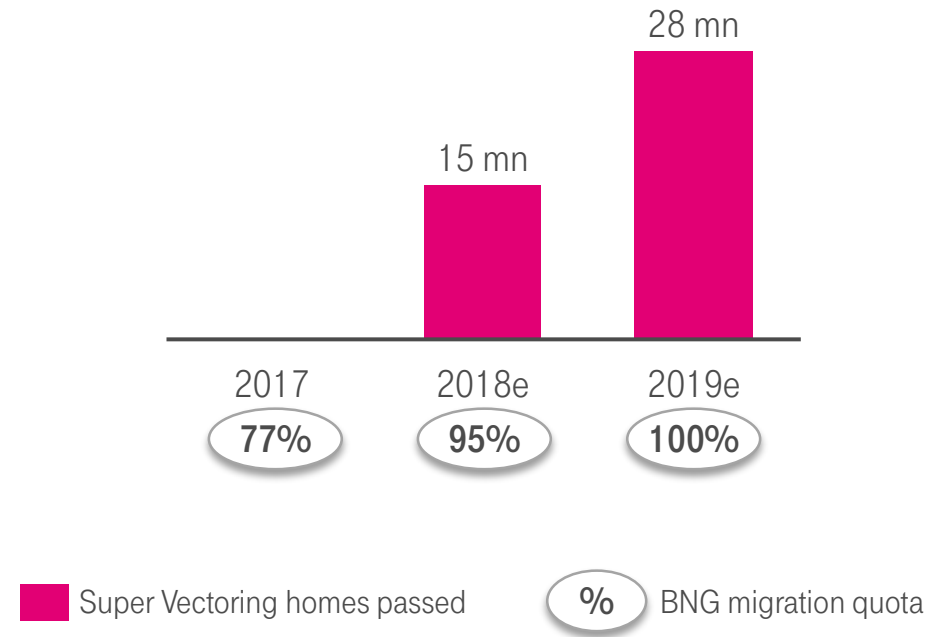
INTEGRATED NETWORK LEADERSHIP IN GERMANY AND EUROPE

Mobile network leadership for best customer experience

TESTSIEGER

CHIN UP, VERIZON,
YOU CAN'T WIN THEM ALL.
I MEAN, WE JUST DID. BUT YOU CAN'T.

T-Mobile just placed #1 in ALL SIX OpenSignal categories!

SPEEDTEST

Connect
Test 2017

OpenSignal
Test 2017
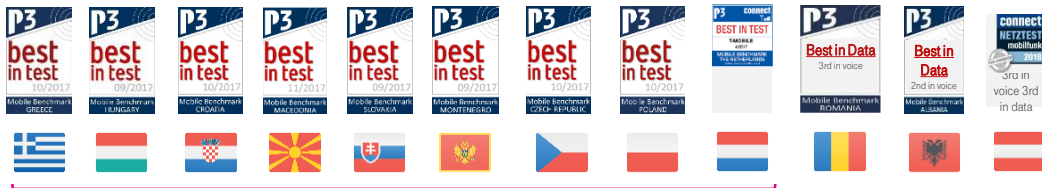
P3 Benchmark 2017:
Mobile technology leadership in 9 of 12 countries
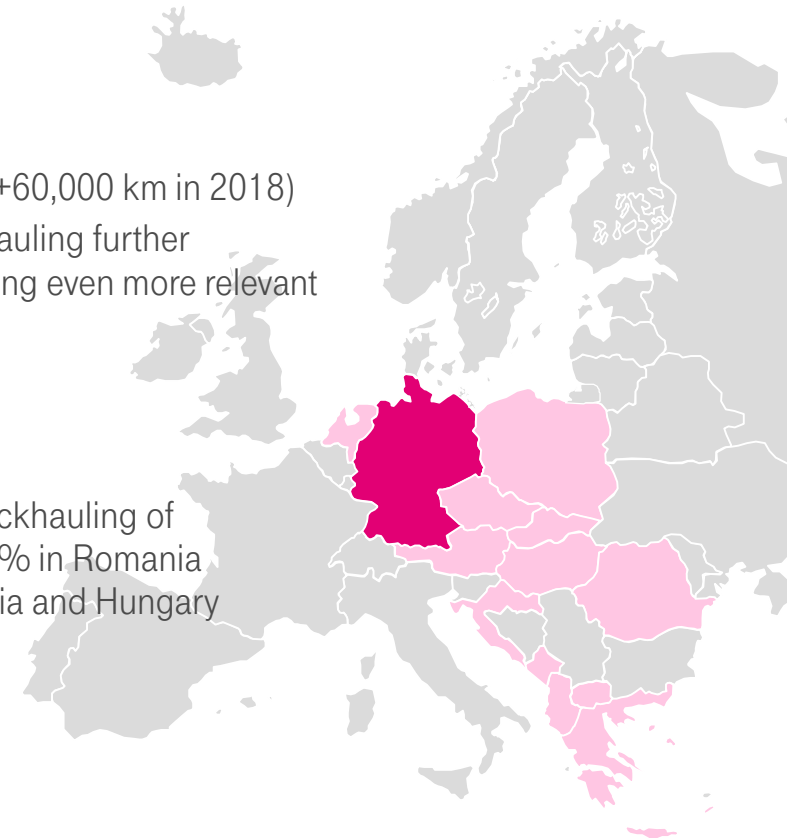
Connect Test
2017

[1] w/o TM NL

Fiber advantages – status 2017

GERMANY

- 455,000 km fiber (+60,000 km in 2018)
- ≈ 80% fiber backhauling further increasing, becoming even more relevant with 5G

EUROPE[1]

- 240,000 km fiber
- Exemplary fiber backhauling of 74% in Croatia, 51% in Romania and 47% in Slovakia and Hungary

STRATEGY 2018 – 2021

TECHNOLOGY & INNOVATION AMBITION

Our strategy

GROW

LEAD IN CUSTOMER EXPERIENCE	LEAD IN TECHNOLOGY	LEAD IN BUSINESS PRODUCTIVITY
ONE CONNECTIVITY & PERFECT SERVICE	INTEGRATED GIGABIT NETWORKS	SECURE ICT SOLUTIONS & BIG IOT
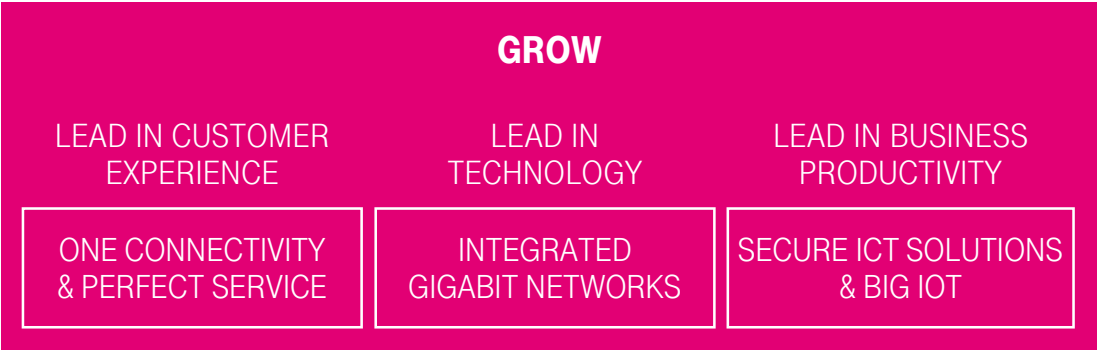
SAVE FOR GROWTH INVESTMENTS

SIMPLIFY, DIGITALIZE, ACCELERATE

Our Technology & Innovation contribution

1 LEAD IN TECHNOLOGY

- Integrated network leadership: Fiber build out and leadership in mobile experience[1]
- Smart 5G leadership

2 VALUE TRANSFORMATION

- Broadband production innovation to drive Opex and Capex efficiencies, IP-migration completion
- Agile approach towards IT transformation to accelerate digitalization

3 LEAD IN CUSTOMER EXPERIENCE AND BUSINESS PRODUCTIVITY

- Market proven innovations in B2C and B2B with compelling innovation pipeline going forward

[1] Covered in segment chapters

1 WE WILL DEPLOY 5G SMARTLY

1. Mobile Capacity/ Speed Upgrade

2. Fixed Wireless Access

3. Selected new products/solutions

	1. Mobile Capacity/Speed Upgrade	2. Fixed Wireless Access	3. Selected new products/solutions
CAPABILITY	▪ Enhanced mobile broadband	▪ Gigabit speed on higher frequencies/millimeter waves	▪ Massive IoT ▪ Low latency, QoS
APPLICATION AREA	▪ Starting with areas of interest (cities, campus networks; as overlay on 4G)	▪ Complement to FTTH/B in (sub-) urban areas	▪ In selected areas of interest
ECONOMIC RATIONALE	▪ More efficient than 4G from 2021 onwards	▪ Depending on topology, more cost-efficient than FTTH/B, faster time to market	▪ Enable new revenue streams

1 ENHANCED MOBILE BROADBAND

Current frequencies
- 800 MHz/900 MHz/1800MHz/2.1 GHz/2.6 GHz

MIMO (multiple input multiple output)
- 2T2R, 4T4R or even 8T8R antenna architecture without usage of massive MIMO

Radius of cell coverage
- Radius of higher frequencies physically lower
- In a standardized environment the radius of 1.8 GHz is two times bigger compared to 3.5 GHz

... will be enlarged by use of additional spectrum bands
- 700 MHz and especially 3.x GHz

... and the evolution towards massive MIMO
- Massive MIMO architecture typically 64T64R on 3.5 GHz within a practical size/dimension of the whole antenna

... lower on 3.5 GHz but optimized by beamforming and smaller cells
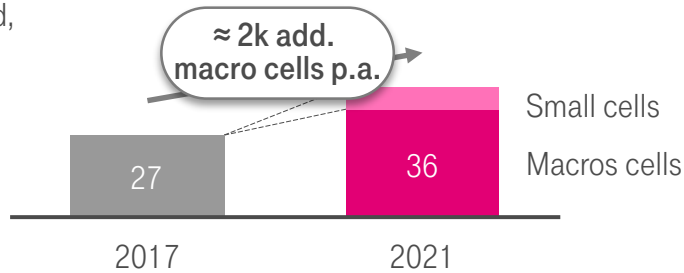- Active antenna technology, massive MIMO and dynamic beamforming optimize coverage and minimize the impact of a reduced radius of cell coverage

1 GETTING READY FOR 5G TO LEVERAGE FUTURE EFFICIENCIES
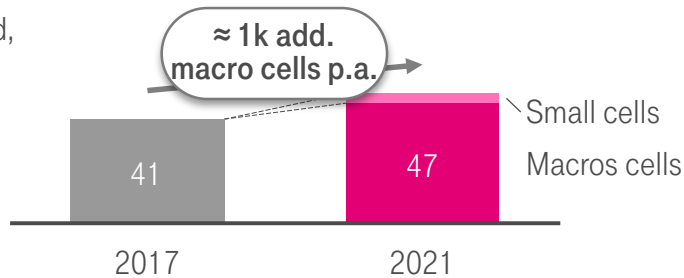
5G readiness, e.g. cell densification until 2021

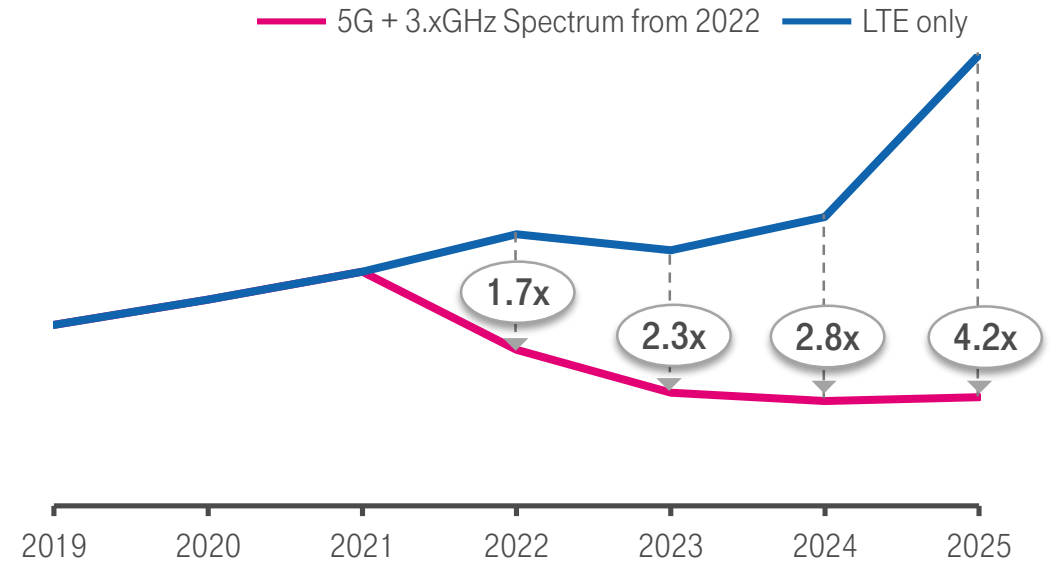### Germany
Cell sites, estimated, k

≈ 2k add. macro cells p.a.

2017	2021
27	36

Small cells
Macros cells

Europe
Cell sites, estimated, k

≈ 1k add. macro cells p.a.

2017	2021
41	47

Small cells
Macros cells

- Cell densification starts in areas of interest (cities, campus networks)
- Superior fiber backhauling and SRAN

Cost per Mbit/s for 4G/LTE only vs. with 5G overlay

€ per Mbit/s as efficiency factor[1]

— 5G + 3.xGHz Spectrum from 2022   — LTE only

1.7x   2.3x   2.8x   4.2x

2019   2020   2021   2022   2023   2024   2025

[1] Network capacity costs per incremental busy hour capacity, assuming annually increasing traffic demand of 45%

1 WITH 5G FWA, WE CAN PROVIDE GIGABIT SPEED FAST

We trialed FWA in different topologies of Germany ...

Example 60 GHz trial

FIBER IN THE STREET
100 M

Sub urban

Dense urban

... with promising results

Explanation

- Millimeter wave frequencies 26 (licensed) and 60 (unlicensed) GHz
- Enables Gigabit speeds
- Number of HH depends on topology (line of sight is mandatory)
- Designed to be at least competitive with cable

Benefits

- Initial Capex demand – 30–50% of FTTH/B. Only after 20 yrs. TCO of FTTH/B more favorable due to higher annual OPEX for FWA
- Faster time to market
- Less underground construction capacity needed
- Equipment reusable
- De-risking fiber roll-out

20–30% of HH where fiber is available in the streets

① CAMPUS NETWORKS ARE FIRST SOLUTIONS WITH 5G/EDGE

Operator managed campus networks

Public cellular coverage

Private indoor & local cellular coverage

Robots & Machinery
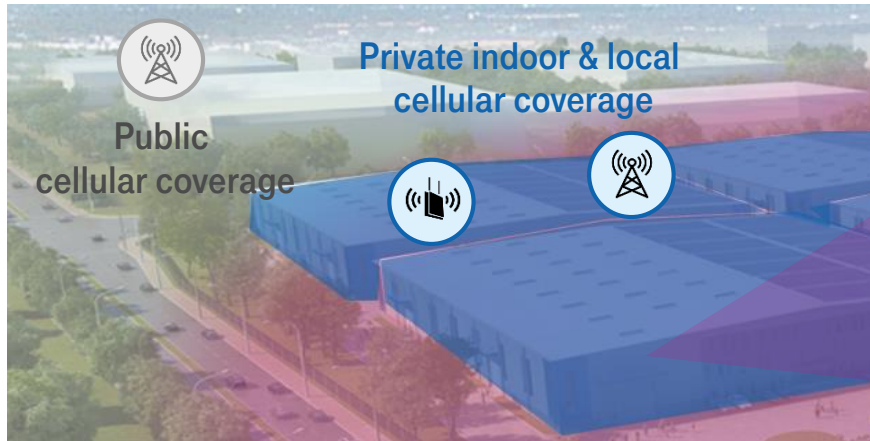
"Dual Slice" Campus
- Connectivity infrastructure
- IoT device management
- Starting now with 4G

➕

Autonomous factory
- Tailored network configuration
- Edge cloud for low latency requirements (robot steering)

Potential 5G application areas:

(Multi-) Local
- **CAMPUS NETWORKS**
- Information augmented visions
- Immersive media, event-driven
- (Decentral) energy management

... and beyond:
- Connected drones
- Emergency health care

1 REAL TIME ECONOMY OPENS BOUNDLESS OPPORTUNITIES

2018   **2019**   **2020**   **2021**   **2022**   **2023**   **2024**   **2025**   **2026**   **2027**   **2028**

Today...

- Humans experience the internet via app or browser on certain devices

- Computing power, storage and algorithmic intelligence hosted in central data centers or on the devices (PC, smartphone, car, etc.)

- Connectivity experience differentiates via speed and coverage

... and in the future

- ... also experience connectivity naturally according to human senses (via voice recognition, ear plugs, lenses, glasses, textiles, etc.)

- ... also in (edge) clouds deeply embedded into the networks

- ... also via low latency, precise positioning, security and massive IoT

2 BROADBAND PRODUCTION INNOVATION DRIVES EFFICIENCY

Examples

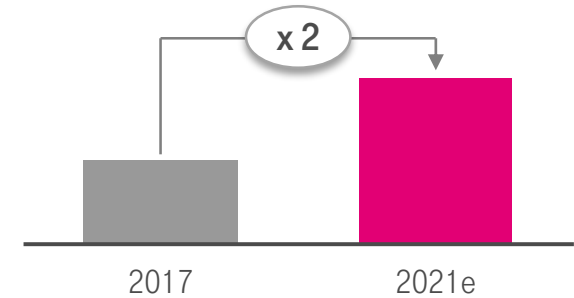**AUTOMATED FIBER ROLL-OUT PLANNING**
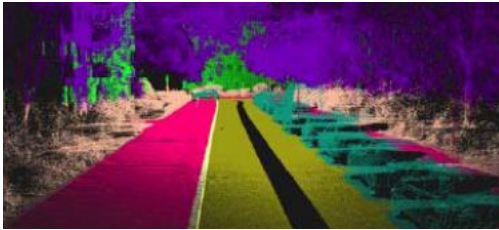
Description

- 3D surface planning put into point cloud
- Applying machine learning
- Generating automated passive infrastructure planning
- Pilot starts in Q3/2018

Impact

- Increase of planning **productivity by FACTOR TWO**

x 2
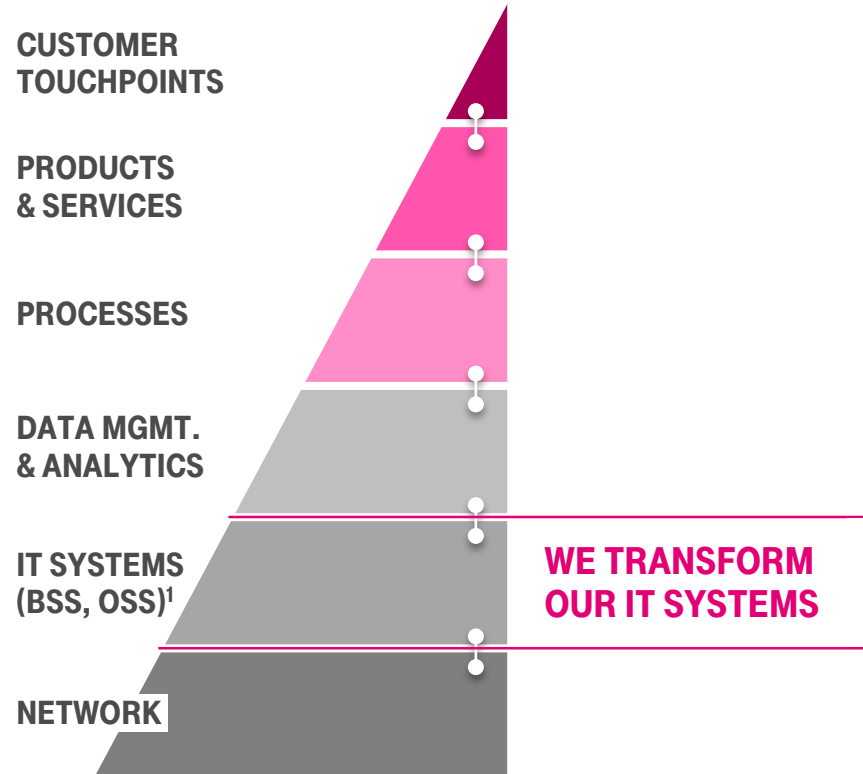
2017   2021e

"ACCESS 4.0"

- Ongoing R&D project to split software and hardware components in wireline like OLT[1] + MSAN ("access virtualization")
- Potential partnering discussions started

- IT will **disrupt** current ecosystem of OEMs (massively lower procurement prices)

[1] OLT = Optical line termination: the endpoint of our passive optical network, mostly located in street cabinets

# 2 IT TRANSFORMATION ENABLES ACCELERATED DIGITALIZATION

CUSTOMER TOUCHPOINTS

PRODUCTS & SERVICES

PROCESSES

DATA MGMT. & ANALYTICS

IT SYSTEMS (BSS, OSS)[1]

NETWORK

WE TRANSFORM OUR IT SYSTEMS

Paradigm shift in our approach towards it transformation

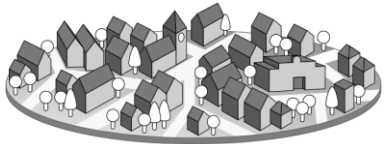| From		To
Big bang for BSS[1]	▶	Portfolio approach
Waterfall	▶	Agile
Traditional skills	▶	Comprehensive skill transformation

[1] BSS: Business Support System/OSS: Operations Support System

2 NEW PORTFOLIO APPROACH REDUCES TRANSFORMATION COMPLEXITY
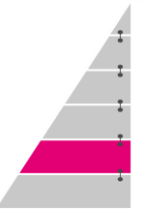
From

Attempt to replace legacy by big bang

- Design for single purpose
- High complexity

To

Portfolio approach with strong business-IT alignment

▶ Selective Greenfield

- Agile scrum teams for dedicated projects:
  - Fiber roll-out
  - Retail FMC
  - B2B FMC

▶ Decoupling

- Esp. customer touch points from the business support system

▶ Modernization

- Modernization for bulk of systems by creation of reusable (Micro-)services
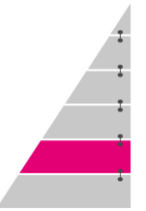
Impact

... reduced delivery time
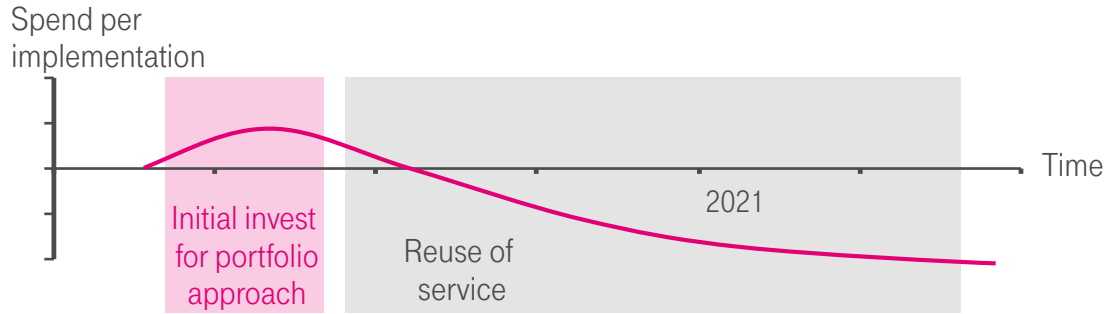
... mitigated risk (compared to big bang)

... higher reusability to reduce IT cost midterm

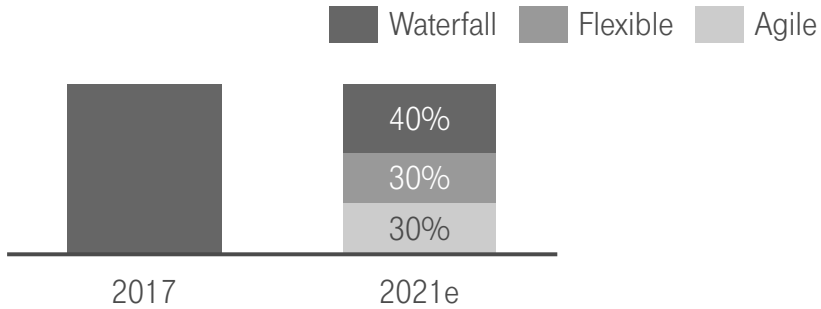# 2 CLEAR IMPACT EXPECTED ESPECIALLY ON TIME TO MARKET

Portfolio approach with payback of 2–3 years
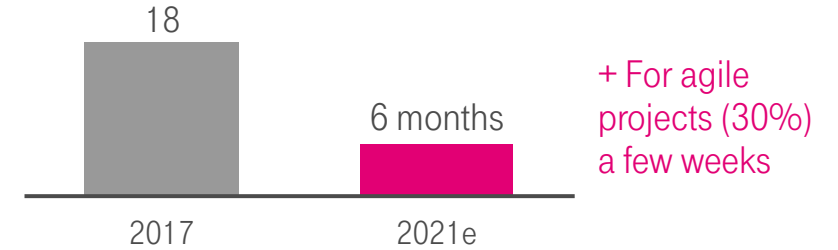
Initial invest for portfolio approach

Spend per implementation

Initial invest for portfolio approach

Reuse of service

2021

Time

Degree of delivery modernization,
% of delivery

■ Waterfall ■ Flexible ■ Agile

2017

2021e
- 40%
- 30%
- 30%

Impact of IT transformation

1 Average delivery time,
month

18 (2017)

6 months (2021e)

+ For agile projects (30%) a few weeks

2 Enabling process efficiencies in segments,
% of delivery

3 IT spend reduction,
bn €

2017

2021e

- €0.2 bn
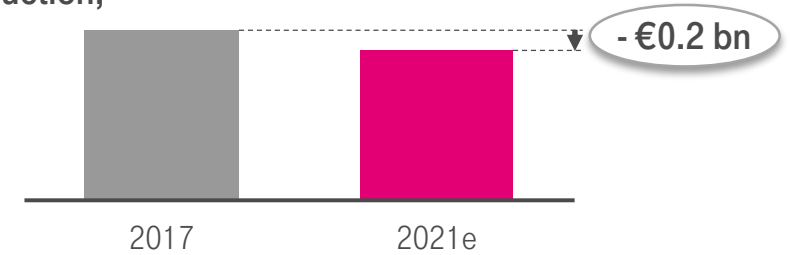
❸ LEAD IN CUSTOMER EXPERIENCE INNOVATION

Market proven

Entertain/TV ✓
- 3.1 mn users in Germany, 4.2 mn in EU
- €2 bn revenues in Germany and EU

Hybrid router ✓
- 370,000 users

Smart Home ✓
- Launched in 7 countries
- 283,000 HH, 80% YoY growth in Q1 2018 in Germany

NOW

Recently launched

Connect App ✓
- Launched in Germany, 1.4 mn users
- 3.9 (Android) and 4.3 (iOS) rating in app store

Inflight connection ✓
- Europe's first and only solution combining LTE and satellite
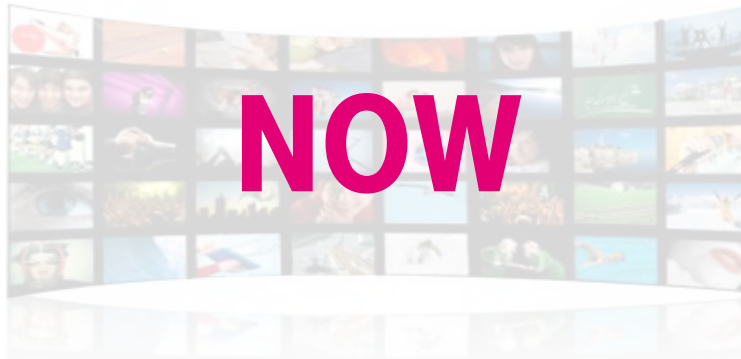
To come in the future

Smart speaker
- Voice control of Telekom services
- Integration of local partners

Entertain over the top ✓
- TV for everybody

Smart Glasses
- JV with Zeiss

NEW

3 LEAD IN BUSINESS PRODUCTIVITY INNOVATION

Market proven

NB IoT in 8 countries
- 200 projects with NB IoT applications, e.g., predictive maintenance solution for bridges, roads, buildings etc.

Smart City projects
- In 10 countries

Recently launched

City pass
- White label solution for digital city services
- Blockchain based

AR Maintenance
- To enhance workforce capabilities esp. in field organizations

Soon to come

Campus networks
- Leveraging 5G capabilities and edge cloud locally

Connected drones
- Starting with drone detection on LTE

Energy Management
- Piloting 5G capabilities for low voltage network steering

NOW

NEW

❸ FINALLY, WE DRIVE CULTURAL TRANSFORMATION

Global excellence in Technology & Innovation, e.g.

Claudia Nemat
Lead

Walter Goldenits
Technology Germany

Alex Jinsung Choi
Research &
Technology Innovation

Omar Tazi
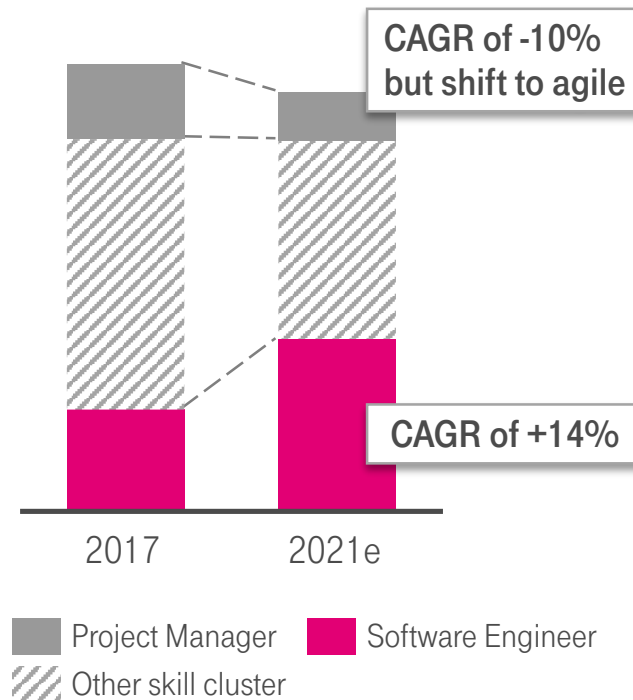Prod. Innovation &
Customer Experience

Peter Leukert
Telekom IT

Jean-Claude Geha
International
Technology & Services

Comprehensive skill transformation

Illustrative org. unit

CAGR of -10%
but shift to agile

CAGR of +14%

2017   2021e

■ Project Manager   ■ Software Engineer
▨ Other skill cluster

Agile working mode

Illustrative changes

- Reduction of organizational hierarchy level in innovation functions by 44%
- 50% of all people in VTI central functions will work in tribes/ squads instead of classical line organization
- Introduction of DevOps in Technology Germany

MID TERM AMBITION LEVEL

MID TERM AMBITION LEVEL

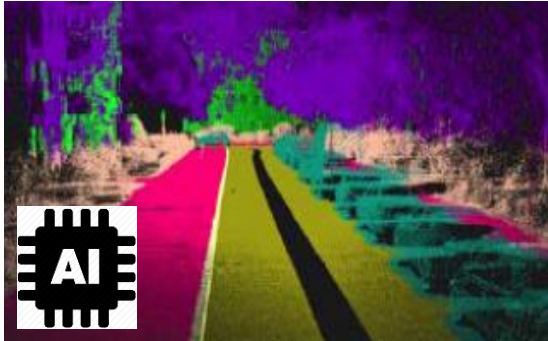|	Mid term ambition level	Commitment/Year
TECHNOLOGY LEADERSHIP	▪ Gigabit rollout in Germany ▪ Gigabit rollout in EU ▪ Mobile network leadership in Germany ▪ Mobile network leadership in EU ▪ 5G innovation leadership	▪ Ramp up to 2 mn HH p.a. by 2021 ▪ Ramp up to 0.75 mn HH p.a. by 2021[1] ▪ Outdoor LTE coverage 99% in 2020 and leading in customer experience ▪ Outdoor LTE coverage 99% in 2021 and leading in customer experience
VALUE TRANSFORMATION	▪ IP transformation completed ▪ IT transformation	▪ Greece in 2019 ▪ Germany B2C in 2019 ▪ Germany B2B in 2020 ▪ Delivery from 18 months today to 6 months on average in 2021 ▪ IT spend reduction of €0.2 bn in 2021

[1] FTTH/B and Cable ED3.1, excluding Romania

DEMONSTRATOR SESSION

3 Topics presented simultaneously in Circuit Training Mode. Your individual starting point is printed on the back of your badge.

Pass by on the way to the Evening Event:

1 | **AUTOMATION OF FIBER ROLLOUT PLANNING**

2 | **5G NEW RADIO + FIXED WIRELESS ACCESS**

3 | **AUGMENTED REALITY + EDGE COMPUTING**

TRENCHING + HORIZONTAL DIRECTIONAL DRILLING

- Use of Digitalization and artificial intelligence for planning of fiber rollout
- Benefit: Efficiency, speed, accuracy
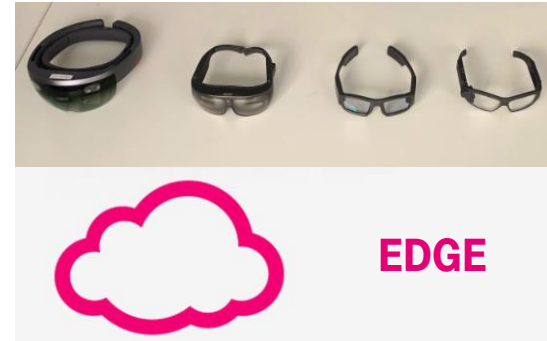
Presented by:
Walter Goldenits, CTO Germany

- 5G New Radio: Massive MIMO and beam forming
- Fixed Wireless Access Equipment
- Benefit: capacity and flexibility

Presented by:
Antje Williams, Executive Program Manager for 5G

- Quality shift in rendering results with edge based vs. on-device rendering
- B2B use cases
- Benefit: Productivity, convenience

Presented by:
Alex Choi, SVP Research & Technology Innovation

- Trenching Machine
- Horizontal Directional Drilling Machine
- Benefit for DT: Efficiency, speed