

# Emerging 5G Technologies Affecting Markets of Composite Materials

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## **1 Introduction**

The imminent 5G technologies are rather different from many other technological waves that change the world and our everyday lives. The difference is that the interests of industry and technological leaps emerge faster than expected for the 5G revolution. The ever-increasing needs of wireless services, such as high-accuracy navigation, mobile services, the multifaceted infrastructure for autonomous vehicles, as well as various local services for individuals require significantly higher data throughput compared to current 3G and 4G technologies. The 5G technology relies on a wide span of frequency ranges also beyond the UHF spectrum, say 24–90 GHz, to overcome the challenges of latency, resilience, and bandwidth limits <sup>1</sup>. In addition to the above-mentioned public services

of future Smart Cities, the 5G technology is a platform for industrial data handling in terms of massive device connectivity <sup>2</sup>.

The implementation process of 5G technology has been anticipated to launch new business concepts <sup>3</sup>. The operation and maintenance of the 5G infrastructure is different from the current operation due to the sheer number of small cell transmitters-receivers. New business models have been suggested for the operation, e.g., a neutral host concept <sup>4</sup>. In future Smart Cities, the infrastructure shall be integrated to smart buildings or multi-technology pole systems <sup>5</sup> in order to combine efficient lighting operation, energy efficient power distribution, and an aesthetic urban environment. The 5G infrastructure will be close to us on the streets, buildings, amidst public spaces, and inside our homes. The realisation of the devices must be done so that they feel like a part of our everyday lives and benefit our wellbeing—an overly essential issue not achieved by the current designs of e.g. antenna base stations and the radios attached to them.

## 2 Composite materials for 5G revolution

The challenge and the opportunity laid down by 5G for composite structures and materials is the very low signal attenuation preferred by the 5–90 GHz signals within the 5G frame. Fibre-reinforced plastics (FRPs) in general pass on radio frequency (RF) signals, yet the attenuation in typical FRPs is rather high and the anisotropy of the materials affects the directionality of attenuation.

New composite materials with optimized attenuation characteristics can be used to build integrated 5G units, poles, walls, window frames the sky being the limit. Naturally, the inherent tailorability of FRPs does not restrict the shape of an aesthetic design of a product and allows the highest mechanical performance compared to all rival building materials.

At Exel Composites (Exel), the emerging 5G revolution is seen as a big opportunity for the whole composites industry. The application possibilities merely lie on radio-integrated infrastructural elements, city base stations and in buildings where composite structures can work as signal window inside and/or outside, but there could be many more applications, especially within the transportation industry. The traditional base stations will not go anywhere either and there will still be masts where composites have had a role for a long time already.

Exel has been supplying FRP radomes for antenna base stations for more than 20 years, but there has been doubts within the telecommunication industry whether FRP is the material for higher frequencies and the broadband signals that the 5G era will be all about.

The answer is that is and it isn't. If you take a conventional FRP radome used in 3G/4G/LTE antenna base stations today, some alternative materials, merely plastics, will do better. However, if the frequency is set, composites can be tailored to work better than most of the alternative materials. At the end of the day, 'composites' means two or more materials being greater together than alone.

Sustainability is the key factor for future structures and this should not be forgotten when new infrastructure is being built. Composites are well known for their long lifetimes as they do not corrode or gather mold. Composites are free from maintenance and that together with the durability puts composites in favourable light in terms of lifetime costs. Lifetime costs have been the single biggest reason for increasing composite usage, e.g., in bridges.

### 3 Strategic management of extensions into novel product ranges - smart light pole-based 5G infrastructure

Exel is engaging in developing new innovative composite products into the emergent market of smart light pole-based 5G infrastructure. Exel has many years of experience in the management of a large variety of product ranges, including airport masts, profile tubes, telescope, profile, cyclical tubes, ski laminates and other sports equipment. Exel's competitive advantages rests on large capacity and the ability to provide tailored products for large customers. For a glass and carbon fibre-based product manufacturer using pultrusion technology, the emergent market and novel envisioned product ranges within smart light pole-based 5G infrastructure presents distinct strategic management challenges for the firm for developing novel products and extending its product range. Smart light pole-based 5G infrastructure initially sets demands to successfully develop capabilities, product designs, and technological innovations to be able to take advantages of the emergent market opportunities in smart light pole 5G infrastructure. Secondly, expanding manufacturing of a product range into an emergent product market domain, where uncertainty and volatility is high, requires the company and its executives to develop strategic flexibility and operational efficiency.

Exel's established long-term relationships with large customers as well as with reference projects, allows the formation of highly capable multipartner projects. Exel is currently engaged in developing the novel products and extending its product range through multipartner innovation and product development projects. These projects strive to develop both the wider ecosystems' capability to advance smart light pole-based 5G infrastructure especially in cities and to develop forerunner products for the novel market. The emergent technological infrastructure and the technologies to be used for smart light pole-based 5G infrastructure sets new demands, both with regard to innovative design and material performance with composite products, especially increasing operating performance parameters of this infrastructure. This requires strategic management of acquiring, embedding, and utilising internal and external knowledge from multiple sources <sup>6</sup>. Furthermore, taking a forerunner role in smart light pole based 5G infrastructure engages Exel and its partners in work to establish industry standards in design and technological properties in smart light pole-based 5G infrastructure. Together these innovation and product development projects develops Exel's abilities to successfully create and manage in-house product innovations efficiently and the development of a new range of advanced composite products for smart light pole-based 5G infrastructure.

Extending firms' product ranges in novel markets requires strategic flexibility. New emergent yet uncertain and volatile market realities require flexible allocation of resources along the internal value creation process <sup>7</sup> as well as buffers and slack. Strategic flexibility critically influences business performance during volatility and unpredictability <sup>8</sup>. It is important to develop strategic flexibility, i.e., development of organic structures and advanced management and partnership practices, as Exel is focused on leading the development of this product segment and to be competitive in the emergent market. Being strategically flexible nurtures the development, production, sales, and distribution of products in an emergent market <sup>7</sup>.

Extension of product ranges to smart light pole-based 5G infrastructure furthermore requires operational efficiencies to strengthening customisation capabilities and abilities in manufacturing to produce tailored solutions with novel technical features and preinstalled functionalities <sup>7</sup>. While customisation is Exel's strength, the novel technical demands from the multiple technology functions of smart light pole-based 5G infrastructure further acerbates both existing and new demands for operational efficiency. These include the overall ability to manage product and/or process diversity through modularity and flexibility of products and processes and flexible automation. To advance them requires investment in advanced manufacturing technologies and digitisation.

tion of manufacturing, i.e., flexibility-enhancing technology investments for increased productivity and inventory turnover advantages and investments in advanced digital interfaces for collaborating and transacting (i.e., verification of quality of products, and producing demand forecasts), with customers with different demands.

## 4 Commercialisation and implementation of composites in the 5G infrastructure

The shift towards 5G technology also affects commercialisation and business development of composites. Firms aiming to commercialise novel technologies typically face commercialisation challenges (see Aarikka-Stenroos & Lehtimäki, 2014<sup>9</sup>), namely choosing a feasible commercialisation strategy in conditions of uncertainty, understanding the benefits of innovation from the customer's perspective, creating credibility for novel solutions, acquiring support from stakeholders and the ecosystem, overcoming adoption barriers, and finally inducing and creating sales for novel technology. Here turning composite to business requires acknowledging and solving several issues. First, it is important to identify the sources of customer value when composites are in the 5G infrastructure. These customer value-creating benefits can be monetary or indirect monetary by nature. Here, customer value can originate, for example, from durability, and lower need for maintenance and from other features that create savings in the short and long term along the life span for different kinds of customer groups and segments in the public and private sectors.

Second, it is relevant to acknowledge who the relevant actors are that can advance commercialisation of composites in the 5G infrastructure<sup>10</sup>. Very diverse stakeholders from experts to regulators can advance implementation and usage by facilitating the adoption of the new technology-critical stakeholders and advancing diffusion. The obstacle to innovation could be the lack of ecosystem and the network.

## 5 Ecosystem development over new business models and products

The creation of new 'entrepreneurial' ecosystems is clearly a major challenge requiring a conducive (local) culture, enabling policies and leadership, availability of appropriate finance, quality human capital, venture-friendly markets for products, and a range of institutional support<sup>11</sup>. The interaction between these favourable, local, sets of conditions and resources facilitates entrepreneurial success<sup>12</sup> within the ecosystem and is marked by a mutual dependence between actors<sup>13</sup> and the co-evolution between organisations<sup>14</sup>.

This kind of interaction perspective emphasises the process of activities and events involved in the emergence of new opportunities. Recent research into new biomaterial ecosystems in Finland<sup>15</sup> suggests that the entrepreneurial ecosystem emerges through co-creative, micro-processes of interaction, through critical learning and reflection events, and is orchestrated by key actors as nascent communities or networks'<sup>16</sup> metamorphose through several phases of development into an ecosystem. Interactional activities are critical in that they determine the emergence of communities, networks, network capabilities, common priorities<sup>17</sup> and create synergies between different actors<sup>18</sup> thereby contributing to the emergence of potential entrepreneurial opportunities<sup>19</sup> and the overall success of the entrepreneurial ecosystem<sup>20</sup>.

## 6 The Luxturrim5G consortium

An ongoing project, LuxTurrim5G <sup>21</sup>, will solve critical challenges developing and demonstrating concrete technical solutions for smart light pole-based 5G infrastructure, and business and service innovations based on it. The project brings different highly committed stakeholders to close collaboration to create new ecosystem building key enablers and solutions utilising modern 5G networks for smart city environmental needs. The project will develop a new light pole with 5G capability, where 5G small cell will be integrated into light pole mechanics. This digital ecosystem requires open interfaces and data access for different stakeholders and service providers. This is a key element for the aim of bringing the effective novel data networks available and open real business base for a variety of services. The new digital ecosystem needs a new kind of business models for stakeholders, as there is a need for new forms of collaboration and new kinds of value will be offered to customers. Smart cities in the future will invest in the city infrastructure just as today, like lighting on streets. However, 5G connectivity is still a question mark for cities in the present day. Today, cities do not own connectivity infrastructure and the LuxTurrim5G project will offer a complete platform with lighting, 5G connectivity and other embedded services with the platform. Taga et al. (2017) <sup>22</sup> estimate that new smart-city operators will come to the ecosystem, who will then invest in platforms to support mobility management, street lighting, waste management, etc. The LuxTurrim5G project is ongoing alongside business ecosystem studies, where different service and business scenarios are being evaluated. New services will certainly be needed in the future and new ecosystem members will take part in the 5G connectivity ecosystem. A couple of service examples will be developed to test the platform and enable early market opportunity for participating companies: imaging (surveillance cameras), climate analysis, location (sensors), info sharing (active screens) and smart lighting control. Many other services can be built on top of the platform, including, e.g., control of autonomous vehicles to enable effective and sustainable modern urban transport. The 5G light pole technology platform, service platform and operational model developed, tested and proven through the LuxTurrim5G project can be replicated in the global market, which gives the ecosystem partners huge potential to grow and expand their businesses.

## 7 Summarising remarks

At Exel Composites, the emerging 5G revolution is seen as a big opportunity for the whole composites industry. The application possibilities merely lie on radio-integrated infrastructural elements, city base stations and in buildings where composite structures can work as a signal window inside and/or outside, but there could be many more applications. To establish and realise the huge business potential, the following issues must be considered:

- it is important to develop strategic flexibility, advanced management and partnership practices, as Exel is focused on leading the development of this product segment and to be competitive in the emergent market;
- it is relevant (1) to identify what the sources of 5G customer value are, (2) to identify who the relevant actors are that can advance the commercialisation of 5G infrastructure, and (3) to support new ecosystem development;
- any entrepreneurial, new ecosystem emergence needs interactional activities that determine the emergence of communities, networks, network capabilities, common priorities and create synergy between different actors;

- the emerging 5G digital ecosystem in particular requires open interfaces and data access for different stakeholders and service providers to bring in data networks available for real business base, new kind of business models to offer new kinds of value to customers.

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