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

- All integrated countries 100% IP-based

### Achievements 2017

- Slovakia, Croatia and Hungary 100%, Greece 45% (100% in 2019\(^1\))
- Germany 67% (consumer 100% in 2019, business finished in 2020)

### Delivered

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

### ALL-IP TRANSFORMATION

- Backend and frontend data centers set up
- Geo-redundant Network Operations Centers established
- Services fully migrated to Pan-Net

### PAN-EUROPEAN NETWORK

- 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: \(\approx 80\%\) Fixed high speed internet HH coverage \(\geq 50\text{ Mbps}\)\(^2\)
- Europe: \(\approx 50\%\) Fixed high speed internet HH coverage \(\geq 100\text{ Mbps}\)
- Germany 94% and Europe 94%
- \(\approx 80\%\) HH vectoring coverage in 2019
- 32%
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

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

Source: CMD 2015 commitment

We confirm CMD 15 gross cost savings of €1.2 bn for early 2020ies as well as customer experience benefits
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: 77%
2018e: 95%
2019e: 100%

Super Vectoring homes passed
BNG migration quota

2017: 15 mn
2018e: 28 mn
2019e:
INTEGRATED NETWORK LEADERSHIP IN GERMANY AND EUROPE

Mobile network leadership for best customer experience

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

EUROPE¹
- 240,000 km fiber
- Exemplary fiber backhauling of 74% in Croatia, 51% in Romania and 47% in Slovakia and Hungary

¹ w/o TM NL

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

Connect Test 2017

TestSIEGER
CHIN UP, VERIZON, YOU CAN'T WIN THEM ALL. I MEAN, WE TESTED BUT YOU CAN'T.
1. Mobile just placed #1 in ALL 12 OpenSignal categories

SPEEDTEST
Connect Test 2017

OpenSignal
Test 2017

1. Exemplary fiber backhauling of 74% in Croatia, 51% in Romania and 47% in Slovakia and Hungary

GROUP STRATEGY    GERMANY    SYSTEMS SOLUTIONS    TECHNOLOGY & INNOVATION    T-MOBILE US    EUROPE    GROUP DEVELOPMENT    FINANCE
STRATEGY 2018 – 2021
TECHNOLOGY & INNOVATION AMBITION

Our strategy

GROW

- LEAD IN CUSTOMER EXPERIENCE
- LEAD IN TECHNOLOGY
- LEAD IN BUSINESS PRODUCTIVITY

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
- 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
WE WILL DEPLOY 5G SMARTLY

1. Mobile Capacity/Speed Upgrade
- Enhanced mobile broadband
- Starting with areas of interest (cities, campus networks; as overlay on 4G)
- More efficient than 4G from 2021 onwards

2. Fixed Wireless Access
- Gigabit speed on higher frequencies/millimeter waves
- Complement to FTTH/B in (sub-)urban areas
- Depending on topology, more cost-efficient than FTTH/B, faster time to market

3. Selected new products/solutions
- Massive IoT
- Low latency, QoS
- In selected areas of interest
- Enable new revenue streams
**1 ENHANCED MOBILE BROADBAND**

From today’s LTE networks ...

- 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

... towards a broader 5G ecosystem

- ... 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
Getting Ready for 5G to Leverage Future Efficiencies

**5G Readiness, e.g. Cell Densification Until 2021**

**Germany**
- Cell sites, estimated, k
- Cell densification starts in areas of interest (cities, campus networks)
- Superior fiber backhauling and SRAN

<table>
<thead>
<tr>
<th>Year</th>
<th>Macros</th>
<th>Small Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td>2021</td>
<td>36</td>
<td>27</td>
</tr>
</tbody>
</table>

**Europe**
- Cell sites, estimated, k

<table>
<thead>
<tr>
<th>Year</th>
<th>Macros</th>
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<tr>
<td>2017</td>
<td>41</td>
<td>47</td>
</tr>
<tr>
<td>2021</td>
<td>47</td>
<td>41</td>
</tr>
</tbody>
</table>

**Cost per Mbit/s for 4G/LTE Only vs. with 5G Overlay**

€ per Mbit/s as efficiency factor

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

<table>
<thead>
<tr>
<th>Year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>1.7x</td>
<td>2.3x</td>
<td>2.8x</td>
<td>4.2x</td>
<td></td>
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</tbody>
</table>

1. Network capacity costs per incremental busy hour capacity, assuming annually increasing traffic demand of 45%
WITH 5G FWA, WE CAN PROVIDE GIGABIT SPEED FAST

We trialed FWA in different topologies of Germany ...

Example 60 GHz trial

... 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
CAMPUS NETWORKS ARE FIRST SOLUTIONS WITH 5G/EDGE

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

Operator managed campus networks

“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)

Public cellular coverage

Private indoor & local cellular coverage

Robots & Machinery

“Dual Slice” Campus

Autonomous factory

Public cellular coverage

Private indoor & local cellular coverage

Robots & Machinery
1 REAL TIME ECONOMY OPENS BOUNDLESS OPPORTUNITIES

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
## BROADBAND PRODUCTION INNOVATION DRIVES EFFICIENCY

### Examples

<table>
<thead>
<tr>
<th>AUTOMATED FIBER ROLL-OUT PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Automated Fiber Roll-Out Planning" /></td>
</tr>
</tbody>
</table>

### 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**

![Impact Chart](image)

### “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

### Impact

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

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\(^1\) OLT = Optical line termination: the endpoint of our passive optical network, mostly located in street cabinets
IT TRANSFORMATION ENABLES ACCELERATED DIGITALIZATION

Paradigm shift in our approach towards it transformation

From

Big bang for BSS
Waterfall
Traditional skills

To

Portfolio approach
Agile
Comprehensive skill transformation

1 BSS: Business Support System; OSS: Operations Support System
NEW PORTFOLIO APPROACH REDUCES TRANSFORMATION COMPLEXITY

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempt to replace legacy by big bang</td>
<td>Portfolio approach with strong business-IT alignment</td>
<td>... reduced delivery time</td>
</tr>
<tr>
<td>Selective Greenfield</td>
<td>Agile scrum teams for dedicated projects:</td>
<td>... mitigated risk (compared to big bang)</td>
</tr>
<tr>
<td>Decoupling</td>
<td>- Fiber roll-out</td>
<td>... higher reusability to reduce IT cost midterm</td>
</tr>
<tr>
<td>Modernization</td>
<td>- Retail FMC</td>
<td></td>
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<tr>
<td></td>
<td>- B2B FMC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Esp. customer touch points from the business support system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Modernization for bulk of systems by creation of reusable (Micro-)services</td>
<td></td>
</tr>
</tbody>
</table>
CLEAR IMPACT EXPECTED ESPECIALLY ON TIME TO MARKET

Portfolio approach with payback of 2–3 years

Initial invest for portfolio approach

Impact of IT transformation

1 Average delivery time, month

2 Enabling process efficiencies in segments, % of delivery

3 IT spend reduction, bn €

- €0.2 bn

+ For agile projects (30%) a few weeks
### 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

### 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
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
Global excellence in Technology & Innovation, e.g.

- Claudia Nemat: Lead
- Alex Jinsung Choi: Research & Technology Innovation
- Peter Leukert: Telekom IT
- Walter Goldenits: Technology Germany
- Omar Tazi: Prod. Innovation & Customer Experience
- Jean-Claude Geha: International Technology & Services

Comprehensive skill transformation

- Illustrative org. unit
- CAGR of -10% but shift to agile

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

FINALLY, WE DRIVE CULTURAL TRANSFORMATION

3
MID TERM AMBITION LEVEL
## MID TERM AMBITION LEVEL

### TECHNOLOGY LEADERSHIP
- Gigabit rollout in Germany
- Gigabit rollout in EU
- Mobile network leadership in Germany
- Mobile network leadership in EU
- 5G innovation leadership

### VALUE TRANSFORMATION
- IP transformation completed
- IT transformation

### Commitment/Year
- Ramp up to 2 mn HH p.a. by 2021
- Ramp up to 0.75 mn HH p.a. by 2021
- Outdoor LTE coverage 99% in 2020 and leading in customer experience
- Outdoor LTE coverage 99% in 2021 and leading in customer experience
- 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

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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.

1. AUTOMATION OF FIBER ROLLOUT PLANNING
   - Use of Digitalization and artificial intelligence for planning of fiber rollout
   - Benefit: Efficiency, speed, accuracy
   Presented by: Walter Goldenits, CTO Germany

2. 5G NEW RADIO + FIXED WIRELESS ACCESS
   - 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

3. AUGMENTED REALITY + EDGE COMPUTING
   - 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

Pass by on the way to the Evening Event:

TRENCHING + HORIZONTAL DIRECTIONAL DRILLING
- Trenching Machine
- Horizontal Directional Drilling Machine
- Benefit for DT: Efficiency, speed