



**Annex Part 1 - Common Priority Key Performance Indicators**

|   | <b>Key Performance Indicator (KPI)</b> | <b>Value in 2017</b>  | <b>Baseline at the start of H2020 (latest available)</b> | <b>Target (for the cPPP) at the end of H2020</b> | <b>Comments</b>   |
|---|--|---|--|--|---|
| 1 | Mobilised Private Investments          | <p>The private investment significantly exceeds the expected leverage factor of 5 to 10 compared to public funding in the 5G PPP Contractual Arrangement.</p> <p><b>For detailed information on the methodology used by 5G IA for the 2017 KPI calculation,</b> please refer to the Business KPI “<i>B1. Leverage effect of EU research and innovation funding in terms of private investment in R&amp;D for 5G systems in the order of 5 to 10 times</i>” in Annex - Part 2 below.</p> |  |  |   |
| 2 | New skills and/or job profiles         |   |  |  | <ul style="list-style-type: none"> <li>This will also have an impact on the curricula of higher education.</li> </ul> |

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|   |                              |  |  |  | <ul style="list-style-type: none"> <li>• The following report provides useful information: <i>e-Skills in Europe - Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020)</i>. 2015<br/> <a href="http://eskills-lead.eu/fileadmin/lead/working_paper_-_supply_demand_forecast_2015_a.pdf">http://eskills-lead.eu/fileadmin/lead/working_paper_-_supply_demand_forecast_2015_a.pdf</a><br/> (e.g., see Table 1 at pg. 5)</li> <li>• Softwarisation driven by 5G will require new skills and increasingly in the software domain in the telecom business.</li> <li>• "<i>Initial feedback from 5G IA Members and 5G PPP Projects on 5G Related Curricula, New Skills and Job Profiles</i>" (Survey launched in July 2018) is enclosed hereunder:</li> </ul> <div style="text-align: center;">  <p>Initial feedback<br/>from 5G IA Members</p> </div> |
| 3 | Impact of the 5G PPP on SMEs |  |  |  | <ul style="list-style-type: none"> <li>• See information on the main PMR document</li> </ul> <p>An SME's business performance can depend on many factors, and not only on the participation in a given R&amp;D programme. It is up to the individual SME to quantify how the participation in 5G PPP projects had an influence on parameters like turnover, job profiles and staff headcount variations, etc... In most cases, they should manage to provide this information, with some degree of precision. <i>A survey to collect such information (turnover, job profiles and staff headcount variations) from the SMEs participating in the 5G PPP will be organised by the end Q1 2019</i></p>   |

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| 4 | Significant Innovations | <p>The Phase 1 ‘<b>Key achievements</b>’ <a href="https://5GPPP.eu/phase-1-key-achievements/">https://5GPPP.eu/phase-1-key-achievements/</a> are a good indicator of innovation (see main PMR document).</p> <p>The document enclosed hereunder “<b>5G IP Landscape Analysis</b>”, prepared by 5G IA Member Thales in the context of the preparation of the 5G PPP Progress Monitoring Report 2017, aims at determining early trends for 5G mobile network underlying technologies and may represent a contribution to the definition of IP KPIs for the 5G PPP.</p>  <p>5G IP Landscape Analysis - Extract for</p> <p>The Excel file enclosed hereunder presents a synthesis of</p> |  |  | <ul style="list-style-type: none"> <li>Information on IPRs is always difficult to assess as from the IPR application to receiving patents certain time-periods have to be respected.</li> </ul> |
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an initial '**patent search**' made on the European Patent Office' Espacenet <https://worldwide.espacenet.com/>




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The document "**5G PPP Work and Impact on Standardization**" enclosed hereunder provides an overview of the main activities, successes and challenges related to pre-standardization activities




5G PPP Work and Impact on Standardi

The document "**5G PPP Phase 1 and 2 Projects in the EC Innovation Radar**" hereunder provides information on

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|  |  | <p>innovations from 5G<br/>PPP Projects</p> <p></p> <p>5G PPP Phase 1 and<br/>2 Projects in the EC 1</p> |  |  |  |
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Part 2 - Specific Key Performance Indicators for the 5G PPP <sup>1</sup>

|   | KPI domain  | Key Performance Indicator (KPI)   | Value in 2017   | Baseline at the start of H2020 (latest available)  | Target (for the cPPP) at the end of H2020 | Comments |
|---|-------------|---|---|--|---|----------|
| 1 | Performance | P1. Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010                                      | Please refer to enclosed document hereunder<br><br>5GInfraPPP<br>TB_Performance-KPIs | A useful reference is the table on Performance KPIs evaluated by phase 1 project METIS-II (see Table A at the end of Annex – Part 2) |   |          |
| 2 | Performance | P2. Reducing the average service creation time cycle from 90 hours to 90 minutes  |   |  |   |          |
| 3 | Performance | P3. Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people |   |  |   |          |
| 4 | Performance | P4. Creating a secure, reliable and dependable internet with a "zero perceived" downtime for services provision                                   |   |  |   |          |

<sup>1</sup> It is often not possible to adequately present/capture the progress made on KPIs in a table. *Deliverable 2.6 "Final report on programme progress and KPIs"*



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| 5 | Business | B1. Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times |  |  |  | <p><u>Assessment methodology used</u></p> <p>Our methodology is based upon gathering the published public figures from annual reports for worldwide R&amp;D expenses. The main challenge is then to assess the declared R&amp;D figures of a representative set of key ICT players and deduce which proportion of their R&amp;D spend is 5G related. We also discussed if the 5G spend in Europe could be identified or at least assessed.</p> <p>We made conservative assumptions on what the 5G activities share of their worldwide R&amp;D was – usually in the order of 10% and then we further reduced that to reflect what European share of the 5G activities as part of the total R&amp;D expenses could be – typically we ended up with a figure of about 5% of global R&amp;D. To further eliminate over-assessment risks and to give us a very conservative figure we also considered the European 5G as 2% of Global R&amp;D. These proportions of 5G research of total research expenses will increase as 5G moves into full standardisation, development and production over the next few years and future iterations of these assessments will take account of this.</p> <p>Our first release dated July 2016 was based on publicly available figures for FY2015. The third edition uses FY2017 figures. We did not modify the shares applied last year as we consider the full standardisation phase has not been achieved yet. In our view, 2018 will be a transition year from standardisation to trials.</p> <p>For direct evaluation purposes, we took into account</p> |
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|  |  |  |  |  | <p>a representative set of players active in the 5G PPP. For a second reference figure we have considered a wider set of players in different aspects of the ICT sector including: equipment manufacturers, mobile network operators, test equipment manufacturers and device manufacturers, and chipset manufacturers.</p> <p><u>Main biases from the methodology and declared figures</u></p> <p>There are significant methodology biases that we have to be aware of.</p> <p>First, R&amp;D figures are often considered as critical by companies. As such, data on trends are not always consistent and public figures can be misleading. Some companies disclose information on Capital Expenditures, other on “innovation” – innovation appears as a portmanteau word that leaves much space for interpretation-, and still others prefer to use the term “R&amp;D expenses”, without one knowing the method actually used of what is counted.</p> <p>Second, the assumptions we made on what the 5G activities share of the worldwide figures collected was is based on our expertise but could significantly vary depending on companies. We tried to lower the uncertainty in this field as much as possible and correct misperceptions.</p> <p>Third, we selected a wide set of players involved in the 5G field but could not gather information from all companies. Information could remain fragmentary in some areas. However, we consider our sample of 23 organizations is reliable and representative.</p> |
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|   |          |   |                              |  | <p><u>Assessment of leverage ratio for 2017</u></p> <p>Redoing the same exercise in 2017, we get the results illustrated in Table B at the end of Annex – Part 2).</p> <p>From Table B it can be seen that the most conservative assessment of 2% of the Global R&amp;D spend being invested in 5G would increase in a <b>leverage factor of 21</b> considering the whole 5G PPP 2017 investment (Phase 1 third year and Phase 2 first year).</p> <p>The 5G PPP funding for phase 1 and phase 2 projects was about 70 MEUR for bigger industry, which facilitated projects with a value of around 30 MEUR per year – allowing for projects with different durations (between 24 to 26 months). The total funding budget for 5G PPP Call 1 was 125 MEUR. It was 150 MEUR for phase 2.</p> <p>Such a high leverage ratio is also due to the fact that we used a top-down approach based on information from the overall industry, rather than exclusively from R&amp;D activities related to 5G PPP.</p> <p><u>Conclusion on Leverage ratio for 2017</u></p> <p>From the above exercise, even allowing for the assumptions and generalisations, we can confidently state that the European ICT sector is exceeding, the planned level of investment leverage expected in the 5G PPP Contractual Arrangement.</p> |
| 6 | Business | B2. Target SME participation under this initiative commensurate with an | SMEs represent an average of |  | Small and Medium-sized Enterprises (SMEs) have an important role to play in developing, piloting and deploying 5G technologies, both to help with  |



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|  |  | allocation of 20% of the total public funding | 19% of the participants in budget in the 5G PPP Phase 1 and Phase 2 projects, almost reaching the objective of 20% that is the minimum share set as a KPI for the 5G PPP. |  | <p>disruptive technologies and to address the needs of various vertical sectors. European SMEs have a great added value in providing innovative concepts and solutions with an important impact on the 5G value chain. They have the agility and flexibility required in a fast evolving market.</p> <p>The SME Working Group, supported by Euro-5G and then To-Euro-5G Coordination and Support Action projects, involved 100 SMEs, as well as 12 industrial companies and 18 research organisations by the end of 2017. It succeeded in increasing the visibility and exposure of SME's expertise and skills to the point that SME represent an average of nearly 20% of the participants in budget in the 5G PPP Phase 1 and Phase 2 projects, almost reaching the objective of 20% that is the minimum share set as a KPI for the 5G PPP. The next challenge is to reach 20% or more for the upcoming Phase 3.</p> <p>To reach this ambitious objective, the "Find the SME you need!"<sup>2</sup> web page was completely revamped to match SMEs' experience and expertise with the new requirements set for Phase 3 of the 5G PPP, looking for developing 5G platforms and large-scale trials in various vertical industrial sectors. The page now includes the way to find SMEs via topics of the 5G PPP calls, and by vertical industrial sector. Detailed information is provided for each SME. New success stories on SME involvement have been published. An active promotion of SMEs was performed via social channels and participation in events. In June</p> |
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<sup>2</sup> <https://www.networld2020.eu/find-the-sme-you-need/>


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|   |          |  |  |  |  | <p>2017 and 2018, a dedicated “SME booth” was set at the European Conference for Networks and Communication (EuCNC). Several SME videos are available on the 5G PPP YouTube channel<sup>3</sup>.</p> <p>SMEs participating in the SME Working Group have confirmed that their presence on the SME web page have increased their visibility and exposure, and in some cases have facilitated their involvement in 5G PPP Phase 3 proposals -in addition to being contacted by organisations that they had already known and worked with.</p> |
| 7 | Business | B3. Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43% global market share in communication infrastructure |  |  |  | As 5G services have not yet been introduced to the market it is too early to report on this business KPI  |
| 8 | Societal | S1. Enabling advanced user controlled privacy  |  |  |  | As 5G services have not yet been introduced to the market it is too early to report on this societal KPI.   |
| 9 | Societal | S2. Reduction of energy consumption per service up to 90% (as compared to 2010)  |  |  |  | <p>More than 10 years battery lifetime on a single 5 Wh battery were achieved.</p> <p>For the capacityX1000, network energy efficiency</p>  |


<sup>3</sup> <https://5G PPP.eu/video/> and <https://www.youtube.com/channel/UCY8mTTwrDoMI35vGkiKq1Eg>

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|    |          |   |   |  |  | improvements of 350-7500 were reported.  |
| 10 | Societal | S3. European availability of a competitive industrial offer for 5G systems and technologies                 |   |  |  | Information is not available yet.  |
| 11 | Societal | S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications |   |  |  | <p>NetWorld2020 and 5G IA document “<i>Economic considerations on Smart Networks as key enabler of the Human Centric Internet and the digital transformation research in FP9</i>” (enclosed hereunder) provides an excellent description of the essential link between 5G and Smart Networks and their strong positive impact on economy and society in Europe and globally.</p> <p><br/> Networld2020 -<br/> 5GIA Socio-economi</p> <p>Some considerations and findings extracted from the document are reported in the main PMR document.</p> |
| 12 | Societal | S5. Establishment and availability of 5G skills development curricula (in partnership with the EIT)         | In June 2016, 5G IA made a survey to collect information among NetWorld2020 research Members on 5G curricula (see |  |  | <p>5G IA and EIT Digital have established a positive dialogue on how the two organisations could mutually benefit from a close cooperation in particular in relation to the establishment and availability of 5G skill development curricula.</p> <p>In particular, discussions with EIT Digital have been initiated to cooperate on curricula for higher education (e.g. possible 5G IA’s involvement in the activities of the EIT’s ‘Summer School’).</p>  |

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|  |  |  | <p>document enclosed hereunder)</p> <p><br/>5G skills development curricula</p> <p>The survey was meant to give an initial/partial overview of the types of curricula available as a basis for discussion with EIT Digital.</p> |  | <p>Further collaboration in this area and implementation of actions are planned in 2018.</p> <ul style="list-style-type: none"><li>• <i>"Initial feedback from 5G IA Members and 5G PPP Projects on 5G Related Curricula, New Skills and Job Profiles"</i> (Survey launched in July 2018) is enclosed hereunder:</li></ul> <p><br/>Initial feedback from 5G IA Members</p> |
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**Annex Part 3 Contribution to Programme-Level KPI's**

|   | <b>Key Performance Indicator</b> | <b>Definition/Responding to question</b>  | <b>Type of data required</b>  | <b>Data [Commission]</b> | <b>Baseline at the start of H2020 (latest available)</b> | <b>Target (for the cPPP) at the end of H2020</b> | <b>Comments</b> |
|---|----------------------------------|---|---|--------------------------|--|--|-----------------|
| 1 | Patents                          | <p>The document enclosed hereunder “<b>5G IP Landscape Analysis</b>”, prepared by 5G IA Member Thales in the context of the preparation of the 5G PPP Progress Monitoring Report 2017, aims at determining early trends for 5G mobile network underlying technologies and may represent a contribution to the definition of IP KPIs for the 5G PPP.</p> <p align="center"> <br/>                     5G IP Landscape Analysis - Extract for                 </p> <p>The document provides information on key issues, including:</p> <ul style="list-style-type: none"> <li>• Patents Search Methodolgy</li> <li>• General Trends</li> <li>• Geographical coverage</li> </ul> | <p>Number of patent applications.</p><br><p>Number of patents awarded</p> |                          |  |  |                 |

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|   |   | <ul style="list-style-type: none"> <li>• Top 20 assignees</li> <li>• Technology segments evolution</li> </ul>  |   |  |  |  |  |
| 2 | <p>Standardisation activities (project level)</p> <p>Contributions to new standards (PPP level)</p> | <p>The document “<b>5G PPP Work and Impact on Standardization</b>” enclosed hereunder provides an overview of the main activities, successes and challenges related to pre-standardization activities</p> <p> 5G PPP Work and Impact on Standardi</p> <p>In 5G PPP Phase 1, there were 317 contributions towards 19 standards groups.</p> <p>In 5G PPP Phase 2, 40 contributions towards 19 standards groups have</p> | <p>Number of activities leading to standardisation</p> <p>Number of working items in European Standardisation Bodies.</p> <p>Number of pre-normative research files – prEN - under consultation in ESBs</p> |  |  |  |  |

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|   |                         | <p>been identified so far.<br/>Based on current evidence, the total number of relevant standards organisations is expected to increase with the involvement of vertical industries.</p>   |  |  |  |  |  |
| 3 | Operational performance | <p>Time-to-grant ICT-07-2017:</p> <ul style="list-style-type: none"> <li>• Call closure date: 08 November 2016</li> <li>• Start of large majority of the projects: 1 June 2017 – More details available at: <a href="https://5g-ppp.eu/5g-ppp-phase-2-projects/">https://5g-ppp.eu/5g-ppp-phase-2-projects/</a></li> </ul> <p>Time-to-grant ICT-08-2017:</p> <ul style="list-style-type: none"> <li>• Call closure date: 08 November 2016</li> <li>• Start of large majority of the projects: 1 June 2017 – More details available at: <a href="https://5g-ppp.eu/5g-ppp-phase-2-projects/">https://5g-ppp.eu/5g-ppp-phase-2-projects/</a></li> </ul> |  |  |  |  |  |



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| 5 | <b>H2020 - LEIT</b><br>- Number of joint public-private publications | Number and share of joint public-private publications out of all LEIT publications. | Properly flagged publications data (DOI) from LEIT funded projects |  |  |  |  |
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*Table A - Performance KPIs evaluated by phase 1 project METIS-II*

| KPI                        | Requirement                         | METIS-II performance                | Key contributor  |
|----------------------------|-------------------------------------|-------------------------------------|--|
| C-Plane latency            | < 10 ms                             | 7.125 ms                            | RRC Connected Inactive, reduction of processing time in BS and UE                    |
| U-Plane latency            | < 1ms                               | 0.763 ms                            | Shortening of TTI, reduction of processing time in BS and UE                         |
| mMTC energy efficiency     | > 10 years on a single 5 Wh battery | > 10 years on a single 5 Wh battery | Extension of DRX, C-Plane latency reduction, deep sleep energy conservation features |
| Peak data rates            | > 20/10 Gbps for DL/UL              | 21.7/12.4 Gbps for DL/UL            | MIMO spatial multiplexing (for lower frequencies), exploitation of mmW bands         |
| Mobility interruption time | 0 ms                                | 0 ms                                | Multi-connectivity + make-before-brake   |

| KPI   | Requirements  | METIS-II performance   | Comments  |
|---|---|--|---|
| <b>User throughput</b><br>(use case 1, UC2 and UC3) | UC1: 300 Mbps<br>UC2: up to 5 Gbps<br>UC3: 50/25 Mbps for DL/UL | UC1: 1 Gbps+<br>UC2: up to 7.85 Gbps<br>UC3: 50/25 Mbps for DL/UL                        | Only DL values for UC1 and UC2<br><br>Different methodology applied for UC3 evaluation                                    |
| <b>mMTC device density</b><br>(UC4)                 | > 1 mln/km <sup>2</sup>   | 4 mln/km <sup>2</sup>  | Depends heavily on the traffic/report periodicity of mMTC devices. 1 upload of 1000 bits every 100 s was used in METIS-II |
| <b>Reliability</b><br>(UC5)                         | 99.999% at 50/1000m for urban/highway                           | 99.999% at 45/150m for urban/highway   | For highway scenario, requirements seems very difficult to meet (revision needed?)  |
| <b>Network energy efficiency</b><br>(UC1, UC3)      | Should follow (at least) capacity improvement                   | For the capacity x1000, network energy efficiency improvements of 350-7500 were reported | Evaluation done only for Dense Urban environment. Savings depend on the load level in LTE-A/5G network                    |

*Table B - 5G R&D expenses – Investment Leverage Effect*

| 5G PRIVATE R&D SPENDING (Million EUR)                  |                            | 2017R&D | 5G as 10% of global R&D | 5G as 5% of Global R&D | 5G as 2% of Global R&D |            |
|--|----------------------------|---------|-------------------------|------------------------|------------------------|------------|
| <b>Infrastructure Vendors</b>                          |                            |         |                         |                        |                        |            |
|  | Ericsson                   | 3 932   | 393                     | 197                    | 79                     |            |
|  | Nokia (Incl. ALU)          | 4 916   | 492                     | 246                    | 98                     |            |
|  | Huawei                     | 11 772  | 1 177                   | 589                    | 235                    |            |
|  | NEC Europe                 | ?       | 50                      | 25                     | 10                     |            |
|  | Samsung*                   | 13 185  | 659                     | 330                    | 132                    |            |
| <b>MNOs</b>  |                            |         |                         |                        |                        |            |
|  | British Telecom            | ?       | 50                      | 25                     | 10                     |            |
|  | Deutsche Telekom           | 5 500   | 550                     | 275                    | 110                    |            |
|  | Orange                     | 781     | 78                      | 39                     | 16                     |            |
|  | Portugal Telecom           | ?       | 7                       | 3                      | 1                      |            |
|  | TIM                        | 1 900   | 190                     | 95                     | 38                     |            |
|  | Telefonica                 | 906     | 91                      | 45                     | 18                     |            |
|  | Telenor                    | 60      | 6                       | 3                      | 1                      |            |
| <b>Test equipment</b>                                  |                            |         |                         |                        |                        |            |
|  | Keysight Technologies*     | 442     | 22,1                    | 11,05                  | 6                      |            |
|  | Rohde & Schwartz           | 285     | 29                      | 14                     | 6                      |            |
| <b>Chipset</b>   |                            |         |                         |                        |                        |            |
|  | Intel*                     | 11 618  | 576                     | 288                    | 115                    |            |
|  | Sequans                    | 23      | 2                       | 1                      | 0                      |            |
| <b>IT</b>  |                            |         |                         |                        |                        |            |
|  | ATOS                       | ?       | 29                      | 14                     | 6                      |            |
|  | IBM                        | 1350    | 135                     | 67,5                   | 27                     |            |
| <b>Others</b>  |                            |         |                         |                        |                        |            |
|  | ADVA                       | 24      | 2                       | 1                      | 0,5                    |            |
|  | CEA                        | 47,25   | 7                       | 3                      | 1                      |            |
|  | Hewlett Packard Enterprise | ?       | 7                       | 3                      | 1                      |            |
|  | Thales                     | 750     | 75                      | 38                     | 15                     |            |
|  | IHP                        | 22,4    | 2                       | 1                      | 0                      |            |
| <b>TOTAL 5G PRIVATE R&amp;D SPENDING (Million EUR)</b> |                            |         | <b>57 514</b>           | <b>4 630</b>           | <b>2 312</b>           | <b>926</b> |
| Phase 1 total funding from EC                          |                            |         | 125                     | 125                    | 125                    | 125        |
| Phase 1 third year funding                             |                            |         | 45                      | 45                     | 45                     | 45         |
| The players in the table share of EU funding is        |                            |         | 50%                     | 50%                    | 50%                    | 50%        |
| Phase 1 third year funding for above mentioned players |                            |         | 23                      | 23                     | 23                     | 23         |
| Phase 2 total funding from EC                          |                            |         | 150                     | 150                    | 150                    | 150        |
| Phase 2 first year funding                             |                            |         | 33                      | 33                     | 33                     | 33         |
| The players in the table share of EU funding is        |                            |         | 50%                     | 50%                    | 50%                    | 50%        |
| Phase 2 1st year funding for above mentioned players   |                            |         | 17                      | 17                     | 17                     | 17         |
| Leverage factor 2017**                                 |                            |         |                         | 104                    | 52                     | 21         |
| Leverage factor 2017 for above mentioned players       |                            |         |                         | 207                    | 104                    | 42         |

*Assumptions are in italics when R&D expenses are unknown*

\*: For companies not based in Europe

\*\* : (Phase 1 3rd year and Phase 2 1st year funding) divided by TOTAL 5G PRIVATE R&D SPENDING

*Source: To-Euro-5G, based on publicly available figures and estimates*